

True Color VGA Family *CL-GD542X*

Technical Reference Manual



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Revision History

This technical reference manual has been modified to incorporate a new member of the True Color VGA family, the CL-GD5425. All pertinent information has been added, including:

- Functional descriptions
- Pin diagrams and descriptions
- Bus interface specifications
- Timing considerations
- Register information
- BIOS functions
- Schematics
- TV output support
- Glossary definitions

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1. INTRODUCTION

1.1 Scope of Document

This manual provides technical information for the CL-GD542X family of VGA controllers. This manual includes a description of each major component integrated into the chip, a data book, detailed information on each register, BIOS, and a number of application notes to assist hardware and software designers.

1.2 Applicable Chip Types

This manual documents chip Revision A or later.

The CL-GD542X ID Register — CR27, will read back a value indicating the chip-family member. Refer to Chapter 9, “Extension Register Descriptions”, for further information.

1.3 Intended Audience

This manual is intended for the technically sophisticated audience. It is assumed that the reader is familiar with assembly language programming on the 8088/8086, 80286/80386/80486, 80386SX, or similar microprocessor, and understands the fundamentals of video display technology.

Management personnel should find Chapter 2, “Overview”, useful.

Hardware engineers should find Chapter 3, “Data Book”, useful. It contains the pinouts and detailed pin descriptions, tables indicating how the various interfaces must be connected, and detailed DC and AC characteristics. In addition, the application notes in Appendix B should be helpful for board designs.

Software engineers should find Chapters 4–9 (register descriptions) useful for BIOS- and driver-level codes. All registers are described to the bit level. Also, the application notes in Appendices B–D should be helpful, especially those discussing the palette DAC and clock options, and programming methods.

1.4 Conventions

This section discusses conventions used throughout this document. Conventions include acronyms, abbreviations, and nomenclature usage. For a quick reference of acronyms see Table 1-1.

Bits

Bits are always listed in descending order, most-significant (highest number) to least-significant (lowest number). When discussing a bit field within a register or memory, the bit number of the most-significant bit is given on the left, followed by a colon (:) and then the bit number of the least-significant bit (for example, bits 7:0). A field consists of a set of adjoining bits with common functionality. Registers are made up of fields of one or more bits.

Acronyms

Table 1-1 lists acronyms common to this manual. For further definitions, refer to Appendix F1, "Glossary and Bibliography".

Table 1-1. Acronym Quick Reference

Acronym	Definition
A.N.	alpha numeric
BIOS	basic input output system
BPP	bits per pixel
CGA	color graphics adapter
CMOS	complementary metal-oxide semiconductor
DRAM	dynamic random access memory
EGA	enhanced graphics adapter
EPROM	electrically programmable read-only memory
High-Z	high-impedance
I/O	input/output
LUT	lookup table
MSB	most-significant bit
RAM	random access memory
RGB	red, green, blue
SR logic	set/reset logic
VAFC	VESA® Advanced Feature Connector
VGA	video graphics array
VRAM	video (dynamic) random access memory

Acronym	Definition
A.P.A.	all points addressable
BitBLT	bit boundary block transfer
CAS	column address strobe
CLUT	color lookup table
DI	data in
EEPROM	electrically erasable/programmable read-only memory
EISA	extended industry standard architecture
FIFO	first-in/first-out
HSYNC/VSNC	horizontal/vertical synchronization
LSB	least-significant bit
MD	memory data
N/A	not available
RAS	row address strobe
R/W	read/write
TTL	transistor-transistor logic
VESA®	Video Electronics Standards Association
VLUT	video lookup table

Abbreviations

The unit 'Kbyte' designates 1024 bytes. The unit 'Mbyte' designates 1,048,576 bytes (1024 squared). The unit 'Gbyte' designates 1000 megabytes. The unit 'Hz' designates hertz. The unit 'kHz' designates 1000 hertz. The unit 'MHz' designates 1000 kilohertz. The unit 'ns' designates nanosecond. The unit ' μ s' designates microsecond (1000 nanoseconds). The unit 'ms' designates millisecond (1000 microseconds). The unit 'mA' designates milliampere. The use of 'tbd' in tables indicates values that are 'to be determined'.

Numeric Naming

Hexadecimal numbers are represented with all letters in uppercase and a lowercase 'h' is appended to them (for example, '14h', '3A7h', and 'C000h' are hexadecimal numbers). Numbers not indicated by an 'h' are decimal. Octal numbers are not used in this manual.

Reserved

When a system memory or I/O address is referred to as 'Reserved', it means that writing to that address is not permitted. Reserved bits *must* be written as '0' to maintain upward compatibility.

Read-Only

The word 'Read-only' is used to indicate registers and bits that can be read, but not written to.

2. OVERVIEW

The True Color VGA family of VGA controllers supports high-resolution graphics and text display modes for a variety of color CRT monitors using industry-standard 15-pin analog video and VESA interfaces.

The CL-GD542X chips are hardware- and software-compatible with the IBM® VGA, and provide improved performance and additional functionality.

Highly integrated, these chips include a programmable dual-frequency synthesizer and palette DAC. A complete 512 Kbyte motherboard solution can be implemented with a single DRAM.

The CL-GD542X implements all control and data registers in the standard VGA controller. It also implements all data manipulation capabilities and data paths in the standard VGA adapter.

2.1 Features

Table 2-1 is a list of the major features of the CL-GD542X family of VGA controllers.

Table 2-1. CL-GD542X Family Features

Features	'GD5420	'GD5422	'GD5424	'GD5425	'GD5426	'GD5428	'GD5429
Performance							
VESA® VL-Bus™ and Direct '386 or '486 CPU Interface			✓	✓	✓	✓	✓
BitBLT engine					✓	Enhanced	Memory-mapped I/O
Zero-wait-state operation	✓	✓	✓	✓	✓	✓	✓
Maximum display memory	1 Mbyte	1 Mbyte	1 Mbyte	1 Mbyte	2 Mbytes	2 Mbytes	2 Mbytes
Display memory interface	16-bit	32-bit	32-bit	32-bit	32-bit	32-bit	32-bit
Hardware cursor (in pixels)	up to 32 × 32	up to 64 × 64	up to 64 × 64	up to 64 × 64	up to 64 × 64	up to 64 × 64	up to 64 × 64
Maximum dot clock frequency	75 MHz	80 MHz	80 MHz	80 MHz	80 MHz	80 MHz	86 MHz
Maximum MCLK frequency	50 MHz	50 MHz	50 MHz	60 MHz	50 MHz	50 MHz	60 MHz
High Integration							
Integrated palette DAC and dual-frequency synthesizer	✓	✓	✓	✓	✓	✓	✓
Motherboard VGA solution with only two ICs	✓	✓	✓	✓	✓	✓	✓
Built-in port for VESA® feature connector	✓	✓	✓	✓	✓	✓	✓
Built-in ISA (up to 12.5 MHz), MicroChannel® bus support	✓	✓	✓	✓	✓	✓	✓
Built-in TV output support				✓			

Table 2-1. CL-GD542X Family Features *(cont.)*

Features	'GD5420	'GD5422	'GD5424	'GD5425	'GD5426	'GD5428	'GD5429
Flexibility							
Support for ×4-, ×8-, and ×16-bit-wide memory DRAMs	✓	✓	✓	✓	✓	✓	✓
8- or 16-bit host bus I/O and memory interface	✓	✓	✓	✓	✓	✓	✓
8-bit gray and 3-3-2 RGB DAC modes				✓		✓	✓
CCIR 601 YCrCb mode				✓			
General							
100% hardware- and BIOS-compatible with IBM® VGA display standards	✓	✓	✓	✓	✓	✓	✓
'Green PC' compliant	✓	✓	✓	✓	✓	✓	✓
132-column text mode support	✓	✓	✓	✓	✓	✓	✓
46E8 or 3C3 sleep mechanism		✓	✓	✓	✓	✓	✓
Video overlay and 'color key' support		✓	✓	✓	✓	✓	✓
VESA® VAFCTM base support (for video overlay)				✓			✓
Clocking support for CL-PX2080 MediaDAC™				✓		✓	✓
Low-power CMOS, 160-pin package	✓	✓	✓	✓	✓	✓	✓
Screen resolution and colors							
640 × 480	up to 256	up to 16M	up to 16M	up to 16M	up to 16M	up to 16M	up to 16M
800 × 600	up to 256	up to 64K	up to 64K	up to 64K	up to 64K	up to 64K	up to 64K
1024 × 768 (interlaced)	up to 256	up to 256	up to 256	up to 256	up to 256	up to 64K	up to 64K
1024 × 768 (non-interlaced)	up to 256	up to 256	up to 256	up to 256	up to 256	up to 256	up to 256
1280 × 1024 (interlaced)		up to 16	up to 16	up to 16	up to 256	up to 256	up to 256

Table 2-2. Summary of Screen Resolutions

Resolutions	CL-GD5420	CL-GD5422	CL-GD5424 CL-GD5425	CL-GD5426 CL-GD5428 CL-GD5429
640 × 480 × 256 color, 8 bits/pixel	✓	✓	✓	✓
640 × 480 × 32K color, 16 bits/pixel		✓	✓	✓
640 × 480 × 64K color, 16 bits/pixel		✓	✓	✓
640 × 480 × 16M color, 24 bits/pixel		✓	✓	✓
800 × 600 × 16 color, 4 bit planes	✓	✓	✓	✓
800 × 600 × 256 color, 8 bits/pixel	✓	✓	✓	✓
800 × 600 × 32K color, 16 bits/pixel		✓	✓	✓
800 × 600 × 64K color, 16 bits/pixel		✓	✓	✓
1024 × 768 × 16 color, 4 bit planes (interlaced and non-interlaced)	✓	✓	✓	✓
1024 × 768 × 256 color, 8 bits/pixel (interlaced and non-interlaced)	✓	✓	✓	✓
1024 × 768 × 32K color, 16 bits/pixel (interlaced)				✓
1024 × 768 × 64K color, 16 bits/pixel (interlaced)				✓
1280 × 1024 × 16 color, 4 bit planes (interlaced)		✓	✓	✓
1280 × 1024 × 256 color, 8 bits/pixel (interlaced)				✓

2.2 Chip Architecture

The CL-GD542X includes all the hardware required to implement CPU updates to display memory, Screen Refresh, and DRAM Refresh. It interfaces directly with the host system or the local bus, the display memory, and the monitor. The host interface can be either 8-or-16-bits-wide for memory and I/O. The CL-GD542X requires no glue logic for address decoding and control logic handshaking.

The four major activities supported by the CL-GD542X are:

- **Host access to CL-GD542X registers**
- **Host access to display memory**
- **Display access to display memory (screen refresh)**
- **Display Memory Refresh**

2.2.1 Host Access to CL-GD542X Registers

The host (typically an ISA, MicroChannel®, or '386 and '486/VESA VL local bus) can access CL-GD542X registers by setting up 16- or 24-bit addresses and generating I/O control signals to read or write 8- or 16-bit data. Other activities, such as DRAM refresh, screen refresh, and delayed CPU writes to display memory can take place concurrently with accesses to registers.

The registers are listed in Chapter 3, "Data Book", and described in Chapters 4–9. These registers include all the standard VGA registers, and are host-readable to allow BIOS and driver software to determine the state of the graphics adapter.

2.2.2 Host Access to Display Memory

The CL-GD542X handles the host access to display memory. The host effects memory accesses in the VGA address range to transfer data to or from one or more of the four display memory Planes. All of the required video handshake interface signals are internally generated by the CL-GD542X with no requirement for external logic decoding.

The CL-GD542X takes 24-bit addresses from the host, and transforms them according to the selected addressing mode and address space mappings, finally issuing multiplexed addresses to the planes via the MA[9:0] Address bus. RAS*, CAS*, OE*, and WE[3:0]* provide timing and control to the display memories. When interfacing to DRAMs that have dual-CAS* signals, the CAS* pin becomes WE*, and the WE[3:0]* pins become CAS[3:0]*.

A Write Buffer is logically located at the CPU interface to isolate the CPU from the display memory. The CPU Write accesses to display memory take place immediately until the Write Buffer is full. The address and data are written into the cache, and the actual write into display memory occurs later. If the Write Buffer is full, wait states will be inserted until there is space.

2.2.3 Display Access to Display Memory

The CL-GD542X also contains an intelligent Address Sequencer that allocates display memory cycles not only to the host, but also to the display CRT Controller for screen refresh.

A FIFO logically between the Memory Sequencer and the Attribute Controller decouples the memory speed from the display speed, allowing the execution of Fast-page-mode accesses for screen refresh. This minimizes the memory bandwidth required.

The display is blanked during horizontal and vertical retrace intervals, freeing additional memory bandwidth for host access. The CL-GD542X improves on the performance of the IBM VGA implementation, especially for lower-resolution displays.

2.2.4 Display Memory Refresh

The CL-GD542X handles the refresh of the dynamic RAMs used for the display memory. During each horizontal blanking period, a selectable number of CAS*-before-RAS* refresh cycles are executed.

2.3 Major Components

The CL-GD542X incorporates all the major subsections of the IBM VGA/EGA into a single integrated circuit:

- **Sequencer**
- **CRT Controller**
- **Graphics Controller**
- **Attribute Controller**
- **Programmable Dual-Frequency Synthesizer**
- **Palette DAC**

In describing the CL-GD542X family of VGA controllers, it is useful to retain the identity of the original major subsections found in the IBM EGA and VGA controllers. The architectures of these major subsections are described on the following pages.

2.3.1 Sequencer

The Sequencer controls access to the display memory. It ensures that the necessary screen refresh and dynamic memory refresh cycles are executed, and that the remaining memory cycles are made available for CPU and BLT read/write operations.

The Sequencer consists of a memory arbitrator and a memory controller. It accepts requests from memory address counters associated with the CRTC, and address transformation logic associated with the Graphics Controller. It uses the Video FIFO to deliver data to the Attribute Controller, and the Write Buffer to transfer data to the Graphics Controller.

The Memory Sequencer registers are described in Chapter 5.

The memory controller is driven by a memory clock (MCLK) optimized for the speed of the DRAM used, independent of the video clock. It generates the signals and addresses necessary for accessing the display memory. The memory arbitrator is also driven by the memory clock. It implements a policy that selects requests from either the CPU or the CRT on a dynamic priority.

2.3.2 CRT Controller

The CRT Controller generates the horizontal and vertical synchronization signals for the CRT display. It includes various registers that allow flexible configuration options. These options include user-configurable horizontal and vertical timing and polarity, cursor position, horizontal scanlines, and other display-related characteristics. The CRT Controller registers are described in Chapter 6.

The CRT Controller is equivalent to the IBM CRTC as implemented in the IBM VGA hardware. The CRT Controller also provides split screen capability and smooth scrolling. A simplified block diagram of the CRT Controller is shown in Figure 2-1.

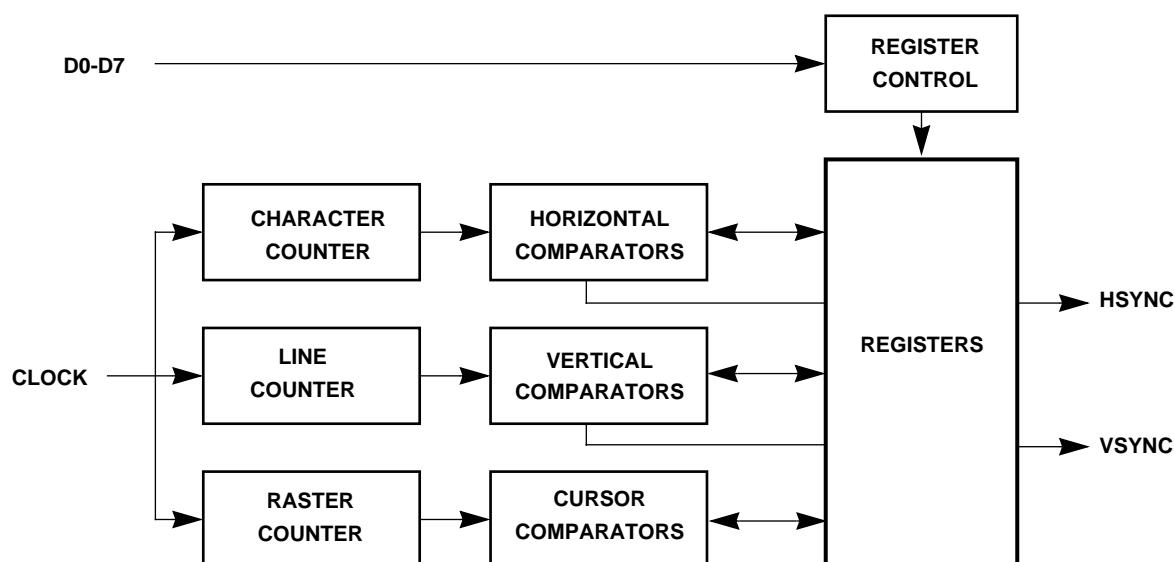


Figure 2-1. CRT Controller Functional Block Diagram

2.3.3 Graphics Controller

The Graphics Controller operates in either text or graphics modes and has the following major functions:

- Provides the host CPU a read/write access path to display memory
- Controls all four memory planes
- Allows data to be manipulated prior to being written to display RAM
- Formats data for use in various backward compatibility modes
- Provides color comparators for use in color painting modes
- Reads/writes 32-bit words through the 32-bit display memory interface
- Combines display RAM data and attribute data for output to the Pixel bus

The Graphics Controller directs data from the display memory to the Attribute Controller and to the CPU. Figure 2-2 and Figure 2-3 illustrate typical write and read operations, respectively.

For a write operation, the data from the CPU bus are combined with the data from the Set/Reset Logic, depending on the Write mode. In addition, the data may be combined with the contents of the read latches, and some bits or planes may be masked (prevented from being changed). See the descriptions of the Graphics Controller registers in Chapter 7 for more information.

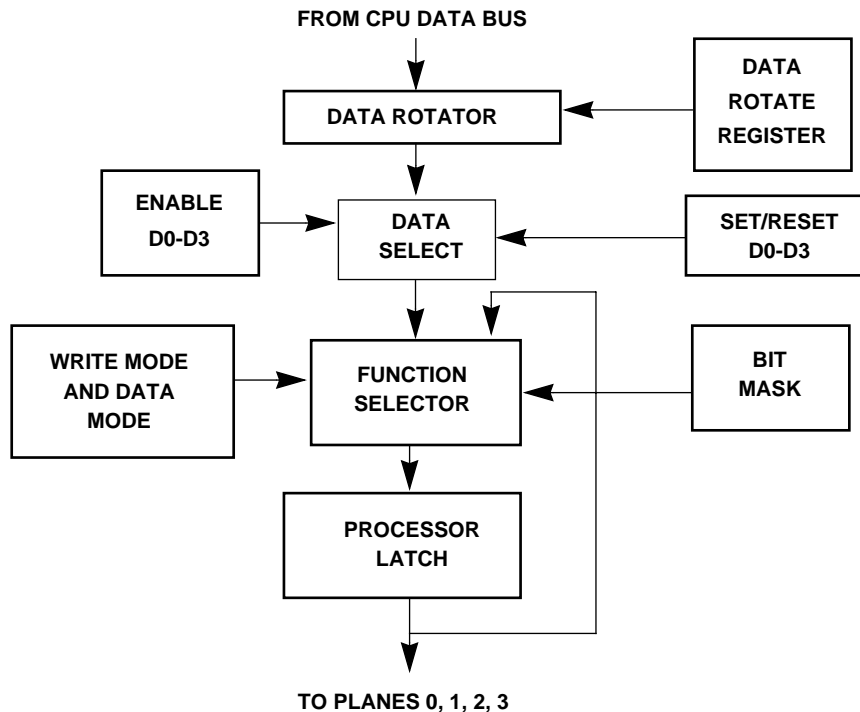


Figure 2-2. Graphics Controller Write Operation

The Graphics Controller is also involved when the CPU is reading data from display memory. Depending on the Read mode, the data returned may be the actual contents of the display memory, or it may reflect the outcome of comparisons with the color value in one of the Graphics Controller registers. See the descriptions of the Graphics Controller registers in Chapter 7 for more information.

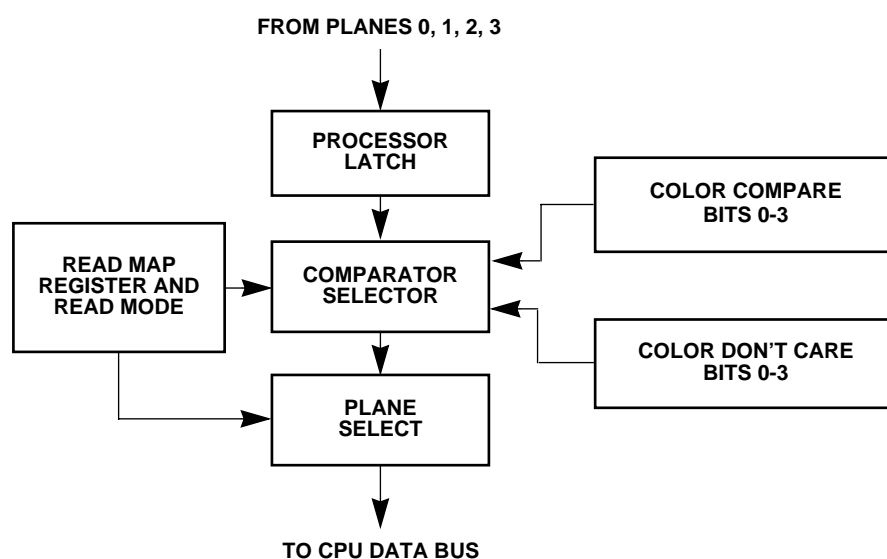


Figure 2-3. Graphics Controller Read Operation

2.3.4 Attribute Controller

The Attribute Controller controls blinking and underline operations in alphanumeric modes. It also provides the horizontal pixel panning capability in both alphanumeric and graphics modes. The Attribute Controller registers are described in Chapter 8. Figure 2-4 depicts the functional block diagram of the Attribute Controller.

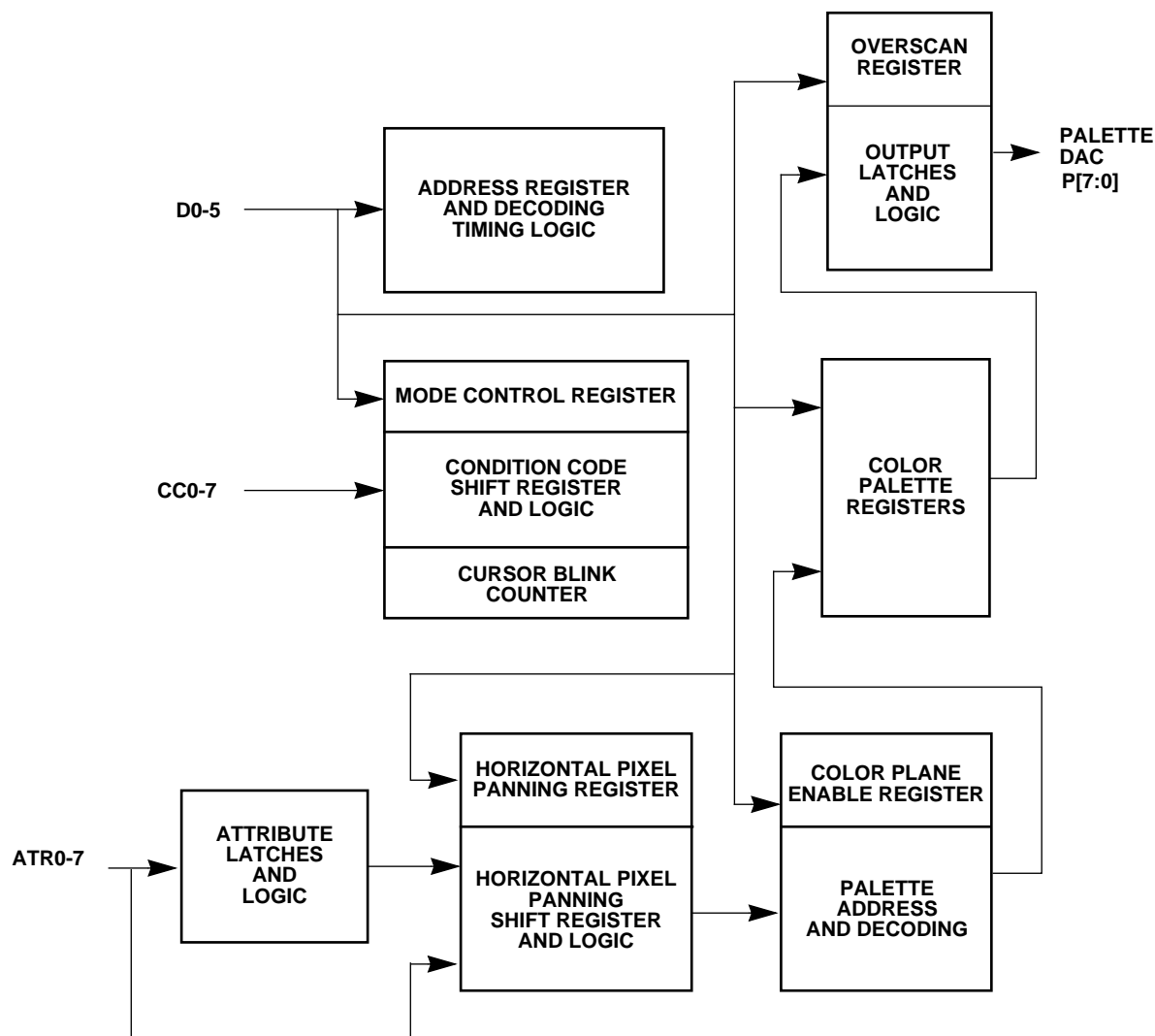


Figure 2-4. Attribute Controller Functional Block Diagram

2.3.5 Dual-Frequency Synthesizer

The CL-GD542X includes an integrated dual-frequency synthesizer that can be programmed to generate the VCLK for many standard screen formats, and the MCLK used by the Sequencer. The synthesizer requires a single-reference frequency of 14.31818 MHz that can be supplied by the on-chip oscillator, or can be injected from an external source.

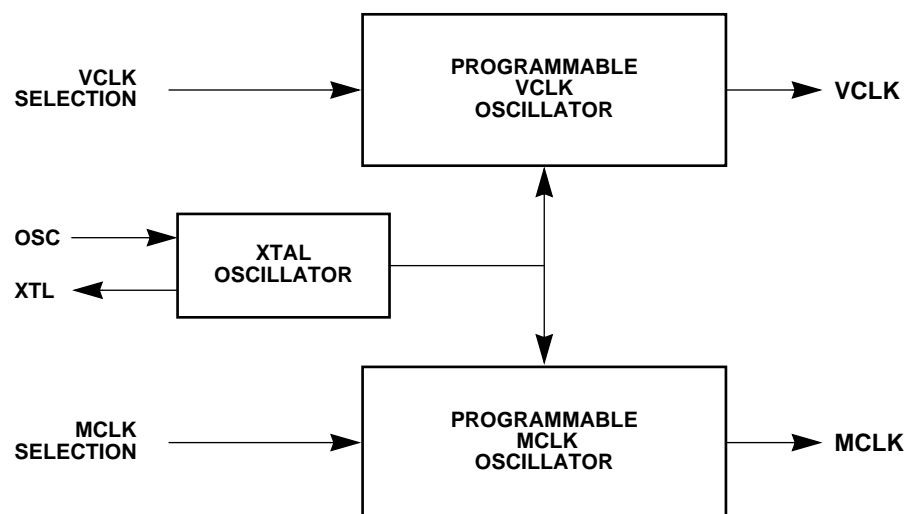


Figure 2-5. Programmable Dual-Frequency Synthesizer Functional Diagram

2.3.6 Palette DAC

The CL-GD542X includes an integrated palette DAC that can interface directly to the monitor connector via appropriate RFI filters. The palette DAC can be programmed for 256 simultaneous colors from a palette of 256K, Direct-color mode, or YCrCb (CL-GD5425 only). In Direct-color mode, two or three contiguous bytes from the display memory are combined for each pixel. This allows 32K, 64K, or 16.8 million simultaneous colors on the screen. The CL-GD5425 can be programmed for YCrCb (16 bpp) or AccuPak™, a proprietary compression method. In addition, the CL-GD5425 can be configured for a 7.5 IRE offset black level. Figure 2-6 is a functional block diagram of the palette DAC.

The pixel bus, DCLK, and BLANK* can be driven into the CL-GD542X. This allows it to operate in the VESA-standard VGA passthrough connector mode. Fifteen- or sixteen-bit data can also be inserted from an external source through the P[7:0] pins. In addition to the VESA standard, the EVIDEO input is capable of switching at the pixel rate.

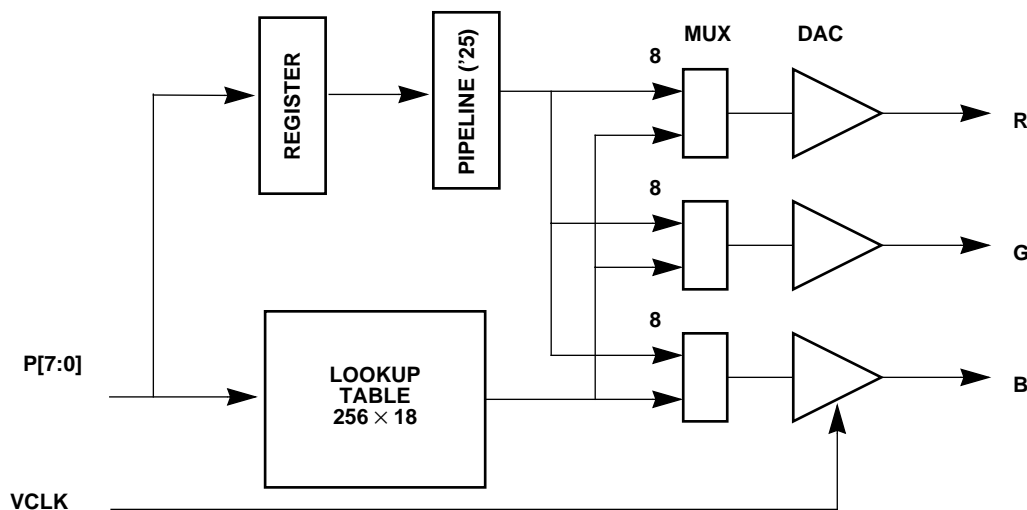


Figure 2-6. Palette DAC

2.4 Hardware/Software Compatibility

The CL-GD542X includes all registers and data paths required for VGA controllers. Enhancements include 1024×768 , 8-bit Pixel mode, an internal color palette, eight simultaneously loadable text fonts, Write mode 3, and readable registers.

Extended-resolution display modes are made possible by the high video clock rates and high display memory bandwidth.

Extended text and graphics resolutions beyond the 640×350 IBM EGA and 640×480 VGA standards are also supported by the Cirrus Logic BIOS on both fixed-frequency, PS/2™-compatible monitors as well as multiple-frequency monitors such as the NEC® MultiSync™. These include 132-column and 60-line text modes, 640×480 and 800×600 32,768 and 65,536-color graphics modes, 800×600 16-color VESA mode, and 640×480 16.8-million True Color mode. The extended-resolution capabilities of the CL-GD542X are listed in the Chapter 3, "Data Book", along with the listing of the standard screen formats.

2.5 Video Subsystem Architecture

The following diagram shows the main components needed to implement a functional VGA subsystem using the CL-GD542X. The interfaces that must be implemented are the host CPU interface, the BIOS interface (for adapter board implementation only), the display memory interface, and the CRT interface.

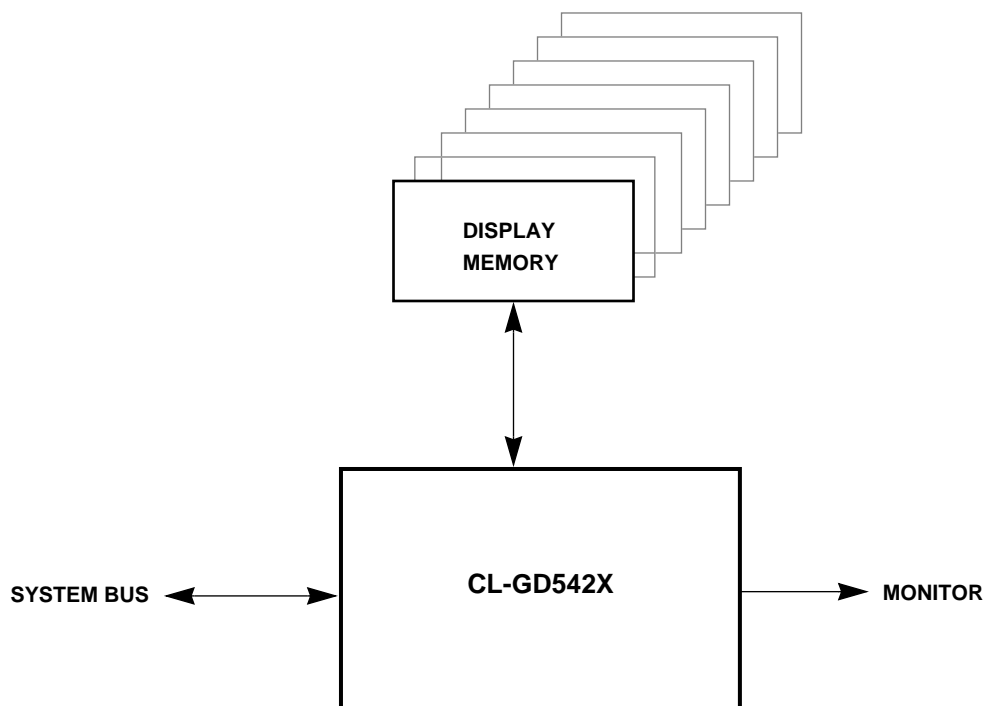


Figure 2-7. Video Subsystem Architecture

FEATURES

- **32-bit GUI acceleration (CL-GD5426/'28/'29)**
 - BitBLT (Bit block transfer) engine
 - Color expansion for 8- or 16-bit pixels
- **16/32-bit CPU interface**
 - VESA® VL-Bus™ (up to 50 MHz)
 - ISA bus (12.5 MHz)
 - Zero-wait-state write cycles
- **Resolutions up to 1280 × 1024**
 - 1024 × 768 × 256 colors, non-interlaced
 - 800 × 600 × 64K colors, non-interlaced
 - 640 × 480 × 16M colors, non-interlaced
 - 1280 × 1024 × 256 colors, interlaced
 - 1024 × 768 × 64K colors, interlaced
- **Programmable dual-clock synthesizer**
 - Pixel clock programmable up to 86 MHz
 - Memory clock programmable up to 60 MHz
- **Integrated 24-bit true-color RAMDAC**
- **'Green PC' power-saving features**
 - VESA® DPMS (Display Power Management Signal)
 - Internal DAC with programmable power-down mode
 - Static monitor sync signals
- **Support for multimedia applications**
 - 3-3-2 RGB DAC modes for video playback (CL-GD5425/'28/'29)
 - Support of VAFC (VESA® advanced feature connector) baseline for video overlay (CL-GD5425/'29)
- **100% hardware- and BIOS-compatible with IBM® VGA display standards**

True Color VGA Family

- CL-GD5429** — Memory-Mapped I/O VGA GUI Accelerator with Local Bus
- CL-GD5428** — Enhanced VGA GUI Accelerator with Local Bus
- CL-GD5426** — VGA GUI Accelerator with Local Bus
- CL-GD5425** — True Color VGA Controller with TV Output
- CL-GD5424** — True Color VGA with Local Bus
- CL-GD5422** — True Color VGA
- CL-GD5420** — Super VGA

OVERVIEW

The CL-GD542X family of true-color VGA controllers offers an extensive range of industry-leading features and functionality for IBM®-compatible personal computers.

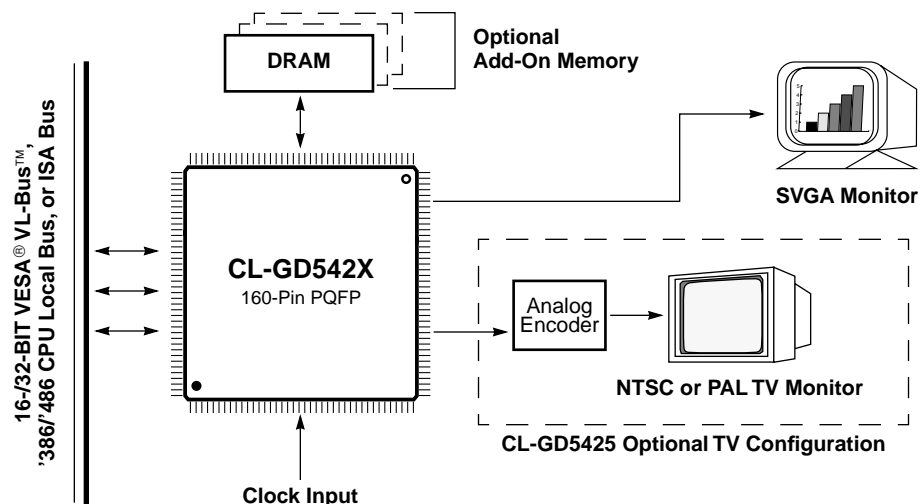
Ideally suited to highly integrated systems, CL-GD542X devices require no external support other than display memory and a crystal frequency reference. CL-GD542X devices are 100% hardware- and BIOS-compatible with IBM VGA standards, and connect directly to an ISA or local bus, allowing a minimum adapter solution.

Operating at dot clock rates programmable up to 86 MHz, CL-GD542X devices support standard and VESA® high-resolution and extended modes. The internal palette DAC may be configured as an industry-standard RAMDAC to provide a palette of 256K colors, or true-color displays of 32K, 64K, and 16.8 million colors.

(cont.)

(cont.)

System Block Diagram



OVERVIEW (cont.)

The internal dual-frequency synthesizer requires a single crystal or reference for all supported screen resolutions, as well as all standard display memory speeds and formats. The CL-GD542X devices implement all control and data registers according to current VGA standards. They also implement all standard data path and manipulation functions, providing complete hardware compatibility.

In addition, the CL-GD542X devices support extended registers and capabilities to provide functional and performance enhancements beyond standard VGA.

CL-GD542X devices support ISA or 32-bit VESA VL-Bus interfaces in all operations, including I/O and memory

operations in planar modes. The write cycles to memory are optimized with zero-wait-state capability. Sixteen-/thirty-two-bit local bus interfacing can be achieved for '386SX, '386DX, and '486 microprocessors as well as VESA VL-Bus. The CL-GD5426/'28/'29 also offer BitBLT operation for GUI acceleration.

The CL-GD542X family also includes many power-saving ('Green PC') features, including an internal DAC with programmable power-down mode, sync signals that can be individually disabled (static levels), and internal clocks programmable to low frequencies for nearly static operation.

Software Support

Software Drivers	Resolution Supported ^a	No. of Colors
Microsoft® Windows® 95 CL-GD5425	640 × 480, 800 × 600, 1024 × 768	256
	640 × 480, 800 × 600	32,768
	640 × 480	16.8 million
Microsoft® Intel® DCI CL-GD5425	640 × 480, 800 × 600, 1024 × 768	256
	640 × 480, 800 × 600	65,536
	640 × 480	16.8 million
Microsoft® Windows® v3.X CL-GD5425	640 × 480, 800 × 600, 1024 × 768, 1280 × 1024	16
	640 × 480, 800 × 600, 1024 × 768, 1280 × 1024	256
	640 × 480, 800 × 600, 1024 × 768	65,536
	640 × 480	16.8 million
Microsoft® Windows NT™ v1.X	640 × 480, 800 × 600, 1024 × 768	16 and 256
OS/2® v2.0, v2.1	800 × 600, 1024 × 768	16 ^b
	640 × 480, 800 × 600, 1024 × 768	256 ^b
AutoCAD® v11, v12, Autoshade® v2.0, w/ Renderman, 3D Studio™ v1,v2	640 × 480, 800 × 600, 1024 × 768, 1280 × 1024	16
	640 × 480, 800 × 600, 1024 × 768, 1280 × 1024	256
	640 × 480, 800 × 600, 1024 × 768	65,536
	640 × 480	16.8 million
GEM™ v3.X	800 × 600, 1024 × 768	16
Ventura Publisher® v2, v3	800 × 600, 1024 × 768	16
Lotus® 1-2-3® v2.X,	132 × 25, 132 × 43 (text)	16
	800 × 600	16
Lotus® 1-2-3® v3.X	132 × 25, 132 × 43 (text)	16
	800 × 600, 1024 × 768	16
Microsoft® Word v5.X	132 × 25, 132 × 43 (text)	16
	800 × 600, 1024 × 768	16
WordPerfect® v5.0	800 × 600	16
WordPerfect® v5.1	132 × 25, 132 × 43 (text)	16
	800 × 600, 1024 × 768	16
WordStar® v5.5–v7.0	800 × 600, 1024 × 768	16

^a Not all monitors support all resolutions; 640 × 480 drivers will run on PS/2®,-type monitors. Extended resolutions are dependent upon monitor type and VGA system implementation.

^b OS/2® v2.0 requires a v2.0 Corrective Service Pack for 256 .

CL-GD5425 Highlights

True Color VGA Controller with TV Output

FEATURES

- **True color VGA controller with TV output**
 - Scaling fits full VGA display into TV viewing area while maintaining proper aspect ratio
 - Flicker-filter reduces interlaced artifacts associated with computer-generated graphic images
- **Glueless interface to popular TV encoders**
- **Multimedia support**
 - Video overlay of 16-bit RGB, 16-bit YCrCb
 - 8-bit feature connector
 - 16-bit VAFC (VESA[®] advanced feature connector)
 - GENLOCK support
- **Graphics acceleration features:**
 - Color expansion reduces host bus traffic
 - 64 × 64 hardware cursor
 - Display memory linear addressing
- **Flexible 16-bit host interface**
 - VESA[®] VL-Bus[™] (up to 50 MHz)
 - ISA bus
- **Flexible 32-bit display memory interface**
 - Supports 256K ×4, ×8, ×16 DRAMs
 - 512-Kbyte or 1-Mbyte memory capacity
- **Integrated 24-bit DAC**
 - VGA resolution up to 1024 × 768, 256 colors
 - NTSC resolution up to 640 × 480, 64K colors, scaled with flicker filter
 - PAL resolution up to 640 × 480, 64K colors with flicker filter

OVERVIEW

The CL-GD5425 integrates a Super VGA controller, dual-frequency synthesizer, true-color palette DAC, and TV processing support into a single device.

A member of the industry-standard CL-GD542X family of true color VGA controllers, the CL-GD5425 is fully backed by software and design support.

The CL-GD5425 provides NTSC/PAL timing for standard VGA display modes, as well as the following extended resolutions:

Extended Resolutions for TV Output

Resolution	No. of Colors	Memory
640 × 480	256	512 Kbyte
640 × 480	64K	1 Mbyte
640 × 400	64K	512 Kbyte

The CL-GD5425 provides integrated scaling, flicker reduction, and a glueless encoder interface that delivers high-quality TV display at the lowest possible cost without the need for additional frame or line stores.

The programmable flicker-reduction function reduces interlaced artifacts inherent in computer-generated images displayed on interlaced TV monitors. The degree of filtering is selectable by the end-user.

The CL-GD5425 is 100% hardware- and BIOS-compatible with VGA standards, and connects directly to the VESA[®] VL-Bus[™] or ISA bus. A single DRAM, two frequency references, and an economical analog encoder are added to make a complete set-top graphics system.

CL-GD542X ADVANTAGES

Unique Features

Cost Effectiveness —

- Glueless interface to as few as one DRAM, built-in true-color palette DAC and dual-frequency synthesizer
- Interface to $\times 4$, $\times 8$, $\times 16$ DRAMs

High Performance —

- 16-bit VESA® VL-Bus™ and local bus interface
- Hardware BitBLT for Windows® (CL-GD5425/'26/'28/'29)
- 32-bit-wide DRAM interface
- Maximizes fast-page mode access to display-memory DRAMs
- Host access to DRAMs through advanced write buffers
- 15-, 16-, or 24-bit true-color palette DAC

Multimedia —

- 3-3-2 RGB DAC modes for video playback (CL-GD5425/'28/'29)
- NTSC or PAL output (CL-GD5425)
- Overlay and 'color key', and GENLOCK support

Compatibility —

- Compatible with VGA and VESA® standards
- Drivers supplied at various resolutions for Windows® 3.1, Windows® 95™, and other key applications
- Connects directly to multifrequency analog monitors

BIOS SUPPORT

- Fully IBM® VGA-compatible BIOS
- Relocatable, 32 Kbytes with VESA® VL-Bus™ local bus support
- VBE (VESA® BIOS extensions) support in ROM
- Support for DPMS (display power management signaling) in ROM

Benefits

- ☐ Minimizes chip count and board space; enables a cost-effective solution.
- ☐ Allows design flexibility for use of appropriate type and amount of memory.
- ☐ Increases system throughput.
- ☐ Accelerates GUI applications such as Microsoft® Windows® and similar applications.
- ☐ Eliminates display-memory bottleneck.
- ☐ Improves CPU performance by accessing maximum bandwidth available from DRAM display memory.
- ☐ Provides faster host access for writes to display memory.
- ☐ Provides high- and true-color display for photo-realistic images; 32K, 64K, or 16.8 million colors displayed simultaneously on screen for lifelike images.
- ☐ Enables high-resolution playback for live video applications.
- ☐ Allows TV viewing of PC games and applications.
- ☐ Allows 16-bit per pixel interfacing through the VESA® connector for multimedia applications.
- ☐ Ensures compatibility with installed base of systems and software.
- ☐ Provides a 'ready-to-go' solution that minimizes the need for additional driver development.
- ☐ Drives all PC-industry-standard, high-resolution monitors to ensure compatibility.

UTILITIES

- Graphics and video diagnostics test
- Windows® and DOS utilities
- Video mode configuration utility — CLMODE
- Set resolution in Windows® utility — WINMODE
- Configurable system integration for OEMs — OEMSI

CL-GD542X Family Features

Features	'GD5420	'GD5422	'GD5424	'GD5425	'GD5426	'GD5428	'GD5429
Performance							
VESA® VL-Bus™ and Direct 80386 or 80486 CPU interface			✓	✓	✓	✓	✓
BitBLT engine					✓	Enhanced	MM I/O
Zero-wait-state operation	✓	✓	✓	✓	✓	✓	✓
Maximum display memory	1 Mbyte	1 Mbyte	1 Mbyte	1 Mbyte	2 Mbytes	2 Mbytes	2 Mbytes
Display memory interface	16-bit	32-bit	32-bit	32-bit	32-bit	32-bit	32-bit
Hardware cursor (in pixels)	up to 32 × 32	up to 64 × 64	up to 64 × 64	up to 64 × 64	up to 64 × 64	up to 64 × 64	up to 64 × 64
Maximum dot clock frequency	75 MHz	80 MHz	80 MHz	80 MHz	80 MHz	80 MHz	86 MHz
Maximum MCLK frequency	50 MHz	50 MHz	50 MHz	60 MHz	50 MHz	50 MHz	60 MHz
High integration							
Integrated palette DAC and dual-frequency synthesizer	✓	✓	✓	✓	✓	✓	✓
Motherboard VGA solution with only two ICs	✓	✓	✓	Plus Encoder	✓	✓	✓
Built-in port for VESA® feature connector	✓	✓	✓	✓	✓	✓	✓
Built-in ISA (up to 12.5 MHz) bus support	✓	✓	✓	✓	✓	✓	✓
Built-in TV output support				✓			
Flexibility							
Support for x4-, x8-, and x16-bit-wide DRAMs	✓	✓	✓	✓	✓	✓	✓
8- or 16-bit host bus I/O and memory interface	✓	✓	✓	✓	✓	✓	✓
8-bit gray and 3-3-2 RGB DAC modes				✓		✓	✓
CCIR 601 YCrCb mode				✓			
General							
100% hardware- and BIOS-compatible with IBM® VGA display standards	✓	✓	✓	✓	✓	✓	✓
'Green PC' compliant	✓	✓	✓	✓	✓	✓	✓
132-column text mode support	✓	✓	✓	✓	✓	✓	✓
46E8 or 3C3 sleep mechanism		✓	✓	✓	✓	✓	✓
Video overlay and 'color key' support		✓	✓	✓	✓	✓	✓
VESA® VAFC™ base support (for video overlay)				✓			✓
Low-power CMOS, 160-pin package	✓	✓	✓	✓	✓	✓	✓
Screen resolution and colors							
640 × 480	up to 256	up to 16M	up to 16M	up to 16M	up to 16M	up to 16M	up to 16M
800 × 600	up to 256	up to 64K	up to 64K	up to 64K	up to 64K	up to 64K	up to 64K
1024 × 768 (interlaced)	up to 256	up to 256	up to 256	up to 256	up to 256	up to 64K	up to 64K
1024 × 768 (non-interlaced)	up to 256	up to 256	up to 256	up to 256	up to 256	up to 256	up to 256
1280 × 1024 (interlaced)		up to 16	up to 16	up to 16	up to 256	up to 256	up to 256

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Revision History

The following are the differences between the July 1994 and May 1995 versions of this data book:

- The CL-GD5425 device and all pertinent information regarding it has been added.
- The BIOS timing diagrams have been updated.

CONVENTIONS

This section lists conventions used in this data book. 'CL-GD542X' represents CL-GD5420, CL-GD5422, CL-GD5424, CL-GD5425, CL-GD5426, CL-GD5428, and CL-GD5429, the six members of the True Color VGA controller family.

Abbreviations

Units of measure	Symbol
degree Celsius	°C
hertz (cycle per second)	Hz
kilobyte (1,024 bytes)	Kbyte
kilohertz	kHz
kilohm	kΩ
megabyte (1,048,576 bytes)	Mbyte
megahertz (1,000 kilohertz)	MHz
microfarad	μF
microsecond (1,000 nanoseconds)	μs
milliampere	mA
millisecond (1,000 microseconds)	ms
nanosecond	ns
pico volt	pV

The use of 'tbd' indicates values that are 'to be determined', 'n/a' designates 'not available', and 'n/c' indicates a pin that is a 'no connect'.

Acronyms

The following table lists acronyms used in this data book.

Acronym	Definition
AC	alternating current
BIOS	basic input/output system
BitBLT	bit boundary block transfer
CAD	computer-aided design
CAS	column address strobe
CLUT	color lookup table
CMOS	complementary metal-oxide semiconductor
CRT	cathode ray tube
DAC	digital-to-analog converter
DC	direct current

Acronym	Definition (cont.)
DPMS	display power management signaling
DRAM	dynamic random-access memory
EEPROM	electrically erasable/programmable read-only memory
EISA	extended industry standard architecture
EPROM	electrically programmable read-only memory
FIFO	first in/first out
HI-Z	high-impedance
HSYNC/VSYNC	horizontal/vertical synchronization
ISA	industry standard architecture
LSB	least-significant bit
LUT	lookup table
MD	memory data
MSB	most-significant bit
PCI	peripheral component interconnect
PQFP	plastic quad-flat pack
RAM	random-access memory
RAS	row address strobe
RGB	red, green, blue
ROPs	raster operations
R/W	read/write
SC	serial clock
TSR	terminate and stay resident
TTL	transistor-transistor logic
VAFC	VESA® advance feature connector
VESA®	Video Electronics Standards Association
VGA	video graphics array
VRAM	video random-access memory

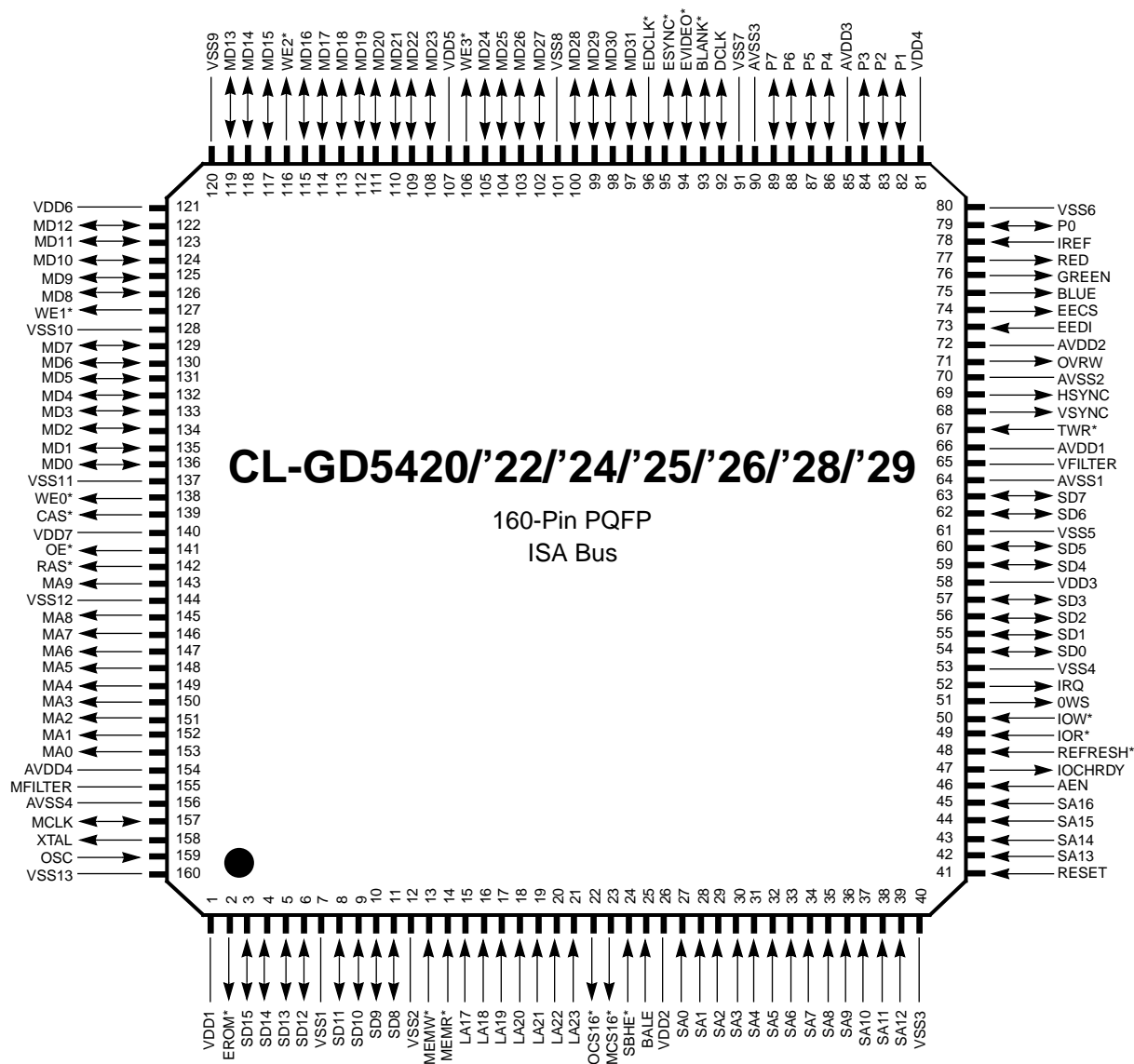
Numeric Naming

Hexadecimal numbers are represented with all letters in uppercase and a lowercase 'h' is appended to them (for example, '14h', '3A7h', and 'C000h' are hexadecimal numbers). Numbers not indicated by an 'h' are decimal.

1. PIN INFORMATION

The CL-GD542X family of VGA controllers is available in a 160-pin quad flat pack device configuration, shown below.

1.1 Pin Diagram (ISA Bus)



NOTE: WE1*, WE0*, MD[15:0], and OVRW are reserved on CL-GD5420.

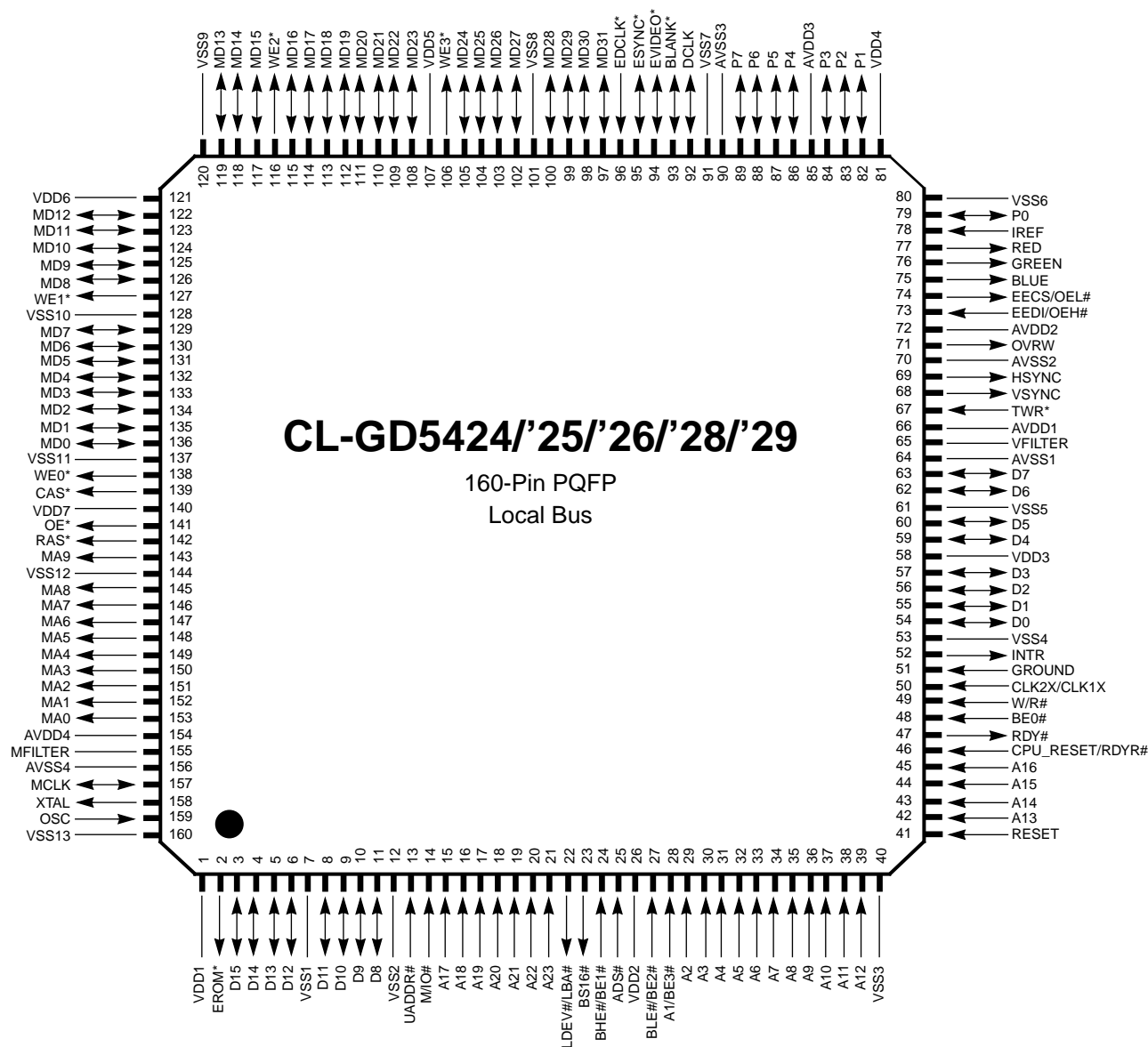
CL-GD5420/22/24/25/26/28/29

160-Pin PQFP

MicroChannel® Bus

- 1) WE1*, WE0*, MD[15:0], and OVRW are reserved on CL-GD5420.
- 2) '-' indicates active-low on the MicroChannel bus.

1.3 Pin Diagram (Local Bus)



1.4 Pin Summary

The following abbreviations are used for pin types in the following tables: (I) indicates input; (O) indicates output; (I/O) indicates input or output depending on how the device is configured and programmed

Table 1-1. Host Interface — ISA/MicroChannel®

Pin Number	Pin Type	Pull-up ^a	I _{OH} ^b (mA)	I _{OL} (mA)	Load (pF)	ISA	MicroChannel®
21	I	•				LA23	A23
20	I	•				LA22	A22
19	I	•				LA21	A21
18	I	•				LA20	A20
17	I	•				LA19	A19
16	I	•				LA18	A18
15	I	•				LA17	A17
45	I					SA16	A16
44	I					SA15	A15
43	I					SA14	A14
42	I					SA13	A13
39	I					SA12	A12
38	I					SA11	A11
37	I					SA10	A10
36	I					SA9	A9
35	I					SA8	A8
34	I					SA7	A7
33	I					SA6	A6
32	I					SA5	A5
31	I					SA4	A4
30	I					SA3	A3
29	I					SA2	A2
28	I					SA1	A1
27	I					SA0	A0
3	I/O	•	-3	12	240	SD15	D15
4	I/O	•	-3	12	240	SD14	D14
5	I/O	•	-3	12	240	SD13	D13
6	I/O	•	-3	12	240	SD12	D12
8	I/O	•	-3	12	240	SD11	D11
9	I/O	•	-3	12	240	SD10	D10
10	I/O	•	-3	12	240	SD9	D9
11	I/O	•	-3	12	240	SD8	D8
63	I/O		-3	12	240	SD7	D7
62	I/O		-3	12	240	SD6	D6
60	I/O		-3	12	240	SD5	D5
59	I/O		-3	12	240	SD4	D4
57	I/O		-3	12	240	SD3	D3
56	I/O		-3	12	240	SD2	D2

Table 1-1. Host Interface — ISA/MicroChannel® (cont.)

Pin Number	Pin Type	Pull-up ^a	I _{OH} ^b (mA)	I _{OL} (mA)	Load (pF)	ISA	MicroChannel®
55	I/O		-3	12	240	SD1	D1
54	I/O		-3	12	240	SD0	D0
24	I	•				SBHE*	-SBHE
25	I					BALE	MADE24
46	I					AEN	-CD_SETUP
49	I					IOR*	-S1
50	I					IOW*	-CMD
14	I					MEMR*	M/-IO
13	I					MEMW*	-S0
41	I	•				RESET	CHRESET
48	I					REFRESH*	-REFRESH
47	O		-3	20	200	IOCHRDY	CD_CHRDY
22	O		-3	20	200	IOCS16*	-CD_SFDBK
23	O		-3	20	200	MCS16*	-CD_DS16
51	O		(OC)	20	200	OWS	(unused)
52	O		-3	20	200	IRQ	-IRQ

^a • indicates the presence of a 250 kΩ, ± 50 % pull-up resistor.

^b Data pads nominally rated at -3 mA I_{OH} will sink -15 mA at V_{OH} = 2.0 V.

Table 1-2. Host Interface — Local Bus (CL-GD5424/'25/'26/'28/'29 only)

Pin Number	Pin Type	Pull-up ^a	I _{OH} ^b (mA)	I _{OL} (mA)	Load (pF)	'386SX	'386DX	'486	VESA® VL-Bus™
21	I	•				A23	A23	A23	A23
20	I	•				A22	A22	A22	A22
19	I	•				A21	A21	A21	A21
18	I	•				A20	A20	A20	A20
17	I	•				A19	A19	A19	A19
16	I	•				A18	A18	A18	A18
15	I	•				A17	A17	A17	A17
45	I					A16	A16	A16	A16
44	I					A15	A15	A15	A15
43	I					A14	A14	A14	A14
42	I					A13	A13	A13	A13
39	I					A12	A12	A12	A12
38	I					A11	A11	A11	A11
37	I					A10	A10	A10	A10
36	I					A9	A9	A9	A9
35	I					A8	A8	A8	A8
34	I					A7	A7	A7	A7
33	I					A6	A6	A6	A6

Table 1-2. Host Interface — Local Bus (CL-GD5424/'25/'26/'28/'29 only) (cont.)

Pin Number	Pin Type	Pull-up ^a	I _{OH} ^b (mA)	I _{OL} (mA)	Load (pF)	'386SX	'386DX	'486	VESA® VL-Bus™
32	I					A5	A5	A5	A5
31	I					A4	A4	A4	A4
30	I					A3	A3	A3	A3
29	I					A2	A2	A2	A2
28	I					A1	BE3#	BE3#	BE3#
27	I					BLE#	BE2#	BE2#	BE2#
3	I/O	•	–3	12	240	D15	D15	D15	D15
4	I/O	•	–3	12	240	D14	D14	D14	D14
5	I/O	•	–3	12	240	D13	D13	D13	D13
6	I/O	•	–3	12	240	D12	D12	D12	D12
8	I/O	•	–3	12	240	D11	D11	D11	D11
9	I/O	•	–3	12	240	D10	D10	D10	D10
10	I/O	•	–3	12	240	D9	D9	D9	D9
11	I/O	•	–3	12	240	D8	D8	D8	D8
63	I/O		–3	12	240	D7	D7	D7	D7
62	I/O		–3	12	240	D6	D6	D6	D6
60	I/O		–3	12	240	D5	D5	D5	D5
59	I/O		–3	12	240	D4	D4	D4	D4
57	I/O		–3	12	240	D3	D3	D3	D3
56	I/O		–3	12	240	D2	D2	D2	D2
55	I/O		–3	12	240	D1	D1	D1	D1
54	I/O		–3	12	240	D0	D0	D0	D0
24	I	•				BHE#	BE1#	BE1#	BE1#
25	I					ADS#	ADS#	ADS#	LADS#
46	I					CPU–Reset	CPU–Reset	CPU–Reset	RDYRTN#
49	I					W/R#	W/R#	W/R#	W/R#
50	I					CLK2X	CLK2X	CLK1X	LCLK
14	I					M/IO#	M/IO#	M/IO#	M/IO#
13	I					(unused)	UADDR#	UADDR#	UADDR#
41	I	•				RESET	RESET	RESET	RESET
48	I					(unused)	BE0#	BE0#	BE0#
47	O		–3	20	200	READY#	READY#	RDY#	RDY#
22	O		–3	20	200	LBA#	LBA#	LBA#	LDEV#
23	O		–3	20	200	(unused)	BS16#	BS16#	LDS16#
51	I		(OC)	20	200	GROUND	GROUND	GROUND	GROUND
52	O		–3	20	200	INTR	INTR	INTR	INTR

^a • indicates the presence of a 250 kΩ, ± 50 % pull-up resistor.

^b Data pads nominally rated at –3 mA I_{OH} will sink –15 mA at V_{OH} = 2.0 V.

Table 1-3. Synthesizer Interface

Pin Number	Pin Type	Pull-up	I _{OH} (mA)	I _{OL} (mA)	Load (pF)	Name
159	I					OSC
158	Analog Out/TTL In (CL-GD5425 only)					XTAL
155	Analog					MFILTER
65	Analog					VFILTER
157	I/O		-12	12	20	MCLK

Table 1-4. Video Interface

Pin Number	Pin Type	Pull-up ^a	I _{OH} (mA)	I _{OL} (mA)	Load (pF)	Name
68	I/O		-12	-12	50	VSYNC
69	I/O		-12	-12	50	HSYNC
93	I/O		-12	12	50	BLANK*
89	I/O		-12	12	50	P7
88	I/O		-12	12	50	P6
87	I/O		-12	12	50	P5
86	I/O		-12	12	50	P4
84	I/O		-12	12	50	P3
83	I/O		-12	12	50	P2
82	I/O		-12	12	50	P1
79	I/O		-12	12	50	P0
92	I/O		-12	12	50	DCLK
95	I/O	•				ESYNC*
94	I/O	•				EVIDEO*
96	I	•				EDCLK*
77	Analog Out					RED
76	Analog Out					GREEN
75	Analog Out					BLUE
78	Analog In					IREF

^a • indicates the presence of a 250 kΩ, ± 50% pull-up resistor.

Table 1-5. Display Memory Interface

Pin Number	Pin Type	Pull-up ^a	I _{OH} (mA)	I _{OL} (mA)	Load (pF)	Name
142	O		-8	12	50	RAS*
139	O		-12	12	50	CAS* ^b
141	O		-12	12	50	OE* ^c
106	O		-12	12	50	WE3* ^d
116	O		-12	12	50	WE2*
127	O		-12	12	50	WE1* ^e
138	O		-12	12	50	WE0* ^e
143	O		-12	12	50	MA9
145	O		-12	12	50	MA8
146	O		-12	12	50	MA7
147	O		-12	12	50	MA6
148	O		-12	12	50	MA5
149	O		-12	12	50	MA4
150	O		-12	12	50	MA3
151	O		-12	12	50	MA2
152	O		-12	12	50	MA1
153	O		-12	12	50	MA0
97	I/O	•	-12	12	50	MD31
98	I/O	•	-12	12	50	MD30
99	I/O	•	-12	12	50	MD29
100	I/O	•	-12	12	50	MD28
102	I/O	•	-12	12	50	MD27
103	I/O	•	-12	12	50	MD26
104	I/O	•	-12	12	50	MD25
105	I/O	•	-12	12	50	MD24
108	I/O	•	-12	12	50	MD23
109	I/O	•	-12	12	50	MD22
110	I/O	•	-12	12	50	MD21

Table 1-5. Display Memory Interface *(cont.)*

Pin Number	Pin Type	Pull-up ^a	I _{OH} (mA)	I _{OL} (mA)	Load (pF)	Name
111	I/O	•	-12	12	50	MD20
112	I/O	•	-12	12	50	MD19
113	I/O	•	-12	12	50	MD18
114	I/O	•	-12	12	50	MD17
115	I/O	•	-12	12	50	MD16
117	I/O	•	-12	12	50	MD15 ^e
118	I/O	•	-12	12	50	MD14 ^e
119	I/O	•	-12	12	50	MD13 ^e
122	I/O	•	-12	12	50	MD12 ^e
123	I/O	•	-12	12	50	MD11 ^e
124	I/O	•	-12	12	50	MD10 ^e
125	I/O	•	-12	12	50	MD9 ^e
126	I/O	•	-12	12	50	MD8 ^e
129	I/O	•	-12	12	50	MD7 ^e
130	I/O	•	-12	12	50	MD6 ^e
131	I/O	•	-12	12	50	MD5 ^e
132	I/O	•	-12	12	50	MD4 ^e
133	I/O	•	-12	12	50	MD3 ^e
134	I/O	•	-12	12	50	MD2 ^e
135	I/O	•	-12	12	50	MD1 ^e
136	I/O	•	-12	12	50	MD0 ^e

^a • indicates the presence of a 250 kΩ, ± 50 % pull-up resistor.

^b CAS* is redefined as WE* for multiple-CAS* 256K × 16 DRAMs for the CL-GD5422/24/25/26/28/29.

^c OE* is redefined as RAS1* for 2-Mbyte display memory configurations for the CL-GD5426/28/29 only.

^d WE*[3:0] are redefined as CAS*[3:0] for multiple-CAS* 256K × 16 DRAMs for the CL-GD5422/24/25/26/28/29.

^e WE1*, WE0, MD[15:0] are reserved on the CL-GD5420.

Table 1-6. Miscellaneous Pins

Pin Number	Pin Type	Pull-up ^a	I _{OH} (mA)	I _{OL} (mA)	Load (pF)	Name
74	Out		-12	12	35	EECS ^b
73	In					EEDI ^c
2	Out		-12	12	35	EROM*
71	Out		-12	12	35	OVRW ^d
67	In					TWR*

^a • indicates the presence of a 250 kΩ, ± 50 % pull-up resistor.

^b EECS is redefined as OEL# when the CL-GD5424/'25/'26/'28/'29 (only) is configured for '486, VESA VL-Bus, or local bus operation.

^c EEDI is redefined as OEH# when the CL-GD5424/'25/'26/'28/'29 (only) is configured for '486, VESA VL-Bus, or local bus operation.

^d OVRW is reserved on the CL-GD5420.

Table 1-7. Power and Ground

Pin Number	Pin Type	Pull-up	I _{OH}	I _{OL}	Load (pF)	Name	Note
140	Power					VDD7	Digital
121	Power					VDD6	Digital
107	Power					VDD5	Digital
81	Power					VDD4	Digital
58	Power					VDD3	Digital
26	Power					VDD2	Digital
1	Power					VDD1	Digital
160	Ground					VSS13	Digital
144	Ground					VSS12	Digital
137	Ground					VSS11	Digital
128	Ground					VSS10	Digital
120	Ground					VSS9	Digital
101	Ground					VSS8	Digital
91	Ground					VSS7	Digital
80	Ground					VSS6	Digital
61	Ground					VSS5	Digital
53	Ground					VSS4	Digital
40	Ground					VSS3	Digital
12	Ground					VSS2	Digital
7	Ground					VSS1	Digital
66	Power					AVDD1	VCLK
64	Ground					AVSS1	VCLK
154	Power					AVDD4	MCLK
156	Ground					AVSS4	MCLK
85	Power					AVDD3	DAC
72	Power					AVDD2	DAC
90	Ground					AVSS3	DAC
70	Ground					AVSS2	DAC

2. DETAILED PIN DESCRIPTIONS

The following abbreviations are used for pin types in the following sections: (I) indicates input; (O) indicates output; (I/O) indicates a bidirectional signal; (TS) indicates three-state; (OC) indicates open collector.

2.1 Host Interface — ISA Bus Mode

Name	Type	Description															
LA[23:17]	I	ADDRESS [23:17]: These inputs, in conjunction with SA[16:0], are used to select the resource to be accessed during memory operations. These address bits are latched with the falling edge of BALE.															
SA[16:0]	I	ADDRESS [16:0]: These inputs, in conjunction with LA[23:17], are used to select the resource to be accessed during any memory or I/O operation. These address bits must remain valid throughout the cycle.															
SD[15:8]	TS	SYSTEM DATA [15:8]: These bidirectional pins are used to transfer data during 16-bit memory or I/O operations. These pins can be directly connected to the corresponding ISA bus pins. These pads have pull-up resistors to guarantee a valid input level when not connected.															
SD[7:0]	TS	SYSTEM DATA [7:0]: These bidirectional pins are used to transfer data during any memory or I/O operation. These pins can be directly connected to the corresponding ISA bus pins.															
SBHE*	I	SYSTEM BYTE HIGH ENABLE: This input is used in conjunction with A[0] to determine the width and alignment of a data transfer. SBHE* and A[0] are decoded as shown in Table 2-1:															
Table 2-1. SBHE/A0 Decoding <table border="1"> <thead> <tr> <th>SBHE*</th><th>A0</th><th>Function</th></tr> </thead> <tbody> <tr> <td>0</td><td>0</td><td>16-bit Transfer</td></tr> <tr> <td>0</td><td>1</td><td>Upper-byte Transfer</td></tr> <tr> <td>1</td><td>0</td><td>Lower-byte Transfer</td></tr> <tr> <td>1</td><td>1</td><td>Lower-byte Transfer (on odd address)</td></tr> </tbody> </table>			SBHE*	A0	Function	0	0	16-bit Transfer	0	1	Upper-byte Transfer	1	0	Lower-byte Transfer	1	1	Lower-byte Transfer (on odd address)
SBHE*	A0	Function															
0	0	16-bit Transfer															
0	1	Upper-byte Transfer															
1	0	Lower-byte Transfer															
1	1	Lower-byte Transfer (on odd address)															
BALE	I	BUS ADDRESS LATCH ENABLE: This active-high input is used to latch LA[23:17] on the high-to-low transition.															
AEN	I	ADDRESS ENABLE: If this input is high, it indicates that the current cycle is a DMA cycle. In this case, the CL-GD542X will not respond to I/O cycles. There is no effect on memory cycles.															

2.1 Host Interface — ISA Bus Mode *(cont.)*

Name	Type	Description
IOR*	I	I/O READ: This active-low input is used to indicate that an I/O read is occurring. If the address on SA[15:0] is within the range of the CL-GD542X, it will respond by placing the contents of the appropriate register on the System Data bus.
IOW*	I	I/O WRITE: This active-low input is used to indicate that an I/O write is occurring. If the address on SA[15:0] is within the range of the CL-GD542X, it will respond by transferring the contents of the System Data bus into the appropriate register. The transfer will occur on the trailing (rising) edge of this signal. A list of I/O addresses that the CL-GD542X will respond appears in Section 5 on page 47. When a 16-bit I/O write is done, the address specified is typically the Index register for one of the VGA groups. The index should appear on SD[7:0] and the data should appear on SD[15:8].
MEMR*	I	MEMORY READ: This active-low input is used to indicate that a memory read is occurring. If linear addressing is being used, this pin must be connected to ISA signal MEMR*. If linear addressing is not being used, this pin must be connected to ISA signal SMEMR*. The CL-GD542X decodes A[23:15] to determine if a display memory read is occurring. If so, data is placed on the System Data pins according to the read mode and the contents of display memory. The CL-GD542X decodes A[23:15] to determine if a BIOS read is occurring. If so, the CL-GD542X makes EROM* active for the duration of MEMR*.
MEMW*	I	MEMORY WRITE: This active-low input is used to indicate that a memory write is occurring. If linear addressing is being used, this pin must be connected to ISA signal MEMW*. If linear addressing is not being used, this pin must be connected to ISA signal SMEMW*. The CL-GD542X decodes A[23:15] to determine if a display memory write is occurring. If so, data is written into display memory according to the write mode and the data on SD[15:0]. The data are latched in the CL-GD542X on the rising edge of this signal, and are actually transferred to display memory later.
RESET	I	RESET: This active-high signal is used to initialize the CL-GD542X to a known state. The trailing (falling) edge of this input loads the Configuration register CF[14:0] with the data on MD[30:16], determined by internal pull-up resistors and (optional) external pull-down resistors.
REFRESH*	I	REFRESH*: This active-low signal indicates that a DRAM refresh is occurring. The CL-GD542X ignores memory read operations occurring when REFRESH* is active since it controls the refresh of display memory.

2.1 Host Interface — ISA Bus Mode *(cont.)*

Name Type Description

IOCHRDY TS I/O CHANNEL READY: When driven low, this output indicates that additional wait states are to be inserted into the current display memory read or write cycle. This output is never driven low during I/O cycles or BIOS reads. During a display memory read cycle, this signal is always driven low as soon as MEMR* goes active. When the data are ready to be placed on the System Data bus, this signal is driven high. It remains high until MEMR* goes inactive; it then goes high impedance. During a display memory write cycle, this signal is driven high as soon as MEMW* goes active if there is space in the Write Buffer. If there is no space in the Write Buffer, this signal is driven low as soon as MEMW* goes active and remains low until there is space. Once there is space in the Write Buffer, this signal is driven high. It will remain high until MEMW* goes inactive; it then goes high-impedance.

IOCS16* OC I/O CHIP SELECT 16*: This open-collector output is driven low to indicate that the CL-GD542X can execute an I/O operation at the address currently on the bus in 16-bit mode. This signal is generated from a decode of A[15:0] and AEN. Table 2-2 indicates the range of addresses that the CL-GD542X will generate IOCS16*:

Table 2-2. IOCS16* Addresses

Address	Function
3C4, 3C5	Sequencer
3CE, 3CF	Graphics controller
3B4/3D4, 3B5/3D5	CRT controller
3BA/3DA	Input Status register 1

MCS16* OC MEMORY CHIP SELECT 16*: This open-collector output is driven low to indicate that the CL-GD542X can execute a memory operation at the address currently on the bus in 16-bit mode. Table 2-3 summarizes the conditions where MCS16* is made active.

Table 2-3. MSC16* Addresses

Resource	Address Bits	Address Range	Qualifier
Display memory	A[23:17]	A000:0-BFFF:F	SR8[6] = 1 (No other VGA card)
Display memory	A[23:17]	1 Mbyte	SR7[7:4] ≠ 0 Linear Addressing
BIOS	A[23:15]	C000:0-C7FF:F	CF[6] = 0 (16-bit BIOS)

NOTE: The SA bits are generated late enough to typically make them unusable for generating MCS16*. The CL-GD542X uses a fast path from SA[16:15] to MCS16*.

2.1 Host Interface — ISA Bus Mode *(cont.)*

Name	Type	Description
OWS*	OC	ZERO WAIT STATE* : This open-collector output is driven low to indicate that the current cycle can be completed without any additional wait states. The circumstances under which OWS* will be made active are summarized in Table 2-4.

Table 2-4. Zero Wait State* Cycles

Cycle Type	Qualifier
Display memory write	Write buffer not full
BIOS Read	CF[1] = 0 (not on CL-GD5429)

IRQ	TS	INTERRUPT REQUEST : This active-high output indicates the CL-GD542X has reached the end of an active field. Specifically, the transition occurs at the beginning of the bottom border. This pin is typically unused in PC/AT add-in cards, but can be connected to IRQ2/IRQ9 via a jumper block. See register CR11 for a description of the controls for this pin.
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2.2 Host Interface — MicroChannel® Bus Mode

Name	Type	Description
A[23:0]	I	ADDRESS [23:0]: These inputs are used to select the resource to be accessed during a memory or I/O operation. These address bits are latched with the falling edge of $\overline{\text{CMD}}$. A[23:17] have internal pull-ups, whereas A[16:0] do not.
D[15:0]	TS	DATA [15:0]: These bidirectional pins are used to transfer data during memory or I/O operation. These pins can be directly connected to the corresponding MicroChannel bus pins.
$\overline{\text{SBHE}}$	I	$\overline{\text{SYSTEM BYTE HIGH ENABLE}}$: This input is used in conjunction with A[0] to determine the width and alignment of a data transfer. This signal is latched with $\overline{\text{CMD}}$ low. This pad has a pull-up resistor. $\overline{\text{SBHE}}$ and A[0] are decoded as shown in Table 2-5.

Table 2-5. $\overline{\text{SBHE}}$ /A0 Decoding

$\overline{\text{SBHE}}$	A0	Function
0	0	16-bit Transfer
0	1	Upper-byte Transfer
1	0	Lower-byte Transfer
1	1	Lower-byte Transfer (<i>on odd address</i>)

MADE24	I	MEMORY ADDRESS ENABLE 24: This active-high input is latched the falling edge of $\overline{\text{CMD}}$. It indicates that the address is in the lower 16 Mbytes of address space. MADE24 must be high for the CL-GD542X to participate in a memory cycle.
$\overline{\text{CD_SETUP}}$	I	$\overline{\text{CARD SETUP}}$: When this active-low input is active, the CL-GD542X is placed in Setup mode. In Setup mode, the CL-GD542X will respond only to POS102 accesses. It will not respond to any other I/O accesses or to display memory accesses. It will respond to BIOS reads. This signal is latched with the falling edge of $\overline{\text{CMD}}$.

2.2 Host Interface — MicroChannel® Bus Mode (cont.)

Name	Type	Description
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–S1	I	– STATUS 1 : This signal, in conjunction with –S0 and M/-IO, is used to determine the cycle type that occurs. The encoding is shown in Table 2-6:
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Table 2-6. MicroChannel® Cycle Type Encoding

M/-IO	–S0	–S1	Cycle
0	0	0	Reserved
0	0	1	I/O write
0	1	0	I/O read
0	1	1	Reserved
1	0	0	Reserved
1	0	1	Memory write
1	1	0	Memory read
1	1	1	Reserved

–CMD	I	– COMMAND : The falling edge of this input is used to latch the address bus, MADE24, –SBHE, –REFRESH, M/-IO, –CD_SETUP, –S0, and –S1. It is also used to time the actual data transfer. During I/O or memory-read cycles, the CL-GD542X drives valid data onto the bus prior to the trailing edge of this signal. During write cycles, the CL-GD542X expects valid data while this input is active and latches the data at the trailing edge.
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M/-IO	I	MEMORY/-IO : This signal, in conjunction with –S0 and –S1, is decoded to determine the cycle type. See the description of –S1.
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–S0	I	– STATUS 0 : This signal, in conjunction with –S1 and M/-IO, is decoded to determine the cycle type. See the description of –S1.
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RESET	I	RESET : This active-high signal is used to initialize the CL-GD542X to a known state. The trailing (falling) edge of this input loads the Configuration register CF[14:0] with the data on MD[30:16], determined by internal pull-up resistors and (optional) external pull-down resistors.
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–REFRESH	I	– REFRESH : This active-low signal indicates that a DRAM refresh is occurring. This signal is latched with –CMD low. The CL-GD542X ignores memory-read operations occurring when –REFRESH is active since it controls the refresh of display memory.
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2.2 Host Interface — MicroChannel® Bus Mode (cont.)

Name	Type	Description
CD_CHRDY	O	CARD CHANNEL READY: This output is driven low to request that additional wait states be inserted into the current display memory read or write cycle. This output is never driven low during I/O cycles or BIOS reads. During a display memory read cycle, this signal is always driven low as soon as --S1 goes low. When the data are ready to be placed on the System Data bus, this signal is driven high. During a display memory write cycle, this signal is driven high as soon as --S0 goes low if there is space in the Write Buffer. If there is no space in the Write Buffer, this signal is driven low as soon as --S0 goes low, and remains low until there is space. Once there is space in the Write Buffer, this signal is driven high.
--CD_SFDBK	OC	$\text{--CARD SELECTED FEEDBACK}$: This open-collector output is driven low to indicate that the CL-GD542X can respond to the addresses currently on the bus. This signal is generated from a decode of --REFRESH , MADE24 , $\text{A}[23:0]$, and M-/IO . This signal is made active for the Address Range C000:0--C7FF:F only if $\text{CF}[6] = 0$ (indicating a 16-bit BIOS). If $\text{CF}[6] = 1$, this signal will not be made active for Address Range C000:0--C7FF:F . Also, this signal will not be made active for Addresses 102 or 103 if M-/IO is low, indicating I/O.
--CD_DS16	OC	--CARD SIZE 16: This open-collector output is driven low to indicate that the CL-GD542X can execute a memory or I/O operation at the address currently on the bus in 16-bit mode. This output is generated from a decode of $\text{A}[23:0]$, MADE24 , --REFRESH , and M-/IO . Table 2-7 summarizes the conditions under which --CD_DS16 is made active.
Table 2-7. --CD_DS16 Addresses		
Resource	Address Bits	Address Range
Display memory	$\text{A}[23:15]$	A000:0--BFFF:F
Display memory	$\text{A}[23:15]$	1 Mbyte
BIOS ($\text{CF}[6] = 0$ only)	$\text{A}[23:11]$	C000:0--C7FF:F
I/O	$\text{A}[15:1]$	3C4, 3C5 3CE, 3CF 3B/D4, 3B/D5 3B/DA
--IRQ	OC	$\text{--INTERRUPT REQUEST}$: This open-collector output indicates the CL-GD542X has reached the end of an active field. Specifically, the transition occurs at the beginning of the bottom border. This pin is typically connected to IRQ9 via a jumper block. See register CR11 for a description of the controls for this pin. This pin is never driven high.

2.3 Host Interface — Local Bus (CL-GD5424/'25/'26/'28/'29 only)

A number of bus interface pins are redefined according to the local bus type connecting to the CL-GD5424/'25/'26/'28/'29. The host interface pins are listed in Table 2-8 by CL-GD5424/'25/'26/'28/'29 pin number.

Table 2-8. Redefined Host Interface Pins

Pin	'386SX	'386DX	'486	VESA® VL-Bus™
13	(unused)	UADDR#	UADDR#	UADDR#
23	(unused)	BS16#	BS16#	LBS16#
24	BHE#	BE1#	BE1#	BE1#
27	BLE#	BE2#	BE2#	BE2#
28	A1	BE3#	BE3#	BE3#
46	CPU-RESET	CPU-RESET	GND	RDYRTN#
47	READY#	READY#	BRDY#	BRDY#
48	(unused)	BE0#	BE0#	BE0#
50	CLK2X	CLK2X	CLK1X	LCLK
51	GROUND	GROUND	GROUND	GROUND
73	(unused)	(unused)	OE#	OE#
74	(unused)	(unused)	OEL#	OEL#

2.3 Host Interface — Local Bus (CL-GD5424/'25/'26/'28/'29 only) (cont.)

Name	Type	Description
A[23:2]	I	ADDRESS [23:2]: These inputs are used to select the resource to be accessed during memory or I/O operations. A[23:17] have internal pull-up resistors; A[16:2] do not. A[3:2] are burst address bits for the '486.
D[15:0]	TS	DATA [15:0]: These bidirectional pins are used to transfer data during any memory or I/O operation. These pins are directly connected to D[15:0] of the '386SX or '386DX bus. These pins are connected via four bidirectional data transceivers to the 32 data pins of the '486 or VESA VL-Bus. The transceivers are controlled with OE# ₁ , OEL# ₁ , and W/R#. These pads have pull-up resistors.
BE[3:0]#	I	BYTE ENABLE [3:0]#: These active-low inputs are directly connected to the '386DX/'486 or VESA VL-Bus byte enable outputs. In the case of the '386SX, BE0# is unused and can be left unconnected. BE1#, 2, and 3 are redefined as BHE#, BLE#, and A1, respectively. They must be directly connected to the corresponding '386 outputs.
ADS#	I	ADDRESS STROBE: This active-low input indicates that a new cycle has begun. It must be directly connected to the ADS# pin on the CPU. For VESA VL-Bus, this pin is connected to LADS#.
CPU-RESET	I	CPU RESET: When this active-high input is active, the CL-GD542X is forced into an initial condition. It is used to synchronize the CL-GD542X to CLK1X or CLK2X. This pin <i>must</i> be connected to the RESET pin of the CPU in a '386 system; it <i>must</i> be connected to ground in a '486 system; it <i>must</i> be connected to RDYRTN# in a VESA VL-Bus system.
W/R#	I	WRITE/READ: This input indicates whether a write or read operation is to occur. It must be directly connected to the W/R# pin on the CPU. If W/R# is high, a write will occur. If it is low, a read will occur.
CLK2X	I	CLOCK 2X: This is the timing reference for the CL-GD542X when connected to a '386SX or '386DX local bus. This is redefined as CLK1X for the '486 local bus. In either case, it must be directly connected to the corresponding CPU pin. For VESA VL-Bus, this pin is connected to LCLK.
M/IO#	I	MEMORY/IO#: This input indicates whether a memory or I/O operation is to occur. It must be directly connected to the M/IO# pin on the CPU. If M/IO# is high, a memory operation will occur. If it is low, an I/O operation will occur.
UADDR#	I	UPPER ADDRESS: This active-low input is a decode of the upper-CPU Address bits A[32:24]. This input is unused in the case of a '386SX local bus and can be left unconnected. Refer to appendixes in the <i>CL-GD542X Technical Reference Manual</i> for information on the generation of this signal.

2.3 Host Interface — Local Bus (CL-GD5424/'25/'26/'28/'29 only) (cont.)

Name	Type	Description
RESET	I	RESET: This active-high input initializes the CL-GD542X to a known state. The trailing (falling) edge of this input loads the Configuration register CF[14:0] with the data on MD[30:16], determined by internal pull-up resistors and (optional) external pull-down resistors.
RDY#	TS	RDY #: This active-low signal is used as an output to terminate a CL-GD542X bus cycle.
LBA#	TS	LOCAL BUS ACKNOWLEDGE #: This open-collector output is driven low to indicate that the CL-GD542X will respond to the current cycle. This signal is generated from a decode of A[23:2], UADDR#, and M/IO#. This output will be active before the middle of the first T2 after an active ADS#. For VESA VL-Bus, this pin is connected to LDEV#.
BS16#	OC	BUS SIZE 16 #: This active-low output is driven by the CL-GD542X to indicate that the current cycle addresses a 16-bit resource. The '386DX/'486 will convert the cycle to an appropriate number of 16-bit transfers. This pin is not used for a '386SX local bus and can be left unconnected. For VESA VL-Bus, this pin is connected to LBS16#.
INTR	TS	INTERRUPT REQUEST: This active-high output indicates the CL-GD542X has reached the end of an active field. Specifically, the transition occurs at the beginning of the bottom border. See register CR11 for a description of the controls for this pin.
OEH#	O	OUTPUT ENABLE HIGH#: This active-low output controls the output enables for the data transceivers that connect the CL-GD542X SD[15:0] pins to the '486 or VESA VL-Bus D[31:16] pins.
OEL#	O	OUTPUT ENABLE LOW#: This active-low output controls the output enables for the data transceivers that connect the CL-GD542X SD[15:0] pins to the '486 or VESA VL-Bus D[15:0] pins.

2.4 Dual-Frequency Synthesizer Interface

Name	Type	Description
OSC	I	<p>OSCILLATOR INPUT: This TTL input pin supplies the reference frequency for the dual-frequency synthesizer. It requires an input frequency of $14.31818 \pm 0.01\%$ MHz with a duty cycle of $50 \pm 10\%$. This input can be supplied from the appropriate pin on the ISA or MicroChannel bus, from an oscillator, or with a series-resonant crystal connected between this pin and the XTAL pin.</p> <p>NOTE: When the CL-GD5425 (only) is configured for PAL/NTSC operation (pull-down installed on MD16), this pin should be driven with 17.734475 MHz. This is the reference frequency for PAL.</p>
XTAL	I/O	<p>CRYSTAL: This output pin allows the use of a crystal to supply the reference frequency for the synthesizer. A series-resonant crystal can be connected between this pin and the OSC pin. If this pin is not used for a crystal connection, it <i>must</i> be left unconnected (except for CL-GD5425).</p> <p>When the CL-GD5425 (only) is configured for PAL/NTSC operation (pull-down installed on MD16), this is an input pin and should be driven with 14.31818 MHz. This is the reference frequency for NTSC, the MCLK synthesizer, and VGA modes.</p>
MFILTER	O	<p>MEMORY CLOCK FILTER: This pin must be connected to a π RC filter returned to AVSS4. The values of the two capacitors and the resistor are shown in Appendix B17 in the <i>CL-GD542X Technical Reference Manual</i>. The filter components, especially the input capacitor and the resistor, must be placed as closely as possible to this pin.</p>
VFILTER	O	<p>VIDEO CLOCK FILTER: This pin <i>must</i> be connected to a π RC filter returned to AVSS1 or AVDD1, depending on processing. The values of the two capacitors and the resistor are shown in Appendix B17 in the <i>CL-GD542X Technical Reference Manual</i>. The filter components, especially the input capacitor and the resistor, <i>must</i> be placed as closely as possible to this pin.</p>
MCLK	I/O	<p>MEMORY CLOCK: This pin is normally an output and can be used to monitor the internal MCLK. Typically, it would not be connected. If CF[4] is a zero, MCLK will be an input and the internal MCLK oscillator will be disabled. This configuration is intended for testing only.</p> <p>NOTE: For the CL-GD5425 and CL-GD5429 only, this pin can be configured to output the internal VCLK VCO. If a pull-down is installed on MD31 (and no pull-down on MD20), the internal VCLK VCO (prior to the post-scalar) will be driven onto this pin.</p>

2.5 Video Interface

Name	Type	Description
VSYNC	I/O	<p>VERTICAL SYNC: This output supplies the vertical synchronization pulse to the monitor. The polarity of this output is programmable. This pin is put into high impedance when ESYNC* is low. This pin can be directly connected to the corresponding pin on the feature connector.</p> <p>NOTE: When the CL-GD5425 (only) is configured for VSYNC GENLOCK, by programming CR1C[7] to '1', VSYNC becomes an input.</p>
HSYNC	I/O	<p>HORIZONTAL SYNC: This output supplies the horizontal synchronization pulse to the monitor. The polarity of this output is programmable. This pin is put into high impedance when ESYNC* is low. This pin can be directly connected to the corresponding pin on the feature connector.</p> <p>NOTE: When the CL-GD5425 (only) is configured for HSYNC GENLOCK, by programming CR1C[6] to '1', HSYNC becomes an input.</p>
BLANK*	I/O	<p>BLANK*: This is a bidirectional pin. If ESYNC* is high, BLANK* is an output. As an output, it supplies a blanking signal to the feature connector. If ESYNC* is low, BLANK* is an input. As an active-low input, it forces the RED, GREEN, and BLUE outputs to zero current. This pin can be directly connected to the corresponding pin on the feature connector.</p> <p>NOTE: When the CL-GD5425 (only) is configured for TV mode by programming CR30[3] to '1', this pin becomes the Color Carrier Reference (Nx fsc).</p>
P[7:0]	I/O	<p>PIXEL BUS [7:0]: These are bidirectional pins. If EVIDEO* is high, these pins are outputs and reflect the address into the palette DAC. If EVIDEO* is low, these pins are inputs and can be used to drive pixel values into the palette DAC. These pins can be directly connected to the corresponding pins on the feature connector.</p>
DCLK	I/O	<p>VIDEO DOT CLOCK: This is a bidirectional pin. If EDCLK* is high, this is an output and can be used to externally latch the data on the Pixel Bus. If EDCLK* is low, this is an input and can be used to clock data on the Pixel bus into the CL-GD542X. This pin can be directly connected to the corresponding pin on the feature connector.</p>
ESYNC*	I/O	<p>ENABLE SYNC AND BLANK: This input is used to control the buffers on HSYNC, VSYNC, and BLANK*. If ESYNC* is high, the controlled pins are outputs. If ESYNC* is low, BLANK* is an input. HSYNC and VSYNC are not driven by the CL-GD542X and must be driven externally to valid input levels. This pin can be directly connected to the corresponding pin on the feature connector.</p> <p>NOTE: For the CL-GD5425, the ESYNC* pin will be an output and will reflect SR8[2] whenever Overlay mode is selected by programming CR1A[3:2] to any value other than '0,0' or whenever TV mode is selected by programming CR30[3] to '1'.</p>
EVIDEO*	I/O	<p>ENABLE VIDEO: This input controls the buffers on P[7:0]. If EVIDEO* is high, P[7:0] are outputs; if EVIDEO* is low, P[7:0] are inputs. This pin can be directly connected to the corresponding pin on the feature connector. This pin is not limited to static operation; it can switch at the DCLK rate.</p>

2.5 Video Interface (cont.)

Name	Type	Description
EDCLK*	I	ENABLE DOT CLOCK: This input is used to control the buffer on DCLK. If EDCLK* is high, DCLK is an output; if EDCLK* is low, DCLK is an input. This pin can be directly connected to the corresponding pin on the feature connector.
RED	O	<p>RED VIDEO: This analog output supplies current corresponding to the red value of the pixel being displayed. Each of the three DACs consists of 255 summed current sources. For each pixel, either the 6-bit value from the LUT or a 5-, 6-, or 8-bit true-color value is applied to each DAC input to determine the number of current sources to be summed. Full-scale current on the RED, GREEN, and BLUE outputs is related to IREF as follows:</p> $I_f = (63/30) \times I_{REF}$ <p>To maintain IBM VGA compatibility, each DAC output is typically terminated to monitor ground with a 75-Ω 2-percent resistor. This resistor, in parallel with the 75-Ω resistor in the monitor, will yield a 37.5-Ω impedance to ground. For a full-scale voltage of 700 mV, full-scale current output should be 18.7 mA.</p>
GREEN	O	GREEN VIDEO: This analog output supplies current corresponding to the green value of the pixel being displayed. See the description of RED for information regarding the termination of this pin.
BLUE	O	BLUE VIDEO: This analog output supplies current corresponding to the blue value of the pixel being displayed. See the description of RED for information regarding the termination of this pin.
IREF	I	DAC CURRENT REFERENCE: The current drawn from AV _{DD} through this pin determines the full-scale output of each DAC. Connect this pin to a constant current source. A recommended circuit is provided in appendixes of the <i>CL-GD542X Technical Reference Manual</i> .

2.6 Display Memory Interface

Name	Type	Description
RAS*	O	<p>ROW ADDRESS STROBE *: This active-low output is used to latch the row address from MA[9:0] into the DRAMs. This pin must be connected to the RAS* pins of all the DRAMs in the display memory array. These pads, and those for the other DRAM controls, are matched for one-to-four loads. If eight DRAMs are used, damping resistors may be required to control edge rates and undershoot on these, and other, control pins.</p>
CAS*	O	<p>COLUMN ADDRESS STROBE *: This active-low output is used to latch the Column Address from MA[9:0] into the DRAMs. This pin must be connected to the CAS* pins of all the DRAMs in the display memory array.</p> <p>NOTE: If CF[12] = 0 (dual-CAS* DRAMs), this pin becomes WE*.</p>
OE*	O	<p>OUTPUT ENABLE *: This active-low output is used to control the output enables of the DRAMs. For 256K × 4 DRAMs and 256K × 16 DRAMs with Dual-write Enables, this pin <i>must</i> be connected to the OE* pins of all the DRAMs in the display memory array. For 256K × 16 DRAMs with dual-CAS*, this pin is a no-connect. For the CL-GD5426/'28/'29 with 2 Mbytes of display memory, this pin becomes RAS1*. See the DRAM configuration tables in Section 4 on page 41.</p> <p>NOTE: For the CL-GD5425 (only), this pin is ODD/EVEN when the chip is configured for TV-out and indicates which field is being displayed.</p>
WE[3:0]*	O	<p>WRITE ENABLE [3:0]*: These active-low outputs are used to control the write enable inputs of the DRAMs. These pins <i>must</i> be connected to the WE* pins of the DRAMs as indicated in the DRAM configuration tables in Section 4 on page 41.</p> <p>NOTE: If CF[12] = 0 (dual-CAS* DRAMs) these pins become CAS[3:0]*. These pins can be connected to the CAS* pins of the DRAMs. WE[1:0]* are reserved on the CL-GD5420 (Revision 'A').</p>
MA[9]	O	<p>MEMORY ADDRESS [9]: This pin controls one address input of the DRAMs. See the DRAM configuration tables in Section 4 on page 41.</p> <p>When the CL-GD5425 (only) is configured for TV mode, by programming CR30[3] to '1', this pin becomes CSYNC out. CSYNC includes all horizontal and vertical timing and serration pulses.</p>
MA[8:0]	O	<p>MEMORY ADDRESS [8:0]: These pins control the address inputs of the DRAMs. These pins must be connected to the address pins of the DRAMs. See the DRAM configuration tables in Section 4 on page 41.</p>
MD[31:0]	TS	<p>MEMORY DATA [31:0]: These pins are used to transfer data between the CL-GD542X and the display memory. These pins must be connected to the data pins of the DRAMs. See the DRAM configuration tables in Section 4 on page 41. These pins are forced into high impedance when RESET is active. This allows the configuration pull-down resistors to override the weak pull-ups and be loaded into the Configuration register CF. MD[15:0] are reserved on the CL-GD5420 (Revision 'A').</p>

2.7 Miscellaneous Pins

Name	Type	Description
EECS	O	<p>EEPROM CHIP SELECT: This pin is used to control the Chip Select of the optional configuration EEPROM, and should be directly connected to that pin (ISA and Micro-channel only).</p> <p>NOTE: This pin is redefined as OEL* for the '486 or VESA VL-Bus (CL-GD5424/'26/'28/'29 only).</p>
EEDI	I	<p>EEPROM DATA IN: This pin is used to read the data from the optional configuration EEPROM, and should be directly connected to the Data Out pin (ISA and Micro-channel only).</p> <p>NOTE: This pin is redefined as OEH* for the '486 or VESA VL-Bus (CL-GD5424/'26/'28/'29 only).</p>
EROM*	O	<p>ENABLE ROM BUFFERS*: This active-low output is used to control the Output Enable pins of up to two 8-bit bus drivers. These buffers are used to connect the data pins of the BIOS EPROMs to the System Data bus. This output is forced high when RESET is active. This output goes active only for memory read cycles to the address range C000:0–C7FF:F. It is gated with MEMR* in ISA mode, and with –CMD in MicroChannel mode. It is un-latched address decode in Local Bus modes.</p>
OVRW	O	<p>OVERLAY WINDOW: This output signal is active-high. It is intended to be used in applications involving video overlays. For additional connectivity information, see Appendix B14 in the CL-GD542X technical reference manual. OVRW is reserved on the CL-GD5420.</p>
TWR*	I	<p>TEST LATCH LOAD ENABLE*: This pin is intended for factory testing and must be pulled-up for normal operation. It can be used in board-level testing to disable most of the CL-GD542X output pins. For additional information, see Appendix B14 in the <i>True Color VGA Family — CL-GD542X Technical Reference Manual</i>.</p>

2.8 Power Pins

Name	Type	Description
VDD[7:1]	Power	PLUS FIVE (LOGIC): These seven pins are used to supply +5 volts to the core logic of the CL-GD542X. Each pin <i>must</i> be connected to the VCC rail as described in Appendixes B1–B3 of the <i>True Color VGA Family — CL-GD542X Technical Reference Manual</i> . Each pin <i>must</i> be bypassed with a 0.1-μF capacitor with proper high-frequency characteristics, placed as closely to the pin as possible. If a multi-layer board is used, each VDD pin <i>must</i> be connected to the power plane as outlined in Appendixes B1–B3 in the <i>True Color VGA Family — CL-GD542X Technical Reference Manual</i> .
VSS[13:1]	Ground	GROUND (LOGIC): These 13 pins are used to supply ground reference to the core logic of the CL-GD542X. Each pin <i>must</i> be directly connected to the GND rail. If a multi-layer board is used, each VSS pin <i>must</i> be connected to the ground plane.
AVDD[1]	Power	PLUS FIVE (VCLK): This pin is used to supply +5 volts to the video clock synthesizer of the CL-GD542X. This pin must be connected to the VCC rail via a 33-Ω resistor, and bypassed to AVSS4 with a 10-μF capacitor.
AVSS[1]	Ground	GROUND (VCLK): This pin is used to supply ground reference to the video clock synthesizer of the CL-GD542X. This pin <i>must</i> be connected to the GND rail.
AVDD[4]	Power	PLUS FIVE (MCLK): This pin is used to supply +5 volts to the memory clock synthesizer of the CL-GD542X. This pin must be connected to the VCC rail through a 33-Ω resistor and bypassed to AVSS4 with a 10-μF capacitor.
AVSS[4]	Ground	GROUND (MCLK): This pin is used to supply ground reference to the video clock synthesizer of the CL-GD542X. This pin <i>must</i> be connected to the GND rail.
AVDD[3:2]	Power	PLUS FIVE (DAC): These two pins are used to supply +5 volts to the palette DAC of the CL-GD542X. Each pin must be directly connected to the VCC rail. Each pin must be bypassed, as closely to the pin as possible, with a 0.1-μF capacitor with proper high-frequency characteristics. If a multi-layer board is used, each VDD pin <i>must</i> be connected to the power plane.
AVSS[3:2]	Ground	GROUND (DAC): These two pins are used to supply the ground reference to the palette DAC of the CL-GD542X. Each pin must be connected to the GND rail. For various adapter board and motherboard solutions, see the appendixes in the <i>True Color VGA Family — CL-GD542X Technical Reference Manual</i> .

3. FUNCTIONAL DESCRIPTION

3.1 General

The CL-GD542X family of VGA controllers offers a complete VGA-standards-compatible solution. All of the hardware necessary for CPU updates to memory, screen refresh, and DRAM refresh is included in the CL-GD542X. A complete VGA motherboard solution can be implemented with one 256K × 16 DRAM with any CL-GD542X chip.

The chip block diagram in Figure 3-1 shows the CL-GD542X connection to the host, display memory, and monitor. Each member of the CL-GD542X family of VGA controllers is pin-to-pin compatible on the system bus.

3.2 Functional Blocks

The following functional blocks have been integrated into the CL-GD542X.

CPU Interface

The CL-GD542X connects directly to the ISA bus, E-ISA bus, MicroChannel bus, or '386 and '486 bus (CL-GD5424/'26/'28/'29 only). No glue logic is required. The CL-GD542X internally decodes a 16- or 24-bit address, and responds to the applicable control lines. It executes both I/O accesses and memory accesses as either an 8- or 16-bit device.

CPU Write Buffer

The CPU Write Buffer contains a queue of CPU write accesses to display memory that have not been executed because of memory arbitration. Maintaining a queue allows the CL-GD542X to release the CPU as soon as it has recorded the address and data, and to execute the operation when display memory is available, increasing CPU performance.

Graphics Controller

The Graphics Controller is located between the CPU interface and the Memory Sequencer. It performs text manipulation, data rotation, color mapping, and other miscellaneous operations.

BitBLT

This is a unique GUI acceleration feature in the CL-GD5426/'28/'29. The BitBLT function moves data with ROPs (raster operations). This operation occurs in Packed-pixel modes with 8-, 16-, or 24-bit-per-pixel transfers. Color expansion can be used to translate monochrome images to 8- or 16-bit color. The source or destination of a BitBLT operation can be system memory.

Memory Arbitrator

The Memory Arbitrator allocates bandwidth to the four functions that compete for the limited bandwidth of display memory. These are CPU access, screen refresh, DRAM refresh, and BitBLT operations. DRAM refresh is handled invisibly by allocating a selectable number of CAS*-before-RAS* refresh cycles at the beginning of each scanline. Screen refresh and CPU/BitBLT accesses are allocated cycles according to the FIFO-control parameters, with priority given to screen refreshes.

Memory Sequencer

The Memory Sequencer generates timing for display memory. This includes RAS*, CAS* and multiplexed-address timing, as well as WE* and OE* timing. The Sequencer generates CAS*-before-RAS* refresh cycles, Random Read and Random Early Write cycles, and Fast-page mode Read and Early Write cycles. The Memory Sequencer generates multiple-CAS* or multiple-WE* signals according to the memory type used.

CRT Controller

The CRT controller generates the HSYNC and VSYNC Signals required for the monitor, as well as the BLANK* signals required by the palette DAC.

Video FIFO

The Video FIFO allows the Memory Sequencer to execute the display memory accesses needed for screen refresh at maximum memory speed rather than at the screen refresh rate. This makes it possible to collect the accesses for screen refresh near the beginning of the scanline, and to execute them in Fast-page mode rather than Random Read mode.

Attribute Controller

The Attribute Controller formats the display for the screen. Display color selection, text blinking and underlining are performed by the Attribute Controller. Alternate font selection also occurs in the Attribute Controller.

Palette DAC

The palette DAC block contains the color palette and three 8-bit digital-to-analog converters. The color palette, with 256 18-bit entries, converts a color code that specifies the color of a pixel into three 6-bit values, one each for red, green, and blue. The CL-GD5425 (only) supports YCrCb and AccuPak-to-RGB conversion.

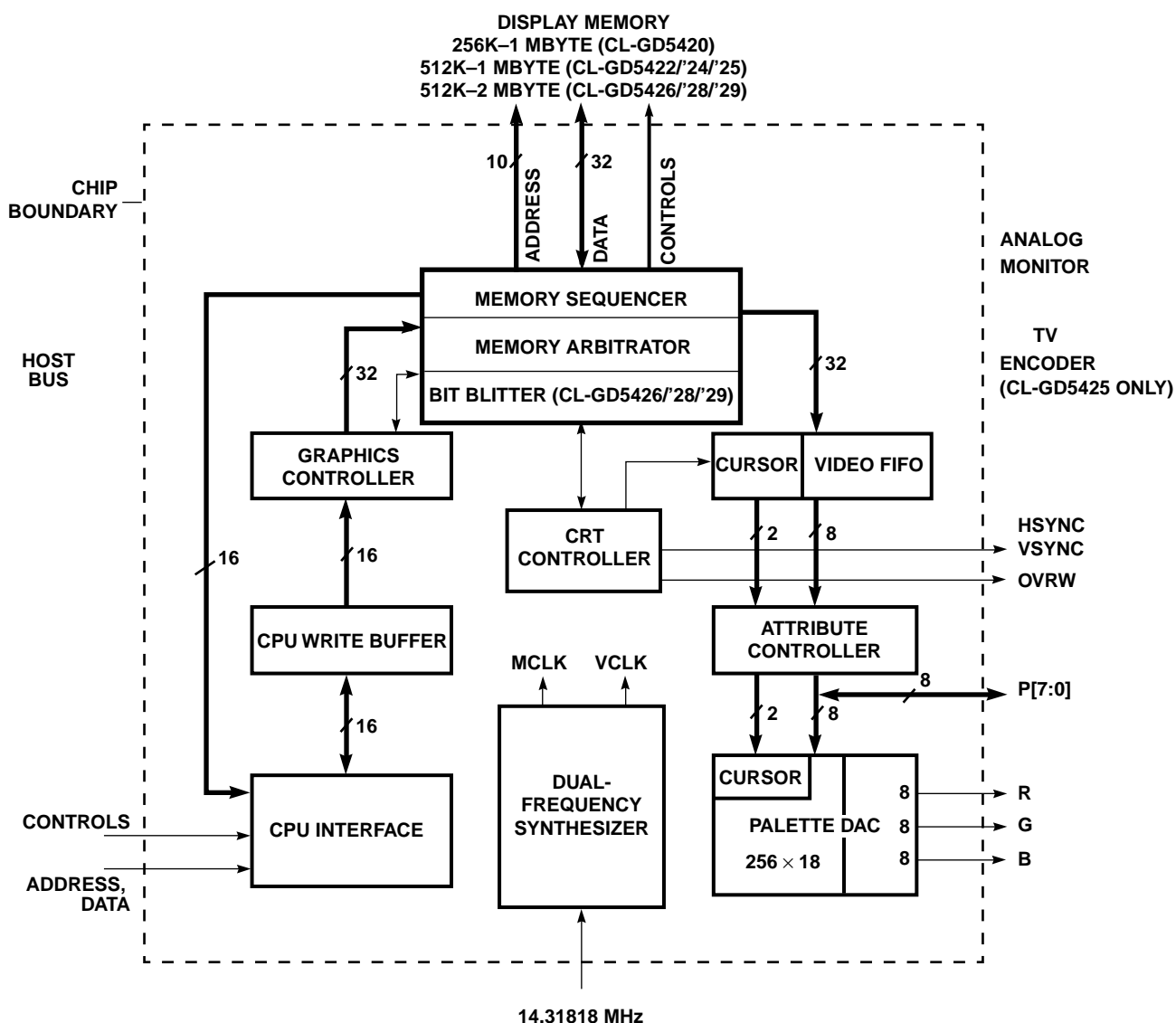


Figure 3-1. CL-GD542X Chip Block Diagram

Alternatively, the CL-GD542X (excluding the CL-GD5420) can be configured for 15-, 16-, or 24-bit pixels. This allows 32K, 65K, or 16 million simultaneous colors to be displayed on the screen. The bits are allocated as 8-8-8 for the 16 million colors, 5-6-5 for the 64K Color mode, or five to each (red, green, and blue) DAC for the 32K Color mode.

Dual-Frequency Synthesizer

The dual-frequency synthesizer generates the Memory Sequencer Clock and the Video Display Clock from a single reference frequency. The frequency of each clock is programmable. The reference frequency can be generated with an internal crystal-controlled oscillator. Alternatively, it can be supplied from an external TTL source.

VESA® Connector/VGA Pass-through Connector

The CL-GD542X is designed to connect directly to a VESA connector. It supports the three enable/disable inputs, and the Pixel bus can directly drive the connector. Through this connector, the overlay feature could be used in multimedia applications. This allows for internal DAC utilization in 16-bit-per-pixel mode. The CL-GD5425/'29 supports the VAFC (VESA Advanced Feature Connector) Baseline for Video Overlay.

TV Encoder (CL-GD5425 only)

The CL-GD5425 provides integrated scaling, flicker reduction, and a glueless encoder interface that delivers high-quality TV display at the lowest possible cost without the need for additional frame or line stores.

The programmable flicker-reduction function reduces interlaced artifacts inherent in computer-generated images displayed on interlaced TV monitors. The degree of filtering is selectable by the end-user.

3.3 Functional Operation

The four major operations handled by the CL-GD542X are discussed below.

CPU Access to Registers

The host can be any processor controlling an ISA, E-ISA, MicroChannel, or '386 and '486 local bus. It accesses CL-GD542X registers by setting up 16- or 24-bit addresses and making controls such as IORD* or IOWR* active. The CL-GD542X can respond either as an 8- or 16-bit peripheral, depending on how the chip has been designed into the system.

DRAM and screen refresh occur concurrently with, and independently of, register access (unless the host is changing display parameters or has suppressed refresh). Registers are described in detail in the *True Color VGA Family — CL-GD542X Technical Reference Manual*.

CPU Access to Display Memory

All host accesses to display memory are handled by the CL-GD542X. The host first sets up certain parameters, such as color and write masks, then generates a memory access in the range where the CL-GD542X is programmed to respond.

Display Memory Refresh

The CL-GD542X automatically generates a selectable number of CAS*-before-RAS* refresh cycles during each horizontal timing period.

Screen Refresh

The CRT monitor requires a near-constant rewriting since its only memory is the phosphor persistence. This persistence is typically only a few milliseconds. The CL-GD542X fetches information from the display memory for each scanline as quickly as possible, using Fast-page mode cycles to fill the Video FIFO. This allows the maximum possible time for the host to access the display memory.

3.4 Performance

The CL-GD542X is designed with the following performance-enhancing features:

- Accelerated Microsoft Windows with BitBLT (CL-GD5426/'28/'29 only)
- 16-bit CPU interface to I/O registers for faster host access
- 16-bit CPU interface to display memory for faster host access in all modes, including Planar mode
- 32-bit display memory data bus for faster access to display memory (CL-GD5422/'24/'25/'26/'28/'29)
- DRAM Fast-page mode operations for faster access to display memory
- Zero-wait-state performance and a CPU write buffer allows faster CPU access for writes to display memory
- Video FIFO to minimize memory contention
- 32×32 and 64×64 hardware cursor to improve Microsoft Windows performance
- Increased throughput with '386 and '486 local bus interface (CL-GD5424/'25/'26/'28/'29)

3.5 Compatibility

The CL-GD542X includes all registers and data paths required for VGA controllers.

The CL-GD542X supports extensions to VGA, including $1024 \times 768 \times 256$ interlaced and non-interlaced, and $1280 \times 1024 \times 256$ interlaced modes. Additionally, various 132-column text modes are supported.

3.6 Board Testability

The CL-GD542X chip is testable, even when installed on a PC board. By using pin scan testing, any IC signal pins not connected to the board or shorted to a neighboring pin or trace, will be detected. The Signature Generator allows the entire system, including the display memory, to be tested at speed. For further information on pin scan testing and the Signal Generator, refer to Appendixes B11 and B13 in the *True Color VGA Family — CL-GD542X Technical Reference Manual*.

4. CL-GD542X CONFIGURATION TABLES

4.1 Video Modes

Table 4-1. Standard VGA Modes

Mode No.	VESA® Mode No.	No. of Colors	Char. × Row	Char. Cell	Screen Format	Display Mode	Horiz. Freq. kHz	Vert. Freq. Hz
00/01	—	16/256	40 × 25	8 × 8	320 × 200	Text	31.5	70
00*/01*	—	16/256	40 × 25	8 × 14	320 × 350	Text	31.5	70
00+/01+	—	16/256	40 × 25	9 × 16	360 × 400	Text	31.5	70
02/03	—	16/256	80 × 25	8 × 8	640 × 200	Text	31.5	70
02*/03*	—	16/256	80 × 25	8 × 14	640 × 350	Text	31.5	70
02+/03+	—	16/256	80 × 25	9 × 16	720 × 400	Text	31.5	70
04/05	—	4/256	40 × 25	8 × 8	320 × 200	Graphics	31.5	70
6	—	2/256	80 × 25	8 × 8	640 × 200	Graphics	31.5	70
07*	—	Monochrome	80 × 25	9 × 14	720 × 350	Text	31.5	70
07+	—	Monochrome	80 × 25	9 × 16	720 × 400	Text	31.5	70
0D	—	16/256	40 × 25	8 × 8	320 × 200	Graphics	31.5	70
0E	—	16/256	80 × 25	8 × 8	640 × 200	Graphics	31.5	70
0F	—	Monochrome	80 × 25	8 × 14	640 × 350	Graphics	31.5	70
10	—	16/256	80 × 25	8 × 14	640 × 350	Graphics	31.5	70
11	—	2/256	80 × 30	8 × 16	640 × 480	Graphics	31.5	60
11+	—	2/256	80 × 30	8 × 16	640 × 480	Graphics	37.9	72
12	—	16/256	80 × 30	8 × 16	640 × 480	Graphics	31.5	60
12+	—	16/256	80 × 30	8 × 16	640 × 480	Graphics	37.9	72
13	—	256/256	40 × 25	8 × 8	320 × 200	Graphics	31.5	70

Table 4-2. Cirrus Logic Extended Video Modes

Mode No.	VESA® No.	No. of Colors	Char. × Row	Char. Cell	Screen Format	Display Mode	Pixel Freq. MHz	Horiz. Freq. kHz	Vert. Freq. Hz
14	—	16/256K	132 × 25	8 × 16	1056 × 400	Text	41.5	31.5	70
54	10A	16/256K	132 × 43	8 × 8	1056 × 350	Text	41.5	31.5	70
55	109	16/256K	132 × 25	8 × 14	1056 × 350	Text	41.5	31.5	70
58, 6A	102	16/256K	100 × 37	8 × 16	800 × 600	Graphics	36	35.2	56
58, 6A	102	16/256K	100 × 37	8 × 16	800 × 600	Graphics	40	37.8	60
58, 6A	102	16/256K	100 × 37	8 × 16	800 × 600	Graphics	50	48.1	72
58, 6A	102	16/256K	100 × 37	8 × 16	800 × 600	Graphics	49.5	46.9	75
5C	103	256/256K	100 × 37	8 × 16	800 × 600	Graphics	36	35.2	56
5C	103	256/256K	100 × 37	8 × 16	800 × 600	Graphics	40	37.9	60
5C	103	256/256K	100 × 37	8 × 16	800 × 600	Graphics	50	48.1	72
5C	103	256/256K	100 × 37	8 × 16	800 × 600	Graphics	49.5	46.9	75
5D†	104	16/256K	128 × 48	8 × 16	1024 × 768	Graphics	44.9	35.5	87†
5D	104	16/256K	128 × 48	8 × 16	1024 × 768	Graphics	65	48.3	60
5D	104	16/256K	128 × 48	8 × 16	1024 × 768	Graphics	75	56	70
5D	104	16/256K	128 × 48	8 × 16	1024 × 768	Graphics	77	58	72
5D	104	16/256K	128 × 48	8 × 16	1024 × 768	Graphics	78.7	60	75
5E	100	256/256K	80 × 25	8 × 16	640 × 400	Graphics	25	31.5	70
5F	101	256/256K	80 × 30	8 × 16	640 × 480	Graphics	25	31.5	60
5F	101	256/256K	80 × 30	8 × 16	640 × 480	Graphics	31.5	37.9	72
60†	105	256/256K	128 × 48	8 × 16	1024 × 768	Graphics	44.9	35.5	87†
60	105	256/256K	128 × 48	8 × 16	1024 × 768	Graphics	65	48.3	60
60	105	256/256K	128 × 48	8 × 16	1024 × 768	Graphics	75	56	70
60	105	256/256K	128 × 48	8 × 16	1024 × 768	Graphics	77	58	72
60	105	256/256K	128 × 48	8 × 16	1024 × 768	Graphics	78.7	60	75
64	111	64K	—	—	640 × 480	Graphics	25	31.5	60
64	111	64K	—	—	640 × 480	Graphics	31.5	37.9	72
65	114	64K	—	—	800 × 600	Graphics	36	35.2	56
65	114	64K	—	—	800 × 600	Graphics	40	37.8	60
65	114	64K	—	—	800 × 600	Graphics	50	48.1	72

Table 4-2. Cirrus Logic Extended Video Modes (cont.)

Mode No.	VESA® No.	No. of Colors	Char. × Row	Char. Cell	Screen Format	Display Mode	Pixel Freq. MHz	Horiz. Freq. kHz	Vert. Freq. Hz
66	110	32K‡	–	–	640 × 480	Graphics	25	31.5	60
66	110	32K‡	–	–	640 × 480	Graphics	31.5	37.9	72
67	113	32K‡	–	–	800 × 600	Graphics	36	35.2	56
67	113	32K‡	–	–	800 × 600	Graphics	40	37.8	60
67	113	32K‡	–	–	800 × 600	Graphics	50	48.1	72
68†	116	32K‡	–	–	1024 × 768	Graphics	44.9	35.5	87†
6C†	106	16/256K	160 × 64	8 × 16	1280 × 1024	Graphics	75	48	87†
6D†	107	256/256K	160 × 64	8 × 16	1280 × 1024	Graphics	75	48	87†
71	112	16M	–	–	640 × 480	Graphics	25	31.5	60
74†	117	64K	–	–	1024 × 768	Graphics	44.9	35.5	87†

NOTES:

- 1) Some modes are not supported by all CL-GD542X controllers. Refer to the CL-GD542X data book and software release kit for the list of video modes supported by the CL-GD542X BIOS.
- 2) Not all monitors support all modes. The fastest vertical refresh rate for the monitor type selected will be used automatically.
- 3) ‡ indicates 32K Direct-Color/256-color Mixed mode.
- 4) † indicates Interlaced mode.

Table 4-3. NTSC TV Video Modes (CL-GD5425 only)

Mode No.	Colors	Screen Format	Char. × Row	Char. Cell	Display Mode	Note
00/01	16/256K	320 × 200	40 × 25	8 × 8	Text	—
02/03	16/256K	640 × 200	80 × 25	8 × 8	Text	—
04/05	4/256K	320 × 200	40 × 25	8 × 8	Graphics	Double scanned
06	2/256K	640 × 200	80 × 25	8 × 8	Graphics	Double scanned
0D	16/256K	320 × 200	40 × 25	8 × 8	Graphics	Double scanned
0E	16/256K	640 × 200	80 × 25	8 × 8	Graphics	Double scanned
10	16/256K	640 × 350	80 × 25	8 × 14	Graphics	7:8 expansion
11/12	16/256K	640 × 480	80 × 30	8 × 16	Graphics	6:5 scale
13	256/256K	320 × 200	40 × 25	8 × 8	Graphics	Double scanned
5E	256/256K	640 × 400	80 × 25	8 × 16	Graphics	—
5F	256/256K	640 × 480	80 × 30	8 × 16	Graphics	6:5 scale
64	64K	640 × 480	—	—	Graphics	6:5 scale
7A	64K	640 × 400	—	—	Graphics	—

Table 4-4. PAL TV Video Modes (CL-GD5425 only)

Mode No.	Colors	Screen Format	Char. × Row	Char. Cell	Display Mode	Note
00/01	16/256K	320 × 200	40 × 25	8 × 8	Text	5:6 expansion
02/03	16/256K	640 × 200	80 × 25	8 × 8	Text	5:6 expansion
04/05	4/256K	320 × 200	40 × 25	8 × 8	Graphics	Double Scanned 5:6 expansion
06	2/256K	640 × 200	80 × 25	8 × 8	Graphics	Double Scanned 5:6 expansion
0D	16/256K	320 × 200	40 × 25	8 × 8	Graphics	Double scanned 5:6 expansion
0E	16/256K	640 × 200	80 × 25	8 × 8	Graphics	Double scanned 5:6 expansion
10	16/256K	640 × 350	80 × 25	8 × 14	Graphics	5:7 expansion 490 scanlines
11/12	16/256K	640 × 480	80 × 30	8 × 16	Graphics	—
13	256/256K	320 × 200	40 × 25	8 × 8	Graphics	5:6 expansion
5E	256/256K	640 × 400	80 × 25	8 × 16	Graphics	5:6 Expansion
5F	256/256K	640 × 480	80 × 30	8 × 16	Graphics	—
64	64K	640 × 480	—	—	Graphics	—
7A	64K	640 × 400	—	—	Graphics	5:6 expansion

4.2 Configuration Register, CF1

When RESET (system power-on reset) goes active, the CL-GD542X samples the levels on several of the Display Memory Data MD[x] pins. These levels are latched into a write-only configuration register (CF1). The data bits in this register are not accessible to the host CPU. The levels on the Memory Data bus are, by default, a logic '1' during power-on reset due to internal 250-k Ω pull-up resistors. A logic '0' is achieved by installing an external 6.8-k Ω pull-down resistor on the memory data line corresponding to the appropriate bit in the Configuration register. The following table identifies the Configuration register bits and the particular VGA function enabled by the latched level on the Memory Data bus during power-on reset.

Table 4-5. Configuration Register Bits

CF Bits	Level	Description	Memory Data Bit	Pin Number
15	0 1	Source VCLK on MCLK pin (CL-GD5425/'29) Source MCLK on MCLK pin (CL-GD5425/'29)	MD31	97
14, 7, 5	000 001 010 011 100 101 110 111	Reserved '386DX local bus (CL-GD5424/'25/'26/'28/'29) '386SX local bus (CL-GD5424/'25/'26/'28/'29) '486SX/DX local bus (CL-GD5424/'25/'26/'28) VESA® VL-Bus™ > 33 MHz (CL-GD5425/'29) MicroChannel® bus VESA® VL-Bus™ (CL-GD5424/'25/'26/'28/'29) ISA bus	MD30, 23, 21	98, 108, 110
13	0 1	Asymmetric DRAM (Not CL-GD5425) Symmetric DRAM IREF Adjust (CL-GD5425)	MD29	99
12	0 1	CAS[3:0]*, single-WE* (Reserved in CL-GD5420/'25) WE[3:0]*, single-CAS*	MD28	100
11	0 1	7-MCLK RAS* cycle 6-MCLK RAS* cycle	MD27	102
10,9	00 01 10 11	50.11363-MHz MCLK (Reserved in CL-GD5425) 44.74431-MHz MCLK 41.16477-MHz MCLK 37.58523-MHz MCLK	MD26, 25	103, 104
8	0 1	64K ROM BIOS @ C0000–CFFFF 32K ROM BIOS @ C0000–C7FFF	MD24	105
6	0 1	16-bit BIOS ROM (ISA bus only) (MCS16* generated for 64K or 32K) 8-bit BIOS ROM (CL-GD5424 does not generate MCS16*)	MD22	109
4	0 1	External MCLK (pin 157 is an input) (Test) Internal MCLK (pin 157 is an output)	MD20	111
3	0 1	Port 3C3h is Video System Sleep register Port 46E8h is Video System Sleep register	MD19	112
2		Reserved	MD18	113
1	0 1 0 1	Zero wait enabled (except CL-GD5425/'29) Zero wait disabled (except CL-GD5425/'29) Disable NTSC Black-Level offset (CL-GD5425) Enable NTSC Black-Level offset (CL-GD5425)	MD17	114
0	0 1	XTAL, OSC configured for two ref (CL-GD5425) XTAL, OSC configured for one ref (CL-GD5425)	MD16	115

4.3 Host Interface Signals

With the pin connections listed below, the CL-GD542X will interface directly to an ISA, MicroChannel, or local bus.

Table 4-6. Bus Connections

CL-GD542X Pin	ISA Bus	MicroChannel® Bus	'386SX	'386DX	'486	VESA® VL-Bus™
[45..42], [39..29]	SA[16:2]	A[16:2]	A[16:2]	A[16:2]	A[16:2]	A[16:2]
28	SA1	A1	A1	BE3#	BE3#	BE3#
27	SA0	A0	BLE#	BE2#	BE2#	BE2#
[21..15]	LA[23:17]	A[23:17]	A[23:17]	A[23:17]	A[23:17]	A[23:17]
[11..8], [6..3]	SD[15:8]	D[15:8]	D[15:8]	D[15:8]	D[15:8]†	D[15:8]†
[63..62], [60..59], [57..54]	SD[7:0]	D[7:0]	D[7:0]	D[7:0]	D[7:0]†	D[7:0]†
24	SBHE*	–SBHE	BHE#	BE1#	BE1#	BE1#
25	BALE	MADE24	ADS#	ADS#	ADS#	ADS#
46	AEN	–CD_SETUP	CPU-Reset	CPU-Reset	Ground	RDYRTN#
49	IOR*	–S1	W/R#	W/R#	W/R#	W/R#
50	IOW*	–CMD	CLK2X	CLK2X	CLK1X	CLK1X
14	MEMR*	M-/IO	M/IO#	M/IO#	M/IO#	M/IO#
13	MEMW*	–S0	(unused)	UADDR#	UADDR#	UADDR#
41	RESET	CHRESET	RESET	RESET	RESET	RESET
48	REFRESH	–REFRESH	(unused)	BE0#	BE0#	BE0#
23	MCS16*	–CD_DS16	(unused)	BS16#	BS16#	BS16#
51	OWS*	(unused)	GROUND	GROUND	GROUND	GROUND
52	IRQ	–IRQ	INTR	INTR	INTR	INTR
47	IOCHRDY	CD_CHRDY	READY#	READY#	RDY#	RDY#
22	IOCS16*	–CD_SFDBK	LBA#	LBA#	LBA#	LBA#
159	OSC	OSC	OSC	OSC	OSC	OSC
2	EROM*	EROM*	EROM*	EROM*	EROM*	EROM*

NOTES:

- 1) For ISA-bus applications, note that SA[19..17] are not found on the CL-GD542X; this means that an adapter board will only function in a 16-bit slot.
- 2) The OSC and EROM* pins are common in all configurations.
- 3) The OSC pin is an input for 14.31818 MHz.
- 4) † Data lines D[15:0] connect to external, data-steering transceiver.

5. VGA REGISTER PORT MAP

Table 5-1. VGA Register Port Map

Address	Port
94	POS 102 Access Control (3C3 sleep)
102	POS102 register
3B4	CRT Controller Index (R/W — monochrome)
3B5	CRT Controller Data (R/W — monochrome)
3BA	Feature Control (W), Input Status register 1 (R — monochrome)
3C0	Attribute Controller Index/Data (Write)
3C1	Attribute Controller Index/Data (Read)
3C2	Miscellaneous Output (W), Input Status register 0 (R)
3C3	MotherBoard Sleep
3C4	Sequencer Index (R/W)
3C5	Sequencer Data (R/W)
3C6	Video DAC Pixel Mask (R/W), Hidden DAC register (R/W)
3C7	Pixel Address Read mode (W), DAC State (R)
3C8	Pixel Mask Write mode (R/W)
3C9	Pixel Data (R/W)
3CA	Feature Control Readback (R)
3CC	Miscellaneous Output Readback (R)
3CE	Graphics Controller Index (R/W)
3CF	Graphics Controller Data (R/W)
3D4	CRT Controller Index (R/W — color)
3D5	CRT Controller Data (R/W — color)
3DA	Feature Control (W), Input Status register 1 (R — color)
46E8	Adapter Sleep

6. CL-GD542X REGISTERS

Table 6-1. External/General Registers

Abbreviation	Register Name	Index	Port
102 Access	POS 94: 102 Access Control	–	94
POS102	POS102	–	102
VSSM	Motherboard Sleep Address (<i>CL-GD5424/'25/'26/'28/'29 only</i>)	–	3C3
VSSM	Adapter Sleep	–	46E8
MISC	Miscellaneous Output	–	3C2 (Write)
MISC	Miscellaneous Output	–	3CC (Read)
FC	Feature Control	–	3?A (Write) ^a
FC	Feature Control	–	3CA (Read)
FEAT	Input Status Register 0	–	3C2
STAT	Input Status Register 1	–	3?A
3C6	Pixel Mask	–	3C6
3C7	Pixel Address Read Mode	–	3C7 (Write)
3C7	DAC State	–	3C7 (Read)
3C8	Pixel Address Write Mode	–	3C8
3C9	Pixel Data	–	3C9

^a '?' in the above register addresses is 'B' in Monochrome mode and 'D' in Color mode.

Table 6-2. VGA Sequencer Registers

Abbreviation	Register Name	Index	Port
SRX	Sequencer Index	–	3C4
SR0	Reset	0	3C5
SR1	Clocking Mode	1	3C5
SR2	Plane Mask	2	3C5
SR3	Character Map Select	3	3C5
SR4	Memory Mode	4	3C5

Table 6-3. CRT Controller Registers

Abbreviation	Register Name	Index	Port
CRX	CRTC Index	—	3?4 ^a
CR0	Horizontal Total	0	3?5
CR1	Horizontal Display End	1	3?5
CR2	Horizontal Blanking Start	2	3?5
CR3	Horizontal Blanking End	3	3?5
CR4	Horizontal Sync Start	4	3?5
CR5	Horizontal Sync End	5	3?5
CR6	Vertical Total	6	3?5
CR7	Overflow	7	3?5
CR8	Screen A Preset Row Scan	8	3?5
CR9	Character Cell Height	9	3?5
CRA	Text Cursor Start	A	3?5
CRB	Text Cursor End	B	3?5
CRC	Screen Start Address High	C	3?5
CRD	Screen Start Address Low	D	3?5
CRE	Text Cursor Location High	E	3?5
CRF	Text Cursor Location Low	F	3?5
CR10	Vertical Sync Start	10	3?5
CR11	Vertical Sync End	11	3?5
CR12	Vertical Display End	12	3?5
CR13	Offset	13	3?5
CR14	Underline Row Scanline	14	3?5
CR15	Vertical Blanking Start	15	3?5
CR16	Vertical Blanking End	16	3?5
CR17	Mode Control	17	3?5
CR18	Line Compare	18	3?5
CR22	Graphics Data Latches Readback	22	3?5
CR24	Attribute Controller Toggle Readback	24	3?5
CR26	Attribute Controller Index Readback	26	3?5

^a '?' in the above register addresses is 'B' in Monochrome mode and 'D' in Color mode.

Table 6-4. VGA Graphics Controller Registers

Abbreviation	Register Name	Index	Port
GRX	Graphics Controller Index	–	3CE
GR0	Set/Reset	0	3CF
GR1	Set/Reset Enable	1	3CF
GR2	Color Compare	2	3CF
GR3	Data Rotate	3	3CF
GR4	Read Map Select	4	3CF
GR5	Mode	5	3CF
GR6	Miscellaneous	6	3CF
GR7	Color Don't Care	7	3CF
GR8	Bit Mask	8	3CF

Table 6-5. VGA Attribute Controller Registers

Abbreviation	Register Name	Index	Port
ARX	Attribute Controller Index	–	3C0/3C1
AR0-ARF	Attribute Controller Palette	0:F	3C0/3C1
AR10	Attribute Controller Mode	10	3C0/3C1
AR11	Overscan (Border) Color	11	3C0/3C1
AR12	Color Plane Enable	12	3C0/3C1
AR13	Pixel Panning	13	3C0/3C1
AR14	Color Select	14	3C0/3C1

Table 6-6. Extension Registers

Abbreviation	Register Name	Index	Port
SR2	Enable Writing Pixel Extension	2	3C5
SR6	Unlock ALL Extensions	6	3C5
SR7	Extended Sequencer Mode	7	3C5
SR8	EEPROM Control	8	3C5
SR9	Scratch-Pad 0	9	3C5
SRA	Scratch-Pad 1	A	3C5
SRB	VCLK0 Numerator	B	3C5
SRC	VCLK1 Numerator	C	3C5
SRD	VCLK2 Numerator	D	3C5
SRE	VCLK3 Numerator	E	3C5
SRF	DRAM Control	F	3C5
SR10	Graphics Cursor Y Position	10	3C5
SR11	Graphics Cursor X Position	11	3C5
SR12	Graphics Cursor Attributes	12	3C5
SR13	Graphics Cursor Pattern Address Offset	13	3C5
SR14	Scratch-Pad 2 (<i>CL-GD5425/26/28/29 only</i>)	14	3C5
SR15	Scratch-Pad 3 (<i>CL-GD5425/26/28/29 only</i>)	15	3C5
SR16	Performance Tuning (<i>CL-GD5424/25/26/28/29 only</i>)	16	3C5
SR17	Configuration Readback and Extended Control (<i>except CL-GD5420</i>)	17	3C5
SR18	Signature Generator Control (<i>except CL-GD5420</i>)	18	3C5
SR19	Signature Generator Result Low Byte (<i>except CL-GD5420</i>)	19	3C5
SR1A	Signature Generator Result High Byte (<i>except CL-GD5420</i>)	1A	3C5
SR1B	VCLK0 Denominator and Post-Scalar Value	1B	3C5
SR1C	VCLK1 Denominator and Post-Scalar Value	1C	3C5
SR1D	VCLK2 Denominator and Post-Scalar Value	1D	3C5
SR1E	VCLK3 Denominator and Post-Scalar Value	1E	3C5
SR1F	BIOS ROM Write Enable and MCLK Select	1F	3C5
GR0	Write Mode 5 Background Extension	0	3CF
GR1	Write Mode 4, 5 Foreground Extension	1	3CF
GR9	Offset Register 0	9	3CF
GRA	Offset Register 1	A	3CF

Table 6-6. Extension Registers (cont.)

Abbreviation	Register Name	Index	Port
GRB	Graphics Controller Mode Extensions	B	3CF
GRC	Color Key (CL-GD5424/'25/'26/'28/'29 only)	C	3CF
GRD	Color Key Mask (CL-GD5424/'25/'26/'28/'29 only)	D	3CF
GRE	Miscellaneous Control (CL-GD5425/'28/'29 only)	E	3CF
GR10	16-bit Pixel BG Color High Byte (except CL-GD5420)	10	3CF
GR11	16-bit Pixel FG Color High Byte (except CL-GD5420)	11	3CF
GR18	Extended DRAM Controls (CL-GD5429 only)	18	3CF
CR19	Interlace End	19	3?5 ^a
CR1A	Miscellaneous Control	1A	3?5
CR1B	Extended Display Controls	1B	3?5
CR1C	Sync Adjust and GENLOCK (CL-GD5425 only)	1C	3?5
CR1D	Overlay Mode Controls (CL-GD5425/'29 only)	1D	3?5
CR25	Part Status	25	3?5
CR27	ID	27	3?5
CR30	TV-Out Mode Control (CL-GD5425 only)	30	3?5
HDR	Hidden DAC (except CL-GD5420)	–	3C6

^a '?' in the above register addresses is 'B' in Monochrome mode and 'D' in Color mode.

Table 6-7. CL-GD5426/'28/'29 BitBLT Registers

Abbreviation	Register Name	Index	Port
GR20	BLT Width Low	20	3CF
GR21	BLT Width High	21	3CF
GR22	BLT Height Low	22	3CF
GR23	BLT Height High	23	3CF
GR24	BLT Destination Pitch Low	24	3CF
GR25	BLT Destination Pitch High	25	3CF
GR26	BLT Source Pitch Low	26	3CF
GR27	BLT Source Pitch High	27	3CF
GR28	BLT Destination Start Low	28	3CF
GR29	BLT Destination Start Mid	29	3CF
GR2A	BLT Destination Start High	2A	3CF

Table 6-7. CL-GD5426/'28/'29 BitBLT Registers *(cont.)*

Abbreviation	Register Name	Index	Port
GR2C	BLT Source Start Low	2C	3CF
GR2D	BLT Source Start Mid	2D	3CF
GR2E	BLT Source Start High	2E	3CF
GR2F	BLT Write Mask Destination <i>(CL-GD5429 only)</i>	2F	3CF
GR30	BLT Mode	30	3CF
GR31	BLT Start/Status	31	3CF
GR32	BLT Raster Operation	32	3CF
GR34	Transparent Color Select Low <i>(except CL-GD5429)</i>	34	3CF
GR35	Transparent Color Select High <i>(except CL-GD5429)</i>	35	3CF
GR38	Transparent Color Mask Low <i>(except CL-GD5429)</i>	38	3CF
GR39	Transparent Color Mask High <i>(except CL-GD5429)</i>	39	3CF

7. ELECTRICAL SPECIFICATIONS

7.1 Absolute Maximum Ratings

Ambient temperature under bias	0° to 70° C
Storage temperature.....	-65° to 150° C
Voltage on any pin	$V_{SS} - 0.5\text{ V}$ to $V_{CC} + 0.5\text{ V}$
Operating power dissipation	1.5 Watts
Power supply voltage.....	7 Volts
Injection current (latch-up testing)	100 mA

NOTE: Stresses above those listed may cause permanent damage to system components. These are stress ratings only. Functional operation at these or any conditions above those indicated in the operational ratings of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect system reliability.

7.2 DC Specifications (Digital)

($V_{CC} = 5V \pm 5\%$, $T_A = 0^\circ$ to 70° C, unless otherwise specified)

Symbol	Parameter	MIN	MAX	Units	Test Conditions	Note
V_{CC}	Power Supply Voltage	4.75	5.25	Volts	Normal Operation	
V_{IL}	Input Low Voltage	0	0.8	Volts		
V_{IH}	Input High Voltage	2.0	$V_{CC} + 0.5$	Volts		
V_{OL}	Output Low Voltage		0.5	Volts	$I_{OL} = 4$ mA	1
V_{OH}	Output High Voltage	2.4		Volts	$I_{OH} = 400$ μ A	2
I_{CC}	Supply Current				V_{CC} Nominal	3
I_{IH}	Input High Current		10	μ A	$V_{IL} = V_{DD}$	
I_{IL}	Input Low Current	-10		μ A	$V_{DD} = 5.25$, $V_{IL} = 0$	
I_{IHP}	Input High Current (pull-up)	-10	10	μ A	$V_{IL} = V_{DD}$	
I_{ILP}	Input Low Current (pull-up)	-45	-12	μ A	$V_{DD} = 5.25$, $V_{IL} = 0$	
I_{OZ}	Input Leakage	-10	10	μ A	$0 < V_{IN} < V_{CC}$	
C_{IN}	Input Capacitance		10	pF		4
C_{OUT}	Output Capacitance		10	pF		4

NOTES:

- 1) I_{OL} is specified for a standard buffer. See the pin summary for further information.
- 2) I_{OH} is specified for a standard buffer. See the pin summary for further information.
- 3) I_{CC} is measured with VCLK and MCLK as indicated in the table below:

Part Number	VCLK	MCLK	I_{CC}
CL-GD5420	75 MHz	50 MHz	250 mA
CL-GD5422	80 MHz	50 MHz	260 mA
CL-GD5424/'25	80 MHz	50 MHz	260 mA
CL-GD5426/'28	80 MHz	50 MHz	260 mA
CL-GD5429	86 MHz	70 MHz	310 mA

- 4) This is not 100% tested, but is periodically sampled.

7.3 DC Specifications (Palette DAC)

($V_{CC} = 5V \pm 5\%$, $T_A = 0^\circ$ to 70° C, unless otherwise specified)

Symbol	Parameter	MIN	MAX	Units	Test Conditions	Note
A_{VDD}	DAC Supply Voltage	4.75	5.25	Volts	Normal Operation	
I_{REF}	DAC Reference Current	-3	-10	mA		1

NOTE: See the Detailed Pin Description for information regarding nominal I_{REF} .

7.4 DC Specifications (Frequency Synthesizer)

($V_{CC} = 5V \pm 5\%$, $T_A = 0^\circ$ to 70° C, unless otherwise specified)

Symbol	Parameter	MIN	MAX	Units	Test Conditions	Note
A_{VDD}	Synthesizer Supply Voltage	4.75	5.25	Volts		

7.5 DAC Characteristics

($V_{CC} = 5\text{ V} \pm 5\%$, $T_A = 0^\circ$ to 70° C , unless otherwise specified)

Symbol	Parameter	MIN	MAX	Units	Test Conditions	Note
R	Resolution	8	Max	Bits		
IO	Output Current	30	Max	mA	$V_O < 1\text{ V}$	
TR	Analog Output Rise/Fall Time	8	Max	ns		2, 3, 4
TS	Analog Output Settling Time	15	Max	ns		2, 3, 5
TSK	Analog Output Skew	tbd	Max	ns		2, 3, 6
DT	DAC-to-DAC Correlation	2.5	Max	%		6, 7
GI	Glitch Impulse		Typical	pV-sec.		2, 3, 6
IL	Integral Linearity	1.5	Max	LSB		
DL	Differential Linearity	1.5	Max	LSB		

NOTES:

- 1) TD is measured from the 50% point of VCLK to the 50% point of full-scale transition.
- 2) Load is $50\ \Omega$ and 30 pF per analog output.
- 3) $I_{REF} = -6.67\text{ mA}$.
- 4) TR is measured from 10% to 90% full-scale.
- 5) TS is measured from 50% of full-scale transition to the output remaining within 2% of final value.
- 6) Outputs loaded identically.
- 7) About the mid-point of the distribution of the three DACs measured at full-scale output.

7.6 List of Waveforms

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7-45	PAL Vertical Retrace (CL-GD5425 only)	100

Table 7-1. I/O Write Timing (ISA Bus)^a

Symbol	Parameter	MIN	MAX	Units
t_1	Address, SBHE* setup to IOW* active	5	—	ns
t_2	IOW* pulse width	40	—	ns
t_3	Data setup to IOW* inactive	5	—	ns
t_4	Data hold from IOW* inactive	10	—	ns
t_5	Address, SBHE* hold from IOW* inactive	5	—	ns
t_6	IOW* inactive to any command active	80	—	ns

^a AEN must be inactive.

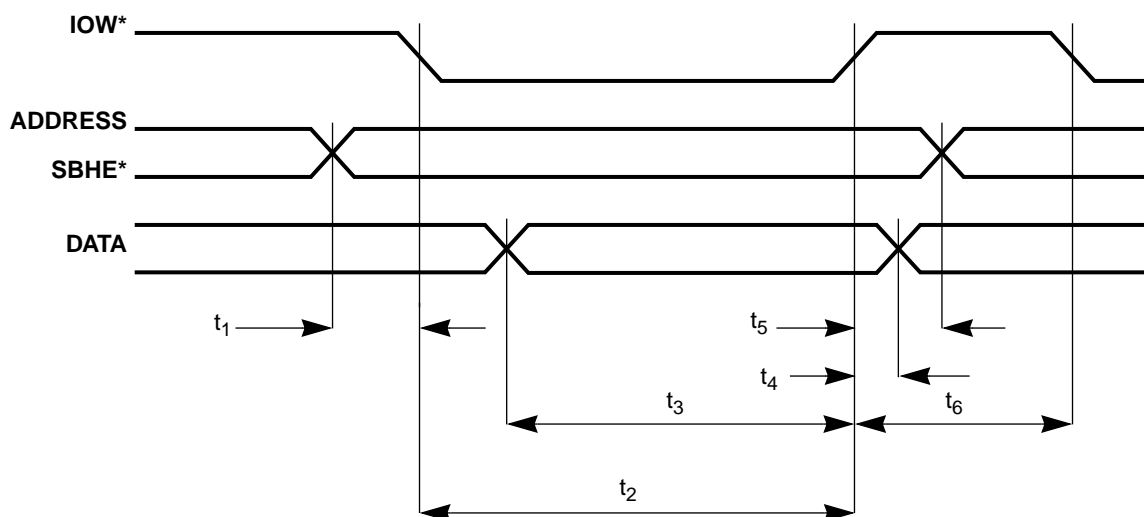


Figure 7-1. I/O Write Timing (ISA Bus)

Table 7-2. I/O Read Timing (ISA Bus)^a

Symbol	Parameter	MIN	MAX	Units
t_1	Address, SBHE* setup to IOR* active	5	—	ns
t_2	IOR* active to low-impedance delay	0	—	ns
t_3	Data delay from IOR* active (IOR* access time)	—	60	ns
t_4	IOR* pulse width	70	—	ns
t_5	Data hold from IOR* inactive	0	20	ns
t_6	Address, SBHE* hold from IOR* inactive	0	—	ns
t_7	IOR* inactive to high-impedance delay	0	20	ns

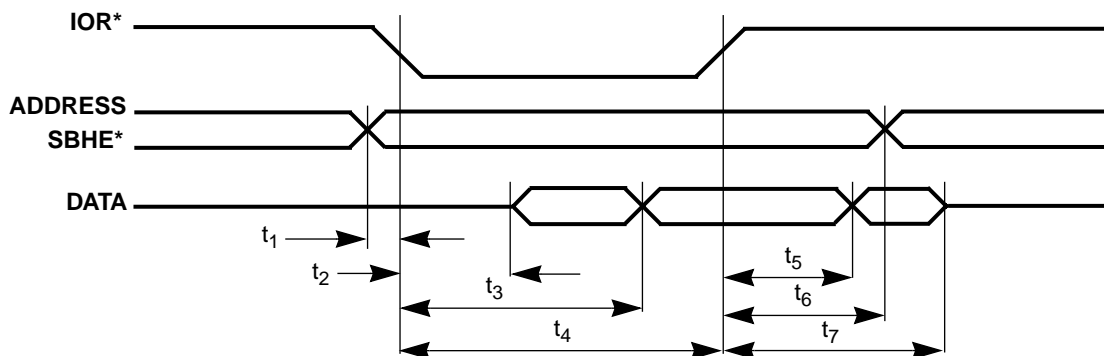
^a AEN must be inactive.

Figure 7-2. I/O Read Timing (ISA Bus)

Table 7-3. Memory Write Timing (ISA Bus)

Symbol	Parameter	MIN	MAX	Units
t_1	Address, SBHE* to SMEMW* active setup	5	—	ns
t_2	SMEMW* pulse width	3	—	m ^a
t_3	Data valid from SMEMW* active	—	3	m
t_4	Data hold from SMEMW* inactive	10	—	ns
t_5	Address, SBHE* hold from SMEMW* inactive	0	—	ns
t_6	SMEMW* inactive to next SMEMW*	3	—	m

^a m = MCLK period.

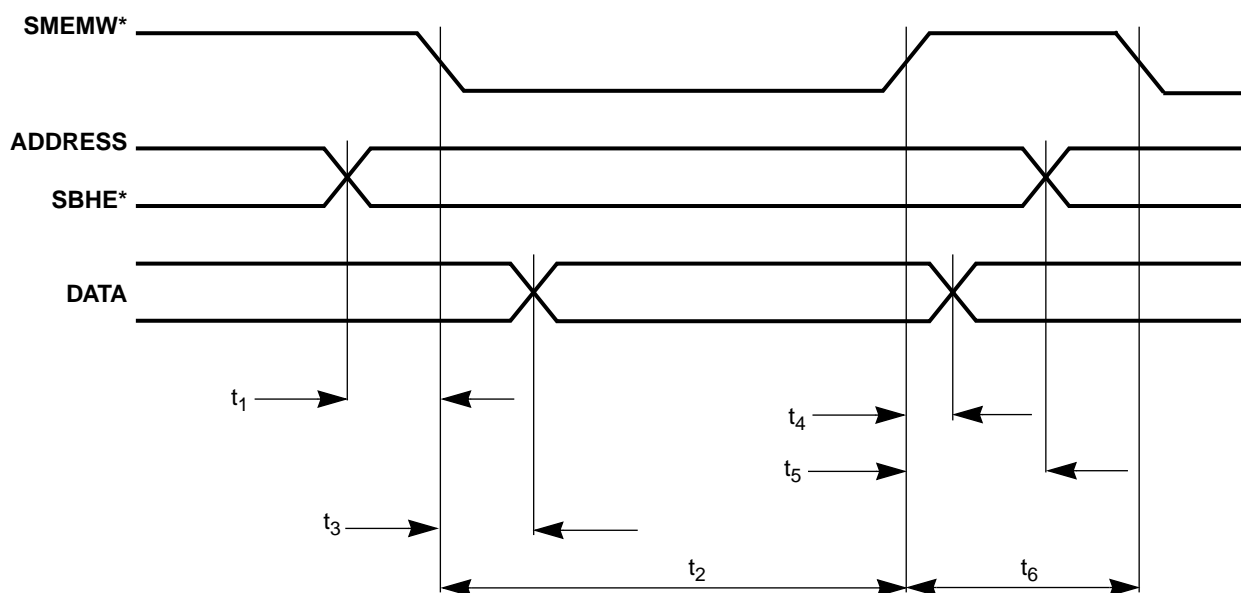


Figure 7-3. Memory Write Timing (ISA Bus)

Table 7-4. Memory Read Timing (ISA Bus)

Symbol	Parameter	MIN	MAX	Units
t_1	Address, SBHE* to SMEMR* active	5	—	ns
t_2	SMEMR* active to low-impedance delay	0	—	ns
t_3	Data delay from IOCHRDY active	—	15	ns
t_4	SMEMR* pulse width	—	a	ns
t_5	Data hold from SMEMR* inactive	0	20	ns
t_6	Address, SBHE* hold from SMEMR* inactive	0	—	ns
t_7	SMEMR* inactive to high-impedance delay	—	20	ns

^a SMEMR* active-pulse width is determined by IOCHRDY.

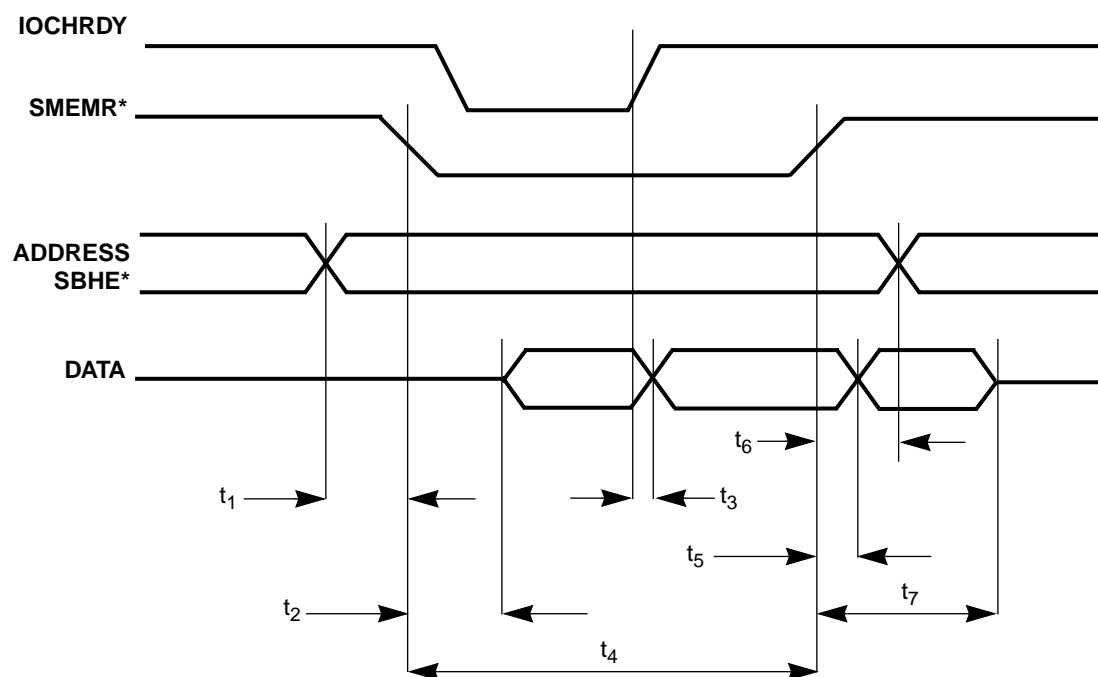

Figure 7-4. Memory Read Timing (ISA Bus)

Table 7-5. MCS16* Timing (ISA Bus)

Symbol	Parameter	MIN	MAX	Units
t_{1a}	MCS16* active delay from LA[23:17] valid	—	20	ns
t_{1b}	MCS16* active delay from SA[16:15] valid	—	14	ns
t_2	MCS16* inactive delay from address invalid	—	25	ns

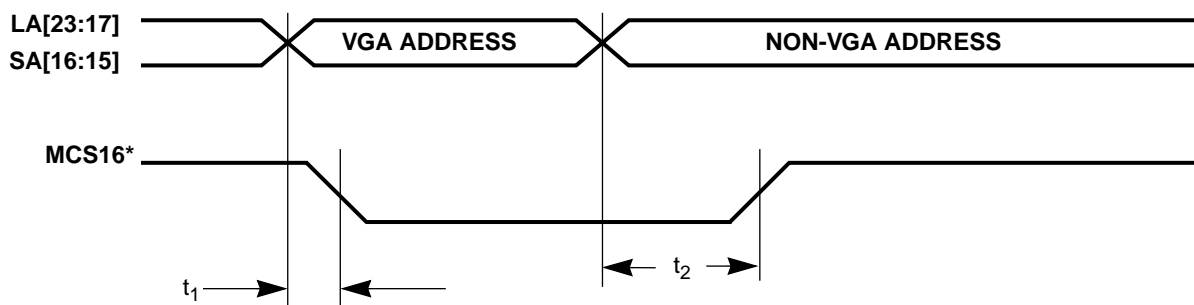


Figure 7-5. MCS16* Timing (ISA Bus)

Table 7-6. IOCS16* Timing (ISA Bus)

Symbol	Parameter	MIN	MAX	Units
t_1	IOCS16* active delay from address	—	25	ns
t_2	IOCS16* inactive delay from address	—	30	ns

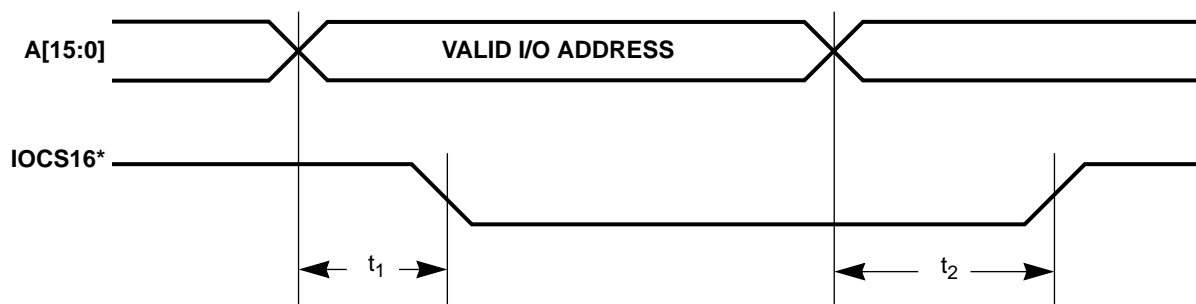


Figure 7-6. IOCS16* Timing (ISA Bus)

Table 7-7. BALE Timing (ISA Bus)

Symbol	Parameter	MIN	MAX	Units
t_1	LA[23:17] setup to BALE negative transition	20	–	ns
t_2	SBHE* setup to BALE negative transition	20	–	ns
t_3	LA[23:17] hold from BALE negative transition	20	–	ns
t_4	SBHE* hold from BALE negative transition	20	–	ns
t_5	BALE pulse width	20	–	ns

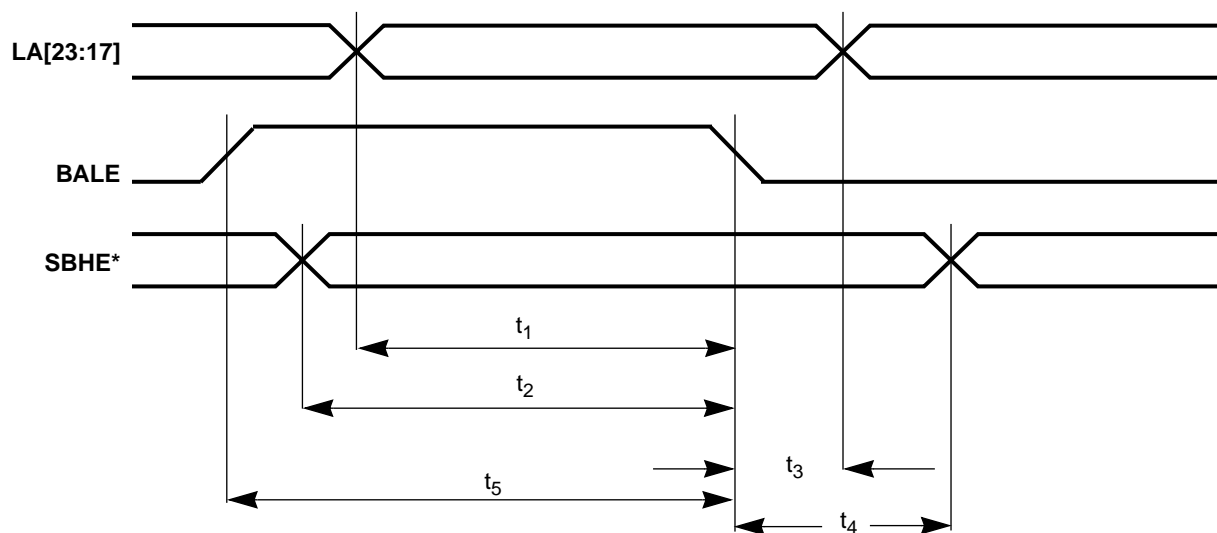

Figure 7-7. BALE Timing (ISA Bus)

Table 7-8. IOCHRDY for Memory Access Timing (ISA Bus)

Symbol	Parameter	MIN	MAX	Units
t_1	SMEMR* or SMEMW* active to IOCHRDY inactive low	—	28	ns
t_2	IOCHRDY inactive low pulse width	10	a	ns

a Video mode dependent.

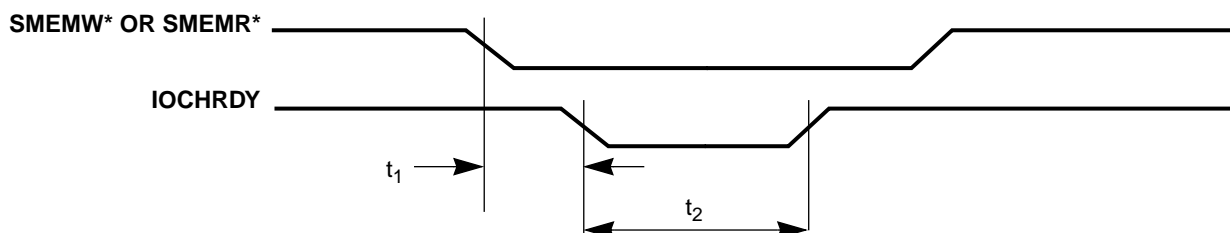


Figure 7-8. IOCHRDY for Memory Access Timing (ISA Bus)

Table 7-9. OWS* Timing (ISA Bus)

Symbol	Parameter	MIN	MAX	Units
t_{1a}	OWS* active delay from SMEMR* (BIOS ACCESS)	—	22	ns
t_{1b}	OWS* active delay from SMEMW* (display memory write)	—	18	ns
t_{2a}	OWS* high-impedance delay from SMEMR*	—	18	ns
t_{2b}	OWS* high-impedance delay from SMEMW*	—	19	ns

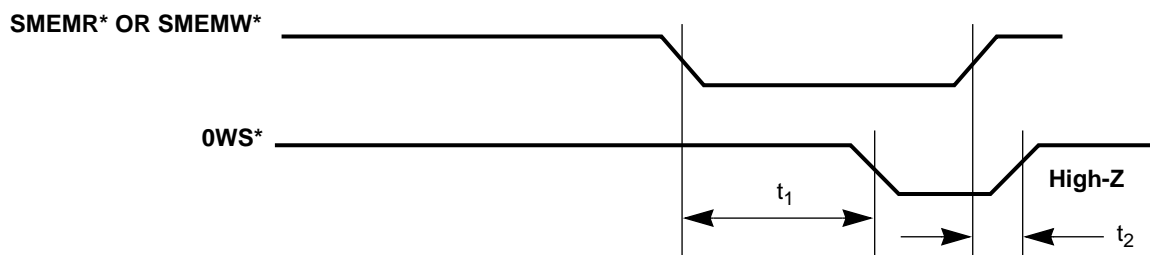
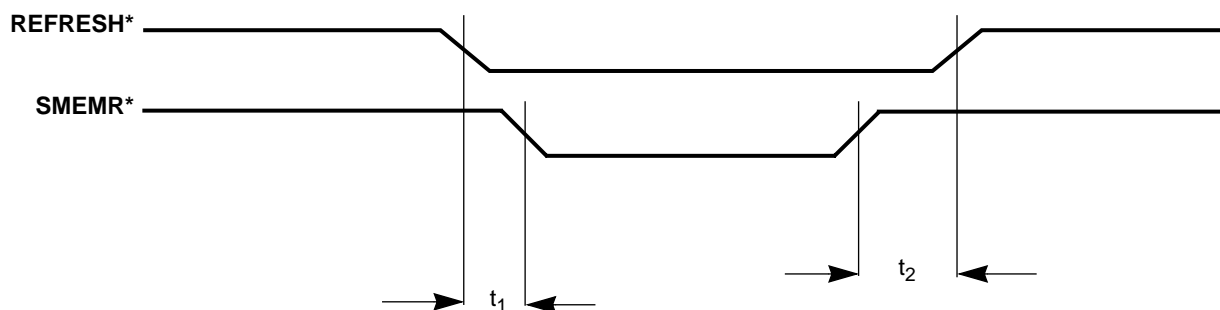


Figure 7-9. OWS* Timing (ISA Bus)

Table 7-10. Refresh Timing (ISA Bus)

Symbol	Parameter	MIN	MAX	Units
t_1	REFRESH* active setup to SMEMR* active	20	—	ns
t_2	REFRESH* active hold from SMEMR* active	0	—	ns


Figure 7-10. Refresh Timing (ISA Bus)
Table 7-11. EROM* Timing (ISA Bus)

Symbol	Parameter	MIN	MAX	Units
t_1	EROM* active delay from SMEMR* active	—	30	ns
t_2	EROM* inactive delay from SMEMR* inactive	—	20	ns

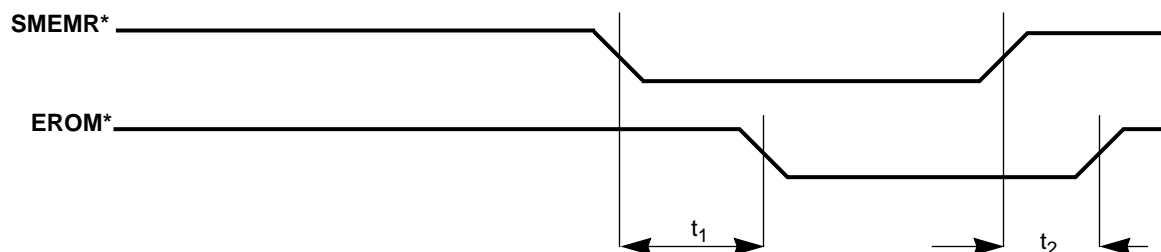

Figure 7-11. EROM* Timing (ISA Bus)

Table 7-12. AEN Timing (ISA Bus)^a

Symbol	Parameter	MIN	MAX	Units
t_1	AEN setup to IOR* or IOW* active	5	—	ns
t_2	AEN hold from IOR* or IOW* inactive	5	—	ns

^a AEN high, as shown below, will cause the CL-GD542X to **ignore** the I/O cycle.

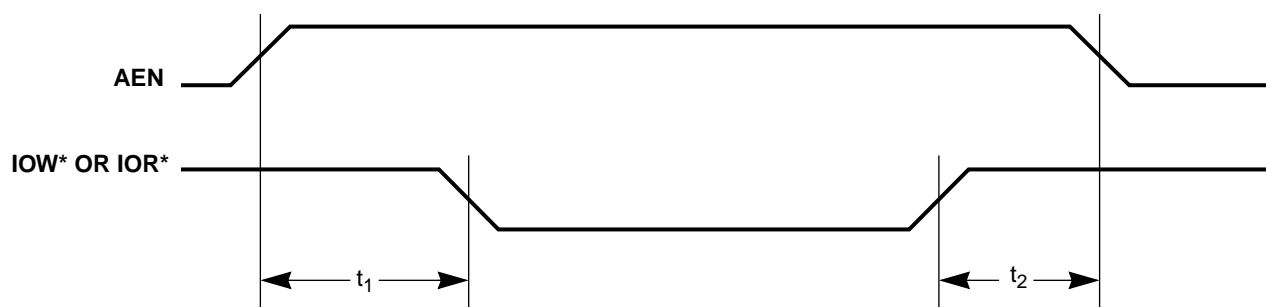


Figure 7-12. AEN Timing (ISA Bus)

Table 7-13. Write Timing (MicroChannel® Bus)

Symbol	Parameter	MIN	MAX	Units
t_1	Data to -CMD active setup	-15	—	ns
t_{2a}	-CMD active pulse width (default cycle)	90	—	ns
t_{2b}	-CMD active pulse width (synchronous extended cycle)	190	—	ns
t_{2c}	-CMD active pulse width (asynchronous extended cycle)	a	a	ns
t_3	Data hold from -CMD inactive	0	—	ns
t_4	CD_CHRDY active to -CMD inactive delay	0	—	ns

^a The maximum t_{2c} depends on display memory activity.

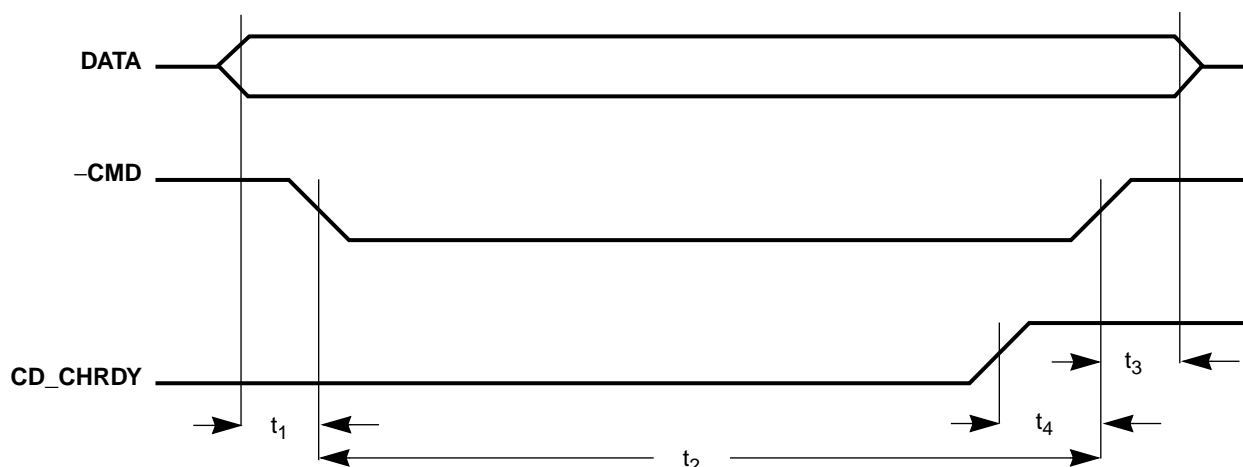

Figure 7-13. Write Timing (MicroChannel® Bus)

Table 7-14. Read Timing (MicroChannel® Bus)

Symbol	Parameter	MIN	MAX	Units
t_1	–CMD active to DATA valid delay (default cycle) (I/O read)	–	45	ns
t_2	CD_CHRDY active to DATA valid delay (memory read cycle)	–	45	ns
t_3	READ DATA hold from –CMD inactive	0	–	ns
t_4	READ DATA high-impedance from –CMD inactive	–	30	ns

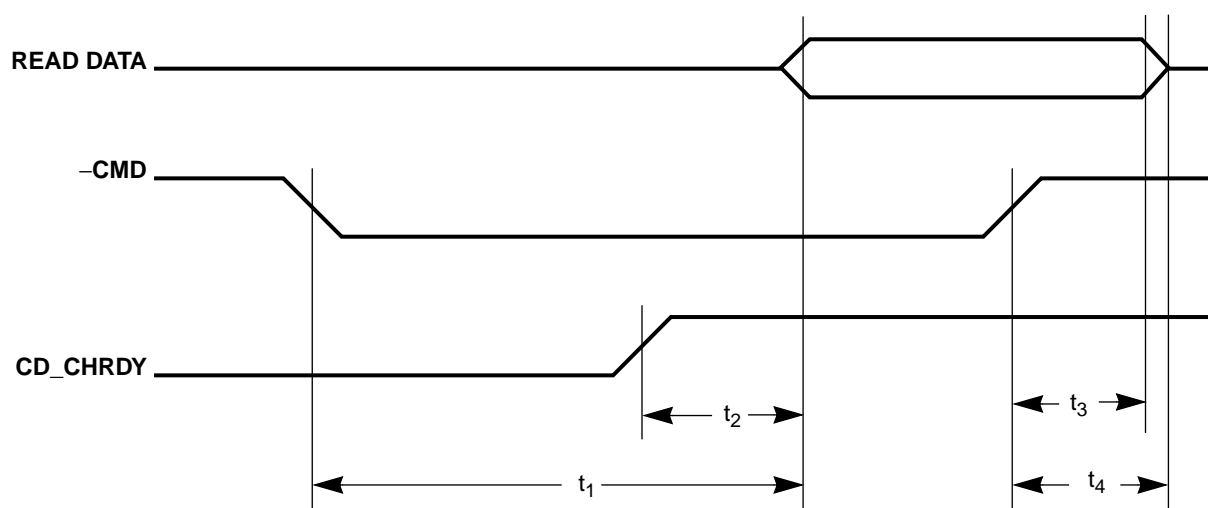


Figure 7-14. Read Timing (MicroChannel® Bus)

Table 7-15. -CD_DS16 Timing (MicroChannel® Bus)

Symbol	Parameter	MIN	MAX	Units
t_1	-CD_DS16 active from address, M/-IO, MADE24 valid	0	50	ns

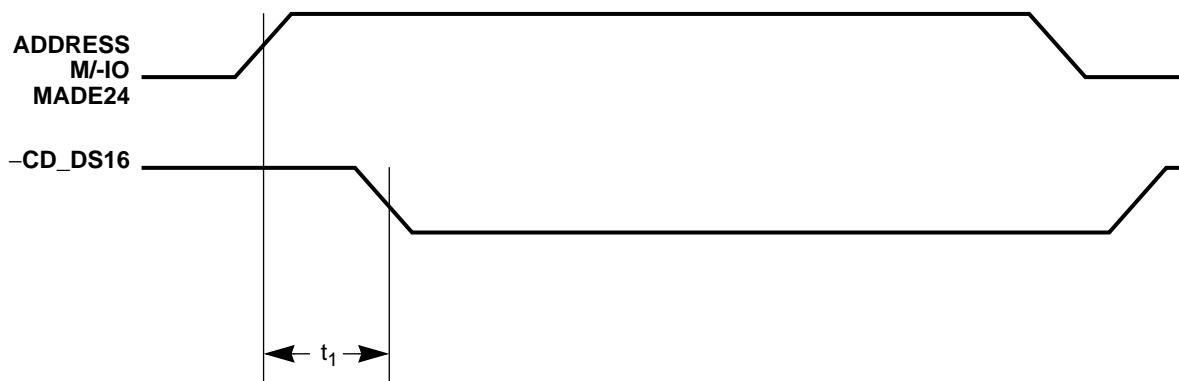

Figure 7-15. -CD_DS16 Timing (MicroChannel® Bus)

Table 7-16. –CMD Timing (MicroChannel® Bus)

Symbol	Parameter	MIN	MAX	Units
t_1	Address valid setup to –CMD active	80	–	ns
t_2	Status active setup to –CMD active	50	–	ns
t_3	–SBHE valid setup to –CMD active	35	–	ns
t_4	–CMD pulse width	90	–	ns
t_5	Address, –SBHE hold from –CMD active	25	–	ns
t_6	Status hold from –CMD active	25	–	ns

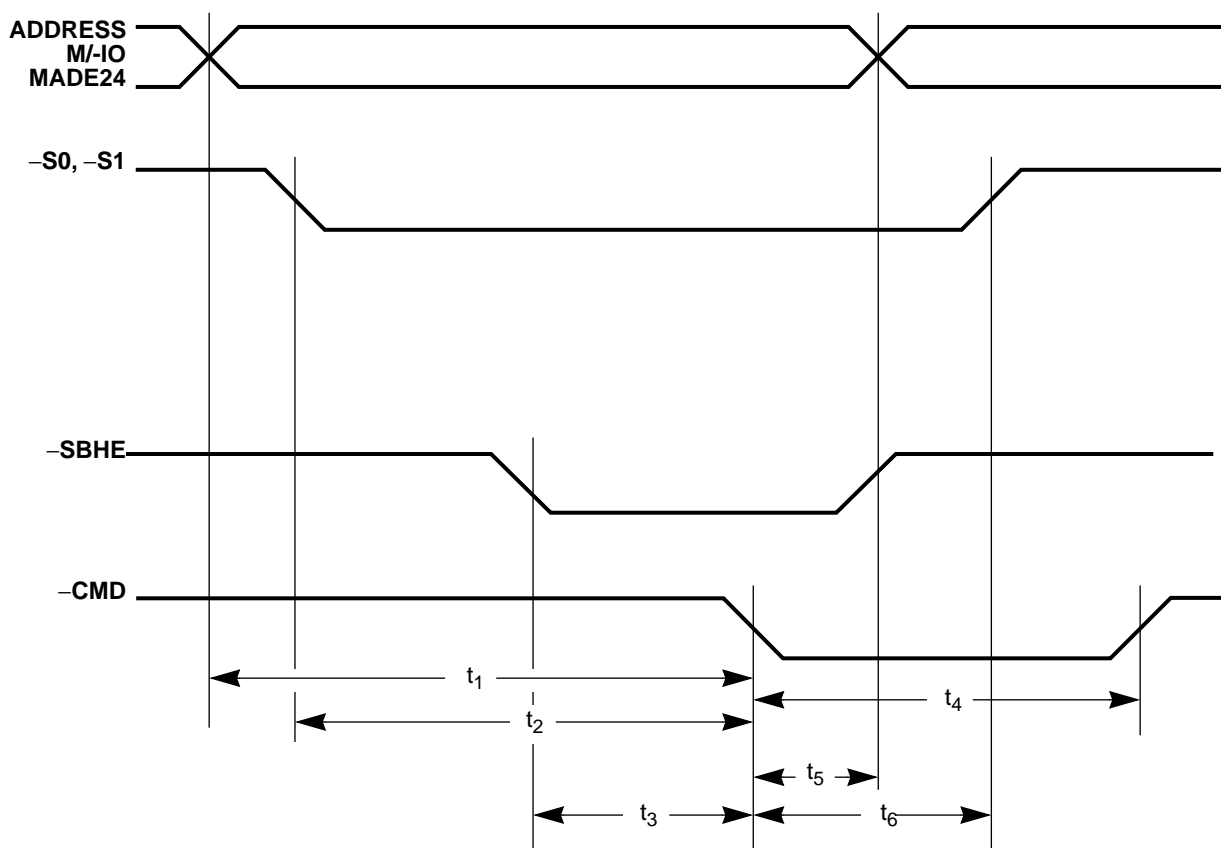


Figure 7-16. –CMD Timing (MicroChannel® Bus)

Table 7-17. CD_CHRDY Timing (MicroChannel® Bus)

Symbol	Parameter	MIN	MAX	Units
t_1	CD_CHRDY inactive (low) from Address valid	—	50	ns
t_2	CD_CHRDY inactive (low) from Status active	—	25	ns
t_3	CD_CHRDY inactive (low) pulse width	—	3.5	ms

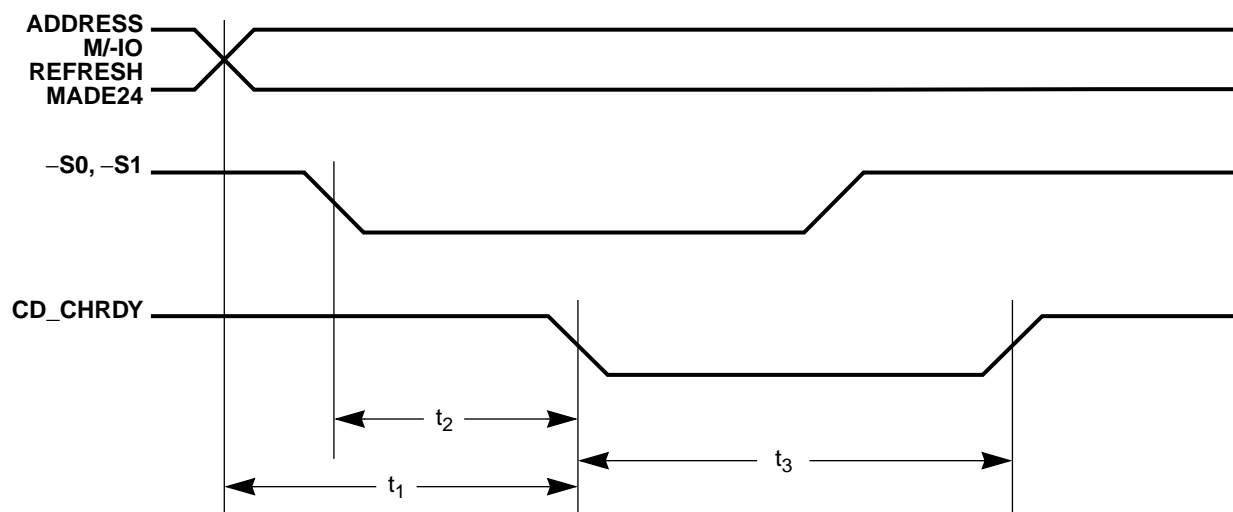

Figure 7-17. CD_CHRDY Timing (MicroChannel® Bus)

Table 7-18. –REFRESH Timing (MicroChannel® Bus)

Symbol	Parameter	MIN	MAX	Units
t_1	–REFRESH setup to –Status active	5	–	ns
t_2	–REFRESH setup to –CMD active	40	–	ns
t_3	–REFRESH hold from –CMD active	25	–	ns

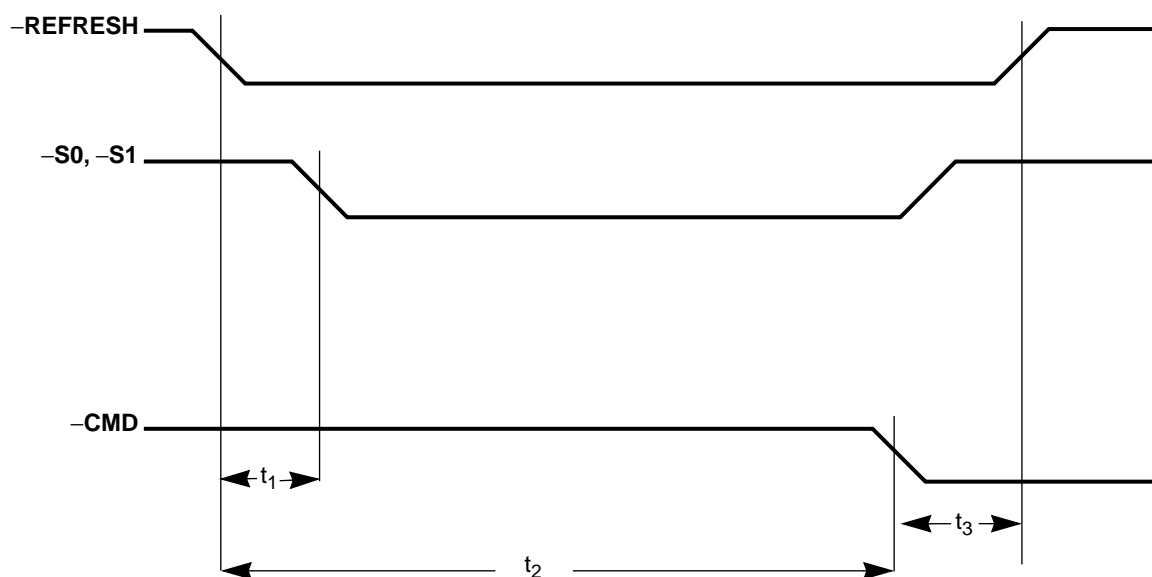
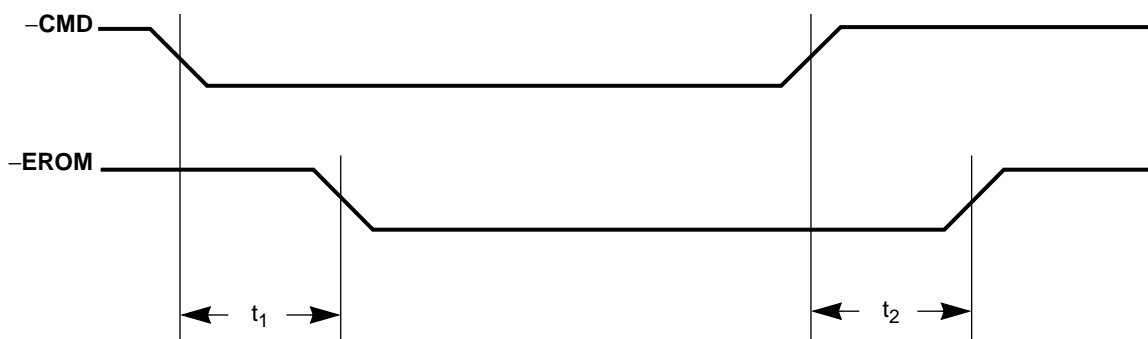


Figure 7-18. –Refresh Timing (MicroChannel® Bus)

Table 7-19. -EROM Timing (MicroChannel® Bus)

Symbol	Parameter	MIN	MAX	Units
t_1	-CMD active to -EROM active	—	30	ns
t_2	-CMD inactive to -EROM inactive	0	30	ns


Figure 7-19. -EROM Timing (MicroChannel® Bus)
Table 7-20. -CD_SFDBK Timing (MicroChannel® Bus)

Symbol	Parameter	MIN	MAX	Units
t_1	Address, M/-IO, MADE24 valid to -CD_SFDBK active delay	—	55	ns
t_2	Address, M/-IO, MADE24 invalid to -CD_SFDBK inactive delay	0	—	ns

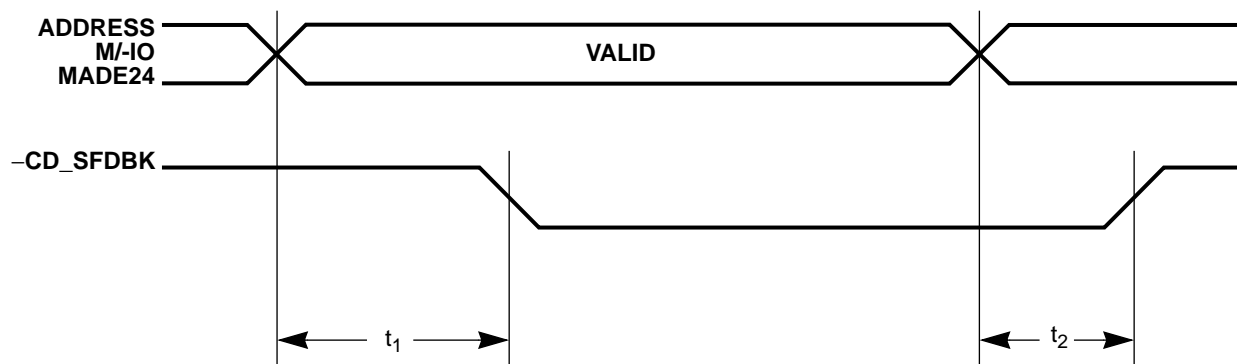

Figure 7-20. -CD_SFDBK Timing (MicroChannel® Bus)

Table 7-21. -CD_SETUP Timing (MicroChannel® Bus)

Symbol	Parameter	MIN	MAX	Units
t_1	-CD_SETUP active setup to -CMD active	10	—	ns
t_2	-CD_SETUP delay to CD_CHRDY inactive	—	95	ns
t_3	-CMD active to -CD_SETUP inactive hold	25	—	ns

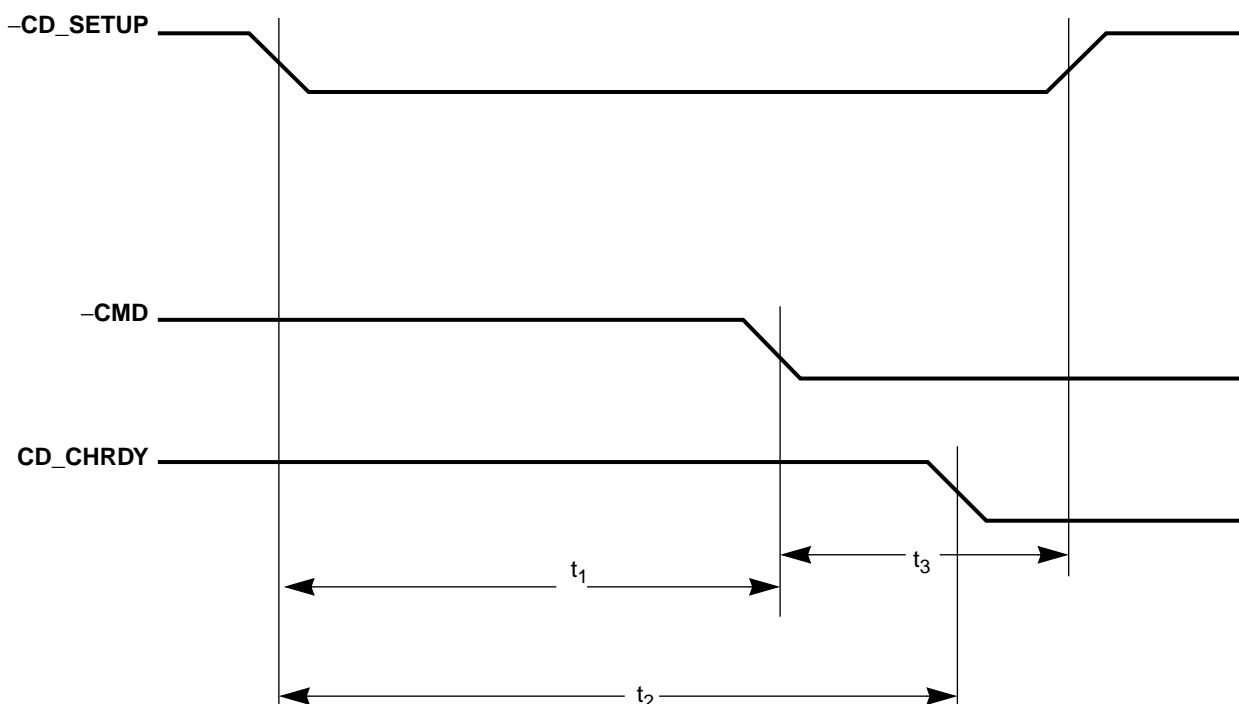


Figure 7-21. -CD_SETUP Timing (MicroChannel® Bus)

Table 7-22. CLK1X, CLK2X Timing (Local Bus)

Symbol	Parameter	MIN	MAX	Units
t_1	Rise time (CLK1X) '486 ($V_{IL} - V_{IH}$)	—	4	ns
t_2	Fall time (CLK1X) '486 ($V_{IH} - V_{IL}$)	—	4	ns
t_3	High period (CLK1X) '486 ($V_{IH} - V_{IH}$)	40	60	% t_5
t_4	Low period (CLK1X) '486 ($V_{IL} - V_{IL}$)	40	60	% t_5
t_5	Period (CLK1X) '486	25	—	ns
t_5	Period (CLK1X) '486 (CL-GD5429)	20	—	ns
t_1	Rise time (CLK2X) '386 ($V_{IL} - V_{IH}$)	—	4	ns
t_2	Fall time (CLK2X) '386 ($V_{IH} - V_{IL}$)	—	4	ns
t_3	High period (CLK2X) '386 ($V_{IH} - V_{IH}$)	40	60	% t_5
t_4	Low period (CLK2X) '386 ($V_{IL} - V_{IL}$)	40	60	% t_5
t_5	Period (CLK2X) '386	12.5	—	ns

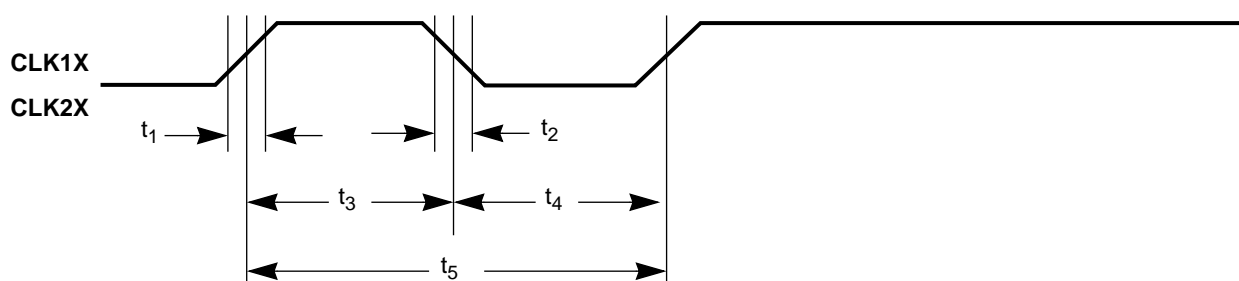

Figure 7-22. CLK1X, CLK2X Timing (Local Bus)

Table 7-23. RESET Timing (Local Bus)^a

Symbol	Parameter	MIN	MAX	Units
t_1	CPU_RESET hold time from CLK2X	10	—	ns
t_2	CPU_RESET setup time to CLK2X	2	—	ns

^a Applies to '386 only. For '486, pin 46 must be tied to ground. For VESA VL-Bus, pin 46 must be tied to RDYRTN#.

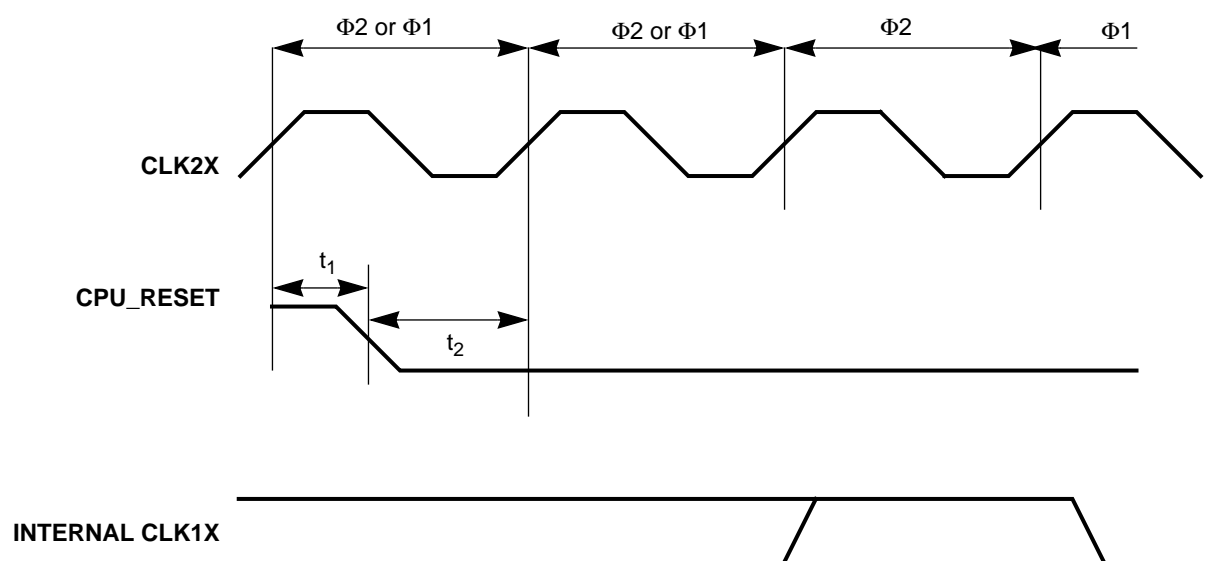


Figure 7-23. RESET Timing (Local Bus)

Table 7-24. ADS#, LBA#, BS16# Timing (Local Bus)

Symbol	Parameter	MIN '24/'26/'28	MAX '24/'26/'28	MIN '29	MAX '29	Units
t_1	Address, Status, ADS# setup to CLK1X	8	—	4	—	ns
t_2	LBA#/LDEV# active delay from Address, Status	—	15	—	15	ns
t_3	BS16# active delay CLK1X	—	15	—	3	ns
t_4	LBA# inactive delay from Address, Status	—	18	—	18	ns

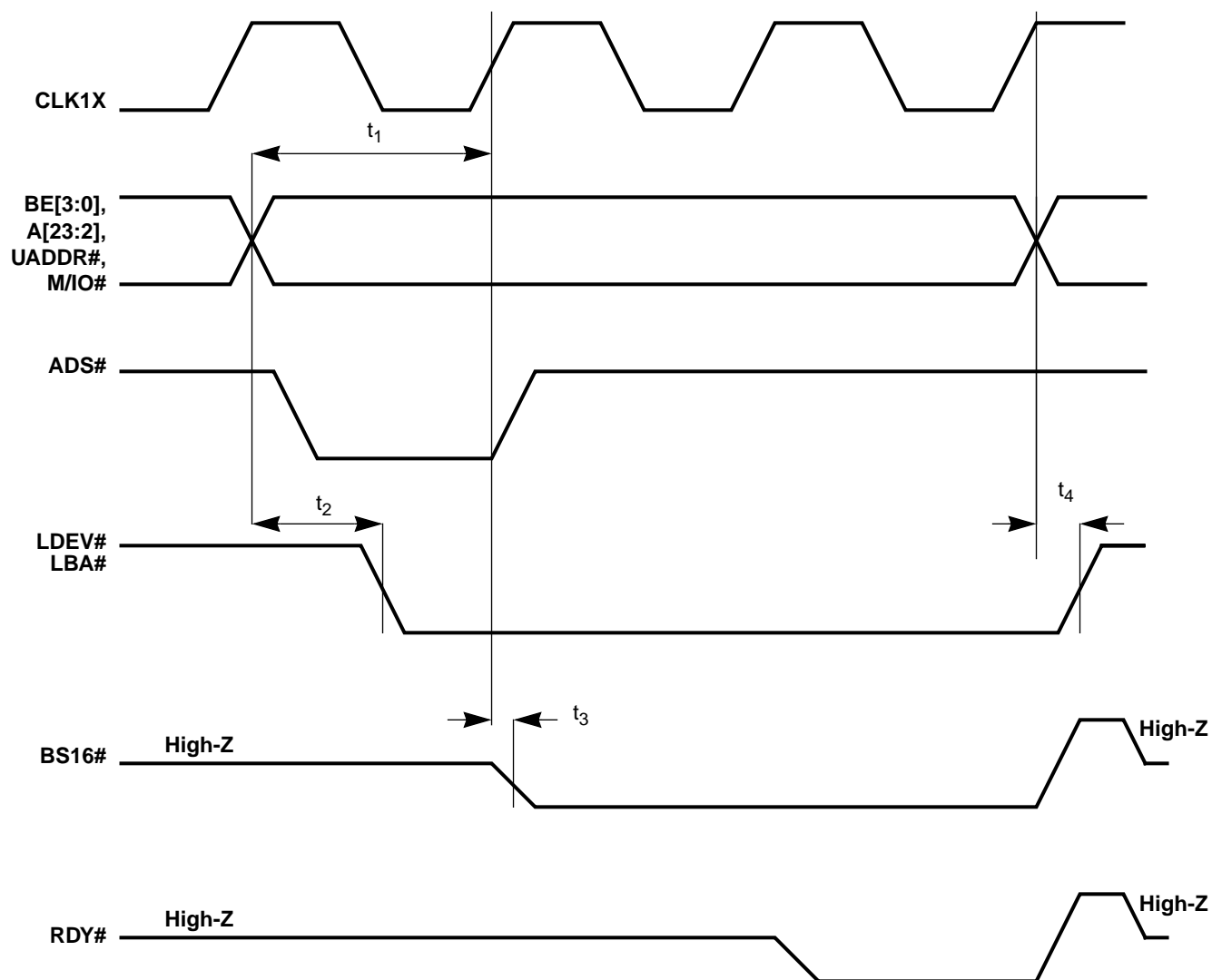

Figure 7-24. ADS#, LBA#, BS16# Timing (Local Bus)

Table 7-25. RDY# Delay (Local Bus)

Symbol	Parameter	MIN	MAX	Units
t_1	RDY# active delay from CLK1X	3	13	ns
t_2	RDY# inactive delay from CLK1X	—	23	ns
t_3	RDY# high before High-Z	—	1/2	CLK1X

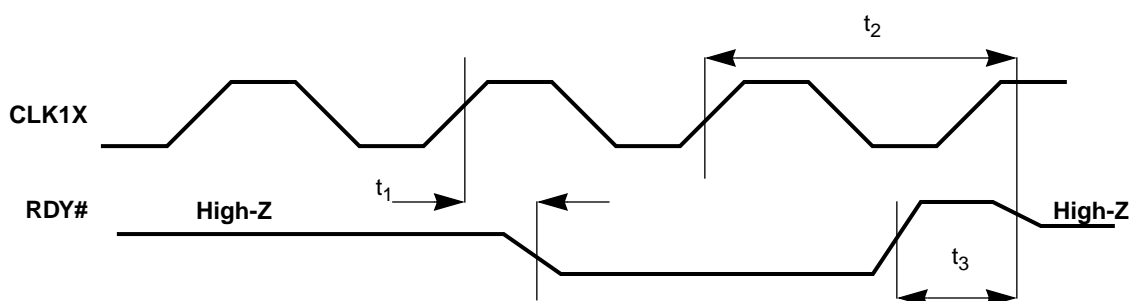


Figure 7-25. RDY# Delay (Local Bus)

Table 7-26. Read Data Timing (Local Bus)

Symbol	Parameter	MIN '24/'26/'28	MAX '24/'26/'28	MIN '5429	MAX '5429	Units
t_1	Read data setup to RDY# active	0	—	0	—	ns
t_2	Read data hold from RDY# inactive	12	—	12	—	ns
t_3	RDYRTN# setup to CLK1X	8	—	5	—	ns
t_4	RDYRTN# hold from CLK1X	5	—	2	—	ns

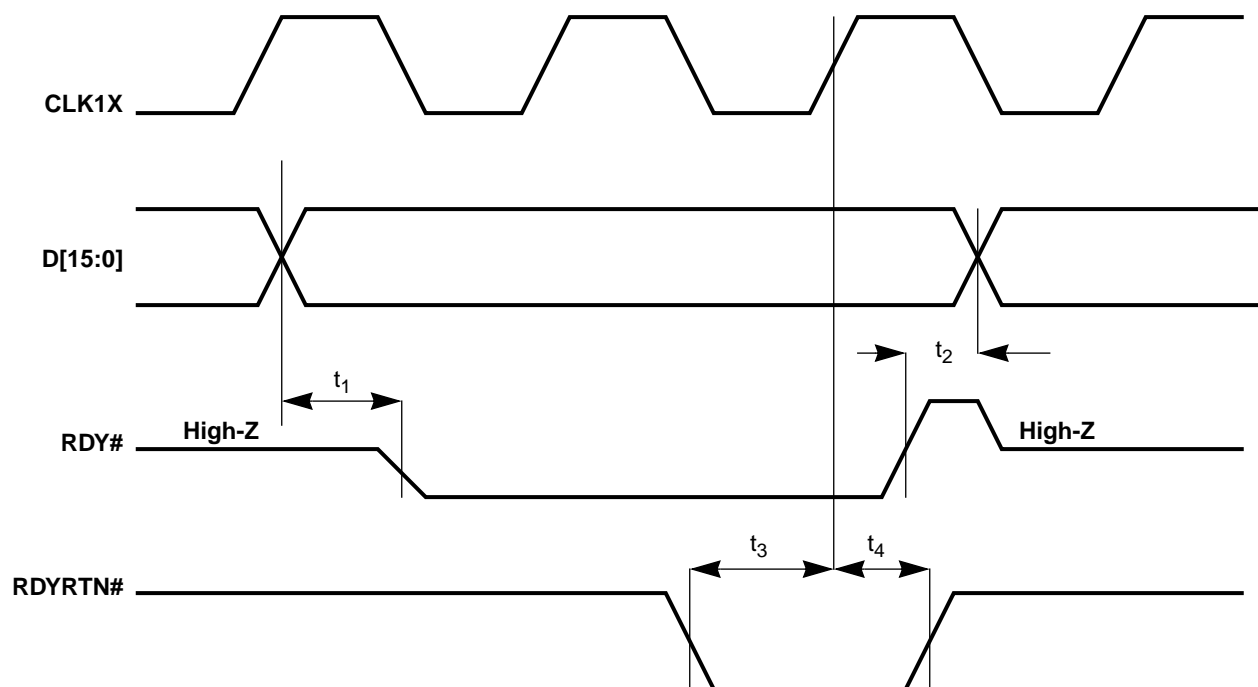
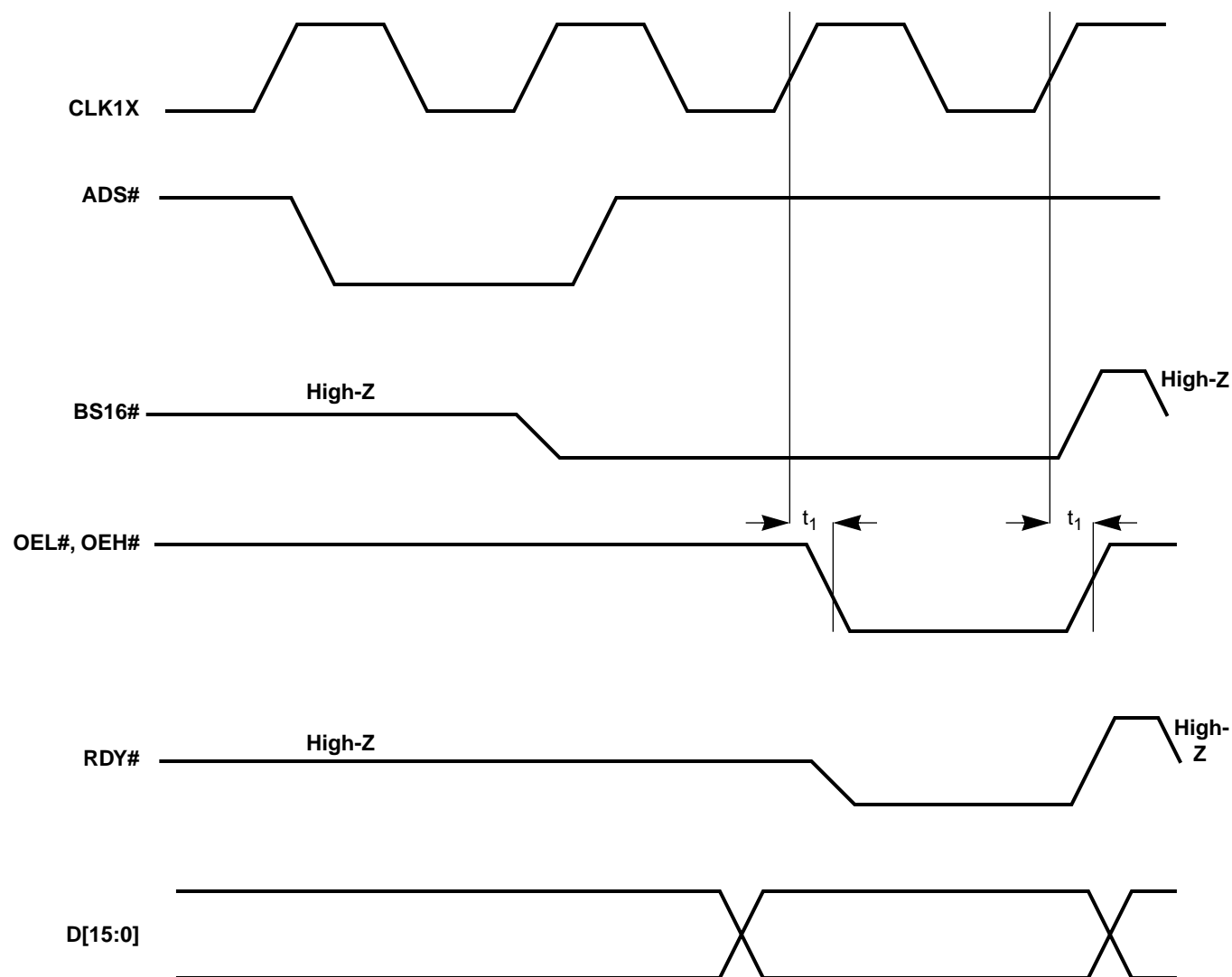

Figure 7-26. Read Data Timing (Local Bus)

Table 7-27. Buffer Control Timing – Read Cycle (Local Bus)

Symbol	Parameter	MIN	MAX	Units
t_1	OEL#, OEH# delay	0	14	ns

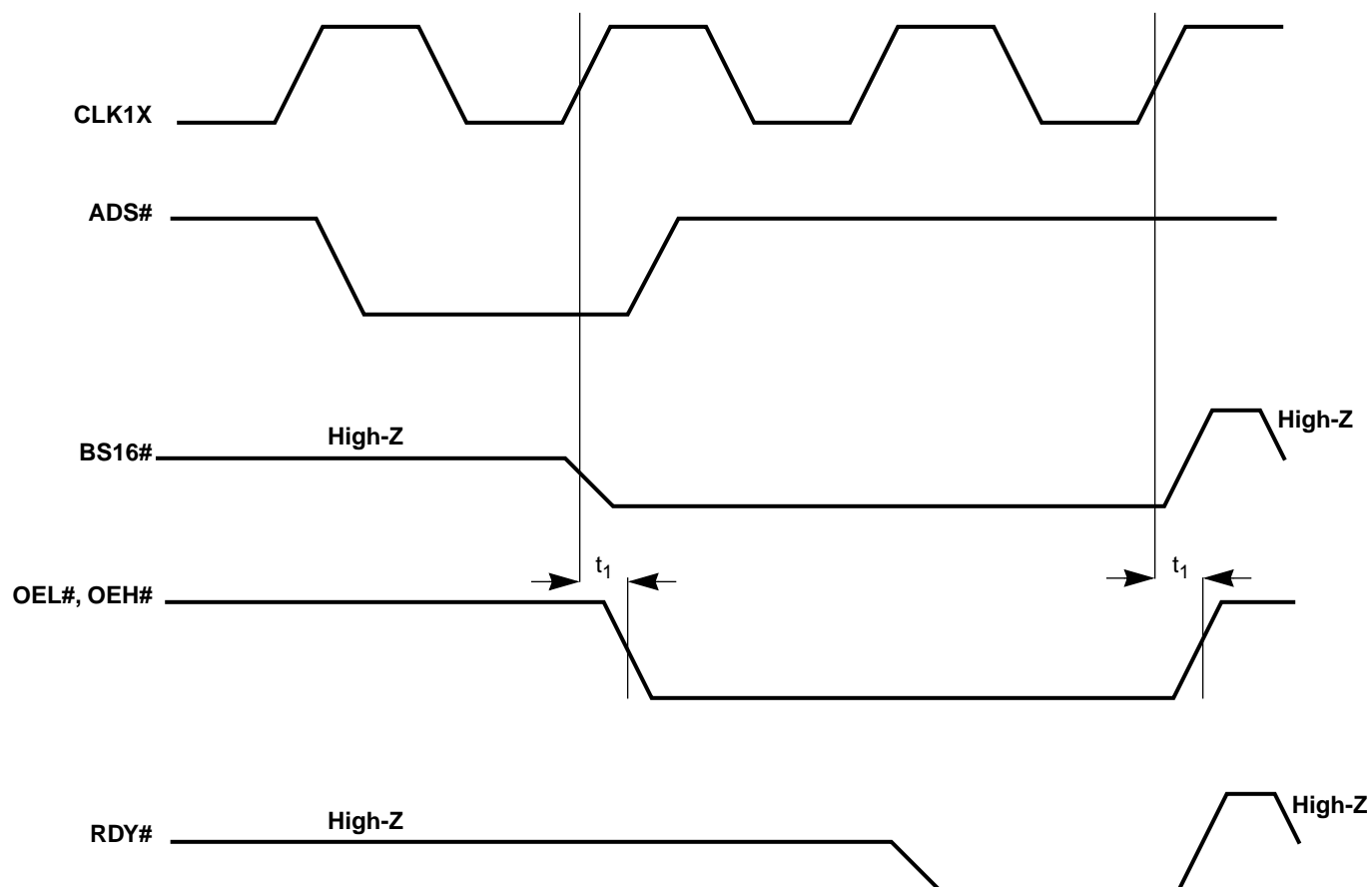


NOTE: Both OEL# and OE# are active for read cycles.

Figure 7-27. Buffer Control Timing – Read Cycle (Local Bus)

Table 7-28. Buffer Control Timing – Write Cycle (Local Bus)

Symbol	Parameter	MIN	MAX	Units
t_1	OEL#, OEH# delay	0	14	ns



NOTE: Only one of OEL# and OEH# is active for write cycles.

Figure 7-28. Buffer Control Timing – Write Cycle (Local Bus)

Table 7-29. Display Memory Bus – Common Parameters

Symbol	Parameter	MIN	MAX
t ₁	t _{ASR} : address setup to RAS* active	1.5m ^a – 2 ns	–
t ₂	t _{RAH} : row address hold from RAS* active	1.5m	–
t ₃	t _{ASC} : address setup to CAS* active	1m – 1 ns	–
t ₄	t _{CAH} : column address hold from CAS* active	1m	–
t ₅	t _{RCD} : RAS* active to CAS* active delay (standard RAS)	2.5m – 2 ns	–
t ₅	t _{RCD} : RAS* active to CAS* active delay (extended RAS)	3m – 2 ns	–
t ₆	t _{RAS} : RAS* pulse width low (standard RAS)	3.5m	–
t ₆	t _{RAS} : RAS* pulse width low (extended RAS)	4m – 2 ns	–
t ₇	t _{RP} : RAS* precharge (RAS* pulse width high — standard RAS)	2.5 m – 2 ns	–
t ₇	t _{RP} : RAS* precharge (RAS* pulse width high — extended RAS)	3m	–
t ₈	t _{CAS} : CAS* pulse width low	1m + 3 ns	1m + 6 ns
t ₉	t _{CP} : CAS* precharge (CAS* pulse width high)	1m – 6 ns	1m – 3 ns
t ₁₀	t _{RC} : Random cycle (standard RAS)	6m	–
t ₁₀	t _{RC} : Random cycle (extended RAS)	7m	–
t ₁₁	t _{PC} : Page mode cycle	2m	–

^a m = MCLK

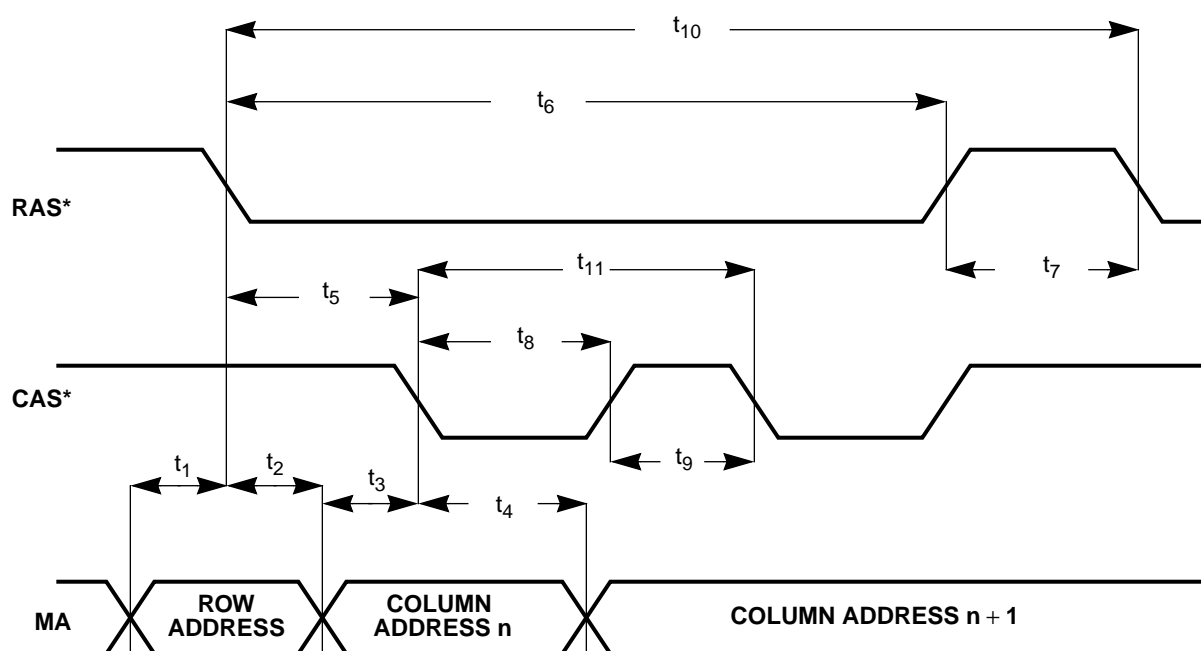


Figure 7-29. Display Memory Bus – Common Parameters

Table 7-30. Display Memory Bus – Read Cycles^a

Symbol	Parameter	MIN	MAX
t_1	Read data setup to CAS* rising edge	0	–
t_2	Read data hold from CAS* high	10 ns	–
t_3^b	RAS* active to first CAS* rising edge delay (standard RAS)	–	4m – 1 ns
t_3	RAS* active to first CAS* rising edge delay (extended RAS)	–	4.5m – 1 ns
t_4^c	Column address valid to CAS* rising edge delay	–	2m
t_5^d	CAS* active pulse width	–	1m + 3 ns
t_6^e	CAS* period	–	2m

^a Only parameters t_1 and t_2 are defined for the device. The remaining parameters in this table are calculated from parameters in the Table 7-29. They are provided so that system designers can determine DRAM requirements.

^b Parameter t_3 corresponds to DRAM parameter t_{RAC} (access time from RAS*).

^c Parameter t_4 corresponds to DRAM parameter t_{AA} (access time from column address).

^d Parameter t_5 corresponds to DRAM parameter t_{CAC} (access time from CAS*).

^e Parameter t_6 corresponds to DRAM parameter t_{CAP} (access time from CAS* precharge).

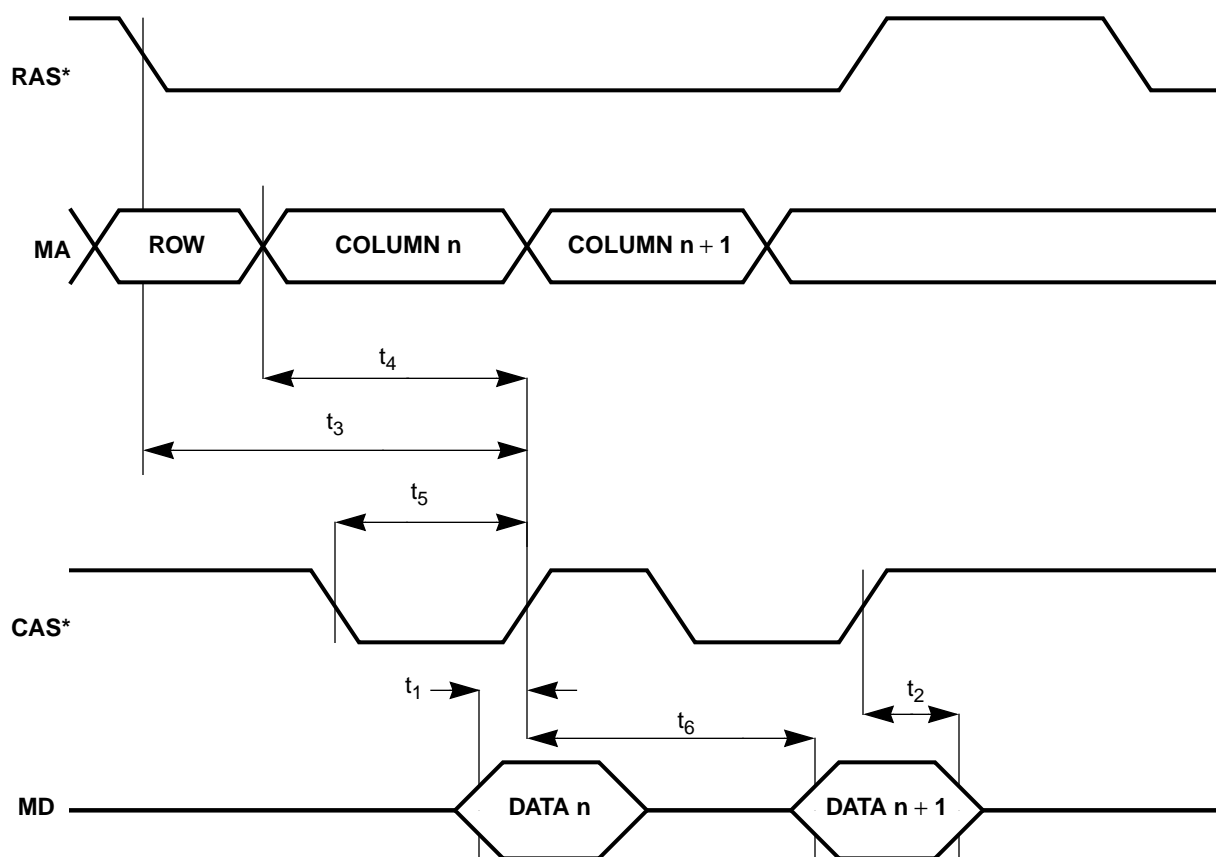


Figure 7-30. Display Memory Bus – Read Cycles

Table 7-31. Display Memory Bus – Write Cycles

Symbol	Parameter	MIN	MAX
t_1	t_{CWL} : WE* active setup to CAS* active	$1m^a + 2\text{ ns}$	–
t_2	t_{DS} : Write data setup to CAS* active	$1m - 2\text{ ns}$	$1m + 2\text{ ns}$
t_3	t_{DH} : write data hold from CAS* active	$1m + 1\text{ ns}$	–
t_4	t_{WCH} : WE active hold from CAS* active	$1.5m$	–

^a m = MCLK

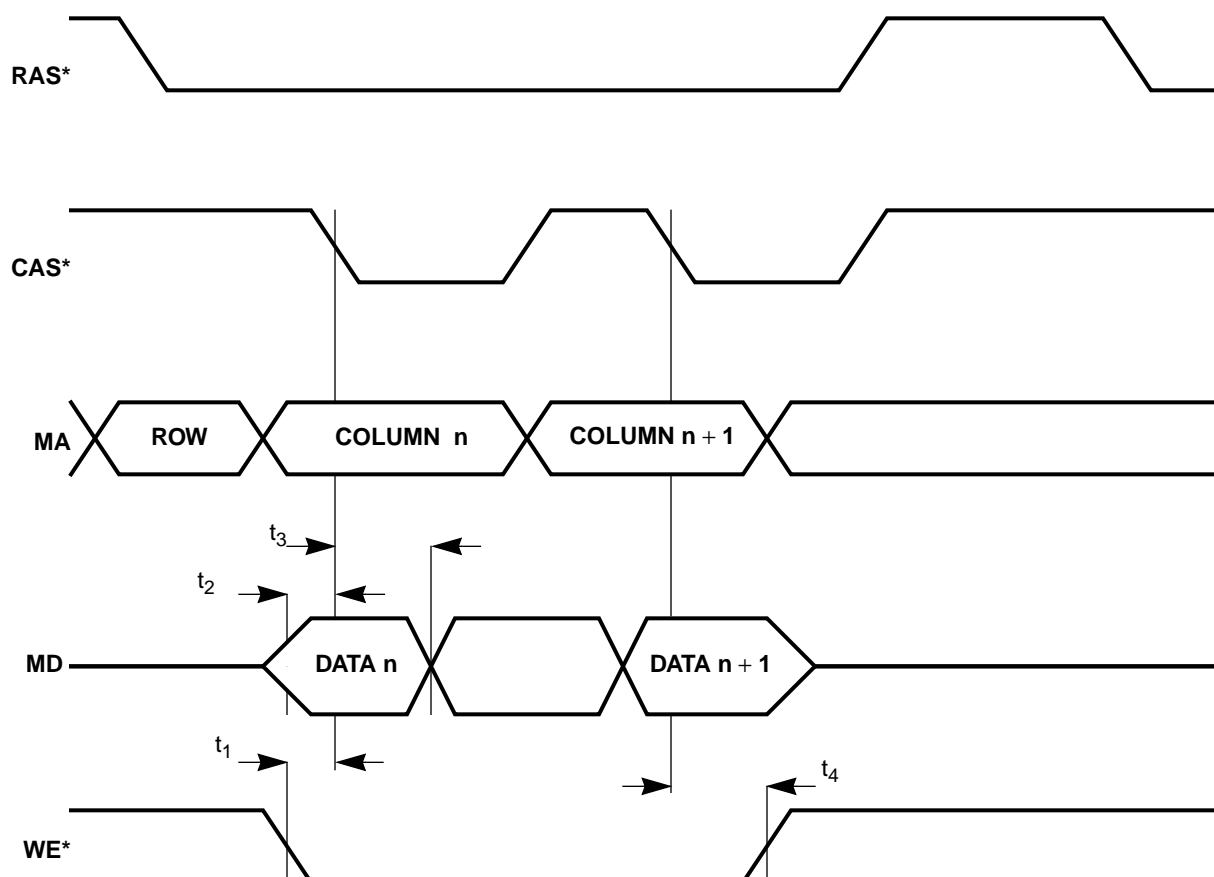


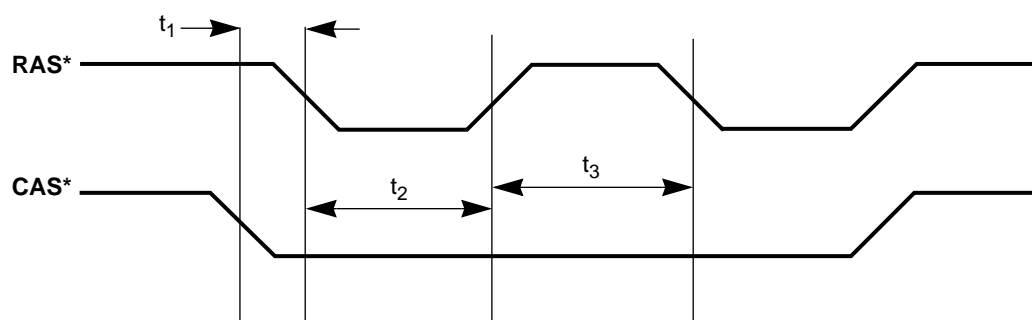
Figure 7-31. Display Memory Bus – Write Cycles

Table 7-32. CAS*-before-RAS* Refresh Timing (Display Memory Bus)^a

Symbol	Parameter	MIN	MAX
t_1	t_{CSR} : CAS* active setup to RAS* active1	1m ^b	—
t_2	t_{RAS} : RAS* low pulse width	4m	—
t_3	t_{RP} : RAS* high pulse width	3m	—

^a There will be either three or five RAS* pulses while CAS* remains low.

^b m = MCLK


Figure 7-32. CAS*-before-RAS* Refresh Timing (Display Memory Bus)
Table 7-33. P-Bus as Inputs, 8-Bit Mode (DCLK input as reference)

Symbol	Parameter	MIN	MAX	Units
t_1	P[7:0], BLANK* setup to DCLK	-1	—	ns
t_2	P[7:0], BLANK* hold from DCLK	7	—	ns

NOTE: CL-GD542X RAMDAC driven externally

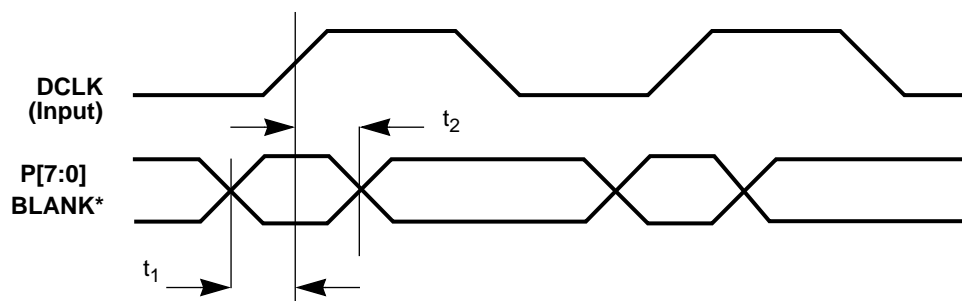

Figure 7-33. P-Bus as Inputs, 8-bit Mode (External DCLK)

Table 7-34. Feature Bus Timing, 8-Bit Mode, Outputs (DCLK output as reference)

Symbol	Parameter	MIN	MAX	Units
t_1	DCLK to BLANK* delay	-1	1	ns
t_2	DCLK to HSYNC, VSYNC delay	1	3	ns
t_3	DCLK to P[7:0] delay	-2	0	ns
t_4	DCLK to OVRW delay	-1	1	ns

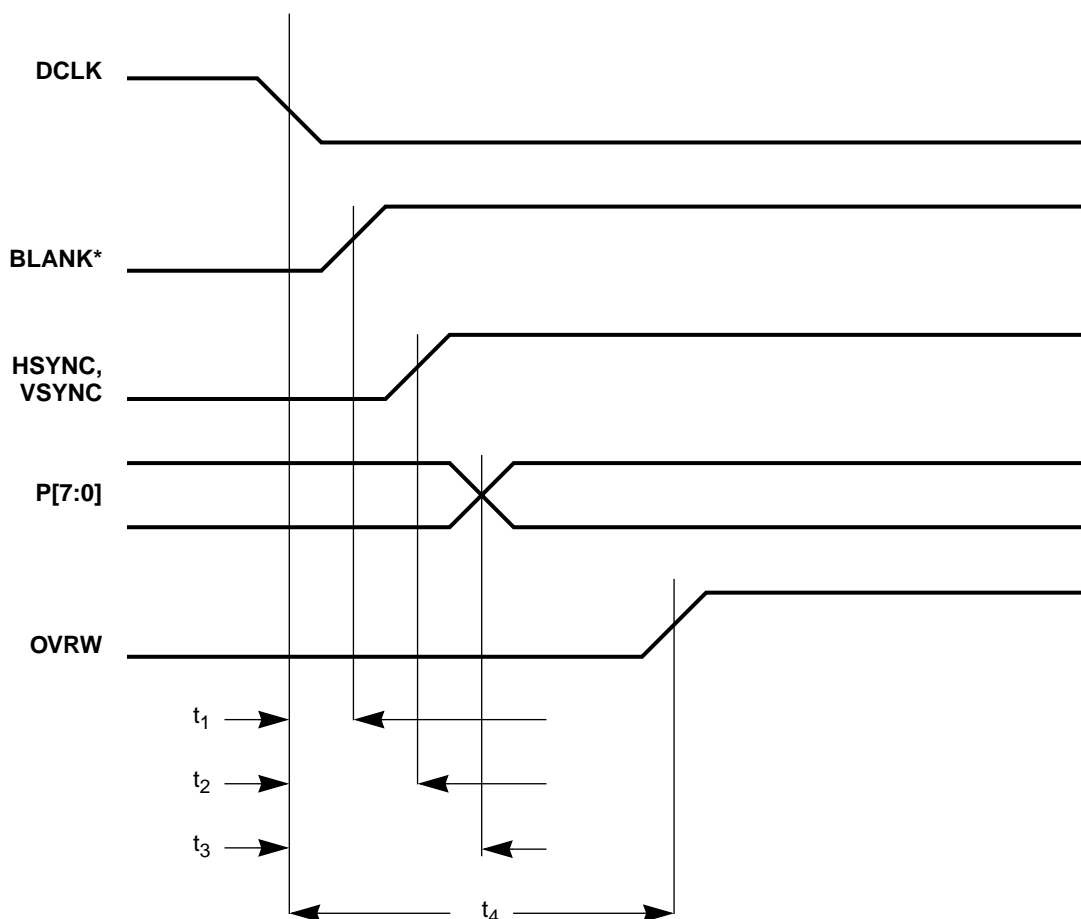


Figure 7-34. Feature Bus Timing, 8-Bit Mode, Outputs (Internal DCLK)

Table 7-35. P-Bus as Outputs, 16-bit Mode (DCLK output as reference) CL-GD5425/'28/'29 only^a

Symbol	Parameter	MIN	MAX	Units
t_1	DCLK (rising edge) to P[7:0] delay	-2	0	ns
t_2	DCLK (falling edge) to P[7:0] delay	-1	1	ns

^a SR7[2:1] is programmed to '0,1' and GRE[0] is programmed to '1'.

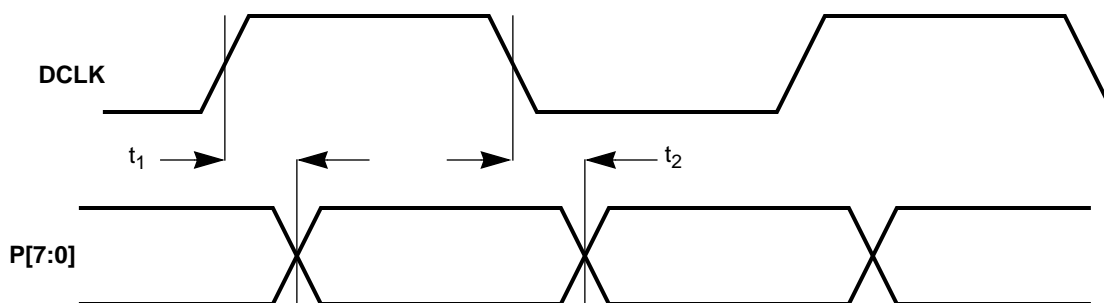

Figure 7-35. P-Bus as Outputs, 16-bit Mode (Internal DCLK) CL-GD5425/'28/'29 only

Table 7-36. P-Bus as Inputs, 16-Bit Mode, Clock Mode 1 (DCLK input as reference) ^a

Symbol	Parameter	MIN '24/'26	MIN '28	MIN '25/'29	Units
t_1	P[7:0] setup to DCLK (rising edge — external DCLK)	-1	-1	-3	ns
t_2	P[7:0] hold from DCLK (rising edge — external DCLK)	5	5	7	ns
t_3	P[7:0] setup to DCLK (falling edge — external DCLK)	-1	-1	-3	ns
t_4	P[7:0] hold from DCLK (falling edge — external DCLK)	5	5	7	ns

^a Clock mode 1 selected in Hidden DAC register (D5 programmed to '0').

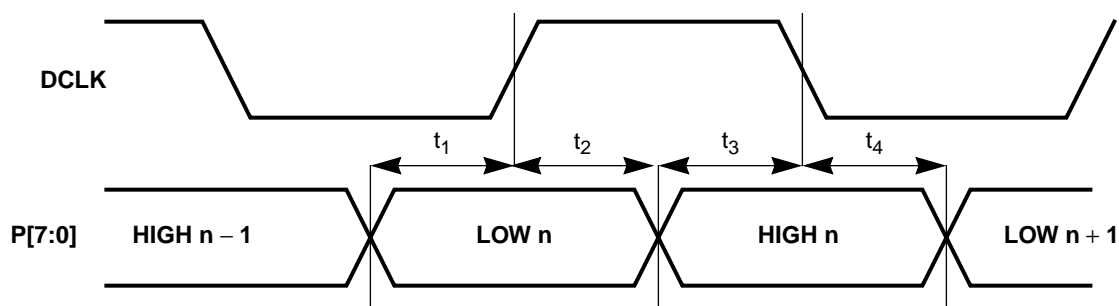


Figure 7-36. P-Bus as Inputs, 16-Bit Mode, Clock Mode 1 (External DCLK)

Table 7-37. P-Bus as Inputs, 16-Bit Mode, Clock Mode 2^a (DCLK input as reference)

Symbol	Parameter	MIN '24/'26	MIN '28	MIN '25/'29	Units
t_1	P[7:0], BLANK* ^b setup to DCLK	-1	-2	-2	ns
t_2	P[7:0], BLANK* hold from DCLK	5	6	4	ns

^a Clock mode 2 selected in Hlidden DAC register (D5 = '1').

^b The first low byte of 16-bit data input must be synchronized with BLANK* or the start of overlay window, whichever is later. The first high byte will be clocked on the next rising edge of DCLK.

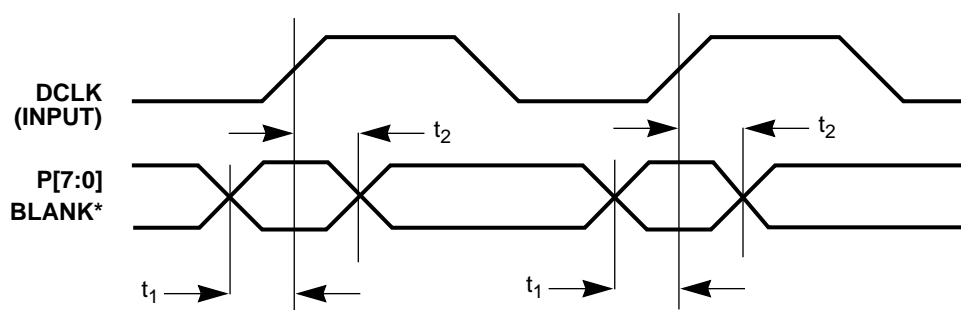

Figure 7-37. P-Bus as Inputs, 16-Bit Mode, Clock Mode 2 (External DCLK)

Table 7-38. P-Bus as Inputs, 16-Bit Mode (DCLK output as reference)^a

Symbol	Parameter	MIN '24/'26	MIN '28	MIN '25/'29	Units
t_1	P[7:0] setup to DCLK (rising edge — internal DCLK)	3	2	3	ns
t_2	P[7:0] hold from DCLK (rising edge — internal DCLK)	1	1	1	ns
t_3	P[7:0] setup to DCLK (falling edge — internal DCLK)	3	2	3	ns
t_4	P[7:0] hold from DCLK (rising edge — internal DCLK)	1	1	1	ns

^a Clock mode 1 selected in Hidden DAC register (D5 = '0').

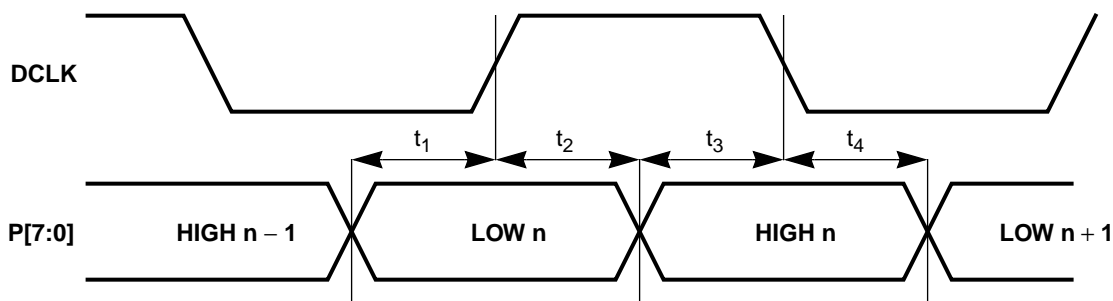


Figure 7-38. P-Bus as Inputs, 16-Bit Mode (External DCLK)

Table 7-39. DCLK as Input

Symbol	Parameter: CL-GD5420/'22/'24/'26/'28	MIN	MAX	Units
t_1	Rise time	—	3	ns
t_2	Fall time	—	3	ns
t_3	High period	40	60	% of t_5
t_4	Low period	40	60	% of t_5
t_5	Period	17	—	ns
Parameter: CL-GD5425/'29				
t_1	Rise time	—	3	ns
t_2	Fall time	—	3	ns
t_3	High period: Clock mode 1	45	55	% of t_5
t_3	High period: Clock mode 2	30	70	% of t_5
t_4	Low period: Clock mode 1	45	55	% of t_5
t_4	Low period: Clock mode 2	30	70	% of t_5
t_5	Period (DCLK)	12.5	—	ns

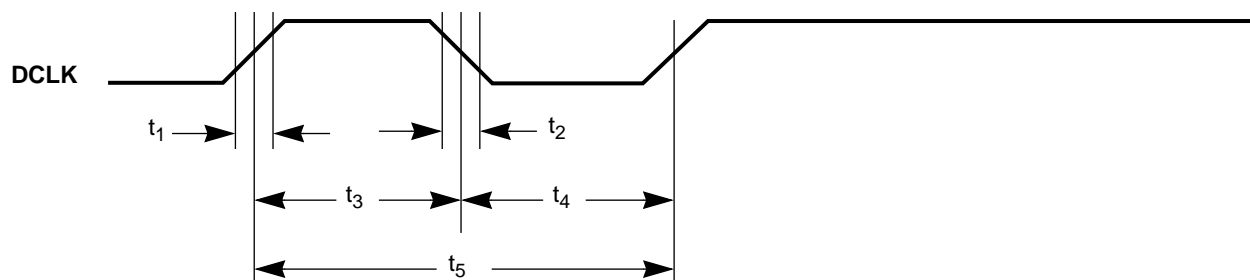

Figure 7-39. DCLK As Input

Table 7-40. RESET Timing

Symbol	Parameter	MIN	MAX	Units
t_1	RESET pulse width	12	—	MCLK
t_2	MD[31:16] setup to RESET falling edge	2	—	ns
t_3	MD[31:16] hold from RESET falling edge	25	—	ns
t_4	RESET low to first IOW*	12	—	MCLK

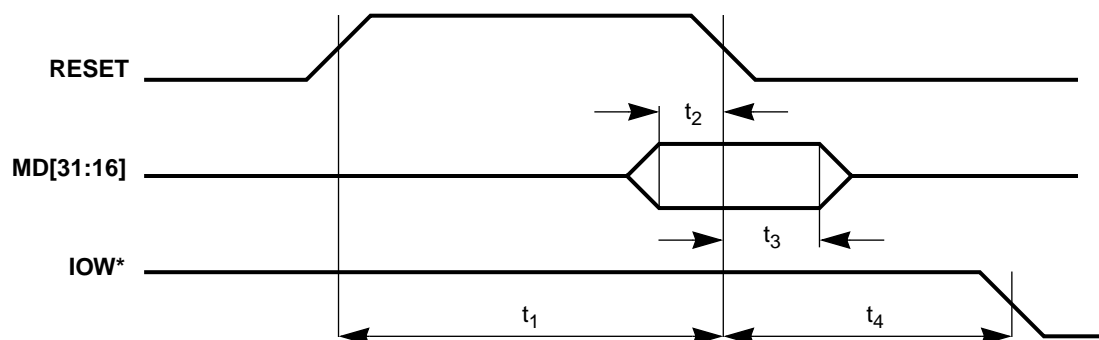


Figure 7-40. RESET Timing

Table 7-41. Horizontal Period (NTSC — CL-GD5425 only)

Symbol	Parameter	Nominal	Units
t_1	Horizontal period	63.56	$\mu\text{sec.}$
t_2	HSYNC pulse width (low)	4.65	$\mu\text{sec.}$

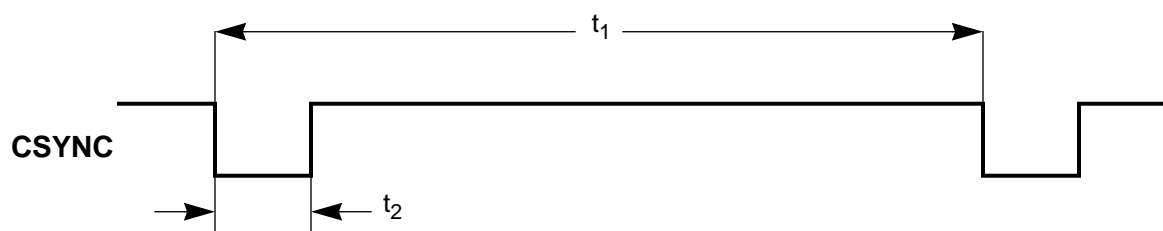

Figure 7-41. Horizontal Period (NTSC — CL-GD5425 only)

Table 7-42. NTSC Vertical Retrace (CL-GD5425 only)

Symbol	Parameter	Nominal	Units
t_1	Vertical blanking period	20	H-period

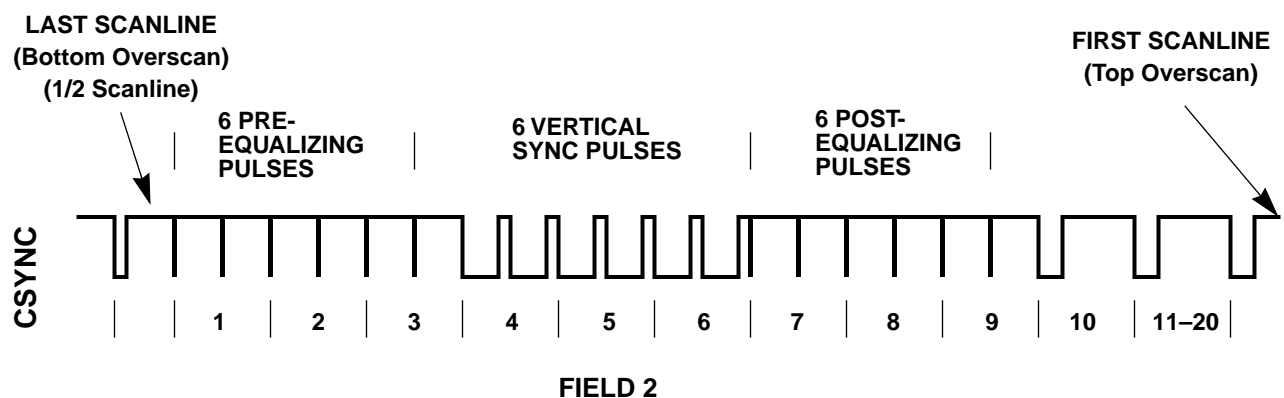
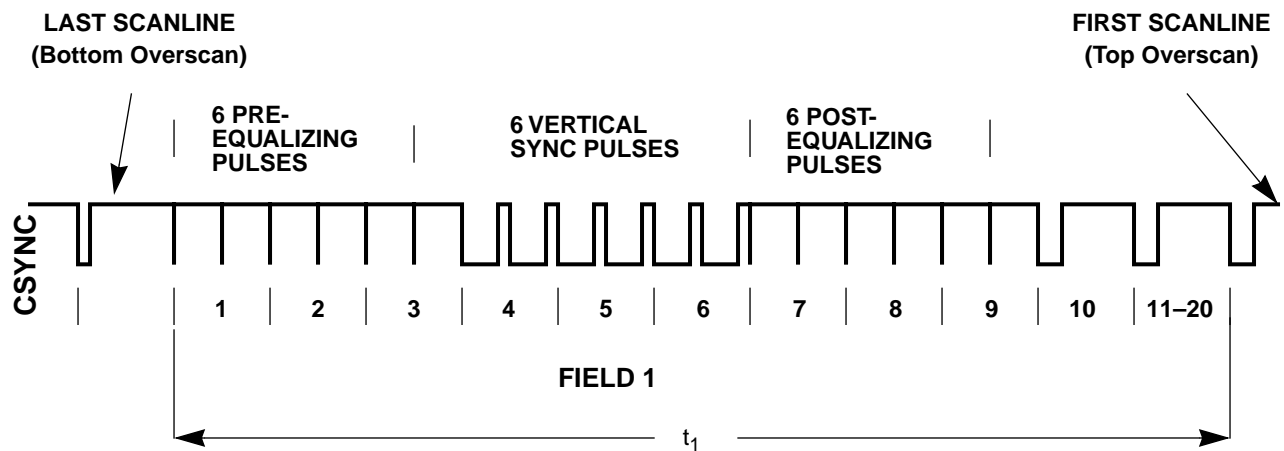


Figure 7-42. NTSC Vertical Retrace (CL-GD5425 only)

Table 7-43. NTSC Vertical Blanking Detail (CL-GD5425 only)

Symbol	Parameter	Nominal	Units
t_1	Equalizing pulse width (low)	2.32	$\mu\text{sec.}$
t_2	Serrations pulse width (high)	4.65	$\mu\text{sec.}$
t_3	Equalization to serration	1	H-period
t_4	First serration	1/2	H-period

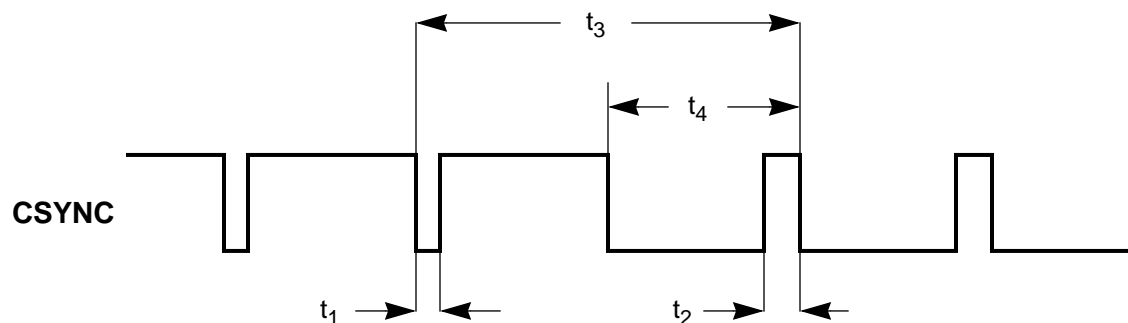

Figure 7-43. NTSC Vertical Blanking Detail (CL-GD5425 only)

Table 7-44. Horizontal Period (PAL — CL-GD5425 only)

Symbol	Parameter	Nominal	Units
t_1	Horizontal period	64.00	$\mu\text{sec.}$
t_2	HSYNC pulse width (low)	4.65	$\mu\text{sec.}$

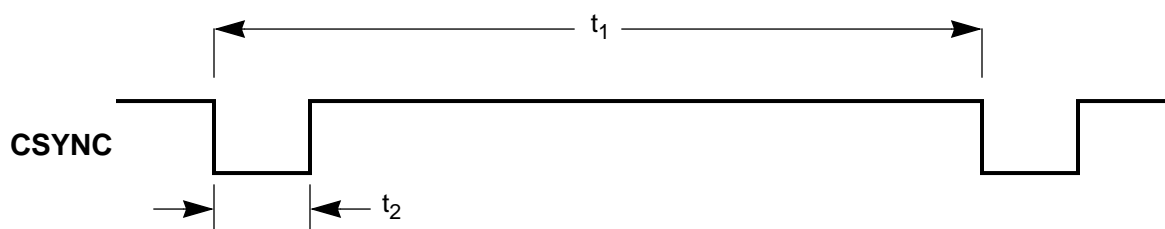
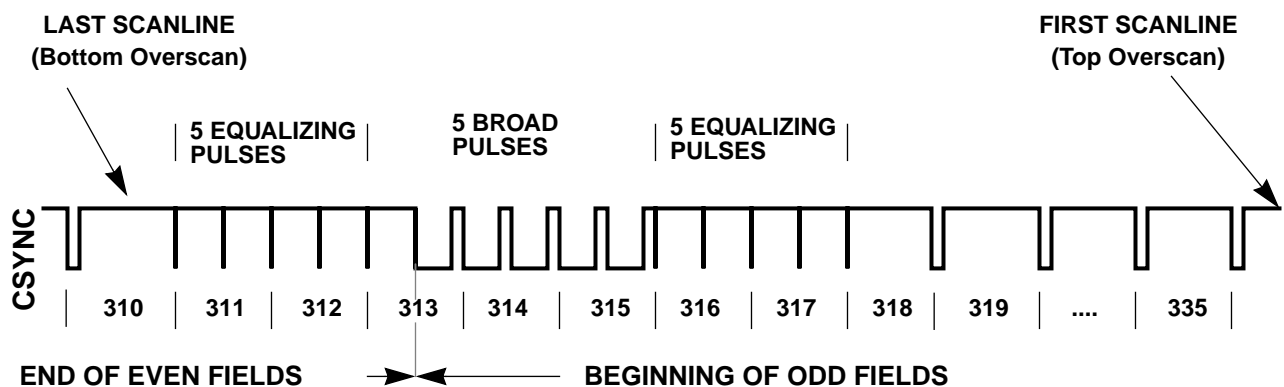
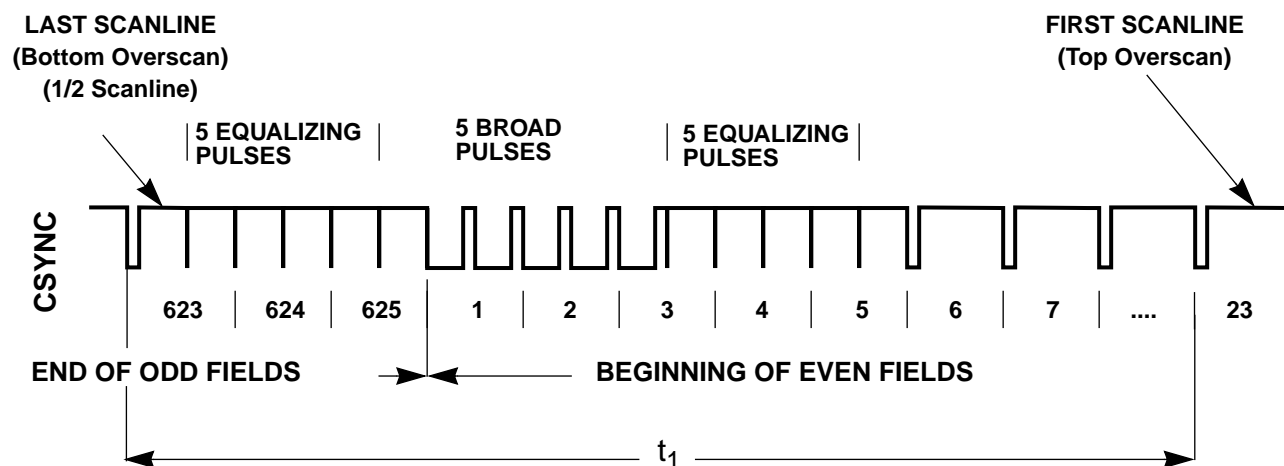


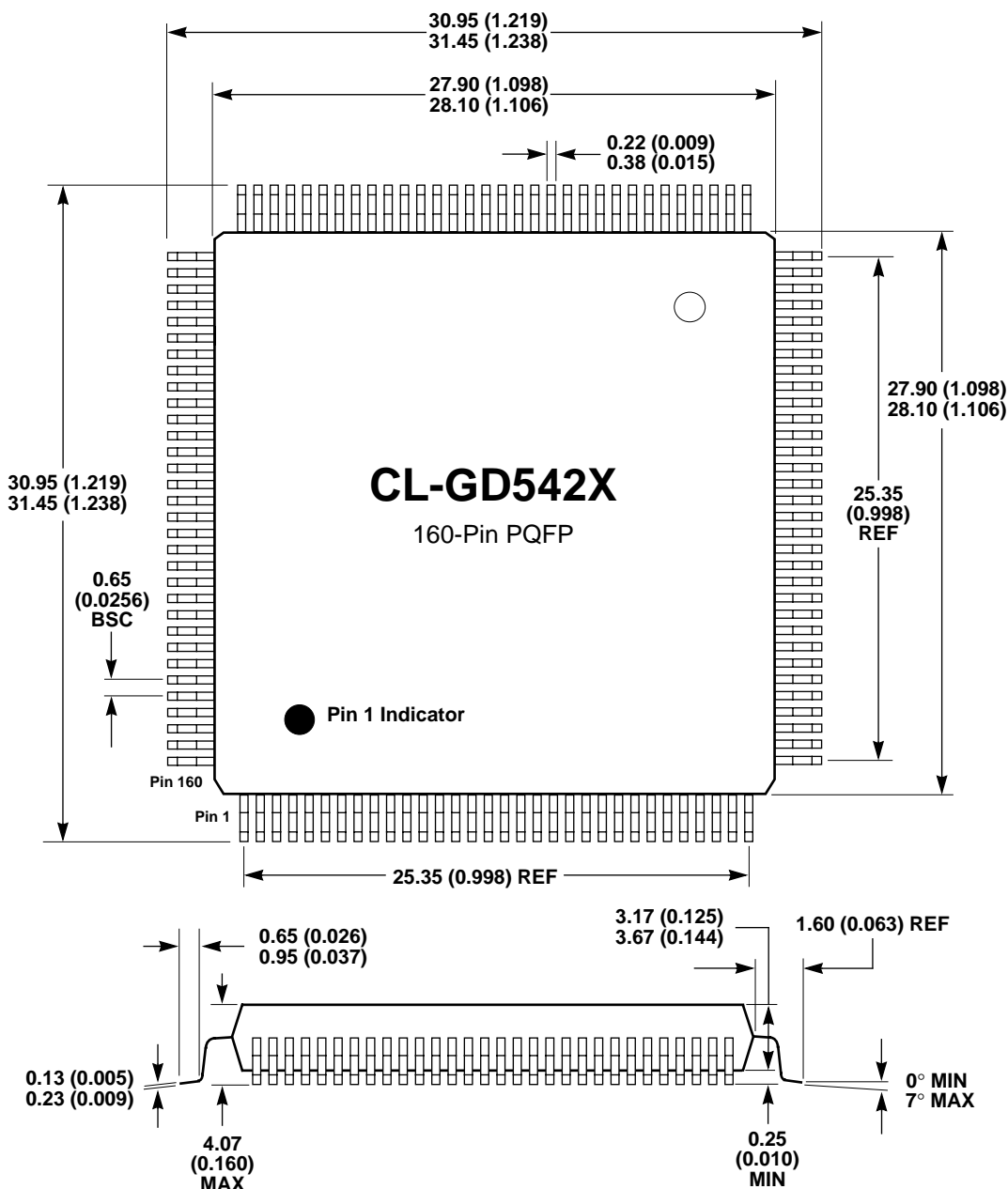
Figure 7-44. Horizontal Period (PAL — CL-GD5425 only)

Table 7-45. PAL Vertical Retrace (CL-GD5425 only)

Symbol	Parameter	Nominal	Units
t_1	Vertical blanking period	25	H-period


Figure 7-45. PAL Vertical Retrace (CL-GD5425 only)

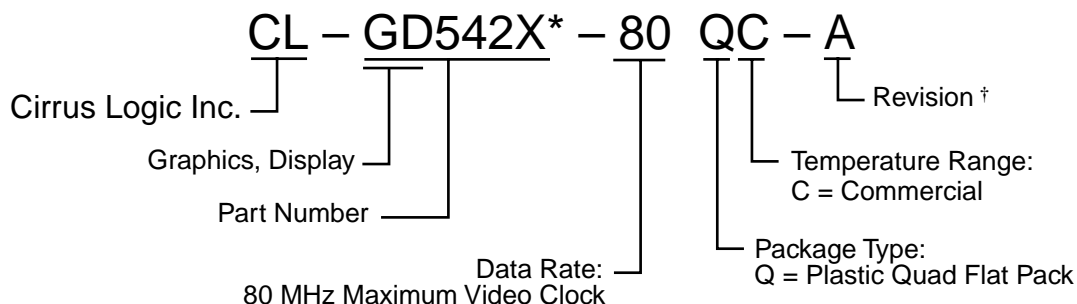
8. PACKAGE DIMENSIONS



NOTES:

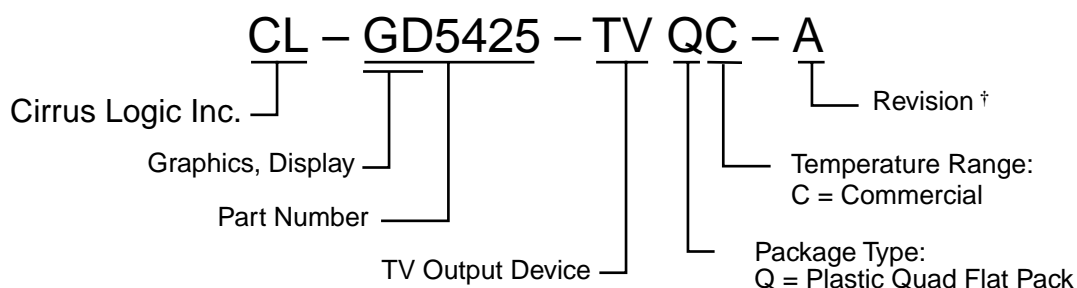
- 1) Dimensions are in millimeters (inches), and controlling dimension is millimeter.
- 2) Drawing above does not reflect exact package pin count.
- 3) Before beginning any new design with this device, please contact Cirrus Logic for the latest package information..

9. ORDERING INFORMATION EXAMPLES



† Contact Cirrus Logic Inc. for up-to-date information on revisions.

* '2X' represents CL-GD5420/'22/'24/'26/'28/'29, respectively.



† Contact Cirrus Logic Inc. for up-to-date information on revisions.

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The Company

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345429-007

4. EXTERNAL AND GENERAL REGISTERS

The External and General registers in the CL-GD542X are summarized in Table 4-1.

Table 4-1. External and General Registers Quick Reference

Abbreviation	Register Name	Index	Port	Page
102 Access	POS 94: 102 Access Control	—	94	4-3
POS102	POS102	—	102	4-4
VSSM	Motherboard Sleep (CL-GD5424/'25/'26/'28 only)	—	3C3	4-5
VSSM	Adapter Sleep	—	46E8	4-6
MISC	Miscellaneous Output	—	3C2 (write)	4-7
MISC	Miscellaneous Output	—	3CC (read)	4-7
FC	Feature Control	—	3?A (write)	4-9
FC	Feature Control	—	3CA (read)	4-9
FEAT	Input Status Register 0	—	3C2	4-10
STAT	Input Status Register 1	—	3?A	4-11
3C6	Pixel Mask	—	3C6	4-12
3C7	Pixel Address (Read mode)	—	3C7 (write)	4-13
3C7	DAC State	—	3C7 (read)	4-14
3C8	Pixel Address (Write mode)	—	3C8	4-15
3C9	Pixel Data	—	3C9	4-16

NOTE: '?' in the above register address is 'B' in Monochrome mode and 'D' in Color mode.

4.1 POS 94: 102 Access Control Register (Write only)

I/O Port Address: 94

Index: –

Bit	Description	Reset State
7	Reserved	
6	Reserved	
5	POS 102 Access	1
4	Reserved	
3	Reserved	
2	Reserved	
1	Reserved	
0	Reserved	

This register contains the enable bit for POS102. This register is accessible only when the CL-GD542X is configured for 3C3 sleep and for the ISA or local bus. This register is not readable. When the CL-GD542X is configured for local bus, it responds to writes to the register by latching the data, but does not generate LBA# or LRDY#.

Bit	Description
7:6	Reserved
5	<p>POS102 Access: This bit controls access to POS102 if the CL-GD542X is configured for 3C3 sleep and is configured for the ISA bus or local bus. If this bit is programmed to '0', POS102 is accessible; if it is programmed to '1', POS102 is not accessible.</p> <p>In addition, if this bit is programmed to '0', the Video Subsystem Enable in 3C3 is overridden, and the CL-GD542X remains asleep.</p>
4:0	Reserved

4.2 POS102: POS102 Register

I/O Port Address: 102

Index: –

Bit	Description	Reset State
7	Reserved	
6	Reserved	
5	Reserved	
4	Reserved	
3	Reserved	
2	Reserved	
1	Reserved	
0	Video Subsystem Enable	0

This register contains a Video Subsystem Enable bit. This register is accessible when the CL-GD542X is configured for a MicroChannel host and if –CD_SETUP was active when –ADL went active.

Bus Configuration	Sleep Address	Register Accessibility
ISA, local	46E8	46E8 [4] = 1
Local	3C3	3C3[4] = 1
MicroChannel	Any	–CD_SETUP pin low

Bit	Description
7:1	Reserved
0	Video Subsystem Enable: If this bit is programmed to a '1', the CL-GD542X is enabled and operates normally (if the VSE bit in 46E8 or 3C3 is also '1'). If this bit is programmed to '0', the CL-GD5420/22 is disabled. It does not respond to any accesses except setup accesses to I/O Address 102. If this bit is programmed to '0', the CL-GD5424/25/26/28 is disabled. It does not respond to any accesses except setup accesses to I/O Address 102 or 3C3.

4.3 VSSM: Sleep Address Register (CL-GD5424/'25/'26/'28/'29 only)

I/O Port Address: 3C3

Index: –

Bit	Description	Reset State
7	Reserved	
6	Reserved	
5	Reserved	
4	Reserved	
3	Reserved	
2	Reserved	
1	Reserved	
0	Video Subsystem Enable	0

This is the Video Subsystem enable at 3C3h. This register is accessible under the following circumstances:

Device	Bus Type	CF3
CL-GD5420/'22	Never use 3C3 sleep	–
CL-GD5424/'25	Not MicroChannel	CF3 = 0
CL-GD5424/'25	MicroChannel	CF3 = 1
CL-GD5429	Any bus	CF3 = 0

Bit	Description
7:1	Reserved
0	<p>Video Subsystem Enable: If the CL-GD542X is <i>not</i> configured for 3C3 sleep, this bit cannot be accessed. If the CL-GD542X is configured for 3C3 sleep, this bit has the following definition:</p> <p>If this bit is programmed to '1', the CL-GD542X is enabled and operates normally. If this bit is programmed to '0', the CL-GD542X is disabled. It does not respond to any I/O access except those addressed to 3C3. It does not respond to any accesses to display memory, but responds normally to BIOS accesses. If a CL-GD542X is disabled, the video enable is unaffected and screen refresh continues if enabled.</p>

4.4 VSSM: Adapter Sleep Address Register (Write only)

I/O Port Address: 46E8

Index: –

Bit	Description	Reset State
7	Reserved	
6	Reserved	
5	Reserved	
4	Setup	0
3	Video Subsystem Enable	0
2	Reserved	
1	Reserved	
0	Reserved	

This is the Sleep Address for an adapter VGA. This register can be accessed only if the CL-GD542X is configured for 46E8 Sleep Address. The CL-GD5422 is always configured for 46E8 sleep. The CL-GD5420 can be configured for 46E8 or 46E9 sleep according to CF3 (see Appendix B9). The CL-GD5424/25 are configured for 46E8 Sleep Address if CF[3] = 1. This register is write only.

Bit	Description
7:5	Reserved
4	Setup: If this bit is programmed to '1', the CL-GD542X is in Setup mode. In Setup mode, the register at I/O Address 102 is accessible, and the register at 46E8 is accessible. The device responds normally to accesses to BIOS, but does not respond to accesses to display memory. If this bit is programmed to '0', the device is not in Setup mode and operates normally.
3	Video Subsystem Enable: If the CL-GD542X is not configured for 46E8 Sleep Address, this bit cannot be accessed. If the CL-GD542X is configured for 46E8 Sleep Address, this bit has the following meaning: If this bit is programmed to '1', the CL-GD542X is enabled and operates normally. If this bit is programmed to '0', the CL-GD542X is disabled; it does not respond to any I/O accesses except those addressed to 46E8 and 102. It does not respond to any accesses to display memory, but responds normally to BIOS accesses. The video enable is unaffected.
2:0	Reserved

4.5 MISC: Miscellaneous Output Register

I/O Port Address: 3C2 (write) 3CC (read)

Index: –

Bit	Description
7	Vertical Sync Polarity
6	Horizontal Sync Polarity
5	Page Select
4	Reserved
3	Clock Select [1]
2	Clock Select [0]
1	Enable Display Memory
0	CRTC I/O Address

This is one of the standard VGA registers with an assortment of bits that have nothing in common.

Bit	Description
7	Vertical Sync Polarity: If this bit is programmed to '0', the Vertical Sync is normally a low signal, going high to indicate the beginning of sync time. If this bit is programmed to '1', the Vertical Sync is normally a high signal, going low to indicate the beginning of sync time. See the description of GRE in Chapter 9, "Extension Registers" for information regarding static Sync outputs.
6	Horizontal Sync Polarity: If this bit is programmed to '0', the Horizontal Sync is normally a low signal, going high to indicate the beginning of sync time. If this bit is programmed to '1', the Vertical Sync is normally a high signal, going low to indicate the beginning of sync time. See the description of GRE in Chapter 9, "Extension Registers" for information regarding static Sync outputs. For some monitors, the polarity of Vertical and Horizontal Sync indicate the number of scanlines per frame. The following table summarizes this:

MISC[7]	MISC[6]	Vertical Size
0 (+)	0 (+)	Reserved
0 (+)	1 (–)	400
1 (–)	0 (+)	350
1 (–)	1 (–)	480

4.5 MISC: Miscellaneous Output Register *(cont.)*

Bit	Description
5	<p>Page Select: This bit affects the meaning of the LSB of display memory address when in Even/Odd modes (SR4[2] = 1). If this bit is programmed to '0', only odd memory locations are selected. If this bit is programmed to '1', only even memory locations are selected.</p> <p>NOTE: This bit is effective in modes 6, D, E, 11, and 12. This bit is ignored if Chain (GR6[1]) or Chain4 (SR4[3]) are enabled.</p>

4	Reserved
---	-----------------

3:2	<p>Clock Select: This two-bit field is used to choose among the four VCLK frequencies, as shown in the following table:</p>
-----	--

EDCLK	MISC[3]	MISC[2]	VCLK Source	Default Frequency
1	0	0	VCLK0	25.180 MHz
1	0	1	VCLK1	28.325 MHz
1	1	0	VCLK2	41.165 MHz
1	1	1	VCLK3	36.082 MHz
0	1	x	DCLK pin (DAC and CRTC Counters)	
0	0	x	DCLK pin (DAC only)	

NOTE: Refer to Appendix B8, "Clock Options", for programming additional VCLK frequencies.

1	<p>Enable Display Memory: If this bit is programmed to '0', the CL-GD542X does not respond to any accesses to display memory. If this bit is programmed to '1', the CL-GD542X responds normally to accesses to display memory.</p>
---	---

0	<p>CRTC I/O Address: This bit selects I/O addresses for either Monochrome or Color mode. The affected addresses are summarized in the table below:</p>
---	---

MISC[0]	ISR/FC	CRTC Index	CRTC Data	Mode
0	3BA	3B4	3B5	Monochrome
1	3DA	3D4	3D5	Color

4.6 FC: Feature Control Register

I/O Port Address: 3?A (Write) 3CA (Read)

Index: –

Bit	Description	Reset State
7	Reserved	
6	Reserved	
5	Reserved	
4	Reserved	
3	VSYNC Control	0
2	Reserved	
1	Reserved	
0	Reserved	

This is one of the original IBM PC registers.

Bit	Description
7:4	Reserved
3	VSYNC Control: If this bit is programmed to '1', VSYNC is logically OR'ed with Display Enable (an internal signal) prior to going to the VSYNC pin. If this bit is programmed to '0', VSYNC is unchanged.
2:0	Reserved

NOTE: '?' in the above register address is 'B' in Monochrome mode and 'D' in Color mode.

4.7 FEAT: Input Status Register 0

I/O Port Address: 3C2

Index: –

Bit	Description
7	Interrupt Pending
6	Reserved
5	Reserved
4	DAC Sensing
3	Reserved
2	Reserved
1	Reserved
0	Reserved

The bits in this read-only register are mostly undefined.

Bit	Description
7	Interrupt Pending: If this bit is '1', an interrupt request is pending. If this bit is '0', no interrupt is pending. See the description of CR11 for more information regarding the CL-GD542X interrupt system.
5	Reserved
4	DAC Sensing: This bit is used for DAC sensing.
3:0	Reserved

4.8 STAT: Input Status Register 1

I/O Port Address: 3?A

Index: –

Bit	Description
7	Reserved
6	Reserved
5	Diagnostic [1]
4	Diagnostic [0]
3	Vertical Retrace
2	Reserved
1	Reserved
0	Display Enable

This read-only register contains some status bits.

Bit	Description																				
7:6	Reserved																				
5:4	Diagnostic [1:0]: These bits follow two of eight outputs of the Attribute Controller. The selection is made according to AR12[5:4] (Color Plane Enable register) as indicated in the following table:																				
<table><tr><th>AR12[5]</th><th>AR12[4]</th><th>STAT[5]</th><th>STAT[4]</th></tr><tr><td>0</td><td>0</td><td>P[2]</td><td>P[0]</td></tr><tr><td>0</td><td>1</td><td>P[5]</td><td>P[4]</td></tr><tr><td>1</td><td>0</td><td>P[3]</td><td>P[1]</td></tr><tr><td>1</td><td>1</td><td>P[7]</td><td>P[6]</td></tr></table>		AR12[5]	AR12[4]	STAT[5]	STAT[4]	0	0	P[2]	P[0]	0	1	P[5]	P[4]	1	0	P[3]	P[1]	1	1	P[7]	P[6]
AR12[5]	AR12[4]	STAT[5]	STAT[4]																		
0	0	P[2]	P[0]																		
0	1	P[5]	P[4]																		
1	0	P[3]	P[1]																		
1	1	P[7]	P[6]																		
For the CL-GD5424/'25/'26/'28/'29 only, these bits can reflect the Input Data on P[7:0]. This occurs only if P[7:0] are inputs as set by CR1A[3:2]. Refer to Application Note B14, <i>Video Overlay and DAC Mode Switching</i> .																					
3	Vertical Retrace: A '1' indicates that vertical retrace is in progress.																				
2:1	Reserved																				
0	Display Enable: If this bit is read as '0', video is being serialized and displayed. If this bit is read as '1', vertical or horizontal blanking is active. When the CL-GD5425 is in an interlaced TV-out mode (CR30[3] = '1'), it generates a 2× rate signal that simulates a 32 kHz HSYNC.																				

NOTE: '?' in the above register address is 'B' in Monochrome mode and 'D' in Color mode.

4.9 Pixel Mask Register

I/O Port Address: 3C6

Index: –

Bit	Description
7	Pixel Mask [7]
6	Pixel Mask [6]
5	Pixel Mask [5]
4	Pixel Mask [4]
3	Pixel Mask [3]
2	Pixel Mask [2]
1	Pixel Mask [1]
0	Pixel Mask [0]

The bits in this read register form the Pixel Mask for the palette DAC. This is typically programmed to all ones by the Cirrus Logic BIOS. The same address is used to access the Hidden DAC register described in Chapter 9, "Extension Registers".

Bit	Description
7:0	Pixel Mask [7:0]: This field is the Pixel Mask for the palette DAC. If a bit in this field is programmed to '0', the corresponding bit in the pixel data is ignored in looking up an entry in the LUT.

4.10 Pixel Address Register (Read Mode — Write only)

I/O Port Address: 3C7

Index: —

Bit	Description
7	Pixel Address (Read Mode) [7]
6	Pixel Address (Read Mode) [6]
5	Pixel Address (Read Mode) [5]
4	Pixel Address (Read Mode) [4]
3	Pixel Address (Read Mode) [3]
2	Pixel Address (Read Mode) [2]
1	Pixel Address (Read Mode) [1]
0	Pixel Address (Read Mode) [0]

The bits in this write-only register form the Pixel Address (Read mode) for the palette DAC. This is used to specify the entry in the LUT to be read.

Bit	Description
7:0	Pixel Address (Read Mode) [7:0]: This field is the Pixel Address (Read mode) for the Video LUT. This address is incremented at the conclusion of every third read of the Pixel Data register.

4.11 DAC State Register (Read only)

I/O Port Address: 3C7

Index: –

Bit	Description
7	Reserved
6	Reserved
5	Reserved
4	Reserved
3	Reserved
2	Reserved
1	DAC State [1]
0	DAC State [0]

The bits in this read-only register indicate whether a read or write to the LUT occurred last.

Bit	Description
7:2	Reserved
1:0	DAC State [1:0]: This field indicates whether the Pixel Address Read register or the Pixel Address Write register was accessed last. The two bits are always the same. If they are '0,0', a write operation is in progress. If they are '1,1', a read operation is in progress.

4.12 Pixel Address Register (Write Mode)

I/O Port Address: 3C8

Index: –

Bit	Description
7	Pixel Address (Write Mode) [7]
6	Pixel Address (Write Mode) [6]
5	Pixel Address (Write Mode) [5]
4	Pixel Address (Write Mode) [4]
3	Pixel Address (Write Mode) [3]
2	Pixel Address (Write Mode) [2]
1	Pixel Address (Write Mode) [1]
0	Pixel Address (Write Mode) [0]

The bits in this registers form the Pixel Address (Write mode) for the palette DAC. This is used to specify the entry in the LUT that is to be written.

Bit	Description
7:0	Pixel Address (Write Mode) [7:0]: This field is the Pixel Address (Write mode) for the Video LUT. This address is incremented at the conclusion of every third write to the Pixel Data register.

4.13 Pixel Data Register

I/O Port Address: 3C9

Index: –

Bit	Description
7	Pixel Data [7]
6	Pixel Data [6]
5	Pixel Data [5]
4	Pixel Data [4]
3	Pixel Data [3]
2	Pixel Data [2]
1	Pixel Data [1]
0	Pixel Data [0]

This is the Pixel Data for the palette DAC.

Bit	Description
7:0	<p>Pixel Data [7:0]: This field is the Pixel Data for the palette DAC. This is a read/write register. Prior to writing to this register, 3C8 is written with the first or only pixel address. Then three values, corresponding to the Red, Green, and Blue values for the pixel, are written to this address. Following the third write, the values are actually transferred to the LUT and the Pixel Address is incremented in case new values for the next pixel address are to be written.</p> <p>Prior to reading from this register, 3C7 is written with the first or only pixel address. Then three values, corresponding to the Red, Green, and Blue values for the pixel, can be read from this address. Following the third read, the Pixel Address is incremented in case the value for the next pixel address are to be read.</p>

5. VGA SEQUENCER REGISTERS

The CL-GD542X VGA Sequencer registers are summarized in the following table. Please note that there are Extension registers that are accessed using the VGA Sequencer Ports.

Table 5-1. VGA Sequencer Registers Quick Reference

Abbreviation	Register Name	Index	Port	Page
SRX	Sequencer Index	–	3C4	5-3
SR0	Reset	0	3C5	5-4
SR1	Clocking Mode	1	3C5	5-5
SR2	Plane Mask	2	3C5	5-7
SR3	Character Map Select	3	3C5	5-8
SR4	Memory Mode	4	3C5	5-10

5.1 SRX: Sequencer Index Register

I/O Port Address: 3C4

Index: –

Bit	Description
7	Reserved
6	Reserved
5	Reserved
4	Sequencer Index [4]
3	Sequencer Index [3]
2	Sequencer Index [2]
1	Sequencer Index [1]
0	Sequencer Index [0]

This register is used to specify the register in the sequencer block to be accessed by the next I/O Read or Write to Address 3C5. Indices greater than five point to registers that are defined in Chapter 9, “Extension Registers”.

Bit	Description
7:5	Reserved
4:0	Sequencer Index [4:0]: This field selects the register to be accessed with the next I/O Read or I/O Write to 3C5.

5.2 SR0: Reset Register

I/O Port Address: 3C5

Index: 0

Bit	Description	Reset State
7	Reserved	
6	Reserved	
5	Reserved	
4	Reserved	
3	Reserved	
2	Reserved	
1	Synchronous Reset	1
0	Asynchronous Reset	1

This register is used to reset the Sequencer. These bits are for compatibility only and need never be used in the CL-GD542X.

Bit	Description
7:2	Reserved
1	Synchronous Reset: If this bit is programmed to '0', the sequencer is cleared and halted. This disables screen refresh and display memory refresh. If this bit is programmed to '1', the sequencer operates normally (if SR0[0] is '1').
0	Asynchronous Reset: If this bit is programmed to '0', the sequencer is cleared and halted. In addition, SR3 is cleared. If this bit is programmed to '1', the sequencer operates normally (if SR0[1] is a '1').

5.3 SR1: Clocking Mode Register

I/O Port Address: 3C5

Index: 1

Bit	Description
7	Reserved
6	Reserved
5	Full Bandwidth
4	Shift and Load 32
3	Dot Clock $\div 2$
2	Shift and Load 16
1	Reserved
0	8/9 Dot Clock

This register is used to control some miscellaneous functions in the Sequencer.

Bit	Description												
7:6	Reserved												
5	Full Bandwidth: If this bit is programmed to '1', screen refresh stops. This allows the CPU to use nearly 100% of the display memory bandwidth. HSYNC and VSYNC continue normally and display memory refresh continues. BLANK* goes and stays active (the DAC outputs are zero). If this bit is programmed to '0', the CL-GD542X operates normally.												
4	Shift and Load 32: This bit, in conjunction with bit 2 of this register, controls the Display Data Shifters in the Graphics Controller according to the following table: <table><tr><th>SR1[4]</th><th>SR1[2]</th><th>Data Shifters Loaded</th></tr><tr><td>0</td><td>0</td><td>Every character clock</td></tr><tr><td>0</td><td>1</td><td>Every 2nd character clock</td></tr><tr><td>1</td><td>x</td><td>Every 4th character clock</td></tr></table>	SR1[4]	SR1[2]	Data Shifters Loaded	0	0	Every character clock	0	1	Every 2nd character clock	1	x	Every 4th character clock
SR1[4]	SR1[2]	Data Shifters Loaded											
0	0	Every character clock											
0	1	Every 2nd character clock											
1	x	Every 4th character clock											
3	Dot Clock ÷ 2: If this bit is programmed to '1', the VCLK is divided by two to generate DCLK. This is used for low-resolution Video modes such as 0, 1, 4, 5, and D. If this bit is programmed to '0', the Master Clock is not divided by two.												

5.3 SR1: Clocking Mode Register (*cont.*)

Bit	Description
2	Shift and Load 16: See the description of bit 4 of this register.
1	Reserved
0	8/9 Dot Clock: If this bit is programmed to '1', DCLK is divided by eight to generate the character clock. If this bit is programmed to '0', DCLK is divided by nine to generate the character clock. This is used for 720 × 350 and 720 × 400 resolution Text modes.

5.4 SR2: Plane Mask Register

I/O Port Address: 3C5

Index: 2

Bit	Description
7	Enable Writing Pixel 7
6	Enable Writing Pixel 6
5	Enable Writing Pixel 5
4	Enable Writing Pixel 4
3	Map 3 Enable/Enable Writing Pixel 3
2	Map 2 Enable/Enable Writing Pixel 2
1	Map 1 Enable/Enable Writing Pixel 1
0	Map 0 Enable/Enable Writing Pixel 0

This register is used to enable or disable writing to the four planes of display memory. If Extended Write modes 4 or 5 are selected, or if Write mode 1 is selected and GRB[1] = 1, this register is redefined as controlling the writing of up to eight pixels.

Bit	Description
7:4	Reserved: These four bits are reserved if Extended Write modes 4 and 5 are disabled. This would be the case for VGA compatibility modes.
3:0	Map Enable [3:0]: These four bits are used to individually control whether bit planes 3:0 are written with Write modes 0 through 3.
7:0	Enable Writing Pixel [7:0]: These eight bits are used to individually control whether pixels 7:0 are written if Extended Write modes 4 or 5 are selected, or if Write mode 1 is selected and GRB[2] = 1. Programming with '1' enables the corresponding pixel.

5.5 SR3: Character Map Select Register

I/O Port Address: 3C5

Index: 3

Bit	Description
7	Reserved
6	Reserved
5	Secondary Map Select [0]
4	Primary Map Select [0]
3	Secondary Map Select [2]
2	Secondary Map Select [1]
1	Primary Map Select [2]
0	Primary Map Select [1]

This register is used to specify the primary and secondary character sets (fonts). This is applicable to Text modes only.

Bit	Description
-----	-------------

7:6	Reserved
-----	----------

5, 3:2	Secondary Map Select: These three bits select the Secondary Character Map according to the following table:
--------	--

SR3[5]	SR3[3]	SR3[2]	Map	Offset
0	0	0	0	0K
0	0	1	1	16K
0	1	0	2	32K
0	1	1	3	48K
1	0	0	4	8K
1	0	1	5	24K
1	1	0	6	40K
1	1	1	7	56K

5.5 SR3: Character Map Select Register *(cont.)*

Bit	Description
4, 1:0	Primary Map Select: These three bits select the Primary Character Map according to the following table:

SR3[4]	SR3[1]	SR3[0]	Map	Offset
0	0	0	0	0K
0	0	1	1	16K
0	1	0	2	32K
0	1	1	3	48K
1	0	0	4	8K
1	0	1	5	24K
1	1	0	6	40K
1	1	1	7	56K

NOTES:

- 1) In Text Video modes, the ASCII text character is stored in Plane 0, the attribute is stored in Plane 1, and the font is stored in Plane 2.
- 2) Bit 3 of the Attribute byte normally controls the intensity of the foreground color. This bit may be redefined to be a switch between character sets, allowing 512 displayable characters. This switch is enabled whenever there is a difference between the values of the Primary Map Select and Secondary Map Select, and SR4[1] is '1'.
- 3) The format of the Plane 2 Font Address bits 15:0 is:

F0 F1 F2 C7 C6 C5 C4 C3 C2 C1 C0 R4 R3 R2 R1 R0

where F[2:0] is the Character Map Select, C[7:0] is the ASCII character, and R[4:0] is the Character Row (scanline in the character cell).

5.6 SR4: Memory Mode Register

I/O Port Address: 3C5

Index: 4

Bit	Description
7	Reserved
6	Reserved
5	Reserved
4	Reserved
3	Chain-4
2	Odd/Even
1	Extended Memory
0	Reserved

This register is used to control some miscellaneous functions in the Sequencer.

Bit	Description
7:4	Reserved
3	Chain-4: If this bit is programmed to '1', A0 provides Plane Select bit 0, and A1 provides Plane Select bit 1. This has an effect similar to Odd/Even mode, except that both A1 and A0 are used. This bit takes priority over SR4[2] (Odd/Even) and GR5[4]. There is not a separate bit in the Graphics Controller to select Chain-4 Addressing, as is the case with the Odd/Even bit. The Graphics Controller Read Map register (GR4) is ignored when this bit is '1'.
2	Odd/Even: If this bit is programmed to '0', the sequencer is put into Odd/Even mode. Even CPU addresses access Planes 0 and 2; odd CPU addresses access Planes 1 and 3. This bit must be programmed to '0' for text modes. The value of this bit must track GR5[4] (Odd/Even). The values are opposite.
1	Extended Memory: If this bit is programmed to '0', the effective memory size is 64K, regardless of the memory actually installed. EGA modes require this to be the case. If this bit is programmed to '1', the effective memory size is equal to the actual memory installed.
0	Reserved

6. CRT CONTROLLER REGISTERS

The CL-GD542X VGA CRT Controller registers are summarized in the following table. Please note that there are Extension registers that are accessed using the VGA CRT Controller Ports.

While reading this chapter, refer to Figure 6-1 and Table 6-2 for a summary of CRTC registers.

Table 6-1. CRT Controller Registers Quick Reference

Abbreviation	Register Name	Index	Port	Page
CRX	CRTC Index	—	3?4 ^a	6-3
CR0	Horizontal Total	0	3?5	6-4
CR1	Horizontal Display End	1	3?5	6-7
CR2	Horizontal Blanking Start	2	3?5	6-8
CR3	Horizontal Blanking End	3	3?5	6-9
CR4	Horizontal Sync Start	4	3?5	6-11
CR5	Horizontal Sync End	5	3?5	6-12
CR6	Vertical Total	6	3?5	6-14
CR7	Overflow	7	3?5	6-15
CR8	Screen A Preset Row Scan	8	3?5	6-16
CR9	Character Cell Height	9	3?5	6-17
CRA	Text Cursor Start	A	3?5	6-18
CRB	Text Cursor End	B	3?5	6-19
CRC	Screen Start Address High	C	3?5	6-20
CRD	Screen Start Address Low	D	3?5	6-21
CRE	Text Cursor Location High	E	3?5	6-22
CRF	Text Cursor Location Low	F	3?5	6-23
CR10	Vertical Sync Start	10	3?5	6-24
CR11	Vertical Sync End	11	3?5	6-25
CR12	Vertical Display End	12	3?5	6-26
CR13	Offset	13	3?5	6-27
CR14	Underline Row Scanline	14	3?5	6-28
CR15	Vertical Blanking Start	15	3?5	6-29
CR16	Vertical Blanking End	16	3?5	6-30
CR17	Mode Control	17	3?5	6-31
CR18	Line Compare	18	3?5	6-33
CR22	Graphics Data Latches Readback	22	3?5	6-34
CR24	Attribute Controller Toggle Readback	24	3?5	6-35
CR26	Attribute Controller Index Readback	26	3?5	6-36

a. '?' in the above register address is 'B' in Monochrome mode and 'D' in Color mode.

6.1 CRX: CRTC Index Register

I/O Port Address: 3?4

Index: –

Bit	Description
7	Reserved
6	Reserved
5	CRTC Index [5]
4	CRTC Index [4]
3	CRTC Index [3]
2	CRTC Index [2]
1	CRTC Index [1]
0	CRTC Index [0]

This register is used to specify the register in the CRTC Controller block to be accessed by the next I/O Read or I/O Write to Address 3?5. The registers at indices 19, 1A, 1B, 25, and 27 are described in Chapter 9, "Extension Registers".

Bit	Description
7:6	Reserved
5:0	CRTC Index [5:0]: This value points to the register to be accessed in the next I/O Read or I/O Write to address 3?5. NOTE: Registers above 18 were never documented by IBM.

NOTE: '?' in the above register address is 'B' in Monochrome mode and 'D' in Color mode.

6.2 CR0: Horizontal Total Register

I/O Port Address: 3?5

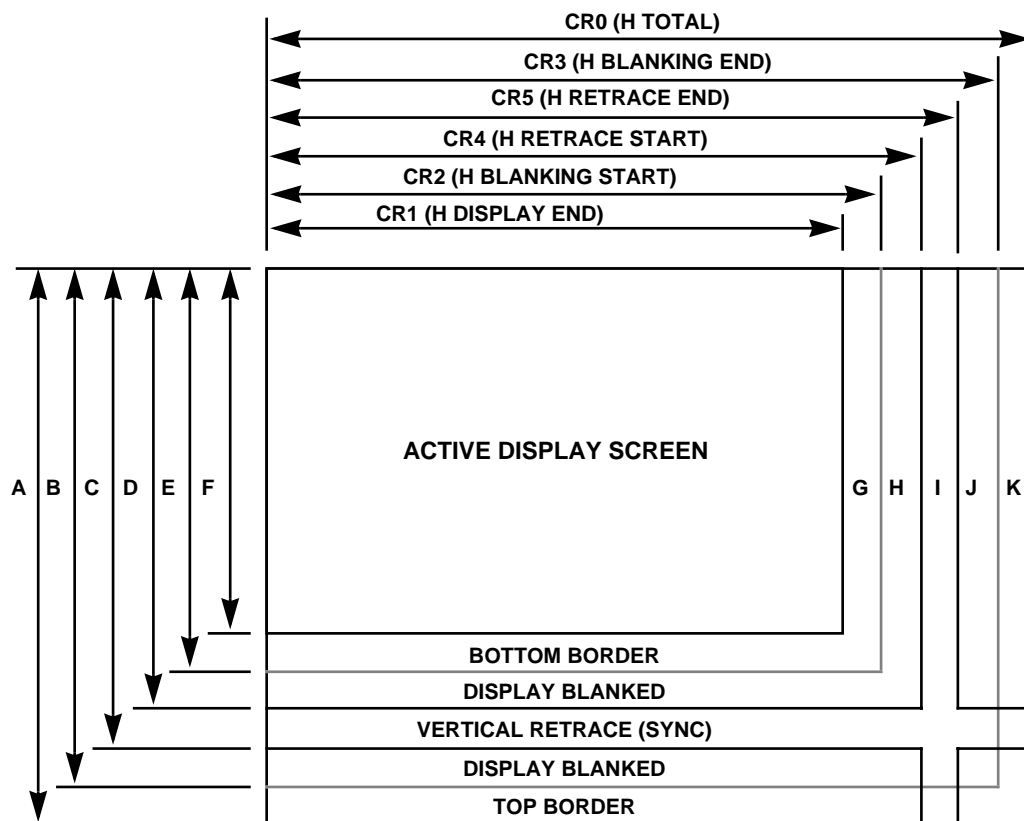
Index: 0

Bit	Description
7	Horizontal Total [7]
6	Horizontal Total [6]
5	Horizontal Total [5]
4	Horizontal Total [4]
3	Horizontal Total [3]
2	Horizontal Total [2]
1	Horizontal Total [1]
0	Horizontal Total [0]

This register is used to specify the total number of character clocks per horizontal period.

Bit	Description
7:0	<p>Horizontal Total: This eight-bit field specifies the total number of character clocks per horizontal period. The Character Clock (derived from the VCLK according to the character width) is counted in the Character Counter. The value of the Character Counter is compared with the value in this register to provide the basic horizontal timing. All horizontal and vertical timing is eventually derived from the register. The value in the register is 'Total number of character times minus five'.</p> <p>Figure 6-1 indicates the way the horizontal and vertical timing is defined. The horizontal timing is calculated in terms of character clock periods and the vertical timing is calculated in terms of horizontal periods. Table 6-2 indicates how the various timing registers are extended.</p>

NOTE: '?' in the above register address is 'B' in Monochrome mode and 'D' in Color mode.



- A - CR6 (V TOTAL)
- B - CR16 (V BLANKING END)
- C - CR11 (V RETRACE END)
- D - CR10 (V RETRACE START)
- E - CR15 (V BLANKING START)
- F - CR12 (V DISPLAY END)
- G - RIGHT BORDER
- H - DISPLAY BLANKED
- I - HORIZONTAL RETRACE (SYNC)
- J - DISPLAY BLANKED
- K - LEFT BORDER

Figure 6-1. CRTC Timing Registers

The Extension and Overflow bits are organized by parameter and bit position as outlined in Table 6-2.

Table 6-2. Summary of CRTC Timing Registers^a

Parameter/Bit	9	8	7	6	5	4:0
H Total			CR0[7]	CR0[6]	CR0[5]	CR0[4:0]
H Display End			CR1[7]	CR1[6]	CR1[5]	CR1[4:0]
H Blank Start			CR2[7]	CR2[6]	CR2[5]	CR2[4:0]
H Blank End			CR1A[5]	CR1A[4]	CR5[7]	CR3[4:0]
H Sync Start			CR4[7]	CR4[6]	CR4[5]	CR4[4:0]
H Sync End						CR5[4:0]
V Total	CR7[5]	CR7[0]	CR6[7]	CR6[6]	CR6[5]	CR6[4:0]
V Sync Start	CR7[7]	CR7[2]	CR10[7]	CR10[6]	CR10[5]	CR10[4:0]
V Sync End						CR11[3:0]
V Display End	CR7[6]	CR7[1]	CR12[7]	CR12[6]	CR12[5]	CR12[4:0]
V Blank Start	CR9[5]	CR7[3]	CR15[7]	CR15[6]	CR15[5]	CR15[4:0]
V Blank End	CR1A[7]	CR1A[6]	CR16[7]	CR16[6]	CR16[5]	CR16[4:0]
Line Compare	CR9[6]	CR7[4]	CR18[7]	CR18[6]	CR18[5]	CR18[4:0]
Offset		CR1B[4]	CR13[7]	CR13[6]	CR13[5]	CR13[4:0]

a. Bits shown in **bold** text are extensions.

6.3 CR1: Horizontal Display End Register

I/O Port Address: 3?5

Index: 1

Bit	Description
7	Horizontal Display End [7]
6	Horizontal Display End [6]
5	Horizontal Display End [5]
4	Horizontal Display End [4]
3	Horizontal Display End [3]
2	Horizontal Display End [2]
1	Horizontal Display End [1]
0	Horizontal Display End [0]

This register is used to specify the number of character clocks during horizontal display time.

Bit	Description
7:0	<p>Horizontal Display End [7:0]: This register specifies the number of character clocks during horizontal display time. For text modes, this is the number of characters; for graphics modes, this is the number of pixels per scanlines divided by the number of pixels per character clock. The value in the register is the number of character clocks minus one.</p> <p>Refer to Figure 6-1 and Table 6-2 for a summary of CRTIC Timing registers.</p>

NOTE: '?' in the above register address is 'B' in Monochrome mode and 'D' in Color mode.

6.4 CR2: Horizontal Blanking Start Register

I/O Port Address: 3?5

Index: 2

Bit	Description
7	Horizontal Blanking Start [7]
6	Horizontal Blanking Start [6]
5	Horizontal Blanking Start [5]
4	Horizontal Blanking Start [4]
3	Horizontal Blanking Start [3]
2	Horizontal Blanking Start [2]
1	Horizontal Blanking Start [1]
0	Horizontal Blanking Start [0]

This register is used to specify the Character Count where Horizontal Blanking starts.

Bit	Description
7:0	Horizontal Blanking Start [7:0]: The contents of this register specify the Character Count where Horizontal Blanking starts. For text modes, this is the number of characters; for graphics modes, this is the number of pixels per scanline divided by the number of pixels per character clock. The value programmed into CR2 must always be larger than the value programmed into CR1. Refer to Figure 6-1 and Table 6-2 for a summary of CRTIC Timing registers.

NOTE: '?' in the above register address is 'B' in Monochrome mode and 'D' in Color mode.

6.5 CR3: Horizontal Blanking End Register

I/O Port Address: 3?5

Index: 3

Bit	Description
7	Compatible Read
6	Display Enable Skew [1]
5	Display Skew [0]
4	Horizontal Blanking End [4]
3	Horizontal Blanking End [3]
2	Horizontal Blanking End [2]
1	Horizontal Blanking End [1]
0	Horizontal Blanking End [0]

This register is used to determine the width of the Horizontal Blanking Period. In addition, this register controls Display Enable Skew and access to CR10 and CR11.

Bit	Description
7	Compatible Read: If this bit is programmed to '0', registers CR10 and CR11 are write-only registers. If this bit is programmed to '1', registers CR10 and CR11 are read/write registers.
6:5	Display Enable Skew [1:0]: This two-bit field is used to specify the number of character clocks that display enable is to be delayed from Horizontal Total. This is necessary to compensate for the accesses of the character code and Attribute byte, the accesses of the font, etc. The following table indicates the coding of CR3[6:5].

CR3[6]	CR3[5]	Skew	Note
0	0	0	
0	1	1	Typical setting
1	0	2	
1	1	3	

NOTE: If the skew is programmed too low, the left most character is repeated. If the skew is programmed too high, one or more characters disappears at the left of each character row.

6.5 CR3: Horizontal Blanking End Register (*cont.*)

Bit	Description
4:0	<p>Horizontal Blanking End [4:0]: This field determines the width of the Horizontal Blanking Period. This field is extended with CR5[7]. The least-significant five or six bits of the Character Counter are compared with the contents of this field. When a match occurs, the Horizontal Blanking Period is ended. Note that the Horizontal Blanking Period is limited to 63 character-clock times. The value to be programmed into this register can be calculated by subtracting the desired blanking period from the value programmed into CR2 (Horizontal Blanking Start). Never program the blanking period to extend past the Horizontal Total.</p> <p>If CR1B[5] or CR1B[7] is programmed to '1', this field is extended with Extension register CR1A[5:4].</p> <p>Refer to Figure 6-1 and Table 6-2 for a summary of CRTIC Timing registers.</p>

NOTE: '?' in the above register address is 'B' in Monochrome mode and 'D' in Color mode.

6.6 CR4: Horizontal Sync Start Register

I/O Port Address: 3?5

Index: 4

Bit	Description
7	Horizontal Sync Start [7]
6	Horizontal Sync Start [6]
5	Horizontal Sync Start [5]
4	Horizontal Sync Start [4]
3	Horizontal Sync Start [3]
2	Horizontal Sync Start [2]
1	Horizontal Sync Start [1]
0	Horizontal Sync Start [0]

This register specifies the time where Horizontal Sync becomes active.

Bit	Description
7:0	Horizontal Sync Start [7:0]: This field specifies the Character Count where HSYNC (Horizontal Sync) becomes active. Adjusting the value in this field moves the display horizontally on the screen. The Horizontal Sync Start <i>must</i> be programmed to a value equal to or greater than Horizontal Display End. The time from Horizontal Sync Start to Horizontal Total <i>must</i> be equal to or greater than four character times. Refer to Figure 6-1 and Table 6-2 for a summary of CRTIC Timing registers.

NOTE: '?' in the above register address is 'B' in Monochrome mode and 'D' in Color mode.

6.7 CR5: Horizontal Sync End Register

I/O Port Address: 3?5

Index: 5

Bit	Description
7	Horizontal Blanking End [5]
6	Horizontal Sync Delay [1]
5	Horizontal Sync Delay [0]
4	Horizontal Sync End [4]
3	Horizontal Sync End [3]
2	Horizontal Sync End [2]
1	Horizontal Sync End [1]
0	Horizontal Sync End [0]

This register specifies the position where the Horizontal Sync pulse ends, effectively specifying the width of the pulse. In addition, this register contains an overflow bit and a skew field.

Bit	Description
-----	-------------

7	Horizontal Blanking End [5]: This bit extends the Horizontal Blanking End value by one bit. Refer to register CR3 for an explanation of the Horizontal Blanking End Value.
---	---

6:5	Horizontal Sync Delay [1:0]: This two-bit field is used to delay the external Horizontal Sync pulse from the position implied in CR4. This is necessary in some modes to allow internal timing signals triggered from Horizontal Sync Start to begin prior to Display Enable. The following table summarizes the HSYNC delay:
-----	--

CR5[6]	CR5[5]	Skew In Character Clocks
0	0	0
0	1	1
1	0	2
1	1	3

6.7 CR5: Horizontal Sync End Register *(cont.)*

Bit	Description
4:0	Horizontal Sync End [4:0]: This field determines the width of the Horizontal Sync pulse. The least-significant five bits of the Character Counter are compared with the contents of this field. When a match occurs, the Horizontal Sync pulse is ended. Note the Horizontal Sync pulse is limited to 31 character-clock times. The value to be programmed into this register can be calculated by subtracting the desired sync width from the value programmed into CR4 (Horizontal Sync Start). Never program the sync pulse to extend past the Horizontal Total. In addition, HSYNC should always end during the Horizontal Blanking period. Refer to Figure 6-1 and Table 6-2 for a summary of CRTIC Timing registers.

NOTE: '?' in the above register address is 'B' in Monochrome mode and 'D' in Color mode.

6.8 CR6: Vertical Total Register

I/O Port Address: 3?5

Index: 6

Bit	Description
7	Vertical Total [7]
6	Vertical Total [6]
5	Vertical Total [5]
4	Vertical Total [4]
3	Vertical Total [3]
2	Vertical Total [2]
1	Vertical Total [1]
0	Vertical Total [0]

This register specifies the total number of scanlines per frame.

Bit	Description
7:0	Vertical Total [7:0]: This field is the low-order eight bits of a ten-bit field that defines the total number of scanlines per frame. This field is extended with CR5[7] and CR5[0]. The value programmed into the Vertical Total field is the total number of scanlines minus two. Refer to Figure 6-1 and Table 6-2 for a summary of CRTIC Timing registers.

NOTE: '?' in the above register address is 'B' in Monochrome mode and 'D' in Color mode.

6.9 CR7: Overflow Register

I/O Port Address: 3?5

Index: 7

Bit	Description
7	Vertical Sync Start [9]
6	Vertical Display End [9]
5	Vertical Total [9]
4	Line Compare [8]
3	Vertical Blanking Start [8]
2	Vertical Sync Start [8]
1	Vertical Display End [8]
0	Vertical Total [8]

This register contains bits that extend various vertical count fields. Refer to Figure 6-1 and Table 6-2 for a summary of CRTC Timing registers.

Bit	Description
7	Vertical Retrace Start [9]: This bit extends the Vertical Retrace Start (CR10) field to ten bits.
6	Vertical Display End [9]: This bit extends the Vertical Display End (CR12) field to ten bits.
5	Vertical Total [9]: This bit extends the Vertical Total (CR6) field to ten bits.
4	Line Compare [8]: This bit extends the Line Compare (CR18) field to nine bits.
3	Vertical Blanking Start [8]: This bit extends the Vertical Blanking Start (CR15) field to nine bits.
2	Vertical Retrace Start [8]: This bit extends the Vertical Retrace Start (CR10) field to nine bits.
1	Vertical Display End [8]: This bit extends the Vertical Display End (CR12) field to nine bits.
0	Vertical Total [8]: This bit extends the Vertical Total (CR6) field to nine bits.

NOTE: '?' in the above register address is 'B' in Monochrome mode and 'D' in Color mode.

6.10 CR8: Screen A Preset Row Scan Register

I/O Port Address: 3?5

Index: 8

Bit	Description
7	Reserved
6	Byte Pan [1]
5	Byte Pan [0]
4	Screen A Preset Row Scan [4]
3	Screen A Preset Row Scan [3]
2	Screen A Preset Row Scan [2]
1	Screen A Preset Row Scan [1]
0	Screen A Preset Row Scan [0]

This register specifies the row scanline where Screen A begins, allowing scrolling on a scanline basis (soft scroll). In addition, this register specifies the Byte Pan (coarse panning).

Bit	Description																				
7	Reserved																				
6:5	Byte Pan [1:0]: This two-bit field controls coarse panning. It can specify a pan of up to 24 pixels with a resolution of eight pixels. AR13 provides for panning on a pixel basis. The values programmed into CR8[6:5] are interpreted as indicated in the following table: <table><tr><th>CR8[6]</th><th>CR8[5]</th><th>Bytes</th><th>Pixels</th></tr><tr><td>0</td><td>0</td><td>0</td><td>0</td></tr><tr><td>0</td><td>1</td><td>1</td><td>8</td></tr><tr><td>1</td><td>0</td><td>2</td><td>16</td></tr><tr><td>1</td><td>1</td><td>3</td><td>24</td></tr></table>	CR8[6]	CR8[5]	Bytes	Pixels	0	0	0	0	0	1	1	8	1	0	2	16	1	1	3	24
CR8[6]	CR8[5]	Bytes	Pixels																		
0	0	0	0																		
0	1	1	8																		
1	0	2	16																		
1	1	3	24																		
4:0	Screen A Preset Row Scan [4:0]: This field specifies the scanline where the first character row begins. This provides scrolling on a scanline basis (soft scrolling). The contents of this field should be changed only during Vertical Retrace time.																				

NOTE: '?' in the above register address is 'B' in Monochrome mode and 'D' in Color mode.

6.11 CR9: Character Cell Height Register

I/O Port Address: 3?5

Index: 9

Bit	Description
7	CRTC Scan Double
6	Line Compare [9]
5	Vertical Blank Start [9]
4	Character Cell Height [4]
3	Character Cell Height [3]
2	Character Cell Height [2]
1	Character Cell Height [1]
0	Character Cell Height [0]

This register specifies the number of scanlines in the character cell. In addition, it contains two vertical overflow bits and one control bit.

Bit	Description
7	CRTC Scan Double: If this bit is programmed to '1', every scanline is displayed twice in succession. The Scanline Counter-based addressing (Character Height, Cursor Start and End, and Underline location) double.
6	Line Compare [9]: This bit extends the Line Compare field (CR18) to ten bits.
5	Vertical Blank Start [9]: This bit extends the Vertical Blank Start field (CR15) to ten bits.
4:0	Character Cell Height [4:0]: This field specifies the vertical size of the character cell in terms of scanlines. The value programmed into this field is the actual size minus 1. Refer to Figure 6-1 and Table 6-2 for a summary of CRTC Timing registers.

NOTE: '?' in the above register address is 'B' in Monochrome mode and 'D' in Color mode.

6.12 CRA: Text Cursor Start Register

I/O Port Address: 3?5

Index: A

Bit	Description
7	Reserved
6	Reserved
5	Disable Text Cursor
4	Text Cursor Start [4]
3	Text Cursor Start [3]
2	Text Cursor Start [2]
1	Text Cursor Start [1]
0	Text Cursor Start [0]

This register specifies the scanline where the text cursor is to begin. In addition, this register contains a bit that will disable the text cursor.

Bit	Description
7:6	Reserved
5	Disable Text Cursor: If this bit is programmed to '1', the text cursor is disabled (that is, it is not displayed). If this bit is programmed to '0', the text cursor functions normally.
4:0	Text Cursor Start [4:0]: This field specifies the scanline within the Character Cell where the text cursor is to start. If the Text Cursor Start value is greater than the Text Cursor End value, there is no text cursor displayed. If the Text Cursor Start value is equal to the Text Cursor End value, the text cursor occupies a single scanline.

NOTE: '?' in the above register address is 'B' in Monochrome mode and 'D' in Color mode.

6.13 CRB: Text Cursor End Register

I/O Port Address: 3?5

Index: B

Bit	Description
7	Reserved
6	Text Cursor Skew [1]
5	Text Cursor Skew [0]
4	Text Cursor End [4]
3	Text Cursor End [4]
2	Text Cursor End [4]
1	Text Cursor End [4]
0	Text Cursor End [4]

This register specifies the scanline within the character cell where the text cursor is to end. It also contains a field that allows the text cursor to be skewed from the location specified in CRE and CRF.

Bit	Description
7	Reserved
6:5	Text Cursor Skew [1:0]: This two-bit field specifies a delay, in character clocks, from the Text Cursor Location specified in CRE and CRF to the actual cursor.
4:0	Text Cursor End [4:0]: This field specifies the scanline within the Character where the text cursor is to end. A value greater than the character cell height yields an effective ending value equal to the cell height.

NOTE: '?' in the above register address is 'B' in Monochrome mode and 'D' in Color mode.

6.14 CRC: Screen Start Address High Register

I/O Port Address: 3?5

Index: C

Bit	Description
7	Screen Start A Address [15]
6	Screen Start A Address [14]
5	Screen Start A Address [13]
4	Screen Start A Address [12]
3	Screen Start A Address [11]
2	Screen Start A Address [10]
1	Screen Start A Address [9]
0	Screen Start A Address [8]

This register, and CRD, specify the location in display memory where the data to be displayed on the screen begins.

Bit	Description
7:0	Screen Start A Address [15:8]: The Screen Start A field specifies the location in display memory where the screen begins. This register contains bits 15:8 of this value; bits 7:0 are in register CRD; bits 17:16 are in CR1B. Refer to Figure 6-1 and Table 6-2 for a summary of CRTC Timing registers.

NOTE: '?' in the above register address is 'B' in Monochrome mode and 'D' in Color mode.

6.15 CRD: Screen Start Address Low Register

I/O Port Address: 3?5

Index: D

Bit	Description
7	Screen Start A Address [7]
6	Screen Start A Address [6]
5	Screen Start A Address [5]
4	Screen Start A Address [4]
3	Screen Start A Address [3]
2	Screen Start A Address [2]
1	Screen Start A Address [1]
0	Screen Start A Address [0]

This register, and CRC, specify the location in display memory where the data to be displayed on the screen begins.

Bit	Description
7:0	Screen Start A Address [7:0]: The Screen Start A field specifies the location in display memory where the screen begins. This register contains bits 7:0 of this value; bits 15:8 are in register CRC; bits 18:16 are in CR1B. Refer to Figure 6-1 and Table 6-2 for a summary of CRTC Timing registers.

NOTE: '?' in the above register address is 'B' in Monochrome mode and 'D' in Color mode.

6.16 CRE: Text Cursor Location High Register

I/O Port Address: 3?5

Index: E

Bit	Description
7	Text Cursor Location [15]
6	Text Cursor Location [14]
5	Text Cursor Location [13]
4	Text Cursor Location [12]
3	Text Cursor Location [11]
2	Text Cursor Location [10]
1	Text Cursor Location [9]
0	Text Cursor Location [8]

This register, with CRF, specifies the location in display memory where the text cursor is to be displayed.

Bit	Description
7:0	<p>Text Cursor Location [15:8]: The Text Cursor Location is a 16-bit field that specifies the location in display memory where the text cursor is to be displayed. This register contains bits 15:8 of this field; CRF contains bits 7:0.</p> <p>NOTE: The value contained in this field is an address in display memory, not an offset from the beginning of the screen. If the value of Screen A Start is changed without a compensating change in the Text Cursor Location field, the text cursor moves on the screen.</p> <p>Refer to Figure 6-1 and Table 6-2 for a summary of CRTC Timing registers.</p>

NOTE: '?' in the above register address is 'B' in Monochrome mode and 'D' in Color mode.

6.17 CRF: Text Cursor Location Low Register

I/O Port Address: 3?5

Index: F

Bit	Description
7	Text Cursor Location [7]
6	Text Cursor Location [6]
5	Text Cursor Location [5]
4	Text Cursor Location [4]
3	Text Cursor Location [3]
2	Text Cursor Location [2]
1	Text Cursor Location [1]
0	Text Cursor Location [0]

This register, with CRE, specifies the location in display memory where the text cursor is to be displayed.

Bit	Description
7:0	Text Cursor Location [7:0]: The Text Cursor Location is a 16-bit field that specifies the location in display memory where the text cursor is to be displayed. This register contains bits 7:0 of this field. Refer to Figure 6-1 and Table 6-2 for a summary of CRTC Timing registers.

NOTE: '?' in the above register address is 'B' in Monochrome mode and 'D' in Color mode.

6.18 CR10: Vertical Sync Start Register

I/O Port Address: 3?5

Index: 10

Bit	Description
7	Vertical Sync Start [7]
6	Vertical Sync Start [6]
5	Vertical Sync Start [5]
4	Vertical Sync Start [4]
3	Vertical Sync Start [3]
2	Vertical Sync Start [2]
1	Vertical Sync Start [1]
0	Vertical Sync Start [0]

The Vertical Sync Start field specifies the scanline where the Vertical Sync pulse becomes active. This register contains the low-order eight bits of that field.

Bit	Description
7:0	Vertical Sync Start [7:0]: The Vertical Sync field specifies the scanline where the Vertical Sync pulse becomes active. This register contains bits 7:0 of that field. This register is extended by the bits in CR7. Refer to Figure 6-1 and Table 6-2 for a summary of CRTC Timing registers.

NOTE: '?' in the above register address is 'B' in Monochrome mode and 'D' in Color mode.

6.19 CR11: Vertical Sync End Register

I/O Port Address: 3?5

Index: 11

Bit	Description
7	Write Protect CR7-CR0
6	Refresh Cycle Control
5	Disable Vertical Interrupt
4	Clear Vertical Interrupt
3	Vertical Sync End [3]
2	Vertical Sync End [2]
1	Vertical Sync End [1]
0	Vertical Sync End [0]

This register specifies the scanline where the Vertical Sync pulse is to become inactive, thereby effectively specifying the Vertical Sync pulse width. In addition, this register contains controls for the interrupt and two miscellaneous control bits.

Bit	Description
7	<p>Write Protect CR7–CR0: If this bit is programmed to '1', registers CR0–CR7 cannot be written. Writes addressed to those registers are ignored. CR7[4] (Line Compare Extension) can always be written. If this bit is programmed to '0', registers CR0–CR7 can be written normally.</p> <p>For the CL-GD5425 only, these registers can be write-protected by programming GRE[7] to '1'. See the description of GRE in Chapter 9, "Extension Registers".</p>
6	<p>Refresh Cycle Control: If this bit is programmed to '1', five refresh cycles are executed per scanline. If this bit is programmed to '0', three refresh cycles are executed per scanline.</p>
5	<p>Disable Vertical Interrupt: If this bit is programmed to '1', the vertical interrupt is disabled. In this case, the Interrupt Request pin can never go active. If this bit is programmed to '0', the vertical interrupt is enabled and functions normally.</p>
4	<p>Clear Vertical Interrupt: If this bit is programmed to '0', the Interrupt Pending bit (FEAT[7]) is cleared to '0' and the Interrupt Request pin is forced inactive. Programming this bit to '1' allows the next occurrence of the interrupt. This may be done immediately after programming it to '0'.</p>
3:0	<p>Vertical Sync End [3:0]: This field determines the width of the Vertical Sync pulse. The least-significant four bits of the Scanline Counter are compared with the contents of this field. When a match occurs, the Vertical Sync pulse is ended. Note the Vertical Sync pulse is limited to 15 scanlines.</p> <p>The value to be programmed into this register can be calculated by subtracting the desired Sync width from the value programmed into the Vertical Sync Start field. Never program the Sync pulse to extend past the Vertical Total. Refer to Figure 6-1 and Table 6-2 for a summary of CRTC Timing registers.</p>

NOTE: '?' in the above register address is 'B' in Monochrome mode and 'D' in Color mode.

6.20 CR12: Vertical Display End Register

I/O Port Address: 3?5

Index: 12

Bit	Description
7	Vertical Display End [7]
6	Vertical Display End [6]
5	Vertical Display End [5]
4	Vertical Display End [4]
3	Vertical Display End [3]
2	Vertical Display End [2]
1	Vertical Display End [1]
0	Vertical Display End [0]

The Vertical Display End field is used to specify the scanline where the display is to end.

Bit	Description
7:0	Vertical Display End [7:0]: The Vertical Display End field is used to specify the scanline where the display is to end. This register contains the least-significant eight bits of this field. Refer to Figure 6-1 and Table 6-2 for a summary of CRTC Timing registers.

NOTE: '?' in the above register address is 'B' in Monochrome mode and 'D' in Color mode.

6.21 CR13: Offset Register

I/O Port Address: 3?5

Index: 13

Bit	Description
7	Offset [7]
6	Offset [6]
5	Offset [5]
4	Offset [4]
3	Offset [3]
2	Offset [2]
1	Offset [1]
0	Offset [0]

This register specifies the distance in display memory between the beginnings of adjacent character rows or scanlines. This is sometimes referred to as display 'pitch'.

Bit	Description
7:0	Offset [7:0]: This register specifies the distance in display memory between the beginnings of adjacent character rows or scanlines. This field with CR1B[4] is extended to nine bits. At the beginning of each scanline (except the first), the address where data fetching begins is calculated by adding the contents of this register to the beginning address of the previous scanline or character row. The offset is left-shifted one or two bit positions, depending on CR17[6].

NOTE: '?' in the above register address is 'B' in Monochrome mode and 'D' in Color mode.

6.22 CR14: Underline Row Scanline Register

I/O Port Address: 3?5

Index: 14

Bit	Description
7	Reserved
6	Doubleword Mode
5	Count by Four
4	Underline Scanline [4]
3	Underline Scanline [3]
2	Underline Scanline [2]
1	Underline Scanline [1]
0	Underline Scanline [0]

This register is used to specify the underline scanline.

Bit	Description
7	Reserved
6	Doubleword Mode: When this bit is programmed to '1', doubleword addresses are forced. The CRTC Memory Address Counter is rotated left two bit positions, so that Display Memory Address bits 1 and 0 are sourced from CRTC Address Counter bits 13 and 12, respectively. When this bit is programmed to '0', CR17[6] controls whether the chip uses byte or word addresses.
5	Count by Four: This bit must be programmed to '1' when Doubleword mode is enabled, to clock the Memory Address Counter with the character clock divided by four. This bit must be programmed to '0' when Doubleword mode is not enabled.
4:0	Underline Scanline [4:0]: This field specifies the scanline within the Character Cell where the underline occurs.

NOTE: '?' in the above register address is 'B' in Monochrome mode and 'D' in Color mode.

6.23 CR15: Vertical Blank Start Register

I/O Port Address: 3?5

Index: 15

Bit	Description
7	Vertical Blank Start [7]
6	Vertical Blank Start [6]
5	Vertical Blank Start [5]
4	Vertical Blank Start [4]
3	Vertical Blank Start [3]
2	Vertical Blank Start [2]
1	Vertical Blank Start [1]
0	Vertical Blank Start [0]

This register specifies the scanline where Blank is to become active.

Bit	Description
7:0	Vertical Blank Start [7:0]: The Vertical Blank Start field specifies the scanline where Vertical Blank is to begin. The low-order eight bits of that field are in this register. Refer to Table 6-1 and Table 6-2 for a summary of CRTC Timing registers.

NOTE: '?' in the above register address is 'B' in Monochrome mode and 'D' in Color mode.

6.24 CR16: Vertical Blank End Register

I/O Port Address: 3?5

Index: 16

Bit	Description
7	Vertical Blank End [7]
6	Vertical Blank End [6]
5	Vertical Blank End [5]
4	Vertical Blank End [4]
3	Vertical Blank End [3]
2	Vertical Blank End [2]
1	Vertical Blank End [1]
0	Vertical Blank End [0]

The Vertical Blank End field specifies the scanline where Vertical Blank is to end.

Bit	Description
7:0	<p>Vertical Blank End [7:0]: The Vertical Blank End field specifies the scanline where Vertical Blank is to end. This register contains the low-order eight bits of that field. If CR1B[5] is programmed to '0', this register contains the entire field.</p> <p>The contents of the Vertical Blank End field are compared to the Scanline Counter to determine when to terminate Vertical Blank. This limits the duration of Vertical Blank to 255 scanlines if CR1B[5] is programmed to '0'. Refer to Figure 6-1 and Table 6-2 for a summary of CRTC Timing registers.</p>

NOTE: '?' in the above register address is 'B' in Monochrome mode and 'D' in Color mode.

6.25 CR17: Mode Control Register

I/O Port Address: 3?5

Index: 17

Bit	Description
7	Timing Enable
6	Byte/Word Mode
5	Address Wrap
4	Reserved
3	Count by Two
2	Multiply Vertical Registers by Two
1	Select Row Scan Counter
0	Compatibility Mode (CGA) Support

This register contains miscellaneous control bits.

Bit	Description
7	Timing Enable: If this bit is programmed to '1', CRTC Timing Logic is enabled and functions normally. If this bit is programmed to '0', CRTC Timing Logic is disabled.
6	Byte/Word Mode: If this bit is programmed to '1', the contents of the CRTC Address Counter are sent to the display memory without being rotated. If this bit is programmed to '0', the contents of the CRTC Address Counter are rotated left one bit position before being sent to display memory.
5	Address Wrap: If CR17[6] is programmed to '1', this bit is ignored. If CR17[6] is programmed to '0' and this bit is programmed to '1', the left rotation described above involves 16 bits of the CRTC Address Counter. If CR17[6] is programmed to '0' and this bit is programmed to '0', the left rotation described above involves 14 bits of the CRTC Address Counter.
4	Reserved
3	Count by Two: If this bit is programmed to '1', the CL-GD542X clocks the Memory Address Counter with the character clock divided by two. If this bit is programmed to '0', the CL-GD542X clocks the Memory Address Counter with the character clock.
2	Multiply Vertical Registers by Two: If this bit is programmed to '1', the Scanline Counter is clocked with Horizontal Sync divided by two. This allows the number of scanlines to be doubled to 2048. Observe that all the periods are even multiples of two scanlines. If this bit is programmed to '0', the Scanline Counter is clocked with Horizontal Sync.

6.25 CR17: Mode Control Register (*cont.*)

Bit	Description
1	Select Row Scan Counter: If this bit is programmed to '0', the Row Scan Counter[1] is substituted for the CRTC Address Counter[14]. This provides for Hercules™ compatibility. If this bit is programmed to '1', the substitution described above does not occur.
0	Compatibility Mode (CGA) Support: If this bit is programmed to '0', Row Scan Counter [0] is substituted for CRTC Address Counter [14]. This provides for CGA compatibility. If this bit is programmed to '1', the substitution described above does not occur.

NOTE: '?' in the above register address is 'B' in Monochrome mode and 'D' in Color mode.

6.26 CR18: Line Compare Register

I/O Port Address: 3?5

Index: 18

Bit	Description
7	Line Compare [7]
6	Line Compare [6]
5	Line Compare [5]
4	Line Compare [4]
3	Line Compare [3]
2	Line Compare [2]
1	Line Compare [1]
0	Line Compare [0]

The Line Compare field is used to specify where Screen A terminates and Screen B begins.

Bit	Description
7:0	<p>Line Compare [7:0]: The Line Compare field is used to specify where Screen A terminates and Screen B begins. This register contains the eight least-significant bits of this field. The Line Compare field can be used to implement a vertically split screen. The top portion of the screen is called Screen A and can begin anywhere in display memory. Screen A can be panned and scrolled on a pixel basis. The bottom portion of the screen is called Screen B. Screen B always begins at location '0' in display memory and cannot be panned or scrolled.</p> <p>When the CL-GD5425 is configured for TV-Out mode, the line compare and cursor vertical position functions can be used as though interlace and scaling or expansion were not used. No special software adjustments are required for compatibility between TV and VGA configurations.</p> <p>Refer to Figure 6-1 and Table 6-2 for a summary of CRTC Timing registers.</p>

NOTE: '?' in the above register address is 'B' in Monochrome mode and 'D' in Color mode.

6.27 CR22: Graphics Data Latches Readback Register

I/O Port Address: 3?5

Index: 22

Bit	Description
7	Graphics Data Latch n Readback [7]
6	Graphics Data Latch n Readback [6]
5	Graphics Data Latch n Readback [5]
4	Graphics Data Latch n Readback [4]
3	Graphics Data Latch n Readback [3]
2	Graphics Data Latch n Readback [2]
1	Graphics Data Latch n Readback [1]
0	Graphics Data Latch n Readback [0]

This register address is used to read the four Graphics Controller Data Latches.

Bit	Description
7:0	Graphics Data Latch n Readback [7:0]: This read-only register can be used to read back one of the four Graphics Controller Data Latches. The latch is selected with GR4[1:0]. These latches are loaded whenever display memory is read by the CPU.

NOTE: '?' in the above register address is 'B' in Monochrome mode and 'D' in Color mode.

6.28 CR24: Attribute Controller Toggle Readback Register

I/O Port Address: 3?5

Index: 24

Bit	Description
7	Attribute Controller Toggle
6	Reserved
5	Reserved
4	Reserved
3	Reserved
2	Reserved
1	Reserved
0	Reserved

This read-only register provides access to the Attribute Controller Toggle.

Bit	Description
7	Attribute Controller Toggle: If this bit is '1', the Attribute Controller reads or writes a data value on the next access. If this bit is '0', the Attribute Controller reads or writes an index value on the next access.
6:0	Reserved

NOTE: '?' in the above register address is 'B' in Monochrome mode and 'D' in Color mode.

6.29 CR26: Attribute Controller Index Readback Register

I/O Port Address: 3?5

Index: 26

Bit	Description
7	Reserved
6	Reserved
5	Video Enable
4	Attribute Controller Index [4]
3	Attribute Controller Index [3]
2	Attribute Controller Index [2]
1	Attribute Controller Index [1]
0	Attribute Controller Index [0]

This read-only register provides access to the current Attribute Controller Index.

Bit	Description
7:6	Reserved
5	Video Enable: This bit follows the Video Enable bit in the Attribute Controller Index register.
4:0	Attribute Controller Index [4:0]: This field follows the index in the Attribute Controller Index register.

NOTE: '?' in the above register address is 'B' in Monochrome mode and 'D' in Color mode.

7. VGA GRAPHICS CONTROLLER REGISTERS

The CL-GD542X VGA Graphics Controller registers are summarized in the following table. Please note that there are Extension registers that are accessed using the VGA Graphics Controller Port.

Table 7-1. VGA Graphics Controller Registers Quick Reference

Abbreviation	Register Name	Index	Port	Page
GRX	Graphics Controller Index	—	3CE	7-3
GR0	Set/Reset	0	3CF	7-4
GR1	Set/Reset Enable	1	3CF	7-5
GR2	Color Compare	2	3CF	7-6
GR3	Data Rotate	3	3CF	7-7
GR4	Read Map Select	4	3CF	7-8
GR5	Mode	5	3CF	7-9
GR6	Miscellaneous	6	3CF	7-12
GR7	Color Don't Care	7	3CF	7-13
GR8	Bit Mask	8	3CF	7-14

7.1 GRX: Graphics Controller Index Register

I/O Port Address: 3CE

Index: –

Bit	Description
7	Reserved
6	Reserved
5	Graphics Controller Index [5]
4	Graphics Controller Index [4]
3	Graphics Controller Index [3]
2	Graphics Controller Index [2]
1	Graphics Controller Index [1]
0	Graphics Controller Index [0]

This register is used to specify the register in the VGA Graphics Controller group or the Extension register accessed by the next I/O read or I/O write to 3CF.

Bit	Description
7:6	Reserved
5:0	Graphics Controller Index [5:0]: This field specifies the register in the VGA Graphics Controller group or the Extension register accessed by the next I/O read or I/O write to 3CF. Register indices above 1F are valid for the CL-GD5426/'28/'29 only.

7.2 GR0: Set/Reset Register

I/O Port Address: 3CF

Index: 0

Bit	Description
7	Reserved/ Write Mode 5 Background [7]
6	Reserved/ Write Mode 5 Background [6]
5	Reserved/ Write Mode 5 Background [5]
4	Reserved/ Write Mode 5 Background [4]
3	Set/Reset Plane 3/Write Mode 5 Background [3]
2	Set/Reset Plane 2/Write Mode 5 Background [2]
1	Set/Reset Plane 1/Write Mode 5 Background [1]
0	Set/Reset Plane 0/Write Mode 5 Background [0]

This register specifies the values to be written into the respective display memory planes when the processor executes a Write mode 0 or 3 operation. If Extended Write mode 5 is selected, this register specifies the background color.

Bit	Description
7:4	Reserved: If Extended Write mode 5 is not selected, these bits are reserved. If GRB[2] = 0, writes to these bits are ignored and reads from these bits return zeroes. If GRB[2] = 1, these bits are read/write, but the contents are not used.
3:0	Set/Reset Plane [3:0]: If Extended Write mode 5 is not selected, these bits control the values written into the respective display memory planes for Write modes 0 and 3. Refer to the description of GR5 for an overview of the Write modes.
7:0	Write Mode 5 Background [7:0]: If Extended Write mode 5 is selected, these bits specify the background color. Refer to the description of GR5 for an overview of the Write modes.

7.3 GR1: Set/Reset Enable Register

I/O Port Address: 3CF

Index: 1

Bit	Description
7	Reserved/ Write Mode 4, 5 Foreground [7]
6	Reserved/ Write Mode 4, 5 Foreground [6]
5	Reserved/ Write Mode 4, 5 Foreground [5]
4	Reserved/ Write Mode 4, 5 Foreground [4]
3	Enable SR Plane 3/ Write Mode 4, 5 Foreground [3]
2	Enable SR Plane 2/ Write Mode 4, 5 Foreground [2]
1	Enable SR Plane 1/ Write Mode 4, 5 Foreground [1]
0	Enable SR Plane 0/ Write Mode 4, 5 Foreground [0]

This register is used with GR0 to determine the values to be written into the respective display memory planes when Write mode 0 is selected. If Extended Write modes 4 or 5 are selected, this register defines the foreground color.

Bit	Description
7:4	Reserved: If Extended Write modes 4 or 5 are not selected, these bits are reserved. If GRB[2] = 0, writes to these bits are ignored and reads from these bits return zeroes. If GRB[2] = 1, these bits are read/write, but the contents are not used.
3:0	Enable SR Plane [3:0]: These bits are used with GR0 to determine the values written into the display memory planes when Write mode 0 is selected. If a bit in this field is programmed to '1', the corresponding value in GR0 is written into the corresponding display memory plane. If a bit in this field is programmed to '0', the corresponding value from the CPU data bus is written into the corresponding display memory plane. Refer to the description of GR5 for an overview of the Write modes. For the CL-GD5429 only, if SR7[0] is programmed to '1', the value from the CPU bus is written, regardless of the contents of this field.
7:0	Write Mode 4, 5 Foreground [7:0]: If Extended Write mode 4 or 5 is selected, these bits specify the foreground color. Refer to the description of GR5 for an overview of the Write modes.

7.4 GR2: Color Compare Register

I/O Port Address: 3CF

Index: 2

Bit	Description
7	Reserved
6	Reserved
5	Reserved
4	Reserved
3	Color Compare Plane [3]
2	Color Compare Plane [2]
1	Color Compare Plane [1]
0	Color Compare Plane [0]

This register specifies the color compare value for Read mode 1.

Bit	Description
7:4	Reserved
3:0	Color Compare Plane [3:0]: When a Read mode 1 takes place, these four bits are compared with each of eight bits from the corresponding display memory planes under the mask in GR7. Refer to the description of GR5 for an overview of the Read modes.

7.5 GR3: Data Rotate Register

I/O Port Address: 3CF

Index: 3

Bit	Description
7	Reserved
6	Reserved
5	Reserved
4	Function Select [1]
3	Function Select [0]
2	Rotate Count [2]
1	Rotate Count [1]
0	Rotate Count [0]

This register contains two fields that are used with Write modes 0 and 3.

Bit	Description
7:5	Reserved
4:3	Function Select [1:0]: This field controls the operation that takes place between the data in the latches and the data from the CPU or SR logic. The result of this operation is written into display memory. This field is used for Write mode 0 only. The operations are summarized in the following table:

GR3[4]	GR3[3]	Operation
0	0	None: The data in the latches are ignored.
0	1	Logical 'AND'
1	0	Logical 'OR'
1	1	Logical 'XOR'

2:0	Rotate Count [2:0]: This field allows data from the CPU bus to be rotated up to seven bit positions prior to being altered by the SR logic. Refer to the description of GR5 for an overview of the Write modes.
-----	--

7.6 GR4: Read Map Select Register

I/O Port Address: 3CF

Index: 4

Bit	Description
7	Reserved
6	Reserved
5	Reserved
4	Reserved
3	Reserved
2	Reserved
1	Plane Select [1]
0	Plane Select [0]

This register is used to specify the display memory plane for Read mode 0.

Bit	Description
7:2	Reserved
1:0	Plane Select [1:0]: This field specifies the display memory plane for Read mode 0. The values are shown in the following table:

GR4[1]	GR4[0]	Plane Selected
0	0	0
0	1	1
1	0	2
1	1	3

7.7 GR5: Mode Register

I/O Port Address: 3CF

Index: 5

Bit	Description
7	Reserved
6	256-color Mode
5	Shift Register Mode
4	Odd/Even
3	Read Mode
2	Reserved/Write Mode [2]
1	Write Mode [1]
0	Write Mode [0]

This register specifies the Write mode and Read mode. In addition, it controls the configuration of the Data Shift registers.

Bit	Description
7	Reserved
6	256-color Mode: If this bit is programmed to '1', the Video Shift registers are configured for 256-color Video modes. GR5[5] is ignored. If this bit is programmed to '0', the Video Shift registers are configured for 16-, 4-, or 2-color modes.
5	Shift Register Mode: If this bit is programmed to '1', the Video Shift registers are configured for CGA compatibility. This is used for Video modes 4 and 5. If this bit is programmed to '0', the Video Shift registers are configured for EGA compatibility.
4	Odd/Even: If this bit is programmed to '1', the Graphics Controller is configured for Odd/Even Addressing mode. This bit should always be programmed to the opposite value as SR4[2].

7.7 GR5: Mode Register *(cont.)*

Bit	Description
3	<p>Read Mode: This bit specifies whether the chip is in Read mode 0 or Read mode 1.</p> <p>Read Mode 0: If this bit is programmed to '0', the CPU reads data directly from display memory. Each read returns eight adjacent bits of the display memory plane specified in GR4[1:0]. The color-match logic is not used in Read mode 0. Note that an I/O read of CR22 forces a Read mode 0 operation.</p> <p>Read Mode 1: If this bit is programmed to '1', the CPU reads the results of the color compare logic. Read mode 1 allows eight adjacent pixels (16-color modes) to be compared to a specified color value in a single operation. Each of the eight bits returned to the processor indicates the result of a compare between the four bits of the Color Compare (GR2[3:0]) and the bits from the four display memory planes. If the four bits of the Color Compare match the four bits from the display memory planes, '1' is returned for the corresponding bit position. If any bits in the Color Don't Care (GR7[3:0]) are zeroes, the corresponding plane comparison is forced to match.</p>
2:0	<p>Write Mode [2:0]: These three bits specify the Write mode or Extended Write mode. If GRB[2] is programmed to '0', bit 2 is forced to '0'. Only Write modes 0 through 3 are available.</p> <p>Write Mode 0: Each of the four display memory planes is written with the CPU data rotated by the number of counts in GR3[2:0]. If a bit in GR1[3:0] is programmed to '1', the corresponding plane is written with the contents of the corresponding bit in GR0[3:0]. The contents of the data latches may be combined with the data from the SR logic under control of GR3[4:3]. Bit planes are enabled with SR2[3:0]. Bit positions are enabled with GR8.</p> <p>Write Mode 1: Each of the four display memory planes is written with the data in the Data Latches. The Data Latches had been loaded from display memory with a previous read. GR8 is ignored in Write mode 1.</p> <p>Write Mode 2: Display memory planes 3:0 are written with value of Data bits 3:0, respectively. The four bits are replicated eight times each to write up to eight adjacent pixels. Bit planes are enabled with SR2[3:0]. Bit positions are enabled with GR8. The Data Rotator, SR logic, and Function Select fields are ignored in Write mode 2.</p>

7.7 GR5: Mode Register *(cont.)*

Bit	Description
2:0 <i>(cont.)</i>	<p>Write Mode 3: The data for each display memory plane comes from the corresponding bit of GR0[3:0]. The bit-position-enable field is formed with the logical AND of GR8 and the rotated CPU data. The SR and Function Select fields are ignored in Write mode 3.</p> <p>Extended Write Mode 4: The contents of GR1[7:0] are written into up to eight adjacent pixels. The CPU data is used to control whether pixels are written. If a bit in the CPU is '1', the corresponding pixel is written. If a bit in the CPU data is '0', the corresponding pixel is not changed. This mode is intended for 256-color text expansion where the background is to be preserved. In the CL-GD5422/'24/'25/'26/'28/'29, it can also be used for 64K-color text expansion.</p> <p>Extended Write Mode 5: The contents of either GR1[7:0] or GR0[7:0] are written into each of eight adjacent pixels. The choice between GR1 and GR0 is made for each of the eight pixels according the value of the corresponding bit of the CPU data. This is summarized in the following table. This mode is intended for 256-color text expansion where both the foreground and background are to be written. In the CL-GD5422/'24/'25/'26/'28/'29, it can also be used for 64K-color text expansion.</p>

CPU Data	GR0/GR1	Note
0	GR0	Background
1	GR1	Foreground

7.8 GR6: Miscellaneous Register

I/O Port Address: 3CF

Index: 6

Bit	Description
7	Reserved
6	Reserved
5	Reserved
4	Reserved
3	Memory Map [1]
2	Memory Map [0]
1	Chain Odd Maps to Even
0	Graphics Mode

This register contains miscellaneous control bits.

Bit	Description
-----	-------------

7:4	Reserved
-----	-----------------

3:2	Memory Map [1:0]: This field specifies the beginning address and size of the display memory in the Host Address Space. This is summarized in the following table:
-----	--

GR6[3]	GR6[2]	Memory Map	Beginning Address	Length	Mode(s)
0	0	0	A000:0	128K	Extended
0	1	1	A000:0	64K	EGA/VGA
1	0	2	B000:0	32K	Hercules
1	1	3	B800:0	32K	CGA

1	Chain Odd Maps to Even: When this bit is programmed to '1', CPU Address bit 0 is replaced with a higher-order address bit. This causes even host addresses to access Planes 0 and 2, and odd host addresses to access Planes 1 and 3. This mode is useful for MDA emulation.
---	---

0	Graphics Mode: If this bit is programmed to '1', the CL-GD542X functions in Graphics (A.P.A.) modes. If this bit is programmed to '0', the device functions in Text (A.N.) modes.
---	--

7.9 GR7: Color Don't Care Register

I/O Port Address: 3CF

Index: 7

Bit	Description
7	Reserved
6	Reserved
5	Reserved
4	Reserved
3	Color Don't Care Plane [3]
2	Color Don't Care Plane [2]
1	Color Don't Care Plane [1]
0	Color Don't Care Plane [0]

This register is used with GR2 for Read mode 1 accesses.

Bit	Description
7:4	Reserved
3:0	Color Don't Care Plane [3:0]: These four bits are used to control whether the four planes are involved in color compares. If a bit is programmed to '1', the corresponding plane is involved; if a bit is programmed to '0', the corresponding plane is not involved. Refer to the description of GR5 for an overview of the Read modes.

7.10 GR8: Bit Mask Register

I/O Port Address: 3CF

Index: 8

Bit	Description
7	Write Enable [7]
6	Write Enable [6]
5	Write Enable [5]
4	Write Enable [4]
3	Write Enable [3]
2	Write Enable [2]
1	Write Enable [1]
0	Write Enable [0]

This register is used to control writing to display memory on a bit basis in Write modes 0, 2, and 3.

Bit	Description
7:0	Write Enable [7:0]: Each bit in this register controls whether the corresponding bit in display memory is written in Write modes 0, 2, and 3. If a bit is programmed to '1', the corresponding bit in display memory is written. If a bit is programmed to '0', the corresponding bit in display memory is not written. This write protection is orthogonal to that provided by SR2.

8. ATTRIBUTE CONTROLLER REGISTERS

The CL-GD542X Attribute Controller registers are summarized in the following table:

Table 8-1. Attribute Controller Registers Quick Reference

Abbreviation	Register Name	Index	Port	Page
ARX	Attribute Controller Index	—	3C0/3C1	8-3
AR0–ARF	Attribute Controller Palette	0:F	3C0/3C1	8-4
AR10	Attribute Controller Mode	10	3C0/3C1	8-5
AR11	Overscan (Border) Color	11	3C0/3C1	8-7
AR12	Color Plane Enable	12	3C0/3C1	8-8
AR13	Pixel Panning	13	3C0/3C1	8-9
AR14	Color Select	14	3C0/3C1	8-10

8.1 ARX: Attribute Controller Index Register

I/O Port Address: 3C0 (Write) 3C1 (Read)

Index: –

Bit	Description
7	Reserved
6	Reserved
5	Video Enable
4	Attribute Controller Index [4]
3	Attribute Controller Index [3]
2	Attribute Controller Index [2]
1	Attribute Controller Index [1]
0	Attribute Controller Index [0]

This register is used to specify the register in the Attribute Controller block that is accessed with the next I/O read or I/O write to 3C1 or 3C0, respectively. Observe that the same port addresses are used for the index and data for the Attribute Controller block, unlike the other blocks where the Index and Data registers are at different addresses. Alternate writes toggle between index and data. It is possible to read the toggle at CR24, and the index value at CR26.

Bit	Description
7:6	Reserved
5	Video Enable: When this bit is programmed to '0', the screen displays the color indicated by the Overscan register (AR11). When this bit is programmed to '1', normal video is displayed.
4:0	Attribute Controller Index [4:0]: This field is the index into the Data registers in the Attribute Controller block.

8.2 AR0-ARF: Attribute Controller Palette Registers

I/O Port Address: 3C0 (Write) 3C1 (Read)

Index: 0:F

Bit	Description
7	Reserved
6	Reserved
5	Secondary Red
4	Secondary Green/Intensity
3	Secondary Blue/ Mono
2	Red
1	Green
0	Blue

In 16-color Text and Graphics modes, these digital palette entries are chosen by the four bits of pixel data, and point to Video RAM entries. The Video RAM entries are normally programmed so that the DAC Outputs reflect these values. That is, the Video RAM is programmed to simulate standard EGA colors.

Bit	Description
7:6	Reserved
5:0	Palette Entries

8.3 AR10: Attribute Controller Mode Register

I/O Port Address: 3C0 (Write) 3C1 (Read)

Index: 10

Bit	Description
7	AR14 Video Source Enable
6	Pixel Double Clock Select
5	Pixel Panning Compatibility
4	Reserved
3	Blink Enable
2	Line Graphics Enable
1	Display Type
0	Graphics Mode

This register contains some miscellaneous control bits for the Attribute Controller.

Bit	Description
7	AR14 Video Source Enable: If this bit is programmed to '1', AR14[1:0] are used as the source for the Lookup Table Address bits [5:4]. This allows the rapid selection of four 16-color palettes. If an 8-, 16-, or 24-bit Pixel mode is chosen, this bit is ignored. If this bit is programmed to '0', the Palette registers AR0–F[5:4] are used as the source for the LUT Address bits [5:4].
6	Pixel Double Clock Select: If this bit is programmed to '1', pixels are clocked on every other clock cycle and AR0–F is bypassed. This is used with mode 13. The Sequencer Logic operates at twice the pixel rate. If this bit is programmed to '0', pixels are clocked on every cycle.
5	Pixel Panning Compatibility: If this bit is programmed to '1', a Line Compare match in the CRTIC forces the output of the Pixel Panning register to '0' until the next VSYNC occurs. This allows the panning of Screen A without Screen B. If this bit is programmed to '0', the two parts of a split screen pan together.
4	Reserved
3	Blink Enable: If this bit is programmed to '1', character blinking is enabled at the Vertical Refresh Frequency divided by 32. If this bit is programmed to '0', character blinking is disabled.
2	Line Graphics Enable: If this bit is programmed to '1', the ninth bit of a nine-bit-wide character cell is made the same as the eighth bit for character codes in the range C0 through DF. If this bit is programmed to '0', the ninth bit of nine-bit-wide character cell is the same as the background.

8.3 AR10: Attribute Controller Mode Register *(cont.)*

Bit	Description
-----	-------------

1	<p>Display Type: This bit is useful only if the CL-GD542X is in Alphanumeric (A.N.) modes. If this bit is programmed to '1', the contents of the attribute byte are treated as MDA-compatible attributes. The following table shows examples of monochrome attributes:</p>
---	---

Blink Bit 7	Background Bit [6:4]	Intensity Bit 3	Foreground Bit [2:0]	Hex Code	Attribute
0	0	0	7	07	Normal
0	0	1	7	0F	Intense
0	0	0	1	01	Underline
0	0	1	1	09	Underline intense
0	7	0	0	70	Reverse
1	7	0	0	F0	Blinking reverse

If this bit is programmed to '0', the contents of the attribute byte are treated as color attributes.

0	<p>Graphics Mode: If this bit is programmed to '1', the Attribute Controller functions in Graphics (A.P.A.) mode. If this bit is programmed to '0', the Attribute Controller functions in A.N. modes.</p>
---	--

8.4 AR11: Overscan (Border) Color Register

I/O Port Address: 3C0 (Write) 3C1 (Read)

Index: 11

Bit	Description
7	Reserved
6	Reserved
5	Secondary Red
4	Secondary Green
3	Secondary Blue
2	Red
1	Green
0	Blue

This register points to the entry in the LUT that defines the border color. Typically, the LUT entries are programmed so that the color defined above is the color that actually results. The border is defined as that portion of the raster between blanking and active video, on all four sides. Refer to Figure 6-1 on page 6-5 at register CR0.

Bit	Description
7:6	Reserved
5:0	Border Color [5:0]: Either four or six of these bits are used to select the LUT entry for the border color in CGA and EGA modes.

8.5 AR12: Color Plane Enable Register

I/O Port Address: 3C0 (Write) 3C1 (Read)

Index: 12

Bit	Description
7	Reserved
6	Reserved
5	Video Status Mux [1]
4	Video Status Mux [0]
3	Enable Plane [3]
2	Enable Plane [2]
1	Enable Plane [1]
0	Enable Plane [0]

This register contains a field that enables the four planes into the Attribute Controller Palette registers. It also contains a field that chooses the inputs for Diagnostic bits in STAT[5:4].

Bit	Description
7:6	Reserved
5:4	Video Status Mux [1:0]: This field chooses the inputs for the Diagnostic bits in STAT[5:4] as indicated in the following table:

AR12[5]	AR12[4]	STAT[5]	STAT[4]
0	0	P[2]	P[0]
0	1	P[5]	P[4]
1	0	P[3]	P[1]
1	1	P[7]	P[6]

3:0	Enable Color Plane [3:0]: If any bit in this field is programmed to '1', the data from the corresponding display memory plane is enabled in the choice of the Attribute Controller Palette register. If any bit in this field is programmed to '0', the data from the corresponding display memory plane is forced to '0' in the choice of the Attribute Controller Palette register.
-----	--

8.6 AR13: Pixel Panning Register

I/O Port Address: 3C0 (Write) 3C1 (Read)

Index: 13

Bit	Description
7	Reserved
6	Reserved
5	Reserved
4	Reserved
3	Pixel Panning [3]
2	Pixel Panning [2]
1	Pixel Panning [1]
0	Pixel Panning [0]

This register specifies the number of pixels the display data that will shift to the left. This field functions in both the Graphics (A.N.) and Alphanumeric (A.P.A.) modes.

Bit	Description
-----	-------------

7:4	Reserved
-----	-----------------

3:0	Pixel Panning [3:0]: This field specifies the number of pixels the display data shifts to the left. This field is interpreted as indicated in the following table:
-----	---

AR13[3:0]	9-Bit Characters	8-Bit Characters	Mode 13
0	1 bit left	(none)	(none)
1	2 bits left	1 bit left	—
2	3 bits left	2 bits left	1 bit left
3	4 bits left	3 bits left	—
4	5 bits left	4 bits left	2 bits left
5	6 bits left	5 bits left	—
6	7 bits left	6 bits left	3 bits left
7	8 bits left	7 bits left	—
8–F	no shift	1 bit right	—

8.7 AR14: Color Select Register

I/O Port Address: 3C0 (Write) 3C1 (Read)

Index: 14

Bit	Description
7	Reserved
6	Reserved
5	Reserved
4	Reserved
3	Color Bit C [7]
2	Color Bit C [6]
1	Color Bit C [5]
0	Color Bit C [4]

This register contains two fields that are involved in the selection of addresses into the LUT.

Bit	Description
7:4	Reserved
3:2	Color Bit C [7:6]: These two bits are concatenated with the six bits from the Attribute Controller Palette register to form the address into the LUT and to drive P[7:6]. These bit are ignored in 8-, 16-, and 24-bit Pixel modes.
1:0	Color Bits C [4:5]: If AR10[7] is programmed to '1', these two bits replace the corresponding two bits from the Attribute Controller Palette register to form the address into the LUT and to drive P[7:6]. If AR10[7] is programmed to '0', these two bits are ignored. These bits are ignored in 8-, 16-, and 24-bit Pixel modes.

9. EXTENSION REGISTERS

The CL-GD542X Extension registers are summarized in Table 9-1.

Table 9-1. Extension Registers Quick Reference

Abbreviation	Register Name	Index	Port	Page
SR2	Enable Writing Pixel Extension ^a	2	3C5	5-7
SR6	Unlock ALL Extensions	6	3C5	9-5
SR7	Extended Sequencer Mode	7	3C5	9-6
SR8	EEPROM Control	8	3C5	9-8
SR9	Scratch-Pad 0	9	3C5	9-10
SRA	Scratch-Pad 1	A	3C5	9-10
SRB	VCLK0 Numerator	B	3C5	9-11
SRC	VCLK1 Numerator	C	3C5	9-11
SRD	VCLK2 Numerator	D	3C5	9-11
SRE	VCLK3 Numerator	E	3C5	9-11
SRF	DRAM Control	F	3C5	9-12
SR10	Graphics Cursor Y Position	10	3C5	9-14
SR11	Graphics Cursor X Position	11	3C5	9-15
SR12	Graphics Cursor Attributes	12	3C5	9-16
SR13	Graphics Cursor Pattern Address Offset	13	3C5	9-17
SR14	Scratch-Pad 2 (<i>CL-GD5425/26/28/29 only</i>)	14	3C5	9-18
SR15	Scratch-Pad 3 (<i>CL-GD5425/26/28/29 only</i>)	15	3C5	9-18
SR16	Performance Tuning (<i>except CL-GD5420</i>)	16	3C5	9-19
SR17	Configuration Readback and Extended Control (<i>CL-GD5428/29 only</i>)	17	3C5	9-21
SR18	Signature Generator Control (<i>except CL-GD5420</i>)	18	3C5	9-22
SR19	Signature Generator Result Low Byte (<i>except CL-GD5420</i>)	19	3C5	9-24
SR1A	Signature Generator Result High Byte (<i>except CL-GD5420</i>)	1A	3C5	9-25
SR1B	VCLK0 Denominator and Post-Scalar Value	1B	3C5	9-26
SR1C	VCLK1 Denominator and Post-Scalar Value	1C	3C5	9-26
SR1D	VCLK2 Denominator and Post-Scalar Value	1D	3C5	9-26
SR1E	VCLK3 Denominator and Post-Scalar Value	1E	3C5	9-26

Table 9-1. Extension Registers Quick Reference(*cont.*)

Abbreviation	Register Name	Index	Port	Page
SR1F	BIOS ROM Write Enable and MCLK Select	1F	3C5	9-27
GR0	Write Mode 5 Background Extension ^b	0	3CF	9-4
GR1	Write Mode 4, 5 Foreground Extension [‡]	1	3CF	9-5
GR9	Offset Register 0	9	3CF	9-29
GRA	Offset Register 1	A	3CF	9-31
GRB	Graphics Controller Mode Extensions	B	3CF	9-32
GRC	Color Key (<i>CL-GD5424/25/26/28/29 only</i>)	C	3CF	9-34
GRD	Color Key Mask (<i>CL-GD5424/25/26/28/29 only</i>)	D	3CF	9-35
GRE	Miscellaneous Control (<i>CL-GD5425/28/29 only</i>)	E	3CF	9-36
GR10	16-bit Pixel Background Color High Byte (<i>except CL-GD5420</i>)	10	3CF	9-38
GR11	16-bit Pixel Foreground Color High Byte (<i>except CL-GD5420</i>)	11	3CF	9-39
GR18	Extended DRAM Controls (<i>CL-GD5429 only</i>)	18	3CF	9-40
GR20	BLT Width Low (<i>CL-GD5426/28/29 only</i>)	20	3CF	9-41
GR21	BLT Width High (<i>CL-GD5426/28/29 only</i>)	21	3CF	9-42
GR22	BLT Height Low (<i>CL-GD5426/28/29 only</i>)	22	3CF	9-43
GR23	BLT Height High (<i>CL-GD5426/28/29 only</i>)	23	3CF	9-44
GR24	BLT Destination Pitch Low (<i>CL-GD5426/28/29 only</i>)	24	3CF	9-45
GR25	BLT Destination Pitch High (<i>CL-GD5426/28/29 only</i>)	25	3CF	9-46
GR26	BLT Source Pitch Low (<i>CL-GD5426/28/29 only</i>)	26	3CF	9-47
GR27	BLT Source Pitch High (<i>CL-GD5426/28/29 only</i>)	27	3CF	9-48
GR28	BLT Destination Start Low (<i>CL-GD5426/28/29 only</i>)	28	3CF	9-49
GR29	BLT Destination Start Mid (<i>CL-GD5426/28/29 only</i>)	29	3CF	9-50
GR2A	BLT Destination Start High (<i>CL-GD5426/28/29 only</i>)	2A	3CF	9-51
GR2C	BLT Source Start Low (<i>CL-GD5426/28/29 only</i>)	2C	3CF	9-52
GR2D	BLT Source Start Mid (<i>CL-GD5426/28/29 only</i>)	2D	3CF	9-53
GR2E	BLT Source Start High (<i>CL-GD5426/28/29 only</i>)	2E	3CF	9-54
GR2F	BLT Write Mask Destination (<i>CL-GD5429 only</i>)	2F	3CF	9-55
GR30	BLT Mode (<i>CL-GD5426/28/29 only</i>)	30	3CF	9-56

Table 9-1. Extension Registers Quick Reference*(cont.)*

Abbreviation	Register Name	Index	Port	Page
GR31	BLT Start/Status <i>(CL-GD5426/'28/'29 only)</i>	31	3CF	9-59
GR32	BLT Raster Operation <i>(CL-GD5426/'28/'29 only)</i>	32	3CF	9-60
GR34	Transparent Color Select Low <i>(CL-GD5426/'28 only)</i>	34	3CF	9-62
GR35	Transparent Color Select High <i>(CL-GD5426/'28 only)</i>	35	3CF	9-63
GR38	Transparent Color Mask Low <i>(CL-GD5426/'28 only)</i>	38	3CF	9-64
GR39	Transparent Color Mask High <i>(CL-GD5426/'28 only)</i>	39	3CF	9-65
CR19	Interlace End	19	3?5 ^c	9-66
CR1A	Interlace Control	1A	3?5	9-67
CR1B	Extended Display Controls	1B	3?5	9-69
CR1C	Sync Adjust and GENLOCK <i>(CL-GD5425 only)</i>	1C	3?5	9-71
CR1D	Overlay Mode Controls <i>(CL-GD5425/'29 only)</i>	1D	3?5	9-73
CR25	Part Status	25	3?5	9-75
CR27	ID	27	3?5	9-76
CR30	TV-Out Mode Control <i>(CL-GD5425 only)</i>	30	3?5	9-77
HDR	Hidden DAC <i>(except CL-GD5420)</i>	—	3C6	9-80

- a. Refer to Chapter 5 (Section 5.4) for the description of this register.
b. Refer to Chapter 7 (Sections 7.2 and 7.3) for the description of these registers.
c. '?' in the above register address is 'B' in Monochrome mode and 'D' in color mode.

9.1 SR6: Unlock ALL Extensions Register

I/O Port Address: 3C5

Index: 6

Bit	Description	Reset State
7	Don't Care	0
6	Don't Care	0
5	Don't Care	0
4	Unlock	0
3	Don't Care	1
2	Unlock	1
1	Unlock	1
0	Unlock	1

This register enables or disables access to the Extension registers.

Bit	Description
7:0	<p>Extensions Register Access Value: If this field is loaded with 'xxx1x010', it is read as '00010010', and the Extension registers are enabled for read and write access. If this field is loaded with any other value, it is read as '00001111', and the Extension registers are disabled for read and write access.</p> <p>The Extension registers on the CL-GD5429 are always unlocked.</p>

9.2 SR7: Extended Sequencer Mode Register

I/O Port Address: 3C5

Index: 7

Bit	Description	Reset State
7	Memory Segment 3 (<i>except CL-GD5420</i>)	0
6	Memory Segment 2 (<i>except CL-GD5420</i>)	0
5	Memory Segment 1 (<i>except CL-GD5420</i>)	0
4	Memory Segment 0 (<i>except CL-GD5420</i>)	0
3	Reserved	
2	Select CRTC Character Clock Divider [1] (<i>except CL-GD5420</i>)	
1	Select CRTC Character Clock Divider [0] (<i>except CL-GD5420</i>)	
0	Select High-Resolution 256-Color (8-bit/pixel)	

This register has several purposes; these are described in the following bit descriptions.

Bit	Description															
7:4	<p>Memory Segment Select (Reserved on CL-GD5420): If this field is programmed to '0000', the CL-GD542X is configured as a standard VGA, responding to accesses at Axxx:x or Bxxx:x, or both. Refer to the description of GR6[3:2].</p> <p>If this field is programmed to any value other than '0000', the CL-GD542X is configured for 1-Mbyte linear addressing. The device responds to any memory access where Address bits 23:20 match the Memory Segment Select field. If GRB[5] is programmed to '1', the CL-GD5426/'28/'29 (only) responds to a 2-Mbyte address range.</p> <p>The 1-Mbyte Address Range has a one-to-one mapping to the 1 Mbyte of installed display memory only if there is a full 1 Mbyte of memory installed, and the device is configured for extended 256-color Chain-4 addressing. If the device is configured for unchained BY8 or BY16 addressing, or less than 1 Mbyte of display memory is installed, the device responds to the entire 1-Mbyte range, but address wrapping takes place.</p> <p>If GRB[5] is programmed to '1', the CL-GD5426/'28/'29 responds to a 2-Mbyte address range. In this case, SR7[4] is a don't care; the address range must be aligned on a 2-Mbyte boundary. When SR7[7:4] is programmed to any odd value, the next lower Mbyte is used producing uncertain results.</p>															
3	Reserved															
2:1	<p>Select CRTC Character Clock Divider [1:0] (except CL-GD5420): This field selects the CRTC Character Clock Divider mode, as indicated in the following table:</p> <table><tr><th>SR7[2]</th><th>SR7[1]</th><th>Mode</th></tr><tr><td>0</td><td>0</td><td>Normal Operation</td></tr><tr><td>0</td><td>1</td><td>Clock ÷ 2 for 16 bit/pixel data</td></tr><tr><td>1</td><td>0</td><td>Clock ÷ 3 for 24 bit/pixel data</td></tr><tr><td>1</td><td>1</td><td>16 bit/pixel data at pixel rate (CL-GD5425/'26/'28/'29 only)</td></tr></table>	SR7[2]	SR7[1]	Mode	0	0	Normal Operation	0	1	Clock ÷ 2 for 16 bit/pixel data	1	0	Clock ÷ 3 for 24 bit/pixel data	1	1	16 bit/pixel data at pixel rate (CL-GD5425/'26/'28/'29 only)
SR7[2]	SR7[1]	Mode														
0	0	Normal Operation														
0	1	Clock ÷ 2 for 16 bit/pixel data														
1	0	Clock ÷ 3 for 24 bit/pixel data														
1	1	16 bit/pixel data at pixel rate (CL-GD5425/'26/'28/'29 only)														

9.2 SR7: Extended Sequencer Mode Register (*cont.*)

Bit	Description
2:1 (<i>cont.</i>)	<p>Clock ÷ 2 for 16-Bit/Pixel Data: If this mode is selected, the DAC and Video Shift register is clocked at the VCLK (data byte) rate, and the CRTC is clocked with a character clock of 8 pixels (16 VCLKs). This allows the CRTC timing value for 640 × 480 and 800 × 600 with 16-bit pixels to be programmed in units of an 8-pixel character clock. CR13 (Offset register) is set to A0h for 640 × 480 mode, and C8h for 800 × 600 mode. This mode is available only if the CL-GD542X is configured for a 32-bit DRAM interface. The hardware cursor X-position can be set in pixel units. The cursor is only supported with the internal DAC and not through the feature connector. The Cursor Data Invert function operates on the actual 15-, 16-, or 18-bit RGB data presented to the DAC.</p> <p>Clock ÷ 3 for 24-Bit/Pixel Data: If this mode is selected, the DAC and Video Shift register is clocked at the VCLK (Data Byte) rate, and the CRTC is clocked with a character clock of 8 pixels (24 VCLKs). This allows the CRTC timing value for 640 × 480 with 24-bit pixels to be programmed in units of an 8-pixel character clock. CRTC13 (Offset register) is set to F0h. This mode is available only if the CL-GD542X is configured for a 32-bit DRAM interface. The hardware cursor is not supported in this configuration.</p> <p>16-Bit/Pixel Data at Pixel Rate: If this mode is selected, the Sequencer provides 16-bit data to the palette DAC at the displayed pixel rate. This allows 5-5-5 or 5-6-5 Color modes to be selected with a 1× VCLK. The data at P[7:0] is only the low-byte of the Pixel Data. The high-byte is not available externally. This mode provides for 1024 × 768, 5-5-5 or 5-6-5 color with a VCLK equal to the pixel rate. This mode is available on the CL-GD5425/'26/'28/'29 only.</p>
0	<p>Select High Resolution 256-color Mode: If this bit is programmed to '1', the Video Shift registers are configured so that one character clock is equal to eight pixels. In addition, true packed-pixel memory addressing is enabled. This is used with all extended resolution packed-pixel modes.</p> <p>For the CL-GD5429 only, this bit disables the Set/Reset logic. Write mode 0 writes the CPU data regardless of the value in GR1[3:0]. A video mode similar to VGA Mode 13 (320 × 200, 256 colors) can be configured by programming this bit to '1' (the CRTC registers <i>must</i> be programmed to be consistent with other 40 column modes).</p> <p>NOTE: In true packed-pixel addressing, consecutive pixels are stored at consecutive addresses. This is in contrast with Chain-4 addressing where consecutive pixels are stored at every fourth address in display memory.</p>

9.3 SR8: EEPROM Control Register

I/O Port Address: 3C5

Index: 8

Bit	Description
7	EEPROM Input Data
6	Disable MCS16* for Display Memory
5	Latch ESYNC and EVIDEO*
4	Enable EEPROM Data and SK
3	DI to EEPROM
2	SK to EEPROM
1	Enable EEPROM Data In
0	CS Out to EEPROM

This register controls the optional configuration EEPROM. In addition, SR8[6] controls MCS16*. The EEPROM contains configuration data such as monitor timing options. Typically, the EEPROM is a 1-Kbit serial EEPROM compatible with the NM93C46N. This option is not available when the CL-GD5424/'26/'28/'29 is configured for the '486 local bus or VESA VL-Bus because pins 73 and 74 are redefined.

Bit	Description
7	EEPROM Input Data: This read-only bit reflects the state of the EEDI pin (pin 73) if SR8[1] is '1'. If SR8[1] is '0', this bit is always read as '0'.
6	Disable MCS16* for Display Memory: If this bit is programmed to '1', accesses to display memory do not cause MCS16* to go active. This prevents interference when two video cards are installed. This bit is meaningful only when the CL-GD542X is installed on an ISA bus adapter. For all other configurations, this bit <i>must</i> be programmed to '0'. In addition, this bit <i>must</i> be programmed to '0' when programming BitBLTs using system memory for either the source or destination.
5	Latch ESYNC and EVIDEO*: When this bit is programmed to '0', the ESYNC and EVIDEO* pins are inputs and control the HSYNC, VSYNC, BLANK*, and the P[7:0] drivers in the normal manner. When this bit is programmed to '1', the input levels on ESYNC and EVIDEO* are latched internally and these latched levels control the HSYNC, VSYNC, BLANK*, and P[7:0] drivers. This frees the ESYNC and EVIDEO* pins to control the EEPROM. This bit should be programmed to '1' prior to setting SR8[4] and programmed to '0' after clearing SR8[4:0].
4	Enable EEPROM Data and SK: When this bit is programmed to '1', ESYNC and EVIDEO* become outputs and reflect the values in SR8[2] and SR8[3], respectively. When this bit is programmed to '0', ESYNC and EVIDEO* are inputs.

9.3 SR8: EEPROM Control Register *(cont.)*

Bit	Description
3	DI to EEPROM: When SR8[4] is programmed to '1', the level on EVIDEO* reflects the value of this bit. This bit controls the data in (DI) of the EEPROM.
2	SK to EEPROM: When SR8[4] is programmed to '1', the level on ESYNC reflects the value of this bit. This bit controls SK of the EEPROM.
1	Enable EEPROM Data In: When this bit is programmed to '1', the level on EEDI (pin 73) is reflected on SR8[7].
0	CS Out to EEPROM: The level on EECS (pin 74) reflects the value of this bit.

9.4 SR9, SRA: Scratch Pad 0, 1 Registers

I/O Port Address: 3C5

Index: 9, A

Bit	Description	Reset State
7	R/W Data [7]	0
6	R/W Data [6]	0
5	R/W Data [5]	0
4	R/W Data [4]	0
3	R/W Data [3]	0
2	R/W Data [2]	0
1	R/W Data [1]	0
0	R/W Data [0]	0

These two registers are reserved for the exclusive use of the CL-GD542X BIOS, and must never be written by any application program. They are listed here only for completeness. The bit assignments are shown in Section 1.3 of Appendix E1, "VGA BIOS Specification".

Bit	Description
7:0	R/W Data[7:0]: These bits are reserved for the Cirrus Logic BIOS.

9.5 SRB, SRC, SRD, SRE: VCLK0, 1, 2, 3 Numerator Registers

I/O Port Address: 3C5

Index: B, C, D, E

Bit	Description
7	Reserved
6	VCLK Numerator [6]
5	VCLK Numerator [5]
4	VCLK Numerator [4]
3	VCLK Numerator [3]
2	VCLK Numerator [2]
1	VCLK Numerator [1]
0	VCLK Numerator [0]

These registers, in conjunction with SR1B–SR1E, set the frequency of the video clocks. Refer to Appendix B8 for complete programming information for the synthesizers.

Bit	Description
-----	-------------

7	Reserved
---	----------

6:0 **VCLK Numerator [6:0]:** The following table shows the values these registers are loaded with at reset:

Clock	Freq. (MHz)	N	D	P	Numerator	Denominator/ Prescaler
VCLK0	25.180	102	29	1	66h	3Bh
VCLK1	28.325	91	23	1	5Bh	2Fh
VCLK2	41.165	69	24	0	45h	30h
VCLK3	36.082	126	25	1	7Eh	33h

9.6 SRF: DRAM Control Register

I/O Port Address: 3C5

Index: F

Bit	Description	Reset State
7	DRAM Bank Select (<i>CL-GD5426/'28/'29 only</i>)	—
6	Disable CRT FIFO Fast-Page Detection Mode	0
5	CRT FIFO Depth Control (<i>except CL-GD5420</i>)	0
4	DRAM Data Bus Width [1] (<i>except CL-GD5420</i>)	0
3	DRAM Data Bus Width [0]	0
2	RAS* Timing: MD[27] (Read-only)	CF[11]
1	MCLK Select [1] (Read-only)	CF[10]
0	MCLK Select [0] (Read-only)	CF[9]

This register controls the display memory.

Bit	Description
7	<p>DRAM Bank Select (CL-GD5426/'28/'29 only): If this bit is programmed to '1', the CL-GD5426/'28/'29 is configured for four 256K × 16 DRAMs. OE* (pin 141) is redefined as RAS1*. For more information, refer to Appendix B7, "Memory Configurations". This mode is possible with the CL-GD5426/'28/'29 only.</p> <p>If this bit is programmed to '0', the CL-GD5426/'28/'29 is configured for four 512K × 8 DRAMs.</p>
6	<p>Disable CRT FIFO Fast-Page Detection Mode: When this bit is programmed to '1', writes to display memory take place as random cycles. This bit <i>must</i> be programmed to '1' when loading font data for page-mode font access and when performing multiple color-expand writes in 16-bit pixel modes. This avoids CRT FIFO underruns. This mode is required for the CL-GD5422/'24 only.</p> <p>When this bit is programmed to '0', consecutive writes to display memory are executed as Fast-page mode writes whenever possible. The reset value of this bit is '0'.</p>
5	<p>CRT FIFO Depth Control (except CL-GD5420): When this bit is programmed to '0', the default CRT FIFO depth is set to eight levels (32 bits/level). This is typically used for standard video modes and extended 16-color modes.</p> <p>When this bit is programmed to '1', the CRT FIFO depth is set to 16 levels (64 bytes). This setting should never be used for any text mode. This is typically used for any 16-bit or 24-bit pixel modes and extended 8-bit pixel modes.</p> <p>For the CL-GD5429 only, programming this bit to '1' sets the CRT FIFO depth to 20.</p>

9.6 SRF: DRAM Control Register *(cont.)*

Bit Description

4:3 **DRAM Data Bus Width:** This two-bit field specifies the display memory Data bus width according to the following table:

SRF[4]	SRF[3]	Data Bus Width	Total Memory
0	0	8 bit (CL-GD5420 only)	256K
0	1	16 bit	512K (1 Mbyte for the CL-GD5420 using 512K × 8 DRAMs)
1	0	32 bit (not available in CL-GD5420)	1 Mbyte (2 Mbyte for CL-GD5426/'28/'29)
1	1	Reserved	

These bits have one level of buffering. At the end of each horizontal scanline refresh interval (that is, when Horizontal Blanking begins), these bits are transferred to the timing logic. This avoids changing the timing logic in the middle of a scanline.

2 **RAS* Timing MD[27]:** This read-only bit indicates the RAS* timing as selected in CF[11]. This is summarized in the following table:

SRF[2] CF[11]	Pull-down on MD[27]	RAS* High	RAS* Low	Note
0	Yes	3 MCLK	4 MCLK	Extended RAS*
1	No	2.5 MCLK	3.5 MCLK	Standard RAS*

1:0 **MCLK Select (Read only):** This two-bit read-only field indicates the default MCLK frequency as selected in CF[10:9]. This is summarized in the following table:

SRF[1] CF[10]	SRF[0] CF[9]	Pull-down on MD[26]	Pull-down on MD[25]	Frequency (MHz)
0	0	Yes	Yes	50.11363
0	1	Yes	No	44.74431
1	0	No	Yes	41.16477
1	1	No	No	37.58523

9.7 SR10: Graphics Cursor X Position Register

I/O Port Address: 3C5

Index: 10, 30, 50, 70, 90, B0, D0, F0

Bit	Description	Reset State
7	Cursor X [10]	0
6	Cursor X [9]	0
5	Cursor X [8]	0
4	Cursor X [7]	0
3	Cursor X [6]	0
2	Cursor X [5]	0
1	Cursor X [4]	0
0	Cursor X [3]	0

This register, and bits 7:5 of the index used to access it, define the horizontal (X) pixel offset of the graphics cursor. Refer to Appendix D3 for more information regarding the graphics cursor.

The data forms the upper-eight bits of the 11-bit position; bits 7:5 of the index form the lower-three bits of the 11-bit position. This allows the entire 11-bit cursor offset to be written in a single 16-bit I/O write. The offset must be placed in AX[15:5], AX[4:0] must be '10000', and DX must be 03C4. If 10, 30, 50...F0 is written to 3C4 without writing to 3C5 (a byte write), a read of 3C4 then returns the previously stored three bits of the cursor position.

Bit	Description
7:0	Cursor X [10:3]: This 8-bit field forms the upper-eight bits of the 11-bit horizontal offset of the graphics cursor. The index used to access this register forms the low-order three bits of the 11-bit offset.

9.8 SR11: Graphics Cursor Y Position Register

I/O Port Address: 3C5

Index: 11, 31, 51, 71, 91, B1, D1, F1

Bit	Description	Reset State
7	Cursor Y [10]	0
6	Cursor Y [9]	0
5	Cursor Y [8]	0
4	Cursor Y [7]	0
3	Cursor Y [6]	0
2	Cursor Y [5]	0
1	Cursor Y [4]	0
0	Cursor Y [3]	0

This register, and bits 7:5 of the index used to access it, define the vertical (Y) scanline offset of the graphics cursor. Refer to Appendix D3 for more information regarding the graphics cursor.

The data forms the upper-eight bits of the 11-bit position; bits 7:5 of the index form the lower-three bits of the 11-bit position. This allows the entire 11-bit cursor offset to be written in a single 16-bit I/O write. The offset must be placed in AX[15:5], AX[4:0] must be '10001', and DX must be 03C4. If 11, 31, 51...F1 is written to 3C4 without writing to 3C5 (a byte write), a read of 3C4 then returns the previously stored three bits of the cursor position.

For the CL-GD5424/'26/'28, the hardware cursor cannot be used if CR17[2] (Multiply Vertical Registers by Two) is programmed to '1'. The CL-GD5429 does not have this restriction.

When the CL-GD5425 is configured for TV-Out mode, the line compare and cursor vertical position functions can be used as though interlace and scaling or expansion were not used. No special software adjustments are required for compatibility between TV and VGA configurations.

Bit	Description
7:0	Cursor Y[10:3]: This 8-bit field forms the upper-eight bits of the 11-bit horizontal offset of the graphics cursor. The index used to access this register forms the low-order three bits of the 11-bit offset.

9.9 SR12: Graphics Cursor Attributes Register

I/O Port Address: 3C5

Index: 12

Bit	Description
7	Overscan Color Protect (<i>CL-GD5424/25/26/28/29 only</i>)
6	Reserved
5	Reserved
4	Reserved
3	Reserved
2	Cursor Size Select (<i>reserved in CL-GD5420</i>)
1	Allow Access to DAC Extended Colors
0	Graphics Cursor Enable

This register enables or disables the graphics cursor and sets the size of the palette DAC LUT entries that define the colors. Refer to Appendix D3 for a complete programming guide for the Graphics Cursor.

Bit	Description
7	Overscan Color Protect (CL-GD5424/25/26/28/29 only): If this bit is programmed to '1', the border color is DAC LUT entry 258. Note that entry 258 can be accessed only if SR12[1] is programmed to '1'. If this bit is programmed to '0', the border color is normal (that is, the contents of the palette pointed to by AR11). AR11 normally contains '0', and palette entry '0' normally contains values corresponding to black.
6:3	Reserved
2	Cursor Size Select (reserved in CL-GD5420): If this bit is programmed to '0', the graphics cursor is 32 × 32 pixels. If this bit programmed to '1', the graphics cursor is 64 × 64 pixels. This bit <i>must always</i> be programmed to '0' for the CL-GD5420.
1	Allow Access to DAC Extended Colors: If this bit is programmed to '1', DAC LUT entries 256 and 257 are accessible as locations x0h and xFh. Entry 256 is used as the cursor background; entry 257 is used as the cursor foreground. This provides for a cursor that is completely independent of the display data colors. Entry 258 is accessible as location x2h, and provides a selected over-scan color. If this bit is programmed to '0', the DAC LUT is VGA-compatible.
0	Graphics Cursor Enable: If this bit is programmed to '1', the graphics cursor is enabled and appears on the screen. If this bit programmed to '0', the graphics cursor is disabled and does not appear on the screen.

9.10 SR13: Graphics Cursor Pattern Address Offset Register

I/O Port Address: 3C5

Index: 13

Bit	Description
7	Reserved
6	Reserved
5	Cursor Select [5] (<i>except CL-GD5420</i>)
4	Cursor Select [4] (<i>except CL-GD5420</i>)
3	Cursor Select [3] (<i>except CL-GD5420</i>)
2	Cursor Select [2] (<i>except CL-GD5420</i>)
1	Cursor Select [1] (<i>except CL-GD5420</i>)
0	Cursor Select [0] (<i>except CL-GD5420</i>)

This register selects one of 64-cursor patterns (32×32 cursor) or one of 16-cursor patterns (64×64 cursor). Refer to Appendix D3 for a complete programming guide for the Graphics Cursor.

Bit	Description
7:6	Reserved
5:0	Cursor Select (32×32 Cursor): This six-bit field selects one of 64 possible cursor patterns stored at the top (highest addressed 16 Kbytes) of display memory. This definition of these six bits is valid only if SR12[2] is programmed to '0'.
5:2	Cursor Select (64×64 Cursor) (except CL-GD5420): This 4-bit field selects one of 16 possible cursor patterns stored at the top (highest addressed 16 Kbytes) of display memory. This definition of these four bits is valid only if SR12[2] is programmed to '1'. SR13[1:0] are ignored in this case.

9.11 SR14, SR15: Scratch Pad 2, 3 Registers (CL-GD5425/'26/'28/'29 only)

I/O Port Address: 3C5

Index:14, 15

Bit	Description	Reset State
7	R/W Data [7]	0
6	R/W Data [6]	0
5	R/W Data [5]	0
4	R/W Data [4]	0
3	R/W Data [3]	0
2	R/W Data [2]	0
1	R/W Data [1]	0
0	R/W Data [0]	0

These two registers are reserved for the exclusive use of the CL-GD542X BIOS and must never be written by any application program. They are listed here only for completeness.

Bit	Description
7:0	R/W Data[7:0]: These bits are reserved for the Cirrus Logic BIOS.

9.12 SR16: Performance Tuning Register (CL-GD5424/'25/'26/'28/'29 only)

I/O Port Address: 3C5

Index:16

Bit	Description	Reset State
7	RDY Delay for I/O [1]	1
6	RDY Delay for I/O [0]	1
5	RDY Delay for Memory Write [1]	1
4	RDY Delay for Memory Write [0]	1
3	FIFO Demand Threshold [3]	0
2	FIFO Demand Threshold [2]	0
1	FIFO Demand Threshold [1]	0
0	FIFO Demand Threshold [0]	0

This register controls the delay from ADS# to RDY#, and the threshold where the CRT FIFO is refilled. This register is defined only for the CL-GD5424/'25/'26/'28/'29. This register must never be written by an application program. It is listed here for completeness only.

Bit	Description
-----	-------------

7:6	RDY Delay for I/O [1:0]: This field controls the delay from ADS# to RDY# for I/O cycles. This field applies only when the CL-GD5424/'25/'26/'28/'29 is configured for local bus. The following table summarizes the values:
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SR16[7]	SR16[6]	CPU1X Clock Delay	Note
0	0	1	
0	1	1	
1	0	2	
1	1	2	Default

9.12 SR16: Performance Tuning Register (CL-GD5424/'25/'26/'28/'29 only) (cont.)

Bit	Description
5:4	RDY Delay for Memory Write [1]: This field controls the delay from ADS# to RDY# for memory write cycles. This field applies only when the CL-GD5424/'25/'26/'28/'29 is configured for local bus. The following table summarizes the values:

SR16[5]	SR16[4]	CPU1X Clock Delay CL-GD5424/'25/'26/'28	CL-GD5429	Note
0	0	2	1	
0	1	3	2	
1	0	4	3	
1	1	5	4	Default

The value programmed into this field must satisfy the following inequality:

$$ClockDelay \times CPUClockPeriod > 3 \times MCLKPeriod + 2ns$$

3:0	<p>FIFO Demand Threshold [3:0]: The value written to this field selects the level at which the Sequencer begins cycles to refill the CRT FIFO (and thereby hold off CPU cycles or preempt Fast-page mode BLT cycles).</p> <p>For each video mode and MCLK frequency, there is an optimum value that most efficiently uses the DRAM. These values are automatically programmed by the Cirrus Logic BIOS.</p> <p>When the CL-GD5425 is programmed for TV-Out modes with flicker filter or 480–400 scaling enabled, this field must be programmed to the value '0010'. When the CL-GD5425 is programmed for NTSC modes 11h or 12h, this field must be programmed to the value '0001'.</p>
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9.13 SR17: Configuration Readback and Extended Control Register (Except CL-GD5420)

I/O Port Address: 3C5

Index:17

Bit	Description	Reset State
7	Reserved	
6	Memory-Mapped I/O Address (<i>CL-GD5429 only</i>)	
5	System Bus Select [2]: MD30 (Read-only)	CF[14]
4	System Bus Select [1]: MD23 (Read-only)	CF[7]
3	System Bus Select [0]: MD21 (Read-only)	CF[5]
2	Enable Memory-Mapped I/O (<i>CL-GD5429 only</i>)	
1	Power-down Palette Memory (<i>CL-GD5429 only</i>)	
0	Shadow DAC Writes on Local Bus	1

This register contains a read-only field that allows the BIOS to determine the bus type. In addition, bit 0 can be used to control DAC shadowing.

Bit	Description
7	Reserved
6	Memory-Mapped I/O Address (CL-GD5429 only): If either memory-mapped I/O or linear addressing is not enabled, this bit is ignored. If linear addressing and memory-mapped I/O are both enabled, this bit has the following meaning: If this bit is programmed to '0', the address space for memory-mapped I/O is 256 bytes beginning at B800:0. If this bit is programmed to '1', the address space for memory-mapped I/O is the last 256 bytes of the 2 Mbytes of linear address space.
5:3	System Bus Select [2:0] (read-only): This read-only field reflects Configuration bits CF[14, 7, 5], the System Bus Select bits. See Appendix B9 for the definition of these bits. This field is intended for use by the Cirrus Logic BIOS.
2	Enable Memory-Mapped I/O (CL-GD5429 only): If this bit is programmed to '0', memory-mapped I/O is not enabled. If this bit is programmed to '1', the BLT registers (GR0, GR1, GR10-11, and GR20-32) are addressed as a 256-byte block of memory. This allows faster accesses. See Appendix B20, "Memory-Mapped I/O", for more information.
1	Power-down Palette Memory (CL-GD5429 only): If this bit is programmed to '0', the DAC palette memory (SRAM) is clocked and functions normally. If this bit is programmed to '1', the DAC palette memory is not clocked. This reduces power in the device.
0	Shadow DAC Writes on Local Bus: If this bit is programmed to '0', writes to the internal DAC return LBA# and RDY# normally. If this bit is programmed to '1', writes to the DAC addresses accept data, but do not return LBA# or RDY#, causing the write to be passed on to an external DAC on the ISA bus. The reset state of this bit is '1'. Reads to the DAC addresses always operate normally.

9.14 SR18: Signature Generator Control Register (Except CL-GD5420)

I/O Port Address: 3C5

Index:18

Bit	Description
7	Disable MCLK Driver (<i>CL-GD5424/25/26/28/29 only</i>)
6	Disable DCLK/Pixel Bus Drivers (<i>CL-GD5424/25/26/28/29 only</i>)
5	Enable Data Generator (<i>CL-GD5428/29 only</i>)
4	Pixel Bus Select [2]
3	Pixel Bus Select [1]
2	Pixel Bus Select [0]
1	Reset Signature Generator
0	Signal Generator Enable/Status

This register controls and monitor the status of the Signature Generator. The CL-GD542X Signature Generator is used for board-level testing of the video sub-system. Refer to Appendix B11 for a complete description of the Signature Generator.

Bit	Description
7	Disable MCLK Driver (CL-GD5424/25/26/28/29 only): If this bit is programmed to '1', the MCLK driver is disabled. This is intended for testing. If this bit is programmed to '0', the MCLK driver operates normally.
6	Disable DCLK/Pixel Bus Drivers (CL-GD5424/25/26/28/29 only): If this bit is programmed to '1', the DCLK and Pixel bus drivers are disabled. This is intended for testing. If this bit is programmed to '0', the DCLK and Pixel bus drivers operate normally. In addition, if the CL-GD5428/29 is programmed for Video Overlay, programming this bit to a '1' forces the overlay data to come from the frame buffer instead of the Pixel bus. This is useful for changing the mode from VGA-LUT to, for example, 3-3-2 RGB. For more information, see Appendix B14, "Video Overlay and DAC Mode Switching".
5	Enable Data Generator (CL-GD5428/29 only): If this bit is programmed to '1', pseudo-random data is placed on the Memory Data bus. This is used in conjunction with the Signature Generator for factory testing only.

9.14 SR18: Signature Generator Control Register (Except CL-GD5420) (cont.)

Bit

Description

4:2

Pixel Bus Select [2:0]:

This field selects the bit of the Pixel bus used as the input for the Signature Generator according to the following table:

SR18[4]	SR18[3]	SR18[2]	P-Bus Bit
0	0	0	P[0]
0	0	1	P[1]
0	1	0	P[2]
0	1	1	P[3]
1	0	0	P[4]
1	0	1	P[5]
1	1	0	P[6]
1	1	1	P[7]

1

Reset Signature Generator:

When this bit is programmed to ‘1’, the Signature Generator is reset to an initial, defined condition. When this bit is programmed to ‘0’, the Signature Generator is allowed to run under the control of SR18[0].

0

Signature Generator Enable/Status:

When this bit is programmed to ‘1’, the Signature Generator begins operation on the next VSYNC. It accumulates a signature from the Pixel Bus bit chosen by SR18[4:2] for one video frame and then stop, forcing this bit to ‘0’. The program can determine when the signature is complete by monitoring this bit.

9.15 SR19: Signature Generator Result Low Byte Register (Except CL-GD5420)

I/O Port Address: 3C5

Index: 19

Bit	Description	Reset State
7	Signature Generator Result [7]	0
6	Signature Generator Result [6]	0
5	Signature Generator Result [5]	0
4	Signature Generator Result [4]	0
3	Signature Generator Result [3]	0
2	Signature Generator Result [2]	0
1	Signature Generator Result [1]	0
0	Signature Generator Result [0]	0

This register reads the low-order byte of the Signature Generator result. The CL-GD542X Signature Generator is used for board-level testing of the video sub-system. Refer to Appendix B11 for a complete description of the Signature Generator.

Bit	Description
7:0	Signature Generator Result [7:0]

9.16 SR1A: Signature Generator Result High Byte Register (Except CL-GD5420)

I/O Port Address: 3C5

Index: 1A

Bit	Description	Reset State
7	Signature Generator Result [15]	0
6	Signature Generator Result [14]	0
5	Signature Generator Result [13]	0
4	Signature Generator Result [12]	0
3	Signature Generator Result [11]	0
2	Signature Generator Result [10]	0
1	Signature Generator Result [9]	0
0	Signature Generator Result [8]	0

This register reads the high-order byte of the Signature Generator result. The CL-GD542X Signature Generator is used for board-level testing of the video subsystem. Refer to Appendix B11 for a complete description of the Signature Generator.

Bit	Description
7:0	Signature Generator Result [15:8]

9.17 SR1B, SR1C, SR1D, SR1E: VCLK Denominator and Post Scalar Value Registers

I/O Port Address: 3C5

Index: 1B, 1C, 1D, 1E

Bit	Description
7	VCLK Denominator [6] (<i>CL-GD5425 only</i>)
6	VCLK Denominator [5] (<i>CL-GD5425 only</i>)
5	VCLK Denominator [4]
4	VCLK Denominator [3]
3	VCLK Denominator [2]
2	VCLK Denominator [1]
1	VCLK Denominator [0]
0	VCLK Post Scalar ($\div 2$)

This register, in conjunction with SRB, determines the frequency of video clock 0 (VCLK0). Refer to Appendix B8 for complete programming information for the synthesizers. The reset values for these four registers are shown in the table in the VCLK Numerator.

Bit	Description
7:6	Reserved: For the CL-GD5425 only, these two bits extend the Denominator field to 7 bits.
5:1	VCLK Denominator [4:0]
0	VCLK Post Scalar ($\div 2$)

9.18 SR1F: BIOS ROM Write Enable and MCLK Select Register (CL-GD5424/'25/'26/'28/'29 only)

I/O Port Address: 3C5

Index: 1F

Bit	Description	Reset State
7	Reserved	0
6	Use MCLK as VCLK (<i>CL-GD5428/'29 only</i>)	0
5	MCLK Frequency [5]	0
4	MCLK Frequency [4]	(Refer to MCLK Table below)
3	MCLK Frequency [3]	(Refer to MCLK Table below)
2	MCLK Frequency [2]	(Refer to MCLK Table below)
1	MCLK Frequency [1]	(Refer to MCLK Table below)
0	MCLK Frequency [0]	(Refer to MCLK Table below)

This register is defined only for the CL-GD5424/'25/'26/'28/'29. It allows the MCLK frequency to be programmed. This register should never be programmed by an applications program; it is listed for completeness only.

Bit	Description
7	Reserved:
6	Use MCLK as VCLK (CL-GD5428/'29 only): If this bit is programmed to '0', the VCLK Synthesizer operates normally. If this bit is programmed to '1', VCLK is derived from MCLK as follows:

SR1F[6]	SR1E[0]	VCLK Source
0	x	VCLK (Normal Operation)
1	0	VCLK = MCLK
1	1	VCLK = MCLK ÷ 2

9.18 SR1F: BIOS ROM Write Enable and MCLK Select Register (CL-GD5424/25/26/28/29 only) (cont.)

Bit	Description
5:0	<p>MCLK Frequency [5:0]: This field directly programs the MCLK frequency as indicated in the following equation:</p> $\text{MCLK} = \text{Reference} \div 8 \times \text{SR1F}[5:0]$ $= 1.79 \times \text{SR1F}[5:0], \text{ assuming a reference frequency of 14.3 MHz.}$ <p>This field can be programmed with any value from 4 to 28 (decimal). The CL-GD5429 can be programmed to any value to 33 (decimal). Refer to Appendix B7 for information regarding the DRAM specification requirements for various MCLK frequencies. The following table shows examples assuming a reference frequency of 14.31818 MHz:</p>

SR1F[5:0] (Decimal)	SR1F[5:0] (Hex)	MCLK Frequency	Corresponding CF[10:9]
21	15	37.585 MHz	11
23	17	41.165 MHz	10
25	19	44.744 MHz	01
28	1C	50.114 MHz	00
32	20	57.273 MHz	—
34	22	60.852 MHz	—

NOTE: The appearance of any frequency above 50 MHz in this table is not to be taken as a guarantee that any particular Cirrus Logic product will operate at that frequency, or that DRAMs are available that support that frequency.

9.19 GR9: Offset Register 0

I/O Port Address: 3CF

Index:9

Bit	Description	Reset State
7	Offset 0 [7]	0
6	Offset 0 [6]	0
5	Offset 0 [5]	0
4	Offset 0 [4]	0
3	Offset 0 [3]	0
2	Offset 0 [2]	0
1	Offset 0 [1]	0
0	Offset 0 [0]	0

This register provides access to up to 1 Mbyte of display memory with 4-Kbytes granularity or 2 Mbytes of display memory with 16-Kbytes granularity. The contents of this register are added to A[19:12] when GRB[0] is programmed to '0', GRB[0] is programmed to '1', and SA15 = 0. For the CL-GD5426/'28 only, if GRB[5] is programmed to '1', bits 6:0 of this register are added to A[20:14] to provide access to up to 2 Mbytes of display memory with 16-Kbytes granularity.

The Display Memory Address, prior to being modified by address wrap controls, is called XMA. It is the sum of XA and an Offset register. XA is the address on the bus with bits 16 and 15 possibly forced to '0' as indicated in the following table:

Configuration	XA[16]	XA[15]	XA[14:0]
128K Memory: GR6[3:2] = 0,0	SA[16]	SA[15]	SA[14:0]
64K Memory: GR6[3:2] = 0,1 AND'ed Offset 1 Disabled: GRB[0] = 0	0	SA[15]	SA[14:0]
64K Memory: GR6[3:2] = 0,1 OR'ed Offset 1 Enabled: GRB[0] = 1	0	0	SA[14:0]

The XA address is summed with the contents of an Offset register with one of three relative alignments according to the configuration. These are indicated in the three diagrams that follow:

1 Mbyte Memory, 4-Kbyte Granularity, VGA Mapping

0	0	0	XA[16]	XA[15]	SA[14]	SA[13]	SA[12]
+OFF[7]	OFF[6]	OFF[5]	OFF[4]	OFF[3]	OFF[2]	OFF[1]	OFF[0]
XMA[19]	XMA[18]	XMA[17]	XMA[16]	XMA[15]	XMA[14]	XMA[13]	XMA[12]

9.19 GR9: Offset Register 0 (*cont.*)**2 Mbyte Memory, 16-Kbyte Granularity, VGA Mapping**

0	0	0	0	XA[16]	XA[15]	SA[14]	SA[13]	SA[12]
+OFF[6]	OFF[5]	OFF[4]	OFF[3]	OFF[2]	OFF[1]	OFF[0]	0	0
XMA[20]	XMA[19]	XMA[18]	XMA[17]	XMA[16]	XMA[15]	XMA[14]	XMA[13]	XMA[12]

1 or 2 Mbyte Memory, 16-Kbyte Granularity, Linear Addressing

LA[20]	LA[19]	LA[18]	LA[17]	SA[16]	SA[15]	SA[14]	SA[13]	SA[12]
+OFF[6]	OFF[5]	OFF[4]	OFF[3]	OFF[2]	OFF[1]	OFF[0]	0	0
XMA[20]	XMA[19]	XMA[18]	XMA[17]	XMA[16]	XMA[15]	XMA[14]	XMA[13]	XMA[12]

NOTE: Refer to Appendix D1 for programming notes regarding extended addressing.

Bit	Description
7:0	Offset 0 [7:0]: This value is added to A[19:12] to provide the address into display memory. This Offset register is selected when GRB[0] is programmed to '0', or when GRB[0] is '1' and SA15 = 0.

9.20 GRA: Offset Register 1

I/O Port Address: 3CF

Index: A

Bit	Description	Reset State
7	Offset 1 [7]	0
6	Offset 1 [6]	0
5	Offset 1 [5]	0
4	Offset 1 [4]	0
3	Offset 1 [3]	0
2	Offset 1 [2]	0
1	Offset 1 [1]	0
0	Offset 1 [0]	0

This register provides access to up to 1 Mbyte of display memory with 4-Kbytes granularity. The contents of this register are added to A[19:12] when GRB[0] is programmed to '1' and SA15 = 1. For the CL-GD5426/'28/'29 only, if GRB[5] is programmed to '1', bits 6:0 of this register are added to A[20:14] to provide access to up to 2 Mbytes of display memory with 16-Kbytes granularity.

Bit	Description
7:0	Offset 1 [7:0]: This value is added to A[19:12] to provide the address into display memory. This Offset register is selected when GRB[0] is programmed to '1' and SA15 = 1. If GRB[0] is programmed to '0', this register is unused.

9.21 GRB: Graphics Controller Mode Extensions Register

I/O Port Address: 3CF

Index: B

Bit	Description
7	Reserved
6	Reserved
5	Offset Granularity (<i>CL-GD5426/28/29 only</i>)
4	Enable Enhanced Writes for 16-bit pixels
3	Enable Eight Byte Data Latches
2	Enable Extended Write Modes
1	Enable BY8 Addressing
0	Enable Offset Register 1

This register enables or disables extended write modes. These extended modes provide enhanced performance.

Bit	Description
7:6	Reserved
5	Offset Granularity (CL-GD5426/28/29 only): This bit is defined for the CL-GD5426/28/29 only. If this bit is programmed to '1', the Offset registers are redefined as containing bits [6:0] added to Address bits [20:14] to provide access to 2 Mbytes of display memory with 16-Kbytes granularity. SR7[4] (low-order bit of 1-Mbyte address page) becomes a don't care.
4	<p>Enable Enhanced Writes for 16-bit pixels: When this bit and GRB[2] are both programmed to '1', the CL-GD542X executes enhanced Write mode 4 and 5 writes. In particular:</p> <ul style="list-style-type: none"> • BY16 Addressing Enabled: The system address is shifted by four, relative to true packed-pixel addressing, so that each system byte address points to a different 8-pixel (16-byte) block in display memory. • 16 Byte Transfer Enabled: Up to 16 bytes (8 pixels) can be written into display memory for each CPU byte transfer. • GR10 and GR11 Enabled: GR10 and GR11 are enabled as foreground and background color extensions. • SR2 Doubling Enabled: Each bit of SR2 is used as a pixel write mask for two bytes (one pixel).
3	Enable Eight Byte Data Latches: If this bit is programmed to '1', the display memory latches are 8 bytes wide, rather than the normal four.

9.21 GRB: Graphics Controller Mode Extensions Register (*cont.*)

Bit	Description
2	<p>Enable Extended Write Modes: If this bit is programmed to '1', the CL-GD542X executes extended mode write. In particular:</p> <ul style="list-style-type: none"> • 8-Byte Transfer Enabled: Up to 8 bytes (8 pixels) can be written into display memory for each CPU byte transferred. If GRB[4] is programmed to '1', up to 16 bytes can be written for color expansion. • GR5[2] Enabled: Extended Write modes 4 and 5 can be enabled. • GR0 Extended: register GR0 is extended from 4 to 8 bits. • GR1 Extended: register GR1 is extended from 4 to 8 bits. • SR2 Extended: register SR2 is extended from 4 to 8 bits. • GRB[4] Enabled: GRB[2] must be programmed to '1' to enable GRB[4]. <p>NOTE: For the CL-GD5426/28/29, programming this bit from '1' to '0' clears GR0[7:4] and GR1[7:4] to '0'.</p>
1	<p>Enable BY8 Addressing: The system address is shifted by three, relative to true packed-pixel addressing, so that each system byte address points to a different 8-pixel (8-byte) block in display memory. If GRB[4] is programmed to '1', this bit must be programmed to '0'.</p>
0	<p>Enable Offset Register 1: If this bit is programmed to '1', SA15 chooses between Offset register 0 and 1. If this bit is programmed to '0', Offset register 0 is always chosen regardless of the value of SA15. For 1 Mbyte of linear addressing, this bit <i>must always</i> be programmed to '0'.</p>

9.22 GRC: Color Key Compare Register (CL-GD5424/'25/'26/'28/'29 only)

I/O Port Address: 3CF

Index: C

Bit	Description	Reset State
7	Color Key Compare [7]	1
6	Color Key Compare [6]	1
5	Color Key Compare [5]	1
4	Color Key Compare [4]	1
3	Color Key Compare [3]	1
2	Color Key Compare [2]	1
1	Color Key Compare [1]	1
0	Color Key Compare [0]	1

This register contains an 8-bit value that is compared to the video data. A match, when Mode Switching 10 or 11 is chosen, causes the pixel to be replaced with data from the feature connector. Refer to Appendix B14, "Video Overlay and DAC Mode Switching".

Bit	Description
7:0	Color Key Compare [7:0]: This value is the color key used with Mode Switching 10 and 11. Refer to Appendix B14.

9.23 GRD: Color Key Compare Mask Register (CL-GD5424/'25/'26/'28/'29 only)

I/O Port Address: 3CF

Index: D

Bit	Description	Reset State
7	Color Key Compare Mask [7]	0
6	Color Key Compare Mask [6]	0
5	Color Key Compare Mask [5]	0
4	Color Key Compare Mask [4]	0
3	Color Key Compare Mask [3]	0
2	Color Key Compare Mask [2]	0
1	Color Key Compare Mask [1]	0
0	Color Key Compare Mask [0]	0

This register contains an 8-bit mask where the color key compare is made. '1' causes the corresponding bit to *not* participate in the compare. Refer to Appendix B14, "Video Overlay and DAC Mode Switching".

Bit	Description
7:0	Color Key Compare Mask [7:0]: This value is the mask where the color key compare is made. Refer to Appendix B14.

9.24 GRE: Miscellaneous Control Register (CL-GD5425/'28/'29 only)

I/O Port Address: 3CF

Index: E

Bit	Description
7	Write-protect Timing Registers (<i>CL-GD5429 only</i>)
6	Reserved
5	DAC Current Reference Adjust (<i>CL-GD5425 only</i>)
4	System Level Power Management (<i>CL-GD5429 only</i>)
3	Static Clock (<i>CL-GD5429 only</i>)
2	Static VSYNC (<i>CL-GD5425/'29 only</i>)
1	Static HSYNC (<i>CL-GD5425/'29 only</i>)
0	DCLK Output ($\div 2$)

This register contains bits relating to power management. For the CL-GD5425 only, bit 7 write-protects the registers that control sync timing.

Bit	Description
7	<p>Write-protect Timing Registers (CL-GD5425 only): When this bit is programmed to '1', the following registers are write protected: MISC (3C2), CR0 through CR9, CR10, CR11, CR12, CR15, and CR16. I/O writes are acknowledged by the device (for example, LBA# is generated for the VESA VL-Bus) and I/O reads take place normally. This bit does not lock CR1, CR9, or MISC[2] if SR1[3] is set to '0'. This bit does lock CR11[7].</p> <p>When this bit is programmed to '0', the registers can be written normally. This bit is functionally OR'ed with CR11[7]. If either bit is programmed to '1', the respective registers are write protected.</p>
6	Reserved
5	<p>DAC Current Reference Adjust (CL-GD5425 only): This bit should be set to '1' for the case of TV output when a VGA monitor is connected. This increases the DAC output current to compensate for the additional load imposed by the monitor. This bit should be set to '1' for the case of VGA output. This bit should be set to '0' for the case of TV output when a VGA monitor is not connected.</p>
4	<p>System Level Power Management (CL-GD5429 only): If this bit is programmed to '1', host access to the display memory is disabled (see MISC[1]) and screen refresh is disabled (see SR1[5]). This bit <i>must</i> be programmed to '1' prior to programming GRE[3] to a '1', and <i>must</i> be programmed to '0' after programming GRE[3] to a '0'. The MCLK and VCLK VCOs continue to operate at their programmed frequencies, but reduce the power.</p>

9.24 GRE: Miscellaneous Control Register (CL-GD5425/'28/'29 only) (cont.)

Bit	Description
3	<p>Static Clock (CL-GD5429 only): If this bit is programmed to '1', the CL-GD5429 is placed in Static Clock mode. VCLK and MCLK are gated off so that the device does not dissipate any dynamic power. The RAMDAC is powered down; DRAM refresh continues.</p> <p>NOTE: When the device is in Static Clock mode, memory accesses are not possible. The only host access that is allowed is an I/O cycle to remove the device from Static Clock mode.</p>
2	<p>Static VSYNC (CL-GD5425/'29 only): If this bit is programmed to '1', the VSYNC output is static. The level is as programmed in MISC[7]. In addition, the RAMDAC is powered down.</p> <p>If this bit is programmed to '0', the VSYNC pin functions as programmed by the CRTC registers. See Appendix B21, "Power Management", for detailed information regarding 'green computing'.</p>
1	<p>Static HSYNC (CL-GD5425/'29 only): If this bit is programmed to '1', the HSYNC output is static. The level is as programmed in MISC[6]. In addition, the RAMDAC is powered down.</p> <p>If this bit is programmed to '0', the HSYNC pin functions as programmed by the CRTC registers. See Appendix B21, "Power Management", for detailed information regarding 'green computing'.</p>
0	<p>DCLK Output (÷2): If this bit is programmed to '0', the CL-GD542X operates normally. If this bit is programmed to '1', the CL-GD5425/'28/'29 simulates external DAC Clocking mode 1. The rising edge of DCLK can be used to clock the low byte of 16-bit data; the falling edge of DCLK can be used to clock the high byte of 16-bit data.</p>

9.25 GR10: 16-bit Pixel Background Color High Byte Register

I/O Port Address: 3CF

Index: 10

Bit	Description
7	Background Color [15]
6	Background Color [14]
5	Background Color [13]
4	Background Color [12]
3	Background Color [11]
2	Background Color [10]
1	Background Color [9]
0	Background Color [8]

This register contains the high-order 8 bits of the extended background color for Extended Write mode 5 and color expanded BitBLT operations.

Bit	Description
7:0	Background Color [15:8]: These are the high-order 8 bits of the background color for Write mode 5.

9.26 GR11: 16-bit Pixel Foreground Color High Byte Register

I/O Port Address: 3CF

Index: 11

Bit	Description
7	Foreground Color [15]
6	Foreground Color [14]
5	Foreground Color [13]
4	Foreground Color [12]
3	Foreground Color [11]
2	Foreground Color [10]
1	Foreground Color [9]
0	Foreground Color [8]

This register contains the high-order 8 bits of the extended foreground color for Extended Write mode 5 and 4 and color expanded BitBLT operations.

Bit	Description
7:0	Foreground Color [15:8]: These are the high-order 8 bits of the foreground color for Extended Write modes 5 and 4.

9.27 GR18: Extended DRAM Controls (CL-GD5429 only)

I/O Port Address: 3CF

Index: 18

Bit	Description	Reset State
7	Reserved	
6	Reserved	
5	Reserved	
4	Reserved	
3	Reserved	
2	Reserved	
1	Enhanced Write Following Read Timing	0
0	Enhanced WE* Active Delay	0

This register contains bits for DRAM timing controls. This register is reset to '0'. This register should be programmed to '3' at POST time and should remain unchanged thereafter. This register is implemented on the CL-GD5429 only.

Bit	Description
7:2	Reserved
1	Enhanced Write Following Read Timing: If this bit is programmed to '0', there is a 3-MCLK delay of a write CAS* that follows a read CAS*. If this bit is programmed to a '1', there is a 2-MCLK delay of a write CAS* that follows a read CAS*.
0	Enhanced WE* Active Delay: If this bit is programmed to '0', there is a two MCLK delay of WE* following a read cycle. If this bit is programmed to '1', there is a 1-MCLK delay of WE* following a read cycle.

9.28 GR20: BLT Width Low Register (CL-GD5426/'28/'29 only)

I/O Port Address: 3CF

Index: 20

Bit	Description
7	BLT Width [7]
6	BLT Width [6]
5	BLT Width [5]
4	BLT Width [4]
3	BLT Width [3]
2	BLT Width [2]
1	BLT Width [1]
0	BLT Width [0]

This register contains the low-order 8 bits of the 11-bit value specifying the width-1, in bytes, of the areas involved in a BitBLT. Refer to Appendix D8, "BitBLT Engine".

Bit	Description
7:0	BLT Width [7:0]: This field is the low-order 8 bits of the BLT width. Refer to Appendix D8.

***NOTE:** For Sections 9.27 through 9.49 refer to Appendix D8, "BitBLT Engine", for additional detailed information.

9.29 GR21: BLT Width High Register (CL-GD5426/'28/'29 only)

I/O Port Address: 3CF

Index: 21

Bit	Description
7	Reserved
6	Reserved
5	Reserved
4	Reserved
3	Reserved
2	BLT Width [10]
1	BLT Width [9]
0	BLT Width [8]

This register contains the high-order 3 bits of the 11-bit value specifying the width-1, in bytes, of the areas involved in a BitBLT.

Bit	Description
7:3	Reserved
2:0	BLT Width [10:8]: This field is the high-order 3 bits of the BLT width.

9.30 GR22: BLT Height Low Register (CL-GD5426/'28/'29 only)

I/O Port Address: 3CF

Index: 22

Bit	Description
7	BLT Height [7]
6	BLT Height [6]
5	BLT Height [5]
4	BLT Height [4]
3	BLT Height [3]
2	BLT Height [2]
1	BLT Height [1]
0	BLT Height [0]

This register contains the low-order 8 bits of the 10-bit value specifying the height-1, in scanlines, of the areas involved in a BitBLT. This register is double-buffered.

Bit	Description
7:0	BLT Height [7:0]: This field is the low-order 8 bits of the BLT height.

9.31 GR23: BLT Height High Register (CL-GD5426/'28/'29 only)

I/O Port Address: 3CF

Index: 23

Bit	Description
7	Reserved
6	Reserved
5	Reserved
4	Reserved
3	Reserved
2	Reserved
1	BLT Height [9]
0	BLT Height [8]

This register contains the high-order 2 bits of the 10-bit value specifying the height-1, in scanlines, of the areas involved in a BitBLT. This register is double-buffered.

Bit	Description
7:2	Reserved
1:0	BLT Height [9:8]: This field is the high-order 2 bits of the BLT height.

9.32 GR24: BLT Destination Pitch Low Register (CL-GD5426/'28/'29 only)

I/O Port Address: 3CF

Index: 24

Bit	Description
7	BLT Destination Pitch [7]
6	BLT Destination Pitch [6]
5	BLT Destination Pitch [5]
4	BLT Destination Pitch [4]
3	BLT Destination Pitch [3]
2	BLT Destination Pitch [2]
1	BLT Destination Pitch [1]
0	BLT Destination Pitch [0]

This register contains the low-order 8 bits of the 12-bit (13-bit for CL-GD5429 only) value specifying the destination pitch (that is, the scanline-to-scanline byte address offset) of the areas involved in a BitBLT.

Bit	Description
7:0	BLT Destination Pitch [7:0]: This field is the low-order 8 bits of the BLT destination pitch.

9.33 GR25: BLT Destination Pitch High Register (CL-GD5426/'28/'29 only)

I/O Port Address: 3CF

Index: 25

Bit	Description
7	Reserved
6	Reserved
5	Reserved
4	BLT Destination Pitch [12] (<i>CL-GD5429 only</i>)
3	BLT Destination Pitch [11]
2	BLT Destination Pitch [10]
1	BLT Destination Pitch [9]
0	BLT Destination Pitch [8]

This register contains the high-order 4 bits (5 bits for CL-GD5429) of the 12-bit (13-bit for the CL-GD5429) value specifying the destination pitch (that is, the scanline-to-scanline byte address offset) of the areas involved in a BitBLT.

Bit	Description
7:5	Reserved
4	BLT Destination Pitch [12] (CL-GD5429 only): This is the high-order bit of the BLT destination pitch.
3:0	BLT Destination Pitch [11:8]: This field is the high-order 4 bits of the BLT destination pitch. Bit 4 is also used for the CL-GD5429.

9.34 GR26: BLT Source Pitch Low Register (CL-GD5426/'28/'29 only)

I/O Port Address: 3CF

Index: 26

Bit	Description
7	BLT Source Pitch [7]
6	BLT Source Pitch [6]
5	BLT Source Pitch [5]
4	BLT Source Pitch [4]
3	BLT Source Pitch [3]
2	BLT Source Pitch [2]
1	BLT Source Pitch [1]
0	BLT Source Pitch [0]

This register contains the low-order 8 bits of the 12-bit (13-bit for the CL-GD5429) value specifying the source pitch (that is, the scanline-to-scanline byte address offset) of the areas involved in a BitBLT.

Bit	Description
7:0	BLT Source Pitch [7:0]: This field is the low-order 8 bits of the BLT source pitch.

9.35 GR27: BLT Source Pitch High Register (CL-GD5426/'28/'29 only)

I/O Port Address: 3CF

Index: 27

Bit	Description
7	Reserved
6	Reserved
5	Reserved
4	BLT Source Pitch [12] (<i>CL-GD5429 only</i>)
3	BLT Source Pitch [11]
2	BLT Source Pitch [10]
1	BLT Source Pitch [9]
0	BLT Source Pitch [8]

This register contains the high-order 4 bits (5 bits for the CL-GD5429) of the 12-bit (13-bit for the CL-GD5429) value specifying the source pitch (that is, the scanline-to-scanline byte address offset) of the areas involved in a BitBLT.

Bit	Description
7:5	Reserved
4	BLT Source Pitch [12] (CL-GD5429 only): This is the high-order bit of the BLT source pitch.
3:0	BLT Source Pitch [11:8]: This field is the high-order 4 bits of the BLT source pitch. Bit 4 is used for the CL-GD5429.

9.36 GR28: BLT Destination Start Low Register (CL-GD5426/'28/'29 only)

I/O Port Address: 3CF

Index: 28

Bit	Description
7	BLT Destination Start [7]
6	BLT Destination Start [6]
5	BLT Destination Start [5]
4	BLT Destination Start [4]
3	BLT Destination Start [3]
2	BLT Destination Start [2]
1	BLT Destination Start [1]
0	BLT Destination Start [0]

This register contains the low-order 8 bits of the 21-bit value specifying the byte address of the beginning destination pixel for a BitBLT.

Bit	Description
7:0	BLT Destination Start [7:0]: This field is the low-order 8 bits of the BLT destination start.

9.37 GR29: BLT Destination Start Mid Register (CL-GD5426/'28/'29 only)

I/O Port Address: 3CF

Index: 29

Bit	Description
7	BLT Destination Start [15]
6	BLT Destination Start [14]
5	BLT Destination Start [13]
4	BLT Destination Start [12]
3	BLT Destination Start [11]
2	BLT Destination Start [10]
1	BLT Destination Start [9]
0	BLT Destination Start [8]

This register contains the middle 8 bits of the 21-bit value specifying the byte address of the beginning destination pixel for a BitBLT.

Bit	Description
7:0	BLT Destination Start [15:8]: This field is the middle 8 bits of the BLT destination start.

9.38 GR2A: BLT Destination Start High Register (CL-GD5426/'28/'29 only)

I/O Port Address: 3CF

Index: 2A

Bit	Description
7	Reserved
6	Reserved
5	Reserved
4	BLT Destination Start [20]
3	BLT Destination Start [19]
2	BLT Destination Start [18]
1	BLT Destination Start [17]
0	BLT Destination Start [16]

This register contains the high-order 5 bits of the 21-bit value specifying the byte address of the beginning destination pixel for a BitBLT.

Bit	Description
7:5	Reserved
4:0	BLT Destination Start [20:16]: This field is the high-order 5 bits of the BLT destination start.

9.39 GR2C: BLT Source Start Low Register (CL-GD5426/'28/'29 only)

I/O Port Address: 3CF

Index: 2C

Bit	Description
7	BLT Source Start [7]
6	BLT Source Start [6]
5	BLT Source Start [5]
4	BLT Source Start [4]
3	BLT Source Start [3]
2	BLT Source Start [2]
1	BLT Source Start [1]
0	BLT Source Start [0]

This register contains the low-order 8 bits of the 21-bit value specifying the byte address of the beginning source pixel for a BitBLT. This register must be accessed for write in the process of programming any system-to-screen BitBLT that uses color expansion. The data written can be anything; it is the write access that is necessary.

Bit	Description
7:0	BLT Source Start [7:0]: This field is the low-order 8 bits of the BLT source start.

9.40 GR2D: BLT Source Start Mid Register (CL-GD5426/'28/'29 only)

I/O Port Address: 3CF

Index: 2D

Bit	Description
7	BLT Source Start [15]
6	BLT Source Start [14]
5	BLT Source Start [13]
4	BLT Source Start [12]
3	BLT Source Start [11]
2	BLT Source Start [10]
1	BLT Source Start [9]
0	BLT Source Start [8]

This register contains the middle 8 bits of the 21-bit value specifying the byte address of the beginning source pixel for a BitBLT.

Bit	Description
7:0	BLT Source Start [15:8]: This field is the middle 8 bits of the BLT source start.

9.41 GR2E: BLT Source Start High Register (CL-GD5426/'28/'29 only)

I/O Port Address: 3CF

Index: 2E

Bit	Description
7	Reserved
6	Reserved
5	Reserved
4	BLT Source Start [20]
3	BLT Source Start [19]
2	BLT Source Start [18]
1	BLT Source Start [17]
0	BLT Source Start [16]

This register contains the high-order 5 bits of the 21-bit value specifying the byte address of the beginning source pixel for a BitBLT.

Bit	Description
7:5	Reserved
4:0	BLT Source Start [20:16]: This field is the high-order 5 bits of the BLT source start.

9.42 GR2F: BLT Write Mask Destination Register (CL-GD5429 only)

I/O Port Address: 3CF

Index: 2E

Bit	Description
7	Pattern Offset (NOT)
6	Reserved
5	Reserved
4	Reserved
3	Reserved
2	Write Mask [2]
1	Write Mask [1]
0	Write Mask [0]

This register contains a write mask used for clipping on the left edge of color-expanded Bit-BLTs. This register is programmable only on the CL-GD5429.

Bit	Description
7	Pattern Offset (NOT): If XY Pattern Offset is not being used, this bit must be programmed to '1'. If XY Pattern Offset is being used, this bit must be programmed to '0'.
6:3	Reserved
2:0	BLT Source Start [20:16]: If this field is written to any value other than '0', then 'n' pixels will not be written on the left edge of each scanline for a color-expanded BitBLT.

9.43 GR30: BLT Mode Register (CL-GD5426/'28/'29 only)

I/O Port Address: 3CF

Index: 30

Bit	Description
7	Enable Color Expand
6	Enable 8 × 8 Pattern Copy
5	Reserved
4	Color Expand/Transparency Width
3	Enable Transparency Compare
2	BLT Source Display/System Memory
1	Reserved
0	BLT Direction

This register contains the bits that specify the details, but not the ROP, of the BLT.

Bit	Description
7	<p>Enable Color Expand: If this bit is programmed to '1', the ROP source is the expanded result from the bit-mapped source. The destination must be screen memory, and the direction must be 'increment'. The Color registers at GR0, GR1, GR10, and GR11 are used for the bit-map color expand BLT operations. All ROPs are available.</p> <p>When the source data is expanded, the MSB of the first source byte becomes the first pixel in the screen destination. For color-expanded BLTs (system or display memory source), each logical line must be filled out to an even byte with 'dummy' bits, if it is not an even multiple of eight pixels (that is, the source bytes must be completely used). These extra bits are ignored under the control of the BLT width setting.</p> <p>When the source of color-expand data is display memory, the source starting address must be on a 4-byte boundary, and the addressing is always linear (the source pitch is ignored). Refer to Appendix D6 for information regarding color expansion.</p> <p>If this bit is programmed to '0', the ROP source is the pixel data read from the source.</p> <p>For the CL-GD5429 only: The 8-byte monochrome pattern for a color expanded BLT must begin on an 8-byte boundary. The low-order three bits of the source start address determines which byte of the pattern is used for the first scanline of the destination. That is, the low-order three bits of the source address function as a vertical offset for the pattern.</p>

9.43 GR30: BLT Mode Register (CL-GD5426/'28/'29 only) (cont.)

Bit	Description								
6	<p>Enable 8 × 8 Pattern Copy: If this bit is programmed to '1', the source pattern is copied repeatedly to the destination rectangular area. The pattern source must be aligned on a four-byte boundary, except for color expansion, when the source must be aligned on an eight-byte boundary. The source is linear addressed data, in one of three arrangements as shown in the following table.</p> <table> <tr> <th>Operating Mode</th><th>Arrangement</th></tr> <tr> <td>Color expansion enabled</td><td>8 bytes of Monochrome bitmap for the 8 × 8 pattern</td></tr> <tr> <td>8-bit pixels</td><td>64 bytes of color data for 64 pixels</td></tr> <tr> <td>16-bit pixels</td><td>128 bytes of color data for 64 pixels</td></tr> </table>	Operating Mode	Arrangement	Color expansion enabled	8 bytes of Monochrome bitmap for the 8 × 8 pattern	8-bit pixels	64 bytes of color data for 64 pixels	16-bit pixels	128 bytes of color data for 64 pixels
Operating Mode	Arrangement								
Color expansion enabled	8 bytes of Monochrome bitmap for the 8 × 8 pattern								
8-bit pixels	64 bytes of color data for 64 pixels								
16-bit pixels	128 bytes of color data for 64 pixels								
5	Reserved								
4	<p>Color Expand/Transparency Width: If this bit is programmed to '1' and color expansion is enabled, the bit-mapped source is expanded to 16 bits/pixel. If this bit is programmed to '0' and color expansion is enabled, the bit-mapped source is expanded to 8 bits/pixel.</p> <p>If this bit is programmed to '1' and GR30[3] is programmed to '1', the transparency compare is done on 16-bit pixels (CL-GD5426/'28 only). If this bit is programmed to '0' and GR30[3] is programmed to '1', the transparency compare is done on 8-bit pixels.</p>								
3	<p>Enable Transparency Compare: For the CL-GD5426/'28 only: if this bit is programmed to '1', then the result of the ROP is compared to the Transparent Color register for each pixel. If the compare is a match, then the data are <i>not</i> written to the destination. The transparency feature must be used, and the transparent color set to the background color, if the color expand BLT is to be used with an opaque foreground and a transparent background (similar to Extended Write mode 4).</p> <p>If this bit is programmed to '0', the data are written to the destination without regard of the Transparent Color register.</p> <p>For the CL-GD5429 only: this bit is used for color expand with transparency. If this bit is programmed to '1', then zeroes in the monochrome image being expanded result in the corresponding pixel not being written. This is the equivalent of Extend Write mode 4; only the foreground is written.</p> <p>If this bit is programmed to '0', then zeroes in the monochrome image being expanded result in the background color being written into the corresponding pixel.</p>								

9.43 GR30: BLT Mode Register (CL-GD5426/'28/'29 only) (cont.)

Bit	Description
2	<p>BLT Source Display/System Memory: If this bit is programmed to '1', the BLT source is system memory rather than display memory. The CPU performs the system bus transfers; the CL-GD5426/'28/'29 ignores the address provided with such transfers. The CPU is required to transfer data in increments of four bytes. If the total number of bytes moved for a BLT is not a multiple of four, the CPU must write 'extra' bytes. System memory-to-system memory BLTs are not allowed.</p> <p>If this bit is programmed to '0', the BLT source is display memory.</p> <p>NOTE: When system-to-screen BitBLTs are being executed, 16- or 32-bit host transfers must be used.</p> <p>When system-to-screen BitBLTs involving color expansion are being executed, the BLT Source Start registers must be programmed to '0'.</p>
1	Reserved
0	<p>BLT Direction: If this bit is programmed to '1', the source and destination addresses are decremented. The BLT proceeds from higher addresses to lower addresses. In this case, the starting address is the highest addressed byte in each area.</p> <p>If this bit is programmed to '0', the source and destination addresses are incremented. The BLT proceeds from lower addresses to higher addresses.</p>

9.44 GR31: BLT Start/Status Register (CL-GD5426/'28/'29 only)

I/O Port Address: 3CF

Index: 31

Bit	Description
7	Reserved
6	Reserved
5	Reserved
4	Reserved
3	BLT Progress Status (read-only)
2	BLT Reset
1	BLT Start/Suspend
0	BLT Status (read-only)

This register contains the bit that actually begins a BLT, and a bit that indicates whether the BLT has completed.

Bit	Description
7:4	Reserved
3	BLT Progress Status (Read-only): At the start of a BLT this bit is set to '1' and resets to '0' when the entire operation completes. If the BLT is <i>suspended</i> (refer to GR31[1]), this bit remains '1'. If the BLT is <i>reset</i> (refer to GR31[2]), this bit is reset to '0'.
2	BLT Reset: If this bit is programmed to '1', the entire BLT engine immediately resets and any operation in progress is terminated. The operation cannot be restarted.
1	BLT Start/Suspend: When this bit is programmed to '1', the BLT begins with the next available display memory cycle. When the BLT is completed, this bit is cleared to '0'. If this bit is programmed to '0', the BLT is suspended at the end of the current scanline. GR31[0] must be monitored to determine when the BLT actually stops. If the BLT is suspended by programming this bit to '0', then the BLT Height registers reflect the line count for the last completed transfer. A suspended BLT can be resumed merely by programing this bit to '1'. Only screen-to-screen BLTs can be suspended.
0	BLT Status (Read-only): If this bit is '1', the BLT is in progress. If this bit is '0', then the BLT is complete.

9.45 GR32: BLT Raster Operation Register (ROP) (CL-GD5426/'28/'29 only)

I/O Port Address: 3CF

Index: 32

Bit	Description
7	f [7]
6	f [6]
5	f [5]
4	f [4]
3	f [3]
2	f [2]
1	f [1]
0	f [0]

This register selects a two-operand ROP.

Bit	Description
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7:0 **f [7:0]:** This eight-bit value selects a two-operand raster operation, as indicated in the table below. This table is ordered by Microsoft ROP.

Z RPN	Z	ROP (hex)	Microsoft® Name	Microsoft ROP
0	0	00	BLACKNESS	00000042
DPon	~P.~D	90	—	000500A9
DPna	~P.D	50	—	000A0329
Pn	~P	D0	—	000F0001
DSon	~S.~D	90	NOTSRCERASE	001100A6
DSna	~S.D	50	—	00220326
Sn	~S	D0	NOTSRCCOPY	00330008
SDna	S.~D	09	SRCERASE	00440328
PDna	P.~D	09	—	00500325
Dn	~D	0B	DSTINVERT	00550009
DPx	P~=D	59	PATINVERT	005A0049
DPan	~P+~D	DA	—	005F00E9
DSx	S~=D	59	SRCINVERT	00660046
DSan	~S+~D	DA	—	007700E6
DSa	S.D	05	SRCAND	008800C6

9.45 GR32: BLT Raster Operation Register (ROP) (CL-GD5426/'28/'29 only) (cont.)

Bit	Description
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7:0(cont.)

Z RPN	Z	ROP (hex)	Microsoft® Name	Microsoft ROP
DSxn	S=D	95	—	00990066
DPa	P.D	05	—	00A000C9
PDxn	P=D	95	—	00A50065
D	D	06	—	00AA0029
DPno	~P+D	D6	—	00AF0229
DSno	~S+D	D6	MERGEPAINT	00BB0226
S	S	0D	SRCCOPY	00CC0020
SDno	S+~D	AD	—	00DD0228
DSo	S+D	6D	SRCPAINT	00EE0086
P	P	0D	PATCOPY	00F00021
PDno	P+~D	AD	—	00F50225
DPo	P+D	6D	—	00FA0089
1	1	0E	WHITENESS	00FF0062

NOTE: In the first two columns 'D' denotes destination, 'S' denotes source, and 'P' denotes pattern.

The first column is reverse Polish notation (RPN). The operators are: 'a' denotes AND, 'o' denotes OR, 'x' denotes exclusive OR, and 'n' denotes NOT. As an example, the second entry would be interpreted: Destination, (enter), Pattern, oR, nOT.

The second column is provided as a service for those who prefer to avoid RPN. The operators are: '~' denotes NOT, '.' denotes AND, and '+' denotes OR. As an example, the second entry would be interpreted: NOT pattern AND NOT destination. (Demorgan's theorem says these two interpretations are equivalent.)

9.46 GR34: BLT Transparent Color Low Register (CL-GD5426/'28 only)

I/O Port Address: 3CF

Index: 34

Bit	Description
7	BLT Transparent Color [7]
6	BLT Transparent Color [6]
5	BLT Transparent Color [5]
4	BLT Transparent Color [4]
3	BLT Transparent Color [3]
2	BLT Transparent Color [2]
1	BLT Transparent Color [1]
0	BLT Transparent Color [0]

This register contains the low-order 8 bits of the 16-bit transparent color. If GR30[3] is programmed to '1', this value is compared with the ROP result. If it is equal, the ROP result is not written to the destination.

Bit	Description
7:0	BLT Transparent Color [7:0]: This field is the low-order 8 bits of the BLT transparent color.

9.47 GR35: BLT Transparent Color High Register (CL-GD5426/'28 only)

I/O Port Address: 3CF

Index: 35

Bit	Description
7	BLT Transparent Color [15]
6	BLT Transparent Color [14]
5	BLT Transparent Color [13]
4	BLT Transparent Color [12]
3	BLT Transparent Color [11]
2	BLT Transparent Color [10]
1	BLT Transparent Color [9]
0	BLT Transparent Color [8]

This register contains the high-order 8 bits of the 16-bit transparent color. If GR30[3] is programmed to '1', this value is compared with the ROP result. If it is equal, the ROP result is not written to the destination. For 8-bit color modes, GR35 must be set equal to GR34.

Bit	Description
7:0	BLT Transparent Color [15:8]: This field is the high-order 8 bits of the BLT transparent color.

9.48 GR38: BLT Transparent Color Mask Low Register (CL-GD5426/'28 only)

I/O Port Address: 3CF

Index: 38

Bit	Description
7	BLT Transparent Color Mask [7]
6	BLT Transparent Color Mask [6]
5	BLT Transparent Color Mask [5]
4	BLT Transparent Color Mask [4]
3	BLT Transparent Color Mask [3]
2	BLT Transparent Color Mask [2]
1	BLT Transparent Color Mask [1]
0	BLT Transparent Color Mask [0]

This register contains the low-order 8 bits of the 16-bit transparent color mask. If GR30[3] is programmed to '1', the transparent color is compared with the ROP result under this mask. If it is equal, the ROP result is not written to the destination.

Bit	Description
7:0	BLT Transparent Color Mask [7:0]: This field is the low-order 8 bits of the BLT transparent color mask. A '1' in any bit location makes the corresponding compare a don't care.

9.49 GR39: BLT Transparent Color Mask High Register (CL-GD5426/'28 only)

I/O Port Address: 3CF

Index: 39

Bit	Description
7	BLT Transparent Color Mask [15]
6	BLT Transparent Color Mask [14]
5	BLT Transparent Color Mask [13]
4	BLT Transparent Color Mask [12]
3	BLT Transparent Color Mask [11]
2	BLT Transparent Color Mask [10]
1	BLT Transparent Color Mask [9]
0	BLT Transparent Color Mask [8]

This register contains the high-order 8 bits of the 16-bit transparent color mask. If GR30[3] is programmed to '1', the transparent color is compared with the ROP result under this mask. If it is equal, the ROP result is not written to the destination. For 8-bit color modes, GR39 must be equal to GR38.

Bit	Description
7:0	BLT Transparent Color Mask [15:8]: This field is the high-order 8 bits of the BLT transparent color mask. A '1' in any bit location makes the corresponding compare a don't care.

9.50 CR19: Interlace End Register

I/O Port Address: 3?5

Index: 19

Bit	Description
7	Interlace End [7]
6	Interlace End [6]
5	Interlace End [5]
4	Interlace End [4]
3	Interlace End [3]
2	Interlace End [2]
1	Interlace End [1]
0	Interlace End [0]

This register contains the ending horizontal character count for the Odd Field VSYNC.

Bit	Description
7:0	Interlace End: This value is the number of characters in the last scanline of the Odd Field in interlaced timing. This can be adjusted to center the scanlines in the Odd Field half way between scanlines in the Even Field. This register is typically programmed to approximately half the Horizontal Total.

NOTE: '?' in the above register address is 'B' in Monochrome mode and 'D' in Color mode.

9.51 CR1A: Miscellaneous Control Register

I/O Port Address: 3?5

Index: 1A

Bit	Description
7	Vertical Blank End Overflow [9]
6	Vertical Blank End Overflow [8]
5	Horizontal Blank End Overflow [7]
4	Horizontal Blank End Overflow [6]
3	Overlay/DAC Mode Switching Control [1]
2	Overlay/DAC Mode Switching Control [0]
1	Enable Double Buffered Display Start Address
0	Enable Interlaced

This register contains timing overflow bits as well as some miscellaneous control bits.

Bit	Description
7:6	Vertical Blank End Overflow: This 2-bit field extends the Vertical Blank End value to 10 bits. Refer to the description of CR0 for a table containing all the timing value bits. These bits are enabled only if CR1B[5] is programmed to '1', or if CR1B[7] is programmed to '1' for the CL-GD5424/'25/'26/'28/'29 only.
5:4	Horizontal Blank End Overflow: This 2-bit field extends the Horizontal Blanking End value to 8 bits. Refer to the description of CR0 for a table containing all the timing value bits. These bits are enabled only if CR1B[5] is programmed to '1', or if CR1B[7] is programmed to '1' for the CL-GD5424/'25/'26/'28/'29 only.
3:2	Overlay/DAC Mode Switching Control [1:0]: This 2-bit field selects the Overlay and DAC Mode Switch term. The values are summarized in the following table. Refer to Appendix B14, "Video Overlay and DAC Mode Switching".

CR1A[3]	CR1A[2]	Switch Enabled with:	P[7:0]	Note
0	0	Normal operation (Switch disabled)	Outputs	
0	1	Timing: EVIDEO* or OVRW	Inputs	See CR1D[6]
1	0	OVRW AND'ed with Color Key	Inputs	CL-GD5424/'26/'28
1	0	EVIDEO* AND'ed with Color Key	Inputs	CL-GD5425/'29
1	1	Color Key	Inputs	

9.51 CR1A: Miscellaneous Control Register (*cont.*)

Bit	Description
1	Enable Double Buffered Display Start Address: If this bit is programmed to '1', the Display Start Address is updated on the VSYNC following a write to Start Address Low. This provides control of display frame switching without the need to explicitly monitor VSYNC.
0	Enable Interlaced: If this bit is programmed to '1', interlaced timing is enabled. Interlaced timing means interlaced sync in text mode, and interlaced sync <i>and</i> video data in graphics mode. In addition, IRQ requests are generated only at the end of odd fields (that is, at the end of a frame). For interlaced sync and data in graphics mode, the CRTC Scan Double (CR9[7]) must be programmed to '0'.

NOTE: '?' in the above register address is 'B' in Monochrome mode and 'D' in Color mode.

9.52 CR1B: Extended Display Controls Register

I/O Port Address: 3?5

Index: 1B

Bit	Description
7	Enable Blank End Extensions (<i>CL-GD5424/25/26/28/29 only</i>)
6	Enable Text Mode Fast-Page
5	Blanking Control
4	Offset Register Overflow 8
3	Extended Display Start Address Bit 18 (<i>CL-GD5426/28/29 only</i>)
2	Extended Display Start Address Bit 17
1	Enable Extended Address Wrap
0	Extended Display Start Address Bit 16

This register contains a number of miscellaneous bits that control extended display functions.

Bit	Description
7	<p>Enable Blank End Extensions (CL-GD5424/25/26/28/29 only): If this bit is programmed to '0', the Vertical and Horizontal Blank End Extension bits in CR1A are disabled if CR1B[5] is also '0'.</p> <p>If this bit is programmed to '1', the Vertical and Horizontal Blank End Extension bits in CR1A are enabled, regardless of the programming of CR1B[5].</p>
6	<p>Enable Text Mode Fast-Page: If this bit is programmed to '0', all font fetch cycles take place as random read cycles. This bit must be programmed to '0' for standard VGA dual-font operation.</p> <p>If this bit is programmed to '1', Fast-page mode cycles are used to fetch font data. This allows for text modes with a VCLK greater than 30 MHz, as is required for 132-column modes.</p>
5	<p>Blanking Control: If this bit is programmed to '0', the DAC blanking is controlled by the blanking signal generated by the CRTC. In this case, the border can be used (Refer to AR11).</p> <p>If this bit is programmed to '1', the DAC blanking is controlled by Display Enable. The DAC is blanked during the time when the border is normally displayed. In addition, the OVRW pin (pin 71) is an output and follows the blanking signal generated by the CRTC. This signal can be directed to the feature connector or can be used to control an external overlay circuit. Finally, programming this bit to '1' enables the Vertical and Horizontal Blank End Extension bits in CR1A. Refer to Appendix B14.</p>

9.52 CR1B: Extended Display Controls Register *(cont.)*

Bit	Description
4	Offset Register Overflow 8: This bit extends the CRTC Offset register (CR13) by one bit. Refer to the description of CR0 in Table 6-2 for a summary of CRTC Timing register.
3	Extended Display Start Address Bit 18 (CL-GD5426/'28/'29 only): This is bit 17 of the Display Start Address. Refer to the description of CR1 in Table 6-2 for a summary of CRTC Timing register.
2	Extended Display Start Address Bit 17: This is bit 17 of the Display Start Address. Refer to the description of CR1 in Table 6-2 for a summary of CRTC Timing register.
1	<p>Enable Extended Address Wrap: If this bit is programmed to '0', the display memory address wraps at 64K maps (256K total memory). This provides VGA compatibility. If this bit is programmed to '1', the display memory address wraps at the total available memory size. In particular, this bit provides the following functions:</p> <p>If this bit is programmed to '1' and Chain-4 addressing is selected (SR4[3] = 1), DRAM addresses A0 and A1 are supplied from addresses XMA[16] and XMA[17]. XMA[18:12] addresses are the sum of XA[16:12] and either Offset register 0 or 1.</p> <p>If this bit is programmed to '1' and CRTC Double Word addressing is selected (CR14[6] = 1), DRAM addresses A0 and A1 are supplied from CRTC addresses CR[14] and CR[15]. This provides four displayable pages in Video mode 13h. Character counter addresses CA[16] and CA[18] provide up to 256 Kbytes in each bit plane, or 1 Mbyte of packed-pixel memory.</p> <p>If this bit is programmed to '0', the CRTC character address counter is 16-bits-wide, providing VGA compatibility. If this bit is programmed to '1', the Counter is 18-bits-wide (19-bits-wide in CL-GD5426/'28/'29 only).</p>
0	Extended Display Start Address Bit 16: This is bit 16 of the Extended Display Start Address. Refer to the description of CR0 in Table 6-2 for a summary of CRTC Timing register.

NOTE: '?' in the above register address is 'B' in Monochrome mode and 'D' in Color mode.

9.53 CR1C: Sync Adjust and GENLOCK Register (CL-GD5425 only)

I/O Port Address: 3?5

Index: 1C

Bit	Description
7	Enable VSYNC GENLOCK
6	Enable HSYNC GENLOCK
5	Horizontal Total Adjust [2]
4	Horizontal Total Adjust [1]
3	Horizontal Total Adjust [0]
2	Horizontal Sync Start Adjust [2]
1	Horizontal Sync Start Adjust [1]
0	Horizontal Sync Start Adjust [0]

This register enables GENLOCK, and for horizontal timing adjustments.

Bit	Description
7	<p>Enable VSYNC GENLOCK: If this bit is programmed to '1', VSYNC GENLOCK is enabled. The VSYNC pin becomes an input, internally synchronized to VCLK. A high-to-low transition clears the CRTC vertical counter and returns the display to the top of the screen.</p> <p>If the CL-GD5425 is programmed for interlaced operation, the first transition sampled after this bit has been programmed to '1' also clears the interlace field state to 'even'.</p>
6	<p>Enable HSYNC GENLOCK: If this bit is programmed to '1', HSYNC GENLOCK is enabled. The HSYNC pin becomes an input, internally synchronized to VCLK. The high-to-low transition is synchronized to VCLK and the VCLK edges, later the Character Clock generator (VCLK counter) is cleared. The next character clock causes the equivalent of Horizontal Total.</p> <p>The value programmed into the Horizontal Total register must be so that the external HSYNC occurs before the programmed value is reached. This function is independent of VSYNC GENLOCK.</p> <p>Either VSYNC GENLOCK or Horizontal GENLOCK is used with an external VCLK derived externally from the video source and supplied to DCLK (EDCLK is Low). MISC register 3C2[3:2] must be programmed to '1,X' so that the externally generated DCLK drives the CRT Controller as well as the DAC. The external master supplies HSYNC and VSYNC to the display as well as to CL-GD5425.</p>

9.53 CR1C: Sync Adjust and GENLOCK Register (CL-GD5425 only) (cont.)

Bit	Description
5:3	Horizontal Total Adjust [2:0]: This field allows for a $-3/+4$ VCLK adjustment of the programmed Horizontal Total. The length of the character, which occurs two character clocks after the Horizontal Counter has reached the value programmed into Horizontal Total, is adjusted according to this field. The following table shows this adjustment:

CR1C[5:3]	Character Clock Adjustment
000	0 (Normal)
001	-3 VCLKs
010	-2 VCLKs
011	-1 VCLKs
100	+1 VCLKs
101	+2 VCLKs
110	+3 VCLKs
111	+4 VCLKs

2:0	Horizontal Sync Start Adjust [2:0]: This field allows a 0–7 VCLK adjustment of the position of Horizontal Sync Start (relative to BLANK). HSYNC is delayed an additional number of VCLKs programmed in this field. The HSYNC width is still adjustable only in Character Clock increments.
-----	---

9.54 CR1D: Overlay Mode Register (CL-GD5425/'29 only)

I/O Port Address: 3?5

Index: 1D

Bit	Description
7	Reserved
6	Overlay Timing Signal Source
5	Reserved
4	Reserved
3	Color Compare Data Width (<i>CL-GD5425 only</i>)
2	DAC Mode Switching Control [1]
1	DAC Mode Switching Control [0]
0	TV Mode Interlaced Sync Control (<i>CL-GD5425 only</i>)

This register contains bits that control extended overlay modes.

Bit	Description
7	Reserved
6	<p>Overlay Timing Signal Source: If this bit is programmed to '0', the EVIDEO* input is used as the timing signal for Overlay modes 01 and 10 (refer to the table in bit description 3:2, "Overlay/DAC Mode Switching Control [1:0]", on page 9-67). This is the default.</p> <p>If this bit is programmed to '1', the internally generated signal OVRW is used as the timing signal for Overlay modes 01 and 10. This avoids the requirement to connect OVRW to EVIDEO*.</p>
5:4	Reserved
3	<p>Color Compare Data Width (CL-GD5425 only): If this bit is programmed to '1' and the SR7[2:1] field is programmed to '1,1', all 16 bits of each pixel are used for the color key compare. The low byte of the VGA data is compared to the value in GRC and the high byte of the VGA data is compared to the value in GRD. Since GRD is used as the high-byte comparand, no mask is available. This feature is not available when the SR7[2:1] field is programmed for the 16- or 24-bit byte serial modes (0,1 or 1,0).</p> <p>If this bit is programmed to '0', only the high-order byte of each VGA pixel is used for color key compare.</p>

9.54 9.53 CR1D:Overlay Mode Register (CL-GD5425/'29 only) (cont.)

Bit	Description								
2:1	<p>DAC Mode Switching Control [1:0]: This field controls DAC Mode Switching. This controls only DAC Mode Switching; the selection of pixel data is still done as programmed into CR1A[3:2].</p> <table border="1"> <thead> <tr> <th>CR1D[2:1]</th><th>DAC Mode Switching</th></tr> </thead> <tbody> <tr> <td>00</td><td>Switch True selected Extended DAC mode</td></tr> <tr> <td>01</td><td>Switch False selected Extended DAC mode</td></tr> <tr> <td>1x</td><td>Disable DAC Mode Switching (DAC always in Extended mode)</td></tr> </tbody> </table>	CR1D[2:1]	DAC Mode Switching	00	Switch True selected Extended DAC mode	01	Switch False selected Extended DAC mode	1x	Disable DAC Mode Switching (DAC always in Extended mode)
CR1D[2:1]	DAC Mode Switching								
00	Switch True selected Extended DAC mode								
01	Switch False selected Extended DAC mode								
1x	Disable DAC Mode Switching (DAC always in Extended mode)								
0	<p>TV Mode Interlaced Sync Control (CL-GD5425 only): When this bit is programmed to '0', interlaced sync and/or data is generated as programmed in CR1A[0].</p> <p>When this bit is programmed to '1', sync timing for even fields is generated — although the data may still be 'interlaced' (displayed in alternate fields). This results in zero flicker at the expense of reduced vertical resolution for PAL output.</p>								

NOTE: '?' in the above register address is 'B' in Monochrome mode and 'D' in Color mode.

9.55 CR25: Part Status Register

I/O Port Address: 3?5

Index: 25

Bit	Description
7	PSR [7]
6	PSR [6]
5	PSR [5]
4	PSR [4]
3	PSR [3]
2	PSR [2]
1	PSR [1]
0	PSR [0]

This read-only register is used for factory testing and internal tracking only.

Bit	Description
7:0	Part Status Value

NOTE: '?' in the above register address is 'B' in Monochrome mode and 'D' in Color mode.

9.56 CR27: ID Register

I/O Port Address: 3?5

Index: 27

Bit	Description
7	Device ID [5]
6	Device ID [4]
5	Device ID [3]
4	Device ID [2]
3	Device ID [1]
2	Device ID [0]
1	Reserved
0	Reserved

This read-only register returns a value that uniquely identifies the device.

Bit	Description
-----	-------------

7:2	Device ID: This six-bit field contains a unique value that identifies the device according to the following table:
-----	---

Product	CR27[7:2]
CL-GD5420	100010
CL-GD5422	100011
CL-GD5424	100101
CL-GD5425	100000
CL-GD5426	100100
CL-GD5428	100110
CL-GD5429	100111

1:0	Reserved
-----	-----------------

NOTE: '?' in the above register address is 'B' in Monochrome mode and 'D' in Color mode.

9.57 CR30: TV-Out Mode Control Register (CL-GD5425 only)

I/O Port Address: 3?5

Index: 30

Bit	Description
7	Color Carrier Reference Divisor [1]
6	Color Carrier Reference Divisor [0]
5	Enable Two-line Vertical Filter
4	Filter Control
3	TV-Out Enable
2	PAL/NTSC Select
1	Enable Vertical Expansion/Scaling
0	Vertical Scaling Mode

This register contains bits that control the TV-Out formats. This register is implemented on the CL-GD5425 only.

Bit	Description
-----	-------------

7:6	Color Carrier Reference Divisor [1:0]: This field selects the divisor for the Color Carrier Reference. The Color Carrier Reference is output on BLANK* (pin 93) if CR30[3] = '1'. The frequency is as indicated in the following table.
-----	--

CR30[2]	CR30[7:6]	Output	Nominal Frequency (MHz)	Note	Standard
0	00	VCLK	17.734476	4x fsc	PAL
0	01	VCLK/2	8.867238	2x fsc	PAL
0	10	VCLK/4	4.433619	1x fsc	PAL
1	00	VCLK	14.31818	4x fsc	NTSC
1	01	VCLK/2	7.15909	2x fsc	NTSC
1	10	VCLK/4	3.5795	1x fsc	NTSC
x	11	—	—	Reserved	Reserved

9.57 CR30: Extended Display Controls Register (CL-GD5425 only) (cont.)

Bit	Description
5	<p>Two-line Flicker Filter Enable: If this bit is programmed to '1', two-line flicker filter is enabled.</p> <p>If this bit is programmed to '0', two-line flicker filter is disabled.</p>
4	<p>Two-Line Flicker Filter Control: If CR30[5] is set to '0', this bit has no effect. If CR30[5] is set to '1', this bit has the following meaning:</p> <p>If this bit is set to '0', the two-line flicker filter uses 1/2 the upper line plus 1/2 the lower line function for all interlaced modes, except the 480-400 scaled mode.</p> <p>If this bit is '1', third line 2-bit Y information is enabled. The adjust method ('max') is used only for 480-400 NTSC scaling (for Revision AB silicon).</p> <p>NOTE: When 480-400 scaling is selected, CR30[5] must = '1' or filtered scaling is disabled and the screen has missing lines.</p>
3	<p>TV-Out Enable: When this bit is programmed to '1', CSYNC output is enabled on MA9. Either PAL or NTSC format is chosen, as selected in CR30[2]. In addition, FSC output is enabled on the BLANK* pin. When this bit is programmed to '0', CSYNC and FSC output is disabled.</p>
2	<p>PAL/NTSC Select: If this bit is programmed to '1', NTSC format CSYNC is selected when CR30[3] is programmed to '1'. In addition, if CF0 is 0, the XTAL pin is selected as the input for the VCO.</p> <p>If this bit is programmed to '0', PAL format CSYNC is selected when CR30[3] is programmed to '1'. In addition, if CF0 is 0, the OSC pin is selected as the input for the VCO.</p>
1	<p>Enable Vertical Expansion/Scaling: If this bit is programmed to '1', vertical expansion/scaling is performed according to the programming of CR30[2] and CR30[0]. Vertical expansion/scaling changes the number of scanlines per field (or frame) to compensate for the fact that standard VGA aspect ratios are not the same as PAL or NTSC aspect ratios. Scanlines are either repeated (expansion), replicated, or scaled on a regular basis to generate the correct number for the TV standard being used. See the description of CR30[0] for details.</p> <p>If this bit is programmed to '0', vertical expansion/scaling is disabled.</p>

9.57 CR30: Extended Display Controls Register (CL-GD5425 only) (cont.)

Bit	Description
0	Vertical Scaling Mode: If CR30[1] is programmed to '1', this bit, in conjunction with CR30[2], specifies the details of vertical scaling.

CR30[2]	CR30[0]	Mode	Expansion/ Scaling	Notes
0	0	PAL	5:6 expansion	200 lines expanded to 240 lines (200-240 OK for text modes) 400 lines expanded to 480 lines
0	1	PAL	5:7 expansion	350 lines expanded to 490 lines
1	0	NTSC	7:8 expansion	350 lines expanded to 400 lines
1	1	NTSC	6:5 scaling	480 lines scaled to 400 lines 240 lines scaled to 200 lines

NOTE: '?' in the above register address is 'B' in Monochrome mode and 'D' in Color mode.

9.58 HDR: Hidden DAC Register (Except CL-GD5420)

I/O Port Address: 3C6

Index: –

Bit	Description	Reset State
7	Enable 5-5-5 Mode	0
6	Enable All Extended Modes	0
5	Clocking Mode	0
4	32K Color Control	0
3	Extended Mode Select [3] (<i>CL-GD5428 only</i>)	0
2	Extended Mode Select [2]	0
1	Extended Mode Select [1]	0
0	Extended Mode Select [0]	0

This register enables extended color modes, including 15-bit/pixel, 16-bit/pixel, and 24-bit/pixel modes. This register is cleared to all zeroes at reset, putting the CL-GD542X in VGA-compatibility mode.

This register is accessed by reading the Pixel Mask register at 03C6h four times in succession; the next write or read at 03C6h will access the Hidden DAC register. When the Hidden DAC register is written, the internal counter is reset and the four dummy reads must be executed again. For the CL-GD5422/24/26/28/29, a read from the Hidden DAC register resets the counter and the four dummy reads must be executed again. For the CL-GD5428 only, reads from 3C6 do not lock the Hidden DAC register.

Bit	Description
7	Enable 5-5-5 Mode: If this bit is programmed to '0', the extended color modes are disabled and the palette DAC is VGA-compatible. If this bit is programmed to '1', extended color modes are enabled, as chosen by bit 6 and bits 2:0 of this register.
6	Enable ALL Extended Modes: If this bit is programmed to '0' and bit 7 is programmed to '1', the palette DAC will be in 5-5-5 Sierra™ mode, regardless of the value programmed into bits 3:0. If this bit is programmed to '1' and bit 7 is programmed to '1', the palette DAC mode is chosen by the value programmed into bits 3:0 of this register.
5	<p>Clocking Mode: If this bit is programmed to '0', Clocking mode 1 is chosen. In Clocking mode 1, 16-bit/pixel modes use both edges of DCLK to latch data. The rising edge of DCLK latches the low byte and the falling edge of DCLK latches the high byte.</p> <p>If this bit is programmed to '1', Clocking mode 2 is chosen. In Clocking mode 2, 16-bit/pixel modes use only the rising edge of DCLK to latch data. The DCLK must be supplied at twice the pixel rate. The least-significant byte is latched on the first rising edge and the most-significant byte is latched on the second rising edge.</p> <p>NOTE: All modes other than 16-bit/pixel use only the rising DCLK edge regardless of this bit. This bit should be programmed to '0' only for externally supplied DCLK and data.</p>

9.58 HDR: Hidden DAC Register (Except CL-GD5420) (cont.)

Bit	Description
5 (cont.)	<p>Clocking Mode: For the CL-GD5429 only, this bit controls the clocking of input data. If this bit is programmed to '0', both edges of DCLK are used. The rising edge latches the low byte and the falling edge latches the high byte.</p> <p>If this bit is programmed to '1', the CL-GD5429 is configured for VESA VAFC 2X mode. Each rising edge clocks-in one byte. Every two bytes is assembled into a single 16-bit pixel which is displayed twice (two clock periods).</p>
4	<p>32K Color Control: If this bit is programmed to '0', 5-5-5 operation takes place normally. If this bit is programmed to '1', Pixel Data bit 15 chooses between palette operation and 5-5-5 color. This allows 5-5-5 data to overlay 256-color images on a pixel-by-pixel basis. If Pixel Data bit 15 is '1', then bits 7:0 choose a palette entry and bits 14:8 are ignored. If Pixel Data bit 15 is '0', then 5-5-5 operation is chosen.</p>
3:0	<p>Extended Mode Select [3:0]: If bits 7 and 6 are both programmed to '1', then this four-bit field selects the extended DAC mode according to the following table. Bits 7 and 6 are included in this table for completeness.</p>

Bit 7	Bit 6	Bit 3	Bit 2	Bit 1	Bit 0	Mode	Note
0	x	x	x	x	x	VGA compatibility	
1	0	x	x	x	x	5-5-5 Sierra™	
1	1	0	0	0	0	5-5-5 Sierra™	
1	1	0	0	0	1	5-6-5 XGA™	
1	1	0	0	1	0	Reserved	
1	1	0	0	1	1	CCIR601 YCrCb (16-bit 4:2:2)	CL-GD5425
1	1	0	1	0	0	AccuPak™ YCrCb (8-bit 4:1:1)	CL-GD5425
1	1	0	1	0	1	8-8-8 16 million colors	
1	1	0	1	1	x	DAC power-down	CL-GD5425/'28/'29
1	1	1	0	0	0	8-bit grayscale	CL-GD5425/'28/'29
1	1	1	0	0	1	3-3-2 8-bit RGB	CL-GD5425/'28/'29
1	1	1	0	1	x	16-bit RGB with 16-bit YCrCb overlay	CL-GD5425 ^a
1	1	1	1	0	x	16-bit RGB with AccuPak™ overlay	CL-GD5425 ^a
1	1	1	1	1	x	Reserved	

a. This mode allows the DAC to switch between two extended modes, rather than between VGA compatibility and a single extended mode. They are for the CL-GD5425 only. CR1D[2:1] is programmed to 00b. Refer to Appendix B14, "Mode Switching", for more information.

10. VGA BIOS

10.1 BIOS Overview

The CL-GD542X VGA BIOS is a high-performance firmware product optimized to take full advantage of the CL-GD542X True Color VGA controller. The CL-GD542X BIOS is based on proven BIOS technology, and is fully compatible with the IBM VGA BIOS interrupt 10h interface. The BIOS is designed to provide a well-defined interface between MS-DOS, application software, and special OEM utility programs. In addition, it provides an extended set of functions to support the CL-GD542X VGA controller.

10.1.1 Main BIOS Features

The CL-GD542X VGA BIOS supports the following key features:

- 100% IBM VGA-compatible BIOS
- Support for high-resolution, extended 256-colors, Direct-Color™ and True Color Video Modes
- High-performance operation
- Modular, proven design
- Adapter or system board implementation (C000/E000 segments)
- Can be integrated with system BIOS
- Supports switch-less configuration
- Can be customized without source code
- VESA-compatible modes and interface

10.1.2 Extended Video Mode Support

The CL-GD542X VGA BIOS provides full support for all extended high-resolution video modes via interrupt 10h function calls. In addition, the CL-GD542X VGA BIOS supports a variety of extended functions, such as VGA display configuration and extended VGA inquiry. For a detailed description of these functions, refer to the CL-GD542X VGA BIOS External Software Specification document (Appendix E1).

10.1.3 Direct-Color Operation

The CL-GD542X BIOS supports Direct-color and True Color Video Modes. The CL-GD542X simultaneously displays 32K or 64K colors at resolutions of up to 800 x 600 and 16M colors at up to 640 x 480. This 15/16/24-bits per pixel Video Mode is TARGA- and XGA-Mode-compatible.

10.1.4 High Performance

The BIOS is optimized to provide maximum performance in adapter or motherboard implementations. The 16-bit system bus and Display Memory Interface of the CL-GD542X and its internal FIFOs are fully used by the BIOS. In addition, time critical routines — such as TTY output and scroll — are designed to provide maximum throughput in both text and graphics modes.

10.1.5 System Integration

The CL-GD542X VGA BIOS can easily be integrated for an adapter or motherboard design. The BIOS — 32K bytes in size — is provided for both the C000 and E000 address segments. To save space on the system board, the CL-GD542X VGA BIOS can be incorporated into the system BIOS ROM at either C000 or E000 addresses.

The BIOS does not require DIP switches or external hardware to be properly configured. A well-defined interface to the CL-GD542X BIOS configuration is available for system BIOS or OEM setup routines.

10.1.6 Customization

The default CL-GD542X BIOS is designed to be implemented without modification in almost all environments. However, the CL-GD542X BIOS can also be easily customized for a specific system environment. Modifications can also be accomplished with the Cirrus Logic OEM System Integration (OEMSI) utility program; such modifications do not require the CL-GD542X VGA BIOS source code. Hundreds of BIOS parameters and features can be modified, including:

- Sign-on message
- Display type configuration
- Video Mode parameter tables
- Font tables

10.1.7 Compatibility

The CL-GD542X BIOS is 100-percent compatible with the IBM VGA BIOS and supports BIOS-level compatibility for adapter card or integrated VGA on the system board. In addition, the CL-GD542X BIOS complies fully with the video modes and specifications issued by the Video Electronics Standards Association (VESA).

10.2 CL-GD542X VGA BIOS Initialization and Power-Up Diagnostics

The CL-GD542X VGA BIOS is shipped in two formats — a segment-C000-based VGA BIOS configured for VGA adapter cards that will be plugged into PC systems, and segment-E000-based VGA BIOS configured for integrated VGA video subsystems on the motherboard. The following sequence of steps is performed by the VGA BIOS at power-up initialization:

For Segment-C000-Adapter-Based VGA BIOS:

1. Checks if VGA BIOS Vector Interrupt 10h is already initialized.
2. If so, calls the INT 10h Function to disable the existing VGA card to sleep.
3. Disables the VGA adapter by writing a value of 16h to I/O Port 46E8H.
4. Programs I/O Port 102h with data 01h to enable video subsystem.
5. Writes a value of 0eh to 46E8H to enable I/O and memory addressing.
6. Writes I/O Port 4AE8H to disable 8514/A.
7. Disables VGA video (by programming Sequencer Clocking Mode Register, [Bit 5] = 1).
8. Initializes Video Vectors INT 10h and INT 42h.

9. Enables extensions by writing GR0A (I/O Port 3CE, Index = 0aH) with data 0ECH.
10. Initializes CL-GD542X Extension Registers.
11. Checks for co-resident MDA video adapter; if MDA is present, initializes co-resident bits and sets up MDA adapter.
12. Checks for CGA; if present, initializes co-resident bits, sets VGA to monochrome, and enables CGA.
13. Tests Video Memory.
14. Initializes Text Mode 3.
15. Displays sign-on message.
16. If any POST error flags are set, prints error messages.

For Segment-E000-Motherboard-Based VGA BIOS (CL-GD5424 or higher):

1. Enables VGA Setup Mode by writing VGA Video Sleep Enable Register (VSE I/O Port 46E8H with value of 16H).
2. Programs POS 2 Register (I/O Port 102H with data 01H) to enable video subsystem.
3. Writes a value of 0H to 46E8H to disable existing VGA adapter I/O and memory addressing.
4. Enables motherboard VGA by programming VSE Register 3C3H with data value 1.
5. Writes I/O Port 4AE8H to disable 8514/A.
6. Disables VGA video (by programming Sequencer Clocking Mode Register, [Bit 5] = 1).
7. Initializes Video Vectors INT 10H and INT 42H.
8. Enables extensions by writing GR0A (I/O Port 3CE, Index = 0AH) with data 0ECH.
9. Initializes CL-GD542X Extension Registers.
10. Checks for co-resident MDA video adapter; if MDA is present, initializes co-resident bits and sets up MDA adapter.
11. Checks for CGA, if present, initializes co-resident bits, and sets VGA to monochrome and enables CGA.
12. Tests Video Memory.
13. Initializes Text Mode 3.
14. Displays sign-on message.
15. If any POST error flags are set, prints error messages.
16. Checks to see if a VGA adapter is also present in the system; if so, disables motherboard VGA controller.

10.3 Video BIOS Interrupt Vectors

The interrupt vectors that must be initialized by DOS (including the planar and video BIOSes) are listed in Table 10–4 later in this chapter. Of these, the vectors (at locations 0:0040, 0000:007C, 0000:0108, 0000:010C) corresponding to vectors 10, 1F, 42, 43 are handled by the video BIOS.

10H — Video Services (Vector Location = 0000:0040H)

The CL-GD542X BIOS functions are accessed using interrupt 10H. Application programs place a function code in AH, and, if required, in other registers calling parameters and then execute an INT 10H instruction. When the BIOS gains control, the appropriate code is executed to perform the function; parameter values may be left in processor registers to be returned to the calling program upon exit from the interrupt routine.

The functions supported by the CL-GD542X BIOS allow the calling program to set the current mode, manipulate the cursor, place characters and individual pixels on the display, scroll the screen, load character fonts and color palette values, and read the light pen position. These functions are described in following sections.

1DH — 6845 Initialization (Vector Location = 0000:0074H)

This vector points to the parameter tables that set up the 6845.

1FH — CGA Character Set (Vector Location = 0000:007CH)

This pointer is used for the table of the upper 128 characters in CGA Modes 4, 5, and 6. The INT 43H Vector is used for the lower 128 characters for these modes.

42H — Old Video Services Pointer (Vector Location = 0000:0108H)

This location used to be the INT 10H vector for planar BIOS video services. When the EGA/VGA is installed, BIOS routines reload this address with a pointer to the planar INT 10H video service routine entry point.

43H — Graphics Character Table (Vector Location = 0000:010CH)

BIOS routines use this vector to point to a table of bitmaps that are used when graphics characters are displayed. This table is used for the lower 128 characters in Video Modes 4, 5, and 6. This table is also used for 256 characters in all additional graphics modes (IBM standard as well as Cirrus Logic extensions).

The Interrupt 10H calls constitute the bulk of the services provided by the video BIOS and will be later described in detail. They are listed along with the function and subfunction that define the particular service required. Note that some INT 10H services were introduced with the VGA and are not available on the earlier EGA. The services have been divided up into functional groupings.

10.3.1 Interrupt 10H: BIOS Video Service Routines Contents

Function	Sub-Function	Description	Adapter
00H		Set Video Mode	EGA,VGA
01H		Set Cursor Type	EGA,VGA
02H		Set Cursor Position	EGA,VGA
03H		Get Cursor Position	EGA,VGA
04H		Get Light Pen Position	EGA,VGA
05H		Select Active Display Page	EGA,VGA
06H		Window Scroll-Up	EGA,VGA
07H		Window Scroll-Down	EGA,VGA
08H		Read Character/Attribute at Cursor Position	EGA,VGA
09H		Write Character/Attribute at Cursor Position	EGA,VGA
0AH		Write Character at Cursor Position	EGA,VGA
0BH	00H	Set Background/Border Color	EGA,VGA
	01H	Select the Palette Set	EGA,VGA
0CH		Write Dot (Pixel)	EGA,VGA
0DH		Read Dot (Pixel)	EGA,VGA
0EH		Write Teletype Character to Active Page	EGA,VGA
0FH		Get Video Mode	EGA,VGA
10H		Palette Manipulations	EGA,VGA
	00H	Set Individual Palette Register (Internal Palette Register)	
	01H	Set OverScan (Border) Register	
	02H	Set All Palette Registers and OverScan Register	
	03H	Intensity/Blinking	
	04H-06H	Reserved	
	07H	Read Individual Palette Register (Internal Palette Register)	
	08H	Read OverScan (Border) Register	
	09H	Read All Palette Registers and OverScan Register	
	0AH-0FH	Reserved	
	10H	Set Individual Color Register (RAMDAC/External Palette Register)	
	11H	Reserved	
	12H	Set Block of Color Registers	
	13H	Select Color Page (Not Valid in Mode 13H)	
	14H	Reserved	
	15H	Read Individual Color Register (RAMDAC/External Palette Register)	
	16H	Reserved	
	17H	Read Block of Color Registers	
	18H-19H	Reserved	

10.3.1 Interrupt 10H: BIOS Video Service Routines Contents (cont.)

Function	Sub-Function	Description	Adapter
11H	1AH	Read Current State of Color Page	EGA,VGA
	1BH	Sum Color Values To Gray Shades	
		Character Generator	
	00H	Load User Text Font	
	01H	Load 8 x 14 ROM Text Font	
	02H	Load 8 x 8 ROM Text Font	VGA
	03H	Select Block Specifier	
	04H	Load 8 x 16 ROM Text Font	
	10H	Load User Text Font and Reprogram Controller	
	11H	Load 8 x 14 ROM Text Font and Reprogram Controller	
	12H	Load 8 x 8 ROM Text Font and Reprogram Controller	VGA
	14H	Load 8 x 16 ROM Text Font and Reprogram Controller	
	20H	Set Pointer of User's Graphics Font Table to Interrupt 1FH	
	21H	Set Pointer of User's Graphics Font Table to Interrupt 43H	
	22H	Set Pointer of 8 x 14 ROM Graphics Font Table to Interrupt 43H	
	23H	Set Pointer of 8 x 8 ROM Graphics Font Table to Interrupt 43H	VGA
	24H	Set Pointer of 8 x 16 ROM Graphics Font Table to Interrupt 43H	
	30H	Get Font Information	
		Alternate Select	
12H	10H	Get Configuration Information	EGA,VGA
	20H	Select Alternate PrintScreen Routine	
	30H	Select Scanlines (Alphanumeric Mode)	
	31H	Enable/Disable Default Palette Loading	
	32H	Enable/Disable Video	
	33H	Enable/Disable Grayscale Summing	
	34H	Enable/Disable Cursor Emulation	
	35H	Switch Active Display	
	36H	Enable/Disable Screen Refresh	
13H		Write String in Teletype	EGA,VGA
1AH		Get/Set Display Combination Code	VGA
1BH		Get Functionality/State Information	VGA
1CH		Save/Restore Video State	VGA
1DH - FFH		Reserved	

10.4 Description Of Functions

10.4.1 Function: 00H • Set Video Mode

[Entry]

AH = 00H

AL = Video Mode (see below)

[Return]

NONE

[Note]

1. Video Mode Table for standard VGA:

Mode	Resolution	Type	Colors	Pages
00H/01H	40 x 25 (360 x 400)	Text	16	8
02H/03H	80 x 25 (640 x 400)	Text	16	8
04H/05H	320 x 200 (40 x 25)	Graphics	4	1
06H	640 x 200 (80 x 25)	Graphics	2	1
07H	80 x 25 (720 x 400)	Text	Monochrome	8
08H - 0CH	Reserved			
0DH	320 x 200 (40 x 25)	Graphics	16	8
0EH	640 x 200 (80 x 25)	Graphics	16	4
0FH	640 x 350 (80 x 25)	Graphics	Monochrome	2
10H	640 x 350 (80 x 25)	Graphics	16	2
11H	640 x 480 (80 x 25)	Graphics	2	1
12H	640 x 480 (80 x 25)	Graphics	16	1
13H	320 x 200 (40 x 25)	Graphics	256	1

2. If Bit 7 of AL is set, the display buffer will not be cleared. Otherwise, the display buffer will be cleared during mode setting (EGA, VGA only) (Clear Screen).
3. No hardware cursor in graphics modes.
4. Default Mode during POST: Mode 3H = Color Monitor, Mode 07H = Monochrome Monitor.
5. There is no difference between Modes 00H and 01H, 02H and 03H, or 05H and 06H on EGA/VGA. They are only different on CGA, which supports composite video displays.
6. The default settings of each Video Mode can be overridden by several subfunctions in Function 12H or by supply user's video service table whose address is stored in BIOS data area (0040:A8H).
7. See Application Note E1 for extended modes.

10.4.2 Function: 01H • Set Cursor Type**[Entry]**

AH = 01H

CH = Start scanline of cursor (0 base)

CL = End scanline of cursor (0 base)

[Return]

NONE

[Notes]

1. This function is available in text modes only. The values of cursor type are stored at [40:60].
2. The definition of value in Register CH:

Bit	Definition
7-6	Reserved = 0
5	1 = No cursor display 0 = Normal blinking cursor
4-0	Start scanline (0 base)

3. The definition of value in Register CL:

Bit	Definition
7	Reserved = 0
6-5	Number of character skew
4-0	End scanline (0 base)

* On EGA, the value in this register should be one greater than the real bottom of the cursor.

4. Default setting:

Font Size	Start	End
8 x 8	6	7
8 x 14	11	12
8 x 16	13	14

5. If cursor emulation is turned off, the values passed in CH and CL will be programmed directly into the hardware. The Cursor Emulation Flag is located in Bit 0 of [40:87]. It can be turned on/off by Subfunction 34H of Function 12H call.

10.4.3 Function: 02H • Set Cursor Position

[Entry]

AH = 02H

BH = Display page (0 base)

DH = Row number of cursor location start (0 base)

DL = Column number of cursor location end (0 base)

[Return]

NONE

[Notes]

1. This function is available for both text and graphics modes.
2. If Register DL is specified over the width of screen displayable area, it will cause the cursor to wrap to the next row. If Register DH is specified over the height of screen displayable area, it causes the cursor to disappear.
3. Default setting for each mode: Cursor Location at 0000H.
4. BIOS maintains one cursor location for each page and supports up to eight pages. These values are recorded at [40:50], and occupy eight words (one word for each location).

10.4.4 Function: 03H • Get Cursor Position

[Entry]

AH = 03H

BH = Display page (0 base)

[Return]

CH = Start scanline of cursor (0 base)

CL = End scanline of cursor (0 base)

DH = Row number of cursor start location (0 base)

DL = Column number of cursor end location (0 base)

[Note]

1. Cursor type is same for all pages. The cursor location of each page is maintained separately.

10.4.5 Function: 04H • Get Light Pen Position***[Entry]**

AH = 04H

[Return]

AH = 00H

Light Pen inactive

or

AH = 01H

Light Pen active and returns following values

BX = Pixel column

(X coordinate in graphics modes (0 base))

CX = Pixel row

(Y coordinate in graphics modes above Mode 06H (0 base))

CH = Pixel row

(Y coordinate in Graphics Modes 04H - 06H (0 base))

DH = Character row

(Y coordinate in text modes (0 base))

DL = Character column

(X coordinate in text modes (0 base))

[Notes]

1. The color of background and foreground will affect the sensitivity of light pen.
2. High-resolution device affects the accuracy of light pen.

*** Not supported****10.4.6 Function: 05H • Select Active Display Page****[Entry]**

AH = 05H

AL = Display page (0 base)

[Return]

None

[Notes]

1. The contents of each page will not be altered by changing to other pages.
2. Please refer to mode table of Function 00H.

10.4.7 Function: 06H • Window Scroll Up

[Entry]

AH = 06H

AL = Number of rows to be scrolled up (0 = scroll up and clear entire window)

BH = Attribute to be used in inserting blank lines

CH = Y coordinate of top left corner of window (0 base)

CL = X coordinate of top left corner of window (0 base)

DH = Y coordinate of bottom right corner of window (0 base)

DL = X coordinate of bottom right corner of window (0 base)

[Return]

None

[Notes]

1. This function will clear the entire window when it encounters the number of rows of window equal to the value in Register AL or AL = 0.
2. The image, outside the window, will not be changed. The cursor will not be updated.
3. A new blank line with attribute value specified in BH is inserted from the bottom of window whenever an old line at the top of window is scrolled out of window.
4. This function is available for both text and graphics modes.

10.4.8 Function: 07H • Window Scroll Down

[Entry]

AH = 07H

AL = Number of rows to be scrolled down (0 = scroll down and clear entire window)

BH = Attribute to be used in inserting blank lines

CH = Y coordinate of top left corner of window (0 base)

CL = X coordinate of top left corner of window (0 base)

DH = Y coordinate of bottom right corner of window (0 base)

DL = X coordinate of bottom right corner of window (0 base)

[Return]

None

[Notes]

1. This function will clear entire window when it encounters the number of rows of window equal to the value in Register AL or AL = 0.
2. The image, outside the window, will not be changed. The cursor will not be updated.
3. A new blank line with attribute value specified in BH is inserted from the top of window whenever an old line at the bottom of window is scrolled out of window.
4. This function is available for both text and graphics modes.

10.4.9 Function: 08H • Read Character/Attribute at Cursor Position**[Entry]**

AH = 08H

BH = Display page (0 base)

[Return]

AH = Attribute (Valid on text modes)

AL = ASCII character code

[Notes]

1. This function is able to read data from other valid inactive pages in multiple page modes at any time.
2. The cursor is not updated after reading a character from the screen, and has to be moved explicitly.
3. No control characters are recognized such as LF, CR, BACKSPACE, and BELL.
4. In Graphics Modes 04H - 06H of CGA adapter, the first half of character font (Code 00H - 7FH) is maintained in system ROM only. To support the second half of character font (Code 80H - FFH), the Interrupt Vector 1FH, at 0000:007CH, has to be initialized to point to the second half of character font.
5. Graphics modes return the Character Code only. Three characters, 00H/20H/FFH, cannot be distinguished, and the function always reads them back as Character Code 00H.
6. The character codes will be read back as Character Code 00H when they are written with a color that is same as the background color in graphics modes.

10.4.10 Function: 09H • Write Character/Attribute at Cursor Position**[Entry]**

AH = 09H

AL = ASCII character code

BH = Display page (0 base)

or

BL = Attribute (text modes)

Display color (graphics modes)

CX = Repeat character count

[Return]

None

[Notes]

1. This function is able to write data to other valid inactive pages in multiple page modes at any time.
2. The cursor is not updated after writing a character to the screen, and has to be moved explicitly.
3. No control characters are recognized such as LF, CR, BACKSPACE, and BELL.
4. Graphics Modes 04H - 06H of CGA adapter, the first half of character font (Code 00H -

7FH) is maintained in system ROM only. To support the second half of character font (Code 80H - FFH), the Interrupt Vector 1FH, at 0000:007CH, has to be initialized to point to the second half of character font.

5. In graphics modes, the color (attribute) is treated as pixel color to generate an ASCII character pattern. And the color value will be masked according to the number of colors in the video modes.
6. The character codes will be displayed as blank when they are written with the color that is the same as the background color in graphics modes.
7. The characters written to the screen, specified in CX, should not extend to the next row in graphics modes. Otherwise, invalid results would be generated.
8. If Bit 7 of Register BL is set, the function will take the color value X'OR with the value in display memory. (Valid in all graphics modes except Mode 13H). This feature can be used in fast character/dot erasing.

10.4.11 Function: 0AH • Write Character at Cursor Position

[Entry]

AH = 0AH

AL = ASCII character code

BH = Display page (0 base)

or

BL = Foreground color (graphics modes only)

CX = Repeat character count

[Return]

None

[Notes]

1. This function is able to write data to other valid inactive pages in multiple page modes at any time.
2. The cursor is not updated after writing a character to screen and has to be moved explicitly.
3. No control characters are recognized such as LF, CR, BACKSPACE, and BELL.
4. Graphics Modes 04H - 06H of CGA adapter, the first half of character font (Code 00H - 7FH) is maintained in system ROM only. To support the second half of character font (Code 80H - FFH), the Interrupt Vector 1FH, at 0000:007CH, has to be initialized to point to the second font.
5. In graphics modes, the color (attribute) is treated as pixel color to generate ASCII character pattern. And the color value will be masked according to the number of colors in the video modes.
6. The character codes will be displayed as blank when they are written with the color same as background color in graphics modes.
7. The characters written to screen, specified in CX, should not extend to next row in graphics modes. Otherwise, invalid results would be generated.
8. If Bit 7 of Register BL is set, the function will take the color value X'OR with the value in display memory (valid in all graphics modes except Mode 13H). This feature can be used in fast character/dot erasing.

10.4.12 Function: 0BH • CGA Palette***Function: 0BH • Subfunction: 00H — Set Background/Border Color*****[Entry]**

AH = 0BH

BH = 00H

BL = Color Value (0 - 31: Low-Intensity Colors = 0 - 15, High-Intensity Colors = 16 - 31)

– Border Color for text modes (Modes 00H - 03H)

– Color for 640 x 200 Graphics Mode (Mode 06H)

[Return]

None

[Note]

1. There are several functions in Function 10H that allow extensive display colors control for both text and graphics modes.

Function: 0BH • Subfunction: 01H — Select Palette Set**[Entry]**

AH = 0BH

BH = 01H (Valid on Modes 04H and 05H 320 x 200 only)

BL = 0 - palette set: Background, Green, Red, Brown

1 – palette set: Background, Cyan, Magenta, White

[Return]

None

[Note]

1. For the CGA adapter, the palette set is defined as follows:

Mode	BL	Palette Set
04H	00H	Background, Green, Red, Yellow
	01H	Background, Cyan, Violet, White
05H	00/01H	Background, Cyan, Red, White

10.4.13 Function: 0CH • Write Dot (Pixel)**[Entry]**

AH = 0CH
AL = Color value for pixel (Bit 7 is X'OR flag)
BH = Display page (0 base)
CX = X coordinate, column number (0 base)
DX = Y coordinate, row number (0 base)

[Return]

None

[Notes]

1. For coordinates' range, please refer to the resolution field of mode table in Function 00H.
2. Bit 7 of Register AL set will cause the requesting color value X'OR with memory color value.

10.4.14 Function: 0DH • Read Dot (Pixel)**[Entry]**

AH = 0DH
BH = Display page (0 base)
CX = X coordinate, column number (0 base)
DX = Y coordinate, row number (0 base)

[Return]

AL = Dot (Pixel) color

[Note]

1. For coordinates' range, please refer to the resolution field of mode table in Function 00H.

10.4.15 Function: 0EH • Write Character to Active RAM in Teletype Mode**[Entry]**

AH = 0EH
AL = ASCII character
BL = Foreground color in graphics modes

[Return]

None

[Notes]

1. Control characters such as LF, CR, Backspace, and BELL are recognized. (ASCII Codes: LF = 0AH, CR = 0DH, Backspace = 08H, BELL = 07H).
2. Line wrapping and screen scrolling are supported.
3. Cursor is moved to next position after writing a character to screen.

4. PC BIOS Version 10/19/81 or earlier; the Register BH has to be set to a 0.
5. The color value in Register BL will do X'OR with the content of display memory if Bit 7 of the register is set in graphics modes.
6. In text modes, the attribute of a character written to a new line is taken from the attribute of the last character in previous line. In such a case, control the attribute for a character, use Function 09H with blank character/attribute first before the function issued.

10.4.16 Function: 0FH • Get Video State

[Entry]

AH = 0FH

[Return]

AH = Number of displayable columns (1 base)

AL = Current video mode

BH = Current active page (0 base)

10.4.17 Function: 10H • VGA Palette

***Function 10H • Subfunction: 00H — Set Individual Palette Register
(Internal Palette Register)***

[Entry]

AH = 10H

AL = 00H (Subfunction)

BH = Color value

BL = Palette Register (0 - 0FH)

[Return]

None

[Notes]

1. Color value in the Internal Palette Register serves as a pointer that points to one of external registers (RAMDAC).
2. The color would not be changed by this function on Mode 13H.

Function: 10H • Subfunction: 01H — Set Overscan (Border) Register**[Entry]**

AH = 10H
AL = 01H (Subfunction)
BH = Color value (00H - FFH)

[Return]

None

[Note]

1. Border color is driven by one of 256 external registers.

Function: 10H • Subfunction: 02H — Set All Palette Registers and OverScan Register**[Entry]**

AH = 10H
AL = 02H (Subfunction)
ES: DX = Point to a 17-byte buffer

[Return]

None

[Notes]

1. The first 16 bytes in the buffer are used to store the values for 16 Internal Palette Registers. The last byte is the value for Overscan Register.
2. The display color would not be affected except Overscan Register on Mode 13H.

Function: 10H • Subfunction: 03H — Toggle Intensify/Blinking Bit**[Entry]**

AH = 10H
AL = 03H (Subfunction)
BL = 00H - Intensify
 01H - Blinking

[Return]

None

[Notes]

1. Bit 7 of Attribute Byte is interpreted according to the setting state by this function, which can provide 16 background colors (in intensify state) of 16-color text modes.
2. This function also supports Monochrome Modes (07H, 0FH).

Function: 10H • Subfunction: 4-6H — Reserved***Function: 10H • Subfunction: 07H — Read Individual Palette Register (Internal Palette Register)*****[Entry]**

AH = 10H
AL = 07H (Subfunction)
BL = Palette Register (0 - 0FH)

[Return]

BH = Color value

[Note]

1. Color Value in Internal Palette Register is served as a pointer that points to one of external registers (RAMDAC).

Function: 10H • Subfunction: 08H — Read Overscan (Border) Register**[Entry]**

AH = 10H
AL = 08H (Subfunction)

[Return]

BH = Color value

[Note]

1. Border color is from 00H to FFH.

Function: 10H • Subfunction: 09H — Read All Palette Registers and OverScan Register**[Entry]**

AH = 10H
AL = 09H (Subfunction)
ES: DX = Point to a 17-byte buffer
(The first 16 bytes for returning values from 16 palette registers respectively and the last byte for Overscan Register).

[Return]

ES: DX = Point to the same buffer provided from the entry of function call.

Function: 10H • Subfunction: 0A-0FH — Reserved

Function: 10H • Subfunction: 10H — Set Individual Color Register (RAMDAC/External Palette Registers)**[Entry]**

AH = 10H
AL = 10H (Subfunction)
BX = Color Register (00H - FFH)
DH = Red color
CH = Green color
CL = Blue color

[Return]

None

[Notes]

1. Currently, each color is only 6-bit significant. Three colors, RGB, are worked as a group and are formed into a 18-bit datum stored in the Color Register.
2. The maximum displayable colors are 256 out of 256K colors (two exponential 18).
3. In standard VGA, Mode 13H uses all 256 Color Registers to display colors.
4. BIOS will load default values into Color Registers whenever Function 00H (set Video Mode) is called. This is true only when the disable flag of default palette loading is not set (refer to Subfunction 31H of Function 12H).
5. With gray-summing flag set, or with a gray-scale monitor attached, BIOS will weight three color values and sum-to-grayshade value; and then it will use the value for all three colors.

Function: 10H • Subfunction: 11H — Reserved***Function: 10H • Subfunction: 12H — Set Block of Color Registers*****[Entry]**

AH = 10H
AL = 12H (Subfunction)
BX = Start Color Register (00H - FFH)
CX = Number of color registers to set
ES: DX = Point to table of color values (each table entry is in RGB format)

[Return]

None

[Notes]

1. Currently, each color is only 6-bit significant. Three colors, RGB, are worked as a group and are formed into a 18-bit datum stored in the Color Register.
2. The maximum displayable colors are 256 out of 256K colors (2 exponential 18).
3. In standard VGA, Mode 13H uses all 256 Color Registers to display colors.

4. BIOS will load default values into Color Registers whenever Function 00H (set Video Mode) is called. This is true only when the disable flag of default palette loading is not set (refer to Subfunction 31H of Function 12H).
5. With gray-summing flag set, BIOS will weight three color elements (RGB) of Color Register; and sum them to grayshade value, which is based on the formula (30% Red + 59% Green + 11% Blue). The grayshade value will be written back to three elements (RGB) of Color Register.

Function: 10H • Subfunction: 13H — Select Color Page (Not valid on Mode 13H)

[Entry]

AH = 10H
AL = 13H (Subfunction)
BL = 00H (select paging mode)
 01H (select color page)
 When BL = 00H -
 BH = 00H (select 4 pages of 64-color Register page)
 01H (select 16 pages of 16-color Register page)
 When BL = 01H -
 BH = Color page number (0 base)

[Return]

None

[Notes]

1. All video modes except 256-color modes are supported by the function.
2. This function treats 256-color Registers as sets of 16- or 64-color Registers. It can be used to display different colors quickly by switching among color sets (pages).
3. Default setting is Page 0 of 64-color Page Mode after Video Mode set. Normally, Function 00H (set Video Mode) will load the default colors of the first 64-color Registers (Page 00H) for all standard VGA modes except Mode 13H (248 registers loading).

Function: 10H • Subfunction: 14H — Reserved

Function: 10H • Subfunction: 15H — Read Individual Color Register (RAMDAC/External Palette Registers)

[Entry]

AH = 10H
AL = 15H (Subfunction)
BX = Color Register (00H - FFH)

[Return]

DH = Red color
CH = Green color
CL = Blue color

[Notes]

1. Currently, each color is only 6-bit significant. Three colors, RGB, are worked as a group and they are formed into a 18-bit datum stored in the Color Register.
2. The maximum displayable colors are 256 out of 256K colors (2 exponential 18).
3. In standard VGA, Mode 13H uses all 256-color Registers to display colors.
4. With gray-summing flag set, the only value returned from all three color elements of Color Register is the grayshade value.

Function: 10H • Subfunction: 16H — Reserved***Function: 10H • Subfunction: 17H — Read Block of Color Registers***

[Entry]

AH = 10H

AL = 17H (Subfunction)

BX = Start Color Register (00H - FFH)

CX = Number of Color Registers to read

ES: DX = Point to user provided buffer for returned color values

[Return]

ES: DX = Point to same buffer from function call entry (buffer is treated as a color table and each entry of the table consists of three bytes in RGB format).

[Notes]

1. Currently, each color is a 6-bit value. All three colors form a 18-bit datum.
2. The maximum displayable colors are 256 out of 256K colors (two exponential 18).
3. In standard VGA, Mode 13H uses all 256-color Registers to display colors.
4. BIOS will load default values into Color Registers whenever Function 00H (set Video Mode) is called. This is true only when the disable flag of default palette loading is not set (please refer to Subfunction 31H of Function 12H).
5. With gray-summing flag set, the only value returned for all three colors is grayshade value.

Function: 10H • Subfunction: 18-19H — Reserved***Function: 10H • Subfunction: 1AH — Read Current State of Color Page
(Not valid on Mode 13H)***

[Entry]

AH = 10H

AL = 1AH (Subfunction)

[Return]

BH = Current page (Value depends on Paging Mode, 00H is default)

BL = Current Paging Mode

(00H = 4 pages of 64-Color Registers (default), 01H = 16 pages of 16-color Registers)

[Notes]

1. All video modes except 256-color modes are supported by the function.
2. This function treats 256-color Registers as sets of 16- or 64-color Registers. It can be used to display different colors quickly by switching among color sets (pages).
3. Default setting is page 00H of 6-color page mode after Video Mode set.

Function: 10H • Subfunction: 1BH — Sum Color Values to Grayshades**[Entry]**

AH = 10H

AL = 1BH (Subfunction)

BX = Start Color Register (00H - FFH)

CX = Number of Color Registers to sum

[Return]

None

[Note]

1. This function will sum the Color Registers desired into grayshade values regardless the gray-summing flag.

10.4.18 Function: 11H • Fonts/ Character Generator***Function: 11H • Subfunction: 00H — Load User Text Font*****[Entry]**

AH = 11H

AL = 00H (Subfunction)

BH = Number of bytes per character

BL = Block to load (00H - 07H)

CX = Number of characters to store

DX = ASCII character ID of the first character in the font table (ES: BP)

ES: BP = Point to user-provided font table

[Return]

None

[Notes]

1. This function is only available for text modes. The value in Register BH represents the height of each character. It can be specified a maximum of 32 bytes per character in standard VGA specification.

2. In VGA, the character font is loaded into RAM Map 2 (0 base), which can contain up to eight fonts at any time, and is available for the Character Generator only. Consequently, the block value specified in Register BL is ranged from 00H (Default) to 07H.
3. Two character fonts out of eight can be used at any time. This provides 512 simultaneously displayable characters instead of 256 characters. The way to display two different fonts at one time can be accomplished by the following:
 - a) Load fonts into desired blocks.
 - b) Subfunction 03H (Select Block Specifier) of Function 11H is called to select two different font blocks out of eight font blocks; one for primary font, the other for secondary font.
 - c) The Bit 3 of Attribute Byte is served as the Font Block Selector and foreground intensity for the character.
 - Bit 3 = 0 — Primary font selected and normal display (eight foreground colors) if Subfunction 00H of Function 10H is called with BX = 0712H.
 - Bit 3 = 1 — Secondary font selected and normal display (eight foreground colors) else
 - Bit 3 = 1 — Secondary font selected and intensity display (16 foreground colors).
4. Default setting by BIOS loads a font into Block 0, which is used for both primary font and secondary font (256 displayable characters).
5. The font loading by Subfunction 00H requires caution since the controller is not reprogrammed; abnormal character display may occur. For example:

If a font table is loaded to override the font in a block, a double image may result (especially when the loaded font size is smaller than the one previously displayed). In this instance, the application should use sub function 10h.

Function: 11H • Subfunction: 01H — Load 8 × 14 ROM Font

[Entry]

AH = 11H
 AL = 01H (Subfunction)
 BL = Block to load (00H - 07H)

[Return]

None

[Notes]

1. This function is only available for text modes.
2. The height of character is 14 bytes, but the height of display cell is same as default setting.
3. In VGA, the character font is loaded into RAM Map 2 (0 base), which can contain up to eight fonts at any time, and is available for the Character Generator only. Consequently, the block value specified in Register BL is ranged from 00H (Default) to 07H.
4. Two character fonts out of eight can be used at any time. This provides 512 simultaneously displayable characters instead of 256 characters. The way to display two different fonts at one time can be accomplished by the following:
 - a) Load fonts into desired blocks.
 - b) Subfunction 03H (Select Block Specifier) of Function 11H is called to select two different font blocks out of eight font blocks; one for primary font, the other for secondary

font.

- c) The Bit 3 of Attribute Byte is served as the Font Block Selector and foreground intensity for the character.

Bit 3 = 0 — Primary font selected and normal display (eight foreground colors).

if Subfunction 00H of Function 10H is called with BX = 0712H

Bit 3 = 1 — Secondary font selected and normal display (eight foreground colors)

else

Bit 3 = 1 — Secondary font selected and intensity display (16 foreground colors).

5. Default setting by BIOS loads a font into Block 0, which is used for both primary font and secondary font (256 displayable character).
6. The font loading by Subfunction 00H requires caution since the controller is not reprogrammed; abnormal character display may occur. For example:
If a font table is loaded to override the font in a block, a double image may result (especially when the loaded font size is smaller than the one previously displayed). In this instance the application should use sub function 11h.

Function: 11H • Subfunction: 02H — Load 8 x 8 ROM Font

[Entry]

AH = 11H

AL = 08H (Subfunction)

BL = Block to load (00H - 07H)

[Return]

None

[Notes]

1. This function is only available for text modes.
2. The height of character is eight bytes, but the height of display cell is same as default setting.
3. In VGA, the character font is loaded into RAM Map 2 (0 base), which can contain up to eight fonts at any time, and is available only for the Character Generator. Consequently, the block value specified in Register BL is ranged from 00H (Default) to 07H.
4. Two character fonts out of eight can be used at any time. This provides 512 simultaneously displayable characters instead of 256 characters. The way to display two different fonts at one time can be accomplished by the following:
 - a) Load fonts into desired blocks.
 - b) Subfunction 03H (Select Block Specifier) of Function 11H is called to select two different font blocks out of eight font blocks; one for primary font, the other for secondary font.
 - c) The Bit 3 of Attribute Byte is served as the Font Block Selector and foreground intensity for the character.

Bit 3 = 0 — Primary font selected and normal display (eight foreground colors).

if Subfunction 00H of Function 10H is called with BX = 0712H

Bit 3 = 1 — Secondary font selected and normal display (eight foreground colors)

else

Bit 3 = 1 — Secondary font selected and intensity display (16 foreground colors).

5. Default setting by BIOS loads a font into Block 0, which is used for both primary font and secondary font (256 displayable characters).
6. The font loading by Subfunction 00H requires caution since the controller is not reprogrammed; abnormal character display may occur. For example:
If a font table is loaded to override the font in a block, a double image may result (especially when the loaded font size is smaller than the one previously displayed). In this instance, the application should use sub function 12h.

Function: 11H • Subfunction: 03H — Select Block Specifier

[Entry]

AH = 11H
AL = 03H (Subfunction)
BL = Selection of character generator blocks

[Return]

None

[Notes]

1. The definition of the value in Register BL as follows:

Bits	Font Blocks
4, 1, 0	Primary Font Block (00H - 07H)
5, 3, 2	Secondary Font Block (00H - 07H)
2. For EGA-compatible operation, Bits 0-1 is used for primary font, and Bits 2-3 for secondary font.
3. To retain eight consistent colors during 512-character display, the Subfunction 00H of Function 10H has to be called first with the following setting:
AX = 1000H, BX = 0712H

Function: 11H • Subfunction: 04H — Load 8 x 16 ROM Font

[Entry]

AH = 11H
AL = 04H (Subfunction)
BL = Block to load (00H - 07H)

[Return]

None

[Notes]

1. This function is only available for text modes.
2. The height of character is 16 bytes, but the height of the display cell is the same as default setting.
3. In VGA, the character font is loaded into RAM Map 2 (0 base), which can contain up to eight fonts, and is available for the Character Generator only. Consequently, the block value specified in Register BL is ranged from 00H (Default) to 07H.

4. Two character fonts out of eight can be used at any time (512 simultaneously displayable characters, not 256 characters). The way to display two different fonts at one time can be accomplished by the following:
 - a) Load fonts into desired blocks.
 - b) Subfunction 03H (Select Block Specifier) of Function 11H is called to select two different font blocks out of eight font blocks; one for primary font, the other for secondary font.
 - c) The Bit 3 of Attribute Byte is served as the Font Block Selector and foreground intensity for the character.
 - Bit 3 = 0 — Primary font selected and normal display (eight foreground colors).
 - if Subfunction 00H of Function 10H is called with BX = 0712H
 - Bit 3 = 1 — Secondary font selected and normal display (eight foreground colors)
 - else
 - Bit 3 = 1 — Secondary font selected and intensity display (16 foreground colors).
5. Default setting by BIOS loads a font into Block 0, which is used for both primary font and secondary font (256 displayable characters).
6. The font loading by Subfunction 00H requires caution since the controller is not reprogrammed; abnormal character display may occur. For example:

If a font table is loaded to override the font in a block, a double image may result (especially when the loaded font size is smaller than the one previously displayed). In this instance, the application should use sub function 14h.

Function: 11H • Subfunction: 10H — Load User Text Font and Reprogram Controller

[Entry]

AH = 11H
 AL = 10H (Subfunction)
 BH = Number of bytes per character
 BL = Block to load (00H - 07H)
 CX = Number of characters to store
 DX = ASCII character ID of the first character in the font table (ES: BP)
 ES: BP = Point to user-provided font table

[Return]

None

[Notes]

1. This function is only available for text modes.
2. The value in Register BH represents the height of each character. It can be specified a maximum of 32 bytes per character in standard VGA specification.
3. In VGA, the character font is loaded into RAM Map 2 (0 base), which can contain up to eight fonts at any time, and is available for the Character Generator only. Consequently, the block value specified in Register BL is ranged from 00H (Default) to 07H.
4. Two character fonts out of eight can be at any time. This means 512 simultaneously displayable characters instead of 256 characters. The way to display two different fonts at one time can be accomplished by the following:

- a) Load fonts into desired blocks.
- b) Subfunction 03H (Select Block Specifier) of Function 11H is called to select two different font blocks out of eight font blocks; one for primary font, the other for secondary font.
- c) The Bit 3 of Attribute Byte is served as the Font Block Selector and foreground intensity for the character.
 - Bit 3 = 0 — Primary font selected and normal display (eight foreground colors).
 - if Subfunction 00H of Function 10H is called with BX = 0712H
 - Bit 3 = 1 — Secondary font selected and normal display (eight foreground colors)
 - else
 - Bit 3 = 1 — Secondary font selected and intensity display (16 foreground colors).
- 5. Default setting by BIOS loads a font into Block 0, which is used for both primary font and secondary font (256 displayable characters).
- 6. Subfunction 10H is almost identical to Subfunction 00H except the following differences:
 - a) Page 00H has to be active.
 - b) Character Height (Bytes per character) will be recalculated.
 - c) Number of rows (0 base) are recalculated as:
(scanlines per screen/Character Height) minus 1.
 - d) The length of display buffer will be recalculated as (Total number of rows x Total number of columns) x 2 (1 base).
 - e) The CRTC Registers are reprogrammed as follows:

Index	Register Name	Change
09H	Maximum scanlines	Character Height minus 1
0AH	Cursor Start	Character Height minus 2
0BH	Cursor End	Character Height minus 1
12H	Vertical Display Enable End	
	For 350 or 400 scanline Modes	
	(Rows per screen x Character Height) minus 1	
	For 200 scanline Modes	
	(Rows per screen x Character Height) x 2) minus 1	
14H	Underline Location	Character Height minus 1 (Mode 07H only)
 - f) It has to be called immediately after Function 00H call (set Video Mode). Otherwise, the result will be unpredictable.

Function: 11H • Subfunction: 11H — Load 8 x 14 ROM Font and Reprogram Controller

[Entry]

AH = 11H
 AL = 11H (Subfunction)
 BL = Block to load (00H - 08H)

[Return]

None

[Notes]

1. This function is only available for text modes.
2. The character and display cells are both 14 bytes high (scanlines).
3. In VGA, the character font is loaded into RAM Map 2 (0 base), which can contain up to eight fonts at any time and is available for the Character Generator only. Consequently, the block value specified in Register BL is ranged from 00H (Default) to 07H.
4. Two character fonts out of eight can be used at any time. This means 512 simultaneously displayable characters instead of 256 characters. The way to display two different fonts at one time can be accomplished by the following:
 - a) Load fonts into desired blocks.
 - b) Subfunction 03H (Select Block Specifier) of Function 11H is called to select two different font blocks out of eight font blocks; one for primary font, the other for secondary font.
 - c) The Bit 3 of Attribute Byte is served as the Font Block Selector and foreground intensity for the character.

Bit 3 = 0 — Primary font selected and normal display (eight foreground colors).
if Subfunction 00H of Function 10H is called with BX = 0712H

Bit 3 = 1 — Secondary font selected and normal display (eight foreground colors)
else

Bit 3 = 1 — Secondary font selected and intensity display (16 foreground colors).
5. Default setting by BIOS loads a font into Block 0, which is used for both primary font and secondary font (256 displayable characters).
6. Subfunction 11H is almost identical to Subfunction 01H except the following differences:
 - a) Page 00H has to be active.
 - b) Character Height = 14.
 - c) Number of rows (0 base) are recalculated as:
(Scanlines per screen/Character Height) minus 1.
 - d) The length of display buffer will be recalculated as:
(Total number of rows x Total number of columns) x 2 (1 base)
 - e) The CRTC Registers are reprogrammed as follows:

Index	Register Name	Change
09H	Maximum Scanlines	13 (0DH)
0AH	Cursor Start	12 (0CH)
0BH	Cursor End	13 (0DH)
12H	Vertical Display Enable End	(Rows per screen x 14) minus 1
14H	Underline Location (Mode 07H only)	13 (0DH)
 - f) It has to be called immediately after Function 00H call (set Video Mode). Otherwise, the result will be unpredictable.

Function: 11H • Subfunction: 12H — Load 8 x 8 ROM Font and Reprogram Controller**[Entry]**

AH = 11H

AL = 12H (Subfunction)

BL = Block to load (00H - 07H)

[Return]

None

[Notes]

1. This function is only available for text modes.
2. The height of character and display cell are all eight bytes (scanlines).
3. In VGA, the character font is loaded into RAM Map 2 (0 base), which can contain up to eight fonts at any time and is available for the Character Generator only. Consequently, the block value specified in Register BL is ranged from 00H (Default) to 07H.
4. Two character fonts out of eight can be used at any time. This means 512 simultaneously displayable characters instead of 256 characters. The way to display two different fonts at one time can be accomplished by the following:
 - a) Load fonts into desired blocks.
 - b) Subfunction 03H (Select Block Specifier) of Function 11H is called to select two different font blocks out of eight font blocks; one for primary font, the other for secondary font.
 - c) The Bit 3 of Attribute Byte is served as the Font Block Selector and foreground intensity for the character.
 - Bit 3 = 0 — Primary font selected and normal display (eight foreground colors).
 - if Subfunction 00H of Function 10H is called with BX = 0712H
 - Bit 3 = 1 — Secondary font selected and normal display (eight foreground colors)
 - else
 - Bit 3 = 1 — Secondary font selected and intensity display (16 foreground colors).
5. Default setting by BIOS loads a font into Block 0, which is used for both primary font and secondary font (256 displayable characters).
6. Subfunction 12H is almost identical to Subfunction 02H except the following differences:
 - a) Page 00H has to be active.
 - b) Character Height = 8.
 - c) Number of rows (0 base) are recalculated as (Scanlines per screen/Character Height) minus 1.
 - d) The length of display buffer will be recalculated as: (Total number of rows x Total number of columns) x 2 (1 base).
 - e) The CRTC Registers are reprogrammed as follows:

Index	Register Name	Change
09H	Maximum Scanlines	7 (07H)
0AH	Cursor Start	6 (06H)
0BH	Cursor End	7 (07H)
12H	Vertical Display Enable End	(Rows per screen x 8) minus 1
14H	Underline Location (Mode 07H only)	7 (07H)
 - f) It has to be called immediately after Function 00H call (set Video Mode). Otherwise, the result will be unpredictable.

Function: 11H • Subfunction: 14H — Load 8 x 16 ROM Font and Reprogram Controller**[Entry]**

AH = 11H
 AL = 14H (Subfunction)
 BL = Block to load (00H - 07H)

[Return]

None

[Notes]

1. This function is only available for text modes.
2. The height of character and display cell are all 16 bytes (scanlines).
3. In VGA, the character font is loaded into RAM Map 2 (0 base), which can contain up to eight fonts at any time and is available for the Character Generator only. Consequently, the block value specified in Register BL is ranged from 00H (Default) to 07H.
4. Two character fonts out of eight can be used at any time. This means 512 simultaneously displayable characters instead of 256 characters. The way to display two different fonts at one time can be accomplished by the following:
 - a) Load fonts into desired blocks.
 - b) Subfunction 03H (Select Block Specifier) of Function 11H is called to select two different font blocks out of eight font blocks; one for primary font, the other for secondary font.
 - c) The Bit 3 of Attribute Byte is served as the Font Block Selector and foreground intensity for the character. Bit 3 = 0 — Primary font selected and normal display (eight foreground colors). If Subfunction 00H of Function 10H is called with BX = 0712H
 Bit 3 = 1 — Secondary font selected and normal display (eight foreground colors)
 else
 Bit 3 = 1 — Secondary font selected and intensity display (16 foreground colors).
5. Default setting by BIOS loads a font into Block 0, which is used for both primary font and secondary font (256 displayable characters).
6. Subfunction 14H is almost identical to Subfunction 04H except the following differences:
 - a) Page 00H has to be active.
 - b) Character Height = 16.
 - c) Number of Rows (0 base) are recalculated as:
 (Scanlines per screen/Character Height) minus 1.
 - d) The length of display buffer will be recalculated as (Total number of rows x Total number of columns) x 2 (1 base).
 - e) The CRTC Registers are reprogrammed as follows:

Index	Register Name	Change
09H	Maximum Scanlines	15 (0FH)
0AH	Cursor Start	14 (0EH)
0BH	Cursor End	15 (0FH)
12H	Vertical Display Enable End	(Rows per screen x16) minus 1
14H	Underline Location	15 (0FH) (Mode 07H only)
 - f) It has to be called immediately after Function 00H call (set Video Mode). Otherwise, the result will be unpredictable.

Function: 11H • Subfunction: 20H — Set Pointer of User's Graphics Font Table to Interrupt 1FH**[Entry]**

AH = 11H

AL = 20H (Subfunction)

ES: BP = Point to user's graphics font table

[Return]

None

[Notes]

1. The value in this Interrupt Vector serves as a pointer that points to Graphics Font for character codes (80H - FFH) in Modes 04H, 05H, and 06H.
2. In CGA adapter, the planar BIOS only provides 128 character codes (00H - 7FH). The user can supply the other half of character codes (80H - FFH), or use GRAFTABL in DOS to load this half.
3. This function has to be called immediately after setting Video Mode.

Function: 11H • Subfunction: 21H — Set Pointer of User's Graphics Font Table to Interrupt 43H**[Entry]**

AH = 11H

AL = 21H (Subfunction)

BL = Character rows specifier

00H = Value in Register DL (the number of displayable rows specified by user)

01H = 14 (0EH) character rows

02H = 25 (19H) character rows

03H = 43 (2BH) character rows

CX = Bytes per character

DL = Number of character rows (if Register BL = 00H)

ES: BP = Point to user's graphics font table

[Return]

None

[Note]

1. The value in this Interrupt Vector serves as a pointer that points to Graphics Font for character codes (00H - 7FH) in Modes 04H, 05H, and 06H. The vector also handles Graphics Font for character codes (00H - FFH) in all other graphics modes.
2. This function should only be called immediately after setting Video Mode.
3. The portion of character rows above displayable rows will not be displayed unless it is scrolled up.
4. The overlapping screen may occur on video modes that use all display memory addresses such as Mode 13H.

Function: 11H • Subfunction: 22H — Set Pointer of ROM 8 x14 Graphics Font Table to Interrupt 43H**[Entry]**

AH = 11H

AL = 22H (Subfunction)

BL = The specifier of character rows on screen

00H = Value in Register DL (the number of displayable rows specified by user)

01H = 14 (0EH) character rows

02H = 25 (19H) character rows

03H = 43 (2BH) character rows

DL = Number of character rows to display (if Register BL = 00H)

[Return]

None

[Notes]

1. The value in this Interrupt Vector serves as a pointer that points to Graphics Font for character codes (00H - 7FH) in Modes 04H, 05H, and 06H. The vector also handles Graphics Font for character codes (00H - FFH) in all other graphics modes.
2. This function should only be called immediately after setting Video Mode.
3. The portion of character rows above displayable rows will not be displayed unless it is scrolled up.
4. The overlapping screen may occur on video modes that use all display memory addresses such as Mode 13H.

Function: 11H • Subfunction: 23H — Set Pointer of ROM 8 x 8 Graphics Font Table to Interrupt 43H**[Entry]**

AH = 11H

AL = 23H (Subfunction)

BL = Specifier of character rows on screen

00H = Value in Register DL (the number of displayable rows specified by user)

01H = 14 (0EH) character rows

02H = 25 (19H) character rows

03H = 43 (2BH) character rows

DL = Number of character rows to display (if Register BL = 00H)

[Return]

None

[Notes]

1. The value in this Interrupt Vector serves as a pointer that points to Graphics Font for character codes (00H - 7FH) in Modes 04H, 05H, and 06H. The vector also handles Graphics Font for character codes (00H - FFH) in all other graphics modes.
2. This function should only be called immediately after setting Video Mode.

3. The portion of character rows above displayable rows will not be displayed unless it is scrolled up.
4. The overlapping screen may occur on video modes that use all display memory addresses such as Mode 13H.

Function: 11H • Subfunction: 24H — Set Pointer of ROM 8 x 16 Graphics Font Table to Interrupt 43H

[Entry]

AH = 11H

AL = 24H (Subfunction)

BL = Specifier of character rows on screen

00H = Value in Register DL (the number of displayable rows specified by user)

01H = 14 (0EH) character rows

02H = 25 (19H) character rows

03H = 43 (2BH) character rows

DL = Number of character rows to display (if Register BL = 00H)

[Return]

None

[Notes]

1. The value in this Interrupt Vector serves as a pointer that points to Graphics Font for character codes (00H - 7FH) in Modes 04H, 05H, and 06H. The vector also handles Graphics Font for character codes (00H - FFH) in all other graphics modes.
2. This function should only be called immediately after setting Video Mode.
3. The portion of character rows above displayable rows will not be displayed unless it is scrolled up.
4. The overlapping screen may occur on video modes that use all display memory addresses such as Mode 13H.

Function: 11H • Subfunction: 30H — Get Pointer Information of Fonts**[Entry]**

AH = 11H

AL = 30H (Subfunction)

BH = Pointer information of fonts

00H - Current Font Pointer stored in Interrupt Vector 1FH

01H - Current Font Pointer stored in Interrupt Vector 43H

02H - Font Pointer of ROM 8 x 14 Font Table

03H - Font Pointer of ROM 8 x 8 Font Table (Character Codes 00H - 7FH)

04H - Font Pointer of ROM 8 x 8 Font Table (Character Codes 80H - FFH)

05H - Font Pointer of ROM 9 x 14 Alternate Font Table

06H - Font Pointer of ROM 8 x 16 Font Table

07H - Font Pointer of ROM 9 x 16 Alternate Font Table

[Return]

CX = Current character height (Bytes per Character)

DL = Number of rows of current video mode (0 base)

ES: BP = Pointer information of desired font

10.4.19 Function: 12H • Alternate Select***Function: 12H • Subfunction: 10H — Get Current Video Configuration*****[Entry]**

AH = 12H

BL = 10H (Subfunction)

[Return]

BH = 00H - Color Mode (3Dx)

01H - Monochrome Mode (3Bx)

BL = Video Memory Size

00H = 64K bytes

01H = 128K bytes

02H = 192K bytes

03H = 256K bytes

CH = Feature Bits**Feature Control Output
Bit Setting****Input Status Register 0 - (3C2H)**

0

0

Bit 5

1

0

Bit 6

2

1

Bit 5

3

1

Bit 6

4 - 7

Reserved

CL = Switch Settings**Description**

Bit 0

Configuration Switch-1

Bit 1

Configuration Switch-2

Bit 2

Configuration Switch-3

Bit 3

Configuration Switch-4

Bit 4 - Bit 7

Reserved

Function: 12H • Subfunction: 20H — Alternate PrintScreen Handler**[Entry]**

AH = 12H

BL = 20H (Subfunction)

[Return]

None

[Note]

1. This function call will replace original PrintScreen Interrupt Handler (Interrupt 05H) to support the modes whose displayable rows on screen are over 25 rows.

Function: 12H • Subfunction: 30H — Select Scanlines for Text Modes**[Entry]**

AH = 12H
BL = 30H (Subfunction)
AL = Specifier of scanlines
 00H = 200 scanlines
 01H = 350 scanlines
 02H = 400 scanlines

[Return]

AL = 12H (function supported)

[Notes]

1. The selected scanlines will take effect on next mode setting.
2. Mode 07H only supports 350/400 scanlines. Modes 00H - 03H support 200/350/400 scanlines.
3. 200 scanlines, are double scanned to 400 lines.

Function: 12H • Subfunction: 31H — Enable/Disable Default Palette Loading**[Entry]**

AH = 12H
BL = 31H (Subfunction)
AL = 00H - Enable default palette loading
 01H - Disable default palette loading

[Return]

AL = 12H (function supported)

[Notes]

1. This function will take effect on next mode setting.
2. All Internal/External Palette Registers will be affected.

Function: 12H • Subfunction: 32H — Enable/Disable Video**[Entry]**

AH = 12H
BL = 32H (Subfunction)
AL = 00H - Enable Video
 01H - Disable Video

[Return]

AL = 12H (function supported)

[Note]

1. Video subsystem will not respond to any I/O or Video Memory Addressing.

Function: 12H • Subfunction: 33H — Enable/Disable Summing-to-Grayshades**[Entry]**

AH = 12H
BL = 33H (Subfunction)
AL = 00H - Enable summing-to-grayshades
 01H - Disable summing-to-grayshades

[Return]

AL = 12H (function supported)

[Note]

1. This function will take effect on a subsequent mode setting or internal/external palettes setting.

Function: 12H • Subfunction: 34H — Enable/Disable Cursor Emulation**[Entry]**

AH = 12H
BL = 34H (Subfunction)
AL = 00H - Enable cursor emulation
 01H - Disable cursor emulation

[Return]

AL = 12H (function supported)

[Notes]

1. This function will take effect on a subsequent mode setting or Function 01H call (set cursor type).
2. Bit 0 of Address [40:87] Emulation Flag is affected.

Function: 12H • Subfunction: 35H — Switch Video Display**[Entry]**

AH = 12H

BL = 35H (Subfunction)

AL = 00H - Initial video adapter turned off

(ES:DX must point to a 128-byte buffer for switching state save area)

01H - System board video turned on

02H - Active video turned off (ES:DX must point to a buffer for switching state save area)

03H - Inactive video turned on (ES:DX must point to a buffer which saves switching state previously)

ES:DX = Buffer for switching state (valid when AL = 00H, 02H, or 03H)

[Return]

AL = 12H (function supported)

[Notes]

1. There are several requirements have to be met before using this function. Requirements:
 - a) Two video subsystems coexisting: system board video and video adapter.
 - b) The usage of video resources has conflicted between two video systems.
 - c) Video adapter is primary video, system board is secondary video.
 - d) This function has to be supported by system board video and video adapter.
2. If the first time switching from video adapter to system board video:
Call the function with Register AL = 00H
Call the function with Register AL = 01H
else
Call the function with Register AL = 02H
Call the function with Register AL = 03H

Function: 12H • Subfunction: 36H — Enable/Disable Screen Display**[Entry]**

AH = 12H

BL = 36H (Subfunction)

AL = 00H - Enable screen display

01H - Disable screen display

[Return]

AL = 12H (function supported)

[Note]

1. This function can be used for fast video memory updating without losing synchronization.

10.4.20 Function: 13H • Write Teletype String**[Entry]**

AH = 13H

AL = Write function specifier

00H - Write character string without updating cursor (BL = Attribute)

01H - Write character string with updating cursor (BL = Attribute)

02H - Write character/attribute string without updating cursor

03H - Write character/attribute string with updating cursor

BH = Display page (0 base)

BL = Attribute (valid when AL = 00H or 01H)

CX = String length

DH = Start Y coordinate of string displayed on screen

DL = Start X coordinate of string displayed on screen

ES: BP = Start address of string (in Segment: Offset Format)

[Return]

None

[Notes]

1. Control Characters: LF, CR, Backspace, and BELL are recognized. (ASCII Codes: LF = 0AH, CR = 0DH, Backspace = 08H, BELL = 07H).
2. String can be written to any pages regardless of active state.
3. Line wrapping and screen scrolling are supported. Screen scrolling is only supported on active page.
4. The color value in Register BL will be XORed with the contents of display memory, if Bit 7 of the register is set in graphics modes.

10.4.21 Function: 1AH • Display Combination Code***Function: 1AH • Subfunction: 00H — Get Display Combination Code (DCC)*****[Entry]**

AH = 1AH

AL = 00H (Subfunction)

[Return]

If function supported:

AL = 1AH

BH = Alternate display code

BL = Active display code

[Notes]

1. The index of current DCC entry in DCC table is stored in address [40:8A].
2. Display Combination Code Definition:

Code	Definition
00H	No Display
01H	Monochrome Display Adapter (MDA)
02H	Color Display Adapter (CGA)
03H	Reserved
04H	EGA with Color Monitor (EGA)
05H	EGA with Monochrome Monitor (MEGA)
06H	Professional Graphics Adapter with Color Display (PGA)
07H	Video Graphics Array with Analog Monochrome Monitor (MVGA)
08H	Video Graphics Array with Analog Color Monitor (VGA)

Function: 1AH • Subfunction: 01H — Set Display Combination Code (DCC)**[Entry]**

AH = 1AH
 AL = 01H (Subfunction)
 BH = Alternate display code
 BL = Active display code

[Return]

If function supported:
 AL = 1AH

[Note]

1. Display Combination Code Definition:

Code	Definition
00H	No Display
01H	Monochrome Display Adapter (MDA)
02H	Color Display Adapter (CGA)
03H	Reserved
04H	EGA with Color Monitor (EGA)
05H	EGA with Monochrome Monitor (MEGA)
06H	Professional Graphics Adapter with Color Display (PGA)
07H	Video Graphics Array with Analog Monochrome Monitor (MVGA)
08H	Video Graphics Array with Analog Color Monitor (VGA)

2. User is responsible for providing correct DCC. There is no physical checking of the device.

10.4.22 Function: 1BH • Get Functionality/State Information**Function: 1BH • Collection of Video Information****[Entry]**

AH = 1BH
 BX = 00H
 ES: DI = Pointer points to 128-byte buffer

[Return]

If function supported
 AL = 1BH

[Notes]

1. Video information in 128-byte buffer:

Offset	Size	Definition																
00H	2 Words	Pointer points to collection of static functionality information																
04H	Byte	Current Video Mode																
05H	Word	Number of columns (1 base)																
07H	Word	Refresh Buffer Length (unit: byte)																
09H	Word	The starting address of Refresh Buffer (Offset value relates to start of video memory; default = 0000H)																
0BH	8 Words	Cursor Position for each page (maximum eight pages supported)																
1BH	Word	Current Cursor Type (High Byte = start scanline, Low Byte = end scanline)																
1DH	Byte	Active Video Page																
1EH	Word	Base Port Address of CRT Controller (CRTC) (Monochrome = 3BxH, Color = 3DxH)																
20H	Byte	Current setting of 3B8H or 3D8H (Mode Control Register)																
21H	Byte	Current setting of 3B9H or 3D9H																
22H	Byte	Number of rows (1 base)																
23H	Word	Character height (1 base; unit: scanline)																
25H	Byte	Active Display Code																
26H	Byte	Alternate Display Code																
27H	Word	Number of displayable colors (1 base; monochrome = 0000H)																
29H	Byte	Number of Pages (1 base)																
2AH	Byte	Specifier of vertical resolution 00H = 200 scanlines 01H = 350 scanlines 02H = 400 scanlines 03H = 480 scanlines 04H - FFH = Reserved																
2BH	Byte	Primary Font Block (00H - 07H)																
2CH	Byte	Secondary Font Block (00H - 07H)																
2DH	Byte	Flags of Video State: <table><tr><th>Bit</th><th>Definition</th></tr><tr><td>7-6</td><td>Reserved</td></tr><tr><td></td><td>0 = Background intensity 1 = Blinking (Default)</td></tr><tr><td>4</td><td>0 = Cursor Emulation Disable 1 = Cursor Emulation Enable</td></tr><tr><td>3</td><td>0 = Default Palette Loading Enable 1 = Default Palette Loading Disable</td></tr><tr><td>2</td><td>0 = Color Monitor Attached 1 = Monochrome Monitor Attached</td></tr><tr><td>1</td><td>0 = Summing-to-grayshades Disable 1 = Summing-to-grayshades Enable</td></tr><tr><td>0</td><td>1 = All Modes are active on all displays</td></tr></table>	Bit	Definition	7-6	Reserved		0 = Background intensity 1 = Blinking (Default)	4	0 = Cursor Emulation Disable 1 = Cursor Emulation Enable	3	0 = Default Palette Loading Enable 1 = Default Palette Loading Disable	2	0 = Color Monitor Attached 1 = Monochrome Monitor Attached	1	0 = Summing-to-grayshades Disable 1 = Summing-to-grayshades Enable	0	1 = All Modes are active on all displays
Bit	Definition																	
7-6	Reserved																	
	0 = Background intensity 1 = Blinking (Default)																	
4	0 = Cursor Emulation Disable 1 = Cursor Emulation Enable																	
3	0 = Default Palette Loading Enable 1 = Default Palette Loading Disable																	
2	0 = Color Monitor Attached 1 = Monochrome Monitor Attached																	
1	0 = Summing-to-grayshades Disable 1 = Summing-to-grayshades Enable																	
0	1 = All Modes are active on all displays																	
2E - 30H	Reserved																	
31H	Byte	Specifier of total video RAM 00H = 64K bytes																

		01H = 128K bytes
		02H = 192K bytes
		03H = 256K bytes
		04H - FFH = Reserved
32H	Byte	Save pointer state information:
		Bit Definition
		7-6 Reserved
		5 1 = Extension of Display Combination Code Active
		4 1 = Palette Override Active
		3 1 = Graphics Font Override Active
		2 1 = Alpha Font Override Active
		1 1 = Dynamic Save Area Active
		0 1 = 512-character Set Active
33 - 3FH	Reserved	

2. Collection of static functionality information:

Offset	Size	Definition
00H	Byte	Available video modes if bit set:
		Bit Video Mode
		0 00H
		1 01H
		2 02H
		3 03H
		4 04H
		5 05H
		6 06H
		7 07H
01H	Byte	Available video modes if bit set:
		Bit Video Mode
		0 08H
		1 09H
		2 0AH
		3 0BH
		4 0CH
		5 0DH
		6 0EH
		7 0FH
00H	Byte	Available video modes if bit set:
		Bit Video Mode
		0 10H
		1 11H
		2 12H
		3 13H
		4 - 7 Reserved
03 - 06H	Reserved	
07H	Byte	Number of scanlines available in text modes: (Subfunction 30H, Function 12H)

		Bit	Scanlines (if Bit = 1)
		0	200
		1	350
		2	400
		3 - 7	Reserved
08H	Byte	Number of active character blocks available in text modes	
09H	Byte	Maximum number of character blocks available in text modes	
0AH	Byte	Supported functions (No. 1):	
		Bit	Function (if Bit = 1)
		0	All Modes on All Displays
		1	Summing to grayshades
		2	Character fonts Loading
		3	Default Palette Loading
		4	Cursor Emulation
		5	EGA Palettes (Internal Palettes)
		6	Color Palettes (External Palettes/RAMDAC)
		7	Color Paging
0BH	Byte	Supported functions (No. 2):	
		Bit	Function (if Bit = 1)
		0	Reserved
		1	Save/Restore Video State
		2	Background Intensity/Blinking Control
		3	Set Display Combination Code
		4 - 7	Reserved
0C - 0DH	Reserved		
0EH	Save Pointer Functions:		
		Bit	Function (if Bit = 1)
		0	512-character Set
		1	Dynamic Save Area
		2	Alpha Font Override
		3	Graphics Font Override
		4	Palette Override
		5	Extension of Display Combination Code
		6 - 7	Reserved
0FH	Reserved		

10.4.23 Function: 1CH • Save/Restore Video State***Function: 1CH • Subfunction: 00H — Get Buffer Size for Video State*****[Entry]**

AH = 1CH

AL = 00H (Subfunction)

CX = Requested Video State:

Bit	Video State
0	Hardware State
1	BIOS Data Area
2	Color Registers (External Palettes/RAMDAC)
3 - 15	Reserved

[Return]

If function supported

AL = 1CH

BX = Blocks/Buffer (Unit: 64 Byte/Block)

[Note]

1. This function will report the sufficient size of buffer to save video state. To guarantee Subfunction 01H and 02H performed successfully, this subfunction should be called first.

Function: 1CH • Subfunction: 01H — Saving Video State**[Entry]**

AH = 1CH

AL = 01H (Subfunction)

CX = Requested Video States:

Bit	Video States
0	Hardware State
1	BIOS Data Area
2	Color Registers (External Palettes/RAMDAC)
3 - 15	Reserved

ES: BX = Pointer points to buffer (Segment: Offset format)

[Return]

If function supported:

AL = 1CH

ES: BX = State information saved in user-supplied buffer

Function: 1CH • Subfunction: 02H — Restore Video State**[Entry]**

AH = 1CH

AL = 02H (Subfunction)

CX = Requested Video States:

Bit	Video States
0	Hardware State
1	BIOS Data Area
2	Color Registers (External Palettes/RAMDAC)
3 - 15	Reserved

ES: BX = Pointer points to previous saved buffer (Segment: Offset format)

[Return]

If function supported:

AL = 1CH

10.5 VGA Sleep Mode and Display Switching

The IBM VGA standard supports a Sleep Mode feature to enable/disable CPU addressing of the VGA subsystem video memory and I/O ports. For integrated VGA subsystems on the motherboard, the video subsystem is enabled or disabled by programming a Video Subsystem Enable Register at I/O Port 3C3H. On VGA adapter cards, a control register at I/O Port 46E8H is used. These two separate schemes of enabling/disabling addressing allows two VGAs (driving separate display monitors) to coexist in a system and have the capability to switch active video from one display to another. The IBM standard VGA BIOS supports a set of function calls to select Sleep Mode and display switching features.

The CL-GD542X VGA controller, depending on the application, can be programmed to respond at either 3C3H or 46E8H I/O Port for enabling/disabling CPU addressing. This allows for full IBM VGA compatibility, whether the design is an integrated motherboard VGA or an adapter card solution.

See Section 10.2 for the power-on initialization sequence.

10.6 Address Maps

The tables on the following pages provide background information regarding the usage of system memory, port address space, and interrupt vectors by DOS and its I/O routines (Planar and Peripheral BIOSes). The areas of interest to video subsystem users and designers are highlighted in bold text.

Table 10–1. MS DOS Memory Map After Loading

FE0000 - FFFFFFFF	128K bytes to 'shadow' system ROM BIOS
100000 - FDFFFF	15 Mbytes of extended memory in protected mode only
FFFF:000F (1 Mbyte)	
	Planar BIOS
F000:0000	
	Expansion BIOS (motherboard video BIOS)
E000:0000	
	Voice Communication BIOS/LIM EMS page map area
D000:8000	
	Network BIOS/LIM EMS page map area
D000:0000	
	LIM EMS page map area
C000:C000	
	Hard disk BIOS
C000:8000	
	EGA/VGA adapter BIOS
C000:0000	
	EGA display RAM
B000:C000	
	CGA display RAM (or HGC mode graphics RAM)
B000:8000	
	HGC display RAM
B000:4000	
	MDA/HGC display RAM
B000:0000	
	EGA/VGA display RAM
A000:0000	Top of system RAM COMMAND.COM (transient portion), free RAM, COMMAND.COM (resident portion), installable device drivers, file control blocks, disk buffers, DOS tables, DOS kernel (MSDOS.SYS), resident DOS device drivers (IO.SYS)
0000:0600	
	ROM BIOS data area
0000:0400	
	Interrupt vectors
0000:0000	

Table 10–2. BIOS Data Area Assignments

0040:0000 WORD		COM1 Port base address
0040:0002 WORD		COM2 Port base address
0040:0004 WORD		COM3 Port base address
0040:0006 WORD		COM4 Port base address
0040:0008 WORD		Printer 1 port base address
0040:000A WORD		Printer 2 port base address
0040:000C WORD		Printer 3 port base address
0040:000E WORD		Printer 4 port base address
0040:0010 WORD	EQUIPMENT_FLAG	
	Bit	Definition
	D15, D14	No. or printer adapters
	D13, D12	reserved
	D11, D10, D9	No. of RS232-C
	D8	reserved
	D7, D6	No. of diskette drives
	D5, D4	Identify the current primary display device:
		D5 D4 Adapter
		0 0 EGA (or none)
		0 1 CGA 40 x 25
		1 0 CGA 80 x 25
		1 1 MDA
	D3, D2	reserved
	D1	math coprocessor
	D0	IPL diskette
0040:0012 BYTE		reserved
0040:0013 WORD	USABLE_RAM	Usable memory size in kilobytes
0040:0015 BYTE		reserved
0040:0016 BYTE		reserved
0040:0017 WORD	KBD_CNTRL	stores status of special keys
0040:0019 BYTE	ALT_KBD	alternate keypad entry
0040:001A WORD	KBD_BUF_HD	Points to head of keyboard buffer
0040:001C WORD	KBD_BUF_TL	Points to tail of keyboard buffer
0040:001E 16 WDS	KBD_BUFFER	Circular keyboard buffer
0040:003E BYTE		Diskette drive re-calibrate status
0040:003F BYTE		Diskette drive motor status
0040:0040 BYTE		Diskette drive motor off counter
0040:0041 BYTE		Last diskette driver operation status
0040:0042 7 BYTES		Diskette driver controller status
0040:0049 BYTE	VIDEO_MODE	Current BIOS Video Mode
0040:004A WORD	COLUMNS	Number of text columns
0040:004C WORD	PAGE_LENGTH	Length of each page in bytes
0040:004E WORD	START_ADDR	Start Address Register value for page
0040:0050 8 WDS	CURSOR_POS	Cursor positions for all eight pages
		The high byte of each word contains
		the character row, the low byte the column

0040:0060 WORD	CURSOR_TYPE	Start and ending lines for text cursor. High byte has start line.
0040:0062 BYTE	ACTIVE_PAGE	Currently displayed page number
0040:0063 WORD	ADDR_CRTC	I/O Port address of 6845/CRTC address register (3B4 monochrome; 3D4 color)
0040:0065 BYTE	CRT_MODE_SET	Current value for Mode Control register (3B8 MDA; 3D8 CGA). The EGA and VGA values emulate the MDA/CGA values
0040:0066 BYTE	CRT_PALETTE	Current value for the CGA color select register (3D9); emulated by EGA/VGA
0040:0067 DWORD		pointer to MCA PS/2 reset code
0040:006B BYTE		reserved
0040:006C DWORD		Timer counter
0040:0070 BYTE		Timer overflow
0040:0071 BYTE		Break key state
0040:0072 WORD		RESET flag
0040:0074 BYTE		Last hard disk drive operation status
0040:0075 BYTE		No. of hard disk drives attached
0040:0076 BYTE		PC XT hard disk drive control
0040:0077 BYTE		PC XT hard disk drive controller port
0040:0078 BYTE		Printer 1 Time-out value
0040:0079 BYTE		Printer 2 Time-out value
0040:007A BYTE		Printer 3 Time-out value
0040:007B BYTE		Printer 4 Time-out value
0040:007C BYTE		COM1 Time-out value
0040:007D BYTE		COM2 Time-out value
0040:007E BYTE		COM3 Time-out value
0040:007F BYTE		COM4 Time-out value
0040:0080 WORD		Keyboard Buffer Start Offset pointer
0040:0082 WORD		Keyboard Buffer End Offset pointer
0040:0084 BYTE	ROWS	Number of text rows minus 1
0040:0085 WORD	CHAR_HEIGHT	Bytes per character
0040:0087 BYTE	INFO_1	
	Bit	Description
	D7	equals Bit D7 from AL register on most recent mode select. (A one indicates display memory was not cleared by mode select).
	D6, D5	Display memory size (00=64K, 01=128K, 10=192K, 11=256K)
	D4	reserved
	D3	A zero indicates EGA is the primary display
	D2	A one will force the BIOS to wait for Vertical Retrace before memory write.
	D1	A one indicates that EGA is in Monochrome Mode.
	D0	A zero means that CGA cursor emulation is enabled. The cursor shape will be modified if enhanced text is used.
0040:0088 BYTE	INFO_3	
	D4-D7	Feature Control Bits (from Feature Control Register)

DO-D3 EGA Configuration Switch settings

0040:0089 BYTE**FLAGS****Miscellaneous flags**

D7	Alphanumeric Scanlines (with Bit 4):		
	Bit 7	Bit 4	
	0	0	350-line Mode
	0	1	400-line Mode
	1	0	200-line Mode
	1	1	(reserved)
D6	1 – display switching is enabled		
	0 – display switching is disabled		
D5	(reserved)		
D4	(see Bit 7)		
D3	1 – default palette loading is disabled		
	0 – default palette loading is enabled		
D2	1 – using monochrome monitor		
	0 – using color monitor		
D1	1 – grayscale summing is enabled		
	0 – grayscale summing is disabled		
D0	1 – VGA active		
	0 – VGA not active		

0040:008A BYTE	reserved
0040:008B BYTE	media control
0040:008C BYTE	Hard disk drive controller status
0040:008D BYTE	Hard disk drive error status
0040:008E BYTE	Hard disk drive interrupt control
0040:008F BYTE	reserved
0040:0090 BYTE	Drive 0 Media state
0040:0091 BYTE	Drive 1 Media state
0040:0092 BYTE	reserved
0040:0093 BYTE	reserved
0040:0094 BYTE	Drive 0 Current cylinder
0040:0095 BYTE	Drive 1 Current cylinder
0040:0096 BYTE	Keyboard Mode State and Type flags
0040:0097 BYTE	Keyboard LED Flags
0040:0098 WORD	Address offset to User Wait Complete flag
0040:009A WORD	Segment address to User Wait Complete flag
0040:009C WORD	User wait count – Low word (μsecs)
0040:009E WORD	User wait count – High word (μsecs)
0040:00A0 BYTE	Wait active flag
0040:00A1 BYTE	reserved
0040:00A2 BYTE	reserved
0040:00A3 BYTE	reserved
0040:00A4 BYTE	reserved
0040:00A5 BYTE	reserved
0040:00A6 BYTE	reserved
0040:00A7 BYTE	reserved

0040:00A8 DWORD SAVE_PTR Pointer to BIOS Save Pointer Table

NOTE: The next 84 bytes from 0040:00A1 to 0040:00FF are reserved.

Table 10–3. I/O Port Assignment for PC XT and AT Computers

Port Usage for PC XT	I/O Address	Port Usage for AT
DMA Controller	000 - 01F	DMA Controller, Note 1
Interrupt Controller	020 - 03F	Interrupt Controller, Note 1
Timer	040 - 04F	Coprocessor access, Timer
	050 - 05F	Timer
PPI (system configuration)	060 - 063	
	060 - 06F	Keyboard
Reserved	070 - 07F	Real-time Clock
DMA Page Register	080 - 09F	DMA Page Register
NMI Mask Register	0A0 - 0AF	
	0A0 - 0BF	Interrupt Controller, Note 2
Reserved	0B0 - 0FF	
	0C0 - 0DF	DMA Controller, Note 2
	0F0 - 0FF	Math coprocessor
Unusable	100 - 13F	Reserved
Unusable	140 - 14F	Token Ring Adapter, Note 2
Unusable	150 - 15F	Advanced Color Graphics Display
Unusable	160 - 16F	Advanced Mono Graphics Display
Unusable	170 - 17F	Fixed-disk Adapter, Note 2
Unusable	1C0 - 1CF	Token Ring Adapter, Note 1
Unusable	1E8 - 1EF	Streaming Tape Drive Adapter
Unusable	1F0 - 1F7	Fixed-Disk Adapter, Note 1
Unusable	1F8 - 1FF	Reserved
Game I/O	200 - 20F	Game I/O
Expansion Unit	210 - 217	
Multifunction Card, Note 1	218 - 21F	Multifunction Card, Note 1
Reserved	220 - 24F	
	278 - 27F	Parallel Port 2
Clock Calendar, Note 1	2C0 - 2CF	Clock Calendar, Note 1
	2D0 - 2DF	3278/79 Emulation Adapter, Clock/calender, Note 1
Serial Port 4, Note 1	2E0 - 2E7	
Serial Port 3 or 4, Note 1	2E8 - 2EF	
Reserved	2F0 - 2F7	Interrupt Sharing
Serial Port 2	2F8 - 2FF	Serial Port 2
Prototype Card	300 - 31F	Prototype Card
Fixed Disk	320 - 32F	
	360 - 36F	PC Network
Parallel Port 1	378 - 37F	Parallel Port 1
SDLC	380 - 38F	SDLC, Bisync 2
Bisync	3A0 - 3AF	Bisync 1
MDA and printer adapter	3B0 - 3BF	MDA, EGA/VGA and printer adapter
EGA/VGA Adapter	3C0 - 3CF	EGA/VGA
CGA	3D0 - 3DF	CGA, EGA/VGA
Reserved	3E0 - 3E7	
Serial Port 3, Note 1	3E8 - 3EF	

Table 10–3. I/O Port Assignment for PC XT and AT Computers (cont.)

Port Usage for PC XT	I/O Address	Port Usage for AT
Diskette Controller	3F0 - 3F7	Diskette Controller
Serial Port 1	3F8 - 3FF	Serial Port 1
	400 - 43F	Reserved
	440 - 44F	Coprocessor Access
	450 - 50F	Reserved
	510 - 52F	Multi-protocol Adapter
	550 - 557	Coprocessor to main CPU communication
	6F0 - 6F7	Interrupt sharing
	910 - 92F	Multi-protocol Adapter
	D10 - D2F	Extended Monochrome Graphics Display
	E90 - E9F	PSLA
	1230-124F	1st Address range: multi-port async
	2230-224F	2nd Address range: multi-port async
	3230-324F	3rd Address range: multi-port async
	4230-424F	4th Address range: multi-port async
	46E8	VGA add-in Adapter Sleep Enable

NOTE: Use of port for this function is common, but not standard.

Table 10–4. Interrupt Vector Assignments

VECTOR TABLE ENTRY	INT NO.	NAME
0000:0000	0	Divide by zero
0000:0004	1	Single step
0000:0008	2	Non-maskable
0000:000C	3	Break-point
0000:0010	4	Overflow
0000:0014	5	Print screen
0000:0018	6	(Reserved)
0000:001D	7	(Reserved)
0000:0020	8	Time H/W IRQ0
0000:0024	9	Keyboard H/W IRQ1
0000:0028	A	Network H/W IRQ2
0000:002C	B	Comm. Port 2 H/W IRQ3
0000:0030	C	Comm. Port 1 H/W IRQ4
0000:0034	D	Hard disk H/W IRQ5
0000:0038	E	Diskette H/W IRQ6
0000:003C	F	Printer H/W IRQ7
0000:0040	10	EGA/VGA BIOS Video Services
0000:0044	11	Equipment check
0000:0048	12	Determine memory size
0000:004C	13	Diskette/disk
0000:0050	14	Communications
0000:0054	15	Cassette (see Notes)
0000:0058	16	Keyboard
0000:005C	17	Printer
0000:0060	18	Resident BASIC
0000:0064	19	Bootstrap
0000:0068	1A	Time of day
0000:006C	1B	Keyboard break
0000:0070	1C	Timer tick
0000:0074	1D	Video initialization
0000:0078	1E	Diskette parameters
0000:007C	1F	Optional Pointer to Upper 128 CGA 8 x 8 characters

Table 10–4. Interrupt Vector Assignments (cont.)**THE FOLLOWING INTERRUPTS ARE RESERVED FOR USE BY DOS:**

VECTOR TABLE ENTRY	INT NO.	NAME
0000:0080	20	Program Terminate
0000:0084	21	Function Request
0000:0088	22	Terminate Process Exit Address
0000:008C	23	Control-C Handler Address
0000:0090	24	Critical Error Handler Address
0000:0094	25	Absolute Disk Read
0000:0098	26	Absolute Disk Write
0000:009C	27	Terminate But Stay Resident
0000:00AA-00B8	28-2E	RESERVED
0000:00BC	2F	Print Spool Control
0000:00C0-00FC	30-3F	RESERVED
0000:0108	42	Old BIOS Video Services
0000:010C	43	Pointer to CGA 8 x 8 Char Set

NOTES:

- 1) The INT 15 interrupt service handler has an additional responsibility in systems with an E000 segment video BIOS; besides cassette service, it will handle video subsystem services.
- 2) The complete list of interrupt numbers goes to FFH; each vector is a double word so the pointer for INT xH is stored at absolute location 4xH.

Appendix A1

Connector Pinouts

CONNECTOR PINOUTS

Table A1-1. VGA DB15

Pin Number	Function
1	Analog RED
2	Analog GREEN
3	Analog BLUE
4	Monitor ID 2
5	No Connection
6	Analog RED Return
7	Analog GREEN Return
8	Analog BLUE Return
9	No Connection
10	Digital Ground
11	Monitor ID 0
12	Monitor ID 1
13	HSYNC
14	VSYNC
15	Monitor ID 3

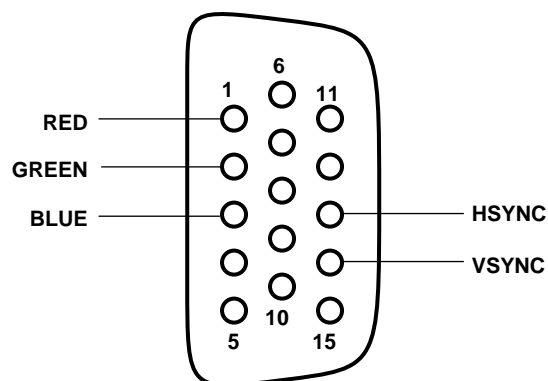


Table A1-2. PAL SCART Connector (For CL-GD5425 Evaluation Board)

Header	DB9	European SCART Connector	Function
1	1	20	Composite Sync
2	6	8	Function Switching
3	2	16	Blanking
4	7	5	Ground
5	3	7	Blue
6	8	9	Ground
7	4	11	Green
8	9	13	Ground
9	5	15	Red
10	n/c	n/c	VCC

Cirrus Logic designs the header onto reference designs. A standard COM1 flat cable adapter yields the DB9 pinouts. A drawing appended to the Reference Board schematics shows the connections between the DB9 and the European SCART connector. Customers wishing to have a SCART cable made can contact:

Redmond Cable
15331 N.E. 90th Street
Redmond, WA 98052

Phone: 206.882.2009
Fax: 206.883.1430
Part Number: 38355865

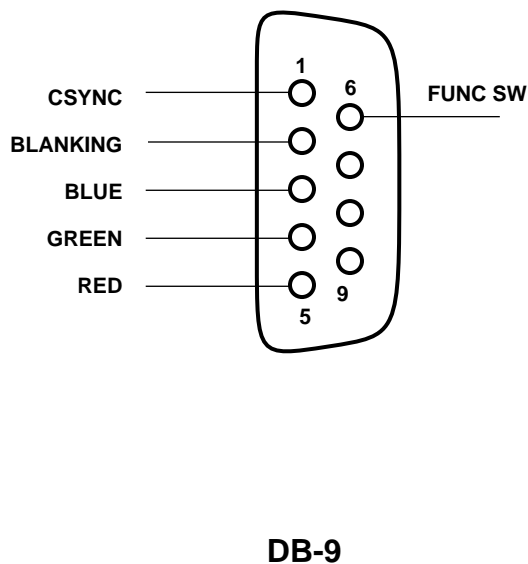
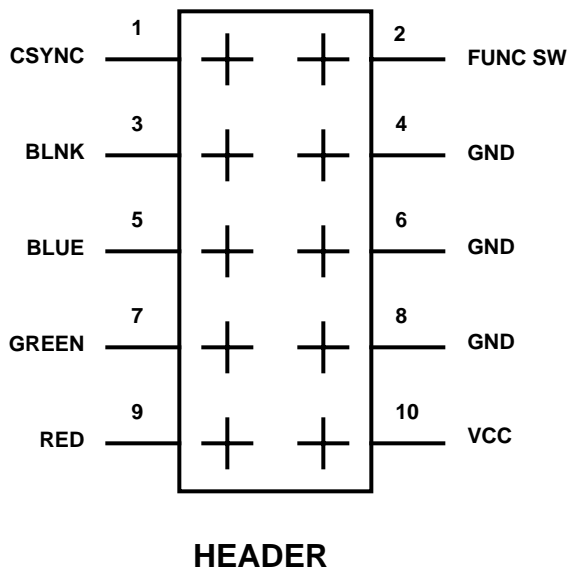


Table A1-3. S-Video (For CL-GD5425 Evaluation Board)

Pin Number	Function
1	Ground
2	Ground
3	Luminance
4	Chrominance
Shield	Ground

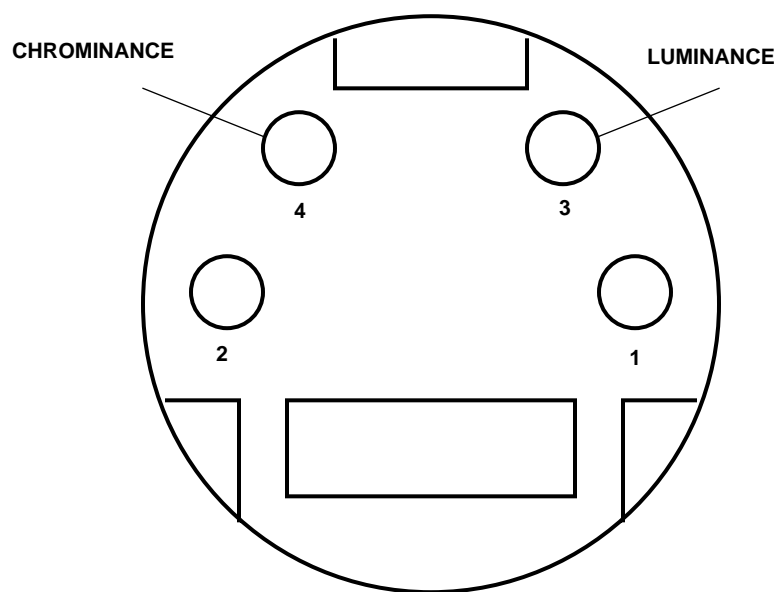
**FACING RECEPTACLE**

Table A1-4. VESA® Passthrough Connector

Number	Z	Y
1	Ground	P[0]
2	Ground	P[1]
3	Ground	P[2]
4	EVIDEO*	P[3]
5	ESYNC*	P[4]
6	EDCLK*	P[5]
7	+5V (Note)	P[6]
8	Ground	P[7]
9	Ground	DCLK
10	Ground	BLANK*
11	Ground	HSYNC
12	MCLK (Note)	VSYNC
13	OVW*	Ground

NOTE: These pins are assigned by Cirrus Logic for VAFC Support.

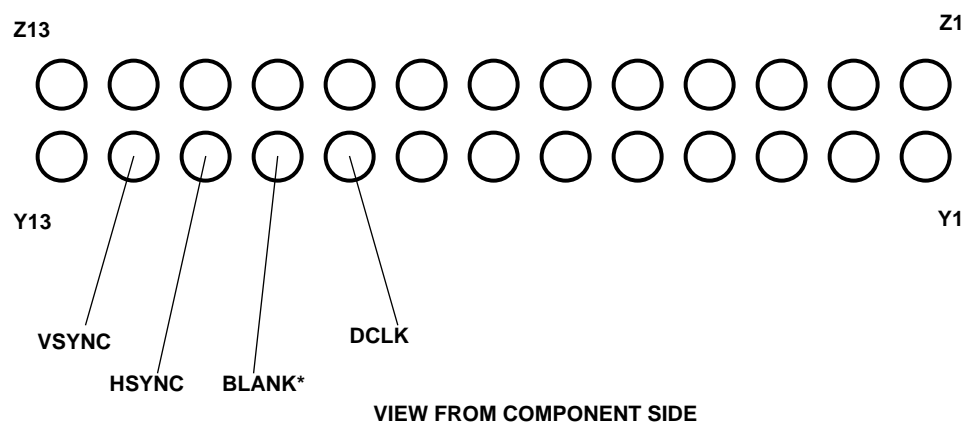
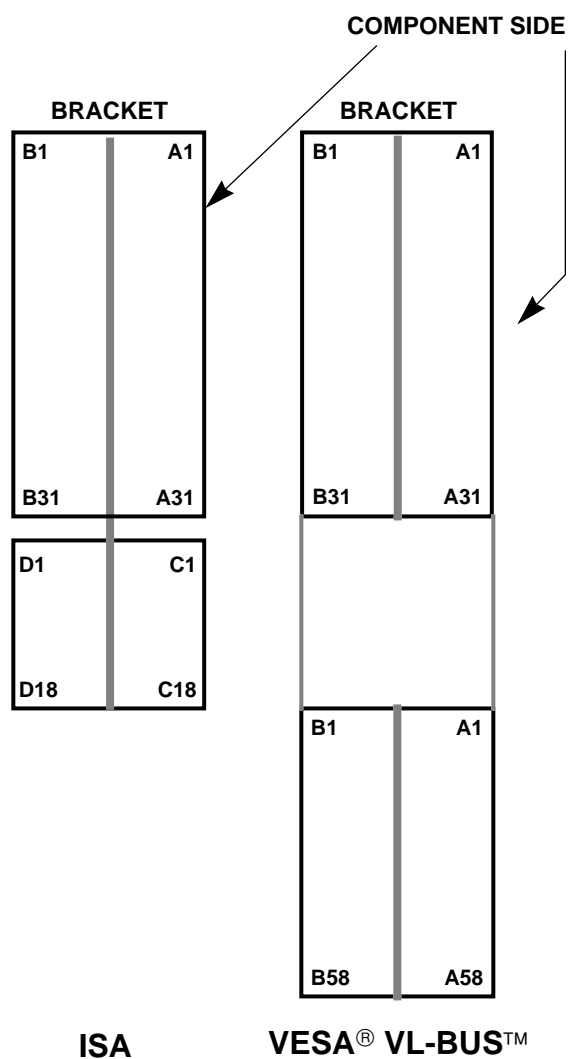


Table A1-5. ISA Bus

Pin	Component Side A	Solder Side B	Component Side C	Solder Side D
1	IOCHCHK*	Ground	SBHE*	MCS16*
2	SD7	RESET	LA23	IOCS16*
3	SD6	+5V	LA22	IRQ10
4	SD5	IRQ9	LA21	IRQ11
5	SD4	-5V	LA20	IRQ12
6	SD3	DRQ2	LA19	IRQ15
7	SD2	-12V	LA18	IRQ14
8	SD1	0WS*	LA17	DACK0*
9	SD0	+12V	MEMR*	DRQ0
10	IOCHRDY	Ground	MEMW*	DACK5*
11	AEN	SMEMW*	SD8	DRQ5*
12	SA19	SMEMR*	SD9	DACK6*
13	SA18	IOW*	SD10	DRQ6
14	SA17	IOR*	SD11	DACK7*
15	SA16	DACK3*	SD12	DRQ7
16	SA15	DRQ3	SD13	+5V
17	SA14	DACK1*	SD14	MASTER*
18	SA13	DRQ1	SD15	Ground
19	SA12	REFRESH*		
20	SA11	CLK		
21	SA10	IRQ7		
22	SA9	IRQ6		
23	SA8	IRQ5		
24	SA7	IRQ4		
25	SA6	IRQ3		
26	SA5	DACK2*		
27	SA4	T/C		
28	SA3	BALE		
29	SA2	+5V		
30	SA1	OSC		
31	SA0	Ground		

Table A1-6. VESA® VL-Bus™ (CL-GD5424/25/26/28/29 only)

Pin	Solder Side 'B'	Component Side 'A'	Pin	Solder Side 'B'	Component Side 'A'
1	DAT00	DAT01	30	ADR17	ADR16
2	DAT02	DAT03	31	ADR15	ADR14
3	DAT04	GND	32	V _{CC}	ADR12
4	DAT06	DAT05	33	ADR13	ADR10
5	DAT08	DAT07	34	ADR11	ADR08
6	GND	DAT09	35	ADR09	GND
7	DAT10	DAT11	36	ADR07	ADR06
8	DAT12	DAT13	37	ADR05	ADR04
9	V _{CC}	DAT15	38	GND	WBACK# (not used)
10	DAT14	GND	39	ADR03	BE0#
11	DAT16	DAT17	40	ADR02	V _{CC}
12	DAT18	V _{CC}	41	n/c	BE1#
13	DAT20	DAT19	42	RESET# (not used)	BE2#
14	GND	DAT21	43	D/C# (not used)	GND
15	DAT22	DAT23	44	M/IO#	BE3#
16	DAT24	DAT25	45	W/R#	ADS#
17	DAT26	GND	46	Key	Key
18	DAT28	DAT27	47	Key	Key
19	DAT30	DAT29	48	RDYRTN#	LRDY#
20	V _{CC}	DAT31	49	GND	LDEV<X>#
21	ADR31	ADR30	50	IRQ9 (not used)	LREQ<X># (not used)
22	GND	ADR28	51	BRDY# (not used)	GND
23	ADR29	ADR26	52	BLAST# (not used)	LGNT<X>#
24	ADR27	GND	53	ID0 (not used)	V _{CC}
25	ADR25	ADR24	54	ID1 (not used)	ID2 (not used)
26	ADR23	ADR22	55	GND	ID3 (not used)
27	ADR21	V _{CC}	56	LCLK	ID4 (not used)
28	ADR19	ADR20	57	V _{CC}	LKEN# (not used)
29	GND	ADR18	58	LBS16#	LEADS# (not used)



Appendix B1

16-Bit ISA Adapter Board Schematics

**FOR THE LATEST SCHEMATICS,
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16-BIT ISA ADAPTER BOARD

1. INTRODUCTION

This application note discusses the logic design and layout of an ISA adapter for the CL-GD542X family of VGA controllers; please refer to Chapter 3, “Data Book”, for a list of controller features. Since the CL-GD542X family shares a common pinout, the only schematic differences are in the Video Memory interface. The CL-GD5420 is limited to a maximum of 512K bytes of DRAM, the CL-GD5422 and CL-GD5424 are limited to 1 Mbyte, and the CL-GD5426/28/29 can support up to 2 Mbytes. This application note covers the ISA bus interface, BIOS, display memory, Monitor/Video DAC interface, Integrated Clock, and hardware features.

A sample system schematic and bill of materials are included at the end of this appendix. The schematic capture program used for generating the sample adapter schematic is ORCAD™ SDT 4.10. The schematic and layout (Gerber Output) files are included with the manufacturing package, or these files can be downloaded from the Cirrus Logic Bulletin Board Service, (510) 440-9080 (refer to Appendix D9 for more information about the BBS). The manufacturing package consists of all the documentation, software, firmware, working files, and sample components necessary for evaluating the CL-GD542X in an adapter implementation.

2. ISA BUS INTERFACE

An adapter board based on this schematic will not function in an 8-bit ISA connector; the schematic shown is for an implementation of the CL-GD542X for a 16-bit-only ISA bus Interface. The adapter board is limited to a 16-bit ISA interface because SA17, SA18, and SA19 (from the 8-bit connector) are not used and are replaced by LA17, LA18, and LA19 (from the 16-bit connector).

The Bus Interface signals do not require additional buffering, as the CL-GD542X will directly drive the ISA bus. The active-high RESET DRV signal from the ISA bus needs to be conditioned by an R/C network (R2 and C19) to filter out any possible noise or glitches. Jumper JP1 is for PC/AT 0WS (zero-wait-state) operation. Placing a shunt on this jumper allows the CL-GD542X to signal the system processor that the present bus cycle can be completed without inserting additional ISA bus wait states. The reference 14.31818-MHz signal required by the integrated frequency synthesizer is obtained from the unbuffered ISA bus OSC input.

3. BIOS

The BIOS EPROM support logic consists of either one or two sets of EPROM and octal bidirectional buffers. One set (U2 and U3) is required for an 8-bit-only BIOS. The complete complement of U2, U3, U5, and U6, as well as R15 (pull-down resistor on MD22), is required for a 16-bit BIOS. The BIOS is linear, that is, both EPROMs contain identical data and are interchangeable. Configuration resistor R16 (pull-down resistor on MD17) is required if the adapter board is to operate with zero-wait-state access to the BIOS EPROMs. The EPROMs must have a less than 200-ns access time, but 150 ns is best for reliable zero-wait-state operation.

4. DISPLAY MEMORY

The display memory, as shown in the schematics for the CL-GD542X, can be configured for either 512K bytes or 1 Mbyte of $256\text{K} \times 4$ memory (the schematics show both SOJ and DIP package pinouts). The CL-GD5420 display memory (on the board), is limited to 512K bytes; it *cannot* be expanded to 1 Mbyte if $256\text{K} \times 4$ DRAMs are used. The schematics must be redrawn to support different DRAM configurations, such as symmetric or asymmetric, SOJ or DIP, and $256\text{K} \times 4$, $512\text{K} \times 8$, or $256\text{K} \times 16$. Refer to Appendix B7 for an overview of all the possible memory types and their connection to the CL-GD542X.

The allowable DRAM types with the optimum t_{RAC} time for a specific MCLK (memory clock) can also be determined from Appendix B7, which describes the DRAM timings expected from each MCLK selection. The MCLK frequency is selected by R17 and R18, as shown in the DRAM timing options found in the schematic. Resistor R23 is used for choosing high-performance or normal MCLK RAS cycles. Refer to Appendix B9 for an explanation of the various possible configuration settings.

5. MONITOR/VIDEO DAC INTERFACE

The integrated Video DAC requires an external current-reference source (IREF) consisting of Q1 (2N3904), D5 (TL431), and the associated R/C components shown on the schematic. This is an inexpensive IREF circuit that does not require a negative-voltage source. This circuit can easily be replaced with any one of various current-reference circuits based on an LM337, LM334, LP2951, or LM317, as long as the nominal IREF current drawn through the IREF pin is 6.7 mA. The IREF current determines the full-scale output voltage of the Video DAC, and therefore the brightness of the displayed image.

The included schematic shows optional diodes D1, D2, D3, and D4 that can provide Electrostatic Discharge (ESD) protection and prevent latch-up in the CL-GD542X. Latch-up can occur due to high-energy discharges from monitor arc-over or from ‘hot-switching’ AC-coupled monitors. These diodes can be left out of the circuit without affecting the normal operation of the adapter board.

The analog RGB (Red, Green, and Blue) lines going from the CL-GD542X to the Monitor Interface Connector (P1) have standard π -filter circuits to reduce EMI and noise for FCC Class B compliance. The analog outputs are capable of directly driving a singly-terminated $75\text{-}\Omega$ load to a peak-white amplitude of 0.7V. The $150\text{-}\Omega$ pull-down resistors on the RGB lines correspond to an effective DAC output loading of $50\text{ }\Omega$. Each RGB analog output should have a source-load resistor located as close as possible to the CL-GD542X to minimize reflections.

6. INTEGRATED CLOCK

The integrated dual-clock synthesizer uses the 14.31818-MHz clock from the ISA bus as a reference for generating the VCLKs (video clock) and MCLKs. This reference clock can be replaced by a 14.31818-MHz series-resonant crystal by disconnecting the trace to ISA bus pin B30, and connecting the crystal across pins 158 and 159 of the CL-GD542X (pin 158 is a no-connect).

The internal dual-clock synthesizer requires two external loop-filter circuits, one for the VCLK, and the other for MCLK. The Memory Clock filter consists of R19, C29, and CC25. The VCLK filter consists of R13, C13, and C17 for N-WELL devices and R13, C38, and C39 for P-WELL devices. Refer to Appendix B17 for a description of N-WELL versus P-WELL device considerations.

7. HARDWARE FEATURES

The schematic shows that the adapter board can be configured to support an external EEPROM (U1) for storing monitor timing options. Choosing not to install an EEPROM (U1) will not affect the operation of the adapter board, but it will require the execution of a configuration program from within the AUTOEXEC.BAT file. If the EEPROM is not installed, R3 and R4 are not required; however, the traces from J1 pins 10 and 8 must be connected to CL-GD542X pins 94 and 95, respectively, if the VESA Connector is to be used.

Adding J1 provides a VESA-compliant VGA pass-through connector for transferring pixel data to or from the internal Video DAC. The 13-pin-by-2-row connector is a less costly alternative than the IBM version, which requires a routing of the printed circuit board. If the connector is not installed, R3 and R4 are not required. Choosing not to install the connector will not affect the operation of the adapter board.

Appendix B2

Reserved

Appendix B3

'486 VESA® VL-Bus™

Schematics

**FOR THE LATEST SCHEMATICS,
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'486 VESA® LOCAL BUS

1. INTRODUCTION

This application note discusses the logic design and layout of a VGA solution for a VESA VL-Bus '486 local bus adapter based on the CL-GD5424, CL-GD5426, and the CL-GD5428. The CL-GD5424/'26/'28/'29 share a common pinout; however, schematic differences are found in the Video Memory and host CPU bus interface. The CL-GD5424 is limited to a maximum of 1 Mbyte of DRAM, and the CL-GD5426/'28/'29 support a maximum of 2 Mbytes. The discussion covers the VL-Bus interface, BIOS, display memory, the Monitor/Video DAC interface, Integrated Clock, and hardware features.

A sample system schematic and bill of materials are included at the end of this appendix. The schematic and layout (Gerber Output) files are included with the manufacturing package, or these files can be downloaded from the Cirrus Logic Bulletin Board Service, (510) 440-9080 (refer to Appendix D9 for more information on the Cirrus Logic BBS). The schematic-capture program used for generating the sample adapter schematic is ORCAD SDT 4.10. The manufacturing package consists of all the documentation, software, firmware, working files, and sample components necessary for evaluating the CL-GD5424/'26/'28/'29 in a local bus adapter implementation.

2. '486 LOCAL BUS INTERFACE

The CL-GD5424/'26/'28/'29 is designed to interface directly with '386SX/DX and '486SX/DX CPUs with a minimal of glue logic. Configuration Resistor R24 (pull-down resistor on MD21) is required if the CL-GD5424/'26/'28/'29 is to operate in VESA Local Bus mode. The CL-GD5424/'26/'28/'29 connects directly to the CPU address, data and control lines, except for glue logic required for generating control signals missing from the local bus connector and word-steering logic for 32-bit systems. Two possible local bus configurations are discussed in the following sections: Motherboard and VL-Bus adapter.

2.1 Motherboard '486 Local Bus Interface

In a motherboard implementation, the CL-GD5424/'26/'28/'29 interfaces directly to the CPU. In 32-bit systems, no complicated word-steering logic is required if the BS16# line from the CL-GD5424/'26/'28/'29 is connected directly to the CPU. BS16# causes the CPU to run multiple bus cycles to complete a data transaction with the CL-GD5424/'26/'28/'29. Four sets of octal transceivers — U16, U17, U18, and U19 — are used for interfacing the 32-bit CPU with the 16-bit CL-GD5424/'26/'28/'29. In a '486 design, the EEPROM control pins become word-steering control signals (OEL# and OEH#) for the octal transceivers.

2.2 VESA® VL-Bus™ '486 Local Bus Interface

The VESA VL-Bus is generally used for 80486 motherboards with local bus. It provides all of the local bus control signals required by the CL-GD5424/'26/'28/'29 except for UADDR#. This signal is a simple decode of ADR24 and ADR25, indicating that the current address is in the valid Video Memory (lower 64-Mbyte address range). The VL-Bus provides a 1x clock that connects directly to the CL-GD5424/'26/'28/'29 CLK1X pin. For a '486 implementation, the RDYRTN# and RESET pins on the CL-GD5424/'26/'28/'29 connect directly to the VL-Bus RDYRTN# pin.

The active-high RESET DRV signal needs to be conditioned by an R/C network (R2 and C19) to filter out any possible noise or glitches, and is connected to the RESET pin. Holding this signal high disables CL-GD5424/'26/'28/'29.

The 14.31818-MHz reference signal required by the integrated Frequency Synthesizer is obtained from either the unbuffered local bus OSC input or an optional 14.3-MHz crystal. An optional high-pass filter (C42/R42) can be used to filter a noisy reference input.

3. BIOS

For a motherboard implementation, it is assumed that the BIOS is E000:0 (that is, it is linked into the main system BIOS). For adapter card applications, the BIOS EPROM support logic consists of one EPROM (U20) and one octal bi-directional buffer (U21). In adapter Local Bus configuration, the BIOS EPROM interfaces directly to the ISA Bus Address, Data Bus, and SMEMRD signal. The CL-GD5424/'26/'28/'29 generates the appropriate EPROM Enable (EROM#) signal, which must be qualified with SMEMRD# (U22).

4. DISPLAY MEMORY

The display memory, as shown in the included schematics for the CL-GD5424/'26/'28/'29, can be configured for 1 or 2 Mbytes of memory (the schematics show two 256K × 16 SOJ packages for the first 1 Mbyte of memory used by either CL-GD5424, CL-GD5426, or CL-GD5428; the other 256K × 4 DIP package DRAMs are the optional 1-Mbyte upgrade option for the CL-GD5426/'28/'29). The schematics must be redrawn to support different DRAM configurations, such as symmetric or asymmetric, SOJ or DIP, and 256K × 4, 512K × 8, or 256K × 16. Refer to the DRAM configuration table in Appendix B7 for an overview of all the possible memory types and their connection to the CL-GD5424/'26/'28/'29.

The allowable DRAM types with the optimum t_{RAC} time for a specific Memory Clock (MCLK) can also be determined from Appendix B7. The application note describes the DRAM timings expected from each Memory Clock selection. The Memory Clock frequency is selected by R16 and R17, as shown in the DRAM timing options found in the schematic. Resistor R23 is used for choosing high-performance or normal MCLK RAS cycles. Refer to Appendix B9 for an explanation of the various configuration settings possible.

5. MONITOR/VIDEO DAC INTERFACE

The integrated Video DAC requires an external current-reference source (IREF) consisting

of Q1, D5, and the associated R/C components shown on the schematic. This is an inexpensive IREF circuit that does not require a negative-voltage source. This circuit can easily be replaced with any one of various current-reference circuits based on an LM337, LM334, LP2951, or LM317, as long as the nominal IREF current drawn through the IREF pin is 6.7 mA. The IREF current determines the full-scale output voltage of the Video DAC, and therefore determines the brightness of the displayed image.

The analog Red, Green, and Blue (RGB) lines going from the CL-GD5424/'26/'28/'29 to the monitor interface connector (P1) have standard PI-filter circuits to reduce EMI and noise for FCC Class B compliance. The analog outputs are capable of directly driving a singly-terminated 75- Ω load to a peak-white amplitude of 0.7V. The 150- Ω pull-down resistors on the RGB lines correspond to an effective DAC output loading of 50 ohms. Each RGB analog output should have a source-load resistor located as close as possible to the CL-GD5424/'26/'28/'29 to minimize reflections.

6. INTEGRATED CLOCK

The integrated dual-clock synthesizer uses the 14.31818-MHz clock from the local bus as a reference for generating the Video and Memory Clocks. This reference clock can be replaced by a 14.31818-MHz series-resonant crystal by disconnecting the trace to the local bus and connecting the crystal across pins 158 and 159 of the CL-GD5424/'26/'28/'29.

The internal dual-clock synthesizer requires two external loop-filter circuits, one for the Video Clock and the other for the Memory Clock. The Memory Clock filter consists of R19, C29, and C25. The Video Clock filter consists of R13, C13, and C17. The VFILTER circuit has capacitor components C38, C39, C13, and C17. Refer to Appendix B17 for a description of capacitors to use. For example, C38 and C39 are installed for N-WELL devices and C13 and C17 are installed for P-WELL devices. Careful board layout guarantees optimal operation. Refer to Appendix B12 for more information regarding P-WELL and N-WELL configurations.

7. HARDWARE FEATURES

The '486 local bus schematic shows that an external EEPROM for storing monitor timing options is not supported because its control signals are used for word steering. The external EEPROM is supported in '386SX/DX local bus systems. Choosing not to install an EEPROM does not affect the operation of the adapter board, but requires the execution of a configuration program from within the AUTOEXEC.BAT file.

Adding J1 provides a VESA-compliant VGA passthrough connector for transferring pixel data to or from the internal Palette DAC. The 13-pin-by-2-row connector is a less costly alternative than the IBM version, which requires a routing of the printed circuit board. Choosing not to install the connector does not affect the operation of the adapter board.

Appendix B4

CL-GD5425 VESA® VL-Bus™ Schematics

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CL-GD5425 VESA® VL-BUS™ SCHEMATICS

1. INTRODUCTION

This appendix presents layout information for the CL-GD5425.

Appendix B5

CL-GD5420-75QC-B VGA Controller Application Note

CL-GD5420-75QC-B VGA CONTROLLER

1. OVERVIEW

The CL-GD5420-75QC-B video controller is a highly cost-effective 1-Mbyte VGA controller. Incorporating a built-in True Color palette DAC, dual-programmable Clock Synthesizer, and system bus and feature connector interface support, the CL-GD5420-75QC-B requires only DRAMs to complete a video system. Optimized DRAM timing, 32-bit memory interface, and an advanced Write Buffer provides high-performance memory access. A hardware graphics cursor improves the performance and appearance of graphical user interfaces such as Microsoft® Windows™. The CL-GD5420-75QC-B is pin-to-pin compatible with the CL-GD542X product family.

2. FEATURES

- Full IBM VGA-compatibility in a 160-pin plastic quad flat pack (PQFP) package.
- Built-in True Color palette DAC. The video outputs connect directly to analog displays.
- Built-in monitor-type detection circuit.
- Programmable internal memory clock.
- Programmable internal video clocks at up to 75 MHz.
- Connects directly to the MicroChannel or PC/XT/AT system bus.
- Supports 16-bit data for I/O and BIOS ROM.
- Supports 32-bit display memory.
- Supports 1-Mbyte display memory.
- Choice of two flexible DRAM timings.
- Write cycles to display memory are optimized by combining a Memory Write Buffer and zero-wait-state (AT bus) request capability.
- Internal asynchronous display data FIFO allows the system optimum access to memory.
- Supports EEPROM for (switchless) configuration data.
- 132-column A.N. (Alphanumeric mode) on all monitors.
- 256-color Graphics mode at 1024 × 768 at 44 Hz interlace (70-ns DRAMs).
- Pinscan on the pads and signature analysis.
- Graphics Cursor; 32 × 32 pixel, Windows-compatible.

DRAM Support (Refer to Appendix B7 for more information)

Two, 256K × 4; 256 Kbytes

Four, 256K × 4; 512 Kbytes

Eight, 256K × 4; 1 Mbyte

One, 512K × 8; 512 Kbytes

Two, 512K × 8; 1 Mbyte

One, 256K × 16; 512 Kbytes (two WE*-type: asymmetric or symmetric)

Two, 256K × 16; 1 Mbyte (two WE*-type: symmetric only)

Standard RAS Timing

RAS high: 2.5 MCLK MIN

RAS low: 3.5 MCLK MIN

CAS cycle: 2 MCLK

Use MCLK = 37.5 for 80 ns, 41 or 45 MHz for 70 ns

Extended RAS Timing

RAS high: 3 MCLK MIN

RAS low: 4 MCLK MIN

CAS cycle: 2 MCLK

Use MCLK = 45 MHz for 80 ns, 50 MHz for 70 ns

MCLK Options:

Power-on default values are:

CF(10)	CF(9)	MCLK value
0	0	50.11363 MHz
0	1	44.74431 MHz
1	0	41.16477 MHz
1	1	37.58523 MHz

To program the MCLK use the extended Sequencer register (SR:1F). Refer to Appendix B8.

2.1 Video Clock Support

All four VCLK values are programmable, the power-on default values are:

VCLK0 = 25.1802 MHz (Standard VGA graphics)

VCLK1 = 28.3251 MHz (Standard VGA text)

VCLK2 = 41.1648 MHz (132-column text, PS/2 monitors)

VCLK3 = 36.0818 MHz (800 × 600, 56 Hz)

Other available frequencies (VCLK3):

31.193 (640 × 480, 72 Hz), 50.113 (800 × 600, 72 Hz)

39.992 (800 × 600, 60 Hz), 64.982 (1024 × 768, 60-Hz non-interlaced)

44.907 (1024 × 768, interlaced), 75.169 (1024 × 768, 70-Hz non-interlaced)

NOTE: Only those frequencies listed above are guaranteed by testing. All other intermediate frequencies are not tested.

The following register bits have been added to CL-GD5420-75QC-B to support the previously listed features:

1. SRF[4] is no longer reserved. It is used to set 32-bit data path (1-Mbyte memory).
2. SR12[7] — Overscan Color Protect. This bit is not available in CL-GD5420.
3. SR1F[5:0] — Used for the MCLK frequency. The CL-GD5420 does not have a programmable memory clock.
4. The Hidden DAC register (HDR) is located at 3C6.

Refer to Chapters 4–9 for details on above-mentioned registers.

Appendix B6

True Color Modes Application Note

TRUE COLOR MODES

1. INTRODUCTION

Each video controller in the CL-GD542X family has a built-in palette DAC. The CL-GD5420 has an industry-standard palette DAC that provides 256 simultaneous colors out of a palette of 256K on the display screen. The CL-GD5422/'24/'25/'26/'28 have a True Color Multi-mode palette DAC that supports the following modes — useful in multimedia applications:

- 8 bit-per-pixel (VGA-standard 256-color Palette mode)
- 15 bit-per-pixel (32K color, 5-5-5 TARGA™ mode)
- 16 bit-per-pixel (64K color, 5-6-5 XGA™ mode)
- 24 bit-per-pixel (16.8-million color, True Color mode)
- Mix mode: 32K (5-5-5 mode) colors and 256 colors (standard VGA mode)

CL-GD5425/'28/'29 support 8-bit RGB (3-3-2) and 8-bit grayscale.

2. PROGRAMMING FOR A TRUE COLOR MULTI-MODE PALETTE DAC

The Hidden DAC register (I/O port 3C6H) is used to enable the Extended Color modes. At reset, this register is loaded with 00H, and the palette DAC is programmed in a compatible mode. In this mode, the palette DAC is functionally equivalent to the industry-standard Brooktree® BT476 RAMDAC™. By writing code to the Hidden DAC register, the palette DAC can be programmed in one of the modes mentioned above.

The following method is used to write to the Hidden DAC register:

- Step 1: Read from the Pixel Mask register (3C6H) four times in succession. No other read/writes should be directed to that address.
- Step 2: After the fourth read, the Pixel Mask register will point to the Hidden DAC register. At this point, the Hidden DAC register can be programmed by writing a code to it at Port 3C6H. Any other read from/write to any address other than the Pixel Mask register will reset an internal counter to '0' and must be preceded by Step 1 again.

Table B6-1. Extended Mode Select

MSB 7	6	5	4	3	2	1	LSB 0	Hex	Function
1	1	1/0	0	0	0	0	0	E0/C0	5-5-5 mode with 32K colors
1	1	1/0	1	0	0	0	0	F0/D0	5-5-5 and 256-color Mix mode
1	1	x	0	0	0	0	1	E1/C0	5-6-5 mode with 64K colors
1	1	x	0	0	1	0	1	E5/C0	8-8-8 mode with 16.8 million colors
1	1	x	0	0	1	1	x	C6	DAC power-down (CL-GD5429 only)

Table B6-1. Extended Mode Select *(cont.)*

MSB 7	6	5	4	3	2	1	LSB 0	Hex	Function
1	1	x	0	1	0	0	0	C8	8-bit Grayscale (<i>CL-GD5425/28/29 only</i>)
1	1	x	0	1	0	0	1	C9	3-3-2 mode (<i>CL-GD5425/28/29 only</i>)
1	1	x	0	0	0	1	1	C3	CCIR YCrCb (16-bit 4:2:2) (<i>CL-GD5425 only</i>)
1	1	x	0	0	1	0	1	C5	AccuPak™ (<i>CL-GD5425 only</i>)

NOTE: See the Hidden DAC register (Section 9.51) description.

bit 5: Clocking mode 1 = 0

Clocking mode 2 = 1

Use Clocking mode 1 *only* when using a video overlay feature.

2.1 5-5-5 Mode with 32K Colors

This mode supports the industry-standard 5-5-5 RGB mode with 32,768 colors. Each pixel is represented by 15 bits containing five bits of Red, Green, and Blue color information. The input sequence for each pixel is low byte first, followed by high byte by using the Clocking mode 1 or 2. The first low byte will be taken on the first rising edge of clock occurring after BLANK* has gone inactive (HIGH). All subsequent bytes are clocked in on the rising edge of clock. The CLUT is ignored in this mode.

Table B6-2. Pixel Data Format in 5-5-5 Mode

MSB HIGH BYTE								LSB LOW BYTE							
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
x	4	3	2	1	0	4	3	2	1	0	4	3	2	1	0
x	RED					GREEN					BLUE				

2.2 Mix Mode

If bit 4 of the Hidden DAC register is set to '1', the pixel data bit 15 will be used to select between 5-5-5 RGB mode and use of the standard palette DAC on a pixel-by-pixel basis.

Table B6-3. Pixel Data Format in Mix Mode

MSB HIGH BYTE								LSB LOW BYTE							
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	4	3	2	1	0	4	3	2	1	0	4	3	2	1	0
555	RED					GREEN					BLUE				

Table B6-4. PLT: Palette Lookup Table

MSB HIGH BYTE								LOW BYTE LSB							
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	x	x	x	x	x	x	x	7	6	5	4	3	2	1	0
PLT	IGNORED							Palette DAC LUT INPUT							

2.3 5-6-5 Mode with 64K Colors

This mode supports the XGA™ 5-6-5 RGB mode with 65,536 colors. Each pixel is represented by 16 bits containing 5 bits of Red, 6 bits of Green, and 5 bits of Blue color information. The input sequence for each pixel is low byte first, followed by high byte by using the Clocking mode 1 or 2. The first low byte will be taken on the first rising edge of clock occurring when BLANK* has gone inactive (HIGH). All subsequent bytes are clocked in on the rising edge of clock. The CLUT is ignored in this mode.

Table B6-5. Pixel Data Format in 5-6-5 Mode with 64K Colors

MSB HIGH BYTE								LOW BYTE LSB							
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
4	3	2	1	0	5	4	3	2	1	0	4	3	2	1	0
RED					GREEN						BLUE				

2.4 8-8-8 Mode with 16.8 Million Colors

This mode supports the industry-standard 8-8-8 RGB mode with 16,777,216 colors. Each pixel is represented by 24 bits containing 1 byte each of Red, Green, and Blue color information. The input sequence for each pixel is low byte (Blue) first, followed by middle (Green) byte, followed by high (Red) byte by using the Clocking mode 1 or 2. The first low byte will be taken on the first rising edge of clock occurring when BLANK* has gone inactive (HIGH). All subsequent bytes are clocked in on the rising edge of clock. The palette LUT is ignored in this mode. When programming this mode, the BIOS sets the offset to 2048 to facilitate pixel address calculation.

Table B6-6. Pixel Data Format in 8-8-8 Mode with 16.8M Colors

MSB HIGH BYTE								MIDDLE BYTE								LOW BYTE LSB							
23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
RED								GREEN								BLUE							

2.5 3-3-2 Mode with 256 Colors (CL-GD5425/'28/'29 only)

This mode supports the industry standard 3-3-2 RGB mode with 256 colors. Each pixel is represented by 8 bits containing 3 bits of Red color, 3 bits of Green color, and 2 bits of Blue color. The palette LUT is ignored in this mode.

Table B6-7. Pixel Data Format in 3-3-2 Mode with 256 Colors

MSB LSB							
EACH BYTE							
7	6	5	4	3	2	1	0
RED			GREEN			BLUE	

2.6 8-bit Grayscale Mode (CL-GD5425/'28/'29 only)

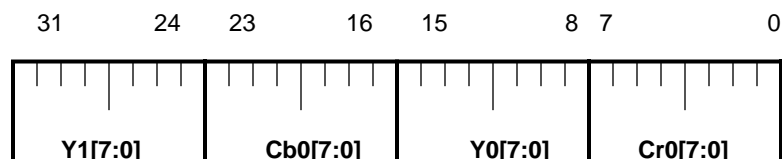
This mode supports the industry standard of 8 bit grayscale with 256 shades of gray. Each pixel is represented by 8 bits. The palette LUT is ignored in the mode.

Table B6-8. Pixel Data Format in 8-bit Grayscale

MSB LSB							
EACH BYTE							
7	6	5	4	3	2	1	0
GRAYSCALE							

2.7 16-bit-per-pixel YCrCb Mode (CL-GD5425 only)

YCrCb is defined in Recommendation CCIR601. The CL-GD5425 supports the YCrCb 4:2:2 format. Each two-pixel unit is stored as one DWORD containing luminance for each of the two pixels, and chrominance for alternate pixels. When YCrCb is displayed, the chrominance values are used for both pixels. For more information on modes supported by the CL-GD5425, refer to Appendix B22, "CL-GD5425 Notes".



Appendix B7

Memory Configurations Application Note

MEMORY CONFIGURATIONS

1. INTRODUCTION

The CL-GD542X supports many display memory configurations, from 256K bytes to 2 Mbytes, using DRAMs that are organized by:

- 256K × 4
- 512K × 8
- 256K × 16 — dual-WE* or dual-CAS*

For 256K × 4 DRAM configuration, the total display memory can be expanded from 256K bytes to 512/1024 Kbytes by adding devices without changing any jumpers. For 256K × 16 DRAM configuration, the total display memory can be expanded from 512K bytes to 2 Mbytes. For 512K × 8 DRAMs, the total display memory can be expanded from 1 to 2 Mbytes. Note that a few signals change functions according to the device organization that is used.

For optimum performance, multiple-CAS* configurations should be chosen over multiple-WE* configurations.

Table B7-1. CL-GD542X Memory Configurations

Memory Configuration	Table	'GD5420	'GD5422	'GD5424	'GD5425	'GD5426/'28/'29
256K × 4 DRAMS: 256 Kbyte	B7-2	✓				
256K × 4 DRAMS: 512 Kbyte	B7-3	✓	✓	✓	✓	✓
512K × 8 DRAMS: 1 Mbyte	B7-4	✓	✓			
256K × 4 DRAMS: 1 Mbyte, multiple WE*	B7-5	✓	✓	✓		
256K × 4 DRAMS: 1 Mbyte, multiple CAS*	B7-6	✓	✓	✓	✓	✓
256K × 16 DRAMS: 512 Kbyte, dual WE*	B7-7	✓	✓	✓		
256K × 16 DRAMS: 512 Kbyte, dual CAS*	B7-8			✓	✓	✓
256K × 16 DRAMS: 1 Mbyte, dual WE*	B7-9	✓	✓	✓		
256K × 16 DRAMS: 1 Mbyte, dual CAS*	B7-10			✓	✓	✓

Table B7-1. CL-GD542X Memory Configurations(*cont.*)

Memory Configuration	Table	'GD5420	'GD5422	'GD5424	'GD5425	'GD5426/'28/'29
256K × 16 DRAMs: 2 Mbyte, dual WE*	B7-11					✓
256K × 16 DRAMs: 2 Mbyte, dual CAS*	B7-12					✓
256K × 16/4 DRAMs: 2 Mbyte, dual CAS*	B7-13					✓

The following tables indicate, for each case, how each device must be connected.

Table B7-1. 256K × 4 DRAMs — 256-Kbyte Display Memory (CL-GD5420 only)

Memory Device	One	Two
OE*	OE*	OE*
WE*	WE3*	WE3*
RAS*	RAS*	RAS*
CAS*	CAS*	CAS*
ADDR	MA[8:0]	MA[8:0]
DATA	MD[27:24]	MD[31:28]
PLANE	0, 1, 2, 3	0, 1, 2, 3

Table B7-2. 256K × 4 DRAMs — 512-Kbyte Display Memory

Memory Device	One	Two	Three	Four
OE*	OE*	OE*	OE*	OE*
WE*	WE3*	WE3*	WE2*	WE2*
RAS*	RAS*	RAS*	RAS*	RAS*
CAS*	CAS*	CAS*	CAS*	CAS*
ADDR	MA[8:0]	MA[8:0]	MA[8:0]	MA[8:0]
DATA	MD[27:24]	MD[31:28]	MD[19:16]	MD[23:20]
PLANE	1, 3		0, 2	

Table B7-3. 512K × 8 DRAMs — 1-Mbyte Display Memory (CL-GD5420 only)

Memory Device	One	Two
OE*	OE*	OE*
WE*	WE2*	WE3*
RAS*	RAS*	RAS*
CAS*	CAS*	CAS*
ADDR	MA[9:0]	MA[9:0]
DATA	MD[23:16]	MD[31:24]
PLANE	0, 2	1, 3

Table B7-4. 256K × 4 DRAMs — 1-Mbyte Display Memory, Multiple WE*

Memory Device	One	Two	Three	Four	Five	Six	Seven	Eight
OE*	OE*	OE*	OE*	OE*	OE*	OE*	OE*	OE*
WE*	WE2*	WE2*	WE3*	WE3*	WE0*	WE0*	WE1*	WE1*
RAS*	RAS*	RAS*	RAS*	RAS*	RAS*	RAS*	RAS*	RAS*
CAS*	CAS*	CAS*	CAS*	CAS*	CAS*	CAS*	CAS*	CAS*
ADDR	MA[8:0]	MA[8:0]	MA[8:0]	MA[8:0]	MA[8:0]	MA[8:0]	MA[8:0]	MA[8:0]
DATA	MD[19:16]	MD[23:20]	MD[27:24]	MD[31:28]	MD[3:0]	MD[7:4]	MD[11:8]	MD[15:12]
PLANE	2		3		0		1	

Table B7-5. $256K \times 4$ DRAMs — 1-Mbyte Display Memory, Multiple CAS*

Mem ory Devi ce	One	Two	Three	Four	Five	Six	Seven	Eight
OE*	GND	GND	GND	GND	GND	GND	GND	GND
WE*	CAS*	CAS*	CAS*	CAS*	CAS*	CAS*	CAS*	CAS*
RAS*	RAS*	RAS*	RAS*	RAS*	RAS*	RAS*	RAS*	RAS*
CAS*	WE2*	WE2*	WE3*	WE3*	WE0*	WE0*	WE1*	WE1*
ADD R	MA[8:0]	MA[8:0]	MA[8:0]	MA[8:0]	MA[8:0]	MA[8:0]	MA[8:0]	MA[8:0]
DATA	MD[19:16]	MD[23:20]	MD[27:24]	MD[31:28]	MD[3:0]	MD[7:4]	MD[11:8]	MD[15:12]
PLA NE	2		3		0		1	

Table B7-6. $256K \times 16$ DRAMs — 512-Kbyte Display Memory, Two-WE* Type

Memory Device	One (symmetric)	One (asymmetric)
LWE*	WE2*	WE2*
UWE*	WE3*	WE3*
OE*	OE*	OE*
RAS*	RAS*	RAS*
CAS*	CAS*	CAS*
ADDR[0]	MA[0]	MA[8]
ADDR[7:1]	MA[7:1]	MA[7:1]
ADDR[8]	MA[8]	MA[0]
ADDR[9]	not valid	MA[9]
DATA	MD[31:16]	MD[31:16]
PLANE	0, 1, 2, 3	0, 1, 2, 3

Table B7-7. 256K × 16 DRAMs — 512-Kbyte Display Memory, Two-CAS* Type

Memory Device	One (symmetric)	One (asymmetric)
LCAS*	WE2* ^a	WE2* ^a
UCAS*	WE3* ^b	WE3* ^b
OE*	GND	GND
RAS*	RAS*	RAS*
WE*	CAS* ^c	CAS* ^c
ADDR[0]	MA[0]	MA[8]
ADDR[7:1]	MA[7:1]	MA[7:1]
ADDR[8]	MA[8]	MA[0]
ADDR[9]	not valid	MA[9]
DATA	MD[31:16]	MD[31:16]
PLANE	0, 1, 2, 3	0, 1, 2, 3

a. WE2* pin becomes CAS2* for dual-CAS* 256K × 16 DRAM.

b. WE3* pin becomes CAS3* for dual-CAS* 256K × 16 DRAM.

c. CAS* pin becomes WE* signal for dual-CAS* 256K × 16 DRAM.

Table B7-8. 256K × 16 DRAMs — 1-Mbyte Display Memory, Two-WE* Type

Memory Device	One (symmetric)	Two (symmetric)	One (asymmetric)	Two (asymmetric)
LWE*	WE2*	WE0*	WE2*	WE0*
UWE*	WE3*	WE1*	WE3*	WE1*
OE*	OE*	OE*	OE*	OE*
RAS*	RAS*	RAS*	RAS*	RAS*
CAS*	CAS*	CAS*	CAS*	CAS*
ADDR[0]	MA[0]	MA[0]	MA[8]	MA[8]
ADDR[7:1]	MA[7:1]	MA[7:1]	MA[7:1]	MA[7:1]
ADDR[8]	MA[8]	MA[8]	MA[0]	MA[0]
ADDR[9]	not valid	not valid	MA[9]	MA[9]
DATA	MD[31:16]	MD[15:0]	MD[31:16]	MD[15:0]
PLANE	2, 3	0, 1	2, 3	0, 1

Table B7-9. 256K × 16 DRAMs — 1-Mbyte Display Memory, Two-CAS* Type

Memory Device	One (symmetric)	Two (symmetric)	One (asymmetric)	Two (asymmetric)
LCAS*	WE2* ^b	WE0* ^a	WE2* ^b	WE0* ^a
UCAS*	WE3* ^d	WE1* ^c	WE3* ^d	WE1* ^c
OE*	GND	GND	GND	GND
RAS*	RAS*	RAS*	RAS*	RAS*
WE*	CAS* ^e	CAS* ^e	CAS* ^e	CAS* ^e
ADDR[0]	MA[0]	MA[0]	MA[8]	MA[8]
ADDR[7:1]	MA[7:1]	MA[7:1]	MA[7:1]	MA[7:1]
ADDR[8]	MA[8]	MA[8]	MA[0]	MA[0]
ADDR[9]	not valid	not valid	MA[9]	MA[9]
DATA	MD[31:16]	MD[15:0]	MD[31:16]	MD[15:0]
PLANE	2, 3	0, 1	2, 3	0, 1

a. WE0* pin becomes CAS0* for dual-CAS* 256K × 16 DRAM.

b. WE2* pin becomes CAS2* for dual-CAS* 256K × 16 DRAM.

c. WE1* pin becomes CAS1* for dual-CAS* 256K × 16 DRAM.

d. WE3* pin becomes CAS3* for dual-CAS* 256K × 16 DRAM.

e. CAS* pin becomes WE* signal for dual-CAS* 256K × 16 DRAM.

Table B7-10. 256K × 16 DRAMs — 2-Mbyte Display Memory, Two-WE* Type (Symmetric)

Memory Device	One (symmetric)	Two (symmetric)	Three (symmetric)	Four (symmetric)
LWE*	WE2*	WE0*	WE2*	WE0*
UWE*	WE3*	WE1*	WE3*	WE1*
OE*	OE*	OE*	OE*	OE*
RAS*	RAS*	RAS*	MA[9] ^a	MA[9] ^a
CAS*	CAS*	CAS*	CAS*	CAS*
ADDR[8:0]	MA[8:0]	MA[8:0]	MA[8:0]	MA[8:0]
DATA	MD[31:16]	MD[15:0]	MD[31:16]	MD[15:0]
PLANE	2, 3	0, 1	2, 3	0, 1

a. MA[9] pin becomes RAS1* for dual-WE* 256K × 16 DRAM (symmetric).

Table B7-11. 256K × 16 DRAMs — 2-Mbyte Display Memory, Two-CAS* Type (Symmetric)

Memory Device	One (symmetric)	Two (symmetric)	Three (symmetric)	Four (symmetric)
LCAS*	WE2* ^b	WE0* ^a	WE2* ^b	WE0* ^a
UCAS*	WE3* ^d	WE1* ^c	WE3* ^d	WE1* ^c
OE*	GND	GND	GND	GND
RAS*	RAS*	RAS*	OE* ^e	OE* ^e
WE*	CAS* ^f	CAS* ^f	CAS* ^f	CAS* ^f
ADDR[8:0]	MA[8:0]	MA[8:0]	MA[8:0]	MA[8:0]
DATA	MD[31:16]	MD[15:0]	MD[31:16]	MD[15:0]
PLANE	2, 3	0, 1	2, 3	0, 1

- a. WE0* pin becomes CAS0* for dual-CAS* 256K × 16 DRAM.
b. WE2* pin becomes CAS2* for dual-CAS* 256K × 16 DRAM.
c. WE1* pin becomes CAS1* for dual-CAS* 256K × 16 DRAM.
d. WE3* pin becomes CAS3* for dual-CAS* 256K × 16 DRAM.
e. OE* pin becomes RAS1* signal for dual-CAS* 256K × 16 DRAM.
f. CAS* pin becomes WE* signal for dual-CAS* 256K × 16 DRAM.

Table B7-12. 256K × 16/256K × 4 DRAMs — 2-Mbyte Display Memory, Two-CAS* Type (Symmetric)

Device s	1 256 × 16	2 256 × 16	3 256 × 4	4 256 × 4	5 256 × 4	6 256 × 4	7 256 × 4	8 256 × 4	9 256 × 4	10 256 × 4
LCAS	WE0* ^a	WE2* ^c	—	—	—	—	—	—	—	—
VCAS	WE1* ^b	WE3* ^d	—	—	—	—	—	—	—	—
CAS	—	—	WE0* _a	WE0* _a	WE1* _b	WE1* _b	WE2* _c	WE2* _c	WE3* _d	WE3* _d
OE	GND	GND	GND	GND	GND	GND	GND	GND	GND	GND
RAS	RAS*	RAS*	OE* ^e	OE* ^e	OE* ^e	OE* ^e	OE* ^e	OE* ^e	OE* ^e	OE* ^e
WE	CAS* ^f	CAS* ^f	CAS* ^f	CAS* ^f	CAS* ^f	CAS* ^f	CAS* ^f	CAS* ^f	CAS* ^f	CAS* ^f
ADDR	8:0	8:0	8:0	8:0	8:0	8:0	8:0	8:0	8:0	8:0
DATA	15:0	31:16	3:0	7:4	11:8	15:12	16:14	23:20	27:24	31:28

- a. WE0* pin becomes CAS0* for dual-CAS* 256K × 16 DRAM.
b. WE1* pin becomes CAS1* for dual-CAS* 256K × 16 DRAM.
c. WE2* pin becomes CAS2* for dual-CAS* 256K × 16 DRAM.
d. WE3* pin becomes CAS3* for dual-CAS* 256K × 16 DRAM.
e. OE* pin becomes RAS1* signal for dual-CAS* 256K × 16 DRAM.
f. CAS* pin becomes WE* signal for dual-CAS* 256K × 16 DRAM.

Appendix B8

**Clock Options
Application Note**

CLOCK OPTIONS

1. INTRODUCTION

This application note discusses clock options available to CL-GD542X-based system designs.

2. MCLK — MEMORY CLOCK SELECTION

The Clock Synthesizer generates all the clocks needed for the memory timing (RAS*, CAS*, etc.) using an external reference clock, typically 14.31818 MHz. The Clock Synthesizer is a built-in feature of the CL-GD542X family.

The CL-GD5420 and the CL-GD5422 have four fixed memory clocks. At reset, data present on the Memory Data lines (MD26 and MD25) are loaded into the Configuration register, which is not accessible to software. Data can be presented via internal pull-up or external pull-down resistors. Typical values for an external pull-down resistor is 6.8 k Ω , and 250 k Ω for an internal pull-up resistor. A pull-down resistor causes the corresponding Configuration bit to be '0', and '1' for pull-up resistor. Table B8-1 provides proper MCLK rates to use depending on the type of DRAM installed.

Table B8-1. MCLK Frequencies

MD26	MD25	MCLK (MHz)
0	0	50.11363
0	1	44.74431
1	0	41.16477
1	1	37.58523

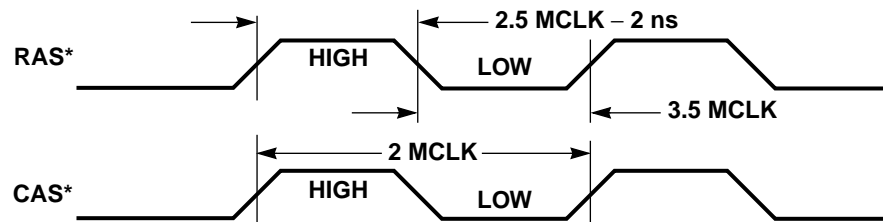
NOTE: A '0' corresponds to an external pull-down resistor (6.8 k Ω); a '1' corresponds to an internal pull-up resistor.

The CL-GD542X family supports two types of DRAM timing: standard and extended RAS* timing. A standard timing is used for generic DRAMs. Selection of DRAM timing can be made by setting the Configuration register bit 12 (MD27). A pull-down resistor causes the corresponding Configuration bit to be a '0' and a '1' for pull-up resistor. Refer to Table B8-2.

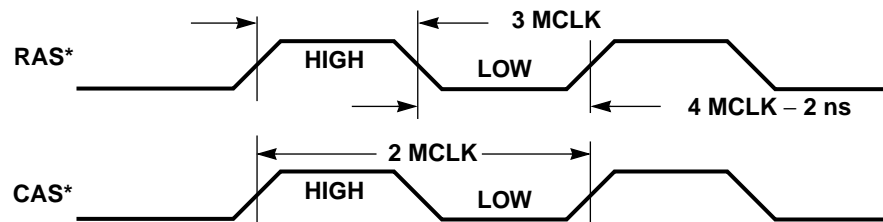
Table B8-2. DRAM Timing

MD27	DRAM Timing Selection
0	Extended RAS* (7-MCLK RAS* cycle)
1	Standard RAS* (6-MCLK RAS* cycle)

Refer to Appendix B19, “DRAM Timing Calculations”, for determining that DRAMs can be used at a given MCLK frequency. In standard DRAM timing, the CAS* and RAS* cycle have the following parameters:



Refer to Appendix B19, “DRAM Timing Calculations”, for determining that DRAMs can be used at a given MCLK frequency. In the extended DRAM timing, the CAS* and RAS* cycles have the following parameters:



3. PROGRAMMING MCLK FREQUENCY

For the CL-GD5424/'25/'26/'28/'29, MCLK is directly programmed by writing the value into SR1F[5:0] that most nearly corresponds to the desired frequency. The standard BIOS always overwrites the value loaded at reset.

$$MCLK = SR1F \cdot \left(\frac{Reference}{8} \right)$$

Table B8-3 shows examples assuming a reference clock of 14.31818 MHz. For the CL-GD5425 only, the frequencies are also shown with a reference of 17.734475 MHz. This table is for reference only. Some members of the CL-GD542X family are limited to an MCLK frequency of 50 MHz; other members are limited to 60 MHz.

Table B8-3. Programming MCLK Frequency Reference

SR1F[5:0] (Dec.)	SR1F[5:0] (Hex.)	MCLK Frequency (Reference = 14.3 MHz)	MCLK Frequency (Reference = 17.7 MHz)
21	15	37.6 MHz	46.6 MHz
23	17	41.2 MHz	51.0 MHz
24	18	43.0 MHz	53.2 MHz
25	19	44.7 MHz	55.5 MHz
26	1A	46.5 MHz	57.7 MHz
27	1B	48.3 MHz	59.9 MHz
28	1C	50.1 MHz	
29	1D	51.9 MHz	
30	1E	53.7 MHz	
31	1F	55.5 MHz	
32	20	57.3 MHz	
33	21	59.1 MHz	
34	22	60.9 MHz	

4. VCLK — VIDEO CLOCK PROGRAMMING

This clock is used to derive the Video Dot Clock (DCLK), VS (Vertical Sync), and HS (Horizontal Sync) timing for various SVGA modes. Video Clock (VCLKx) are generated internally using an external reference clock, typically 14.31818 MHz. There are four video clocks supported in the CL-GD542X family. All four VCLK values are programmable with following power-on default values:

- **VCLK0 = 25.1802 MHz (Standard VGA graphics)**
- **VCLK1 = 28.3251 MHz (Standard VGA text)**
- **VCLK2 = 41.1648 MHz (132-column text)**
- **VCLK3 = 36.082 MHz (Used for 800 × 600 Graphics mode)**

For the CL-GD5420, the maximum VCLKx is up to 75 MHz. For CL-GD5422/24/26/28, the maximum VCLKx is up to 80 MHz. For the CL-GD5429, the maximum VCLKx is 86 MHz. The maximum VCLK for a given MCLK frequency depends upon the following factors:

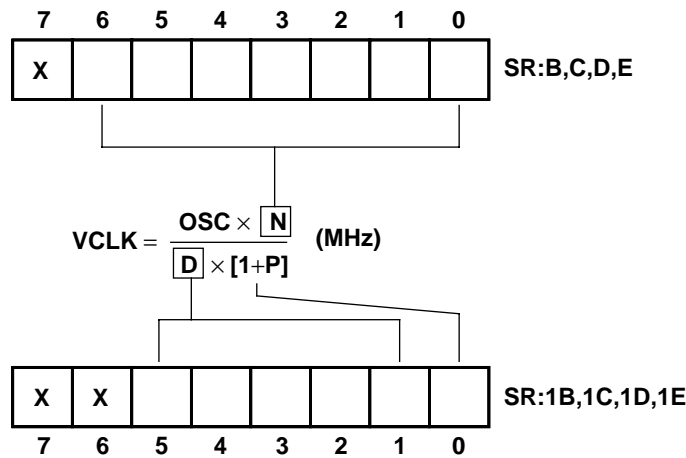
- Memory Data bus width: 8, 16, or 32 bits (for text modes, the 32-bit DRAM data width is the same performance as 16-bit data)
- **Display Mode**
 - Standard VGA Text (dual font)
 - Page Mode Text (single font, but higher VCLK possible, used for 132-column)
 - All standard VGA Graphics modes: 2-, 4-, 16-color and 320 × 200 × 256-color modes
 - Super VGA 256-color modes
 - 16-bit-per-pixel modes (32K and 64K colors)
 - 24-bit-per-pixel modes (16.8 million colors)
 - Hardware limit of VCLK
- For text modes, the DRAM-timing parameter of standard/high performance is important.
- For text modes, the font width of 8 or 9 dots also determines the maximum VCLK.
- The display FIFO depth also affects text mode maximum VCLKs.

Eight extended Sequencer registers are used to program VCLKx. These registers are accessible only if all the Extended registers are unlocked (the Extended Registers are not lockable on the CL-GD5429). A Sequencer register (SR:6) must be loaded with 12h to unlock all CL-GD542X Extended registers. The following extended Sequencer registers are used to program the VCLKx:

Sequencer I/O Address = 3C4

SR:B = VCLK0 numerator value
 SR:1B = VCLK0 denominator and post-scalar value
 SR:C = VCLK1 numerator value
 SR:1C = VCLK1 denominator and post-scalar value
 SR:D = VCLK2 numerator value
 SR:1D = VCLK2 denominator and post-scalar value
 SR:E = VCLK3 numerator value
 SR:1E = VCLK3 denominator and post-scalar value

The 7-bit Numerator (N), 5-bit Denominator (D), and 1-bit Post (P) for each Video Clock (VCLKx) determines its frequency according to the following formula:



The registers are read/write and preset with the following data by RESET: *i* = B, C, D, E.

CLOCK	VCLK (MHz)	N	D	P (SR1i[0])	SRi[6:0]	SR1i[5:0]
VCLK0	25.225	74	21	1	4A _h	2B _h
VCLK1	28.325	91	23	1	5B _h	2F _h
VCLK2	41.165	69	24	0	45 _h	30 _h
VCLK3	36.082	126	25	1	7E _h	33 _h

For the CL-GD5425 only, bits 7:6 of the denominator extend the field to seven bits. This provides more precision.

Other tested frequencies:

VCLK (MHz)	N	D	P (SR1i[0])	SRi[6:0]	SR1i[5:0]
31.499	66	15	1	42 _h	1F _h
39.992	81	29	0	51 _h	3A _h
44.907	85	29	0	55 _h	36 _h
49.866	101	29	0	65 _h	3A _h
64.982	118	26	0	76 _h	34 _h
72.163	126	25	0	7E _h	32 _h
74.999	110	21	0	6E _h	2A _h
80.013	95	17	0	5F _h	22 _h

4.1 Video Dot Clock (VCLKx) Selection

The Video Dot Clock is selected by a combination of Configuration register bit CF[5], Miscellaneous Output register (I/O port 3C2) bits 2:3, and input EDCLK* (pin 96). The Configuration register (CF[14:0]) cannot be accessed by software, and is used to select the MCLK source. Bit 5 of this register can be set by an external pull-down resistor (6.8 kW) on MD20. If no pull-down resistor is installed on MD20, bit 5 of Configuration register is set to '1' by an internal pull-up resistor (250 kW).

Bit 5 (MD20) of Configuration register: MCLK (pin 157) source.

0 = External, MCLK is configured as an input for test purposes.

1 = Internal, MCLK is configured to output the internally generated MCLK.

Table B8-4 provides VCLKx selection information.

Table B8-4. VCLKx Selection

EDCLK* (pin 96)	3C2: 3	3C2: 2	Dot Clock selected
1	0	0	VCLK0
1	0	1	VCLK1
1	1	0	VCLK2
1	1	1	VCLK3
0	1	x	DCLK input to DAC and CRTC
0	0	x	DCLK to DAC only

4.2 Using MCLK as VCLK (CL-GD5428/'29 only)

If the two synthesizers are programmed to frequencies that are very close, or are nearly harmonically related, there is a possibility that they will interfere with each other. This can result in jitter on the screen. The solution to this problem is to simply shut down the VCLK synthesizer and use the MCLK synthesizer for both frequencies. This is controlled with SR1F[6] and SR1E[6] as indicated in the following table. See SR1F.

Table B8-5. MCLK/VCLK Selection Through SR1F[6]/SR1E[6]

SR1F[6]	SR1E[6]	VCLK Source
0	x	VCLK (Normal Operation)
1	0	VCLK = MCLK
1	1	VCLK = MCLK ÷ 2

Appendix B9

Configuration Notes

CONFIGURATION NOTES

1. INTRODUCTION

This application note documents the Configuration register (CF[15:0]) of the CL-GD542X. An overview is provided that shows all the bits for each family member. Then the Configuration register is described individually for the CL-GD5420, the CL-GD5422, and CL-GD5424/'26/'28, the CL-GD5425, and the CL-GD5429.

CONFIGURATION REGISTER (CF15:0)

This 16-bit register configures the CL-GD542X into various modes of operation. Software *cannot* access this register. Data present on the Memory Data bus MD[31:16] is loaded into this register by power-on reset. Data on the MD bus can be presented via internal pull-up or external pull-down resistors. Typical values for an external pull-down resistor is 6.8 k Ω , and 250 k Ω for an internal pull-up resistor. A pull-down resistor causes the corresponding Configuration bit to be a '0' and a '1' for pull-up resistor. If no pull-down resistors are installed on the MD bus, this register is loaded with data FFFF at power-on RESET.

NOTE: A '0' corresponds to an external pull-down resistor (6.8 k Ω); a '1' corresponds to an internal pull-up resistor.

2. CONFIGURATION OVERVIEW

The following table may be used as an overview to the configuration register for all family members. It can be seen that considerable commonality exists.

Table B9-1. Configuration Overview

CF-	MD-	CL-GD5420	CL-GD5422	CL-GD5424/'26/'28	CL-GD5429	CL-GD5425
15	31	SR7[7]	Reserved	Reserved	MCLK output source	
14	30	SR7[6]	Reserved	Host bus configuration select [2]		
13	29	SR7[5]	Select asymmetric RAS*/CAS* addressing			DAC IREF adjust
12	28	SR7[4]	Select multiple CAS* DRAM interface			Reserved
11	27	Select Extended RAS* timing				
10	26	Default MCLK select (CF10 and CF9)				Reserved
9	25					Reserved
8	24	Select 64K ROM BIOS				
7	23	Select MicroChannel host interface		Host bus configuration select [1]		
6	22	Select 16-bit ROM BIOS width (enable MCS16* — ISA configuration only)				
5	21	Reserved		Host bus configuration select [0]		
4	20	Select MCLK pin to be input (Factory testing only)				

Table B9-1. Configuration Overview (*cont.*)

CF-	MD-	CL-GD5420	CL-GD5422	CL-GD5424/'26/'28	CL-GD5429	CL-GD5425
3	19	46E9 Sleep	Reserved	VGA Sleep address select		
2	18	Reserved				
1	17	Enable zero-wait-state BIOS			Reserved	NTSC offset
0	16	Reserved				XTAL

3. CONFIGURATION NOTES FOR CL-GD5420

Table B9-2. CF[15:0] for the CL-GD5420

Configuration Register															
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
MD 31	MD 30	MD 29	MD 28	MD 27	MD 26	MD 25	MD 24	MD 23	MD 22	MD 21	MD 20	MD 19	MD 18	MD 17	MD 16

CF15 : Latched input for optional configuration switch; readable at SR7[7].

CF14 : Latched input for optional configuration switch; readable at SR7[6].

CF13 : Latched input for optional configuration switch; readable at SR7[5].

CF12 : Latched input for optional configuration switch; readable at SR7[4].

CF11 : DRAM Timing Select

0 : Extended RAS* (RAS* HIGH = 3 MCLK, RAS* LOW = 4 MCLK)

1 : Standard RAS* (RAS* HIGH = 2.5 MCLK, RAS* LOW = 3.5 MCLK)

CF10 : MCLK Frequency Select bit 1 (MSB)

CF9 : MCLK Frequency Select bit 0 (LSB)

CF10	CF9	MCLK (MHz)
0	0	50.11363
0	1	44.74431
1	0	41.16477
1	1	37.58523

CF8 : ROM BIOS Size Select

0 : 64K at C0000 to CFFFF

1 : 32K at C0000 to C7FFF

CF7 : System (Host) Bus Interface Select

0 : MicroChannel interface

1 : ISA (PC/XT/AT) bus interface

CF6 : VGA BIOS ROM select

0 : 16-bit BIOS ROM

1 : 8-bit BIOS ROM

CF5 : Reserved

CF4 : MCLK Source Select

0 : External supply, MCLK pin is configured as an input

1 : Internally generated, MCLK pin is configured as an output

CF3 : VGA Enable Register Address (AT-bus interface only) Select

0 : VGA Enable register is mapped into 46E9

1 : VGA Enable register is mapped into 46E8

NOTE: This bit changes the I/O Port Address of the VGA Enable register normally mapped into Port 46E8 for use in motherboard implementations of the CL-GD5420. This bit allows disabling the CL-GD5420 through Port 46E9 instead. Therefore, any VGA video adapters enabled by Port 46E8 will not conflict with the CL-GD5420. The BIOS must be configured for this option. This bit has no effect in a MicroChannel bus configuration because the VGA Enable register is 3C3h.

CF2 : Reserved

CF1 : Enable BIOS ROM Zero-Wait-State

0 : Enable Output ZWS* to be driven active accessing the BIOS ROM

1 : Output ZWS* remains high-impedance when accessing the BIOS ROM

CF0: Reserved

4. CONFIGURATION NOTES FOR CL-GD5422

Table B9-3. CF15:0 for the CL-GD5422

Configuration Register															
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
MD 31	MD 30	MD 29	MD 28	MD 27	MD 26	MD 25	MD 24	MD 23	MD 22	MD 21	MD 20	MD 19	MD 18	MD 17	MD 16

CF15: Reserved

CF14: Reserved

CF13: Asymmetric RAS*/CAS* Addressing Select

0: CAS* address uses MA[7:0], RAS* address uses MA[9:0]

1: RAS* and CAS* addresses are output on MA[8:0]

CF12: Multiple-CAS* or Multiple-WE* DRAM Interface Select

0: Multiple-CAS* — CAS[3:0]* used with one WE*

1: Multiple-WE* — WE[3:0]* used with one CAS**

CF11: DRAM Timing Select

- 0: Extended RAS* (RAS* HIGH = 3 MCLK, RAS* LOW = 4 MCLK)
 1: Standard RAS* (RAS* HIGH = 2.5 MCLK, RAS* LOW = 3.5 MCLK)

CF10: MCLK Frequency Select bit 1 (MSB)

CF9: MCLK Frequency Select bit 0 (LSB)

CF10	CF9	MCLK (MHz)
0	0	50.11363
0	1	44.74431
1	0	41.16477
1	1	37.58523

CF8: ROM BIOS Size Select

0: 64K at C0000 to CFFFF

1: 32K at C0000 to C7FFF

CF7: System (Host) Bus Interface Select

0: MicroChannel interface

1: ISA (PC/XT/AT) bus interface

CF6: VGA BIOS ROM Select

0: 16-bit BIOS ROM

MCS16* for BIOS ROM is decoded from C0000–C7FFF or C0000–CFFFF, depending on CF8 (Configuration bit 8).

1: 8-bit BIOS ROM (MCS16* will not be decoded)

CF5 : Reserved

CF4: MCLK Source Select

0: External supply, the MCLK pin is configured as an input

1: Internally generated, the MCLK pin is configured as an output

CF3: Reserved

CF2: Reserved

CF1: Enable BIOS ROM Zero-Wait-State

0: Enable output ZWS* to be driven active accessing the BIOS ROM

1: Output ZWS* remains high impedance when accessing the BIOS ROM

CF0: Reserved

5. CONFIGURATION NOTES FOR CL-GD5424/'26/'28

Table B9-4. CF15:0 for the CL-GD5424/'26/'28

Configuration Register															
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
MD 31	MD 30	MD 29	MD 28	MD 27	MD 26	MD 25	MD 24	MD 23	MD 22	MD 21	MD 20	MD 19	MD 18	MD 17	MD 16

CF14: Bus-Type Select [2]

CF13: Asymmetric RAS*/CAS* Addressing Select

0: CAS* address uses MA[7:0], RAS* address uses MA[9:0]

1: RAS* and CAS* addresses are output on MA[8:0]

CF12: Multiple-CAS* or Multiple-WE* DRAM Interface Select

0: Multiple-CAS* — CAS[3:0]* used with one WE*

1: Multiple-WE* — WE[3:0]* used with one CAS*

Table B9-5. Special case for the CL-GD5426/'28

CF13	CF12	Note
0	0	OE* pin becomes RAS1* for 2-Mbyte memory option

CF11: DRAM Timing Select

0: Extended RAS* (RAS* HIGH = 3 MCLK, RAS* LOW = 4 MCLK)

1: Standard RAS* (RAS* HIGH = 2.5 MCLK, RAS* LOW = 3.5 MCLK)

CF10: MCLK Frequency Select bit 1 (MSB)

CF9: MCLK Frequency Select bit 0 (LSB)

CF10	CF9	MCLK (MHz)
0	0	50.11363
0	1	44.74431
1	0	41.16477
1	1	37.58523

CF8: ROM BIOS Size Select

0: 64K at C0000 to CFFFF

1: 32K at C0000 to C7FFF

CF7: Bus-Type Select[1] (see CF5 for details)

CF6: VGA BIOS ROM select

0: 16-bit BIOS ROM

MCS16* for BIOS ROM is decoded from C0000–C7FFF or C0000–CFFFF, depending on CF8 (Configuration bit 8).

1: 8-bit BIOS ROM (MCS16* will not be decoded)

CF5: Bus-Type Select[0]

Table B9-6. Bus Select

Bus Interface	CF14	CF7	CF5
Reserved	0	0	0
'386DX local bus	0	0	1
'386SX local bus	0	1	0
'486SX/DX local bus	0	1	1
Reserved	1	0	0
VESA® VL-Bus™	1	1	0
MicroChannel® bus	1	0	1
ISA bus	1	1	1

NOTE: When configured for the VESA VL-Bus, the CPU RESET signal becomes the RDYRTN# signal.

CF4: MCLK Source Select

0: External supply, MCLK pin is configured as an input

1: Internally generated, MCLK pin is configured as an output

CF3 (MD19)

MicroChannel: If a pull-down is installed on MD19, the CL-GD5426/'28 will be configured for 46E8 sleep. Bit 3 of 46E8 is the VGA Enable bit. If no pull-down is installed on MD19, the CL-GD5426/'28 will be configured for 3C3 sleep. Bit 0 of 3C3 is the VGA Enable bit.

All other Buses: If a pull-down is installed on MD19, the CL-GD5426/'28 will be configured for 3C3 sleep. Bit 0 of 3C3 is the VGA Enable bit. If no pull-down is installed on MD19, the CL-GD5426/'28 will be configured for 46E8 sleep. Bit 3 of 46E8 is the VGA Enable bit; bit 4 of 46E8 enables access to POS102.

POS102 Access

MicroChannel: If the CL-GD5426/'28 is configured for the MicroChannel bus, CD-SETUP controls access to POS102.

All other Buses: If the CL-GD5426/'28 is configured for 46E8 sleep, 46E8[4] controls access to POS102. If the CL-GD5426/'28 is configured for 3C3 sleep, 94[5] controls access to POS102.

CF2 Reserved

CF1: Enable BIOS ROM Zero-Wait Select

0: Enable output ZERO* to be driven active accessing the BIOS ROM

1: Output ZERO* remains high impedance when accessing the BIOS ROM

CF0: Reserved

6. CONFIGURATION NOTES FOR CL-GD5425

Table B9-7. CF[15:0] for the CL-GD5425

Configuration Register															
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
MD 31	MD 30	MD 29	MD 28	MD 27	MD 26	MD 25	MD 24	MD 23	MD 22	MD 21	MD 20	MD 19	MD 18	MD 17	MD 16

CF15: MCLK Select Pin Output Source (see also CF4)
 0: The MCLK pin will source the internal VCLK VCO signal.
 1: The MCLK pin will source the internal MCLK VCO signal.

CF14: Bus-Type Select[2]. See CF5.

CF13: DAC Current Reference Adjust

0: Enable IREF Adjust: See B22.
 1: Disable IREF Adjust

CF12: Reserved

CF11: DRAM Timing Select
 0: Extended RAS* (RAS* HIGH = 3 MCLK, RAS* LOW = 4 MCLK)
 1: Standard RAS* (RAS* HIGH = 2.5 MCLK, RAS* LOW = 3.5 MCLK)

CF10: Reserved

CF9: Reserved

CF8: ROM BIOS Size Select
 0: 64K at C0000 to CFFFF
 1: 32K at C0000 to C7FFF

CF7: Bus-Type Select[1] (see CF5)

CF6: VGA BIOS ROM Select
 0: 16-bit BIOS ROM

MCS16* for BIOS ROM is decoded from C0000–C7FFF or C0000–CFFFF, depending on CF8 (Configuration bit 8).

1: 8-bit BIOS ROM (MCS16* will not be decoded)

CF5: Bus-Type Select

Table B9-8. Bus Select

Bus Interface	CF14	CF7	CF5
Reserved	0	0	0
'386DX local bus	0	0	1
'386SX local bus	0	1	0
Reserved	0	1	1
Reserved	1	0	0
VESA® VL-Bus™	1	1	0
MicroChannel® bus	1	0	1
ISA bus	1	1	1

CF4 (MD20):MCLK Source Select

- 0: External supply, MCLK pin is configured as an input. Factory Testing only.
- 1: Internally generated, MCLK pin is configured as an output.

CF3 (MD19)

- 0: If a pull-down is installed on MD19, the CL-GD5429 will be configured for 3C3 sleep. Bit 0 of 3C3 is the VGA Enable bit.
- 1: If no pull-down is installed on MD19, the CL-GD5429 will be configured for 46E8 sleep. Bit 3 of 46E8 is the VGA Enable bit; bit 4 of 46E8 enables access to POS102.

POS102 Access

If the CL-GD5425 is configured for 46E8 sleep, 46E8[4] controls access to POS102. If the CL-GD5425 is configured for 3C3 sleep, 94[5] controls access to POS102.

CF2 (MD18): Reserved**CF1 (MD17): Disable NTSC Black-level Offset**

- 0: If a pull-down is installed on MD17, there will be no black-level offset for NTSC video. The black level will be equal to the Blank level.
- 1: If no pull-down is installed on MD17, 7.5 IRE units will be added to each DAC output during active video whenever NTSC-TV mode is selected. This is required for some encoders.

CF0 (MD16): XTAL Pin 2nd Reference Input

- 0: If a pull-down is installed on MD16, XTAL (pin 158) is configured as a second synthesizer reference input. XTAL will typically be configured for 14.31818 MHz and OSC will typically be configured for 17.734476 MHz. The synthesizer reference will be XTAL unless CR30[3:2] is programmed to 10b.
- 1: If no pull-down is installed on MD16, XTAL is configured as the driver output of a crystal-controlled oscillator. Typically, a 14.31818 MHz crystal is connected between XTAL and OSC for NTSC operation or a 17.73367 MHz crystal is connected between XTAL and OSC for PAL operation.

7. CONFIGURATION NOTES FOR CL-GD5429

Table B9-9. CF[15:0] for the CL-GD5429

Configuration Register															
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
MD 31	MD 30	MD 29	MD 28	MD 27	MD 26	MD 25	MD 24	MD 23	MD 22	MD 21	MD 20	MD 19	MD 18	MD 17	MD 16

CF15: MCLK Select Pin Output Source (see also CF4)

0: The MCLK pin will source the internal VCLK VCO signal.

1: The MCLK pin will source the internal MCLK VCO signal.

CF14: Bus-Type Select[2]. See CF5.

CF13: Asymmetric RAS*/CAS* Addressing Select

0: CAS* address uses MA[7:0], RAS* address uses MA[9:0]

1: RAS* and CAS* addresses are output on MA[8:0]

CF12: Multiple-CAS* or Multiple-WE* DRAM Interface Select

0: Multiple-CAS* — CAS[3:0]* used with one WE*

1: Multiple-WE* — WE[3:0]* used with one CAS*

Table B9-10. Special case for the CL-GD5429

CF13	CF12	Note
0	0	OE* pin becomes RAS1* for 2-Mbyte memory option

CF11: DRAM Timing Select

0: Extended RAS* (RAS* HIGH = 3 MCLK, RAS* LOW = 4 MCLK)

1: Standard RAS* (RAS* HIGH = 2.5 MCLK, RAS* LOW = 3.5 MCLK)

CF10: MCLK Frequency Select bit 1 (MSB)

CF9: MCLK Frequency Select bit 0 (LSB)

CF10	CF9	MCLK (MHz)
0	0	50.11363
0	1	44.74431
1	0	41.16477
1	1	37.58523

CF8: ROM BIOS Size Select

0: 64K at C0000 to CFFFF

1: 32K at C0000 to C7FFF

CF7: Bus-Type Select[1] (see CF5)

CF6: VGA BIOS ROM Select
0: 16-bit BIOS ROM

MCS16* for BIOS ROM is decoded from C0000–C7FFF or C0000–CFFFF, depending on CF8 (Configuration bit 8).

1: 8-bit BIOS ROM (MCS16* will not be decoded)

CF5: Bus-Type Select

Table B9-11. Bus Select

Bus Interface	CF14	CF7	CF5
Reserved	0	0	0
'386DX local bus	0	0	1
'386SX local bus	0	1	0
Reserved	0	1	1
VESA® VL-Bus™ (> 33 MHz)	1	0	0
VESA® VL-Bus™ (≤ 33 MHz)	1	1	0
MicroChannel® bus	1	0	1
ISA bus	1	1	1

CF4: MCLK Source Select

0: External supply, MCLK pin is configured as an input. Factory Testing only

1: Internally generated, MCLK pin is configured as an output

CF3 (MD19)

0: If a pull-down is installed on MD19, the CL-GD5429 will be configured for 3C3 sleep. Bit 0 of 3C3 is the VGA Enable bit.

1: If no pull-down is installed on MD19, the CL-GD5429 will be configured for 46E8 sleep. Bit 3 of 46E8 is the VGA Enable bit; bit 4 of 46E8 enables access to POS102.

POS102 Access

If the CL-GD5428 is configured for 46E8 sleep, 46E8[4] controls access to POS102. If the CL-GD5428 is configured for 3C3 sleep, 94[5] controls access to POS102.

CF2 Reserved

CF1: Reserved

CF0: Reserved

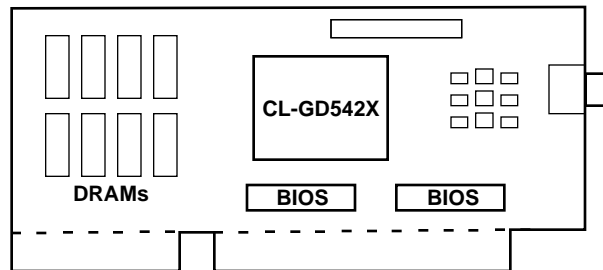
Appendix B10

PC Board Layout Considerations Application Note

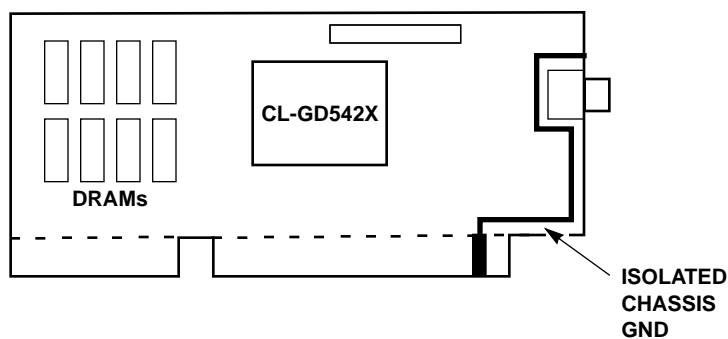
PC BOARD LAYOUT CONSIDERATIONS

1. LAYOUT CONSIDERATIONS

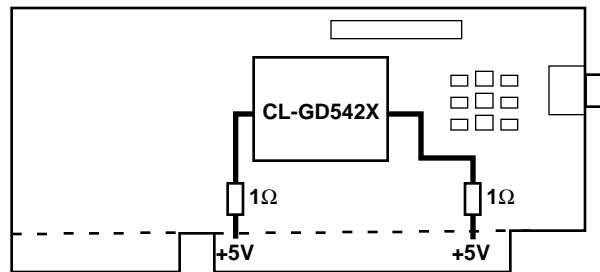
For dependable performance, it is very important to have a proper board layout. General placement of the components on an ISA board should match the following figure.



The layout should be optimized for the lowest noise on the VDD and VSS and provide good decoupling. A well-designed power distribution network is critical to reduce digital switching noise. For the two-layer design, **solid wide** traces are recommended on the power and ground lines. The width of the power traces should be at least 0.050 inches. The chassis ground plane should be isolated from the digital ground as indicated in the diagram below. Only the video connector mounting holes should be connected to the chassis ground plane. On the multi-layer boards, VSS (GND) pins should be directly connected to the ground plane.



The CL-GD542X family has built-in latch-up protection circuitry, but to add **additional** latch-up protection, power to the CL-GD542X should be provided through two 1Ω 1/4-watt resistors. These resistors should be placed in parallel to +5V, with the power pins AVDDx and VDDx of CL-GD542X along with the decoupling capacitors shown in the following figure.



All the appropriate interface traces should be as short as possible, especially OSC (pin 159) and RESET (pin 41). All decoupling capacitors should be located close to the device with short leads to reduce lead inductance (refer to Appendix B1).

2. CLOCK SYNTHESIZER

The Clock Synthesizer is a built-in feature of the CL-GD542X product line. All needed frequencies are derived from a reference clock, typically 14.318 MHz. AVDD1 and AVDD4 to the Clock Synthesizer requires a low-noise power supply. The filter components for the MFILTER and VFILTER should be placed close to the pins to reduce power-supply noise, which can cause clock jitter. Refer to the Appendix B1 for the detailed values of the filter components.

3. HOST BUS INTERFACE

A digital ground plane (thick trace) should be used to isolate RESET and I/OCHRDY from high-speed system data lines to minimize cross-talk. Also, provide a RC-filter to the RESET Signal to reduce noise. A short trace length for the Address/Data bus will minimize noise and cross-talk.

4. VIDEO OUTPUT

The RGB, HSYNC, and VSYNC Output pins should be located close to the Video Connectors to minimize noise pickup. Place a PI-shape filter, consisting of two 47-pF capacitors and a ferrite bead, between the RGB line and the Video Connector (15-pin D-SUB). Refer to the schematics in Appendix B1 for additional details.

5. LAYOUTS AVAILABLE

Complete manufacturing kits, consisting of schematics, BOMs, and Gerber files are available to OEMs on the Cirrus Logic, Inc. Bulletin Board System (refer to Appendix D9 for more information on the BBS). These are for both ISA and VESA VL boards. Contact your sales office for further information.

Appendix B11

Signature Generator Application Note

SIGNATURE GENERATOR

1. INTRODUCTION

To automatically test the CL-GD542X video-output logic at full speed, Signature Generator (SG) logic has been added to the IC. With the addition of this feature, it is possible to capture a unique 16-bit signature for any given mode setup and video memory data. An error in the Video Memory interface, control logic, or pixel data manipulation will produce a different signature which can be compared to a known good signature value obtained from the same image. This allows the test technician to quickly and accurately test a video screen without having to visually inspect the screen for errors. This method is used extensively in the Manufacturing Test.

To run the SG, bits must be written in extended Sequencer register SR18 to initialize and arm the SG. A Status bit will reflect that the SG is running; when the Status bit changes state to 'not running', the signature may be read from extended Sequencer registers SR19 and SR1A.

Note that the signature is a function of the displayed pixels, not the display data. If the display screen includes blinking attributes or a blinking cursor, then the signature will be different for those frames when the pixel is blinked off as compared to those when the pixel is blinked on.

The SG register definitions are as follows:

SR18: Signature Generator Control

D[7:5]	Reserved
D[4:2]	Pixel Data Select. These three bits select one of the eight Pixel Data Bits to use as SG Input. 111 = P[7], 110 = [6]... 000 = P[0]
D[1]	Reset Signature Generator 1 = Reset the Signature Generator 0 = Allow the Signature Generator to operate
D[0]	Signature Generator Enable/Status 1 = Start Generating Signature on next VSYNC (write) 0 = Signature Generator finished running; signature data ready (read)

NOTE: This bit must be set to start the SG and is automatically cleared when the SG is done.

SR19: Signature Generator Result — low byte

D[7:0] Low byte of the 16-bit result from one video frame of signature data

SR1A: Signature Generator Result — high byte

D[7:0] High byte of the 16-bit result from one video frame of signature data

The following code example in 'C' describes the method a programmer would take to capture eight signatures for any given screen. It is assumed that the screen is already being displayed, and no blinking attributes (in Text mode) are being displayed:

```
signature_capture () /*Capture eight signatures for any given mode*/
{
    unsigned int result,i,SR19,SR1A;
    unsigned int SIG [8];
    union REGS in;

    in.x.ax = 0x0100; /* shut of the cursor, if in text mode */
    in.x.cx = 0x2000;
    int86x (0x10,&in,&out,&seg);
    outp (0x3c4,6); /* unlock extended registers */
    outp (0x3c5,0x12); /* (not required for CL-GD5429) */
    for (i = 0;i <= 7; i++) { /* cycle through all pixel data bits */
        outp (0x3c4,0x18); /* arm the SG and set for pixel data bit */
        outp (0x3c5, (2 | (i<<2))); /* reset */
        outp (0x3c5, (i << 2)); /*select the data bit*/
        outp (0x3c4,0x18);
        outp (0x3c5, (1 | (i << 2))); /*and start the SG */
        result = inp (0x3c5); /* pre-read SG status */
        while ((result & 0x01) != 0) { /*wait until signature is done */
            outp (0x3c4,0x18);
            result = inp (0x3c5); /* read the status*/
        }
        outp (0x3c4,0x19); /* get low signature byte */
        SR19 = inp (0x3c5);
        outp (0x3c4,0x1A); /* get high signature byte */
        SR1A = inp (0x3c5);
        SIG [i] = (SR1A << 8) + SR19;
    }
}
```

Appendix B12

PCB Layout Considerations For Motherboards

Application Note

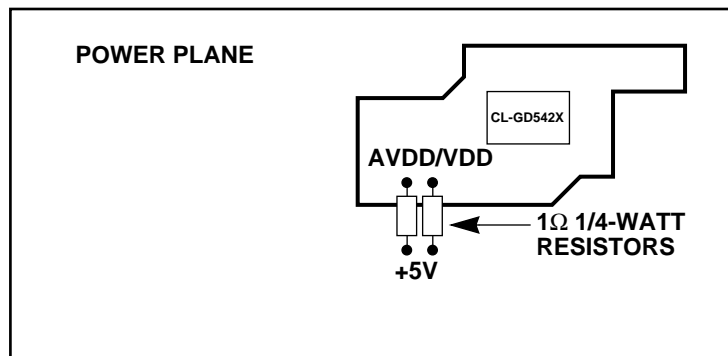
PCB LAYOUT CONSIDERATIONS FOR MOTHERBOARDS

1. LAYOUT CONSIDERATIONS (FOR FOUR LAYERS)

For dependable performance, it is important to have a proper layout. Refer to Appendix B10 for detailed description for two-layer PCB layout considerations and component placement. Follow the same guidelines as described in Appendix B10 except for the Power and Ground Planes.

2. POWER PLANE

The CL-GD542X family has built-in latch-up protection circuitry, but to add **additional** latch-up protection, power to the CL-GD542X should be provided through two 1Ω , 1/4-watt resistors. These resistors should be placed in parallel with each other, but in series with VCC (+5V) to VDDx and AVDD2-3. Power to AVDD1 and AVDD4 is provided through RC networks. Refer to Appendix B1 for ISA adapter board schematics. A block diagram for the Power Plane is shown below:

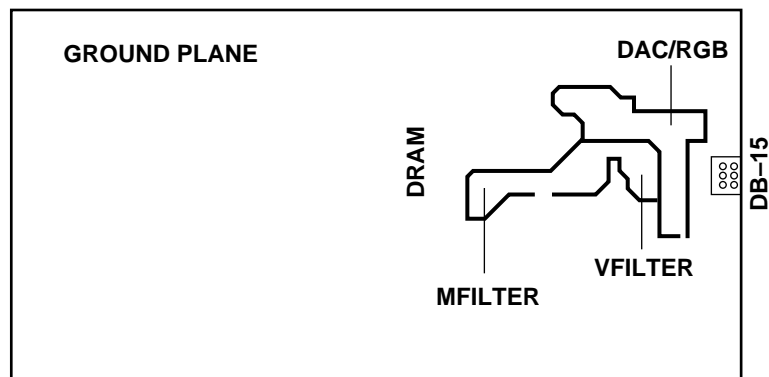


NOTE: The solid line cuts the main Power Plane and creates a separate power segment for the CL-GD542X. The main Power Plane can be used to supply the power for the DRAMs, Buffers, and EPROMs (if any).

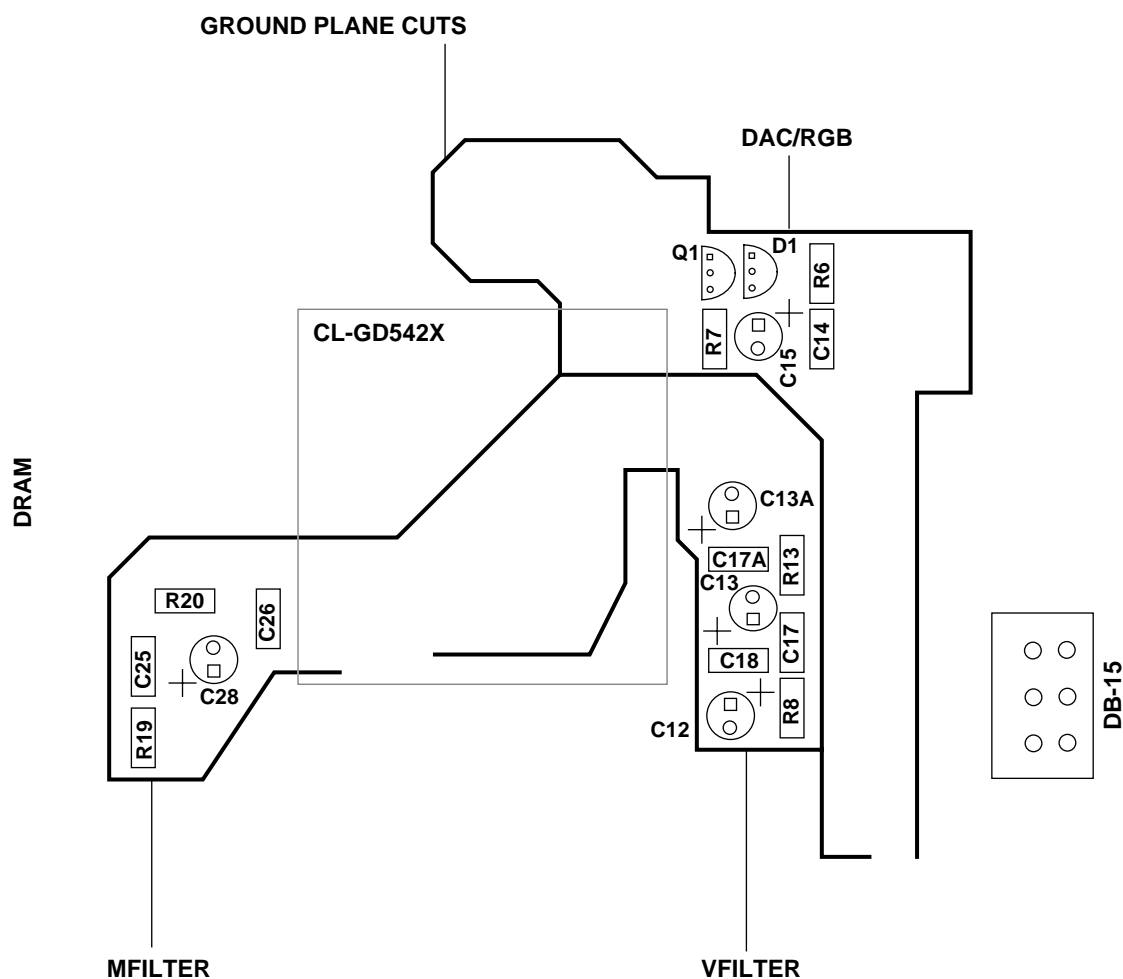
3. GROUND PLANE

Since the CL-GD542X has a built-in True Color Multi-mode palette DAC and Clock Synthesizer, it is important that these analog components have noise-free power and ground. Special attention must be paid to the VFILTER, MFILTER, and IREF pins, and the associated passive components for those pins. The VFILTER pin is used to generate the Video Clock for all graphics and text modes. The MFILTER pin is used for the memory (DRAM) timing. The IREF pin provides the constant current to the True Color palette DAC, which provides the analog output on the RGB lines. The chassis and the RGB signal should also be isolated from the main ground.

Use the following diagram as a reference for ground plane layout.



The figure below shows the detailed placement of the passive components for the MFILTER, VFILTER, and IREF circuitry (refer to Appendix B1 for ISA adapter board schematics and for the reference names of the components).



Appendix B13

Pin Scan Testing Application Note

PIN SCAN TESTING

1. INTRODUCTION

Pin scan testing is a technique for verifying if an IC has been properly soldered to a circuit board. Any IC signal pin that is not connected to the board, or that is shorted to any neighboring pin or trace, can be detected using automated testing. The advantage of pin scan testing is that the test patterns to verify full-board connectivity are much simpler than would otherwise be possible. The pins are connected sequentially around the IC in a single chain, so that the value on each output pin depends only on the values applied to other pins, rather than the internal state of the VGA processor. In addition, the pin scan logic is strictly combinatorial, so no clock pulses are required.

The first pin in the chain is an input pin; the last pin is an output pin. Each input signal is exclusive-OR'ed (XOR'ed) with the scan data from its lower-numbered neighboring input or output pin. The result of this XOR is passed to its higher-numbered neighbor. Each output pin will be driven with the value passed from its lower-numbered neighbor; that value is inverted and passed to its higher-numbered neighbor.

In Pin Scan mode, the test program begins by driving all the input pins to '0', and verifying that the output pins match the values shown in the table that follows. On subsequent cycles, the program drives each input pin, one at a time, to '1' and verifies that all the 'down-stream' outputs match the values shown. In each case, the output is inverted from the value for the all-zeroes case.

If the value applied to an input is changed and the 'down-stream' output pins do not change, then that input is shorted or not soldered. If any single output is wrong, then it is either shorted or not soldered.

Entering Pin Scan Mode

The CL-GD542X is placed into Pin Scan mode by making RESET HIGH for at least 20 ns while TWR* is low.

Exiting Pin Scan Mode

The CL-GD542X is removed from Pin Scan mode by making RESET HIGH with TWR* high.

Pin Scan Order

In the following table, the pin names are for ISA bus. Both versions of the CL-GD5420 are slightly different from the newer members of the family. These differences are covered in the notes.

Table B13-1. Pin Scan Order

Pin Name	Pin Number	Direction	All Inputs = 0	1 Input = 1	CL-GD5420 -65QC (P-well) Note	CL-GD5420 -75QC (N-well) Note
SD[15]	3	In				
SD[14]	4	In				
SD[13]	5	In				
SD[12]	6	In				
SD[11]	8	In				
SD[10]	9	In				
SD[9]	10	In				
SD[8]	11	In				
MEMW*	13	In				
MEMR*	14	In				
LA[17]	15	In				
LA[18]	16	In				
LA[19]	17	In				
LA[20]	18	In				
LA[21]	19	In				
LA[22]	20	In				
LA[23]	21	In				
IOCS16*	22	Out	1	0		
MCS16*	23	Out	0	1		
SBHE*	24	In				
BALE	25	In				
SA[0]	27	In				
SA[1]	28	In				
SA[2]	29	In				
SA[3]	30	In				
SA[4]	31	In				
SA[5]	32	In				
SA[6]	33	In				

Table B13-1. Pin Scan Order *(cont.)*

Pin Name	Pin Number	Direction	All Inputs = 0	1 Input = 1	CL-GD5420 -65QC (P-well) Note	CL-GD5420 -75QC (N-well) Note
SA[7]	34	In				
SA[8]	35	In				
SA[9]	36	In				
SA[10]	37	In				
SA[11]	38	In				
SA[12]	39	In				
RESET	41	In				
SA[13]	42	In				
SA[14]	43	In				
SA[15]	44	In				
SA[16]	45	In				
AEN	46	In				
IOCHRDY	47	Out	0	1		
REFRESH*	48	In				
IOR*	49	In				
IOW*	50	In				
OWS*	51	Out	Hi-Z	0		
IRQ	52	Out	0	1		
SD[0]	54	In				
SD[1]	55	In				
SD[2]	56	In				
SD[3]	57	In				
SD[4]	59	In				
SD[5]	60	In				
SD[6]	62	In				
SD[7]	63	In				
TWR*	67	In				
VSYNC	68	Out	1	0		

Table B13-1. Pin Scan Order *(cont.)*

Pin Name	Pin Number	Direction	All Inputs = 0	1 Input = 1	CL-GD5420 -65QC (P-well) Note	CL-GD5420 -75QC (N-well) Note
HSYNC	69	Out	0	1		
OVW*	71	Out	1	0	n/c	n/c
EEDI	73	In				
EECS	74	Out	0	1	1 for all inputs = 0, 0 for 1 input = 1	
P[0]	79	In				
P[1]	82	In				
P[2]	83	In				
P[3]	84	In				
P[4]	86	In				
P[5]	87	In				
P[6]	88	In				
P[7]	89	In				
DCLK	92	In				
BLANK*	93	In				
EVIDEO*	94	In				
ESYNC*	95	In				
EDCLK*	96	In				
MD[31]	97	In				
MD[30]	98	In				
MD[29]	99	In				
MD[28]	100	In				
MD[27]	102	In				
MD[26]	103	In				
MD[25]	104	In				
MD[24]	105	In				
WE3*	106	In	0	1	Output: See Note 1	
MD[23]	108	In				
MD[22]	109	In				

Table B13-1. Pin Scan Order *(cont.)*

Pin Name	Pin Number	Direction	All Inputs = 0	1 Input = 1	CL-GD5420 -65QC (P-well) Note	CL-GD5420 -75QC (N-well) Note
MD[21]	110	In				
MD[20]	111	In				
MD[19]	112	In				
MD[18]	113	In				
MD[17]	114	In				
MD[16]	115	In				
WE2*	116	In	1	0	Output: See Note 2	
MD[15]	117	In				n/c
MD[14]	118	In				n/c
MD[13]	119	In				n/c
MD[12]	122	In				n/c
MD[11]	123	In				n/c
MD[10]	124	In				n/c
MD[9]	125	In				n/c
MD[8]	126	In				n/c
WE1*	127	In	0	1	Output: Note 3	n/c
MD[7]	129	In				n/c
MD[6]	130	In				n/c
MD[5]	131	In				n/c
MD[4]	132	In				n/c
MD[3]	133	In				n/c
MD[2]	134	In				n/c
MD[1]	135	In				n/c
MD[0]	136	In				n/c
WE0*	138	In	1	0	Output: Note 4	n/c
CAS*	139	In				
OE*	141	Out	0	1	Note 5	
RAS	142	Out	1	0	Note 5	

Table B13-1. Pin Scan Order *(cont.)*

Pin Name	Pin Number	Direction	All Inputs = 0	1 Input = 1	CL-GD5420 -65QC (P-well) Note	CL-GD5420 -75QC (N-well) Note
MA[9]	143	Out	0	1	Note 5	
MA[8]	145	Out	1	0	Note 5	
MA[7]	146	Out	0	1	Note 5	
MA[6]	147	Out	1	0	Note 5	
MA[5]	148	Out	0	1	Note 5	
MA[4]	149	Out	1	0	Note 5	
MA[3]	150	Out	0	1	Note 5	
MA[2]	151	Out	1	0	Note 5	
MA[1]	152	Out	0	1	Note 5	
MA[0]	153	Out	1	0	Note 5	
MCLK	157	In				
EROM*	2	Out	0	1	Note 5	

NOTES:

1. Pin 106 is an input on all chips except both versions of the CL-GD5420. On the '20, it is an output with the sense indicated in the table.
2. Pin 116 is an input on all chips except both versions of the CL-GD5420. On the '20, it is an output with the sense indicated in the table.
3. Pin 127 is an input on all chips except both versions of the CL-GD5420. On the '20-65QC, it is a no-connect. On the '20-75QC, it is an output with the sense indicated in the table.
4. Pin 138 is an input on all chips except both versions of the CL-GD5420. On the '20-65QC, it is a no-connect. On the '20-75QC, it is an output with the sense indicated in the table.
5. The CL-GD5420-65QC, all outputs from pin 141 through pin 2 have opposite sense as the rest of the family. That is, the sense for the '20-65QC is *opposite* as indicated in the table.

Appendix B14

Video Overlay and DAC Mode Switching Application Note

VIDEO OVERLAY AND DAC MODE SWITCHING

1. INTRODUCTION

This appendix describes the Video Overlay and DAC Mode Switching functions available on the CL-GD542X family. The following table indicates the capabilities of each family member.

Table B14-1. Video Overlay Functions

Capability	'GD5420	'GD5422	'GD5424	'GD5426/'28	'GD5425 'GD5429
VESA pass-through	Yes	Yes	Yes	Yes	Yes
Switch with EVIDEO*	No	Yes	Yes	Yes	Yes
On-chip Window timing generator	No	Yes	Yes	Yes	Yes
Switch with Color Key	No	Yes	Yes	Yes	Yes
Switch with OVRW and Color Key	No	No	Yes	Yes	No
Switch with EVIDEO* and Color Key	No	No	No	No	Yes
VAFC Output Baseline	Yes	Yes	Yes	Yes	Yes
VAFC Input Baseline	No	No	No	No	Yes

2. OVERVIEW

Video Overlay refers to dynamically changing the video source between data from the VGA display memory and data from an external source. The overlay can take place on a pixel basis. Refer to Figure B14-1.

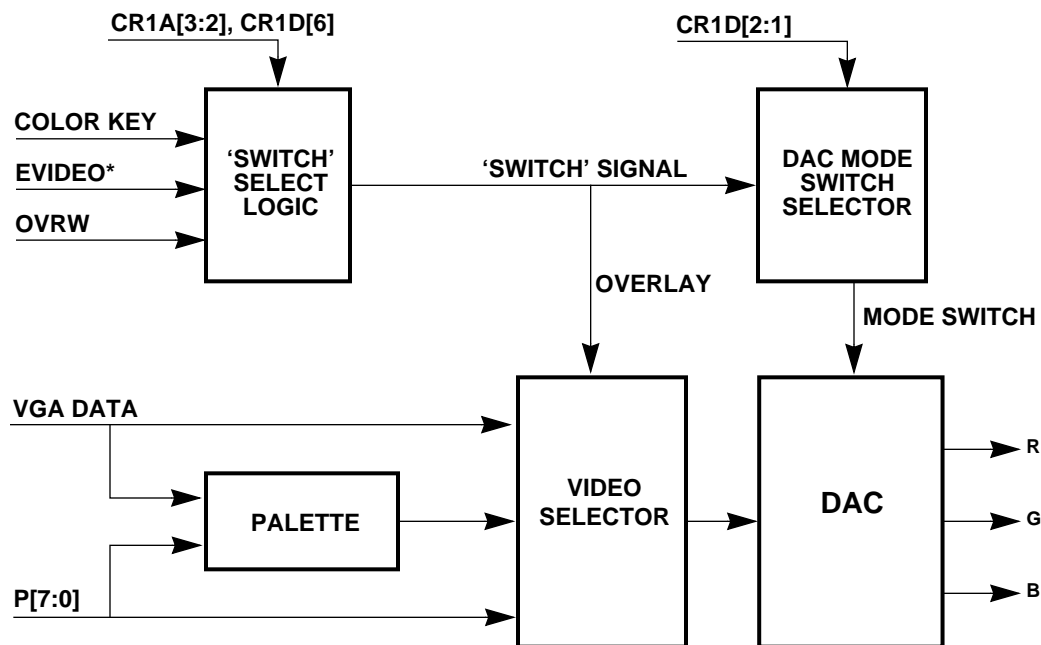


Figure B14-1. Mode Switching

The pixels that are to be overlayed can be chosen with the EVIDEO* pin or the internally generated OVRW signal (for the CL-GD5429 only). This selection method is called *timing*. The pixels to be overlaid can be chosen with the Color Key Compare logic. This selection method is called *key*. The selection method is determined by CR1A[3:2] and CR1D[6].

The following table enumerates the six cases that are covered in detail later in this appendix.

Table B14-2. SWITCH Chosen With

CR1A[3]	CR1A[2]	CR1D[6]	Source of Switch	EVIDEO*
0	0	x	VGA-compatible Operation: Switch disabled	Input
0	1	0	EVIDEO* pin	Input
0	1	1	OVRW signal CL-GD5429 only	Input
1	0	0	EVIDEO* pin AND'ed with Color Key Compare CL-GD5429 only	Input
1	0	1	OVRW signal AND'ed with Color Key Compare Except CL-GD5429	Output
1	1	x	Color Key Compare	Output

DAC Mode Switching refers to dynamically changing the DAC mode between standard VGA 8-bit-per-pixel through the palette, and another mode (such as 8- or 16-bit RGB). DAC Mode Switching can take place on a pixel basis.

For the CL-GD5424/26/28, in all cases where DAC Mode Switching is used, one mode is the standard VGA 8-bit mode through the DAC mode. The second mode is programmed into the Hidden DAC register. For the CL-GD5429 only, DAC mode switching can be disabled by programming CR1D[2:1] to '1,x'.

The CL-GD542X can be programmed so that DAC Mode Switching occurs when 'Switch' is active, or when 'Switch' is not active, or not at all, as shown Table B14-3.

Table B14-3. Relationship Between Switch and DAC Mode Switching

CR1D[2:1]	DAC Mode Switching
00	Choose Extended DAC mode on Switch true
01	Choose Extended DAC mode on Switch false
1x	Mode switching disabled

The various cases of extended DAC mode programming and DAC Mode Switching selections are all more or less orthogonal, leading to many combinations. Table B14-4 lists various useful combinations. Observe that these combinations are independent of the actual source of the Switch Signal (that is, how the window is defined).

Table B14-4. Switch and DAC Mode Switching Combinations

BackGround	Window	CR1D[2:1]	HDR	Note
Internal LUT	External 8-bit RGB	00	0xC9	
Internal LUT	External grayscale	00	0xC8	
Internal LUT	External 15-bit RGB	00	0xC0	
Internal LUT	External 16-bit RGB	00	0xC1	VAFC Baseline
Internal LUT	External LUT	1x	0x00	
Internal 8-bit RGB	External LUT	01	0xC9	
Internal 8-bit RGB	External 8-bit RGB	1x	0xC9	
Internal 15-bit RGB	External 8-bit LUT	01	0xC0	
Internal 16-bit RGB	External 8-bit LUT	01	0xC1	

Table B14-5. Notes on Switch Combinations

Label	Data Source	Data Format
Internal LUT	Display memory	8 BPP through palette
External 8-bit RGB	Pixel bus	3-3-2 RGB
External grayscale	Pixel bus	8 BPP grayscale
External 15-bit RGB	Pixel bus	5-5-5 RGB
External 16-bit RGB	Pixel bus	6-6-6 RGB
External LUT	Pixel bus	8 BPP through palette
Internal 8-bit RGB	Display memory	3-3-2 RGB
Internal 15-bit RGB	Display memory	5-5-5 RGB
Internal 16-bit RGB	Display memory	5-6-5 RGB

3. SWITCH WITH EVIDEO*

Switch with EVIDEO* is selected when the CR1A[3,2] field is programmed to '0,1'. For the CL-GD5429 only, CR1D[6] must be programmed to '0'. The P-bus is switched to inputs. The external Video Generator must always drive the bus to guarantee valid CMOS logic levels, even when the inputs are being ignored.

There is no requirement for pixels to be overlayed to be contiguous (adjacent), either horizontally or vertically. The extended DAC mode programmed into the HDR is chosen either when EVIDEO* is active, or when EVIDEO* is not active, or not at all. This depends on the programming of CR1D[2:1]. The block diagram in Figure B14-2 indicates how a system might be configured to use this mode.

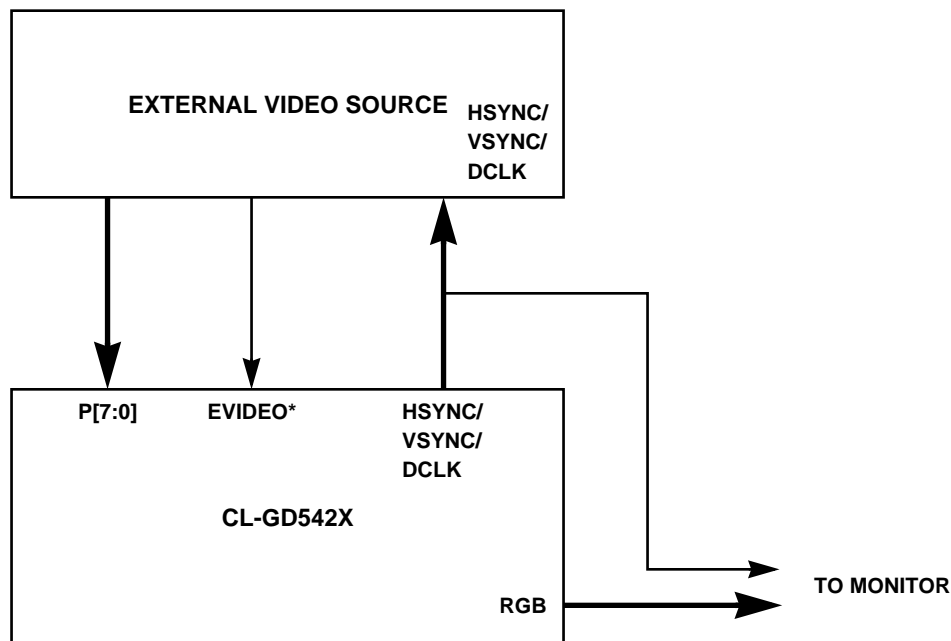


Figure B14-2. System Configuration with EVIDEO*

The external video source has the responsibility for determining which portion of the screen is going to be overlayed with its video. For every pixel that is to be overlayed, it must drive EVIDEO* active, and it must provide either 8- or 16-bit video at the P-bus.

The system designer must guarantee that the External Video Source and the CL-GD542X are in synchrony (otherwise the overlayed video appears at random places on the screen). This is why the sync and DCLK signals are made available from the CL-GD542X to the External Video Source.

EVIDEO* has a setup and hold time requirement with respect to DCLK to guarantee that the desired pixel is overlayed and that adjacent pixels is not overlayed. Observe that DCLK is an output and EVIDEO* is an input. This is not a typical definition of set up and hold times.

If 8-bit data is being clocked into the P-bus, there is a data setup and hold requirement to the positive-going edge of DCLK. If 16-bit data is being clocked into the P-bus, there is a data setup and hold requirement to both edges of DCLK (the DAC is in Clocking mode 1). The rising edge of DCLK clocks the least-significant byte of the pixel; the falling edge clocks the most-significant byte.

4. SWITCH WITH COLOR KEY

Switch with Color Key is enabled when the CR1A[3:2] field is programmed to '1,1'. In this mode, the choice of pixels to be overlayed is controlled strictly by the contents of display memory. If a VGA pixel byte compares with the contents of the Color Key register, Switch is enabled. EVIDEO* is a normally low output in this mode; it goes high one VCLK period before any pixel is replaced. If horizontally contiguous pixels are to be replaced, EVIDEO* remains high appropriately.

The matching of the pixel with the Color Key is done under a mask. GRC contains the Color Key; GRD contains the mask. The key is compared with the pixel from display memory only for those bits for which the mask is a '0'. If the values 0xFC through 0xFF are to be used for the key, register GRC can be loaded with any value in the range 0xFC though 0xFF, and GRD would be loaded with the value 0x03.

In cases where the CL-GD542X is programmed for other than 8-bits-per-pixel, the high-order byte of the pixel is compared; the other(s) are ignored. This is shown in Table B14-6.

Table B14-6. Color Key Bytes

Mode	Byte Compared
8 bits-per-pixel	Every byte
16 bits-per-pixel	High byte

There is no requirement that the pixels to be overlayed are contiguous (adjacent), either horizontally or vertically. The Extended DAC mode programmed into the HDR is chosen either when the color key matches, when the color key does not match, or not at all. This depends on the programming of CR1D[2:1]. The block diagram in Figure B14-3 indicates how a system might be configured to use this mode.

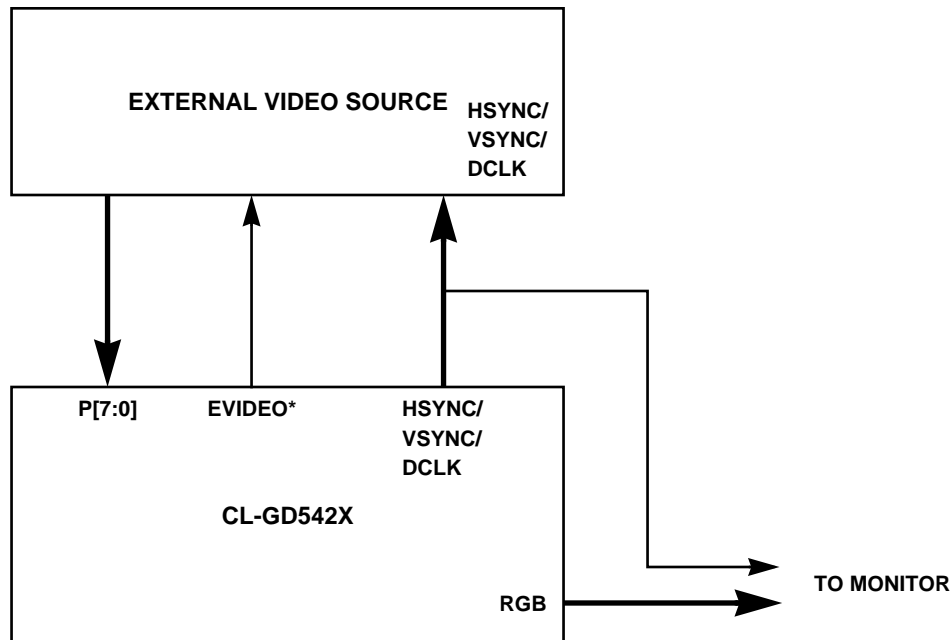


Figure B14-3. System Configuration with Color Key

The external video source can determine which pixels are to be overlayed by monitoring the EVIDEO* output of the CL-GD542X. For every pixel that is to be overlayed, it must provide either 8- or 16-bit video at the P-bus.

If 8-bit data is being clocked into the P-bus, there is a data setup and hold requirement to the positive-going edge of DCLK. If 16-bit data is being clocked into the P-bus, there is a data setup and hold requirement to both edges of DCLK (the DAC is in Clocking Mode 1). The rising edge of DCLK clocks the least-significant byte of the pixel; the falling edge clocks the most-significant byte.

5. SWITCH WITH COLOR KEY AND'ed with EVIDEO* (CL-GD5429)

Switch with Color Key AND'ed with EVIDEO* when the CR1A[3:2] field is programmed to '1,0'. CR1D[6] must be programmed to a '0'. The Switch signal is the logical 'AND' of the Color Key Comparison and EVIDEO* being low. EVIDEO* is an input in this mode. This mode is available only on the CL-GD5429.

The extended DAC mode programmed into the HDR is chosen either when the condition is true, or when the condition is not true, or not at all. This depends on the programming of CR1D[2:1]. This mode is intended to restrict the Color Key effect to a specified area.

This mode can also be used to mechanize a dynamic window with horizontal resolution finer than an eight-pixel character clock. The coarse horizontal timing would be generated with the on-chip Window Timing Generator as described above, and the fine (pixel resolution) would be controlled by changing either the contents of display memory or the Color Key Mask.

6. ON-CHIP WINDOW TIMING GENERATOR

The CL-GD542X contains logic to generate a single rectangular window. If this mode is enabled, the window timing comes out on OVRW, which may be fed back into EVIDEO*; the chip specifies its own window. For the CL-GD5429 only, the internal signal is directly available as the Switch signal. For the CL-GD5424/26/28, OVRW can be ANDed with Color Key to provide the switch signal.

This mode is chosen by programming CR1B[5] to a '1'. When this is done, the blanking term to the palette DAC comes from Display Enable, and there is no border. This frees the Blank Generator Logic, which is used as a window generator. The following timing diagram shows how the Blank Start and Blank End registers specify either the horizontal or vertical component of the window; the other is similar. The Horizontal Blank End field is extended to eight bits and the Vertical Blank End is extended to 10 bits.

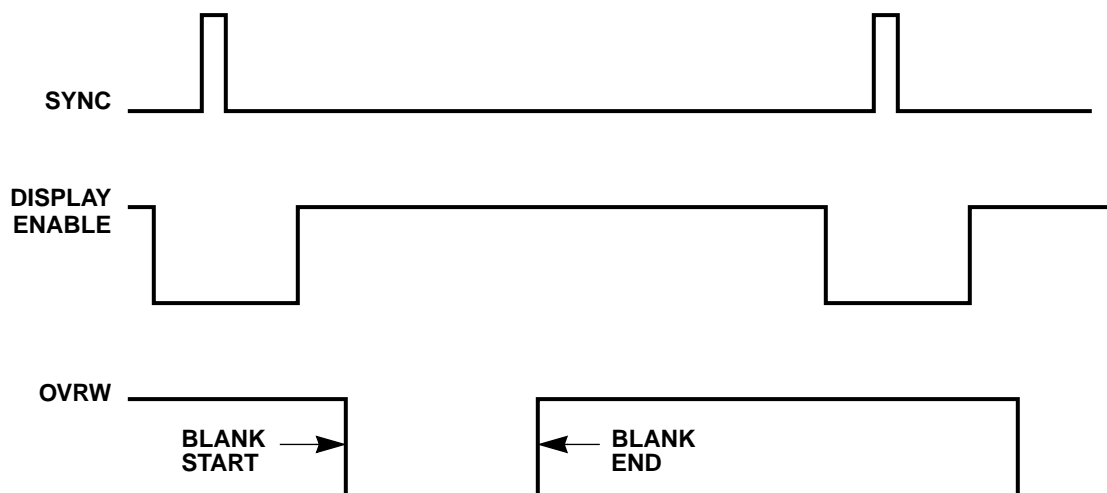


Figure B14-4. Blank End And Blank Start Timing

When the vertical timing and the horizontal timing generated coincide, OVRW is driven low, and this indicates the window. OVRW may be connected directly to EVIDEO* if Switch on Color Key only is never going to be chosen. If Switch on Color Key only is chosen, OVRW must be driven into EVIDEO* with an external three-state buffer to avoid a potential bus collision. This is avoided on the CL-GD5429 by making the term available internally.

This method of generating timing has four restrictions that require consideration. First, since the blank timing generation logic is used for window generation, there can be no border. This is inconsequential since the VESA timing specifications do not include a border. Second, since the Horizontal Counters operate on an eight-pixel character clock, the resolution of the horizontal component of the window is eight pixels. This can be overcome at least in part by using EVIDEO* AND'ed with Color Key, as previously discussed. Third, there can only be a single window and it must be rectangular. Finally, the first or third (or subsequent) scanline or group of eight pixels can be chosen as a window boundary, but not the second scanline or group of eight pixels.

When programming horizontal and vertical blanking, nine registers must be programmed to set the four blank parameters. Five of these registers contain bits related to other functions.

Table B14-7. Programming of Horizontal and Vertical Blanking

Register	Bits	Parameter	Other Bits
CR2	7:0	Horizontal Blank Start [7:0]	—
CR3	4:0	Horizontal Blank End [4:0]	7:5
CR5	7	Horizontal Blank End [5]	6:0
CR7	3	Vertical Blank Start [8]	7:4, 2:0
CR9	5	Vertical Blank Start [9]	7:6, 4:0
CR15	[7:0]	Vertical Blank Start [7:0]	—
CR16	[7:0]	Vertical Blank End [7:0]	—
CR1A	[7:6]	Vertical Blank End [9:8]	3:0
CR1A	[5:4]	Horizontal Blank End [7:6]	—

7. SWITCH WITH OVRW (CL-GD5429 only)

Switch with OVRW is selected when the CR1A[3,2] field is programmed to '0,1' and CR1D[6] must be programmed to '1'. This mode is available on the CL-GD5429 only. The P-bus is switched to inputs. The external Video Generator must always drive the bus to guarantee valid CMOS logic levels, even when the inputs are being ignored.

The Extended DAC mode programmed into the HDR is chosen either when OVRW is active, or when OVRW is not active, or not at all. This depends on the programming of CR1D[2:1]. The block diagram in Figure B14-5 indicates how a system might be configured to use this mode.

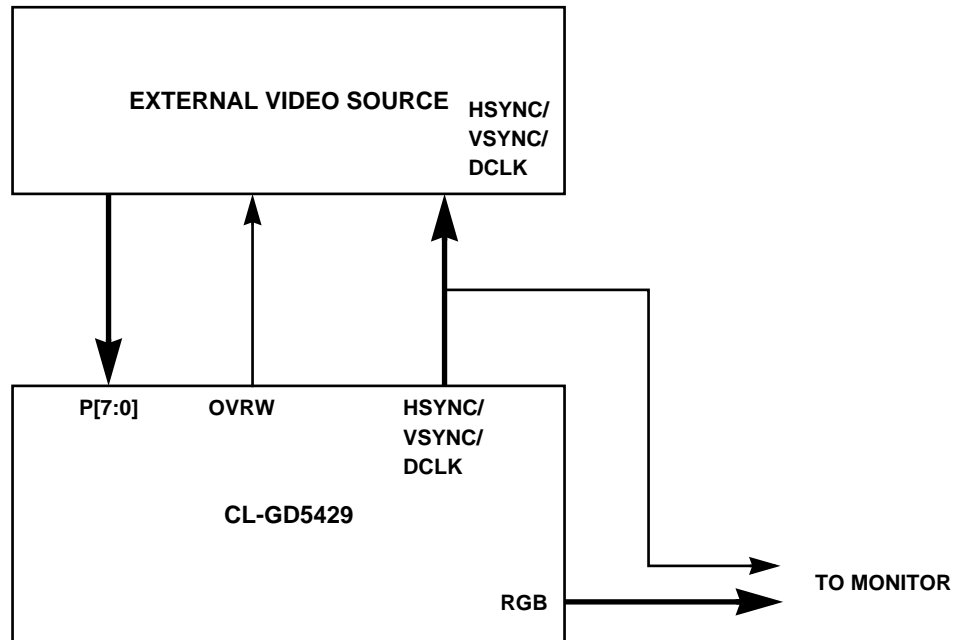


Figure B14-5. System Configuration with OVRW (CL-GD5429 only)

The external video source must monitor OVRW to determine which portion of the screen is going to be overlayed with its video. For every pixel that is to be overlayed, it must provide either 8- or 16-bit video at the P-bus.

If 8-bit data is being clocked into the P-bus, there is a data setup and hold requirement to the positive-going edge of DCLK. If 16-bit data is being clocked into the P-bus, there is a data setup and hold requirement to both edges of DCLK (the DAC is in Clocking mode 1). The rising edge of DCLK clocks the least-significant byte of the pixel; the falling edge clocks the most-significant byte.

8. VESA ADVANCED FEATURE CONNECTOR (VAFC)

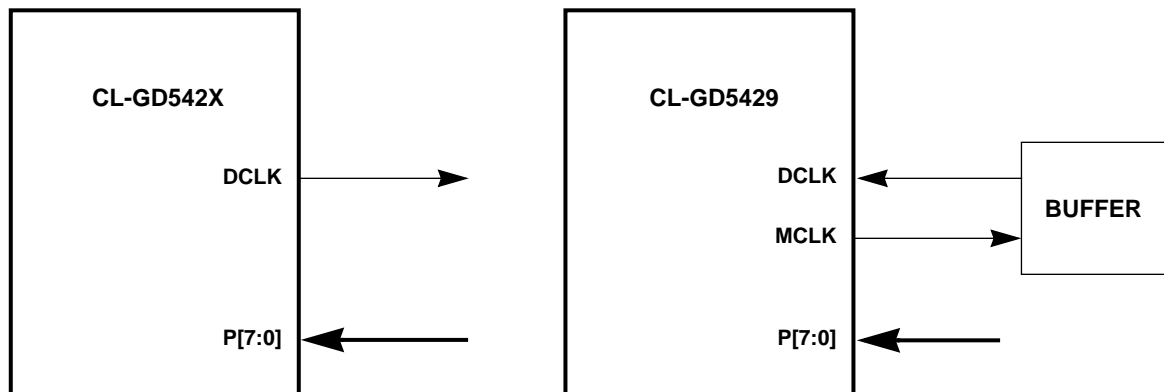
All members of the CL-GD542X family support VAFC baseline output; the CL-GD5429 also supports VAFC baseline input. At the time of this writing, hardware and software to implement baseline input is in development. For board support of these functions, ensure that the extra pins on the feature connector are wired via jumpers or zero- Ω resistors, as indicated in Table B14-8.

Table B14-8. Connections to VESA Feature Connector for VAFC Compatibility

Pin	Jumper to:	Note
Z7	VCC	Power for VESA VAFC bridge
Z12	MCLK	Will be VCLK VCO
Z13	OVW	Internally generated window timing

9. USING THE INTERNAL CLOCK WITH DCLK AS INPUT

The overlay modes described in this Appendix are intended to be used in a configuration where the video clock is provided by the external video source. If the clock were to be provided by the CL-GD542X, then the result is a situation of clocking data into a device where the device itself is providing the clock.

**Figure B14-6. DCLK as an Input**

This presents an almost impossible situation when it comes to characterizing the setup and hold times involved. Since the characterization equipment operates synchronously, it was never intended to deal with internally generated, asynchronous clocks. The result is, with respect to the internal DCLK, setup and hold times are not specified.

As a configuration option, the CL-GD5429 VCLK VCO can be sourced onto the MCLK pin. This is selected when a pull-down resistor is installed on MD31. Supplying an external buffer drives MCLK into DCLK making both DCLK and the Pixel-bus inputs, making it possible to specify setup and hold times.

10. STATIC OVERLAY

The CL-GD542X supports the standard VESA pass-through function, during which the EVIDEO* pin is statically driven low and video is driven into the P-bus. The entire frame is overlaid, and the contents of display memory are ignored. EDCLK* is typically driven low so that DCLK as well as the video are supplied externally.

Appendix B15

EEPROM Interface and Programming Application Note

EEPROM INTERFACE AND PROGRAMMING

1. INTRODUCTION

This application note covers the interface and programming details of the optional EEPROM (Electrically Erasable Programmable Read-Only Memory), and provides an overview of Extension register SR8. The timing restrictions imposed by the EEPROM device are covered along with examples of writing and reading the EEPROM.

The EEPROM is used by the Cirrus Logic BIOS to contain system configuration information, such as monitor type and refresh rate. The BIOS uses the first eight bytes of the EEPROM; it would be possible to use the rest for other applications.

The programming examples are for the XL93C46 1024-bit device.

The EEPROM option is available only if the CL-GD542X is configured for ISA bus.

2. EXTENSION REGISTER SR8

The EEPROM interface is controlled through the Extension register SR8 (refer to Chapter 9 for details on this register). The bits are summarized in Table B15-1.

Table B15-1. Extension Register SR8 Bit Summary

Bit	Function
7	EEPROM Input Data
6	Disable MCS16* for display memory (NOTE: This bit <i>must</i> be preserved.)
5	Latch ESYNC/EVIDEO* Input state
4	Enable ESYNC/EVIDEO* as outputs for EEPROM Data and Serial Data Clock (SK)
3	Serial Data Input (DI) to EEPROM if bit 4 = 1
2	SK to EEPROM if bit 4 = 1
1	Enable EEPROM Data In
0	Chip Select (CS) to EEPROM

3. TIMING CONSIDERATIONS

Serial EEPROMs are inherently slow devices. Software written to control EEPROMs must include timing delays so that signal transitions do not take place too quickly. A data sheet for the particular device should be consulted; the parameters listed in Table B15-2 are typical.

Table B15-2. Typical Timing Parameters

Parameter	MIN	MAX	Units
DI setup to SK positive transition	1	–	μSec
DI hold from SK positive transition	1	–	μSec
SK high-pulse Width	2	–	μSec
SK low-pulse Width	2	–	μSec
DO delay from SK positive transition	2	–	μSec

The times specified in Table B15-2 are minimums. Longer delays will not damage the device. The EEPROM write operation requires 10 μsec after the last bit has been transferred; no other operation is allowed until this time has elapsed.

The XL95C46 EEPROMs are organized as 64 sixteen-bit locations (each with a 6-bit address). Any data transfer, read, or write must transfer all 16 bits for correct operation.

3.1 Write Example

1. Set the CL-GD542X for EEPROM Control:
 - a. Unlock the Extended registers (SR6 = 12h).
 - b. Determine the state of SR8[6] and save it for all subsequent writes.
 - c. Latch ESYNC and EVIDEO* Inputs (SR8[5] = 1).
 - d. Enable EEPROM Interface (SR8[4] = 1, SR8[1] = 1). For all writes to SR8 from now until Step 5, bits 5, 4, and 1 must be uniformly, and Bit 6 must *always* be as determined in Step 1b.
2. Enable the EEPROM for writes:
 - a. Set the EEPROM Chip Select high (SR8[0] = 1).
 - b. Send the Write Enable Command (0100 1100000) to the EEPROM:
 - write data bit into SR8[3]
 - set SK high (SR8[2] = 1)
 - set SK low (SR8[2] = 0)
 - get the next data bit and repeat the sequence until all 11 bits are sent.
 - c. Set the EEPROM Chip Select low (SR8[0] = 0).
3. Write 16 bits of data to the EEPROM location desired:
 - a. Set the EEPROM Chip Select high (SR8[0] = 1).
 - b. Send the Write Register Command (0101 A5..A0 D15..D0) to the EEPROM:
 - write data bit into SR8[3]
 - set SK high (SR8[2] = 1)
 - set SK low (SR8[2] = 0)
 - the bit sequence is 0101 A5..A0 D15..D0
 - where A5..A0 is the 6-bit address and D15..D0 is the data.
 - c. Set the EEPROM Chip Select low (SR8[0] = 0).

4. Repeat Step 3, if required.
5. Disable the EEPROM:
 - a. Set the EEPROM Chip Select high (SR8[0] = 1).
 - b. Send the Disable Programming Command (0100 0000000) to the EEPROM
 - write data bit into SR8[3]
 - set SK high (SR8[2] = 1)
 - set SK low (SR8[2] = 0)
 - get the next data bit and repeat the sequence until all 11 bits are sent.
 - c. Set the EEPROM Chip Select low (SR8[0] = 0).
6. Remove the CL-GD542X from EEPROM Control:
 - a. Disable the EEPROM Interface (SR8[4] = 0, SR8[1] = 0).
 - b. Un-latch ESYNC and EVIDEO* (SR8[5] = 0).
 - c. Lock the Extended registers (SR6 = 0).

3.2 Read Example

1. Set the CL-GD542X for EEPROM Control:
 - a. Unlock the Extended registers (SR6 = 12h).
 - b. Determine the state of SR8[6] and save it for all subsequent writes.
 - c. Latch ESYNC and EVIDEO* Inputs (SR8[5] = 1).
 - d. Enable EEPROM Interface (SR8[4] = 1, SR8[1] = 1). For all writes to SR8 from now until Step 5, bits 5, 4, and 1 must be uniformly, and Bit 6 must *always* be as determined in Step 1b.
2. Read the EEPROM:
 - a. Set the EEPROM Chip Select high (SR8[0] = 1).
 - b. Send the READ Command (010 A5..A0) to the EEPROM:
 - write data bit into SR8[3]
 - set SK high (SR8[2] = 1)
 - set SK low (SR8[2] = 0)
 - get the next data bit and repeat the sequence until all 10 bits are sent.
 - c. Read EEPROM Data D15..D0.
 - set SK high (SR8[2] = 1)
 - set SK low (SR8[2] = 0)
 - read the data bit at SR8[7]: first bit is D15
 - continue until all 16 bits are read.
 - d. Set the EEPROM Chip Select low (SR8[0] = 0).
3. Repeat Step 2, if required.
4. Remove the CL-GD542X from EEPROM Control:
 - a. Disable the EEPROM Interface (SR8[4] = 0, SR8[1] = 0).
 - b. Un-latch ESYNC and EVIDEO* (SR8[5] = 0).
 - c. Lock the Extended registers (SR6 = 0).

Appendix B16

Family Compatibility and Upgrading Application Note

FAMILY COMPATIBILITY AND UPGRADING

1. INTRODUCTION

This application note shows the relationship among members of the True Color VGA family and also provides some insight into planning the end-user product for upgrading.

The CL-GD542X family of VGA controllers consists of six members. In order of increasing capability and cost, the True Color family members are: CL-GD5420, CL-GD5422, CL-GD5424, CL-GD5426, CL-GD5428, and CL-GD5429.

The CL-GD5425, because of its TV-out capability, is unique in the family and is not covered in this Appendix.

By upgrade path, it is meant that a higher-numbered (more capable) family member can be soldered onto the same board that previously supported a lower-numbered family member. Clearly, if more memory is to be used than was possible with the less capable family member, there must be space for an upgrade on the board.

In some cases it makes sense to upgrade without increasing the memory capability. For example, an upgrade from a CL-GD5420 to a CL-GD5422 will take advantage of the board-level tests made possible by the Signature Generator feature.

Table B16-1 provides an overview of the *differences* in the family members, and is *not* a capability chart for the family.

Table B16-1.CL-GD542X Family Differences

Item	'GD5420	'GD5422	'GD5424	'GD5426/'28	'GD5429
Host Bus					
Bus connections	ISA, Micro-Channel	ISA, Micro-Channel	ISA, Micro-Channel, '386/'486 Local	ISA, Micro-Channel, '386/'486 Local	ISA, Micro-Channel, '386/'486 Local
Linear Addressing	–	✓	✓	✓	✓
Display Memory					
Maximum Memory	1024K	1024K	1024K	2048K	2048K
Colors @ 640 × 480	256	16M	16M	16M	16M
Colors @ 800 × 600	256	64K	64K	64K	64K
Colors @ 1024 × 768	256 ^a	256	256	64K (Interlaced)	64K (Interlaced)
Colors @ 1280 × 1024	–	16 (Interlaced)	16 (Interlaced)	256 (Interlaced)	256 (Interlaced)
Video Overlay					
Video Overlay with 'Color Key'	–	✓	✓	✓	✓

Table B16-1.CL-GD542X Family Differences (cont.)

Item	'GD5420	'GD5422	'GD5424	'GD5426/'28	'GD5429
Color Key Mask	—	—	✓	✓	✓
Video Overlay (cont.)					
VAFC Baseline compliance	—	—	—	—	✓
GENLOCK Support	—	—	—	—	✓
Performance Enhancement					
Graphics cursor	32 × 32	32 × 32, 64 × 64	32 × 32, 64 × 64	32 × 32, 64 × 64	32 × 32, 64 × 64
Local bus	—	—	✓	✓	✓
BitBLT engine	—	—	—	✓	✓
Performance tuning	—	—	✓	✓	✓
Miscellaneous					
True Color DAC	—	✓	✓	✓	✓
Signature Generator	—	✓	✓	✓	✓
Programmable MCLK	_b	_b	✓	✓	✓
Maximum pixel rate	75 MHz	80 MHz	80 MHz	80 MHz	86 MHz

- a. If the CL-GD5420 is configured for 1024 Kbytes of display memory, it can support 1024 × 768 × 256 colors in Interlaced mode only.
- b. CL-GD5420-75QC-B and CL-GD5422-80QC-C have a programmable MCLK.

2. DRAM UPGRADES

Table B16-2 indicates the amount of DRAM of each DRAM type that can be supported by each family member. For each DRAM type, a common layout can be used. If the chip supports only a limited number of DRAMs, the other DRAM positions will be left un-populated.

Table B16-2.DRAM Upgrade

DRAM Configuration	'GD5420	'GD5422	'GD5424	'GD5426/'28	'GD5429
256K × 4	2, 4, or 8	4 or 8	4 or 8	4 or 8	4 or 8
512K × 8	2	—	—	4	4
256K × 16 symmetric dual-WE*	1	1 or 2	1 or 2	1, 2, or 4	1, 2, or 4
256K × 16 symmetric dual-CAS*	—	1 or 2	1 or 2	1 or 2	1 or 2
256K × 16 asymmetric dual-WE*	1	1 or 2	1 or 2	1, 2, or 4	1, 2, or 4

3. SOFTWARE CONSIDERATIONS

A common BIOS is provided for the CL-GD5422/'24/'26/'28/'29. To take advantage of the BitBLT engine, there are different drivers for the CL-GD5426/'28/'29. The CL-GD5420 shares the BIOS and drivers with the CL-GD5402.

4. LOCAL BUS CONSIDERATIONS

For a local bus application, only the CL-GD5424/'26/'28/'29 should be considered. However, to take advantage of the BitBLT engine in an ISA or MicroChannel bus application, it is possible to upgrade from the CL-GD5422 to a CL-GD5426/'28/'29.

Appendix B17

P-WELL/N-WELL Layout Considerations Application Note

P-WELL/N-WELL LAYOUT CONSIDERATIONS

1. INTRODUCTION

This application note discusses video-clock filter components and layout changes for the CL-GD542X family of VGA controllers. The current video-clock filter is designed for a silicon process known as the 'P-WELL' substrate. The changes recommended in this application note are for CL-GD542X controllers that have been manufactured with either the 'P-WELL' or 'N-WELL' process. The CL-GD5420 and CL-GD5402 VGA controllers manufactured using the P-WELL can still be obtained, though the N-WELL is preferred for future designs. A board layout can be designed to accommodate either the N-WELL or P-WELL process. CL-GD5424/26/28/29 will only ever be supplied in N-WELL material. Boards intended for these devices should make provisions for N-WELL only.

2. P-WELL VERSUS N-WELL PROCESS

The P-WELL process has been used for manufacturing all CL-GD5402, CL-GD5420, and CL-GD5422 devices. However, the need for faster operation and low-power consumption requires that all future CL-GD542X and CL-GD5402 devices be manufactured using the N-WELL process. Internal to the device, the P-WELL process uses the silicon substrate as the conductor for VDD. In contrast, the N-WELL process uses the substrate as the conductor for VSS. The internal VCO relies on a variable-voltage difference between it and the substrate to generate the desired video clock frequency. Using the N-WELL process gives a finer control of this difference when using higher frequencies.

2.1 Identifying P-WELL and N-WELL Devices

Table B17-1 indicates which devices are P-WELL and N-WELL.

Table B17-1. P-WELL, N-WELL Products

Device Order Number	Processing	Note
CL-GD5401-42QC-B	P-WELL	
CL-GD5402-65QC-B	P-WELL	Product obsolete Not recommended for new designs
CL-GD5402-75QC-C	N-WELL	Product obsolete Not recommended for new designs
CL-GD5420-65QC-A	P-WELL	Product obsolete Not recommended for new designs
CL-GD5420-75QC-B	N-WELL	Product obsolete Not recommended for new designs
CL-GD5420-75QC-C	N-WELL	

Table B17-1. P-WELL, N-WELL Products (*cont.*)

Device Order Number	Processing	Note
CL-GD5422-75QC-A	P-WELL	
CL-GD5422-80QC-C	N-WELL	Product obsolete Not recommended for new designs
CL-GD5422-80QC-D	N-WELL	
CL-GD5424	N-WELL	All
CL-GD5425	N-WELL	All
CL-GD5426	N-WELL	All
CL-GD5428	N-WELL	All
CL-GD5429	N-WELL	All

3. RECOMMENDED CHANGES

For optimal operation, circuit designs using CL-GD542X and CL-GD5402 devices based on N-WELL process must provide a well-filtered VDD source and a means of selecting either VDD or VSS for the video-clock filter.

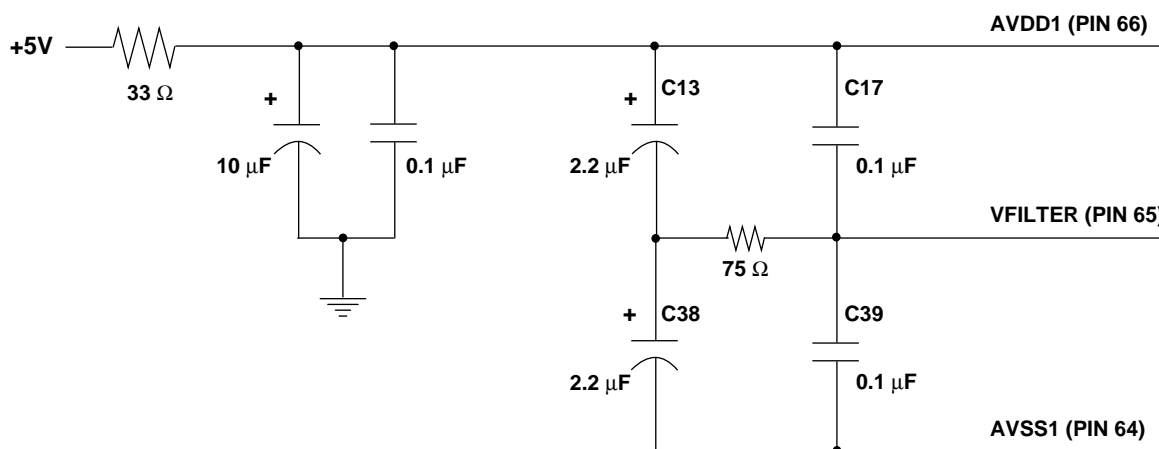
3.1 VDD Filter Change

Higher video clock frequencies require a well-filtered VDD source. This can be accomplished by changing the value of the 33- Ω resistor, 10- μ F and 0.1- μ F capacitors, or any other method that will provide a well-filtered VDD. Modifying the VDD filter to use ferrite beads is not recommended. The circuit also shows a VFILTER network comprising of a 75- Ω resistor, and C13 and C17 capacitors. For improved high-frequency noise rejection, the value of the C13 capacitor can be varied from 2.2 μ F to 1.0 μ F, and the value of the C17 capacitor from 0.1 μ F to 0.03 μ F. Recommended values are 2.2 μ F and 0.1 μ F.

3.2 Layout Change

The VFILTER design layout should accommodate either an N-WELL or P-WELL device. The design layout in Figure B17-1 shows how the VFILTER circuit is configured for this dual purpose. If an N-WELL device is used, capacitors C38 (C13A in some designs) and C39 (C17A in some designs) are installed instead of C13 and C17. For a P-WELL device, install capacitors C13 and C17. Note that the 75- Ω resistor and the VFILTER, AVSS1, and AVDD1 connections are common to either device type.

NOTE: For an N-WELL connection, the polarity of C38 (C13A) is *opposite* that of C13 for a P-WELL connection.

**Figure B17-1. VFILTER Design Layout**

Appendix B18

Manufacturing Test Application Note

MANUFACTURING TEST

1. MANUFACTURING TEST PROGRAM

1.1 Specifications and Operating Instructions

The Manufacturing Test Program (MFGTST.EXE) provides the ability to visually and programmatically verify correct operation of the CL-GD542X family. Primary features include write/read/compare tests of all video register groups, write/read/compare tests of all video RAM, display patterns for visual verification of all primary video modes, as well as a complete set of miscellaneous video tests designed to verify proper operation of the video chip. All RAM and register tests are self-checking to the extent that values will be read and compared to expected values. When a difference is detected, an error message will be generated. All display patterns (except for signature testing) must be visually inspected to verify proper operation.

The program also detects chip type and automatically configures itself to run all valid tests for the video chip installed in the system. For example, if a CL-GD5422 is installed in the system, the program automatically sets internal menus and external command-line options to run CL-GD5422-specific tests. In all cases where a particular test is chip-specific, the program senses and records it.

The operating mode of the test program may be selected from display-menu options, or may be specified with command-line parameters. This overview details the user interface and operation of the test program.

1.2 Using the MFGTST Menu-Driven Interface

At the DOS prompt type:

```
MFGTST /m [Enter]
```

When the '/m' option is selected, the user is in Menu mode (after the initial Cirrus Logic logo screen). From these menus, the user may select from a variety of register, display, or miscellaneous video tests. To select a test, the up, down, left, or right arrow keys are used to change the currently highlighted selection. Optionally, a 'point and shoot' interface may be used if a mouse driver has been loaded. When the desired selection is highlighted, press the Enter key to execute the test. The ESC key always terminates a test, as well as the program when at the main menu. The following section lists and discusses tests available while in Menu mode.

1.2.1 Register Tests

- Memory tests, for current Video RAM installed in the video system
- Input Status Register 1 test (Sync bits)
- Sequencer register tests
- CRTC register tests
- Graphics Controller register tests

- Attribute Controller register tests
- Miscellaneous Output register test
- Feature Control register test
- DAC State register test
- PEL Mask register test
- DAC Palette register tests
- Extended register tests
- DAC Comprehensive Test

All registers that are both writable and readable are tested by writing bit patterns to the register and then reading the same register. The result of the read operation is compared with the expected result. If a difference is detected, an error message is generated. If reserved bits are defined for a register, they are not included in the write pattern (that is, they are excluded from the compare). An extra test insures that if ones are written to any reserved bits, they remain set to zeros in the read value.

The test patterns used for the write operation are derived from the loop count. Write values range from 0 to 255 (all possible bit patterns). When an error occurs, the loop does not abort. The error bits are recorded, and the register test continues. When all bit patterns have been written, the bit errors are analyzed. Information regarding bits that appear to be stuck high or stuck low are included in the error message that is generated.

If multiple compare errors occur on a single register, a count of bad registers is incremented by one, even though the total number of compare errors is greater than one. For example, if a register has one bit stuck low (0), the bad register is incremented (to 1), and the total number of compare errors will be 128. These statistics will be displayed in a summary, if the Verbose mode (option '/v') was specified at the command line at program execution.

In addition to write/read/compare tests, Write Protection register tests are also performed. If Write Protect registers can be modified while locked, an error will be generated. Finally, the display enabled, and Vertical Retrace bits in the Input Status Register 1 are verified to ensure that they toggle between active video and retrace states.

First Mbyte Video Memory Test performs a write/read/compare loop on the first Mbyte of display memory. Before the memory test begins, the video chip is configured for a Packed-pixel mode. Using Write mode 2, all planes are written with a pre-selected test pattern (color). This value is loaded into the Color Compare register. Using Read mode 1, the entire memory address space is read (and compared) against the write value. If all pixels do not compare successfully, an error will be generated. When an error has been detected, RAM locations above the error location are not checked, that is, an error is only generated for the first faulty location. The RAM test verifies 16 different test patterns written to the video memory.

Video Memory Test 2 uses Write mode 0 in an appropriate Video mode, where the test patterns are written to and read back from video RAM directly. If the write value is different when read back, an error will be generated.

When running the test from the command line, all tests listed above are run as a complete set. Individual register tests may only be selected while in Menu mode.

1.3 Display and Miscellaneous Tests

- 80-column Text mode 3 test pattern
- 80-column Text mode 3 test (8 pages)
- 80 column Text mode 7 test pattern
- 40 column Text mode 1 test pattern
- 320 × 200 Graphics mode 4 test pattern
- 640 × 200 Graphics mode 6 test pattern
- 640 × 350 Graphics mode 10h test pattern
- 640 × 480 Graphics mode 12h test pattern
- 640 × 480 Graphics mode 11h test pattern
- 320 × 200 Graphics mode 13h test pattern
- VGA graphics standard 256-color palette test pattern
- Extended Video mode patterns (See Tables 4-1 and 4-2 in Chapter 3, “Data Book”. Note that not all video modes are available on all chip/memory configuration combinations.)
- Rotate DAC test pattern
- 512-character set test
- Pan and scroll test
- Split-screen test
- 360 × 480 × 256 non-standard VGA mode test pattern
- Summing-to-Grayscale test
- 12-rows × 80-columns Text mode test
- Text mode scanline test (200, 350, or 400 scanlines)
- Reset DAC, display static screens
- Hardware Graphics Cursor tests
- Write mode Tests
- BY8 and BY16 Addressing Tests, Latches
- Signature Generator tests
- Signature Generator output
- BitBLT Tests
- Non-standard mode 71h @ 65 MHz through 95 MHz DCLK

1.4 Miscellaneous Test Descriptions

1. **Rotate DAC Test Pattern:** In this test, the DAC is reset to a color spectrum and then slowly rotated from right to left. The spectrum is rotated on the register-level only. For example, the color in register 1 is loaded into register 0, and the color in register 0 is loaded into register 255, and so on. Once the pattern is first drawn to memory, no other writes to memory are made. The test is run in mode 13h ($320 \times 200 \times 256$ colors). If colors seem to remain stationary (not rotated) or migrate in an unusual manner, this may indicate a chip-level problem.
2. **512-Character Test:** In this test, both a 9×16 character set (left side) and 8×8 character set (right side) are displayed simultaneously in mode 3. This is accomplished by loading two 256-character sets into Memory Plane 2. Sequencer register 3 is then set to select character sets 0 and 1. This enables Character Attribute bit 3 to select between the first or second set when writing characters to the display.
3. **Pan and Scroll Test:** By setting and continually updating several CRTC registers, it is possible on a standard VGA to achieve a smooth pan and scroll of the display. The logical width of the display in this case must be larger than the display screen itself to permit horizontal scrolling. The text 'PANNING AND SCROLLING TEST,' with normal VGA operation, should pan and scroll from the lower right-hand corner of the screen to the upper left-hand corner of the screen and stop.
4. **Split-screen Test:** In this test, the display is split into two pieces, upper and lower. The upper portion of the screen remains stationary, while the lower portion is slowly scrolled up over the upper, and then scrolled down, out of sight. A split screen on a standard VGA can be achieved by adjusting the Line Compare and Start Address CRTC registers.
5. **$360 \times 480 \times 256$ Non-standard VGA Mode Test Pattern:** It is possible on standard VGA hardware to create a graphics mode that is $360 \times 480 \times 256$ colors (using only the standard VGA 28-MHz dot clock). This mode is currently supported in many major software packages. This display pattern verifies correct operation of this non-standard VGA mode.
6. **Summing-to-Grayscale Test:** Grayscale summing (summing color values to their grayscale equivalents, 256 colors to 64 shades of gray) is verified in this test. The pattern is the same one displayed in the 256-color palette test, only in this case, the colors are summed to grayscale.
7. **12×80 Text Mode Test:** It is possible in mode 3, to display a 'stretched' 8×16 character (pseudo 8×32) by performing the following:
 - a) Set character font to 200 scanlines.
 - b) Set mode 3, to allow 200-scanline option to take effect.
 - c) Set an 8×16 character font on.This test verifies this hidden standard VGA feature.
8. **Select Scanlines Test:** This test displays mode 3 in 200, 350, and 400 scanlines.
9. **Reset DAC, Display Static Screens:** The DAC is reset to a color spectrum in the first screen as well as an RGB gradient in the second screen. Both screens are displayed in VGA mode 13h ($320 \times 200 \times 256$ color).
10. **Hardware Graphics Cursor Tests:** The Hardware Cursor is used in 16-color planar and 256-color Packed-pixel modes to provide a pointer for graphical user interfaces. A Hardware Cursor (mouse pointer) will improve performance because the screen data will

not have to be rewritten when the cursor is moved; it will improve the appearance of the screen by providing a smoothly moving cursor. The cursor is a 32×32 or 64×64 (CL-GD5422/'24/'25/'26/'28/'29 only) pixel array of two planes. The following tests are performed on both the 32×32 and 64×64 Hardware Cursor:

- a) **Pattern Address Tests:** The 32×32 cursor has space for 64 possible patterns that can be loaded into video memory and made available to any graphical application, while the 64×64 cursor has a possible space for 16 patterns. This test loads the maximum possible number of patterns into memory, and displays each pattern on the screen.
 - b) **Cursor Attribute Tests:** It is possible (with the Hardware Cursor) to set foreground and background colors for the cursor that are independent of the colors stored in the standard palette DAC. This test verifies the correct operation of Hardware-cursor Colors 0 and 1.
 - c) **Cursor Attribute Tests (inverted):** This test verifies the correct operation of the Hardware Cursor when programmed for Inverted mode.
 - d) **Cursor X/Y Position Test:** To ensure proper positioning of the graphics cursor on the screen, the Hardware Cursor in this test is moved across the screen from the top right-hand corner to the bottom left-hand corner. All Hardware Cursor tests are performed while in VGA mode 12h.
11. **Write Mode Tests:** Write mode 1, as well as Extended Write modes 4 and 5, are tested in BY8 and BY16 addressing, fill, scroll, and color expansion tests. Tests are also performed on the 4-byte and 8-byte-wide latches. The following tests are available:
- a) Write mode 1, standard addressing and latches (mode 5FH) with scroll.
 - b) Write mode 1, BY8 addressing, 8-byte-wide data latches (mode 5FH) with scroll.
 - c) Write mode 4, BY8 addressing (mode 5FH) Fill Test.
 - d) Write mode 4, BY8 addressing (mode 5FH) Mask Tests (2 screens).
 - e) Write mode 5, BY8 addressing (mode 5FH) Mask Tests (5 screens).
 - f) Write mode 4, Text Write Test, BY8 addressing (mode 5FH).
 - g) Write mode 5, Text Write Test, BY8 addressing (mode 5FH).
 - h) Write mode 4 Fill, Write mode 1 Scroll, with 8-byte-wide latches (mode 5FH).
 - i) Write mode 4 Monochrome Bitmap Conversion Test (mode 5FH).
 - j) Write mode 0, with Raster OPs (GR3), 4 screens in mode 13H.
 - k) Write mode 0, Data Rotator Test (GR3), 8 screens.
 - l) Write mode 1, 8-byte wide data latches (mode 64H) with scroll.
 - m) Write mode 4, BY16 addressing (mode 64H) Fill Test.
 - n) Write mode 4, BY16 addressing (mode 64H) Mask Tests (2 screens).
 - o) Write mode 5, BY16 addressing (mode 64H) Mask Tests (5 screens).
 - p) Write mode 4, Text Write Test, BY16 addressing (mode 64H).
 - q) Write mode 5, Text Write Test, BY16 addressing (mode 64H).
 - r) Write mode 4 Fill, Write mode 1 Scroll, with 8-byte-wide latches (mode 64H).
 - s) Write mode 4 Monochrome Bitmap Conversion Test (mode 64H).

NOTE: At the time of this publication, plans are underway to add other Write mode tests, which will include tests for the other CL-GD545X family-specific features.

12. **Signature Generator Tests** (except the CL-GD5420): To automatically test CL-GD542X video-output logic at full speed, Signature Generator (SG) logic was added to the IC. The SG uses a 16-bit CCITT-standard Cyclic Redundancy Check (CRC) algorithm, commonly used in data communications to ensure the integrity of large blocks of data. The SG operates on the Pixel Data P[7:0] over the active display time of a video frame. In the case of interlaced modes, the SG operates over one full video-refresh cycle of an odd and an even frame. The data from one bit at a time of the Pixel Data bus is used by the SG to produce a unique signature for any given mode setup or video memory data. By storing known good values, the Manufacturing Test samples signatures from a set of display patterns, and compares the known signatures to the newly sampled signatures. If both match, then the screen is said to be correct. If a mismatch occurs, then a problem may exist in the VGA hardware or firmware. This allows the user to automatically test screen data without having to visually inspect a screen for error (which can be complicated, especially in High-color and True Color modes). The CCITT CRC is designed to run on a serial bit stream. The SG has a 3-bit control field to select which bit of the Pixel Data bus to run through the CRC on each frame. Checking the entire Pixel Data bus requires that a signature be taken for each Pixel Data Bus bits, or eight signatures per screen. Running one signature per Pixel Data Bus bit helps pinpoint the cause of a failure, since seven of the SG runs may be good and only one fail; isolating the problem to a subset of the IC pins and/or memory is achievable.

Using most of the manually viewed screens as input, signatures are captured and compared for possible errors. In operations where speed of testing is of the essence as well as eliminating human error, signature testing takes the place of the visual inspection of display screens; in most cases, it would be the most desirable and accurate way to test a Video mode.

13. **Signature Generator Output** (*Except the CL-GD5420*): This option displays the eight signatures captured for each screen tested. This information can be used to determine where a possible problem may exist within the IC.
14. **BitBLT tests:** The following BitBLT tests are available that test all the basic BitBLT functions of the CL-GD542X family.
- a) Screen-to-screen, mode 5Fh
 - b) Screen-to-screen with Overlap, mode 5Fh
 - c) Large BitBLT, mode 5Fh
 - d) Large BitBLT, mode 64h
 - e) Large BitBLT, mode 71h
 - f) Full-screen BitBLT, mode 5Fh
 - g) Screen-to-off-screen-to-screen
 - h) System-to-screen (9 × 4 boxes)
 - i) System-to-screen (160 × 120 boxes)
 - j) Pattern Copy, 8-bits (mode 5Fh)
 - k) Pattern Copy, 16-bits (mode 64h)
 - l) Screen-to-system (160 × 120 box)
 - m) Pattern Copy with Color Expand, 8-bit
 - n) Pattern Copy with Color Expand, 16-bit

NOTE: At the time of this publication, plans are underway to add other CL-GD545X-family-specific BitBLT tests. These tests will be added in future updates to the Manufacturing Test and its documentation.

15. **Non-standard Mode 71h @ 65 MHz through 95 MHz:** This test allows the user to reset mode 71h from its default dot clock setting of 75 MHz to non-standard values in the range given above. The MHz values are selected by using the left and right arrow keys while the test pattern is visible on screen. When a new value is selected, the dot clock is reprogrammed and the resulting screen is adjusted.

1.5 Running MFGTST from the Command Line

Running the Manufacturing Test with no parameters simply runs all standard tests. The following options are available from the command line:

/h	Displays a help screen while in DOS (/? also accepted); a brief, one screen list of valid command line options are shown. No tests are run.
/m	Runs the program in Menu mode, as described above.
/x	Runs all self-checking tests only (register tests); this option does not display test patterns or miscellaneous tests.
/n	Runs all display pattern tests only; this option does not run self-checking register and video RAM tests
/d<n>	Maximum time each test pattern is displayed. the default is to wait indefinitely until a key is pressed. If <n> is not specified, default <n> is one second. The maximum delay is nine.
/v	Generates detailed messages on test status. Additional test information in Verbose mode is displayed for self-checking tests. Successful completion messages are generated in addition to any error messages.
/q	Do not display messages to standard output (con:); no test messages will be output to the display in Quiet mode.
/e<n>	Number of errors permitted before program aborts; the maximum number of bad register/RAM locations that will be tolerated before the program terminates (default is 1). The actual number of compare errors (on a single register/RAM location) may be higher than this number.
/w	Pause after error message (until any key pressed).
/r<n>	Number of test passes; default <n> = 1;
/c<n>	Send message output to com<n>, default <n> = 1; <n> specifies the port to be used, and may range from 1 to 4.
/p<n>	Send message output to lpt<n>, default <n> = 1; LPT1, LPT2, or LPT3 may be selected with <n> set to 1, 2, or 3.
f <path name>	Send message output to disk file, <path name> name of file, default =<path name> \video.rpt. This is in addition to the screen output, unless the /q option has been specified. The file name may be a fully qualified (path) file name. If <path name> is not specified, the default file ~video.rpt is used. This parameter must be the last item on the command line, when several options are grouped together (for example, /vsf err.rpt).

/+	Runs extended miscellaneous tests along with standard tests; this is a lengthy test set and should only be used when the most complete comprehensive test suite is desired.
/s	Runs signature testing on selected video screens (except the CL-GD5420)
/u	User-defined test scripts option: Syntax: C:>mfgtst /u<path scriptfilename> This option runs the Manufacturing Test from the command line with a user-defined script file, instead of using the default tests and test order. If this option is not used, the normal default tests and order will be used during command line run. When the script option is active, the following command line options are suppressed: '/s', '/n', and '/x'. A sample script file is available (SCRIPT.MFG) which has all the current test options available in the form of string input to the program. Only one test string may occupy a line in the script file. The script file may have any name, and may be used as many times as needed. Tests may also be in any order. While this option is active, Verbose mode ('/v') is always turned on.

NOTE: Strings in the script file must be written exactly as those shown in the sample script file. If the strings are altered, MFGTST.EXE will not recognize the test and will pass it over and go on to the next test command in the script file.

1.6 Command Line Examples

- 1) MFGTST /sv This execution invokes the Self-checking register and RAM tests only. No test patterns or miscellaneous tests are displayed. Verbose mode displays messages to the display screen indicating successful test completion.
- 2) MFGTST /s /v Same as example 1.
- 3) MFGTST -sv Same as example 1.
- 4) MFGTST /nd The display patterns are run with a maximum delay of 1 second between each screen, or until a key is pressed. No self-checking tests are run.
- 5) MFGTST /f error.rpt Message output is sent to file error.rpt in addition to the display.
- 6) MFGTST /d 3 ILLEGAL parameter, this must be specified as /d3, as well as any other command-line parameter that has <n> as a sub-parameter.

1.7 Manufacturing Test Updates

The Manufacturing Test is constantly updated. As more and more products are added to the Cirrus Logic family of graphics controllers, more tests are added to the Manufacturing Test Software to support new functions and features of our current and future products. Contact Cirrus Logic for up-to-date Manufacturing Test Software and documentation.

OEMs can download the latest Manufacturing Test from the Cirrus Logic Bulletin Board Service at (510) 440-9080. See Appendix D9, "Cirrus Logic BBS" for information on the BBS.

Appendix B19

DRAM Timing Calculations Application Note

DRAM TIMING CALCULATIONS

1. INTRODUCTION

This application note discusses DRAM timing for the CL-GD542X family. Included is a table (Table B19-1) that calculates the available times for various MCLK frequencies. Standard RAS* timing and extended RAS* timing are both covered. Next, Table B19-4 shows the same parameters from data sheets of various DRAMs. Finally, an example shows how the data from the two tables can be combined.

2. MCLK FREQUENCIES

Table B19-1 evaluates the parameters in Table 7-29 of the CL-GD542X Data Book (Chapter 3) for various values of SR1F[4:0]. For each value of SR1F[4:0], the frequency and period of MCLK is calculated. Then each parameter in Table 7-29 is evaluated. The resulting numbers are the DRAM requirement for that MCLK frequency. Table B19-1 also shows MCLK values above 50 MHz, for reference only. Only the CL-GD5429 is specified for an MCLK above 50 MHz. The columns corresponding to frequencies that can be selected without programming SR1F are in **bold**.

NOTE: The numbers in this table are the results of calculations. Measure the signals at the DRAMs in your environment with your layout, damping resistors, and capacitive loading.

Table B19-1. MCLK Frequencies

SR1F[4:0] (hex):		1A	1B	1C	1D	1E	1F	20	21	22	23	24	25	26	27
Frequency (MHz):		46.5	48.3	50.1	51.9	53.7	55.5	57.3	59.1	60.9	62.6	64.4	66.2	68.0	69.8
Period (ns):		21.5	20.7	20.0	19.3	18.6	18.0	17.5	16.9	16.4	16.0	15.5	15.1	14.7	14.3
Period/Two:		10.7	10.3	10.0	9.6	9.3	9.0	8.7	8.5	8.2	8.0	7.8	7.6	7.4	7.2
t ₁	t _{ASR} : Address setup to RAS*	30.2	29.0	27.9	26.9	25.9	25.0	24.2	23.4	22.6	21.9	21.3	20.7	20.1	19.5
t ₂	t _{ASC} : Address setup to CAS*	20.5	19.7	19.0	18.3	17.6	17.0	16.5	15.9	15.4	15.0	14.5	14.1	13.7	13.3
t ₃	t _{RCD} : RAS* to CAS* (standard RAS*)	51.7	49.7	47.9	46.2	44.6	43.1	41.7	40.3	39.1	37.9	36.8	35.8	34.8	33.8
t ₃	t _{RCD} : RAS* to CAS* (extended RAS*)	62.5	60.1	57.9	55.8	53.9	52.1	50.4	48.8	47.3	45.9	44.6	43.3	42.1	41.0
t ₄	t _{RAH} : Row address hold	32.2	31.0	29.9	28.9	27.9	27.0	26.2	25.4	24.6	23.9	23.3	22.7	22.1	21.5
t ₅	t _{CAH} : Column address hold	21.5	20.7	20.0	19.3	18.6	18.0	17.5	16.9	16.4	16.0	15.5	15.1	14.7	14.3
t ₇	WE* inactive to OE* active	30.2	29.0	27.9	26.9	25.9	25.0	24.2	23.4	22.6	21.9	21.3	20.7	20.1	19.5

Table B19-1. MCLK Frequencies *(cont.)*

SR1F[4:0] (hex):		1A	1B	1C	1D	1E	1F	20	21	22	23	24	25	26	27
Frequency (MHz):		46.5	48.3	50.1	51.9	53.7	55.5	57.3	59.1	60.9	62.6	64.4	66.2	68.0	69.8
Period (ns):		21.5	20.7	20.0	19.3	18.6	18.0	17.5	16.9	16.4	16.0	15.5	15.1	14.7	14.3
Period/Two:		10.7	10.3	10.0	9.6	9.3	9.0	8.7	8.5	8.2	8.0	7.8	7.6	7.4	7.2
t ₈	t _{RAC} : RAS* access (standard RAS*)	85.0	81.8	78.8	76.1	73.5	71.1	68.8	66.7	64.7	62.9	61.1	59.4	57.8	56.3
t ₈	t _{RAC} : RAS* access (extended RAS*)	95.7	92.1	88.8	85.7	82.8	80.1	77.6	75.2	72.9	70.8	68.8	67.0	65.2	63.5
t ₉	t _{CAC} : CAS* access (MAX)	24.5	23.7	23.0	22.3	21.6	21.0	20.5	19.9	19.4	19.0	18.5	18.1	17.7	17.3
t ₁₀	t _{AA} : Column address access (MAX)	43.0	41.4	39.9	38.5	37.2	36.0	34.9	33.9	32.9	31.9	31.0	30.2	29.4	28.7
t ₁₂	t _{RP} : RAS* precharge (standard RAS*)	51.7	49.7	47.9	46.2	44.6	43.1	41.7	40.3	39.1	37.9	36.8	35.8	34.8	33.8
t ₁₂	t _{RP} : RAS* precharge (extended RAS*)	64.5	62.1	59.9	57.8	55.9	54.1	52.4	50.8	49.3	47.9	46.6	45.3	44.1	43.0
t ₁₃	t _{RC} : Random cycle (standard RAS*)	128.9	124.2	119.7	115.6	111.7	108.1	104.8	101.6	98.6	95.8	93.1	90.6	88.2	86.0
t ₁₃	t _{RC} : Random cycle (extended RAS*)	150.4	144.9	139.7	134.9	130.4	126.2	122.2	118.5	115.0	111.7	108.6	105.7	102.9	100.3
t ₁₄	t _{RCH} : Read command hold	5.7	5.3	5.0	4.6	4.3	4.0	3.7	3.5	3.2	3.0	2.8	2.6	2.4	2.2
t ₁₇	t _{CP} : CAS* precharge	15.5	14.7	14.0	13.3	12.6	12.0	11.5	10.9	10.4	10.0	9.5	9.1	8.7	8.3
t ₁₈	t _{CWL} : WE* active to CAS*	23.5	22.7	22	21.3	20.6	20.0	19.5	18.9	18.4	18.0	17.5	17.1	16.7	16.3
t ₁₉	t _{WCH} : WE* active hold	32.2	31.0	29.9	28.9	27.9	27.0	26.2	25.4	24.6	23.9	23.3	22.7	22.1	21.5
t ₂₀	t _{WP} : WE* pulse width	51.7	49.7	47.9	46.2	44.6	43.1	41.7	40.3	39.1	37.9	36.8	35.8	34.8	33.8
t ₂₁	t _{DS} : Data setup to CAS*	19.5	18.7	18.0	17.3	16.6	16.0	15.5	14.9	14.4	14.0	13.5	13.1	12.7	12.3
t ₂₂	t _{DH} : Data hold from CAS*	22.5	21.7	21.0	20.3	19.6	19.0	18.5	17.9	17.4	17.0	16.5	16.1	15.7	15.3
t ₂₃	t _T : Transition time	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
t ₂₅	t _{RAS} : (standard RAS*)	75.2	72.4	69.8	67.4	65.2	63.1	61.1	59.3	57.5	55.9	54.3	52.9	51.5	50.1

Table B19-1. MCLK Frequencies *(cont.)*

SR1F[4:0] (hex):		1A	1B	1C	1D	1E	1F	20	21	22	23	24	25	26	27
Frequency (MHz):		46.5	48.3	50.1	51.9	53.7	55.5	57.3	59.1	60.9	62.6	64.4	66.2	68.0	69.8
Period (ns):		21.5	20.7	20.0	19.3	18.6	18.0	17.5	16.9	16.4	16.0	15.5	15.1	14.7	14.3
Period/Two:		10.7	10.3	10.0	9.6	9.3	9.0	8.7	8.5	8.2	8.0	7.8	7.6	7.4	7.2
t ₂₅	t _{RAS} : (extended RAS*)	84.0	80.8	77.8	75.1	72.5	70.1	67.8	65.7	63.7	61.9	60.1	58.4	56.8	55.3
t ₂₆	t _{CAS} : CAS*	24.5	23.7	23.0	22.3	21.6	21.0	20.5	19.9	19.4	19.0	18.5	18.1	17.7	17.3
t ₂₇	Read Data to CAS* high	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
t ₂₈	Read data from CAS* high	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
t ₂₉	t _{PC} : Page-mode cycle	43.0	41.4	39.9	38.5	37.2	36.0	34.9	33.9	32.9	31.9	31.0	30.2	29.4	28.7
t _x	t _{CAP} : Access time from CAS* high	43.0	41.4	39.9	38.5	37.2	36.0	34.9	33.9	32.9	31.9	31.0	30.2	29.4	28.7

3. STANDARD RAS* VS. EXTENDED RAS*

In Table B19-1, there are five pairs of parameters that are calculated twice — once for six-MCLK random cycles and once for seven-MCLK random cycles. RAS* timing is controlled by CF[11]. A summary is listed in Table B19-2.

Table B19-2. CF[11] – RAS* Timing

CF[11]	MD27	New Name	Old Name	t _{RC}
1	No pull-down	Standard RAS* timing	Default	6-MCLK
0	Pull-down	Extended RAS* timing	High performance	7-MCLK

If a pull-down is installed, 1/2 MCLK cycle is added to the RAS* precharge period (t_{RP}) and 1/2 MCLK cycle is added to the delay between RAS* and CAS* (t_{RCD}). This allows the system designer to take full advantage of DRAM with faster relative CAS* times. The MCLK can be increased, decreasing the CAS* times (t_{CAC}, t_{PC}) while maintaining relatively long RAS* times.

There are five parameters in Table 7-29 in Chapter 3, “Data Book”, that are redefined depending on which RAS* timing is selected, enumerated in Table B19-3.

Table B19-3. New Timing Definitions

Symbols	Parameter	Standard	Extended
t_3	t_{RCD} : RAS* to CAS*	2.5m ^a - 2 ns	3m - 2 ns
t_8	t_{RAC} : Data from RAS*	4m - 1 ns	4.5m - 1 ns
t_{12}	t_{RP} : RAS* precharge	2.5m - 2 ns	3m
t_{13}	t_{RC} : Random cycle	6m	7m
t_{25}	t_{RAS} : RAS* pulse width	3.5m	4m - 2 ns

a. m = MCLK

There is a decrease in performance when switching from standard RAS* timing to extended RAS* timing without an accompanying increase in MCLK. If the memory is lightly loaded (as would be the case of a CL-GD5422 in an ISA bus environment), the decrease is less than 5%. If the memory is very heavily loaded (as would be the case of a CL-GD5426/'28/'29 in a VESA VL-Bus environment), the decrease can approach 20%. It is best to run the target application in the intended configuration and obtain system-specific numbers before deciding.

4. 70-NS DRAMS

Table B19-4 contains data sheet values for a number of DRAMs with 70-ns Row Access Time (t_{RAC}). Using this table, it can be determined that most of the values do not vary from vendor to vendor. The obvious exception is Page-mode Cycle Time (t_{PC}). The fastest data sheet value is for the brand 'M' 256K \times 4; the slowest data sheet value is for the brand 'H' 256K \times 4.

Table B19-4. 70-ns DRAMs

	Vendor:	Brand H	Brand M	Brand S	Brand H
	Part Number: Configuration: Speed:	HM514256A 256K \times 4 70	MT4C4256 256K \times 4 70	KM44C256B 256K \times 4 70	HM514260 256K \times 16 70
t_1	t_{ASR} : Address setup to RAS*	0	0	0	0
t_2	t_{ASC} : Address setup to CAS*	0	0	0	0
t_3	t_{RCD} : RAS* to CAS* (standard RAS*)	20	20	20	20
t_3	t_{RCD} : RAS* to CAS* (extended RAS*)	20	20	20	20
t_4	t_{RAH} : Row address hold	10	10	10	10
t_5	t_{CAH} : Column address hold	15	15	15	15
t_7	WE* Inactive to OE* Active	–	–	–	–
t_8	t_{RAC} : RAS* access (standard RAS*)	70	70	70	70
t_8	t_{RAC} : RAS* access (extended RAS*)	70	70	70	70
t_9	t_{CAC} : CAS* access (MAX)	20	20	20	20
t_{10}	t_{AA} : Column address access (MAX)	35	35	35	35
t_{12}	t_{RP} : RAS* precharge (standard RAS*)	50	50	50	50
t_{12}	t_{RP} : RAS* precharge (extended RAS*)	50	50	50	50
t_{13}	t_{RC} : Random cycle (standard RAS*)	130	130	130	130
t_{13}	t_{RC} : Random cycle (extended RAS*)	130	130	130	130
t_{14}	t_{RCH} : Read command hold	0	0	0	0
t_{17}	t_{CP} : CAS* precharge	10	10	10	10
t_{18}	t_{CWL} : WE* active to CAS*	20	20	20	20
t_{19}	t_{WCH} : WE* active hold	15	15	15	15
t_{20}	t_{WP} : WE* pulse width	10	15	15	10
t_{21}	t_{DS} : Data setup to CAS*	0	0	0	0

Table B19-4. 70-ns DRAMs (cont.)

	Vendor:	Brand H	Brand M	Brand S	Brand H
	Part Number: Configuration: Speed:	HM514256A 256K × 4 70	MT4C4256 256K × 4 70	KM44C256B 256K × 4 70	HM514260 256K × 16 70
t ₂₂	t _{DH} : Data hold from CAS*	15	15	15	15
t ₂₃	t _T : Transition time	3	3	3	3
t ₂₅	t _{RAS} : (Standard RAS*)	70	70	70	70
t ₂₅	t _{RAS} : (Extended RAS*)	70	70	70	70
t ₂₆	t _{CAS} : CAS*	20	20	20	20
t ₂₇	Read data to CAS* high	–	–	–	–
t ₂₈	Read data from CAS* high	0	0	0	0
t ₂₉	t _{PC} : Page-mode cycle	50	40	45	45

5. A COMBINED EXAMPLE

Comparing the times available (Table B19-1) with the times required (Table B19-4), the times available should be equal to or greater than the times required. As an example, Table B19-5 includes the Brand 'S' numbers with those of Table B19-1 so that the numbers can be easily compared. With an MCLK frequency of 43.0 MHz, no parameters are violated. In every case, for standard RAS* or extended RAS*, more time is available than is required.

Table B19-5. Brand 'S' DRAMs

	SR1F (Hex):	15	16	17	18	19	Brand S	1A
	Frequency (MHz):	37.6	39.4	41.2	43.0	44.7	KM44C256B	46.5
	Period (ns):	26.6	25.4	24.3	23.3	22.3	256K × 4	21.5
	Period/Two:	13.3	12.7	12.1	11.6	11.2	70	10.7
t ₁	t _{ASR} : Address setup to RAS*	37.9	36.1	34.4	32.9	31.5	0	30.2
t ₂	t _{ASC} : Address setup to CAS*	25.6	24.4	23.3	22.3	21.3	0	20.5
t ₃	t _{RCD} : RAS* to CAS* (standard RAS*)	64.5	61.5	58.7	56.2	53.9	20	51.7
t ₃	t _{RCD} : RAS* to CAS* (extended RAS*)	77.8	74.2	70.9	67.8	65.0	20	62.5
t ₄	t _{RAH} : Row address hold	39.9	38.1	36.4	34.9	33.5	10	32.2
t ₅	t _{CAH} : Column address hold	26.6	25.4	24.3	23.3	22.3	15	21.5
t ₇	WE* inactive to OE* active	37.9	36.1	34.4	32.9	31.5	–	30.2
t ₈	t _{RAC} : RAS* access (standard RAS*)	105.4	100.6	96.2	92.1	88.4	70	85.0

Table B19-5. Brand ‘S’ DRAMs (*cont.*)

	SR1F (Hex):	15	16	17	18	19	Brand S	1A
	Frequency (MHz):	37.6	39.4	41.2	43.0	44.7	KM44C256B	46.5
	Period (ns):	26.6	25.4	24.3	23.3	22.3	256K × 4	21.5
	Period/two:	13.3	12.7	12.1	11.6	11.2	70	10.7
t ₈	t _{RAC} : RAS* access (extended RAS*)	118.7	113.3	108.3	103.8	99.6	70	95.7
t ₉	t _{CAC} : CAS* access (MAX)	29.6	28.4	27.3	26.3	25.3	20	24.5
t ₁₀	t _{AA} : Column address access (MAX)	53.2	50.8	48.6	46.6	44.7	35	43.0
t ₁₂	t _{RP} : RAS* precharge (standard RAS*)	71.5	68.5	65.7	63.2	60.9	50	58.7
t ₁₂	t _{RP} : RAS* precharge (extended RAS*)	79.8	76.2	72.9	69.8	67.0	50	64.5
t ₁₃	t _{RC} : Random cycle (standard RAS*)	159.6	152.4	145.8	139.7	134.1	130	128.9
t ₁₃	t _{RC} : Random cycle (extended RAS*)	186.2	177.8	170.0	163.0	156.4	130	150.4
t ₁₄	t _{RCH} : Read command hold	8.3	7.7	7.1	6.6	6.2	0	5.7
t ₁₇	t _{CP} : CAS* precharge	20.6	19.4	18.3	17.3	16.3	10	15.5
t ₁₈	t _{CWL} : WE* active to CAS*	28.6	27.4	26.3	25.3	24.3	20	23.5
t ₁₉	t _{WCH} : WE* active hold	39.9	38.1	36.4	34.9	33.5	15	32.2
t ₂₀	t _{WP} : WE* pulse width	64.5	61.5	58.7	56.2	53.9	15	51.7
t ₂₁	t _{DS} : Data setup to CAS*	24.6	23.4	22.3	21.3	20.3	0	19.5
t ₂₂	t _{DH} : Data hold from CAS*	27.6	26.4	25.3	24.3	23.3	15	22.5
t ₂₃	t _T : Transition time	2.0	2.0	2.0	2.0	2.0	3	2.0
t ₂₅	t _{RAS} : (standard RAS*)	93.1	88.9	85.0	81.5	78.2	70	75.2
t ₂₅	t _{RAS} : (extended RAS*)	104.4	99.6	95.2	91.1	87.4	70	84.0
t ₂₆	t _{CAS} : CAS*	29.6	28.4	27.3	26.3	25.3	20	24.5
t ₂₇	Read data to CAS* high	0.0	0.0	0.0	0.0	0.0	–	0.0
t ₂₈	Read data from CAS* high	10.0	10.0	10.0	10.0	10.0	0	10.0
t ₂₉	t _{PC} : Page-mode cycle	53.2	50.8	48.6	46.6	44.7	45	43.0

With an MCLK frequency of 44.7 MHz, a single parameter would be violated. The importance of this violation must be examined on a case-by-case basis. The parameter violations are summarized in Table B19-6.

Table B19-6. Parameter Violation Summary

Symbol	Parameter	Required	Available	Difference
t_{29}	t_{PC} : Page-mode cycle	45 MHz	44.7 MHz	0.7%

Appendix B20

Memory-Mapped I/O

MEMORY-MAPPED I/O

1. INTRODUCTION

The CL-GD5429 (only) allows application programs to access the BLT-control registers as memory locations. This can be up to four times faster than using I/O accesses, particularly when multiple registers must be changed at once. The register address is implied in the address rather than being transferred as part of the data (the Index field). This doubles the data transfer rate at once. Since DWORD transfers are allowed, the data transfer rate is doubled again.

Memory-mapped I/O is enabled when SR17[2] is programmed to a '1'. GR6[3:2] must be programmed to '0,1'. This means that if the CL-GD5429 is not programmed for Linear Addressing, the window into display memory is 64K (A000:0 to AFFF:F).

If SR17[6] is programmed to a '0', a block of 256 bytes of memory address space is reserved beginning at B800:0. If SR17[6] is programmed to a '1', *and* linear addressing is enabled, a block of 256 bytes of memory address space is reserved at the end of the 2 Mbyte linear address space. In this case, the block appears at the end of the 2 Mbyte space regardless of the amount of DRAM actually installed.

Memory-mapped I/O can be done using BYTE, WORD, or DWORD cycles. Memory-mapped Read cycles are valid only for the BLT Status register (GR31). Memory-mapped I/O and normal I/O cannot be mixed.

The Table B20-1 indicates the registers that are accessible using memory-mapped I/O. Alternate doublewords are shaded to make it more easy to determine which registers are grouped together by virtue of being in a common doubleword.

Table B20-1. Memory-mapped I/O Registers

Offset (Hex)	Register	Description
00	GR0	Background Color Low Byte
01	GR10	Background Color High Byte
02	–	Reserved
03	–	Reserved
04	GR1	Foreground Color Low Byte
05	GR11	Foreground Color High Byte
06	–	Reserved
07	–	Reserved
08	GR20	BLT Width Low
09	GR21	BLT Width High
0A	GR22	BLT Height Low
0B	GR23	BLT Height High
0C	GR24	BLT Destination Pitch Low
0D	GR25	BLT Destination Pitch High
0E	GR26	BLT Source Pitch Low
0F	GR27	BLT Source Pitch High
10	GR28	BLT Destination Address Low
11	GR29	BLT Destination Address Mid
12	GR2A	BLT Destination Address High
13	GR2B	Reserved
14	GR2C	BLT Source Address Low
15	GR2D	BLT Source Address Mid
16	GR2E	BLT Source Address High
17	GR2F	BLT Destination Write Mask
18	GR30	BLT Mode
19	–	Reserved
1A	GR32	BLT Raster OP
1B–3F	–	Reserved
40	GR31	BLT Start/Status (R/W)
41–FF	–	Reserved

Appendix B21

Power Management

POWER MANAGEMENT

1. INTRODUCTION

The CL-GD542X family of graphics controllers feature comprehensive PC power management functions that support compliance with the United States Environmental Protection Agency's Energy Star Computer Program, a voluntary program that promotes energy efficient technology for desktop computers. Compliance with the Energy Star Program will be a qualification for federal government purchases of computers, monitors, and printers.

The purpose of this appendix is to describe the methods used in the CL-GD542X family to comply with Energy Star.

Some of the methods described in this appendix involve programming registers in the CL-GD542X. If the application program does reprogram registers, it *must* first save the register contents so that it can subsequently restore them. In addition, it may be necessary to unlock the extended registers.

2. DISPLAY POWER MANAGEMENT SIGNALING - DPMS

The method by which the greatest power savings can be obtained is by putting the monitor into a low-power mode. This requires, of course, that the monitor respond to DPMS (Display Power Management Signal).

The VESA (Video Electronics Standards Association) DPMS proposal defines four levels of Display Power, as shown in the following table.

Table B21-1. VESA® DPMS Proposal States

Name	Definition	HSYNC	VSYNC	Note
On	Full operation	Active	Active	
Standby	Optional state of minimal power reduction	Inactive	Active	CL-GD5429 only
Suspend	Significant reduction of power consumption	Active	Inactive	
Off	Lowest level of power consumption	Inactive	Inactive	

The CL-GD542X family is compliant with the VESA Display Power Management BIOS Extensions, VBE/PM. These calls are described in the sections that follow.

2.1 Report VBE/PM Capabilities

Input:	AH = 4fh	VESA Extension
	AL = 10h	VBE/PM Services
	BL = 00h	Report VBE/PM Capabilities
	ES:DI	Null pointer, must be 0000:0000h Reserved for future use
Output:	AX =	Status
	BH =	Power saving state signals supported by the controller (Note 1) 1 = supported, 0 = not supported
	Bit 0	STAND BY
	Bit 1	SUSPEND
	Bit 2	OFF
	Bit 3	REDUCED ON (intended for flat panel displays)

NOTES

- 1) The attached display may not support all the power states that can be signaled by the controller. It is the responsibility of the power management program to determine the power saving states that are offered by the controller. If the controller has means of determining which power saving state is implemented in the attached display device, that function reports the power saving states which are supported by both the controller and the display.

The CL-GD5422/24/26/28 support SUSPEND and OFF. In addition, the CL-GD5429 supports STAND-BY.

2.2 Set Display Power State

Input:	AH = 4fh	VESA Extension
	AL = 10h	VBE/PM Services
	BL = 01h	Set Display Power State
	BH =	Requested Power state
	00h	ON
	01h	STAND BY
	02h	SUSPEND
Output:	04h	OFF
	08h	REDUCED ON (intended for flat panel displays)
	AX =	Status: If the requested state is not available, this function will return AX = 14h to indicate that the function is supported but the call failed. The BH register and Display Power State shall be left unchanged in this case.
	BH =	Unchanged

2.3 Get Display Power State

Input: AH = 4fh VESA Extension
 AL = 10h VBE/PM Services
 BL = 02h Get Display Power State

Output: AX = Status: If this function is not supported by the controller hardware, AL = 01 should be returned in the status.

BH = Power state currently requested by the controller

00h	ON
01h	STAND BY
02h	SUSPEND
04h	OFF
08h	REDUCED ON (intended for flat panel displays)

3. POWER MANAGEMENT HARDWARE BITS (CL-GD5425/'29 only)

The following descriptions indicate how the VGA controller chip can be put into a reduced-power mode. Placing the device in reduced-power mode has system implications. When the chips are in reduced-power mode, accesses to the display and palette memory will not produce reliable results and must *not* be attempted.

The CL-GD5425/'29 have bits in Extension register GRE that are intended for power management. These are shown in the diagram below. Note that other bits in this register may perform other functions. See Chapter 9 for a complete description of register GRE.

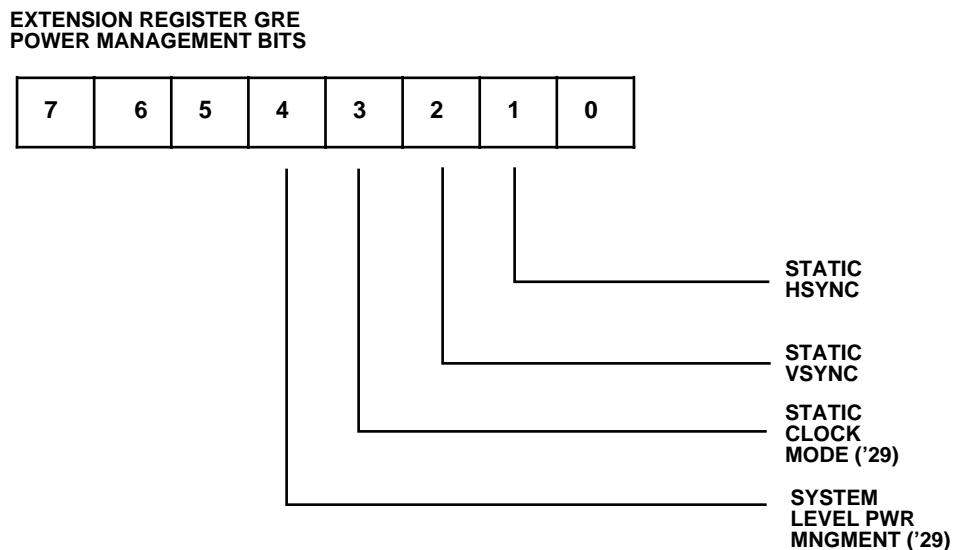


Figure B21-1. Register GRE Power Management Bits

GRE[4] (CL-GD5429 only) is used in conjunction with GRE[3]. When this bit is programmed to '1', host access to display memory and screen refresh are disabled. This bit must be programmed to '1', prior to programming bit 3 to '1'.

- When GRE[3] is programmed to '1', the CL-GD5429 is switched to Static Clock mode. This does the following:
 - Screen refresh is turned off
 - VCLK is turned off
 - MCLK is turned off. This action, along with turning off VCLK, results in zero dynamic power.
 - DRAM refresh continues
 - DAC is powered-down

When GRE[2] is programmed to '1', the VSYNC output will be static. The level will be as programmed in MISC[7]. In addition, the DAC will be powered-down. This bit is available on both the CL-GD5425 and CL-GD5429.

When GRE[1] is programmed to '1', the HSYNC output will be static. This bit, in conjunction with GRE[2], provides for direct programming of the DPMS states previously described. The level will be as programmed in MISC[6]. In addition, the DAC will be powered-down. This bit is available on both the CL-GD5425 and CL-GD5429.

4. POWER MANAGEMENT HARDWARE BITS (CL-GD5422/'24/'26/'28)

The following descriptions indicate how the VGA controller chip can be put into a reduced-power mode. This is independent of putting the monitor into a power-down state and has system implications. When the chips are in low-power mode, accesses to the display and palette memory will not produce reliable results and must *not* be attempted.

4.1 DAC Power-Down

The DAC can be put into a power-down state by programming the Hidden DAC register to C7h. The CL-GD5429 also supports this.

4.2 Video Clock/Display Memory Refresh

The video clock can be reduced to as low as 3.46 MHz and the DRAM refresh can be reduced to 5 cycles every 4.6 μ sec, without losing the contents of display memory. This reduces the power in the display memory array and also reduces the power in the controller chip. The following steps are involved:

1. Divide DCLK by two and select 8 pixels-per-character
 - Program SR1 to 29h.
2. Select VCLK0
 - Program MISC[3:2] to 00h.
3. Set VCLK0 to 3.48 MHz
 - Program SR0B to 0fh.
 - Program SR1B to 3fh.
4. Unlock Horizontal Timing and select 5 refresh cycles-per-scanline
 - Program CR11 to 40h.
5. Set Horizontal Total to 14 character clocks

- Program CR0 to 09h.
- 6. Set other horizontal parameters to be consistent with HTOTAL of 16
 - Program CR1 to 02h
 - Program CR4 to 03h
 - Program CR5 to 02h

4.3 Memory Clock

MCLK can be reduced to as low as 7.14 MHz. This reduces the power in the device. Program SR1F to 04h.

Appendix B22

CL-GD5425 Notes

CL-GD5425 NOTES

1. INTRODUCTION

This appendix discusses the unique features of the CL-GD5425. It is assumed that the reader is familiar with the CL-GD542X family of graphics controllers and television broadcast standards.

2. OVERVIEW

The CL-GD5425 is based on the CL-GD5424 and includes TV-output and YCrCb (and AccuPak™) support. TV-output support integrates line-locked subcarrier generation, flicker reduction, and scaling into the VGA core for low-cost, high-quality TV output.

The CL-GD5425 is pin-compatible with all other members of the CL-GD542X VGA family. Typically, a new board layout is required since a TV encoder is required to take full advantage of the capabilities of the CL-GD5425.

The CL-GD5425 can be combined with a single 256K × 16 DRAM, an analog TV encoder, and optional BIOS EPROM (all 'jelly-bean' components) to implement a complete set-top graphics system.

3. TV OUTPUT SUPPORT

The most-significant capability of the CL-GD5425 is NTSC/PAL TV output. The MA[9] pin outputs composite sync for either NTSC or PAL; the BLANK* pin outputs the Color Carrier reference. These pins and the RGB outputs directly drive the analog TV encoder chips that produce composite video, S-video, or both.

3.1 Pins Redefined for TV Modes

The following pins are redefined when the CL-GD5425 is configured and programmed for TV output.

Pin Name	Pin Number	TV Function	Note
OSC	159	Secondary frequency reference	Not required for single-format solutions
XTAL	158	Primary frequency reference	14.3 MHz or 17.7 MHz
MA[9]	143	Composite sync out	CSYNC to encoder
ESYNC*	95	Encoder control	NTSC/PAL mode select
BLANK*	93	Color Carrier reference	fsc to encoder
OE*	141	ODD/EVEN field indicator	

The MA[9] pin is redefined as composite sync, and the BLANK* pin is redefined as the Color Carrier reference. ESYNC* is redefined as a static-programmable output that can be used to select PAL or NTSC encoder operation. Most applications are only for one TV standard and the encoder is hard-wired for that standard. In this case, ESYNC* can be used for any desired control purpose. These three outputs provide a glueless connection to standard analog encoders.

3.2 Reference Frequencies for TV Modes

Table B22-2 indicates the reference frequencies that must be used.

Table B22-2. Reference Frequencies

TV Format(s)	XTAL (pin 158)	OSC (pin 159)	MD16	Note
NTSC only	Parallel resonant crystal at 14.31818 MHz with 20-pF load capacitance		No pull-down	Osc could drive OSC pin
PAL only	Parallel resonant crystal at 17.734476 MHz with 20-pF load capacitance		No pull-down	Osc could drive OSC pin
NTSC/PAL	14.31818-MHz Osc	17.734476-MHz Osc	Pull-down	AB or later silicon

All CL-GD542X VGA controllers have a dual-frequency synthesizer that uses a 14.31818-MHz reference for all graphics and memory timing signals (see Appendix B8, “Clock Options”). The NTSC video standard and its associated color subcarrier can be easily derived from this reference. The PAL standard requires signal timing and a color subcarrier that must be derived from a 17.734476-MHz reference.

NOTE: SECAM differs from PAL only in encoding methodology and requires the same signal timing. If an NTSC-only system is being designed, no changes in reference frequency or register programming are required. No pull-down is installed on MD16. Due to tolerance requirements, a different type of crystal may have to be specified; see the discussion of crystal types in the ‘Crystal Specifications’ section.

CAUTION: The 14.318-MHz signal on the ISA bus is unlikely to have either the required accuracy or stability and should not be used.

If a PAL-only (or SECAM) system is being designed, a 17.734476-MHz reference is required. No pull-down is installed on MD16. The board design is the same as an NTSC-only design (assuming the reference was not taken from the ISA bus). Since all graphics and memory timing is derived from this reference, the VCLK and MCLK divider values need to be changed to reflect the different reference. The registers that contain these dividers are Cirrus Logic extension registers and will be correctly programmed by the BIOS (this change is made using the OEMSI utility). No changes to any of the standard VGA registers are required.

If a system that supports both NTSC and PAL is being designed, two external TTL or CMOS oscillators are required. A pull-down is installed on MD16 to configure the CL-GD5425 for dual-oscillator mode. The 17.734476-MHz reference is driven into OSC (pin 159); the 14.31818-MHz reference is driven into XTAL (pin 158). This configuration allows the CL-GD5425 to generate either NTSC or PAL timing. Since the VGA and memory timing are always derived from the 14.318-MHz reference in this configuration, no BIOS changes are required.

Both NTSC and PAL require very accurate and very stable frequency sources to encode the color component. If the color subcarrier, which is derived from the VGA clock source, is not both accurate (± 10 Hz for NTSC, ± 1 Hz for PAL) and stable, the image is displayed in monochrome. This is because either the encoder fails to properly encode the color content, or the TV is unable to decode the color information.

Crystal Specifications

This accuracy requirement has implications for crystal selection. Most VGA designs use a 'series-resonant' crystal. If a series-resonant crystal is used with the Cirrus Logic synthesizer, it operates slightly off-frequency. With a 14.31818-MHz crystal, the error will be approximately 2–3 kHz, not enough to be noticed on a VGA monitor but enough to prevent most TVs from decoding the color component.

The proper crystal type is 'parallel-resonant'. A parallel-resonant crystal requires that the load capacitance be specified. This is actually part of the crystal specification. The correct load capacitance can be calculated using the following equation.

$$CL = \left(\frac{C1 \times C2}{C1 + C2} \right) + C_{Stray}$$

Using standard 27 pF capacitors and assuming a 10–15 pF stray capacitance, is calculated to be approximately 20 pF. Therefore, the proper specification for an NTSC system is a parallel-resonant crystal at 14.31818 MHz with a load capacitance of 20 pF. The proper specification for an PAL/SECAM system is a parallel-resonant crystal at 17.734476 MHz with a load capacitance of 20 pF.

Parallel resonant crystals can be tuned by adjusting the external capacitors. If very accurate color encoding is required, one of the 27-pF capacitors can be replaced with a 15–35-pF trimmer capacitor and the frequency can be adjusted at final test time.

Alternatively, an external TTL or CMOS crystal oscillator can be used. Cirrus Logic has observed that 25-ppm oscillators provide satisfactory results.

CAUTION: The 14.318-MHz signal on the ISA bus is unlikely to have either the required accuracy or stability and should not be used.

3.2.1 NTSC Timing

Table B22-3 indicates timing that will be generated for NTSC. Any error in the 14.31818-MHz reference will scale.

Table B22-3. NTSC Timing Parameters

Parameter	Generated	NTSC Specification
4x fsc (color sub-carrier)	14.31818 MHz	14.31818 MHz (± 40 Hz)
Horizontal frequency	15.734 kHz	15.734 kHz
Horizontal sync pulse width	4.65 μ sec.	4.65 μ sec. (± 0.1 μ sec.)
Equalizing sync pulse width	2.32 μ sec.	2.3 μ sec. (± 0.1 μ sec.)
Horizontal blanking	11.04 μ sec.	10.9 μ sec.
Viewable pixels	640 \times 400	n/a

The CL-GD5425 generates NTSC-compatible composite sync during Vertical Retrace. For specific timing diagrams refer to Chapter 3, "Data Book".

3.2.2 PAL Timing

Table B22-4 indicates timing that will be generated for PAL. Any error in the 17.734475 MHz reference will scale.

Table B22-4. PAL Timing Parameters

Parameter	Generated	PAL Specification
4x fsc (color sub-carrier)	17.734476	17.734475 (± 4 Hz)
Horizontal frequency	15.62508 kHz	15.62500 kHz
Horizontal sync pulse width	4.65 μ sec.	4.65 μ sec. (± 0.1 μ sec.)
Equalizing sync pulse width	2.26 μ sec.	2.3 μ sec. (± 0.1 μ sec.)
Horizontal blanking	12.4 μ sec.	12.0 μ sec.
Viewable pixels	640 \times 480	n/a

The CL-GD5425 generates PAL-compatible composite sync during Vertical Retrace. For specific timing diagrams refer to Chapter 3, "Data Book".

3.3 Modes Supported for TV Output

When configured for VGA output, the CL-GD5425 supports all modes supported by the CL-GD5424 subject to display memory requirements. When configured for TV output, the CL-GD5425 supports most standard VGA modes plus three extended modes. The supported modes are enumerated in Table B22-5. For further details of the video modes supported, refer to Tables 4-3 and 4-4 in Chapter 3, "Data Book".

Table B22-5. CL-GD5425 Video Modes

Mode No	Colors	Resolution	Note
0,1	16/256K	40 × 25 Chars.	Text mode
2,3	16/256K	80 × 25 Chars.	Text mode
4,5	4/256K	320 × 200	
6	2/256K	640 × 200	
0D	16/256K	320 × 200	
0E	16/256K	640 × 200	
10	16/256K	640 × 350	
12	16/256K	640 × 480	
13	256/256K	320 × 200	
5F	256/256K	640 × 480	
64	64K	640 × 480	1-Mbyte display memory
7A	64K	640 × 400	

3.4 Expansion/Scaling

NTSC formats can display 200 (or 400 interlaced) scanlines in the underscan area; PAL format can display 240 (or 480 interlaced) scanlines in the underscan area. VGA modes have various numbers of scanlines, specifically 200, 350, 400, and 480. It is not practical to change the TV format to any large extent, or to change the video modes at all. The CL-GD5425 must convert the number of scanlines in the video mode to the number of scanlines supported by the TV format. This is done by replicating or expanding scanlines in a regular pattern. When scanlines are replicated (for example, an increase from 350 to 400) this is called 'expansion'. For 480-line modes on NTSC (400 lines), the CL-GD5425 uses a smooth scaling and flicker-filter process (see Section 3.8) to scale the video 6:5.

Table B22-6. NTSC/PAL Expansion and Scaling

Scanlines In VGA Mode	NTSC	PAL
200	–	5:6 expansion
350	7:8 expansion	5:7 expansion yields 490 lines
400	–	5:6 expansion
480	6:5 scaling	–

3.5 Color Subcarrier Reference Output

BLANK* is used to output the Color Subcarrier reference to the color encoder. It will be either the selected input reference frequency (14.318 or 17.734 MHz) or the input reference frequency divided by two or four. The choice among the reference frequency (or submultiples) is made according to the requirements of the encoder. Refer to the table in the description of register CR30 in Chapter 9, “Extension Registers”.

3.6 Encoders Supported

The CL-GD5425 can be used with inexpensive analog NTSC/PAL encoders. No glue logic is required; the connection is pin-to-pin. The color subcarrier reference for the encoder is output on the BLANK* pin. The CL-GD5425 interfaces with any of the commercially available encoders listed in Table B22-7.

The CL-GD5425 has been tested only with the Sony® CXA1645 and the Analog Devices® AD720. Refer to the respective encoder application note for specific information about the digital and analog power supplies, and other requirements and sensitivities regarding individual inputs or outputs.

Table B22-7. CL-GD5425 Supported Encoders

Vendor	Part Number
Sony®	CXA1645/CXA1145
Analog Devices®	AD720/AD722
Motorola®	MC1377/MC1378
Phillips®	TDA8501
Phillips®	TDA8505 (SECAM only)

3.7 Encoder Application and Layout Considerations

The CL-GD5425 outputs all required signals to connect to most analog RGB-to-NTSC/PAL encoders. The CL-GD5425 outputs a reference time base signal, which can be a multiple of the color subcarrier used in the system.

The CL-GD5425 also outputs a composite sync signal that is a combination of the horizontal and vertical timing signals with a sequence of equalization pulses. The composite signal is derived from the reference oscillator and is phase-locked to it.

The CL-GD5425 can be configured to add a 7.5 IRE black level offset to the RGB outputs. This option should be disabled for encoders that add black level to the incoming RGB. Additionally, a pin can be programmed to control one alternate signal to the encoder.

3.7.1 Noise Reduction

A properly designed, low-impedance analog ground plane is important to provide good grounding for decoupling noise on the positive supply voltage. The analog ground plane also provides a low noise reference for low-level analog signals. The power supply plane should be filtered from the PC power-supply noise. Normally, an RC or a second-order (LC) filter is sufficient.

The AD720 encoder is prone to high-frequency noise on the reference input and requires an RC filter. Because the CXA1645 is prone to high frequency noise, RC filters are required on the reference clock and sync inputs. The outputs of the CXA1645 encoder are very sensitive to ringing. The effect is minimized with careful layout design.

To meet FCC requirements, it is crucial that the ground plane have the lowest possible impedance. Place an LC filter using a ferrite bead and capacitor on the composite signal on the RCA jack and the Luma and Chroma signals on the S-video connector. The S-video connector can be wired so the shield ground is separate from the signal ground returns. If this is the case, the ground returns can also be filtered using the LC filter as described above. The RCA jack has a common signal/shield ground that cannot be separated.

Encoders that support both NTSC and PAL have a control input that switches between the video standards. Some encoders, such as the Analog Devices AD722, have a control input which can enable/disable the encoding function. Proper programming of the EEPROM control register (SR8[4]) can control one encoder function through the ESYNC* pin. If the board is designed for a dual standard use, this programmable signal can be used to switch the encoding standard (NTSC or PAL). The Cirrus Logic evaluation board is designed in this manner. Use the extended BIOS function B0 to program the encoder to switch standards. If the board is designed for NTSC or PAL through manufacturing stuffing options, a jumper can be used to select the standard while the programmable pin disables the encoder.

3.7.2 Coupling Capacitors

Most encoders have high-impedance RGB inputs. In these encoders, 0.1- μ F input coupling capacitors are required. Older encoders, such as the MC1377 and MC1378, require 10- μ F tantalum capacitors to couple the 60-Hz vertical component. The AD722 has high-impedance inputs and built-in coupling capacitors, which do not require any external components. Encoders normally clamp the RGB black level after the coupling capacitors during horizontal sync time. In more sophisticated encoders, the black level is clamped to the black level present during burst. The signal used to clamp is called 'burst gate', and is very useful for video mixing and video signal processing.

3.7.3 Limiting Bandwidth

The VGA RAMDAC bandwidth exceeds NTSC specification. The Analog Devices and Philips encoders filter the U and V components individually after the RGB encoding matrix. The Sony CXA1645 band-pass filters the Chroma internally and provides additional pins to control the amount of filtering on the Luma output. It is necessary to low-pass filter the Luma output in order to attenuate Chroma information in the Luma band. A low-pass or band-stop filter can be used. The Analog Devices and Phillips encoders internally filter the video before the output buffer.

Older encoders, such as the MC1377 and CXA1145, do not limit the bandwidth of the video signal. These encoders, supply pins for bandwidth limiting circuits and delay lines to be externally applied to the Chroma and Luma paths. However, a delay is introduced when filter elements are inserted into the chroma path. As a result, an external delay line is required in the Luma path for the Chroma and Luma components to align. The CXA1645 uses one external 20-k Ω 1% resistor to adjust the Luma delay for NTSC. For PAL, the resistor should be 16-k Ω . The TDA8501 requires an external delay line, the AD720 and AD722 delay the Luma internally. The MC1377 and MC1378 can be run with no external filter or delay components; but, the cost will be cross-Luma and cross-Chroma artifacts. This may be acceptable in some applications.

3.7.4 Subcarrier Reference Frequency

Establishing the correct horizontal frequency is critical when encoding NTSC video from VGA RGB. In NTSC video, there is a mathematical relationship between the horizontal, vertical, and subcarrier frequencies. Any deviation introduces artifacts into the video that commonly manifest as banding in the Luma component. Register CR1C in the CL-GD5425 has a programmable field, Horizontal Total Adjust, to adjust the horizontal total by ± 4 VCLKS. This controls the horizontal frequency to the VCLK resolution. By programming the VCLK frequency so that an integral number of VCLK cycles occurs in 910×14.318 -MHz reference clock cycles, the horizontal frequency can be correctly programmed. This also enables scaling in the horizontal direction.

The mathematical relationship of the subcarrier frequency to the horizontal frequency in PAL video is more complex. PAL contains a 100-Hz frequency offset. In PAL mode, there is neither the dynamic range nor the resolution to achieve the 100-Hz offset in the PLL and the divisor circuit, therefore horizontal frequency cannot be exactly programmed.

Analog RGB encoders require a subcarrier reference input to generate burst and modulate the color information. The reference signal to the encoder is derived from the 14.318-MHz oscillator reference and is a multiple of the 3.579545-MHz NTSC subcarrier frequency. Certain encoders use this frequency internally to sample the sync inputs. Different encoders need different reference frequencies: the CXA1645, MC1377, and TDA8501 require $1\times$ or 3.579 MHz; the AD720 requires $4\times$ or 14.318 MHz.

3.8 Flicker-filter Processing

Flicker-filter is a process that reduces the apparent flicker caused by interlaced video. Since individual scanlines are refreshed as seldom as 25 times per second (PAL format), significant flicker can be observed when there are sharp vertical brightness changes. Flicker-filter reduces the apparent flicker at the expense of some loss of vertical image quality. The CL-GD5425 uses a proprietary method of reducing flicker while maintaining most of the vertical image quality. The software supports three settings of flicker-filter. When flicker-filter is enabled the top 32 Kbytes of display memory are reserved.

3.9 TV Operation with and without a VGA Monitor Connected

If a pull-down resistor is installed on MD29 (CF13), a programmable adjustment in the DAC full scale current output is enabled. This simplifies the RGB outputs to the TV encoder under the two cases of a VGA monitor connected or not connected, while still supporting monitor sensing.

GRE[5] is programmed to adjust the full scale current (keeping the voltage to the encoder constant). The following table summarizes the cases.

TV Display	VGA Monitor Connected	Load	CR30[3]	GRE[5]	Peak Output	Note
Active	Yes	37.5 Ω	1	1	0.95 V	VGA disabled (GRE[2:1] = 11)
Active	No	75 Ω	1	0	0.95 V	
Inactive	Yes (active)	37.5 Ω	0	1	0.70 V	TV-out disabled (CSYNC is low)

There are two cases that can result in an out-of-specification voltage appearing in the system:

1. If the VGA monitor is connected, but the CL-GD5425 is switched to TV-out mode, the monitor detects 0.95 V on the RGB inputs.
2. If TV-out mode is enabled and the monitor gets disconnected, the encoder detects 1.9 V on the RGB inputs until the current reference is changed. There is no automatic method to lower the current reference. Until reprogrammed, the TV display is very bright.

If either of these cases is possible, and the resulting out-of-specification voltage is unacceptable, disable this feature by not installing a pull-down resistor on MD29.

4. MODE 13X

4.1 Introduction

Mode 13X is a group of video modes used by DOS games to provide 256 colors at greater than 320×200 pixels. This mode is not compatible with the 'official' VGA mode 13. Mode 13X combines the 256 clocking mode (see GR5[6]) with system memory access of mode 12h (planar).

4.2 Vertical Resolution Changes

The vertical size is often changed from 200 to 240 lines (if double-scan is turned off, this means changing the vertical size from 400 to 480 lines). The scaling or expansion requirements are different for each vertical size, and the CL-GD5425 must automatically (silently) respond for TV vertical size compatibility. The CL-GD5425 detects attempts to change the vertical size and automatically selects the proper scaling or expansion. The CRTC registers must be locked with GRE[7] to enable this feature. The initial mode set by the BIOS always starts with the correct vertical adjust (for the 'raw' mode).

4.3 Mode 13X Horizontal Adjust for 360-Pixel Resolution

Another variation of mode 13X is to select VCLK1 (28 MHz) and change the horizontal display size to 90 character clocks. This provides a 256-color horizontal resolution of 360 pixels. For compatibility, the CL-GD5425 has secondary (or alternate) registers.

Register	Name	Hardwired?
CR0	Horizontal Total	Yes
CR4	Horizontal Sync Start	No
CR1C[5:3]	Horizontal Total Adjust	Yes

These alternate registers are automatically selected whenever VCLK1 is used in TV-out mode. This is determined by programming the following three fields to the indicated values.

Field	Value	Note
MISC[3:2]	'x1'	VCLK1 (28 MHz)
GRE[7]	'1'	Write-protect Timing registers
CR30[3]	'1'	TV-out enable

For flexibility in centering the screen, the alternate CR4 (Horizontal Sync Start) is unlocked when $CR30[3] = 1$, $GRE[7] = 0$, and $MISC[3:2] = x1$. Finally, CR1 (Horizontal Display End) is not write-protected when $CRE[7]$ is programmed to '1'.

The following register settings are recommended for 360 pixel, 256-color mode.

Register	NTSC		PAL	
VCLK	30.839156	$56/26 \times \text{Reference}$	34.468952	$40/20 \times \text{Reference}$
alt-CR0	75h	980 pixels; 122 clocks	89h	1135 pixels; 142 clocks
alt-CR1C[5:3]	111b	+ 4 pixel clocks	011b	–1 pixel clock
alt-CR4	5Fh	(Horizontal Sync Start)	60h	(Horizontal Sync Start)
SR0B	38h	$(56/26) \times 14.3$	28h	$(40/20) \times 17.7$
SR1B	34h	–	28h	–

5. MULTIMEDIA FEATURES

The CL-GD5425 supports two video modes not supported by other members of the CL-GD542X family: YCrCb and AccuPak. AccuPak support will be defined in a future revision of this manual.

5.1 YCrCb Support

The CL-GD5425 supports YCrCb 4:2:2 mode (as defined in CCIR 601). In this mode, each two-pixel unit is stored as a DWORD containing luminance for each pixel and chrominance for alternate pixels. When YCrCb is displayed, the chrominance values are used for both pixels.

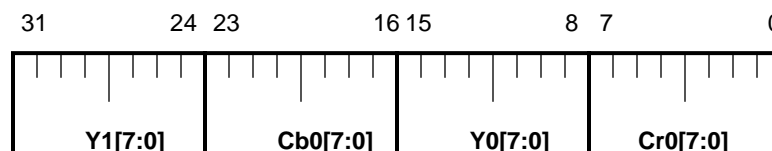


Figure B22-1. YCrCb

5.2 Overlay Modes

The CL-GD5425 supports the same overlay modes as the CL-GD5429. For more information on these modes, refer to the *True Color VGA Family — CL-GD542X Technical Reference Manual*.

5.3 DAC Modes

The CL-GD5425 supports four new DAC modes allowing the DAC to switch between two extended modes, instead of between VGA palettized and a single extended mode.

- DAC mode 1010: The primary display mode is 15-bit RGB (5-5-5). The Switch signal changes the DAC to YCrCb. If SR18[6] is programmed to '0', the overlay data is taken from P[7:0] with a 2× DCLK. If SR18[6] is programmed to '1', the overlay data is taken from display memory (only the DAC mode is changed). CR1D[2:1] must be programmed to '0,0' to use this mode.
- DAC mode 1011: The primary display mode is 16-bit RGB (5-6-5). The Switch signal changes the DAC to YCrCb. If SR18[6] is programmed to '0', the overlay data is taken from P[7:0] with a 2× DCLK. If SR18[6] is programmed to '1', the overlay data is taken from display memory (only the DAC mode is changed). CR1D[2:1] must be programmed to '0,0' to use this mode.
- DAC mode 1100: The primary display mode is 15-bit RGB (5-5-5). The Switch signal changes the DAC to AccuPak. SR18[6] must be programmed to '0'; the overlay data is taken from P[7:0]. CR1D[2:1] must be programmed to '0,0' to use this mode.
- DAC mode 1101: The primary display mode is 16-bit RGB (5-6-5). The Switch signal changes the DAC to AccuPak. SR18[6] must be programmed to '0'; the overlay data is taken from P[7:0]. CR1D[2:1] must be programmed to '0,0' to use this mode.

6. 640 × 480 NTSC 'OVERSCAN' IN MODES 5F AND 64

The full NTSC non-blank period can be filled with active video while preserving the display aspect ratio in the VESA compatible resolution of 640 × 480. This is useful when producing animation intended for output to a VCR for later playback on TV. The 'overscan' screen would be compatible with the normal TV picture that never has a 'border'. The following table shows the BIOS changes.

Register	Name	Value	Note
CR0	Horizontal Total	5Ch	780 dots; 97 character clocks
CR1C[5:3]	Horizontal Total Adjust	111b	An adjustment of +4 pixel clocks
CR4	Horizontal Sync Start	50h	—
CR30[1:0]	Scaling Control	00b	480-400 scaling off
CR30[5:4]	Flicker-filter Control	xxb	Flicker-filter Optional
CR12	Vertical Display End	EFh	240 scan lines
CR10	Vertical Sync Start		Adjust for vertical centering
SR0B	Numerator	30h	48/28 × 14.31818 MHz
SR1B	Denominator	38h	—

7. NTSC COMPOSITE OUTPUT

The color effect caused by the uninterlaced mode (CR1D[0] = 1) can be reduced by changing the VCLK frequency to one that is slightly 'off'. The recommended setting is $48/25 \times 14.31818$ MHz. The synthesizer register values are shown in the following table.

Register	Name	Value
SR0x	Numerator	30h
SR1x	Denominator	32h

8. CRTC PROGRAMMING VALUES

The following tables show how the CRTC registers are intended to be programmed for NTSC and PAL modes. There are three tables each for NTSC and PAL. These tables reflect the actual BIOS programming as of March 1995. Registers not listed should be programmed for standard VGA values.

Table B22-8. NTSC Programming Recommendations

Mode	CR0	CR2	CR3	CR4	CR5	CR6	CR7	CR9
0,1	68h	55h	88h	58h	82h	04h	11h	47h
2,3	68h	55h	88h	56h	9Eh	04h	11h	47h
4,5	68h	55h	88h	57h	81h	04h	11h	41h
6	68h	55h	88h	55h	9Dh	04h	11h	41h
D	68h	55h	88h	57h	81h	04h	11h	C0h
E	68h	55h	88h	55h	9Dh	04h	11h	C0h
10*	68h	55h	88h	55h	9Dh	04h	11h	40h
11/12	68h	55h	88h	53h	9Bh	04h	11h	40h
13	68h	55h	88h	55h	9Dh	04h	11h	C0h
5E*	68h	55h	88h	55h	9Dh	04h	11h	40h
5F	68h	55h	88h	53h	9Bh	04h	11h	40h
64	68h	55h	88h	53h	9Bh	04h	11h	40h
7A*	68h	55h	88h	55h	9Dh	04h	11h	40h

NOTE: When flicker filter is enabled for the modes marked with *, the horizontal sync position in CR4 must be adjusted by -2.

Table B22-9. NTSC Programming Recommendations

Mode	CR10	CR11	CR12	CR15	CR16	CR19	CR1C[5:3]	CR1C[2:0]
0,1	DDh	C6h	C7h	DDh	F1h	1Eh	110b	011b
2,3	DDh	C6h	C7h	DDh	F1h	1Eh	110b	011b
4,5	DDh	C6h	C7h	DDh	F1h	1Eh	110b	011b
6	DDh	C6h	C7h	DDh	F1h	1Eh	110b	011b
D	DDh	C6h	C7h	DDh	F1h	1Eh	110b	011b
E	DDh	C6h	C7h	DDh	F1h	1Eh	110b	011b
10	DDh	C6h	C7h	DDh	F1h	1Eh	110b	011b
11/12	DDh	C6h	C7h	DDh	F1h	1Eh	110b	011b
13	DDh	C6h	C7h	DDh	F1h	1Eh	110b	011b
5E	DDh	C6h	C7h	DDh	F1h	1Eh	110b	011b
5F	DDh	C6h	C7h	DDh	F1h	1Eh	110b	011b
64	DDh	C6h	C7h	DDh	F1h	1Eh	110b	011b
7A	DDh	C6h	C7h	DDh	F1h	1Eh	110b	011b

Table B22-10. NTSC Programming Recommendations

Mode	SR1[3]	SR1[0]	SR0E	SR1E	CR30[1:0]	CR30[5:4]	CR1A[0]	GRE[7]	MISC[3:2]
0,1	1b	1b	32h	34h	00b	00b	1b	1b	11b
2,3	0b	1b	32h	34h	00b	00b	1b	1b	11b
4,5	1b	1b	32h	34h	00b	00b	1b	1b	11b
6	0b	1b	32h	34h	00b	00b	1b	1b	11b
D	1b	1b	32h	34h	00b	00b	1b	1b	11b
E	0b	1b	32h	34h	00b	00b	1b	1b	11b
10	0b	1b	32h	34h	10b	00b, 10b, 11b	1b	1b	11b
11/12	0b	1b	32h	34h	11b	00b, 11b	1b	1b	11b
13	0b	1b	32h	34h	00b	00b	1b	1b	11b
5E	0b	1b	32h	34h	00b	00b	1b	1b	11b
5F	0b	1b	32h	34h	11b	00b, 11b	1b	1b	11b
64	0b	1b	32h	34h	11b	00b, 11b	1b	1b	11b
7A	0b	1b	32h	34h	00b	00b	1b	1b	11b

Table B22-11. PAL Programming Recommendations

Mode	CR0	CR2	CR3	CR4	CR5	CR6	CR7	CR9
0,1	6Ch	55h	8Bh	5Ah	84h	36h	1Dh	47h
2,3	6Ch	55h	8Bh	57h	9Eh	36h	1Dh	47h
4,5	6Ch	55h	8Bh	59h	83h	36h	1Dh	41h
6	6Ch	55h	8Bh	56h	9Dh	36h	1Dh	41h
D	6Ch	55h	8Bh	59h	83h	36h	1Dh	C0h
E	6Ch	55h	8Bh	56h	9Dh	36h	1Dh	C0h
10*	6Ch	55h	8Bh	56h	9Dh	36h	1Dh	40h
11/12*	6Ch	55h	8Bh	56h	9Dh	36h	1Dh	40h
13	6Ch	55h	8Bh	56h	9Dh	36h	1Dh	C0h
5E*	6Ch	55h	8Bh	56h	9Dh	36h	1Dh	40h
5F*	6Ch	55h	8Bh	56h	9Dh	36h	1Dh	40h
64*	6Ch	55h	8Bh	56h	9Dh	36h	1Dh	40h
7A*	6Ch	55h	8Bh	56h	9Dh	36h	1Dh	40h

Table B22-12. PAL Programming Recommendations

Mode	CR10	CR11	CR12	CR15	CR16	CR19	CR1C[5:3]	CR1C[2:0]
0,1	06h	DEh	EFh	05h	1Eh	1Ch	111b	011b
2,3	06h	DEh	EFh	05h	1Eh	1Ch	111b	011b
4,5	06h	DEh	EFh	05h	1Eh	1Ch	111b	011b
6	06h	DEh	EFh	05h	1Eh	1Ch	111b	011b
D	06h	DEh	EFh	05h	1Eh	1Ch	111b	011b
E	06h	DEh	EFh	05h	1Eh	1Ch	111b	011b
10	08h	D1h	F4h	08h	21h	1Ch	111b	011b
11/12	06h	DEh	EFh	05h	1Eh	1Ch	111b	011b
13	06h	DEh	EFh	05h	1Eh	1Ch	111b	011b
5E	06h	DEh	EFh	05h	1Eh	1Ch	111b	011b
5F	06h	DEh	EFh	05h	1Eh	1Ch	111b	011b
64	06h	DEh	EFh	05h	1Eh	1Ch	111b	011b
7A	06h	DEh	EFh	05h	1Eh	1Ch	111b	011b

Table B22-13. PAL Programming Recommendations

Mode	SR1[3]	SR1[0]	SR0E	SR1E	CR30[1:0]	CR30[5:4]	CR1A[0]	GRE[7]	MISC[3:2]
0,1	1b	1b	20h	28h	10b	00b	1b	1b	11b
2,3	0b	1b	20h	28h	10b	00b	1b	1b	11b
4,5	1b	1b	20h	28h	10b	00b	1b	1b	11b
6	0b	1b	20h	28h	10b	00b	1b	1b	11b
D	1b	1b	20h	28h	10b	00b	1b	1b	11b
E	0b	1b	20h	28h	10b	00b	1b	1b	11b
10	0b	1b	20h	28h	11b	00b, 10b, 11b	1b	1b	11b
11/12	0b	1b	20h	28h	00b	00b, 10b, 11b	1b	1b	11b
13	0b	1b	20h	28h	10b	00b	1b	1b	11b
5E	0b	1b	20h	28h	10b	00b, 10b, 11b	1b	1b	11b
5F	0b	1b	20h	28h	00b	00b, 10b, 11b	1b	1b	11b
64	0b	1b	20h	28h	00b	00b, 10b, 11b	1b	1b	11b
7A	0b	1b	20h	28h	10b	00b, 10b, 11b	1b	1b	11b

9. BIOS FUNCTIONS

Three extended BIOS functions have been added for the CL-GD5425. These are described below in the standard BIOS function syntax.

9.1 Get/Set Video Display State

Input: AH = 012h
 BL = B0h
 AL[3:0] = Display Mode
 0000 = VGA
 0001 = NTSC
 0010 = PAL
 0011–1110 = Reserved
 1111 = Preserve Current Setting

AL[7:4] = Flicker Filter
 0000 = No Flicker Filter Reduction
 0001 = Minimal Flicker Filter
 0010 = Maximal Flicker Filter
 0011 = Extreme Flicker Filter
 0100–1110 = Reserved
 1111 = Preserve Current Setting

Output: AL[3:0] = Display Mode
 0000 = VGA
 0001 = NTSC
 0010 = PAL
 0011–1111 = Reserved

AL[7:4] = Flicker Filter
 0000 = No Flicker Filter Reduction
 0001 = Minimal Flicker Filter
 0010 = Maximal Flicker Filter
 0011 = Extreme Flicker Filter
 0100–1111 = Reserved

BL[0] = Horizontal State
 0 = Underscan
 1 = Overscan

BL[1] = Vertical Scaling
 0 = Disabled
 1 = Enabled

BL[7:2] = Reserved

BH[0] = Set Display Mode Function
 0 = Not Supported
 1 = Supported

BH[1] = Set Flicker Filter Function
 0 = Not Supported
 1 = Supported

BH[2] = NTSC Output
0 = Not Supported
1 = Supported
BH[3] = PAL Output
0 = Not Supported
1 = Supported
BH[4] = Horizontal Underscan/Overscan
0 = Not Supported
1 = Supported
BH[5] = Vertical Scaling
0 = Not Supported
1 = Supported
BH[7:6] = Reserved

9.2 Set Horizontal Underscan/Overscan

Input: AH = 012h
BL = B1h
AL = Underscan/Overscan
0 = Normal Underscan Mode
1 = Horizontal Overscan Mode

9.3 Set Vertical Scaling Enable/Disable

Input: AH = 012h
BL = B2h
AL = Enable/Disable
0 = Disable Vertical Scaling
1 = Enable Vertical Scaling

Appendix C1

**Software Support
Application Note**

SOFTWARE SUPPORT

1. INTRODUCTION

The True Color VGA family of controllers is provided with the CL-GD542X VGA BIOS and an extensive set of utilities and software drivers. The following sections briefly describe some of the utilities and software drivers available.

To get an up-to-date list of utilities and software drivers supported, refer to the CL-GD542X True Color VGA BIOS or CL-GD542X Software Drivers Kit. The latest drivers are available on the Cirrus Logic Bulletin Board Service at (510) 440-9080 (refer to Appendix D9 for more information on the Cirrus Logic BBS).

1.1 CL-GD542X VGA SOFTWARE UTILITIES

This section describes the software utilities provided with the CL-GD542X VGA controllers, and explains the function and usage of each.

1.1.1 CLMODE — A CL-GD542X Video Mode Configuration Utility

The CL-GD542X VGA controllers support many more video modes than the original IBM VGA. Some of these extended modes are 132-column Text modes, 800×600 , 1024×768 , and $1280 \times 1024 \times 16/256$ -color Graphics modes, 800×600 Direct-Color, and 640×480 True Color modes. To take advantage of these features, a compatible monitor must be installed, and the proper monitor parameters need to be selected.

The CLMODE utility provides a number of graphics configuration options, all of which are selectable from a menu or by direct keyboard input at the DOS command line. The menu options include:

- Monitor-type selection based on monitor's vertical and horizontal sync frequencies.
- Selection and setting of CL-GD542X VGA BIOS Standard and Extended Video modes.
- Extended Video Mode preview to verify high-resolution modes supported by the video subsystem.
- Selection and setting of video refresh rates for each individual video mode resolution (such as, 640×480 , 800×600 , 1024×768 , and 1280×1024) to match video refresh rates supported by a monitor.

1.1.2 VGA.EXE — RAMBIOS Utility

This VGA.EXE utility is an executable version of the VGA BIOS EPROM code that can be loaded into DOS memory. The VGA.EXE utility allows the VGA BIOS to be executed out of 16- or 32-bit system memory, instead of an 8-bit or 16-bit bus ROM. This permits most operations that use the VGA BIOS to run much faster.

The most noticeable performance boost is in text modes where VGA BIOS character-write and text-scrolling functions are used. Common benchmark programs that can be used to demonstrate this increase in performance are PC Bench™ from Ziff-Davis Publishing Company®, and QA Plus™ from Diagsoft®.

However, most GUI (graphical user interface) applications do not use the BIOS heavily, so actual performance increases vary between applications, and in some cases may not be significant.

Many of the newest '386 and '486 PCs automatically cache (copy into system memory) the VGA BIOS upon booting the machine. This is sometimes called 'Shadow RAM'. In this case, the BIOS is already executing out of 16- or 32-bit memory, and the VGA.EXE utility is not necessary.

The VGA.EXE utility can be executed from the command line or inserted in the AUTOEXEC.BAT. The utility will then automatically install itself in system memory at the correct address, shortly after power-on or a warm-boot.

The RAMBIOS utility only works with MS-DOS or PC-DOS, and does not work with OS/2™, Unix®, or Xenix®.

1.1.3 OEM System Integration (OEMSI) Utility

The OEMSI (OEM System Integration) utility enables the Cirrus Logic VGA BIOS to be customized to system requirements. Since the OEMSI operates upon the binary (executable) image of the BIOS, source code is no longer necessary for customization. Several different derivative BIOSes can easily be generated from the same core, which reduces maintenance problems and simplifies software-generation control. If OEMSI is used, the RAM BIOS should not be shipped since its use would override the changes.

A wide range of parameters, default values, and tables can easily be modified or replaced using the OEMSI program. The following components of the Cirrus Logic VGA BIOS can be modified with the OEMSI program:

Sign-on message. In addition to the Cirrus Logic copyright notices displayed when the system boots up, custom copyright messages may be inserted. The positioning of the cursor, after the copyright messages have been displayed, can also be changed.

Display-type configuration. The standard mechanism can be chosen, in which the display type is determined by reading software-configuration switches, or by a software interrupt 15H call.

Hardware Configuration Registers. The CL-GD542X VGA BIOS hardware configuration table includes register values that are programmed at POST. This allows customizing of register values that program video dot clocks, memory clocks, and other programmable settings.

Video Mode parameter tables. These tables contain the complete set of register values for each Standard and Extended Video mode. Values for both the Standard VGA registers and Cirrus Logic Extension registers are contained in the tables.

Font tables. All fonts used by the Cirrus Logic VGA BIOS can be modified or completely replaced by using the OEMSI utility. A flexible scheme is implemented, whereby font tables can be exported from the binary image of the BIOS or imported to it.

1.1.4 SETRES Utility

The SETRES utility is a Windows application that can be used to conveniently set the resolution and number of colors of the display. It is intended primarily for end users who will be changing the resolution fairly often.

1.2 CL-GD542X VGA Software Drivers

A number of text and graphics device drivers are available to enhance the operation of VGA graphics applications.

1.2.1 Driver Applicability

The VGA graphics portion of a system needs no software drivers to run applications in Standard-resolution mode. The following drivers are provided as a service to the user for improved resolution and performance to many software packages.

Cirrus Logic recognizes that quality device drivers are an important feature of any video subsystem; therefore, our list of available device drivers is continuously expanding. Please refer to the CL-GD542X Software Drivers Kit for the latest list of available device drivers.

Table C1-1.Cirrus Logic Text and Graphics Drivers

Software Drivers	Resolution Supported ^a	No. of Colors
Microsoft® Windows® 95 <i>CL-GD5425</i>	640 × 480, 800 × 600, 1024 × 768	256
	640 × 480, 800 × 600	32,768
	640 × 480	16.8 million
Microsoft® Intel® DCI <i>CL-GD5425</i>	640 × 480, 800 × 600, 1024 × 768	256
	640 × 480, 800 × 600	65,536
	640 × 480	16.8 million
Microsoft® Windows® v3.X <i>CL-GD5425</i>	640 × 480, 800 × 600, 1024 × 768, 1280 × 1024	16
	640 × 480, 800 × 600, 1024 × 768, 1280 × 1024	256
	640 × 480, 800 × 600, 1024 × 768	65,536
	640 × 480	16.8 million
Microsoft® Windows NT™ v1.X	640 × 480, 800 × 600, 1024 × 768	16 and 256
OS/2® v2.0, v2.1	800 × 600, 1024, × 768	16 ^b
	640 × 480, 800 × 600, 1024, × 768	256 ^b
AutoCAD® v11, v12, Autoshade® v2.0, w/ Renderman, 3D Studio™ v1,v2	640 × 480, 800 × 600, 1024 × 768, 1280 × 1024	16
	640 × 480, 800 × 600, 1024 × 768, 1280 × 1024	256
	640 × 480, 800 × 600, 1024 × 768	65,536
	640 × 480	16.8 million
GEM™ v3.X	800 × 600, 1024 × 768	16
Ventura Publisher® v2, v3	800 × 600, 1024 × 768	16
Lotus® 1-2-3® v2.X,	132 × 25, 132 × 43 (text)	16
	800 × 600	16
Lotus® 1-2-3® v3.X	132 × 25, 132 × 43 (text)	16
	800 × 600, 1024 × 768	16
Microsoft® Word v5.X	132 × 25, 132 × 43 (text)	16
	800 × 600, 1024 × 768	16
WordPerfect® v5.0	800 × 600	16
WordPerfect® v5.1	132 × 25, 132 × 43 (text)	16
	800 × 600, 1024 × 768	16
WordStar® v5.5–v7.0	800 × 600, 1024 × 768	16

a. Not all monitors support all resolutions; 640 × 480 drivers will run on PS/2®,-type monitors. Extended resolutions are dependent upon monitor type and VGA system implementation.

b. OS/2® v2.0 requires a v2.0 Corrective Service Pack for 256 .

Appendix D1

Extended Video Modes Programming Application Note

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EXTENDED VIDEO MODES PROGRAMMING

1. INTRODUCTION

The CL-GD542X family of VGA controllers is capable of supporting a wide range of Super VGA high-resolution video graphics modes. The CL-GD542X supports graphics modes of up to:

- $1280 \times 1024 \times 16$ colors
- $1280 \times 1024 \times 256$ colors
- $800 \times 600 \times 32K$ and $64K$ colors
- $640 \times 480 \times 16.8$ million colors

The Extended VGA Video modes are described in terms of video memory organization, extended display memory addressing, and mapping schemes as supported by the CL-GD542X VGA controllers.

This application note also includes software programming examples demonstrating how to implement some of these features.

2. SUPER VGA DISPLAY MODES

Table D1-1 shows the Extended Video Graphics modes supported by the CL-GD542X:

Table D1-1. Extended Modes

Mode Number*	Resolution	Colors	Bits/Pixel	Memory Organization	Memory Required
58h, 6Ah	800 × 600	16	4	Planar	256K
5Ch	800 × 600	256	8	Packed	512K
5Dh	1024 × 768	16	4	Planar	512K
5Fh	640 × 480	256	8	Packed	512K
60h	1024 × 768	256	8	Packed	1024K
62h	640 × 480	32,768	15	RGB ^a (5-5-5)	1024K
63h	800 × 600	32,768	15	RGB ^a (5-5-5)	1024K
64h	640 × 480	65,536	16	RGB ^b (5-6-5) Packed	1024K
65h	800 × 600	65,536	16	RGB ^b (5-6-5) Packed	1024K
66h	640 × 480	32,768	15/8	Mixed ^c RGB(5-5-5)/ 256-colors Packed	1024K
67h	800 × 600	32,768	15/8	Mixed ^c RGB(5-5-5)/ 256-colors Packed	1024K
6Ch	1280 × 1024	16	4	Planar	1024K
6Dh	1280 × 1024	256	8	Packed	2048K
6Fh	320 × 200	65,536	16	RGB ^b (5-6-5) Packed	512K
70h	320 × 200	16.8 million	24	RGB ^d (8-8-8) Packed	512K
71h	640 × 480	16.8 million	24	RGB ^d (8-8-8) Packed	1024K
74h	1024 × 768	65, 536	16	RGB ^b (5-6-5) Packed	2048K

NOTES:

- * Not all video modes are available on all CL-GD542X controllers. Refer to Chapter 3, Data Book', and the Software Release Kit for the list of video modes supported by the CL-GD542X BIOS.
- a) The 32,768-color Video modes are RGB (5-5-5) Packed-pixel modes compatible with industry standard.
- b) The 65,536 Direct-Color Video modes are RGB (5-6-5) Packed-pixel modes compatible with industry standard.
- c) The Mixed format allows 32,768-color Video modes RGB (5-5-5) and 256-colors (8-bits/pixel) packed format to be combined.
- d) The 640 × 480 × 16.8 million True Color Video mode with 1024K display memory is RGB (8-8-8) Packed-pixel modes compatible with 24-bit/pixel TARGA™ Truevision format.

3. 16-COLOR PLANAR MODE MEMORY ORGANIZATION

The planar video memory denotes that a pixel is represented by bits of information dispersed across a set of planes. The 16-color mode requires four bits per pixel, which means four display planes have the pixel represented by one bit per plane. The display memory is organized as bytes, and there are eight pixels per byte. The memory planes are overlaid in the CPU memory address space so that each plane occupies the same CPU address. The CPU can access any of these planes independently for read/write operations by programming the appropriate select registers.

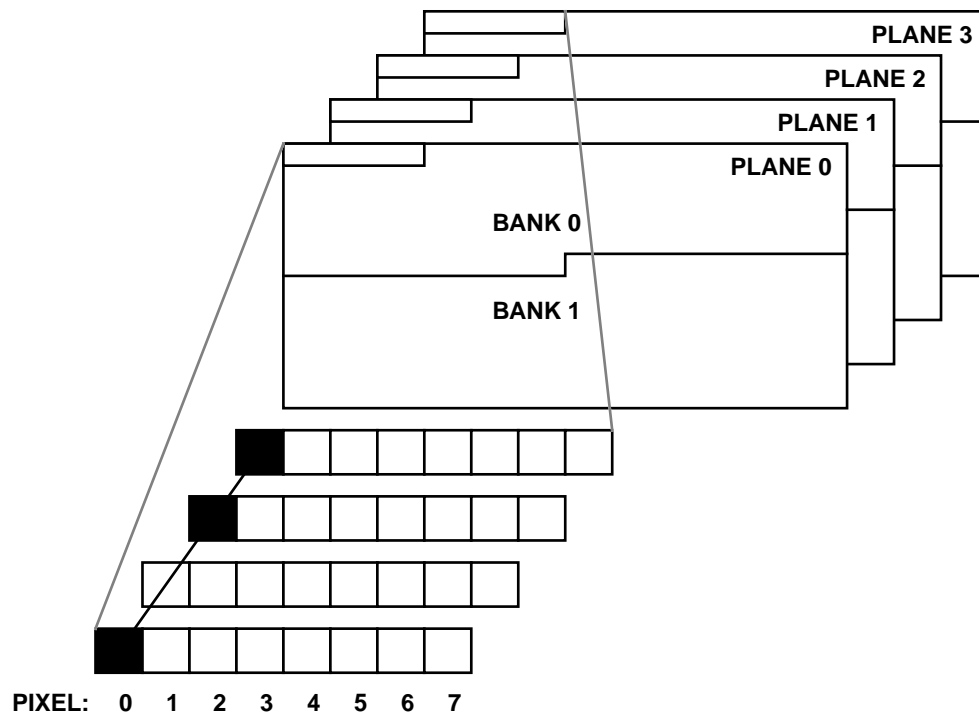


Figure D1-1. 16-Color Planar Modes

Figure D1-1 shows the video memory organized in four display planes for 16-color Planar mode. The color information for each pixel is stored in corresponding bits across four planes. The figure also depicts how Bank 0 and Bank 1 are aligned across each plane.

The standard IBM VGA supports 256 Kbytes of video memory. In 16-color Planar mode, the video memory is divided into four planes with 64 Kbytes per plane. The 64 Kbytes segment of each plane is mapped normally from A0000 to AFFFF, and the CPU can easily address each of the video memory planes. The problem arises for a video mode that requires more than 64 Kbytes of addressable video memory per plane. For example the 1024×768 , 16-color Planar mode requires 98,304 bytes of display memory per plane, and a way to remap different segments of display memory into the CPU-limited address range. The display memory address remapping scheme is discussed in a later section.

4. 256-COLOR PACKED PIXEL MODES

The 256-color modes use eight bits (or one byte) per pixel; the term 'packed' means all information about each pixel is packed in one plane. The CL-GD542X memory controller handles all the address generation; to the CPU the display memory appears as if it were linear 64 Kbytes of addressable display memory. For high-resolution modes that require addressing beyond the 64-Kbyte segment of video memory, the CL-GD542X has display memory remapping schemes to 'page-in' the display memory segments.

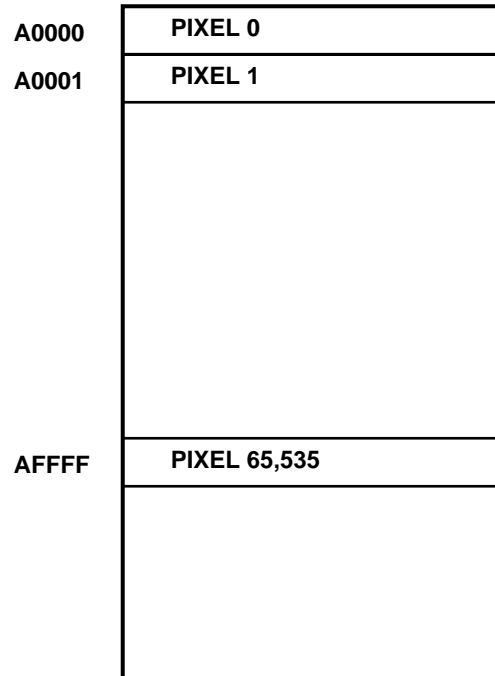


Figure D1-2. 256-Color Packed-Pixel Mode

Figure D1-2 shows how eight bits per pixel (Packed-pixel mode) bytes are stored in terms of physical plane organization. The memory controller makes this organization completely transparent; therefore to the CPU the byte addressing is sequential. For example, at Segment A000, Pixel 0 resides at offset 0, Pixel 1 at offset 1, and Pixel 65535 at offset 65535. To address display memory beyond 64-Kbyte segment boundary, the CL-GD542X supports a display memory paging scheme that allows up to 1 Mbyte of display memory to be paged into the CPU address range.

5. DIRECT-COLOR (32,768 OR 65,536 COLORS), PACKED-PIXEL MODES

The CL-GD542X VGA controllers support a Direct-Color mode that is capable of displaying 32,768 or 65,536 colors simultaneously at screen resolutions of up to 800×600 . The CL-GD542X uses its internal palette DAC to support this TARGA- or IBM XGA-compatible mode, where 15 or 16 bits per pixel of color information is used to display 32,768 or 65,536 colors. The VGA-standard palette DAC LUT is limited to 256 addresses. This scheme bypasses the LUT, and passes 15 or 16 bits of RGB (RED, GREEN, and BLUE) color information directly to the DAC to generate the high-range colors. The CL-GD542X Direct-Color mode displays close to true-color images on standard VGA analog monitors for desktop and multimedia applications.

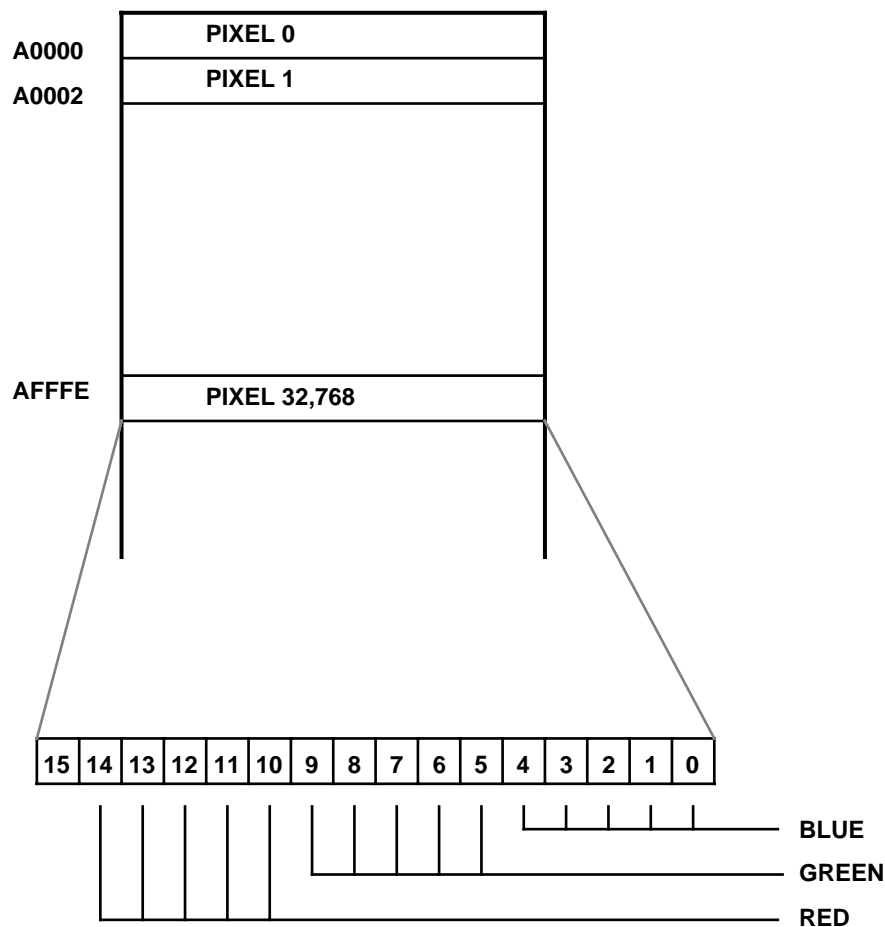


Figure D1-3. 32,768 Color (15-Bit) Packed-Pixel Mode

Figure D1-3 shows the 15-bit (32,768 colors) Direct-Color, Packed-Pixel mode organization. The RGB color information is stored in 5-5-5 format, and the MSB (bit 15) is ignored. Two bytes per pixel are used for storing the color information. The CPU addressing is completely sequential. The 5-5-5 format represents most-significant bits of RED, GREEN, and BLUE of the 24-bit DAC output.

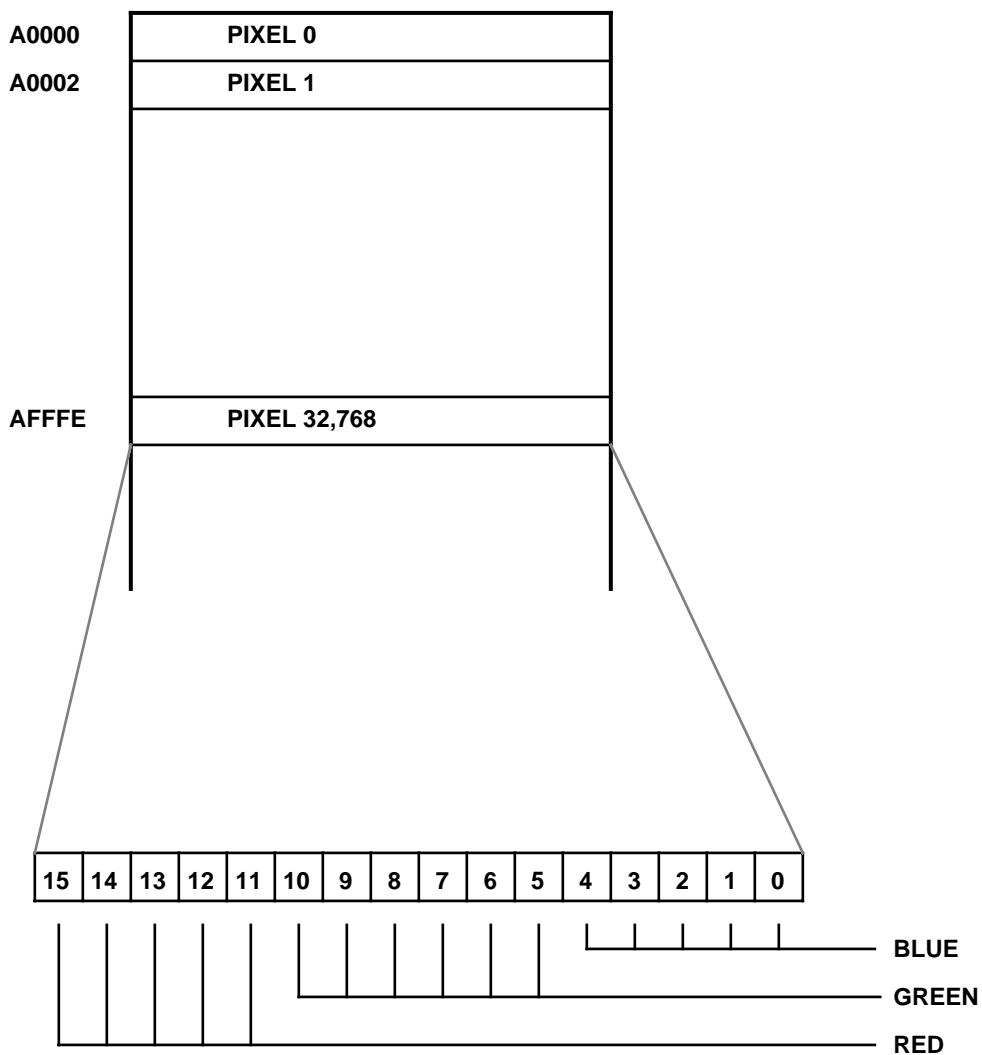


Figure D1-4. 65,536 Color (16-Bit) Packed-Pixel Mode

Figure D1-4 shows the 16-bit (65,536 colors) Direct-Color, Packed-Pixel mode organization. The RGB color information is stored in a 5-6-5 format comprising 5-bits of RED, 6-bits of GREEN, and 5-bits of BLUE. The color information (per pixel) is read from display memory, and used by the internal palette DAC in Direct-Color mode to display 65,536 colors simultaneously.

6. MIXED 32,768 COLORS (RGB 5-5-5) and 256-COLOR (8-BITS/PIXEL) PACKED-PIXEL MODES

The CL-GD542X VGA controllers palette DAC supports a Mixed-Color mode that is capable of combining RGB 5-5-5 format and packed 8-bit per pixel format. The CL-GD542X internal palette DAC is set to mixed mode format by programming the Hidden DAC register 3C6h. In mixed mode operation, Pixel Data bit 15 is used to choose between palette operation and RGB 5-5-5 color. This allows 5-5-5 data to overlay 256-color images on a pixel-by-pixel basis. If bit 15, the most-significant bit (MSB) of the 16-bit pixel data, is '0', then bits 14:0 are treated as 5-5-5 RGB data. If the most-significant bit (MSB) is set to '1' then bits 7:0 choose a palette entry in the palette DAC LUT and bits 14:8 are ignored.

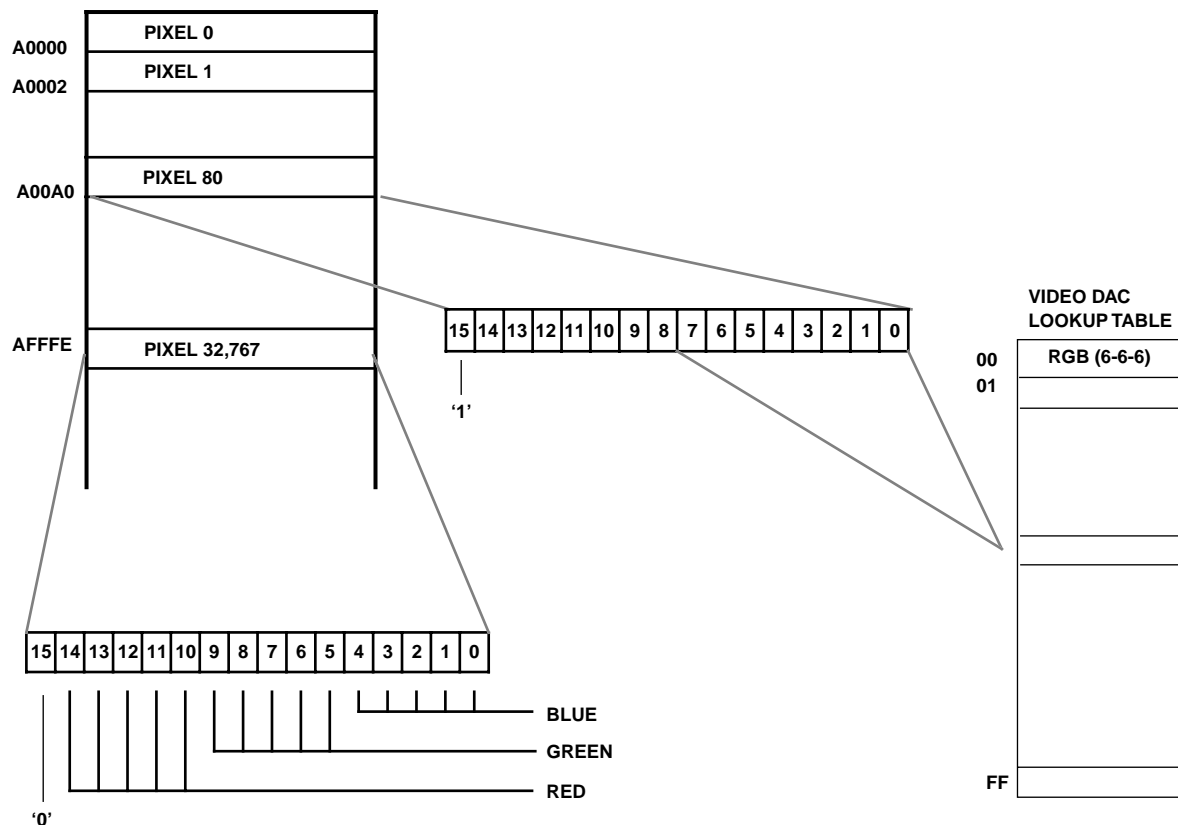


Figure D1-5. Mixed-32,768-Color (15-Bit) Packed-Pixel Data Format

Figure D1-5 shows the mixed-color, RGB 5-5-5 packed-pixel data format. Two bytes per pixel are used for storing the color information. The MSB (bit 15) of pixel data is '0', so bits 14:0 are treated as RGB 5-5-5 format. If the MSB (bit 15) is '1' then bits 7:0 are used as index to look up color information from the palette DAC LUT. The CPU addressing is completely sequential.

7. TRUE COLOR 24-BIT (16.8 MILLION COLORS), PACKED-PIXEL MODES

The CL-GD542X VGA controller supports a True Color mode that is capable of displaying 16-million colors simultaneously at screen resolutions of up to 640×480 . The CL-GD542X uses its internal palette DAC to support this TARGA-compatible mode, where 24 bits per pixel of color information is used to display 16-million colors. The VGA-standard palette DAC LUT is limited to 256 addresses. This scheme bypasses the LUT, and passes 24 bits of RGB (RED, GREEN, and BLUE) color information directly to the DAC to generate the high-range of colors. The CL-GD542X True Color mode offers professional-quality color images to be displayed on standard VGA analog monitors for desktop and multimedia applications.

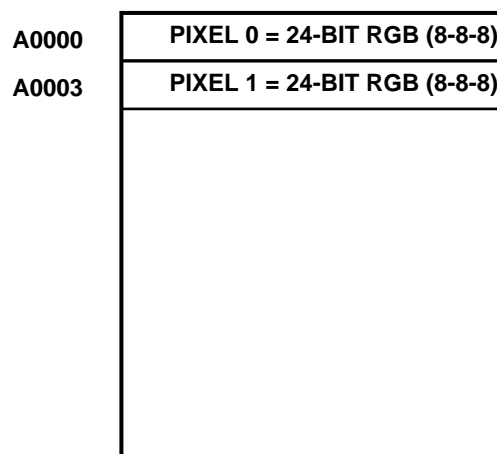


Figure D1-6. 24-bit True Color Packed-Pixel Mode

Figure D1-6 shows how True Color 24-bits per pixel (RGB 8-8-8) video mode data bytes are stored in terms of physical plane organization. The memory controller makes this organization completely transparent, hence to the CPU the byte addressing is sequential. For example, at Segment A000, Pixel 0 RGB color information is stored in three sequential bytes: Blue color information resides at offset 0, Green color information resides at offset 1, and Red color information resides at offset 2. Pixel 1 RGB information is at offset 3. To address display memory beyond 64K segment boundary, the CL-GD542X supports a display memory paging scheme that allows up to 1 Mbyte of display memory to be paged into the CPU address range.

NOTE: When programming this mode, the BIOS sets the offset to 2048 to facilitate pixel address calculation.

8. EXTENDED VIDEO MEMORY ADDRESSING TECHNIQUES

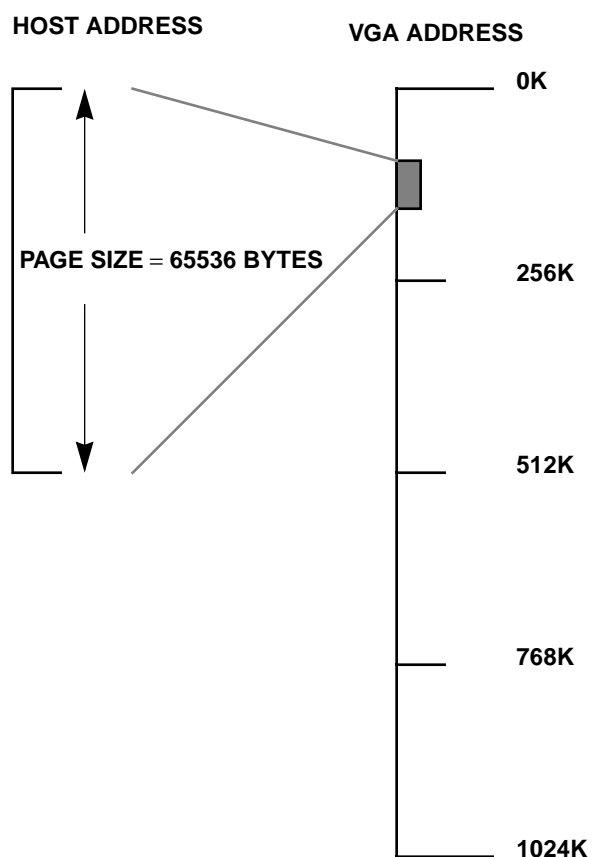
The CL-GD542X is capable of addressing up to 1 Mbyte of display memory. In the DOS environment, there is 128 Kbytes of memory space at A0000–BFFFF reserved for display memory. If the VGA has to share this memory with MDA, Hercules, or CGA, it is left with the single 64-Kbyte segment from A0000 to AFFFF.

The CL-GD542X supports single- and dual-paging display memory addressing schemes that allow mapping of two 32-Kbyte segments, or one 64-Kbyte segment of display memory into CPU address space.

The CL-GD542X also supports a linear address mapping scheme that allows the display memory to be mapped to a continuous 1-Mbyte region above the standard 1-Mbyte DOS address space. This allows application programs to access the full 1 Mbyte of display memory instead of being constrained to a 64-Kbyte window. To take advantage of this linear-addressing feature, drivers need to be written to ensure compatibility with the operating systems.

8.1 Single-Page Addressing

The single-page addressing scheme allows a 64-Kbyte segment of display memory to be mapped to the A0000–AFFFF of CPU address range. The segment of display memory that is mapped into the CPU address range is selected by programming the Extension register GR9: Offset register 0 (I/O Port Address 3CF, Index = 0 x 09).

**Figure D1-7. Single-Page Mapping Scheme**

8.2 Dual-Page Addressing

The dual-page addressing scheme allows two segments of display memory to be mapped into the CPU address range. The two segments are mapped into address range A0000–A7FFF and A8000–AFFFF. The two segments of display memory mapped into the CPU address range is determined by the Offset Register 0 and Offset Register 1. The dual-page address mapping is used for read-modify-write operation on large blocks of data. The two separate display memory segments can be accessed by the CPU for read and write operations. This allows block transfer of data via repeat move string DMA instructions.

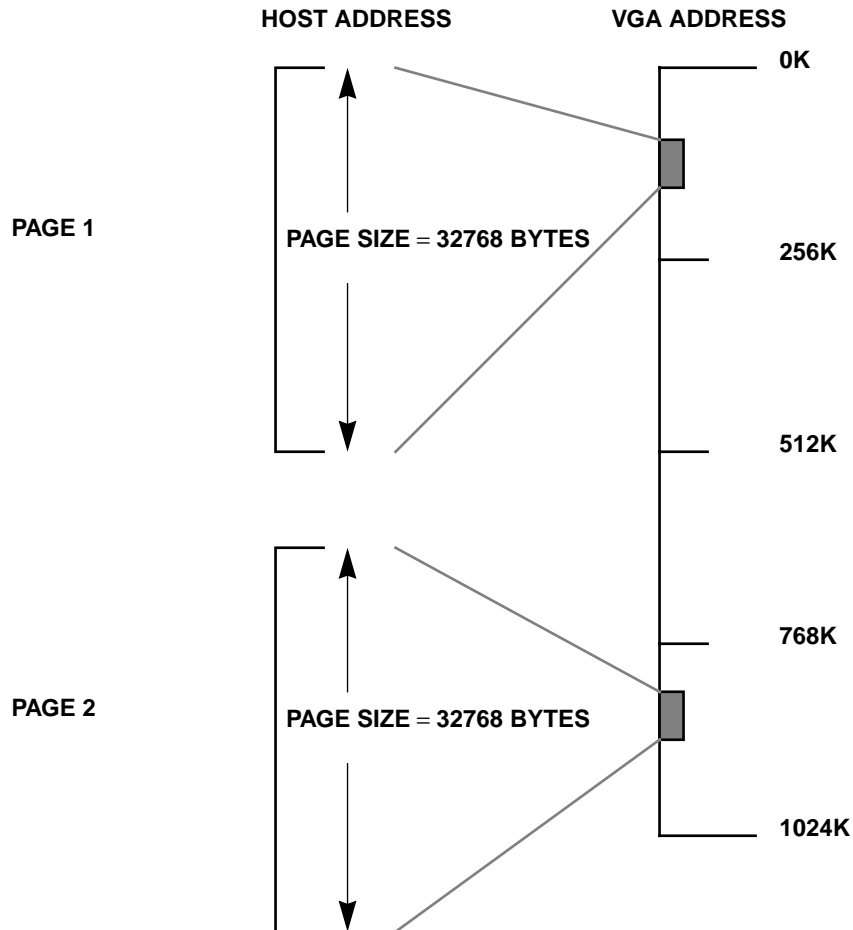


Figure D1-8. Dual-Page Mapping Scheme

The start address of a page is determined by the 8-bit value programmed in the corresponding Offset register.

For 1-Mbyte VGA mapping, the 8-bit Offset register value is added to the 16 bits of CPU address, to generate the 20-bit display memory address.

For a page size of 64 Kbytes, Figure D1-9 shows the Offset register and the CPU Address bits that are added to generate the Display Memory Address. Note that the corresponding four bits that are overlapping allow the start page address to begin at any 4K boundary of display memory.

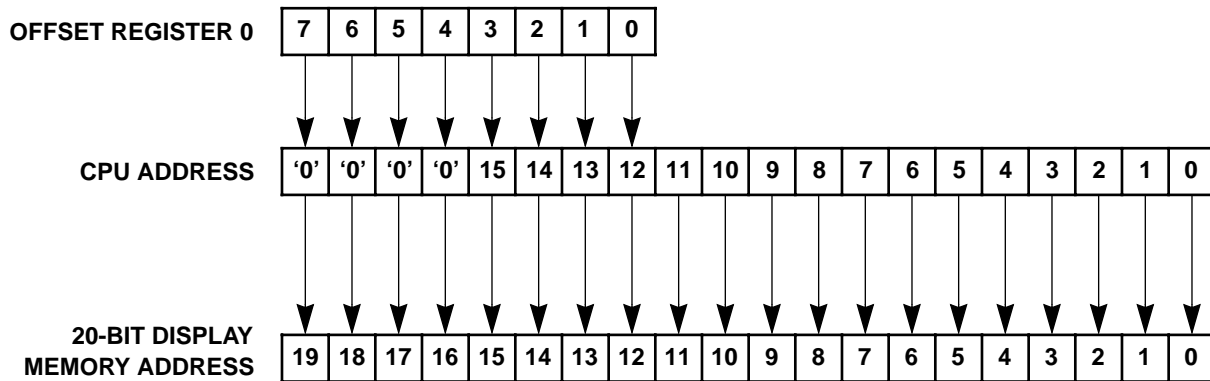


Figure D1-9. 64K Page Mode Remapping Adder Alignment for 1-Mbyte Memory

For 2-Mbytes VGA mapping, the 8-bit Offset register value is added to the bits of CPU address, to generate the 21-bit display memory address.

For a page size of 64 Kbytes, Figure D1-10 shows the Offset register and the CPU Address bits that are added to generate the 2-Mbyte display memory address. Note that the corresponding two bits that are overlapping allow the start page address to begin at any 16-Kbyte boundary of display memory.

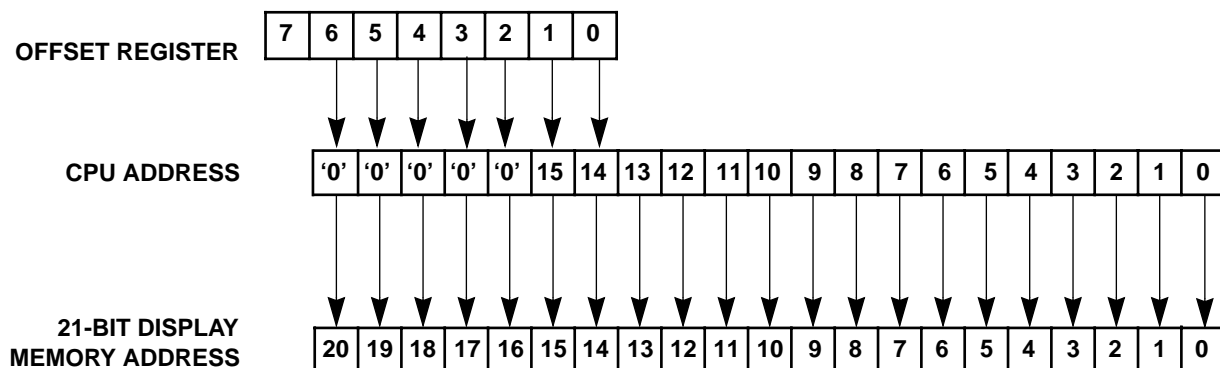
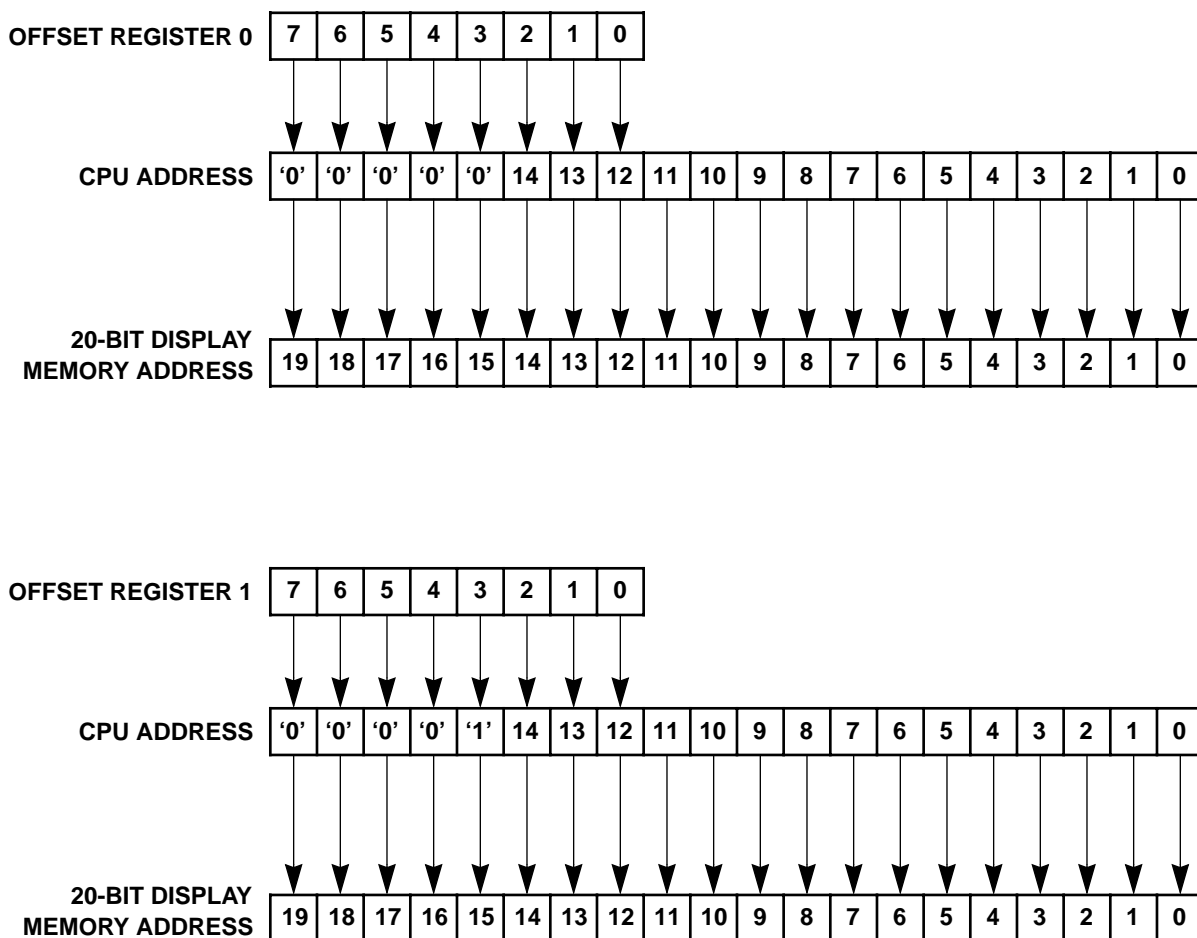


Figure D1-10. 64K Page Mode Remapping Adder Alignment for 2-Mbyte Memory (CL-GD5426/'28 Only)

For dual-page mapping, the start address of pages can be at any 4-Kbyte boundary of display memory. The two pages that are mapped into CPU address range can be any two separate or overlapping segments of display memory.

For a page size of 32 Kbytes, Figure D1-11 shows how the Base Address Remapping and CPU Address bits are added to find the resulting display memory address. Note that the CPU Address bit 15 is used to select whether Offset Register 0 or Offset Register 1 will be used to calculate resulting value of display memory address.



**Figure D1-11. 32K Page Mode Remapping Adder Alignment
For 1-Mbyte Display Memory**

Note that in Figure D1-11, bit 15 of the CPU address selects whether Offset 0 or Offset 1 will be used for the display memory addressing.

Table D1-2 lists the CL-GD542X Extension registers that control the CPU base address and display memory mapping functions.

Table D1-2. CL-GD542X Extension Registers

Function	Register Name	Port	Index	Bit	Value
Single-page	GRB: Graphics Controller Mode Extensions	3CF	0B	0	0
Dual-page	GRB: Graphics Controller Mode Extensions	3CF	0B	0	1
Offset register granularity 4- or 16-Kbyte	GRB: Graphics Controller Mode Extensions	3CF	0B	5	0 or 1
Linear Addressing	SR7: Graphics Controller Mode Extensions	3C4	07	7:4	15n0
Offset Register 0	GR9: Offset register 0	3CF	09	7:0	255..0
Offset Register 1	GRA: Offset register 1	3CF	0A	7:0	255..0

Figure D1-12 and Figure D1-13 show the Extension registers that control the Extended Memory-mapping functions. The following figures show the register bits as listed in Table D1-2.

GRB: GRAPHICS CONTROLLER MODE EXTENSIONS

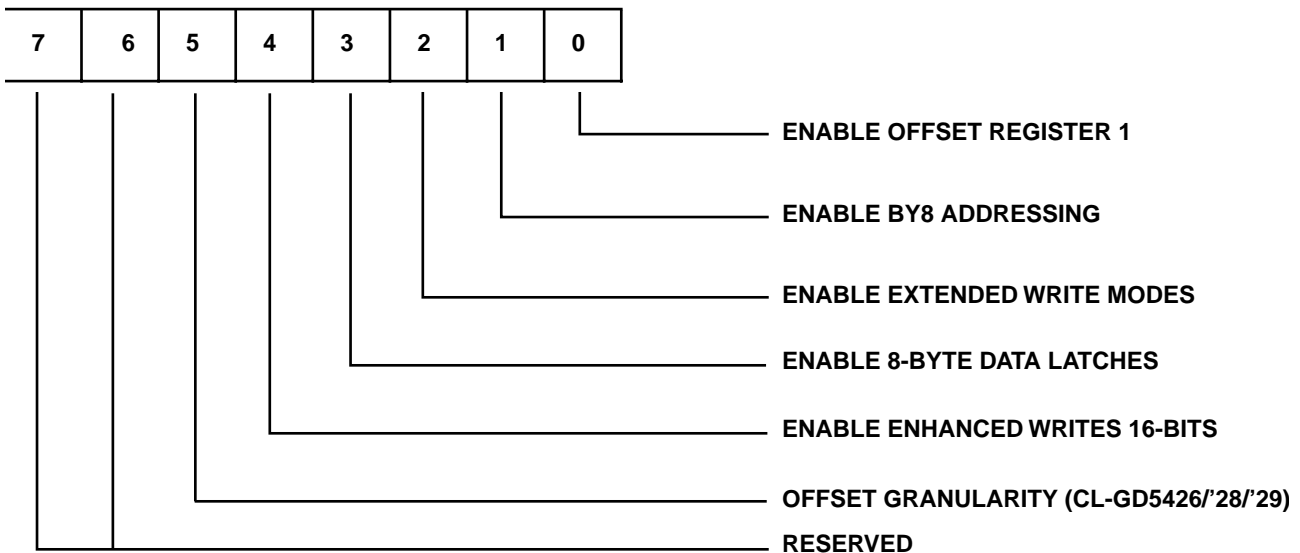


Figure D1-12. Extension Register GRB

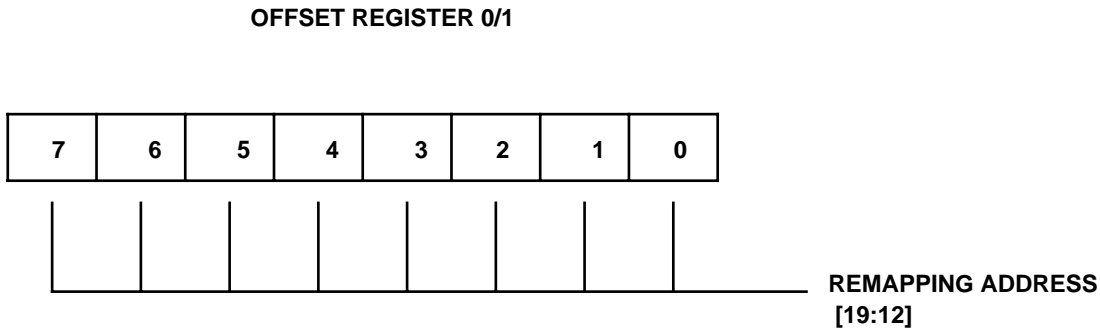


Figure D1-13. Extension Register GR9/GRA

9. VGA PROGRAMMING EXAMPLES

This section provides the software programming examples with source code listing and discussion on the following topics:

- Identifying CL-GD542X VGA Controllers
- Setting up CL-GD542X Extended Video modes via INT 10h Function Call
- Enabling/disabling Extension register Access
- Selecting Single-Page Mapping
- Selecting Dual-Page Mapping
- Loading Single-Page Bank with a new start address
- Loading Dual-Page Banks with new start addresses

9.1 Identifying the CL-GD542X VGA Controllers

The CL-GD542X VGA controllers can be identified by calling the Extended VGA BIOS inquiry function via INT 10h. If a VGA BIOS is not available, then a controller can be identified by programming the Unlock ALL Extension register (SR6) and reading the Chip ID register (CR27). The following code shows the steps to enable/disable CL-GD542X Extended register access:

Enable Extension Register Macro:

```
; Function:
;   Enabling Extensions
;   Calling Protocol:
;   enable_extensions

enable_extensions macro
mov     dx,03c4h           ; select Extended Register SR6 i/o port
mov     al,06h             ; Unlock All Extension register index
mov     ah,12h             ; load with xxx1x010 to enable extension
out     dx,ax              ; write index and data
endm
```

Disable Extension Register Macro:

```
; Function:
;   Disabling Extensions
;   Calling Protocol:
;   disable_extensions

disable_extensions macro
mov     dx,03c4h           ; select Extended Register SR6 i/o port
mov     al,06h             ; Unlock All Extension register index
mov     ah,00h             ; load with 00 to disable extension
out     dx,ax              ; write index and data
endm
```

NOTE: SR6 is not implemented on the CL-GD5429. This means that the extension registers are always enabled. The two code segments listed above have no effect on the CL-GD5429.

9.2 Determining if VGA Controller is a CL-GD542X

The CL-GD542X Chip ID register (CR 27) is used to identify the CL-GD542X family of controllers. The following sample code shows how to program the Extension registers to read the Chip ID and determine the chip type:

```
;Function: Identify Cirrus Logic CL-GD542X VGA controller
;Input Parameters: none
;Output Parameters:
;    AL =00      ID FAILED
;    AL =11      CL-GD5402
;    AL =12      CL-GD5420
;    AL =13      CL-GD5422
;    AL =14      CL-GD5424
;    AL =15      CL-GD5426
;    AL =16      CL-GD5420r1
;    AL =17      CL-GD5402r1
;    AL =18      CL-GD5428
;    AL =19      CL-GD5429
;    AL =1A      CL-GD5429
; Calling Protocol:
; VGAchip = Id_GD542x()*/

_Id_GD542x proc far
    mov     dx,3c4h        ; load Unlock All Extensions I/O port
    mov     al,06          ; load SR6 register index
    out     dx,al          ; write index and data register
    inc     dx              ;
    in      al,dx          ; read data register
    mov     ah,00h         ;
    cmp     al,12h         ; check SR6 read back value
    jne     chk29          ; see if this is a 5429 (no SR6)
    mov     dx,3d4h        ; load chip Id CR27 I/O port return
    mov     al,27h         ; select CR27 index
    out     dx,al          ;
    inc     dx              ;
    in      al,dx          ; read chip id
    mov     ah,11h         ;
    cmp     al,89h         ; check for CL-GD5402
    jb      exit           ;
    mov     ah,17h         ; check for CL-GD5402r1
    je      exit           ;
    mov     ah,12h         ;
    cmp     al,8ah         ; check for CL-GD5420
    je      exit           ;
    mov     ah,16h         ;
    cmp     al,8bh         ; check for CL-GD5420r1
    je      exit           ;
    shr     al,1           ;
    shr     al,1           ;
    mov     ah,13h         ;
```

```

        cmp     al,23h      ; check if GD5422
        je      exit       ;
        mov     ah,14h      ;
        cmp     al,25h      ; check if GD5424
        je      exit       ;
        mov     ah,1Ah      ;
        cmp     al,80h      ;check if GD5425
        mov     ah,15h      ;
        cmp     al,24h      ; check if GD5426
        je      exit       ;
        mov     ah,16h      ;
        cmp     al,26h      ; check if GD5428
        je      exit       ;
        mov     ah,16h      ;
        cmp     al,26h      ; check if GD5428
        je      exit       ;
        mov     ah,00h      ; failed id
exit:    mov     al,ah       ; return in AL the chip id value
        xor     ah,ah       ; zero AH
        ret
chk29:  mov     dx,3d4h     ;we will read out
        mov     al,27h     ;the chip ID register
        out     dx,al      ;point to chip ID register
        inc     dl         ;data register
        in      al,dx      ;read chip ID
        shr     al,1       ;shift to discard
        shr     al,1       ; revision level bits
        mov     ah,18h     ;in case it is
        cmp     al,27h     ;CL-GD5429 ID
        je      exit       ;yes it was
        xor     ah,ah      ;no it wasn't
        jmp     exit
_Id_GD542x endp

```

9.3 Initializing CL-GD542X Super VGA Mode via INT 10h Call

The following listing is used to initialize the desired video mode by calling the Cirrus Logic VGA BIOS Set Mode Function:

```

;Set Video Mode
;set up Extended Video mode supported by CL-GD542X VGA BIOS
;
;Calling Protocol
; al = desired CL-GD542X video mode number
;Return
; al = current video mode
;
Set_Video_Mode proc near
    mov ah,0 ; VGA BIOS setmode function 0
    int 10h ; call VGA BIOS interrupt 10 Hex, al= mode number
    mov ah,0Fh; VGA BIOS get current video mode number
    int 10h ;
    ret     ; return current video mode number in al
Set_Video_Mode endp

```

9.4 Programming Single-Page Mapping

The following listing shows the Extension registers that need to be programmed to set up CL-GD542X Single-Page Mapping:

```

; Single Page Mapping
; Setup Single-Page Mapping

; Calling Protocol
;     Set_Single_Page

Set_Single_Page proc near
;setup CPU Base Address Control Register for single page, 64k page size
    mov     dx,03ceh    ; select GRB extension register i/o port
    mov     al,0bh      ; select GRB register index
    out     dx,al       ; write index register
    inc     dx          ; inc dx to read data port
    in      al,dx       ; read data
    and     al,0feh     ; apply mask to set GRB[0] = 0
    out     dx,al       ; write i/o port with new data
    ret
Set_Single_Pageendp

```

9.5 Programming Dual-Page Mapping

The following listing shows the Extension registers that need to be programmed to set up CL-GD542X Dual-Page Mapping:

```

; Dual Page Mapping
;     Setup Dual-Page Mapping
;
; Calling Protocol
;     Set_Dual_Page

Set_Dual_Page proc far

; setup Graphics Controller Mode Extensions Register for dual page size
    mov     dx,03ceh    ; select extension register i/o port
    mov     al,0bh      ; select CPU Base Address Register index
    out     dx,al       ; write index register
    inc     dx          ; inc dx to read data port
    in      al,dx       ; read data
    or      al,01h      ; data = enable 32k pagesize, dual page
    out     dx,al       ; write i/o port with new data
    ret
Set_Dual_Page endp

```

9.6 Programming the Address Remapping Registers

The CPU Base Address Mapping registers represent the eight most-significant bits of the 1 Mbyte address range that can be mapped into the limited CPU address range of A0000–BFFFF. If the page size is selected to be 64 Kbytes, then the display memory is mapped into CPU address range A0000–AFFFF. The 64-Kbyte segment that is remapped into CPU address range can start at any 4-Kbyte address boundary of display memory. This means that with 1 Mbyte of display memory, the Remapping registers can select any one of the possible 256 start address locations.

The following examples shows how to select the desired page for Single-Page Mapping with 64K page size, and Dual-Page Mapping with 32-Kbyte page size.

9.7 Programming Single-Page Remapping Address with a 64-Kbyte Segment Bank Address

The following listing shows how the Extension Offset register 0 needs to be programmed to map a desired page (64 Kbytes) of display memory into CPU address at segment A000.

```
;Function:
;Load the Single Page Offset Register 0 with the new start address
;of a 64K byte segment
; Input:
; bl = 0..255
; page number for start address of desired 64k byte segment
;
; Calling Protocol:
; Select_Single_Page

Select_Single_Page macro
    mov     dx,3CEh      ; load GR09 extension register i/o port
    mov     al,09h       ; load Offset Register 0 index
    mov     ah,bl        ; get page number
    out     dx,ax        ; program selected page
Select_Single_Page endm
```

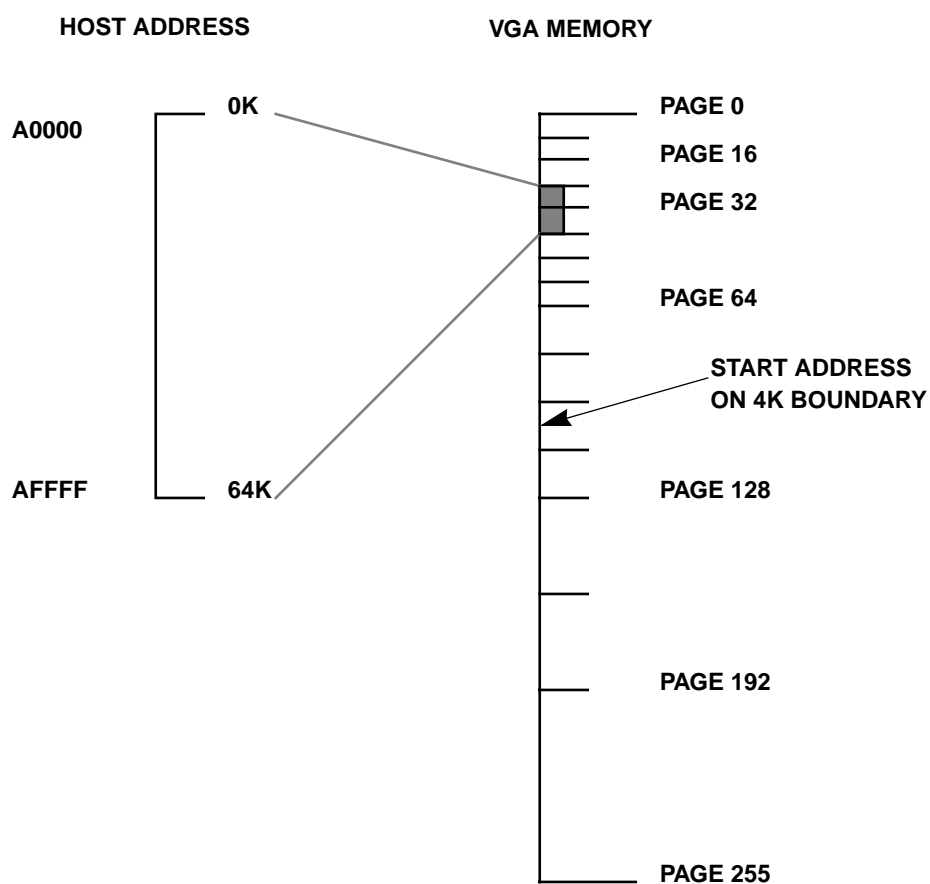


Figure D1-14. Single 64-Kbyte Page Mapping Scheme

Figure D1-15 shows how the eight bits of the Offset register 0, is added with 20 bits of CPU address to generate a 20-bit Display Memory Address.

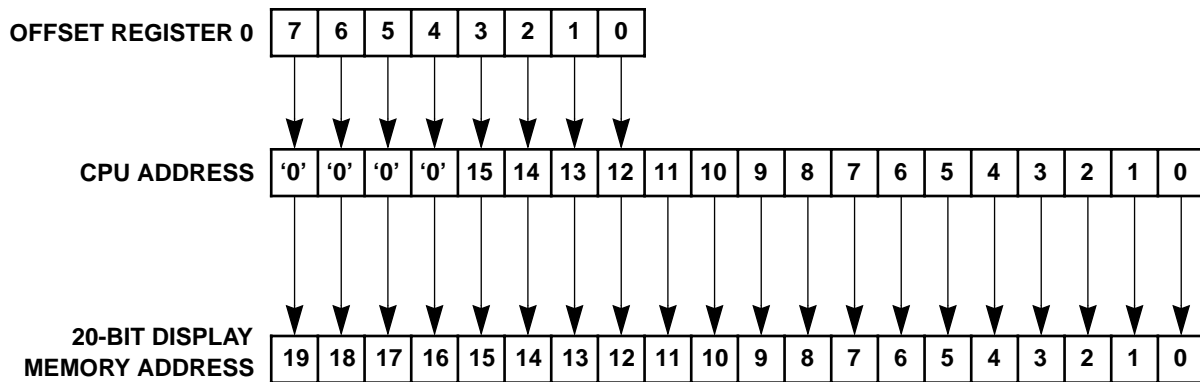


Figure D1-15. 64-Kbyte Page Mode Remapping Address Alignment For 1-Mbyte Display Memory

9.8 Programming Dual-Page Remapping Address with a 32-Kbyte Segment Bank Address

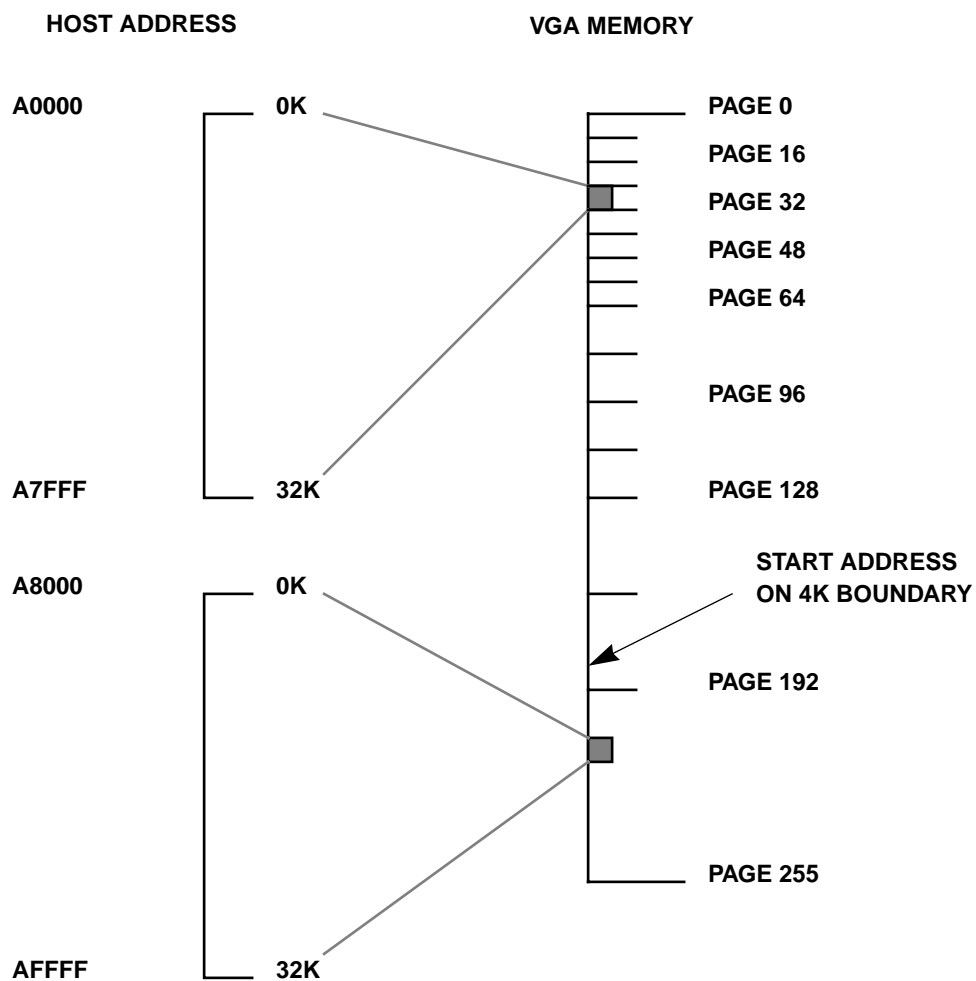
The following listing shows the Extension registers that need to be programmed to set up Dual-Page Remapping Address with a 32-Kbyte Segment Bank Address:

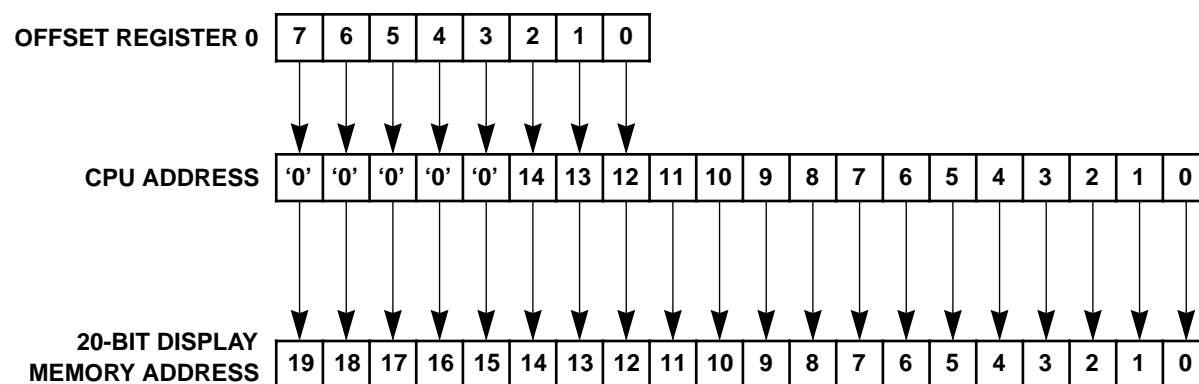
```
;Function:
;Load the Dual Page Remapping Registers with the new star address
;at 32K byte segments

; Input:
;bl = 0..255 page number for segment mapped to A0000 - A7FFF
;bh = 0..255 page number for segment mapped to A8000 - AFFFF

; Calling Protocol:
;Select_Dual_Pages

Select_Dual_Pages macro
mov     dx,3CEh    ; load extension register i/o port
mov     al,09h     ; load CPU Base Addr. Mapping Register A index
mov     ah,bl       ; get page number for A0000-A7FFF mapping
out     dx,ax       ; program selected page
mov     al,0ah     ; load CPU Base Addr. Mapping Register A index
mov     ah,bh       ; get page number for A8000-AFFFF mapping
out     dx,ax       ; program selected page
Select_Dual_Pages endm
```

**Figure D1-16. Dual-Page (32 Kbyte) Mapping Scheme**



**Figure D1-17. 32-Kbyte Page Mode Remapping Address Alignment
For 1-Mbyte Display Memory**

Figure D1-17 shows how the eight bits of the Offset register 0 or Offset register 1 (based on CPU address bit 15) is used along with 16-bit CPU address to generate a 20-bit Display Memory Address.

Appendix D2

Linear Addressing Application Note

LINEAR ADDRESSING

1. INTRODUCTION

The CL-GD542X family of VGA controllers can be configured to access display memory in a linear or a segmented fashion. The Linear Addressing mode forces all display memory to be continuous.

In extended DOS or OS/2 applications, it is possible to place the VGA memory into high memory where there is space to place one (or two) Mbytes of display memory into a contiguous address space. This allows the application programs to ignore the Offset register programming.

2. LINEAR ADDRESS ADVANTAGES

The Linear Addressing of display memory offers two advantages. Firstly, it ensures faster programs; secondly, it ensures contiguous high-speed operation from a hardware perspective.

The software advantage requires an extended operating system and access to the memory through the 80286, 80386, or 80486 processors. The 32-bit instructions can be used to access the 1 Mbyte memory without Segment registers.

The hardware advantage is primarily aimed at video frame grabbers/overlay devices where the hardware has a continuous stream of data coming in to the True Color VGA controller display memory.

3. LINEAR ADDRESS MAPPING

The Extended Sequencer Modes register SR7 bits 7:4 determine the 1-Mbyte system memory segment of the 16-Mbyte address space that can be selected for CL-GD542X display memory mapping.

If these bits are all zeroes, then the CL-GD542X is configured as a standard VGA mapped to the 64K segments of 0A000h and/or 0B000h as selected by the VGA Register bits GR6[3:2].

If these bits are non-zeroes, then the CL-GD542X is set for linear addressing in the 1 Mbyte of system address selected. With the linear address selected, the standard VGA address GR6[3:2] and 3C2[5] have no effect on video memory mapping.

With 1 Mbyte of display memory installed and extended 256-color Chain-4 addressing selected, the 1 Mbyte of linear system address will have a one-to-one mapping to display memory addressing.

If the CL-GD542X is set for unchained, BY8 or BY16 addressing, each bit plane will be seen as a 256K linear map that is duplicated four times in the selected 1 Mbyte of system address space.

If less than 1 Mbyte of display memory is installed, the CL-GD542X will still respond to the entire 1 Mbyte of system address space, but display memory 'Address Wrapping' will occur.

4. SUMMARY

The CL-GD542X Linear Addressing option allows applications running under extended operating systems to take advantage of the linear display memory access and offer faster performance.

Appendix D3

Hardware Cursor Application Note

HARDWARE CURSOR

1. INTRODUCTION

The CL-GD542X family of VGA controllers is capable of supporting a 32×32 or 64×64 hardware cursor (mouse pointer) in 16-color planar, 256-color, and 32K and 64K Packed--pixel Graphics modes.

The hardware cursor replaces the software mouse pointer commonly used by GUI (graphics user interface) applications. The hardware cursor eliminates the need for application software to save and restore the screen data as the mouse cursor position changes.

The application software needs to initialize the hardware cursor once, and from that point only needs to update the cursor (x,y) position to move the cursor on the screen. The hardware cursor offers a smooth-moving mouse pointer with improved performance as compared to a software cursor.

Multiple hardware cursor patterns can be loaded into the upper display memory area, allowing application programs to select one of the patterns as the active-cursor pattern.

2. HARDWARE CURSOR OPERATION

The hardware cursor is a pixel array of two planes: Cursor Plane 0 and Cursor Plane 1. Table D3-1 shows how the corresponding bits of the two planes determine the displayed state of each cursor pixel. The P-bus output will reflect the cursor state as indicated for 8-bpp modes, and for byte-serial 16-bpp modes.

Table D3-1. Hardware Cursor Planes

Cursor Plane 0	Cursor Plane 1	Hardware Cursor Pixel Display State	Pixel Bus
0	0	Transparent	Display memory
0	1	Inverted VGA Display Data	Inverted display memory
1	0	Cursor Color 0	00h
1	1	Cursor Color 1	FFh

The Cursor Color 0 and 1 is supplied by the internal palette DAC two extra LUT (lookup table) locations at Index 00h and 0Fh. This allows for hardware cursor colors to be independent of the palette DAC Table Index 00h through FFh.

The CL-GD542X Extension register SR12, Graphics Cursor Attributes, can be programmed to:

- Select the cursor size,
- Enable access to the palette DAC cursor colors, and
- Enable/disable the cursor.

The hardware cursor data is located in the upper 16K of display memory (or upper 4K of each logical memory plane). Based on the cursor size selected, 32×32 or 64×64 , the number of cursor patterns that can be loaded in display memory at one time is either 64 or 16. The Graphics Cursor Pattern Address Offset register (SR13) allows the application to select one of the cursor patterns loaded in display memory to be selected as the active-graphics cursor.

The hardware cursor position is controlled by programming the graphics cursor X position and graphics cursor Y position. The 11-bit cursor X location and cursor Y location values are programmed by initiating a 16-bit I/O write, where bits 7:5 of the Index register are the least-significant bits of the 11-bit value.

Table D3-2 shows the CL-GD542X Extension register bits for programming the hardware cursor:

Table D3-2. CL-GD542X Extension Register Bits

Function Description	Extension Register	I/O Port Address	Register Bits	Value
Graphics cursor enable	SR12	3C5h	0	1
Access Graphics palette DAC colors	SR12	3C5h	1	1
32×32 graphics cursor size	SR12	3C5h	2	0
64×64 graphics cursor size	SR12	3C5h	2	1
Graphics cursor pattern offset	SR13	3C5h	5:0	63..0
Graphics cursor X position	SR10, 30, 50, 70, 90, B0, D0, F0	3C4h/3C5h	7:5/7:0	2047..0
Graphics cursor Y position	SR11, 31, 51, 71, 91, B1, D1, F1	3C4h/3C5h	7:5/7:0	2047..0

3. 32×32 HARDWARE CURSOR

For a 32×32 cursor size, each cursor pattern requires 256 bytes (128 bytes per plane $\times 2$ cursor planes). This allows for 64-cursor patterns to be loaded into hardware cursor data area at the top of display memory. The active-graphics-cursor pattern is selected by programming the Graphics Cursor Pattern Address register (SR12) bits 5:0.

The hardware cursor pattern data from Cursor Plane 0 and Cursor Plane 1 is loaded into display memory in the following order. The 256 bytes are stored across the four logical display memory planes — 64 bytes per plane. The first 32 bytes of each memory plane are from Cursor Plane 0 and last 32 bytes are from Cursor Plane 1.

4. **64 × 64 HARDWARE CURSOR**

The 64 × 64 cursor size is only available with 32-bit-wide display memory.

For a 64 × 64 cursor size, each cursor pattern requires 1024 bytes (512 bytes per plane × 2 cursor planes). This allows for 16-cursor patterns to be loaded into hardware cursor data area at the top of display memory. The active-graphics-cursor pattern is selected by programming the Graphics Cursor Pattern Address register (SR12) bits 5:2.

The 64 × 64 hardware cursor pattern data from Cursor Plane 0 and Cursor Plane 1 is loaded into display memory one cursor scanline at a time; 8 bytes written across the four logical display planes (2 bytes per plane). One cursor scanline is loaded from Cursor Plane 0 followed by one cursor scanline from Cursor Plane 1. This is done until all 64 scanlines from the Cursor Plane 0 and Cursor Plane 1 are loaded into display memory.

5. **SUMMARY**

The CL-GD542X programmable 32 × 32 or 64 × 64 size hardware cursor eliminates the application program's overhead of maintaining a software mouse pointer. The hardware cursor offers a smooth and fast-moving mouse pointer interface.

Appendix D4

Interlaced Mode Application Note

INTERLACED MODE

1. INTRODUCTION

In the CL-GD542X family of VGA controllers, the CRT registers can be programmed to operate Text or Graphics Video modes on interlaced or non-interlaced monitors.

The following sections describe the Interlaced mode display operation as well as Interlaced modes supported by CL-GD542X VGA controllers.

2. INTERLACED MODE DISPLAY OPERATION

Video displays are either interlaced or non-interlaced. In an interlaced display, alternate scanlines are updated every frame, and in a non-interlaced display, every scanline is updated every frame.

Interlaced mode is used when the VGA controller or monitor hardware cannot keep up with the data required by the video system. The greater the resolution of the video system, the faster the hardware must be to keep pace with the data rates.

The interlaced hardware needs to only be half as fast as the non-interlaced hardware. The disadvantage of the interlaced display is that the eye can begin to detect the alternating frequencies on the screen, especially when used under the fluorescent light, which operates at 60 Hz.

3. 1024 × 768 INTERLACED MODE

The standard VGA Video modes are non-interlaced modes. However, Super VGA modes, such as 1024 × 768 resolution, require a data clock rate of 65 MHz for non-interlaced operation. The display monitor also need to support the 65-MHz Dot Clock and support 48.3-kHz horizontal scan rate to run at 60-Hz vertical refresh rate.

The other alternative is to run the 1024 × 768 Interlaced Video mode, which requires a dot clock of 44.9 MHz and a monitor that supports 35.5-kHz horizontal scan rate.

For interlaced mode, the CL-GD542X CR Vertical Timing register values are typically programmed based on vertical resolution divided by two.

The CL-GD542X Extension register CR1A, Miscellaneous Control bit 0 is set to '1' to select Interlaced mode operation. Also CR19, Interlace End bits [7:0] need to be programmed to center the scanlines in the odd field half way between scanlines in the even field.

Appendix D5

132-Column Text Mode Application Note

132-COLUMN TEXT MODE

1. INTRODUCTION

The CL-GD542X family of controllers is capable of supporting 132-column Alphanumeric Text modes. The CL-GD542X VGA BIOS supports the extended 132-column Text modes listed in Table D5-1.

Table D5-1. CL-GD542X Extended 132-Column Text Modes

Mode Number	Resolution	Colors	Timing Options
14h (XGA)	132 × 25 Text	16 colors	70 Hz
53h	132 × 60 Text	16 colors	60 Hz
54h	132 × 43 Text	16 colors	70 Hz

The CL-GD542X VGA BIOS supports all standard interrupt 10h function calls to support 132-column text mode operation. As in standard VGA 80-column text modes, the application program can call the VGA BIOS 'Set Mode' function call to initialize the 132-column mode. From this point the application program can either call the VGA BIOS to manipulate text or write character/attribute data directly to display memory.

The following section describes the CL-GD542X extended 132-column Text mode operation.

2. 132-COLUMN TEXT MODE OPERATION

The CL-GD542X has hardware enhancements to support the extended 132-column-wide text modes. The 132-column Extended Video Mode is selected by setting CR1B, Miscellaneous Control register bit 6. The following is a description of the steps executed by the BIOS to set 132-column mode of operation:

1. The Video Dot Clock is set to 41.164 MHz to support 31.5-MHz Horizontal Sync rate.
2. The Sequencer is programmed to select eight-dot character clock.
3. The memory organization for character font tables is different for 132-column modes. With the 132-column mode selected, CR1B[6] = 1. The font tables that are normally loaded in Plane 2 are automatically remapped into Plane 2 and Plane 3 of the physical DRAM pages. The CL-GD542X re-maps character generator dot patterns of all lower 128-character codes into Plane 2, and all the upper 128-character codes into Plane 3. One half of each 64 Kbyte of physical plane is used, providing a total of eight Character Maps (8 Kbyte each) to be loaded into Memory Plane 2 and 3.
4. Due to the Plane 2 and 3 remapping, the 132-column mode does not support displaying two different character maps on the screen at the same time. (This is normally done in standard VGA 80-column text modes by selecting Character Attribute bit 3 of the selected character).

3. 132-COLUMN CRT CONTROLLER PROGRAMMING

The following horizontal CRT Controller register values are recommended for 132-column Text modes.

Table D5-2. 132-Column Text Mode CRT Horizontal Parameters 3?4/3?5^a

CRT Register	CRT Register Description	Index	Value
CR0	Horizontal Total	0	9Fh
CR1	Horizontal Display Enable End	1	83h
CR2	Start Horizontal Blanking	2	84h
CR3	End Horizontal Blanking	3	82h
CR4	Start Horizontal Retrace	4	8Ah
CR5	End Horizontal Retrace	5	9Eh
CR13	Offset	13	42h

a. '?' in the above addresses is 'B' for Monochrome mode and 'D' for Color mode.

The values in Table D5-2 correspond to 132-column Text mode for 31.5-kHz horizontal scan rate using a 41.164-MHz dot clock.

Appendix D6

Color Expansion and Extended Write Modes

COLOR EXPANSION AND EXTENDED WRITE MODES

1. INTRODUCTION

The CL-GD542X family supports color expansion for faster CPU write performance. This is implemented via two Extended Write modes and the BitBLT engine. These Extended Write modes operate on eight pixels at a time, in 8- or 16-bits-per-pixel Graphics modes with packed-pixel addressing. Extended Write modes can be used for faster text write, pattern fill, and block-move operations in Graphics modes. In addition, the BitBLT engine supports color expansion for 8- and 16-bit-per-pixel modes.

The following sections cover Extended Write modes from a programming point of view. The basic advantage of color expansion is explained and the registers involved described. Finally, the capabilities of the BitBLT engine are covered.

2. COLOR EXPANSION — PERFORMANCE ENHANCEMENT

In many configurations the CPU cannot send data across the host interface as quickly as it can be written into display memory. This results in a level of performance less than is possible, particularly in configurations involving a 32- or 64-bit display memory bus.

Consider an ISA bus machine with a 32-bit display memory bus using Video mode 5F (640 × 480 × 256 colors). With an MCLK of 50 MHz, the total display memory bandwidth is about 100 Mbytes/second. With a refresh rate of 72 Hz, 31.5 Mbytes/second of that bandwidth is used to refresh the screen (neglecting retrace time), leaving nearly 70 Mbytes/second available for the CPU to update the screen. An ISA bus has a theoretical bandwidth of no more than 8–12 Mbytes/second, leaving as much as 60 Mbytes/second unused.

The standard VGA includes some write modes to help with the situation discussed above. These modes involve replicating CPU data for more than one bit plane and writing directly from the display memory interface latches. The latter allows the movement of data within the display memory without crossing the host bus.

The CL-GD542X family takes these performance-enhancing measures to their logical conclusion in the following way. It is often the case that only one or two colors need to be written into display memory at any time (consider filling the screen with a pattern or writing text with a single background and a single foreground color). If the actual foreground and background colors are stored in the chip itself, then a single bit is all that must be sent across the host bus for each pixel. This leverages the host-interface bandwidth by a factor of 8 or 16, making it possible to use nearly all the available display memory bandwidth. This is called *color expansion* and is implemented with Extended Write modes 4 and 5.

3. COLOR EXPANSION WITHOUT THE BITBLT ENGINE

The controls that enable the Extended Write modes are in GRB[4:1], as indicated in Figure D6-1. These bits are described in detail in Chapter 9, “Extension Registers”. Briefly, bits 3:1 are programmed to ‘1’s for 8-bit-per-pixel modes, and bits 4:2 are programmed to ‘1’s for 16-bit-per-pixel modes.

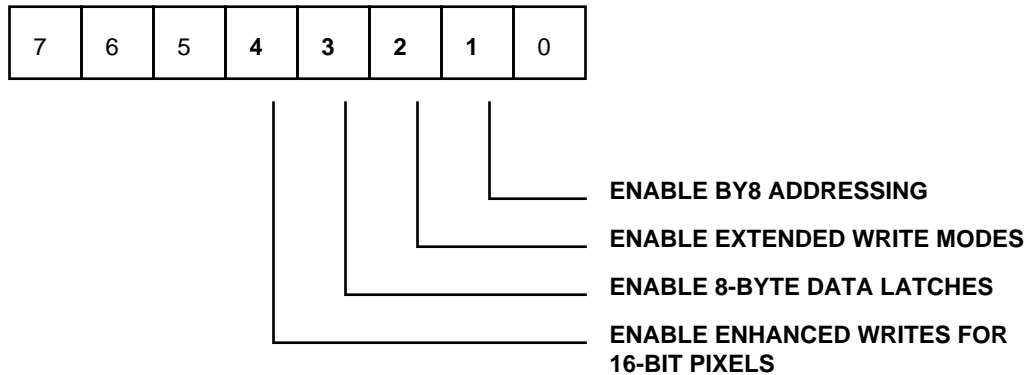


Figure D6-1. Color Expansion Controls

Enable BY8 Addressing shifts the address bits between the host and display memory three bits. This means that each **bit** within the host address space corresponds to a pixel in display memory. The pattern to be expanded is an ordered string of bits, each bit corresponding to a pixel. It can be transferred across the bus with a move string instruction. Each bit is expanded into a complete 8- or 16-bit pixel.

Enable Extended Write Modes can be considered a master enable; it must be programmed to ‘1’ to turn any of this procedure on.

Enable 8-byte Data Latches allows the use of eight, rather than the standard four data latches at the display memory interface.

Enable Enhanced Write for 16-bit Pixels must be programmed to ‘1’ to use color expansion in 16-bit-per-pixel Video modes. When this bit is programmed to ‘1’, each bit across the host bus still corresponds to a pixel, now a 16-bit pixel. Observe that 24-bit-per-pixel color expansion is not supported.

4. EXTENDED WRITE MODE 4

Extended Write mode 4 is enabled when the GR5[2:0] field is programmed to ‘100’, and the Extended Write modes are enabled as described above. In Extended Write mode 4, the foreground color is written into each pixel where the corresponding bit on the host bus is ‘1’. The foreground color is contained in GR1 and GR11 (for 8-bit pixels GR11 is ignored).

Pixels corresponding to CPU bus bits that are ‘0’, are not written in Extended Write mode 4. Extended Write mode 4 is intended for writing text into display memory for which the back-

ground is not to be modified.

5. EXTENDED WRITE MODE 5

Extended Write mode 5 is enabled when the GR5[2:0] field is programmed to '101', and the Extended Write modes are enabled as described above. In Extended Write mode 5, the foreground color is written into each pixel where the corresponding bit on the host bus is '1'. The foreground color is contained in registers GR1 and GR11 (for 8-bit pixels GR11 is ignored). The background color is written into each pixel where the corresponding bit on the host bus is '0'. The background color is contained in registers GR0 and GR10 (for 8-bit pixels GR10 is ignored). Extended Write mode 5 supports 8- and 16-bits-per-pixel.

6. COLOR EXPANSION USING BITBLT ENGINE

This appendix reviews the information regarding Color Expansion. The data can be expanded into 8- or 16-bits-per-pixel. Refer to Appendix D8 for detailed information on the BitBLT engine.

The data to be expanded is always a single bit-per-pixel. The data can represent text or icons. In this case it would typically, but not necessarily, be transferred across the host interface. That is, Color Expansion would typically be a system-to-screen BitBLT operation.

The data could also be a pattern that is to be repeatedly expanded and written into display memory. In this case, the source data must be in display memory (pattern copies are supported only for screen-to-screen BitBLTs).

The Foreground Color registers are GR1 and GR11; Background Color registers are GR0 and GR10. Tables D6-1 and D6-2 indicate how the registers are allocated to the various colors.

Table D6-1. Background Color Registers

Format	GR0	GR10
8 bits/pixel	Single byte	Don't care
16 bits/pixel	Low byte	High byte

Table D6-2. Foreground Color Registers

Format	GR1	GR11
8 bits/pixel	Single byte	Don't care
16 bits/pixel	Low byte	High byte

Appendix D7

Reserved

Appendix D8

BitBLT Engine Application Note

BITBLT ENGINE

1. INTRODUCTION

This appendix describes the CL-GD542X BitBLT engine. The CL-GD5426, CL-GD5428, and CL-GD5429 all include a BitBLT engine. To help establish a common nomenclature, relevant terms are defined. Also included is an example of basic operation. Various methods of modifying the source data before writing it into the destination region are covered, these are: ROPs (raster operations), color expansion, and pattern fill. Practical considerations covered are: BLT direction, using system memory for either the source or destination, and how to start, suspend, and resume a BLT. This document concludes with a complete summary of BLT registers, a discussion of memory-mapped I/O, and some practical examples.

2. DEFINITIONS

This section includes a definition of terms.

Source Area: The *source area* of a BitBLT is the area from which the data are copied. The source area may be in display or system memory; it can be a monochrome image expanded into color; it a single 8×8 pixel image replicated to fill a larger area. The source area is never written, except in special cases where it and the destination area overlap in display memory.

Destination Area: The *destination area* of a BitBLT is the area into which the data are written. The destination area may be in display or system memory.

Width: The *width* of a BitBLT refers to the number of bytes (not pixels) of destination that are processed before adding the pitch values to the address values. If the destination area is actually or potentially on the screen (that is, if it is a rasterized area displayed), the Width is the number of bytes (not necessarily pixels) in each scanline. If the destination area is off-screen (or in system memory) and the source is a rasterized area (and there is no pattern copy or color expansion), the width is the number of bytes per scanline of source. If neither the destination or source is a rasterized area, Width is simply the number of bytes that are processed before the pitch values are added to the address values, and has no special meaning. Width is specified in the register pair GR20/GR21. The number actually written into this register pair is one less than the actual desired width. This is an 11-bit value, allowing a maximum width of 2048 bytes.

Height: The *height* of a BitBLT refers to the number of times the pitch values are added to the address values. If the destination area, source area, or both are actually or potentially on the screen (if either is a rasterized area displayed), the height is the number of scanlines in that area. If not, height is simply the number of times the pitch values are added to the address values and has no special meaning. In this case, width and height are simply two numbers that are multiplied together to define the number of bytes in the destination. Height is specified in the register pair GR22/GR23. The number actually written into the register pair is one less than the actual desired height. This is a 10-bit value, allowing a maximum height of 1024 scanlines. The contents of the registers containing the height are not modified during the operation.

Width and height are shown for a displayable area in Figure D8-1.

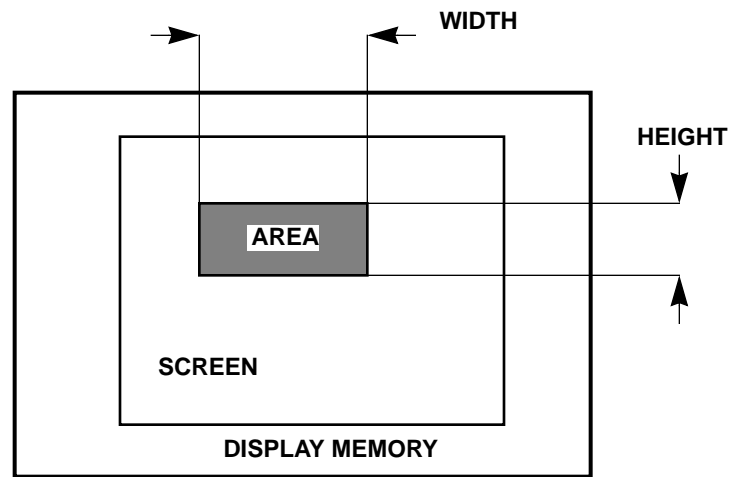


Figure D8-1. Width and Height

Pitch: The destination *pitch* and source *pitch* are the values that are added to the respective addresses after each *width* bytes of destination have been processed. Destination and source pitch are specified separately. When an area is a rasterized image, the respective pitch is the number of bytes between vertically adjacent pixels. This is the number of bytes between the (first) pixels of scanline *n* and scanline *n*+1; the number that is added to the address to get from one scanline to the next. When an area is off-screen display memory, it is often stored so that scanlines are in contiguous locations. This minimizes fragmentation. In this case, the respective pitch would be set equal to the width (+1). When an area is in system memory, the respective pitch is unused and is a 'don't care'. When executing BLTs with pattern copy or color expansion, the source area is taken to be linear and the source pitch is a 'don't care'. The source pitch is specified in register pair GR26/GR27. The destination pitch is specified in register pair GR24/GR25. For the CL-GD5426/'28, these register pairs are both 12-bit values, allowing a pitch of 4095 bytes. For the CL-GD5429, these register pairs are both 13-bit values, allowing a pitch of 8191 bytes. Figure D8-2 shows pitch for the case of a rasterized image.

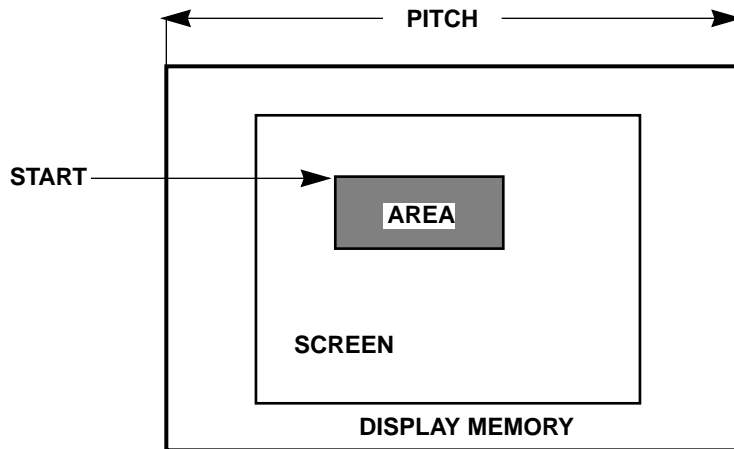


Figure D8-2. Pitch and Start

Start: Refers to the address of the first byte of a destination or source area. This is a byte offset from the beginning of display memory. The start address of the destination area is specified in register triplet GR28/GR29/GD2A. The start address of the source area is specified in register triplet GR2C/GR2D/GR2E. Each start address is a 21-bit value, allowing up to 2 Mbytes of display memory. The start address is shown in Figure D8-2.

3. DISPLAY MEMORY TO DISPLAY MEMORY: AN EXAMPLE

Table D8-1 shows how the BLT registers would have to be programmed for a very simple BLT operation. This copies a 128-byte \times 64-scanline area in display memory. The CL-GD542X is assumed to be programmed in Video Mode 65 (800×600 , 16-bits per pixel). Therefore, each 128-byte scanline actually represents 64 pixels. The source begins at location 0, and the destination begins at location 160200 (100 scanlines from the top of the screen, 100 pixels from the left edge).

Table D8-1. Source Copy BLT

Register(s)	Contents (Decimal)	Field	How Calculated
GR0/GR10	Don't care	Background color	Only for color expansion
GR1/GR11	Don't care	Foreground color	Only for color expansion
GR20/GR21	127	Width	$(64 \times 2) - 1$
GR22/GR23	63	Height	$64 - 1$
GR24/GR25	1600	Destination pitch	800×2
GR26/GR27	1600	Source pitch	800×2

Table D8-1. Source Copy BLT (*cont.*)

Register(s)	Contents (Decimal)	Field	How Calculated
GR28/GR29/GR2A	160200	Destination start	$(100 \times 1600) + (100 \times 2)$
GR2C/GR2D/GR2E	0	Source start	Beginning of display memory
GR2F	don't care	Write mask	Only for color expansion
GR30	0	Mode	Vanilla BLT
GR32	0Dh	ROP	SRC COPY
GR33	0	Mode extension	Unused
GR31	2	Start	Set bit 1

This BLT is executed as indicated in the following fragment of pseudo-code:

```

sourceAdrs = sourceStartAdrs;
destAdrs = destStartAdrs;
for (i = 0; i < Height; i++)                               /*for each scan line*/
{
    workingSourceAdrs = sourceAdrs
    workingDestAdrs = destAdrs
    for (j = 0; j < Width; j++)                               /*for each byte*/
    {
        Process one byte of Destination;
        workingDestAdrs++;                                    /*to next byte*/
        workingSourceAdrs++;
    }
    sourceAdrs = sourceAdrs + sourcePitch; /*next scan line*/
    destAdrs = destAdrs + destPitch;
}

```

The BLT engine processes *width* bytes of destination, incrementing temporary source and destination addresses after each byte (actually, multiple bytes are processed in parallel). At the end of each *width* bytes, the respective pitch values are added to the addresses as they were at the beginning of the scanline, moving on to the next scanline. This continues for *height* iterations.

All BLTs are processed in this general manner. There are some variations. For color expansion, the SourceAdrs is incremented as a bit address rather than a byte address. For pattern copies, the SourceAdrs is incremented modulo some number so that it is used over and over. If the decrement bit is set, the addresses is decremented rather incremented.

4. ROPs (RASTER OPERATIONS)

In addition to merely moving bytes from the source area to the destination area, the CL-GD542X BitBLT engine can combine the source or pattern bytes with the destination

bytes using various logical operations. Further, the source or destination or both can be ignored.

There are exactly 16 ways in which two bits can be logically combined; these are enumerated in Table D8-2. The same value for GR32 is used regardless of whether the operation uses Source or Pattern. The same information is given in non-reverse notion in the description of register GR32 in Chapter 9.

The CL-GD542X BitBLT engine directly implements all 16 ways of logically combining two operands. Combinations of three operands can be synthesized from these in the unusual cases where this is necessary.

Table D8-2. Raster Operations

Source Operation	Microsoft® Name/ Raster Operation	Pattern Operation	Microsoft® Name/ Raster Operation	GR32 (Hex)
0	BLACKNESS 00000042	0	BLACKNESS 00000042	00
DSon	NOTSRCERASE 001100A6	DPon	— 000500A9	90
DSna	— 00220326	DPna	— 000A0329	50
Sn	NOTSRCCOPY 00330008	Pn	— 000F0001	D0
SDna	SRCERASE 00440328	PDna	— 00500325	09
Dn	DSTINVERT 00550009	Dn	DSTINVERT 00550009	0B
DSx	SRCINVERT 00660046	DPx	PATINVERT 005A0049	59
DSan	— 007700E6	DPan	— 005F00E9	DA
DSa	SRCAND 008800C6	DPa	— 00A000C9	05
DSxn	— 00990066	PDxn	— 00A50065	95
D	— 00AA0029	D	— 00AA0029	06
DSno	MERGEPAINT 00BB0226	DPno	— 00AF0229	D6
S	SRCCOPY 00CC0020	P	PATCOPY 00F00021	0D
SDno	— 00DD0228	PDno	— 00F50225	AD

Table D8-2. Raster Operations (*cont.*)

Source Operation	Microsoft® Name/ Raster Operation	Pattern Operation	Microsoft® Name/ Raster Operation	GR32 (Hex)
DSO	SRCPAINT 00EE0086	DPo	— 00FA0089	6D
1	WHITENESS 00FF0062	1	WHITENESS 00FF0062	0E

5. COLOR EXPANSION

If GR30[7] is programmed to '1', the source input to the ROP is not actual data from the source area, but *color expanded* data. The source area is a monochrome image. Since the source image is a single bit-per-pixel, substantial performance benefits can be gotten, especially if the source is being expanded to 16-bits. Color expansion can be used anytime a single foreground color or a single foreground color and a single background color are to appear in the destination. The CL-GD542X supports color expansion for 8- and 16-bit-per-pixel modes. The source can be either an 8×8 pattern (display memory only) or it can be monochrome data from either display memory or system memory. When the source is in display memory, it must be on a four-byte boundary. When the source is an 8×8 pattern, it must be on an eight-byte boundary.

Ones in the source area results in the foreground color being written into the corresponding byte(s) of the destination area. Zeroes in the source area results in either the background color being written into the corresponding byte(s) of the destination area, or no alteration to the destination area (transparency). The destination must be screen memory and the direction must be increment. Any ROP can be used, although SRCCOPY is most common when using color expansion.

The most-significant-bit of the first source byte is expanded into the ROP source data for the first pixel of the destination. Depending on the contents of GR30[4], it is expanded to 1 or 2 bytes. The following tables indicate the registers that contain the expansion colors.

Table D8-3. Color Expansion ('1' in source)

GR30[4]	Width	GR1	GR11
0	8-bit	Color	Don't care
1	16-bit	Low byte	High byte

Table D8-4. Color Expansion ('0' in source)

GR30[4]	Width	GR0	GR10
0	8-bit	Color	Don't care
1	16-bit	Low byte	High byte

The next bit of source data is processed for the next 1 or 2 bytes of destination, and so on, until *width* bytes of destination have been processed. Unused source bits are discarded to the end of the current byte. The destination address is modified by the destination pitch. The source pitch is ignored since the source is taken to be a linear string of bytes. The next byte of source is the first eight pixels for the next scanline.

6. COLOR EXPANSION WITH TRANSPARENCY (CL-GD5426/'28)

For the CL-GD5426/'28, if GR30[3] is programmed to '1', Transparency Compare is enabled. The results of the ROP are compared to the contents of the Transparent Color register (GR34, GR35) for each pixel. If they compare in all bit positions for which the Transparent Compare Mask register (GR38/39) are '0', the results are *not* written to display memory. In 8-bit pixel modes (GR30[4] = 0), registers GR34 and GR35 *must* be programmed identically, as must GR38 and GR39.

The transparency feature must be used, and the transparent color set to the background color if color expansion is to be used with an opaque foreground and a transparent background (analog of Extended Write mode 4). The Foreground Color registers are used as indicated in Table D8-5.

Table D8-5. Color Expansion with Transparency ('1' in Source)

GR30[4]	Width	GR1	GR11
0	8-bit	Color	Don't care
1	16-bit	Low byte	High byte

7. COLOR EXPANSION WITH TRANSPARENCY (CL-GD5429)

For the CL-GD5429, if GR30[3] is programmed to '1', the pixels corresponding to '0's in the source area are not written. This is the analog of Extended Write mode 4. This is used for a Transparent Write. If GR30[2] is programmed to '0', the pixels corresponding to '0's in the source area are written with the contents of the background color register(s). This is the analog of Extended Write mode 5.

NOTE: A write to GR2C must be included as part of the setup for any system-to-screen BitBLT with color expansion. The data value written is not important.

For a screen-to-screen BitBLT, the following ROPs cannot be used with transparency:

00 BLACKNESS, 0B DSTINVERT, 0E WHITENESS

For the CL-GD5429, the Background Color registers are ignored when transparency is enabled. The Foreground Color registers are used as indicated in Table D8-6.

Table D8-6. Color Expansion with Transparency ('1' in Source)

GR30[4]	Width	GR1	GR11
0	8-bit	Color	Don't care
1	16-bit	Low byte	High byte

8. COLOR EXPANSION with LEFT EDGE CLIPPING (CL-GD5429 only)

For the CL-GD5429 only, if registers GR2F[2:0] are programmed to any value other than zero, the first 'n' pixels of each scanline of the destination are not written. The destination address must be on an eight pixel boundary. This is typically used in conjunction with pattern fills with color expansion.

9. PATTERN FILLS

In some cases it is necessary to fill an area with a repeating pattern. The CL-GD542X BitBLT engine has provisions for pattern replication with or without color expansion. The pattern size is 8 pixels × 8 pixels, chosen for compatibility with Microsoft Windows.

If GR30[6] is programmed to '1', the source is taken to be an array of 8 pixels × 8 pixels. It is repeatedly copied to the destination area with, color expansion if necessary. For any scanline, the same eight pixels of source data are used repeatedly. The source pitch is ignored. The number of bytes in the source pattern is a function of the operating mode, as indicated in Table D8-5.

Table D8-7. Source for Pattern Fills

Operating Mode	Arrangement	Starting Address Boundary
Color Expansion	8 bytes of monochrome data for 64 pixels	8 bytes
8-bit pixels	64 bytes of color data for 64 pixels	64 bytes
16-bit pixels	128 bytes of color data for 64 pixels	128 bytes
32-bit pixels	256 bytes of color data for 64 pixels	256 bytes

10. PATTERN VERTICAL PRESET (CL-GD5429 only)

The CL-GD5429 supports pattern vertical preset for pattern fill with color expansion. The low-order 3 bits of the Source Start Address register (GR2C[2:0]) selects the eight pixels to be used for the first (or only) scanline. This is possible because the pattern must be in an eight-byte boundary. This makes it possible to force vertical alignment of the pattern. The vertical alignment is useful for the filled rectangles and polygons described in the following section.

11. PATTERNED POLYGON FILLS (CL-GD5429 only)

The CL-GD5429 has special provisions for patterned polygon fills. The polygon to be filled is decomposed into a series of single scanlines, each of which are filled with a single BitBLT. The first such operation reads all eight bytes of monochrome pattern. Thereafter, as long as no writes to the Source Start Address registers or to the BLT Mode register occur, subsequent operations use the previously loaded source data (skipping the read cycle). In addition, the Y offset initially set by the three low-order bits of the Source Start Address (GR2C[2:0]) is incremented modulo eight at the end of each operation. This results in each scan line starting one byte further into the pattern than the scanline immediately above. The polygon may be filled with a series of single scanline fills that change only the Destination Start Address, left-edge pixel clipping, and width. The operation should proceed from top to bottom (if it goes from bottom to top, the pattern is vertically flipped).

NOTE: If XY pattern offset is being used, always program GR2F[7] to '0'.

12. BLT DIRECTION

If the source and destination areas overlap in display memory, one must be certain that the operation progresses so that the source area is not overwritten prior to being used. Consider Figure D8-3. If the operation were to begin with the upper left corner of the source and destination, the contents of the overlapped area would be overwritten before being used.

If register GR30[0] is programmed to '1', the direction in which the operation progresses is reversed. The bytes are processed right-to-left and bottom-to-top. In Figure D8-3 this guarantees that bytes of the source are used prior to being changed. Observe that the start addresses in this case are the highest in the areas, not the lowest.

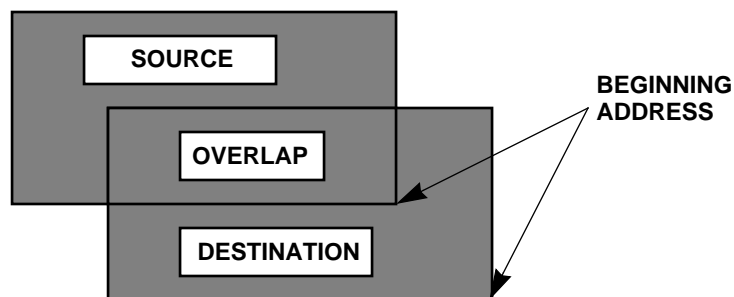


Figure D8-3. Overlapping BLT

13. SYSTEM MEMORY

The source area of a BitBLT can be system memory. What this means from the point of view of the CL-GD542X, is that the source is the system bus. If the source of a BitBLT is system memory, SR8[6] *must* be programmed to '0'.

If GR30[2] is programmed to '1', the BitBLT source is system memory. The CPU must perform the bus transfers; the CL-GD542X is never a bus master. The address provided by the CPU with such transfers is ignored (except it must be in the range being decoded as display memory). The CPU *must* execute DWORD transfers (even though these would be broken into pairs of WORD transfers for ISA bus).

For system-to-screen BitBLTs, up to three bytes of the last transfer for each scanline is ignored (depending on width). The next scanline begins with the next DWORD transfer. For system-to-screen BitBLTs without color expansion, the last DWORD or partial DWORD must be transferred as two WORD operations. Both words must be transferred, even if the second word is not actually required to complete the operation.

14. START/SUSPEND/RESET CONTROLS

Once the parameters have been loaded into the registers the BitBLT can be started. It is possible to suspend and then resume a BitBLT. It is also possible to unconditionally reset the BitBLT engine. These functions are controlled by bits in GR31.

Register GR31[1] is programmed to '1' to start a BLT. So long as the BLT is in progress, GR31[0] is '1'. When the BLT has completed, GR31[0] is '0'. Monitoring GR31[0] is the most direct way to synchronize with the BitBLT engine. While the BLT is in progress, the CL-GD542X display memory and BLT registers (except GR31) must not be accessed for read or write. If the write buffer is not empty when a BitBLT is started, the BitBLT does not take place correctly. This was uncovered by a programming sequence where the BLT registers were loaded, the pattern was written to memory, and the BitBLT was immediately started.

It is recommended that this sequence be reversed so that any necessary writes to DRAM take place before the registers are loaded. This allows the write buffer to be emptied before the BitBLT is started.

It is possible to suspend a BLT by programming register GR31[1] to '0'. Register GR31[0] must be monitored to determine when the BLT has actually been suspended and it is safe to access display memory. When register GR31[0] is '0', then the BLT has been successfully suspended or has been completed. Only screen-to-screen BLTs can be suspended.

When a BLT has been suspended, the CPU may access display memory only for write operations. If the program reads display memory during a suspended BLT, working registers are overwritten and the first few bytes of the BLT, when it is resumed, uses invalid data.

The CPU can determine whether a suspended BLT was actually suspended, or went to completion coincidentally with the suspension, by reading GR31[3]. If it is '1', the BLT was suspended and must be resumed. If it is '0', the BLT was actually completed and need not be resumed. The BLT is resumed by programming GR31[1] to '1'. BLTs can be suspended and resumed multiple times.

The current operation can be unconditionally stopped, and the entire BitBLT engine reset by programming GR31[2] to '1'. GR31[3] and GR31[0] is forced to '0' and the operation stops after the next write. This can result in partial pixels being written.

NOTE: A BLT operation that is reset *cannot* be resumed.

15. COMPLETE BLT REGISTER LIST

Table D8-8 lists every register associated with the BitBLT engine.

Table D8-8. BLT Register List

Register	Memory-Mapped I/O Offset (Hex)	Used In	Size (Bits)	Modified	Note
GR0	00	Background Color byte 0	8	No	–
GR1	04	Foreground Color byte 0	8	No	–
GR10	01	Background Color byte 1	8	No	–
GR11	05	Foreground Color byte 1	8	No	–
GR20	08	Width byte 0	8	–	–
GR21	09	Width byte 1	3	–	–
GR22	0A	Height byte 0	8	No	–
GR23	0B	Height byte 1	2	No	–
GR24	0C	Destination Pitch byte 0	8	No	–
GR25	0D	Destination Pitch byte 1	4	No	5 bits on CL-GD5429
GR26	0E	Source Pitch byte 0	8	No	–
GR27	0F	Source Pitch byte 1	4	No	5 bits on CL-GD5429
GR28	10	Destination Start byte 0	8	Yes	–
GR29	11	Destination Start byte 1	8	Yes	–
GR2A	12	Destination Start byte 2	5	Yes	–
GR2B	13	Reserved			–
GR2C	14	Source Start byte 0	8	Yes	–
GR2D	15	Source Start byte 1	8	Yes	–
GR2E	16	Source Start byte 2	5	Yes	–
GR2F	17	Destination Write Mask	3	No	CL-GD5429 only
GR30	18	BLT mode	8	No	–
GR31	40	Start/Status	4	–	–

Table D8-8. BLT Register List (*cont.*)

Register	Memory-Mapped I/O Offset (Hex)	Used In	Size (Bits)	Modified	Note
GR32	1A	ROP	8	No	–
GR33	1B	BLT reserved	–	–	–
SR2	–	Plane Mask register	8	No	–

16. MEMORY-MAPPED I/O (CL-GD5429 only)

All the registers listed above, except SR2, can be written as memory locations. This is called *memory-mapped I/O*. This makes it possible to load the registers more quickly because they can be written four-per-access. This capability is unique to the CL-GD5429.

Memory-mapped I/O is enabled when SR17[2] is programmed to a '1'. The registers are mapped beginning at address B800:0. The CL-GD5430 can be programmed to place the memory-mapped I/O area at the last 256 bytes of the linear address space. GR6[3:2] must be programmed to 01. When memory-mapped I/O is enabled, only GR31 is accessible as an I/O location. Appendix B20, "Memory-Mapped I/O", contains a list of registers ordered by offset.

17. MISCELLANEA

BLT Registers Modified: A few of the registers associated with a BLT are modified while the BLT is occurring. Therefore, they must be re-written prior to the next BLT even if the initial values are to be the same. An exception is the Height registers (GR22/GR23). A working copy of this field is made when the BLT begins so that the field itself is not changed. This is useful for repeatedly drawing horizontal lines and for patterned polygon fills.

18. EXAMPLES

Text Expansion Example: Using color expansion, a text string is copied from system memory. The monochrome image of the string is arranged in system memory by scanline. The destination area is 150 pixels × 25 scanlines, 8-bits-per-pixel. The destination pitch is 1024 pixels. The registers must be loaded as indicated in Table D8-9. If the background pixels are not to be written, GR30[3] would be set to '1'.

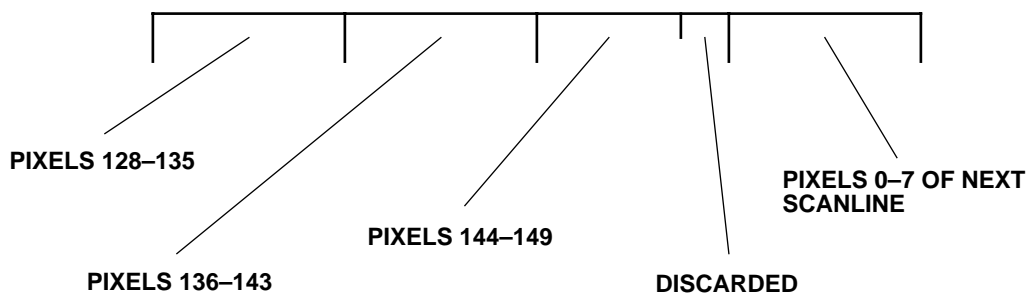
Table D8-9. Text Expansion BLT

Register(s)	Contents (Decimal)	Field	Calculated As
GR0/GR10	xx	Background Color	As desired
GR1/GR11	xx	Foreground Color	As desired
GR20/GR21	149	Width	150 – 1

Table D8-9. Text Expansion BLT (*cont.*)

Register(s)	Contents (Decimal)	Field	Calculated As
GR22/GR23	24	Height	25 – 1
GR24/GR25	1024	Destination Pitch	–
GR26/GR27	n/a	Source Pitch	(System memory)
GR28/GR29/GR2A	xxxxx	Destination Start	–
GR2C/GR2D/GR2E	n/a	Source Start	(System memory)
GR2F	0	Write Mask	No clipping
GR30	84h	Mode	Color expansion, system memory source
GR32	0Dh	ROP	SRCCOPY
GR33	0	Mode Extension	Unused
GR31	2	Start	Set bit 1

After the registers are loaded the source bitmap must be transferred, the first DWORD write transfers the image for pixels 0–31; the second write transfers the image for pixels 32–63; the third transfers the image for pixels 64–95; the fourth transfers the image for pixels 96–127. The fifth DWORD transfer is special. The data for this transfer is shown in Figure D8-4.

**Figure D8-4. Color Expand Transfer**

A total of 119 DWORD transfers are required; the final byte of the last transfer is discarded.

Appendix D9

Cirrus Logic Bulletin Board Service

CIRRUS LOGIC BBS

1. INTRODUCTION

This appendix discusses the Cirrus Logic BBS (Bulletin Board Service). The BBS is intended primarily for one-way communication from Cirrus Logic to its OEMs and end users. The latest drivers are available to Cirrus Logic OEMs and end users, but only Cirrus Logic OEMs can obtain the latest BIOS images over the BBS.

Cirrus Logic maintains strict access control to this bulletin board to minimize the possibility of distribution of pirated or virus-ridden software. Only Cirrus Logic employees have upload access to publicly downloadable file areas. An end user or OEM can upload files, but not to a publicly downloadable area.

The software running on this board is Wildcat!™ IM, written by Mustang Software, Inc.®. Cirrus Logic operates eight remote nodes and one local node to the BBS.

2. TELEPHONE NUMBER AND COMMUNICATION PARAMETERS

The telephone number of the Cirrus Logic BBS is (510) 440-9080. The communication parameters are:

- 8 data bits
- no parity
- 1 stop bit

The Cirrus Logic BBS line supports up to a 14,400 baud rate. However, baud connections of 300 and 1200 bps are allowed, as long those connections do not prohibit access and cause complaints to be registered.

3. FIRST TIME LOG ON

Upon connection with the bulletin board, a name and password for a guest-account fields have default entries. If merely downloading drivers, demonstration programs, or utilities use the default entry. This avoids filling and out the questionnaire and purging the user database, yet allows access to most files.

If schematic diagrams or BIOS files are required or if planning to upload files, log on with your name (or company name). The system will prompt a password entry and require that the questionnaire be completed. When completed, the name and password chosen is added to the user database and access is the same as a guest log on.

4. UPGRADED ACCESS

If requiring access to BIOS image or schematic diagram files, or if exchanging files with Cirrus Logic personnel on a regular basis, an upgrade of your account is necessary. Account upgrades are handled through your contact at Cirrus Logic (usually through a sales office).

Setting up an upgrade account requires one working day from the time of request. 3–5 working days are required for the request to be processed after being received at Cirrus Logic in Fremont, California.

5. ORGANIZATION OF THE BOARD

The Cirrus Logic BBS is organized into 'Product' areas plus a 'General Public Messages' area. The Product areas, as of May 1995, are listed in Table D9-1.

Table D9-1. Product Areas

Area	Name	Note
1	General Public Messages	Non-specific programs, README, etc.
2	510/520	
3	5320	
4	5410	
5	5401/'02/'20	Software-wise, 5420 is related to 01, 02
6	5422/'24/'25/'26/'28/'29	
7	5434/'36/'40	Alpine
8	Northstar	Not yet open
9	Spare Desktop	Not yet open
10	610/620	
11	62XX	
12	634X	
13	641X	
14	642X	
15	6440	
16	Spare Laptop	Not yet open
17	Pixel Products	
18	Modems	
19	6710/6720	

The General Public Messages area contains non-specific programs such as PKWare and ID_CHIP. This area also contains README files that describe the contents and layout of the board. The upload areas also reside in the General Public Messages area. The upload areas are readable only by Cirrus Logic employees.

The other product areas are connected to five file areas each. These file areas are listed in Table D9-2.

Table D9-2. File Areas within Product Areas

File Area	Note	Download Access
Drivers	Driver disks	All
Demonstrations	BLT demo, slide viewers, etc.	All
Utilities	for example, CLMODE	All
BIOS	BIOS images, MFGTST	Integrator, OEM
Schematics	ORCAD schematic diagrams	OEM

Appendix E1

VGA BIOS External Function Specification

VGA BIOS EXTERNAL FUNCTION SPECIFICATION

1. INTRODUCTION

This document provides a specification for the external software interface of the Cirrus Logic VGA BIOS (basic input/output system).

The Cirrus Logic VGA BIOS is fully compatible with the standard IBM® VGA BIOS and the Interrupt 10h video service functions. This document does not describe the standard Interrupt 10h functions. These functions are described in detail in various other public documents (see the bibliography in Appendix F1).

All interface extensions to the standard VGA BIOS are fully described in this document.

1.1 Main Features

The Cirrus Logic BIOS is a high-performance firmware product designed to take maximum advantage of the Cirrus Logic VGA controller, especially in the areas of display quality, power management and video performance. The following are some of the major features of the product:

- 100% IBM® VGA-compatible BIOS
- High performance operation
- Modular, proven design
- Adapter or system board implementation (or C000/E000 segments)
- Can be integrated with system BIOS
- Supports switchless configuration
- Can be customized without source code
- VESA®-compatible modes
- VESA®-compatible INT 10h interface

1.2 Implementation Type

The Cirrus Logic VGA controller and BIOS can be implemented as an adapter board or placed directly on the motherboard. The following two sections describe specific information relating to implementation type.

1.2.1 Adapter Implementation

When the video subsystem is implemented as an optional video adapter, the video BIOS will reside at segment C000h for a length of 32 Kbytes.

The video subsystem is initialized in the standard method. The BIOS will begin with 55h, AAh, and a length indicator. The indicated length will check-sum to a '0', modulo 256. The planar BIOS will make a far call to C000:3 to initialize the video subsystem at power-up.

1.2.2 Planar Implementation

When the video subsystem is implemented as an integral part of the system, the BIOS will reside at segment E000h. The planar BIOS must make a far call to E000:3 to initialize the video subsystem at power-up. This initialization must occur, and must occur prior to initializing any adapter video BIOS. Initialization of optional video adapter ROM BIOS at C000h will be done in the standard manner.

For the video subsystem to co-exist with adapter video subsystems, control must be transferred to the video BIOS at E000h from the F000:F065 entry point. The motherboard BIOS must place a far jump to E000:1B at F000:F065. The E000h video BIOS will handle all requirements of CGA and MGA adapters, and coexist with compatible VGA adapters.

For the video subsystem to operate in some environments, a direct BIOS entry is provided to call some BIOS functions without using the interrupt vector table or BIOS data areas in low memory. At offset E000:0019 or C000:0019 is a data word that contains the offset of the VGA BIOS entry point. This word points to the instruction immediately following the CLI clear interrupt instruction. The BIOS preserves the state of the interrupt flag internally, so if interrupts are disabled upon entry through this point, they will remain disabled throughout execution of the BIOS. Note that only certain BIOS functions, such as save/restore state should be used unless the interrupt table and BIOS data area are correctly initialized.

1.3 Configuration

1.3.1 INT 15 Support

The system BIOS should implement INT 15h AX = 448EH. This is a signal that the video BIOS is ready to accept INT 10 option calls. When this interrupt is received, the system BIOS should perform any option selection required via INT 10h Function 12h, as described in this document. Note that the video BIOS invokes this INT 15 call prior to the initial mode set and displaying the sign-on message.

1.3.2 Scratch Register Definitions

For motherboard implementation without the EEPROM, an INT 15 call is made by the CLMODE utility to pass configuration changes to the motherboard BIOS to be saved in the CMOS memory.

Input: AX = 448Fh
 DL = SRA
 DH = SR9

The INT 15 routine service should clear the Carry bit to indicate that the call is supported. The use of these registers is explained below. Cirrus Logic no longer publishes the use of these register bits with the following exception: SR9[0:1] continues to be reserved for OEM use.

SR09:	7:6	1024 × 768 Frequency
	5:4	800 × 600 Frequency
	3:2	Maximum Resolution
	1:0	Unused (for OEM use)
SR0A:	7	Reserved
	6	High refresh (640 × 480 Frequency)
	5	Reserved
	4:3	Memory Size (00 = 256, 01 = 512, 10 = 1 Mbyte, 11 = 2 Mbyte)
	2:1	Reserved
	0	16/8-bit memory (1 = 16 bit, 0 = 8 bit)

2. VIDEO MODES

The Cirrus Logic VGA BIOS supports all standard VGA modes. These standard VGA modes are listed in Table E1-1.

Table E1-1. Standard VGA Modes

Mode No.	VESA® Mode No.	No. of Colors	Char. × Row	Char. Cell	Pixels	Display Mode	Horiz. Freq.	Vert. Freq.
00/01	—	16/256	40 × 25	8 × 8	320 × 200	Text	31.5	70
00*/01*	—	16/256	40 × 25	8 × 14	320 × 350	Text	31.5	70
00+/01+	—	16/256	40 × 25	9 × 16	360 × 400	Text	31.5	70
02/03	—	16/256	80 × 25	8 × 8	640 × 200	Text	31.5	70
02*/03*	—	16/256	80 × 25	8 × 14	640 × 350	Text	31.5	70
02+/03+	—	16/256	80 × 25	9 × 16	720 × 400	Text	31.5	70
04/05	—	4/256	40 × 25	8 × 8	320 × 200	Graphics	31.5	70
6	—	2/256	80 × 25	8 × 8	640 × 200	Graphics	31.5	70
07*	—	Monochrome	80 × 25	9 × 14	720 × 350	Text	31.5	70
07+	—	Monochrome	80 × 25	9 × 16	720 × 400	Text	31.5	70
0D	—	16/256	40 × 25	8 × 8	320 × 200	Graphics	31.5	70
0E	—	16/256	80 × 25	8 × 8	640 × 200	Graphics	31.5	70
0F	—	Monochrome	80 × 25	8 × 14	640 × 350	Graphics	31.5	70
10	—	16/256	80 × 25	8 × 14	640 × 350	Graphics	31.5	70
11	—	2/256	80 × 30	8 × 16	640 × 480	Graphics	31.5	60
12	—	16/256	80 × 30	8 × 16	640 × 480	Graphics	31.5	60
13	—	256/256	40 × 25	8 × 8	320 × 200	Graphics	31.5	70

The CL-GD540X and CL-GD542X VGA BIOS supports standard VESA® and Extended modes. These modes are listed in Table E1-2.

Table E1-2. Cirrus Logic Extended Video Modes

Mode No.	VESA® No.	No. of Colors	Char. × Row	Char. Cell	Screen Format	Display Mode	Pixel Freq. MHz	Horiz. Freq. kHz	Vert. Freq. Hz
14	–	16/256K	132 × 25	8 × 16	1056 × 400	Text	41.5	31.5	70
54	10A	16/256K	132 × 43	8 × 8	1056 × 350	Text	41.5	31.5	70
55	109	16/256K	132 × 25	8 × 14	1056 × 350	Text	41.5	31.5	70
58, 6A	102	16/256K	100 × 37	8 × 16	800 × 600	Graphics	36	35.2	56
58, 6A	102	16/256K	100 × 37	8 × 16	800 × 600	Graphics	40	37.8	60
58, 6A	102	16/256K	100 × 37	8 × 16	800 × 600	Graphics	50	48.1	72
5C	103	256/256K	100 × 37	8 × 16	800 × 600	Graphics	36	35.2	56
5C	103	256/256K	100 × 37	8 × 16	800 × 600	Graphics	40	37.9	60
5C	103	256/256K	100 × 37	8 × 16	800 × 600	Graphics	50	48.1	72
5D†	104	16/256K	128 × 48	8 × 16	1024 × 768	Graphics	44.9	35.5	87†
5D	104	16/256K	128 × 48	8 × 16	1024 × 768	Graphics	65	48.3	60
5D	104	16/256K	128 × 48	8 × 16	1024 × 768	Graphics	75	56	70
5D	104	16/256K	128 × 48	8 × 16	1024 × 768	Graphics	77	58	72
5F	101	256/256K	80 × 30	8 × 16	640 × 480	Graphics	25	31.5	60
5F	101	256/256K	80 × 30	8 × 16	640 × 480	Graphics	31.5	37.9	72
60†	105	256/256K	128 × 48	8 × 16	1024 × 768	Graphics	44.9	35.5	87†
60	105	256/256K	128 × 48	8 × 16	1024 × 768	Graphics	65	48.3	60
60	105	256/256K	128 × 48	8 × 16	1024 × 768	Graphics	75	56	70
60	105	256/256K	128 × 48	8 × 16	1024 × 768	Graphics	77	58	72
64	111	64K	–	–	640 × 480	Graphics	25	31.5	60
64	111	64K	–	–	640 × 480	Graphics	31.5	37.9	72
65	114	64K	–	–	800 × 600	Graphics	36	35.2	56
65	114	64K	–	–	800 × 600	Graphics	40	37.8	60
66	110	32K‡	–	–	640 × 480	Graphics	25	31.5	60
66	110	32K‡	–	–	640 × 480	Graphics	31.5	37.9	72
67	113	32K‡	–	–	800 × 600	Graphics	36	31.5	56

Table E1-2. Cirrus Logic Extended Video Modes *(cont.)*

Mode No.	VESA® No.	No. of Colors	Char. × Row	Char. Cell	Screen Format	Display Mode	Pixel Freq. MHz	Horiz. Freq. kHz	Vert. Freq. Hz
68†	–	32K‡	–	–	1024 × 768	Graphics	44.9	35.5	87†
6C†	106	16/256K	160 × 64	8 × 16	1280 × 1024	Graphics	75	48	87†
6D†	–	256/256K	160 × 64	8 × 16	1280 × 1024	Graphics	75	48	87†
71	112	16M	80 × 30	8 × 16	640 × 480	Graphics	25	31.5	60
74†	–	64K	–	–	1024 × 768	Graphics	44.9	35.5	87†

NOTES:

- 1) Some modes are not supported by all CL-GD542X controllers. Refer to Chapter 3, “Data Book” and the Software Release Kit for the list of Video modes supported by the CL-GD542X BIOS.
- 2) Some modes are not supported by all monitors. The fastest vertical refresh rate for the monitor type selected will be automatically used.
- 3) ‘‡’ character stands for 32K Direct-Color/256-color Mixed mode.
- 4) ‘†’ character stands for Interlaced mode.

3. INTERRUPT 10H INTERFACE EXTENSIONS

The Cirrus Logic BIOS supports all standard VGA BIOS INT 10h video service functions. In addition, the BIOS provides extensive support for various features of the Cirrus Logic VGA controller. These functions are available as extended functions under Interrupt 10h.

The standard VGA BIOS INT 10h video service functions are not described in this document.

All extended function calls will preserve the CPU registers, except those used to pass information from the BIOS.

3.1 Function Summary

Table E1-3 provides an overview of the extended functions provided by the Cirrus Logic BIOS.

Table E1-3. Extended Function Summary

AH Register	BL Register	Function
12h	80h	Inquire VGA type
12h	81h	Inquire BIOS version number
12h	82h	Inquire design revision code
12h	85h	Return installed memory
12h	93h	Force 8 bit
12h	9Ah	Inquire user options
12h	A0h	Query Video mode availability
12h	A1h	Read monitor type and ID
12h	A2h	Set monitor type (horizontal)
12h	A3h	Set VGA refresh
12h	A4h	Set monitor type (vertical)

3.2 Inquiry Functions

The inquiry functions are supported for all versions of the video BIOS. These functions allow applications software to determine and use other functions described in the user options.

3.2.1 Inquire VGA Type

This function provides a mechanism for software to determine the type of Cirrus Logic VGA controller, silicon revision number and its corresponding hardware capabilities. BIOS versions that do not support this family of function will preserve the input value in AL register.

Input:	AH =	12h
	BL =	80h
Output:	AX =	Controller type
	0 =	No extended alternate select support
	1 =	Reserved
	2 =	CL-GD510/520
	3 =	CL-GD610/620
	4 =	CL-GD5320
	5 =	CL-GD6410
	6 =	CL-GD5410
	7 =	CL-GD6420
	8 =	CL-GD6412
	10h =	CL-GD5401
	11h =	CL-GD5402
	12h =	CL-GD5420
	13h =	CL-GD5422
	14h =	CL-GD5424
	15h =	CL-GD5426
	16h =	CL-GD5420r1
	17h =	CL-GD5402rl
	18h =	CL-GD5428
	19h =	CL-GD5429
	1Ah =	CL-GD5425
	20h =	CL-GD6205/15/25
	30h =	CL-GD5432
	31h =	CL-GD5434
	BL =	Silicon revision number
	0–7Fh =	Silicon revision
	80h =	Silicon revision number not available

3.2.2 Inquire BIOS Version Number

This function provides a mechanism for software to determine the BIOS version number.

Input:	AH =	12h
	BL =	81h
Output:	AH =	Major BIOS version number
	AL =	Minor BIOS version number
Example:	If BIOS version is 1.02, then AH is 01 and AL is 02.	

3.2.3 Inquire Cirrus Logic Design Revision Code

This function provides a mechanism for software to determine the revision of Cirrus Logic silicon.

Input: AH = 12h
BL = 82h
Output: AL = Chip revision

3.2.4 Return Installed Memory

The function returns the amount of video memory present in 64K units.

Input: AH = 12h
BL = 85h
Output: AL = Amount of video memory present in 64K units.

3.3 Miscellaneous Functions

The functions in this section are miscellaneous chip set functionality.

3.3.1 Force 8-Bit Operation

This function forces 8-bit operation in an environment where 16-bit operation is possible. Takes effect immediately.

Input: AH = 12h
BL = 93h
AL = 0 Run as 16-bit device
AL = 1 Force 8-bit operation
Output: Nothing

3.4 Additional Functions

The functions in this section support various features of the Cirrus Logic VGA controller.

3.4.1 Inquire User Options

This function returns the current status of user options.

Input: AH = 12h
BL = 9Ah
Output: AX = Contains the following options
Bits 1:0 = Reserved
Bits 4:2 = Monitor Type (Horizontal)
Bits 6:5 = Vertical montype maximum resolution
Bits 9:7 = Reserved
Bit 10 = Force 8-bit operation (0=16-bit, 1=8-bit)
Bits 13:11 = Reserved
Bit 14 = Vertical montype 640 × 480 frequency (VGA refresh)
Bit 15 = Reserved
BX = Reserved
CX = Contains the following options
Bits 3:0 = Reserved

Bits 5:4	=	Vertical montype 1280 × 1024 frequency
Bits 10:6	=	Reserved
Bits 12:11	=	Vertical montype 800 × 600 frequency
Bits 15:13	=	Vertical montype 1024 × 768 frequency
DX	=	Reserved

3.5 Global Functions

3.5.1 Query Video Mode Availability

Input:	AH	=	12h
	AL	=	Video mode number (0-7fh)
	BL	=	A0h
Output:	AH	=	Bit 0
	0	=	Video mode not supported
	1	=	Video mode supported
DS:SI:	Pointer to standard video parameters, or FFFF:FFFF if standard parameters undefined for this mode		
ES:DI:	Pointer to supplemental video parameters, or FFFF:FFFF if supplemental parameters undefined for this mode		
BX	Offset to BIOS sub-routine that will fix up the parameters pointed to by DS:SI. This routine requires ES:DI points to the proper supplemental video parameters.		

3.5.2 Read Monitor ID/Type

This function reads the Monitor ID and senses the type of monitor attached.

NOTE: This function may be deleted from future versions of the BIOS.

Input:	AH	=	12h
	BL	=	A1h Read monitor ID and type from 15-pin connector
Output:	BH	=	Monitor ID
	09h	=	IBM 8604/8507 or equivalent
	0Ah	=	IBM 8514 or equivalent
	0Bh	=	IBM 8515 or equivalent
	0Dh	=	IBM 8503 or equivalent
	0Eh	=	IBM 8512/8513 or equivalent
	0Fh	=	No monitor
	00..08, 0C	=	reserved
	BL	=	Monitor gender
	00	=	Color display
	01	=	Grayscale display
	02	=	No display

3.5.3 Set Monitor Type (Horizontal)

This function sets the monitor type in terms of horizontal timings. The monitor type information is used by the BIOS to select the optimal display timings for extended modes. The current monitor type can be read back using Function 9A.

Input:	AH	=	12h
	BL	=	A2h Set monitor type
	AL	=	Monitor type to set

- 0 = VGA (31.5 kHz)
- 1 = 8514-compatible (31.5kHz and 35.5 kHz(i))
- 2 = Super VGA (31.5 kHz–35.1 kHz)
- 3 = Extended Super VGA (31.5 kHz–35.5 kHz)
- 4 = Multi-freq. (31.5 kHz–37.8 kHz)
- 5 = Extended multi-freq. (31.5 kHz–48.0 kHz)
- 6 = Super multi-freq. (31.5 kHz–56.0 kHz)
- 7 = Extended super multi-freq. (31.5 kHz–64.0 kHz)

Output: Nothing

3.5.4 Set Refresh Type

This function toggles the VGA refresh rate between normal vertical refresh and high vertical refresh for flicker reduction. The current refresh can be read back using Function 9A.

Input:

- AH = 12h
- BL = A3h Set High/Low VGA refresh
- AL = Enable/disable
 - 1 = Enable high refresh
 - 0 = Use normal VGA refresh

Output: Nothing

3.5.5 Set Monitor Type (Vertical)

This function sets the monitor type in terms of vertical timings. The monitor type information is used by the BIOS to determine which frequency to use when selecting an extended mode. It also is used to define what mode resolutions are available. The vertical monitor type can be read back using Function 9A. Calls to Function 0A2h (Set Monitor Type — Horizontal) and Function 0A3h (Set Refresh Type) will be converted into vertical equivalents, thus affecting the state of the maximums allowed.

Input:

- AH = 012h
- BL = 0A4h
- AL[3:0] = Maximum Vertical Resolution
 - 000h = 480 scanlines
 - 001h = 600 scanlines
 - 002h = 768 scanlines
 - 003h = 1024 scanlines
 - 004h–00Fh = Reserved
- AL[7:4] = 640 × 480 Frequency
 - 000h = 60 Hz
 - 001h = 72 Hz
 - 002h–00Fh = Reserved
- BH[3:0] = 800 × 600 Frequency
 - 000h = 56 Hz
 - 001h = 60 Hz
 - 002h = 72 Hz
 - 003h–00Fh = Reserved
- BH[7:4] = 1024 × 768 Frequency
 - 000h = 87i Hz
 - 001h = 60 Hz
 - 002h = 70 Hz

003h = 72 Hz
 004h = 76 Hz
 005h–00Fh = Reserved
 CH[7:4] = 1280 × 1024 Frequency
 000h = 87i Hz
 001h = 60 Hz
 002h = 70 Hz
 003h–00Fh = Reserved
 CL = Reserved
 DX = Reserved

4. VESA® SUPER VGA STANDARD

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Purpose: To standardize a common software interface to Super VGA video adapters to provide simplified software application access to advanced VGA products.

Summary: The standard provides a set of functions that an application program can use to:

- a) Obtain information about the capabilities and characteristics of a specific Super VGA implementation.
- b) Control the operation of such hardware in terms of video mode initialization and video memory access. The functions are provided as an extension to the VGA BIOS video services, accessed through INT 10h.

4.1 Goals and Objectives

The purpose of the VESA VGA BIOS Extension is to provide a common software interface for developers to design applications that work on widely disparate architectures. Being a common software interface to Super VGA graphics products, the primary objective is to enable application and system software to adapt to and exploit the wide range of features available in these VGA extensions.

The VESA BIOS Extension attempts to address the following two main issues:

- a) Return information about the video environment to the application
- b) Assist the application in initializing and programming the hardware.

4.1.1 Video Environment Information

The VESA BIOS Extension provides several functions to return information about the video environment. These functions return system-level information as well as video-mode-specific details. Function 00h returns general system-level information, including an OEM identification string. The function also returns a pointer to the supported video modes. Function 01h may be used by the application to obtain information about each supported video mode. Function 03h returns the current video mode.

4.1.2 Programming Support

The VESA BIOS Extension provides several functions to interface to the different Super VGA hardware implementations. The most important of these is Function 02h, Set Super VGA Video mode. This function isolates the application from the tedious and complicated task of setting up a video mode. Function 05h provides an interface to the underlying memory-mapping hardware. Function 04h enables an application to save and restore a Super VGA state without determining specifics of the particular implementation.

4.1.3 Compatibility

The primary design objective of the VESA BIOS Extension is to preserve maximum compatibility to the standard VGA environment. In no way should the BIOS extensions compromise compatibility or performance. Another related concern is to minimize the changes necessary to an existing VGA BIOS. RAM- as well as ROM-based implementations of the BIOS extension should be possible.

4.2 Standard VGA BIOS

A primary design goal with the VESA BIOS Extension is to minimize the effects on the standard VGA BIOS. Standard VGA BIOS functions should need to be modified as little as possible. This is important since ROM- as well as RAM-based versions of the extension may be implemented.

Two standard VGA BIOS functions are affected by the VESA extension. These are Function 00h (Set Video mode) and Function 0Fh (Read current video state). VESA-aware applications will not set the video mode using VGA BIOS Function 00h. Nor will such applications use VGA BIOS Function 0Fh. VESA BIOS Functions 02h (Set Super VGA mode) and 03h (Get Super VGA mode) will be used instead.

VESA-unaware applications (such as old Pop-up programs and other TSRs, or the CLS command of MS-DOS), might use VGA BIOS Function 0Fh to get the present video mode. Later it may call VGA BIOS Function 00h to restore/re-initialize the old video mode.

To make such applications run properly, VESA recommends that whatever value returned by VGA BIOS Function 0Fh (it is the OEM's responsibility to define this number), it can be used to re-initialize the video mode through VGA BIOS Function 00h. Thus, the BIOS should record the last Super VGA mode in effect.

It is recommended, but not mandatory, to support output functions (such as TTY-output, scroll, set pixel, etc.) in Super VGA modes. If the BIOS extension doesn't support such output functions, Bit D2 (Output functions supported) of the ModeAttributes field (returned by VESA BIOS Function 01h) should be cleared.

4.3 Super VGA Mode Numbers

Standard VGA mode numbers are 7-bits-wide and presently ranges from 00h to 13h. OEMs have defined extended video modes in the range 14h to 7Fh. Values in the range 80h to FFh cannot be used, since VGA BIOS Function 00h (Set Video mode) interprets bit 7 as a flag to clear/not clear video memory.

Due to the limitations of 7-bit mode numbers, VESA Video mode numbers are 15-bits-wide. To initialize a Super VGA mode, its number is passed in the BX register to VESA BIOS Function 02h (Set Super VGA mode).

The format of VESA mode numbers is as follows:

```

D0-D8  = Mode number
          If D8 = 0, this is not a VESA-defined mode
          If D8 = 1, this is a VESA-defined mode
D9-D14 = Reserved by VESA for future expansion (= 0)
D15    = Reserved (= 0)

```

4.4 Extended VGA BIOS

Several new BIOS calls have been defined to support Super VGA Modes. For maximum compatibility with the standard VGA BIOS, these calls are grouped under one function number. This number is passed in the AH Register to the INT 10h handler.

The designated Super VGA extended function number is 4Fh. This function number is presently unused in most, if not all, VGA BIOS implementations. A standard VGA BIOS performs no action when function call 4F is made. Super VGA Standard VS911022 defines subfunctions 00H through 08H. Subfunction numbers 09H through 0FFH are reserved for future use.

4.4.1 Status Information

Every function returns status information in the AX register. The format of the status word is as follows:

```

AL      = 4Fh: Function is supported
AL !    = 4Fh: Function is not supported
AH      = 00h: Function call successful
AH      = 01h: Function call failed

```

Software should treat a non-zero value in the AH register as a general failure condition. In later versions of the VESA BIOS Extension new error codes might be defined.

4.4.2 Function 00h — Return Super VGA information

The purpose of this function is to provide information to the calling program about the general capabilities of the Super VGA environment. The function fills an information block structure at the address specified by the caller. The information block size is 256 bytes.

```

Input:      AH      = 4Fh Super VGA support
              AL      = 00h Return Super VGA information
              ES:DI   = Pointer to buffer
Output:    AX      = Status
              All other registers are preserved.

```

The information block has the following structure:

```

VgaInfoBlock struc
    VESASignature db 'VESA'; 4 signature bytes
    VESAVersion  dw ? ; VESA version number
    OEMStringPtr dd ? ; Pointer to OEM string
    Capabilities db 4 dup (?); capabilities of the video environment
    VideoModePtr dd ? ; pointer to supported Super VGA Modes
    TotalMemory  dw ? ; Number of 64kb memory blocks on board
    Reserved     db 236 dup (?); Remainder of VgaInfoBlock
VgaInfoBlock ends

```

The VESASignature field contains the characters 'VESA' if this is a valid block.

The **VESAVersion** is a binary field that specifies what level of the VESA standard the Super VGA BIOS conforms to. The higher byte specifies the major version number. The lower byte specifies the minor version number. The current VESA version number is 1.2. Applications written to use the features of a specific version of the VESA BIOS Extension are guaranteed to work in later versions. The VESA BIOS Extension will be fully upwards compatible.

The **OEMStringPtr** is a far pointer to a null-terminated OEM-defined string. The string may be used to identify the video chip, video board, memory configuration, etc., to hardware-specific display drivers. There are no restrictions on the format of the string.

The **Capabilities** field describes what general features are supported in the video environment. The bits are defined as follows:

- D0 = DAC is switchable
 - 0 = DAC is fixed width, with 6-bits per primary color
 - 1 = DAC width is switchable
- D1-31 = Reserved

The **VideoModePtr** points to a list of supported Super VGA (VESA-defined as well as OEM-specific) Mode numbers. Each mode number occupies one word (16 bits). The list of mode numbers is terminated by a -1 (0FFFFh). Please refer to Section 4.3 for a description of VESA mode numbers. The pointer could point into either ROM or RAM, depending on the specific implementation. Either the list would be a static string stored in ROM, or the list would be generated at run-time in the information block (see above) in RAM. It is the applications responsibility to verify the current availability of any mode returned by this Function through the Return Super VGA mode information (Function 1) call. Some of the returned modes may not be available due to the video boards current memory and monitor configuration.

The **TotalMemory** field indicates the amount of memory installed on the VGA board. Its value represents the number of 64-Kbyte blocks of memory currently installed.

4.4.3 Function 01h — Return Super VGA Mode Information

This function returns information about a specific Super VGA Video mode that was returned by Function 0. The function fills a mode information block structure at the address specified by the caller. The mode information block size is maximum 256 bytes.

Some information provided by this function is implicitly defined by the VESA mode number. However, some Super VGA implementations might support other video modes than those defined by VESA. To provide access to these modes, this function also returns various other information about the mode.

- Input:**
 - AH = 4Fh Super VGA support
 - AL = 01h Return Super VGA Mode information
 - CX = Super VGA Video Mode number
 - ES:DI = Pointer to 256 byte buffer
 - Output:**
 - AX = Status
- All other registers are preserved.

The mode information block has the following structure:

```
ModelInfoBlock struc
; mandatory information
    ModeAttributes dw ? ; mode attributes
    WinAAttributes db ? ; window A attributes
```

```

WinBAttributes db ? ; window B attributes
WinGranularity dw ? ; window granularity
WinSize dw ? ; window size
WinASegment dw ? ; window A start segment
WinBSegment dw ? ; window B start segment
WinFuncPtr dd ? ; pointer to window function
BytesPerScanLine dw ? ; bytes per scanline extended information
XResolution dw ? ; horizontal resolution
YResolution dw ? ; vertical resolution
XCharSize db ? ; character cell width
YCharSize db ? ; character cell height
NumberOfPlanes db ? ; number of memory planes
BitsPerPixel db ? ; bits per pixel
NumberOfBanks db ? ; number of banks
MemoryModel db ? ; memory model type
BankSize db ? ; bank size in kb
NumberOfImagePages db ? ; Number of Images
Reserved db 1 ; reserved for page function
RedMaskSize db ? ; size of direct color red mask in bits
RedFieldPosition db ? ; bit position of lsb of red mask
GreenMaskSize db ? ; size of direct color green mask in bits
GreenFieldPosition db ? ; bit position of lsb of green mask
BlueMaskSize db ? ; size of direct color blue mask in bits
BlueFieldPosition db ? ; bit position of lsb of blue mask
RsvdMaskSize db ? ; size of direct color reserved mask in bits
RsvdFieldPosition db ? ; bit position of lsb of reserved mask
DirectColorModeInfo db ? ; Direct Color Mode attributes
Reserved db 216 dup (?) ; remainder of ModeInfoBlock
ModeInfoBlock ends

```

The ModeAttributes field describes certain important characteristics of the video mode. Bit D0 specifies whether this mode can be initialized in the present video configuration. This bit can be used to block access to a video mode if it requires a certain monitor type, and that this monitor is presently not connected. Bit D1 specifies whether extended mode information is available. This information is required in VESA BIOS Extension version 1.2 and later. Bit D2 indicates whether the BIOS have support for output functions such as TTY output, scroll, pixel output etc. in this mode (it is recommended, but not mandatory, that the BIOS have support for all output functions).

The field is defined as follows:

- D0 = Mode supported in hardware
 - 0 = Mode not supported in hardware
 - 1 = Mode supported in hardware
- D1 = Extended information available
 - 0 = Extended Mode information not available
 - 1 = Extended Mode information available
- D2 = Output functions supported by BIOS
 - 0 = Output functions not supported by BIOS
 - 1 = Output functions supported by BIOS
- D3 = Monochrome/Color Mode (see note below)
 - 0 = Monochrome Mode
 - 1 = Color Mode

D4 = Mode type
0 = Text Mode
1 = Graphics Mode
D5-D15 = Reserved

NOTE: Monochrome modes have their CRTC address at 3B4h. Color modes have their CRTC address at 3D4h. Monochrome modes have attributes in which only bit 3 (video) and bit 4 (intensity) of the attribute controller output are significant. Therefore, monochrome text modes have attributes of off, video, high intensity, blink, etc. monochrome graphics modes are two-plane graphics modes and have attributes of off, video, high intensity, and blink. Extended two-color modes that have their CRTC address at 3D4h, are color modes with one bit per pixel and one plane. The standard VGA modes, 06h and 11h would be classified as color modes, while the standard VGA modes 07h and 0fh would be classified as monochrome modes.

The BytesPerScanline field specifies how many bytes each logical scanline consists of. The logical scanline could be equal to or larger than the displayed scanline.

The WinAAttributes and WinBAttributes describe the characteristics of the CPU windowing scheme such as whether the windows exist and are read/writeable, as follows:

D0 = Window supported
0 = Window is not supported
1 = Window is supported
D1 = Window is not readable
0 = Window is not readable
1 = Window is readable
D2 = Window writable
0 = Window is not writeable
1 = Window is writeable
D3-D7 = Reserved

If neither window is supported (bit D0 = 0), then an application can assume that window paging is not supported, and that the display memory buffer resides at the CPU address appropriate for the MemoryModel of the mode.

The WinGranularity specifies the smallest boundary, in kilobytes, on which the window can be placed in the video memory. If WinGranularity equals a '0' then CPU display memory windowing is not supported.

The WinSize specifies the size of the window in kilobytes.

The WinASegment and WinBSegment address specify the segment addresses where the windows are located in the CPU address space.

The WinFuncAddr specifies the address of the CPU video memory windowing function. The windowing function can be invoked either through VESA BIOS Function 05h, or by calling the function directly. A direct call will provide faster access to the Hardware Paging registers than using INT 10h, and is intended to be used by high-performance applications. If WinFuncPtr is NULL (0000:0000) then CPU display memory windowing is not supported.

The XResolution and YResolution specify the width and height of the video mode. In graphics modes, this resolution is in units of pixels. In text modes this resolution is in units of characters. Note that text mode resolutions, in units of pixels, can be obtained by multiplying XResolution and YResolution by the cell width and height, if the extended information is present.

The XCharSize and YCharSize specify the size of the character cell in pixels.

The NumberOfPlanes field specifies the number of memory planes available to software in that mode. For standard 16-color VGA graphics, this would be set to a four. For standard Packed-pixel modes, the field would be set to a '1'.

The BitsPerPixel field specifies the total number of bits that define the color of one pixel. For example, a standard VGA Four-plane 16-color Graphics mode would have a four in this field and a packed-pixel 256-color Graphics Mode would specify a eight in this field. The number of bits per pixel per plane can normally be derived by dividing the BitsPerPixel field by the NumberOfPlanes field.

The MemoryModel field specifies the general type of memory organization used in this mode. The following models have been defined:

00h	=	Text Mode
01h	=	CGA graphics
02h	=	Hercules graphics
03h	=	Four-plane planar
04h	=	Packed pixel
05h	=	Non-chain4, 256 color
06h	=	Direct Color
07h	=	YUV
08h-0fh	=	Reserved, to be defined by VESA
10h-ffh	=	To be defined by OEM

In Version 1.1 and earlier of the VESA Super VGA BIOS Extension, Direct Color 1:5:5:5, 8:8:8:8, and 8:8:8:8 are defined as Packed-pixel model with 16, 24, and 32 bits per pixel, respectively. In Version 1.2 and later of the VESA Super VGA BIOS Extension, it is recommended that Direct-color modes use the Direct-color MemoryModel and use the MaskSize and FieldPosition fields of the ModelInfoBlock to describe the pixel format. BitsPerPixel is always defined to be the total size of the pixel, in bits.

The NumberOfBanks is the number of banks in which the scanlines are grouped. The remainder from dividing the scanline number by the number of banks is the bank that contains the scanline and the quotient is the scanline number within the bank. For example, CGA graphics modes have two banks and Hercules® Graphics mode has four banks. For modes that don't have scanline banks (such as VGA modes 0Dh–13h), this field should be set to a '1'.

The BankSize field specifies the size of a bank (group of scanlines) in units of 1 Kbyte. For CGA and Hercules graphics modes this is a eight, as each bank is 8192 bytes in length. For modes that don't have scanline banks (such as VGA modes 0Dh-13h), this field should be set to a '0'.

The NumberOfImagePages field specifies the number of additional complete display images that will fit into the VGA memory, at one time, in this mode. The application may load more than one image into the VGA memory if this field is a non-zero, and flip the display between the images.

The Reserved field has been defined to support a future VESA BIOS extension feature and will always be set to a '1' in this version.

The RedMaskSize, GreenMaskSize, BlueMaskSize, and RsvdMaskSize fields define the size, in bits, of the red, green, and blue components of a Direct-color Pixel. A bit mask can be constructed from the MaskSize fields using simple shift arithmetic. Example MaskSize values for Direct-color 5:6:5 mode would be 5, 6, 5, and 0, for the red, green, blue, and reserved fields, respectively. The MaskSize fields should be set to a '0' in modes using a MemoryModel that does not have pixels with component fields.

The RedFieldPosition, GreenFieldPosition, BlueFieldPosition, and RsvdFieldPosition fields define the bit position within the Direct-color Pixel or YUV pixel of the least-significant bit of the respective color component. A color value can be aligned with its pixel field by shifting the value left by the FieldPosition. Example FieldPosition values for Direct-color 5:6:5 mode would be 11, 5, 0, and 0, for the red, green, blue, and reserved fields, respectively. The FieldPosition fields should be set to a '0' in modes using a MemoryModel that does not have pixels with component fields.

The DirectColorModelInfo field describes important characteristics of Direct-color Modes. Bit D0 specifies whether the color ramp of the DAC is fixed or programmable. If the color ramp is fixed, then it cannot be changed. If the color ramp is programmable, it is assumed that the red, green, and blue lookup tables can be loaded using a standard VGA DAC Color registers BIOS Call (AX=1012h). Bit D1 specifies whether the Rsvd field of the Direct-color pixel can be used by the application or is reserved, and thus unusable.

- D0 = Color ramp is fixed/programmable
 - 0 = Color ramp is fixed
 - 1 = Color ramp is programmable
- D1 = Rsvd field is usable/reserved
 - 0 = Rsvd field is reserved
 - 1 = Rsvd field is usable by the application

The MapFuncAddr specifies the address of the mapping function. The mapping function can be invoked either through VESA BIOS Function 06h, or by calling the function directly. A direct call will provide a faster memory mapping than using INT 10h, and is intended to be used by high-performance applications.

NOTE: Version 1.1 and later VESA BIOS extensions will zero-out all unused fields in the Mode Information Block, always returning exactly 256 bytes. This facilitates upward compatibility with future versions of the standard, as any newly-added fields will be designed such that values of zero will indicate nominal defaults or non-implementation of optional features. (For example, a field containing a bit-mask of extended capabilities would reflect the absence of all such capabilities.) Applications that wish to be backwards-compatible to Version 1.0 VESA BIOS extensions should pre-initialize the 256-byte buffer before calling Return Super VGA mode Information.

4.4.4 Function 02h — Set Super VGA Video Mode

This function initializes a video mode. The BX register contains the video mode number. The format of VESA mode numbers is described in Section 2. If the mode cannot be set, the BIOS should leave the video environment unchanged and return a failure error code.

- Input:**
- AH = 4Fh Super VGA support
 - AL = 02h Set Super VGA Video Mode
 - BX = Video mode

D0-D14 = Video mode number
 D15 = Clear memory flag
 0 = Clear video memory
 1 = Don't clear video memory
Output: AX = Status
 All other registers are preserved.

4.4.5 Function 03h — Return Current Video Mode

This function returns the current video mode in BX register. The format of VESA Video mode numbers is described in Section 2 of this document.

Input: AH = 4Fh Super VGA support
 AL = 03h Return current video mode
Output: AX = Status
 BX = Current video mode number
 All other registers are preserved.

NOTE: In a standard VGA BIOS, Function 0Fh (Read current video state) returns the current video mode in the AL register. In D7 of AL register, it also returns the status of the Memory Clear bit (D7 of 40:87). This bit is set if the mode was set without clearing memory. In this Super VGA Function, the Memory Clear bit will not be returned in BX register since the purpose of the function is to return the video mode only. If an application must obtain the Memory Clear bit, it should call VGA BIOS Function Fh.

4.4.6 Function 04h — Save/Restore Super VGA Video State

These functions provide a mechanism to save and restore the Super VGA video state. The functions are a superset of the three subfunctions under standard VGA BIOS Function 1Ch (Save/restore video state). The complete Super VGA video state (except video memory) should be saveable/restorable by setting the requested states mask (in the CX register) to 000Fh.

Input: AH = 4Fh Super VGA support
 AL = 04h Save/Restore Super VGA video state
 DL = 00h Return save/restore state buffer size
 CX = Requested states
 D0 = Save/restore video hardware state
 D1 = Save/restore video BIOS data state
 D2 = Save/restore video DAC state
 D3 = Save/restore Super VGA state
Output: AX = Status
 BX = Number of 64-byte blocks to hold the state buffer
 All other registers are preserved.
Input: AX = 4Fh Super VGA support
 AL = 04h Save/Restore Super VGA video state
 DL = 01h Save Super VGA video state
 CX = Requested states (see above)
 ES:BX= Pointer to buffer
Output: AX = Status
 All other registers are preserved.
Input: AH= 4Fh Super VGA support
 AL= 04h Save/Restore Super VGA video state

DL = 02h Restore Super VGA video state
 CX = Requested states (see above)
 ES:BX= Pointer to buffer
Output: AX = Status
 All other registers are preserved.

4.4.7 Function 05h — CPU Video Memory Window Control

This function sets or gets the position of the specified window in the video memory. The function allows direct access to the Hardware Paging registers. To use this function properly, the software should use VESA BIOS Function 01h (Return Super VGA mode information) to determine the size, location, and granularity of the windows.

Input: AH = 4Fh Super VGA support
 AL = 05h Super VGA video memory window control
 BH = 00h Select super VGA video memory window
 BL = Window number
 0 = Window A
 1 = Window B
 DX = Window position in video memory
 (in window granularity units)
Output: AX = Status
 See note below.
Input: AH = 4Fh Super VGA support
 AL = 05h Super VGA video memory window control
 BH = 01h Return super VGA video memory window
 BL = Window number
 0 = Window A
 1 = Window B
Output: AX = Status
 DX = Window position in video memory
 (in window granularity units)
 See note below.

NOTE: This function is also directly accessible through a far call from the application. The address of the BIOS function may be obtained by using VESA BIOS Function 01h, return Super VGA mode information. A field in the ModelInfoBlock contains the address of this function. Note that this function may be different among video modes in a particular BIOS implementation so the function pointer should be obtained after each set mode.

In the far call version, no status information is returned to the application. Also, in the far call version, the AX and DX registers will be destroyed. Therefore if AX and/or DX register must be preserved, the application must do so prior to making the far call.

The application must load the input arguments in BH, BL, and DX registers (for Set Window), but does not need to load either AH or AL register to use the far call version of this function.

4.4.8 Function 06h — Set/Get Logical Scanline Length

This function sets or gets the length of a logical scanline. This function allows an application to set up a logical video memory buffer that is wider than the displayed area. Function 07h then allows the application to set the starting position that is to be displayed.

Input:	AH =	4fh	Super VGA Support
	AL =	06h	Logical Scanline Length
	BL =	00h	Select Scanline Length
	CX =		Desired Width in Pixels
Output:	AX =		Status
	BX =		Bytes Per Scanline
	CX =		Actual Pixels Per Scanline
	DX =		Maximum Number of Scanlines
Input:	AH =	4fh	Super VGA Support
	AL =	06h	Logical Scanline Length
	BL =	01h	Return Scanline Length
	CX =		Desired Width in Pixels
Output:	AX =		Status
	BX =		Bytes Per Scanline
	CX =		Actual Pixels Per Scanline
	DX =		Maximum Number of Scanlines

NOTE: The desired width in pixels may not be achievable because of VGA hardware considerations. The next larger value will be selected that will accommodate the desired number of pixels, and the actual number of pixels will be returned in CX register. BX register returns a value that, when added to a pointer into video memory, will point to the next scanline. For example, in a mode 13h this would be 320, but in mode 12h this would be 80. DX register returns the number of logical scanlines based upon the new scanline length and the total memory installed and usable in this display mode. This function is also valid in text modes. In text modes, the application should determine the current character cell width through VESA Function 1 (or VGA BIOS Function 1BH), multiply that times the desired number of characters per line, and pass that value in the CX register.

4.4.9 Function 07h — Set/Get Display Start

This function selects the pixel to be displayed in the upper-left corner of the display from the logical page. This function can be used to pan and scroll around logical screens that are larger than the displayed screen. This function can also be used to rapidly switch between two different displayed screens for double-buffered animation effects.

Input:	AH =	4fh	Super VGA Support
	AL =	07h	Display Start Control
	BH =	00h	Reserved and must be a '0'
	BL =	00h	
	CX =		First Displayed Pixel In Scanline
Output:	DX =		First Displayed Scanline
	AX =		Status
Input:	AH =	4fh	Super VGA Support
	AL =	07h	Display Start Control
	BL =	01h	Return Display Start
	CX =		First Displayed Pixel In Scanline
Output:	AX =		Status
	BH =	00h	Reserved and will be a '0'
	DX =		First Displayed Scanline

NOTE: This function is also valid in text modes. In text modes, the application should find out the current character cell width through VESA Function 1 (or VGA BIOS Function 1BH), multiply that times the desired starting character column, and pass that value in the CX register. It should also multiply the current character cell height times the desired starting character row, and pass that value in the DX register.

4.4.10 Function 08h — Set/Get DAC Palette Control

This function queries and selects the operating mode of the DAC palette. Some DACs are configurable to provide 6 bits, 8 bits, or more of color definition per red, green, and blue primary color. The DAC palette width is assumed to be reset to standard VGA 6 bits per primary during a standard or VESA Set Super VGA mode (AX=4F02h) call.

Input:	AH =	4fh	Super VGA Support
	AL =	08h	Set/Get DAC Palette Control
	BL =	00h	Set DAC Palette Width
	BH =	Desired number of bits of color per primary (Standard VGA = 6)	
Output:	AX =	Status	
	BH =	Current number of bits of color per primary (Standard VGA = 6)	
Input:	AH =	4fh	Super VGA Support
	AL =	08h	Set/Get DAC Palette Control
	BL =	01h	Get DAC Palette Width
Output:	AX =	Status	
	BH =	Current number of bits of color per primary (Standard VGA = 6)	

An application can determine if DAC switching is available by querying bit D0 of the Capabilities field of the VgaInfoBlock structure returned by VESA Return Super VGA Information (AX=4F00h). The application can then attempt to set the DAC palette width to the desired value. If the Super VGA is not capable of selecting the requested palette width, then the next lower value that the Super VGA is capable of selecting. The resulting palette width is returned.

4.4.11 Function 10h — Display Power Management Extensions

This function queries, selects, and returns the Power Management capabilities and states of the controller. An application can determine which states are available using the Query Function; it can select a state, and it can determine which state has been previously selected.

Input:	AH	=	4fh	Super VGA Support
	AL	=	10f	VBE/PM Services
	BL	=	00h	Report VBE/PM Capabilities
	ES:DI	=	Null pointer, must be 0000:0000 in version 1.0	
Output:	AX	=	Status	
	BH	=	Power saving state signals support by the controller: 1 = supported, 0 = not supported bit 0 STAND BY bit 1 SUSPEND bit 2 OFF bit 3 REDUCED ON (not supported by DPMS 1.0) bit 4-7 reserved	
	BL	=	VBE/PM Version number bits 7:4 Major Version number bits 3:0 Minor Version number	
Input:	AH	=	4fh	Super VGA Support
	AL	=	10h	VBE/PM Services
	BL	=	01h	Set Display Power State
	BH	=	Requested Power State 00h ON 01h STAND BY 02h SUSPEND 04h OFF 08h REDUCED ON (not supported by DPMS 1.0)	
Output:	AX	=	Status	
	BH	=	Unchanged	
Input:	AH	=	4fh	Super VGA Support
	AL	=	10h	VBE/PM Services
	BL	=	02h	Get Display Power State
Output:	AX	=	Status	
	BH	=	Display Power State 00h ON 01h STAND BY 02h SUSPEND 04h OFF 08h REDUCED ON (not supported by DPMS 1.0) bits 7:4 are reserved and should be ignored to ensure upward compatability.	

5. EXTENDED MODES IN RAM

5.1 Extensions to the Save Area Table

The Cirrus Logic BIOS (standard versions) supports VGA-compatible modes along with a set of extended modes. OEMs may add new modes to the system, or redefine existing modes that are in the VGA ROM by manipulating the BIOS Save Area Table pointed to by 0040:00A8. This table is located in ROM after the system is booted. Any changes must be made in a RAM copy. The Cirrus Logic BIOS has extended the definition of this table with 'negative' offsets that point to Cirrus Logic-BIOS-defined parameters. The compatible table, along with the defined extensions are listed in Table E1-4.

Table E1-4. Set Area Table and Extensions

Offset	Type	Description
–14h	DWORD	Ptr to next negative offset table in linked list
–10h	WORD	Set to 04h if offset –14h is valid ptr, set to 00h if this link is the last in RAM. To block all ROM-based modes, set this field to 04h, and offset –14 to 0:0
–0Eh	WORD	Size of supplemental table
–0Ch	DWORD	Ptr to extended mode supplemental parameters
–08h	DWORD	Ptr to extended mode standard parameters
–04h	WORD	Number of extended video modes
–02h	WORD	'RV' identifier
00h	DWORD	Pointer to standard mode standard parameters
04h	DWORD	Dynamic saver area pointer (palette save area)
08h	DWORD	Alpha mode auxiliary character generator ptr
0Ch	DWORD	Graphics mode auxiliary character generator ptr
10h	DWORD	Secondary save pointer
14h	DWORD	Reserved and set to a zero
18h	DWORD	Reserved and set to a zero

5.2 BIOS Processing

The Cirrus Logic BIOS will determine what mode to select by processing a linked list of extended mode supplemental parameters tables, while evaluating several factors such as memory size, monitor type, memory clock, and the chipset that it is running on. Traveling from the top down, the BIOS will service a mode set request once all factors have been satisfied. A mode that has multiple horizontal frequencies must be sequentially ordered from the highest frequency at the top to the lowest on the bottom. This ensures that the BIOS will always set the correct mode for the given monitor type.

Modes can be added to the BIOS by manipulating the structure described above. The BIOS

always searches for the RAM-defined links first to satisfy a mode set request. If it cannot find a mode based on the current configuration of the video subsystem, the ROM tables will then be scanned.

If new modes are to be added to the BIOS by defining them in RAM, a TSR need only modify the negative offsets described above (that is, higher refreshes of previously defined modes, or entirely new mode numbers). If modes are to be redefined, special care must be taken. If a TSR modifies a particular frequency of a mode that has higher frequencies already defined in ROM, all frequencies must be redefined in RAM.

5.3 Extended Mode Supplemental Parameters

Table E1-5 describes what the BIOS expects in the supplemental structure discussed above.

Table E1-5. Supplemental Parameters

Offset	Size	Description
00	Byte	Video mode number
01	Word	VESA video mode number
03	Word	Horizontal resolution
05	Word	Vertical resolution
07	Byte	Bits per color
08	Byte	Character width
09	Byte	Character height
0A	Byte	VESA memory model (defined in VESA Function 1)
0B	Byte	VESA mode attributes (defined in VESA Function 1)
0C	Byte	Reserved (00)
0D	Byte	Reserved (00)
0E	Byte	What chip set mode is allowed on (bit location based on return value in AL of alternate Function 80h)
0F	Byte	Memory required, in 64-Kbyte blocks
10	Byte	Bit mask of supported monitors (montype)
11	Byte	SR07, Extended Sequencer Control
12	Byte	SR0F, DRAM Control
13	Byte	SR0E, VCLK3 numerator
14	Byte	SR1E, VCLK3 denominator
15	Byte	GR0B, Graphics extensions
16	Byte	CR19, Interlace end
17	Byte	CR1A, Miscellaneous Control
18	Byte	CR1B, Display Control
19	Byte	DACEXT, Hidden DAC register

Appendix F1

Glossary and Bibliography

Glossary

AccuPak™: A proprietary video compression method.

Add-in Card, Adapter Card: A circuit board that plugs into a computer motherboard and connects it to some external device, such as a video monitor or storage subsystem.

AN: An acronym for alpha numeric. Only those patterns defined in the font tables can be displayed. Information can usually be displayed more quickly than is the case with APA. Images because fewer bits need to be manipulated by the software. These modes are also referred to as Text modes.

APA: An acronym for All Points Addressable. Each pixel on the screen is individually programmable. Any pattern (subject to the resolution of the system) can be displayed. This typically requires that one to two orders of magnitude more information be manipulated than is the case with an AN system. These modes are also referred to as Graphics modes. Nearly all extended modes are APA.

Analog Interface: An interface between a video controller and a video display in which pixel colors are determined by the voltage levels on three output lines (RGB). Theoretically, an unlimited number of colors can be supported by this method (the maximum number anyone talks about is 16,777,216). The voltage level on any line varies between zero volts (for black) to about 700 millivolts (for maximum brightness). The lines are typically terminated in 75 ohms at the monitor end and 150 or 75 Ω at the graphics controller end. In the IBM world, the analog interface is usually mechanized with a 15-pin, 3-row connector (DB15).

Analog Monitor: A video monitor that uses an analog interface. In IBM terms, commonly known as a PS/2 monitor, or a VGA monitor when used in conjunction with a VGA controller. Many modern analog monitors have a switch allowing them to be used as a digital monitor.

Analog: A signal that can assume intermediate levels between on and off. Contrast with Digital.

ASCII: American Standard Code for Information Interchange. This is a 7-bit code used to encode alphanumeric information. In the IBM-compatible world, this is expanded to eight bits to encode a total of 256 alphanumeric (AN) and control characters.

AUTOEXEC.BAT: A file used to direct a series of activities that occur during system boot-up.

Auto-Monitor Detect: A feature of Cirrus Logic VGA controllers and BIOS that senses the type of monitor that is connected. This uses a scheme that involves the use of comparators to sense the terminations present on the RGB lines. This is being replaced with DDC1 and DDC2B.

BIOS-Level Compatibility: With regard to a VGA subsystem, this means that the BIOS supplied is in compliance with the IBM VGA standard. This is the minimum level of compatibility necessary to accommodate the majority of standard applications.

BIOS: An acronym for basic input/output system. In IBM-compatible personal computers, this is a set of ROM-based firmware routines that control the resources of the system and make them available to application programs in an orderly manner. These routines provide basic input/output services for the operating system and for applications programs that use interrupts to call them. Also called ROM BIOS. The Cirrus Logic, Inc. BIOS is written in 80386/486 Assembly Language.

Bit: Binary Digit. A single piece of information: on or off, '0' or '1', high or low, closed or open, up or down, in or out, alive or dead, black or white.

BitBLT: An acronym for bit block transfer. A type of graphics drawing routine that moves a rectangle of data from one area of Display Memory to another or moves data from System Memory to Display Memory. Graphics controllers frequently include varying degrees of hardware to help speed BitBLT operations.

Bitmap: A rectangular array of locations, each of which is associated with a location (pixel) on a monitor. The contents of each location determines the color of the pixel. Often times there are more locations in the bitmap than on the screen, allowing images to be maintained for later presentation.

Block Diagram: A diagram in which blocks are used to represent components or sub-systems of a system. Usually the blocks are connected with lines indicating data or control flow.

Byte: A group of eight bits addressed as a unit. Can take any of 256 (2^8) values.

CAS: An acronym for column address strobe, one of the DRAM control signals.

CGA: An acronym for color graphics adapter. This was the first color adapter available for the IBM personal computer. It has low resolution, both spatial and color. While CGA is generally considered obsolete, the VGA standard includes the video modes originally designed for CGA.

Character Cell Matrix: In Text mode, the area of display used to display one character. On the VGA, character cells are either 8, 9, 12, or 16 pixels wide and usually are either 8, 14, or 16 pixels high.

Character Clock: This clock is generated by dividing the VCLK by either eight or nine. The Monitor Timing Signals (HSYNC, VSYNC) are derived by dividing the character clock.

Color Key: The CL-GD542X has the capability of overlaying the computer-generated video, on a pixel-by-pixel basis, with external video. One method of determining whether to overlay a pixel involves comparing it with a specific color or range of colors.

Color Lookup Table (CLUT): Translates color information from the Display Memory into color information for the CRT display. It may be found in a Video DAC.

Color Modes: Uses two, four, eight, or more bits-per-pixel. The following table summarizes the number of colors and the standards for which the colors were first available.

Table F1-1. Color Modes

Bits per Pixel	Number of Colors	Standards
2	4	CGA
4	16	CGA
8	256	VGA
15	32,368	TARGA™
16	65,536	VGA/XGA™
24	16,777,216	Cirrus Logic True Color
32	16,777,216	True Color with Alpha Channel

Color Planes: In planar modes, the Display Memory is separated into four independent planes of memory, with each plane dedicated to controlling one color component (Red, Green, Blue, and Intensify). Each pixel of the display occupies one bit position in each plane. Planar modes are generally 16 colors. In character modes and packed pixel modes, the data is organized differently.

Color Space: Any of a number of mathematical representations of the color of a pixel. Examples are RGB and YCrCb. The CL-GD5425 can convert from YCrCb to RGB in real time.

Comparator: A hardware element that is used to perform an arithmetic or logical comparison between two fields. The two fields are typically the same width. Arithmetic comparisons include equal, greater than, and less than. Logical comparisons are generally identity

Composite Video: A method of combining the syncs and RGB into a single signal, requiring only a single connection or carrier. *PAL* and *NTSC* are examples of composite video.

CONFIG.SYS: A file that provides the system with information regarding application requirements. This information may include peripherals that are connected and require special drivers (such as a mouse). Other information that might be specified is the number of files that may be open simultaneously, or the number of disk drives that may be accessed.

CMOS: Complementary Metal Oxide Semiconductor. A digital logic family that is characterized by high density, low-to-medium power, and medium-to-high speeds. All modern VGA controllers are fabricated using CMOS.

CPU: An acronym for central processing unit. The master computer unit in a system. In the VGA world, this is typically a 80386, 80486, or Pentium™ microprocessor.

CRT: An acronym for cathode ray tube. An electron beam is generated, accelerated, and made to strike a phosphor coating on the inside of an evacuated glass enclosure. The phosphor glows as a result of the energy imparted by the beam. By precisely controlling the position and intensity of the electron beam, meaningful patterns are made to appear in the phosphor and are visible through the glass.

DAC: An acronym for Digital to Analog Converter. The DACs in a VGA system convert the 6- or 8-digital bits-per-color (RED, GREEN, and BLUE) to analog levels suitable for the Analog Interface.

DCLK: The package pin on which the pixel clock (or a multiple or sub-multiple) is present. See also VCLK.

DDC™: An acronym for Display Data Channel. A definition of a communication channel between a computer display and the host system. This is a VESA proposal. Cirrus Logic components and software support either DDC1 or DDC2B.

Digital Interface: A type of interface used between video controller and video display in which display color is controlled by digital color control lines switching on and off. The number of colors that can be supported depends on the number of signal lines in the interface, and is generally either 8, 16, or 64. Most digital interfaces are TTL (transistor-transistor logic) compatible. CGA, MDA, and EGA use digital interfaces. In the IBM world, the digital interface is usually mechanized with a 9-pin connector.

Digital Monitor (TTL): A monitor that receives its input in the form of a digital code. Typical digital monitors can display 8, 16, or 64 colors. Digital monitors are more or less obsolete.

Digital: A method of representing data whereby the individual components are either fully on or fully off.

Digitize: To convert an analog image or signal to a corresponding series of numbers.

Display Memory: The area in the computer memory where the information used to update the screen is kept. In the IBM-compatible world, the range of addresses for this data is A000:0 through BFFF:F.

Display Modes: In the IBM-compatible world, a number of standard display modes have been defined. Video mode is used interchangeably with Display mode. In addition to the standard modes enumerated below, there are many Extended Display modes.

Table F1-2. Standard Display Modes

Mode(s)	Colors	Alphanumeric Resolution	Pixel Resolution	AN/A.P.A
0,1	16	40 × 25	360 × 400	AN
2,3	16	80 × 25	720 × 400	AN
4,5	4	40 × 25	320 × 200	APA
6	2	80 × 25	640 × 200	APA
7	Monochrome	80 × 25	720 × 400	AN
D	16	40 × 25	320 × 200	APA
E	16	80 × 25	640 × 200	APA

Table F1-2. Standard Display Modes *(cont.)*

Mode(s)	Colors	Alphanumeric Resolution	Pixel Resolution	AN/ A.P.A
F	Monochrome	80 × 25	640 × 250	APA
10	16	80 × 25	640 × 350	APA
11	2	80 × 30	640 × 480	APA
12	16	80 × 30	640 × 480	APA
13	256	40 × 25	320 × 200	APA

Dithering: To intersperse a pattern of one color (for example, blue) with a pattern of another color (for example, red) to give the subjective effect of a color somewhere between the two colors (blue and red together make magenta). This technique is effective over large surfaces but fails if the area is too small. This technique creates the appearance of more colors at the expense of resolution.

DIP: An acronym for dual inline package. A method of packaging semiconductor chips that was essentially ubiquitous until the 1980s. It is being replaced with plastic quad flatpack and pin grid arrays for devices with high pin counts, and small outline packages for devices with low or medium pin counts.

DPMS: An acronym for display power management signaling. A proposal to standardize on a common definition and methodology in which the display controller sends a signal to the display that enables it to enter various power management states. This is a VESA proposal. The VGA controller can instruct the monitor to enter one of a number of reduced power states. DPMS is supported by current Cirrus Logic desktop products.

DRAM: Dynamic Random Access Memory. A memory technology that is characterized by extreme high density, low power, and low cost. It must be more or less continuously refreshed to avoid loss of data.

Driver: A software module that interfaces a particular display device to an application program to allow operation at higher resolutions than standard VGA.

Dual-Page Mapping: Refers to using both Offset Registers, 0 and 1, as the window into Display Memory. This mode is chosen when GRB[0] is programmed to a '1'. In this mode, SA15 is used to choose between Offset Registers 0 and 1.

EDO: An acronym for extended data out. A DRAM technology that is characterized by very short Fast-Page Mode cycle times.

EEPROM: An acronym for electrically erasable programmable read-only memory. A memory storage device that can be written repeatedly with no special erasure fixture. EEPROMs do not lose their contents when they are powered down. The Cirrus Logic, Inc. BIOS can use EEPROMs to record information regarding the connected monitor. This is being replaced with DDC.

EGA: Enhanced Graphics Adapter. This was the second color adapter available for IBM-compatible computers. While EGA is generally considered obsolete, the VGA standard includes the modes originally designed for EGA.

Emulation: Simulation of unavailable hardware by available hardware and software. Emulations improve the usefulness of a product by making it compatible with other products. EGA is capable of emulating MDA and sometimes CGA and Hercules. VGA is capable of emulating EGA, CGA, and MDA.

EPROM: Electrically Programmable Read-only Memory: A memory storage device that can be written once (per erasure cycle) and read many times. In the VGA world, it is used for holding the BIOS.

Fast-Page Mode: A read or write mode of DRAMs that is characterized by a decrease in cycle time of about 2-3 times and a corresponding increase in performance. The data accessed in Fast-Page Mode cycles must be adjacent in memory.

Feature Connector: An expansion connector on the VGA that can be used to accept or drive video signals to or from the VGA. This is used in applications involving video overlay. This is also called the VESA Pass-through connector.

FIFO: First In First Out. A memory that can temporarily hold data so that the sending device can send data faster than the receiving device can accept it. The sending and receiving devices typically operate asynchronously.

Fixed-Frequency Monitor: A monitor that can accept a fixed horizontal frequency, usually 31.5 kHz. Such monitors can accommodate different vertical resolutions by operating at different vertical frequencies, usually either 60 or 70 Hz.

Frequency Synthesizer: An electronic circuit that can generate a number of frequencies from a fixed reference frequency. Some frequency synthesizers can generate only a relatively small number of frequencies; others can generate hundreds of different frequencies.

Genlock: A method of locking a video source to another timing source.

Glue Logic: Additional logic devices required to interconnect the major components of a system.

Graphics Controller: On EGA and VGA, a section of circuitry that can provide hardware assist for graphics drawing algorithms by performing logical functions on data written to Display Memory.

Graphics Mode: (Also A.P.A.) A display mode in which all pixels on the display screen can be controlled independently to draw graphics objects (as opposed to Text Mode, in which only a pre-defined set of characters can be displayed).

Hardware: A computing system is normally spoken of as having two major components: hardware and software. Hardware is the portion that executes the step-by-step procedure necessary to perform a particular task as instructed by the software.

HERC: An acronym for the Hercules graphics adapter. The third display format standardized for the PC family of computers, following the MDA and CGA. It provides standard 80-character-by-25-row alphanumeric display, and 720 horizontal by 348 vertical pixels in Monochrome Graphics Mode. It was designed as a replacement for MDA, and provided monochrome A.P.A.

Hex Code, Hexadecimal: A numbering system using base 16. The allowable digits are 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, and F. A base 16 numbering system is useful because conversion to and from base 2 is trivial. Numbers written in base 16 are typically denoted by a prepended '0x' or an appended 'h'.

HGC: See **HERC**.

Interlaced: A graphics system in which the even scanlines are refreshed in one vertical cycle (field), and the odd scanlines are refreshed in another vertical cycle. The advantage is that the video bandwidth is roughly half that required for a non-interlaced system of the same resolution. This results in less costly hardware. It also may make it possible to display a resolution that would otherwise be impossible on given hardware. The disadvantage of an interlaced system is flicker, especially when displaying objects that are only a single scan line high. This can be reduced with flicker-filter methods.

ISA: Industry Standard Architecture. In reference to IBM-compatible computers, it was the definition of the standard bus until the introduction of VESA and PCI in the early 1990s.

Mapping: Mapping refers to the definition of memory for storing data used by a particular Video Mode. The range of addresses reserved for video information in IBM-compatible systems is from A000:0 to BFFF:F.

MCGA: An acronym for multicolor graphics array. A graphics adapter designed for the PS/2 series of personal computers, with similar function to the CGA and downwardly compatible to the CGA at the BIOS, control register, and Display Memory levels. Like the VGA, the MCGA drives either an analog monochrome or analog RGB monitor.

MDA: An acronym for monochrome display adapter. The original display adapter marketed by IBM for personal computers. MDA has no bit-mapped graphics capability.

Monitor: Another term for a CRT Display.

Monochrome Modes: Uses one bit per pixel. 'Two-color' modes are similar to monochrome modes because they can display two colors; the two colors do not need to be black and white, sometimes they are amber or green with black.

Motherboard: The large printed circuit board in a personal computer into which the adapter boards plug. It contains the CPU and core memory. It may also contain the video controller or a number of other peripheral controllers.

Multiple-FIFO Architecture: A video controller architecture that is characterized by having multiple (two or more) FIFOs or Write Buffers. There is typically one FIFO or Write Buffer at the CPU interface and one or more FIFOs in the screen refresh stream.

Multifrequency Monitor: A monitor that will accommodate a variety of horizontal and vertical synchronization frequencies. This type of monitor accepts inputs from many different video display adapters, and is typically capable of either analog or digital input.

Nibble: A group of four bits, typically contiguous. It can take any of 16 (2^4) values.

Non-interlaced: A video system in which every pixel is refreshed during every vertical scan. A non-interlaced system is normally more expensive than an interlaced system of the same resolution, and is usually said to have a more pleasing appearance.

NTSC: A color encoding scheme used for television. NTSC is used in North America and Japan, as well as some other areas. NTSC is often spoken of as a timing standard; it is an extension of RS-170. It has been suggested that NTSC actually stands for “Never Twice the Same Color”, because of the relatively poor color fidelity.

Overlay: The superimposition of video (typically live) onto computer generated graphics.

Overscan: That portion on all four sides of the display between active video and blanking.

Packed Pixel: Color information for a pixel packed into one word of memory data. For a system with few colors, this packed pixel may require only a part of one word of memory; for very elaborate systems, a packed pixel might be several words long. See **Planar**.

PAL: A color encoding scheme used for television. PAL is used in Europe (except France), as well as some other places.

Palette: The range of colors available on the screen, not necessarily simultaneously. For VGA, this is either 16 or 256 simultaneous colors out of 262,144. For CL-GD542X, the palette is extended to 32,768, 65,536, or 16,777,216 simultaneous colors on the screen.

Palette DAC: The triple eight-bit DAC with its associated Lookup Table.

Pixel: An acronym for picture element, and is also called a pel. A pixel is the smallest addressable graphic on a display screen. In RGB systems, the color of a pixel is defined by some Red intensity, some Green intensity, and some Blue intensity.

Planar: In video terms, the pixel color information is stored in four bits across four memory planes. This allows a maximum of 16 colors (2^4). See **Packed Pixel**.

RAM BIOS: The BIOS can be copied from relatively slow ROM into relatively fast RAM. When this is done, it will execute faster, enhancing performance of the subsystem being controlled.

RAM: An acronym for random access memory. This term has come to mean any semiconductor memory whose write access time is approximately the same as its read access time. This is typically taken to include SRAMs (Static RAMs) and DRAMs (Dynamic RAMs). This definition specifically excludes memories that cannot be altered at all and memories that require a special fixture for erasing (such as EPROMs).

RAS: An acronym for row address strobe, one of the DRAM control signals.

Refresh (Display or Screen Refresh): An image drawn on a CRT display will remain visible only for a few milliseconds (the persistence of the screen phosphor), unless it is redrawn continuously. This process is called display refresh or screen refresh. Different displays use different refresh rates, but display refresh is normally required between 60 and 80 times a second to avoid any visible screen flickering. 75 times a second is a common refresh rate. In general, a higher refresh rate results in more stable appearing display.

Register-Level Compatibility: If a peripheral is compatible at the register level with another peripheral, it means that every bit in every register of the two devices has precisely the same meaning. This implies that application programs can circumvent the BIOS and directly program registers in a peripheral device without functionality problems. The CL-GD542X is register-level-compatible with the IBM VGA standard.

Registers: In a VGA controller, these are the storage elements that contain data relating to the mode or configuration of the device, as opposed to the Display Memory that contains the image. Traditionally, the registers are divided into six groups: General, Sequencer, CRT Controller, Graphics Controllers, Attribute, and Extensions. The VGA registers are accessed by a number of addressing schemes, each involving an index or address register and a data register.

Resolution, Color: The number of simultaneous colors is determined by the number of bits associated with each pixel in the Display Memory. The more colors, the more bits. If n bits-per-pixel are used, 2^n color combinations can be generated. EGA uses from one to four bits-per-pixel, permitting up to 16 (2^4) colors to be displayed on the screen at the same time. The VGA has an added mode that supports eight bits-per-pixel, or 256 (2^8) simultaneous colors. The CL-GD542X has additional modes that support up to 24 bits-per-pixel or 16,777,216 (2^{24}) simultaneous colors. In addition, some modes use a fourth byte, the alpha byte.

Resolution, Spatial: The number of pixels in an area or on the screen. Resolution is typically specified as pixels per scanline and scanlines per frame. Higher resolution images require more processing and greater storage requirements per image. In addition, monitor costs increase with resolution, particularly above about one million pixels. Different applications require different resolutions.

RGB: Used with color displays, an interface that uses three color signals (Red, Green, and Blue), as opposed to an interface used with a monochrome display that requires only a single signal. Both digital and analog RGB interfaces exist.

ROM: An acronym for read-only memory. A type of memory characterized by not being alterable (see EPROM). ROMs are typically used to contain low-level programs that do not change, such as BIOS.

Scaling: A method of changing the effective resolution of an image. The CL-GD5425 can scale VGA images to fit NTSC or PAL formats.

SECAM: A color encoding scheme for television. SECAM is like PAL except that the chrominance is frequency modulated.

Simultaneous Colors: The number of colors in a display system that can be displayed on the screen at one time. This number is limited by the circuitry of the display adapter, and is often much smaller than the number of colors the display device can actually support. The number of simultaneous colors a display adapter will support is normally determined by the number of color planes, or bits per pixel, that it uses. For example, a device with four bits-per-pixel will support 16 simultaneous colors.

Single-Page Mapping: Refers to always using Offset Register 0 (GR9) as the window into Display Memory. The mode is chosen when GRB[0] is programmed to a '0'.

Sleep Mode: A VGA controller can be put to 'sleep' by writing a value to a particular bit of a particular register. The register is normally at address 3C3 or 46E8 in the IBM-compatible world. When a VGA controller is asleep, it will respond to no further commands except a command to wake up or a BIOS read. This allows two VGA controllers to share common addresses, so long as their sleep addresses and BIOS addresses are not the same. PCI uses a different sleep mechanism than do ISA and VESA VL.

Software: A computing system is normally spoken of as having two major components: hardware and software. Software is that portion that instructs the hardware in the step-by-step procedure necessary to perform a particular task.

Super VGA: Graphics adapters that extend the capabilities of the features provided by the original IBM VGA. The first Super VGA provided a 640 x 480 x 256-Color Mode. Also SVGA.

SMT: An acronym for surface mount technology. A method of mounting devices (such as integrated circuits, resistors, capacitors, and others) on a printed circuit board, characterized by not requiring mounting holes. Rather, the devices are soldered to pads on the printed circuit board. Surface-mount devices are typically smaller than the equivalent through-hole devices.

S-Video: A variant of composite video. The Chrominance and Luminance are transmitted on separate pins.

TTL: An acronym for transistor-transistor logic. A collection of logic families developed beginning in the 1960s. TTL is gradually being replaced with CMOS for all but the fastest or most cost-sensitive applications.

True color: 24-or 32-bits-per-pixel color providing photo-realistic image quality.

VCLK: The internal signal operating at the pixel rate.

Vertical Retrace: The time interval immediately following the completion of a complete frame (or field for an interlaced display). The electron beam returns to the top of the display screen in preparation for the next frame or field during this period.

VESA: An acronym for the Video Electronics Standards Association. A consortium of CRT monitor vendors, graphics chip vendors, and graphics software vendors that set hardware and software standards for PC-compatible graphics monitors and software interfaces. Cirrus Logic is an active participant on many of the VESA committees.

VGA: An acronym for video graphics array. The VGA standard was introduced by IBM in 1987. In the IBM definition, the maximum spatial resolution is 640 x 480 (Modes 11 and 12), and the maximum color resolution is 256 colors (Mode 13). This has been enhanced or extended by third party chip vendors to up to 1280 x 1024 and up to 16,777,216 colors.

VLSI: An acronym for very large scale integration. The technology of manufacturing integrated circuits (chips) with thousands of transistors on a single device. The personal computer was made possible because of VLSI technology.

VRAM: An acronym for video (dynamic) random access memory. Memory devices with two ports, one used for random accesses and the other capable of serial accesses. Once the serial port has been initialized (with a transfer cycle), it can operate independently of the random port. This frees the random port for CPU accesses. The result of adding the serial port is a significantly reduced amount of interference from screen refresh. VRAMs cost more per bit than DRAMs.

Wait State: When a system processor is reading or writing a memory or peripheral device that cannot respond fast enough, one or more time intervals (typically on the order of tens of nanoseconds each) are inserted during which the processor does nothing but wait for the slower device. While this has a detrimental effect on system throughput, it is unavoidable. The number of wait states can be reduced using techniques such as CPU-bus caches or write FIFOs.

Word: The amount of memory that a given computer can access in a single cycle. In the IBM-compatible world, this is either 16 or 32 bits.

Write Buffer: A term used in the CL-GD542X literature to denote the buffer that is logically positioned between the CPU interface and the Display Memory.

YCrCb: A color space defined in CCIR601.

YUV: A color space generally associated with color television.

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Char	0x	1x	2x	3x	4x	5x	6x	7x
0	NUL	DLE	space	0	@	P	'	p
1	SOH	DC1	!	1	A	Q	a	q
2	STX	DC2	"	2	B	R	b	r
3	ETX	DC3	#	3	C	S	c	s
4	EOT	DC4	\$	4	D	T	d	t
5	ENQ	NAK	%	5	E	U	e	u
6	ACK	SYN	&	6	F	V	f	v
7	BEL	ETB	`	7	G	W	g	w
8	BS	CAN	(8	H	X	h	x
9	HT	EM)	9	I	Y	i	y
a	LF	SUB	*	:	J	Z	j	z
b	VT	ESC	+	;	K	[k	{
c	FF	FS	,	<	L	\	l	
d	CR	GS	-	=	M]	m	}
e	SO	RS	.	>	N	^	n	~
f	SI	US	/	?	O	_	o	DEL

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The Company

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