Laboratorio de Microprocesadores - 86.07

Registrador de firmas digital

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Turno de las clases prácticas											
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Observaciones:

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Fecha de aprobación				Firma J.T.P

Coloquio	
Nota final	
Firma profesor	

Índice

1. Introducción

En el siguiente informe se pretende explicar el proceso de diseño de un programa para un registrador de firma digital a través del microcontrolador Atmega 328P en lenguaje Assembly. Para ello se utilizó un display TFT de 2.4 pulgadas provisto del controlador ILI9325D con una pantalla táctil resistiva. Los datos registrados son transferidos a través de una interfaz serie y procesados por Matlab. Dada la complejidad en el desarrollo del circuito impreso para el display, se optó por adquirir un Shield compatible con ambos controladores, ILI9325D y ADC.

2. Desarrollo

Para poder interactuar con el display, es necesario inicializarlo. La rutina de inicialización consta de 51 instrucciones que se envían al controlador del display mediante un bus de 8 bits. Estas instrucciones son palabras de 16 bits, por lo que deben ser enviadas en dos partes.

Una vez inicializado el display, es posible enviarle imágenes para mostrarlas en la pantalla. En esta aplicación enviamos la información píxel a píxel, estos datos se graban en la memoria ram del controlador ILI9325D para mantener en pantalla todos los píxeles a medida que se traza la firma en tiempo real hasta que el dispositivo sea reiniciado para leer una nueva firma. A continuación se muestra el diagrama en bloques del proyecto seguido del diagrama de flujo del programa implementado para el sistema de adquisición de la firma:

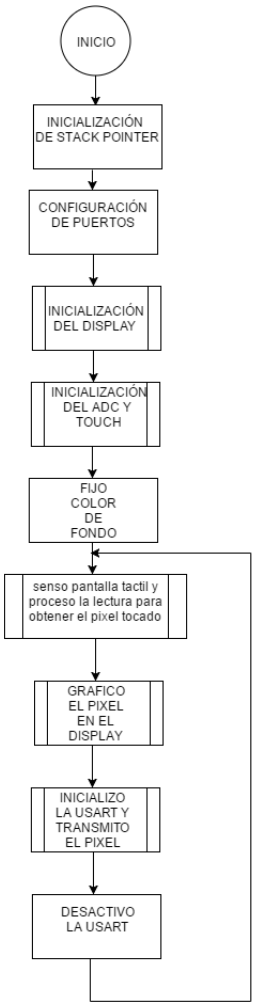

Figura 1: Diagrama de flujo del software desarrollado.

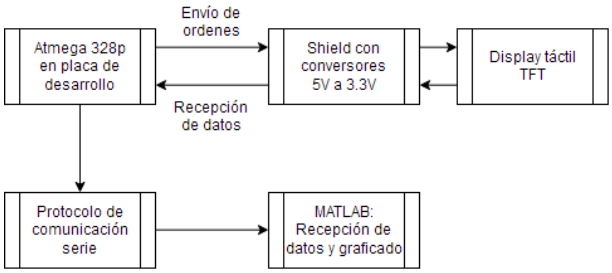

Figura 2: Diagrama en bloques del proyecto

Como se explicará mas adelante, se hace uso de prácticamente la totalidad de los puertos del microcontrolador, con los cual los pines correspondientes a la USART son compartidos por el bus de datos del controlador de la pantalla. Debido a esto se tiene que activar la USART al momento de transmitir y desactivarla una vez finalizada la transmisión.

2.1. Comunicación con controlador `ILI9325D`

El dispositivo usado para controlar la parte gráfica es el ILI9325D. Es un integrado desarrollado para pantallas graficas de hasta 232 mil colores y una resolución de 240x320 pixeles, en cuanto a la comunicación cuenta con 2 modos, SPI y bus paralelo configurable en 8, 9, 16 o 18 bits. Posee además cuatro entradas de control:

- RS : Register select
- WR: Write enable
- CS: Chip select
- RST: Reset

Para nuestra aplicación se descartó el uso de SPI debido a la velocidad de actualización requerida para registrar una firma en tiempo real, por lo cual se opto por un bus de comunicación paralelo de 8bits de datos. Si bien los comandos que el display recibe son palabras de 16bits se programó el sistema de forma tal que sea posible mandar el comando empaquetado en dos bytes. En la figura 3 se muestra un diagrama de bloques simplificado del controlador.

Para comenzar la comunicación con este periférico es necesario inicializarlo y ponerlo en un modo de espera de comandos, para ello se implemento la rutina `INIT_LCD` en la cual se inicializa el modulo y se colocan todas las entradas a valores seguros. La rutina consiste en un envió sucesivo de valores al BUS de 8 bits del display los cuales fueron grabados en la memoria de programa del microprocesador y accedidos a través de un puntero

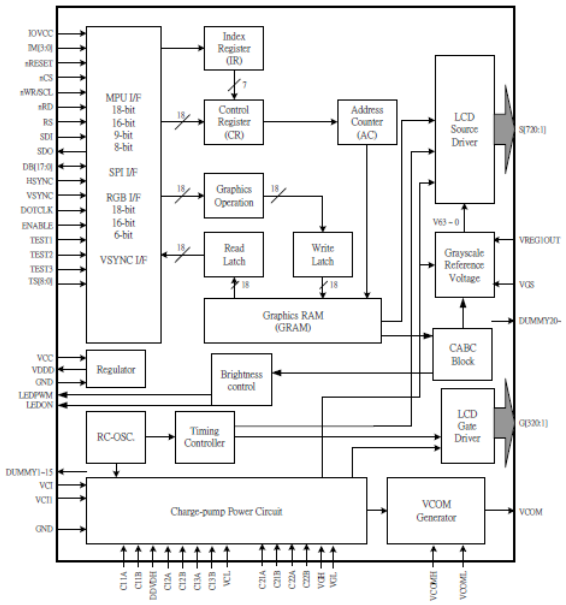

Figura 3: Diagrama en bloques simplificado del ILI9325D

Una vez inicializado el modulo es necesario configurar el área de pantalla sobre la cual se va a trabajar, para ello se implemento la macro `SET_XY_AREA`. Esta macro es llamada por todas las demás macros que utiliza el microprocesador para controlar la pantalla. Luego se llena la pantalla del color deseado con `FILL_SCREEN` y se procede a enviar píxel por píxel las coordenadas X e Y recibidas del sensor táctil a la macro `DRAW_PIXEL`.Esta ultima se encarga de grabar en la memoria ram del controlador las coordenadas a visualizar y envía los comandos necesarios para mostrar las coordenadas anteriores junto con la ultima en pantalla. Se prefirió el uso de macros en lugar de rutinas debido a la alta velocidad de respuesta requerida para la aplicación y además para no atentar contra la portabilidad del sistema. Todas las macros implementadas relacionadas con el manejo de la pantalla se encuentran en el archivo `tft_macros.mac`.

2.2. Comunicación con ADC

Para sensar las coordenadas del pixel presionado, es necesario comunicarse con otra parte del display táctil: el conversor analógico-digital `ADS7843`. Este sistema tiene su propio protocolo de comunicación, con otro juego de ordenes. Las entradas de control disponibles son las siguientes:

- TCLK : Clock interno del ADC
- TCS: Chip select del ADC
- TDIN: Bit de entrada de datos al ADC
- TDOUT: Bit de salida de datos del ADC

El sensor táctil consiste básicamente de un divisor resistivo doble, como se ve en la figura 4. Cuando se le pide al controlador sensar en la coordenada X, este conecta el terminal X+ a una tensión positiva, el terminal X- a una tensión negativa, y el terminal Y+ a la entrada del conversor.

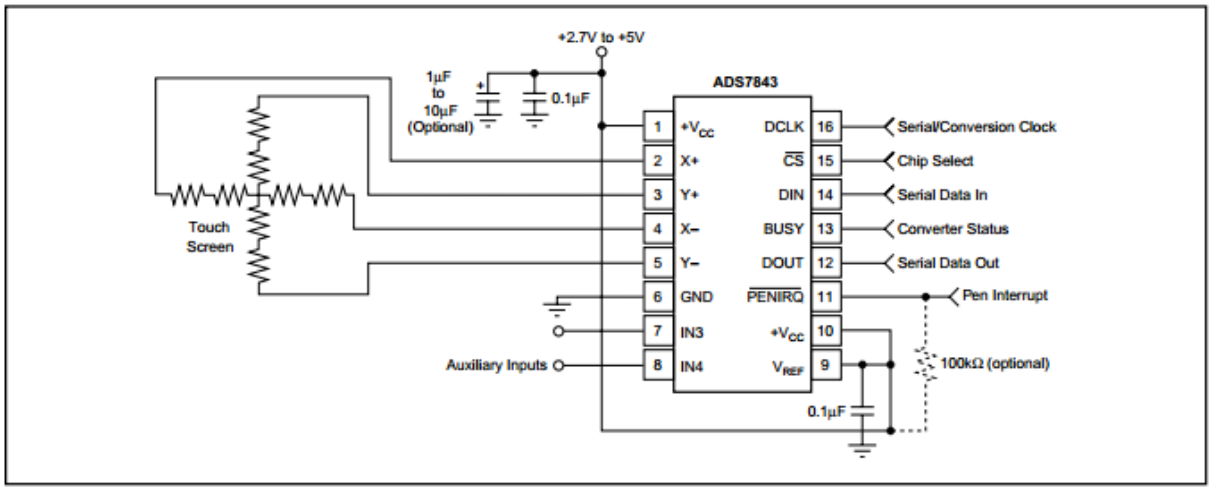

Figura 4: Operación básica del ADS7843

Para especificar cual coordenada se leerá, se envía por el pin DIN mediante comunicación serie la palabra `0xD0` para leer la coordenada X, o la palabra `0x90` para leer la coordenada Y.

Una vez finalizado el sensado el controlador devuelve, nuevamente por comunicación serie, una palabra de 12 bits variando entre `0x000` y `0xFFF`, la cual es separada en parte alta y parte baja y almacenada en dos registros. Este registro es luego convertido en la coordenada correspondiente del pixel seleccionado.

Se muestra en la imagen 5 el tren de pulsos que se envía para iniciar la adquisición, y el tren de pulsos que se recibe tras el sensado.

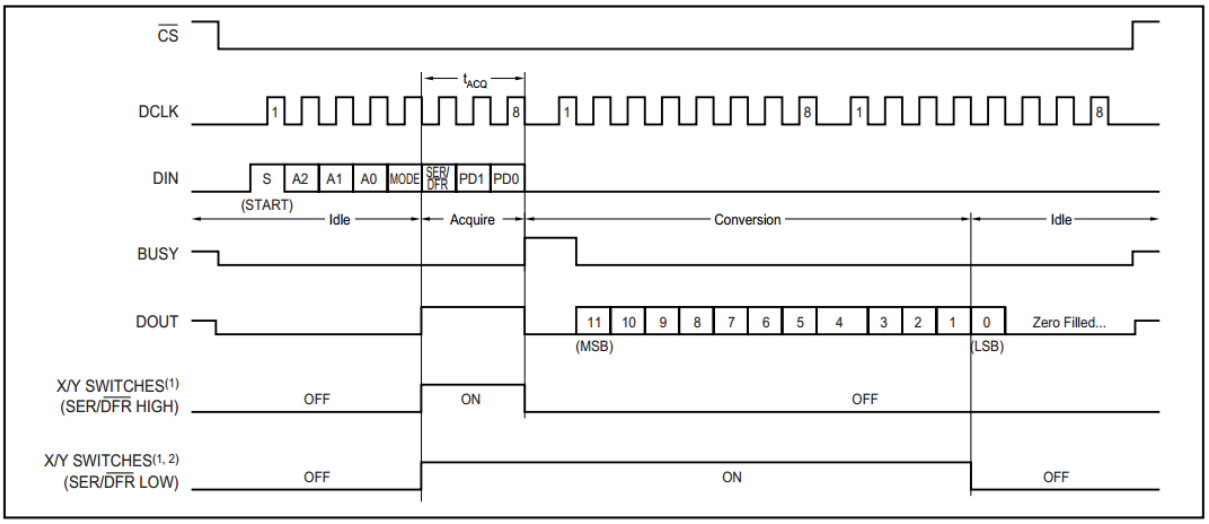

Figura 5: Comunicación con ADC

2.3. Conversión de datos

A causa de imperfecciones en el film táctil, cuando se toca con el lápiz cerca de los extremos el conversor no devuelve `0x000` o `0xFFF`, sino que devuelve valores cercanos. Es necesario tener en cuenta estos valores al hacer la conversión, porque de lo contrario se obtendrá un error importante cuando se grafique el pixel en la pantalla.

Para realizar la conversión, se implementaron las siguientes ecuaciones:

$$Y_{pix} = \frac{Y_{size}}{Y_{top} - Y_{bottom}}(Y_{ADC} - Y_{top})$$

$$X_{pix} = \frac{X_{size}}{X_{right} - X_{left}}(X_{ADC} - X_{left})$$

Donde X_{right}, X_{left}, Y_{top} e Y_{bottom} son constantes de calibración, y Y_{ADC} y X_{ADC} es la lectura entregada por el ADC.

Para implementar esto, se halló el valor de las constantes en base 16 y se programó un esquema de producto por punto fijo.

2.4. Envío de datos por puerto serie y recepción por Matlab

Mientras la firma es graficada en la pantalla táctil los datos son transferidos a la computadora para ser procesados y almacenados en una base datos, el programa de adquisición se desarrolló en Matlab. Su función es la recibir, validar y almacenar los datos provenientes del microcontrolador, graficarlos y a su vez darle la orden al microcontrolador para comenzar o finalizar la adquisición de la firma. La adquisición se hace a través del protocolo serie, vía USB.

Se configuró la USART del microcontrolador para transmitir datos de 8 bits de largo, con un bit de stop y un bit de inicio a una velocidad de 38400 baudios. Para ello se implementó la rutina la inicialización `INIT_USART`, y `DISABLE_USART` para interrumpir la comunicación. Para transmitir el dato se implementó la macro `DATA_TX` disponible en el archivo `IO.mac`.

Dado que el modulo utiliza la totalidad de pines del microcontrolador se tuvo que implementar un algoritmo de transmisión que no genere incompatibilidades entre los comandos enviados por el puerto hacia el software de adquisición y lo que puede interpretar el display. Para ello se activa la USART únicamente al momento de transmitir y luego se desactiva antes de pasar al estado de sensado. Dado que la memoria ram de un atmega328P es insuficiente para almacenar los píxeles de una firma se optó por realizar la trasmisión pixel a pixel en tiempo real en paralelo al sensado. A continuación se ilustra una foto con un dibujo en la pantalla táctil y la imagen generada por el software de adquisición.

Figura 6: Foto de un dibujo realizado sobre la pantalla táctil

Figura 7: Imagen recibida por el software de adquisición

2.5. Hardware utilizado

El modulo de display a utilizar acepta niveles lógicos de hasta 3.3 V, lo cual es un problema al momento de poner en practica el diseño. Para ello se hizo uso de un modulo que adapta las tensiones de salida de los puertos de la placa de desarrollo Arduino al nivel soportado por el display. El dispositivo adapta las tensiones de salida de 5 V provenientes de los puertos de Atmega 328p a logica de 3.3 V y realiza lo mismo con los datos provenientes del display hacia el microcontrolador mediante cuatro integrados 74HC541PW.

Se decidió usar una plataforma de desarrollo Arduino dada la compatibilidad de diversos módulos o "Shields" disponibles en el mercado. A continuación se muestran las imágenes correspondientes a la conexión realizada entre el microcontrolador, el display y un diagrama esquemático de todo el circuito.

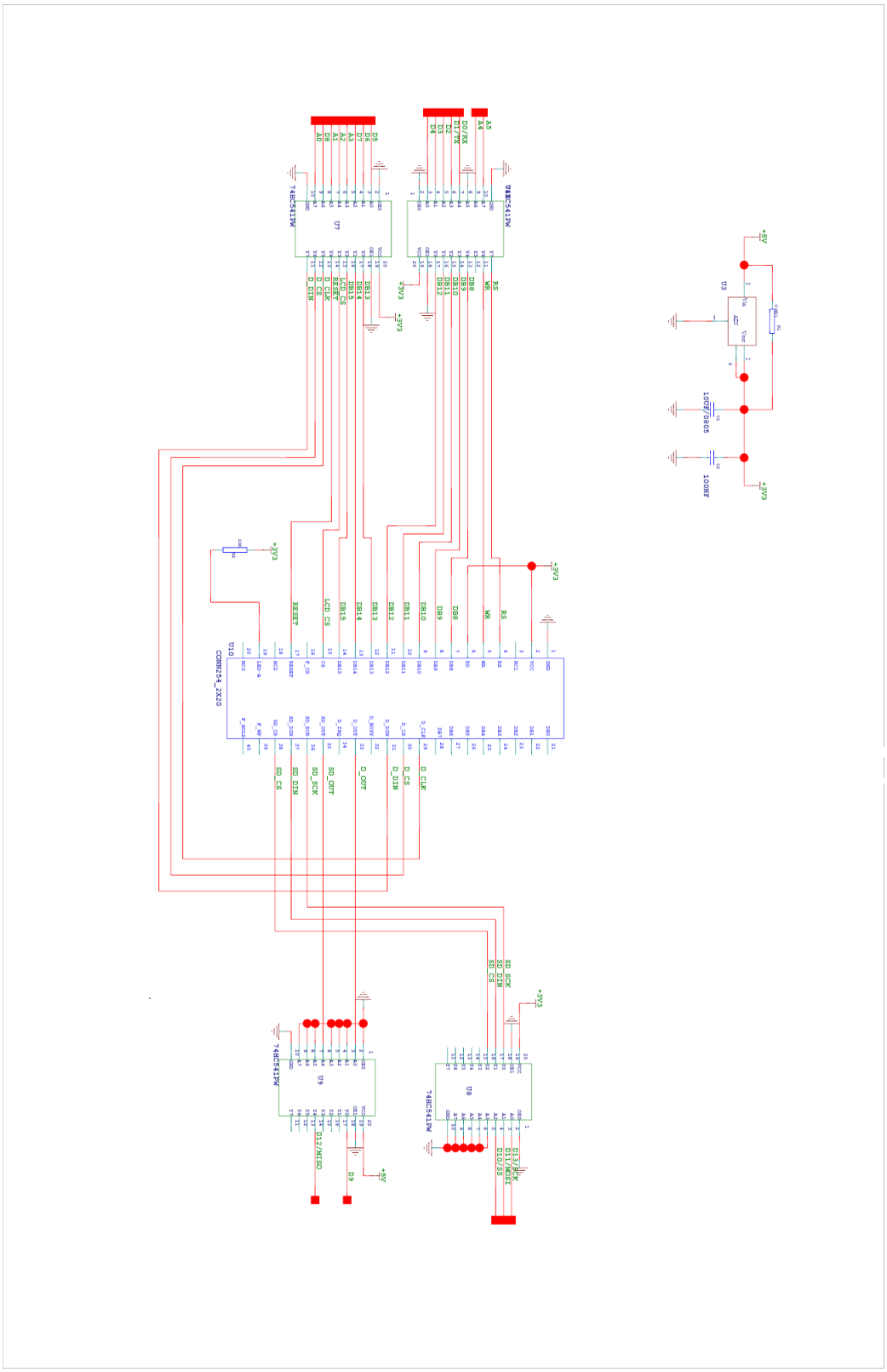

Figura 8: Diagrama esquemático del adaptador de niveles lógicos

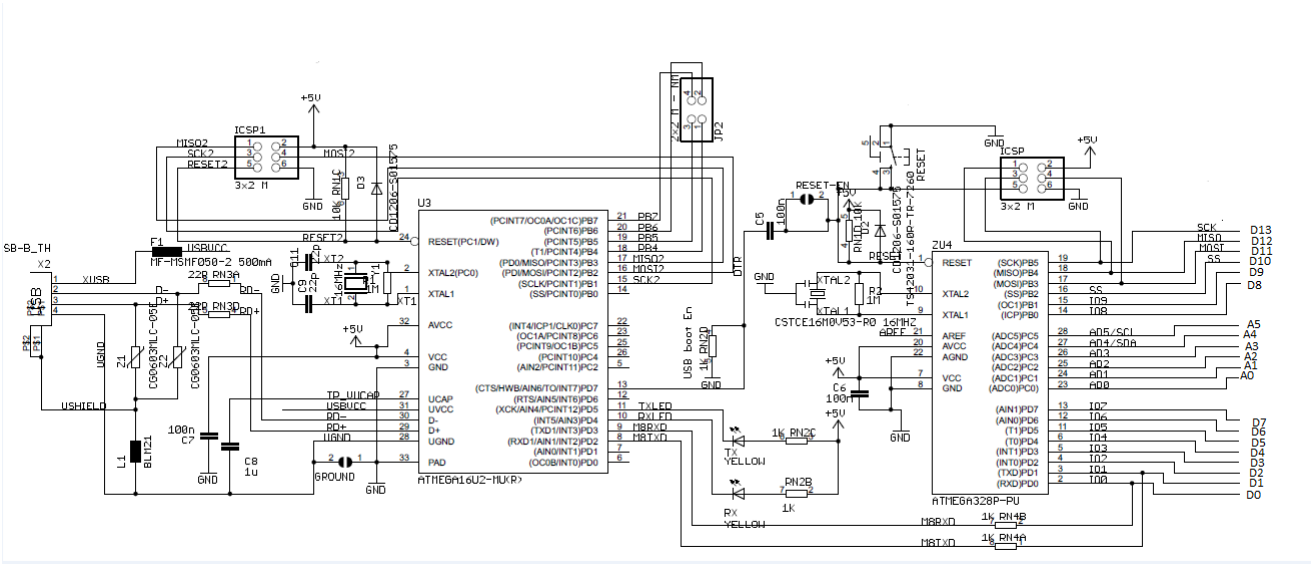

Figura 9: Diagrama esquemático de la placa de desarrollo, conexión entre el microcontrolador Atmega 328P y el 16U2.

Dado el gran tamaño del esquemático este se dividió en dos, por un lado el circuito correspondiente al Shield adaptador de lógica y por otro la placa de desarrollo que contiene a los microcontroladores. El display táctil se conecta a la bornera referenciada en la figura 8, la cual se interconecta con los cuatro integrados 74HC541PW, las distintas salidas de los mismos van a los pines del micro referenciados desde A0-A5 y D0-D13 en la figura 9.

2.5.1. Listado de componentes

A continuación se listan los módulos de desarrollo adquiridos junto con el costo de cada uno. A su vez se mencionan algunos de los componentes principales que las integran.

- Display touch TFT 2.4". Precio $ 240 pesos.
  - Controlador `ILI3925D`
  - Conversor AD `ADS7843`
- Shield adaptador de logica $5V$ a $3{,}3V$. Precio $ 220 pesos.
  - Circuito integrado 74HC541PW, cuatro unidades.
- Placa de desarrollo. Precio $ 150 pesos.
  - Microcontrolador Atmega328P
  - Microcontrolador Atmega16U2 para adaptar la salida de la USART al puerto USB de la PC.

Costo total del proyecto: $610 pesos.

3. Conclusiones

Se logro implementar con éxito el modulo de registro y el software de adquisición para procesamiento de las firmas. Algunas de las mejoras para implementar a futuro: optimizar la transmisión serie para reducir el delay generado entre que se realiza la firma y su visualización en pantalla, transmitir los datos en forma inalámbrica por medio de bluetooth para mayor comodidad y portabilidad del dispositivo, migrar a una plataforma de 32 bits para manejar pantallas mas grandes con mayor resolución con el fin de desarrollar una tableta gráfica con prestaciones comerciales.

4. Apéndices

A. Caracteristicas del microcontrolador

8-bit AVR Microcontrollers

ATmega328/P

DATASHEET COMPLETE

Introduction

The Atmel® picoPower® ATmega328/P is a low-power CMOS 8-bit microcontroller based on the AVR® enhanced RISC architecture. By executing powerful instructions in a single clock cycle, the ATmega328/P achieves throughputs close to 1MIPS per MHz. This empowers system designer to optimize the device for power consumption versus processing speed.

Feature

High Performance, Low Power Atmel®AVR® 8-Bit Microcontroller Family

- Advanced RISC Architecture
  - 131 Powerful Instructions
  - Most Single Clock Cycle Execution
  - 32 x 8 General Purpose Working Registers
  - Fully Static Operation
  - Up to 20 MIPS Throughput at 20MHz
  - On-chip 2-cycle Multiplier
- High Endurance Non-volatile Memory Segments
  - 32KBytes of In-System Self-Programmable Flash program Memory
  - 1KBytes EEPROM
  - 2KBytes Internal SRAM
  - Write/Erase Cycles: 10,000 Flash/100,000 EEPROM
  - Data Retention: 20 years at 85°C/100 years at 25°C(1)
  - Optional Boot Code Section with Independent Lock Bits
    - In-System Programming by On-chip Boot Program
    - True Read-While-Write Operation
  - Programming Lock for Software Security
- Atmel® QTouch® Library Support
  - Capacitive Touch Buttons, Sliders and Wheels
  - QTouch and QMatrix® Acquisition
  - Up to 64 sense channels

- Peripheral Features
  - Two 8-bit Timer/Counters with Separate Prescaler and Compare Mode
  - One 16-bit Timer/Counter with Separate Prescaler, Compare Mode, and Capture Mode
  - Real Time Counter with Separate Oscillator
  - Six PWM Channels
  - 8-channel 10-bit ADC in TQFP and QFN/MLF package
    - Temperature Measurement
  - 6-channel 10-bit ADC in PDIP Package
    - Temperature Measurement
  - Two Master/Slave SPI Serial Interface
  - One Programmable Serial USART
  - One Byte-oriented 2-wire Serial Interface (Philips I^2C compatible)
  - Programmable Watchdog Timer with Separate On-chip Oscillator
  - One On-chip Analog Comparator
  - Interrupt and Wake-up on Pin Change
- Special Microcontroller Features
  - Power-on Reset and Programmable Brown-out Detection
  - Internal Calibrated Oscillator
  - External and Internal Interrupt Sources
  - Six Sleep Modes: Idle, ADC Noise Reduction, Power-save, Power-down, Standby, and Extended Standby
- I/O and Packages
  - 23 Programmable I/O Lines
  - 28-pin PDIP, 32-lead TQFP, 28-pad QFN/MLF and 32-pad QFN/MLF
- Operating Voltage:
  - 1.8 - 5.5V
- Temperature Range:
  - -40°C to 105°C
- Speed Grade:
  - 0 - 4MHz @ 1.8 - 5.5V
  - 0 - 10MHz @ 2.7 - 5.5V
  - 0 - 20MHz @ 4.5 - 5.5V
- Power Consumption at 1MHz, 1.8V, 25°C
  - Active Mode: 0.2mA
  - Power-down Mode: 0.1µA
  - Power-save Mode: 0.75µA (Including 32kHz RTC)

B. Hoja de datos ILI9325D

ILITEK
Enrich visual experience

ILI9325

a-Si TFT LCD Single Chip Driver
240RGBx320 Resolution and 262K color

Datasheet
Preliminary

Version: V0.28
Document No.: ILI9325DS_V0.28.pdf

ILI TECHNOLOGY CORP.
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Taiwan 300, R.O.C.
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http://www.ilitek.com

Table of Contents

Figures

1. Introduction

ILI9325 is a 262,144-color one-chip SoC driver for a-TFT liquid crystal display with resolution of 240RGBx320 dots, comprising a 720-channel source driver, a 320-channel gate driver, 172,800 bytes RAM for graphic data of 240RGBx320 dots, and power supply circuit.

ILI9325 has four kinds of system interfaces which are i80-system MPU interface (8-/9-/16-/18-bit bus width), VSYNC interface (system interface + VSYNC, internal clock, DB[17:0]), serial data transfer interface (SPI) and RGB 6-/16-/18-bit interface (DOTCLK, VSYNC, HSYNC, ENABLE, DB[17:0]).

In RGB interface and VSYNC interface mode, the combined use of high-speed RAM write function and widow address function enables to display a moving picture at a position specified by a user and still pictures in other areas on the screen simultaneously, which makes it possible to transfer display the refresh data only to minimize data transfers and power consumption.

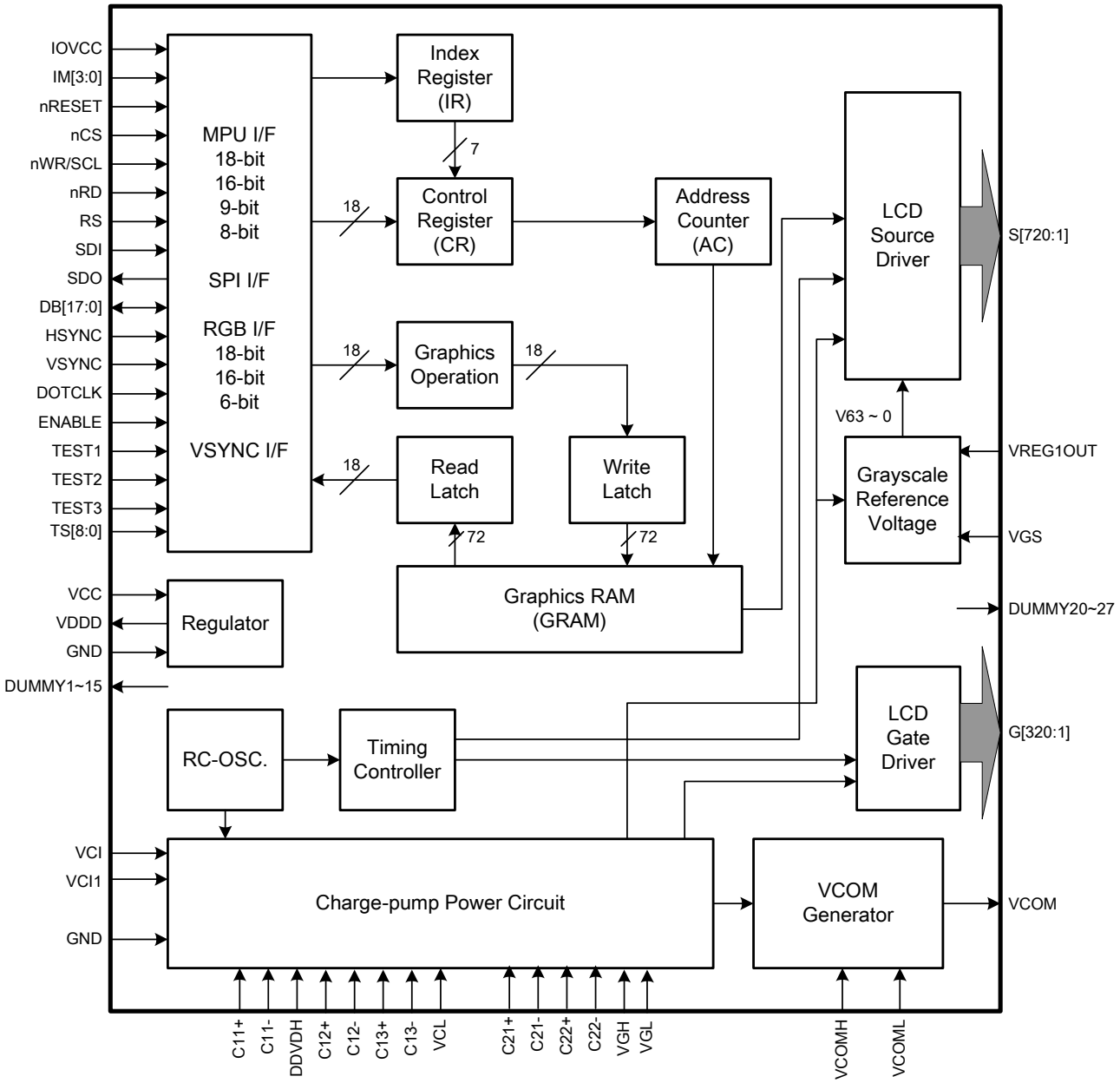
ILI9325 can operate with 1.65V I/O interface voltage, and an incorporated voltage follower circuit to generate voltage levels for driving an LCD. The ILI9325 also supports a function to display in 8 colors and a sleep mode, allowing for precise power control by software and these features make the ILI9325 an ideal LCD driver for medium or small size portable products such as digital cellular phones, smart phone, PDA and PMP where long battery life is a major concern.

2. Features

- Single chip solution for a liquid crystal QVGA TFT LCD display
- 240RGBx320-dot resolution capable with real 262,144 display color
- Support MVA (Multi-domain Vertical Alignment) wide view display
- Incorporate 720-channel source driver and 320-channel gate driver
- Internal 172,800 bytes graphic RAM
- High-speed RAM burst write function
- System interfaces
  - i80 system interface with 8-/ 9-/16-/18-bit bus width
  - Serial Peripheral Interface (SPI)
  - RGB interface with 6-/16-/18-bit bus width (VSYNC, HSYNC, DOTCLK, ENABLE, DB[17:0])
  - VSYNC interface (System interface + VSYNC)
- Internal oscillator and hardware reset
- Resizing function (×1/2, ×1/4)
- Reversible source/gate driver shift direction
- Window address function to specify a rectangular area for internal GRAM access
- Bit operation function for facilitating graphics data processing
  - Bit-unit write data mask function
  - Pixel-unit logical/conditional write function

- Abundant functions for color display control
  - γ-correction function enabling display in 262,144 colors
  - Line-unit vertical scrolling function
- Partial drive function, enabling partially driving an LCD panel at positions specified by user
- Incorporate step-up circuits for stepping up a liquid crystal drive voltage level up to 6 times (x6)
- Power saving functions
  - 8-color mode
  - standby mode
  - sleep mode
- Low -power consumption architecture
  - Low operating power supplies:
    - IOVcc = 1.65V ~ 3.3 V (interface I/O)
    - Vcc = 2.4V ~ 3.3 V (internal logic)
    - Vci = 2.5V ~ 3.3 V (analog)
- LCD Voltage drive:
  - Source/VCOM power supply voltage
    - DVDH - GND = 4.5V ~ 6.0
    - VCL – GND = -2.0V ~ -3.0V
    - VCI – VCL ≦ 6.0V
  - Gate driver output voltage
    - VGH - GND = 10V ~ 20V
    - VGL – GND = -5V ~ -15V
    - VGH – VGL ≦ 32V
  - VCOM driver output voltage
    - VCOMH = 3.0V ~ (DDVDH-0.5)V
    - VCOML = (VCL+0.5)V ~ 0V
    - VCOMH-VCOML ≦ 6.0V
- a-TFT LCD storage capacitor: Cst only

3. Block Diagram



4. Pin Descriptions

<table>
<tr><th>Pin Name</th><th>I/O</th><th>Type</th><th>Descriptions</th></tr>
<tr><td colspan="4">Input Interface</td></tr>
<tr><td>IM3,
IM2,
IM1,
IM0/ID</td><td>I</td><td>IOVcc</td><td>Select the MPU system interface mode
<table>
<tr><th>IM3</th><th>IM2</th><th>IM1</th><th>IM0</th><th>MPU-Interface Mode</th><th>DB Pin in use</th></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td><td>Setting invalid</td><td></td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>1</td><td>Setting invalid</td><td></td></tr>
<tr><td>0</td><td>0</td><td>1</td><td>0</td><td>i80-system 16-bit interface</td><td>DB[17:10], DB[8:1]</td></tr>
<tr><td>0</td><td>0</td><td>1</td><td>1</td><td>i80-system 8-bit interface</td><td>DB[17:10]</td></tr>
<tr><td>0</td><td>1</td><td>0</td><td>ID</td><td>Serial Peripheral Interface (SPI)</td><td>SDI, SDO</td></tr>
<tr><td>0</td><td>1</td><td>1</td><td>*</td><td>Setting invalid</td><td></td></tr>
<tr><td>1</td><td>0</td><td>0</td><td>0</td><td>Setting invalid</td><td></td></tr>
<tr><td>1</td><td>0</td><td>0</td><td>1</td><td>Setting invalid</td><td></td></tr>
<tr><td>1</td><td>0</td><td>1</td><td>0</td><td>i80-system 18-bit interface</td><td>DB[17:0]</td></tr>
<tr><td>1</td><td>0</td><td>1</td><td>1</td><td>i80-system 9-bit interface</td><td>DB[17:9]</td></tr>
<tr><td>1</td><td>1</td><td>*</td><td>*</td><td>Setting invalid</td><td></td></tr>
</table>
When the serial peripheral interface is selected, IM0 pin is used for the device code ID setting.</td></tr>
<tr><td>nCS</td><td>I</td><td>MPU
IOVcc</td><td>A chip select signal.
Low: the ILI9325 is selected and accessible
High: the ILI9325 is not selected and not accessible
Fix to the DGND level when not in use.</td></tr>
<tr><td>RS</td><td>I</td><td>MPU
IOVcc</td><td>A register select signal.
Low: select an index or status register
High: select a control register
Fix to either IOVcc or DGND level when not in use.</td></tr>
<tr><td>nWR/SCL</td><td>I</td><td>MPU
IOVcc</td><td>A write strobe signal and enables an operation to write data when the signal is low.
Fix to either IOVcc or DGND level when not in use.

SPI Mode:
Synchronizing clock signal in SPI mode.</td></tr>
<tr><td>nRD</td><td>I</td><td>MPU
IOVcc</td><td>A read strobe signal and enables an operation to read out data when the signal is low.
Fix to either IOVcc or DGND level when not in use.</td></tr>
<tr><td>nRESET</td><td>I</td><td>MPU
IOVcc</td><td>A reset pin.
Initializes the ILI9325 with a low input. Be sure to execute a power-on reset after supplying power.</td></tr>
<tr><td>SDI</td><td>I</td><td>MPU
IOVcc</td><td>SPI interface input pin.
The data is latched on the rising edge of the SCL signal.</td></tr>
<tr><td>SDO</td><td>O</td><td>MPU
IOVcc</td><td>SPI interface output pin.
The data is outputted on the falling edge of the SCL signal.

Let SDO as floating when not used.</td></tr>
<tr><td>DB[17:0]</td><td>I/O</td><td>MPU
IOVcc</td><td>An 18-bit parallel bi-directional data bus for MPU system interface mode
8-bit I/F: DB[17:10] is used.
9-bit I/F: DB[17:9] is used.
16-bit I/F: DB[17:10] and DB[8:1] is used.
18-bit I/F: DB[17:0] is used.

18-bit parallel bi-directional data bus for RGB interface operation
6-bit RGB I/F: DB[17:12] are used.</td></tr>
</table>

Pin Name	I/O	Type	Descriptions
			16-bit RGB I/F: DB[17:13] and DB[11:1] are used. 18-bit RGB I/F: DB[17:0] are used. Unused pins must be fixed to DGND level.
ENABLE	I	MPU IOVcc	Data ENEABLE signal for RGB interface operation. Low: Select (access enabled) High: Not select (access inhibited) The EPL bit inverts the polarity of the ENABLE signal. Fix to either IOVcc or DGND level when not in use.
DOTCLK	I	MPU IOVcc	Dot clock signal for RGB interface operation. DPL = "0": Input data on the rising edge of DOTCLK DPL = "1": Input data on the falling edge of DOTCLK Fix to the DGND level when not in use
VSYNC	I	MPU IOVcc	Frame synchronizing signal for RGB interface operation. VSPL = "0": Active low. VSPL = "1": Active high. Fix to the DGND level when not in use.
HSYNC	I	MPU IOVcc	Line synchronizing signal for RGB interface operation. HSPL = "0": Active low. HSPL = "1": Active high. Fix to the DGND level when not in use
FMARK	O	MPU IOVcc	Output a frame head pulse signal. The FMARK signal is used when writing RAM data in synchronization with frame. Leave the pin open when not in use.
LCD Driving signals			
S720~S1	O	LCD	Source output voltage signals applied to liquid crystal. To change the shift direction of signal outputs, use the SS bit. SS = "0", the data in the RAM address "h00000" is output from S1. SS = "1", the data in the RAM address "h00000" is output from S720. S1, S4, S7, … display red (R), S2, S5, S8, ... display green (G), and S3, S6, S9, ... display blue (B) (SS = 0).
G320~G1	O	LCD	Gate line output signals. VGH: the level selecting gate lines VGL: the level not selecting gate lines
VCOM	O	TFT common electrode	A supply voltage to the common electrode of TFT panel. VCOM is AC voltage alternating signal between the VCOMH and VCOML levels.
VCOMH	O	Stabilizing capacitor	The high level of VCOM AC voltage. Connect to a stabilizing capacitor.
VCOML	O	Stabilizing capacitor	The low level of VCOM AC voltage. Adjust the VCOML level with the VDV bits. Connect to a stabilizing capacitor.
VGS	I	GND or external resistor	Reference level for the grayscale voltage generating circuit. The VGS level can be changed by connecting to an external resistor.
Charge-pump and Regulator Circuit			
Vci	I	Power supply	A supply voltage to the analog circuit. Connect to an external power supply of 2.5 ~ 3.3V.
GND	I	Power supply	GND for the analog side: GND = 0V. In case of COG, connect to GND on the FPC to prevent noise.
Vci1	O	Stabilizing capacitor	An internal reference voltage for the step-up circuit1. The amplitude between Vci and DGND is determined by the VC[2:0] bits. Make sure to set the Vci1 voltage so that the DDVDH, VGH and VGL voltages are set within the respective specification.
DDVDH	O	Stabilizing	Power supply for the source driver and Vcom drive.

Pin Name	I/O	Type	Descriptions
		capacitor	
VGH	I	Stabilizing capacitor	Power supply for the gate driver.
VGL	I	Stabilizing capacitor	Power supply for the gate driver.
VCL	O	Stabilizing capacitor	VcomL driver power supply. VCL = 0.5 ~ –VCI . Place a stabilizing capacitor between GND
C11+, C11- C12+, C12-	I/O	Step-up capacitor	Capacitor connection pins for the step-up circuit 1.
C13+, C13- C21+, C21- C22+, C22-	I/O	Step-up capacitor	Capacitor connection pins for the step-up circuit 2.
VREG1OUT	I/O	Stabilizing capacitor	Output voltage generated from the reference voltage. The voltage level is set with the VRH bits. VREG1OUT is (1) a source driver grayscale reference voltage, (2) VcomH level reference voltage, and (3) Vcom amplitude reference voltage. Connect to a stabilizing capacitor. VREG1OUT = 3.0 ~ (DDVDH – 0.5)V.
Power Pads			
Vcc	I	Power supply	A supply voltage to the internal logic: Vcc = 2.4~3.3V
IOVcc	I	Power supply	A supply voltage to the interface pins: IM[3:0], nRESET, nCS, nWR, nRD, RS, DB[17:0], VSYNC, HSYNC, DOTCLK, ENABLE, SCL, SDI, SDO. IOVcc = 1.65 ~ 3.3V and Vcc ≧IOVcc. In case of COG, connect to Vcc on the FPC if IOVcc=Vcc, to prevent noise.
VDDD	O	Power	Digital circuit power pad. Connect these pins with the 1uF capacitor.
GND	I	Power supply	GND for the analog side: DGND = 0V.
Test Pads			
DUMMY1~ 15 DUMMY20 ~ 27	-	-	Dummy pad. Leave these pins as open.
IOGNDDUM	O	GND	GND pin.
TESTO1~16	O	Open	Test pins. Leave them open.
TEST1, 2, 3	I	IOGND	Test pins (internal pull low). Connect to GND or leave these pins as open.
TS0~8	I	OPEN	Test pins (internal pull low). Leave them open.

Liquid crystal power supply specifications Table 1

No.	Item		Description
1	TFT Source Driver		720 pins (240 x RGB)
2	TFT Gate Driver		320 pins
3	TFT Display's Capacitor Structure		Cst structure only (Common VCOM)
4	Liquid Crystal Drive Output	S1 ~ S720	V0 ~ V63 grayscales
		G1 ~ G320	VGH - VGL
		VCOM	VCOMH - VCOML: Amplitude = electronic volumes

5	Input Voltage	IOVcc	1.65 ~ 3.30V
		Vcc	2.40 ~ 3.30V
		Vci	2.50 ~ 3.30V
6	Liquid Crystal Drive Voltages	DDVDH	4.5V ~ 6.0V
		VGH	10V ~ 20V
		VGL	-5V ~ -15V
		VCL	-1.9V ~ -3.0V
		VGH - VGL	Max. 32V
		Vci - VCL	Max. 6.0V
7	Internal Step-up Circuits	DDVDH	Vci1 x2
		VGH	Vci1 x4, x5, x6
		VGL	Vci1 x-3, x-4, x-5
		VCL	Vci1 x-1

5. Pad Arrangement and Coordination

Chip Size: 17820um x 870um

Chip thickness : 400um or 280um (typ.)

Pad Location: Pad Center.

Coordinate Origin: Chip center

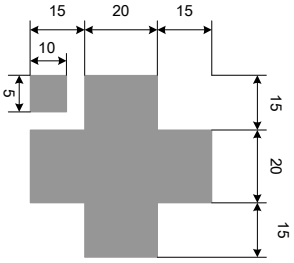
Au bump height: 15um (typ.)

Au Bump Size:

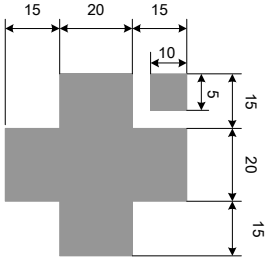
1. 16um x 98um
   Gate: G1 ~ G320
   Source: S1 ~ S720

2. 50um x 80um
   Input Pads
   Pad 1 to 243.

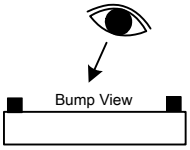
Alignment Marks

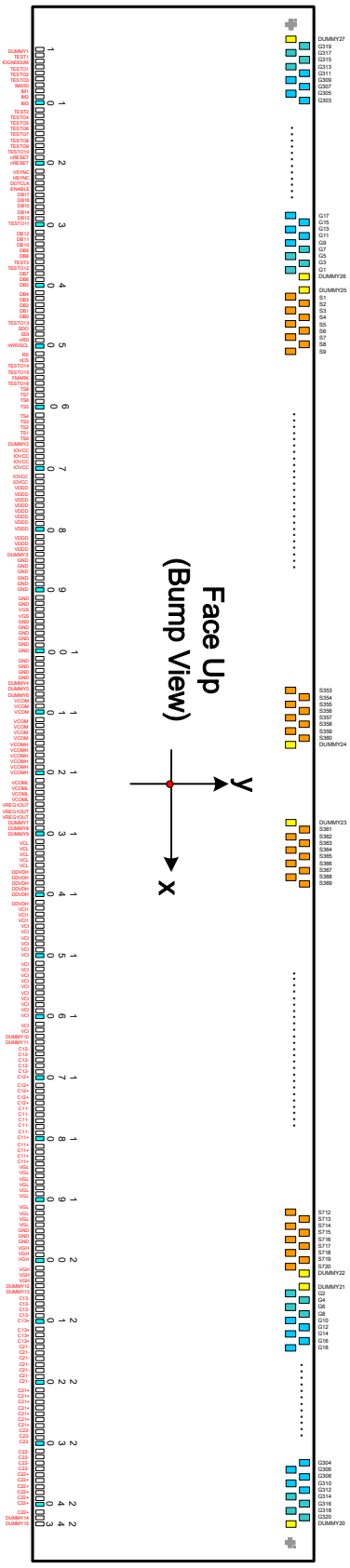


Alignment Mark: A1



Alignment Mark: A2





No.	Name	X	Y	No.	Name	X	Y	No.	Name	X	Y	No.	Name	X	Y	No.	Name	X	Y
1	DUMMY1	-8610	-307.5	61	TS4	-4130	-307.5	121	VCOML	70	-307.5	181	C11+	4270	-307.5	241	C22+	8470	-307.5
2	TEST1	-8540	-307.5	62	TS3	-4060	-307.5	122	VCOML	140	-307.5	182	C11+	4340	-307.5	242	DUMMY14	8540	-307.5
3	IOGNDDUM	-8470	-307.5	63	TS2	-3990	-307.5	123	VCOML	210	-307.5	183	C11+	4410	-307.5	243	DUMMY15	8610	-307.5
4	TESTO1	-8400	-307.5	64	TS1	-3920	-307.5	124	VCOML	280	-307.5	184	C11+	4480	-307.5	244	DUMMY20	8659	202.5
5	TESTO2	-8330	-307.5	65	TS0	-3850	-307.5	125	VREG1OUT	350	-307.5	185	VGL	4550	-307.5	245	G320	8643	319.5
6	TESTO3	-8260	-307.5	66	DUMMY2	-3780	-307.5	126	VREG1OUT	420	-307.5	186	VGL	4620	-307.5	246	G318	8627	202.5
7	IM0/ID	-8190	-307.5	67	IOVCC	-3710	-307.5	127	VREG1OUT	490	-307.5	187	VGL	4690	-307.5	247	G316	8611	319.5
8	IM1	-8120	-307.5	68	IOVCC	-3640	-307.5	128	DUMMY7	560	-307.5	188	VGL	4760	-307.5	248	G314	8595	202.5
9	IM2	-8050	-307.5	69	IOVCC	-3570	-307.5	129	DUMMY8	630	-307.5	189	VGL	4830	-307.5	249	G312	8579	319.5
10	IM3	-7980	-307.5	70	IOVCC	-3500	-307.5	130	DUMMY9	700	-307.5	190	VGL	4900	-307.5	250	G310	8563	202.5
11	TEST2	-7910	-307.5	71	IOVCC	-3430	-307.5	131	VCL	770	-307.5	191	VGL	4970	-307.5	251	G308	8547	319.5
12	TESTO4	-7840	-307.5	72	IOVCC	-3360	-307.5	132	VCL	840	-307.5	192	VGL	5040	-307.5	252	G306	8531	202.5
13	TESTO5	-7770	-307.5	73	VDDD	-3290	-307.5	133	VCL	910	-307.5	193	VGL	5110	-307.5	253	G304	8515	319.5
14	TESTO6	-7700	-307.5	74	VDDD	-3220	-307.5	134	VCL	980	-307.5	194	VGL	5180	-307.5	254	G302	8499	202.5
15	TESTO7	-7630	-307.5	75	VDDD	-3150	-307.5	135	VCL	1050	-307.5	195	GND	5250	-307.5	255	G300	8483	319.5
16	TESTO8	-7560	-307.5	76	VDDD	-3080	-307.5	136	DDVDH	1120	-307.5	196	GND	5320	-307.5	256	G298	8467	202.5
17	TESTO9	-7490	-307.5	77	VDDD	-3010	-307.5	137	DDVDH	1190	-307.5	197	GND	5390	-307.5	257	G296	8451	319.5
18	TESTO10	-7420	-307.5	78	VDDD	-2940	-307.5	138	DDVDH	1260	-307.5	198	VGH	5460	-307.5	258	G294	8435	202.5
19	nRESET	-7350	-307.5	79	VDDD	-2870	-307.5	139	DDVDH	1330	-307.5	199	VGH	5530	-307.5	259	G292	8419	319.5
20	nRESET	-7280	-307.5	80	VDDD	-2800	-307.5	140	DDVDH	1400	-307.5	200	VGH	5600	-307.5	260	G290	8403	202.5
21	VSYNC	-7210	-307.5	81	VDDD	-2730	-307.5	141	DDVDH	1470	-307.5	201	VGH	5670	-307.5	261	G288	8387	319.5
22	HSYNC	-7140	-307.5	82	VDDD	-2660	-307.5	142	VCI1	1540	-307.5	202	VGH	5740	-307.5	262	G286	8371	202.5
23	DOTCLK	-7070	-307.5	83	VDDD	-2590	-307.5	143	VCI1	1610	-307.5	203	VGH	5810	-307.5	263	G284	8355	319.5
24	ENABLE	-7000	-307.5	84	DUMMY3	-2520	-307.5	144	VCI1	1680	-307.5	204	DUMMY12	5880	-307.5	264	G282	8339	202.5
25	DB17	-6905	-307.5	85	GND	-2450	-307.5	145	VCI	1750	-307.5	205	DUMMY13	5950	-307.5	265	G280	8323	319.5
26	DB16	-6825	-307.5	86	GND	-2380	-307.5	146	VCI	1820	-307.5	206	C13-	6020	-307.5	266	G278	8307	202.5
27	DB15	-6745	-307.5	87	GND	-2310	-307.5	147	VCI	1890	-307.5	207	C13-	6090	-307.5	267	G276	8291	319.5
28	DB14	-6665	-307.5	88	GND	-2240	-307.5	148	VCI	1960	-307.5	208	C13-	6160	-307.5	268	G274	8275	202.5
29	DB13	-6585	-307.5	89	GND	-2170	-307.5	149	VCI	2030	-307.5	209	C13-	6230	-307.5	269	G272	8259	319.5
30	TESTO11	-6495	-307.5	90	GND	-2100	-307.5	150	VCI	2100	-307.5	210	C13+	6300	-307.5	270	G270	8243	202.5
31	DB12	-6405	-307.5	91	GND	-2030	-307.5	151	VCI	2170	-307.5	211	C13+	6370	-307.5	271	G268	8227	319.5
32	DB11	-6325	-307.5	92	GND	-1960	-307.5	152	VCI	2240	-307.5	212	C13+	6440	-307.5	272	G266	8211	202.5
33	DB10	-6245	-307.5	93	VGS	-1890	-307.5	153	VCI	2310	-307.5	213	C13+	6510	-307.5	273	G264	8195	319.5
34	DB9	-6165	-307.5	94	VGS	-1820	-307.5	154	VCI	2380	-307.5	214	C21-	6580	-307.5	274	G262	8179	202.5
35	DB8	-6085	-307.5	95	GND	-1750	-307.5	155	VCI	2450	-307.5	215	C21-	6650	-307.5	275	G260	8163	319.5
36	TEST3	-5990	-307.5	96	GND	-1680	-307.5	156	VCI	2520	-307.5	216	C21-	6720	-307.5	276	G258	8147	202.5
37	TESTO12	-5920	-307.5	97	GND	-1610	-307.5	157	VCI	2590	-307.5	217	C21-	6790	-307.5	277	G256	8131	319.5
38	DB7	-5825	-307.5	98	GND	-1540	-307.5	158	VCI	2660	-307.5	218	C21-	6860	-307.5	278	G254	8115	202.5
39	DB6	-5745	-307.5	99	GND	-1470	-307.5	159	VCI	2730	-307.5	219	C21-	6930	-307.5	279	G252	8099	319.5
40	DB5	-5665	-307.5	100	GND	-1400	-307.5	160	VCI	2800	-307.5	220	C21-	7000	-307.5	280	G250	8083	202.5
41	DB4	-5585	-307.5	101	GND	-1330	-307.5	161	VCI	2870	-307.5	221	C21+	7070	-307.5	281	G248	8067	319.5
42	DB3	-5505	-307.5	102	GND	-1260	-307.5	162	VCI	2940	-307.5	222	C21+	7140	-307.5	282	G246	8051	202.5
43	DB2	-5425	-307.5	103	GND	-1190	-307.5	163	DUMMY10	3010	-307.5	223	C21+	7210	-307.5	283	G244	8035	319.5
44	DB1	-5345	-307.5	104	GND	-1120	-307.5	164	DUMMY11	3080	-307.5	224	C21+	7280	-307.5	284	G242	8019	202.5
45	DB0	-5265	-307.5	105	DUMMY4	-1050	-307.5	165	C12-	3150	-307.5	225	C21+	7350	-307.5	285	G240	8003	319.5
46	TESTO13	-5180	-307.5	106	DUMMY5	-980	-307.5	166	C12-	3220	-307.5	226	C21+	7420	-307.5	286	G238	7987	202.5
47	SDO	-5110	-307.5	107	DUMMY6	-910	-307.5	167	C12-	3290	-307.5	227	C21+	7490	-307.5	287	G236	7971	319.5
48	SDI	-5040	-307.5	108	VCOM	-840	-307.5	168	C12-	3360	-307.5	228	C22-	7560	-307.5	288	G234	7955	202.5
49	nRD	-4970	-307.5	109	VCOM	-770	-307.5	169	C12-	3430	-307.5	229	C22-	7630	-307.5	289	G232	7939	319.5
50	nWR/SCL	-4900	-307.5	110	VCOM	-700	-307.5	170	C12+	3500	-307.5	230	C22-	7700	-307.5	290	G230	7923	202.5
51	RS	-4830	-307.5	111	VCOM	-630	-307.5	171	C12+	3570	-307.5	231	C22-	7770	-307.5	291	G228	7907	319.5
52	nCS	-4760	-307.5	112	VCOM	-560	-307.5	172	C12+	3640	-307.5	232	C22-	7840	-307.5	292	G226	7891	202.5
53	TESTO14	-4690	-307.5	113	VCOM	-490	-307.5	173	C12+	3710	-307.5	233	C22-	7910	-307.5	293	G224	7875	319.5
54	TESTO15	-4620	-307.5	114	VCOM	-420	-307.5	174	C12+	3780	-307.5	234	C22-	7980	-307.5	294	G222	7859	202.5
55	FMARK	-4550	-307.5	115	VCOMH	-350	-307.5	175	C11-	3850	-307.5	235	C22+	8050	-307.5	295	G220	7843	319.5
56	TESTO16	-4480	-307.5	116	VCOMH	-280	-307.5	176	C11-	3920	-307.5	236	C22+	8120	-307.5	296	G218	7827	202.5
57	TS8	-4410	-307.5	117	VCOMH	-210	-307.5	177	C11-	3990	-307.5	237	C22+	8190	-307.5	297	G216	7811	319.5
58	TS7	-4340	-307.5	118	VCOMH	-140	-307.5	178	C11-	4060	-307.5	238	C22+	8260	-307.5	298	G214	7795	202.5
59	TS6	-4270	-307.5	119	VCOMH	-70	-307.5	179	C11-	4130	-307.5	239	C22+	8330	-307.5	299	G212	7779	319.5
60	TS5	-4200	-307.5	120	VCOMH	0	-307.5	180	C11+	4200	-307.5	240	C22+	8400	-307.5	300	G210	7763	202.5

No.	Name	X	Y	No.	Name	X	Y	No.	Name	X	Y	No.	Name	X	Y	No.	Name	X	Y
301	G208	7747	319.5	361	G88	6787	319.5	421	S706	5807	202.5	481	S646	4847	202.5	541	S586	3887	202.5
302	G206	7731	202.5	362	G86	6771	202.5	422	S705	5791	319.5	482	S645	4831	319.5	542	S585	3871	319.5
303	G204	7715	319.5	363	G84	6755	319.5	423	S704	5775	202.5	483	S644	4815	202.5	543	S584	3855	202.5
304	G202	7699	202.5	364	G82	6739	202.5	424	S703	5759	319.5	484	S643	4799	319.5	544	S583	3839	319.5
305	G200	7683	319.5	365	G80	6723	319.5	425	S702	5743	202.5	485	S642	4783	202.5	545	S582	3823	202.5
306	G198	7667	202.5	366	G78	6707	202.5	426	S701	5727	319.5	486	S641	4767	319.5	546	S581	3807	319.5
307	G196	7651	319.5	367	G76	6691	319.5	427	S700	5711	202.5	487	S640	4751	202.5	547	S580	3791	202.5
308	G194	7635	202.5	368	G74	6675	202.5	428	S699	5695	319.5	488	S639	4735	319.5	548	S579	3775	319.5
309	G192	7619	319.5	369	G72	6659	319.5	429	S698	5679	202.5	489	S638	4719	202.5	549	S578	3759	202.5
310	G190	7603	202.5	370	G70	6643	202.5	430	S697	5663	319.5	490	S637	4703	319.5	550	S577	3743	319.5
311	G188	7587	319.5	371	G68	6627	319.5	431	S696	5647	202.5	491	S636	4687	202.5	551	S576	3727	202.5
312	G186	7571	202.5	372	G66	6611	202.5	432	S695	5631	319.5	492	S635	4671	319.5	552	S575	3711	319.5
313	G184	7555	319.5	373	G64	6595	319.5	433	S694	5615	202.5	493	S634	4655	202.5	553	S574	3695	202.5
314	G182	7539	202.5	374	G62	6579	202.5	434	S693	5599	319.5	494	S633	4639	319.5	554	S573	3679	319.5
315	G180	7523	319.5	375	G60	6563	319.5	435	S692	5583	202.5	495	S632	4623	202.5	555	S572	3663	202.5
316	G178	7507	202.5	376	G58	6547	202.5	436	S691	5567	319.5	496	S631	4607	319.5	556	S571	3647	319.5
317	G176	7491	319.5	377	G56	6531	319.5	437	S690	5551	202.5	497	S630	4591	202.5	557	S570	3631	202.5
318	G174	7475	202.5	378	G54	6515	202.5	438	S689	5535	319.5	498	S629	4575	319.5	558	S569	3615	319.5
319	G172	7459	319.5	379	G52	6499	319.5	439	S688	5519	202.5	499	S628	4559	202.5	559	S568	3599	202.5
320	G170	7443	202.5	380	G50	6483	202.5	440	S687	5503	319.5	500	S627	4543	319.5	560	S567	3583	319.5
321	G168	7427	319.5	381	G48	6467	319.5	441	S686	5487	202.5	501	S626	4527	202.5	561	S566	3567	202.5
322	G166	7411	202.5	382	G46	6451	202.5	442	S685	5471	319.5	502	S625	4511	319.5	562	S565	3551	319.5
323	G164	7395	319.5	383	G44	6435	319.5	443	S684	5455	202.5	503	S624	4495	202.5	563	S564	3535	202.5
324	G162	7379	202.5	384	G42	6419	202.5	444	S683	5439	319.5	504	S623	4479	319.5	564	S563	3519	319.5
325	G160	7363	319.5	385	G40	6403	319.5	445	S682	5423	202.5	505	S622	4463	202.5	565	S562	3503	202.5
326	G158	7347	202.5	386	G38	6387	202.5	446	S681	5407	319.5	506	S621	4447	319.5	566	S561	3487	319.5
327	G156	7331	319.5	387	G36	6371	319.5	447	S680	5391	202.5	507	S620	4431	202.5	567	S560	3471	202.5
328	G154	7315	202.5	388	G34	6355	202.5	448	S679	5375	319.5	508	S619	4415	319.5	568	S559	3455	319.5
329	G152	7299	319.5	389	G32	6339	319.5	449	S678	5359	202.5	509	S618	4399	202.5	569	S558	3439	202.5
330	G150	7283	202.5	390	G30	6323	202.5	450	S677	5343	319.5	510	S617	4383	319.5	570	S557	3423	319.5
331	G148	7267	319.5	391	G28	6307	319.5	451	S676	5327	202.5	511	S616	4367	202.5	571	S556	3407	202.5
332	G146	7251	202.5	392	G26	6291	202.5	452	S675	5311	319.5	512	S615	4351	319.5	572	S555	3391	319.5
333	G144	7235	319.5	393	G24	6275	319.5	453	S674	5295	202.5	513	S614	4335	202.5	573	S554	3375	202.5
334	G142	7219	202.5	394	G22	6259	202.5	454	S673	5279	319.5	514	S613	4319	319.5	574	S553	3359	319.5
335	G140	7203	319.5	395	G20	6243	319.5	455	S672	5263	202.5	515	S612	4303	202.5	575	S552	3343	202.5
336	G138	7187	202.5	396	G18	6227	202.5	456	S671	5247	319.5	516	S611	4287	319.5	576	S551	3327	319.5
337	G136	7171	319.5	397	G16	6211	319.5	457	S670	5231	202.5	517	S610	4271	202.5	577	S550	3311	202.5
338	G134	7155	202.5	398	G14	6195	202.5	458	S669	5215	319.5	518	S609	4255	319.5	578	S549	3295	319.5
339	G132	7139	319.5	399	G12	6179	319.5	459	S668	5199	202.5	519	S608	4239	202.5	579	S548	3279	202.5
340	G130	7123	202.5	400	G10	6163	202.5	460	S667	5183	319.5	520	S607	4223	319.5	580	S547	3263	319.5
341	G128	7107	319.5	401	G8	6147	319.5	461	S666	5167	202.5	521	S606	4207	202.5	581	S546	3247	202.5
342	G126	7091	202.5	402	G6	6131	202.5	462	S665	5151	319.5	522	S605	4191	319.5	582	S545	3231	319.5
343	G124	7075	319.5	403	G4	6115	319.5	463	S664	5135	202.5	523	S604	4175	202.5	583	S544	3215	202.5
344	G122	7059	202.5	404	G2	6099	202.5	464	S663	5119	319.5	524	S603	4159	319.5	584	S543	3199	319.5
345	G120	7043	319.5	405	DUMMY21	6083	319.5	465	S662	5103	202.5	525	S602	4143	202.5	585	S542	3183	202.5
346	G118	7027	202.5	406	DUMMY22	6047	319.5	466	S661	5087	319.5	526	S601	4127	319.5	586	S541	3167	319.5
347	G116	7011	319.5	407	S720	6031	202.5	467	S660	5071	202.5	527	S600	4111	202.5	587	S540	3151	202.5
348	G114	6995	202.5	408	S719	6015	319.5	468	S659	5055	319.5	528	S599	4095	319.5	588	S539	3135	319.5
349	G112	6979	319.5	409	S718	5999	202.5	469	S658	5039	202.5	529	S598	4079	202.5	589	S538	3119	202.5
350	G110	6963	202.5	410	S717	5983	319.5	470	S657	5023	319.5	530	S597	4063	319.5	590	S537	3103	319.5
351	G108	6947	319.5	411	S716	5967	202.5	471	S656	5007	202.5	531	S596	4047	202.5	591	S536	3087	202.5
352	G106	6931	202.5	412	S715	5951	319.5	472	S655	4991	319.5	532	S595	4031	319.5	592	S535	3071	319.5
353	G104	6915	319.5	413	S714	5935	202.5	473	S654	4975	202.5	533	S594	4015	202.5	593	S534	3055	202.5
354	G102	6899	202.5	414	S713	5919	319.5	474	S653	4959	319.5	534	S593	3999	319.5	594	S533	3039	319.5
355	G100	6883	319.5	415	S712	5903	202.5	475	S652	4943	202.5	535	S592	3983	202.5	595	S532	3023	202.5
356	G98	6867	202.5	416	S711	5887	319.5	476	S651	4927	319.5	536	S591	3967	319.5	596	S531	3007	319.5
357	G96	6851	319.5	417	S710	5871	202.5	477	S650	4911	202.5	537	S590	3951	202.5	597	S530	2991	202.5
358	G94	6835	202.5	418	S709	5855	319.5	478	S649	4895	319.5	538	S589	3935	319.5	598	S529	2975	319.5
359	G92	6819	319.5	419	S708	5839	202.5	479	S648	4879	202.5	539	S588	3919	202.5	599	S528	2959	202.5
360	G90	6803	202.5	420	S707	5823	319.5	480	S647	4863	319.5	540	S587	3903	319.5	600	S527	2943	319.5

No.	Name	X	Y
601	S526	2927	202.5
602	S525	2911	319.5
603	S524	2895	202.5
604	S523	2879	319.5
605	S522	2863	202.5
606	S521	2847	319.5
607	S520	2831	202.5
608	S519	2815	319.5
609	S518	2799	202.5
610	S517	2783	319.5
611	S516	2767	202.5
612	S515	2751	319.5
613	S514	2735	202.5
614	S513	2719	319.5
615	S512	2703	202.5
616	S511	2687	319.5
617	S510	2671	202.5
618	S509	2655	319.5
619	S508	2639	202.5
620	S507	2623	319.5
621	S506	2607	202.5
622	S505	2591	319.5
623	S504	2575	202.5
624	S503	2559	319.5
625	S502	2543	202.5
626	S501	2527	319.5
627	S500	2511	202.5
628	S499	2495	319.5
629	S498	2479	202.5
630	S497	2463	319.5
631	S496	2447	202.5
632	S495	2431	319.5
633	S494	2415	202.5
634	S493	2399	319.5
635	S492	2383	202.5
636	S491	2367	319.5
637	S490	2351	202.5
638	S489	2335	319.5
639	S488	2319	202.5
640	S487	2303	319.5
641	S486	2287	202.5
642	S485	2271	319.5
643	S484	2255	202.5
644	S483	2239	319.5
645	S482	2223	202.5
646	S481	2207	319.5
647	S480	2191	202.5
648	S479	2175	319.5
649	S478	2159	202.5
650	S477	2143	319.5
651	S476	2127	202.5
652	S475	2111	319.5
653	S474	2095	202.5
654	S473	2079	319.5
655	S472	2063	202.5
656	S471	2047	319.5
657	S470	2031	202.5
658	S469	2015	319.5
659	S468	1999	202.5
660	S467	1983	319.5
661	S466	1967	202.5
662	S465	1951	319.5
663	S464	1935	202.5
664	S463	1919	319.5
665	S462	1903	202.5
666	S461	1887	319.5
667	S460	1871	202.5
668	S459	1855	319.5
669	S458	1839	202.5
670	S457	1823	319.5
671	S456	1807	202.5
672	S455	1791	319.5
673	S454	1775	202.5
674	S453	1759	319.5
675	S452	1743	202.5
676	S451	1727	319.5
677	S450	1711	202.5
678	S449	1695	319.5
679	S448	1679	202.5
680	S447	1663	319.5
681	S446	1647	202.5
682	S445	1631	319.5
683	S444	1615	202.5
684	S443	1599	319.5
685	S442	1583	202.5
686	S441	1567	319.5
687	S440	1551	202.5
688	S439	1535	319.5
689	S438	1519	202.5
690	S437	1503	319.5
691	S436	1487	202.5
692	S435	1471	319.5
693	S434	1455	202.5
694	S433	1439	319.5
695	S432	1423	202.5
696	S431	1407	319.5
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703	S424	1295	202.5
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705	S422	1263	202.5
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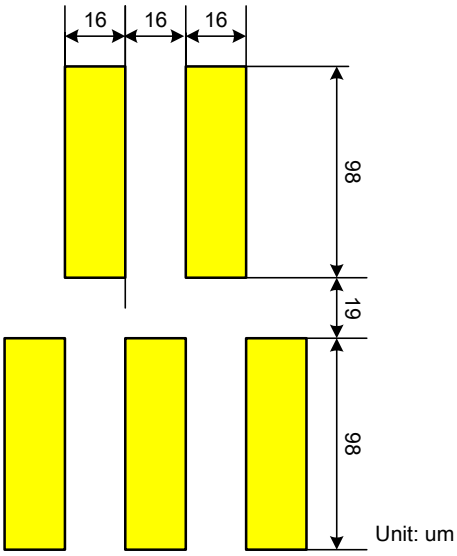
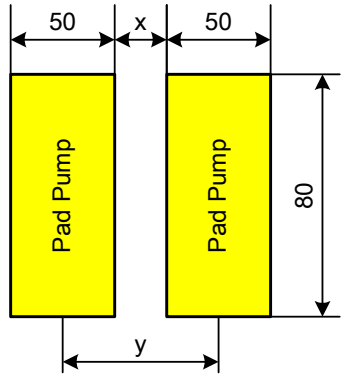
709	S418	1199	202.5
710	S417	1183	319.5
711	S416	1167	202.5
712	S415	1151	319.5
713	S414	1135	202.5
714	S413	1119	319.5
715	S412	1103	202.5
716	S411	1087	319.5
717	S410	1071	202.5
718	S409	1055	319.5
719	S408	1039	202.5
720	S407	1023	319.5
721	S406	1007	202.5
722	S405	991	319.5
723	S404	975	202.5
724	S403	959	319.5
725	S402	943	202.5
726	S401	927	319.5
727	S400	911	202.5
728	S399	895	319.5
729	S398	879	202.5
730	S397	863	319.5
731	S396	847	202.5
732	S395	831	319.5
733	S394	815	202.5
734	S393	799	319.5
735	S392	783	202.5
736	S391	767	319.5
737	S390	751	202.5
738	S389	735	319.5
739	S388	719	202.5
740	S387	703	319.5
741	S386	687	202.5
742	S385	671	319.5
743	S384	655	202.5
744	S383	639	319.5
745	S382	623	202.5
746	S381	607	319.5
747	S380	591	202.5
748	S379	575	319.5
749	S378	559	202.5
750	S377	543	319.5
751	S376	527	202.5
752	S375	511	319.5
753	S374	495	202.5
754	S373	479	319.5
755	S372	463	202.5
756	S371	447	319.5
757	S370	431	202.5
758	S369	415	319.5
759	S368	399	202.5
760	S367	383	319.5
761	S366	367	202.5
762	S365	351	319.5
763	S364	335	202.5
764	S363	319	319.5
765	S362	303	202.5
766	S361	287	319.5
767	DUMMY23	271	202.5
768	DUMMY24	-271	202.5
769	S360	-287	319.5
770	S359	-303	202.5
771	S358	-319	319.5
772	S357	-335	202.5
773	S356	-351	319.5
774	S355	-367	202.5
775	S354	-383	319.5
776	S353	-399	202.5
777	S352	-415	319.5
778	S351	-431	202.5
779	S350	-447	319.5
780	S349	-463	202.5
781	S348	-479	319.5
782	S347	-495	202.5
783	S346	-511	319.5
784	S345	-527	202.5
785	S344	-543	319.5
786	S343	-559	202.5
787	S342	-575	319.5
788	S341	-591	202.5
789	S340	-607	319.5
790	S339	-623	202.5
791	S338	-639	319.5
792	S337	-655	202.5
793	S336	-671	319.5
794	S335	-687	202.5
795	S334	-703	319.5
796	S333	-719	202.5
797	S332	-735	319.5
798	S331	-751	202.5
799	S330	-767	319.5
800	S329	-783	202.5
801	S328	-799	319.5
802	S327	-815	202.5
803	S326	-831	319.5
804	S325	-847	202.5
805	S324	-863	319.5
806	S323	-879	202.5
807	S322	-895	319.5
808	S321	-911	202.5
809	S320	-927	319.5
810	S319	-943	202.5
811	S318	-959	319.5
812	S317	-975	202.5
813	S316	-991	319.5
814	S315	-1007	202.5
815	S314	-1023	319.5
816	S313	-1039	202.5
817	S312	-1055	319.5
818	S311	-1071	202.5
819	S310	-1087	319.5
820	S309	-1103	202.5
821	S308	-1119	319.5
822	S307	-1135	202.5
823	S306	-1151	319.5
824	S305	-1167	202.5
825	S304	-1183	319.5
826	S303	-1199	202.5
827	S302	-1215	319.5
828	S301	-1231	202.5
829	S300	-1247	319.5
830	S299	-1263	202.5
831	S298	-1279	319.5
832	S297	-1295	202.5
833	S296	-1311	319.5
834	S295	-1327	202.5
835	S294	-1343	319.5
836	S293	-1359	202.5
837	S292	-1375	319.5
838	S291	-1391	202.5
839	S290	-1407	319.5
840	S289	-1423	202.5
841	S288	-1439	319.5
842	S287	-1455	202.5
843	S286	-1471	319.5
844	S285	-1487	202.5
845	S284	-1503	319.5
846	S283	-1519	202.5
847	S282	-1535	319.5
848	S281	-1551	202.5
849	S280	-1567	319.5
850	S279	-1583	202.5
851	S278	-1599	319.5
852	S277	-1615	202.5
853	S276	-1631	319.5
854	S275	-1647	202.5
855	S274	-1663	319.5
856	S273	-1679	202.5
857	S272	-1695	319.5
858	S271	-1711	202.5
859	S270	-1727	319.5
860	S269	-1743	202.5
861	S268	-1759	319.5
862	S267	-1775	202.5
863	S266	-1791	319.5
864	S265	-1807	202.5
865	S264	-1823	319.5
866	S263	-1839	202.5
867	S262	-1855	319.5
868	S261	-1871	202.5
869	S260	-1887	319.5
870	S259	-1903	202.5
871	S258	-1919	319.5
872	S257	-1935	202.5
873	S256	-1951	319.5
874	S255	-1967	202.5
875	S254	-1983	319.5
876	S253	-1999	202.5
877	S252	-2015	319.5
878	S251	-2031	202.5
879	S250	-2047	319.5
880	S249	-2063	202.5
881	S248	-2079	319.5
882	S247	-2095	202.5
883	S246	-2111	319.5
884	S245	-2127	202.5
885	S244	-2143	319.5
886	S243	-2159	202.5
887	S242	-2175	319.5
888	S241	-2191	202.5
889	S240	-2207	319.5
890	S239	-2223	202.5
891	S238	-2239	319.5
892	S237	-2255	202.5
893	S236	-2271	319.5
894	S235	-2287	202.5
895	S234	-2303	319.5
896	S233	-2319	202.5
897	S232	-2335	319.5
898	S231	-2351	202.5
899	S230	-2367	319.5
900	S229	-2383	202.5

No.	Name	X	Y	No.	Name	X	Y	No.	Name	X	Y	No.	Name	X	Y	No.	Name	X	Y
901	S228	-2399	319.5	961	S168	-3359	319.5	1021	S108	-4319	319.5	1081	S48	-5279	319.5	1141	G21	-6259	202.5
902	S227	-2415	202.5	962	S167	-3375	202.5	1022	S107	-4335	202.5	1082	S47	-5295	202.5	1142	G23	-6275	319.5
903	S226	-2431	319.5	963	S166	-3391	319.5	1023	S106	-4351	319.5	1083	S46	-5311	319.5	1143	G25	-6291	202.5
904	S225	-2447	202.5	964	S165	-3407	202.5	1024	S105	-4367	202.5	1084	S45	-5327	202.5	1144	G27	-6307	319.5
905	S224	-2463	319.5	965	S164	-3423	319.5	1025	S104	-4383	319.5	1085	S44	-5343	319.5	1145	G29	-6323	202.5
906	S223	-2479	202.5	966	S163	-3439	202.5	1026	S103	-4399	202.5	1086	S43	-5359	202.5	1146	G31	-6339	319.5
907	S222	-2495	319.5	967	S162	-3455	319.5	1027	S102	-4415	319.5	1087	S42	-5375	319.5	1147	G33	-6355	202.5
908	S221	-2511	202.5	968	S161	-3471	202.5	1028	S101	-4431	202.5	1088	S41	-5391	202.5	1148	G35	-6371	319.5
909	S220	-2527	319.5	969	S160	-3487	319.5	1029	S100	-4447	319.5	1089	S40	-5407	319.5	1149	G37	-6387	202.5
910	S219	-2543	202.5	970	S159	-3503	202.5	1030	S99	-4463	202.5	1090	S39	-5423	202.5	1150	G39	-6403	319.5
911	S218	-2559	319.5	971	S158	-3519	319.5	1031	S98	-4479	319.5	1091	S38	-5439	319.5	1151	G41	-6419	202.5
912	S217	-2575	202.5	972	S157	-3535	202.5	1032	S97	-4495	202.5	1092	S37	-5455	202.5	1152	G43	-6435	319.5
913	S216	-2591	319.5	973	S156	-3551	319.5	1033	S96	-4511	319.5	1093	S36	-5471	319.5	1153	G45	-6451	202.5
914	S215	-2607	202.5	974	S155	-3567	202.5	1034	S95	-4527	202.5	1094	S35	-5487	202.5	1154	G47	-6467	319.5
915	S214	-2623	319.5	975	S154	-3583	319.5	1035	S94	-4543	319.5	1095	S34	-5503	319.5	1155	G49	-6483	202.5
916	S213	-2639	202.5	976	S153	-3599	202.5	1036	S93	-4559	202.5	1096	S33	-5519	202.5	1156	G51	-6499	319.5
917	S212	-2655	319.5	977	S152	-3615	319.5	1037	S92	-4575	319.5	1097	S32	-5535	319.5	1157	G53	-6515	202.5
918	S211	-2671	202.5	978	S151	-3631	202.5	1038	S91	-4591	202.5	1098	S31	-5551	202.5	1158	G55	-6531	319.5
919	S210	-2687	319.5	979	S150	-3647	319.5	1039	S90	-4607	319.5	1099	S30	-5567	319.5	1159	G57	-6547	202.5
920	S209	-2703	202.5	980	S149	-3663	202.5	1040	S89	-4623	202.5	1100	S29	-5583	202.5	1160	G59	-6563	319.5
921	S208	-2719	319.5	981	S148	-3679	319.5	1041	S88	-4639	319.5	1101	S28	-5599	319.5	1161	G61	-6579	202.5
922	S207	-2735	202.5	982	S147	-3695	202.5	1042	S87	-4655	202.5	1102	S27	-5615	202.5	1162	G63	-6595	319.5
923	S206	-2751	319.5	983	S146	-3711	319.5	1043	S86	-4671	319.5	1103	S26	-5631	319.5	1163	G65	-6611	202.5
924	S205	-2767	202.5	984	S145	-3727	202.5	1044	S85	-4687	202.5	1104	S25	-5647	202.5	1164	G67	-6627	319.5
925	S204	-2783	319.5	985	S144	-3743	319.5	1045	S84	-4703	319.5	1105	S24	-5663	319.5	1165	G69	-6643	202.5
926	S203	-2799	202.5	986	S143	-3759	202.5	1046	S83	-4719	202.5	1106	S23	-5679	202.5	1166	G71	-6659	319.5
927	S202	-2815	319.5	987	S142	-3775	319.5	1047	S82	-4735	319.5	1107	S22	-5695	319.5	1167	G73	-6675	202.5
928	S201	-2831	202.5	988	S141	-3791	202.5	1048	S81	-4751	202.5	1108	S21	-5711	202.5	1168	G75	-6691	319.5
929	S200	-2847	319.5	989	S140	-3807	319.5	1049	S80	-4767	319.5	1109	S20	-5727	319.5	1169	G77	-6707	202.5
930	S199	-2863	202.5	990	S139	-3823	202.5	1050	S79	-4783	202.5	1110	S19	-5743	202.5	1170	G79	-6723	319.5
931	S198	-2879	319.5	991	S138	-3839	319.5	1051	S78	-4799	319.5	1111	S18	-5759	319.5	1171	G81	-6739	202.5
932	S197	-2895	202.5	992	S137	-3855	202.5	1052	S77	-4815	202.5	1112	S17	-5775	202.5	1172	G83	-6755	319.5
933	S196	-2911	319.5	993	S136	-3871	319.5	1053	S76	-4831	319.5	1113	S16	-5791	319.5	1173	G85	-6771	202.5
934	S195	-2927	202.5	994	S135	-3887	202.5	1054	S75	-4847	202.5	1114	S15	-5807	202.5	1174	G87	-6787	319.5
935	S194	-2943	319.5	995	S134	-3903	319.5	1055	S74	-4863	319.5	1115	S14	-5823	319.5	1175	G89	-6803	202.5
936	S193	-2959	202.5	996	S133	-3919	202.5	1056	S73	-4879	202.5	1116	S13	-5839	202.5	1176	G91	-6819	319.5
937	S192	-2975	319.5	997	S132	-3935	319.5	1057	S72	-4895	319.5	1117	S12	-5855	319.5	1177	G93	-6835	202.5
938	S191	-2991	202.5	998	S131	-3951	202.5	1058	S71	-4911	202.5	1118	S11	-5871	202.5	1178	G95	-6851	319.5
939	S190	-3007	319.5	999	S130	-3967	319.5	1059	S70	-4927	319.5	1119	S10	-5887	319.5	1179	G97	-6867	202.5
940	S189	-3023	202.5	1000	S129	-3983	202.5	1060	S69	-4943	202.5	1120	S9	-5903	202.5	1180	G99	-6883	319.5
941	S188	-3039	319.5	1001	S128	-3999	319.5	1061	S68	-4959	319.5	1121	S8	-5919	319.5	1181	G101	-6899	202.5
942	S187	-3055	202.5	1002	S127	-4015	202.5	1062	S67	-4975	202.5	1122	S7	-5935	202.5	1182	G103	-6915	319.5
943	S186	-3071	319.5	1003	S126	-4031	319.5	1063	S66	-4991	319.5	1123	S6	-5951	319.5	1183	G105	-6931	202.5
944	S185	-3087	202.5	1004	S125	-4047	202.5	1064	S65	-5007	202.5	1124	S5	-5967	202.5	1184	G107	-6947	319.5
945	S184	-3103	319.5	1005	S124	-4063	319.5	1065	S64	-5023	319.5	1125	S4	-5983	319.5	1185	G109	-6963	202.5
946	S183	-3119	202.5	1006	S123	-4079	202.5	1066	S63	-5039	202.5	1126	S3	-5999	202.5	1186	G111	-6979	319.5
947	S182	-3135	319.5	1007	S122	-4095	319.5	1067	S62	-5055	319.5	1127	S2	-6015	319.5	1187	G113	-6995	202.5
948	S181	-3151	202.5	1008	S121	-4111	202.5	1068	S61	-5071	202.5	1128	S1	-6031	202.5	1188	G115	-7011	319.5
949	S180	-3167	319.5	1009	S120	-4127	319.5	1069	S60	-5087	319.5	1129	DUMMY25	-6047	319.5	1189	G117	-7027	202.5
950	S179	-3183	202.5	1010	S119	-4143	202.5	1070	S59	-5103	202.5	1130	DUMMY26	-6083	319.5	1190	G119	-7043	319.5
951	S178	-3199	319.5	1011	S118	-4159	319.5	1071	S58	-5119	319.5	1131	G1	-6099	202.5	1191	G121	-7059	202.5
952	S177	-3215	202.5	1012	S117	-4175	202.5	1072	S57	-5135	202.5	1132	G3	-6115	319.5	1192	G123	-7075	319.5
953	S176	-3231	319.5	1013	S116	-4191	319.5	1073	S56	-5151	319.5	1133	G5	-6131	202.5	1193	G125	-7091	202.5
954	S175	-3247	202.5	1014	S115	-4207	202.5	1074	S55	-5167	202.5	1134	G7	-6147	319.5	1194	G127	-7107	319.5
955	S174	-3263	319.5	1015	S114	-4223	319.5	1075	S54	-5183	319.5	1135	G9	-6163	202.5	1195	G129	-7123	202.5
956	S173	-3279	202.5	1016	S113	-4239	202.5	1076	S53	-5199	202.5	1136	G11	-6179	319.5	1196	G131	-7139	319.5
957	S172	-3295	319.5	1017	S112	-4255	319.5	1077	S52	-5215	319.5	1137	G13	-6195	202.5	1197	G133	-7155	202.5
958	S171	-3311	202.5	1018	S111	-4271	202.5	1078	S51	-5231	202.5	1138	G15	-6211	319.5	1198	G135	-7171	319.5
959	S170	-3327	319.5	1019	S110	-4287	319.5	1079	S50	-5247	319.5	1139	G17	-6227	202.5	1199	G137	-7187	202.5
960	S169	-3343	202.5	1020	S109	-4303	202.5	1080	S49	-5263	202.5	1140	G19	-6243	319.5	1200	G139	-7203	319.5

No.	Name	X	Y
1201	G141	-7219	202.5
1202	G143	-7235	319.5
1203	G145	-7251	202.5
1204	G147	-7267	319.5
1205	G149	-7283	202.5
1206	G151	-7299	319.5
1207	G153	-7315	202.5
1208	G155	-7331	319.5
1209	G157	-7347	202.5
1210	G159	-7363	319.5
1211	G161	-7379	202.5
1212	G163	-7395	319.5
1213	G165	-7411	202.5
1214	G167	-7427	319.5
1215	G169	-7443	202.5
1216	G171	-7459	319.5
1217	G173	-7475	202.5
1218	G175	-7491	319.5
1219	G177	-7507	202.5
1220	G179	-7523	319.5
1221	G181	-7539	202.5
1222	G183	-7555	319.5
1223	G185	-7571	202.5
1224	G187	-7587	319.5
1225	G189	-7603	202.5
1226	G191	-7619	319.5
1227	G193	-7635	202.5
1228	G195	-7651	319.5
1229	G197	-7667	202.5
1230	G199	-7683	319.5
1231	G201	-7699	202.5
1232	G203	-7715	319.5
1233	G205	-7731	202.5
1234	G207	-7747	319.5
1235	G209	-7763	202.5
1236	G211	-7779	319.5
1237	G213	-7795	202.5
1238	G215	-7811	319.5
1239	G217	-7827	202.5
1240	G219	-7843	319.5
1241	G221	-7859	202.5
1242	G223	-7875	319.5
1243	G225	-7891	202.5
1244	G227	-7907	319.5
1245	G229	-7923	202.5
1246	G231	-7939	319.5
1247	G233	-7955	202.5
1248	G235	-7971	319.5
1249	G237	-7987	202.5
1250	G239	-8003	319.5
1251	G241	-8019	202.5
1252	G243	-8035	319.5
1253	G245	-8051	202.5
1254	G247	-8067	319.5
1255	G249	-8083	202.5
1256	G251	-8099	319.5
1257	G253	-8115	202.5
1258	G255	-8131	319.5
1259	G257	-8147	202.5
1260	G259	-8163	319.5

No.	Name	X	Y
1261	G261	-8179	202.5
1262	G263	-8195	319.5
1263	G265	-8211	202.5
1264	G267	-8227	319.5
1265	G269	-8243	202.5
1266	G271	-8259	319.5
1267	G273	-8275	202.5
1268	G275	-8291	319.5
1269	G277	-8307	202.5
1270	G279	-8323	319.5
1271	G281	-8339	202.5
1272	G283	-8355	319.5
1273	G285	-8371	202.5
1274	G287	-8387	319.5
1275	G289	-8403	202.5
1276	G291	-8419	319.5
1277	G293	-8435	202.5
1278	G295	-8451	319.5
1279	G297	-8467	202.5
1280	G299	-8483	319.5
1281	G301	-8499	202.5
1282	G303	-8515	319.5
1283	G305	-8531	202.5
1284	G307	-8547	319.5
1285	G309	-8563	202.5
1286	G311	-8579	319.5
1287	G313	-8595	202.5
1288	G315	-8611	319.5
1289	G317	-8627	202.5
1290	G319	-8643	319.5
1291	DUMMY27	-8659	202.5
Alignment mark		X	Y
	1-a	-8751	269
	1-b	8751	269

S1 ~ S720 G1 ~ G320 DUMMY20~27 (No. 244 ~ 1291)	
I/O Pads (No. 1 ~ 243)	 X=20, 30, 35 Y=70, 80, 85 Unit: um

6. Block Description

MPU System Interface

ILI9325 supports three system high-speed interfaces: i80-system high-speed interfaces to 8-, 9-, 16-, 18-bit parallel ports and serial peripheral interface (SPI). The interface mode is selected by setting the IM[3:0] pins.

ILI9325 has a 16-bit index register (IR), an 18-bit write-data register (WDR), and an 18-bit read-data register (RDR). The IR is the register to store index information from control registers and the internal GRAM. The WDR is the register to temporarily store data to be written to control registers and the internal GRAM. The RDR is the register to temporarily store data read from the GRAM. Data from the MPU to be written to the internal GRAM are first written to the WDR and then automatically written to the internal GRAM in internal operation. Data are read via the RDR from the internal GRAM. Therefore, invalid data are read out to the data bus when the ILI9325 read the first data from the internal GRAM. Valid data are read out after the ILI9325 performs the second read operation.

Registers are written consecutively as the register execution time except starting oscillator takes 0 clock cycle.

Registers selection by system interface (8-/9-/16-/18-bit bus width)		I80	
Function	**RS**	**nWR**	**nRD**
Write an index to IR register	0	0	1
Read an internal status	0	1	0
Write to control registers or the internal GRAM by WDR register.	1	0	1
Read from the internal GRAM by RDR register.	1	1	0

Registers selection by the SPI system interface		
Function	**R/W**	**RS**
Write an index to IR register	0	0
Read an internal status	1	0
Write to control registers or the internal GRAM by WDR register.	0	1
Read from the internal GRAM by RDR register.	1	1

Parallel RGB Interface

ILI9325 supports the RGB interface and the VSYNC interface as the external interface for displaying a moving picture. When the RGB interface is selected, display operations are synchronized with externally supplied signals, VSYNC, HSYNC, and DOTCLK. In RGB interface mode, data (DB17-0) are written in synchronization with these signals according to the polarity of enable signal (ENABLE) to prevent flicker on display while updating display data.

In VSYNC interface mode, the display operation is synchronized with the internal clock except frame synchronization, where the operation is synchronized with the VSYNC signal. Display data are written to the internal GRAM via the system interface. In this case, there are constraints in speed and method in writing data to the internal RAM. For details, see the “External Display Interface” section. The ILI9325 allows for switching between the external display interface and the system interface by instruction so that the optimum interface is

selected for the kind of picture to be displayed on the screen (still and/or moving picture(s)). The RGB interface, by writing all display data to the internal RAM, allows for transferring data only when updating the frames of a moving picture, contributing to low power requirement for moving picture display.

Bit Operation

The ILI9325 supports a write data mask function for selectively writing data to the internal RAM in units of bits and a logical/compare operation to write data to the GRAM only when a condition is met as a result of comparing the data and the compare register bits. For details, see “Graphics Operation Functions”.

Address Counter (AC)

The address counter (AC) gives an address to the internal GRAM. When the index of the register for setting a RAM address in the AC is written to the IR, the address information is sent from the IR to the AC. As writing data to the internal GRAM, the address in the AC is automatically updated plus or minus 1. The window address function enables writing data only in the rectangular area arbitrarily set by users on the GRAM.

Graphics RAM (GRAM)

GRAM is graphics RAM storing bit-pattern data of 172,820 (240 x 320x 18/8) bytes with 18 bits per pixel.

Grayscale Voltage Generating Circuit

The grayscale voltage generating circuit generates a liquid crystal drive voltage according to grayscale data set in the γ-correction register to display in 262,144 colors. For details, see the “γ-Correction Register” section.

Timing Controller

The timing generator generates a timing signal for operation of internal circuits such as the internal GRAM. The timing for the display operation such as RAM read operation and the timing for the internal operation such as access from the MPU are generated in the way not to interfere each other.

Oscillator (OSC)

ILI9325 generates RC oscillation with an internal oscillation resistor. The frame rate is adjusted by the register setting.

LCD Driver Circuit

The LCD driver circuit of ILI9325 consists of a 720-output source driver (S1 ~ S720) and a 320-output gate driver (G1~G320). Display pattern data are latched when the 720th bit data are input. The latched data control the source driver and generate a drive waveform. The gate driver for scanning gate lines outputs either VGH or VGL level. The shift direction of 720 source outputs from the source driver is set with the SS bit and the shift direction of gate outputs from the gate driver is set with the GS bit. The scan mode by the gate driver is

set with the SM bit. These bits allow setting an appropriate scan method for an LCD module.

LCD Driver Power Supply Circuit

The LCD drive power supply circuit generates the voltage levels VREG1OUT, VGH, VGL and Vcom for driving an LCD.

7. System Interface

7.1. Interface Specifications

ILI9325 has the system interface to read/write the control registers and display graphics memory (GRAM), and the RGB Input Interface for displaying a moving picture. User can select an optimum interface to display the moving or still picture with efficient data transfer. All display data are stored in the GRAM to reduce the data transfer efforts and only the updating data is necessary to be transferred. User can only update a sub-range of GRAM by using the window address function.

ILI9325 also has the RGB interface and VSYNC interface to transfer the display data without flicker the moving picture on the screen. In RGB interface mode, the display data is written into the GRAM through the control signals of ENABLE, VSYNC, HSYNC, DOTCLK and data bus DB[17:0].

In VSYNC interface mode, the internal display timing is synchronized with the frame synchronization signal (VSYNC). The VSYNC interface mode enables to display the moving picture display through the system interface. In this case, there are some constraints of speed and method to write data to the internal RAM.

ILI9325 operates in one of the following 4 modes. The display mode can be switched by the control register. When switching from one mode to another, refer to the sequences mentioned in the sections of RGB and VSYNC interfaces.

Operation Mode	RAM Access Setting (RM)	Display Operation Mode (DM[1:0])
Internal operating clock only (Displaying still pictures)	System interface (RM = 0)	Internal operating clock (DM[1:0] = 00)
RGB interface (1) (Displaying moving pictures)	RGB interface (RM = 1)	RGB interface (DM[1:0] = 01)
RGB interface (2) (Rewriting still pictures while displaying moving pictures)	System interface (RM = 0)	RGB interface (DM[1:0] = 01)
VSYNC interface (Displaying moving pictures)	System interface (RM = 0)	VSYNC interface (DM[1:0] = 01)

Note 1) Registers are set only via the system interface.

Note 2) The RGB-I/F and the VSYNC-I/F are not available simultaneously.

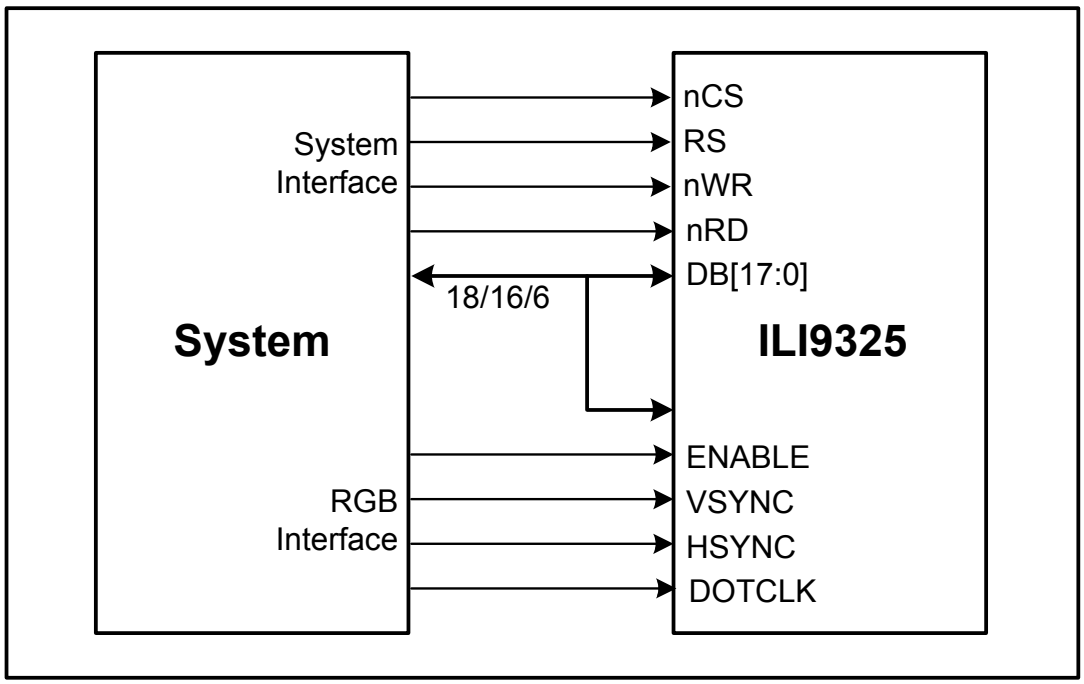


Figure1 System Interface and RGB Interface connection

7.2. Input Interfaces

The following are the system interfaces available with the ILI9325. The interface is selected by setting the IM[3:0] pins. The system interface is used for setting registers and GRAM access.

IM3	IM2	IM1	IM0/ID	Interface Mode	DB Pin
0	0	0	0	Setting invalid	
0	0	0	1	Setting invalid	
0	0	1	0	i80-system 16-bit interface	DB[17:10], DB[8:1]
0	0	1	1	i80-system 8-bit interface	DB[17:10]
0	1	0	ID	Serial Peripheral Interface (SPI)	SDI, SDO (DB[1:0])
0	1	1	*	Setting invalid	
1	0	0	0	Setting invalid	
1	0	0	1	Setting invalid	
1	0	1	0	i80-system18-bit interface	DB[17:0]
1	0	1	1	i80-system 9-bit interface	DB[17:9]
1	1	*	*	Setting invalid	

7.2.1. i80/18-bit System Interface

The i80/18-bit system interface is selected by setting the IM[3:0] as “1010” levels.

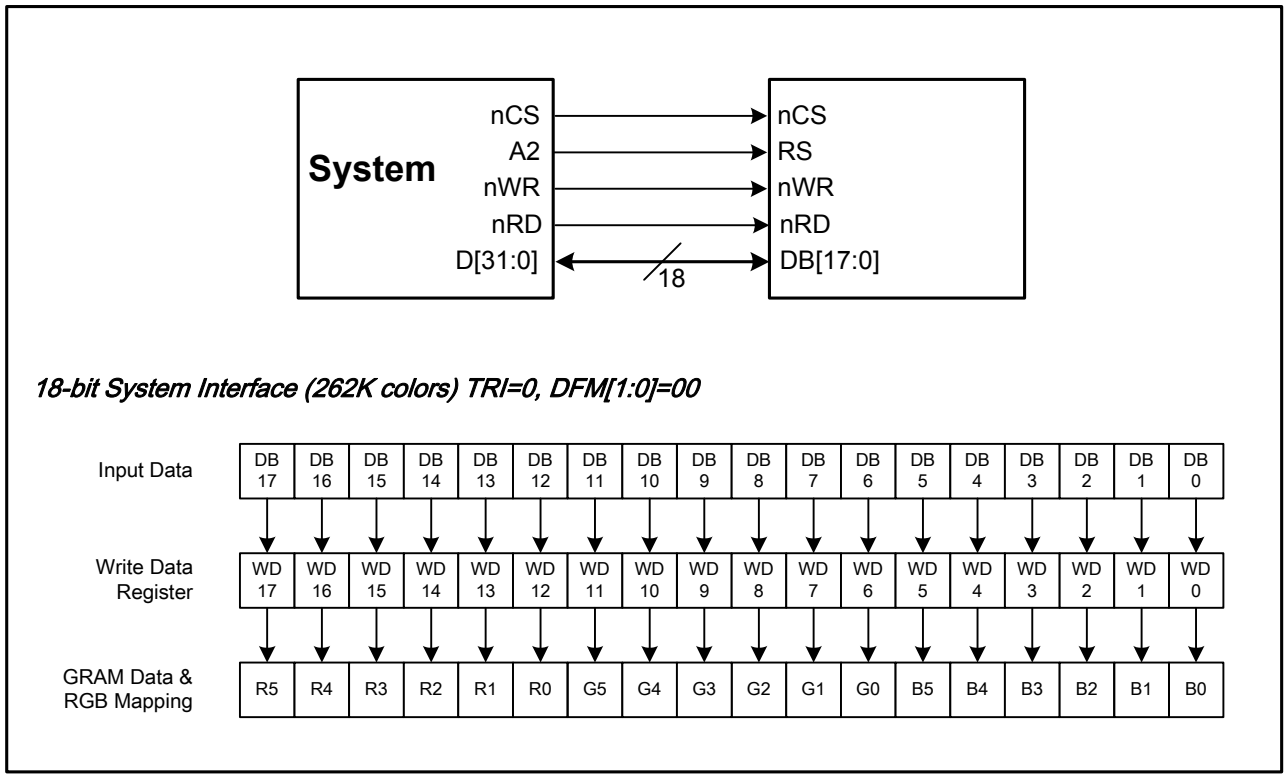


Figure2 18-bit System Interface Data Format

7.2.2. i80/16-bit System Interface

The i80/16-bit system interface is selected by setting the IM[3:0] as “0010” levels. The 262K or 65K color can be display through the 16-bit MPU interface. When the 262K color is displayed, two transfers (1st transfer: 2 bits, 2nd transfer: 16 bits or 1st transfer: 16 bits, 2nd transfer: 2 bits) are necessary for the 16-bit CPU interface.

TRI	DFM	16-bit MPU System Interface Data Format
0	*	**system 16-bit interface (1 transfers/pixel) 65,536 colors** 1st Transfer DB 17 DB 16 DB 15 DB 14 DB 13 DB 12 DB 11 DB 10 DB 8 DB 7 DB 6 DB 5 DB 4 DB 3 DB 2 DB 1 R5 R4 R3 R2 R1 R0 G5 G4 G3 G2 G1 G0 B5 B4 B3 B2 B1 B0
1	0	**80-system 16-bit interface (2 transfers/pixel) 262,144 colors** 1st Transfer 2nd Transfer DB 17 DB 16 DB 15 DB 14 DB 13 DB 12 DB 11 DB 10 DB 8 DB 7 DB 6 DB 5 DB 4 DB 3 DB 2 DB 1 DB 17 DB 16 R5 R4 R3 R2 R1 R0 G5 G4 G3 G2 G1 G0 B5 B4 B3 B2 B1 B0
1	1	**80-system 16-bit interface (2 transfers/pixel) 262,144 colors** 1st Transfer 2nd Transfer DB 2 DB 1 DB 17 DB 16 DB 15 DB 14 DB 13 DB 12 DB 11 DB 10 DB 8 DB 7 DB 6 DB 5 DB 4 DB 3 DB 2 DB 1 R5 R4 R3 R2 R1 R0 G5 G4 G3 G2 G1 G0 B5 B4 B3 B2 B1 B0

Figure3 16-bit System Interface Data Format

7.2.3. i80/9-bit System Interface

The i80/9-bit system interface is selected by setting the IM[3:0] as “1011” and the DB17~DB9 pins are used to transfer the data. When writing the 16-bit register, the data is divided into upper byte (8 bits and LSB is not used) lower byte and the upper byte is transferred first. The display data is also divided in upper byte (9 bits) and lower byte, and the upper byte is transferred first. The unused DB[8:0] pins must be tied to either Vcc or GND.

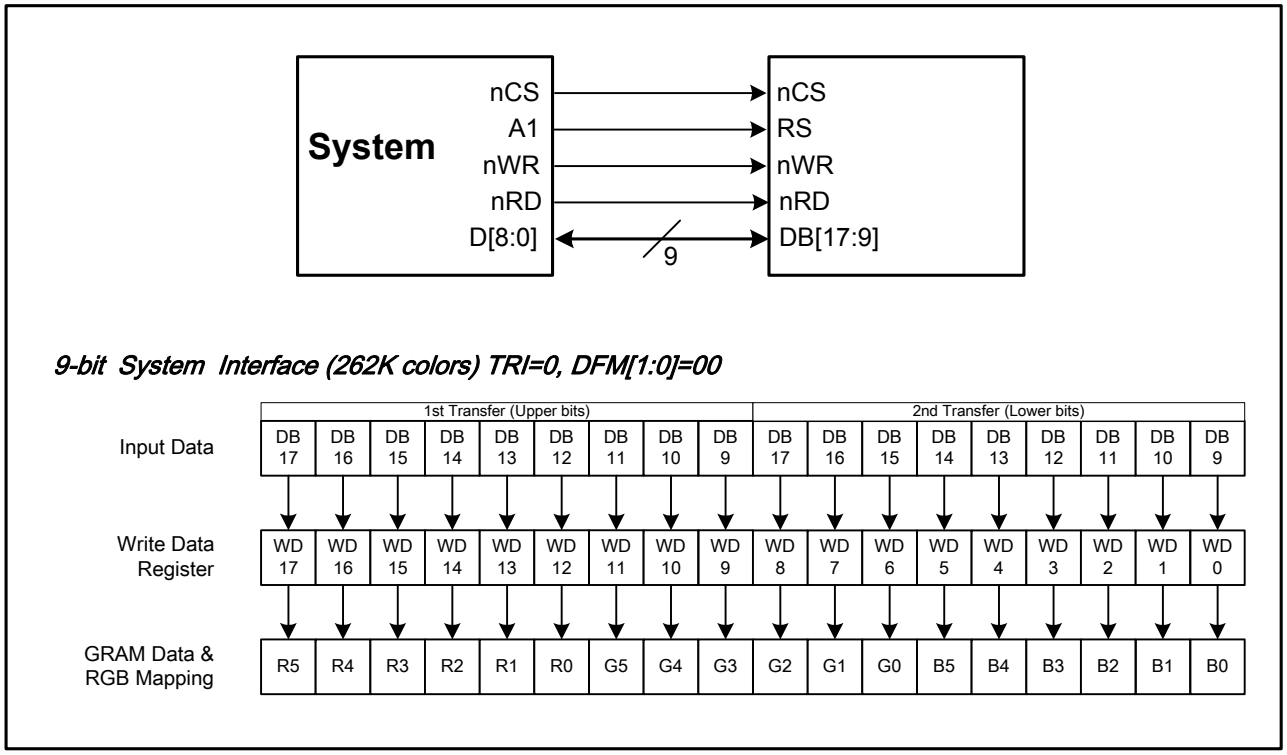


Figure4 9-bit System Interface Data Format

7.2.4. i80/8-bit System Interface

The i80/8-bit system interface is selected by setting the IM[3:0] as “0011” and the DB17~DB10 pins are used to transfer the data. When writing the 16-bit register, the data is divided into upper byte (8 bits and LSB is not used) lower byte and the upper byte is transferred first. The display data is also divided in upper byte (8 bits) and lower byte, and the upper byte is transferred first. The written data is expanded into 18 bits internally (see the figure below) and then written into GRAM. The unused DB[9:0] pins must be tied to either Vcc or GND.

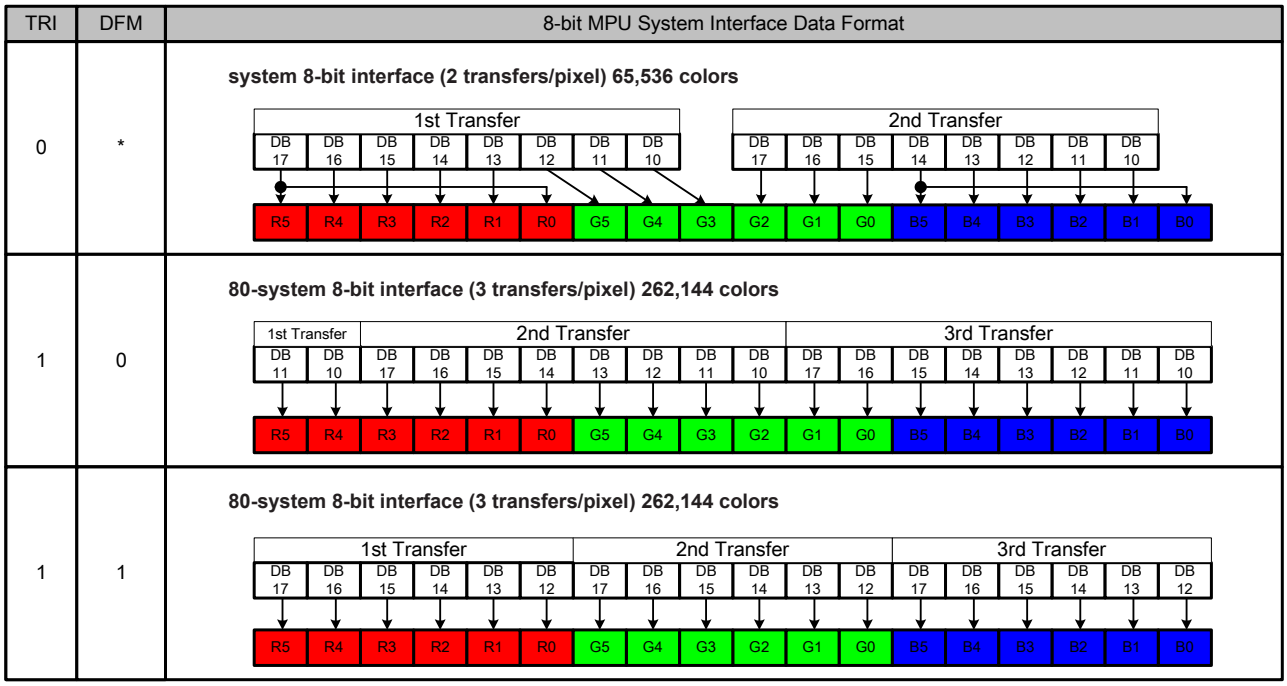


Figure5 8-bit System Interface Data Format

Data transfer synchronization in 8/9-bit bus interface mode

ILI9325 supports a data transfer synchronization function to reset upper and lower counters which count the transfers numbers of upper and lower byte in 8/9-bit interface mode. If a mismatch arises in the numbers of transfers between the upper and lower byte counters due to noise and so on, the “00”h register is written 4 times consecutively to reset the upper and lower counters so that data transfer will restart with a transfer of upper byte. This synchronization function can effectively prevent display error if the upper/lower counters are periodically reset.

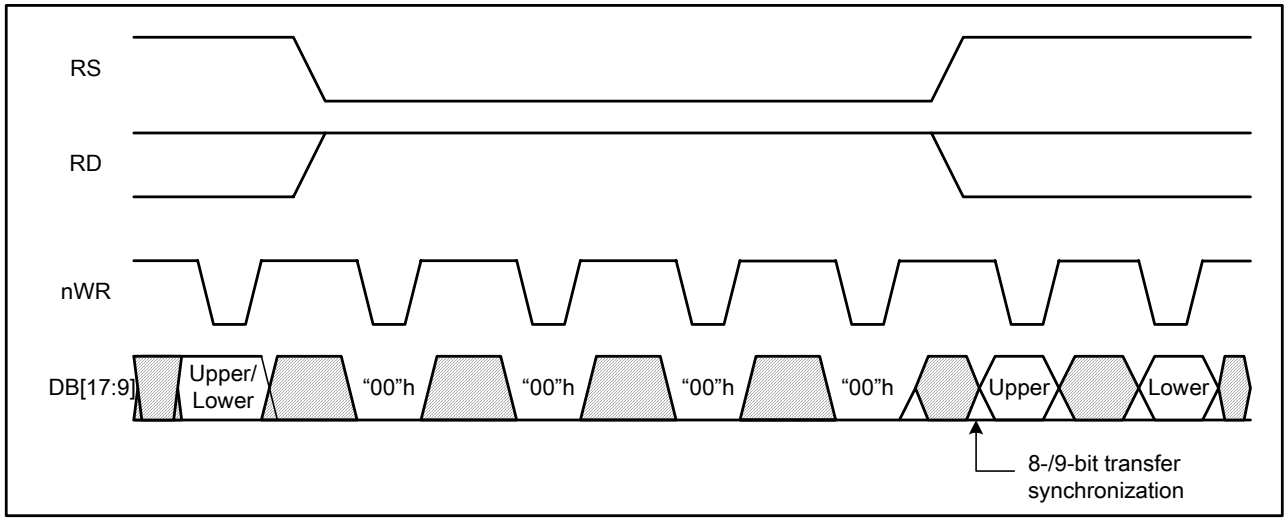


Figure6 Data Transfer Synchronization in 8/9-bit System Interface

7.3. Serial Peripheral Interface (SPI)

The Serial Peripheral Interface (SPI) is selected by setting the IM[3:0] pins as “010x” level. The chip select pin

(nCS), the serial transfer clock pin (SCL), the serial data input pin (SDI) and the serial data output pin (SDO) are used in SPI mode. The ID pin sets the least significant bit of the identification code. The DB[17:0] pins, which are not used, must be tied to either IOVcc or DGND.

The SPI interface operation enables from the falling edge of nCS and ends of data transfer on the rising edge of nCS. The start byte is transferred to start the SPI interface and the read/write operation and RS information are also included in the start byte. When the start byte is matched, the subsequent data is received by ILI9325.

The seventh bit of start byte is RS bit. When RS = "0", either index write operation or status read operation is executed. When RS = "1", either register write operation or RAM read/write operation is executed. The eighth bit of the start byte is used to select either read or write operation (R/W bit). Data is written when the R/W bit is "0" and read back when the R/W bit is "1".

After receiving the start byte, ILI9325 starts to transfer or receive the data in unit of byte and the data transfer starts from the MSB bit. All the registers of the ILI9325 are 16-bit format and receive the first and the second byte datat as the upper and the lower eight bits of the 16-bit register respectively. In SPI mode, 5 bytes dummy read is necessary and the valid data starts from 6th byte of read back data.

Start Byte Format

Transferred bits	S	1	2	3	4	5	6	7	8
Start byte format	Transfer start	Device ID code						RS	R/W
		0	1	1	1	0	ID	1/0	1/0

Note: ID bit is selected by setting the IM0/ID pin.

RS and R/W Bit Function

RS	R/W	Function
0	0	Set an index register
0	1	Read a status
1	0	Write a register or GRAM data
1	1	Read a register or GRAM data

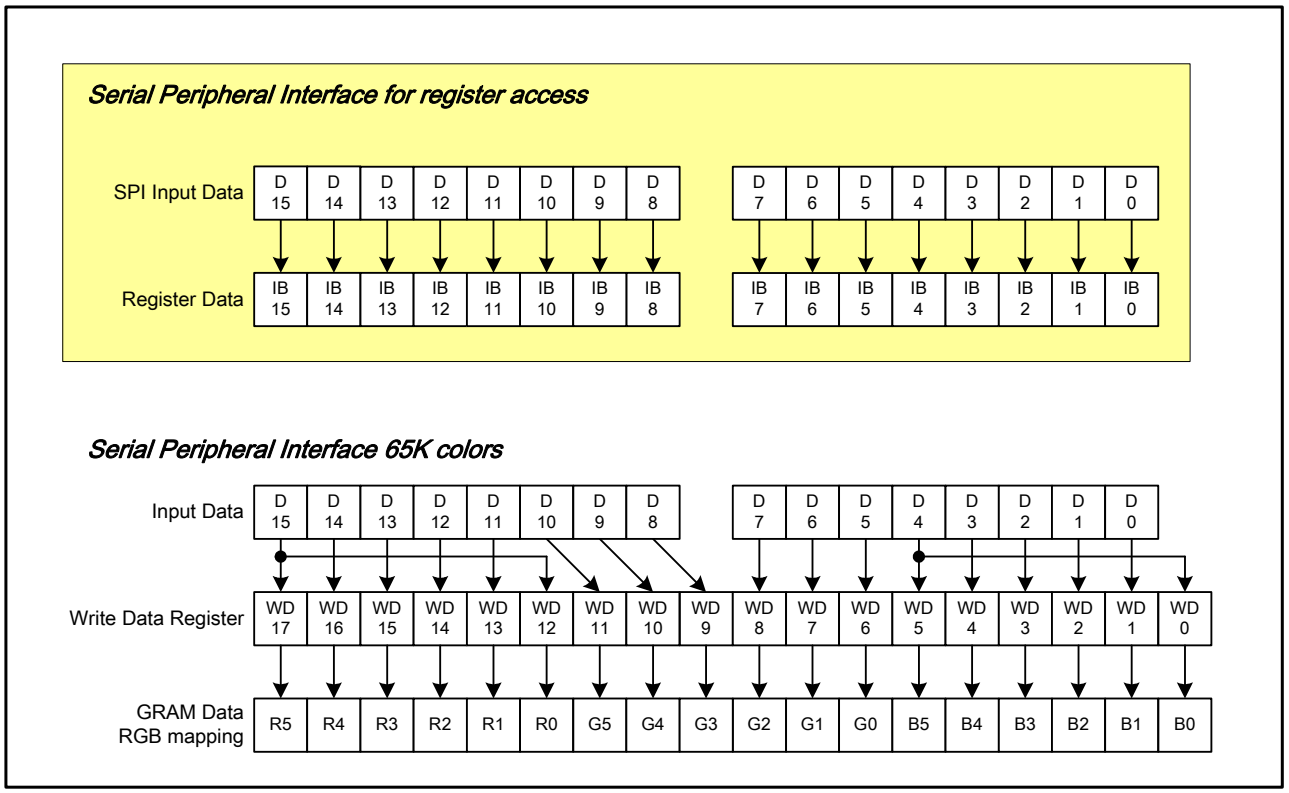


Figure 7 Data Format of SPI Interface

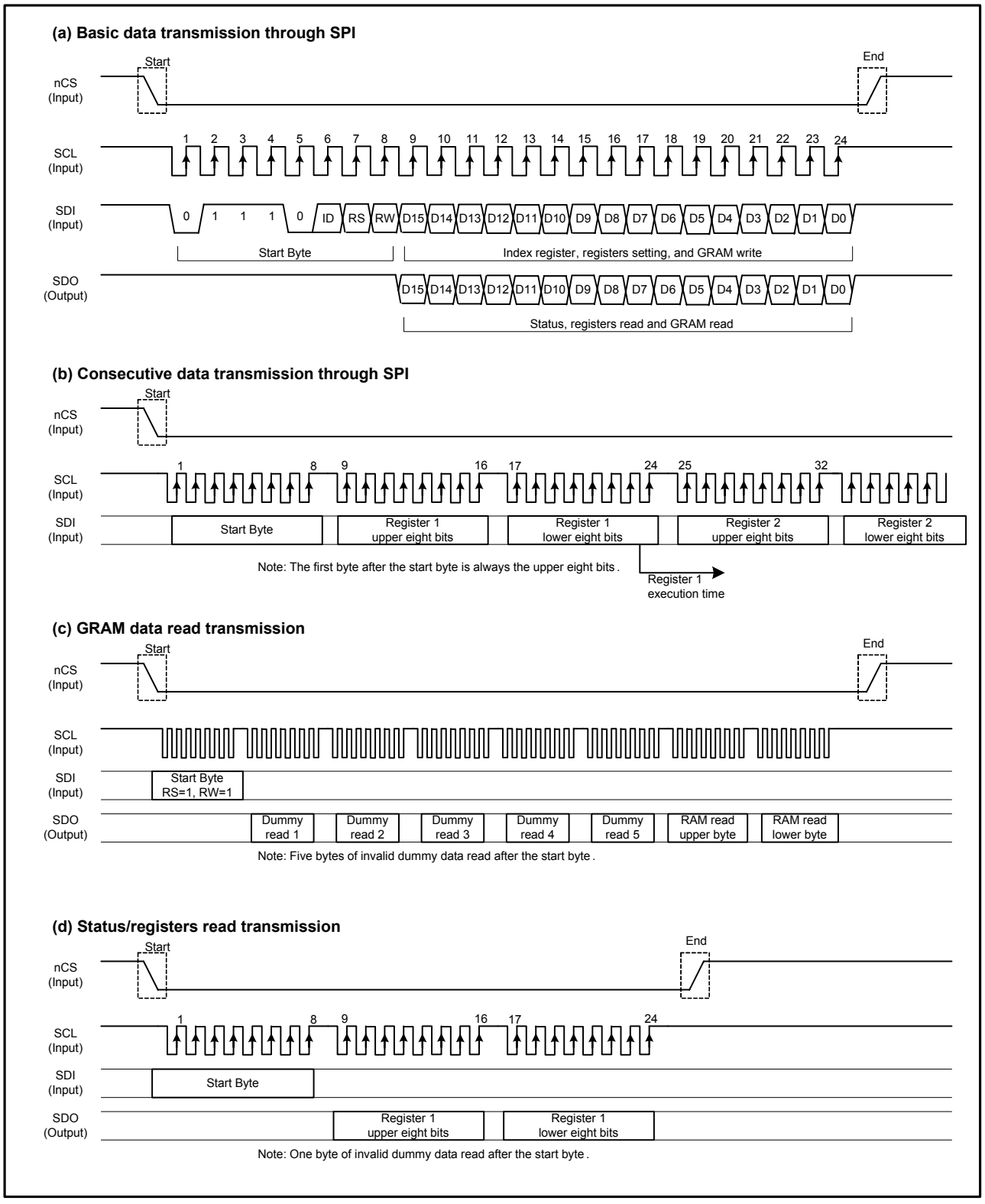
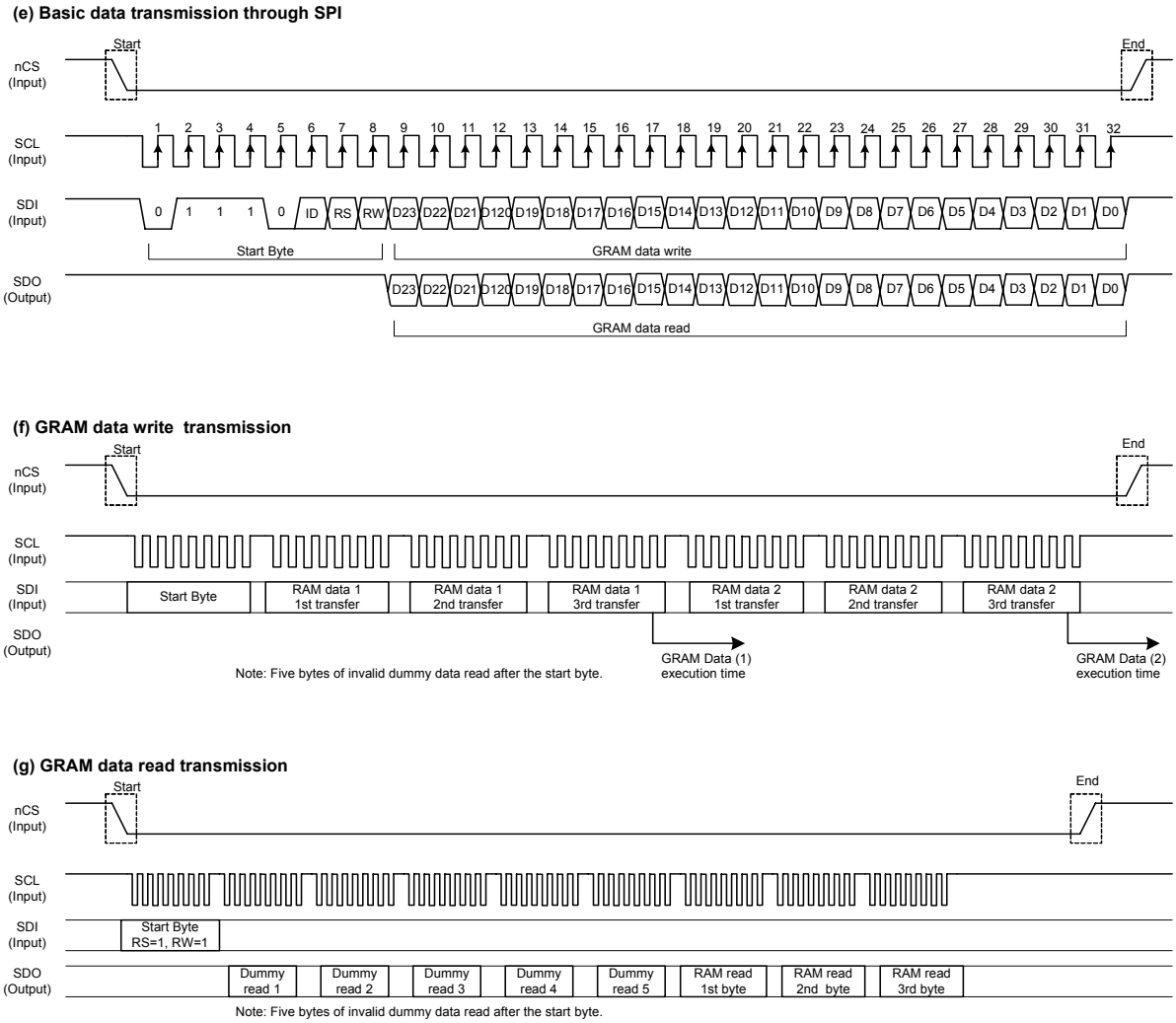


Figure8 Data transmission through serial peripheral interface (SPI)



RAM data transfer in SPI mode when TRI=1 and DFM[1:0]=10.

Figure9 Data transmission through serial peripheral interface (SPI), TRI="1" and DFM="10")

7.4. VSYNC Interface

ILI9325 supports the VSYNC interface in synchronization with the frame-synchronizing signal VSYNC to display the moving picture with the i80 system interface. When the VSYNC interface is selected to display a moving picture, the minimum GRAM update speed is limited and the VSYNC interface is enabled by setting DM[1:0] = “10” and RM = “0”.

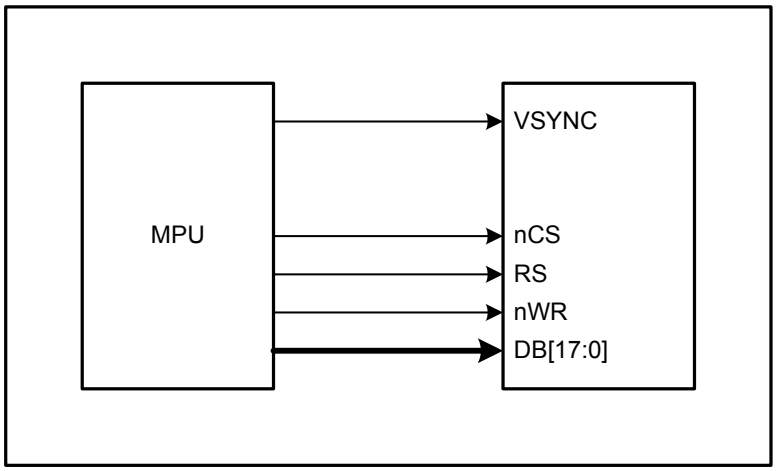


Figure10 Data transmission through VSYNC interface)

In the VSYNC mode, the display operation is synchronized with the internal clock and VSYNC input and the frame rate is determined by the pulse rate of VSYNC signal. All display data are stored in GRAM to minimize total data transfer required for moving picture display.

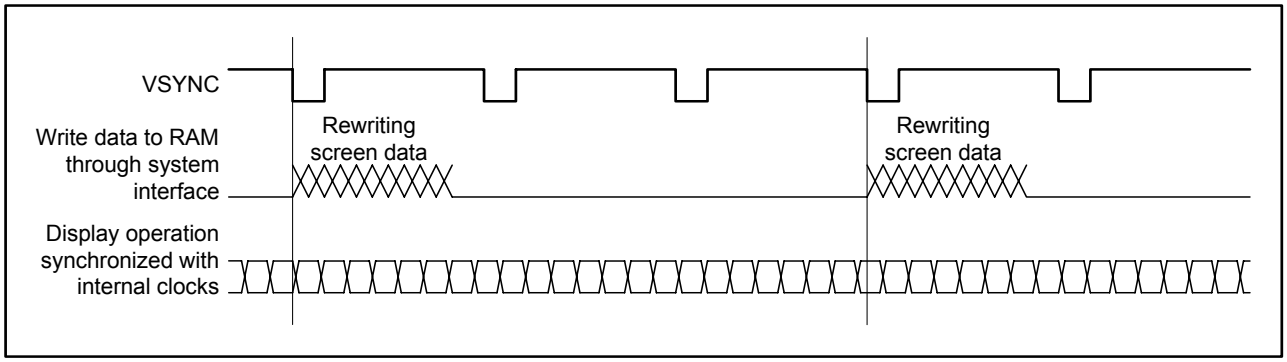


Figure11 Moving picture data transmission through VSYNC interface

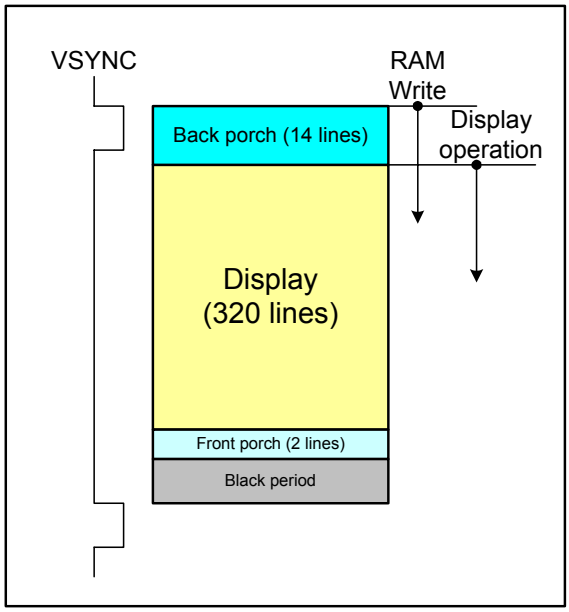


Figure12 Operation through VSYNC Interface

The VSYNC interface has the minimum speed limitation of writing data to the internal GRAM via the system interface, which are calculated from the following formula.

Internal clock frequency (fosc.) [Hz] = FrameFrequency x (DisplayLine (NL) + FrontPorch (FP) + BackPorch (BP)) x ClockCyclePerLines (RTN) x FrequencyFluctuation.

$$\textit{Minimum RAM write speed (HZ)} > \frac{\textit{320 x DisplayLines (NL)}}{\textit{[(BackPorch(BP)+DisplayLines(NL) - margins] x 16 (clocks) x 1/fosc}}$$

Note: When the RAM write operation does not start from the falling edge of VSYNC, the time from the falling edge of VSYNC until the start of RAM write operation must also be taken into account.

An example of minimum GRAM writing speed and internal clock frequency in VSYNC interface mode is as below.

[Example]

Display size: 240 RGB × 320 lines

Lines: 320 lines (NL = 1000111)

Back porch: 14 lines (BP = 1110)

Front porch: 2 lines (FP = 0010)

Frame frequency: 60 Hz

Frequency fluctuation: 10%

Internal oscillator clock (fosc.) [Hz] = 60 x [320+ 2 + 14] x 16 clocks x (1.1/0.9) ≒ 394KHz

When calculate the internal clock frequency, the oscillator variation is needed to be taken into consideration. In the above example, the calculated internal clock frequency with ±10% margin variation is considered and ensures to complete the display operation within one VSYNC cycle. The causes of frequency variation come from fabrication process of LSI, room temperature, external resistors and VCI voltage variation.

Minimum speed for RAM writing [Hz] > 240 x 320 x 394K / [(14 + 320 – 2)lines x 16clocks] ≒ 5.7 MHz

The above theoretical value is calculated based on the premise that the ILI9325 starts to write data into the internal GRAM on the falling edge of VSYNC. There must at least be a margin of 2 lines between the physical display line and the GRAM line address where data writing operation is performed. The GRAM write speed of 5.7MHz or more will guarantee the completion of GRAM write operation before the ILI9325 starts to display the GRAM data on the screen and enable to rewrite the entire screen without flicker.

Notes in using the VSYNC interface

1. The minimum GRAM write speed must be satisfied and the frequency variation must be taken into consideration.
2. The display frame rate is determined by the VSYNC signal and the period of VSYNC must be longer than the scan period of an entire display.
3. When switching from the internal clock operation mode (DM[1:0] = “00”) to the VSYNC interface mode or inversely, the switching starts from the next VSYNC cycle, i.e. after completing the display of the frame.
4. The partial display, vertical scroll, and interlaced scan functions are not available in VSYNC interface mode and set the AM bit to “0” to transfer display data.

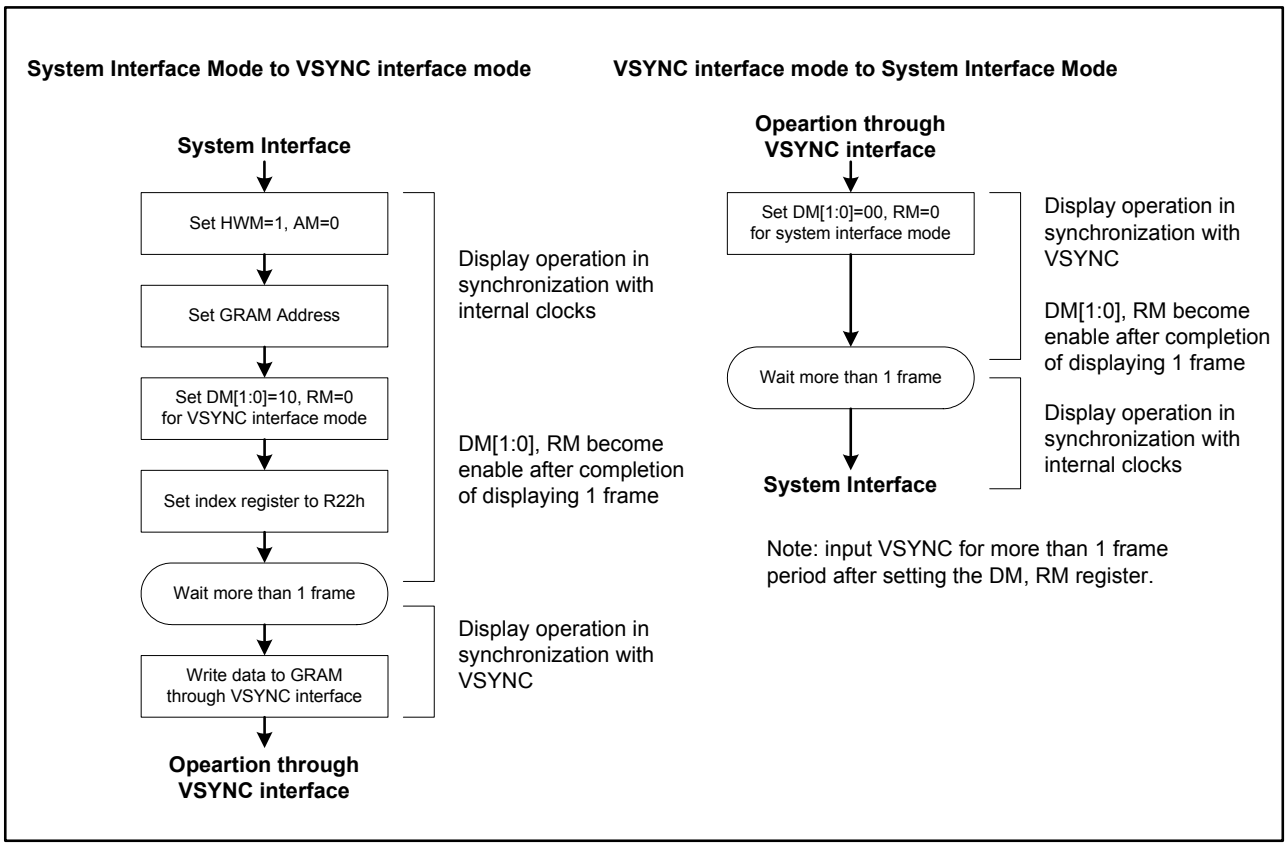


Figure13 Transition flow between VSYNC and internal clock operation modes

7.5. RGB Input Interface

The RGB Interface mode is available for ILI9325 and the interface is selected by setting the RIM[1:0] bits as following table.

RIM1	RIM0	RGB Interface	DB pins
0	0	18-bit RGB Interface	DB[17:0]
0	1	16-bit RGB Interface	DB[17:13], DB[11:1]
1	0	6-bit RGB Interface	DB[17:12]
1	1	Setting prohibited	

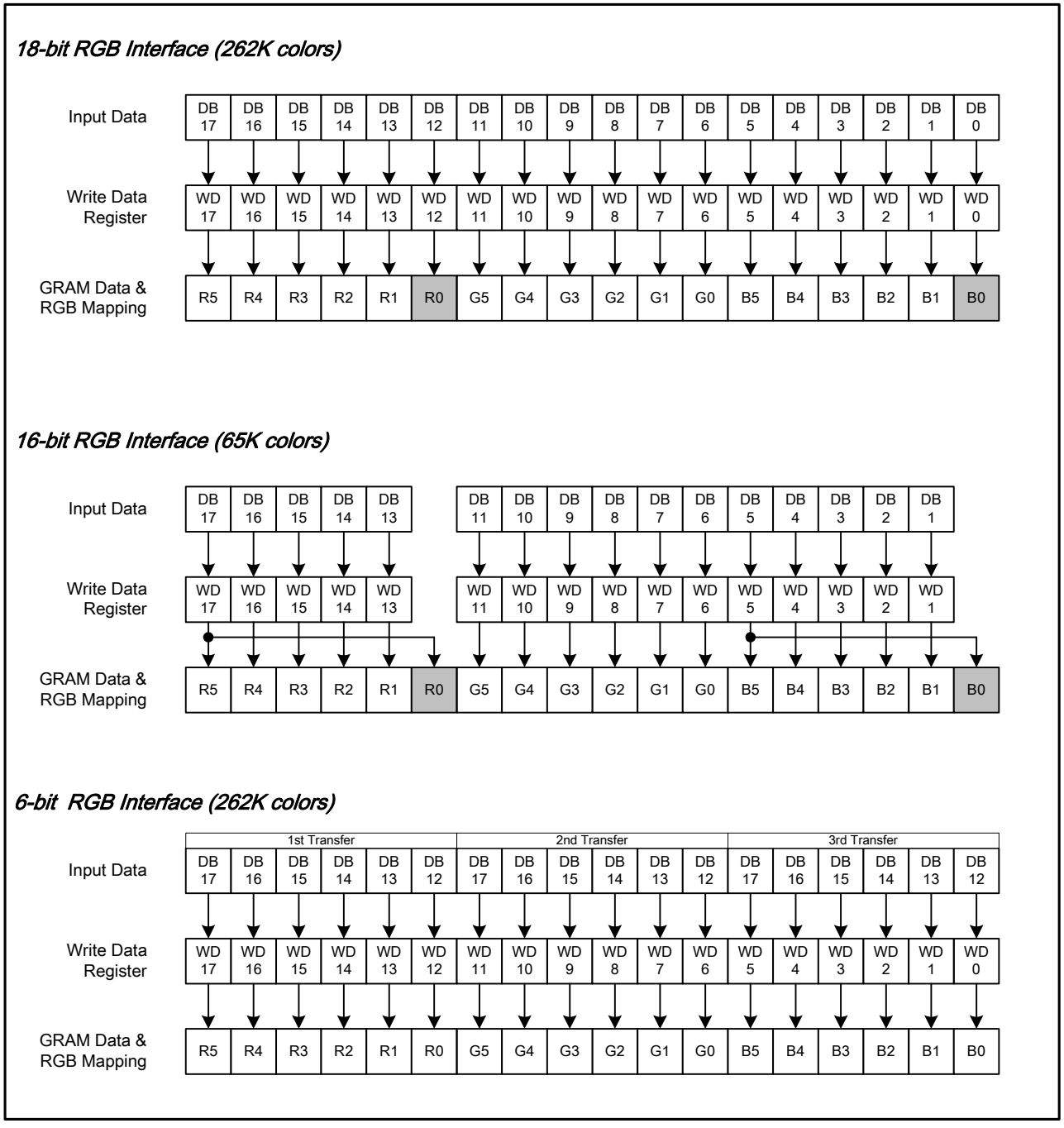


Figure14 RGB Interface Data Format

7.5.1. RGB Interface

The display operation via the RGB interface is synchronized with the VSYNC, HSYNC, and DOTCLK signals. The RGB interface transfers the updated data to GRAM with the high-speed write function and the update area is defined by the window address function. The back porch and front porch are used to set the RGB interface timing.

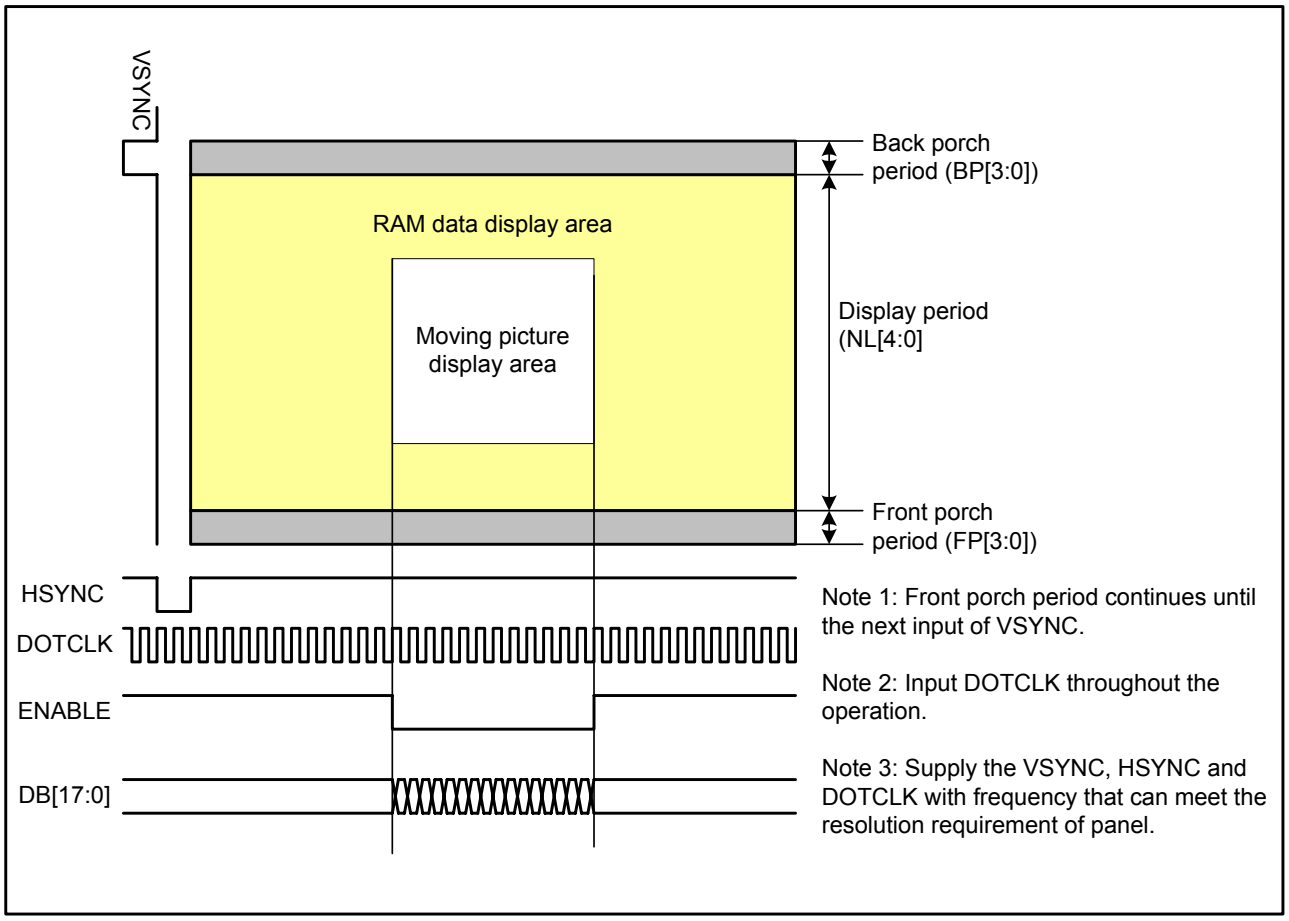


Figure15 GRAM Access Area by RGB Interface

7.5.2. RGB Interface Timing

The timing chart of 18-/16-bit RGB interface mode is shown as follows.

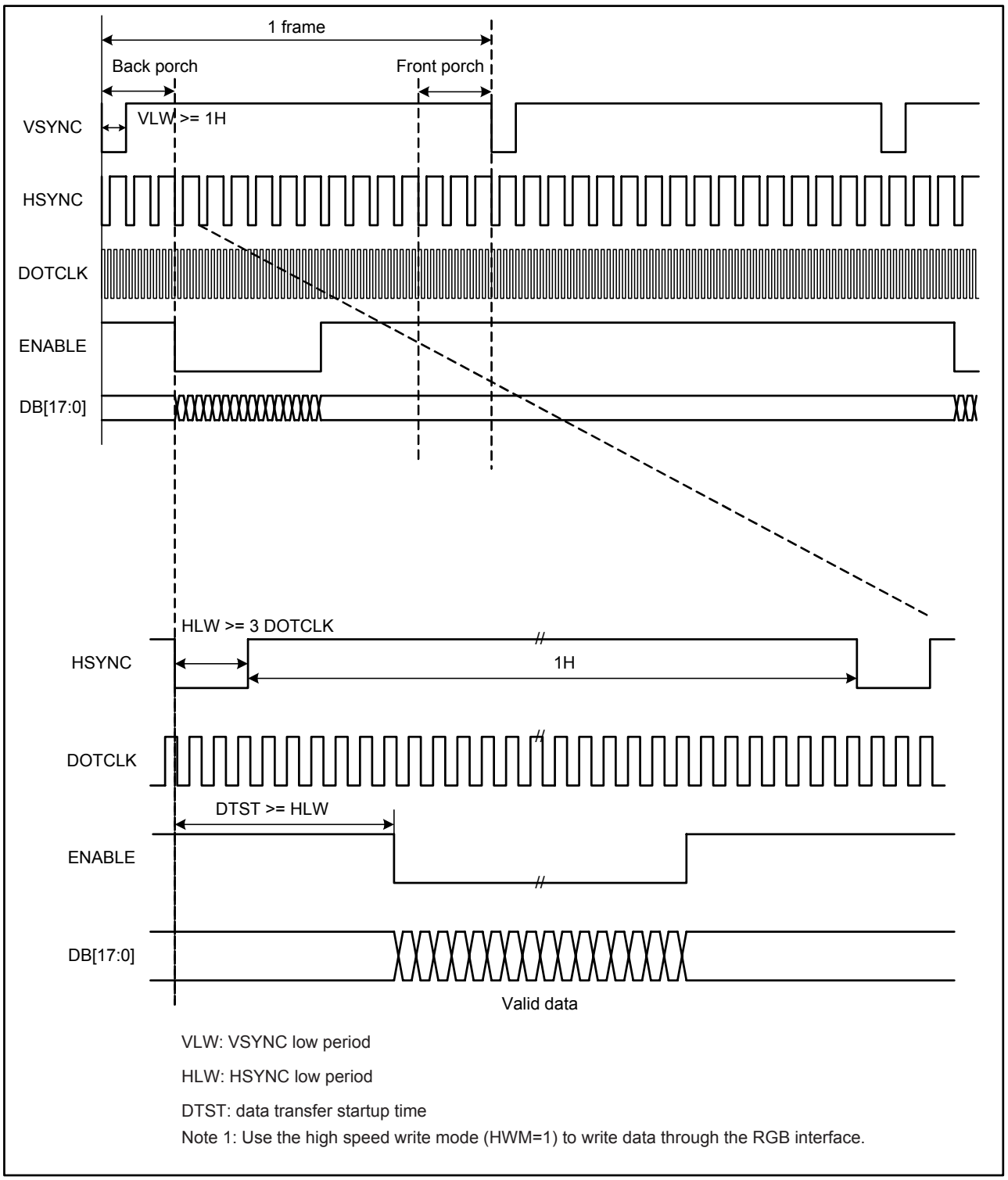
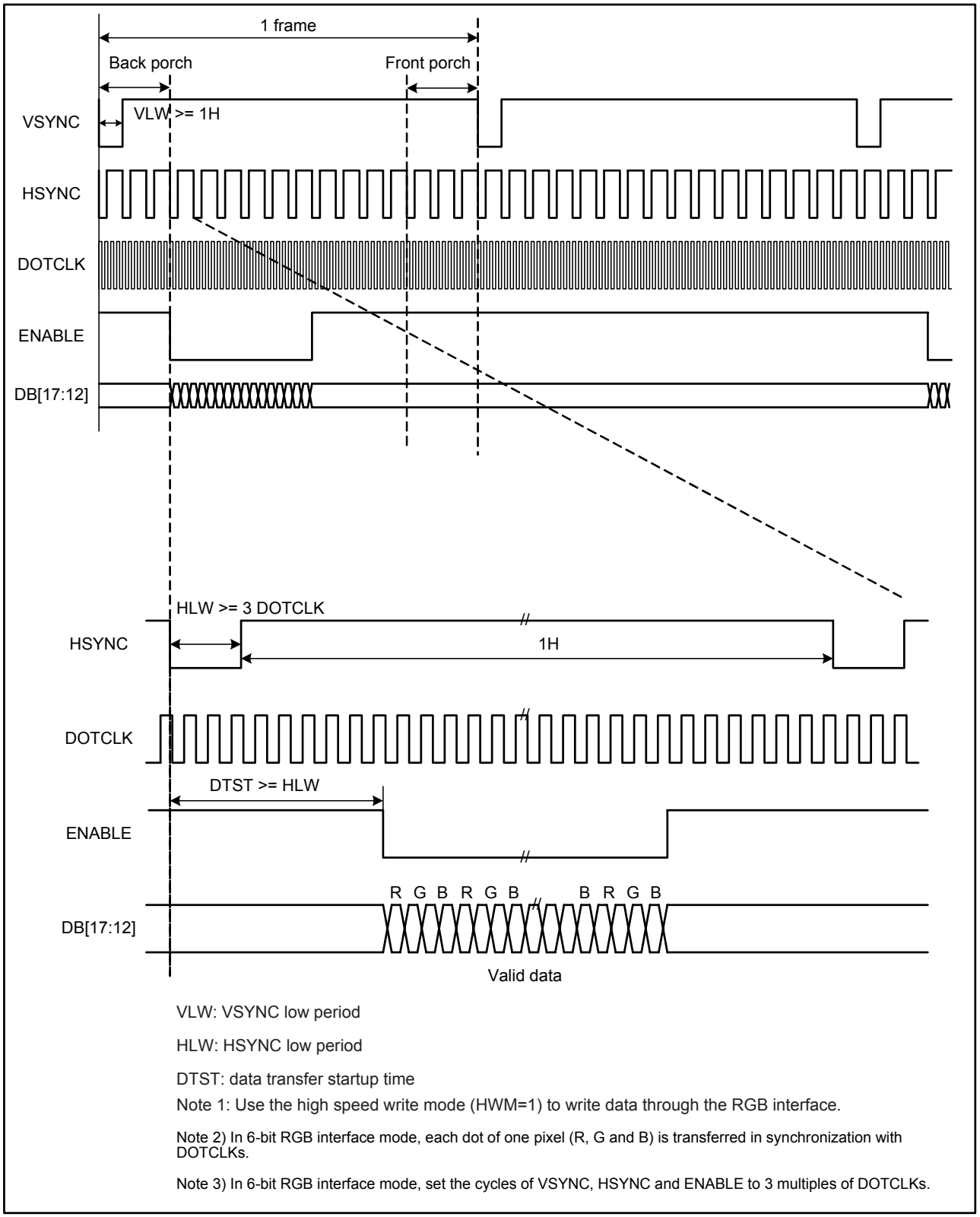


Figure16 Timing Chart of Signals in 18-/16-bit RGB Interface Mode

The timing chart of 6-bit RGB interface mode is shown as follows.



VLW: VSYNC low period

HLW: HSYNC low period

DTST: data transfer startup time

Note 1: Use the high speed write mode (HWM=1) to write data through the RGB interface.

Note 2) In 6-bit RGB interface mode, each dot of one pixel (R, G and B) is transferred in synchronization with DOTCLKs.

Note 3) In 6-bit RGB interface mode, set the cycles of VSYNC, HSYNC and ENABLE to 3 multiples of DOTCLKs.

Figure17 Timing chart of signals in 6-bit RGB interface mode

7.5.3. Moving Picture Mode

ILI9325 has the RGB interface to display moving picture and incorporates GRAM to store display data, which has following merits in displaying a moving picture.

- The window address function defined the update area of GRAM.
- Only the moving picture area of GRAM is updated.
- When display the moving picture in RGB interface mode, the DB[17:0] can be switched as system interface to update still picture area and registers, such as icons.

RAM access via a system interface in RGB-I/F mode

ILI9325 allows GRAM access via the system interface in RGB interface mode. In RGB interface mode, data are written to the internal GRAM in synchronization with DOTCLK and ENABLE signals. When write data to the internal GRAM by the system interface, set ENABLE to terminate the RGB interface and switch to the system interface to update the registers (RM = “0”) and the still picture of GRAM. When restart RAM access in RGB interface mode, wait one read/write cycle and then set RM = “1” and the index register to R22h to start accessing RAM via the RGB interface. If RAM accesses via two interfaces conflicts, there is no guarantee that data are written to the internal GRAM.

The following figure illustrates the operation of the ILI9325 when displaying a moving picture via the RGB interface and rewriting the still picture RAM area via the system interface.

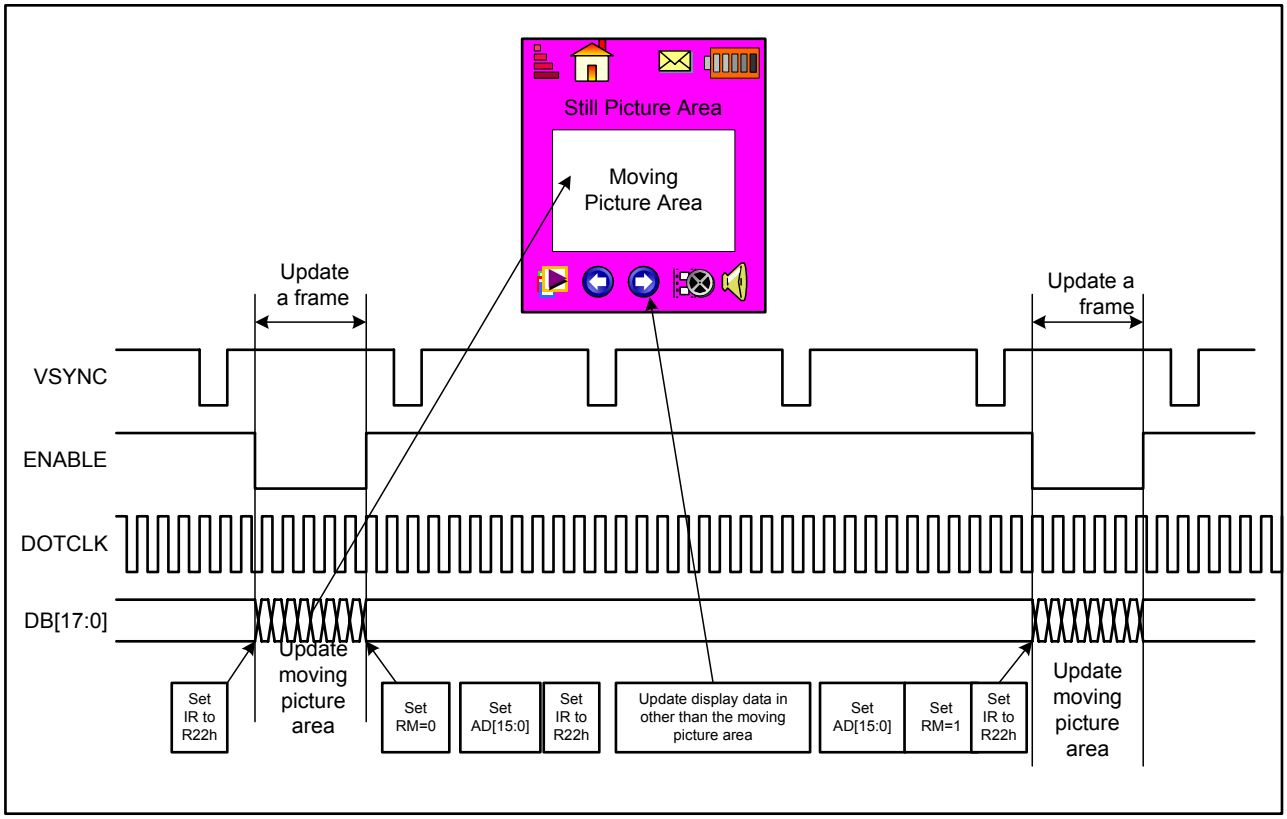


Figure18 Example of update the still and moving picture

7.5.4. 6-bit RGB Interface

The 6-bit RGB interface is selected by setting the RIM[1:0] bits to "10". The display operation is synchronized with VSYNC, HSYNC, and DOTCLK signals. Display data are transferred to the internal GRAM in synchronization with the display operation via 6-bit RGB data bus (DB[17:12]) according to the data enable signal (ENABLE). Unused pins (DB[11:0]) must be fixed at either IOVcc or DGND level. Registers can be set by the system interface (i80/SPI).

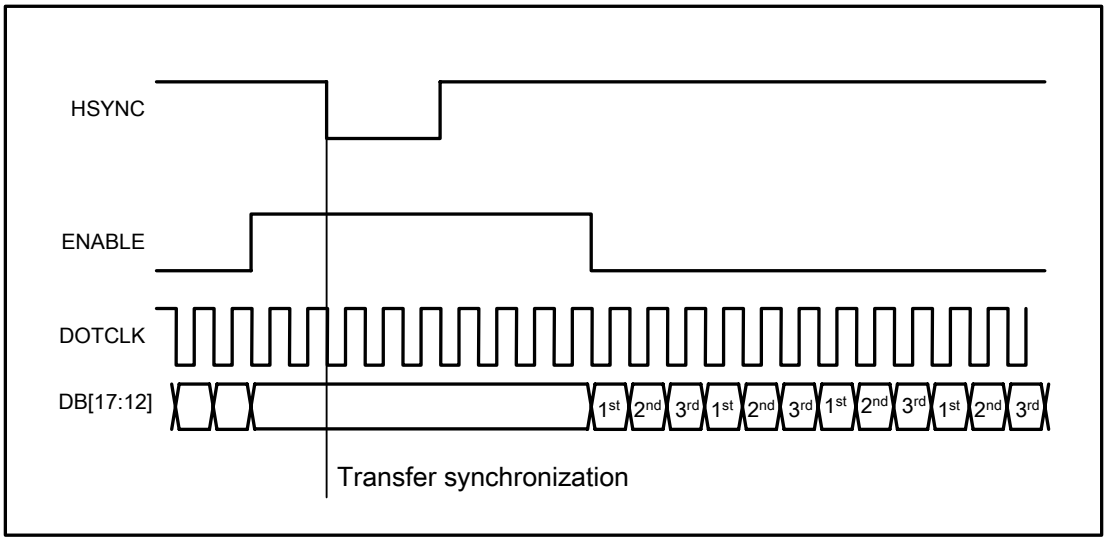
RGB interface with 6-bit data bus

	1st Transfer						2nd Transfer						3rd Transfer					
Input Data	DB 17	DB 16	DB 15	DB 14	DB 13	DB 12	DB 17	DB 16	DB 15	DB 14	DB 13	DB 12	DB 17	DB 16	DB 15	DB 14	DB 13	DB 12
RGB Assignment	R5	R4	R3	R2	R1	R0	G5	G4	G3	G2	G1	G0	B5	B4	B3	B2	B1	B0

Data transfer synchronization in 6-bit RGB interface mode

ILI9325 has data transfer counters to count the first, second, third data transfers in 6-bit RGB interface mode. The transfer counter is always reset to the state of first data transfer on the falling edge of VSYNC. If a mismatch arises in the number of each data transfer, the counter is reset to the state of first data transfer at the start of the frame (i.e. on the falling edge of VSYNC) to restart data transfer in the correct order from the next frame. This function is expedient for moving picture display, which requires consecutive data transfer in light of minimizing effects from failed data transfer and enabling the system to return to a normal state.

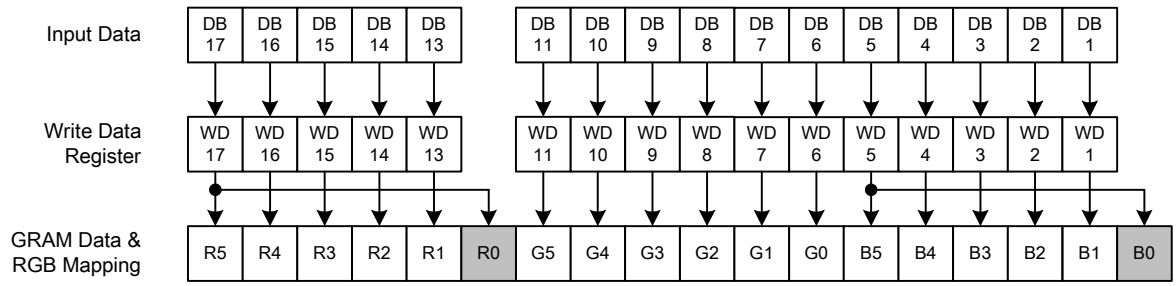
Note that internal display operation is performed in units of pixels (RGB: taking 3 inputs of DOTCLK). Accordingly, the number of DOTCLK inputs in one frame period must be a multiple of 3 to complete data transfer correctly. Otherwise it will affect the display of that frame as well as the next frame.



7.5.5. 16-bit RGB Interface

The 16-bit RGB interface is selected by setting the RIM[1:0] bits to “01”. The display operation is synchronized with VSYNC, HSYNC, and DOTCLK signals. Display data are transferred to the internal RAM in synchronization with the display operation via 16-bit RGB data bus (DB17-13, DB11-1) according to the data enable signal (ENABLE). Registers are set only via the system interface.

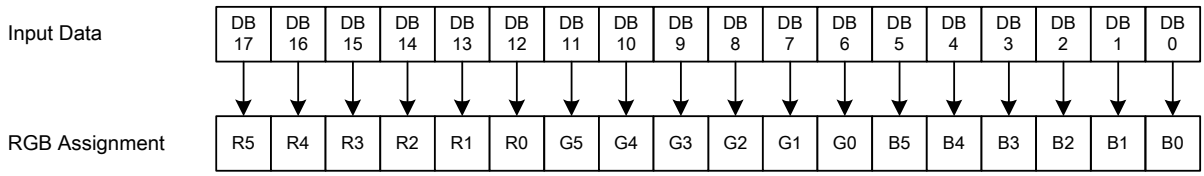
16-bit RGB Interface (65K colors)



7.5.6. 18-bit RGB Interface

The 18-bit RGB interface is selected by setting the RIM[1:0] bits to “00”. The display operation is synchronized with VSYNC, HSYNC, and DOTCLK signals. Display data are transferred to the internal RAM in synchronization with the display operation via 18-bit RGB data bus (DB[17:0]) according to the data enable signal (ENABLE). Registers are set only via the system interface.

RGB interface with 18-bit data bus



Notes in using the RGB Input Interface

1. The following are the functions not available in RGB Input Interface mode.

Function	RGB interface	I80 system interface
Partial display	Not available	Available
Scroll function	Not available	Available
Interlaced scan	Not available	Available
Graphics operation function	Not available	Available

2. VSYNC, HSYNC, and DOTCLK signals must be supplied throughout a display operation period.
3. The periods set with the NO[1:0] bits (gate output non-overlap period), STD[1:0] bits (source output delay period) and EQ[1:0] bits (equalization period) are not based on the internal clock but based on DOTCLK in

RGB interface mode.

4. In 6-bit RGB interface mode, each of RGB dots is transferred in synchronization with a DOTCLK input. In other words, it takes 3 DOTCLK inputs to transfer one pixel. Be sure to complete data transfer in units of 3 DOTCLK inputs in 6-bit RGB interface mode.
5. In 6-bit RGB interface mode, data of one pixel, which consists of RGB dots, are transferred in units of 3 DOTCLK. Accordingly, set the cycle of each signal in 6-bit interface mode (VSYNC, HSYNC, ENABLE, DB[17:0]) to contain DOTCLK inputs of a multiple of 3 to complete data transfer in units of pixels.
6. When switching from the internal operation mode to the RGB Input Interface mode, or the other way around, follow the sequence below.
7. In RGB interface mode, the front porch period continues until the next VSYNC input is detected after drawing one frame.
8. In RGB interface mode, a RAM address (AD[15:0]) is set in the address counter every frame on the falling edge of VSYNC.

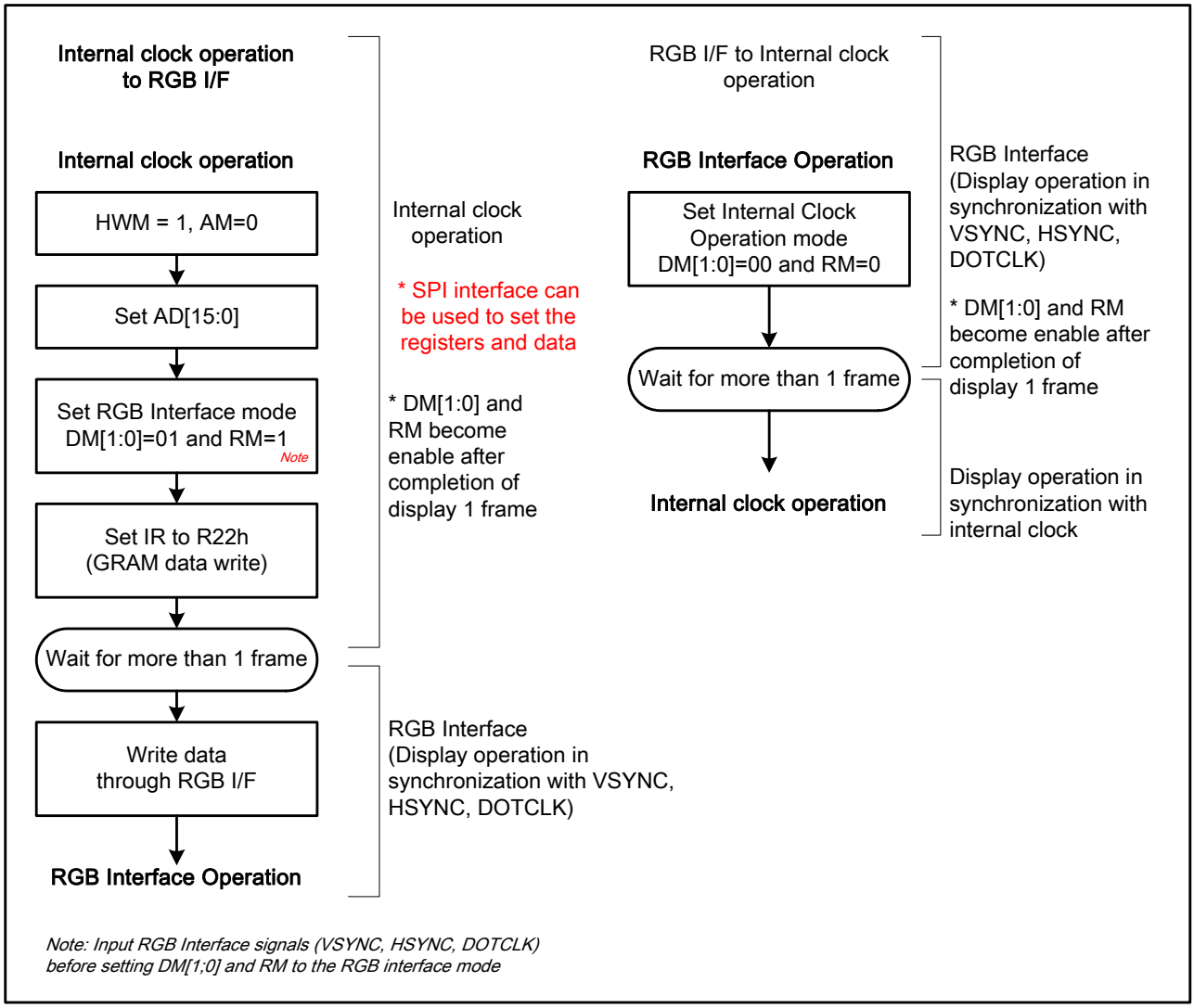


Figure19 Internal clock operation/RGB interface mode switching

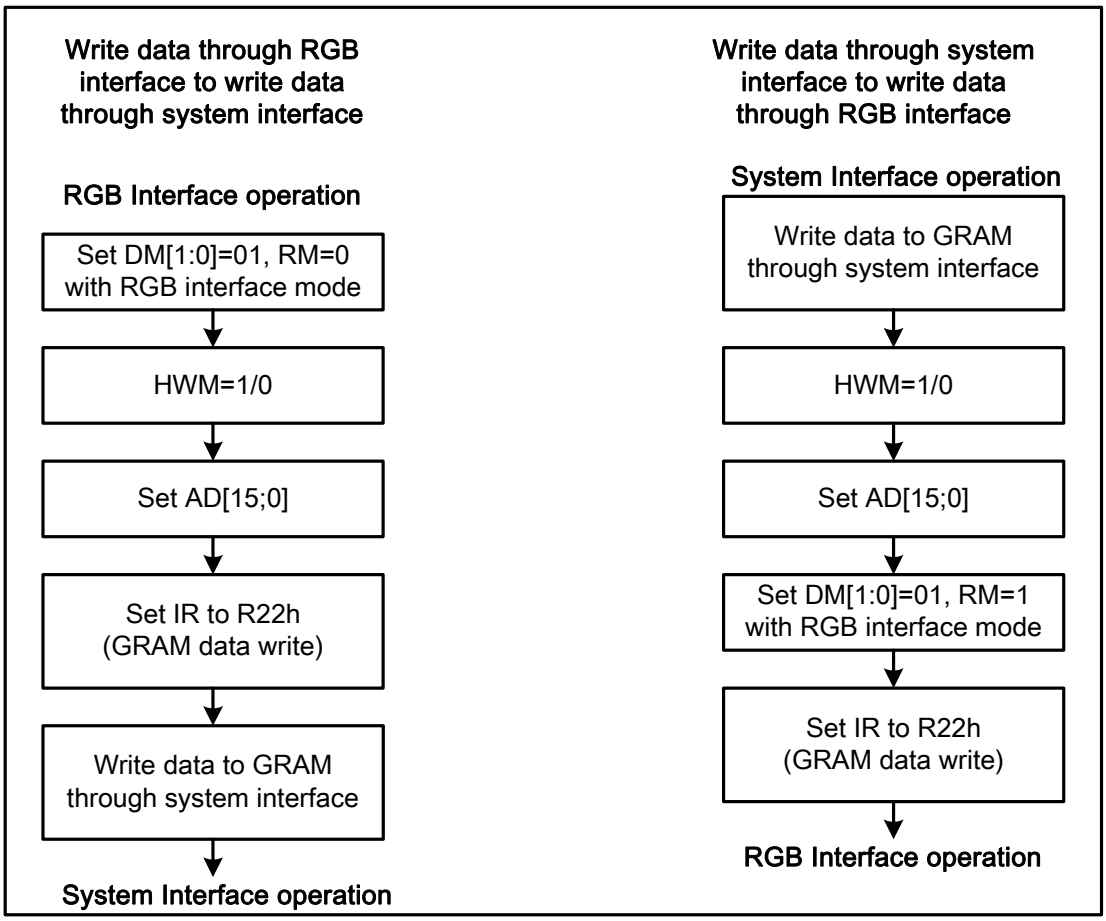


Figure20 GRAM access between system interface and RGB interface

7.6. Interface Timing

The following are diagrams of interfacing timing with LCD panel control signals in internal operation and RGB interface modes.

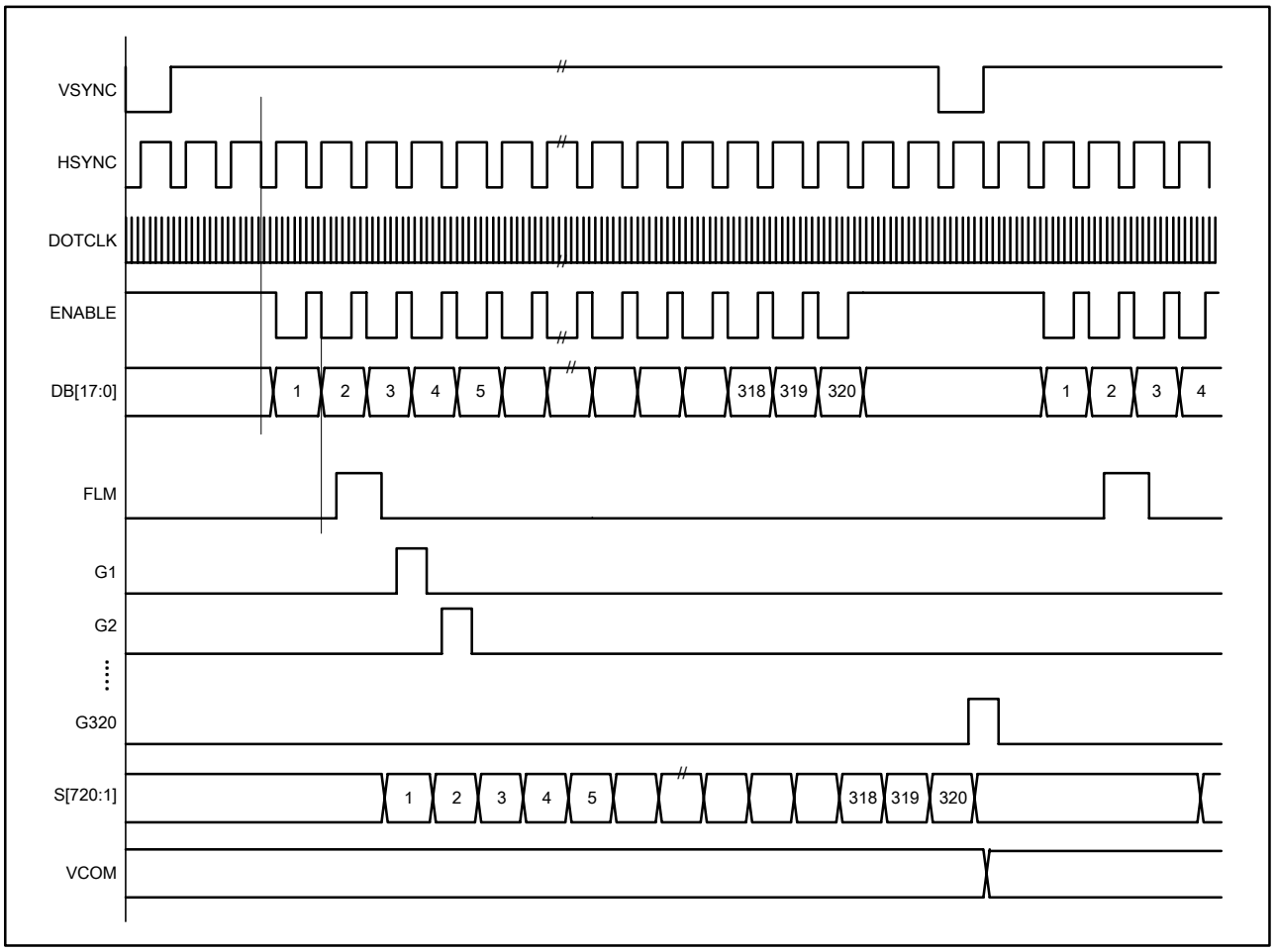


Figure21 Relationship between RGB I/F signals and LCD Driving Signals for Panel

8. Register Descriptions

8.1. Registers Access

ILI9325 adopts 18-bit bus interface architecture for high-performance microprocessor. All the functional blocks of ILI9325 starts to work after receiving the correct instruction from the external microprocessor by the 18-, 16-, 9-, 8-bit interface. The index register (IR) stores the register address to which the instructions and display data will be written. The register selection signal (RS), the read/write signals (nRD/nWR) and data bus D17-0 are used to read/write the instructions and data of ILI9325. The registers of the ILI9325 are categorized into the following groups.

1. Specify the index of register (IR)
2. Read a status
3. Display control
4. Power management Control
5. Graphics data processing
6. Set internal GRAM address (AC)
7. Transfer data to/from the internal GRAM (R22)
8. Internal grayscale γ-correction (R30 ~ R39)

Normally, the display data (GRAM) is most often updated, and in order since the ILI9325 can update internal GRAM address automatically as it writes data to the internal GRAM and minimize data transfer by using the window address function, there are fewer loads on the program in the microprocessor. As the following figure shows, the way of assigning data to the 16 register bits (D[15:0]) varies for each interface. Send registers in accordance with the following data transfer format.

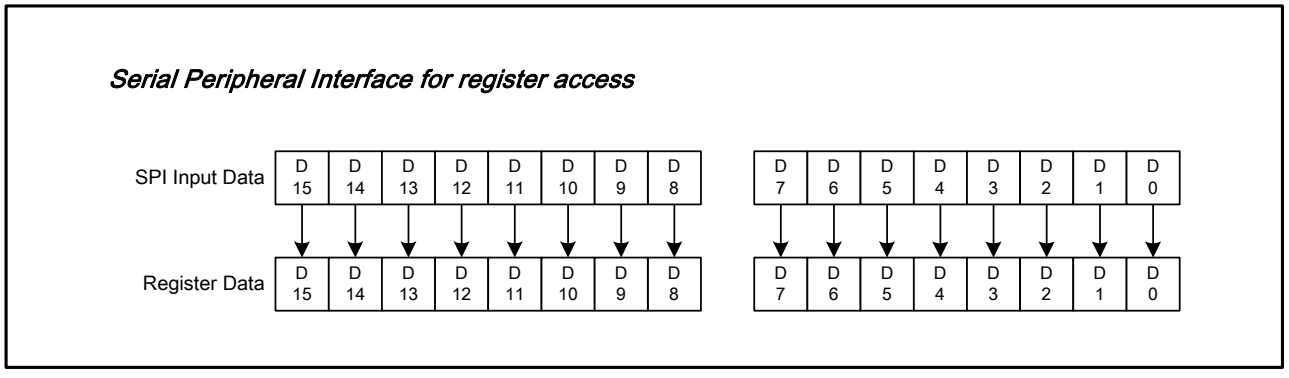
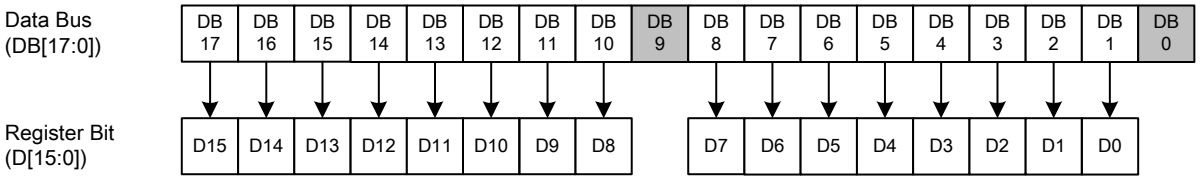
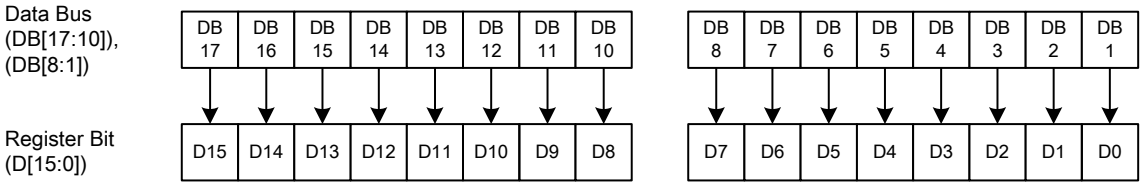


Figure22 Register Setting with Serial Peripheral Interface (SPI)

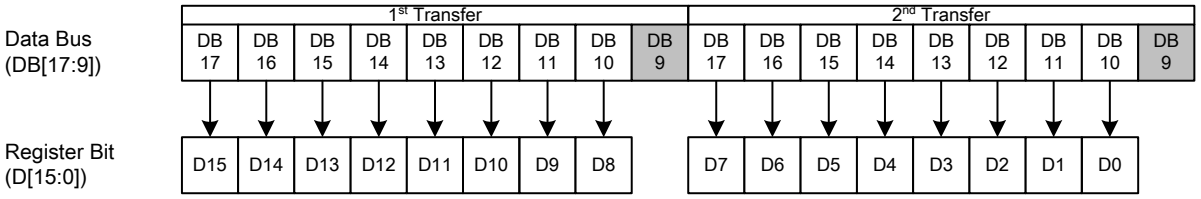
i80/M68 system 18-bit data bus interface



i80/M68 system 16-bit data bus interface



i80/M68 system 9-bit data bus interface



i80/M68 system 8-bit data bus interface/Serial peripheral interface (2/3 transmission)

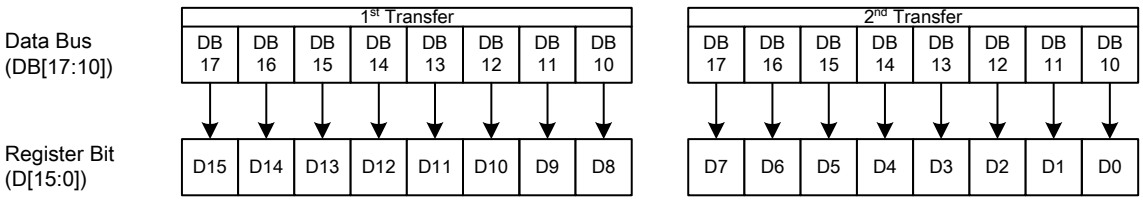


Figure23 Register setting with i80 System Interface

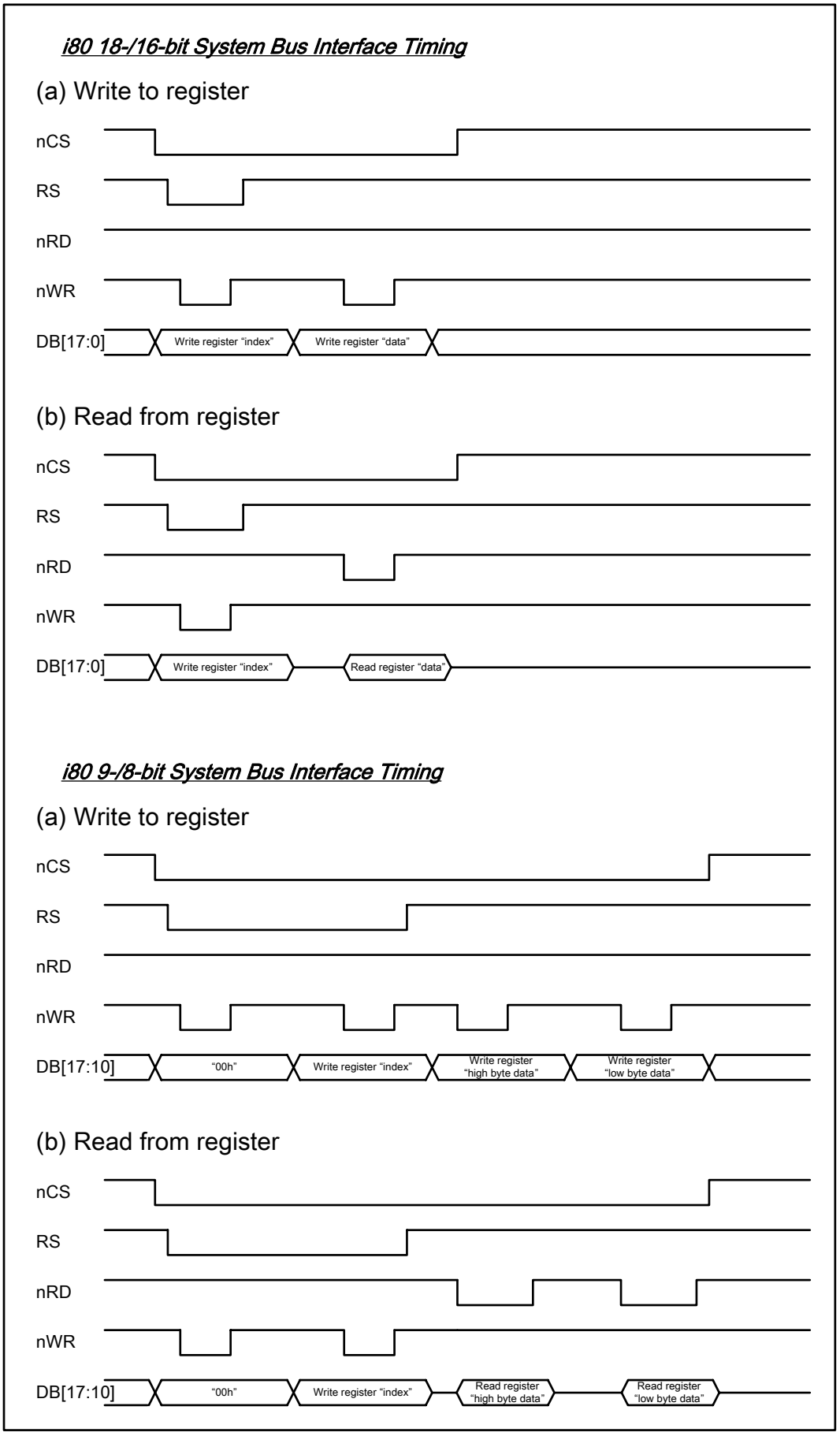


Figure 24 Register Read/Write Timing of i80 System Interface

8.2. Instruction Descriptions

No.	Registers Name	R/W	RS		D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
IR	Index Register	W	0		-	-	-	-	-	-	-	-	ID7	ID6	ID5	ID4	ID3	ID2	ID1	ID0
SR	Status Read	R	0		L7	L6	L5	L4	L3	L2	L1	L0	0	0	0	0	0	0	0	0
00h	Driver Code Read	R	1		1	0	0	1	0	0	1	0	0	0	1	0	0	0	1	0
01h	Driver Output Control 1	W	1		0	0	0	0	0	SM	0	SS	0	0	0	0	0	0	0	0
02h	LCD Driving Control	W	1		0	0	0	0	0	0	BC0	EOR	0	0	0	0	0	0	0	0
03h	Entry Mode	W	1		TRI	DFM	0	BGR	0	DACKE	HWM	0	0	0	I/D1	I/D0	AM	0	0	0
04h	Resize Control	W	1		0	0	0	0	0	0	RCV1	RCV0	0	0	RCH1	RCH0	0	0	RSZ1	RSZ0
07h	Display Control 1	W	1		0	0	PTDE1	PTDE0	0	0	0	BASEE	0	0	GON	DTE	CL	0	D1	D0
08h	Display Control 2	W	1		0	0	0	0	FP3	FP2	FP1	FP0	0	0	0	0	BP3	BP2	BP1	BP0
09h	Display Control 3	W	1		0	0	0	0	0	PTS2	PTS1	PTS0	0	0	PTG1	PTG0	ISC3	ISC2	ISC1	ISC0
0Ah	Display Control 4	W	1		0	0	0	0	0	0	0	0	0	0	0	0	FMARKOE	FMI2	FMI1	FMI0
0Ch	RGB Display Interface Control 1	W	1		0	ENC2	ENC1	ENC0	0	0	0	RM	0	0	DM1	DM0	0	0	RIM1	RIM0
0Dh	Frame Maker Position	W	1		0	0	0	0	0	0	0	FMP8	FMP7	FMP6	FMP5	FMP4	FMP3	FMP2	FMP1	FMP0
0Fh	RGB Display Interface Control 2	W	1		0	0	0	0	0	0	0	0	0	0	0	VSPL	HSPL	0	DPL	EPL
10h	Power Control 1	W	1		0	0	0	SAP	0	BT2	BT1	BT0	APE	AP2	AP1	AP0	0	DSTB	SLP	STB
11h	Power Control 2	W	1		0	0	0	0	0	DC12	DC11	DC10	0	DC02	DC01	DC00	0	VC2	VC1	VC0
12h	Power Control 3	W	1		0	0	0	0	0	0	0	0	VCIRE	0	0	PON	VRH3	VRH2	VRH1	VRH0
13h	Power Control 4	W	1		0	0	0	VDV4	VDV3	VDV2	VDV1	VDV0	0	0	0	0	0	0	0	0
20h	Horizontal GRAM Address Set	W	1		0	0	0	0	0	0	0	0	AD7	AD6	AD5	AD4	AD3	AD2	AD1	AD0
21h	Vertical GRAM Address Set	W	1		0	0	0	0	0	0	0	AD16	AD15	AD14	AD13	AD12	AD11	AD10	AD9	AD8
22h	Write Data to GRAM	W	1		RAM write data (WD17-0) / read data (RD17-0) bits are transferred via different data bus lines according to the selected interfaces.															
29h	Power Control 7	W	1		0	0	0	0	0	0	0	0	0	0	VCM5	VCM4	VCM3	VCM2	VCM1	VCM0
2Bh	Frame Rate and Color Control	W	1		0	0	0	0	0	0	0	0	0	0	0	0	FRS[3]	FRS[2]	FRS[1]	FRS[0]
30h	Gamma Control 1	W	1		0	0	0	0	0	KP1[2]	KP1[1]	KP1[0]	0	0	0	0	0	KP0[2]	KP0[1]	KP0[0]
31h	Gamma Control 2	W	1		0	0	0	0	0	KP3[2]	KP3[1]	KP3[0]	0	0	0	0	0	KP2[2]	KP2[1]	KP2[0]
32h	Gamma Control 3	W	1		0	0	0	0	0	KP5[2]	KP5[1]	KP5[0]	0	0	0	0	0	KP4[2]	KP4[1]	KP4[0]
35h	Gamma Control 4	W	1		0	0	0	0	0	RP1[2]	RP1[1]	RP1[0]	0	0	0	0	0	RP0[2]	RP0[1]	RP0[0]
36h	Gamma Control 5	W	1		0	0	0	VRP1[4]	VRP1[3]	VRP1[2]	VRP1[1]	VRP1[0]	0	0	0	0	VRP0[3]	VRP0[2]	VRP0[1]	VRP0[0]
37h	Gamma Control 6	W	1		0	0	0	0	0	KN1[2]	KN1[1]	KN1[0]	0	0	0	0	0	KN0[2]	KN0[1]	KN0[0]
38h	Gamma Control 7	W	1		0	0	0	0	0	KN3[2]	KN3[1]	KN3[0]	0	0	0	0	0	KN2[2]	KN2[1]	KN2[0]
39h	Gamma Control 8	W	1		0	0	0	0	0	KN5[2]	KN5[1]	KN5[0]	0	0	0	0	0	KN4[2]	KN4[1]	KN4[0]
3Ch	Gamma Control 9	W	1		0	0	0	0	0	RN1[2]	RN1[1]	RN1[0]	0	0	0	0	0	RN0[2]	RN0[1]	RN0[0]
3Dh	Gamma Control 10	W	1		0	0	0	VRN1[4]	VRN1[3]	VRN1[2]	VRN1[1]	VRN1[0]	0	0	0	0	VRN0[3]	VRN0[2]	VRN0[1]	VRN0[0]

No.	Registers Name	R/W	RS		D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
50h	Horizontal Address Start Position	W	1		0	0	0	0	0	0	0	0	HSA7	HSA6	HSA5	HSA4	HSA3	HSA2	HSA1	HSA0
51h	Horizontal Address End Position	W	1		0	0	0	0	0	0	0	0	HEA7	HEA6	HEA5	HEA4	HEA3	HEA2	HEA1	HEA0
52h	Vertical Address Start Position	W	1		0	0	0	0	0	0	0	VSA8	VSA7	VSA6	VSA5	VSA4	VSA3	VSA2	VSA1	VSA0
53h	Vertical Address End Position	W	1		0	0	0	0	0	0	0	VEA8	VEA7	VEA6	VEA5	VEA4	VEA3	VEA2	VEA1	VEA0
60h	Driver Output Control 2	W	1		GS	0	NL5	NL4	NL3	NL2	NL1	NL0	0	0	SCN5	SCN4	SCN3	SCN2	SCN1	SCN0
61h	Base Image Display Control	W	1		0	0	0	0	0	0	0	0	0	0	0	0	0	NDL	VLE	REV
6Ah	Vertical Scroll Control	W	1		0	0	0	0	0	0	0	VL8	VL7	VL6	VL5	VL4	VL3	VL2	VL1	VL0
80h	Partial Image 1 Display Position	W	1		0	0	0	0	0	0	0	PTDP08	PTDP07	PTDP06	PTDP05	PTDP04	PTDP03	PTDP02	PTDP01	PTDP00
81h	Partial Image 1 Area (Start Line)	W	1		0	0	0	0	0	0	0	PTSA08	PTSA07	PTSA06	PTSA05	PTSA04	PTSA03	PTSA02	PTSA01	PTSA00
82h	Partial Image 1 Area (End Line)	W	1		0	0	0	0	0	0	0	PTEA08	PTEA07	PTEA06	PTEA05	PTEA04	PTEA03	PTEA02	PTEA01	PTEA00
83h	Partial Image 2 Display Position	W	1		0	0	0	0	0	0	0	PTDP18	PTDP17	PTDP16	PTDP15	PTDP14	PTDP13	PTDP12	PTDP11	PTDP10
84h	Partial Image 2 Area (Start Line)	W	1		0	0	0	0	0	0	0	PTSA18	PTSA17	PTSA16	PTSA15	PTSA14	PTSA13	PTSA12	PTSA11	PTSA10
85h	Partial Image 2 Area (End Line)	W	1		0	0	0	0	0	0	0	PTEA18	PTEA17	PTEA16	PTEA15	PTEA14	PTEA13	PTEA12	PTEA11	PTEA10
90h	Panel Interface Control 1	W	1		0	0	0	0	0	0	DIVI1	DIVI00	0	0	0	0	RTNI3	RTNI2	RTNI1	RTNI0
92h	Panel Interface Control 2	W	1		0	0	0	0	0	NOWI2	NOWI1	NOWI0	0	0	0	0	0	0	0	0
95h	Panel Interface Control 4	W	1		0	0	0	0	0	0	DIVE1	DIVE0	0	0	RTNE5	RTNE4	RTNE3	RTNE2	RTNE1	RTNE0
A1h	OTP VCM Programming Control	W	1		0	0	0	0	OTP_ PGM_EN	0	0	0	0	0	VCM_ OTP5	VCM_ OTP4	VCM_ OTP3	VCM_ OTP2	VCM_ OTP1	VCM_ OTP0
A2h	OTP VCM Status and Enable	W	1		PGM_ CNT1	PGM_ CNT0	VCM_ D5	VCM_ D4	VCM_ D3	VCM_ D2	VCM_ D1	VCM_ D0	0	0	0	0	0	0	0	VCM_ EN
A5h	OTP Programming ID Key	W	1		KEY 15	KEY 14	KEY 13	KEY 12	KEY 11	KEY 10	KEY 9	KEY 8	KEY 7	KEY 6	KEY 5	KEY 4	KEY 3	KEY 2	KEY 1	KEY 0

8.2.1. Index (IR)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	0	-	-	-	-	-	-	-	-	ID7	ID6	ID5	ID4	ID3	ID2	ID1	ID0

The index register specifies the address of register (R00h ~ RFFh) or RAM which will be accessed.

8.2.2. Status Read (RS)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
R	0	L7	L6	L5	L4	L3	L2	L1	L0	0	0	0	0	0	0	0	0

The SR bits represent the internal status of the ILI9325.

L[7:0] Indicates the position of driving line which is driving the TFT panel currently.

8.2.3. Start Oscillation (R00h)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
R	1	1	0	0	1	0	0	1	1	0	0	1	0	0	1	0	1

The device code “9325”h is read out when read this register.

8.2.4. Driver Output Control (R01h)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	0	0	0	0	0	SM	0	SS	0	0	0	0	0	0	0	0

SS: Select the shift direction of outputs from the source driver.

When SS = 0, the shift direction of outputs is from S1 to S720

When SS = 1, the shift direction of outputs is from S720 to S1.

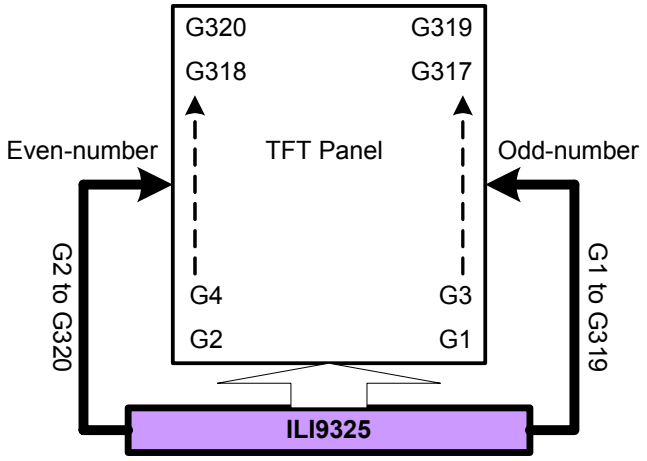
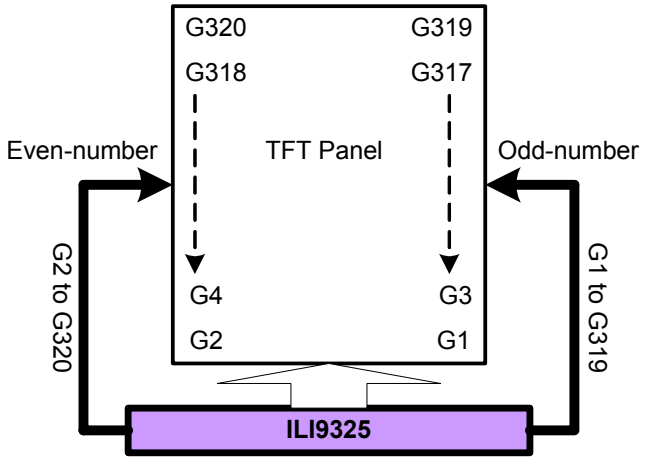
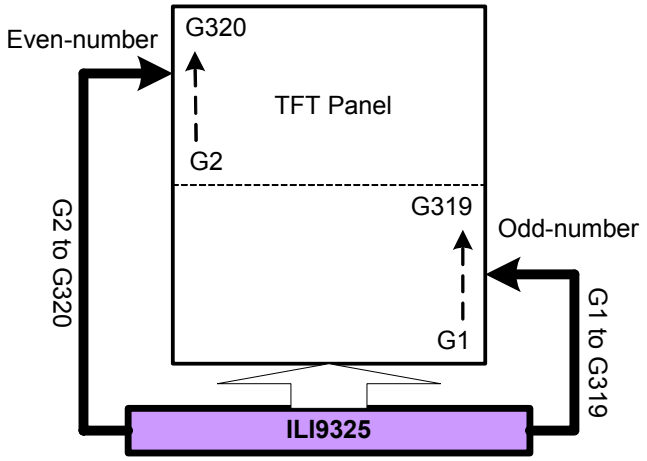
In addition to the shift direction, the settings for both SS and BGR bits are required to change the assignment of R, G, B dots to the source driver pins.

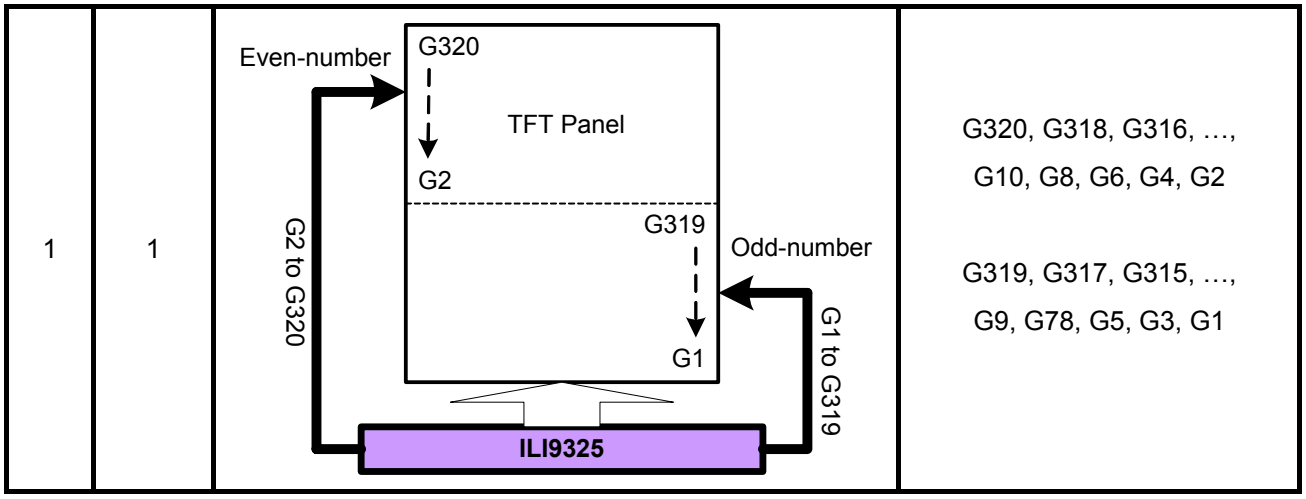
To assign R, G, B dots to the source driver pins from S1 to S720, set SS = 0.

To assign R, G, B dots to the source driver pins from S720 to S1, set SS = 1.

When changing SS or BGR bits, RAM data must be rewritten.

SM: Sets the gate driver pin arrangement in combination with the GS bit (R60h) to select the optimal scan mode for the module.

SM	GS	Scan Direction	Gate Output Sequence
0	0		G1, G2, G3, G4, …,G316 G317, G318, G319, G320
0	1		G320, G319, G318, …, G6, G5, G4, G3, G2, G1
1	0		G1, G3, G5, G7, …,G311 G313, G315, G317, G319 G2, G4, G6, G8, …,G312 G314, G316, G318, G320



8.2.5. LCD Driving Wave Control (R02h)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	0	0	0	0	0	1	B/C	EOR	0	0	0	0	0	0	0	0

.**B/C** 0 : Frame/Field inversion

1 : Line inversion

EOR: EOR = 1 and B/C=1 to set the line inversion.

8.2.6. Entry Mode (R03h)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	TRI	DFM	0	BGR	0	0	HWM	0	ORG	0	I/D1	I/D0	AM	0	0	0

AM Control the GRAM update direction.

When AM = “0”, the address is updated in horizontal writing direction.

When AM = “1”, the address is updated in vertical writing direction.

When a window area is set by registers R50h ~R53h, only the addressed GRAM area is updated based on I/D[1:0] and AM bits setting.

I/D[1:0] Control the address counter (AC) to automatically increase or decrease by 1 when update one pixel display data. Refer to the following figure for the details.

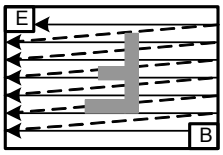
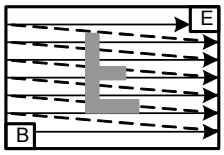
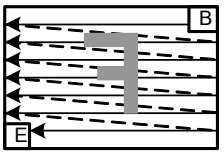
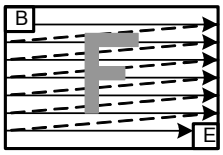
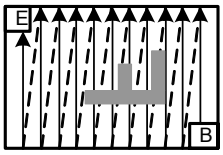
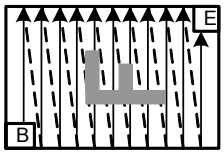
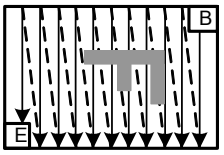
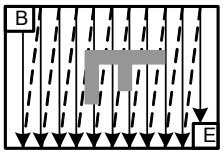
	I/D[1:0] = 00 Horizontal : decrement Vertical : decrement	I/D[1:0] = 01 Horizontal : increment Vertical : decrement	I/D[1:0] = 10 Horizontal : decrement Vertical : increment	I/D[1:0] = 11 Horizontal : increment Vertical : increment
AM = 0 Horizontal				
AM = 1 Vertical				

Figure25 GRAM Access Direction Setting

ORG Moves the origin address according to the ID setting when a window address area is made. This function is enabled when writing data with the window address area using high-speed RAM write.

ORG = “0”: The origin address is not moved. In this case, specify the address to start write operation according to the GRAM address map within the window address area.

ORG = “1”: The original address “00000h” moves according to the I/D[1:0] setting.

Notes: 1. When ORG=1, only the origin address address”00000h” can be set in the RAM address set registers R20h, and R21h.

2. In RAM read operation, make sure to set ORG=0.

BGR Swap the R and B order of written data.

BGR=”0”: Follow the RGB order to write the pixel data.

BGR=”1”: Swap the RGB data to BGR in writing into GRAM.

TRI When TRI = “1”, data are transferred to the internal RAM in 8-bit x 3 transfers mode via the 8-bit interface. It is also possible to send data via the 16-bit interface or SPI in the transfer mode that realizes display in 262k colors in combination with DFM bits. When not using these interface modes, be sure to set TRI = “0”.

DFM Set the mode of transferring data to the internal RAM when TRI = “1”. See the following figures for details.

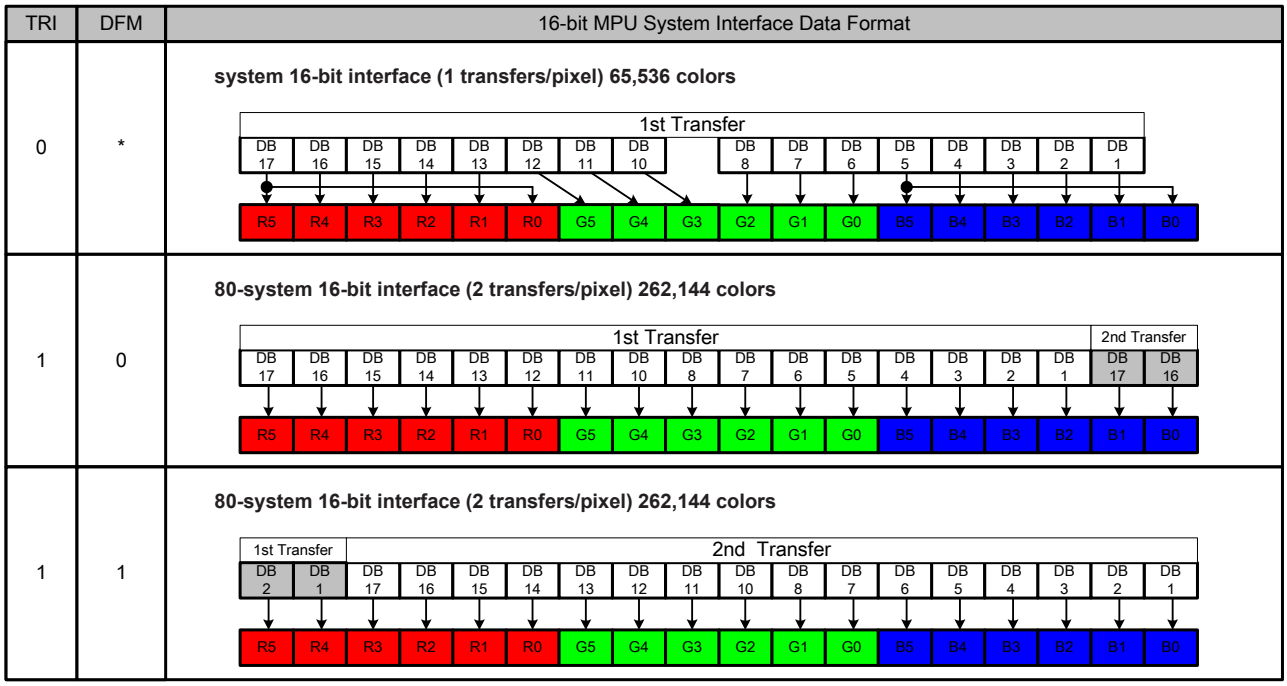


Figure26 16-bit MPU System Interface Data Format

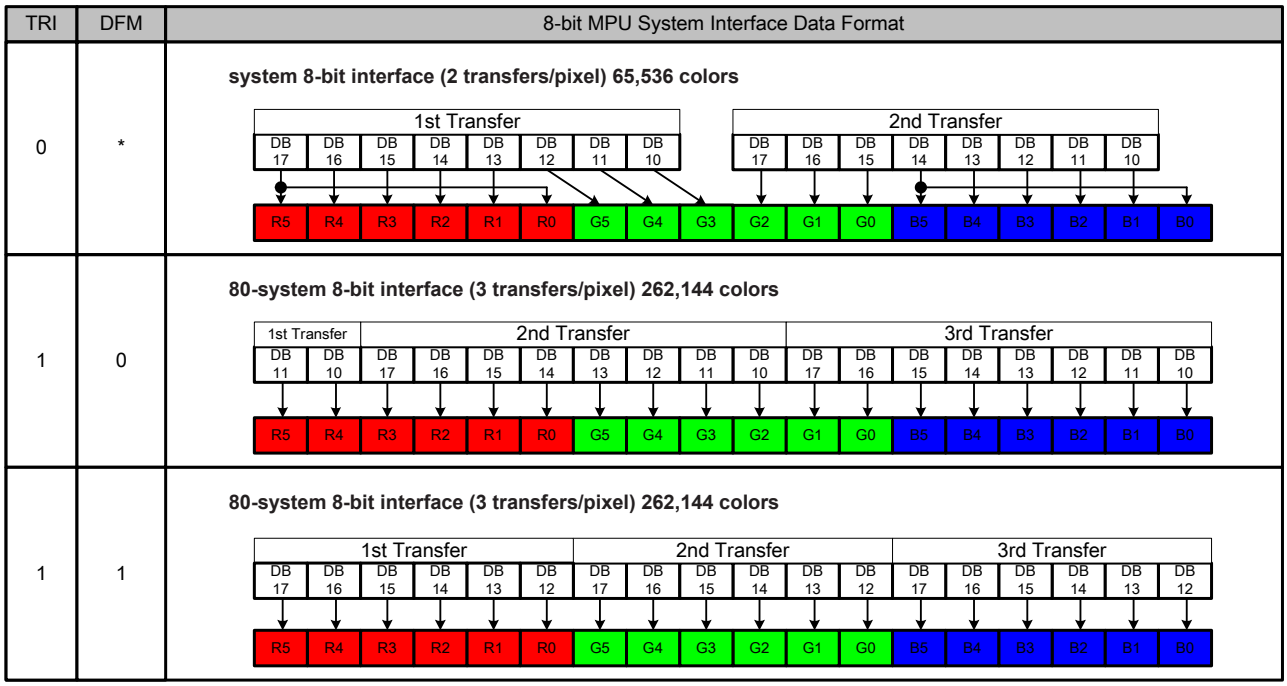


Figure27 8-bit MPU System Interface Data Format

8.2.7. Resizing Control Register (R04h)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	0	0	0	0	0	0	RCV1	RCV0	0	0	RCH1	RCH0	0	0	RSZ1	RSZ0

RSZ[1:0] Sets the resizing factor.

When the RSZ bits are set for resizing, the ILI9325 writes the data according to the resizing factor so that the original image is displayed in horizontal and vertical dimensions, which are contracted

according to the factor respectively. See “Resizing function”.

RCH[1:0] Sets the number of remainder pixels in horizontal direction when resizing a picture.

By specifying the number of remainder pixels by RCH bits, the data can be transferred without taking the reminder pixels into consideration. Make sure that RCH = 2’h0 when not using the resizing function (RSZ = 2’h0) or there are no remainder pixels.

RCV[1:0] Sets the number of remainder pixels in vertical direction when resizing a picture.

By specifying the number of remainder pixels by RCV bits, the data can be transferred without taking the reminder pixels into consideration. Make sure that RCV = 2’h0 when not using the resizing function (RSZ = 2’h0) or there are no remainder pixels.

RSZ[1:0]	Resizing factor
00	No resizing (x1)
01	x 1/2
10	Setting prohibited
11	x 1/4

RCH[1:0]	Number of remainder Pixels in Horizontal Direction
00	0 pixel*
01	1 pixel
10	2 pixel
11	3 pixel

RCV[1:0]	Number of remainder Pixels in Vertical Direction
00	0 pixel*
01	1 pixel
10	2 pixel
11	3 pixel

*1 pixel = 1RGB

8.2.8. Display Control 1 (R07h)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	0	0	PTDE1	PTDE0	0	0	0	BASEE	0	0	GON	DTE	CL	0	D1	D0

D[1:0] Set D[1:0]=”11” to turn on the display panel, and D[1:0]=”00” to turn off the display panel.

A graphics display is turned on the panel when writing D1 = “1”, and is turned off when writing D1 = “0”.

When writing D1 = “0”, the graphics display data is retained in the internal GRAM and the ILI9325 displays the data when writing D1 = “1”. When D1 = “0”, i.e. while no display is shown on the panel, all source outputs becomes the GND level to reduce charging/discharging current, which is generated within the LCD while driving liquid crystal with AC voltage.

When the display is turned off by setting D[1:0] = “01”, the ILI9325 continues internal display operation. When the display is turned off by setting D[1:0] = “00”, the ILI9325 internal display operation is halted completely. In combination with the GON, DTE setting, the D[1:0] setting controls display ON/OFF.

D1	D0	BASEE	Source, VCOM Output	ILI9325 internal operation
0	0	0	GND	Halt
0	1	1	GND	Operate
1	0	0	Non-lit display	Operate
1	1	0	Non-lit display	Operate
1	**1**	**1**	**Base image display**	**Operate**

Note: 1. data write operation from the microcontroller is performed irrespective of the setting of D[1:0] bits.

2. The D[1:0] setting is valid on both 1st and 2nd displays.

3. The non-lit display level from the source output pins is determined by instruction (PTS).

CL When CL = "1", the 8-color display mode is selected.

CL	Colors
0	262,144
1	8

GON and DTE Set the output level of gate driver G1 ~ G320 as follows

GON	DTE	G1 ~G320 Gate Output
0	0	VGH
0	1	VGH
1	0	VGL
1	**1**	**Normal Display**

BASEE

Base image display enable bit. When BASEE = "0", no base image is displayed. The ILI9325 drives liquid crystal at non-lit display level or displays only partial images. When BASEE = "1", the base image is displayed. The D[1:0] setting has higher priority over the BASEE setting.

PTDE[1:0]

Partial image 2 and Partial image 1 enable bits

PTDE1/0 = 0: turns off partial image. Only base image is displayed.

PTDE1/0 = 1: turns on partial image. Set the base image display enable bit to 0 (BASEE = 0).

8.2.9. Display Control 2 (R08h)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	0	0	0	0	FP3	FP2	FP1	FP0	0	0	0	0	BP3	BP2	BP1	BP0

FP[3:0]/BP[3:0]

The FP[3:0] and BP[3:0] bits specify the line number of front and back porch periods respectively.

When setting the FP[3:0] and BP[3:0] value, the following conditions shall be met:

BP + FP ≤ 16 lines

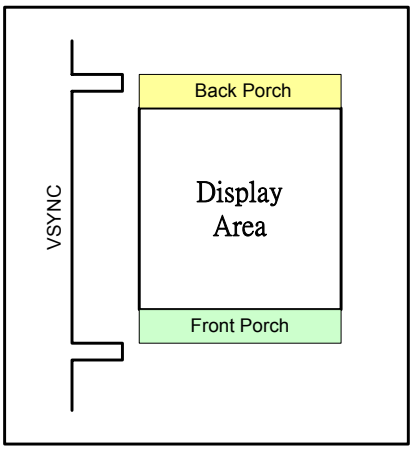
FP ≥ 2 lines

BP ≥ 2 lines

Set the BP[3:0] and FP[3:0] bits as below for each operation modes

Operation Mode	BP	FP	BP+FP
I80 System Interface Operation Mode	BP ≥ 2 lines	FP ≥ 2 lines	FP +BP ≤ 16 lines
RGB interface Operation	BP ≥ 2 lines	FP ≥ 2 lines	FP +BP ≤ 16 lines
VSYNC interface Operation	BP ≥ 2 lines	FP ≥ 2 lines	FP +BP = 16 lines

FP[3:0]	Number of lines for Front Porch
BP[3:0]	Number of lines for Back Porch
0000	Setting Prohibited
0001	Setting Prohibited
0010	2 lines
0011	3 lines
0100	4 lines
0101	5 lines
0110	6 lines
0111	7 lines
1000	8 lines
1001	9 lines
1010	10 lines
1011	11 lines
1100	12 lines
1101	13 lines
1110	14 lines
1111	Setting Prohibited



Note: The output timing to the LCD is delayed by 2 lines period from the input of synchronizing signal.

8.2.10. Display Control 3 (R09h)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	0	0	0	0	0	PTS2	PTS1	PTS0	0	0	PTG1	PTG0	ISC3	ISC2	ISC1	ISC0

ISC[3:0]: Specify the scan cycle interval of gate driver in non-display area when PTG[1:0]=”10” to select interval scan. Then scan cycle is set as odd number from 0~29 frame periods. The polarity is inverted every scan cycle.

ISC3	ISC3	ISC3	ISC3	Scan Cycle	f_{FLM}=60 Hz
0	0	0	0	0 frame	-
0	0	0	1	1 frame	17ms
0	0	1	0	3 frame	50ms
0	0	1	1	5 frame	84ms
0	1	0	0	7 frame	117ms
0	1	0	1	9 frame	150ms
0	1	1	0	11 frame	184ms
0	1	1	1	13 frame	217ms
1	0	0	0	15 frame	251ms
1	0	0	1	17 frame	284ms
1	0	1	0	19 frame	317ms
1	0	1	1	21 frame	351ms
1	1	0	0	23 frame	384ms
1	1	0	1	25 frame	418ms
1	1	1	0	27 frame	451ms
1	1	1	1	29 frame	484ms

PTG[1:0] Set the scan mode in non-display area.

PTG1	PTG0	Gate outputs in non-display area	Source outputs in non-display area	Vcom output
0	**0**	**Normal scan**	**Set with the PTS[2:0] bits**	**VcomH/VcomL**
0	1	Setting Prohibited	-	-
1	0	Interval scan	Set with the PTS[2:0] bits	VcomH/VcomL
1	1	Setting Prohibited	-	-

PTS[2:0]

Set the source output level in non-display area drive period (front/back porch period and blank area between partial displays).

When PTS[2] = 1, the operation of amplifiers which generates the grayscales other than V0 and V63 are halted and the step-up clock frequency becomes half the normal frequency in non-display drive period in order to reduce power consumption.

PTS[2:0]	Source output level		Grayscale amplifier in operation	Step-up clock frequency
	Positive polarity	Negative polarity		
000	V63	V0	V63 to V0	Register Setting (DC1, DC0)
001	Setting Prohibited	Setting Prohibited	-	-
010	GND	GND	V63 to V0	Register Setting (DC1, DC0)
011	Hi-Z	Hi-Z	V63 to V0	Register Setting (DC1, DC0)
100	V63	V0	V63 and V0	frequency setting by DC1, DC0
101	Setting Prohibited	Setting Prohibited	-	-
110	GND	GND	V63 and V0	frequency setting by DC1, DC0
111	Hi-Z	Hi-Z	V63 and V0	frequency setting by DC1, DC0

Notes: 1. The power efficiency can be improved by halting grayscale amplifiers and slowing down the step-up clock frequency only in non-display drive period.
2. The gate output level in non-lit display area drive period is determined by PTG[1:0].

8.2.11. Display Control 4 (R0Ah)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	0	0	0	0	0	0	0	0	0	0	0	0	FMARKOE	FMI2	FMI1	FMI0

FMI[2:0] Set the output interval of FMARK signal according to the display data rewrite cycle and data transfer rate.

FMARKOE When FMARKOE=1, ILI9325 starts to output FMARK signal in the output interval set by FMI[2:0] bits.

FMI[2:0]	Output Interval
000	1 frame
001	2 frame
011	4 frame
101	6 frame
Others	Setting disabled

8.2.12. RGB Display Interface Control 1 (R0Ch)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	0	ENC2	ENC1	ENC0	0	0	0	RM	0	0	DM1	DM0	0	0	RIM1	RIM0

RIM[1:0] Select the RGB interface data width.

RIM1	RIM0	RGB Interface Mode
0	0	18-bit RGB interface (1 transfer/pixel), DB[17:0]
0	1	16-bit RGB interface (1 transfer/pixel), DB[17:13] and DB[11:1]
1	0	6-bit RGB interface (3 transfers/pixel), DB[17:12]
1	1	Setting disabled

Note1: Registers are set only by the system interface.

Note2: Be sure that one pixel (3 dots) data transfer finished when interface switch.

DM[1:0] Select the display operation mode.

DM1	DM0	Display Interface
0	0	Internal system clock
0	1	RGB interface
1	0	VSYNC interface
1	1	Setting disabled

The DM[1:0] setting allows switching between internal clock operation mode and external display interface operation mode. However, switching between the RGB interface operation mode and the VSYNC interface operation mode is prohibited.

RM Select the interface to access the GRAM.

Set RM to "1" when writing display data by the RGB interface.

RM	Interface for RAM Access
0	System interface/VSYNC interface
1	RGB interface

Display State	Operation Mode	RAM Access (RM)	Display Operation Mode (DM[1:0]
Still pictures	Internal clock operation	System interface (RM = 0)	Internal clock operation (DM[1:0] = 00)
Moving pictures	RGB interface (1)	RGB interface (RM = 1)	RGB interface (DM[1:0] = 01)
Rewrite still picture area while Displaying moving pictures.	RGB interface	System interface (RM = 0)	RGB interface (DM[1:0] = 01)
Moving pictures	VSYNC interface	System interface (RM = 0)	VSYNC interface (DM[1:0] = 10)

Note 1: Registers are set only via the system interface or SPI interface.

Note 2: Refer to the flowcharts of "RGB Input Interface" section for the mode switch.

ENC[2:0] Set the GRAM write cycle through the RGB interface

ENC[2:0]	GRAM Write Cycle (Frame periods)
000	1 Frame
001	2 Frames
010	3 Frames
011	4 Frames

100	5 Frames
101	6 Frames
110	7 Frames
111	8 Frames

8.2.13. Frame Marker Position (R0Dh)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	0	0	0	0	0	0	0	FMP8	FMP7	FMP6	FMP5	FMP4	FMP3	FMP2	FMP1	FMP0

EMP[8:0] Sets the output position of frame cycle (frame marker).

When FMP[8:0]=0, a high-active pulse FMARK is output at the start of back porch period for one display line period (1H).

Make sure the 9'h000 ≦ FMP ≦ BP+NL+FP

FMP[8:0]	FMARK Output Position
9'h000	0th line
9'h001	1st line
9'h002	2nd line
9'h003	3rd line
.	.
.	.
.	.
9'h175	373rd line
9'h176	374th line
9'h177	375th line

8.2.14. RGB Display Interface Control 2 (R0Fh)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	0	0	0	0	0	0	0	0	0	0	0	VSPL	HSPL	0	EPL	DPL

DPL: Sets the signal polarity of the DOTCLK pin.

DPL = "0" The data is input on the rising edge of DOTCLK

DPL = "1" The data is input on the falling edge of DOTCLK

EPL: Sets the signal polarity of the ENABLE pin.

EPL = "0" The data DB17-0 is written when ENABLE = "0". Disable data write operation when ENABLE = "1".

EPL = "1" The data DB17-0 is written when ENABLE = "1". Disable data write operation when ENABLE = "0".

HSPL: Sets the signal polarity of the HSYNC pin.

HSPL = "0" Low active

HSPL = "1" High active

VSPL: Sets the signal polarity of the VSYNC pin.

VSPL = "0" Low active

VSPL = "1" High active

8.2.15. Power Control 1 (R10h)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	0	0	0	SAP	0	BT2	BT1	BT0	APE	AP2	AP1	AP0	0	DSTB	SLP	STB

SLP: When SLP = 1, ILI9325 enters the sleep mode and the display operation stops except the RC oscillator to reduce the power consumption. In the sleep mode, the GRAM data and instructions cannot be updated except the following two instructions.

a. Exit sleep mode (SLP = “0”)

b. Start oscillation

STB: When STB = 1, ILI9325 enters the standby mode and the display operation stops except the GRAM power supply to reduce the power consumption. In the sleep mode, the GRAM data and instructions cannot be updated except the following two instructions.

a. Exit standby mode (STB = “0”)

b. Start oscillation

DSTB: When DSTB = 1, the ILI9325 enters the deep standby mode. In deep standby mode, the internal logic power supply is turned off to reduce power consumption. The GRAM data and instruction setting are not maintained when the ILI9325 enters the deep standby mode, and they must be reset after exiting deep standby mode.

AP[2:0]: Adjusts the constant current in the operational amplifier circuit in the LCD power supply circuit. The larger constant current enhances the drivability of the LCD, but it also increases the current consumption. Adjust the constant current taking the trade-off into account between the display quality and the current consumption. In no-display period, set AP[2:0] = “000” to halt the operational amplifier circuits and the step-up circuits to reduce current consumption.

AP[2:0]	Gamma driver amplifiers	Source driver amplifiers
000	Halt	Halt
001	1.00	1.00
010	1.00	0.75
011	1.00	0.50
100	0.75	1.00
101	0.75	0.75
110	0.75	0.50
111	0.50	0.50

SAP: Source Driver output control

SAP=0, Source driver is disabled.

SAP=1, Source driver is enabled.

When starting the charge-pump of LCD in the Power ON stage, make sure that SAP=0, and set the SAP=1, after starting up the LCD power supply circuit.

APE: Power supply enable bit.

Set APE = “1” to start the generation of power supply according to the power supply startup sequence.

BT[3:0]: Sets the factor used in the step-up circuits.

Select the optimal step-up factor for the operating voltage. To reduce power consumption, set a smaller factor.

BT[2:0]	DDVDH	VCL	VGH	VGL
3’h0	Vci1 x 2	- Vci1	Vci1 x 6	- Vci1 x 5
3’h1	Vci1 x 2	- Vci1		- Vci1 x 4
3’h2				- Vci1 x 3
3’h3	Vci1 x 2	- Vci1	Vci1 x 5	- Vci1 x 5
3’h4				- Vci1 x 4
3’h5				- Vci1 x 3
3’h6	Vci1 x 2	- Vci1	Vci1 x 4	- Vci1 x 4
3’h7				- Vci1 x 3

Notes: 1. Connect capacitors to the capacitor connection pins when generating DDVDH, VGH, VGL and VCL levels.

2. Make sure DDVDH = 6.0V (max.), VGH = 15.0V (max.), VGL = – 12.5V (max) and VCL= -3.0V (max.)

8.2.16. Power Control 2 (R11h)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	0	0	0	0	0	DC12	DC11	DC10	0	DC02	DC01	DC00	0	VC2	VC1	VC0

VC[2:0] Sets the ratio factor of Vci to generate the reference voltages Vci1.

VC2	VC1	VC0	Vci1 voltage
0	0	0	0.95 x Vci
0	0	1	0.90 x Vci
0	1	0	0.85 x Vci
0	1	1	0.80 x Vci
1	0	0	0.75 x Vci
1	0	1	0.70 x Vci
1	1	0	Disabled
1	1	1	1.0 x Vci

DC0[2:0]: Selects the operating frequency of the step-up circuit 1. The higher step-up operating frequency enhances the drivability of the step-up circuit and the quality of display but increases the current consumption. Adjust the frequency taking the trade-off between the display quality and the current consumption into account.

DC1[2:0]: Selects the operating frequency of the step-up circuit 2. The higher step-up operating frequency enhances the drivability of the step-up circuit and the quality of display but increases the current consumption. Adjust the frequency taking the trade-off between the display quality and the current consumption into account.

DC02	DC01	DC00	Step-up circuit1 step-up frequency (f_{DCDC1})
0	0	0	Fosc

DC12	DC11	DC10	Step-up circuit2 step-up frequency (f_{DCDC2})
0	0	0	Fosc / 4

0	0	1	Fosc / 2	0	0	1	Fosc / 8
0	1	0	Fosc / 4	0	1	0	Fosc / 16
0	1	1	Fosc / 8	0	1	1	Fosc / 32
1	0	0	Fosc / 16	1	0	0	Fosc / 64
1	0	1	Fosc / 32	1	0	1	Fosc / 128
1	1	0	Fosc / 64	1	1	0	Fosc / 256
1	1	1	Halt step-up circuit 1	1	1	1	Halt step-up circuit 2

Note: Be sure $f_{DCDC1} \geq f_{DCDC2}$ when setting DC0[2:0] and DC1[2:0].

8.2.17. Power Control 3 (R12h)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	0	0	0	0	0	0	0	0	VCIRE	0	0	PON	VRH3	VRH2	VRH1	VRH0

VRH[3:0] Set the amplifying rate (1.6 ~ 1.9) of Vci applied to output the VREG1OUT level, which is a reference level for the VCOM level and the grayscale voltage level.

VCIRE: Select the external reference voltage Vci or internal reference voltage VCIR.

VCIRE=0	External reference voltage Vci (**default**)
VCIRE =1	Internal reference voltage 2.5V

VCIRE =0					VCIRE =1				
VRH3	VRH2	VRH1	VRH0	VREG1OUT	VRH3	VRH2	VRH1	VRH0	VREG1OUT
0	0	0	0	Halt	0	0	0	0	Halt
0	0	0	1	**Vci x 2.00**	0	0	0	1	**2.5V x 2.00 = 5.000V**
0	0	1	0	**Vci x 2.05**	0	0	1	0	**2.5V x 2.05 = 5.125V**
0	0	1	1	**Vci x 2.10**	0	0	1	1	**2.5V x 2.10 = 5.250V**
0	1	0	0	**Vci x 2.20**	0	1	0	0	**2.5V x 2.20 = 5.500V**
0	1	0	1	**Vci x 2.30**	0	1	0	1	**2.5V x 2.30 = 5.750V**
0	1	1	0	**Vci x 2.40**	0	1	1	0	**2.5V x 2.40 = 6.000V**
0	1	1	1	**Vci x 2.40**	0	1	1	1	**2.5V x 2.40 = 6.000V**
1	0	0	0	Vci x 1.60	1	0	0	0	2.5V x 1.60 = 4.000V
1	0	0	1	Vci x 1.65	1	0	0	1	2.5V x 1.65 = 4.125V
1	0	1	0	Vci x 1.70	1	0	1	0	2.5V x 1.70 = 4.250V
1	0	1	1	Vci x 1.75	1	0	1	1	2.5V x 1.75 = 4.375V
1	1	0	0	Vci x 1.80	1	1	0	0	2.5V x 1.80 = 4.500V
1	1	0	1	Vci x 1.85	1	1	0	1	2.5V x 1.85 = 4.625V
1	1	1	0	Vci x 1.90	1	1	1	0	2.5V x 1.90 = 4.750V
1	1	1	1	Vci x 1.95	1	1	1	1	2.5V x 1.95 = 4.875V

When VCI<2.5V, Internal reference voltage will be same as VCI.

Make sure that VC and VRH setting restriction: VREG1OUT ≦ (DDVDH - 0.5)V.

PON: Control ON/OFF of circuit3 (VGL) output.

PON=0	VGL output is disable
PON=1	VGL output is enable

8.2.18. Power Control 4 (R13h)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	0	0	0	VDV4	VDV3	VDV2	VDV1	VDV0	0	0	0	0	0	0	0	0

VDV[4:0] Select the factor of VREG1OUT to set the amplitude of Vcom alternating voltage from 0.70 to 1.24 x VREG1OUT .

VDV4	VDV3	VDV2	VDV1	VDV0	VCOM amplitude
0	0	0	0	0	VREG1OUT x 0.70
0	0	0	0	1	VREG1OUT x 0.72
0	0	0	1	0	VREG1OUT x 0.74
0	0	0	1	1	VREG1OUT x 0.76
0	0	1	0	0	VREG1OUT x 0.78
0	0	1	0	1	VREG1OUT x 0.80
0	0	1	1	0	VREG1OUT x 0.82
0	0	1	1	1	VREG1OUT x 0.84
0	1	0	0	0	VREG1OUT x 0.86
0	1	0	0	1	VREG1OUT x 0.88
0	1	0	1	0	VREG1OUT x 0.90
0	1	0	1	1	VREG1OUT x 0.92
0	1	1	0	0	VREG1OUT x 0.94
0	1	1	0	1	VREG1OUT x 0.96
0	1	1	1	0	VREG1OUT x 0.98
0	1	1	1	1	VREG1OUT x 1.00

VDV4	VDV3	VDV2	VDV1	VDV0	VCOM amplitude
1	0	0	0	0	VREG1OUT x 0.94
1	0	0	0	1	VREG1OUT x 0.96
1	0	0	1	0	VREG1OUT x 0.98
1	0	0	1	1	VREG1OUT x 1.00
1	0	1	0	0	VREG1OUT x 1.02
1	0	1	0	1	VREG1OUT x 1.04
1	0	1	1	0	VREG1OUT x 1.06
1	0	1	1	1	VREG1OUT x 1.08
1	1	0	0	0	VREG1OUT x 1.10
1	1	0	0	1	VREG1OUT x 1.12
1	1	0	1	0	VREG1OUT x 1.14
1	1	0	1	1	VREG1OUT x 1.16
1	1	1	0	0	VREG1OUT x 1.18
1	1	1	0	1	VREG1OUT x 1.20
1	1	1	1	0	VREG1OUT x 1.22
1	1	1	1	1	VREG1OUT x 1.24

Set VDV[4:0] to let Vcom amplitude less than 6V.

8.2.19. GRAM Horizontal/Vertical Address Set (R20h, R21h)

R/W	RS		D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1		0	0	0	0	0	0	0	0	AD7	AD6	AD5	AD4	AD3	AD2	AD1	AD0
W	1		0	0	0	0	0	0	0	AD16	AD15	AD14	AD13	AD12	AD11	AD10	AD9	AD8

AD[16:0] Set the initial value of address counter (AC).

The address counter (AC) is automatically updated in accordance to the setting of the AM, I/D bits as data is written to the internal GRAM. The address counter is not automatically updated when read data from the internal GRAM.

AD[16:0]	GRAM Data Map
17'h00000 ~ 17'h000EF	1st line GRAM Data
17'h00100 ~ 17'h001EF	2nd line GRAM Data
17'h00200 ~ 17'h002EF	3rd line GRAM Data
17'h00300 ~ 17'h003EF	4th line GRAM Data
17'h13D00 ~ 17' h13DEF	318th line GRAM Data
17'h13E00 ~ 17' h13EEF	319th line GRAM Data
17'h13F00 ~ 17'h13FEF	320th line GRAM Data

Note1: When the RGB interface is selected (RM = "1"), the address AD[16:0] is set to the address counter every frame on the falling edge of VSYNC.

Note2: When the internal clock operation or the VSYNC interface mode is selected (RM = "0"), the address AD[16:0] is set to address counter when update register R21.

8.2.20. Write Data to GRAM (R22h)

R/W	RS	D17	D16	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	RAM write data (WD[17:0], the DB[17:0] pin assignment differs for each interface.																	

This register is the GRAM access port. When update the display data through this register, the address

counter (AC) is increased/decreased automatically.

8.2.21. Read Data from GRAM (R22h)

R/W	RS	D17	D16	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
R	1	RAM Read Data (RD[17:0], the DB[17:0] pin assignment differs for each interface.																	

RD[17:0] Read 18-bit data from GRAM through the read data register (RDR).

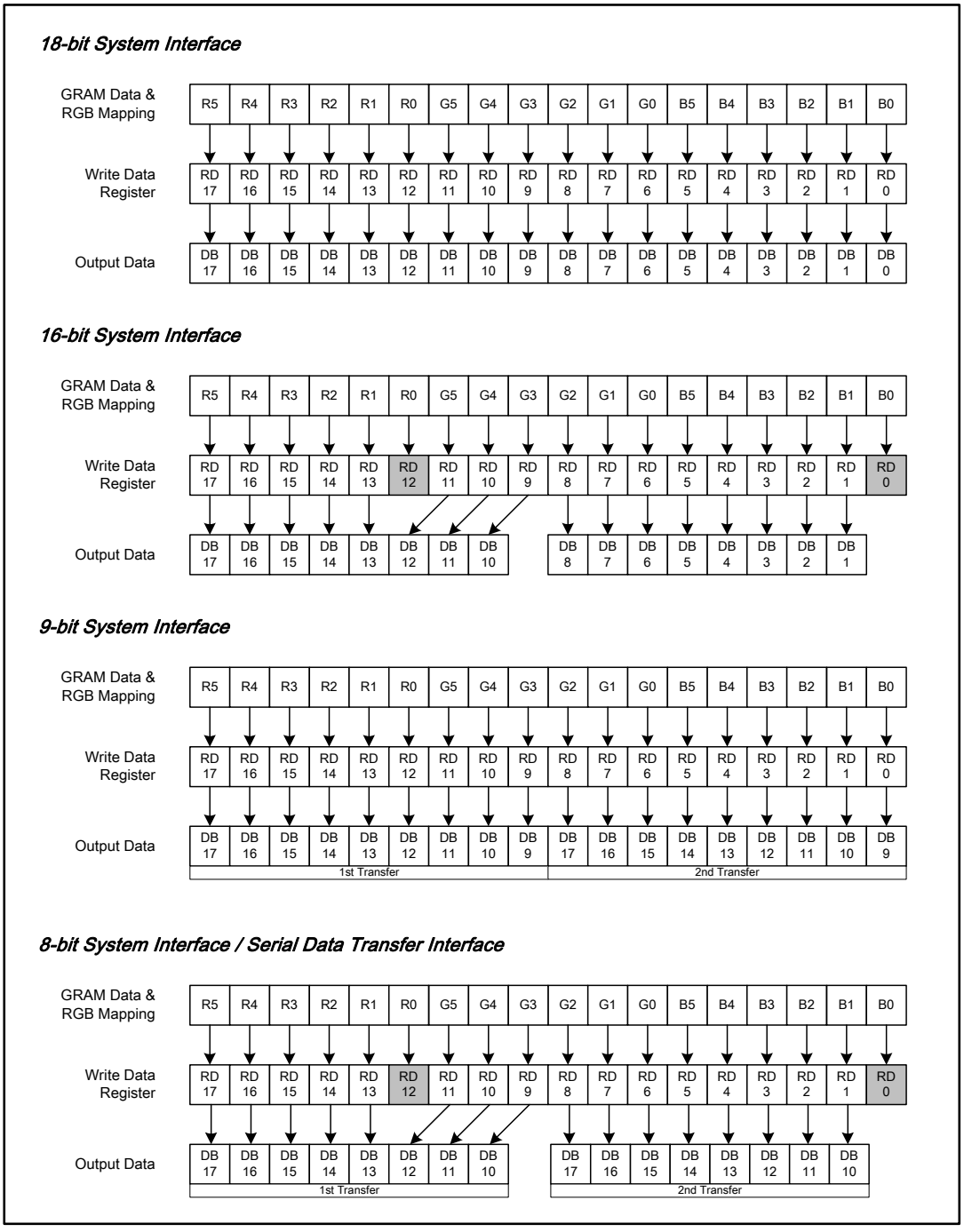


Figure 28 Data Read from GRAM through Read Data Register in 18-/16-/9-/8-bit Interface Mode

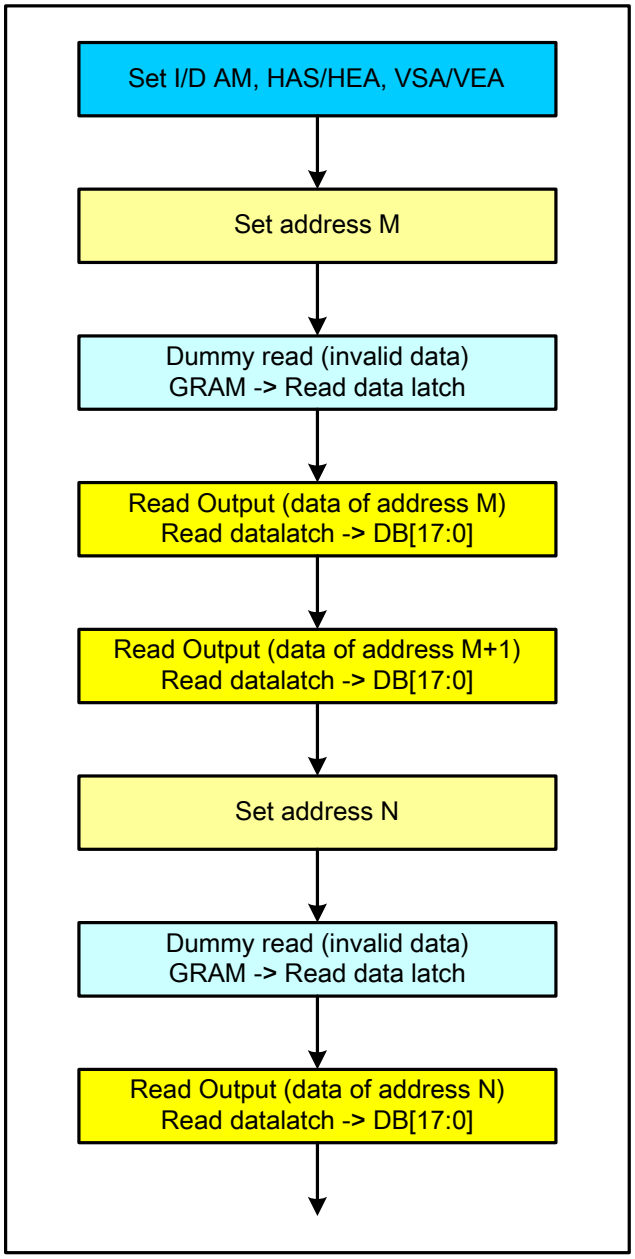


Figure 29 GRAM Data Read Back Flow Chart

8.2.22. Power Control 7 (R29h)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	0	0	0	0	0	0	0	0	0	0	VCM5	VCM4	VCM3	VCM2	VCM1	VCM0

VCM[5:0] Set the internal VcomH voltage.

VCM5	VCM4	VCM3	VCM2	VCM1	VCM0	VCOMH	VCM5	VCM4	VCM3	VCM2	VCM1	VCM0	VCOMH
0	0	0	0	0	0	VREG1OUT x 0.685	1	0	0	0	0	0	VREG1OUT x 0.845
0	0	0	0	0	1	VREG1OUT x 0.690	1	0	0	0	0	1	VREG1OUT x 0.850
0	0	0	0	1	0	VREG1OUT x 0.695	1	0	0	0	1	0	VREG1OUT x 0.855
0	0	0	0	1	1	VREG1OUT x 0.700	1	0	0	0	1	1	VREG1OUT x 0.860
0	0	0	1	0	0	VREG1OUT x	1	0	0	1	0	0	VREG1OUT x

						0.705								0.865
0	0	0	1	0	1	VREG1OUT x 0.710	1	0	0	1	0	1	VREG1OUT x 0.870	
0	0	0	1	1	0	VREG1OUT x 0.715	1	0	0	1	1	0	VREG1OUT x 0.875	
0	0	0	1	1	1	VREG1OUT x 0.720	1	0	0	1	1	1	VREG1OUT x 0.880	
0	0	1	0	0	0	VREG1OUT x 0.725	1	0	1	0	0	0	VREG1OUT x 0.885	
0	0	1	0	0	1	VREG1OUT x 0.730	1	0	1	0	0	1	VREG1OUT x 0.890	
0	0	1	0	1	0	VREG1OUT x 0.735	1	0	1	0	1	0	VREG1OUT x 0.895	
0	0	1	0	1	1	VREG1OUT x 0.740	1	0	1	0	1	1	VREG1OUT x 0.900	
0	0	1	1	0	0	VREG1OUT x 0.745	1	0	1	1	0	0	VREG1OUT x 0.905	
0	0	1	1	0	1	VREG1OUT x 0.750	1	0	1	1	0	1	VREG1OUT x 0.910	
0	0	1	1	1	0	VREG1OUT x 0.755	1	0	1	1	1	0	VREG1OUT x 0.915	
0	0	1	1	1	1	VREG1OUT x 0.760	1	0	1	1	1	1	VREG1OUT x 0.920	
0	1	0	0	0	0	VREG1OUT x 0.765	1	1	0	0	0	0	VREG1OUT x 0.925	
0	1	0	0	0	1	VREG1OUT x 0.770	1	1	0	0	0	1	VREG1OUT x 0.930	
0	1	0	0	1	0	VREG1OUT x 0.775	1	1	0	0	1	0	VREG1OUT x 0.935	
0	1	0	0	1	1	VREG1OUT x 0.780	1	1	0	0	1	1	VREG1OUT x 0.940	
0	1	0	1	0	0	VREG1OUT x 0.785	1	1	0	1	0	0	VREG1OUT x 0.945	
0	1	0	1	0	1	VREG1OUT x 0.790	1	1	0	1	0	1	VREG1OUT x 0.950	
0	1	0	1	1	0	VREG1OUT x 0.795	1	1	0	1	1	0	VREG1OUT x 0.955	
0	1	0	1	1	1	VREG1OUT x 0.800	1	1	0	1	1	1	VREG1OUT x 0.960	
0	1	1	0	0	0	VREG1OUT x 0.805	1	1	1	0	0	0	VREG1OUT x 0.965	
0	1	1	0	0	1	VREG1OUT x 0.810	1	1	1	0	0	1	VREG1OUT x 0.970	
0	1	1	0	1	0	VREG1OUT x 0.815	1	1	1	0	1	0	VREG1OUT x 0.975	
0	1	1	0	1	1	VREG1OUT x 0.820	1	1	1	0	1	1	VREG1OUT x 0.980	
0	1	1	1	0	0	VREG1OUT x 0.825	1	1	1	1	0	0	VREG1OUT x 0.985	
0	1	1	1	0	1	VREG1OUT x 0.830	1	1	1	1	0	1	VREG1OUT x 0.990	
0	1	1	1	1	0	VREG1OUT x 0.835	1	1	1	1	1	0	VREG1OUT x 0.995	
0	1	1	1	1	1	VREG1OUT x 0.840	1	1	1	1	1	1	VREG1OUT x 1.000	

8.2.23. Frame Rate and Color Control (R2Bh)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	0	0	0	0	0	0	0	0	0	0	0	0	FRS3	FRS2	FRS1	FRS0

FRS[4:0] Set the frame rate when the internal resistor is used for oscillator circuit.

FRS[3:0]	Frame Rate
0000	40

0001	43
0010	45
0011	48
0100	51
0101	55
0110	59
0111	64
1000	70
1001	77
1010	85
1011	96 (default)
1100	110
1101	128
Others	Setting Prohibited

8.2.24. Gamma Control (R30h ~ R3Dh)

	R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
R30h	W	1	0	0	0	0	0	KP1[2]	KP1[1]	KP1[0]	0	0	0	0	0	KP0[2]	KP0[1]	KP0[0]
R31h	W	1	0	0	0	0	0	KP3[2]	KP3[1]	KP3[0]	0	0	0	0	0	KP2[2]	KP2[1]	KP2[0]
R32h	W	1	0	0	0	0	0	KP5[2]	KP5[1]	KP5[0]	0	0	0	0	0	KP4[2]	KP4[1]	KP4[0]
R35h	W	1	0	0	0	0	0	RP1[2]	RP1[1]	RP1[0]	0	0	0	0	0	RP0[2]	RP0[1]	RP0[0]
R36h	W	1	0	0	0	VRP1[4]	VRP1[3]	VRP1[2]	VRP1[1]	VRP1[0]	0	0	0	0	VRP0[3]	VRP0[2]	VRP0[1]	VRP0[0]
R37h	W	1	0	0	0	0	0	KN1[2]	KN1[1]	KN1[0]	0	0	0	0	0	KN0[2]	KN0[1]	KN0[0]
R38h	W	1	0	0	0	0	0	KN3[2]	KN3[1]	KN3[0]	0	0	0	0	0	KN2[2]	KN2[1]	KN2[0]
R39h	W	1	0	0	0	0	0	KN5[2]	KN5[1]	KN5[0]	0	0	0	0	0	KN4[2]	KN4[1]	KN4[0]
R3Ch	W	1	0	0	0	0	0	RN1[2]	RN1[1]	RN1[0]	0	0	0	0	0	RN0[2]	RN0[1]	RN0[0]
R3Dh	W	1	0	0	0	VRN1[4]	VRN1[3]	VRN1[2]	VRN1[1]	VRN1[0]	0	0	0	0	VRN0[3]	VRN0[2]	VRN0[1]	VRN0[0]

KP5-0[2:0] : γ fine adjustment register for positive polarity

RP1-0[2:0] : γ gradient adjustment register for positive polarity

VRP1-0[4:0] : γ amplitude adjustment register for positive polarity

KN5-0[2:0] : γ fine adjustment register for negative polarity

RN1-0[2:0] : γ gradient adjustment register for negative polarity

VRN1-0[4:0] : γ amplitude adjustment register for negative polarity

For details "γ -Correction Function" section.

8.2.25. Horizontal and Vertical RAM Address Position (R50h, R51h, R52h, R53h)

	R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
R50h	W	1	0	0	0	0	0	0	0	0	HSA7	HSA6	HSA5	HSA4	HSA3	HSA2	HSA1	HSA0
R51h	W	1	0	0	0	0	0	0	0	0	HEA7	HEA6	HEA5	HEA4	HEA3	HEA2	HEA1	HEA0
R52h	W	1	0	0	0	0	0	0	0	VSA8	VSA7	VSA6	VSA5	VSA4	VSA3	VSA2	VSA1	VSA0
R53h	W	1	0	0	0	0	0	0	0	VEA8	VEA7	VEA6	VEA5	VEA4	VEA3	VEA2	VEA1	VEA0

HSA[7:0]/HEA[7:0] HSA[7:0] and HEA[7:0] represent the respective addresses at the start and end of the

window address area in horizontal direction. By setting HSA and HEA bits, it is possible to limit the area on the GRAM horizontally for writing data. The HSA and HEA bits must be set before starting RAM write operation. In setting these bits, be sure “00”h ≤ HSA[7:0]< HEA[7:0] ≤ “EF”h. and “04”h≦HEA-HAS.

VSA[8:0]/VEA[8:0] VSA[8:0] and VEA[8:0] represent the respective addresses at the start and end of the window address area in vertical direction. By setting VSA and VEA bits, it is possible to limit the area on the GRAM vertically for writing data. The VSA and VEA bits must be set before starting RAM write operation. In setting, be sure “000”h ≤ VSA[8:0]< VEA[8:0] ≤ “13F”h.

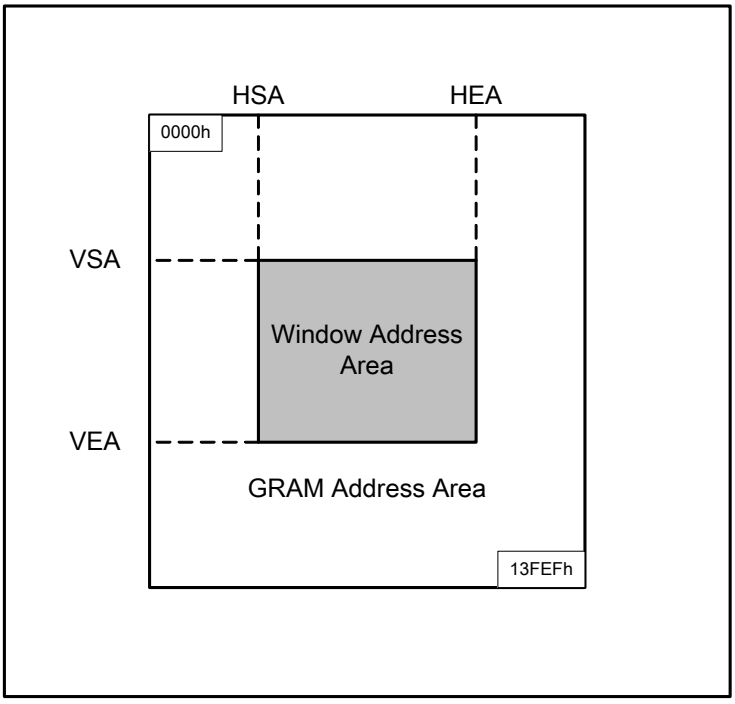


Figure 30 GRAM Access Range Configuration

“00”h ≤HAS[7:0] ≤HEA[7:0] ≤”EF”h
“00”h ≤VSA[7:0] ≤VEA[7:0] ≤”13F”h

Note1. The window address range must be within the GRAM address space.

Note2. Data are written to GRAM in four-words when operating in high speed mode, the dummy write operations should be inserted depending on the window address area. For details, see the High-Speed RAM Write Function section.

8.2.26. Gate Scan Control (R60h, R61h, R6Ah)

	R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
R60h	W	1	GS	0	NL5	NL4	NL3	NL2	NL1	NL0	0	0	SCN5	SCN4	SCN3	SCN2	SCN1	SCN0
R61h	W	1	0	0	0	0	0	0	0	0	0	0	0	0	0	NDL	VLE	REV
R6Ah	W	1	0	0	0	0	0	0	0	VL8	VL7	VL6	VL5	VL4	VL3	VL2	VL1	VL0

SCN[5:0] The ILI9325 allows to specify the gate line from which the gate driver starts to scan by setting the

SCN[5:0] bits.

SCN[5:0]	Scanning Start Position			
	SM=0		SM=1	
	GS=0	GS=1	GS=0	GS=1
00h	G1	G320	G1	G320
01h	G9	G312	G17	G304
02h	G17	G304	G33	G288
03h	G25	G296	G49	G272
04h	G33	G288	G65	G256
05h	G41	G280	G81	G240
06h	G49	G272	G97	G224
07h	G57	G264	G113	G208
08h	G65	G256	G129	G192
09h	G73	G248	G145	G176
0Ah	G81	G240	G161	G160
0Bh	G89	G232	G177	G144
0Ch	G97	G224	G193	G128
0Dh	G105	G216	G209	G112
0Eh	G113	G208	G2	G96
0Fh	G121	G200	G18	G80
10h	G129	G192	G34	G64
11h	G137	G184	G50	G48
12h	G145	G176	G66	G32
13h	G153	G168	G82	G16
14h	G161	G160	G98	G319
15h	G169	G152	G114	G303
16h	G177	G144	G130	G287
17h	G185	G136	G146	G271
18h	G193	G128	G162	G255
19h	G201	G120	G178	G239
1Ah	G209	G112	G194	G223
1Bh	G217	G104	G114	G207
1Ch	G225	G96	G130	G191
1Dh	G233	G88	G146	G175
1Eh	G241	G80	G162	G159
1Fh	G249	G72	G178	G143
20h	G257	G64	G194	G127
21h	G265	G56	G210	G111
22h	G273	G48	G226	G95
23h	G281	G40	G242	G79
24h	G289	G32	G258	G63
25h	G297	G24	G274	G47
26h	G305	G16	G290	G31
27h	G313	G8	G306	G15
28h ~ 3Fh	Setting disabled	Setting disabled	Setting disabled	Setting disabled

NL[5:0]: Sets the number of lines to drive the LCD at an interval of 8 lines. The GRAM address mapping is not affected by the number of lines set by NL[5:0]. The number of lines must be the same or more than the number of lines necessary for the size of the liquid crystal panel.

NL[5:0]	LCD Drive Line

6'h1D	240 lines
6'h1E	248 lines
6'h1F	256 lines
6'h20	264 lines
6'h21	272 lines
6'h22	280 lines
6'h23	288 lines
6'h24	296 lines
6'h25	304 lines
6'h26	312 line
6'h27	320 line
Others	Setting inhibited

NDL: Sets the source driver output level in the non-display area.

NDL	Non-Display Area	
	Positive Polarity	Negative Polarity
0	V63	V0
1	V0	V63

GS: Sets the direction of scan by the gate driver in the range determined by SCN[4:0] and NL[4:0]. The scan direction determined by GS = 0 can be reversed by setting GS = 1.

When GS = 0, the scan direction is from G1 to G320.

When GS = 1, the scan direction is from G320 to G1

REV: Enables the grayscale inversion of the image by setting REV=1.

REV	GRAM Data	Source Output in Display Area	
		Positive polarity	negative polarity
0	18'h00000	V63	V0
	.	.	.
	.	.	.
	.	.	.
	18'h3FFFF	V0	V63
1	18'h00000	V0	V63
	.	.	.
	.	.	.
	.	.	.
	18'h3FFFF	V63	V0

VLE: Vertical scroll display enable bit. When VLE = 1, the ILI9325 starts displaying the base image from the line (of the physical display) determined by VL[8:0] bits. VL[8:0] sets the amount of scrolling, which is the number of lines to shift the start line of the display from the first line of the physical display. Note that the partial image display position is not affected by the base image scrolling.

The vertical scrolling is not available in external display interface operation. In this case, make sure to set VLE = "0".

VLE	Base Image Display
0	Fixed

1	Enable Scrolling

VL[8:0]: Sets the scrolling amount of base image. The base image is scrolled in vertical direction and displayed from the line determined by VL[8:0]. Make sure that VL[8:0] ≦320.

8.2.27. Partial Image 1 Display Position (R80h)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	0	0	0	0	0	0	0	PTDP0[8]	PTDP0[7]	PTDP0[6]	PTDP0[5]	PTDP0[4]	PTDP0[3]	PTDP0[2]	PTDP0[1]	PTDP0[0]

PTDP0[8:0]: Sets the display position of partial image 1. The display areas of the partial images 1 and 2 must not overlap each another.

8.2.28. Partial Image 1 RAM Start/End Address (R81h, R82h)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	0	0	0	0	0	0	0	PTSA0[8]	PTSA0[7]	PTSA0[6]	PTSA0[5]	PTSA0[4]	PTSA0[3]	PTSA0[2]	PTSA0[1]	PTSA0[0]
W	1	0	0	0	0	0	0	0	PTEA0[8]	PTEA0[7]	PTEA0[6]	PTEA0[5]	PTEA0[4]	PTEA0[3]	PTEA0[2]	PTEA0[1]	PTEA0[0]

PTSA0[8:0] PTEA0[8:0]: Sets the start line address and the end line address of the RAM area storing the data of partial image 1. Make sure PTSA0[8:0] ≤ PTEA0[8:0].

8.2.29. Partial Image 2 Display Position (R83h)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	0	0	0	0	0	0	0	PTDP1[8]	PTDP1[7]	PTDP1[6]	PTDP1[5]	PTDP1[4]	PTDP1[3]	PTDP1[2]	PTDP1[1]	PTDP1[0]

PTDP1[8:0]: Sets the display position of partial image 2 The display areas of the partial images 1 and 2 must not overlap each another.

8.2.30. Partial Image 2 RAM Start/End Address (R84h, R85h)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	0	0	0	0	0	0	0	PTSA1[8]	PTSA1[7]	PTSA1[6]	PTSA1[5]	PTSA1[4]	PTSA1[3]	PTSA1[2]	PTSA1[1]	PTSA1[0]
W	1	0	0	0	0	0	0	0	PTEA1[8]	PTEA1[7]	PTEA1[6]	PTEA1[5]	PTEA1[4]	PTEA1[3]	PTEA1[2]	PTEA1[1]	PTEA1[0]

PTSA1[8:0] PTEA1[8:0]: Sets the start line address and the end line address of the RAM area storing the data of partial image 2 Make sure PTSA1[8:0] ≤ PTEA1[8:0].

8.2.31. Panel Interface Control 1 (R90h)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0

W	1	0	0	0	0	0	0	DIVI1	DIVI0	0	0	0	RTNI4	RTNI3	RTNI2	RTNI1	RTNI0

RTNI[4:0]: Sets 1H (line) clock number of internal clock operating mode. In this mode, ILI9325 display operation is synchronized with internal clock signal.

RTNI[4:0]	Clocks/Line
00000~01111	Setting Disabled
10000	16 clocks
10001	17 clocks
10010	18 clocks
10011	19 clocks
10100	20 clocks
10101	21 clocks
10110	22 clocks
10111	23 clocks

RTNI[4:0]	Clocks/Line
11000	24 clocks
11001	25 clocks
11010	26 clocks
11011	27 clocks
11100	28 clocks
11101	29 clocks
11110	30 clocks
11111	31 clocks

DIVI[1:0]: Sets the division ratio of internal clock frequency.

DIVI1	DIVI0	Division Ratio	Internal Operation Clock Frequency
0	0	1	fosc / 1
0	1	2	fosc / 2
1	0	4	fosc / 4
1	1	8	fosc / 8

8.2.32. Panel Interface Control 2 (R92h)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	0	0	0	0	0	NOWI[2]	NOWI[1]	NOWI[0]	0	0	0	0	0	0	0	0

NOWI[2:0]: Sets the gate output non-overlap period when ILI9325 display operation is synchronized with internal clock signal.

NOWI[2:0]	Gate Non-overlap Period
000	0 clocks
001	1 clocks
010	2 clocks
011	3 clocks
100	4 clocks
101	5 clocks
110	6 clocks
111	7 clocks

Note: The gate output non-overlap period is defined by the number of frequency-divided internal clocks, the frequency of which is determined by instruction (DIVI), from the reference point.

8.2.33. Panel Interface Control 4 (R95h)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	0	0	0	0	0	0	DIVE1	DIVE0	0	0	RTNE5	RTNE4	RTNE3	RTNE2	RTNE1	RTNE0

RTNE[5:0]: Sets 1H (line) clock number of RGB interface mode. In this mode, ILI9325 display operation is synchronized with RGB interface signals.

DIVE (division ratio) x RTNE (DOTCLKs) ≤ DOTCLKs in 1H period.

RTNE[5:0]	Clocks per line period (1H)	RTNE[5:0]	Clocks per line period (1H)	RTNE[5:0]	Clocks per line period (1H)	RTNE[5:0]	Clocks per line period (1H)
00h	Setting Prohibited	10h	16 clocks	20h	32 clocks	30h	48 clocks
01h	Setting Prohibited	11h	17 clocks	21h	33 clocks	31h	49 clocks
02h	Setting Prohibited	12h	18 clocks	22h	34 clocks	32h	50 clocks
03h	Setting Prohibited	13h	19 clocks	23h	35 clocks	33h	51 clocks
04h	Setting Prohibited	14h	20 clocks	24h	36 clocks	34h	52 clocks
05h	Setting Prohibited	15h	21 clocks	25h	37 clocks	35h	53 clocks
06h	Setting Prohibited	16h	22 clocks	26h	38 clocks	36h	54 clocks
07h	Setting Prohibited	17h	23 clocks	27h	39 clocks	37h	55 clocks
08h	Setting Prohibited	18h	24 clocks	28h	40 clocks	38h	56 clocks
09h	Setting Prohibited	19h	25 clocks	29h	41 clocks	39h	57 clocks
0ah	Setting Prohibited	1ah	26 clocks	2ah	42 clocks	3ah	58 clocks
0bh	Setting Prohibited	1bh	27 clocks	2bh	43 clocks	3bh	59 clocks
0ch	Setting Prohibited	1ch	28 clocks	2ch	44 clocks	3ch	60 clocks
0dh	Setting Prohibited	1dh	29 clocks	2dh	45 clocks	3dh	61 clocks
0eh	Setting Prohibited	1eh	30 clocks	2eh	46 clocks	3eh	62 clocks
0fh	Setting Prohibited	1fh	31 clocks	2fh	47 clocks	3fh	63 clocks

DIVE[1:0]: Sets the division ratio of DOTCLK when ILI9325 display operation is synchronized with RGB interface signals.

DIVE[1:0]	Division Ratio	18/16-bit RGB Interface	DOTCLK=5MHz	6-bit x 3 Transfers RGB Interface	DOTCLK=5MHz
00	Setting Prohibited	Setting Prohibited	-	Setting Prohibited	-
01	1/4	4 DOTCLKS	0.8 μs	12 DOTCLKS	0.8 μs
10	1/8	8 DOTCLKS	1.6 μs	24 DOTCLKS	1.6 μs
11	1/16	16 DOTCLKS	3.2 μs	48 DOTCLKS	3.2 μs

8.2.34. OTP VCM Programming Control (RA1h)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	0	0	0	0	OTP_ PGM_EN	0	0	0	0	0	VCM_ OTP5	VCM_ OTP4	VCM_ OTP3	VCM_ OTP2	VCM_ OTP1	VCM_ OTP0

OTP_PGM_EN: OTP programming enable. When program OTP, must set this bit. OTP data can be programmed 3 times.

VCM_OTP[5:0]: OTP programming data for VCOMH voltage, the voltage refer to VCM[5:0] value.

8.2.35. OTP VCM Status and Enable (RA2h)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	PGM_ CNT1	PGM_ CNT0	VCM_ D5	VCM_ D4	VCM_ D3	VCM_ D2	VCM_ D1	VCM_ D0	0	0	0	0	0	0	0	VCM_ EN

PGM_CNT[1:0]: OTP programmed record. These bits are read only.

OTP_PGM_CNT[1:0]	Description
00	OTP clean
01	OTP programmed 1 time
10	OTP programmed 2 times
11	OTP programmed 3 times

VCM_D[5:0]: OTP VCM data read value. These bits are read only.

VCM_EN: OTP VCM data enable.

'1': Set this bit to enable OTP VCM data to replace R29h VCM value.

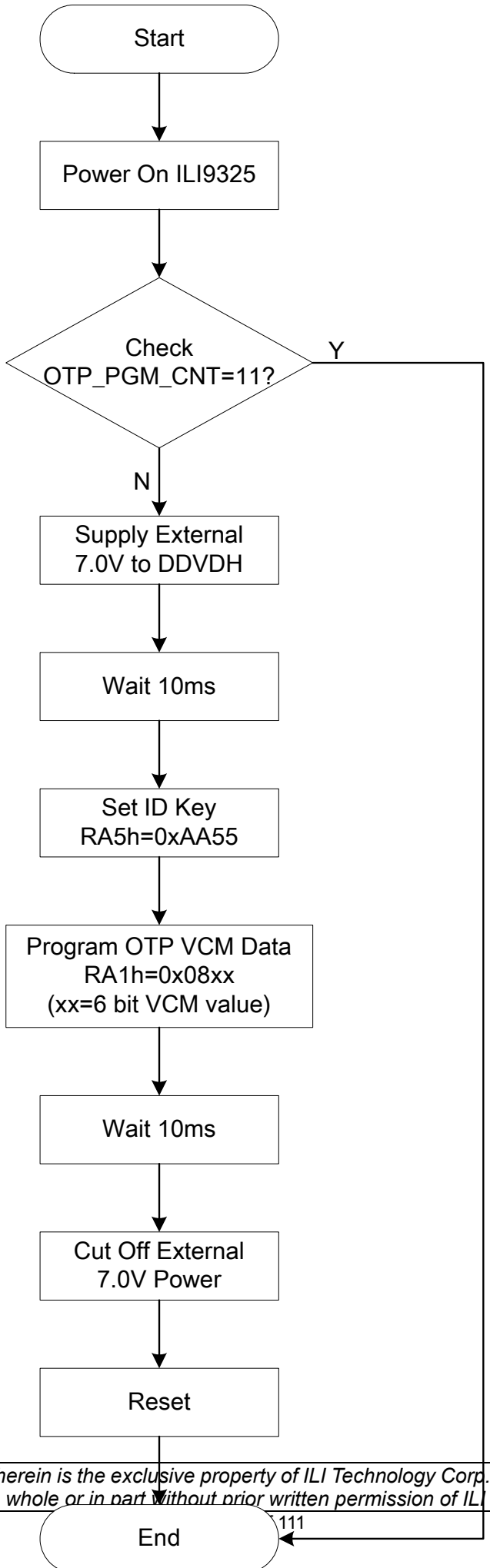
'0': Default value, use R29h VCM value.

8.2.36. OTP Programming ID Key (RA5h)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	KEY 15	KEY 14	KEY 13	KEY 12	KEY 11	KEY 10	KEY 9	KEY 8	KEY 7	KEY 6	KEY 5	KEY 4	KEY 3	KEY 2	KEY 1	KEY 0

KEY[15:0]: OTP Programming ID key protection. Before writing OTP programming data RA1h, it must write RA5h with 0xAA55 value first to make OTP programming successfully. If RA5h is not written with 0xAA55, OTP programming will be fail. See OTP Programming flow.

9. OTP Programming Flow



10. GRAM Address Map & Read/Write

ILI9325 has an internal graphics RAM (GRAM) of 87,120 bytes to store the display data and one pixel is constructed of 18 bits. The GRAM can be accessed through the i80 system, SPI and RGB interfaces.

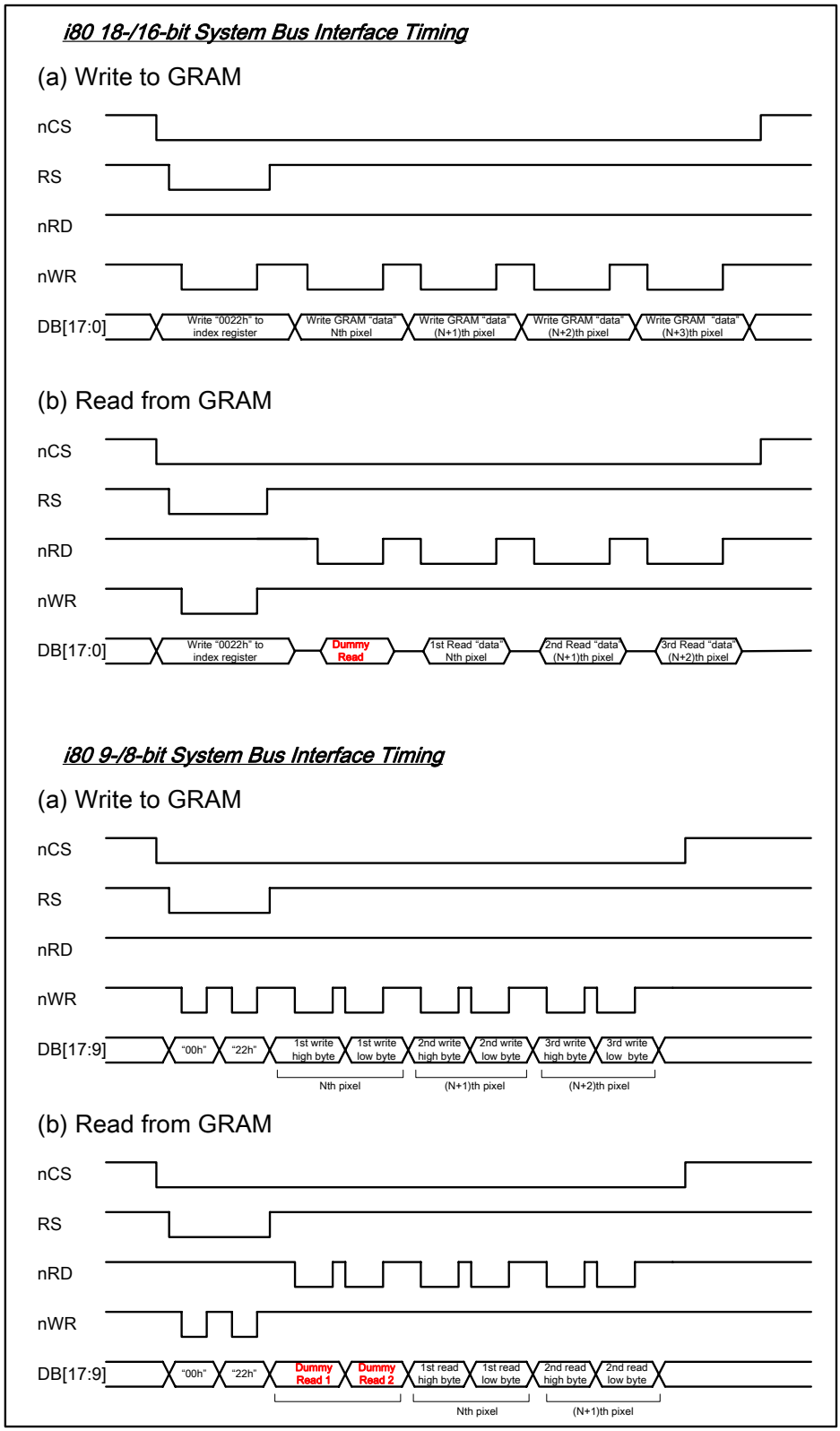
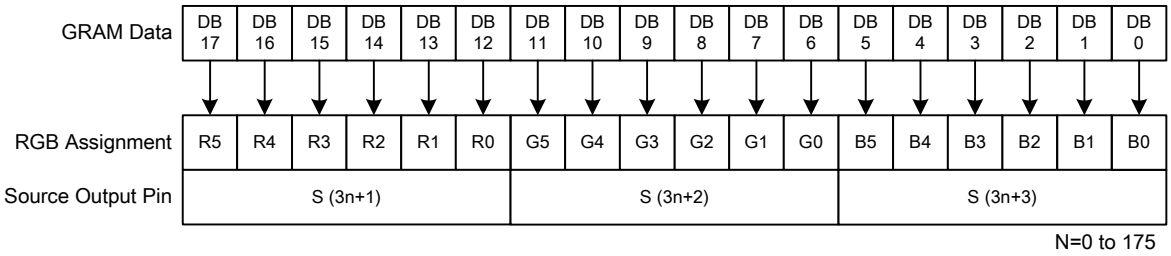


Figure31 GRAM Read/Write Timing of i80-System Interface

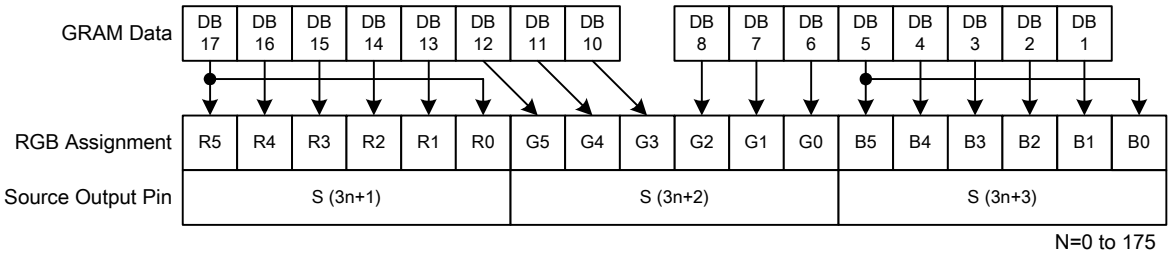
GRAM address map table of SS=0, BGR=0

SS=0, BGR=0		S1…S3	S4…S6	S7…S9	S10…S12	…	S517…S519	S520…S522	S523…S525	S526…S720
GS=0	GS=1	DB17…0	DB17…0	DB17…0	DB17…0	…	DB17…0	DB17…0	DB17…0	DB17…0
G1	G320	“00000h”	“00001h”	“00002h”	“00003h”	…	“000ECh”	“000EDh”	“000EEh”	“000EFh”
G2	G319	“00100h”	“00101h”	“00102h”	“00103h”	…	“001ECh”	“001EDh”	“001EEh”	“001EFh”
G3	G318	“00200h”	“00201h”	“00202h”	“00203h”	…	“002ECh”	“002EDh”	“002EEh”	“002EFh”
G4	G317	“00300h”	“00301h”	“00302h”	“00303h”	…	“003ECh”	“003EDh”	“003EEh”	“003EFh”
G5	G316	“00400h”	“00401h”	“00402h”	“00403h”	…	“004ECh”	“004EDh”	“004EEh”	“004EFh”
G6	G315	“00500h”	“00501h”	“00502h”	“00503h”	…	“005ECh”	“005EDh”	“005EEh”	“005EFh”
G7	G314	“00600h”	“00601h”	“00602h”	“00603h”	…	“006ECh”	“006EDh”	“006EEh”	“006EFh”
G8	G313	“00700h”	“00701h”	“00702h”	“00703h”	…	“007ECh”	“007EDh”	“007EEh”	“007EFh”
G9	G312	“00800h”	“00801h”	“00802h”	“00803h”	…	“008ECh”	“008EDh”	“008EEh”	“008EFh”
G10	G311	“00900h”	“00901h”	“00902h”	“00903h”	…	“009ECh”	“009EDh”	“009EEh”	“009EFh”
. . .	. . .	. . .	. . .	. . .	. . .	…	. . .	. . .	. . .	. . .
G311	G10	“13600h”	“13601h”	“13602h”	“13603h”	…	“136ECh”	“136EDh”	“136EEh”	“136EFh”
G312	G9	“13700h”	“13701h”	“13702h”	“13703h”	…	“137ECh”	“137EDh”	“137EEh”	“137EFh”
G313	G8	“13800h”	“13801h”	“13802h”	“13803h”	…	“138ECh”	“138EDh”	“138EEh”	“138EFh”
G314	G7	“13900h”	“13901h”	“13902h”	“13903h”	…	“139ECh”	“139EDh”	“139EEh”	“139EFh”
G315	G6	“13A00h”	“13A01h”	“13A02h”	“13A03h”	…	“13AECh”	“13AEDh”	“13AEEh”	“13AEFh”
G316	G5	“13B00h”	“13B01h”	“13B02h”	“13B03h”	…	“13BECh”	“13BEDh”	“13BEEh”	“13BEFh”
G317	G4	“13C00h”	“13C01h”	“13C02h”	“13C03h”	…	“13CECh”	“13CEDh”	“13CEEh”	“13CEFh”
G318	G3	“13D00h”	“13D01h”	“13D02h”	“13D03h”	…	“13DECh”	“13DEDh”	“13DEEh”	“13DEFh”
G319	G2	“13E00h”	“13E01h”	“13E02h”	“13E03h”	…	“13EECh”	“13EEDh”	“13EEEh”	“13EEFh”
G320	G1	“13F00h”	“13F01h”	“13F02h”	“13F03h”	…	“13FECh”	“13FEDh”	“13FEEh”	“13FEFh”

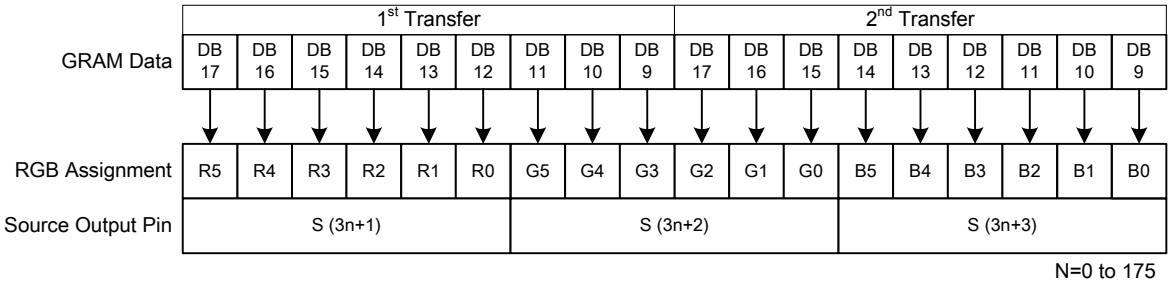
i80/M68 system 18-bit data bus interface



i80/M68 system 16-bit data bus interface



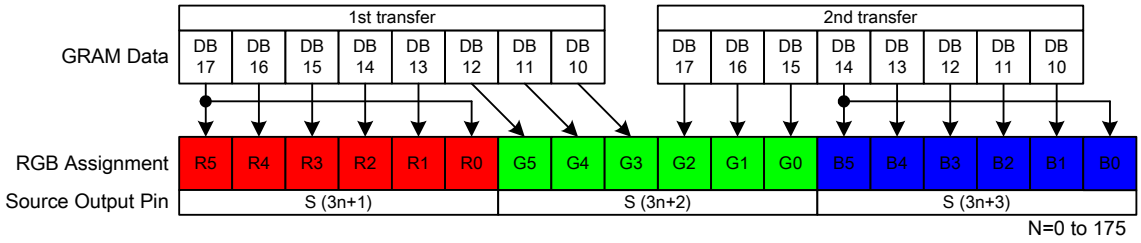
i80/M68 system 9-bit data bus interface



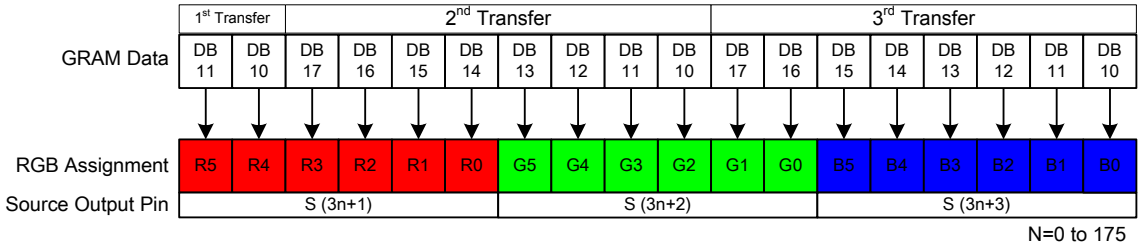
GRAM Data and display data of 18-/16-/9-bit system interface (SS="0", BGR="0")

Figure32 i80-System Interface with 18-/16-/9-bit Data Bus (SS="0", BGR="0")

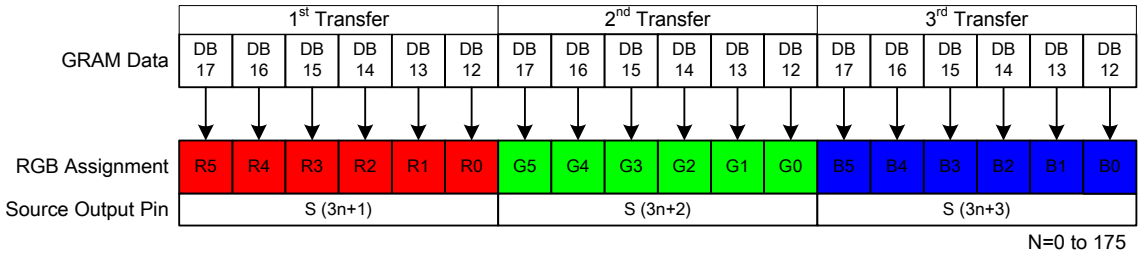
i80/M68 system 8-bit interface / SPI Interface (2 transfers/pixel)



i80/M68 system 8-bit interface (3 transfers/pixel, TRI="1", DFM[1:0]="00")



i80/M68 system 8-bit interface (3 transfers/pixel, TRI="1", DFM[1:0]="10)



i80/M68 system 8-bit interface (SS="0", BGR="0")

Figure33 i80-System Interface with 8-bit Data Bus (SS="0", BGR="0")

GRAM address map table of SS=1, BGR=1

SS=0, BGR=0		S720…S718	S717…S715	S714…S712	S711…S709	…	S12…S10	S9…S7	S6…S4	S3…S1
GS=0	**GS=1**	DB17…0	DB17…0	DB17…0	DB17…0	…	DB17…0	DB17…0	DB17…0	DB17…0
G1	G320	“00000h”	“00001h”	“00002h”	“00003h”	…	“000ECh”	“000EDh”	“000EEh”	“000EFh”
G2	G319	“00100h”	“00101h”	“00102h”	“00103h”	…	“001ECh”	“001EDh”	“001EEh”	“001EFh”
G3	G318	“00200h”	“00201h”	“00202h”	“00203h”	…	“002ECh”	“002EDh”	“002EEh”	“002EFh”
G4	G317	“00300h”	“00301h”	“00302h”	“00303h”	…	“003ECh”	“003EDh”	“003EEh”	“003EFh”
G5	G316	“00400h”	“00401h”	“00402h”	“00403h”	…	“004ECh”	“004EDh”	“004EEh”	“004EFh”
G6	G315	“00500h”	“00501h”	“00502h”	“00503h”	…	“005ECh”	“005EDh”	“005EEh”	“005EFh”
G7	G314	“00600h”	“00601h”	“00602h”	“00603h”	…	“006ECh”	“006EDh”	“006EEh”	“006EFh”
G8	G313	“00700h”	“00701h”	“00702h”	“00703h”	…	“007ECh”	“007EDh”	“007EEh”	“007EFh”
G9	G312	“00800h”	“00801h”	“00802h”	“00803h”	…	“008ECh”	“008EDh”	“008EEh”	“008EFh”
G10	G311	“00900h”	“00901h”	“00902h”	“00903h”	…	“009ECh”	“009EDh”	“009EEh”	“009EFh”
. . .	. . .	. . .	. . .	. . .	. . .	…	. . .	. . .	. . .	. . .
G311	G10	“13600h”	“13601h”	“13602h”	“13603h”	…	“136ECh”	“136EDh”	“136EEh”	“136EFh”
G312	G9	“13700h”	“13701h”	“13702h”	“13703h”	…	“137ECh”	“137EDh”	“137EEh”	“137EFh”
G313	G8	“13800h”	“13801h”	“13802h”	“13803h”	…	“138ECh”	“138EDh”	“138EEh”	“138EFh”
G314	G7	“13900h”	“13901h”	“13902h”	“13903h”	…	“139ECh”	“139EDh”	“139EEh”	“139EFh”
G315	G6	“13A00h”	“13A01h”	“13A02h”	“13A03h”	…	“13AECh”	“13AEDh”	“13AEEh”	“13AEFh”
G316	G5	“13B00h”	“13B01h”	“13B02h”	“13B03h”	…	“13BECh”	“13BEDh”	“13BEEh”	“13BEFh”
G317	G4	“13C00h”	“13C01h”	“13C02h”	“13C03h”	…	“13CECh”	“13CEDh”	“13CEEh”	“13CEFh”
G318	G3	“13D00h”	“13D01h”	“13D02h”	“13D03h”	…	“13DECh”	“13DEDh”	“13DEEh”	“13DEFh”
G319	G2	“13E00h”	“13E01h”	“13E02h”	“13E03h”	…	“13EECh”	“13EEDh”	“13EEEh”	“13EEFh”
G320	G1	“13F00h”	“13F01h”	“13F02h”	“13F03h”	…	“13FECh”	“13FEDh”	“13FEEh”	“13FEFh”

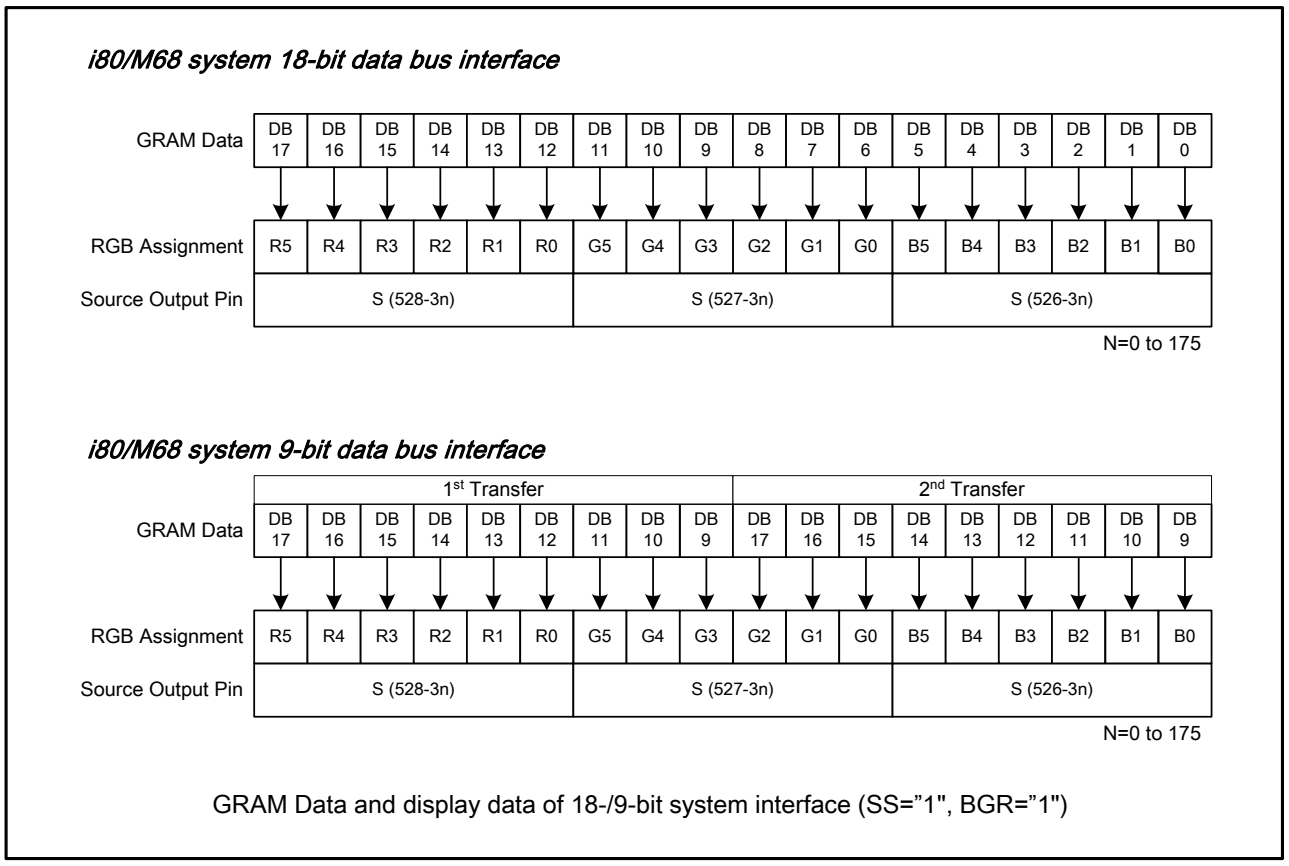


Figure 34 i80-System Interface with 18-/9-bit Data Bus (SS=”1”, BGR=”1”)

11. Window Address Function

The window address function enables writing display data consecutively in a rectangular area (a window address area) made on the internal RAM. The window address area is made by setting the horizontal address register (start: HSA[7:0], end: HEA[7:0] bits) and the vertical address register (start: VSA[8:0], end: VEA[8:0] bits). The AM bit sets the transition direction of RAM address (either increment or decrement). These bits enable the ILI9325 to write data including image data consecutively not taking data wrap positions into account.

The window address area must be made within the GRAM address map area. Also, the GRAM address bits (RAM address set register) must be an address within the window address area.

[Window address setting area]

(Horizontal direction) 00H ≤ HSA[7:0] ≤ HEA[7:0] ≤ "EF"H

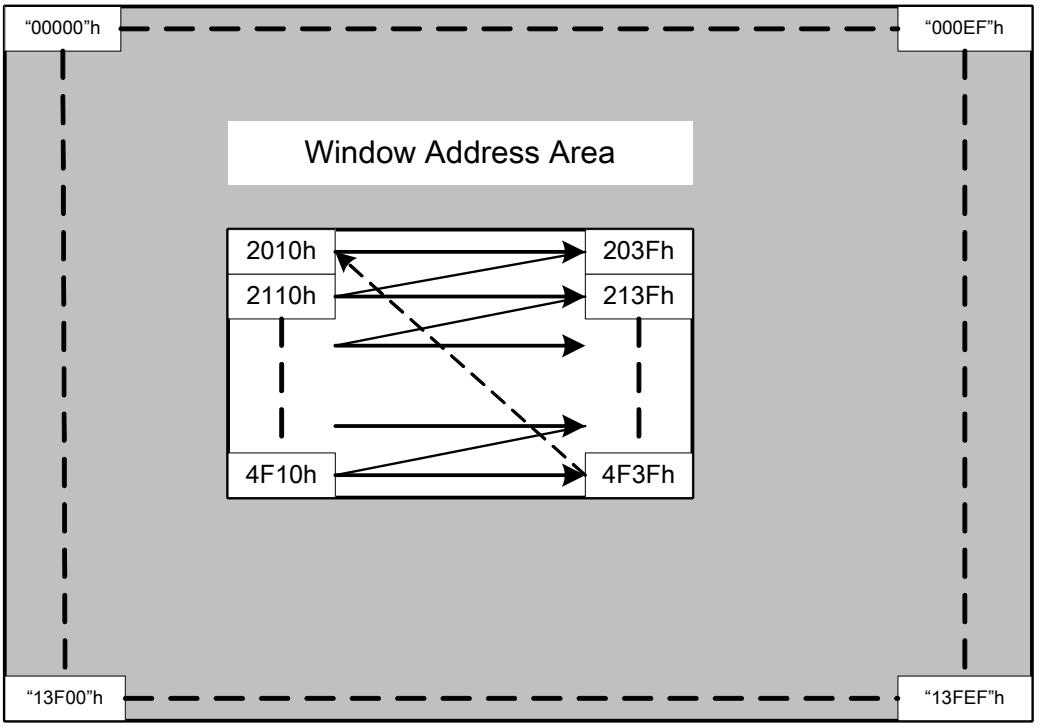
(Vertical direction) 00H ≤ VSA[8:0] ≤ VEA[8:0]≤ "13F"H

[RAM address, AD (an address within a window address area)]]

(RAM address) HSA[7:0] ≤ AD[7:0] ≤ HEA[7:0]

VSA[8:0] ≤ AD[15:8] ≤ VEA[8:0]

GRAM Address Map



Window address setting area

HSA[7:0] = 10h, HSA[7:0] = 3Fh, I/D = 1 (increment)
VSA[8:0] = 20h, VSA[8:0] = 4Fh, AM = 0 (horizontal writing)

Figure 35 GRAM Access Window Map

12. Gamma Correction

ILI9325 incorporates the γ-correction function to display 262,144 colors for the LCD panel. The γ-correction is performed with 3 groups of registers determining eight reference grayscale levels, which are gradient adjustment, amplitude adjustment and fine-adjustment registers for positive and negative polarities, to make ILI9325 available with liquid crystal panels of various characteristics.

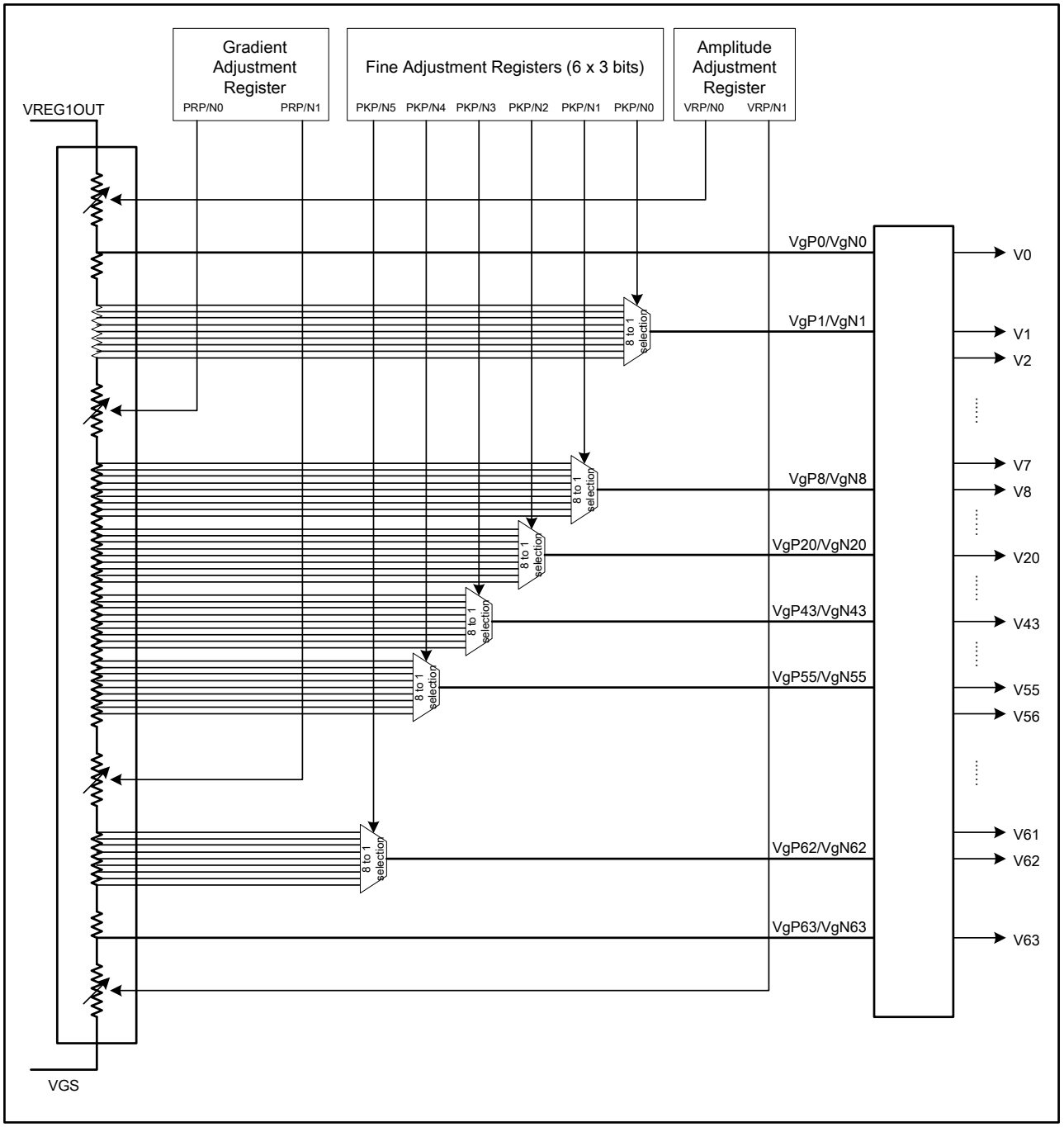


Figure 36 Grayscale Voltage Generation

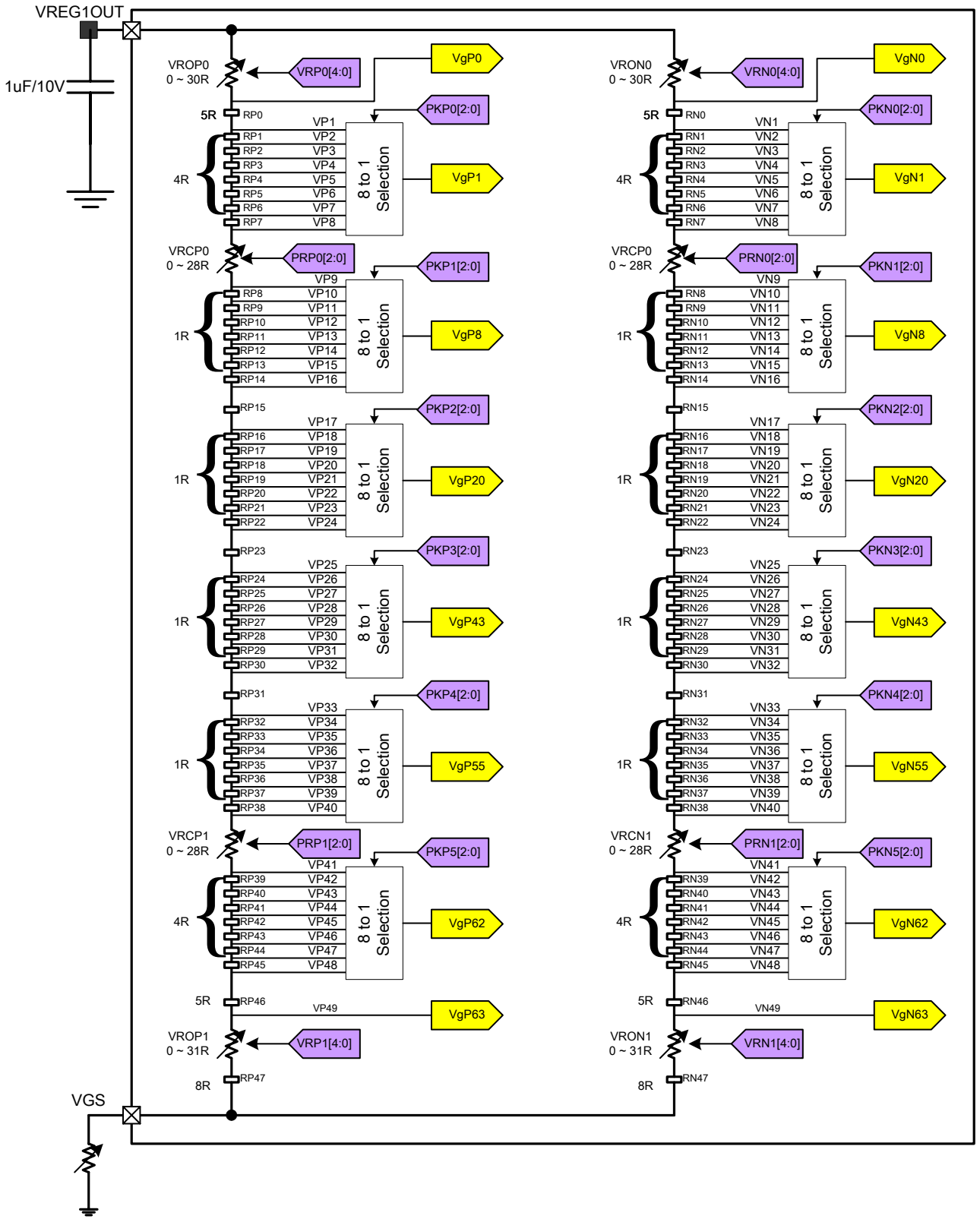


Figure 37 Grayscale Voltage Adjustment

1. Gradient adjustment registers

The gradient adjustment registers are used to adjust the gradient of the curve representing the relationship between the grayscale and the grayscale reference voltage level. To adjust the gradient, the resistance values of variable resistors in the middle of the ladder resistor are adjusted by registers PRP0[2:0]/PRN0[2:0], PRP1[2:0]/PRN1[2:0]. The registers consist of positive and negative polarity registers, allowing asymmetric drive.

2. Amplitude adjustment registers

The amplitude adjustment registers, VRP0[3:0]/VRN0[3:0], VRP1[4:0]/VRN1[4:0], are used to adjust the amplitude of grayscale voltages. To adjust the amplitude, the resistance values of variable resistors at the top and bottom of the ladder resistor are adjusted. Same as the gradient registers, the amplitude adjustment registers consist of positive and negative polarity registers.

3. Fine adjustment registers

The fine adjustment registers are used to fine-adjust grayscale voltage levels. To fine-adjust grayscale voltage levels, fine adjustment registers adjust the reference voltage levels, 8 levels for each register generated from the ladder resistor, in respective 8-to-1 selectors. Same with other registers, the fine adjustment registers consist of positive and negative polarity registers.

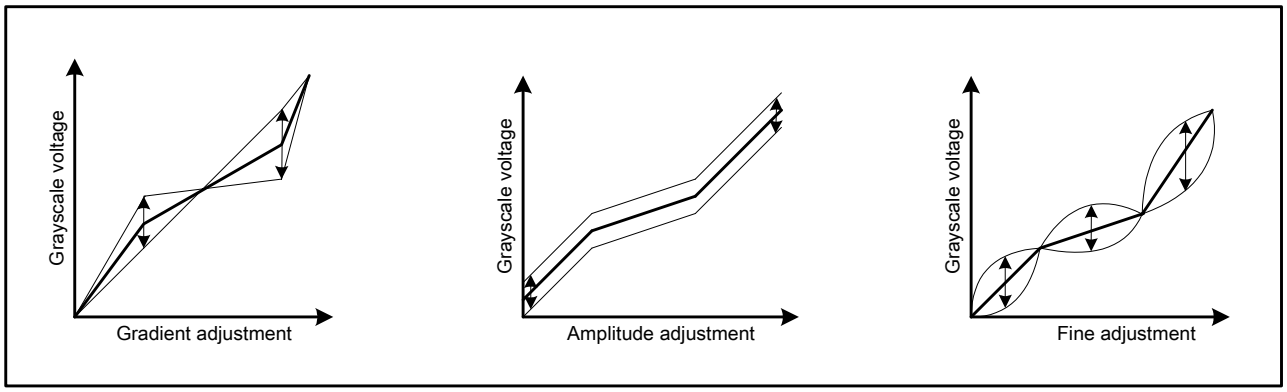


Figure 38 Gamma Curve Adjustment

Register Groups	Positive Polarity	Negative Polarity	Description
Gradient adjustment	PRP0 [2:0]	PRN0 [2:0]	Variable resistor VRCP0, VRCN0
	PRP1 [2:0]	PRN1 [2:0]	Variable resistor VRCP1, VRCN1
Amplitude adjustment	VRP0 [3:0]	VRN0 [3:0]	Variable resistor VROP0, VRON0
	VRP1 [4:0]	VRN1 [4:0]	Variable resistor VROP1, VRON1
Fine adjustment	KP0 [2:0]	KN0 [2:0]	8-to-1 selector (voltage level of grayscale 1)
	KP1 [2:0]	KN1 [2:0]	8-to-1 selector (voltage level of grayscale 8)
	KP2 [2:0]	KN2 [2:0]	8-to-1 selector (voltage level of grayscale 20)
	KP3 [2:0]	KN3 [2:0]	8-to-1 selector (voltage level of grayscale 43)
	KP4 [2:0]	KN4 [2:0]	8-to-1 selector (voltage level of grayscale 55)
	KP5 [2:0]	KN5 [2:0]	8-to-1 selector (voltage level of grayscale 62)

Ladder resistors and 8-to-1 selector Block configuration

The reference voltage generating block consists of two ladder resistor units including variable resistors and 8-to-1 selectors. Each 8-to-1 selector selects one of the 8 voltage levels generated from the ladder resistor unit to output as a grayscale reference voltage. Both variable resistors and 8-to-1 selectors are controlled according to the **γ-**correction registers. This unit has pins to connect a volume resistor externally to compensate differences in various characteristics of panels.

Variable resistors

ILI9325 uses variable resistors of the following three purposes: gradient adjustment (VRCP(N)0/VRCP(N)1); amplitude adjustment (1) (VROP(N)0); and the amplitude adjustment (2) (VROP(N)1). The resistance values of these variable resistors are set by gradient adjustment registers and amplitude adjustment registers as follows.

Gradient adjustment		Amplitude adjustment (1)		Amplitude adjustment (2)	
PRP(N)0/1[2:0] Register	VRCP(N)0 Resistance	VRP(N)0[3:0] Register	VROP(N)0 Resistance	VRP(N)1[4:0] Register	VROP(N)1 Resistance
000	0R	0000	0R	00000	0R
001	4R	0001	2R	00001	1R
010	8R	0010	4R	00010	2R
011	12R	:	:	:	:
100	16R	:	:	:	:
101	20R	1101	26R	11101	29R
110	24R	1111	28R	11110	30R
111	28R	1111	30R	11111	31R

8-to-1 selectors

The 8-to-1 selector selects one of eight voltage levels generated from the ladder resistor unit according to the fine adjustment register and output the selected voltage level as a reference grayscale voltage (VgP(N)1~6). The table below shows the setting in the fine adjustment register and the selected voltage levels for respective reference grayscale voltages.

Fine adjustment registers and selected voltage						
Register	Selected Voltage					
KP(N)[2:0]	VgP(N)1	VgP(N)8	VgP(N)20	VgP(N)43	VgP(N)55	VgP(N)62
000	VP(N)1	VP(N)9	VP(N)17	VP(N)25	VP(N)33	VP(N)41
001	VP(N)2	VP(N)10	VP(N)18	VP(N)26	VP(N)34	VP(N)42
010	VP(N)3	VP(N)11	VP(N)19	VP(N)27	VP(N)35	VP(N)43
011	VP(N)4	VP(N)12	VP(N)20	VP(N)28	VP(N)36	VP(N)44
100	VP(N)5	VP(N)13	VP(N)21	VP(N)29	VP(N)37	VP(N)45
101	VP(N)6	VP(N)14	VP(N)22	VP(N)30	VP(N)38	VP(N)46
110	VP(N)7	VP(N)15	VP(N)23	VP(N)31	VP(N)39	VP(N)47
111	VP(N)8	VP(N)16	VP(N)24	VP(N)32	VP(N)40	VP(N)48

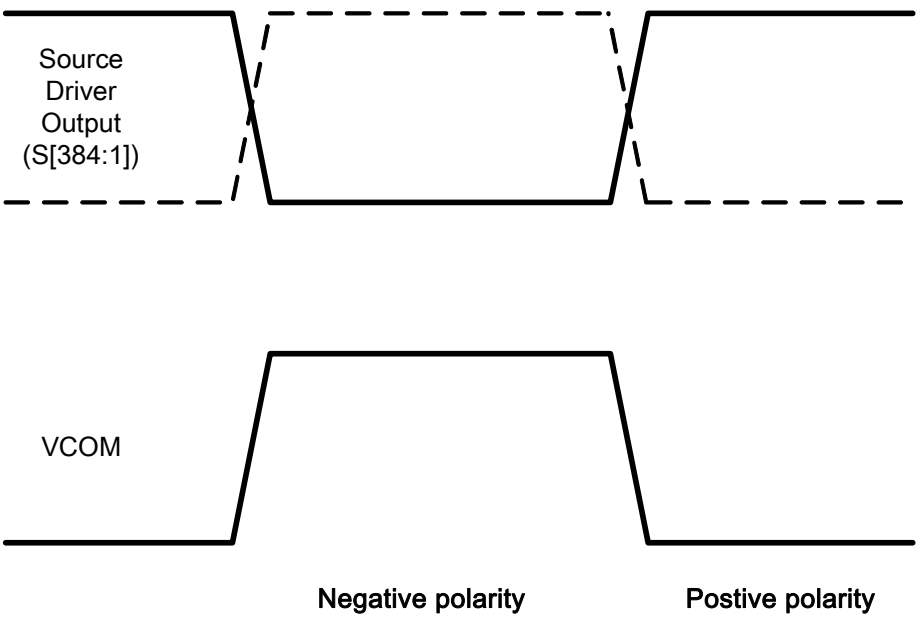


Figure 39 Relationship between Source Output and VCOM

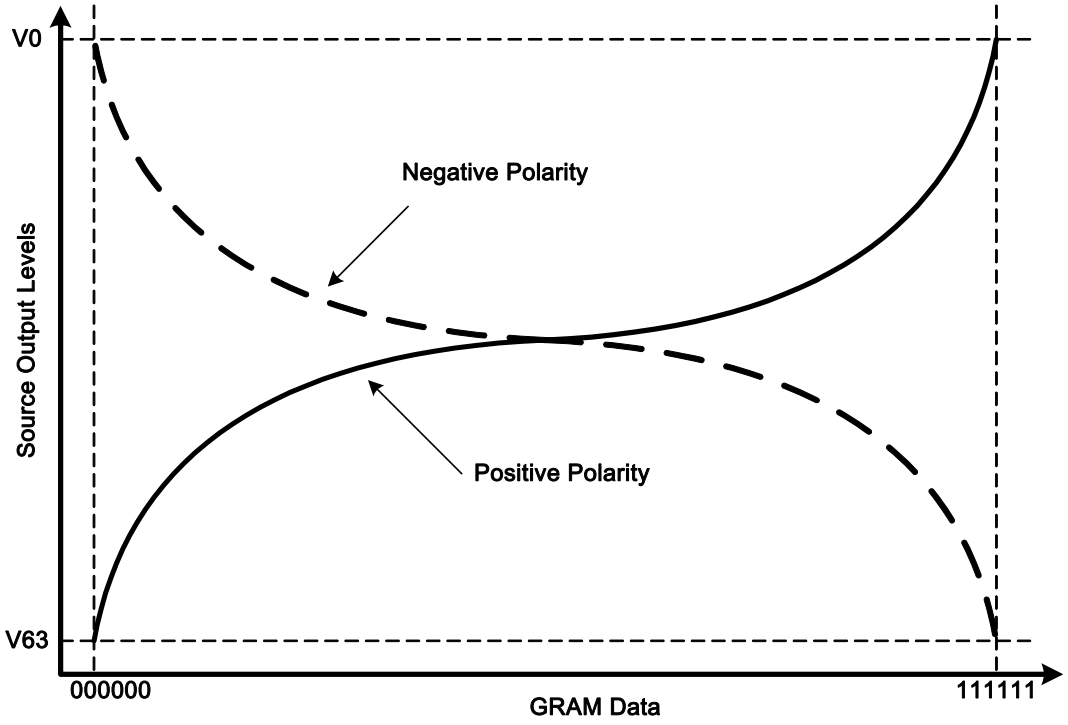


Figure 40 Relationship between GRAM Data and Output Level

13. Application

13.1. Configuration of Power Supply Circuit

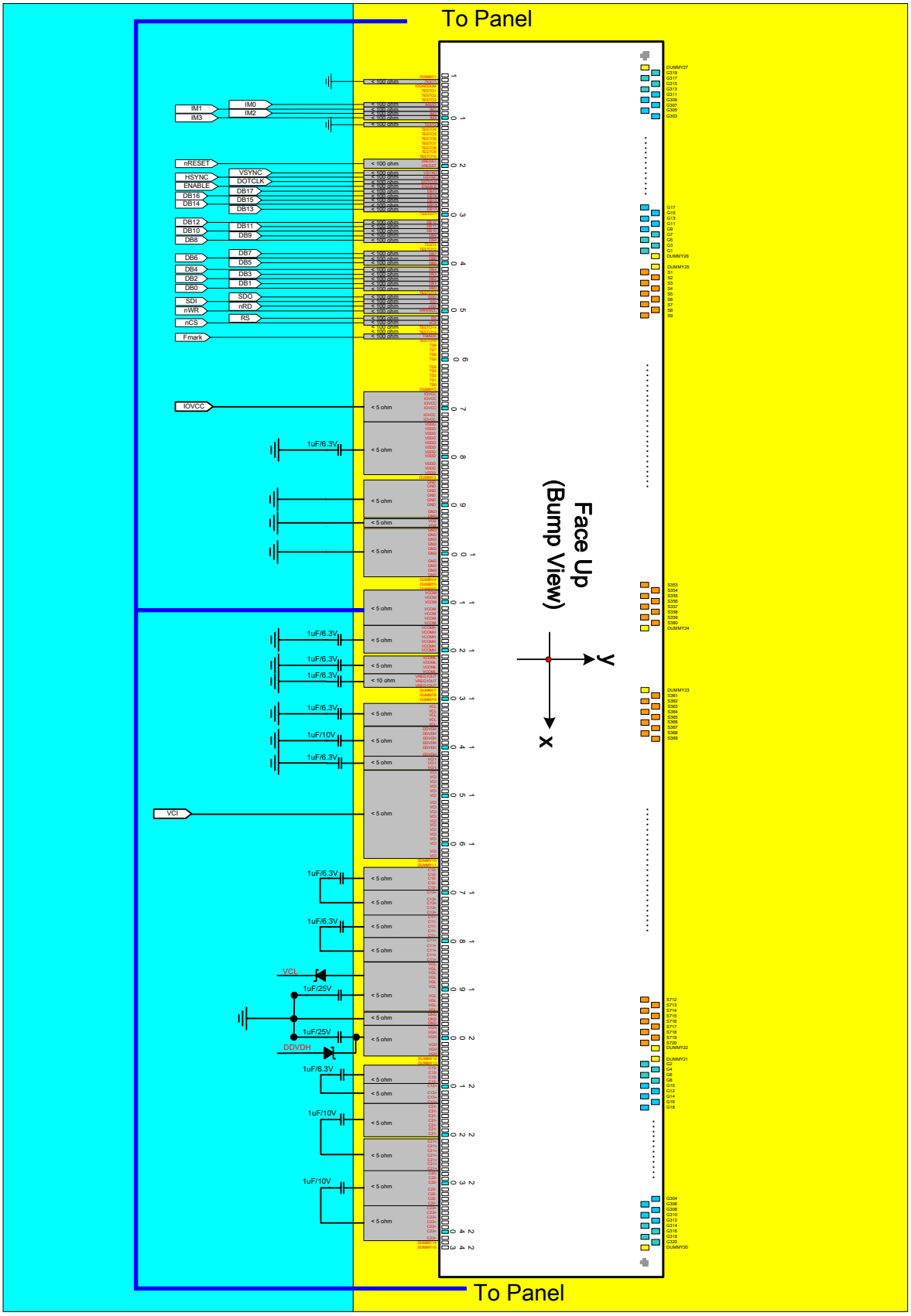


Figure 41 Power Supply Circuit Block

The following table shows specifications of external elements connected to the ILI9325's power supply circuit.

Items	Recommended Specification	Pin connection
Capacity 1 μF (B characteristics)	6.3V	VREG1OUT, VCI1, VDDD, VCL, VCOMH, VCOML, C11+/-, C12+/-, C13+/-,
	10V	DDVDH, C21+/-, C22+/-
	25V	VGH, VGL
Schottky diode	**VF<0.4V/20mA at 25°C, VR ≥30V** **(Recommended diode: HSC226)**	(GND – VGL), (Vci – VGH), (Vci – DDVDH)

13.2. Display ON/OFF Sequence

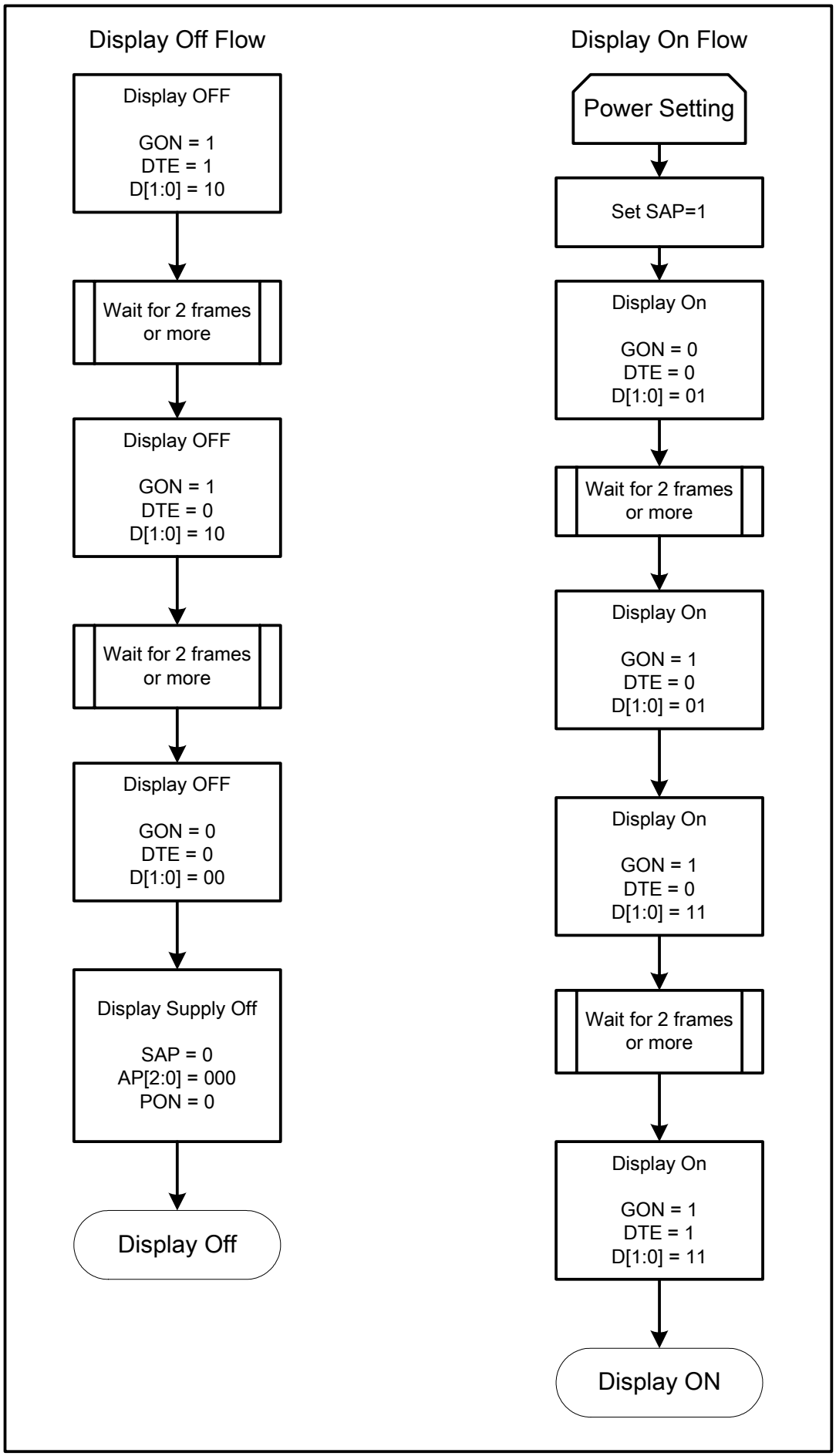


Figure 42 Display On/Off Register Setting Sequence

13.3. Standby and Sleep Mode

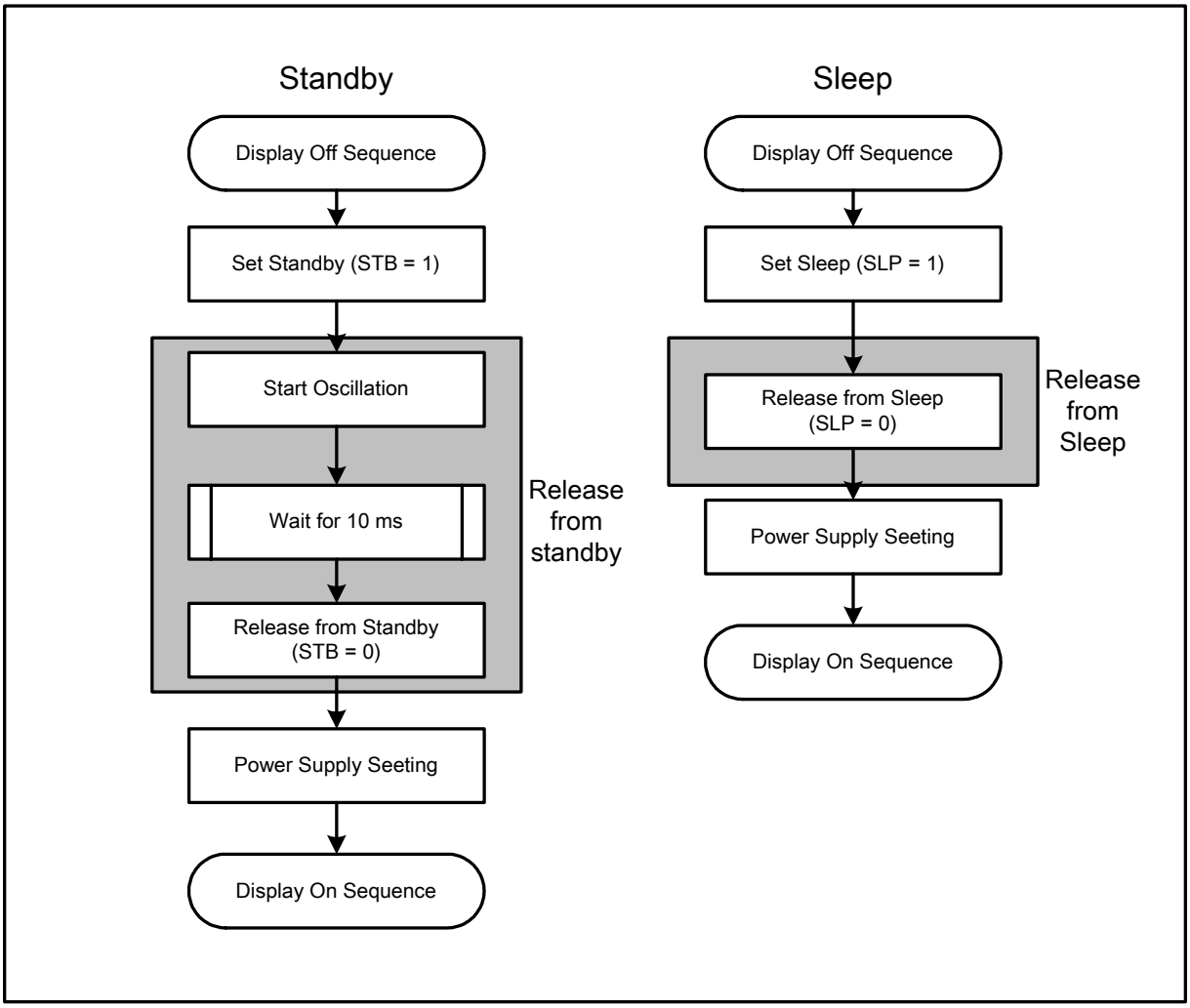


Figure 43 Standby/Sleep Mode Register Setting Sequence

13.4. Power Supply Configuration

When supplying and cutting off power, follow the sequence below. The setting time for oscillators, step-up circuits and operational amplifiers depends on external resistance and capacitance.

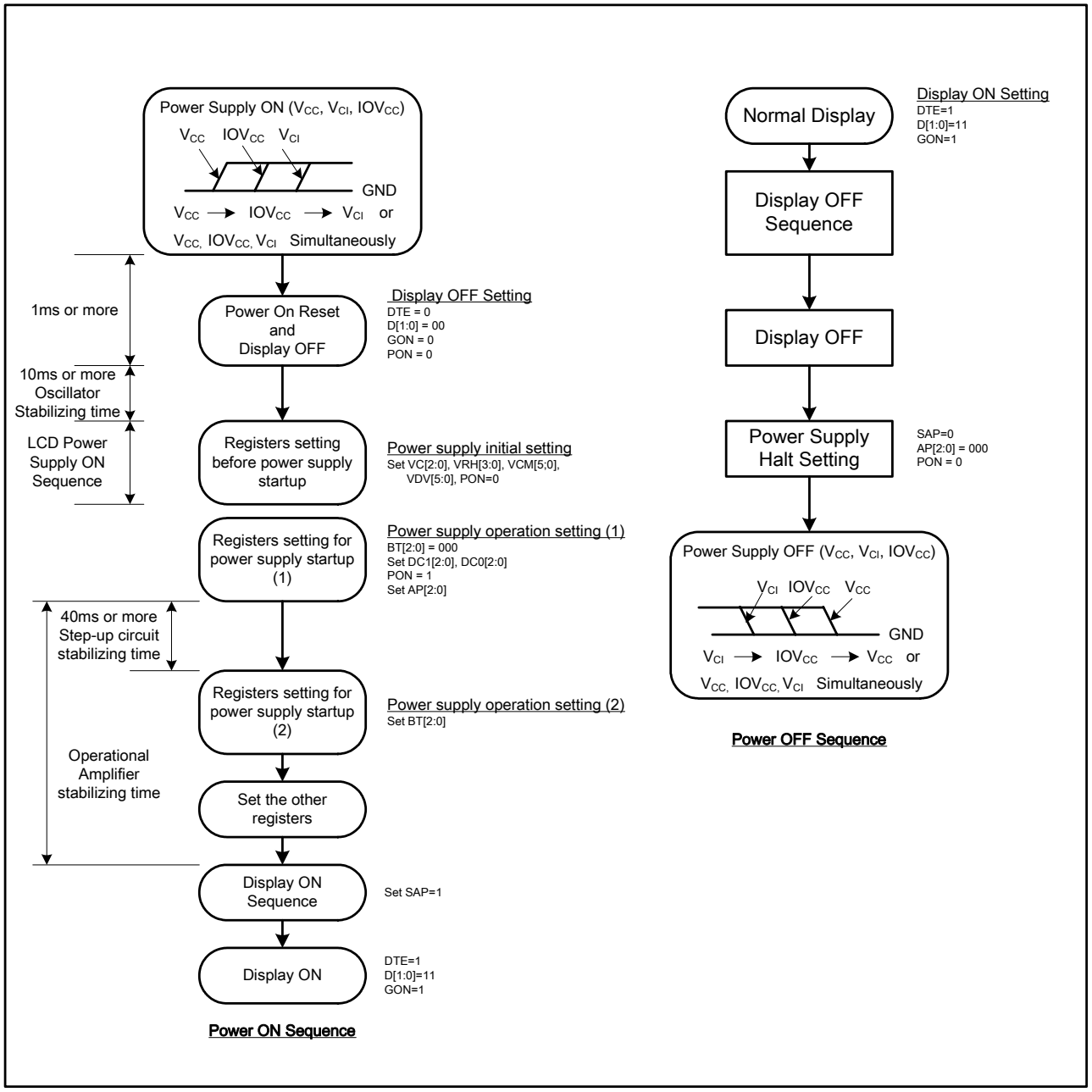


Figure 44 Power Supply ON/OFF Sequence

13.5. Voltage Generation

The pattern diagram for setting the voltages and the waveforms of the voltages of the ILI9325 are as follows.

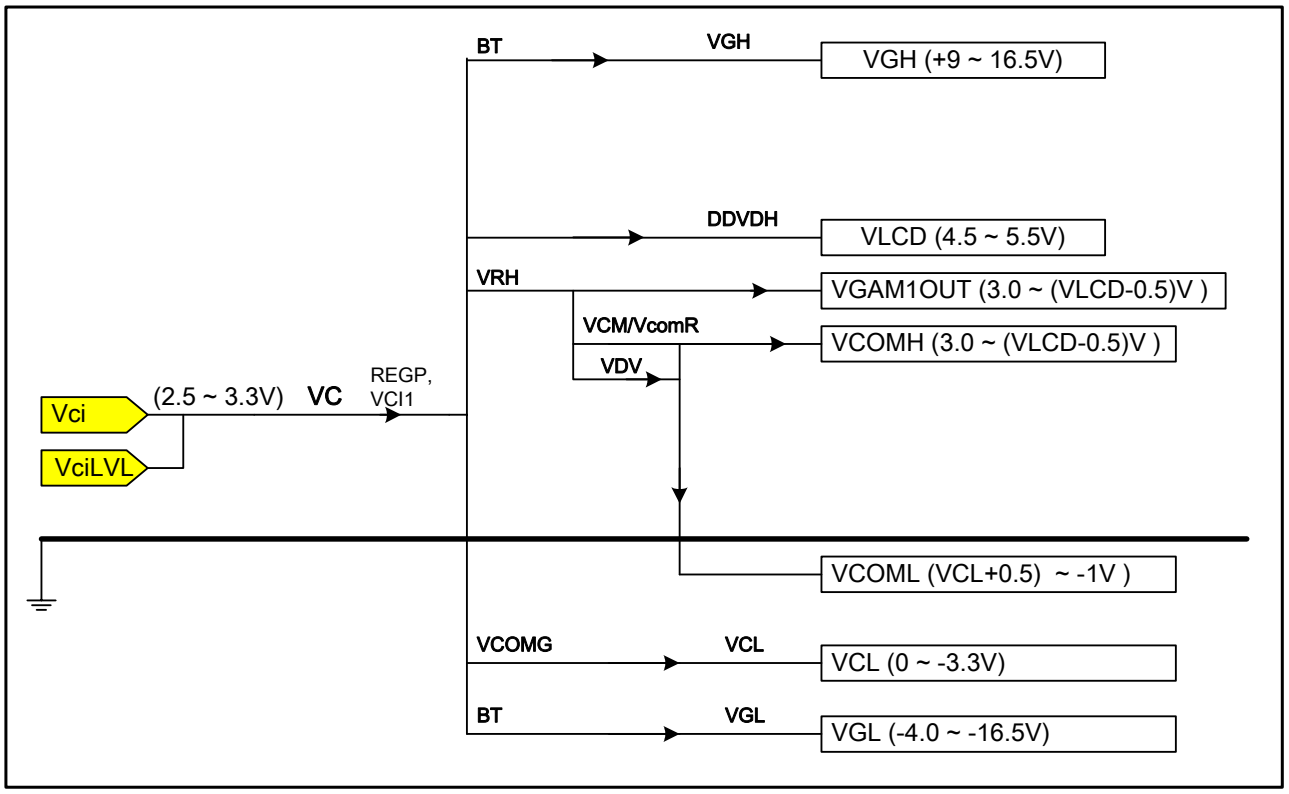


Figure 45 Voltage Configuration Diagram

Note: The DDVDH, VGH, VGL, and VCL output voltage levels are lower than their theoretical levels (ideal voltage levels) due to current consumption at respective outputs. The voltage levels in the following relationships (DDVDH – VREG1OUT) > 0.5V, (VCOML1 – VCL) > 0.5V, (VCOML2 – VCL) > 0.5V are the actual voltage levels. When the alternating cycles of VCOM are set high (e.g. the polarity inverts every line cycle), current consumption is large. In this case, check the voltage before use.

13.6. Applied Voltage to the TFT panel

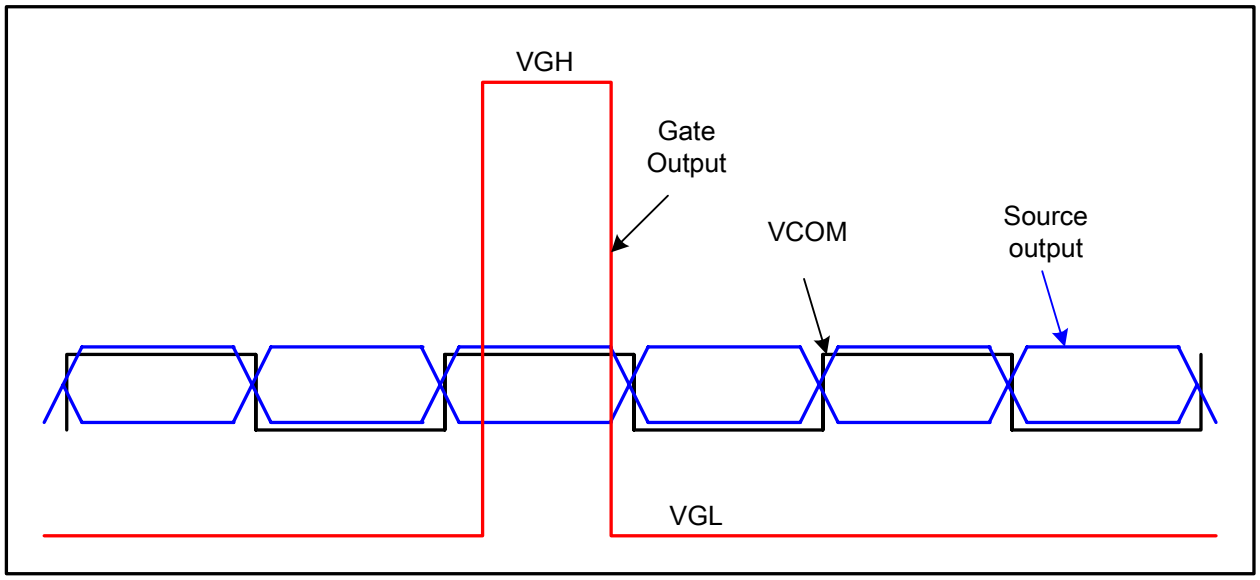


Figure 46 Voltage Output to TFT LCD Panel

13.7. Partial Display Function

The ILI9325 allows selectively driving two partial images on the screen at arbitrary positions set in the screen drive position registers.

The following example shows the setting for partial display function:

Base Image Display Setting	
BASEE	0
NL[5:0]	6'h27
Partial Image 1 Display Setting	
PTDE0	1
PTSA0[8:0]	9'h000
PTEA0[8:0]	9'h00F
PTDP0[8:0]	9'h080
Partial Image 2 Display Setting	
PTDE1	1
PTSA1[8:0]	9'h020
PTEA1[8:0]	9'h02F
PTDP1[8:0]	9'h0C0

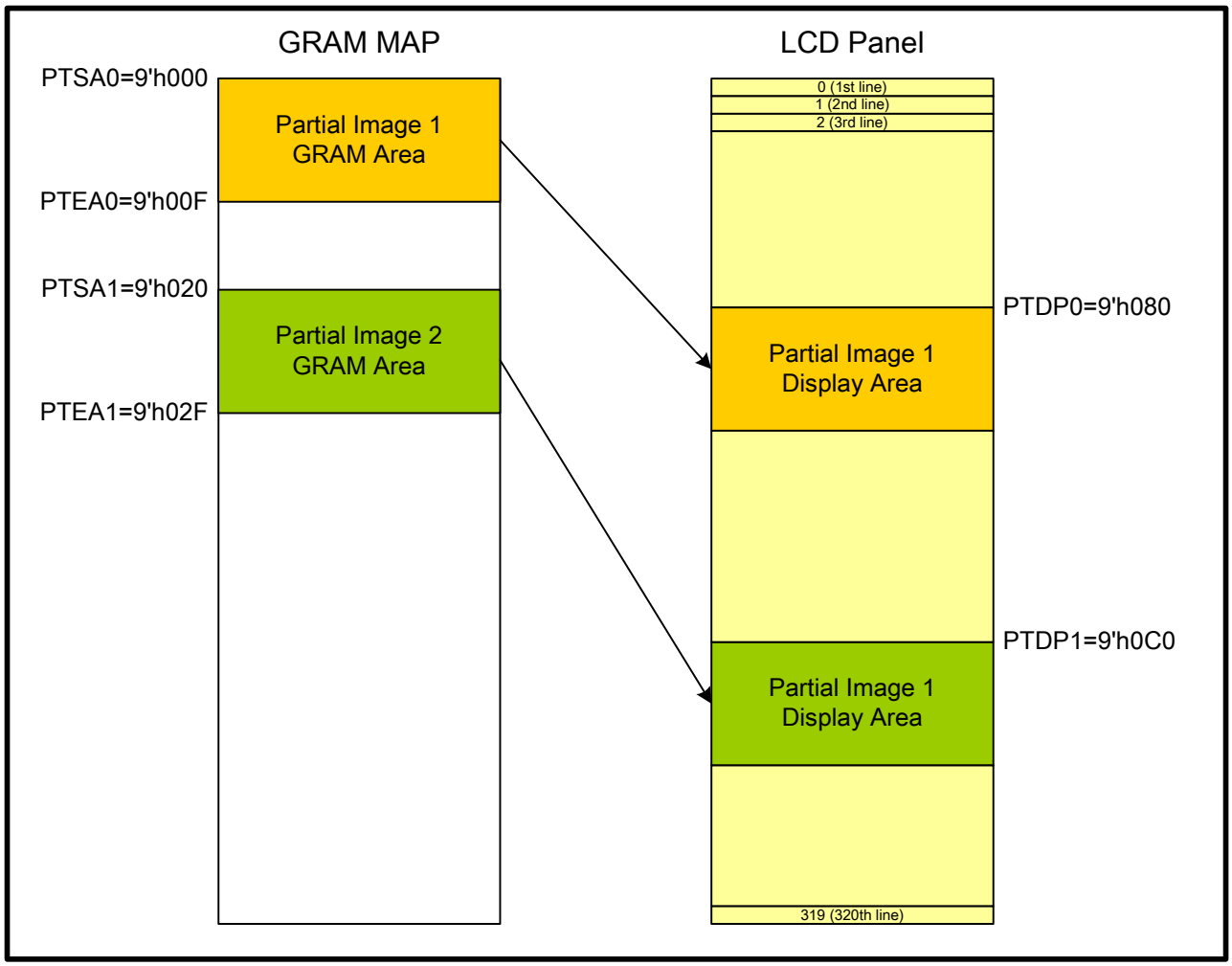
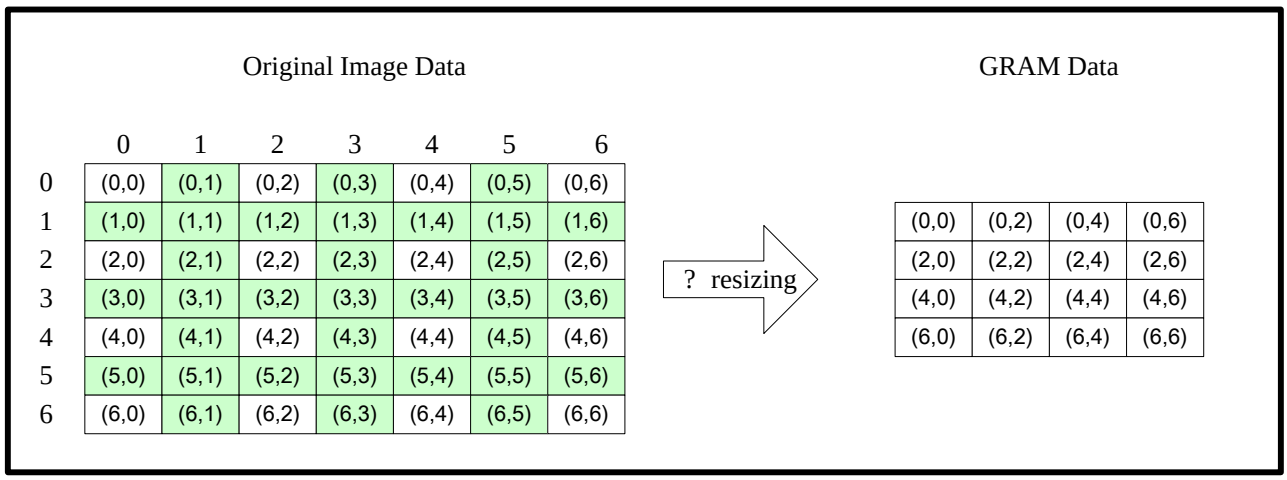


Figure 47 Partial Display Example

13.8. Resizing Function

ILI9325 supports resizing function (x1/2, x1/4), which is performed when writing image data to GRAM. The resizing function is enabled by setting a window address area and the RSZ bit which represents the resizing factor (x1/2, x1/4) of image. The resizing function allows the system to transfer the original-size image data into the GRAM with resized image data.



	0	1	2	3	4	5	6
0	(0,0)	(0,1)	(0,2)	(0,3)	(0,4)	(0,5)	(0,6)
1	(1,0)	(1,1)	(1,2)	(1,3)	(1,4)	(1,5)	(1,6)
2	(2,0)	(2,1)	(2,2)	(2,3)	(2,4)	(2,5)	(2,6)
3	(3,0)	(3,1)	(3,2)	(3,3)	(3,4)	(3,5)	(3,6)
4	(4,0)	(4,1)	(4,2)	(4,3)	(4,4)	(4,5)	(4,6)
5	(5,0)	(5,1)	(5,2)	(5,3)	(5,4)	(5,5)	(5,6)
6	(6,0)	(6,1)	(6,2)	(6,3)	(6,4)	(6,5)	(6,6)

(0,0)	(0,2)	(0,4)	(0,6)
(2,0)	(2,2)	(2,4)	(2,6)
(4,0)	(4,2)	(4,4)	(4,6)
(6,0)	(6,2)	(6,4)	(6,6)

Figure 48 Data transfer in resizing

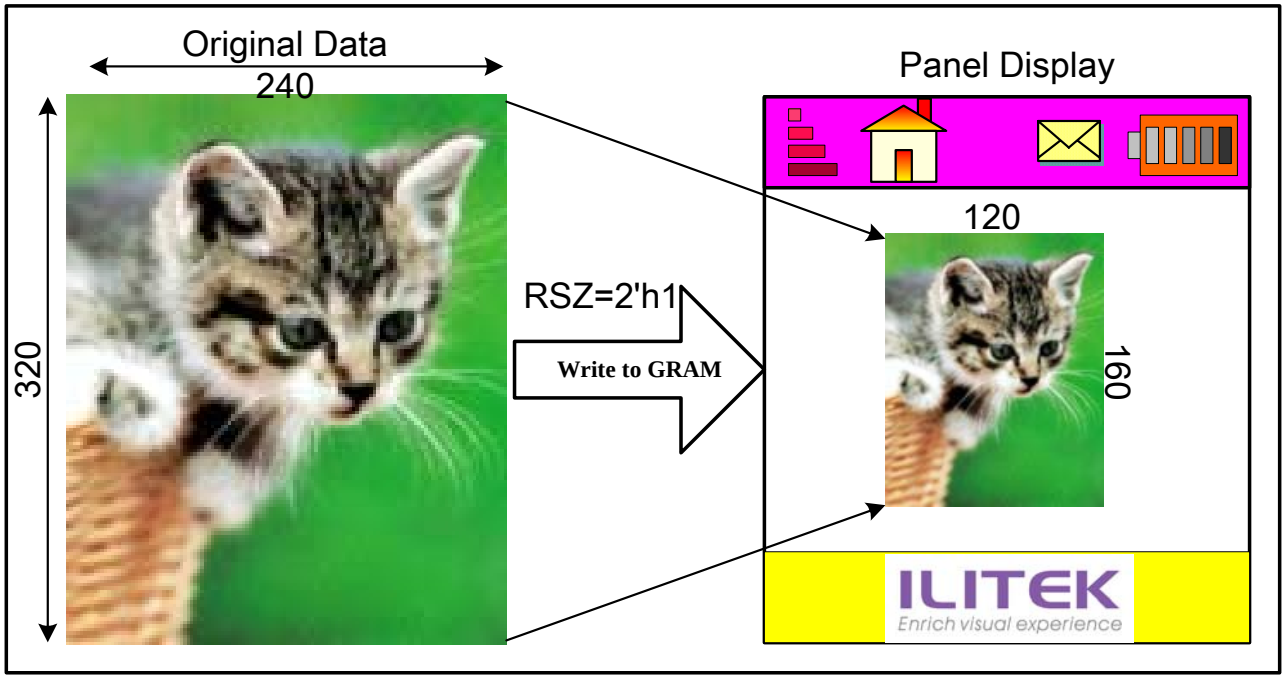
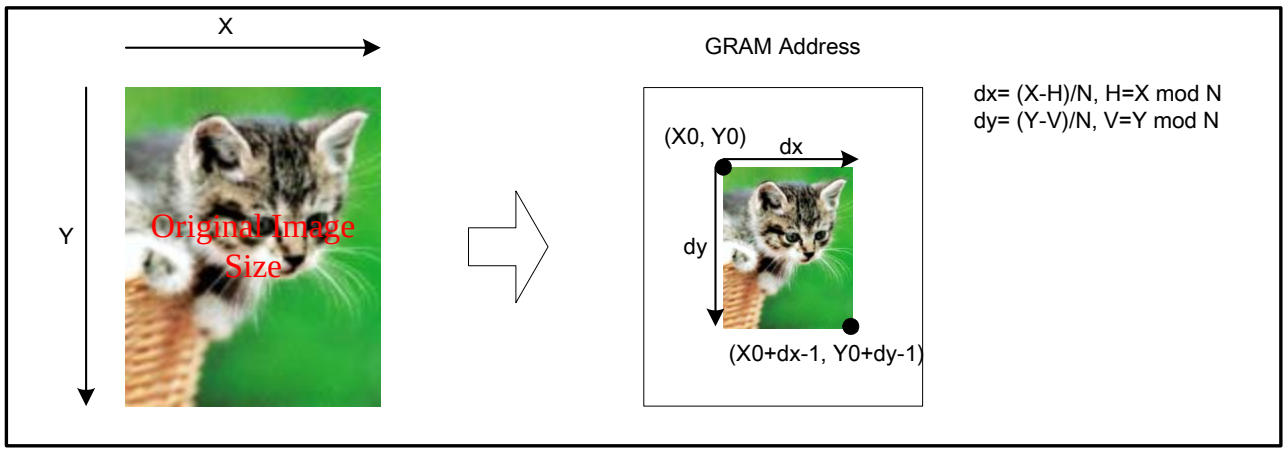


Figure 49 Resizing Example

Original Image Size (X × Y)	Resized Image Resolution	
	1/2 (RSZ=2'h1)	1/4 (RSZ=2'h3)
640 × 480	320 × 240	160 × 120
352 × 288	176 × 144	88 × 72
320 × 240	160 × 120	80× 60
176 × 144	88 × 72	44× 36
120 × 160	60× 80	30 × 40
132 × 132	66 × 66	33 × 33

The RSZ bit sets the resizing factor of an image. When setting a window address area in the internal GRAM, the GRAM window address area must fit the size of resized image. The following example show the resizing setting.



Original image data number in horizontal direction		X
Original image data number in Vertical direction		Y
Resizing Ration		1/N
Resizing Setting	RSZ	N-1
Remainder pixels in horizontal direction	RCH	H
Remainder pixels in vertical direction	RCV	V
GRAM writing start address	AD	(x0, y0)
GRAM window setting	HSA	x0
	HEA	x0+dx-1
	VSA	y0
	VEA	y0+dy-1

14. Electrical Characteristics

14.1. Absolute Maximum Ratings

The absolute maximum rating is listed on following table. When ILI9325 is used out of the absolute maximum ratings, the ILI9325 may be permanently damaged. To use the ILI9325 within the following electrical characteristics limit is strongly recommended for normal operation. If these electrical characteristic conditions are exceeded during normal operation, the ILI9325 will malfunction and cause poor reliability.

Item	Symbol	Unit	Value	Note
Power supply voltage (1)	VCC, IOVCC	V	-0.3 ~ + 4.6	1, 2
Power supply voltage (1)	VCI - GND	V	-0.3 ~ + 4.6	1, 4
Power supply voltage (1)	DDVDH - GND	V	-0.3 ~ + 6.0	1, 4
Power supply voltage (1)	GND -VCL	V	-0.3 ~ + 4.6	1
Power supply voltage (1)	DDVDH - VCL	V	-0.3 ~ + 9.0	1, 5
Power supply voltage (1)	VGH - GND	V	-0.3 ~ + 18.5	1, 5
Power supply voltage (1)	GND - VGL	V	-0.3 ~ + 18.5	1, 6
Input voltage	Vt	V	-0.3 ~ VCC+ 0.3	1
Operating temperature	Topr	°C	-40 ~ + 85	8, 9
Storage temperature	Tstg	°C	-55 ~ + 110	8, 9

Notes:
1. VCC,DGND must be maintained
2. (High) (VCC = VCC) ≥ DGND (Low), (High) IOVCC ≥ DGND (Low).
3. Make sure (High) VCI ≥ DGND (Low).
4. Make sure (High) DDVDH ≥ ASSD (Low).
5. Make sure (High) DDVDH ≥ VCL (Low).
6. Make sure (High) VGH ≥ ASSD (Low).
7. Make sure (High) ASSD ≥ VGL (Low).
8. For die and wafer products, specified up to 85°C.
9. This temperature specifications apply to the TCP package

14.2. DC Characteristics

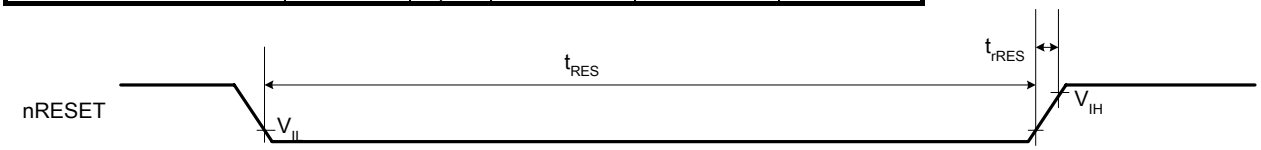
(VCC = 2.40 ~ 3.30V, IOVCC = 1.65 ~ 3.30V, Ta= -40 ~ 85 °C)

Item	Symbol	Unit	Test Condition	Min.	Typ.	Max.	Note
Input high voltage	V_{IH}	V	VCC= 1.8 ~ 3.3V	0.8*IOVCC	-	IOVCC	-
Input low voltage	V_{IL}	V	VCC= 1.8 ~ 3.3V	-0.3	-	0.2*IOVCC	-
Output high voltage(1) (DB0-17 Pins)	V_{OH1}	V	IOH = -0.1 mA	0.8*IOVCC	-	-	-
Output low voltage (DB0-17 Pins)	V_{OL1}	V	IOVCC=1.65~3.3V VCC= 2.4 ~ 3.3V IOL = 0.1mA	-	-	0.2*IOVCC	-
I/O leakage current	I_{LI}	µA	Vin = 0 ~ VCC	-0.1	-	0.1	-
Current consumption during normal operation (V_{CC} – DGND)	I_{OP}	µA	VCC=2.8V , Ta=25°C , fOSC = 512KHz (Line) GRAM data = 0000h	-	100 (VCC)	-	-
Current consumption during standby mode (V_{CC} – DGND)	I_{ST}	µA	VCC=2.8V , Ta=25 °C	-	5	10	-
LCD Drive Power Supply Current (DDVDH-DGND)	ILCD	mA	VCC=2.8V , VREG1OUT =4.8V DDVDH=5.0V , fOSC = 512KHz (320 line) , Ta=25 °C, GRAM data = 0000h, REV="0", SAP="001", ON4-0="0", OP4-0="0", MP52-00="0", MN52-00="0", CP12-00="0" CN12-00="0	-	3.0	-	-
LCD Driving Voltage (DDVDH-DGND)	DDVDH	V	-	4.5	-	6	-
Output voltage deviation		mV	-	-	10	-	-
Dispersion of the Average Output Voltage	V	mV	-	-10	-	10	-

14.3. Reset Timing Characteristics

Reset Timing Characteristics (VCC = 1.8 ~ 3.3 V, IOVCC = 1.65 ~ 3.3 V)

Item	Symbol	Unit	Min.	Typ.	Max.
Reset low-level width	t_{RES}	ms	1	-	-
Reset rise time	t_{rRES}	µs	-	-	10



14.4. LCD Driver Output Characteristics

Item	Symbol	Timing diagram	Min.	Typ.	Max.	Unit
Driver output delay time	tdd	VCC=2.8V, DDVDH=5.0V, VREG1OUT =4.8V, RC oscillation: fosc =512kHz (320 lines), Ta=25°C REV=0, SAP=010, AP=010, 0N14-00=0, 0P14-00=0, MP52-00=0, MN52-00=0, CP12-00=0, CN12-00=0, Load resistance R=10kΩ, Load capacitance C=20pF • when the level changes from a same grayscale level on all pins • Time to reach +/-35mV when VCOM polarity inverts	-	35	-	µs

14.5. AC Characteristics

14.5.1. i80-System Interface Timing Characteristics

Normal Write Mode (IOVCC = 1.65~3.3V, VCC=2.4~3.3V)

Item		Symbol	Unit	Min.	Typ.	Max.	Test Condition
Bus cycle time	Write	t_{CYCW}	ns	100	-	-	-
	Read	t_{CYCR}	ns	300	-	-	-
Write low-level pulse width		PW_{LW}	ns	50	-	500	-
Write high-level pulse width		PW_{HW}	ns	50	-	-	-
Read low-level pulse width		PW_{LR}	ns	150	-	-	-
Read high-level pulse width		PW_{HR}	ns	150	-	-	
Write / Read rise / fall time		t_{WRr}/t_{WRf}	ns	-	-	25	
Setup time	Write (RS to nCS, E/nWR)	t_{AS}	ns	10	-	-	
	Read (RS to nCS, RW/nRD)			5	-	-	
Address hold time		t_{AH}	ns	5	-	-	
Write data set up time		t_{DSW}	ns	10	-	-	
Write data hold time		t_H	ns	15	-	-	
Read data delay time		t_{DDR}	ns	-	-	100	
Read data hold time		t_{DHR}	ns	5	-	-	

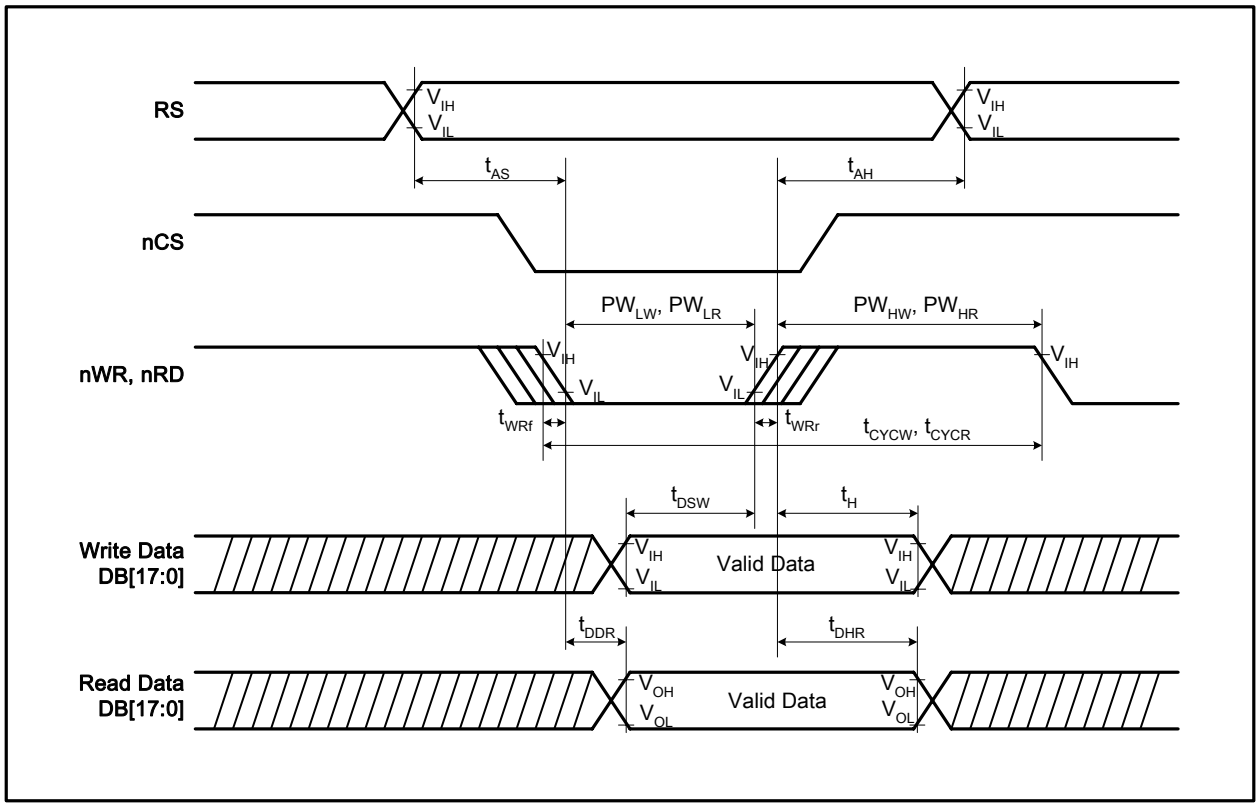


Figure 50 i80-System Bus Timing

14.5.2. Serial Data Transfer Interface Timing Characteristics

(IOVCC= 1.653.3V and VCC=2.4~3.3V)

Item		Symbol	Unit	Min.	Typ.	Max.	Test Condition
Serial clock cycle time	Write (received)	t_{SCYC}	μs	100	-	-	
	Read (transmitted)	t_{SCYC}	μs	200	-	-	
Serial clock high – level pulse width	Write (received)	t_{SCH}	ns	40	-	-	
	Read (transmitted)	t_{SCH}	ns	100	-	-	
Serial clock low – level pulse width	Write (received)	t_{SCL}	ns	40	-	-	
	Read (transmitted)	t_{SCL}	ns	100	-	-	
Serial clock rise / fall time		t_{SCr}, t_{SCf}	ns	-	-	5	
Chip select set up time		t_{CSU}	ns	10	-	-	
Chip select hold time		t_{CH}	ns	50	-	-	
Serial input data set up time		t_{SISU}	ns	20	-	-	
Serial input data hold time		t_{SIH}	ns	20	-	-	
Serial output data set up time		t_{SOD}	ns	-	-	100	
Serial output data hold time		t_{SOH}	ns	5	-	-	

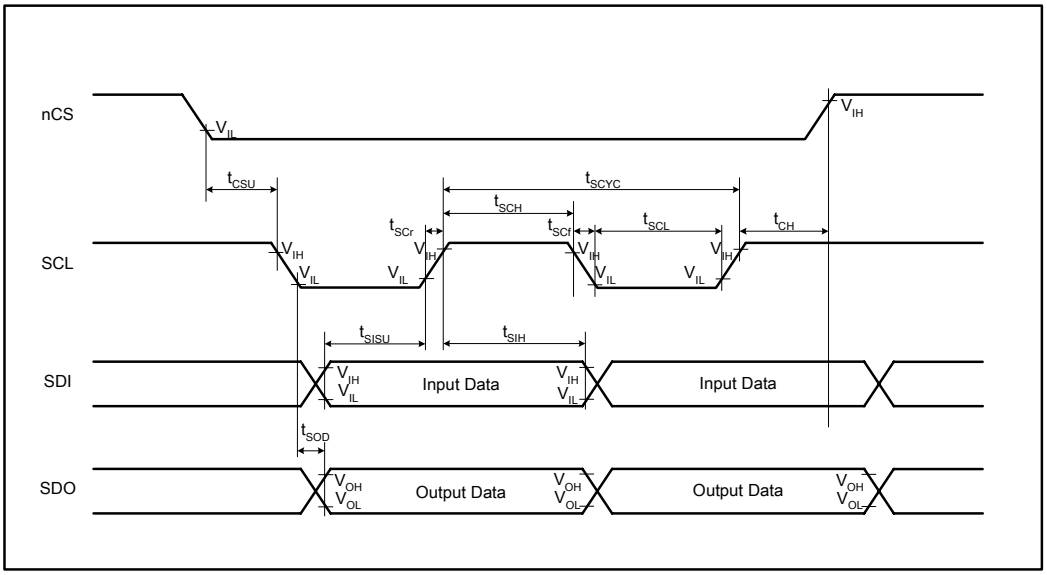


Figure 51 SPI System Bus Timing

14.5.3. RGB Interface Timing Characteristics

18/16-bit Bus RGB Interface Mode (IOVCC = 1.65 ~ 3.3V, VCC=2.4~3.3V)

Item	Symbol	Unit	Min.	Typ.	Max.	Test Condition
VSYNC/HSYNC setup time	t_{SYNCS}	ns	0	-	-	-
ENABLE setup time	t_{ENS}	ns	10	-	-	-
ENABLE hold time	t_{ENH}	ns	10	-	-	-
PD Data setup time	t_{PDS}	ns	10	-	-	-
PD Data hold time	t_{PDH}	ns	40	-	-	-
DOTCLK high-level pulse width	PWDH	ns	40	-	-	-
DOTCLK low-level pulse width	PWDL	ns	40	-	-	-
DOTCLK cycle time	t_{CYCD}	ns	100	-	-	-
DOTCLK, VSYNC, HSYNC, rise/fall time	t_{rghr}, t_{rghf}	ns	-	-	25	-

6-bit Bus RGB Interface Mode (IOVCC = 1.65 ~ 3.3V, VCC=2.4~3.3V)

Item	Symbol	Unit	Min.	Typ.	Max.	Test Condition

VSYNC/HSYNC setup time	t_{SYNCS}	ns	0	-	-	-
ENABLE setup time	t_{ENS}	ns	10	-	-	-
ENABLE hold time	t_{ENH}	ns	10	-	-	-
PD Data setup time	t_{PDS}	ns	10	-	-	-
PD Data hold time	t_{PDH}	ns	30	-	-	-
DOTCLK high-level pulse width	PWDH	ns	30	-	-	-
DOTCLK low-level pulse width	PWDL	ns	30	-	-	-
DOTCLK cycle time	t_{CYCD}	ns	80	-	-	-
DOTCLK, VSYNC, HSYNC, rise/fall time	t_{rghr}, t_{rghf}	ns	-	-	25	-

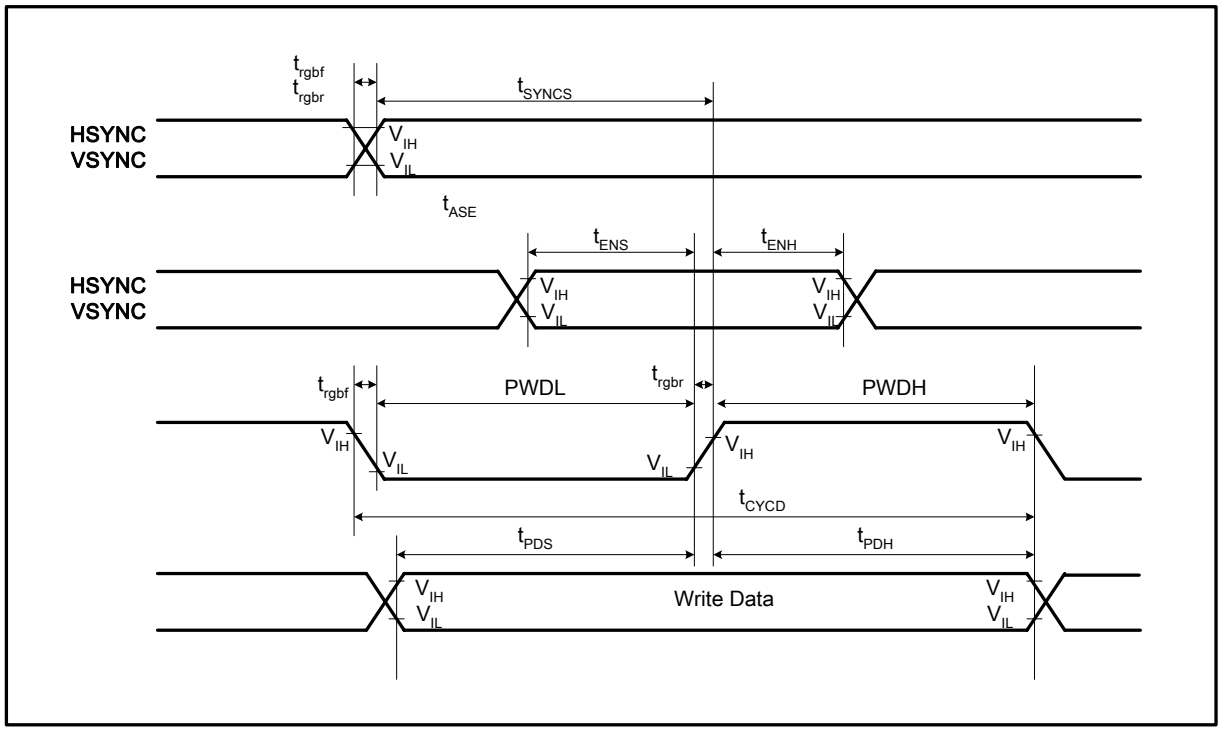


Figure52 RGB Interface Timing

15. Revision History

Version No.	Date	Page	Description
V0.28	2007/07/05	96	Modify the FPC circuit

C. Hoja de datos ADS7843

ADS7843

SBAS090B – SEPTEMBER 2000 – REVISED MAY 2002

TOUCH SCREEN CONTROLLER

FEATURES

- 4-WIRE TOUCH SCREEN INTERFACE
- RATIOMETRIC CONVERSION
- SINGLE SUPPLY: 2.7V to 5V
- UP TO 125kHz CONVERSION RATE
- SERIAL INTERFACE
- PROGRAMMABLE 8- OR 12-BIT RESOLUTION
- 2 AUXILIARY ANALOG INPUTS
- FULL POWER-DOWN CONTROL

APPLICATIONS

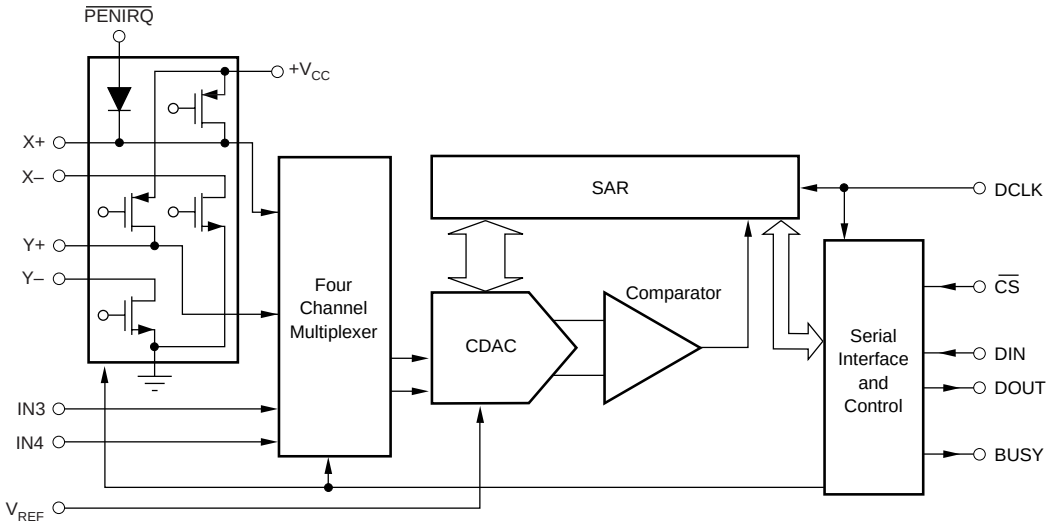
- PERSONAL DIGITAL ASSISTANTS
- PORTABLE INSTRUMENTS
- POINT-OF-SALES TERMINALS
- PAGERS
- TOUCH SCREEN MONITORS

DESCRIPTION

The ADS7843 is a 12-bit sampling Analog-to-Digital Converter (ADC) with a synchronous serial interface and low on-resistance switches for driving touch screens. Typical power dissipation is 750µW at a 125kHz throughput rate and a +2.7V supply. The reference voltage (V_{REF}) can be varied between 1V and $+V_{CC}$, providing a corresponding input voltage range of 0V to V_{REF}. The device includes a shutdown mode which reduces typical power dissipation to under 0.5µW. The ADS7843 is specified down to 2.7V operation.

Low power, high speed, and onboard switches make the ADS7843 ideal for battery-operated systems such as personal digital assistants with resistive touch screens and other portable equipment. The ADS7843 is available in an SSOP-16 package and is specified over the –40°C to +85°C temperature range.

US Patent No. 6246394



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

ABSOLUTE MAXIMUM RATINGS[1]

$+V_{CC}$ to GND	–0.3V to +6V
Analog Inputs to GND	–0.3V to $+V_{CC}$ + 0.3V
Digital Inputs to GND	–0.3V to $+V_{CC}$ + 0.3V
Power Dissipation	250mW
Maximum Junction Temperature	+150°C
Operating Temperature Range	–40°C to +85°C
Storage Temperature Range	–65°C to +150°C
Lead Temperature (soldering, 10s)	+300°C

NOTE: (1) Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. Exposure to absolute maximum conditions for extended periods may affect device reliability.

ELECTROSTATIC DISCHARGE SENSITIVITY

This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

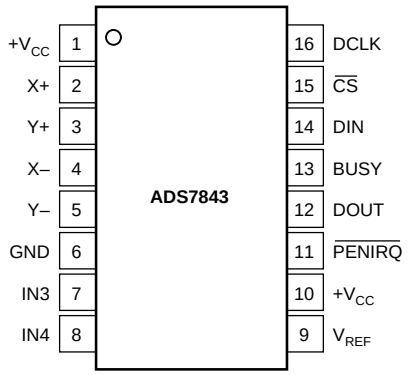
PACKAGE/ORDERING INFORMATION

PRODUCT	MAXIMUM INTEGRAL LINEARITY ERROR (LSB)	PACKAGE-LEAD	PACKAGE DESIGNATOR[1]	SPECIFIED TEMPERATURE RANGE	PACKAGE MARKING	ORDERING NUMBER	TRANSPORT MEDIA, QUANTITY
ADS7843E	±2	SSOP-16	DBQ	–40°C to +85°C	ADS7843E	ADS7843E	Rails, 100
"	"	"	"	"	ADS7843E	ADS7843E/2K5	Tape and Reel, 2500

NOTES: (1) For the most current specifications and package information, refer to our web site at www.ti.com.

PIN CONFIGURATION

Top View **SSOP**



PIN DESCRIPTION

PIN	NAME	DESCRIPTION
1	$+V_{CC}$	Power Supply, 2.7V to 5V.
2	X+	X+ Position Input. ADC input Channel 1.
3	Y+	Y+ Position Input. ADC input Channel 2.
4	X–	X– Position Input
5	Y–	Y– Position Input
6	GND	Ground
7	IN3	Auxiliary Input 1. ADC input Channel 3.
8	IN4	Auxiliary Input 2. ADC input Channel 4.
9	V_{REF}	Voltage Reference Input
10	$+V_{CC}$	Power Supply, 2.7V to 5V.
11	$\overline{PENIRQ}$	Pen Interrupt. Open anode output (requires 10kΩ to 100kΩ pull-up resistor externally).
12	DOUT	Serial Data Output. Data is shifted on the falling edge of DCLK. This output is high impedance when $\overline{CS}$ is HIGH.
13	BUSY	Busy Output. This output is high impedance when $\overline{CS}$ is HIGH.
14	DIN	Serial Data Input. If $\overline{CS}$ is LOW, data is latched on rising edge of DCLK.
15	$\overline{CS}$	Chip Select Input. Controls conversion timing and enables the serial input/output register.
16	DCLK	External Clock Input. This clock runs the SAR conversion process and synchronizes serial data I/O.

ELECTRICAL CHARACTERISTICS

At T_A = –40°C to +85°C, $+V_{CC}$ = +2.7V, V_{REF} = +2.5V, f_{SAMPLE} = 125kHz, f_{CLK} = 16 • f_{SAMPLE} = 2MHz, 12-bit mode, and digital inputs = GND or $+V_{CC}$, unless otherwise noted.

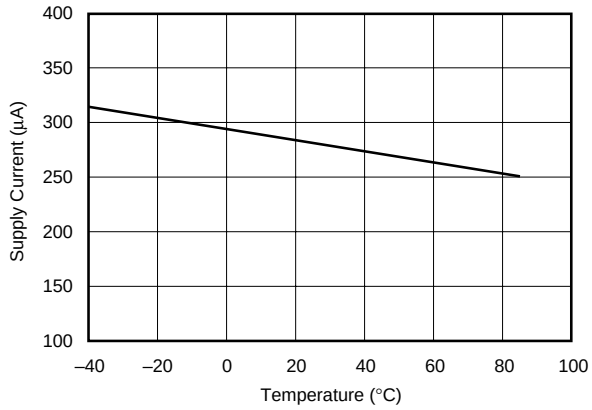
PARAMETER	CONDITIONS	ADS7843E MIN	ADS7843E TYP	ADS7843E MAX	UNITS
ANALOG INPUT					
Full-Scale Input Span	Positive Input – Negative Input	0		V_{REF}	V
Absolute Input Range	Positive Input	–0.2		$+V_{CC}$ +0.2	V
	Negative Input	–0.2		+0.2	V
Capacitance			25		pF
Leakage Current			0.1		µA
SYSTEM PERFORMANCE					
Resolution			12		Bits
No Missing Codes		11			Bits
Integral Linearity Error				±2	LSB(1)
Offset Error				±6	LSB
Offset Error Match			0.1	1.0	LSB
Gain Error				±4	LSB
Gain Error Match			0.1	1.0	LSB
Noise			30		µVrms
Power-Supply Rejection			70		dB
SAMPLING DYNAMICS					
Conversion Time				12	Clk Cycles
Acquisition Time		3			Clk Cycles
Throughput Rate				125	kHz
Multiplexer Settling Time			500		ns
Aperture Delay			30		ns
Aperture Jitter			100		ps
Channel-to-Channel Isolation	V_{IN} = 2.5Vp-p at 50kHz		100		dB
SWITCH DRIVERS					
On-Resistance					
Y+, X+			5		Ω
Y–, X–			6		Ω
REFERENCE INPUT					
Range		1.0		$+V_{CC}$	V
Resistance	$\overline{CS}$ = GND or $+V_{CC}$		5		GΩ
Input Current			13	40	µA
	f_{SAMPLE} = 12.5kHz		2.5		µA
	$\overline{CS}$ = $+V_{CC}$		0.001	3	µA
DIGITAL INPUT/OUTPUT					
Logic Family			CMOS		
Logic Levels, Except $\overline{PENIRQ}$					
V_{IH}	$\lvert I_{IH} \rvert \le +5\mu A$	$+V_{CC}$ • 0.7		$+V_{CC}$ +0.3	
V_{IL}	$\lvert I_{IL} \rvert \le +5\mu A$	–0.3		+0.8	V
V_{OH}	I_{OH} = –250µA	$+V_{CC}$ • 0.8			V
V_{OL}	I_{OL} = 250µA			0.4	V
$\overline{PENIRQ}$					
V_{OL}	T_A = 0°C to +85°C, 100kΩ Pull-Up			0.8	V
Data Format			Straight Binary		
POWER-SUPPLY REQUIREMENTS					
$+V_{CC}$	Specified Performance	2.7		3.6	V
Quiescent Current			280	650	µA
	f_{SAMPLE} = 12.5kHz		220		µA
	Shutdown Mode with DCLK = DIN = $+V_{CC}$			3	µA
Power Dissipation	$+V_{CC}$ = +2.7V			1.8	mW
TEMPERATURE RANGE					
Specified Performance		–40		+85	°C

NOTE: (1) LSB means Least Significant Bit. With V_{REF} equal to +2.5V, 1LSB is 610µV.

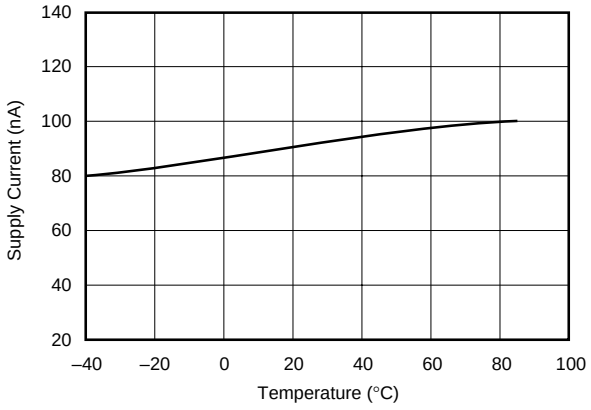
TYPICAL CHARACTERISTICS

At T_A = +25°C, $+V_{CC}$ = +2.7V, V_{REF} = +2.5V, f_{SAMPLE} = 125kHz, and f_{CLK} = 16 • f_{SAMPLE} = 2MHz, unless otherwise noted.

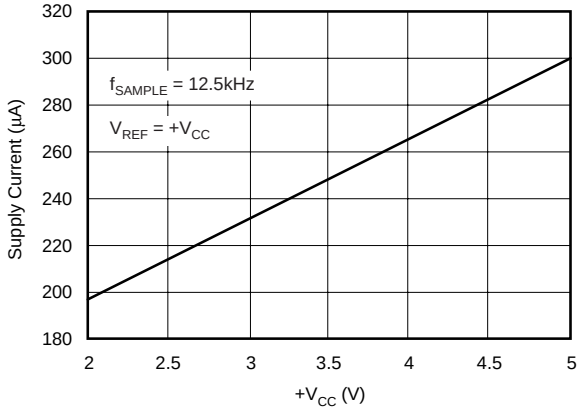
SUPPLY CURRENT vs TEMPERATURE



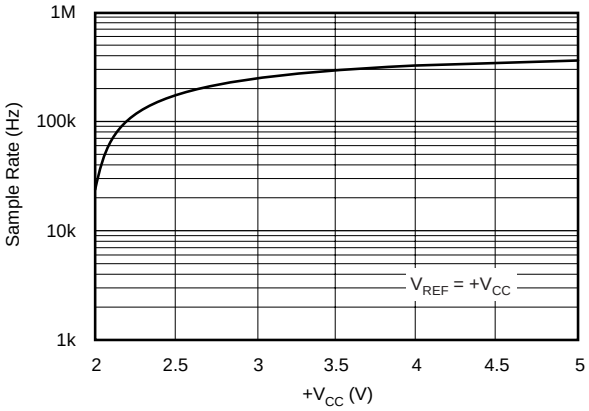
POWER-DOWN SUPPLY CURRENT vs TEMPERATURE



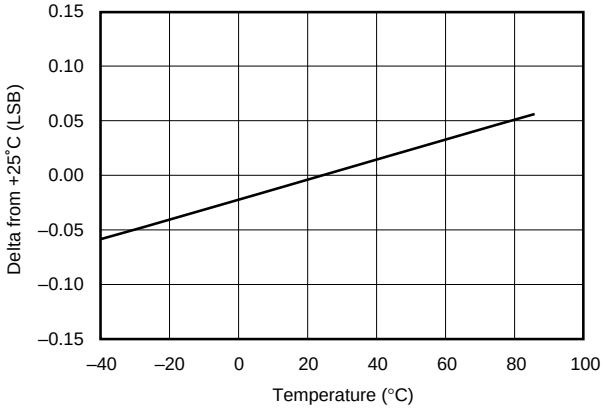
SUPPLY CURRENT vs $+V_{CC}$



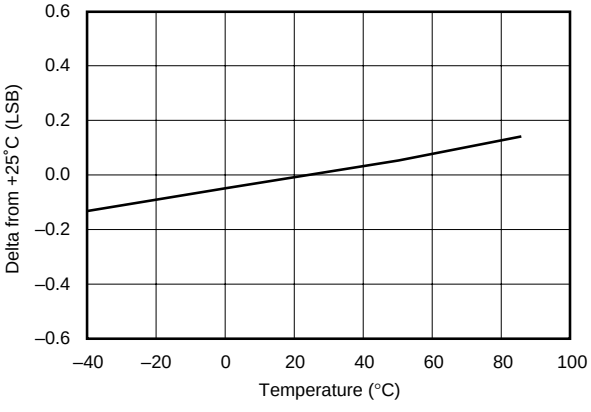
MAXIMUM SAMPLE RATE vs $+V_{CC}$



CHANGE IN GAIN vs TEMPERATURE



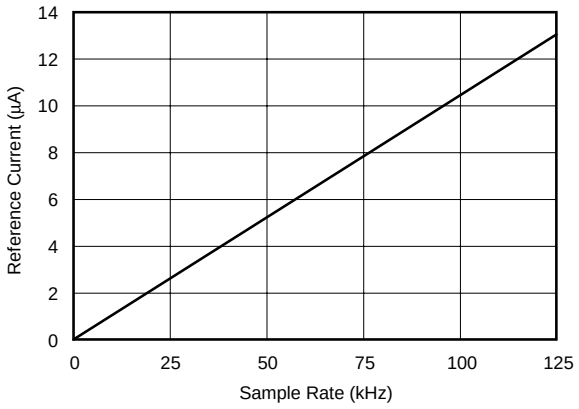
CHANGE IN OFFSET vs TEMPERATURE



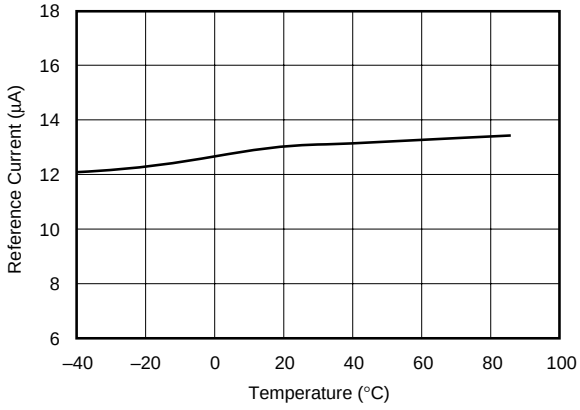
TYPICAL CHARACTERISTICS (Cont.)

At T_A = +25°C, $+V_{CC}$ = +2.7V, V_{REF} = +2.5V, f_{SAMPLE} = 125kHz, and f_{CLK} = 16 • f_{SAMPLE} = 2MHz, unless otherwise noted.

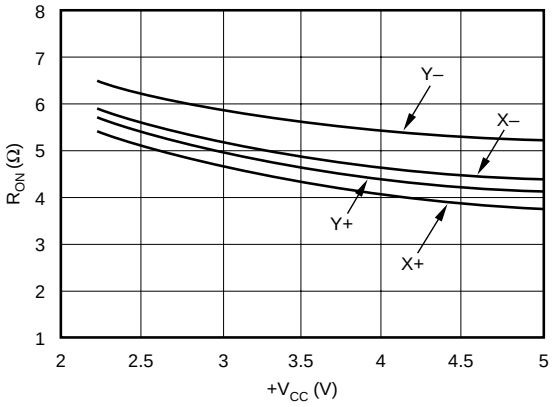
REFERENCE CURRENT vs SAMPLE RATE



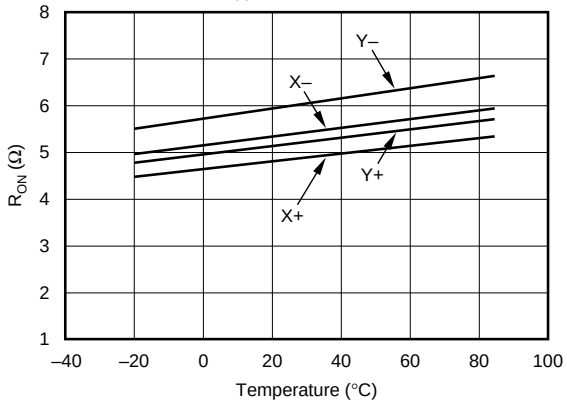
REFERENCE CURRENT vs TEMPERATURE



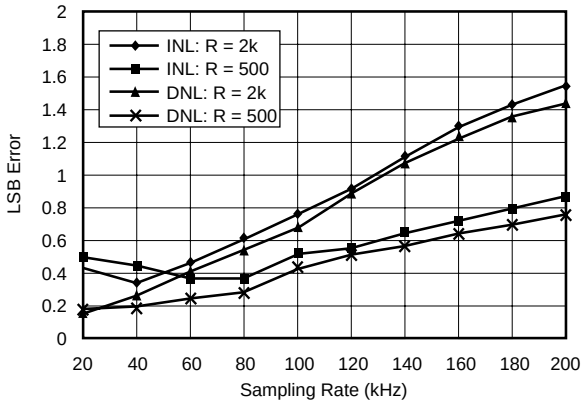
SWITCH-ON RESISTANCE vs $+V_{CC}$
(X+, Y+: $+V_{CC}$ to Pin; X–, Y–: Pin to GND)



SWITCH-ON RESISTANCE vs TEMPERATURE
(X+, Y+: $+V_{CC}$ to Pin; X–, Y–: Pin to GND)



MAXIMUM SAMPLING RATE vs R_{IN}



THEORY OF OPERATION

The ADS7843 is a classic Successive Approximation Register (SAR) ADC. The architecture is based on capacitive redistribution which inherently includes a sample-and-hold function. The converter is fabricated on a 0.6µs CMOS process.

The basic operation of the ADS7843 is shown in Figure 1. The device requires an external reference and an external clock. It operates from a single supply of 2.7V to 5.25V. The external reference can be any voltage between 1V and $+V_{CC}$. The value of the reference voltage directly sets the input range of the converter. The average reference input current depends on the conversion rate of the ADS7843.

The analog input to the converter is provided via a four-channel multiplexer. A unique configuration of low on-resistance switches allows an unselected ADC input channel to provide power and an accompanying pin to provide ground for an external device. By maintaining a differential input to the converter and a differential reference architecture, it is possible to negate the switch's on-resistance error (should this be a source of error for the particular measurement).

ANALOG INPUT

See Figure 2 for a block diagram of the input multiplexer on the ADS7843, the differential input of the ADC, and the converter's differential reference. Table I and Table II show the relationship between the A2, A1, A0, and SER/$\overline{\text{DFR}}$ control bits and the configuration of the ADS7843. The control bits are provided serially via the DIN pin—see the Digital Interface section of this data sheet for more details.

When the converter enters the hold mode, the voltage difference between the +IN and –IN inputs (see Figure 2) is captured on the internal capacitor array. The input current on the analog inputs depends on the conversion rate of the device. During the sample period, the source must charge the internal sampling capacitor (typically 25pF). After the capacitor has been fully charged, there is no further input current. The rate of charge transfer from the analog source to the converter is a function of conversion rate.

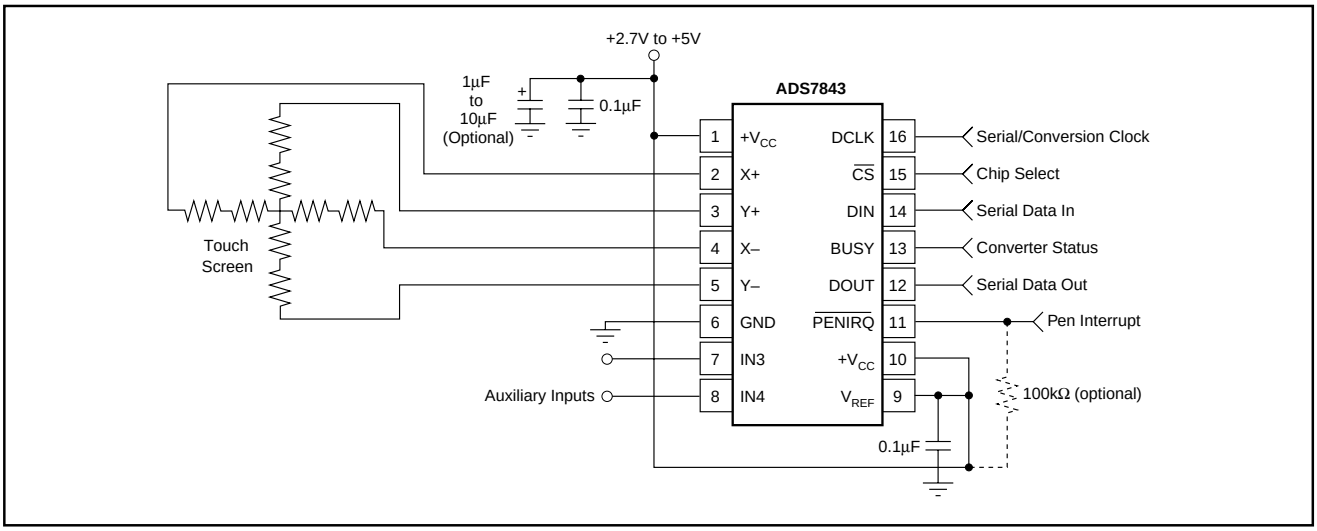


FIGURE 1. Basic Operation of the ADS7843.

A2	A1	A0	X+	Y+	IN3	IN4	–IN(1)	X SWITCHES	Y SWITCHES	+REF(1)	–REF(1)
0	0	1	+IN				GND	OFF	ON	$+V_{REF}$	GND
1	0	1		+IN			GND	ON	OFF	$+V_{REF}$	GND
0	1	0			+IN		GND	OFF	OFF	$+V_{REF}$	GND
1	1	0				+IN	GND	OFF	OFF	$+V_{REF}$	GND

NOTE: (1) Internal node, for clarification only—not directly accessible by the user.

TABLE I. Input Configuration, Single-Ended Reference Mode (SER/$\overline{\text{DFR}}$ HIGH).

A2	A1	A0	X+	Y+	IN3	IN4	–IN(1)	X SWITCHES	Y SWITCHES	+REF(1)	–REF(1)
0	0	1	+IN				–Y	OFF	ON	+Y	–Y
1	0	1		+IN			–X	ON	OFF	+X	–X
0	1	0			+IN		GND	OFF	OFF	$+V_{REF}$	GND
1	1	0				+IN	GND	OFF	OFF	$+V_{REF}$	GND

NOTE: (1) Internal node, for clarification only—not directly accessible by the user.

TABLE II. Input Configuration, Differential Reference Mode (SER/$\overline{\text{DFR}}$ LOW).

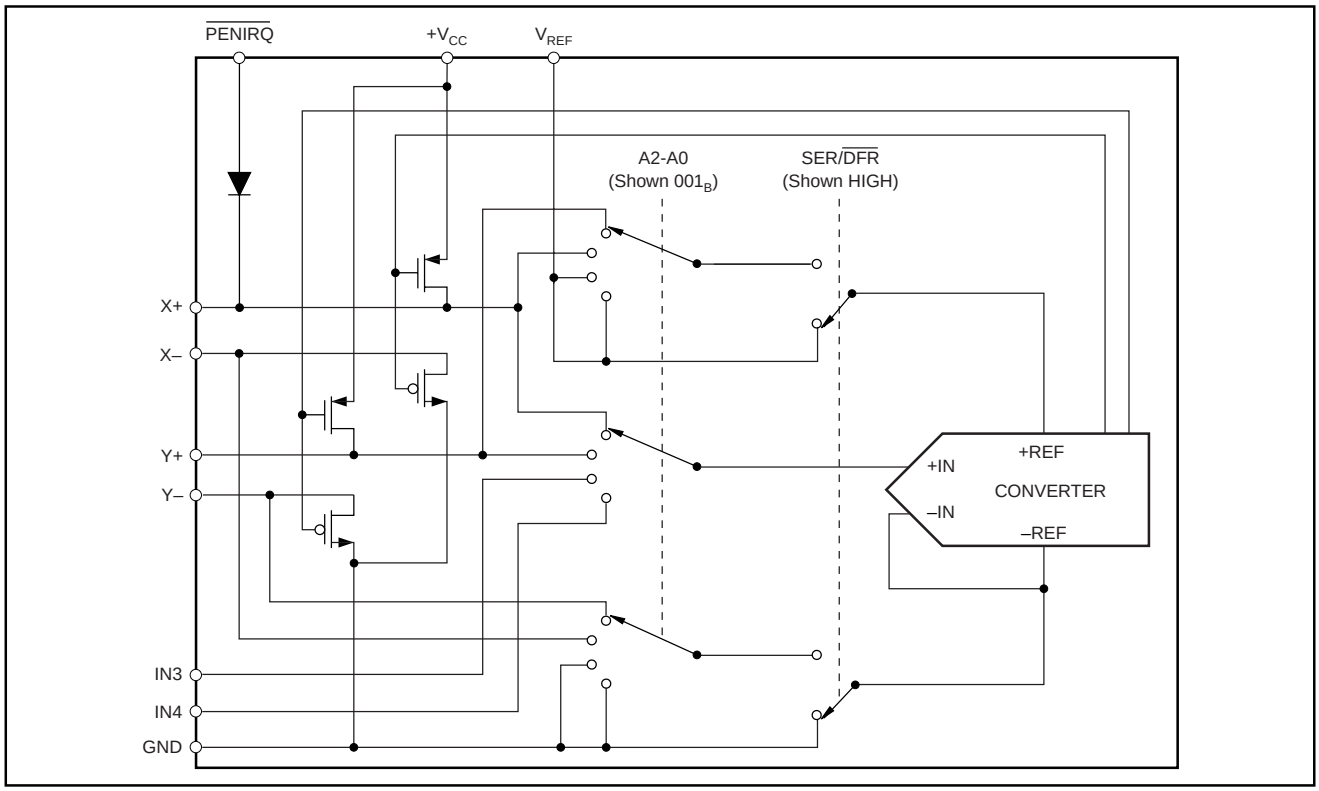


FIGURE 2. Simplified Diagram of Analog Input.

REFERENCE INPUT

The voltage difference between +REF and –REF (shown in Figure 2) sets the analog input range. The ADS7843 will operate with a reference in the range of 1V to $+V_{CC}$. There are several critical items concerning the reference input and its wide voltage range. As the reference voltage is reduced, the analog voltage weight of each digital output code is also reduced. This is often referred to as the LSB (least significant bit) size and is equal to the reference voltage divided by 4096. Any offset or gain error inherent in the ADC will appear to increase, in terms of LSB size, as the reference voltage is reduced. For example, if the offset of a given converter is 2LSBs with a 2.5V reference, it will typically be 5LSBs with a 1V reference. In each case, the actual offset of the device is the same, 1.22mV. With a lower reference voltage, more care must be taken to provide a clean layout including adequate bypassing, a clean (low noise, low ripple) power supply, a low-noise reference, and a low-noise input signal.

The voltage into the V_{REF} input is not buffered and directly drives the Capacitor Digital-to-Analog Converter (CDAC) portion of the ADS7843. Typically, the input current is 13µA with V_{REF} = 2.7V and f_{SAMPLE} = 125kHz. This value will vary by a few microamps depending on the result of the conversion. The reference current diminishes directly with both conversion rate and reference voltage. As the current from the reference is drawn on each bit decision, clocking the converter more quickly during a given conversion period will not reduce overall current drain from the reference.

There is also a critical item regarding the reference when making measurements where the switch drivers are on. For this discussion, it's useful to consider the basic operation of the ADS7843 as shown in Figure 1. This particular application shows the device being used to digitize a resistive touch screen. A measurement of the current Y position of the pointing device is made by connecting the X+ input to the ADC, turning on the Y+ and Y– drivers, and digitizing the voltage on X+ (shown in Figure 3). For this measurement, the resistance in the X+ lead does not affect the conversion (it does affect the settling time, but the resistance is usually small enough that this is not a concern).

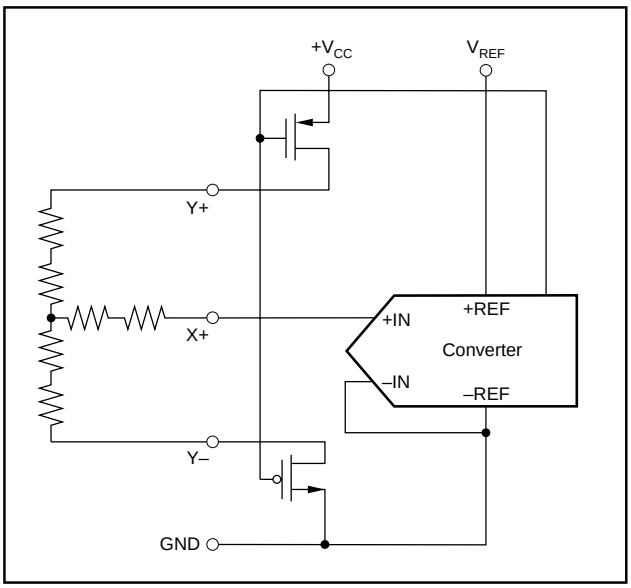


FIGURE 3. Simplified Diagram of Single-Ended Reference (SER/$\overline{DFR}$ HIGH, Y Switches Enabled, X+ is Analog Input).

However, since the resistance between Y+ and Y– is fairly low, the on-resistance of the Y drivers does make a small difference. Under the situation outlined so far, it would not be possible to achieve a 0V input or a full-scale input regardless of where the pointing device is on the touch screen because some voltage is lost across the internal switches. In addition, the internal switch resistance is unlikely to track the resistance of the touch screen, providing an additional source of error.

This situation can be remedied as shown in Figure 4. By setting the SER/$\overline{\text{DFR}}$ bit LOW, the +REF and –REF inputs are connected directly to Y+ and Y–. This makes the A/D conversion ratiometric. The result of the conversion is always a percentage of the external resistance, regardless of how it changes in relation to the on-resistance of the internal switches. Note that there is an important consideration regarding power dissipation when using the ratiometric mode of operation, see the Power Dissipation section for more details.

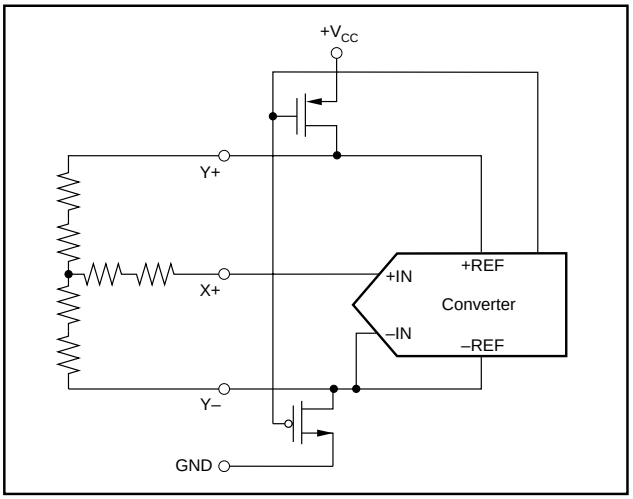


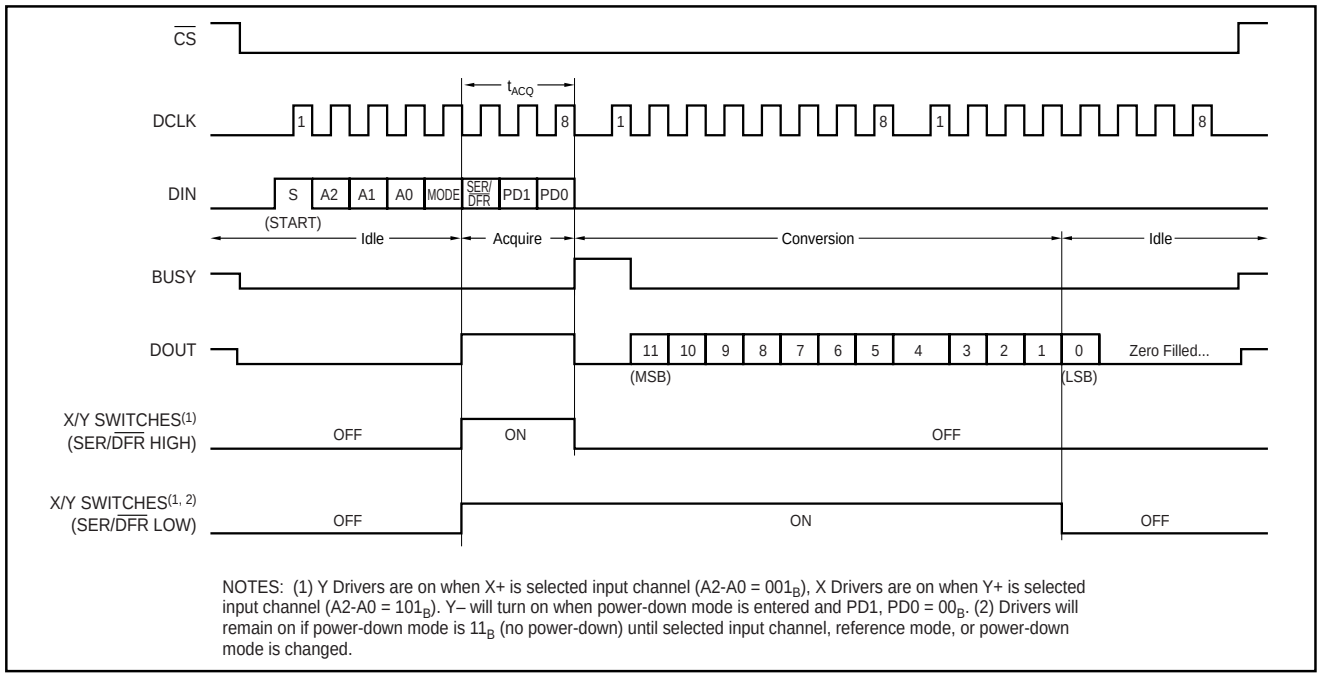
FIGURE 4. Simplified Diagram of Differential Reference (SER/$\overline{\text{DFR}}$ LOW, Y Switches Enabled, X+ is Analog Input).

As a final note about the differential reference mode, it must be used with +V_{CC} as the source of the +REF voltage and cannot be used with V_{REF}. It is possible to use a high precision reference on V_{REF} and single-ended reference mode for measurements which do not need to be ratiometric. Or, in some cases, it could be possible to power the converter directly from a precision reference. Most references can provide enough power for the ADS7843, but they might not be able to supply enough current for the external load (such as a resistive touch screen).

DIGITAL INTERFACE

Figure 5 shows the typical operation of the ADS7843's digital interface. This diagram assumes that the source of the digital signals is a microcontroller or digital signal processor with a basic serial interface. Each communication between the processor and the converter consists of eight clock cycles. One complete conversion can be accomplished with three serial communications, for a total of 24 clock cycles on the DCLK input.

The first eight clock cycles are used to provide the control byte via the DIN pin. When the converter has enough information about the following conversion to set the input multiplexer, switches, and reference inputs appropriately, the converter enters the acquisition (sample) mode and, if needed, the internal switches are turned on. After three more clock cycles, the control byte is complete and the converter enters the conversion mode. At this point, the input sample-and-hold goes into the hold mode and the internal switches may turn off. The



NOTES: (1) Y Drivers are on when X+ is selected input channel (A2-A0 = 001_B), X Drivers are on when Y+ is selected input channel (A2-A0 = 101_B). Y– will turn on when power-down mode is entered and PD1, PD0 = 00_B. (2) Drivers will remain on if power-down mode is 11_B (no power-down) until selected input channel, reference mode, or power-down mode is changed.

FIGURE 5. Conversion Timing, 24 Clocks per Conversion, 8-bit Bus Interface. No DCLK Delay Required with Dedicated Serial Port.

next 12th clock cycles accomplish the actual A/D conversion. If the conversion is ratiometric (SER/$\overline{DFR}$ LOW), the internal switches are on during the conversion. A 13th clock cycle is needed for the last bit of the conversion result. Three more clock cycles are needed to complete the last byte (DOUT will be LOW). These will be ignored by the converter.

Control Byte

See Figure 5 for the placement and order of the control bits within the control byte. Tables III and IV give detailed information about these bits. The first bit, the 'S' bit, must always be HIGH and indicates the start of the control byte. The ADS7843 will ignore inputs on the DIN pin until the start bit is detected. The next three bits (A2-A0) select the active input channel or channels of the input multiplexer (see Tables I and II and Figure 2). The MODE bit determines the number of bits for each conversion, either 12 bits (LOW) or 8 bits (HIGH).

The SER/$\overline{DFR}$ bit controls the reference mode: either single-ended (HIGH) or differential (LOW). (The differential mode is also referred to as the ratiometric conversion mode.) In single-ended mode, the converter's reference voltage is always the difference between the V_{REF} and GND pins. In differential mode, the reference voltage is the difference between the currently enabled switches. See Tables I and II and Figures 2 through 4 for more information. The last two bits (PD1-PD0) select the power-down mode as shown in Table V. If both inputs are HIGH, the device is always powered up. If both inputs are LOW, the device enters a power-down mode between conversions. When a new conversion is initiated, the device will resume normal operation instantly—no delay is needed to allow the device to power up and the very first conversion will be valid. There are two power-down modes: one where $\overline{PENIRQ}$ is disabled and one where it is enabled.

Bit 7 (MSB)	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0 (LSB)
S	A2	A1	A0	MODE	SER/$\overline{DFR}$	PD1	PD0

TABLE III. Order of the Control Bits in the Control Byte.

16-Clocks per Conversion

The control bits for conversion n + 1 can be overlapped with conversion 'n' to allow for a conversion every 16 clock cycles, as shown in Figure 6. This figure also shows possible serial communication occurring with other serial peripherals between each byte transfer between the processor and the converter.

BIT	NAME	DESCRIPTION
7	S	Start Bit. Control byte starts with first HIGH bit on DIN. A new control byte can start every 16th clock cycle in 12-bit conversion mode or every 12th clock cycle in 8-bit conversion mode.
6-4	A2-A0	Channel Select Bits. Along with the SER/$\overline{DFR}$ bit, these bits control the setting of the multiplexer input, switches, and reference inputs, see Tables I and II.
3	MODE	12-Bit/8-Bit Conversion Select Bit. This bit controls the number of bits for the following conversion: 12 bits (LOW) or 8 bits (HIGH).
2	SER/$\overline{DFR}$	Single-Ended/Differential Reference Select Bit. Along with bits A2-A0, this bit controls the setting of the multiplexer input, switches, and reference inputs, see Tables I and II.
1-0	PD1-PD0	Power-Down Mode Select Bits. See Table V for details.

TABLE IV. Descriptions of the Control Bits within the Control Byte.

PD1	PD0	PENIRQ	DESCRIPTION
0	0	Enabled	Power-down between conversions. When each conversion is finished, the converter enters a low power mode. At the start of the next conversion, the device instantly powers up to full power. There is no need for additional delays to assure full operation and the very first conversion is valid. The Y– switch is on while in power-down.
0	1	Disabled	Same as mode 00, except $\overline{PENIRQ}$ is disabled. The Y– switch is off while in power-down mode.
1	0	Disabled	Reserved for future use.
1	1	Disabled	No power-down between conversions, device is always powered.

TABLE V. Power-Down Selection.

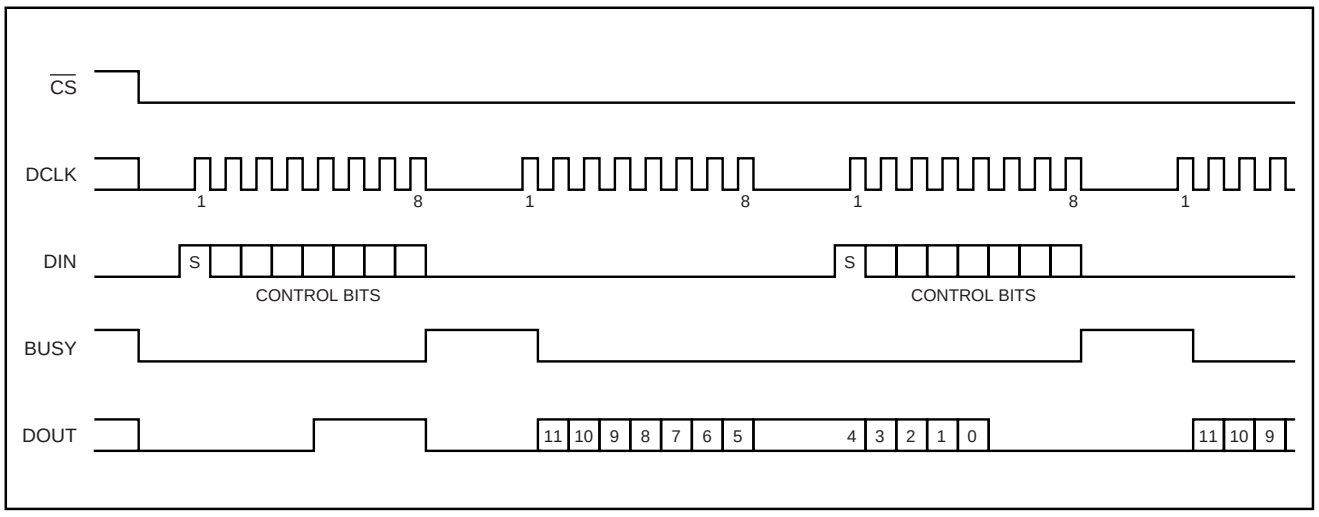


FIGURE 6. Conversion Timing, 16 Clocks per Conversion, 8-bit Bus Interface. No DCLK Delay Required with Dedicated Serial Port.

This is possible provided that each conversion completes within 1.6ms of starting. Otherwise, the signal that has been captured on the input sample-and-hold may droop enough to affect the conversion result. Note that the ADS7843 is fully powered while other serial communications are taking place during a conversion.

Digital Timing

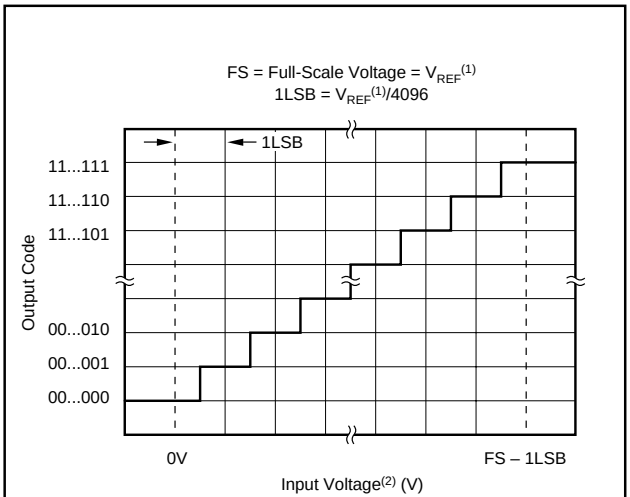
Figure 7 and Table VI provide detailed timing for the digital interface of the ADS7843.

SYMBOL	DESCRIPTION	MIN	TYP	MAX	UNITS
t_{ACQ}	Acquisition Time	1.5			µs
t_{DS}	DIN Valid Prior to DCLK Rising	100			ns
t_{DH}	DIN Hold After DCLK HIGH	10			ns
t_{DO}	DCLK Falling to DOUT Valid			200	ns
t_{DV}	$\overline{CS}$ Falling to DOUT Enabled			200	ns
t_{TR}	$\overline{CS}$ Rising to DOUT Disabled			200	ns
t_{CSS}	$\overline{CS}$ Falling to First DCLK Rising	100			ns
t_{CSH}	$\overline{CS}$ Rising to DCLK Ignored	0			ns
t_{CH}	DCLK HIGH	200			ns
t_{CL}	DCLK LOW	200			ns
t_{BD}	DCLK Falling to BUSY Rising			200	ns
t_{BDV}	$\overline{CS}$ Falling to BUSY Enabled			200	ns
t_{BTR}	$\overline{CS}$ Rising to BUSY Disabled			200	ns

TABLE VI. Timing Specifications ($+V_{CC}$ = +2.7V and Above, T_A = –40°C to +85°C, C_{LOAD} = 50pF).

Data Format

The ADS7843 output data is in Straight Binary format, as shown in Figure 8. This figure shows the ideal output code for the given input voltage and does not include the effects of offset, gain, or noise.



NOTES: (1) Reference voltage at converter: +REF – (–REF). See Figure 2.
(2) Input voltage at converter, after multiplexer: +IN – (–IN). See Figure 2

FIGURE 8. Ideal Input Voltages and Output Codes.

8-Bit Conversion

The ADS7843 provides an 8-bit conversion mode that can be used when faster throughput is needed and the digital result is not as critical. By switching to the 8-bit mode, a conversion is complete four clock cycles earlier. This could be used in conjunction with serial interfaces that provide 12-bit transfers or two conversions could be accomplished with three 8-bit transfers. Not only does this shorten each conversion by four bits (25% faster throughput), but each conversion can actually occur at a faster clock rate. This is because the internal settling time of the ADS7843 is not as critical—settling to better than 8 bits is all that is needed. The clock rate can be as much as 50% faster. The faster clock rate and fewer clock cycles combine to provide a 2x increase in conversion rate.

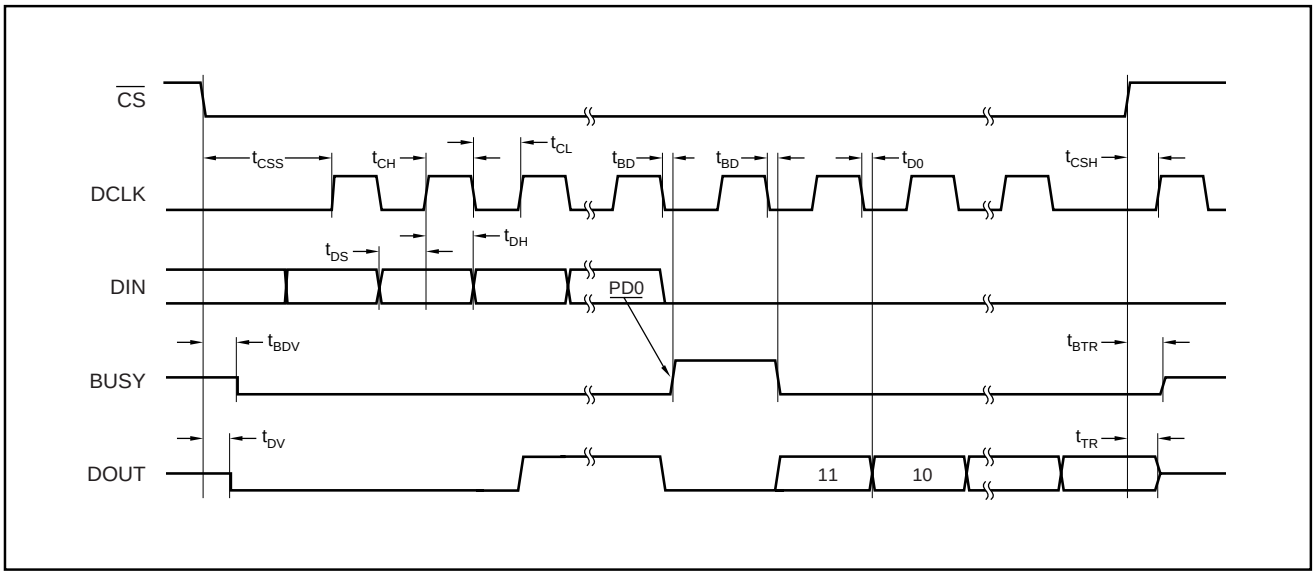


FIGURE 7. Detailed Timing Diagram.

POWER DISSIPATION

There are two major power modes for the ADS7843: full power (PD1-PD0 = 11_B) and auto power-down (PD1-PD0 = 00_B). When operating at full speed and 16 clocks per conversion (see Figure 6), the ADS7843 spends most of its time acquiring or converting. There is little time for auto power-down, assuming that this mode is active. Therefore, the difference between full power mode and auto power-down is negligible. If the conversion rate is decreased by simply slowing the frequency of the DCLK input, the two modes remain approximately equal. However, if the DCLK frequency is kept at the maximum rate during a conversion but conversions are simply done less often, the difference between the two modes is dramatic.

Figure 9 shows the difference between reducing the DCLK frequency ("scaling" DCLK to match the conversion rate) or maintaining DCLK at the highest frequency and reducing the number of conversions per second. In the later case, the converter spends an increasing percentage of its time in power-down mode (assuming the auto power-down mode is active).

Another important consideration for power dissipation is the reference mode of the converter. In the single-ended reference mode, the converter's internal switches are on only when the analog input voltage is being acquired (see Figure 5). Thus, the external device, such as a resistive touch screen, is only powered during the acquisition period. In the differential reference mode, the external device must be powered throughout the acquisition and conversion periods (see Figure 5). If the conversion rate is high, this could substantially increase power dissipation.

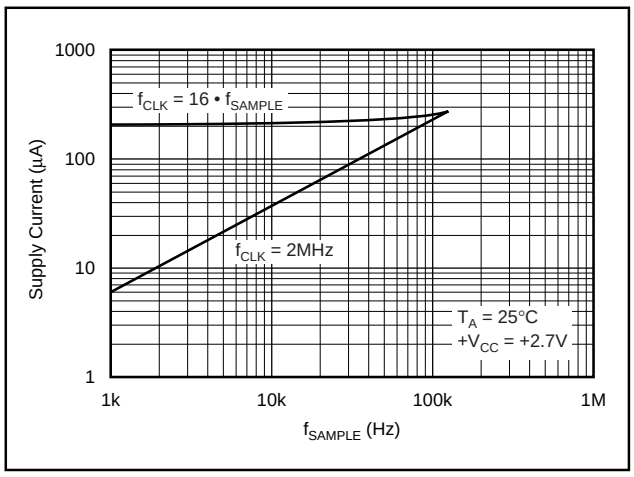


FIGURE 9. Supply Current versus Directly Scaling the Frequency of DCLK with Sample Rate or Keeping DCLK at the Maximum Possible Frequency.

LAYOUT

The following layout suggestions should provide the most optimum performance from the ADS7843. However, many portable applications have conflicting requirements concerning power, cost, size, and weight. In general, most portable devices have fairly "clean" power and grounds because most of the internal components are very low power. This situation would mean less bypassing for the converter's power and less concern regarding grounding. Still, each situation is unique and the following suggestions should be reviewed carefully.

For optimum performance, care should be taken with the physical layout of the ADS7843 circuitry. The basic SAR architecture is sensitive to glitches or sudden changes on the power supply, reference, ground connections, and digital inputs that occur just prior to latching the output of the analog comparator. Thus, during any single conversion for an 'n-bit' SAR converter, there are n 'windows' in which large external transient voltages can easily affect the conversion result. Such glitches might originate from switching power supplies, nearby digital logic, and high-power devices. The degree of error in the digital output depends on the reference voltage, layout, and the exact timing of the external event. The error can change if the external event changes in time with respect to the DCLK input.

With this in mind, power to the ADS7843 should be clean and well bypassed. A 0.1µF ceramic bypass capacitor should be placed as close to the device as possible. A 1µF to 10µF capacitor may also be needed if the impedance of the connection between +V_{CC} and the power supply is high.

The reference should be similarly bypassed with a 0.1µF capacitor. If the reference voltage originates from an op amp, make sure that it can drive the bypass capacitor without oscillation. The ADS7843 draws very little current from the reference on average, but it does place larger demands on the reference circuitry over short periods of time (on each rising edge of DCLK during a conversion).

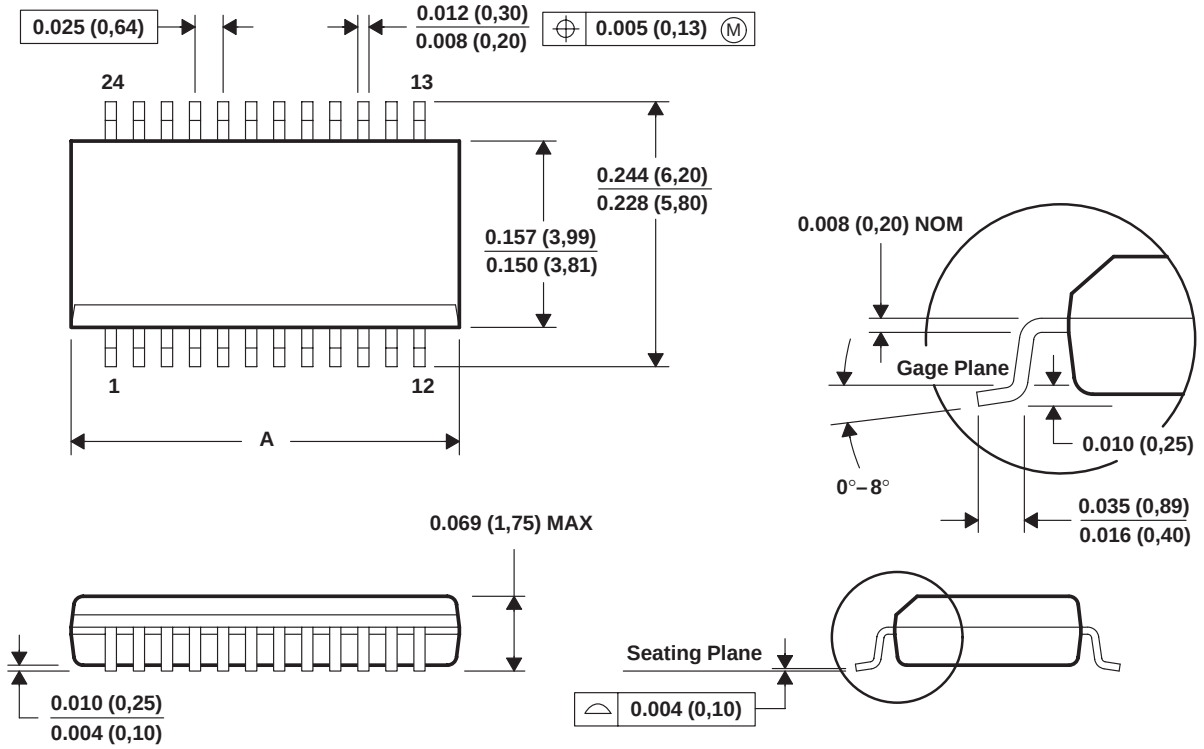
The ADS7843 architecture offers no inherent rejection of noise or voltage variation in regards to the reference input. This is of particular concern when the reference input is tied to the power supply. Any noise and ripple from the supply will appear directly in the digital results. While high frequency noise can be filtered out, voltage variation due to line frequency (50Hz or 60Hz) can be difficult to remove.

The GND pin should be connected to a clean ground point. In many cases, this will be the "analog" ground. Avoid connections which are too near the grounding point of a microcontroller or digital signal processor. If needed, run a ground trace directly from the converter to the power-supply entry or battery connection point. The ideal layout will include an analog ground plane dedicated to the converter and associated analog circuitry.

In the specific case of use with a resistive touch screen, care should be taken with the connection between the converter and the touch screen. Since resistive touch screens have fairly low resistance, the interconnection should be as short and robust as possible. Longer connections will be a source of error, much like the on-resistance of the internal switches. Likewise, loose connections can be a source of error when the contact resistance changes with flexing or vibrations.

DBQ (R-PDSO-G)** **PLASTIC SMALL-OUTLINE**

24 PINS SHOWN



DIM \ PINS **	16	20	24	28
A MAX	0.197 (5,00)	0.344 (8,74)	0.344 (8,74)	0.394 (10,01)
A MIN	0.188 (4,78)	0.337 (8,56)	0.337 (8,56)	0.386 (9,80)

4073301/E 10/00

NOTES: A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15).
D. Falls within JEDEC MO-137

PACKAGING INFORMATION

Orderable Device	Status [1]	Package Type	Package Drawing	Pins	Package Qty	Eco Plan [2]	Lead/Ball Finish	MSL Peak Temp [3]
ADS7843E	ACTIVE	SSOP/ QSOP	DBQ	16	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
ADS7843E/2K5	ACTIVE	SSOP/ QSOP	DBQ	16	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
ADS7843E/2K5G4	ACTIVE	SSOP/ QSOP	DBQ	16	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
ADS7843EG4	ACTIVE	SSOP/ QSOP	DBQ	16	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR

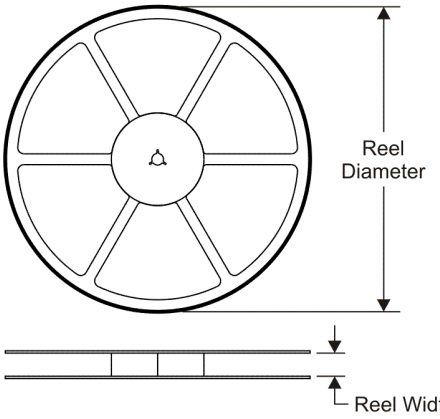
[1] The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

[2] Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

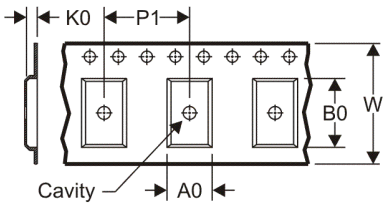
[3] MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

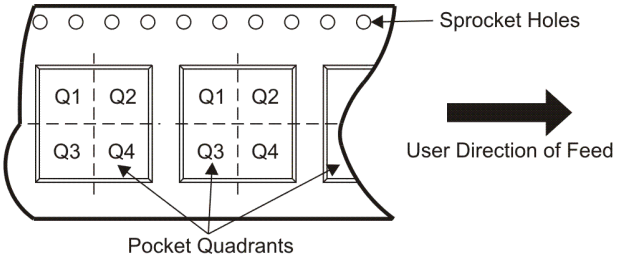


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE

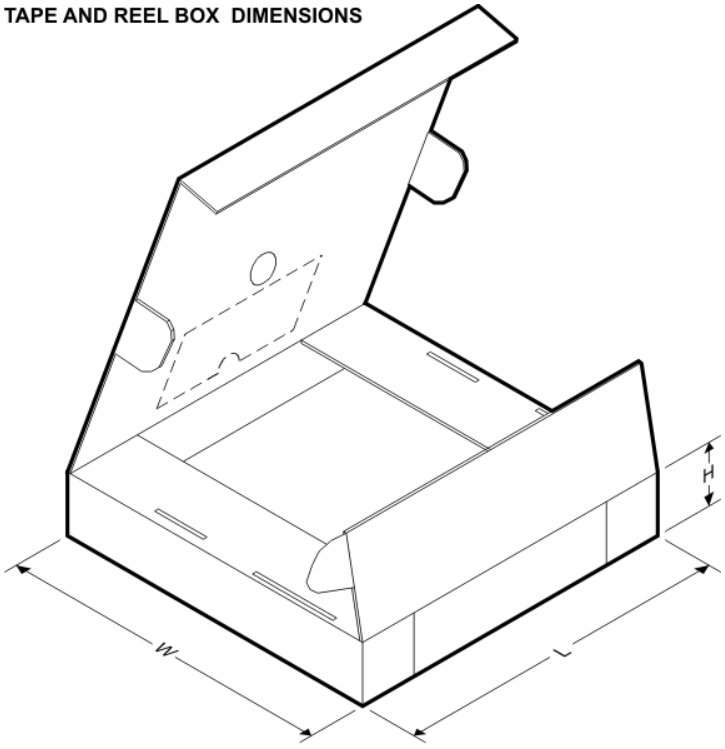


*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
ADS7843E/2K5	SSOP/ QSOP	DBQ	16	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1

PACKAGE MATERIALS INFORMATION

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
ADS7843E/2K5	SSOP/QSOP	DBQ	16	2500	346.0	346.0	29.0

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Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265

D. Hoja de datos del display

CONTENTS PAGE

1. Features & Mechanical Specifications

Item	Contents	Unit
	LCD	
LCD Type	TFT Transmissive Normal White	--
Viewing direction	12:00	--
Backlight	White LED x4 in Parallel	--
Interface	16bit parallel bus interface	--
Driver IC	ILI9325	--
Outline Dimension	42.72(W) × 60.26(H) × 3.7(T)	mm
Glass area (W×H×T)	41.1 ×57.1× 1.44	mm
Active area (W×H)	36.72×48.96	mm
Number of Dots	240(RGB) × 320	--
Pixel pitch (W×H)	0.153 × 0.153	mm
Operating Temperature	-20 ～ +70	℃
Storage temperature	-30 ～ +80	℃

2. Dimensional Outline

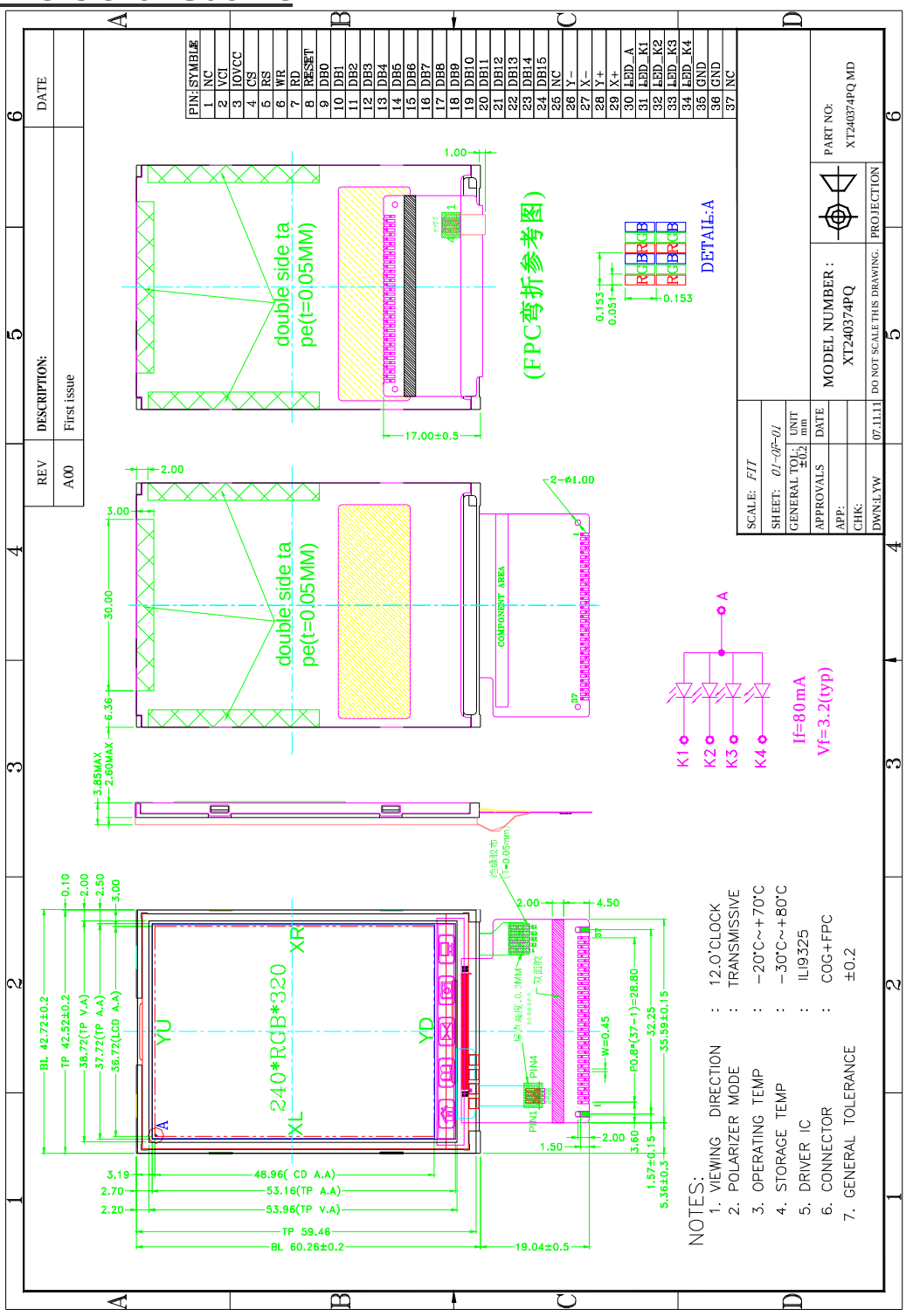


Figure 1. Dimensional outline

3. Block Diagram

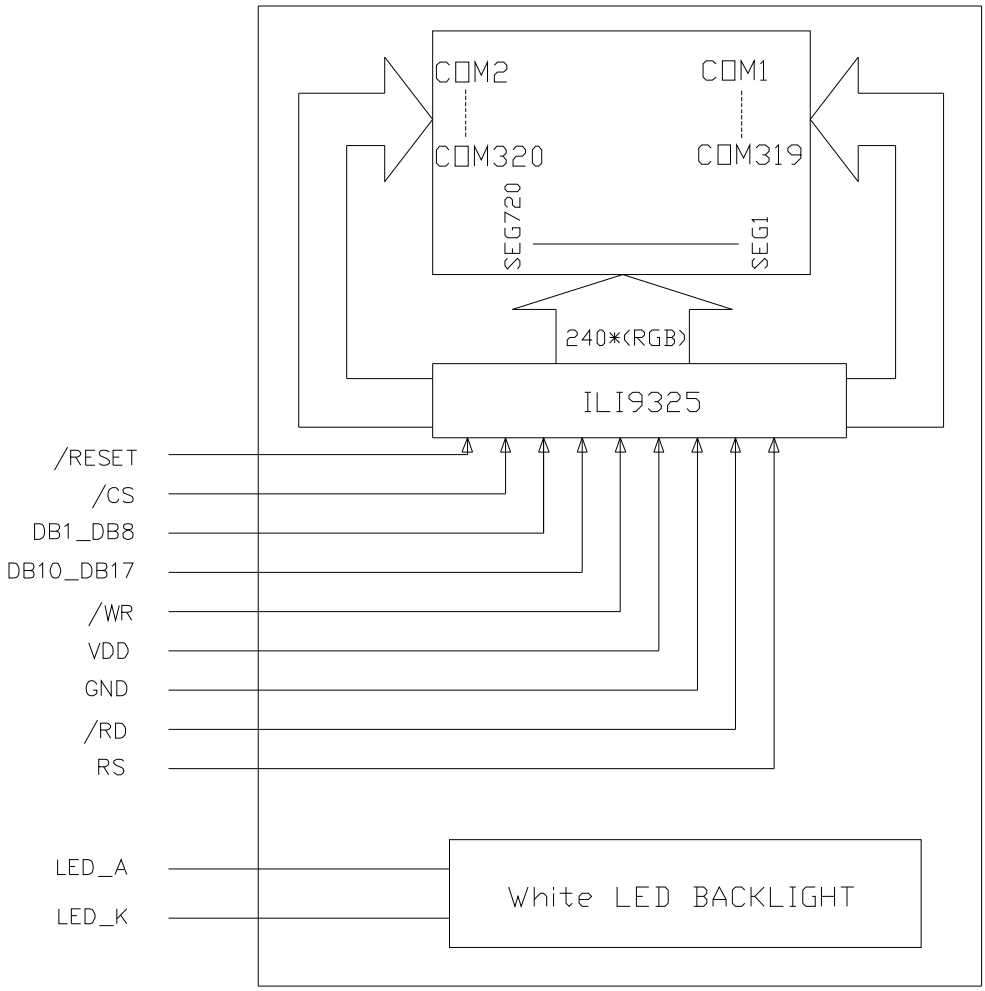


Figure 2. Block diagram

4. Pin Description

PIN No.	SYMBOL	Function
1	NC	NC
2	VDD	Power supply
3	VDD	Power supply
4	CS	Chip Select input pin. (Active Low)
5	RS	Data or command select pin. “H”: Date, “L”: Command.
6	WR	Write signal input pin. (Active Low)
7	RD	Read signal input pin. (Active Low)
8	RESET	Reset Signal pin (“Low” is enable)
9	DB0	Data bus
10	DB1	Data bus
11	DB2	Data bus
12	DB3	Data bus
13	DB4	Data bus
14	DB5	Data bus
15	DB6	Data bus
16	DB7	Data bus
17	DB8	Data bus
18	DB9	Data bus
19	DB10	Data bus
20	DB11	Data bus
21	DB12	Data bus
22	DB13	Data bus
23	DB14	Data bus
24	DB15	Data bus
25	NC	NC
26	Y-	Touch panel contrl signal pin
27	X-	Touch panel contrl signal pin
28	Y+	Touch panel contrl signal pin
29	X+	Touch panel contrl signal pin
30	LEDA	Backlight LED Anode.
31	LEDK1	Backlight LED Cathode.
32	LEDK2	Backlight LED Cathode.

33	LEDK3	Backlight LED Cathode.
34	LEDK4	Backlight LED Cathode.
35	GND	Ground
36	GND	Ground
37	NC	NC

5. Absolute Maximum Ratings

Item	Symbol	Rating			Unit
		MIN.	TYP.	MAX	
Supply Voltage range	VDD	-0.3	-	VDD+0.3	V
Power supply for gate drive	VGH	10		VDD+0.3	V
	VGL	-16.5		-4.0	V
TFT Common Voltage	VcomH	0	-	3.95	V
	VcomL	-1	-	0.5	V
Operating Temperature range	TOP	-20	-	+70	℃
Storage Temperature range	TST	-30	-	+80	℃

6. Electrical Characteristics

DC Characteristics

Item	Symbol	Min.	Type.	Max.	Unit
Logic Supply Voltage	VDD	2.8	-	3.3	V
I/O Supply Voltage	IOVCC	1.65	-	3.0	V

7. Backlight Characteristics

White LED × 4 in parallel **(Ta = 25°C)**

Item	Symbol	Condition	Min	Typ	Max	Unit
Forward Voltage	VF	IF=80mA	-	3.2	-	V
Uniformity	△Bp	-	80	-	-	%
Luminance for LCD	Lv	IF=80mA	3000	3200	-	cd/m^2

8. Electro-Optical Characteristics

Using HYDIS LC+ Normal Polarizer+Corresponding Backlight, reference only (Note 1,Note 2)

Item		Symbol	Conditions	Specifications			Unit	Note
				Min.	Typ.	Max.		
Transmittance		T%	Viewing normal angle $\theta_X = \theta_Y = 0°$		4.7		%	All left side data are based on CMO's following condition – Type 767 NTSC: 60% LC:5066 Light : C light (Machine:BM5A) Normal Polarizer Without DBEF
Contrast Ratio		CR		150	250	-	-	
Response Time		T_R		NA	10	20	ms	
		T_F		NA	20	30	ms	
Chromaticity	Red	X_R		0.603	0.633	0.663		
		Y_R		0.299	0.329	0.359		
	Green	X_G		0.264	0.294	0.324		
		Y_G		0.546	0.576	0.606		
	Blue	X_B		0.103	0.133	0.163		
		Y_B		0.092	0.122	0.152		
	White	X_W		0.278	0.308	0.338		
		Y_W		0.316	0.346	0.376		
Viewing Angle	Hor.	θ_{X+}	Center CR≥10		45	-	deg.	
		θ_{X-}			45	-		
	Ver.	θ_{Y+}			35	-		
		θ_{Y-}			15	-		

*Note (1) Definition of Contrast Ratio (CR):

The contrast ratio can be calculated by the following expression.

Contrast Ratio (CR) = L63 / L0

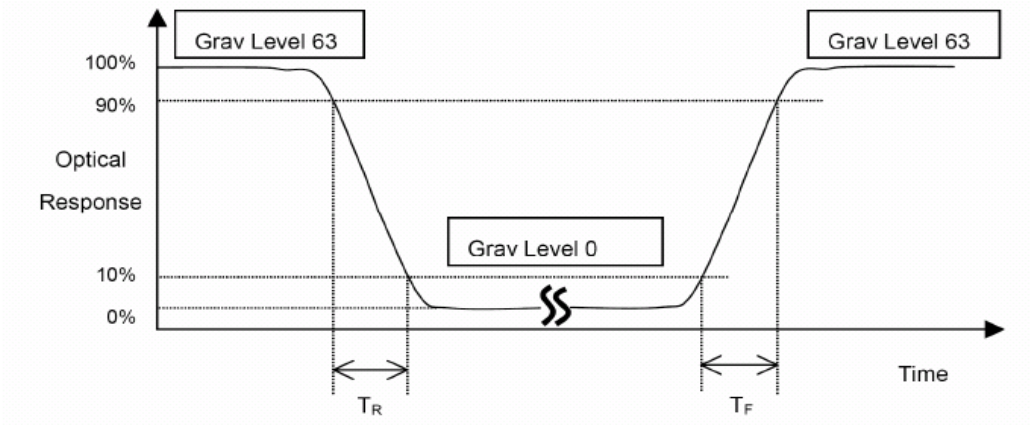
L63: Luminance of gray level 63

L0: Luminance of gray level 0

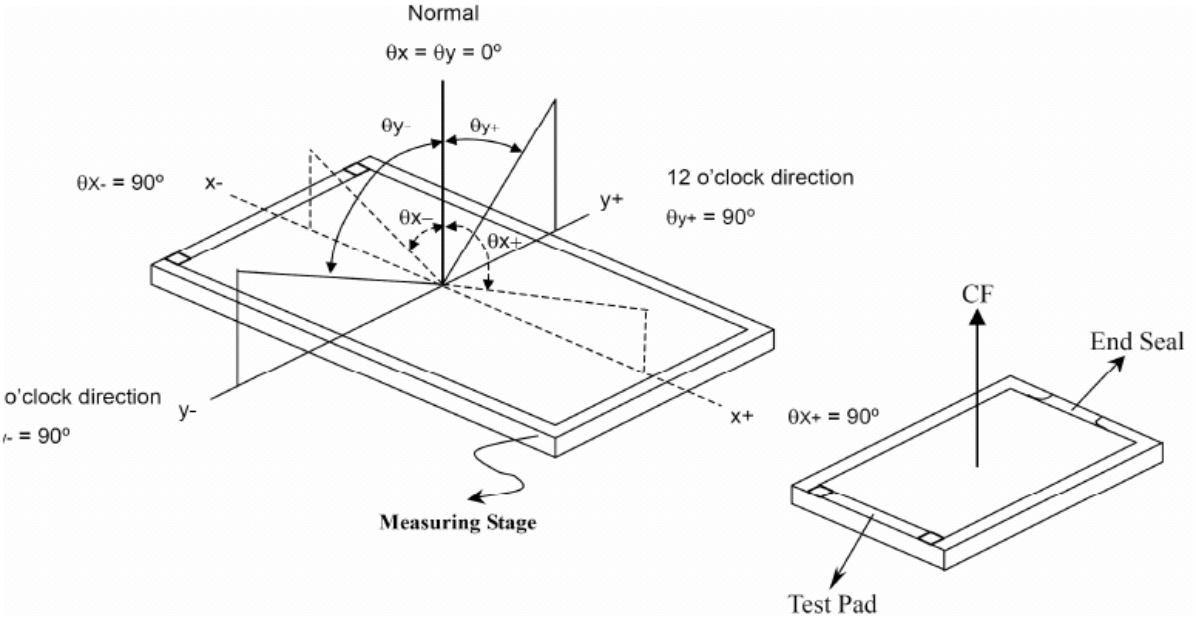
CR = CR (10)

CR (X) is corresponding to the Contrast Ratio of the point X at Figure in Note (6).

*Note (2) Definition of Response Time (TR, TF):



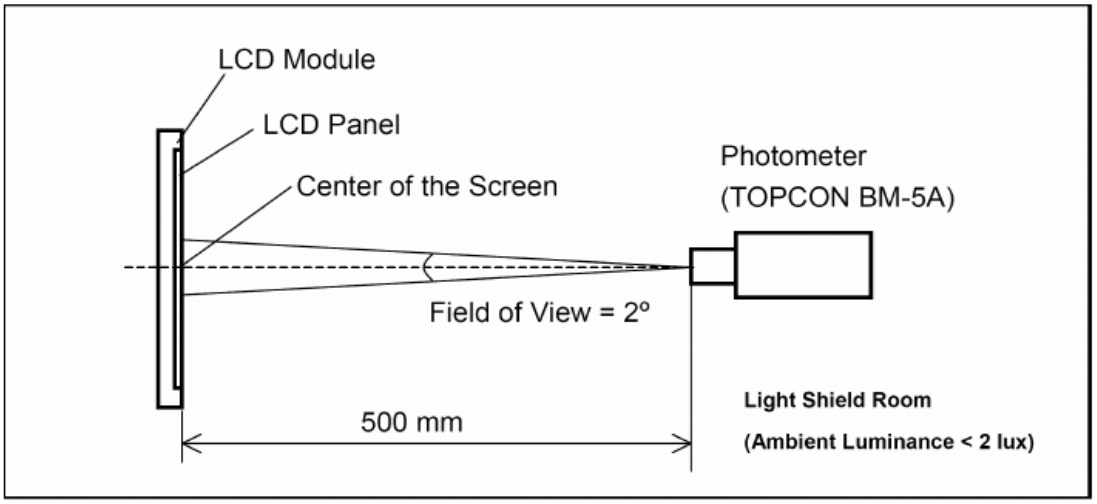
*Note(3) Definition of Viewing Angle



*** The above "Viewing Angle" is the measuring position with Largest Contrast Ratio; not for good image quality. View Direction for good image quality is 6 O'clock. Module maker can increase the "Viewing Angle" by applying Wide View Film.

*Note (4) Measurement Set-Up:

The LCD module should be stabilized at a given temperature for 20 minutes to avoid abrupt temperature change during measuring. In order to stabilize the luminance, the measurement should be executed after lighting Backlight for 20 minutes in a windless room.



9. Instruction Description

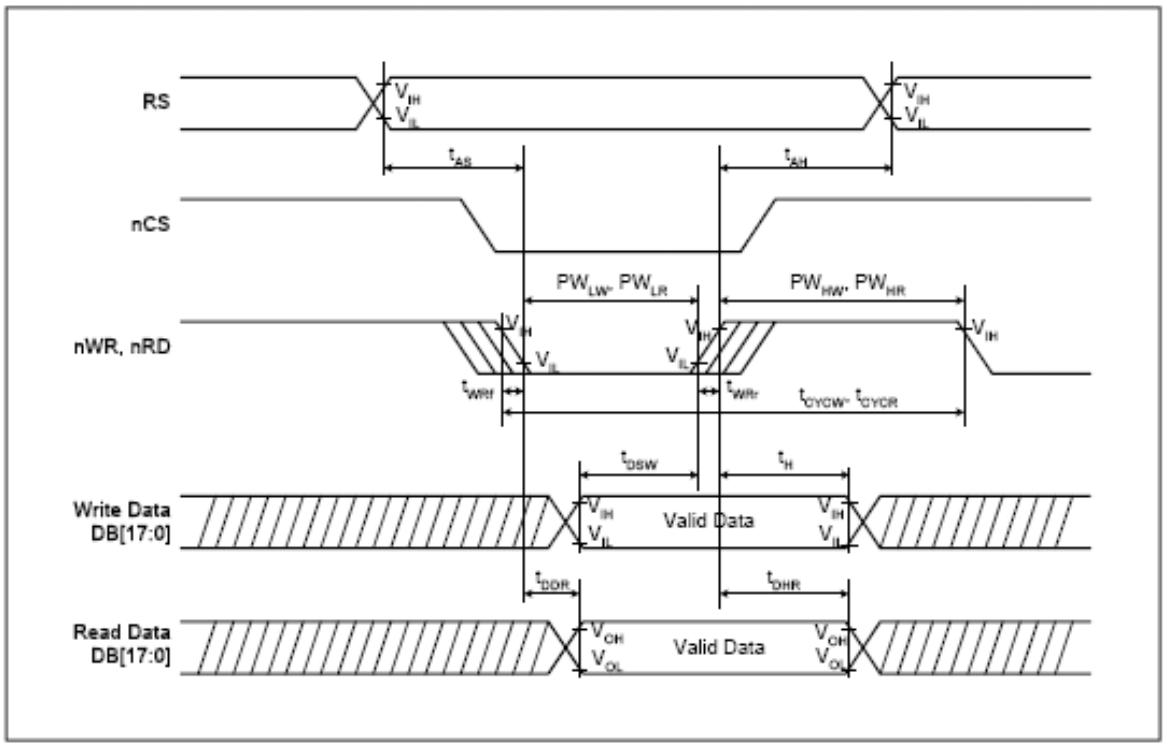
Please refer to ILI9325 datasheet

10. AC Characteristics

8080-series MCU interface Timing Characteristics

Normal Write Mode (IOVCC = 1.65~3.3V, VCC=2.4~3.3V)

Item		Symbol	Unit	Min.	Typ.	Max.	Test Condition
Bus cycle time	Write	t_{CYCW}	ns	100	-	-	-
	Read	t_{CYCR}	ns	300	-	-	-
Write low-level pulse width		PW_{LW}	ns	50	-	500	-
Write high-level pulse width		PW_{HW}	ns	50	-	-	-
Read low-level pulse width		PW_{LR}	ns	150	-	-	-
Read high-level pulse width		PW_{HR}	ns	150	-	-	
Write / Read rise / fall time		t_{WRr}/t_{WRf}	ns	-	-	25	
Setup time	Write (RS to nCS, E/nWR)	t_{AS}	ns	10	-	-	
	Read (RS to nCS, RW/nRD)			5	-	-	
Address hold time		t_{AH}	ns	5	-	-	
Write data set up time		t_{DSW}	ns	10	-	-	
Write data hold time		t_H	ns	15	-	-	
Read data delay time		t_{DDR}	ns	-	-	100	
Read data hold time		t_{DHR}	ns	5	-	-	



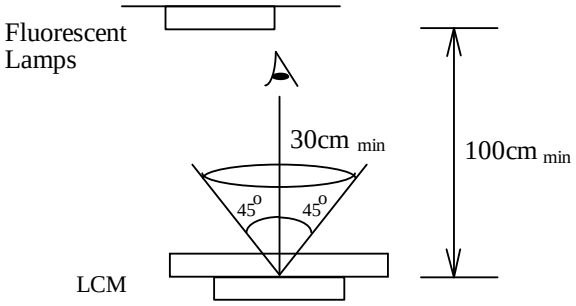
11.Quality Specifications

All The raw material are Rohs complicant.

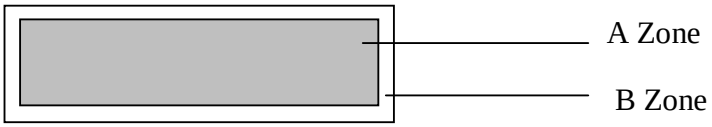
11.1 Standard of the product appearance test

Manner of appearance test: The inspection should be performed in using 20W x 2 fluorescent lamps. Distance between LCM and fluorescent lamps should be 100 cm or more. Distance between LCM and inspector eyes should be 30 cm or more.

Viewing direction for inspection is 45° from vertical against LCM.



Definition of zone:



A Zone: viewing area
B Zone: outside viewing area

11.2 Specification of quality assurance

AQL inspection standard

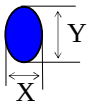
Sampling method: MIL-STD-105E, Level II, single sampling

Defect classification (Note: * is not including)

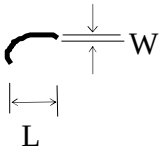
Classify	Item		Note	AQL
Major	Display state	Short or open circuit	1	0.65
		LC leakage		
		Flickering		
		No display		
		Wrong viewing direction		
		Contrast defect (dim, ghost)	2	
		Back-light	1,8	
	Non-display	Flat cable or pin reverse	10	
		Wrong or missing component	11	
Minor	Display state	Background color deviation	2	1.0
		Black spot and dust	3	
		Line defect, Scratch	4	
		Rainbow	5	
		Chip	6	
		Pin hole	7	
	Polarizer	Protruded	12	
		Bubble and foreign material	3	
	Soldering	Poor connection	9	
	Wire	Poor connection	10	
	TAB	Position, Bonding strength	13	

Note on defect classification

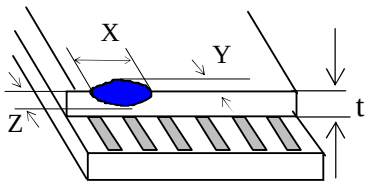
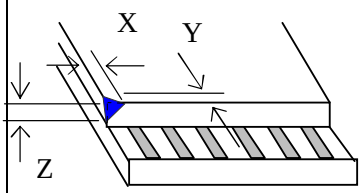
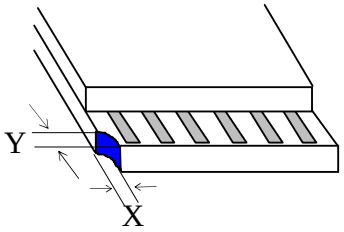
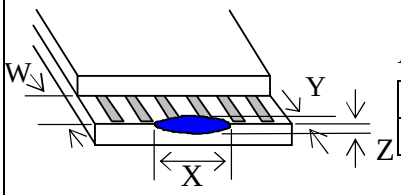
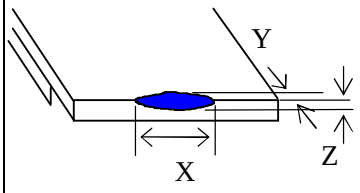
<table>
<tr><th>No.</th><th>Item</th><th>Criterion</th></tr>
<tr><td rowspan="6">1</td><td>Short or open circuit</td><td rowspan="6">Not allow</td></tr>
<tr><td>LC leakage</td></tr>
<tr><td>Flickering</td></tr>
<tr><td>No display</td></tr>
<tr><td>Wrong viewing direction</td></tr>
<tr><td>Wrong Back-light</td></tr>
<tr><td rowspan="2">2</td><td>Contrast defect</td><td rowspan="2">Refer to approval sample</td></tr>
<tr><td>Background color deviation</td></tr>
<tr><td>3</td><td>Point defect,
Black spot, dust
(including Polarizer)

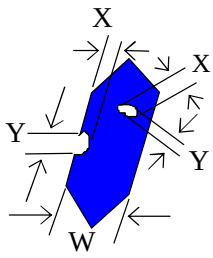
ϕ = (X+Y)/2</td><td> 

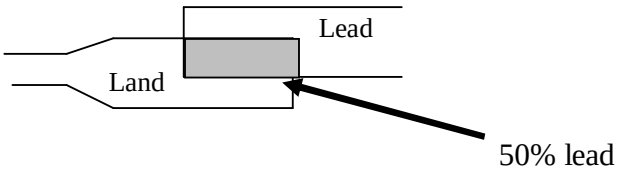
<table>
<tr><th>Point
Size</th><th>Acceptable Qty.</th></tr>
<tr><td>ϕ≤0.10</td><td>Disregard</td></tr>
<tr><td>0.10<ϕ≤0.20</td><td>2（距离大于5mm）</td></tr>
<tr><td>0.20<ϕ≤0.25</td><td>1</td></tr>
<tr><td>ϕ>0.25</td><td>0</td></tr>
</table>
Unit：mm</td></tr>
<tr><td>4</td><td>Line defect,

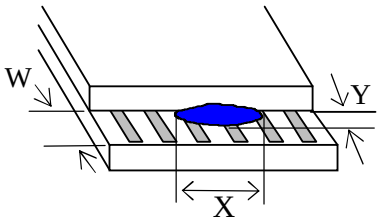
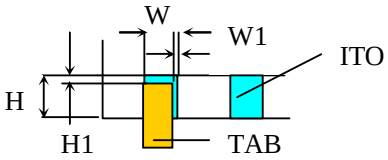
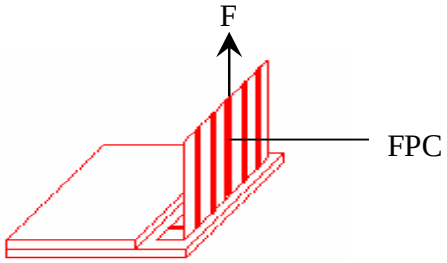
Scratch</td><td> 

<table>
<tr><th colspan="2">Line</th><th>Acceptable Qty.</th></tr>
<tr><td>L</td><td>W</td><td></td></tr>
<tr><td>---</td><td>0.015≥W</td><td>Disregard</td></tr>
<tr><td>3.0≥L</td><td>0.03≥W</td><td rowspan="2">2</td></tr>
<tr><td>2.0≥L</td><td>0.05≥W</td></tr>
<tr><td>1.0≥L</td><td>0.1＞W</td><td>1</td></tr>
<tr><td>---</td><td>0.05<W</td><td>Applied as point defect</td></tr>
</table>
Unit: mm</td></tr>
<tr><td>5</td><td>Rainbow</td><td>Not more than two color changes across the viewing area.</td></tr>
</table>

No	Item	Criterion
6	Chip Remark: X: Length direction Y: Short direction Z: Thickness direction t: Glass thickness W: Terminal Width	 Acceptable criterion X: ⩽2 / Y: 0.5mm / Z: ⩽t/2  Acceptable criterion X: ⩽2 / Y: 0.5mm / Z: ⩽t  Acceptable criterion X: ⩽3 / Y: ⩽2 / Z: ⩽t shall not reach to ITO  Acceptable criterion X: Disregard / Y: ⩽0.2 / Z: ⩽t  Acceptable criterion X: ⩽5 / Y: ⩽2 / Z: ⩽t/3

<table>
<tr><th>No.</th><th>Item</th><th>Criterion</th></tr>
<tr><td>7</td><td>Segment
pattern
W = Segment width
ϕ = (X+Y)/2</td><td>(1) Pin hole
ϕ < 0.10mm is acceptable.
 

<table>
<tr><th>Point Size</th><th>Acceptable Qty</th></tr>
<tr><td>ϕ≤1/4W</td><td>Disregard</td></tr>
<tr><td>1/4W< ϕ≤1/2W</td><td>1</td></tr>
<tr><td>ϕ>1/2W</td><td>0</td></tr>
</table>
Unit: mm</td></tr>
<tr><td>8</td><td>Back-light</td><td>(1) The color of backlight should correspond its specification.
(2) Not allow flickering</td></tr>
<tr><td>9</td><td>Soldering</td><td>(1) Not allow heavy dirty and solder ball on PCB.
(The size of dirty refer to point and dust defect)
(2) Over 50% of lead should be soldered on Land.
 
</td></tr>
<tr><td>10</td><td>Wire</td><td>(1) Copper wire should not be rusted
(2) Not allow crack on copper wire connection.
(3) Not allow reversing the position of the flat cable.
(4) Not allow exposed copper wire inside the flat cable.</td></tr>
<tr><td>11*</td><td>PCB</td><td>(1) Not allow screw rust or damage.
(2) Not allow missing or wrong putting of component.</td></tr>
</table>

No	Item	Criterion
12	Protruded W: Terminal Width	 Acceptable criteria: Y ≤ 0.4
13	TAB	1. Position  W1≤1/3W H1≤1/3H 2 FPC bonding strength test  P (=F/FPC bonding width) ≥650gf/cm ,(speed rate: 1mm/min) 5pcs per SOA (shipment)
14	Total no. of acceptable Defect	A. Zone Maximum 2 minor non-conformities per one unit. Defect distance: each point to be separated over 10mm B. Zone It is acceptable when it is no trouble for quality and assembly in customer's end product.

11.3 Reliability of LCM

Reliability test condition:

Item	Condition	Time (hrs)	Assessment
High temp. Storage	80°C	48	No abnormalities in functions and appearance
High temp. Operating	70°C	48	
Low temp. Storage	-30°C	48	
Low temp. Operating	-20°C	48	
Humidity	60°C/ 90%RH	48	
Temp. Cycle	-30°C ← 25°C →80°C (60 min ← 5 min → 60min)	10cycles	

Recovery time should be 24 hours minimum. Moreover, functions, performance and appearance shall be free from remarkable deterioration within 50,000 hours under ordinary operating and storage conditions room temperature (20±8°C), normal humidity (below 65% RH), and in the area not exposed to direct sun light.

11.4 Precaution for using LCD/LCM

LCD/LCM is assembled and adjusted with a high degree of precision. Do not attempt to make any alteration or modification. The followings should be noted.

General Precautions:

1. LCD panel is made of glass. Avoid excessive mechanical shock or applying strong pressure onto the surface of display area.
2. The polarizer used on the display surface is easily scratched and damaged. Extreme care should be taken when handling. To clean dust or dirt off the display surface, wipe gently with cotton, or other soft material soaked with isoproply alcohol, ethyl alcohol or trichlorotriflorothane, do not use water, ketone or aromatics and never scrub hard.
3. Do not tamper in any way with the tabs on the metal frame.
4. Do not made any modification on the PCB without consulting SUNYEE.
5. When mounting a LCM, make sure that the PCB is not under any stress such as bending or twisting. Elastomer contacts are very delicate and missing pixels could result from slight dislocation of any of the elements.
6. Avoid pressing on the metal bezel, otherwise the elastomer connector could be deformed and lose contact, resulting in missing pixels and also cause rainbow on the display.
7. Be careful not to touch or swallow liquid crystal that might leak from a damaged cell. Any liquid crystal adheres to skin or clothes, wash it off immediately with soap and water.

Static Electricity Precautions:

1. CMOS-LSI is used for the module circuit; therefore operators should be grounded whenever he/she comes into contact with the module.
2. Do not touch any of the conductive parts such as the LSI pads; the copper leads on the PCB and the interface terminals with any parts of the human body.
3. Do not touch the connection terminals of the display with bare hand; it will cause disconnection or defective insulation of terminals.
4. The modules should be kept in anti-static bags or other containers resistant to static for storage.
5. Only properly grounded soldering irons should be used.
6. If an electric screwdriver is used, it should be grounded and shielded to prevent sparks.
7. The normal static prevention measures should be observed for work clothes and working benches.
8. Since dry air is inductive to static, a relative humidity of 50-60% is recommended.

Soldering Precautions:

1. Soldering should be performed only on the I/O terminals.
2. Use soldering irons with proper grounding and no leakage.
3. Soldering temperature: 280°C±10°C
4. Soldering time: 3 to 4 second.
5. Use eutectic solder with resin flux filling.
6. If flux is used, the LCD surface should be protected to avoid spattering flux.
7. Flux residue should be removed.

Operation Precautions:

1. The viewing angle can be adjusted by varying the LCD driving voltage Vo.
2. Since applied DC voltage causes electro-chemical reactions, which deteriorate the display, the applied pulse waveform should be a symmetric waveform such that no DC component remains. Be sure to use the specified operating voltage.
3. Driving voltage should be kept within specified range; excess voltage will shorten display life.
4. Response time increases with decrease in temperature.
5. Display color may be affected at temperatures above its operational range.
6. Keep the temperature within the specified range usage and storage. Excessive temperature and humidity could cause polarization degradation, polarizer peel-off or generate bubbles.
7. For long-term storage over 40°C is required, the relative humidity should be kept below 60%, and avoid direct sunlight.

Limited Warranty

SUNYEE LCDs and modules are not consumer products, but may be incorporated by SUNYEE's customers into consumer products or components thereof, SUNYEE does not warrant that its LCDs and components are fit for any such particular purpose.

1. The liability of SUNYEE is limited to repair or replacement on the terms set forth below. SUNYEE will not be responsible for any subsequent or consequential events or injury or damage to any personnel or user including third party personnel and/or user. Unless otherwise agreed in writing between SUNYEE and the customer, SUNYEE will only replace or repair any of its LCD which is found defective electrically or visually when inspected in accordance with SUNYEE general LCD inspection standard. (Copies available on request)
2. No warranty can be granted if any of the precautions state in handling liquid crystal display above has been disregarded. Broken glass, scratches on polarizer mechanical damages as well as defects that are caused accelerated environment tests are excluded from warranty.
3. In returning the LCD/LCM, they must be properly packaged; there should be detailed description of the failures or defect.