



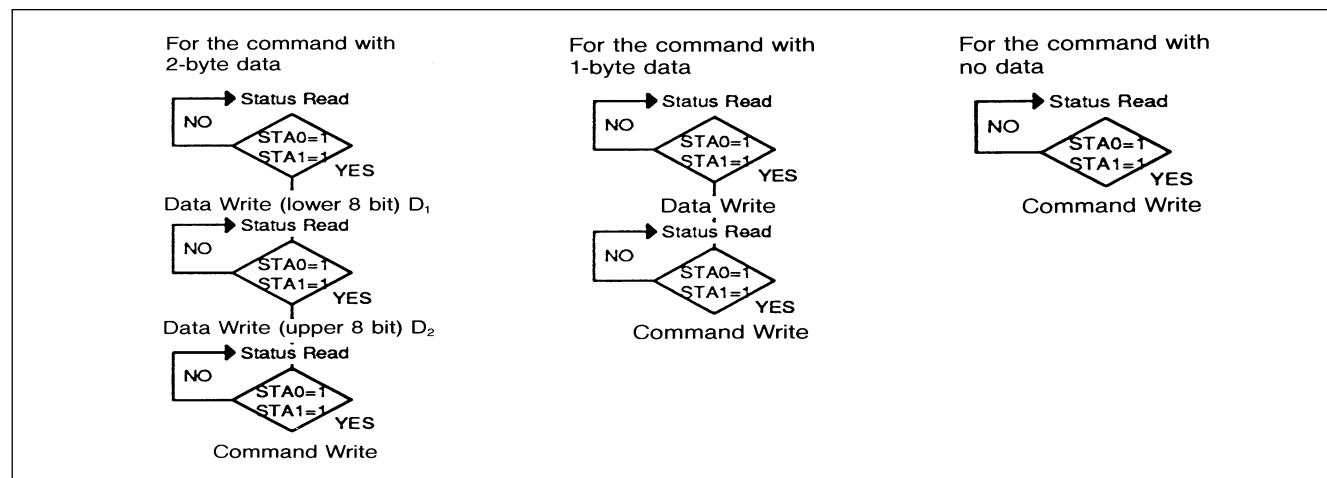
Application Notes



Intelligent Graphics Displays

Data Transmission Method

The T6963C communicates asynchronously. The following procedure is required for proper operation.



Status Check

Status of controller LSI can be read from 8-bit data line (D0 to D7) by setting C/D = "H", RD = "L".

Status Register

STA7	STA6	STA5	STA4	STA3	STA2	STA1	STA0
MSB				LSB			

Status should be checked prior to operation, except STA5, which should be checked after the reset command. The following table lists operations and required status bits.

Status Checks

Operation	Status Bit	Explanation	(Disable-Wait/Enable-Proceed)
Data Read/Write Commands	STA0 (Busy 1)	Check capability of instruction execution	STA0 = 0: Disable 1: Enable
	STA1 (Busy 2)	Check capability of data read or data write	STA1 = 0: Disable 1: Enable
Auto Read Mode	STA2 (DAV)	Check capability of data read (only effective in auto mode)	STA3 = 0: Disable 1: Enable
Auto Write Mode	STA3 (RDV)	Check capability of data write (only effective in auto mode)	STA3 = 0: Disable 1: Enable
N/A	STA4	N/A	N/A
Ready	STA5 (CLR)	Check possibility of controller operation	STA5 = 0: Disable 1: Enable
Screen Peek Screen Copy	STA6 (Error)	Address pointer is out of graphic area on screen peeking and screen copy command	STA6 = 1: Out of Graphic Area
Blink Condition	STA7 (Blink)	Check the condition of blink	STA7 = 0: Display off 1: Normal Display on



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Command List

Command	Command Code									Description	Execution Time (Maximum)
	C/D	D7	D6	D5	D4	D3	D2	D1	D0		
Mode Set	1	1	0	0	0	CG	N ₂	N ₁	N ₀	CG = 0:CG ROM/RAM Mode CG = 1:CG RAM Mode N ₂ N ₁ N ₀ (Graphic and Text) 0 0 0 "OR" 0 0 1 "EXOR" 0 1 1 "AND" 1 0 0 Attribute Capability (Text Only)	32 x 1/fosc
Control Word Set	1	0	1	0	0	0	0	N ₁	N ₀	N ₁ N ₀ 0 0 Text home address set 0 1 Text area set 1 0 Graphic home address set 1 1 Graphic area set	Status Check
Display Mode Set	1	1	0	0	1	N ₃	N ₂	N ₁	N ₀	N ₃ = 0: Graphic display off, 1: Graphic display on N ₂ = 0: Text display off, 1: Text display on N ₁ = 0: Cursor display off, 1: Cursor display on N ₀ = 0: Cursor blink off, 1: Cursor blink on	32 x 1/fosc
Cursor Pattern Select	1	1	0	1	0	0	N ₂	N ₁	N ₀	N ₂ N ₁ N ₀ specify the number of cursor lines (EX) N ₂ N ₁ N ₀ 0 0 0: 1 line cursor (bottom line) 1 1 1: 8 line cursor (8x8 dot cursor)	32 x 1/fosc
Pointer Set	1	0	0	1	0	0	N ₂	N ₁	N ₀	N ₂ N ₁ N ₀ 0 0 1 Cursor pointer set 0 1 0 Offset register set 1 0 0 Address point set	Status Check
Data Auto Read/Write	1	1	0	1	1	0	0	N ₁	N ₀	N ₁ N ₀ 0 0 Data auto write set 0 1 Data auto read set 1 * Auto reset After this command, continuous data can be written or read. The address pointer automatically increments.	32 x 1/fosc
Data Read/Write	1	1	1	0	0	0	N ₂	N ₁	N ₀	Data read/write command for one byte N ₂ = 0: Address pointer up/down; 1: unchanged N ₁ = 0: Address pointer increment; 1: decrement N ₀ = 0: Data write; 1: Data read	32 x 1/fosc
Screen Peek	1	1	1	1	0	0	0	0	0	Read displayed data	Status Check
Screen Copy	1	1	1	1	0	1	0	0	0	One line of display data pointed at by the address pointer is copied into the graphic RAM area.	Status Check
Bit Set/Reset	1	1	1	1	1	N ₃	N ₂	N ₁	N ₀	Set/reset command for a bit in the pointed address by address pointer. N ₃ = 0: Bit reset; 1: Bit set, N ₂ , N ₁ , N ₀ indicates the bit in the pointed address (000 is LSB, and 111 is MSB).	Status Check

Notes

1. "Status check" should be inserted between all command and data information.
2. Written data is displayed on the LCD only after the "Display Mode Set" command has been given.
3. The Display RAM is not automatically cleared upon power up.
4. fosc = 4.55 ± .5 MHz for AND 1013, 1391, 1781
fosc = 2.30 ± .5 MHz for AND 711, 1021
fosc = 5.76 ± .5 MHz for AND 1301, 1741
(For reference purposes only.)



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Initialization

Command	C/D	D7	D6	D5	D4	D3	D2	D1	D0	Note
Power On	Power On									
Hard Reset (use reset terminal)	RESET = "L" (1msec minimum after VDD \geq 4.75V)									
Mode Set	1	1	0	0	0	0	0	0	0	
Control Word Set										
Text Home Position Set (text home position 1000H)	0 0 1	0 0 0	0 0 1	0 0 0	0 1 0	0 0 0	0 0 0	0 0 0	0 0 0	Text Home Address Command
Number of Text Area Set (text 40 characters-0028H)	0 0 1	0 0 0	0 0 1	1 0 0	0 0 0	1 0 0	0 0 0	0 0 0	0 0 1	Number of Area Command
Graphic Home Position Set (graphic home position 0000H)	0 0 1	0 0 0	0 0 1	0 0 0	0 0 0	0 0 0	0 0 0	0 0 1	0 0 0	Graphic Home Command
Number of Graphic Area Set (graphic 40x6 dots-0028H)	0 0 1	0 0 0	0 0 1	1 0 0	0 0 0	1 0 0	0 0 0	0 0 1	0 0 1	Number of Area Command
(Initialize End)										



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Data Write Examples

		C/D	D7	D6	D5	D4	D3	D2	D1	D0	Note
1	Text Data										
	Address Pointer Set	0	0	0	0	0	0	0	0	0	Data LSB
	(Text Home Address)	0	0	0	0	1	0	0	0	0	Data MSB
		1	0	0	1	0	0	1	0	0	Command
	Data Write "A"	0	0	0	1	0	0	0	0	1	Data
		1	1	1	0	0	0	0	0	0	Command
	"N"	0	0	0	1	0	1	1	1	0	Data
		1	1	1	0	0	0	0	0	0	Command
	"D"	0	0	0	1	0	0	1	0	0	Data
		1	1	1	0	0	0	0	0	0	Command
	Display Mode Set (Text On)	1	1	0	0	1	0	1	0	0	Command
2	Graphic Data										
	Address Pointer Set	0	0	0	0	0	0	0	0	0	Data LSBs
	(Graphic Home Address)	0	0	0	0	0	0	0	0	0	Data MSBs
		1	0	0	1	0	0	1	0	0	Command
	Data Write (Every Other Pixel)	0	0	1	0	1	0	1	0	1	Data
		1	1	1	0	0	0	0	0	0	Command
	Data Write (Every Other Pixel)	0	0	1	0	1	0	1	0	1	Data
		1	1	1	0	0	0	0	0	0	Command
	Data Write (Every Other Pixel)	0	0	1	0	1	0	1	0	1	Data
		1	1	1	0	0	0	0	0	0	Command
	Display Mode Set (Graphics On)	1	1	0	0	1	1	0	0	0	Command
3	Auto Mode Write										
	Address Pointer Set	0	0	0	0	0	0	0	0	0	Data LSB
	(Text Home Address)	0	0	0	0	1	0	0	0	0	Data MSB
		1	0	0	1	0	0	1	0	0	Command
	Enter Auto Mode	1	1	0	1	1	0	0	0	0	Command
	"A"	0	0	0	1	0	0	0	0	1	Data
	"N"	0	0	0	1	0	1	1	1	0	Data
	"D"	0	0	0	1	0	0	1	0	0	Data
	Exit Auto Mode	1	1	0	1	1	0	0	1	0	Command
	Address Pointer Set	0	0	0	0	0	0	0	0	0	Data LSB
	(Graphic Home Address)	0	0	0	0	0	0	0	0	0	Data MSB
		1	0	0	1	0	0	1	0	0	Command
	Enter Auto Mode	1	1	0	1	1	0	0	0	0	Command
	Graphic Data	0	0	1	0	1	0	1	0	1	Data
	(Every Other Pixel)	0	0	1	0	1	0	1	0	1	Data
		0	0	1	0	1	0	1	0	1	Data
	Exit Auto Mode	1	1	0	1	1	0	0	1	0	Command
	Display Mode Set	1	1	0	0	1	0	1	0	0	Command
	(Text On -Graphics Off)										
	Display Mode Set	1	1	0	0	1	1	0	0	0	Command
	(Graphics On -Text Off)										
	Display Mode Set	1	1	0	0	1	1	1	0	0	Command
	(Text On -Graphics On)										

Note: In Auto Write Mode, check status bit 3, for all other operations check STA0 and STA1.



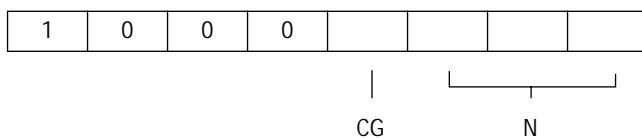
Intelligent Graphics Displays Application Notes

T6963C Instruction Set

The following pages describe how to use the T6963 instruction set.

Mode Set

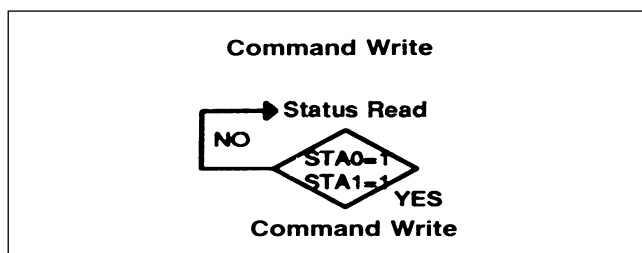
The MODE Set instruction determines how the data in the GRAPHIC and TEXT memories will be displayed. Note that when using the ATTRIBUTE mode, 84H, the data in the GRAPHIC MEMORY is interpreted as ATTRIBUTE information and controls the presentation of the TEXT characters (see ATTRIBUTE FUNCTION). For most applications MODE SET = 80H.



Note: Gr = Graphics
TX = Text
CG = Character Generator

N	Mode
000	Gr and TX are logically "ored"
001	Gr and TX are logically "ex-ored"
011	Gr and TX are logically "anded"
100	TX attribute

CG	Type of Character Generator
0	Internal CG (ROM & RAM)
1	External CG (RAM only)



Modes of Operation

The most common mode of operation occurs when TEXT and GRAPHIC information are logically combined on the screen. In this mode the ATTRIBUTE FUNCTION is not available. The DISPLAY MODE SET command controls the display of both the TEXT and GRAPHIC memories.

A second choice is the ATTRIBUTE FUNCTION mode. In this mode the information held in the GRAPHIC MEMORY is interpreted as ATTRIBUTE data and enables the TEXT MEMORY to generate special characters such as inverse and blinking. To preserve the data in the GRAPHIC

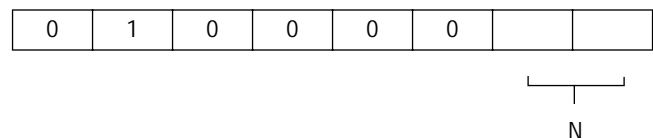
MEMORY you should reassign the GRAPHIC HOME POSITION to the ATTRIBUTE RAM AREA using the CONTROL WORD SET command, 42H. Note that no Graphic data can be displayed.

The CG bit controls how the two Character Generators are configured.

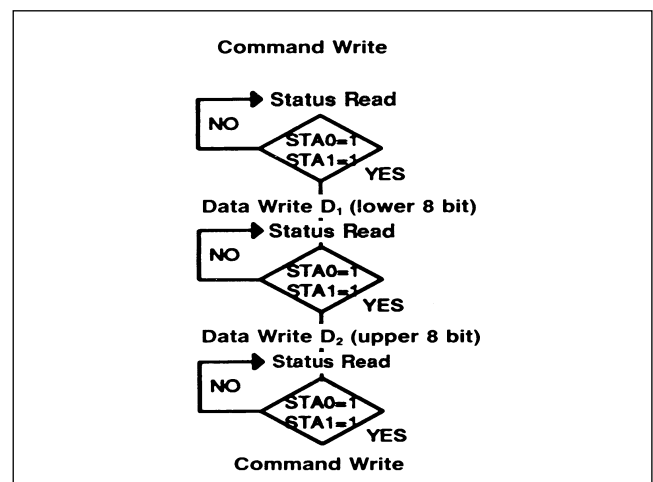
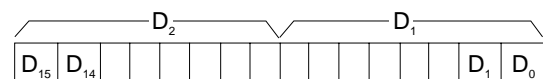
- CG BIT = 0 Both Internal and External CG are available with 128 characters each.
- CG BIT = 1 The Internal CG is not available. The External CG can hold up to 256 characters.

Control Word Set

This set of instructions initializes the TEXT and GRAPHIC MEMORY locations.



	N	Mode	D ₁	D ₂
A	00	Text Home Address	A low	A high
B	01	Text Area Set	column	00H
C	10	Graph. Home Address	A low	A high
D	11	Graphic Area Set	column	00H





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- A. TEXT HOME ADDRESS: 40H-This command sets the address in RAM of the first character in the TEXT MEMORY.
- B. TEXT AREA SET: 41H-The TEXT AREA command defines the number of characters in one row of the TEXT display.
- C. GRAPHIC HOME ADDRESS: 42H-This command sets the Home or First address in the GRAPHIC MEMORY. When using the attribute function, the GRAPHIC HOME ADDRESS must be reassigned to the starting address of the ATTRIBUTE RAM AREA.
- D. GRAPHIC AREA SET: The GRAPHIC AREA SET command defines the number of GRAPHIC Words in one GRAPHIC Row. The GRAPHIC AREA is equal to the TEXT AREA.

TH = TEXT HOME

TA = TEXT AREA

CH = DISPLAY CHARACTER COLUMNS (Hardware Set)

GH = GRAPHIC HOME

GA = GRAPHIC AREA

Text Display

TH	TH +	TH + CH
TH + TA	•	TH + TA + CH
(TH + TA) + TA	•	TH + 2TA + CH
(TH + 2TA) + TA	•	TH + 3TA + CH
TH + (n-1)TA	•	TH + (n-1)TA + CH
TH + nTA	•	TH + nTA + CH

Example:

AND1021 120 x 64 Pixels

8 x 8 Character Font

15 Characters x 8 Lines

TEXT HOME = TH = 1000H

TEXT AREA = TA = 15 Characters 000FH

Graphic Display

GH	GH +	GH + CH
GH + GA	•	GH + GA + CH
(GH + GA) + GA	•	GH + 2GA + CH
(GH + 2GA) + GA	•	GH + 3GA + CH
•	•	•
GH + (n-1)GA	•	GH + (n-1)GA + CH
GH + nGA	•	GH + nGA + CH

Example:

AND1021 120 x 64 Pixels

8 x 8 Character Font

15 Characters x 8 Lines

GRAPHIC HOME = GH = 1000H

GRAPHIC AREA = GA = 000FH

Display Mode Set

This command controls the display of the TEXT and GRAPHIC Displays as well as the CURSOR. To turn both the TEXT and Graphic Displays ON, bit A and B would be HIGH. For a TEXT Display, only bit B would be HIGH.

1	0	0	1	A	B	C	D
A	1/0	Graphic ON/OFF					
B	1/0	Text ON/OFF					
C	1/0	Cursor ON/OFF					
D	1/0	Cursor Blink ON/OFF					

Cursor Pattern Select

A standard one line cursor is generated with the command of A0H while A7H generates an eight line, or Character Block, CURSOR.

1	0	1	0	0			
							N

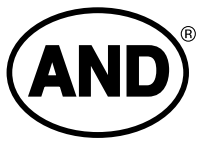
N	Display Pattern
111	8 line cursor
110	7 line cursor
101	6 line cursor
100	5 line cursor
011	4 line cursor
010	3 line cursor
001	2 line cursor
000	1 line cursor

Pointer Set

The POINTER SET command controls the CURSOR POINTER, ADDRESS POINTER and the EXTERNAL CHARACTER GENERATOR OFFSET REGISTER.

0	0	1	0	0			
							N

	N		D ₁	D ₂
A	001	Cursor Pointer Set	Ax (7 bit)	Ay (5 bit)
B	100	Address Pointer Set	A low	A high
C	010	Offset Register Set	DATA (5 bit)	00H

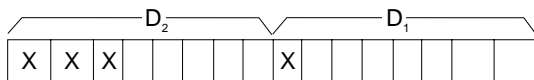


Intelligent Graphics Displays Application Notes

- A. **CURSOR POINTER SET:** The CURSOR is displayed at the position specified by the CURSOR POINTER.

D₁ Horizontal Point In Characters (MSB don't care)

D₂ Vertical Point In Characters (3 MSBs don't care)

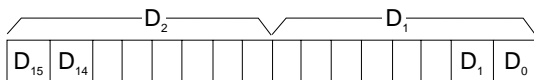


Note: For the AND1013 the LOWER SCREEN CURSOR can be addressed by adding 1000H to the CURSOR ADDRESS, D2-D1.

Example (For AND1013 Only)

Upper Screen Address	1000H
Add Off Set	1000H
Lower Screen Address	2000H

- B. **ADDRESS POINTER SET:** The ADDRESS POINTER may move throughout the 8K or 4K RAM, beginning at 0000H and ending at 1FFFH or 0FFFH respectively. All data transfer takes place at the RAM location pointed at by the ADDRESS POINTER or ADP.



- C. **OFFSET REGISTER SET:** THE OFFSET REGISTER SET command specifies the area in RAM which is used for the EXTERNAL Character generator. The MSB is 00H and the LSB is the Upper 5 bits of the External CG RAM location. See: EXTERNAL CHARACTER GENERATOR.

Example:

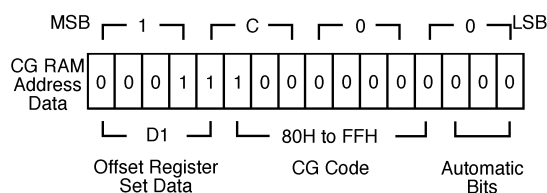
Set OFFSET REGISTER with the External CG Home Position equal to 1C00H

LSB DATA = 03H

MSG DATA = 00H

OFFSET REGISTER

SET COMMAND = 22H



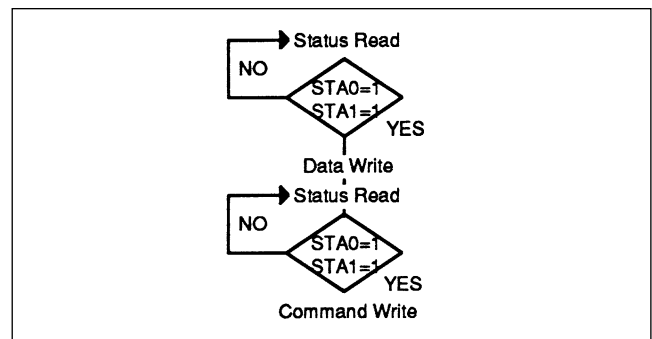
Data Read/Write

Data transfer occurs at the address pointed at by the ADDRESS POINTER. This instruction is a 1 byte data Read/Write command.

1	1	0	0	0	A	B	C
---	---	---	---	---	---	---	---

A	B	C	MODE
0	0	0	Data Write ADP increment
0	0	1	Data Read ADP increment
0	1	0	Data Write address pointer decrement
0	1	1	Data Read address pointer decrement
1	*	0	Data Write ADP nonvariable
1	*	1	Data Read ADP nonvariable

* Don't care



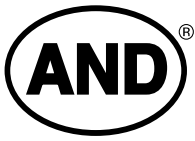
Auto Mode

This instruction is continuous data to Read (or Write) command. Auto Mode operations should be performed after checking status -STA2 or STA3.

1	0	1	1	0	0		
---	---	---	---	---	---	--	--

N

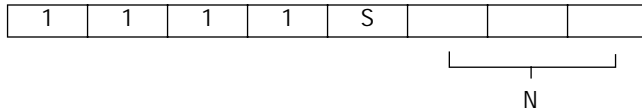
N	Mode
00	Data Auto Write Set
01	Data Auto Read Set
10	Auto Reset (Exit Auto Mode)



Intelligent Graphics Displays Application Notes

Bit Set/Reset

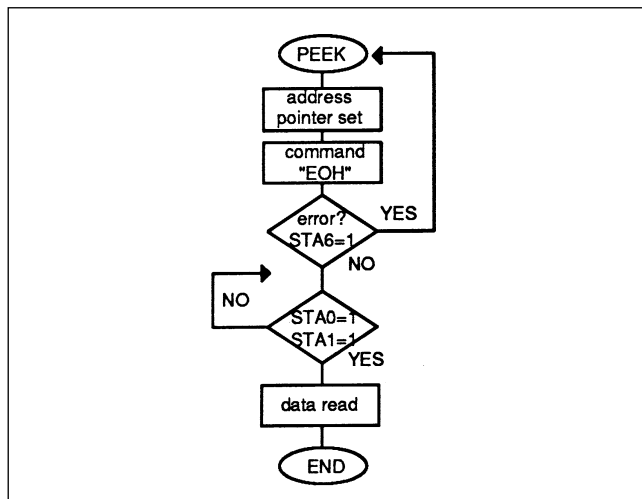
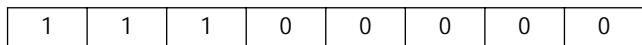
This instruction manipulates individual pixels. The bit is SET/RESET by this command. The ADP points to the byte in GRAPHIC RAM where the bit is to be changed.



S	N	Mode
1: Set	000	bit 0 (LSB)
0: Reset	001	bit 1
	010	bit 2
	011	bit 3
	100	bit 4
	101	bit 5
	110	bit 6
	111	bit 7 (MSB)

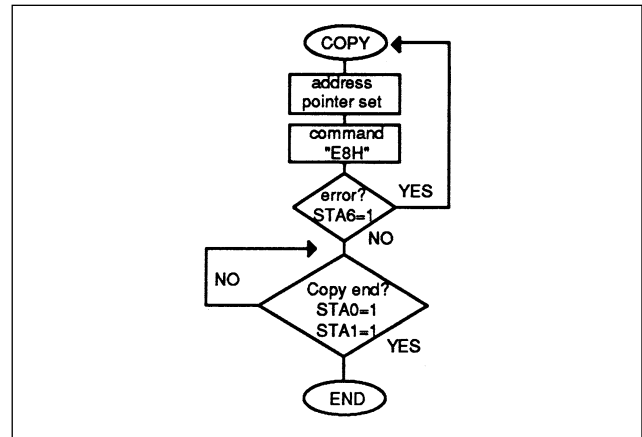
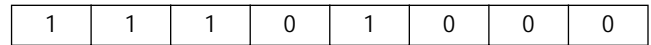
Screen Peeking

This instruction puts 1 byte of displayed data on the 8-bit bus for a Read Operation. It is possible to read logical combination data. If the address pointer is not set to the Graphic RAM area, this instruction is ignored and status bit 6 is set.



Screen Copy

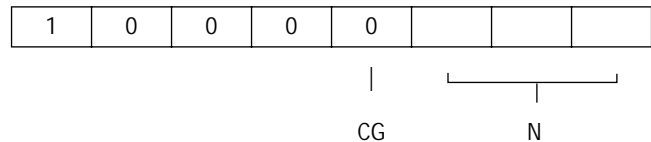
This command copies one line of Text or logical Graphics-Text data from the display to the Graphic RAM. If the address pointer is not set to the Graphic RAM area, this instruction is ignored and status bit 6 is set.



Character Generator

You can use the INTERNAL and EXTERNAL Character Generators, (128 characters each) or you can use the EXTERNAL CG that has 256 characters. The CG bit in the MODE SET command controls this designation.

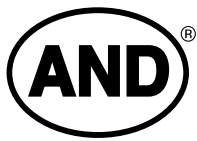
Mode Set Instruction



CG	ROM	RAM
0	128kk	128k
1	0	256k

Internal Character Generator

The following chart illustrates the relationship between CHARACTER CODE and CHARACTER FONT for the INTERNAL CG ROM. The CG bit of the MODE SET command must be LOW, "0", to use the INTERNAL CG.



Character Code Related to Character Font

MSB \ LSB	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0		!	"	#	\$	%	&	'	()	*	+	,	-	.	/
1	0	1	2	3	4	5	6	7	8	9	:	;	<	=	>	?
2	a	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
3	P	Q	R	S	T	U	V	W	X	Y	Z	[\]	^	_
4	`	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o
5	p	q	r	s	t	u	v	w	x	y	z	{		}	~	
6	ÿ	ü	ë	ä	å	ä	ä	ö	ë	ë	ë	ï	ï	ï	ä	ä
7	é	æ	Æ	ä	ä	ä	ö	ö	ö	ö	ö	ø	ø	ø	æ	æ

External Character Generator

You can program CUSTOM CHARACTERS in the EXTERNAL CG RAM memory and retrieve them by using the appropriate CHARACTER CODES. To use the EXTERNAL CG you first set the OFFSET REGISTER that specifies a location of RAM. This is done with the POINTER SET command. You can then program the EXTERNAL CG with custom characters. Once programmed, the EXTERNAL CG can then be used in place of, or in conjunction with, the INTERNAL CG.

Mode Set Command and CG Accessibility

Mode Set	CG Bit	CG ROM	CG RAM
Internal CG Bit = 0	0	128	128
External CG Bit = 1	1	0	256

The CG bit of the MODE SET command controls the configuration of the INTERNAL ROM, and EXTERNAL RAM, character generators.

If the CG bit in the MODE SET COMMAND is high, "1", both the ROM and RAM CHARACTER GENERATORS are available. There are 128 characters available in each CG with ROM character codes from 00H to 7FH and RAM codes from 80H to FFH.

There are 8 bytes of data for each character in the EXTERNAL CG resulting in a memory requirement of 0400H. Because the address of the EXTERNAL CG contains the CHARACTER CODES information, as shown below, the available CG RAM addresses are the following.

0400H	0C00H	1400H	1C00H
to	to	to	to
07FFH	0FFFH	17FFH	1FFFH

The RECOMMENDED AREA IS 1C00H to 1FFFH. This results in the LSB OFFSET REGISTER data of 03H.

MSB = 00H	LSB = 03H
-----------	-----------

If the CG bit of the MODE SET command is LOW, "0", the ROM is not available and the RAM, or EXTERNAL CG, can accommodate 256 characters. Eight bytes per character results in a memory requirement of 0800H. The possible RAM addresses are the following.

0000H	0800H	1800H
TO	TO	TO
07FFH	0FFFH	1FFFH

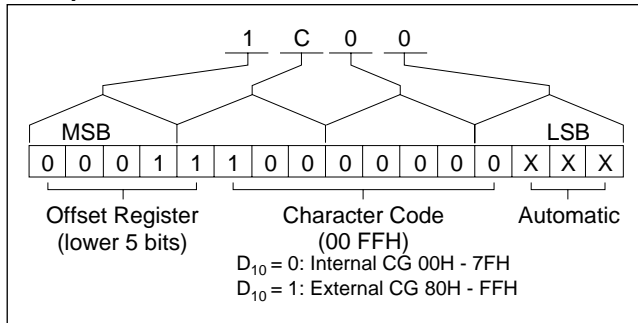
The recommended EXTERNAL CG RAM area is 1800H to 1FFFH. This results in the LSB OFFSET REGISTER data of 03H.

MSB = 00H	LSB = 03H
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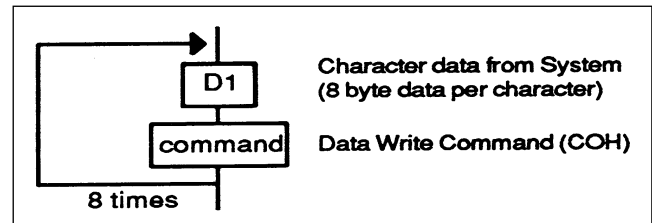


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Example: Address of External Character Generator



The system character data, (Character Data = D₁) is downloaded by the DATA WRITE command, (Command Data = C0H).



Displaying User Character Generator RAM

Character patterns can be displayed by sending the CG code with the "Data Write" command. "Display Mode Set" for TEXT display should be selected before using the CG.

Writing to the External Character Generator RAM

User defined characters can be written into the EXTERNAL CG RAM and retrieved with the appropriate character codes.

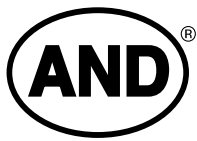
Each custom character requires 8 bytes of data sent to consecutive addresses. The information for the top row of pixels in the first custom character will be stored at the EXTERNAL CG HOME address specified by the OFFSET REGISTER SET command.

Example: CG RAM start address is 1 C00H, "Address Pointer Set" (command data = 24H) requires 2 byte address data D₁ and D₂. The procedure of data transfer is as follows.

D₁ Address data—lower 8-bit (00H)
D₂ Address data—upper 8-bit (1CH)
Command Address Pointer Set command (24H)

CG RAM Address	CG RAM Data (80H)							
	D7	D6	D5	D4	D3	D2	D1	D0
1C00H	+	+	*	*	*	*	*	*
1C01H	+	+	*	*	*	*	*	*
1C02H	+	+	*	*	*	*	*	*
1C03H	+	+	*	*	*	*	*	*
1C04H	+	+	*	*	*	*	*	*
1C05H	+	+	*	*	*	*	*	*
1C06H	+	+	*	*	*	*	*	*
1C07H	+	+	*	*	*	*	*	*

This operation should be repeated for each character.



Relationship between User CG RAM Address and CG Code and Character Pattern

Character Code								RAM Address for User CG																Character Pattern							
7	6	5	4	3	2	1	0	F	E	D	C	B	A	9	8	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
M	0	0	0	0	0	0	0	N	N	N	N	N	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
																							0	0	0	0	0	0	0	0	0
																							0	0	0	0	0	1	0	0	0
																							0	1	0	0	0	0	0	1	0
																							0	1	1	0	1	1	1	1	0
																							1	0	0	0	0	0	0	1	0
																							1	0	1	0	0	0	0	1	0
																							1	1	0	0	0	0	0	0	0
																							1	1	1	0	0	0	0	0	0
M	0	0	0	0	0	0	0	N	N	N	N	N	M	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0
																							0	0	1	0	1	1	1	1	0
																							0	1	0	0	1	1	0	1	0
																							0	1	0	0	0	0	0	1	0
																							1	0	0	0	1	0	0	1	0
																							1	0	1	0	1	0	0	1	0
																							1	1	0	0	1	0	0	1	0
																							1	1	1	0	0	0	0	1	0
M	0	0	0	0	0	0	1	N	N	N	N	N	M	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0
																							0	0	1	0	1	1	0	0	1
																							0	1	0	1	0	0	1	0	0
																						
																						
																						
																							1	1	1	0	0	0	0	0	0
																						
																						
																						
1	1	1	1	1	1	1	1	N	N	N	N	N	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
																							0	0	1	0	1	0	0	0	0
																							0	1	0	0	1	1	0	1	0
																							0	1	1	0	0	1	1	0	1
																							1	0	0	0	1	1	0	1	0
																							1	0	1	0	0	0	1	1	0
																							1	1	0	0	0	0	1	0	1
																							1	1	1	0	0	0	1	0	1

Note

- The character code in User RAM is located from 80H to FFH for MODE SET command - CG Bit = 0, and from 00H to FFH for MODE SET command - CG Bit = 1.
Bit M = 1; CG BIT = 0 for the MODE SET command (Internal CG ROM and External CG RAM)
Bit M = 0; CG BIT = 1 for the MODE SET command (External CG RAM only)
- "NNNNN" is the upper 5 Bits in the start address of the User CG RAM area as defined by the POINTER SET command - OFFSET REGISTER SET option.
- Do not overwrite the CG RAM area with display data.



Intelligent Graphics Displays Application Notes

External Character Generator Write Example

	C/D	D7	D6	D5	D4	D3	D2	D1	D0	Status Check	Comments
Address Pointer Set Data (LSB)	0	0	0	0	0	0	0	0	0	Bit 0,1	Set ADP to 1C00H Start of external CG RAM Status check before operation
Address Pointer Set Data (MSB)	0	0	0	0	1	1	1	0	0	Bit 0,1	
Address Pointer Set Command	1	0	0	1	0	0	1	0	0	Bit 0,1	
Auto Mode	1	1	0	1	1	0	0	0	0	Bit 0,1	Enter auto write mode
Character Data	0	0	0	0	0	0	0	0	0	Bit 3	First byte of Data for a user defined character This example is an upside down letter "A"
Character Data	0	0	0	0	1	0	0	0	1	Bit 3	
Character Data	0	0	0	0	1	0	0	0	1	Bit 3	
Character Data	0	0	0	0	1	1	1	1	1	Bit 3	Note that status bit 3 is checked while in auto write mode
Character Data	0	0	0	0	1	0	0	0	1	Bit 3	
Character Data	0	0	0	0	1	0	0	0	1	Bit 3	
Character Data	0	0	0	0	0	1	1	1	1	Bit 3	Eighth byte of data
Auto Set	1	1	0	1	1	0	0	1	X	Bit 3	Exit auto mode

External Character Generator Read Example (After Installation)

	C/D	D7	D6	D5	D4	D3	D2	D1	D0	Status Check	Comments
Offset Register Data (LSB)	0	0	0	0	0	0	0	1	1	Bit 0,1	The offset register, (0003H), is equal to the first five bits of the external CG home address (1C00h)
Offset Register Data (MSB)	0	0	0	0	0	0	0	0	0	Bit 0,1	
Offset Register Set Command	1	0	0	1	0	0	0	1	0	Bit 0,1	
Data Write Character Code	0	1	0	0	0	0	0	0	0	Bit 0,1	First character in external CG
Data Write Command	1	1	1	0	0	0	0	0	0	Bit 0,1	Note: When the CG Bit of the mode set command is "0", the address of the first character in the external CG RAM is 80H. When the CG bit is "1", the address of the first character is 00H
Data Write Character Code	0	1	0	0	0	0	0	0	1	Bit 0,1	
Data Write Command	1	1	1	0	0	0	0	0	0	Bit 0,1	
Data Write Character Code	0	1	0	0	0	0	0	1	0	Bit 0,1	
Data Write Command	1	1	1	0	0	0	0	0	0	Bit 0,1	
Data Write Character Code	0	1	0	0	0	0	0	1	1	Bit 0,1	Fourth character in external CG
Data Write Command	1	1	1	0	0	0	0	0	0	Bit 0,1	Data write command, ADP increment
Display Mode Set	1	1	0	0	1	0	1	0	0	Bit 0,1	Turn text display on



Intelligent Graphics Displays Application Notes

Attribute Functions

The attribute function is used for a “reverse” and/or “blinking” display. To use the attribute function, you must first reassign the graphic home address to the first address of the attribute RAM area by using the internal RAM write command. Please note that graphic data cannot be displayed. Secondly, you must enter the desired attribute data (see following table) using the “Data Write” command.

The attribute data of the first character in the “text area” is written into the first byte in the “attribute RAM area,” and the attribute data of nth character is written at the nth byte in the “attribute RAM area.”

Attribute RAM-1 Byte

*	*	*	*	N3	N2	N1	N0
---	---	---	---	----	----	----	----

*Don't care

N3	N2	N1	N0	Function
0	0	0	0	Normal display (text only)
0	1	0	1	Reverse display (text only)
0	0	1	1	Inhibit display
1	0	0	0	Blink of normal display
1	1	0	1	Blink of reverse display
1	0	1	1	Inhibit display

Example

Command	C/D	D7	D6	D5	D4	D3	D2	D1	D0	Note
Graphic display off	1	1	0	0	1	0	*	*	*	
Graphic home address set to attribute home address	0	0	0	0	0	0	0	0	0	home address command
	0	0	0	0	1	1	1	1	0	
	1	0	1	0	0	0	0	1	0	
Attribute data write	0	0	0	0	0	0	0	0	0	address D ₁ , D ₂ address pointer set attribute data write command attribute data write command
	0	0	0	0	1	1	1	1	0	
	1	0	0	1	0	0	1	0	0	
	0	0	0	0	0	0	0	0	0	
	1	1	1	0	0	0	0	0	0	
	0	0	0	0	0	1	1	0	1	
	1	1	1	0	0	0	0	0	0	
	
	
	
Mode	1	1	0	0	0	0	1	0	0	
Graphic display on	1	1	0	0	1	1	*	*	*	

Suggested Module Memory Mapping

AND	711, 1391, 1741, 1781, 6 x 8	711, 1391, 1741, 1781, 8 x 8	1021	1013
Text Home	1000H	1000H	1000H	0A00H
Text Area	0028H	001EH	000FH	0014H
Graphic Home	0000H	0000H	0000H	0000H
Graphic Area	0028H	001EH	000FH	0014H
Ext. CG Home	1C00H	1C00H	1C00H	0C00H
Attribute Home	0D00H	0D00H	0D00H	0800H
Valid Address	0000H to 1FFFH	0000H to 1FFFH	0000H to 1FFFH	0000H to 1FFFH and 0008H to 8FFFH



RAM Map

Display RAM is built-in to the module, and display data is written to this display RAM. Built-in controller LSI T6963C is automatically read from display RAM, and sends data to LCD drivers. The "Control word set" command (text home set, text area set, etc.) defines the RAM area that is read by controller LSI, so RAM map can be changed by your preferences. If more than one screen is stored in the RAM, vertical scrolling and paging is easily performed by resetting text home and/or graphic home address. These modules have 8K byte built-in RAM, and the following is an example of RAM mapping.

If the graphic/text home address is specified only for the upper half of the screen, the RAM map of the lower half of the screen is automatically fixed. In the above example, the RAM map is for "CG ROM Mode", in case "CG RAM Mode" is selected, a 2048 byte CG RAM area is necessary. Accordingly, the RAM map should be relocated.

RAM Map for AND 711, 1021, 1391, 1741, 1781

0000H to CFFH	Graphic RAM Area
0D00H to 0FFFH	Attribute RAM Area
1000H to 1BFFH	Text RAM Area
1C00H	CG RAM Area

RAM Map for AND 1013 (Upper Half of Screen)

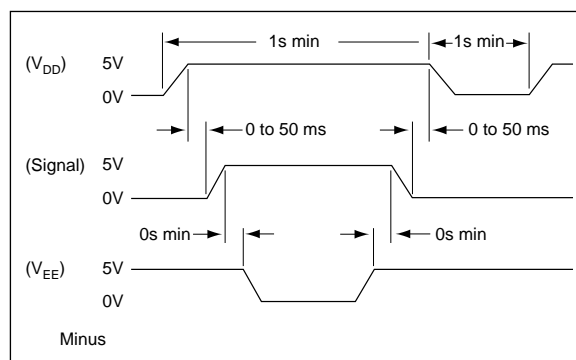
0000H to 7FFH	Graphic RAM Area
0800H to BFFH	Attribute RAM Area
0A00H to BF5H	Text RAM Area
0C00H to 1FFFH	CG RAM Area

RAM Map for AND1013 (Lower Half of Screen)

8000H to 87FFH	Graphic RAM Area
8800H to 89FFH	Attribute RAM Area
8A00H to 8BFFH	Text RAM Area
8C00H to 8FFFH	CG RAM Area

Operation

1. Do not insert or remove an LCD module when power is applied to the device using the LCD module.
2. Employ the following power up sequence to provide the best display quality and reliability. If negative voltage is supplied before V_{DD} reaches 5V you can compromise display quality and shorten the life of the LCD. The input voltage should be active only when V_{DD} is supplied. Otherwise, the internal CMOS-LSI will latch up.



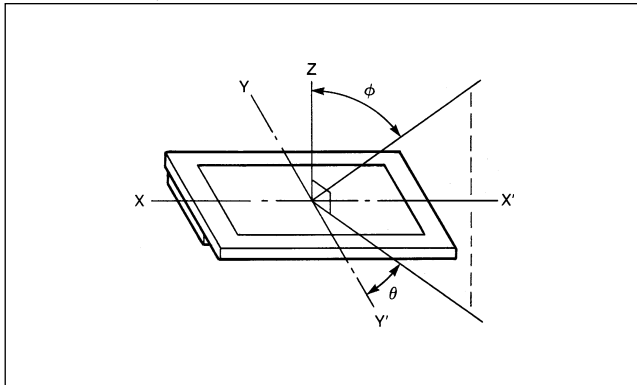
3. You must use an ultra-violet ray cutoff filter for outdoor operation.
4. Avoid condensation of water; water can cause improper operation.
5. Do not exceed maximum rating values under the worst probable operating conditions, accounting for input voltage variation and all other variables.

Optical Definitions

Introduction

The following diagrams explain how various optical specifications are measured.

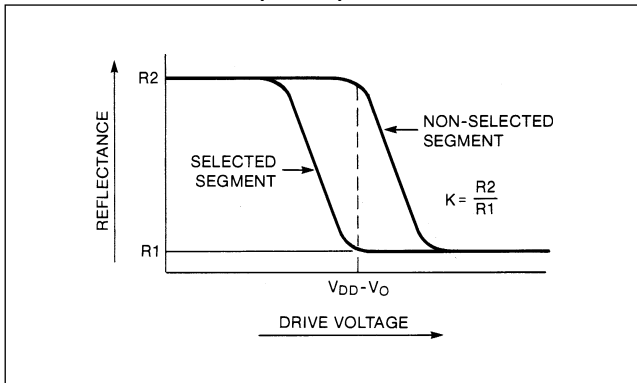
Definition of ϕ and θ (Note 1)



Definition of Viewing Angles

The range of viewing angles, adjusted by varying the V_{EE} value which produce a higher than specified contrast ratio.

Definition of Contrast (Note 3)



Definition of Rise and Decay Time (Note 4)

