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SHARP

ELECTRONIC COMPONENTS GROUP
SHARP CORPORATION

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REPRESENTATIVE DIVISION

IC DIV.

SEMICONDUCTOR APPLICATION DIV.

LCD DIV.

ELECTRONIC COMPONENTS DIV.

DEVICE SPECIFICATION FOR

Dot Matrix LCD Unit
(16-character/2-line Display
built in a LED backlight)

MODEL No.

LM16X21B

CUSTOMER'S APPROVAL

DATE _____

BY _____

"PRESENTED

BY

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Engineering Department
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LM16X21B

1. Overview

The LM16X21B, dot-matrix LCD unit consists of a 5 x 7-dot/16-character 2-line dot-matrix LCD panel, LCD driver, controller LSI and yellow green backlight LED fabricated on a single PCB. Incorporating mask ROM-based character generator and display data RAM in the controller LSI, the unit can efficiently display the desired characters under microprocessor control. LCD is negative type.

(Features)

- (1) The LCD of the unit is STHC (Super Twisted High Contrast) violet negative LyPc-
- (2) Low power consumption with the dot-matrix LCD panel and CMOS LSI. Built-in backlight LED with high luminance and stable radiation.
- (3) Thin, light weight design permits easy installation in a variety of equipment.
- (4) Allowing for being connected at general-purpose CMOS signal level, the unit can be easily interfaced to a microprocessor with common 4-bit and 8-bit parallel inputs and outputs.
- (5) Built-in character generator ROM and RAM, and display data RAM:
 - Character generator ROM
 - 160 different 5 x 7 dot-matrix character patterns
 - (Alphanumeric and symbols)
 - Character generator RAM
 - 8 different user programmed 5 x 7 dot-matrix patterns
 - Display data RAM
 - 80 x 8 bits
- (6) Numerous instructions
 - Display clear, Cursor home, Display ON/OFF, Cursor ON/OFF, Blink character, Cursor shift, Display shift
- (7) Built-in reset circuit is triggered at power ON.
 - (For the operating conditions, refer to the separate user's manual "Dot-Matrix LCD Units with built-in controllers".)
- (8) The unit operates from a single 5V power supply.

* As to the packing, refer to the separate
"COMMON PACKING SPECIFICATION FOR LM16255 series".



2. Construction and Outline

Construct. ion : 5 x 7 dots + cursor, 16-character 2-line dot-matrix display unit (Built-in Yellow-green backlight LED, negative type)

Outline : See Fig. 1.

Interface signals : See Table 5.

Character pattern details : See Fig. 7.

Character codes : See Table 9.

There shall be no scratches, stains, chips, distortions and other external drawbacks that may affect the display function.

Rejection criteria shall be noted in Inspection Standard (S-U-009).

3. Mechanical Specifications

Table 1

Parameter	Specification	Unit
Outline dimensions	84(W) X 44(11) x 16 MAX(D)	mm
Effective display area	61(W) X 15.8(H)	mm
Display format	16 characters X 2 lines	
Character format	5 X 7 dots with cursor	
Character size	2.96(W) X 4.86(11) (5 X 7 dots)	mm
DOL size	0.56(W) X 0.66(11)	mm
DOL spacing	0.04	mm
Character color *	Yellow green	
Background color*	Dark blue	
Weight	Approx. 40	g

* Due to Lhc characteristics of Lhc LC Material, the colors vary with environmental temperature.



4. Electrical Specifications

4.1 Absolute maximum ratings

Table 2

Parameter	Symbol	Min.	Max.	Unit	Remark
Supply voltage (Logic)	$V_{DD} - V_{SS}$	-0.3	+6.5	v	
Supply voltage (LCD drive)	$V_0 - V_{SS}$	0	+6.5	V	$V_{DD} > V_0$
Supply current (Backlight LED)	I_{LED}	-	160	mA	$T_a = 25^\circ C$
Input voltage	V_{IN}	-0.3	$V_{DD} + 0.3$	v	
Storage temperature	T_{stg}	-25	+70	$^\circ C$	
Operating temperature	T_{opr}	0	+50	$^\circ C$	
Reverse voltage (Backlight LED)	$V_{LED} - V_{LSS}$	-5		V	

4.2 Electrical characteristics

Table 3

($T_a = 25^\circ C$)

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Supply voltage (Logic)	$V_{DD} - V_{SS}$	4.75	5.0	5.25	V	
Supply voltage (LCD drive)	$V_0 - V_{SS}$		0.65 ¹		V	$V_{DD} = 5.0V$
Input voltage	" L "	V_{IL}	-0.3	0.6	V	
	" H "	V_{IH}	2.2	DO	V	
Output voltage	" L "	V_{OL}	-	0.4	V	$I_{OL} = 1.2mA$
	" H "	V_{OH}	2.4		V	$-I_{OH} = 0.205mA$
Input leakage current	I_{IL}			1	μA	
Internal oscillating frequency	f_{osc}		250		KHz	
Supply current	J_{DD}		1.6	2.2	mA	$V_{DD} = 5V, V_0 = 0V$
	I_{LED}		80	120	mA	$V_{LED} - V_{LSS} = 5.0V$
Power dissipation	P_d		408	611	mW	$V_{DD} = 5V, V_0 = 0V$ $V_{LED} - V_{LSS} = 5.0V$
Supply voltage (Backlight LED)	$V_{LED} - V_{LSS}$	4.75	5.0	5.25	V	

* Note. After over 30 minutes since backlight begin lighting.



4.3 Timing characteristics

Table 4

$V_{DD}=5.0V \pm 5\%$

$T_a=0 \sim 50^\circ C$

Parameter	Symbol	Min.	Typ.	Max.	Unit
Enable cycle time	t_{cycE}	1000	-	-	ns
Enable pulse width	P_{WEH}	450	-	-	ns
Enable rise/fall time	t_{Er}, t_{Ef}		-	25	ns
RS, R/W setup time	t_{AS}	140	-	-	ns
Address hold time	t_{AH}	10	-	-	ns
Data setup time	t_{DSW}	195	-	-	ns
Data delay time	t_{DDR}		-	320	ns
Data hold time(write)	t_{H}	10	-	-	ns
Data hold time(read)	t_{DHR}	20	-	-	ns

Timing chart: See Fig. 1.

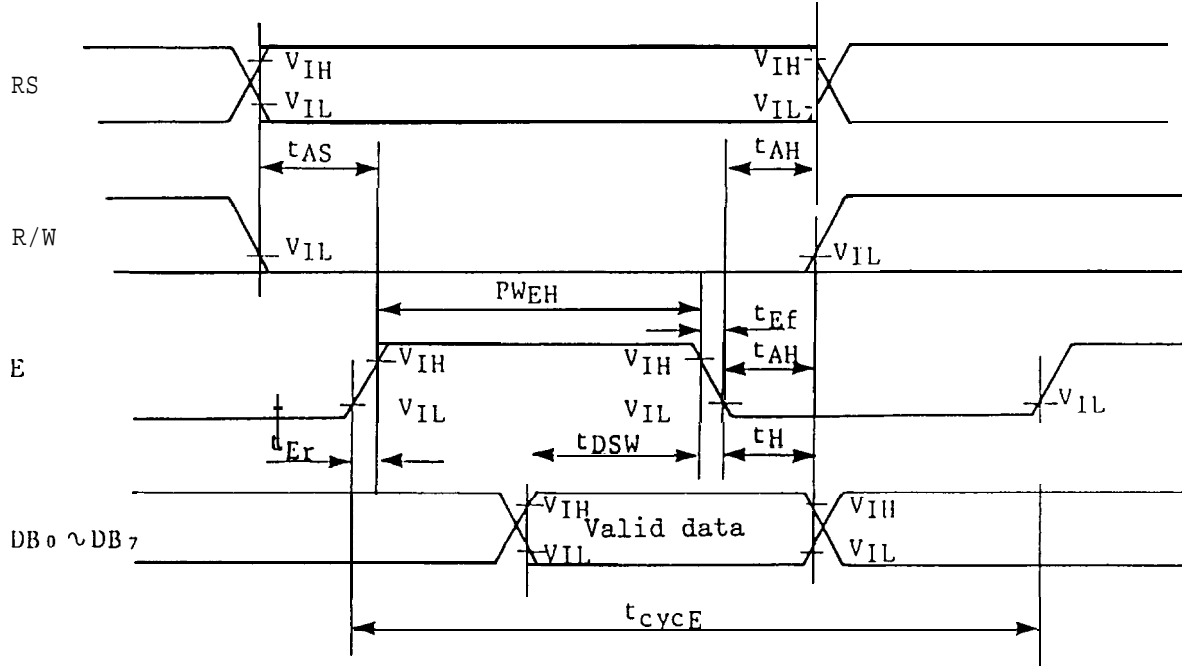
4.4 Interface signals

Table 5

Pin No	Symbol	Description	Connection
1	V_{SS}	Ground potential	GND : 0V
2	V_{DD}	Power supply	+5V
3	V_0	Contrast adjustment Voltage	Adjust the contrast by changing the supply voltage from 0V to 5V.
4	RS	Register select signal	Control signal inputs (For details, see section 6 and 7.)
5	R/W	Read/write select signal	
6	E	Operation (data read/write enable signal)	
7	DB_0	Code I/O data 1st bit	Data bus line • DB_7 may also be used to check the busy flag. Lines $DB_0 \sim DB_3$ are not used when interfacing with a 4-bit microprocessor. (For details, see section 6 and 7.)
8	DB_1	Code I/O data 2nd bit	
9	DB_2	Code I/O data 3rd bit	
10	DB_3	Code I/O data 4th bit	
11	DB_4	Code I/O data 5th bit	
12	DB_5	Code I/O data 6th bit	
13	DB_6	Code I/O data 7th bit	
14	DB_7	Code I/O data MSB	
15	V_{LED}	Power supply (+)	5V power supply between V_{LED} and V_{LSS} .
16	V_{LSS}	Power supply (-)	



Write Operation



Read Operation

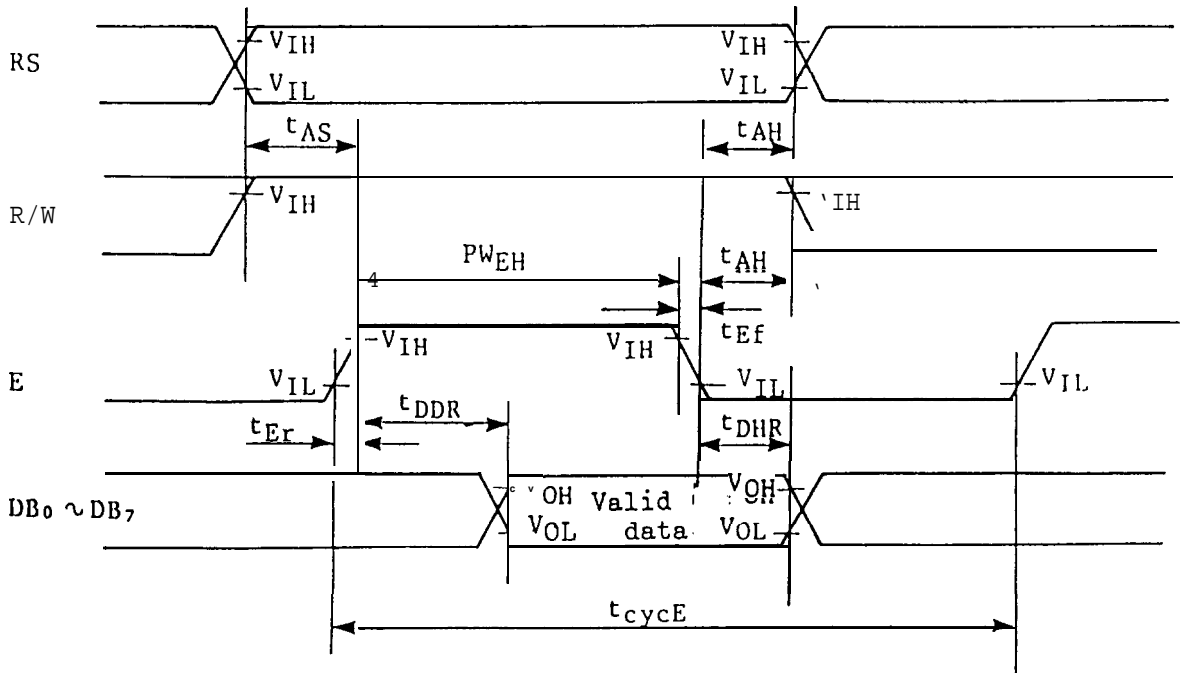


Fig. 1 Timing Chart



5. Optical Characteristics

5.1 When backlight LED is OFF state

Table 6 shows the optical characteristics when .CD drive voltage is adjusted to the maximum contrast in $\theta = 0^\circ$.

Table 6

(Ta=25°C)

Parameter	Symbol	Condition	Min.	Typ.	Max.	Uni	Remark	
Viewing angle range	$\theta_2 - \theta_1$	$\phi = 0^\circ$ $C_0 \geq 4.0$	60	-	-	dgr.	Note 1	
	θ_1	$\theta_1 < \theta_2$ $C_0 = 4.0$	-	-	-25	dgr.	Note 1	
	θ_2		25	-	-			
	Viewing angle range	$\theta_2 - \theta_1$	$\phi = 45^\circ$ $C_0 \geq 4.0$	60	-	-	dgr.	Note 1
		θ_1	315° $C_0 = 4.0$	-	-	-25	dgr.	Note 1
		θ_2		$\theta_1 < \theta_2$	25	-		
Contrast ratio	C_0	$\theta = 0^\circ, \phi = 0^\circ$	7.0	10	-	-	Note 2	
Response time	Rise	t_r	$\theta = 0^\circ, \phi = 0^\circ$	-	150	250	ms	Note 3
	Decay	t_d	$\theta = 0^\circ, \phi = 0^\circ$	-	150	250	ms	Note 3

Note 1) The viewing angle range is defined as shown below.

* Angles θ_1, θ_2 and ϕ shall fall within the range over which the displayed character can be read.

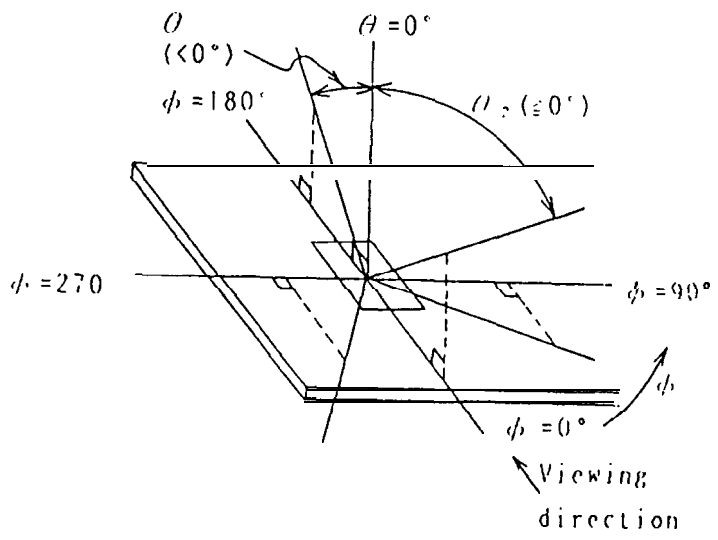


Fig.2 Definition of viewing angle.

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Note 2) Contrast ratio is defined as follows:

When input signal is applied to the unit to select (turn on) the LCD dots (pixels) to be measured in the optical characteristics test method as defined in Fig. 3.

$$\text{Contrast ratio} = \frac{\text{Photodetector output voltage with select waveform being applied}}{\text{Photodetector output voltage with non-select waveform being applied}}$$

Measurement wave length $\lambda = 540\text{nm}$

Note 3) When input signal for selecting or non-selecting Lhc dots to be measured are applied using Lhc optical characteristics test method shown in Fig. 3. The response characteristics of the photo-detector output are measured as shown in Fig. 4.

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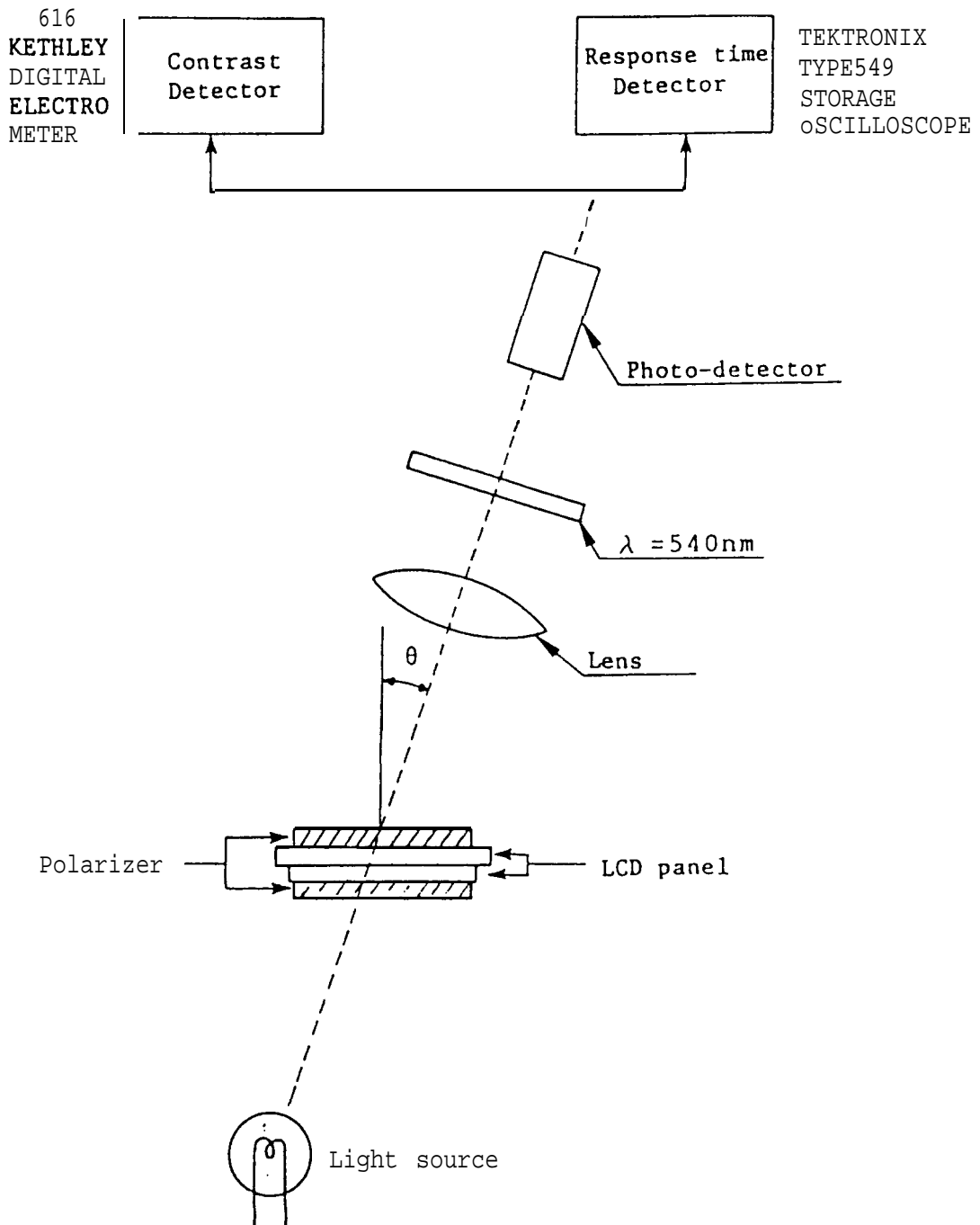


Fig . 3 Optical Characteristics Test Method

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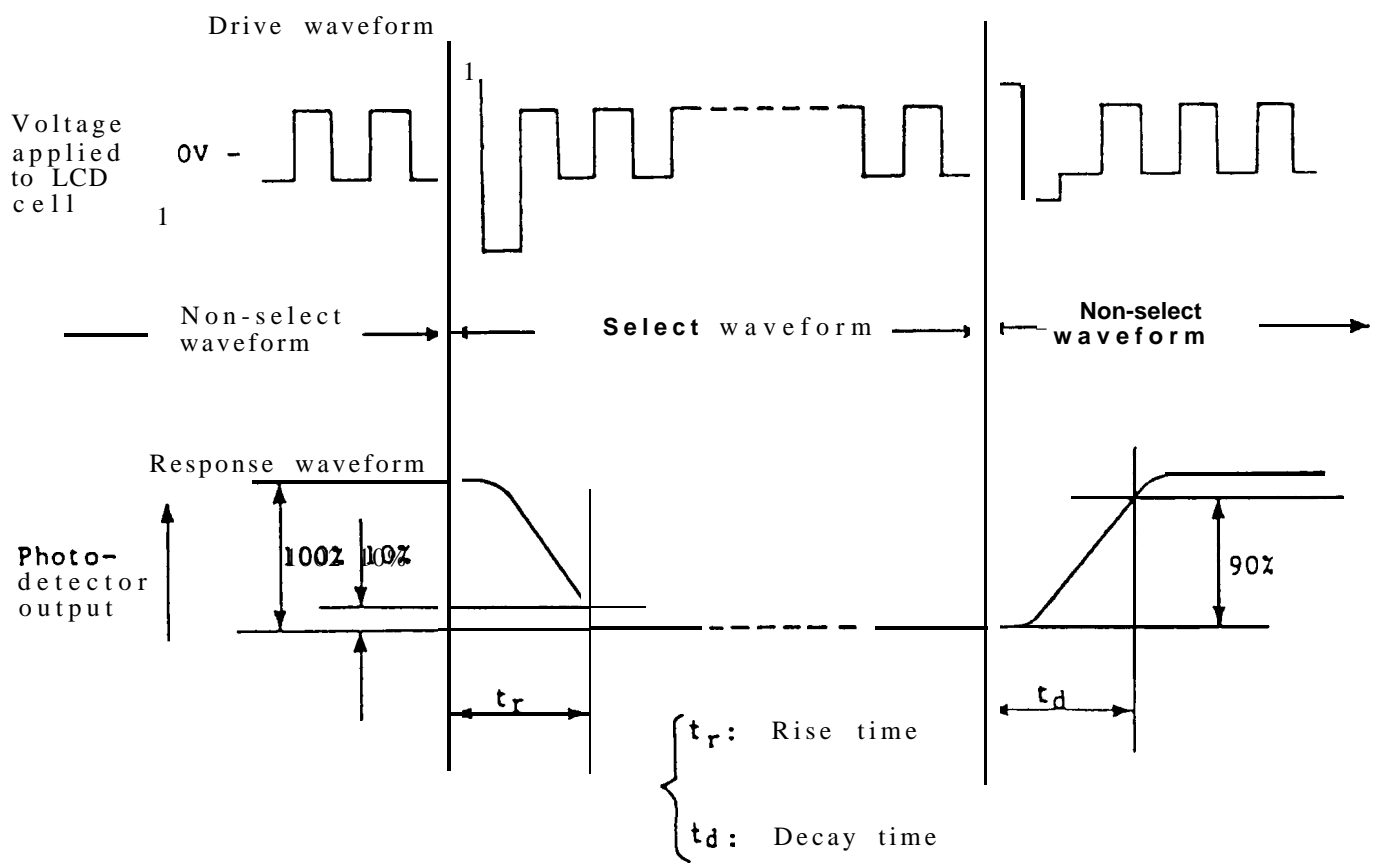


Fig. 4 Definition of Response Time

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5.2 Characteristics of Back light LED (When LCD is ON state)

Table 7

Ta=25°C

V_{LED}-V_{LSS}=5V

Parameter	Min.	Typ.	Max.	Unit	remark
Luminance *	5	15	-	cd/m ²	-
Peak emission wavelength		565	-	nm	
Spectrum radiation bandwidth		30	-	nm	

- Note. Center of the unit with LED backlight lit.

LCD is full dot on.

Non free air state.

After over 30 minutes since LED backlight begin lighting.

LCD drive voltage is adjusted to the maximum contrast in $\theta = 0^\circ$.

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6. Pin Description

1) V_{DD} and V_{SS} Pins

V_{DD} and V_{SS} pins are for power supply. V_{SS} pin is grounded, and V_{DD} pin is supplied with +5V. Each voltage necessary to drive LCD is generated in the unit.

2) RS Pin

The controller LSI has two 8-bit registers; an instruction register (IR) and a data register (DR). RS signal selects these registers.

IR stores instruction codes such as display clear, shift, etc. and also stores address information for the display data RAM (DD RAM), character generator RAM (CG RAM); DR is used for temporarily storing data to be written in DD RAM and CG RAM.

" 0 " : Instruction register (when writing)

Busy flag register; address counter (when reading)

" 1 " : Data register (read/write)

3) R/W Pin

Read or write select signal pin.

" 0 " : Writing

" 1 " : Reading

4) E Pin

Data read or write operation enable signal pin.

5) $DB_0 \sim DB_7$ Pins

Data bus with three-state, bidirectional function for use in data transactions with MPU. DB_7 may also be used to check the busy flag.

$DB_0 \sim DB_3$ are not used when interfacing with a 4-bit microprocessor.

6) V_0 Pin

Viewing angle is varied and contrast is adjusted by changing voltage between +5V ~ 0V by applying bias voltage to the LCD driver.

7) V_{LED} and V_{LSS}

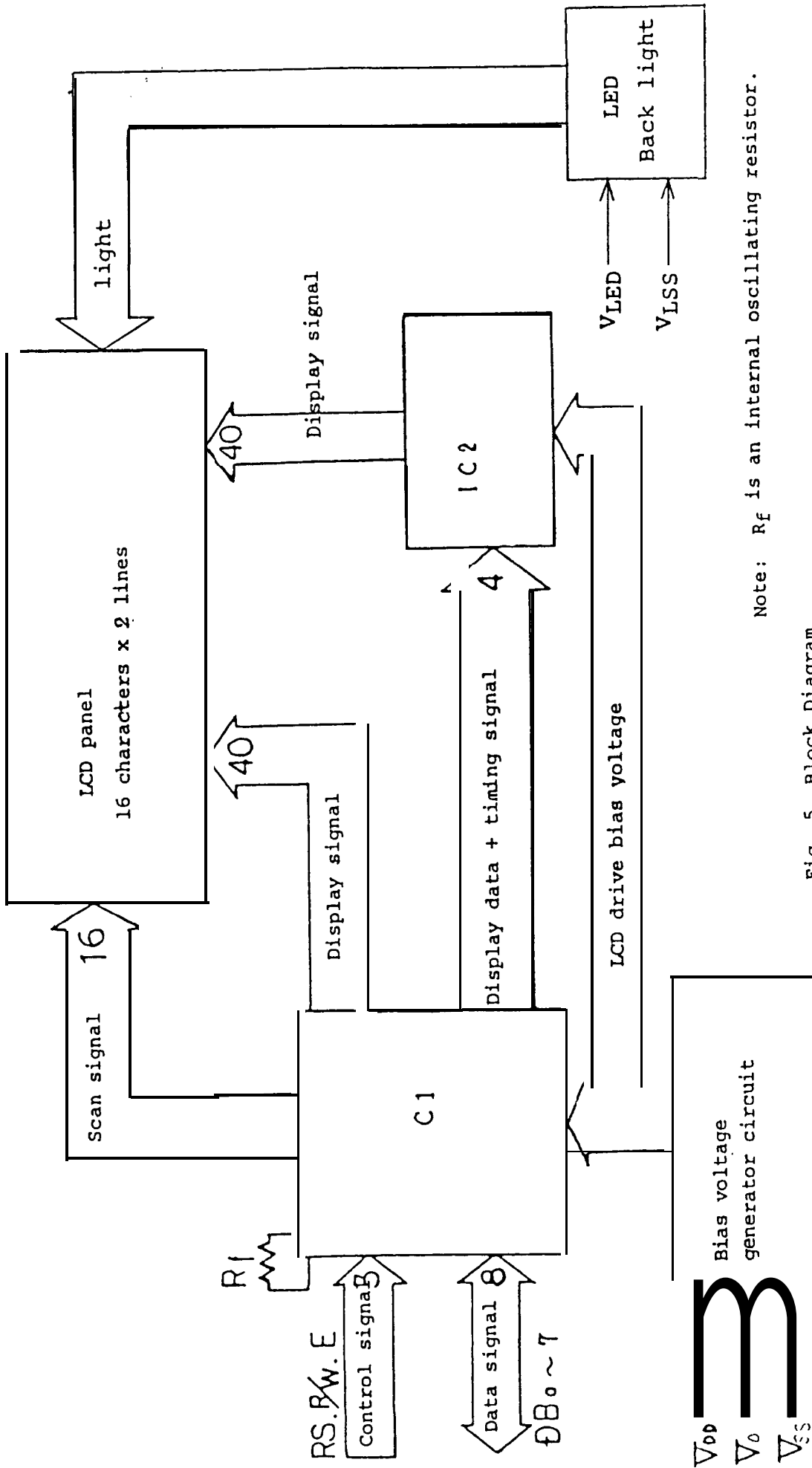
Power supply for LED backlight. (By changing the supply voltage, backlight luminance can be adjusted.) V_{LED} is plus and V_{LSS} is minus.

7. Instruction Set

Table 8

Instruction	Code										Function
	RS	R/U	DB ₇	DB ₆	DB ₅	DB ₄	DB ₃	DB ₂	DB ₁	DB ₀	
Display clear	0	0	0	0	0	0	0	0	0	1	Clear entire display area , restore display from shift, and load address counter with DD RAM address 00H.
Display/cursor home	0	0	0	0	0	0	0	0	1	*	Restore display from shift and load address counter with DD RAM address 00H.
Entry mode set	0	0	0	0	0	0	0	1	I/D	S	Specify cursor advance direction and display shift mode. This operation takes place after each data transfer.
Display ON/OFF	0	0	0	0	0	0	1	D	C	B	Specify activation of display (D), cursor (C), and blinking of character at cursor position (B).
Display/cursor shift	0	0	0	0	0	1	S/C	R/L	*	*	Shift display or move cursor.
Function set	0	0	0	0	1	DL	↑	0	*	*	Set interface data length (DL) .
CG RAM address set	0	0	0	1	ACG					Load the address counter with a CC RAM address. Subsequent data is CC RAM data.	
DD RAM address set	0	0	1	ADD					Load the address counter with a DD RAM address. Subsequent data is DD RAM data.		
Busy flag/address counter read	0	1	BF	AC					Read busy flag (BF) and contents of address counter (AC).		
CG RAM/DD RAM data write	1	0	Write data					Write data to CC RAM or DD RAM .			
CG RAM/DD RAM data read	1	1	Read data					Read data from CC RAM or DD RAM .			

I/D = 1: Increment,	I/D = 0: Decrement	S/C = 1: Shift display,	S/C = 0: Move cursor
s = 1: Shift display,	s = 0: Freeze display	R/L = 1: Shift right,	R/L = 0: Shift left
D = 1: Display ON,	D = 0: Display OFF	DL = 1: 8-bit,	DL = 0: 4-bit
c = 1: Cursor ON,	c = 0: Cursor OFF	BF = 1: During internal operation,	BF = 0: End of internal operation
E = 1: Character at cursor position blinks,	B = 0: Character at cursor position unblinks		



Note: R_f is an internal oscillating resistor.

Fig. 5 Block Diagram

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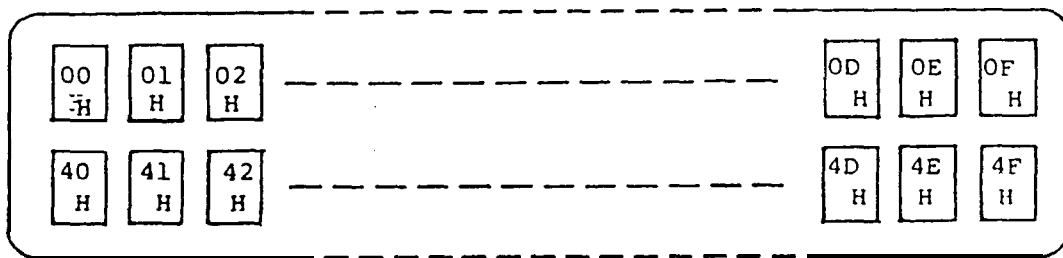


Fig.6 Display Adres (When the display is not shifted)

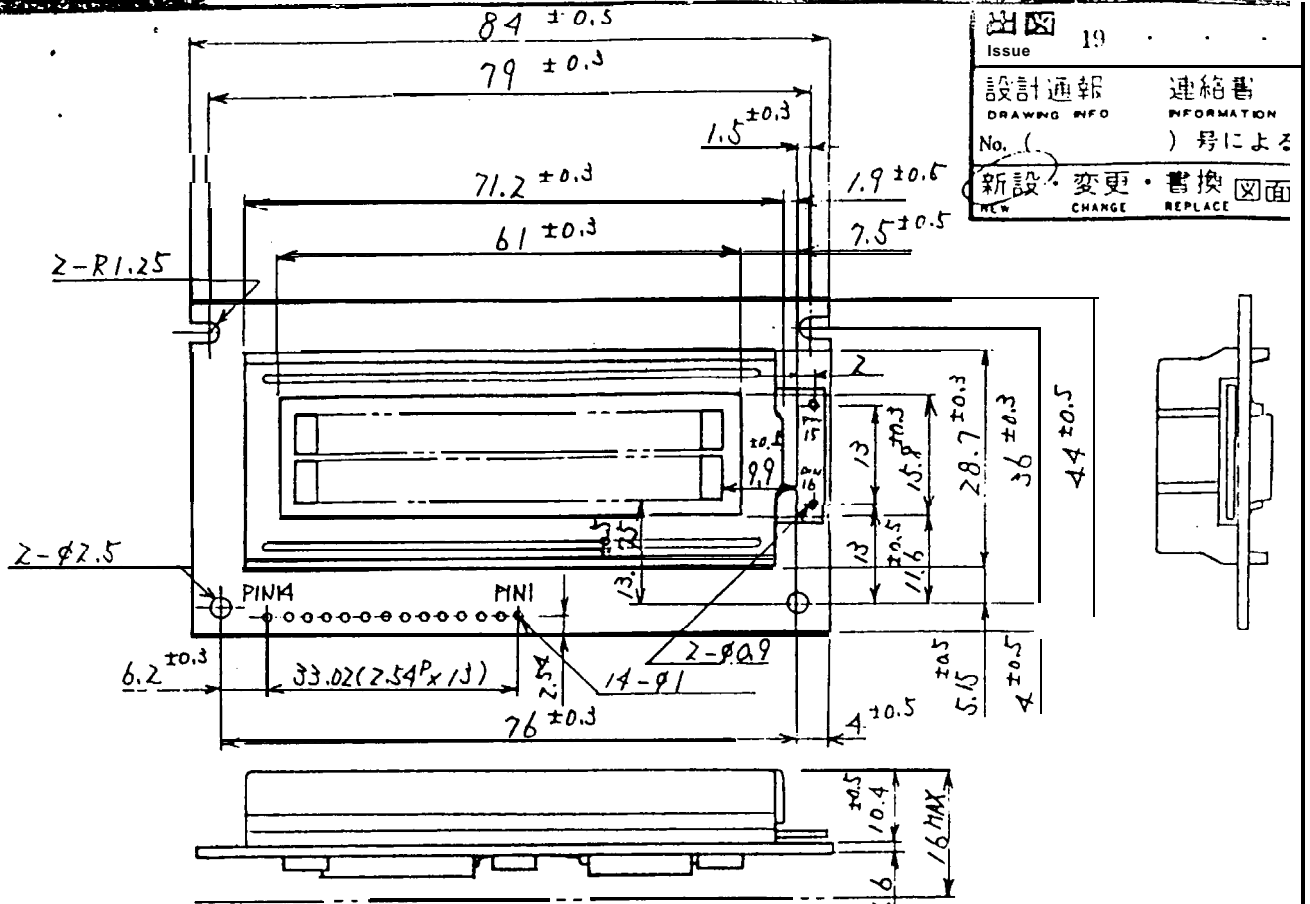
Table 9. Input Code vs. Character Pattern

*1 *2 4bit	0000	0010	0011	0100	0101	0110	0111	1010	1011	1100	1101	1110	1111
xxxx0000	CG RAM (1)												*
xxxx0001	(2)												*
xxxx0010	(3)											*	
xxxx0011	(4)												
xxxx0100	(5)											*	
xxxx0101	(6)												
xxxx0110	(7)											*	
xxxx0111	(8)											*	
xxxx1000	(1)												
xxxx1001	(2)												*
xxxx1010	(3)											*	
xxxx1011	(4)												
xxxx1100	(5)												
xxxx1101	(6)												
xxxx1110	(7)												
xxxx1111	(8)												*

Note 1. CG RAM is character generator RAM in which user-definable character patterns are stored.

Note 2. X mark: prohibition of input

*1 High-order *2 Low-order



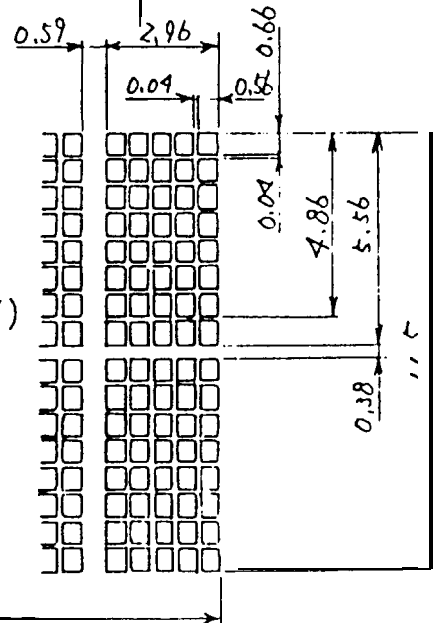
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設計通報 DRAWING INFO	連絡書 INFORMATION		
No. ()	号による		
新設 NEW	変更 CHANGE	書換 REPLACE	図面

*	**
1	V _{SS}
2	V _{DD}
3	V ₀
4	RS
5	R/W
6	E
7	DB ₀
8	DB ₁
9	DB ₂
10	DB ₃
11	DB ₄
12	DB ₅
13	DB ₆
14	DB ₇

* Pin No.
** Display Signal

Dot Size (φ = 5/1)

*	**
15	V _{LFD}
16	V _{LSS}



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△ 19 . .				LM16X21B	名 称 NAME	Fig. 7 Unit Outline Dimensions
△ 19 . .				LM16A01		
年月日 DATE	訂正記事 REVISE	設計No.	担当 PREPA	適用機種 MODEL	記号 SYMBOL	
材 質 MATERIAL	板厚 THICKNESS	仕 上 FINISH		尺 度 SCALE	部品コード PARTS CODE	
設計 DESIGN	写図 TRACE	検図 CHECK	検図 CHECK	承認 APPROVE	作成日付 DATE	1986 . 9 . 4 .
SHARP CORPORATION				発行部門 LCD Division	図 番 DRAWING No.	OD16A0111011