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AN.No.G191C-090E

LIQUID CRYSTAL DISPLAY MODULE

WITH BUILT-IN EL BACKLIGHT

G 1 9 1 C

USER'S MANUAL

Seiko Instruments Inc.



NOTICE

This manual describes the technical information, the function, and the operation of the G191C Liquid Crystal Display Module of Seiko Instruments Inc. Please read this manual carefully to familiarize yourself with the functions and to make best use of them. The descriptions here are subject to change without notice.

Revision Record

<u>Edition</u>	<u>Revision</u>	<u>Date</u>
- 1	Original	September 1990

CONTENTS

1. SPECIFICATIONS

1.1 General	1
1.2 Features	1
1.3 Absolute Maximum Ratings	1
1.4 Electrical Characteristics (Excluding EL Backlight)	1
1.5 Optical Characteristics	2
1.6 EL Backlight Characteristics	3
1.7 Dimensions	4

2. CIRCUIT STRUCTURE

2.1 Liquid Crystal Driving Circuit	5
2.2 Circuit Structure	7
2.3 Timing Characteristics	10
2.4 Interface Circuit	12
2.5 Suitable Inverter SKI-050-05H	16

3. NOTES	17
----------------	----

INDEX

1. SPECIFICATIONS

1.1 General

The G191C is a thin liquid crystal display (LCD) module that consists of a full dot-matrix LCD panel, CMOS LSIs and EL backlight. The panel features a wide viewing angle and high contrast. The full dot-matrix structure allows both graphics and character display. In addition, the display is clear and stable, with no image warping or position skew, because the display position is specified by the intersection of transparent electrodes in a matrix.

1.2 Features

- Full dot-matrix structure with 192 dots×128 dots
- 1 / 128 duty
- FSTN LCD : black and white display using RCF (Retardation Control Film)
- Transflective LCD, anti-glare, 6 o'clock viewing angle
- Built-in EL backlight
- Positive type
display data "H" (display ON) :black, display data "L" (display OFF) : white
- Four-bit parallel data input
- Two power supplies : $V_{DD}=5\text{ V}$, $V_{LC}=-5\text{ V}$ to -20 V (for driving liquid crystal)
- Weight : Approx. 100 g

1.3 Absolute Maximum Ratings

 $V_{SS} = 0\text{ V}$

Item	Symbol	Conditions	Min.	Max.	Unit
Power supply voltage	V_{DD}		0	6.0	V
	V_{LC}		$V_{DD} - 28.0$	0	V
Input voltage	V_{IN}		-0.3	$V_{DD} + 0.3$	V
Operating temperature	T_{opr}	$\leq 65\%RH$	0	+ 50	°C
Storage temperature	T_{stg}		- 20	+ 60	°C

1.4 Electrical Characteristics (Excluding EL Backlight)

 $V_{SS} = 0\text{ V}$, $T_a = 0^\circ\text{C}$ to 50°C

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit
Power supply voltage	V_{DD}		4.75	5.00	5.25	V
	V_{LC}	$V_{DD} = 5\text{ V} \pm 5\%$	- 20.0	—	- 5.0	V
Input voltage	High V_{IH}	$V_{DD} = 5\text{ V} \pm 5\%$	$0.8 V_{DD}$	—	V_{DD}	V
	Low V_{IL}	$V_{DD} = 5\text{ V} \pm 5\%$	0	—	$0.2 V_{DD}$	V
Current consumption*	I_{DD}	$T_a = 25^\circ\text{C}$ $V_{DD} = 5.0\text{ V}$ $V_{LC} = -12.4\text{ V}$ $f_{FRM} = 70\text{ Hz}$	—	3.1	5.0	mA
	I_{LC}		—	2.9	4.5	mA
Frame frequency	f_{FRM}	$V_{DD} = 5\text{ V} \pm 5\%$	65	70	75	Hz

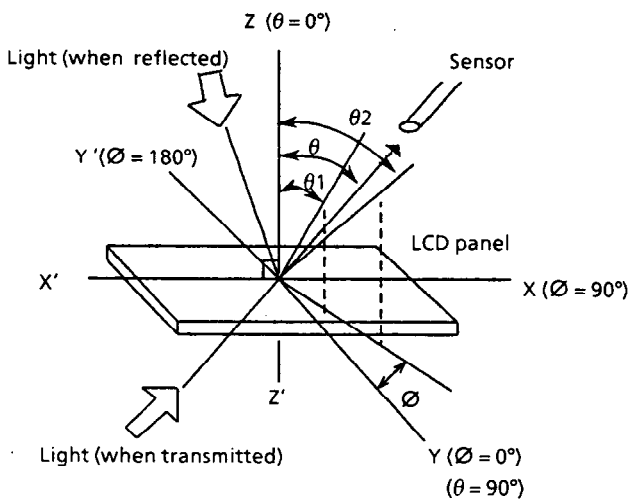
* Display pattern : checker pattern

1.5 Optical Characteristics

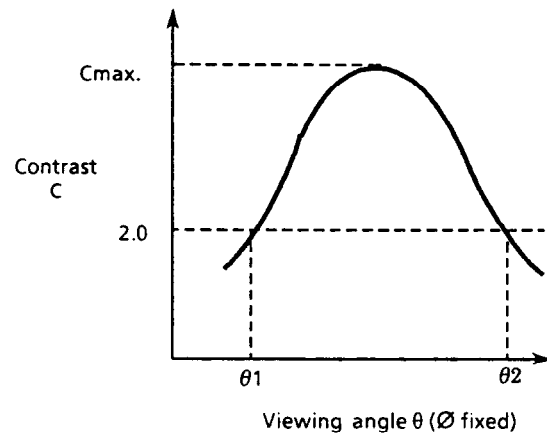
1 / 128 duty, 1 / 12 bias, $V_{opr} = 17.4 \text{ V}$, $T_a = 25^\circ\text{C}$

Item	Symbol	Conditions	Min.	Typ.	Max.	Reference
Viewing angle	$\theta_2 - \theta_1$	$C \geq 2.0$, $\varnothing = 0^\circ$	40°	—	—	Notes 1 & 2
Contrast	C	$\theta = 5^\circ$, $\varnothing = 0^\circ$	2	3	—	Note 3
Response time (rise)	t_{on}	$\theta = 0^\circ$, $\varnothing = 0^\circ$	—	180 ms	270 ms	Note 4
Response time (fall)	t_{off}	$\theta = 0^\circ$, $\varnothing = 0^\circ$	—	150 ms	230 ms	Note 4

Note 1 : Definition of angles θ and $\varnothing$

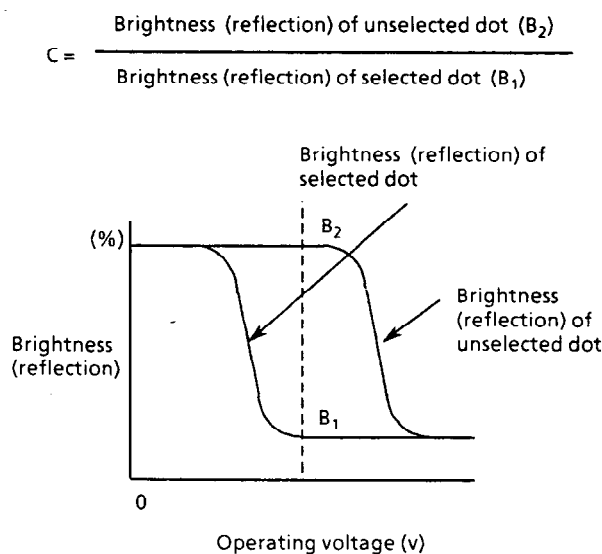


Note 2 : Definition of viewing angles θ_1 and θ_2

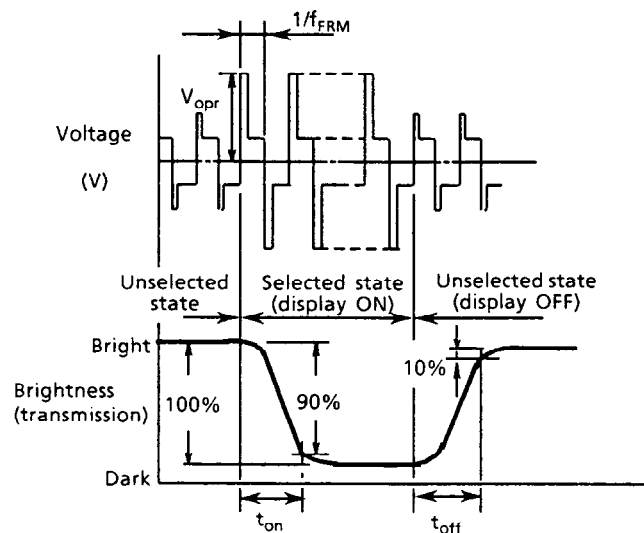


Note : Optimum viewing angle with the naked eye and viewing angle θ at C_{max} above are not always the

Note 3 : Definition of contrast C



Note 4 : Definition of response time



Note : Measured with a transmissive LCD panel which is displayed 1 cm^2

V_{opr} : Operating voltage f_{FRM} : Frame frequency
 t_{on} : Response time (rise) t_{off} : Response time (fall)

1.6 EL Backlight Characteristics

(1) Absolute Maximum Ratings

Item	Symbol	Conditions	Min.	Max.	Unit
Driving voltage	V_{EL}	1 kHz, 1 min	–	200	Vrms
Driving frequency	f_{EL}	115 Vrms, 1 min	–	2.0	kHz
Operating temperature	T_{opr}		– 20	+ 50	°C
Storage temperature	T_{stg}		– 20	+ 60	°C
Operating humidity		40°C	–	95	%RH

(2) Operating Range

Item	Symbol	Min.	Typ.	Max.	Unit
Driving voltage	V_{EL}	41	115	130	Vrms
Driving frequency	f_{EL}	50	400	1000	Hz

(3) Brightness and current consumption characteristics

Item	Conditions	Min.	Typ.	Max.	Unit
Brightness	$V_{EL} = 115 \text{ Vrms}$ $f_{EL} = 400 \text{ Hz}$ $T_a = 23^\circ\text{C} \pm 3^\circ\text{C}$ $50 \pm 10\% \text{ RH}$	60	70	100	cd/m ²
Current consumption		–	0.12	0.15	mA/cm ²
Power consumption		–	4.0	–	mW/cm ²

(4) Service life

Item	Conditions	Ratings	Unit
Service life*	40°C, 95%RH, 100 V rms, 400 Hz	500	hr
	20°C $\pm$ 5°C, 60%RH, 100 V rms, 400 Hz	1800	hr

* Time until the brightness decreases to the half of the initial value

1.7 Dimensions

Unit : mm/inch

General tolerance : ± 0.5 mm

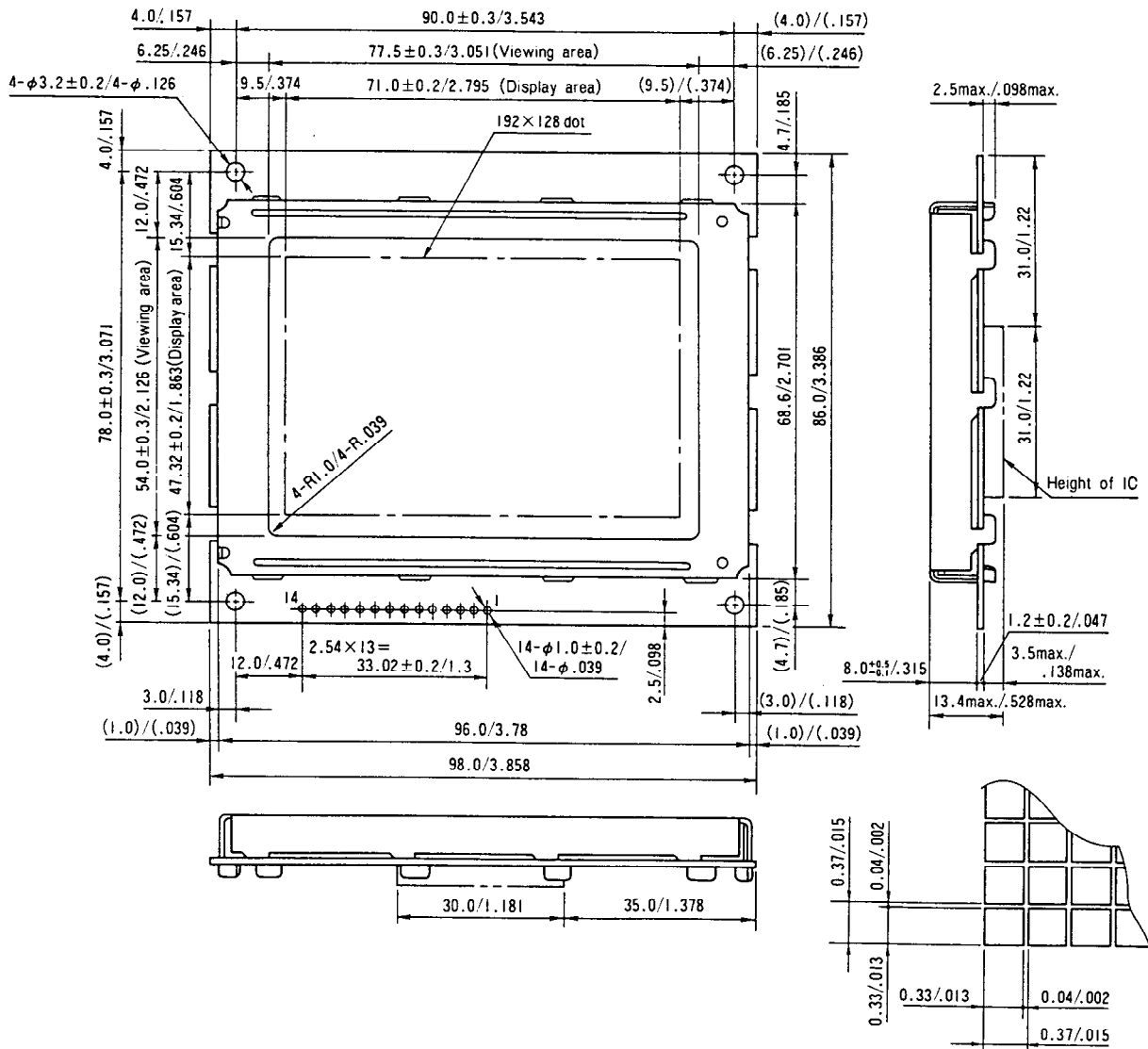


Figure 1 Dimensions

[I/O Terminal Functions]

No.	Symbol	Function
1	D ₃	Display data input
2	D ₂	Display data input
3	FLM	One-frame timing signal
4	M	Liquid crystal AC drive control signal
5	CL1	One-common-line timing signal
6	CL2	Display data shift clock
7	D ₁	Display data input

No.	Symbol	Function
8	D ₀	Display data input
9	V _{DD}	Power supply voltage (1) : + 5 V
10	V _{SS}	GND : 0 V
11	V _{LC}	Power supply voltage (2) : - 12.4 V (typ.)
12	F _{GND}	Frame ground*
13	V _{EL}	EL driving voltage
14	V _{ELG}	EL driving voltage (GND)

* Since F_{GND} terminal is connected to the metal frame of the module, use the terminal to ground the frame.

2. CIRCUIT STRUCTURE

2.1 Liquid Crystal Driving Circuit

The drive waveform of the LCD panel is shown in Figure 2 on the next page. Since DC voltage will damage the liquid crystal, an AC voltage is applied between the two frames. The signal controlling this is the liquid crystal AC drive control signal (M).

The frame frequency is normally set to 70 ± 5 Hz to prevent screen flicker.

The G191C has a 1/128 duty cycle, and the common electrodes are selected within a frame by time division from electrode 1 to electrode 128. This is called line sequential scanning. The voltage level of the segment electrodes determines whether the dots at the intersection of the segment electrodes are selected or not, when the common electrode is selected. As shown in Table 1, there are six drive waveform voltage levels, V_a to V_f . The voltage level is determined by the bias value. The voltage between the segment and common electrodes is thus applied to the liquid crystal. The selection waveform for SEG₀-COM₀ and the non-selection waveform for SEG₁-COM₁ are shown in Figure 2. The size of the effective voltage of the waveform determines whether the liquid crystal under the selected dots is in the selection or non-selection state.

Table 1

V_a	Common and segment selection level
V_b	Common non-selection level
V_c	Segment non-selection level
V_d	Segment non-selection level
V_e	Common non-selection level
V_f	Common and segment selection level

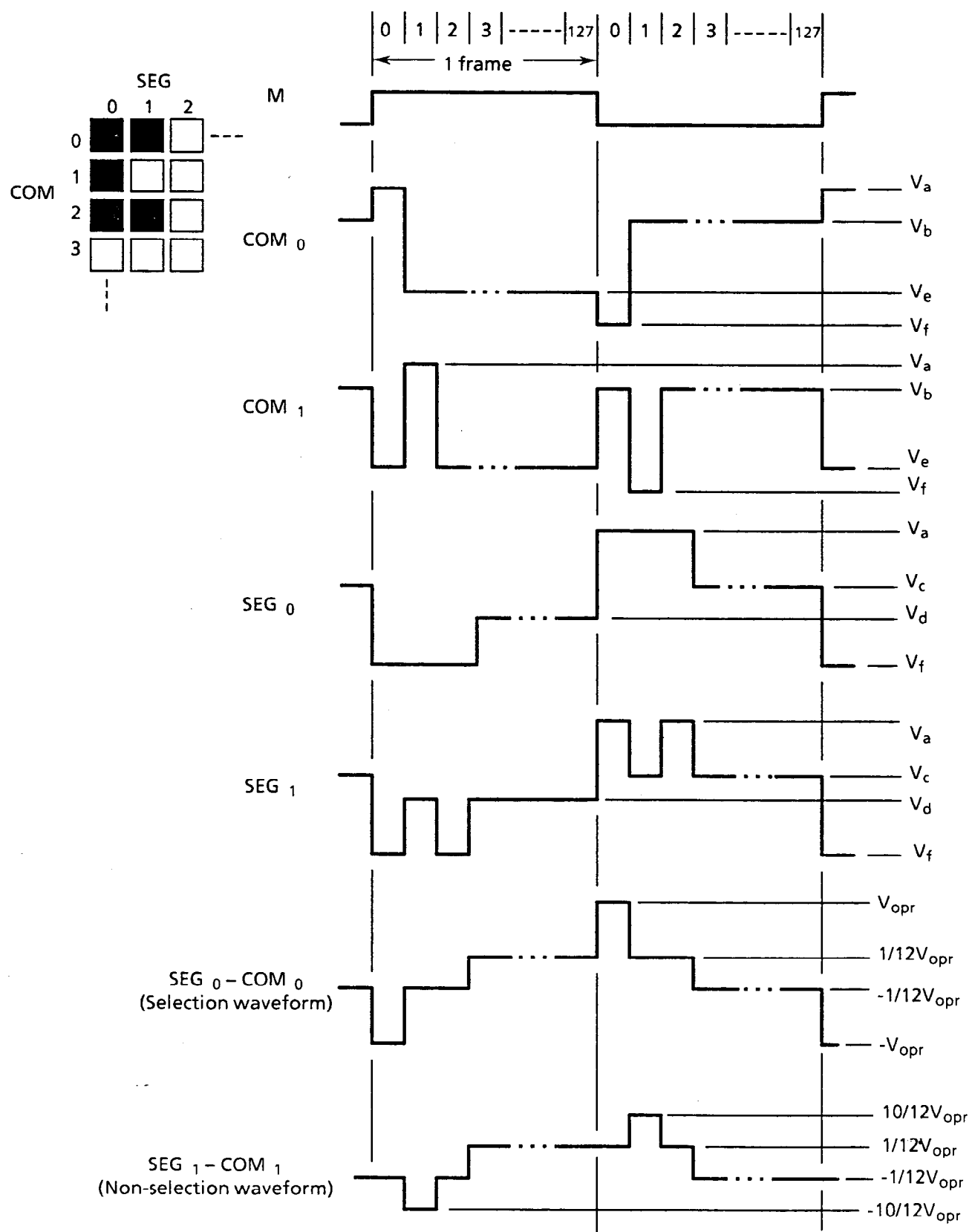


Figure 2 Drive waveform

2.2 Circuit Structure

The G191C consists of common drivers, segment drivers, a bias voltage generation circuit and EL backlight. Figure 3 shows the block diagram.

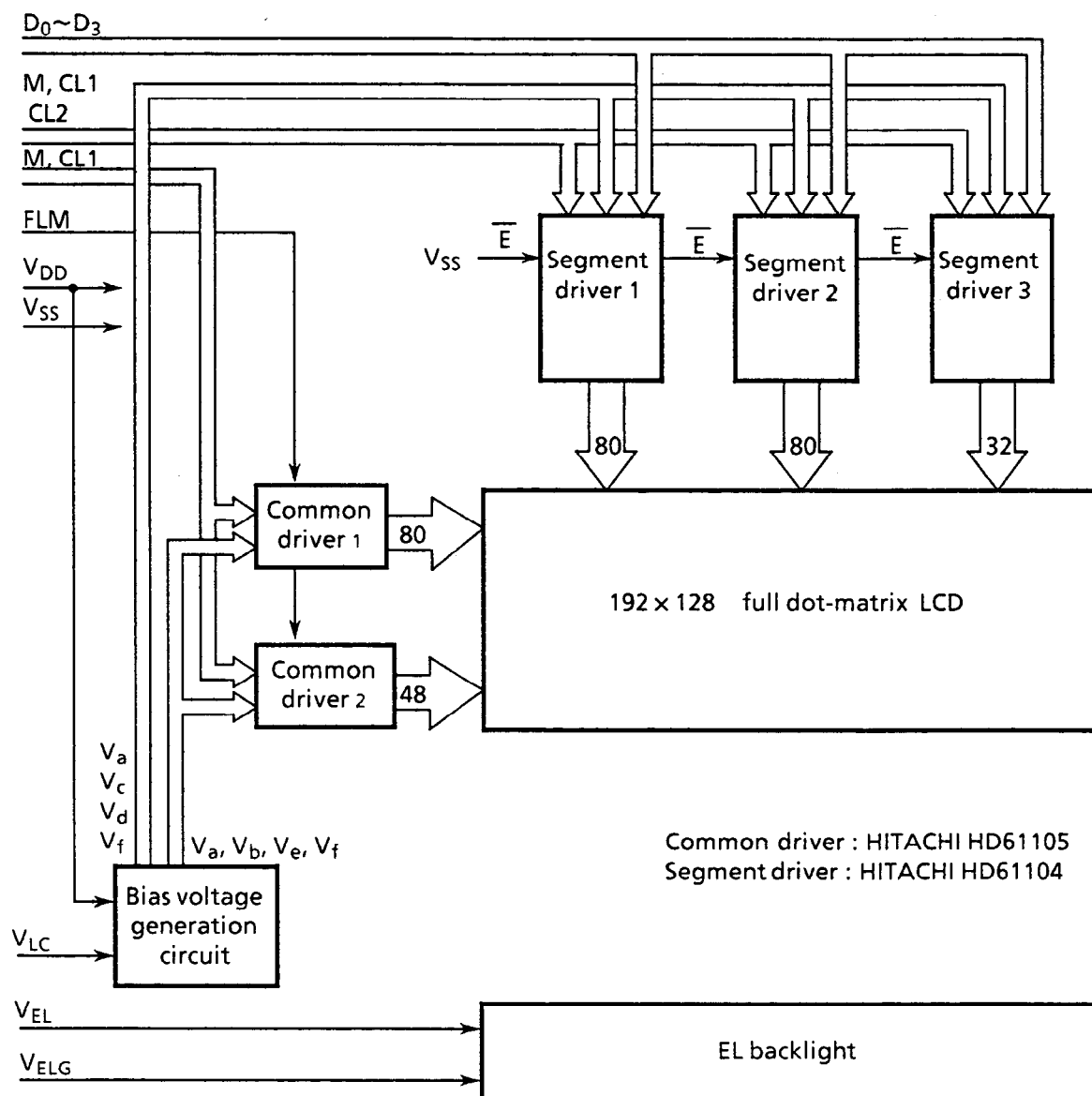


Figure 3 Block diagram

(1) Common driver (HITACHI HD61105)

A common driver (CD) is a CMOS IC with 80 drive outputs. The G191C has two CDs, whose internal registers are connected each other. They operate as follows.

Input one-frame timing signal (FLM) is taken into the internal shift register by the falling edge trigger of the one-common-line timing signal (CL1), and sequentially shifted. After 128-CL1 input, the next FLM is input and the same operation is repeated. As shown in Table 2, the common output is selected according to the shift register contents and the liquid crystal AC drive control signal (M) in the drive circuit, and the common drive waveform is formed.

Table 2

Shift register content	M	COM output
H	H	V_f
	L	V_a
L	H	V_b
	L	V_e

(2) Segment driver (HITACHI HD61104)

A segment driver (SD) is a CMOS IC with 80 drive outputs. It operates as follows.

Input four-bit data is sequentially taken into the internal register by the falling edge trigger of the display data shift clock (CL2). SD has a chip enable function. After 80 bits of data are taken into SD1, the next data is automatically taken into SD2. G191C has three SDs and 192 bits of data can be taken. The display data taken into internal register are latched by the falling edge trigger of CL1. As shown in the Table 3, the segment output is selected according to the display data and M in the drive circuit, and the segment drive waveform is formed.

Table 3

Display data	M	SEG output
H	H	V_a
	L	V_f
L	H	V_c
	L	V_d

The relationship between the display data and display screen is shown below..

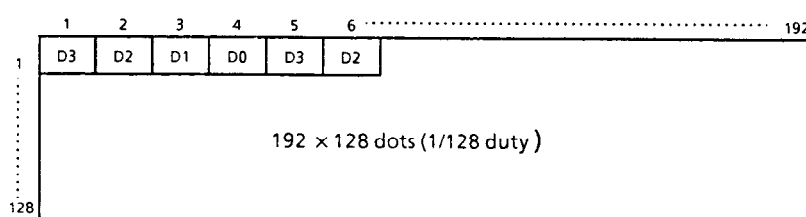


Figure 4

(3) Bias voltage generation circuit

Six levels of voltage, V_a to V_f , are applied to the common and segment drivers. The voltage is generated through operational amplifier by resistance-division from liquid crystal operating voltage (V_{opr}). Here, an operational amplifier is used as a voltage follower.

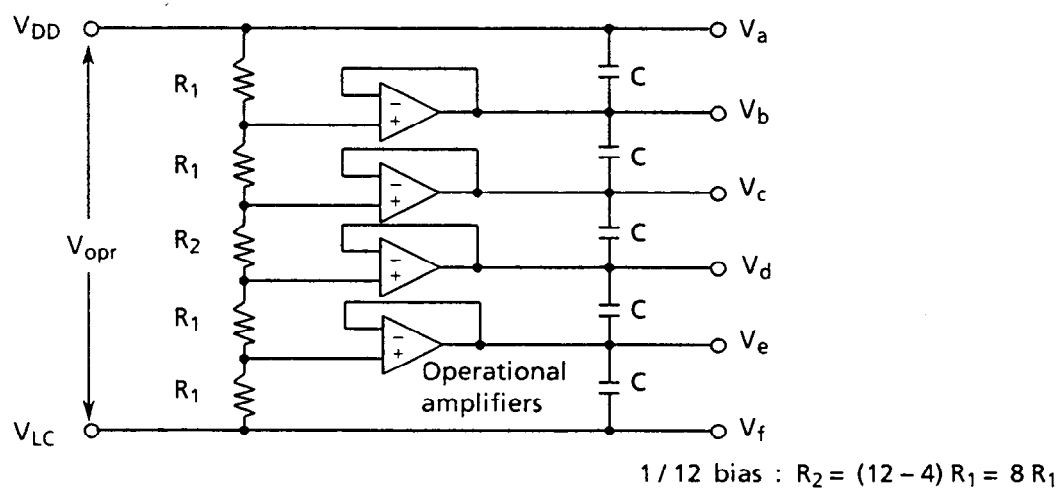


Figure 5 Bias voltage generation circuit

Also, display screen contrast and viewing angle are influenced by the ambient temperature. The recommended V_{opr} level at different temperatures is as follows.

Temperature (°C)	0	25	50
V_{opr} (V)*	18.4	17.4	16.3

* $V_{opr} = V_{DD} - V_{LC}$

(4) EL backlight

To the EL backlight, apply AC signal from low-frequency constant voltage source or from EL inverter.

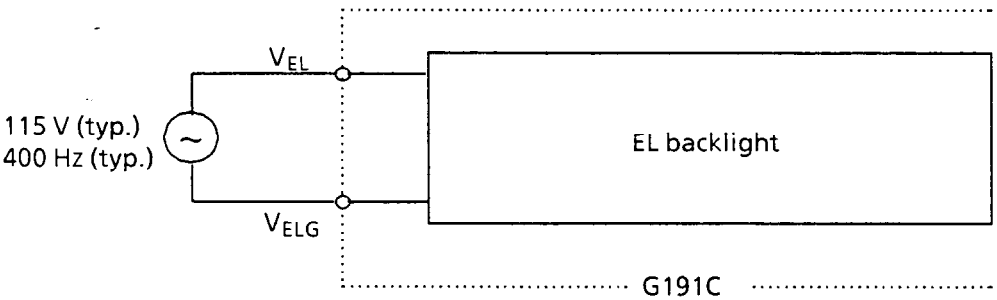


Figure 6

2.3 Timing Characteristics

2.3.1 Power ON/OFF and Signal Input Timing

Power ON/OFF and signal input should be performed according to the timing shown in the figure below in order not to damage the LCD driving circuit and the LCD panel.

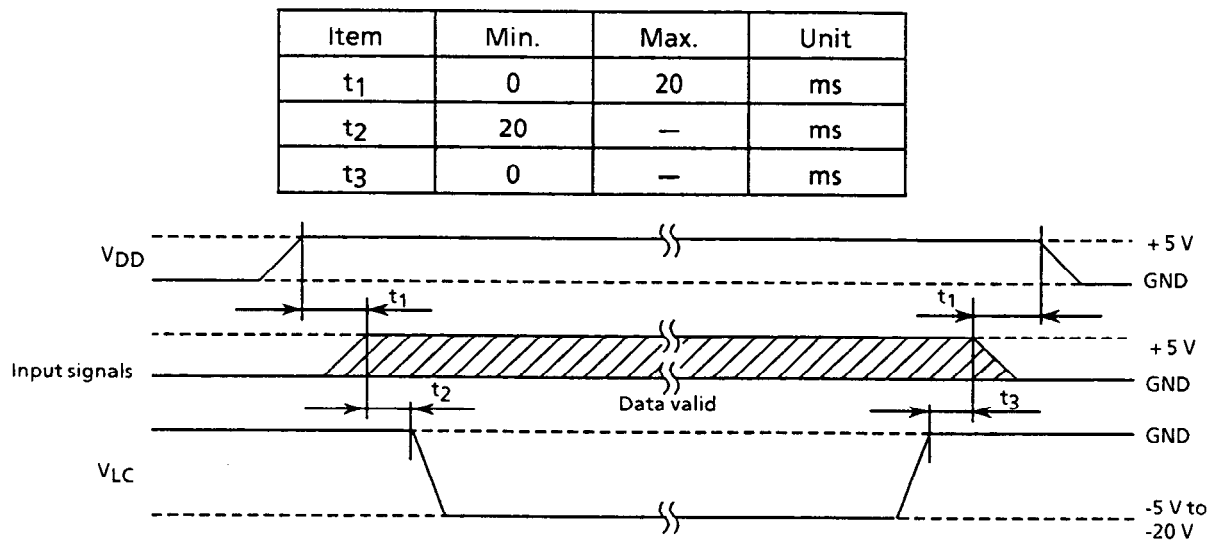
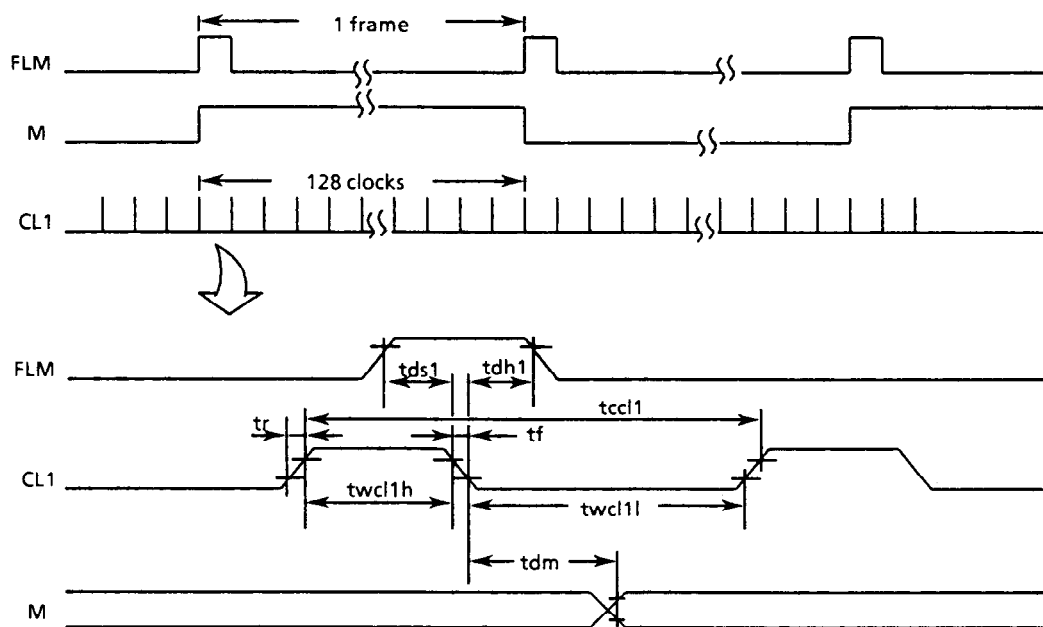
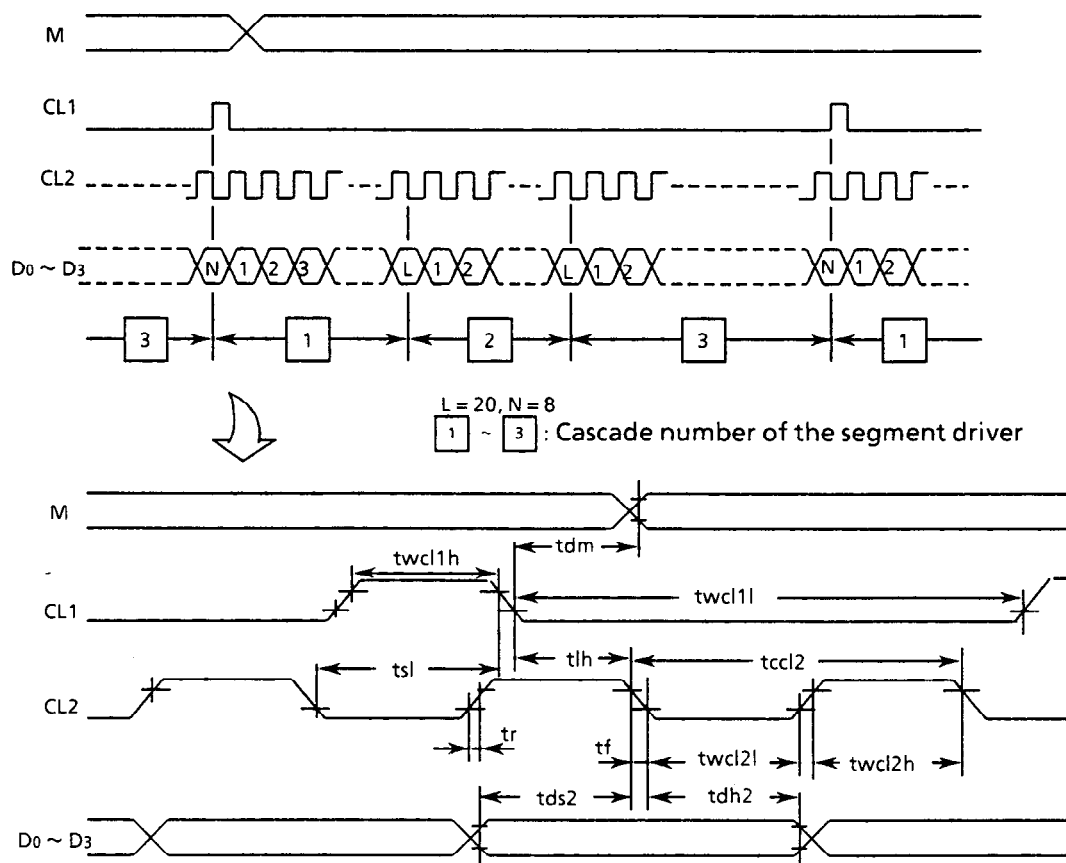


Figure 7 Power ON/OFF and signal input timing

2.3.2 Timing Characteristics

$T_a = 0^\circ\text{C to } 50^\circ\text{C}$, $V_{DD} = 5.0\text{ V} \pm 5\%$, $V_{SS} = 0\text{ V}$

Item	Symbol	Min.	Max.	Unit
CL1 cycle time	$tccl1$	$tccl2 \times 10$	—	ns
CL1 high level width	$twcl1h$	125	—	ns
CL1 low level width	$twcl1l$	5000	—	ns
Data setup time 1	$tds1$	100	—	ns
Data hold time 1	$tdh1$	100	—	ns
M phase difference	tdm	—	300	ns
CL1, CL2 rise time	t_r	—	30	ns
CL1, CL2 fall time	t_f	—	30	ns
CL2 cycle time	$tccl2$	285	—	ns
CL2 high level width	$twcl2h$	110	—	ns
CL2 low level width	$twcl2l$	110	—	ns
Data setup time 2	$tds2$	80	—	ns
Data hold time 2	$tdh2$	80	—	ns
CL2 setup time	tsl	80	—	ns
CL2 hold time	tlh	80	—	ns

Timing chart 1 Timing of signal input into common driver**Figure 8****Timing chart 2 Timing of signal input into segment driver****Figure 9**

2.4 Interface Circuit

2.4.1 Interface with MPU signal

The G191C is controlled by the MPU circuit, whose interface is easily set up when the LCD controller is used. The LCD controller has basic functions such as receiving information related to the display from the MPU circuit, and sending display timing signals and display data to the LCD module, and other functions such as cursor display.

The G191C must use LCD controllers conforming to the following conditions.

- controller for a full dot-matrix LCD module
- capable of transferring data to the LCD module in four-bit parallel
- capable of driving the LCD module at 1/128 duty

The following section gives examples of interfaces using the OKI MSM6255GSK, SEIKO EPSON SED1330FBA and HITACHI HD64646FS controllers.

(1) OKI MSM6255GSK

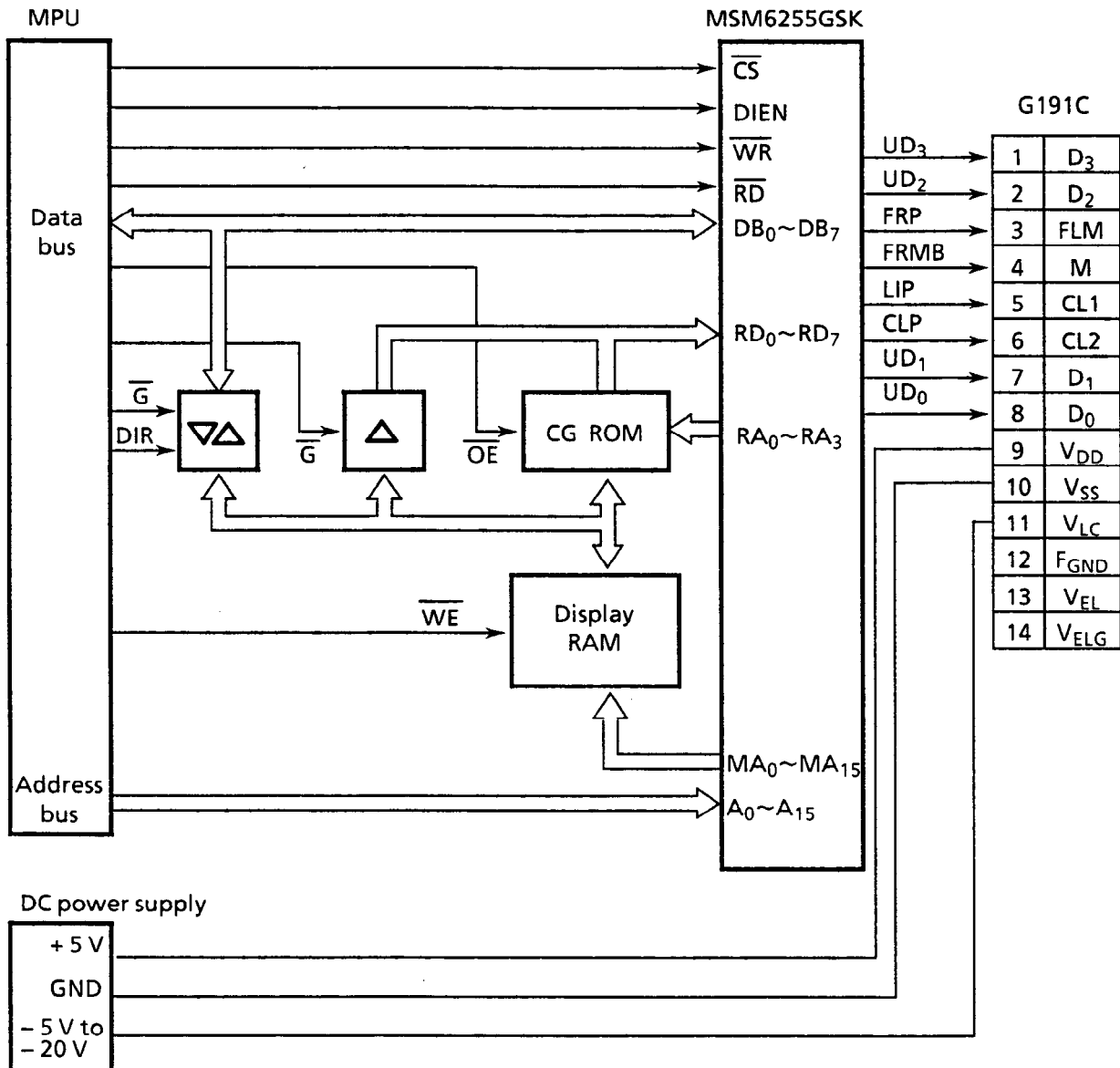


Figure 10 Interface circuit with MSM6255GSK

[Features of the MSM6255GSK]

- Interface with 80-series MPU possible
- Cursor
 - ON/OFF; blinking speed, form, and position are programmable
- Scrolling and paging
- CMOS process
- 5-V single power supply

(2) SEIKO EPSON SED1330FBA

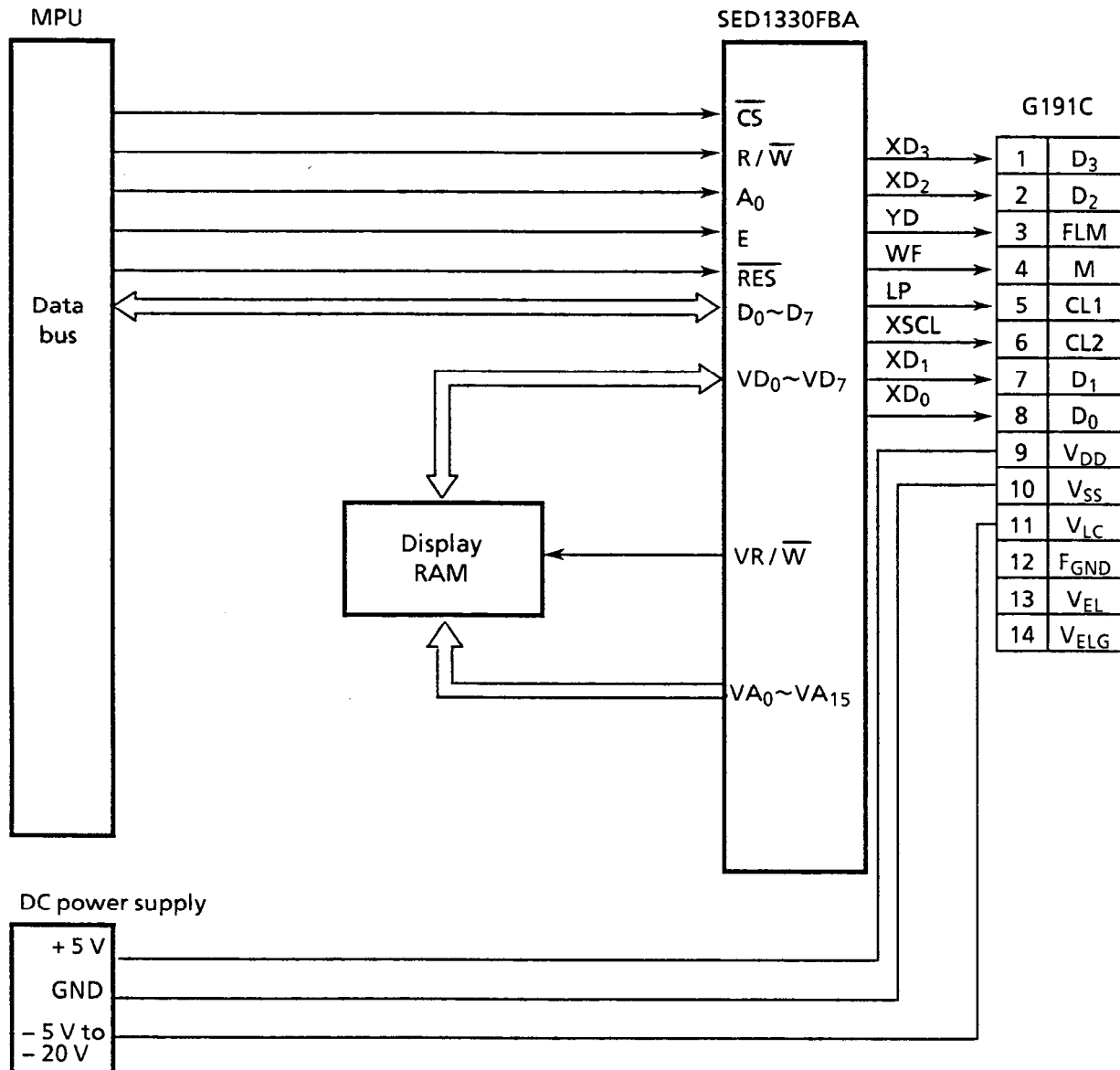


Figure 11 Interface circuit with SED1330FBA

[Features of the SED1330FBA]

- Interface with 80-series or 68-series MPU possible
- Built-in character generator ROM : 160 kinds
- External character generator
 - CG RAM : $(8 \times 16 \text{ dot-matrix}) \times 64$ kinds
 - CG ROM : $(8 \times 16 \text{ dot-matrix}) \times 256$ kinds
- Layered mode : AND, OR, XOR, "preferred" OR
- CMOS process
- Scrolling (vertical and horizontal)
- 5-V single power supply

(3) HITACHI HD64646FS

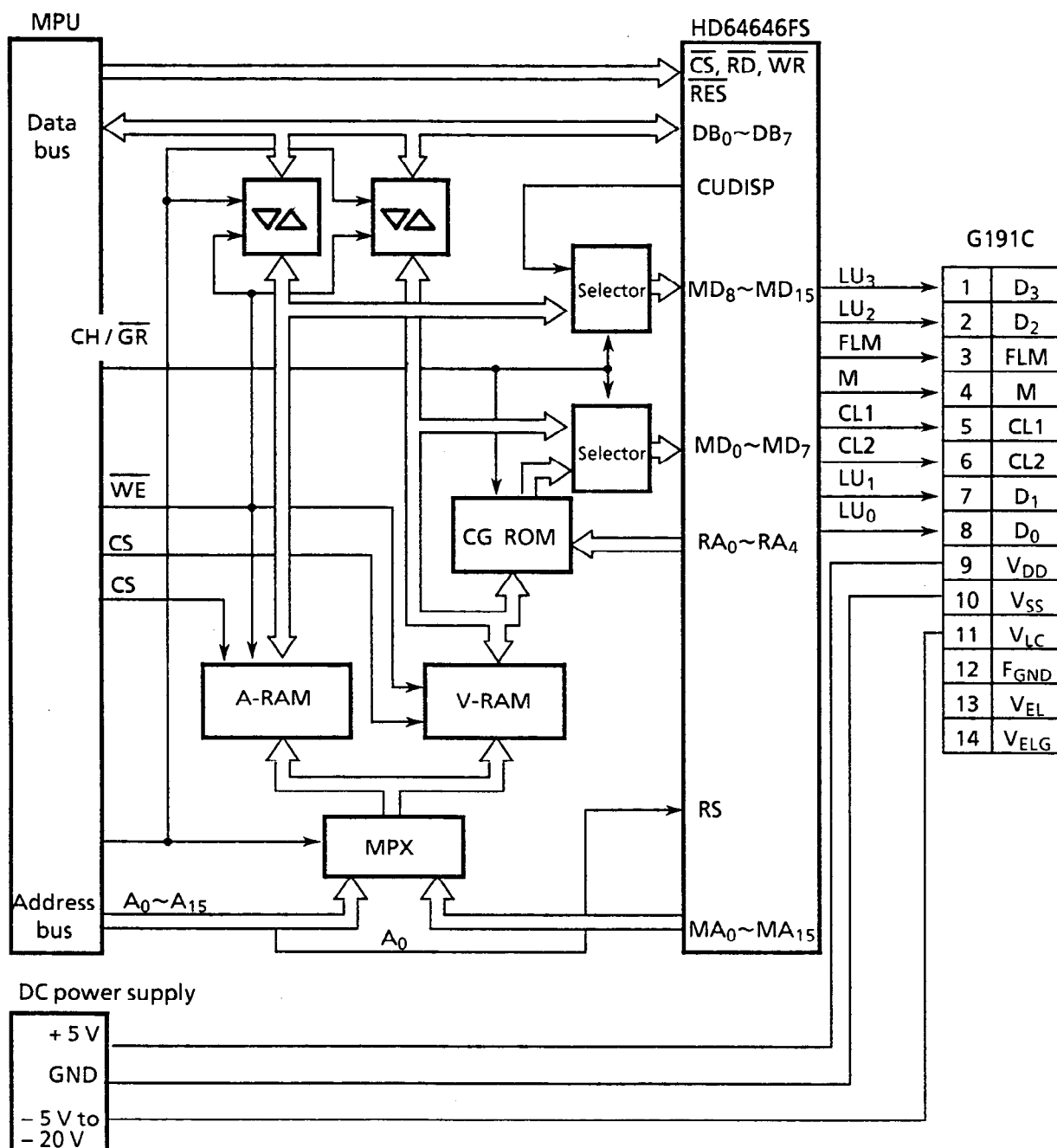


Figure 12 Interface circuit with HD64646FS

[Features of the HD64646FS]

- Interface with 80-series MPU possible
- Layered mode : OR (character and graphics)
- Character reverse, blinking, all black, all white
- Cursor
 - ON/OFF; blinking speed, form and position are programmable
- Character font
 - Vertical : 1 dot to 32 dots
 - Horizontal : 8 dots
- Scrolling
 - Vertical : smooth or character unit
 - Horizontal : character unit
- CMOS process
- 5-V single power supply

2.6 Suitable Inverter SKI-050-05H

The SKI-050-05H is the inverter for EL backlight of G191C. The inverter requires 5V power supply to drive EL lamp. EL lamp service life is much longer when used with an inverter rather than with a fixed power supply, because the inverter adjusts EL brightness by changing output voltage and oscillation frequency as EL lamp life decreases.

(1) Electrical Characteristics (when combined with EL lamp)

Item	Symbol	Conditions	Specifications	Unit
Oscillating frequency	f_{INV}	$T_a = 25^\circ\text{C}$, $V_{IN} = 5\text{ V DC}$	600 typ.	Hz
Output voltage	V_{OUT}	$T_a = 25^\circ\text{C}$, $V_{IN} = 5\text{ V DC}$	100 typ.	V
Output current	I_{OUT}	$T_a = 25^\circ\text{C}$, $V_{IN} = 5\text{ V DC}$	10 typ.	mA
Input current	I_{IN}	$T_a = 25^\circ\text{C}$, $V_{IN} = 5\text{ V DC}$	120 typ.	mA
Input voltage	V_{IN}		5.0 typ.	V DC

(2) Tolerance (inverter only)

Item	Specifications	Unit
Input voltage	4.0 to 5.0	V DC
Load range	25 to 75	cm ²

(3) Maximum ratings (inverter only)

Item	Specifications	Unit
Input voltage	6.0	V DC
Load range	75	cm ²
Operating temperature range	- 10 to + 55	°C
Storage temperature range	- 20 to + 70	°C

(4) Dimensions (Unit: mm)

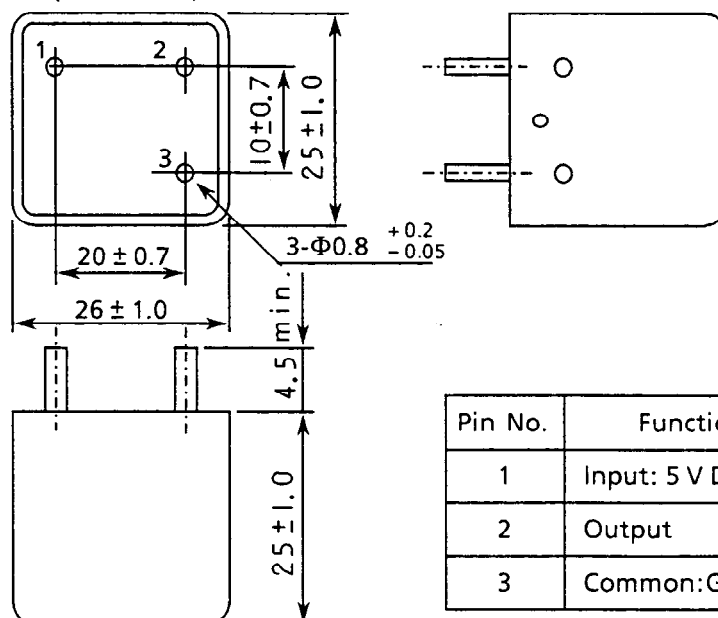


Figure 13

3. NOTES

Safety

- If the LCD panel breaks, be careful not to get the liquid crystal in your mouth. If the liquid crystal touches your skin or clothes, wash it off immediately using soap and plenty of water.

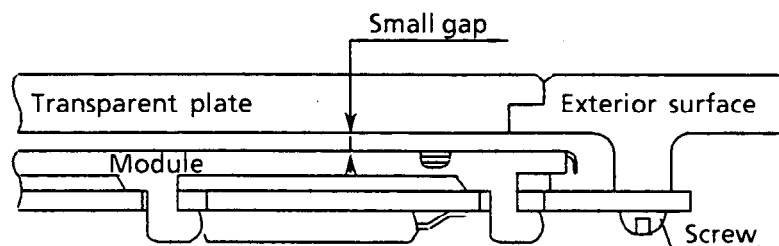
Handling

- Avoid static electricity as this can damage the CMOS LSI.
- The LCD panel is made of plate glass; do not hit or press against it.
- Do not remove the panel or frame from the module.
- The polarizer on the display is very fragile; handle it very carefully.

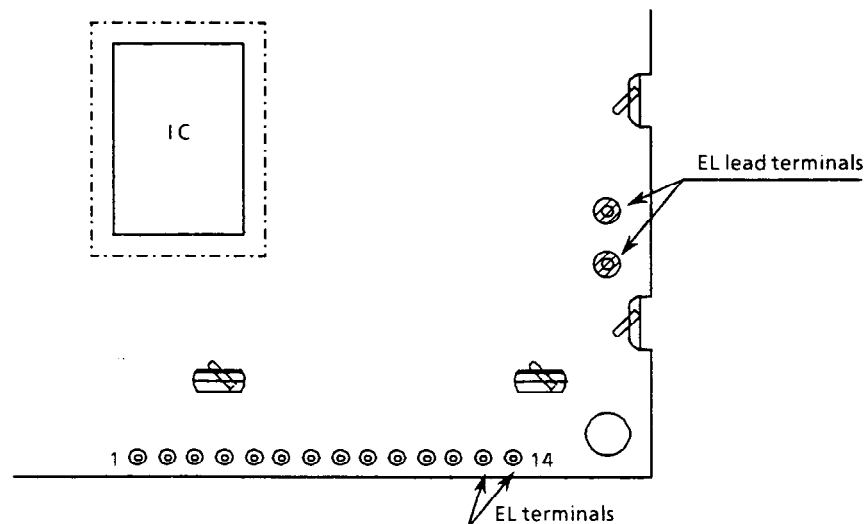
Mounting and Design

- Mount the module in the specified installation sections and holes.
- To protect the module from external pressure, put a plate of transparent material such as acrylic or glass over the display surface, frame, and polarizer. Leave a small gap between the transparent plate and the module.

☆ Example



- Keep the module dry. Condensation can damage the transparent electrodes.
- Since high voltage is applied to the EL terminals, do not touch the EL terminals and the EL lead terminals.



Storage

- Store the module in a dark place where the temperature is $25^{\circ}\text{C} \pm 10^{\circ}\text{C}$ and the humidity below 65% RH.
- Do not store the module near organic solvents or corrosive gases.
- Do not crush, shake, or jolt the module or its components.

Cleaning

- Do not wipe the polarizer with a dry cloth, as it may scratch the surface.
- Wipe the module gently with a soft cloth soaked with a petroleum benzine.
- Do not use ketonic solvents (ketone and acetone) or aromatic solvents (toluene and xylene), as they may damage the polarizer.

Index

-B-

Bias value	5
Bias voltage generation circuit	7, 9
Block diagram	7
Brightness	3

-C-

Chip enable function	8
Cleaning	18
Common drive waveform	8
Common driver	7, 8, 11
Contrast	1, 2
Current consumption	1, 3

-D-

Data valid	10
Definition of contrast	2
Definition of response time	2
Definition of viewing angles	2
Display data input	4
Display data shift clock	4, 8
Drive waveform	5, 6

-E-

Effective voltage	5
EL backlight	1, 3, 7, 9, 16

-F-

Flicker	5
Frame frequency	1, 2, 5

-H-

HITACHI HD64646FS	12, 15
-------------------------	--------

-I-

Input voltage	1, 16
Input current	16
Inverter	9, 16
I/O terminal functions	4

-L-

LCD controller	12
Liquid crystal AC drive control signal	4, 5, 8
Liquid crystal operating voltage	9

-N-

Non-selection waveform	5, 6
------------------------------	------

-O-

OKI MSM6255GSK	12, 13
One-common-line timing signal	4, 8
One-frame timing signal	4, 8
Operating temperature	1, 3, 16
Operational amplifier	9

-P-

Power supply voltage	1, 4
----------------------------	------

-R-

Resistance division	9
Response time (fall)	2
Response time (rise)	2
Retardation control film (RCF)	1

-S-

Segment drive waveform	8
Segment driver	7, 8, 11
SEIKO EPSON SED1330FBA	12, 14
Selection waveform	5, 6
Service life	3
FSTN LCD	1
Storage	18
Storage temperature	1, 3, 16

-V-

Viewing angle	2
---------------------	---

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