LIQUID CRYSTAL DISPLAY MODULE

G 1 9 1 D

USER'S MANUAL

Seiko Instruments Inc.

NOTICE

This manual describes the technical information, as well as the functions and operation of the G191D Liquid Crystal Display Module made by Seiko Instruments Inc. Please read this manual carefully to familiarize yourself with the functions so you can make the best use of them.
The descriptions here are subject to change without notice.

Revision Record

Edition	Revision	Date
1	Original	June 1994

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CONTENTS

1. SPECIFICATIONS

1.1 General

The G191D is a very thin LCD module on which a full-dot matrix LCD panel and a CMOS IC driver are integrated. The LCD panel used here features wide viewing angle and high contrast. This full dot configuration allows a wide variety of patterns to be displayed depending upon the input data. The display position is the intersection point of the matrix transparent electrodes. This prevents display distortion and displacement.

1.2 Features

G191D00P000/G191DB1P000

- 192 × 192 full dot matrix configuration
- 1/192 duty, 1/12 bias
- Four-bit parallel data input
- A wide temperature range, gray mode STN LCD panel
- Positive display

  Display data "H" : Display ON : blue display color

  Display data "L" : Display OFF : gray background

G191D00P000

- Two types of power supply : V_{DD} = +5V, V_{LC} = -24V (for driving liquid crystal)
- Reflective type
- Weight : Approx. 62g

G191DB1P000

- Three types of power supply : V_{DD} = +5V, V_{LC} = -24V, LEDA (for driving LED)
- Transflective type
- A built-in LED backlight (color : yellow-green)
- Weight : Approx. 80g

1.3 Absolute Maximum Ratings (excluding LED backlight)

V_{SS}=0V

Item	Symbol	Conditions	Min.	Max.	Unit
Power supply voltage	V_{DD}		0	7.0	V
	V_{LC}		V_{DD}-30.0	V_{DD}	V
	V_O	$V_O \geq V_{LC}$	V_{DD}-30.0	V_{DD}	V
Input voltage	V_{IN}		-0.3	V_{DD}+0.3	V
Operating temperature	T_{opr}	≤65%RH	-20	+70	°C
Storage temperature	T_{stg}		-30	+80	°C
Storage humidity		≤ 48 hrs	+20	+85	%RH
		≤ 1000 hrs	+20	+65	%RH

1.4 Mechanical Characteristics

Item		Standard
Dot configuration		192×192 dots
Module dimensions (H × V × T)	[mm]	G191D00P000 : 86.0×95.0×7.0 G191DB1P000 : 86.0×95.0×9.0
Viewing area (H × V)	[mm]	67.4×67.4
Active display area (H × V)	[mm]	63.33×63.33
Dot dimensions (H × V)	[mm]	0.3×0.3
Dot pitch (H × V)	[mm]	0.33×0.33
Weight	[g]	G191D00P000 : 75 max. G191DB1P000 : 100 max.

H : Horizontal V : Vertical T : Thickness (max.)

1.5 Electrical Characteristics (excluding LED backlignt)

V_{DD}=5V±5%, V_{SS}=0V, Ta=-20°C to +70°C

Item		Symbol	Conditions	Min	Typ.	Max.	Unit
Power supply voltage		V_{DD}		4.75	5.00	5.25	V
		V_{LC}	V_{DD}=5V $V_O \geq V_{LC}$	-24.5	-24.0	-23.5	V
		V_O		-23.0	—	-5.0	V
Input voltage	High	V_{IH}		0.8V_{DD}	—	V_{DD}	V
	Low	V_{IL}		0	—	0.2V_{DD}	V
Current consumption*1		I_{DD}	V_{DD}=5V, Ta=25°C V_O=-18.9V f_{FLM}=70Hz	—	5.0	10.0	mA
		I_{LC}		—	4.5	9.0	mA
Frame frequency		f_{FLM}		65	70	75	Hz

*1 Display patterns : checkered patterns.
Display data shift clock frequency : f_{CL2}=3.0MHz

1.6 Optical Characteristics

1.6.1 G191D00P000

1/192 duty, 1/12 bias, f_{FLM}=70Hz, $V_{opr}=V_{DD}-V_O$

Item	Symbol	Conditions	Temp.	Min.	Typ.	Max.	Unit	Reference
Viewing angle	θ_1	C≥2.0 ∅=0° V_{opr} =23.9V	25°C	—	—	-5	Degree	Notes 1 & 2
	θ_2			35	—	—		
	$\theta_2-\theta_1$			40	—	—		
Contrast	C	θ=0° ∅=0° V_{opr} =23.9V	25°C	2.5	3.0	—	—	Note 3
Response time	t_{on}	θ=0° ∅=0° V_{opr} =23.9V	25°C	—	200	320	ms	Note 4
	t_{off}			—	130	210		
	t_{on}	θ=0° ∅=0° V_{opr} =26.0V	-20°C	—	1800	2900		
	t_{off}			—	1000	1600		

Measuring instrument : Canon illuminometer LC-3S

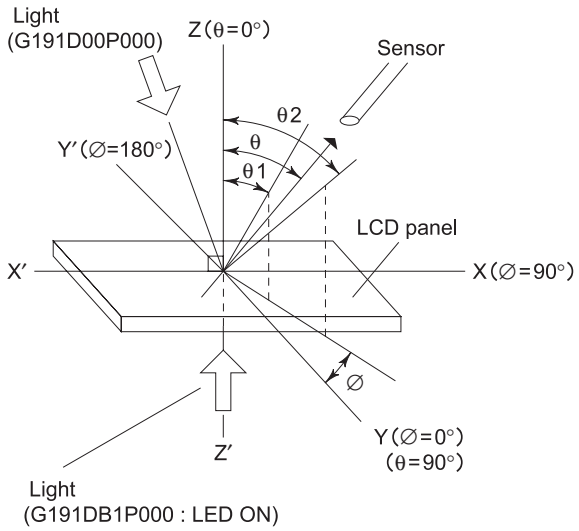
1.6.2 G191DB1P000

1/192duty, 1/12bias, f_{FLM}=70Hz, $V_{opr}=V_{DD}-V_O$, LED backlight : ON

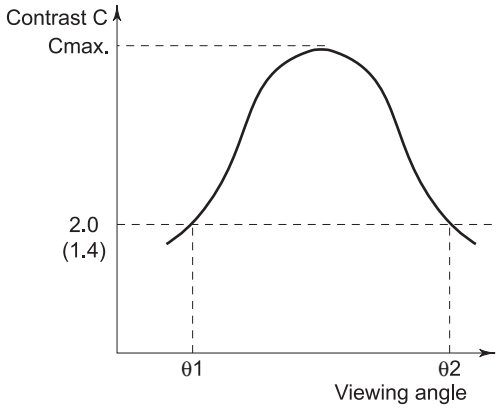
Item	Symbol	Conditions	Temp.	Min.	Typ.	Max.	Unit	Reference
Viewing angle	θ_1	C≥1.4 ∅=0° V_{opr} =23.9V	25°C	—	—	-15	Degree	Notes 1 & 2
	θ_2			30	—	—		
	$\theta_2-\theta_1$			45	—	—		
Contrast	C	θ=0° ∅=0° V_{opr} =23.9V	25°C	1.5	2.0	—	—	Note 3
Response time	t_{on}	θ=0° ∅=0° V_{opr} =23.9V	25°C	—	200	320	ms	Note 4
	t_{off}			—	130	210		
	t_{on}	θ=0° ∅=0° V_{opr} =26.0V	-20°C	—	1800	2900		
	t_{off}			—	1000	1600		

Measuring instrument : Canon illuminometer LC-3S

Note 1 : Definition of angles θ and ∅



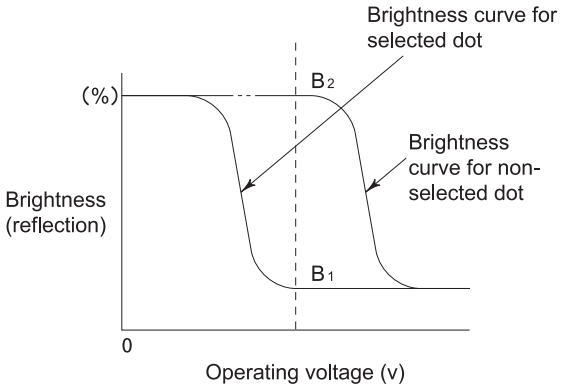
Note 2 : Definition of viewing angles θ1 and θ2



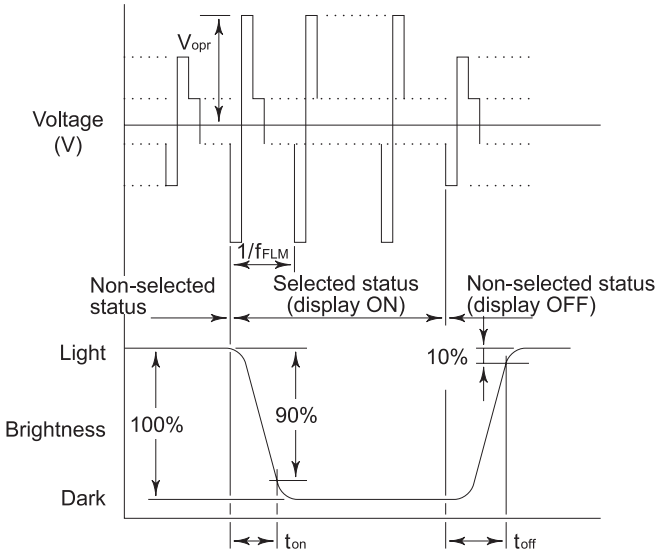
Remark : The optimum viewing angle by visual inspection and angle θ at Cmax do not always match.

Note 3 : Definition of contrast (C)

$$C = \frac{\text{Brightness of non-selected dot (reflection)} \quad B_2}{\text{Brightness of selected dot (reflection)} \quad B_1}$$



Note 4 : Definition of response time



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

Note : Measurement must be made using a transmissive LCD panel.

Figure 1 Definition

1.7 LCD Panel Life Time

Item	Conditions	Standard	Unit
Life time*	25°C±10°C <65%RH	100, 000 or more	hrs

* Definition of life time : the time up to occurrence of any of the following:
  · Contrast reduces to 30% of the initial value.
  · Current consumption becomes three times the initial value.
  · Orientation deteriorates significantly.
  · The display malfunctions.

1.8 Dimensions

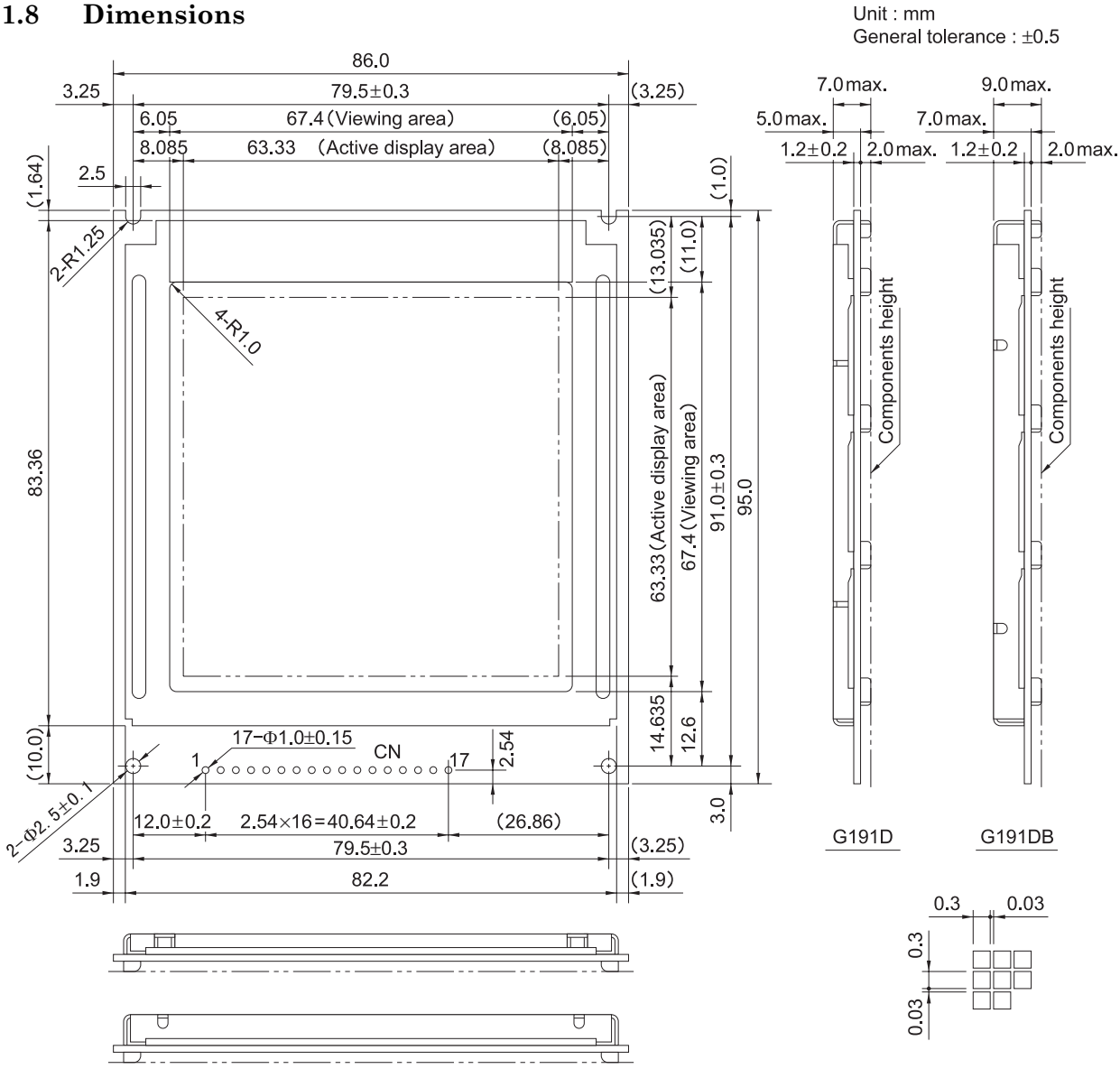


Figure 2 Dimensions

[I/O terminal functions]

No.	Symbol	Functions
1	V_{DD}	Power supply for logic : +5V
2	F_{GND}	Frame ground*1
3	CL2	Display data shift clock
4	INH	Display ON/OFF control terminal*2
5	FLM	One-frame timing signal
6	CL1	One-common-line timing signal
7	V_{SS}	GND : 0V
8	M	NC
9	D_0	Display data input

No.	Symbol	Functions
10	D_1	Display data input
11	D_2	Display data input
12	D_3	Display data input
13	V_{LC}	Power supply for LC drive:-24V
14	V_O	Liquid crystal drive voltage adjustment terminal
15	V_{SS}	GND : 0V
16	NC/LEDA	—*3
17	NC/LEDC	—*3

*1 The F_{GND} terminal is connected to the module metal frame. Use this terminal to ground the frame.
*2 The display is ON when INH is H, and OFF when L.
*3 G191D00P000 : NC
G191DB1P000 : Power supply for LED drive (NO.16 : LEDA, NO.17 : LEDC)

2. CIRCUIT CONFIGURATION

2.1 Liquid Crystal Driving Circuit

The G191D LCD panel drive waveform is shown in Figure 3. Since DC voltage will damage the liquid crystal, AC voltage is applied between the two frames. The signal controlling this is the liquid crystal AC drive control signal M.

Depending on the LCD panels, increasing the liquid crystal AC drive waveform frequency may improve the display quality. The G191D contains a circuit that generates AC drive control signal M', which has a higher frequency than that of M. The frequency of the M' signal is adjusted according to the LCD panel to provide the best display quality.

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

The G191D has a 1/192 duty cycle, and the common electrodes are selected within a frame by time division from electrode 1 to electrode 192. This is called line sequential scanning. The voltage level of the segment electrodes determines whether or not the dots at the intersection of the segment electrodes are selected 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 electrode is then applied to the liquid crystal. The selection waveform for SEG_0-COM_0 and the non-selection waveform for SEG_1-COM_1 are shown in Figure 3. 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

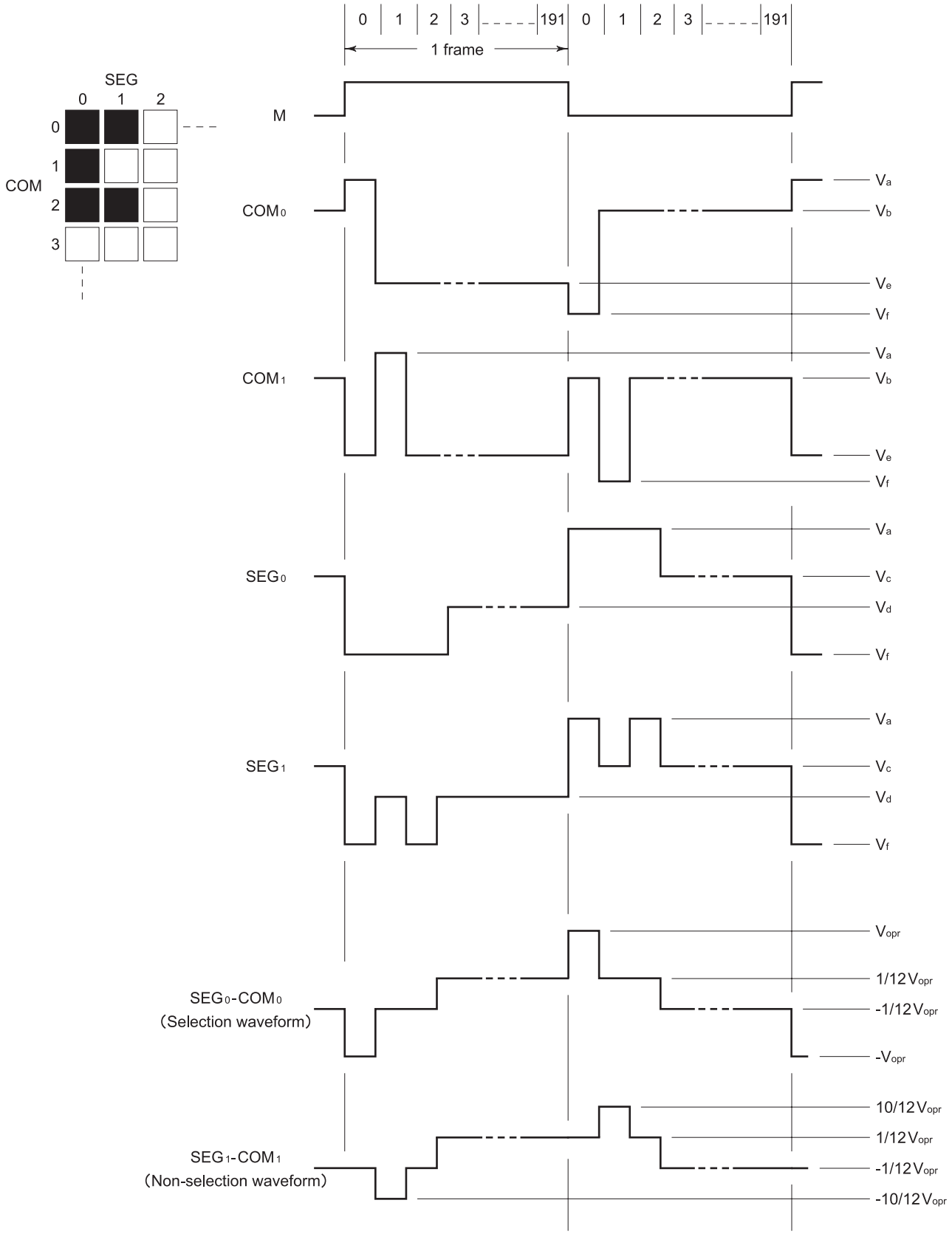


Figure 3 Drive Waveform

2.2 Circuit Configulation

The G191D consists of common drivers, segment divers, a bias voltage generation circuit, an M' generation circuit and a V_{opr} control circuit. Figure 4 shows the block diagram for the G191D.

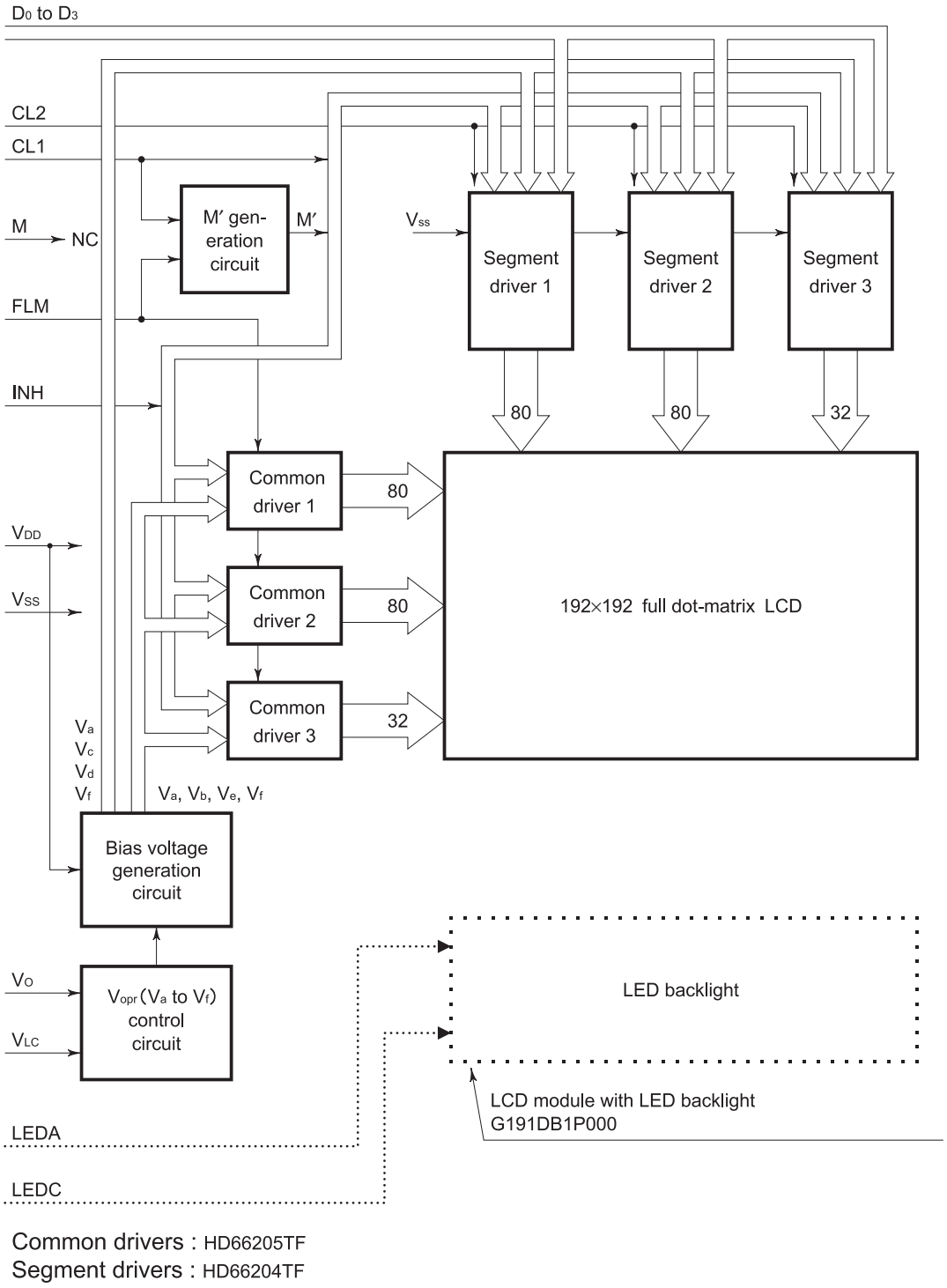


Figure 4 Block Diagram for G191D

(1) Common driver (HITACHI HD66205TF)

A common driver (CD) is a CMOS IC with 80 drive outputs. The G191D has three CDs, whose internal registers are connected to 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 192-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 internally-generated liquid crystal AC drive control signal (M') in the drive circuit, and the common drive waveform are formed.

Table 2 Common Output

INH	Shift register content	M'	COM output	Display
H	H	H	V_a	ON
		L	V_f	
	L	H	V_e	
		L	V_b	
L	×	×	V_a	OFF

× : Invalid

The common output is controlled by the INH signal ; when the INH signal is low, the common output is V_a, irrespective of the shift register contents or the M' signal.

(2) Segment driver (HITACHI HD66204TF)

A segment driver (SD) is a CMOS IC with 80 drive outputs. The G191D has three SDs, which operate 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). The SDs have a chip enable function. After 80 bits of data are taken into SD1, the next bit of data is automatically taken into SD2. Since G191D has three SDs, 192 bits of data can be taken. The display data taken into internal register are latched by the falling edge trigger of CL1. The segment output is selected according to this display data and M' in the drive circuit, and the segment drive waveform is formed as shown in the Table 3.

Table 3 Segment Output

INH	Display data	M'	SEG output	Display
H	H	H	V_f	ON
		L	V_a	
	L	H	V_d	
		L	V_c	
L	×	×	V_a	OFF

× : Invalid

The segment output is controlled by the INH signal. When the INH signal is low, V_a is output to the segment, irrespective of the display data and of the M' signal.

Therefore, by bringing the INH signal to low, Va is output both to the common and to the segment electrodes, making the voltage applied to the liquid crystal zero, and the display goes off. The relationship between the display data and display screen is shown below.

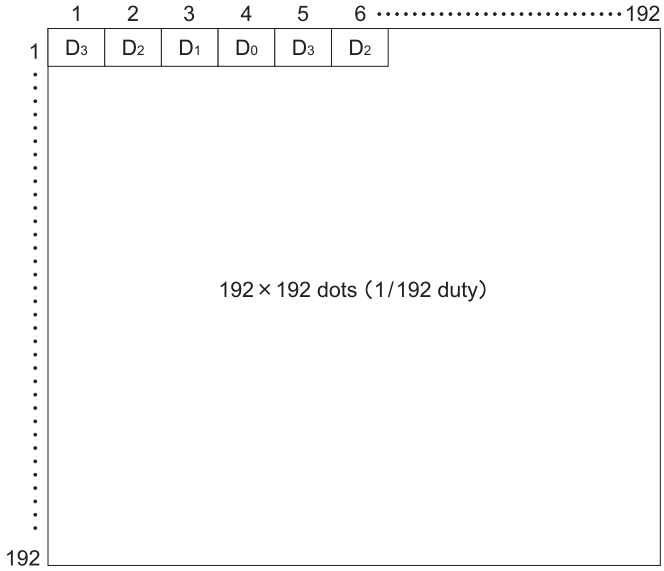


Figure 5 Relationship between the Display Data and Display Screen

(3) Vopr control circuit

Display screen contrast and viewing angle are affected by changes in the liquid crystal operating voltage (Vopr). As shown in Figure 6, external VLC is supplied to the operational amplifier and Vopr (Va to Vf) is generated and applied to the LCD panel.

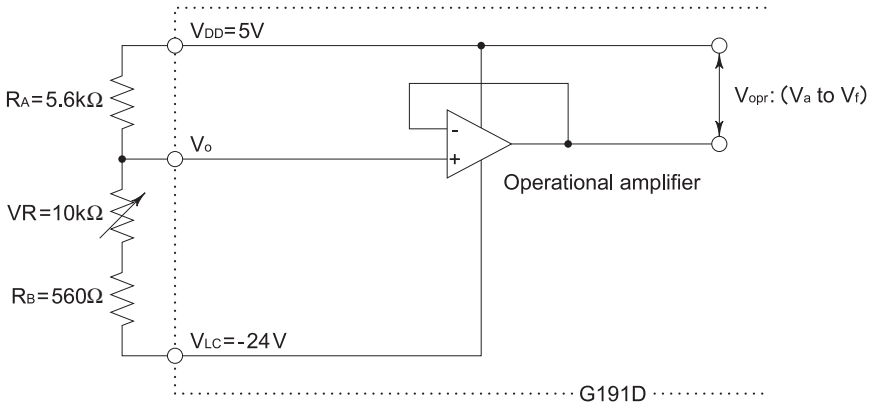


Figure 6 Vopr Control Circuit

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

Table 4 Liquid Crystal Operating Voltage

Temperature (°C)	-20	0	25	50	70
Liquid crystal operating voltage(Vopr)* (V)	26.0	25.0	24.0	22.5	21.0

*Vopr ≈VDD-VO

(4) Bias voltage generation circuit

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

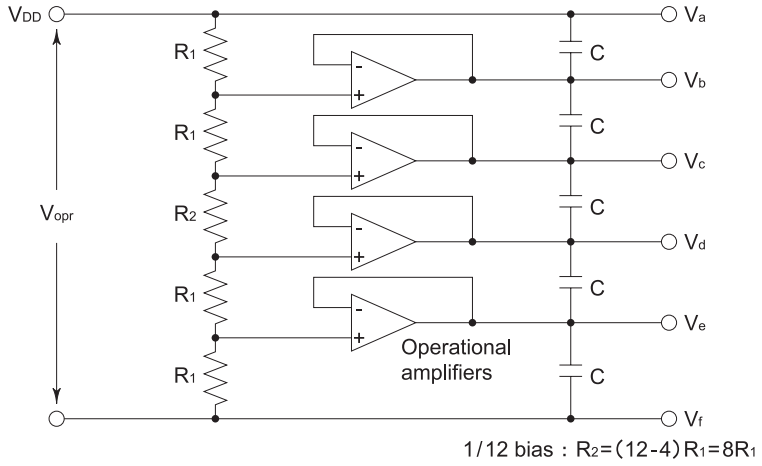


Figure 7 Bias Voltage Generation Circuit

(5) M' generation circuit

As Figure 8 shows, the M' generation circuit performs an XOR on the one-common-line timing signal (CL1) (on which A time division is performed) and the one-frame timing signal (FLM) (on which B time division is performed), and outputs liquid crystal AC drive control signal M'. Values A and B are set according to the LCD panel so that the best display quality can be obtained and the drive voltage can be changed.

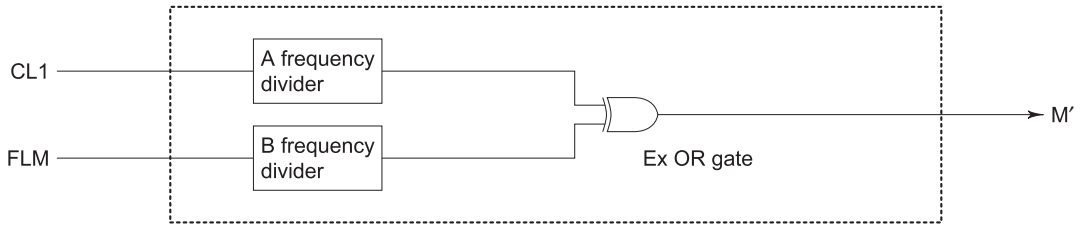


Figure 8 M' Generation Circuit

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.

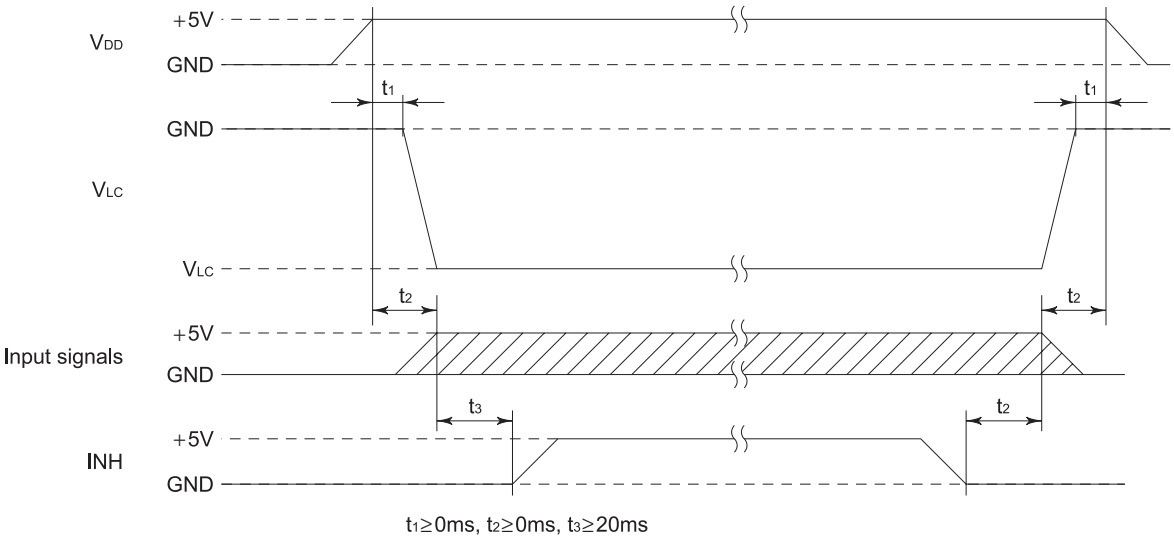


Figure 9 Power ON/OFF and Signal Input Timing

2.3.2 Timing Characteristics

Ta=-20°C to 70°C, V_{DD}=5.0V±5%, V_{SS}=0V

Item	Symbol	Min.	Typ.	Max.	Unit
FLM cycle time	t_{CFLM}	13.3	14.3	15.4	ms
CL1 cycle time	t_{CCL1}	10	74.4	—	µs
CL1 high level width	t_{WCL1H}	50	—	—	ns
CL1 low level width	t_{WCL1L}	1	—	—	µs
CL1 rise time	t_{RCL1}	—	—	30	ns
CL1 fall time	t_{FCL1}	—	—	30	ns
FLM setup time	t_{FLMS}	100	—	—	ns
FLM hold time	t_{FLMH}	100	—	—	ns
Allowable M delay time	t_{DM}	—	—	300	ns
CL2 cycle time	t_{CCL2}	125	—	—	ns
CL2 high level width	t_{WCL2H}	45	—	—	ns
CL2 low level width	t_{WCL2L}	45	—	—	ns
CL2 rise time	t_{RCL2}	—	—	50*	ns
CL2 fall tim	t_{FCL2}	—	—	50*	ns
Data setup time	t_{DS}	20	—	—	ns
Data hold time	t_{DH}	20	—	—	ns
CL2 rise to CL1 rise	t_{LD}	—	—	—	ns
CL2 fall to CL1 fall	t_{SL}	80	—	—	ns
CL1 rise to CL2 rise	t_{LS}	—	—	—	ns
CL1 fall to CL2 fall	t_{LH}	80	—	—	ns

$$*t_{RCL2},\ t_{FCL2} < \frac{t_{CCL2} - t_{WCL2H} - t_{WCL2L}}{2}$$

Timing Chart 1 : Timing of Signal Input Into Common Driver

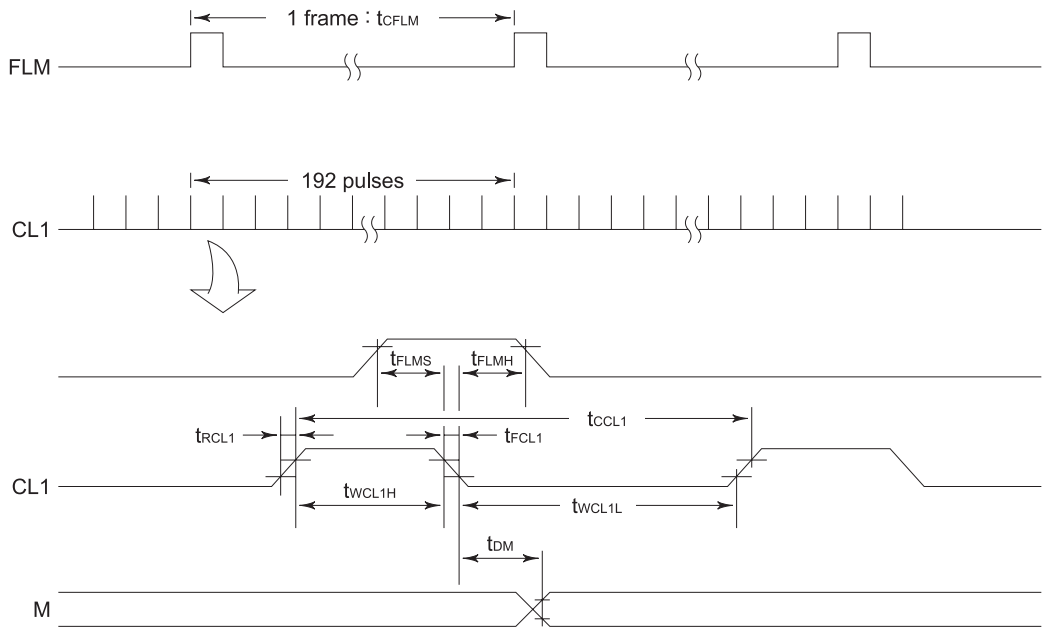


Figure 10

Timing Chart 2 : Timing of Signal Input Into Segment Driver

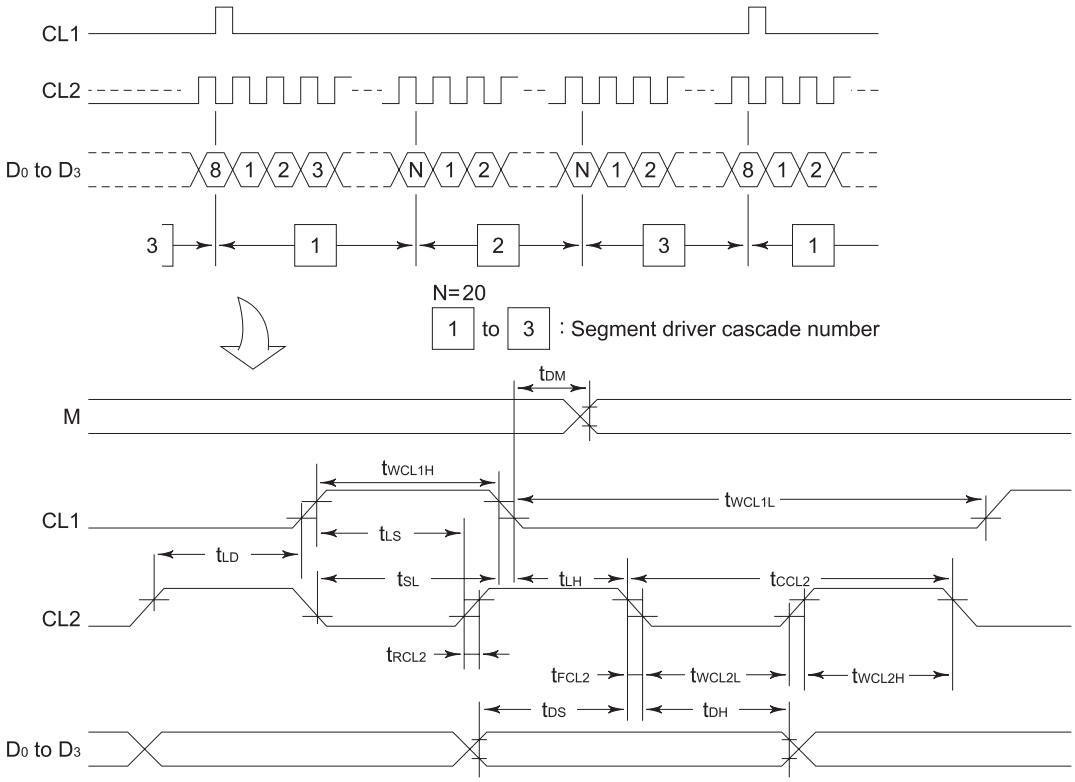


Figure 11

2.4 Interface Circuit

2.4.1 Interface with MPU signal

The G191D 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, sending display timing signals and display data to the LCD module, as well as other functions such as cursor display.

The G191D must use an LCD controllers conforming to the following :

- For a full dot-matrix LCD module
- Where data is transferred to the LCD module in four-bit parallel
- Where G191D display screen has 1/192 duty

The following section gives examples of interfaces using the Oki MSM6255GSK, Seiko Epson SED1330F/1335F, and Hitachi HD64646FS controllers.

(1) OKI MSM6255GSK

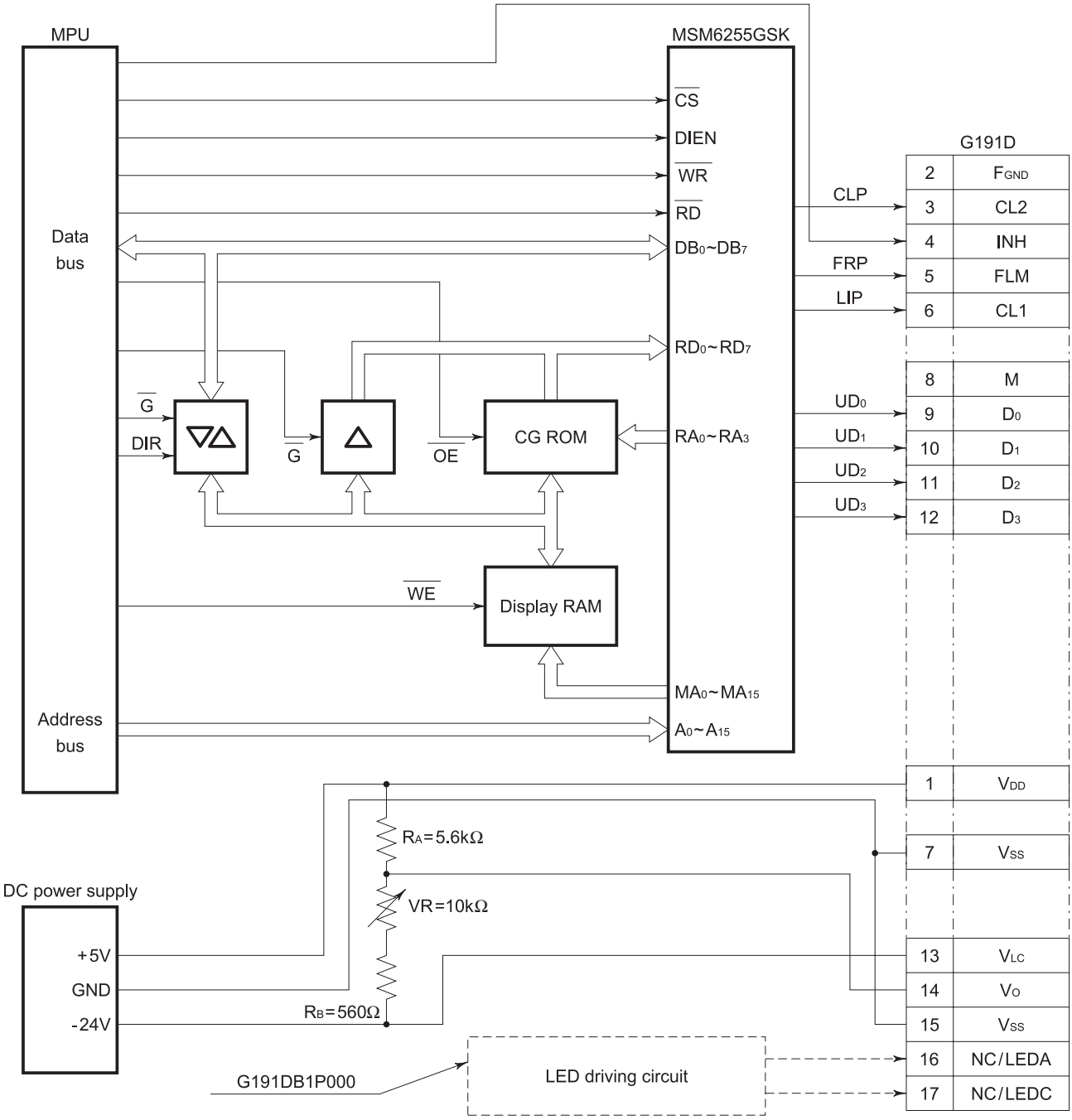


Figure 12 Interface Circuit With MSM6255GSK

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
- Power supply voltage 5V±10%

(2) SEIKO EPSON SED1330F/1335F

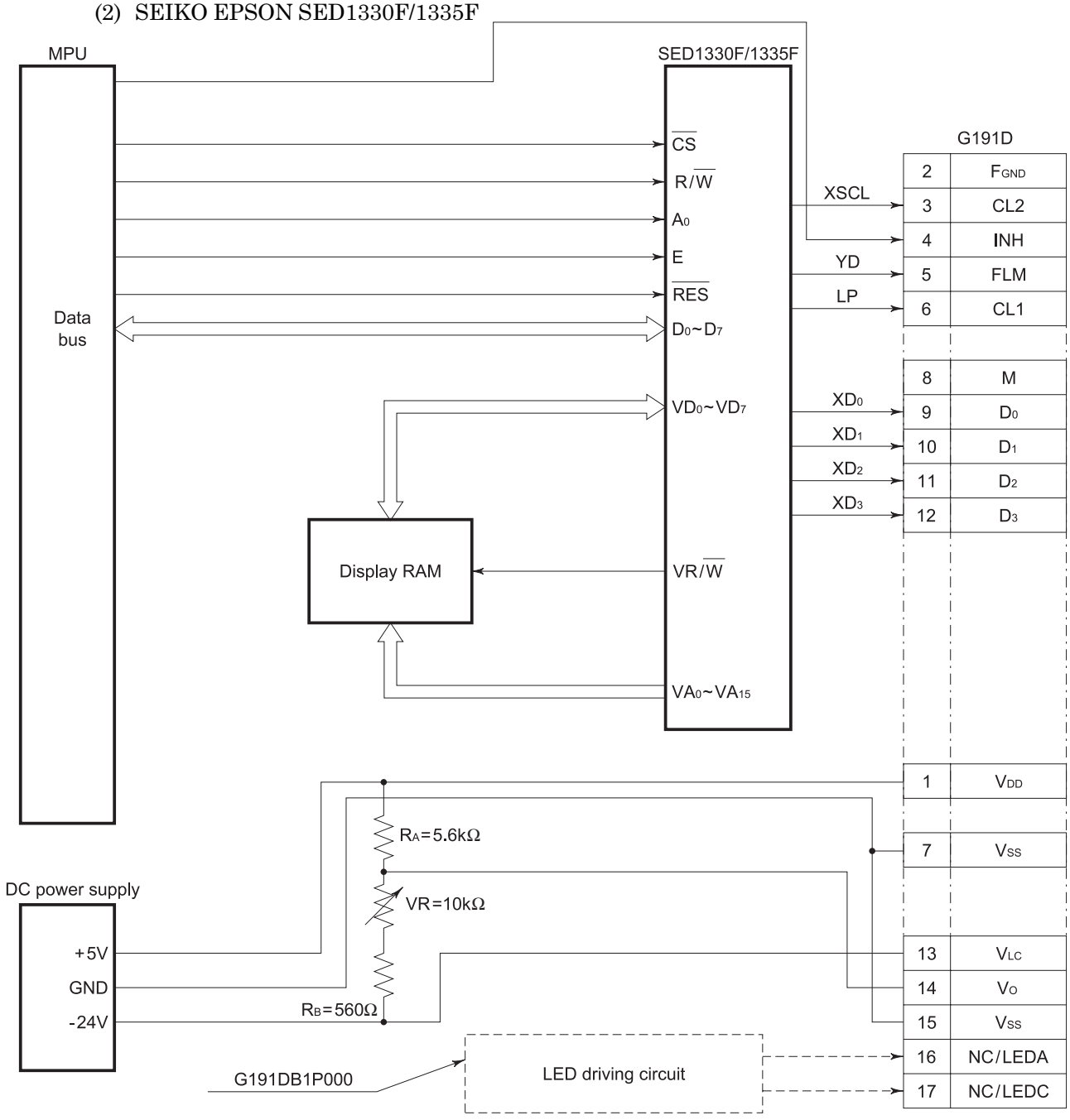


Figure 13 Interface Circuit With SED1330F/SED1335F

Features of the SED1330F/1335F :

- Interface with 80-series or 68-series MPU possible
- Built-in character generator ROM : 160 kinds
- External character generator
  CG RAM : (8 × 16 dot matrix) × 64 kinds
  CG ROM : (8 × 16 dot matrix) × 256 kinds
- Layered mode : AND, OR, XOR, “preferred” OR
- CMOS process
- Scrolling (vertical and horizontal)
- Power supply voltage 5V ± 10% (SED1330F)
  2.7 to 5.5V (SED1335F)

(3) HITACHI HD64646FS

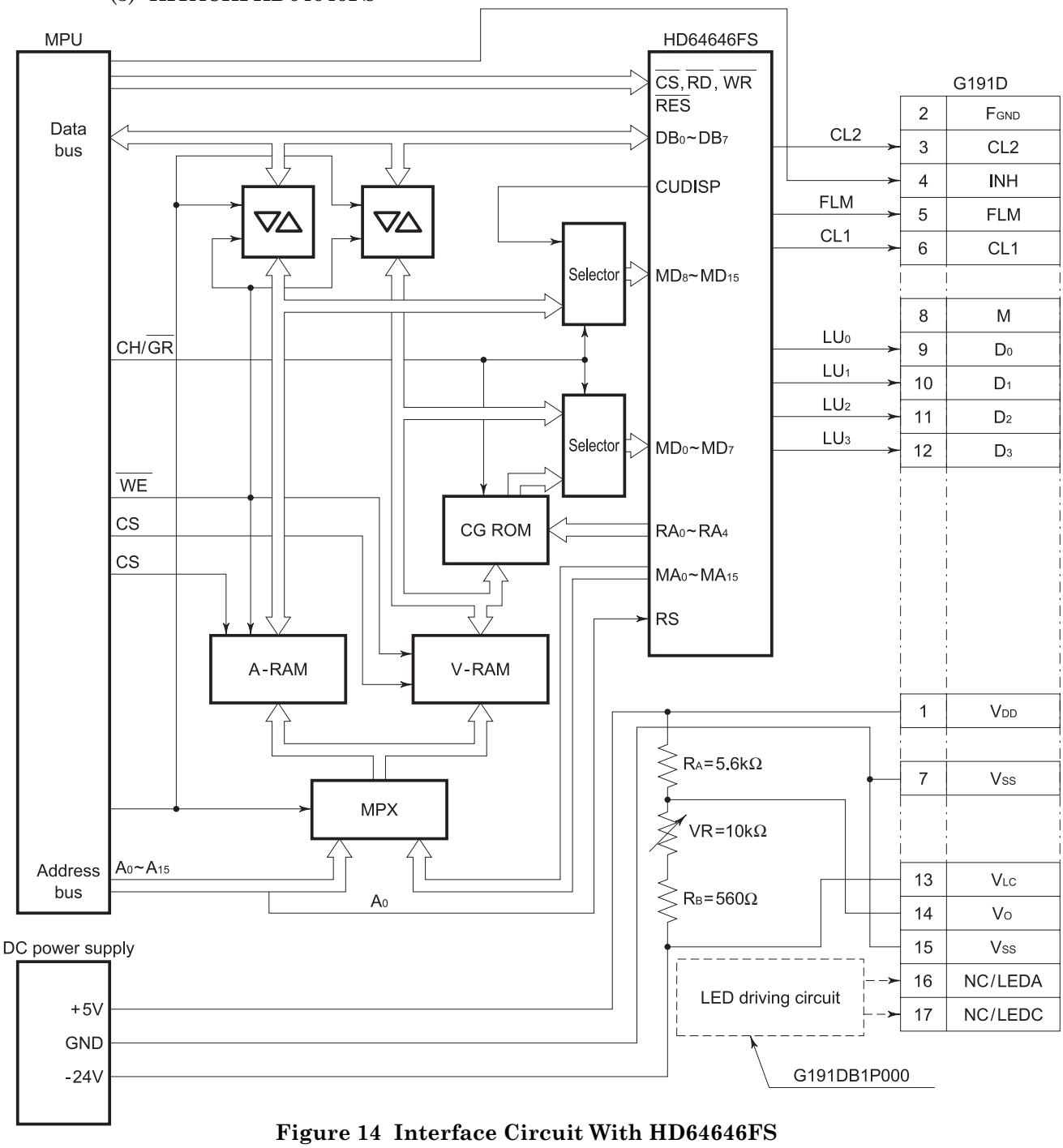


Figure 14 Interface Circuit With HD64646FS

Features of the HD64646FS :

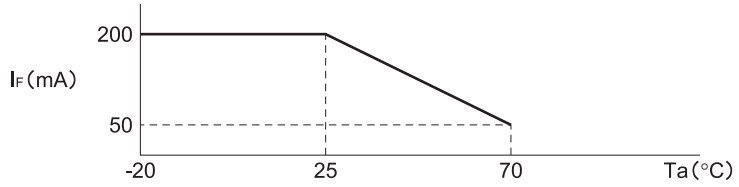
- Interface with 80-series MPU possible
- Layered mode : OR (character and graphics)
- Character reverse, blinking, all black, all white
- Cursor
  ON/OFF
  Blinking speed, form and position are programmable
- Character font
  Vertical : 1 to 32 dots
  Horizontal : 8 dots
- Scrolling
  Vertical : smooth or character unit
  Horizontal : character unit
- CMOS process
- Power supply voltage 5V ± 10%

3. LED BACKLIGHT (G191DB1P000)

3.1 Absolute Maximum Ratings

Item	Symbol	Standard	Unit
DC forward current	I_F	200*	mA
DC reverse voltage	V_R	8	V
Allowable dissipation	P_D	950	mW
Operating temp. range	T_{opr}	-20 to +70	°C
Storage temp. range	T_{stg}	-30 to +80	°C

* Forward current reduction characteristics : The absolute maximum rating of the forward current varies depending on ambient temperature.

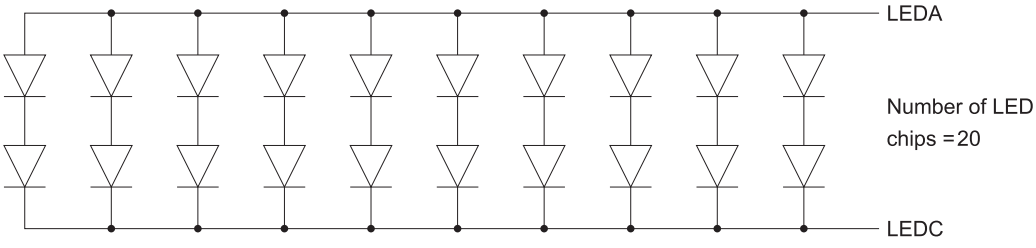


3.2 Electrical and Optical Characteristics

Ta=25°C

Item	Symbol	Meas. Condition	Min.	Typ.	Max.	Unit
Forward voltage	V_F	I_F=100mA	3.7	4.1	4.5	V
Reverse current	I_R	V_R=8V	—	—	0.3	mA

3.3 LED Backlight Connection Diagram



3.4 Brightness (panel upper side)

Item	Symbol	Min.	Typ.	Max.	Unit
Surface brightness (Center of LCD panel)	B_P	1.0	2.0	—	nit

Measurement conditions and a measuring instrument are :

- Ta = 25°C ± 3°C
- 30% to 85%RH
- I_F = 100mA
- f_{FRM} = 70Hz
- V_{LC} = Optimum LC drive voltage
- Display OFF (Entire display data = “L”)
- Measured 30 minutes after LED lights
- Measuring instrument : BM-7 (TOPCON)

3.5 Life Time

Item	Measurement conditions	Standard	Unit
Life time*	Ta=25°C±10°C I_F =100mA	50,000 or more	hrs

*Definition of life time : The time until the brightness decreases to half of the initial brightness.

3.6 LED Backlight Driver Examples

(1) Example 1

A basic LED backlight driver example is shown in Figure 15.

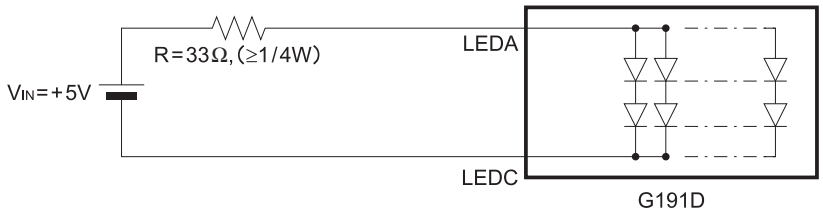


Figure 15 LED Backlight Driver Example 1

Where resistance "R" is the limit resistance of the LED forward current. The forward current depends upon the temperature. Especially, it must be decreased at high temperature. For temperature dependence, refer to forward current reduction characteristics described in 3.1. The operating temperature for the G191D ranges from -20°C to +70°C. It is necessary to determine limit resistance "R" so that the forward current becomes 50 mA or lower at +70°C. Forward voltage V_F at each temperature of the LED backlight is shown in Table 5.

Table 5 Forward Voltage At Temperatures

Temperature (Ta)	Conditions	V_F min.	V_F typ.	V_F max.
-20°C	I_F=100mA	3.9V	4.3V	4.7V
+25°C	I_F=100mA	3.7V	4.1V	4.5V
+70°C	I_F=50mA	3.4V	3.6V	3.9V

Limit resistance "R" is calculated using the following equation. The resistance becomes the value shown in Figure 15.

$$R = \frac{V_{IN} - V_F}{I_F} (\Omega)$$

V_{IN} = Input voltage (power voltage) (V)
V_F = LED forward voltage (V)
I_F = Allowable LED forward current (A)

For this resistance value, the forward current becomes lower than 50 mA at 25°C. The surface brightness of the LED backlight varies with the forward current. See Figure 16. Compared with 3.4 brightness (I_F = 100 mA), the brightness is about 30%.

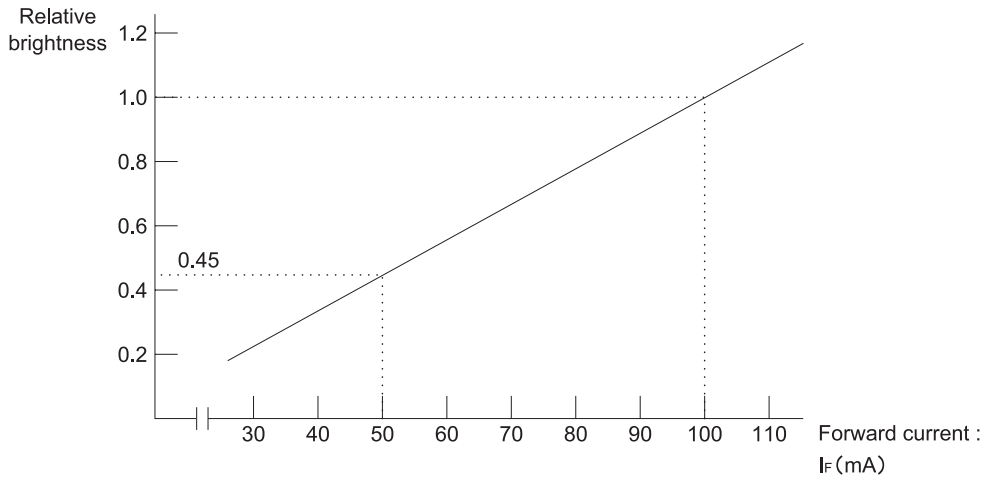


Figure 16 Forward Current-Brightness Characteristics (Ta = 25°C)

(2) Example 2

When you want to keep the brightness (2 nit) at 25°C, use a thermosensitive element, like a thermistor, and a transistor as shown in Figure 17. Set the thermosensitive element to about IF = 100 mA at 25°C and configure it so that "IF" will be reduced as the temperature rises.

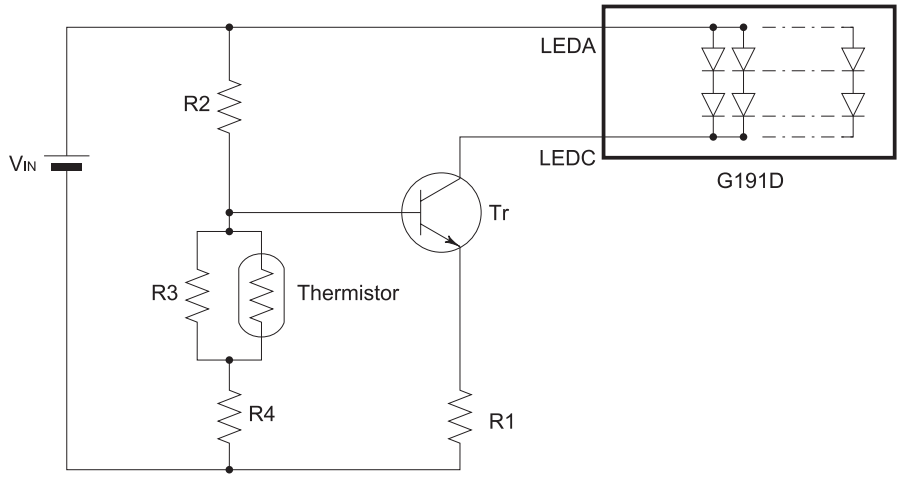


Figure 17 LED Backlight Driver Examples 2

4. PRECAUTIONS

Safety

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

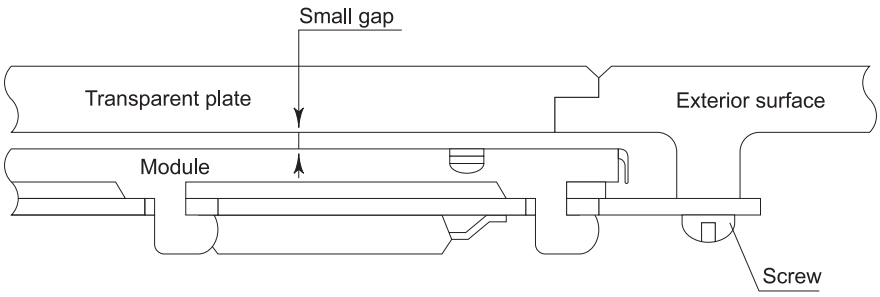
Handling

- 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 using 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.

Storage

- Store the module in a dark place where the temperature is 25°C ± 10°C and the humidity is below 65% RH.
- Do not store the module near organic solvents or corrosive gases.
- Do not crush, shake, or jar 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.

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