

1/53, 1/40 DUTY, LCD CONTROLLER/DRIVER WITH BUILT-IN RAM
DESCRIPTION

The μ PD16680 is a driver which contains a RAM capable of full - dot LCD display. The single μ PD16680 IC chip can operate a full - dot (up to 100 by 51 dots) LCD and pictographs (100 pictographs).

The μ PD16680 can operate on single 3 V-power supply, is suitable for graphic pagers and cellular.

FEATURES

- LCD driver with a built-in display RAM
- Can operate on single 3 V-power supply
- Booster circuit incorporated : Switchable 3 or 4 folds
- Dot display RAM : 100 x 51 bits
- Pictographic display RAM : 100 bits
- Pictographic display's duty changeable : 1/53 or 1/40 duty
- Output for full-dot : 100 segments and 52 commons
- Data input based on serial & 4-bit / 8-bit parallel switch over
- String resistor to output bias level incorporated
- Selectable LCD driving bias level (select from 1/8 bias, 1/7 bias, 1/6 bias)
- Oscillation circuit incorporated
- D/A converter incorporated (for LCD driving voltage adjustment)

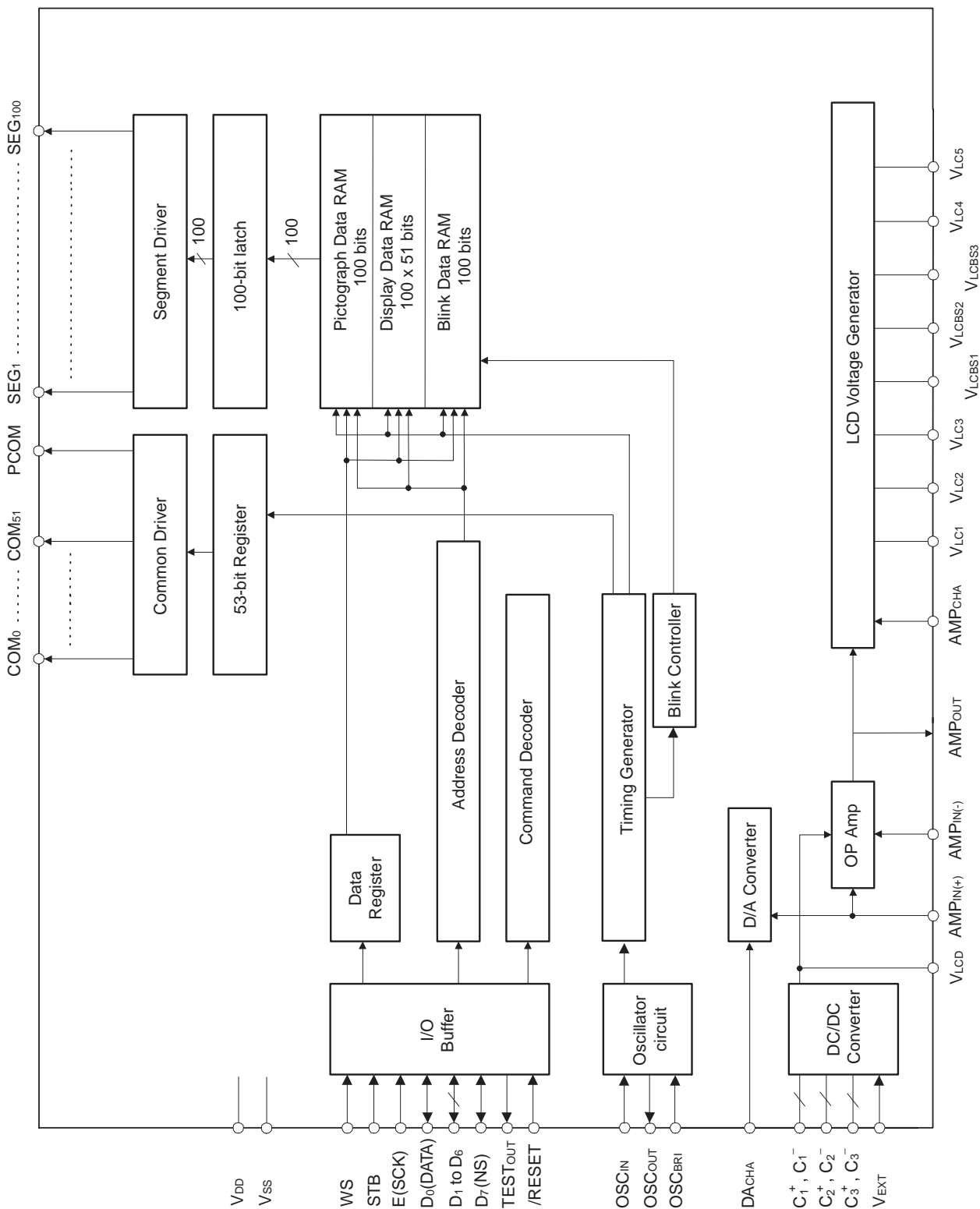
ORDERING INFORMATION

Part number	Package
μ PD16680W/P	Wafer/Chip(Matched COG mounting)

Remark Purchasing the above products in term of chips per requires an exchange of other documents as well, including a memorandum on the product quality. Therefore those who are interested in this regard are advised to contact an NEC salesperson for further details.

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1. BLOCK DIAGRAM



Remark /xxx indicates active low signals.

2. PIN CONFIGURATION (Top view)

Chip Size : 12.5 mm x 1.89 mm

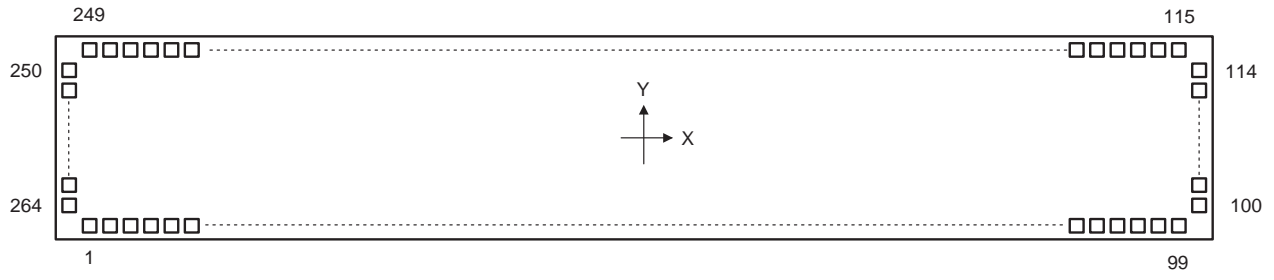


Table 2-1. Pad Layout (1/2)

Pin No.	Pin Name	X(μm)	Y(μm)	Pin No.	Pin Name	X(μm)	Y(μm)
1	Dummy	-5883.2	-811.0	67	C ₃ ⁺	2036.8	-811.0
2	Dummy	-5763.2	-811.0	68	C ₃ ⁺	2156.8	-811.0
3	Dummy	-5643.2	-811.0	69	C ₃ ⁺	2276.8	-811.0
4	V _{LCBS1}	-5523.2	-811.0	70	C ₃ ⁻	2396.8	-811.0
5	V _{LCBS1}	-5403.2	-811.0	71	C ₃ ⁻	2516.8	-811.0
6	Dummy	-5283.2	-811.0	72	C ₃ ⁻	2636.8	-811.0
7	V _{LCBS2}	-5163.2	-811.0	73	V _{DD}	2756.8	-811.0
8	V _{LCBS2}	-5043.2	-811.0	74	V _{DD}	2876.8	-811.0
9	Dummy	-4923.2	-811.0	75	V _{DD}	2996.8	-811.0
10	V _{LCBS3}	-4803.2	-811.0	76	Dummy	3116.8	-811.0
11	V _{LCBS3}	-4683.2	-811.0	77	V _{EXT}	3236.8	-811.0
12	Dummy	-4563.2	-811.0	78	DA _{CHA}	3356.8	-811.0
13	AMP _{OUT}	-4443.2	-811.0	79	AMP _{CHA}	3476.8	-811.0
14	AMP _{OUT}	-4323.2	-811.0	80	OSC _{IN}	3596.8	-811.0
15	Dummy	-4203.2	-811.0	81	OSC _{OUT}	3716.8	-811.0
16	AMP _{IN(-)}	-4083.2	-811.0	82	V _{DD}	3836.8	-811.0
17	AMP _{IN(-)}	-3963.2	-811.0	83	OSC _{BRI}	3956.8	-811.0
18	Dummy	-3843.2	-811.0	84	D ₀ (DATA)	4076.8	-811.0
19	AMP _{IN(+)}	-3723.2	-811.0	85	D ₁	4196.8	-811.0
20	AMP _{IN(+)}	-3603.2	-811.0	86	D ₂	4316.8	-811.0
21	Dummy	-3483.2	-811.0	87	D ₃	4436.8	-811.0
22	V _{DD}	-3363.2	-811.0	88	D ₄	4556.8	-811.0
23	V _{DD}	-3243.2	-811.0	89	D ₅	4676.8	-811.0
24	Dummy	-3123.2	-811.0	90	D ₆	4796.8	-811.0
25	V _{LC5}	-3003.2	-811.0	91	D ₇ (NS)	4916.8	-811.0
26	V _{LC5}	-2883.2	-811.0	92	WS	5036.8	-811.0
27	V _{LC5}	-2763.2	-811.0	93	STB	5156.8	-811.0
28	Dummy	-2643.2	-811.0	94	E(SCK)	5276.8	-811.0
29	V _{LC4}	-2523.2	-811.0	95	/RESET	5396.8	-811.0
30	V _{LC4}	-2403.2	-811.0	96	V _{DD}	5516.8	-811.0
31	V _{LC4}	-2283.2	-811.0	97	TEST _{OUT}	5636.8	-811.0
32	Dummy	-2163.2	-811.0	98	Dummy	5756.8	-811.0
33	V _{LC3}	-2043.2	-811.0	99	Dummy	5876.8	-811.0
34	V _{LC3}	-1923.2	-811.0	100	Dummy	6112.0	-682.2
35	V _{LC3}	-1803.2	-811.0	101	Dummy	6112.0	-592.2
36	Dummy	-1683.2	-811.0	102	COM ₂₇	6112.0	-502.2
37	V _{LC2}	-1563.2	-811.0	103	COM ₂₈	6112.0	-412.2
38	V _{LC2}	-1443.2	-811.0	104	COM ₂₉	6112.0	-322.2
39	V _{LC2}	-1323.2	-811.0	105	COM ₃₀	6112.0	-232.2
40	Dummy	-1203.2	-811.0	106	COM ₃₁	6112.0	-142.2
41	V _{LC1}	-1083.2	-811.0	107	COM ₃₂	6112.0	-52.2
42	V _{LC1}	-963.2	-811.0	108	COM ₃₃	6112.0	37.8
43	V _{LC1}	-843.2	-811.0	109	COM ₃₄	6112.0	127.8
44	Dummy	-723.2	-811.0	110	COM ₃₅	6112.0	217.8
45	V _{LCD}	-603.2	-811.0	111	COM ₃₆	6112.0	307.8
46	V _{LCD}	-483.2	-811.0	112	COM ₃₇	6112.0	397.8
47	V _{LCD}	-363.2	-811.0	113	Dummy	6112.0	487.8
48	V _{DD}	-243.2	-811.0	114	Dummy	6112.0	577.8
49	V _{DD}	-123.2	-811.0	115	Dummy	6030.0	817.8
50	V _{DD}	-3.2	-811.0	116	Dummy	5940.0	817.8
51	V _{SS}	116.8	-811.0	117	COM ₃₈	5850.0	817.8
52	V _{SS}	236.8	-811.0	118	COM ₃₉	5760.0	817.8
53	V _{SS}	356.8	-811.0	119	COM ₄₀	5670.0	817.8
54	Dummy	476.8	-811.0	120	COM ₄₁	5580.0	817.8
55	C ₁ ⁺	596.8	-811.0	121	COM ₄₂	5490.0	817.8
56	C ₁ ⁺	716.8	-811.0	122	COM ₄₃	5400.0	817.8
57	C ₁ ⁺	836.8	-811.0	123	COM ₄₄	5310.0	817.8
58	C ₁ ⁻	956.8	-811.0	124	COM ₄₅	5220.0	817.8
59	C ₁ ⁻	1076.8	-811.0	125	COM ₄₆	5130.0	817.8
60	C ₁ ⁻	1196.8	-811.0	126	COM ₄₇	5040.0	817.8
61	C ₂ ⁺	1316.8	-811.0	127	COM ₄₈	4950.0	817.8
62	C ₂ ⁺	1436.8	-811.0	128	COM ₄₉	4860.0	817.8
63	C ₂ ⁺	1556.8	-811.0	129	COM ₅₀	4770.0	817.8
64	C ₂ ⁻	1676.8	-811.0	130	COM ₅₁	4680.0	817.8
65	C ₂ ⁻	1796.8	-811.0	131	PCOM	4590.0	817.8
66	C ₂ ⁻	1916.8	-811.0	132	SEG ₁₀₀	4500.0	817.8

Table 2-1. Pad Layout (2/2)

Pin No.	Pin Name	X(μm)	Y(μm)	Pin No.	Pin Name	X(μm)	Y(μm)
133	SEG99	4410.0	817.8	199	SEG33	-1530.0	817.8
134	SEG98	4320.0	817.8	200	SEG32	-1620.0	817.8
135	SEG97	4230.0	817.8	201	SEG31	-1710.0	817.8
136	SEG96	4140.0	817.8	202	SEG30	-1800.0	817.8
137	SEG95	4050.0	817.8	203	SEG29	-1890.0	817.8
138	SEG94	3960.0	817.8	204	SEG28	-1980.0	817.8
139	SEG93	3870.0	817.8	205	SEG27	-2070.0	817.8
140	SEG92	3780.0	817.8	206	SEG26	-2160.0	817.8
141	SEG91	3690.0	817.8	207	SEG25	-2250.0	817.8
142	SEG90	3600.0	817.8	208	SEG24	-2340.0	817.8
143	SEG89	3510.0	817.8	209	SEG23	-2430.0	817.8
144	SEG88	3420.0	817.8	210	SEG22	-2520.0	817.8
145	SEG87	3330.0	817.8	211	SEG21	-2610.0	817.8
146	SEG86	3240.0	817.8	212	SEG20	-2700.0	817.8
147	SEG85	3150.0	817.8	213	SEG19	-2790.0	817.8
148	SEG84	3060.0	817.8	214	SEG18	-2880.0	817.8
149	SEG83	2970.0	817.8	215	SEG17	-2970.0	817.8
150	SEG82	2880.0	817.8	216	SEG16	-3060.0	817.8
151	SEG81	2790.0	817.8	217	SEG15	-3150.0	817.8
152	SEG80	2700.0	817.8	218	SEG14	-3240.0	817.8
153	SEG79	2610.0	817.8	219	SEG13	-3330.0	817.8
154	SEG78	2520.0	817.8	220	SEG12	-3420.0	817.8
155	SEG77	2430.0	817.8	221	SEG11	-3510.0	817.8
156	SEG76	2340.0	817.8	222	SEG10	-3600.0	817.8
157	SEG75	2250.0	817.8	223	SEG9	-3690.0	817.8
158	SEG74	2160.0	817.8	224	SEG8	-3780.0	817.8
159	SEG73	2070.0	817.8	225	SEG7	-3870.0	817.8
160	SEG72	1980.0	817.8	226	SEG6	-3960.0	817.8
161	SEG71	1890.0	817.8	227	SEG5	-4050.0	817.8
162	SEG70	1800.0	817.8	228	SEG4	-4140.0	817.8
163	SEG69	1710.0	817.8	229	SEG3	-4230.0	817.8
164	SEG68	1620.0	817.8	230	SEG2	-4320.0	817.8
165	SEG67	1530.0	817.8	231	SEG1	-4410.0	817.8
166	SEG66	1440.0	817.8	232	COM26	-4500.0	817.8
167	SEG65	1350.0	817.8	233	COM25	-4590.0	817.8
168	SEG64	1260.0	817.8	234	COM24	-4680.0	817.8
169	SEG63	1170.0	817.8	235	COM23	-4770.0	817.8
170	SEG62	1080.0	817.8	236	COM22	-4860.0	817.8
171	SEG61	990.0	817.8	237	COM21	-4950.0	817.8
172	SEG60	900.0	817.8	238	COM20	-5040.0	817.8
173	SEG59	810.0	817.8	239	COM19	-5130.0	817.8
174	SEG58	720.0	817.8	240	COM18	-5220.0	817.8
175	SEG57	630.0	817.8	241	COM17	-5310.0	817.8
176	SEG56	540.0	817.8	242	COM16	-5400.0	817.8
177	SEG55	450.0	817.8	243	COM15	-5490.0	817.8
178	SEG54	360.0	817.8	244	COM14	-5580.0	817.8
179	SEG53	270.0	817.8	245	COM13	-5670.0	817.8
180	SEG52	180.0	817.8	246	COM12	-5760.0	817.8
181	SEG51	90.0	817.8	247	COM11	-5850.0	817.8
182	SEG50	0.0	817.8	248	Dummy	-5940.0	817.8
183	SEG49	-90.0	817.8	249	Dummy	-6030.0	817.8
184	SEG48	-180.0	817.8	250	Dummy	-6112.0	577.8
185	SEG47	-270.0	817.8	251	Dummy	-6112.0	487.8
186	SEG46	-360.0	817.8	252	COM10	-6112.0	397.8
187	SEG45	-450.0	817.8	253	COM9	-6112.0	307.8
188	SEG44	-540.0	817.8	254	COM8	-6112.0	217.8
189	SEG43	-630.0	817.8	255	COM7	-6112.0	127.8
190	SEG42	-720.0	817.8	256	COM6	-6112.0	37.8
191	SEG41	-810.0	817.8	257	COM5	-6112.0	-52.2
192	SEG40	-900.0	817.8	258	COM4	-6112.0	-142.2
193	SEG39	-990.0	817.8	259	COM3	-6112.0	-232.2
194	SEG38	-1080.0	817.8	260	COM2	-6112.0	-322.2
195	SEG37	-1170.0	817.8	261	COM1	-6112.0	-412.2
196	SEG36	-1260.0	817.8	262	PCOM	-6112.0	-502.2
197	SEG35	-1350.0	817.8	263	Dummy	-6112.0	-592.2
198	SEG34	-1440.0	817.8	264	Dummy	-6112.0	-682.2

3. PIN DESCRIPTIONS

3.1 Power System Pins

Pin Symbol	Pin Name	Pin No.	I/O	Function Description
V _{DD}	Logic and booster power supply pin	22, 23, 48 to 50, 73 to 75, 82, 96	-	Power supply pin for logic and booster circuit.
V _{SS}	Logic and driver ground pin	51 to 53	-	Ground pin for logic and driver circuit.
V _{LCD}	Driver power supply pin	45 to 47	-	Driver power supply pin. Output pin of internal booster circuit. Please connect with a 1 μF booster capacitor to ground. When not using the internal booster circuit, the driver power can be turned on directly.
★ V _{LC1} to V _{LC5}	Driver reference power supply	25 to 27, 29 to 31, 33 to 35, 37 to 39, 41 to 43	-	Reference power supply pin for LCD drive. When the internal bias is selected, be sure to leave it open. When display contrast is bad, connect a capacitor between these pins and ground.
V _{LCBS1} to V _{LCBS3}	Bias level select pin	4, 5, 7, 8, 10, 11	-	When the internal bias is selected, Connecting these pins outside the IC, the bias level can be changed.
C ₁ ⁺ , C ₁ ⁻ C ₂ ⁺ , C ₂ ⁻ C ₃ ⁺ , C ₃ ⁻	Capacitor connection pins	55 to 72	-	Capacitor connection pins for booster circuit. When using internal booster circuit, connect a 1μF capacitor between these pins.

3.2 Logic System Pins (1/2)

Pin Symbol	Pin Name	Pin No.	I/O	Function Description
WS	Word length select pin (Word Select)	92	I	This pin selects the word length. At High level, it become an 8-bit parallel interface. At Low level, when D ₇ (NS) is High level, it become a serial interface. When the word length is 4 bits, data is transferred in the upper-to-low sequence by mean of data busses D ₀ to D ₃ . The word length cannot be changed after power-on.
DA _{CHA}	D/A converter select pin	78	I	This pin selects whether to use the internal D/A converter for LCD driving voltage adjustment or not. At High level, D/A converter is used. At Low level, unused.
STB	Strobe	93	I	This pin is select signal of device, strobe signal for data transfer. Data transfer is initialized at falling/rising edge of STB. Data can be input/output at Low level either in parallel interface or serial interface mode. When STB is High level, Enable/shift clock is bypassed.
E(SCK)	Enable(shift clock)	94	I	When using parallel interface mode, this pin becomes the data enable input. In reading-in, data is fetched into the interface buffer at rising edge. In reading-out, data is fetched from interface buffer at falling edge. When using serial interface mode, this pin becomes the data shift clock. In reading-in, data is fetched into the interface buffer at rising edge. In reading-out, data is fetched from interface buffer at falling edge.
D ₀ (DATA)	Data-bus(data)	84	I/O	When using parallel interface mode, this pin becomes the D ₀ bit of data-bus. When using serial interface mode, this pin becomes the input/output pin of the command and display data (3 states).
D ₁ to D ₃	Data-bus	85 to 87	I/O	When using parallel interface mode, these pin becomes the D ₁ to D ₃ bits of data-bus. When using serial interface mode, keep them H or L.
D ₄ to D ₆	Data-bus	88 to 90	I/O	When using parallel interface mode, these pin become the D ₄ to D ₆ bits of data-bus. When using serial interface mode, keep them H or L.
D ₇ (NS)	Data-bus(nibble select)	91	I/O	When word select (WS) is High level, this pin becomes the D ₇ bit of data-bus. When word select (WS) is Low level, This pin becomes nibble select pin. At High level, selected 4-bit parallel interface. At Low level, selected serial interface.
TEST _{OUT}	TEST signal output	97	O	When to do test, this pin is output for test signal. When using in normal operation, this pin leave open.
/RESET	Reset	95	I	At Low level, the μPD16680 is initialized.

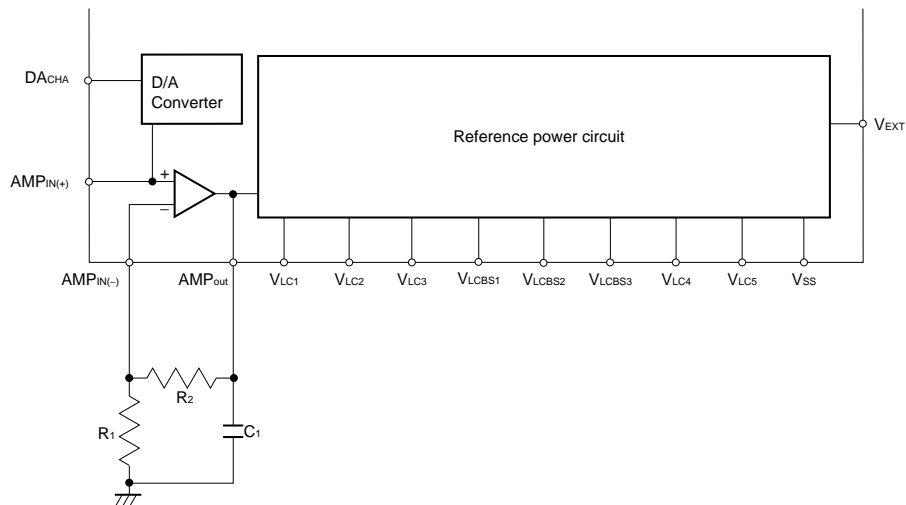
3.2 Logic System Pins (2/2)

Pin Symbol	Pin Name	Pin No.	I/O	Function Description
AMP _{CHA}	Amp mode select pin	79	I	Select operational amplifier mode. At High level, "Level capacitor mode". At Low level, "LCD driving mode".
V _{EXT}	LCD reference supply switching	77	I	Select the method for supplying LCD power circuit. At High level, LCD driving voltage is supplied external circuit. At Low level, it is supplied internal circuit.
OSC _{IN}	Oscillation pin	80	I	These pins are connected with the 1 MΩ resistor. When using external oscillation, input into the OSC _{IN} , and leaving the OSC _{OUT} open.
OSC _{OUT}		81	O	
OSC _{BRI}	Blinking Clock	83	I	This pin is oscillation input for Blinking. To input 2 Hz external clock, when to use Blinking by external clock mode. When not to use this pin, keep it H or L.

3.3 Driver System Pins

Pin Symbol	Pin Name	Pin No.	I/O	Function Description
SEG ₁ to SEG ₁₀₀	Segment	132 to 231	O	Segment output pins.
COM ₁ to COM ₅₁	Common	102 to 112, 117 to 130, 232 to 247, 252 to 261	O	Common output pins
PCOM	Pictographic common	131, 262	O	Common output pins for pictograph. (Same waveform output from these pins.)
AMP _{IN(+)}	Operational amplifier input	19, 20	I	These pins are the input pins of operational amplifier for LCD driving voltage adjustment. When using the internal D/A converter, leave AMP _{IN(+)} open. When not using the internal D/A converter, it is necessary to input the reference voltage. AMP _{IN(-)} is connected to the resistor for LCD driving voltage adjustment. See 4. LCD DRIVING VOLTAGE CONTROL CIRCUIT.
AMP _{IN(-)}		16, 17		
AMP _{OUT}	Operational amplifier output	13, 14	O	This is the input pin of operational amplifier for LCD driving voltage adjustment. Normally it is connected to the resistor for LCD driving voltage adjustment. See 4. LCD DRIVING VOLTAGE CONTROL CIRCUIT. It recommends to connect to this pin a 0.1 to 1 μF capacitor to make the output of the internal operational amplifier be stable.
Dummy	Dummy pad	1, 2, 3, 9, 12, 15, 18, 21, 24, 28, 32, 33, 40, 44, 54, 76, 98 to 101, 113 to 116, 248 to 251, 263, 264	-	Dummy pins are not connected to the internal circuit. Leave open if they are not used.

4. LCD DRIVING VOLTAGE CONTROL CIRCUIT



5. POWER CIRCUIT

The μPD16680 incorporate the booster circuit is switchable between 3 and 4 folds. The boosting magnitude of internal booster circuit is selected by the capacitor connection.

The reference power circuit is switchable between internal driving circuit and external driving circuit. The method for supplying the reference circuit selected by V_{EXT} pin (H : External, L : Internal).

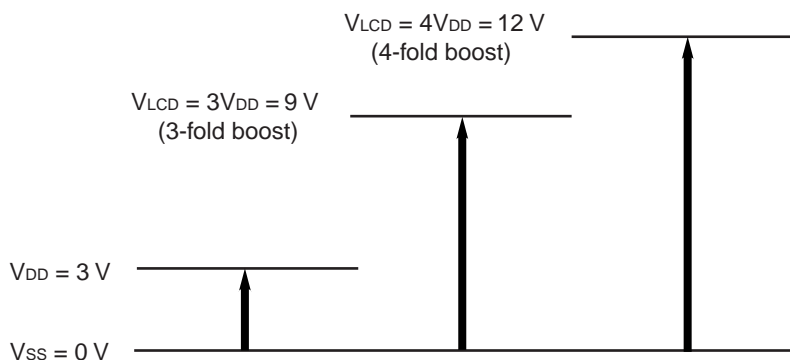
5.1 Booster circuit

Using Internal driving circuit, to connect condenser for boosting between C₁⁺ and C₁⁻, C₂⁺ and C₂⁻, C₃⁺ and C₃⁻, to connect condenser between V_{LCD} and V_{DD} to be stable boosting voltage. And to set V_{EXT} pin to low level, internal booster circuit boost voltage between V_{DD} and V_{SS} to 3 or 4 folds.

The booster circuit is using clock made by internal oscillation circuit. It is necessary that oscillation to be operated.

C₁⁺, C₁⁻, C₂⁺, C₂⁻, C₃⁺, C₃⁻, V_{DD} are pins for booster circuit. To use the wire that have low register value to connect these pins.

Figure 5-1 3x and 4x Booster Circuits



- Remarks 1. When to use 3-fold booster circuit, not to connect condenser between C₃⁺ and C₂⁻, C₁⁺ and C₁⁻, leave open C₂⁺ and C₃⁻.
- 2. When to use external power supply circuit, booster circuit is not operating.

5.2 LCD driving circuit

5.2.1 To use internal driving circuit, not to use D/A converter ($V_{EXT} = L$, $DA_{CHA} = L$)

When to internal driving circuit is chosen, boosted voltage be used for power of internal operational amplifier adjusting LCD driving voltage. To connect external resistor R_1 , R_2 , and input reference voltage to $AMP_{IN(+)}$ pin. It is possible to adjust LCD driving voltage of V_{LC1} . If using thermistor to adjust LCD driving voltage according to the temperature characteristic of LCD panel, we recommend connecting it with R_2 in parallel.

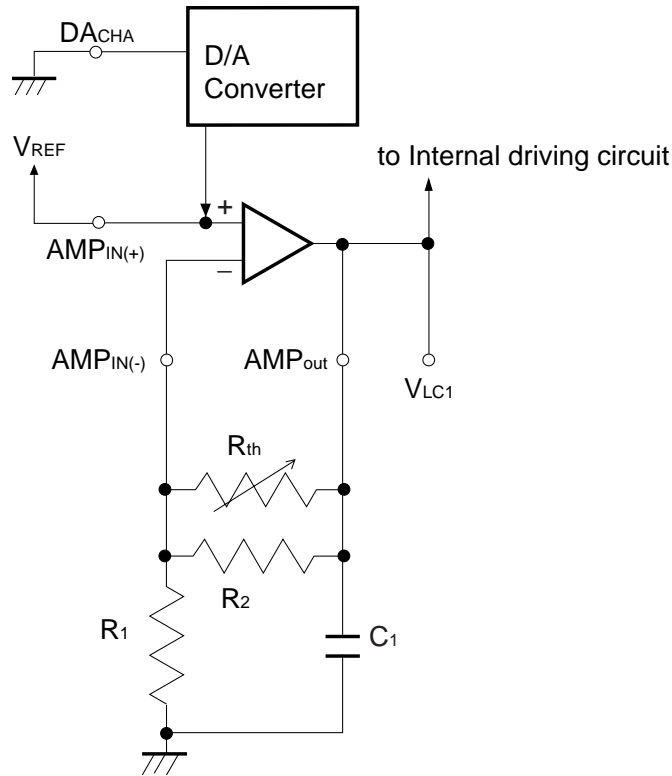
The value of V_{LC1} can be computed by the following formula.

Equation 5-1

$$V_{LC1} = AMP_{IN(+)} = \left(1 + \frac{R_2'}{R_1}\right) V_{REF}$$

Remark $R_2' = \frac{R_2 \times R_{th}}{R_2 + R_{th}}$

Figure 5-2 When not using Internal power supply select or D/A converter



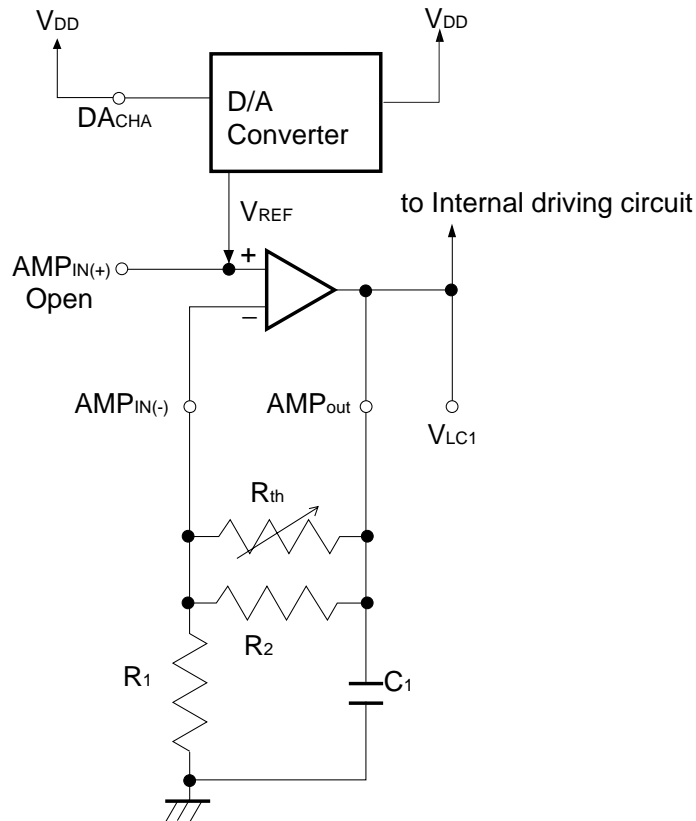
5.2.2 To use internal driving circuit and D/A converter ($V_{EXT} = L$, $DA_{CHA} = H$)

To use D/A converter, it is possible to adjust reference voltage V_{REF} inputted to $AMP_{IN(+)}$ pin for LCD driving by command.

To set 6-bit data to D/A converter register, reference voltage V_{REF} is choose one level from 64 level in $1/2 V_{DD}$ to V_{DD} .

The formula of V_{LC1} is as same written in **Equation 5-1**.

Figure 5-3 Using internal power supply select and D/A converter



5.2.3 To use external driving circuit ($V_{EXT} = H$)

When external voltage supply circuit for LCD driving is chosen, operational amplifier incorporated IC is off. Therefore, it is impossible to use operational amplifier for LCD driving and D/A converter function. LCD driving voltage is adjust by the voltage inputted to V_{LCD} and V_{LC1} pins directly.

- Remarks 1.** Set $V_{LCD} \geq V_{LC1}$.
- 2.** DA_{CHA} , $AMP_{IN(+)}$, $AMP_{IN(-)}$ are CMOS input. Set H level or L level.
- 3.** Set AMP_{OUT} pin "open".

5.3 REFERENCE VOLTAGE CIRCUIT

5.3.1 To use internal reference voltage circuit ($V_{EXT} = L$)

When internal driving circuit is chosen, 6 levels for LCD reference voltage (V_{LC1} , V_{LC2} , V_{LC3} , V_{LC4} , V_{LC5} , V_{SS}) is generate by internal breeder resistor.

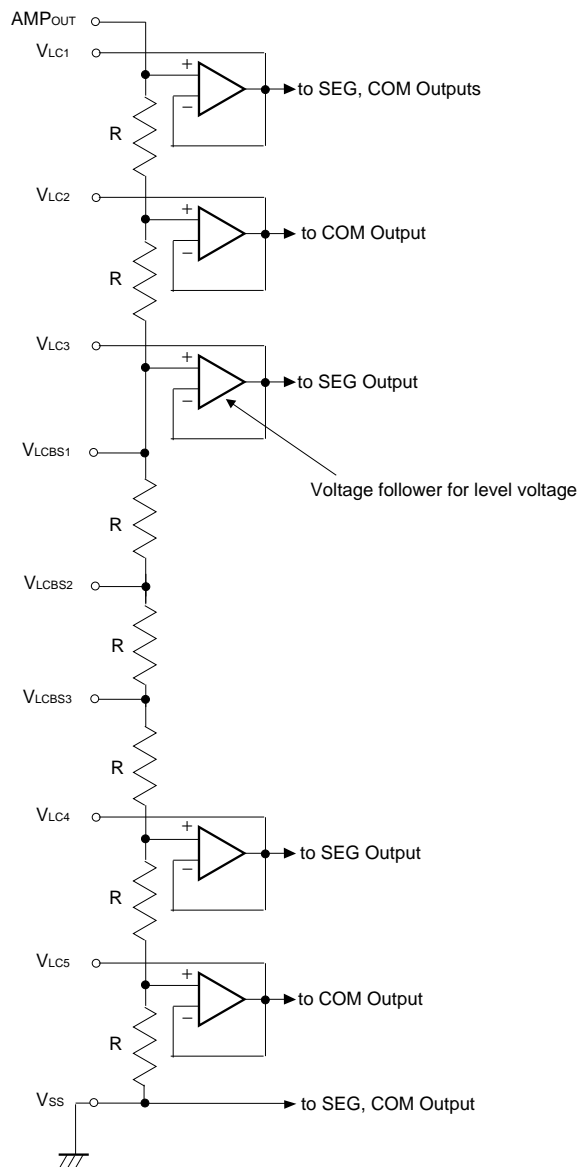
5.3.2 To use external driving circuit ($V_{EXT} = H$)

When external driving circuit is chosen, operational amplifier incorporated IC is Off. It is necessary to input voltage to V_{LC1} , V_{LC2} , V_{LC3} , V_{LC4} and V_{LC5} directly.

Generally, These levels are made by external breeder resistor. The display dignity of LCD declines when these resistance values are big, it is necessary to choose the resistance value which corresponds with the LCD panel. There is an effect that improves display dignity when connecting a capacitor with each level pins and the ground. It is necessary to choose the condenser value which corresponds with the LCD panel.

★

Figure 5-3. Reference voltage circuit



5.4 Setting BIAS value

When internal driving circuit chosen, by connecting the interval of the pin V_{LCBS1} , V_{LCBS2} , V_{LCBS3} outside the IC, the bias value can be set from the 1/6 bias, the 1/7 bias, the 1/8 bias.

Bias value	Pin connection
1/8 bias	V_{LCBS1} , V_{LCBS2} , V_{LCBS3} All open
1/7 bias	To connect V_{LCBS1} and V_{LCBS2} , or V_{LCBS2} and V_{LCBS3}
1/6 bias	To connect V_{LCBS1} and V_{LCBS3} , V_{LCBS2} is open.

5.5 Voltage followers for level power supply

By the input of AMP_{CHA} pin, it controls voltage follower for the LCD drive level power supply.

- LCD driving mode ($AMP_{CHA} = L$)

When this mode is chosen, The voltage follower maximizes electric current supply ability for LCD drive. It doesn't need to connect the external capacitor for the level stability.

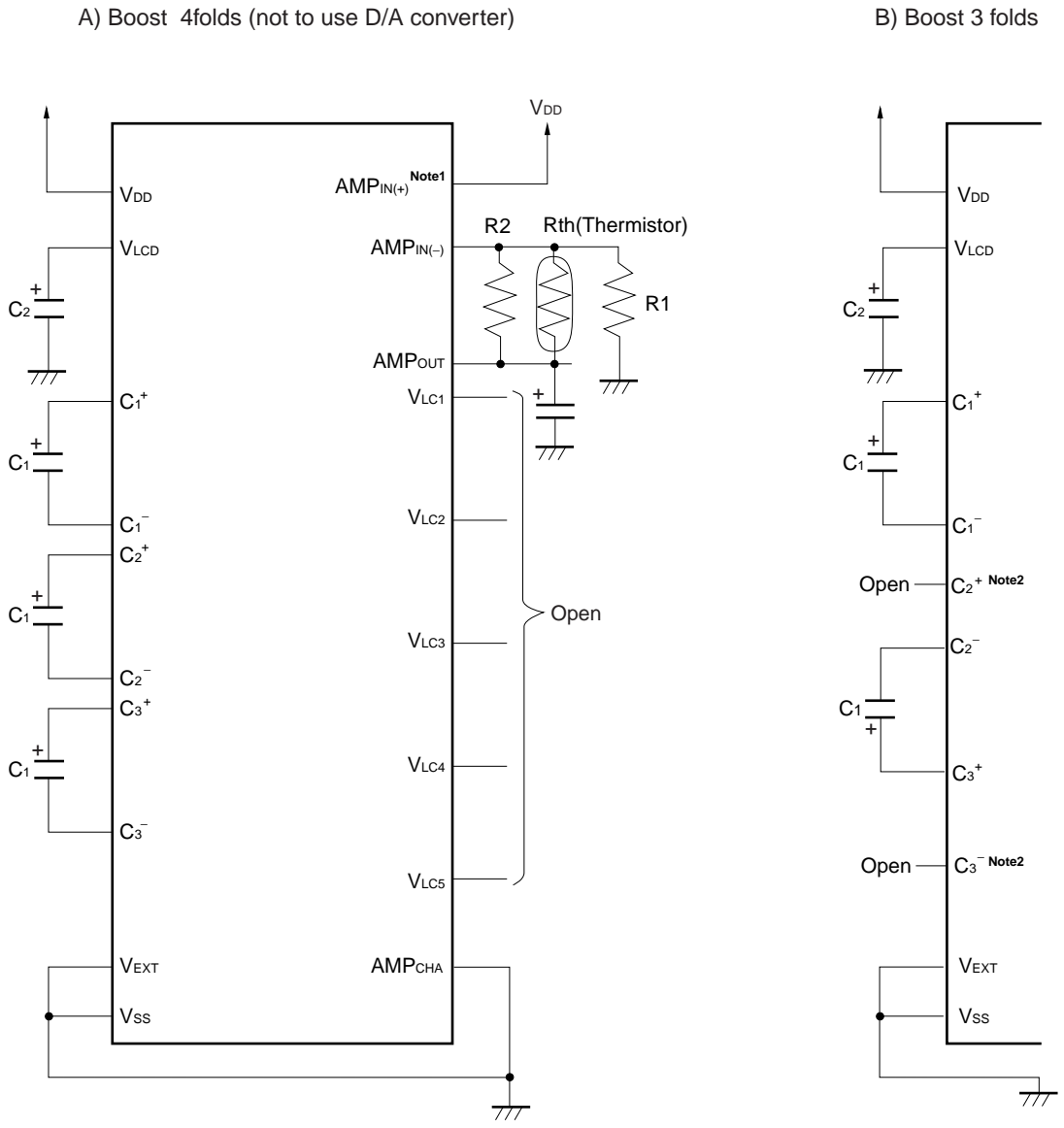
- Level capacitor mode ($AMP_{CHA} = H$)

When this mode is chosen, The voltage follower maximizes electric current supply ability for the external condenser charging. In this mode, it needs to connect the external capacitor (0.1 to 1.0 μF) for the level stability.

Caution When using this mode without connecting capacitor, the display dignity will be bad.

5.6 Application circuit example

5.6.1 To use internal driving circuit, LCD driving mode

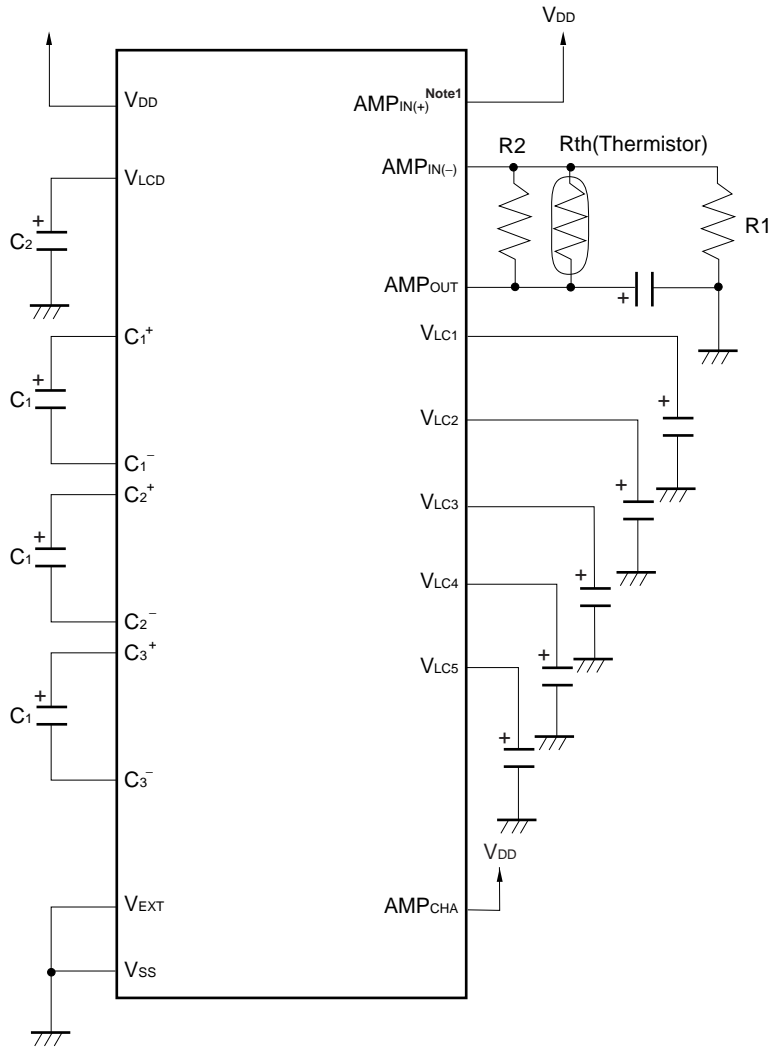


- Notes**
1. When to use D/A converter, AMP_{IN(+)} is open.
 2. C₂⁺, C₃⁻ are open.

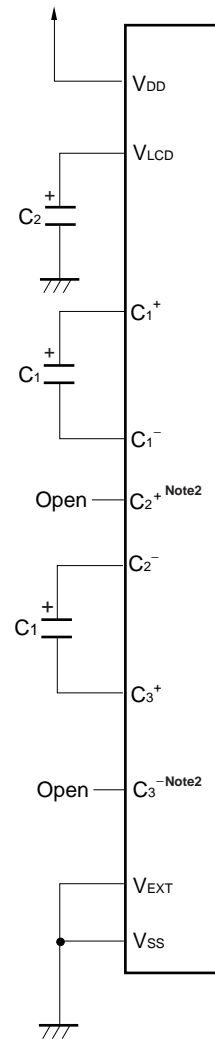
Remark C₁ = C₂ = 1.0 μm

5.6.2 To use internal driving circuit, LCD driving mode

A) Boost 4folds(not to use D/A converter)



B) Boost 3 folds



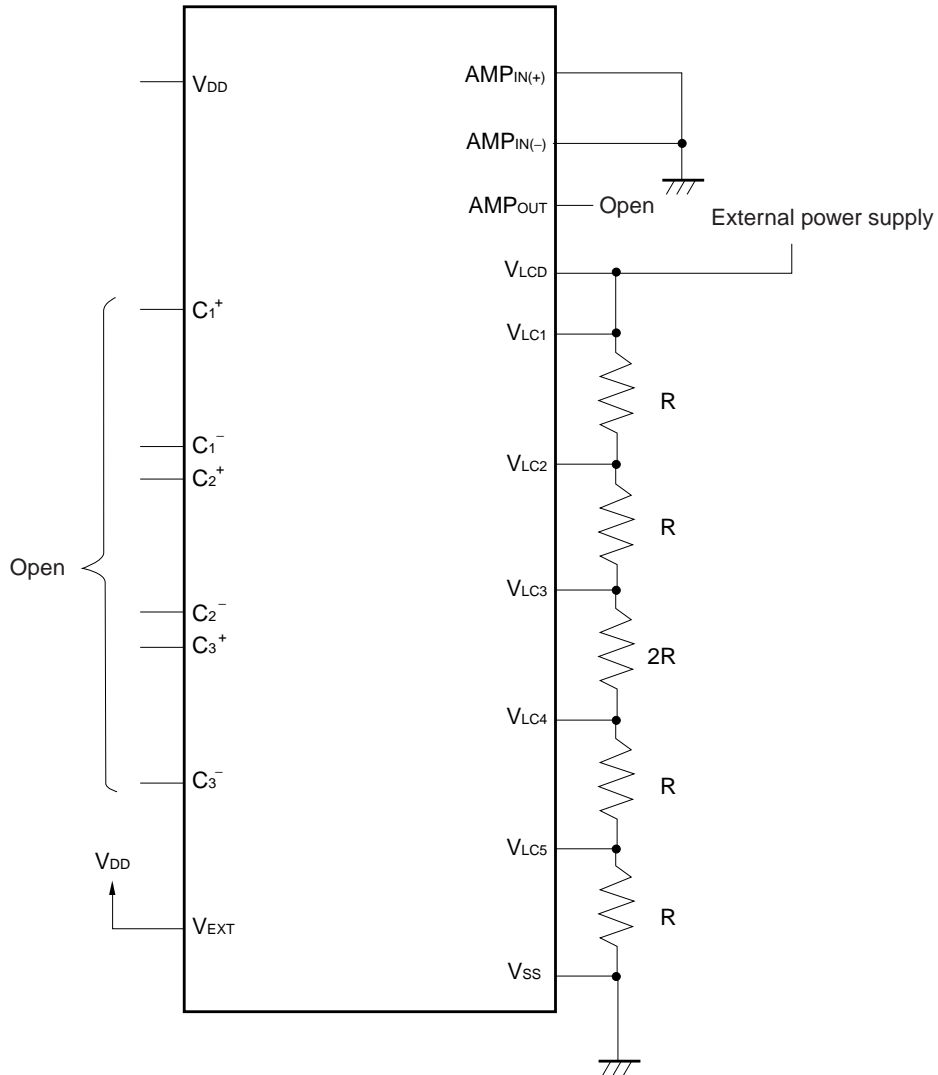
Notes 1. When to use D/A converter, AMP_{IN(+)} is open.

2. C₂₊, C₃₋ are open.

Remark C₁ = C₂ = 1.0 μm

5.6.3 To use external driving circuit

To use 1/6 bias

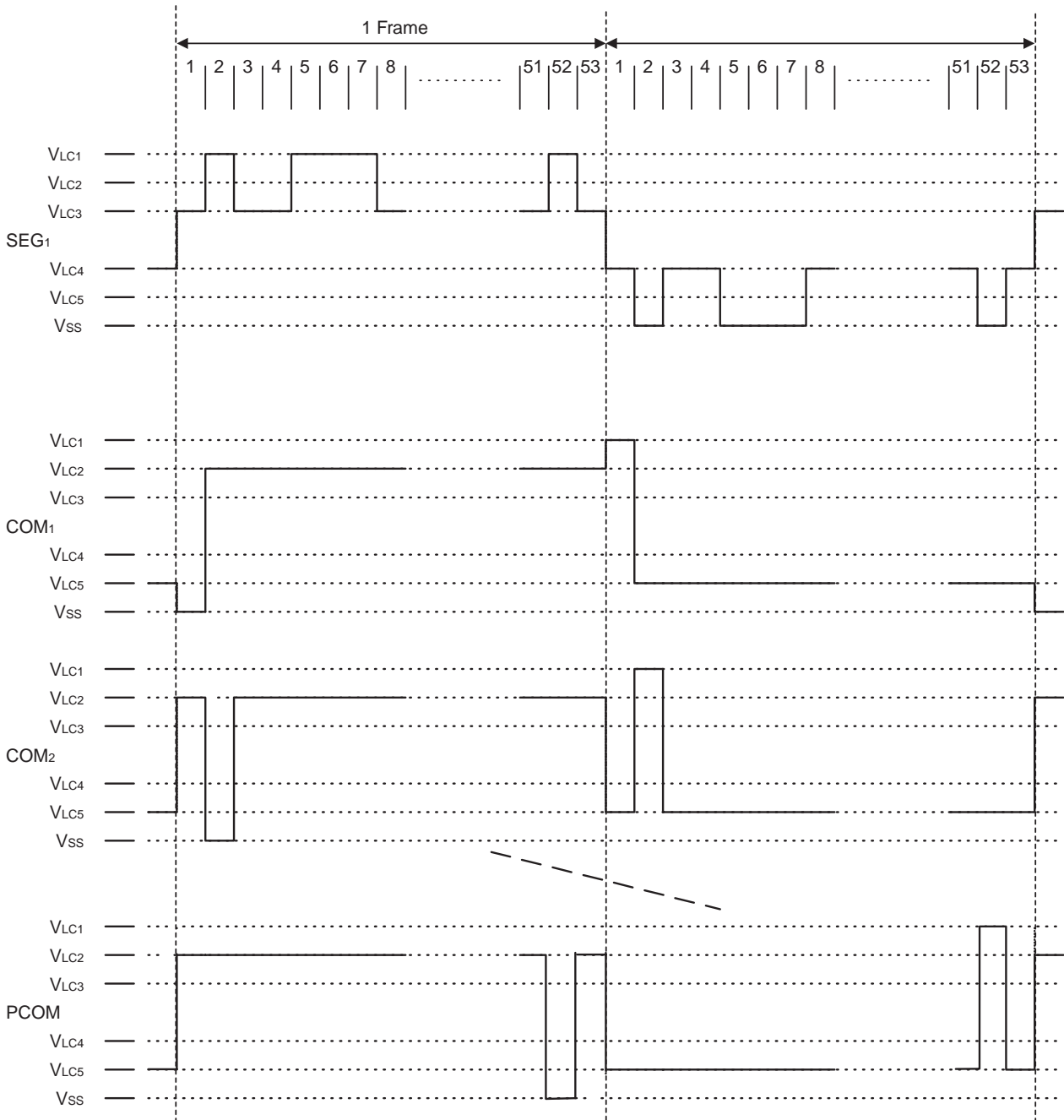


6. LCD DRIVING

The μPD16680 is able to choose duty 1/53 duty or 140 duty.

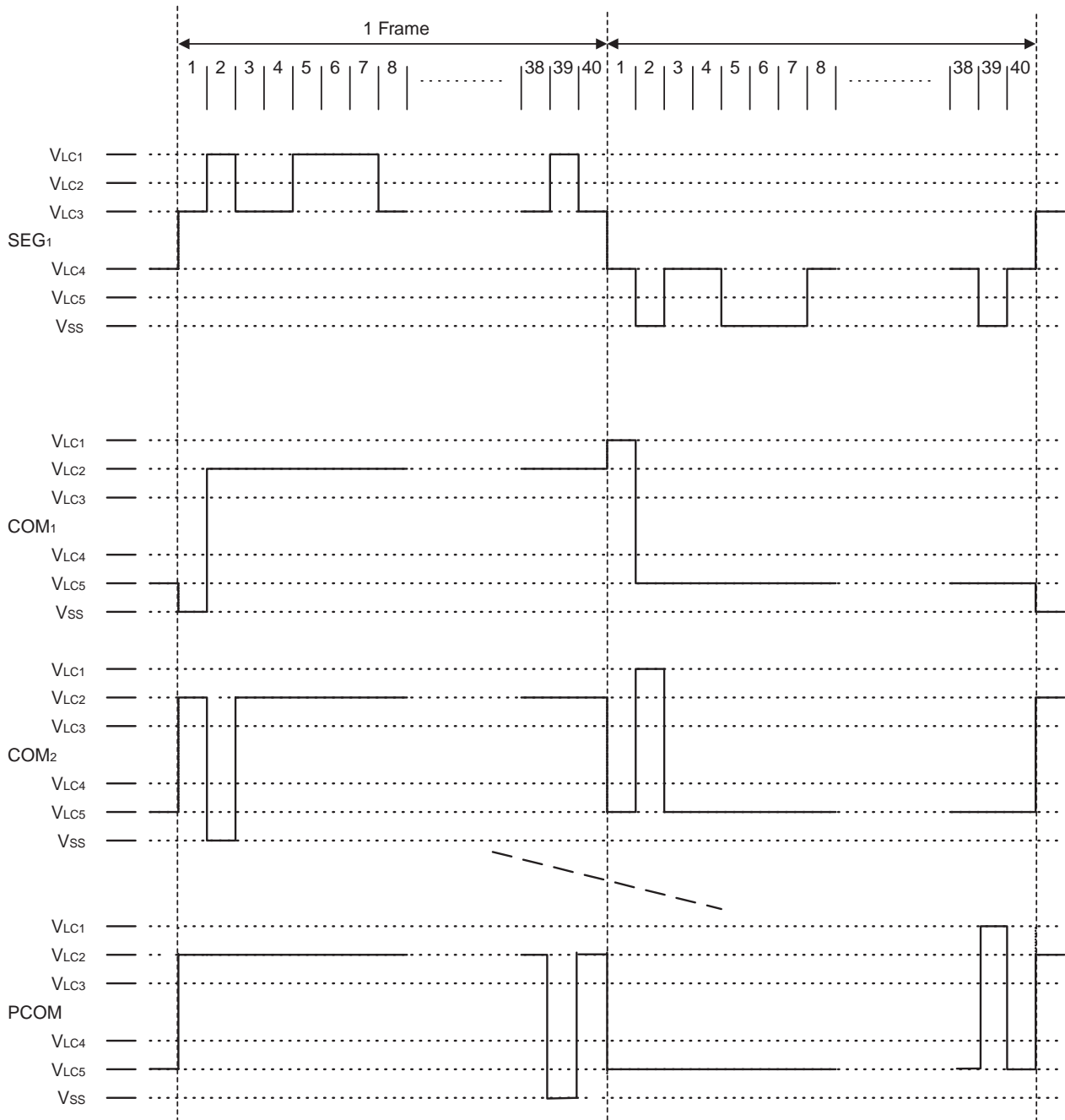
6.1 1/53 duty driving

When 1/53 duty is chosen, the μPD16680 outputs a choice signal once at 1 frame from the dot part common outputs (COM₁ to COM₅), the pictograph part common outputs (PCOM).



6.2 1/40 duty driving

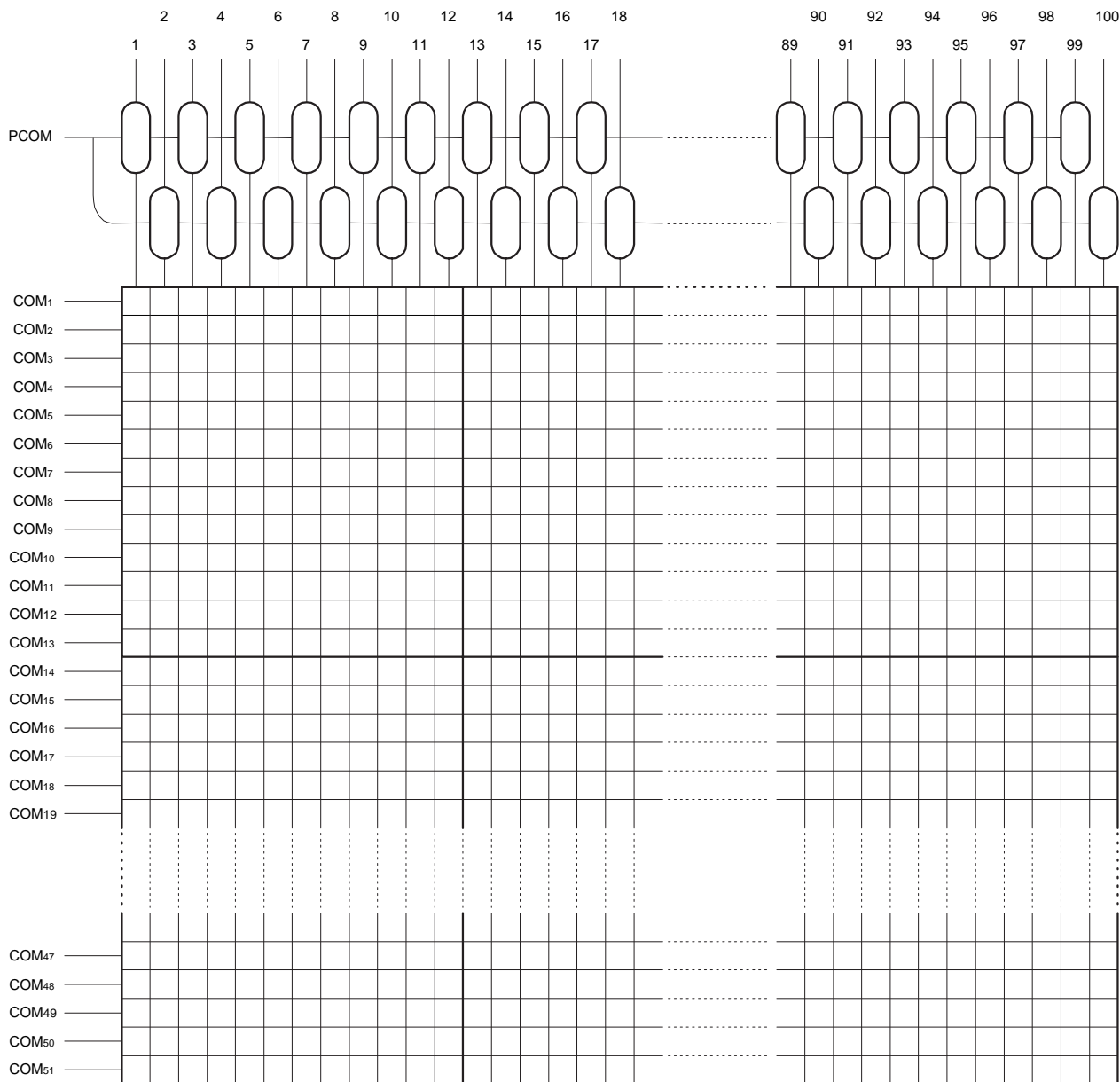
When 1/40 duty is chosen, the μPD16680 outputs a choice signal once at 1 frame from the dot part common outputs (COM₁ to COM₁₉, COM₂₇ to COM₄₅), the pictograph part common outputs (PCOM).



7. LCD DISPLAY

The μPD16680 can display 100 by 51 dots (called full-dot display) LCD display and 100 pictographs.

Figure 7-1 LCD matrix

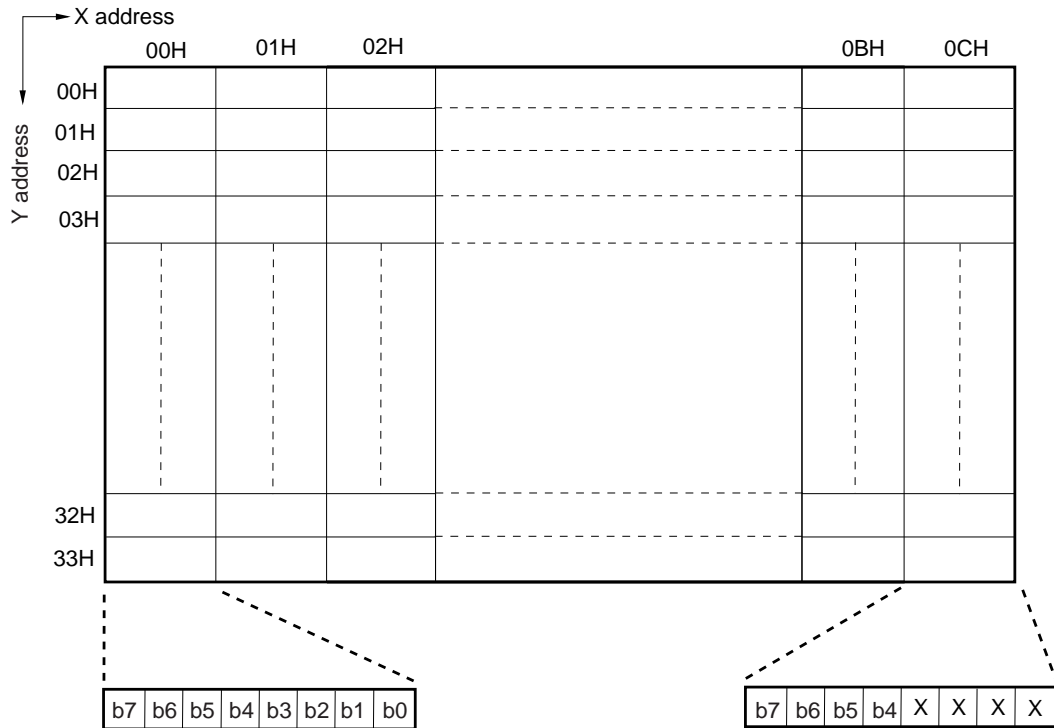


8. GROUP ADDRESSES

8.1 Dot display

The group addresses of dot display are assigned as follows.

To be chosen the address is increment, when X address goes to 0CH, next address is 00H. At this time, Y address goes to next address. When Y address goes to 33H, next address is 00H, too.



Remark Data of X address = 0CH : b7 to b4 are data, b3 to b0 are don't care.

★ When 1/53 duty and using 1/40 duty are used, the RAM addresses and the common pins used are as follows.

Duty	Use RAM Y addresses	Don't use RAM Y addresses	Use common pins	Don't use common pins
1/53 duty	00H to 33H	-	COM1 to COM51	-
1/40 duty	00H to 12H 1AH to 2CH ^{Note}	13H to 19H 2DH to 33H	COM1 to COM19 COM27 to COM45	COM20 to COM26 COM46 to COM51

Note If address incrementation is set when 1/40 duty is used, the X address value following 0CH is 00H. At the same time the Y address is incremented by 1. The Y address value following 12H is 1AH, and the value following 2CH is 00H.

8.2 Pictograph

The group addresses of pictograph are assigned as follows.

To be chosen the address is increment, X address goes to 0CH, next address is 00H.

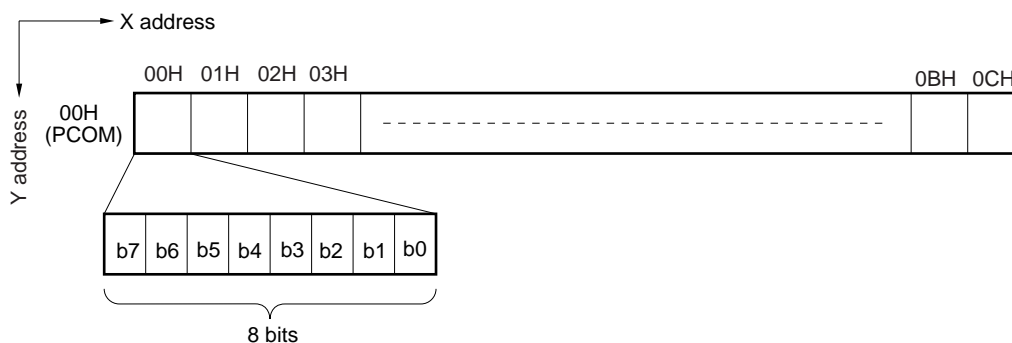


Table 8-1 PCOM (Y address = 00H)

X address	Segment output No.							
	b7	b6	b5	b4	b3	b2	b1	b0
00H	1	2	3	4	5	6	7	8
01H	9	10	11	12	13	14	15	16
02H	17	18	19	20	21	22	23	24
03H	25	26	27	28	29	30	31	32
04H	33	34	35	36	37	38	39	40
05H	41	42	43	44	45	46	47	48
06H	49	50	51	52	53	54	55	56
07H	57	58	59	60	61	62	63	64
08H	65	66	67	68	69	70	71	72
09H	73	74	75	76	77	78	79	80
0AH	81	82	83	84	85	86	87	88
0BH	89	90	91	92	93	94	95	96
0CH	97	98	99	100	X	X	X	X

Remark Data of X address = 0CH :b7 to b4 are data, b3 to b0 are don't care.

8.3 Blink data

The group addresses of blink data are assigned as follows.

To be chosen the address is increment, when X address goes to 0CH, next address is 00H.

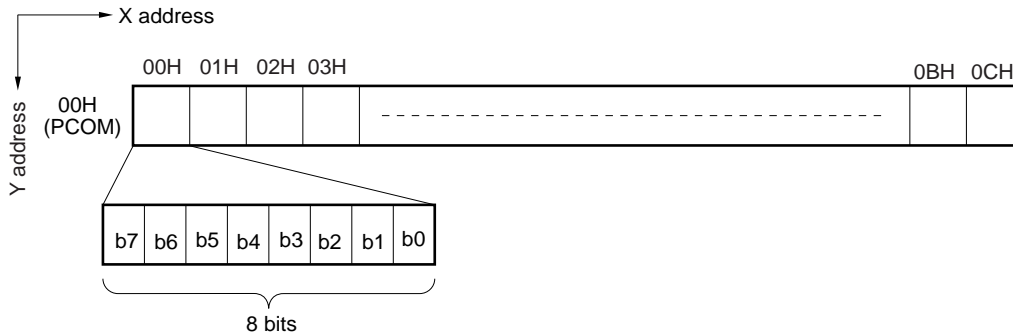


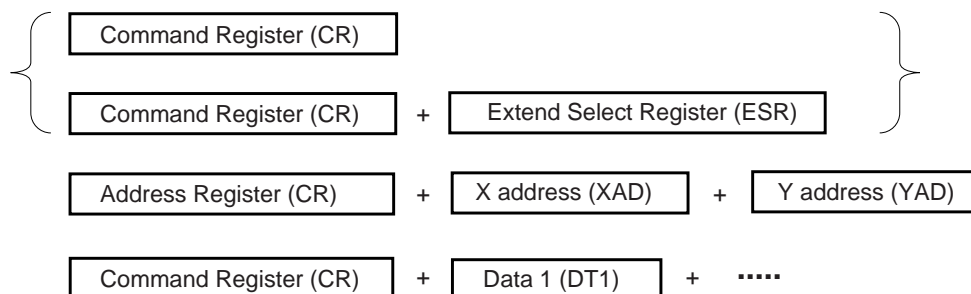
Table 8-2 PCOM (Y address = 00H)

X address	Segment output No.							
	b7	b6	b5	b4	b3	b2	b1	b0
00H	1	2	3	4	5	6	7	8
01H	9	10	11	12	13	14	15	16
02H	17	18	19	20	21	22	23	24
03H	25	26	27	28	29	30	31	32
04H	33	34	35	36	37	38	39	40
05H	41	42	43	44	45	46	47	48
06H	49	50	51	52	53	54	55	56
07H	57	58	59	60	61	62	63	64
08H	65	66	67	68	69	70	71	72
09H	73	74	75	76	77	78	79	80
0AH	81	82	83	84	85	86	87	88
0BH	89	90	91	92	93	94	95	96
0CH	97	98	99	100	X	X	X	X

Remark Data of X address = 0CH :b7 to b4 are data, b3 to b0 are don't care.

9. COMMAND

9.1 Basic form



9.2 Command register

The command register's basic configuration is as follows.

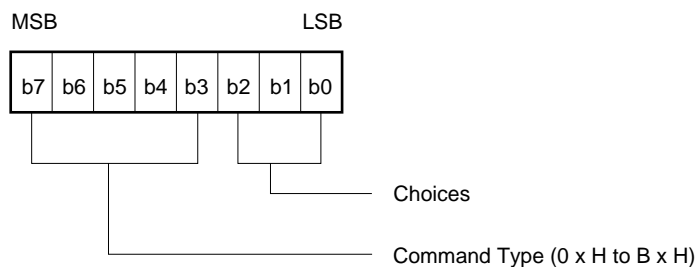
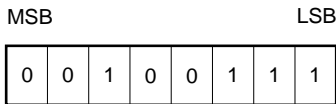


Table 7-1 Command Table

Command	Register							
	D7	D6	D5	D4	D3	D2	D1	D0
Reset	0	0	1	0	0	1	1	1
Display ON/OFF	0	0	0	0	1	b2	b1	b0
Standby	0	0	0	1	0	b2	b1	b0
D/A converter setting	0	0	1	0	1	0	0	0
Duty setting	0	0	0	1	1	b3	b2	b0
Blink setting	0	1	0	0	0	b2	b1	b0
Data R/W mode	1	0	1	1	0	b2	b1	b0
Test mode	1	0	1	1	1	b2	b1	b0

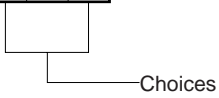
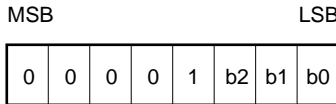
9.2.1 Reset

The all IC's commands are initialized.



9.2.2 Display ON/OFF

ON/OFF of the display is controlled.

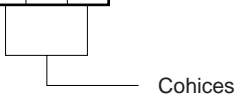
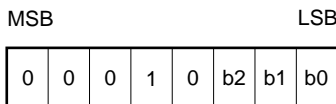


- 000 : LCD OFF (SEG_n, COM_n, PCOM_n = V_{ss})
- 001 : LCD OFF (SEG_n, COM_n, PCOM_n = non-selective output)
- 111 : LCD ON

9.2.3 Standby

The DC/DC converter is stopped, thus reducing the supply current. This display is placed in the OFF state (SEG_n, COM_n = V_{ss}).

Even at Standby, it is possible to write command and data.

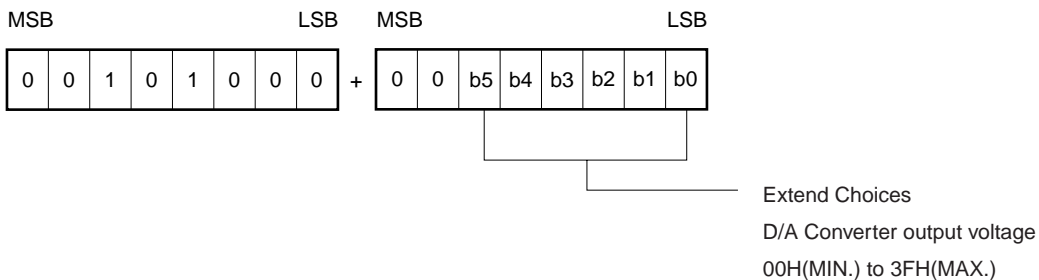


- 000 : Normal operation
- 001 : Standby (DC/DC converter halt, all display OFF^{Note}, OSC halt)

Note SEG_n, COM_n, PCOM = V_{ss}

9.2.4 D/A converter setting

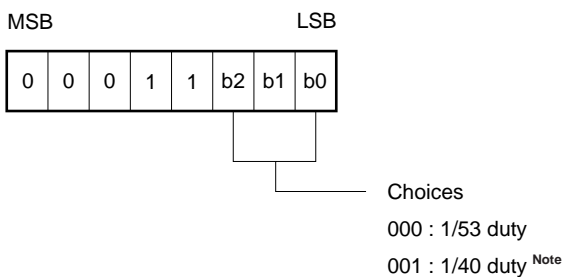
The internal D/A converter is set. D/A converter output voltage is controlled from $1/2V_{DD}$ to V_{DD} .



Caution After resetting, it is set to 20H.

9.2.5 Duty setting

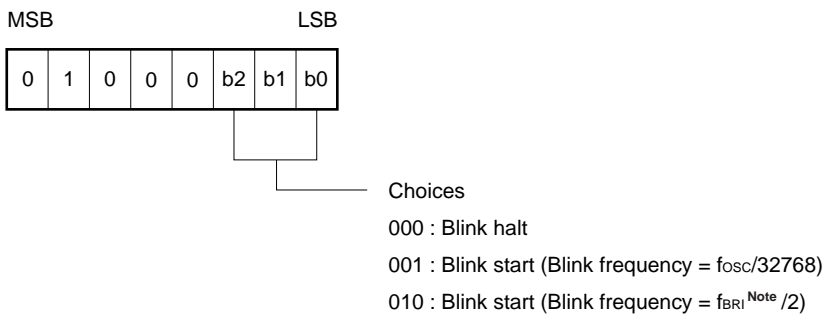
The duty is set.



Note If the duty cycle is 1/40, leave open from COM₃₉ to COM₅₁.

9.2.6 Blink setting

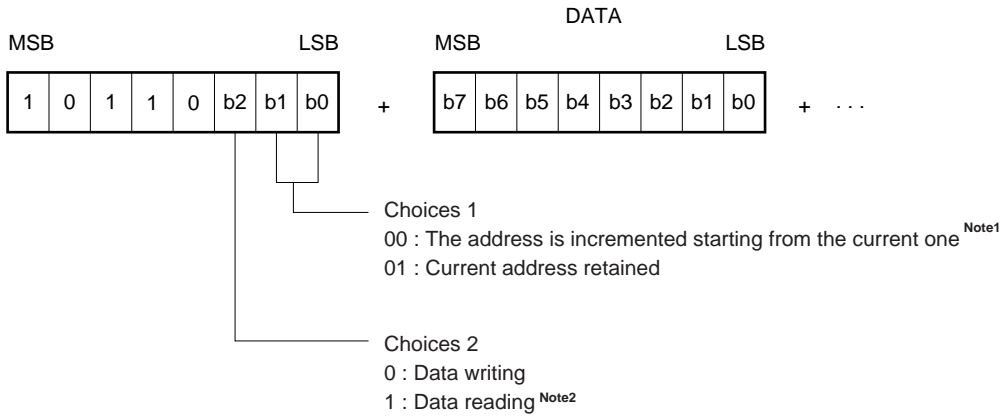
The blinks of the pictograph of the address whose blink data is "1" are controlled.



Note This refers to the frequency of the external clock which is input from the OSC_{BR1} pin.

9.2.7 Data R/W mode

Data Read/Write (R/W), increment, address counter resetting, etc. are set in this mode.

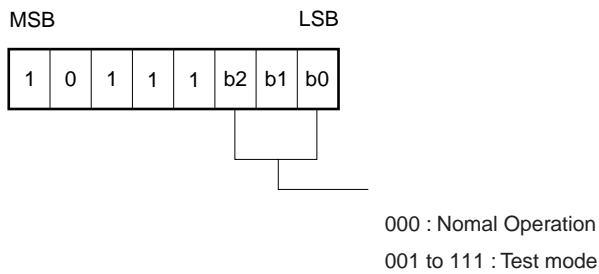


- Notes**
1. When X address and Y address goes to last address, next address is 00H.
 2. The data read mode is canceled at STB's rising edge (Switched to data write mode).

Remark When using serial data transfer, it is necessary to write 8-bit data. No assurance is IC's operation when STB is rising during data transfer.

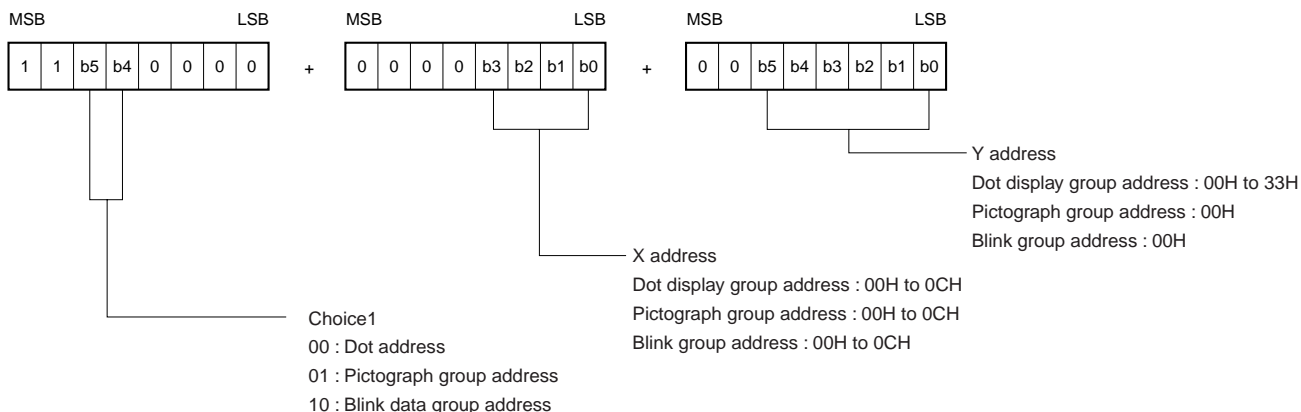
9.2.8 Test mode

The test mode is set. The test mode is for checking IC's operation, and no assurance is made for its regular use or continued operation.



★ 9.3 Address register

Selects the address type and specifies the address.



Caution If unspecified addresses have been set, operation is not assured.

10. RESETTING

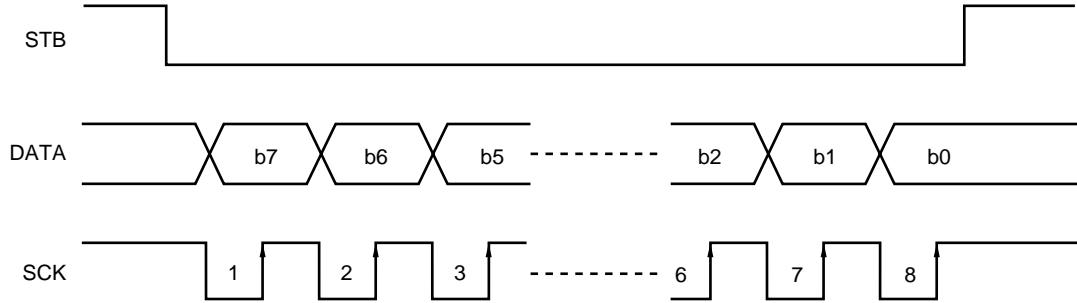
When reset (command reset, hardware (terminal) reset), the contents of each register are as follows.

Register name	Register contents								Status
	b7	b6	b5	b4	b3	b2	b1	b0	
Display ON / OFF	0	0	0	0	1	0	0	0	LCD OFF (SEG _n , COM _n , PCOM = V _{SS})
Standby	0	0	0	1	0	0	0	0	Normal operation
Duty setting	0	0	0	1	1	0	0	0	1/53 duty
D/A converter setting	1	0	0	0	0	0	0	0	To set 20H
Blink setting	0	1	0	0	0	0	0	0	Blink halt
Data R/W mode	1	0	1	1	0	0	0	0	Data write, the address is incremented(+1) starting from current address.
Test mode	1	0	1	1	1	0	0	0	Normal operation

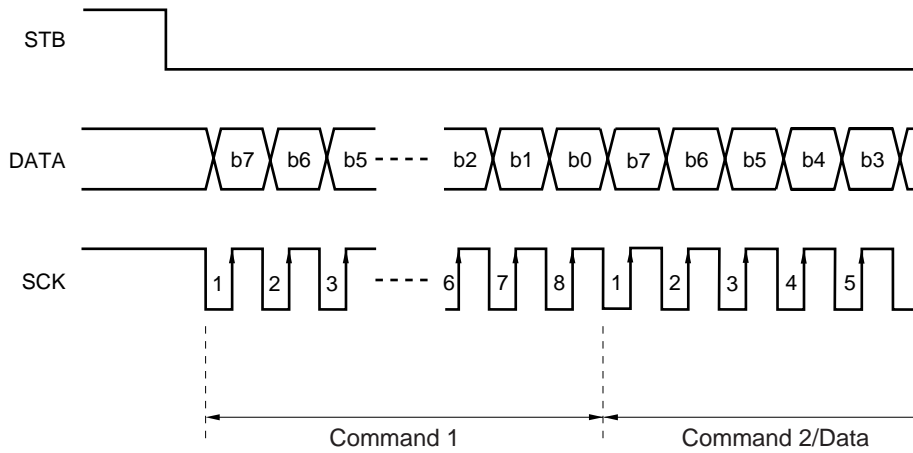
11. COMMUNICATION FORMAT

11.1 serial

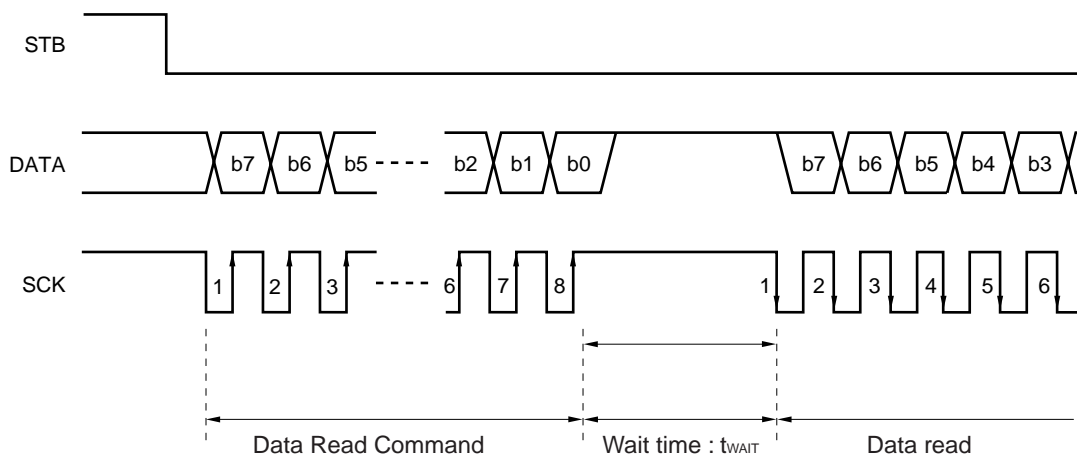
11.1.1 Reception 1 (Command/Data write : 1 byte)



11.1.2 Reception 2 (Command/Data write : 2 bytes or more)

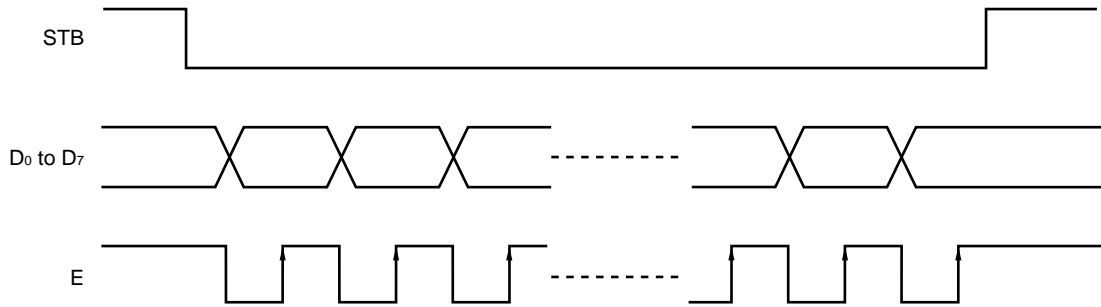


11.1.3 Transmission (Command/Data read)

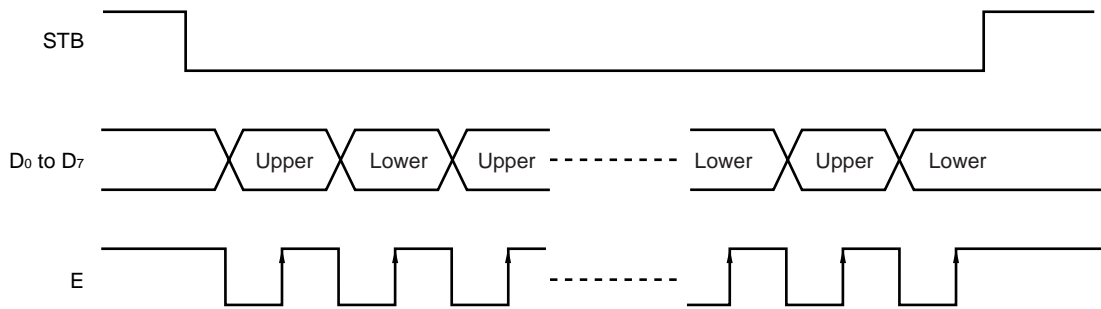


11.2 Parallel

11.2.1 8-bit parallel interface



11.2.2 4-bit parallel interface



12 CPU ACCESS EXAMPLE

12.1 Initialize and write data

Item	STB	Command / Data								Explanation
		b7	b6	b5	b4	b3	b2	b1	b0	
Start	H	x	x	x	x	x	x	x	x	
Reset	L	0	0	1	0	0	1	1	1	
	H	x	x	x	x	x	x	x	x	
Duty setting	L	0	0	0	1	1	0	0	0	1/53 duty
	H	x	x	x	x	x	x	x	x	
Address Register 1	L	1	1	0	0	0	0	0	0	Dot address
Address Register 2	L	0	0	0	0	0	0	0	0	X address = 00H
Address Register 3	L	0	0	0	0	0	0	0	0	Y address = 00H
	H	x	x	x	x	x	x	x	x	
Data R/W mode	L	1	0	1	1	0	0	0	0	Data write, The address is incremented starting from the current one.
Dot display Data 1	L	D	D	D	D	D	D	D	D	Dot data (63 bytes)
Dot display Data 663	L	D	D	D	D	D	D	D	D	
	H	x	x	x	x	x	x	x	x	
Address Register 1	L	1	1	0	1	0	0	0	0	Pictograph group address
Address Register 2	L	0	0	0	0	0	0	0	0	X address = 00H
Address Register 3	L	0	0	0	0	0	0	0	0	Y address = 00H
	H	x	x	x	x	x	x	x	x	
Data R/W mode	L	1	0	1	1	0	0	0	0	Data write, The address is incremented starting from the current one.
Pictograph Data 1	L	D	D	D	D	D	D	D	D	Pictograph data (13 bytes)
Pictograph Data 13	L	D	D	D	D	D	D	D	D	
	H	x	x	x	x	x	x	x	x	
Display ON / OFF	L	0	0	0	0	1	1	1	1	LCD ON
End	H	x	x	x	x	x	x	x	x	

Remark x = Don't Care, D = data

12.2 Change display data and pictograph data (All data are changed)

Item	STB	Command / Data								Explanation
		b7	b6	b5	b4	b3	b2	b1	b0	
Start	H	x	x	x	x	x	x	x	x	
Address Register 1	L	1	1	0	0	0	0	0	0	Dot address
Address Register 2	L	0	0	0	0	0	0	0	0	X address = 00H
Address Register 3	L	0	0	0	0	0	0	0	0	Y address = 00H
	H	x	x	x	x	x	x	x	x	
Data R/W mode	L	1	0	1	1	0	0	0	0	Data write, The address is incremented starting from the current one.
Dot display Data 1	L	D	D	D	D	D	D	D	D	Dot data (663 bytes)
Dot display Data 663	L	D	D	D	D	D	D	D	D	
	H	x	x	x	x	x	x	x	x	
Address Register 1	L	1	1	0	1	0	0	0	0	Pictograph group address
Address Register 2	L	0	0	0	0	0	0	0	0	X address = 00H
Address Register 3	L	0	0	0	0	0	0	0	0	Y address = 00H
	H	x	x	x	x	x	x	x	x	
Data R/W mode	L	1	0	1	1	0	0	0	0	Data write, The address is incremented starting from the current one.
Pictograph Data 1	L	D	D	D	D	D	D	D	D	Pictograph data (13 bytes)
Pictograph Data 13	L	D	D	D	D	D	D	D	D	
End	H	x	x	x	x	x	x	x	x	

Remark x = Don't Care, D = data

12.3 Read display data and pictograph data (All data are read)

Item	STB	Command / Data								Explanation
		b7	b6	b5	b4	b3	b2	b1	b0	
Start	H	x	x	x	x	x	x	x	x	
Address Register 1	L	1	1	0	0	0	0	0	0	Dot address
Address Register 2	L	0	0	0	0	0	0	0	0	X address = 00H
Address Register 3	L	0	0	0	0	0	0	0	0	Y address = 00H
	H	x	x	x	x	x	x	x	x	
Data R/W mode	L	1	0	1	1	0	1	0	0	Data read, The address is incremented starting from the current one.
Dot display Data 1	L	D	D	D	D	D	D	D	D	Dot data (663 bytes)
Dot display Data 663	L	D	D	D	D	D	D	D	D	
	H	x	x	x	x	x	x	x	x	
Address Register 1	L	1	1	0	1	0	0	0	0	Pictograph group address
Address Register 2	L	0	0	0	0	0	0	0	0	X address = 00H
Address Register 3	L	0	0	0	0	0	0	0	0	Y address = 00H
	H	x	x	x	x	x	x	x	x	
Data R/W mode	L	1	0	1	1	0	1	0	0	Data read, The address is incremented starting from the current one.
Pictograph Data 1	L	D	D	D	D	D	D	D	D	Pictograph data (13 bytes)
Pictograph Data 13	L	D	D	D	D	D	D	D	D	
End	H	x	x	x	x	x	x	x	x	

Remark x = Don't Care, D = data

12.4 Blink data setting

Item	STB	Command / Data								Explanation
		b7	b6	b5	b4	b3	b2	b1	b0	
Start	H	x	x	x	x	x	x	x	X	
Address Register 1	L	1	1	1	0	0	0	0	0	Blink group address
Address Register 2	L	0	0	0	0	0	0	0	0	X address = 00H
Address Register 3	L	0	0	0	0	0	0	0	0	Y address = 00H
	H	x	x	x	x	x	x	x	x	
Data R/W mode	L	1	0	1	1	0	0	0	0	Data write, The address is incremented starting from the current one.
★ Blink Data 1	L	D	D	D	D	D	D	D	D	Blink data (13 bytes)
Blink Data 13	L	D	D	D	D	D	D	D	D	
★	H	x	x	x	x	x	x	x	x	
★ Blink setting	L	0	1	0	0	0	0	1	0	Blink start, blink frequency = $f_{BRI}/2$
End	H	x	x	x	x	x	x	x	x	

Remark x= Don't Care, D = data

13. ELECTRICAL SPECIFICATIONS

Absolute maximum ratings (T_A =+25°C, V_{SS} =0 V)

Parameter	Symbol	Ratings	Unit
Supply voltage (4-fold voltage mode)	V _{DD}	-0.3 to +3.75	V
Supply voltage (3-fold voltage mode)	V _{DD}	-0.3 to +5.0	V
Driver supply voltage	V _{LCD}	-0.3 to +15.0, V _{DD} ≤ V _{LCD}	V
Driver reference supply input voltage	V _{LC1} to V _{LC5}	-0.3 to V _{LCD} +0.3	V
Logic system input voltage	V _{IN1}	-0.3 to V _{DD} +0.3	V
Logic system output voltage	V _{OUT1}	-0.3 to V _{DD} +0.3	V
Logic system input/output voltage	V _{I/O1}	-0.3 to V _{DD} +0.3	V
Driver system input voltage	V _{IN2}	-0.3 to V _{LCD} +0.3	V
Driver system output voltage	V _{OUT2}	-0.3 to V _{LCD} +0.3	V
Operating temperature	T _A	-40 to +85	°C
Storage temperature	T _{stg}	-55 to +150	°C

Caution If the absolute maximum rating of even one of the above parameters is exceeded even momentarily, the quality of the product may be degraded. Absolute maximum ratings, therefore, specify the values exceeding which the product may be physically damaged. Be sure to use the product within the range of the absolute maximum ratings.

Recommended operating range

Parameter	Symbol	MIN.	TYP.	MAX.	Unit
Supply voltage (4-fold voltage mode)	V _{DD}	2.4		3.0	V
Supply voltage (3-fold voltage mode)	V _{DD}	2.4		4.0	V
Driver supply voltage ^{Note}	V _{LCD}	5.0	10	12	V
Logic system input voltage	V _{IN}	0		V _{DD}	V
Driver system input voltage	V _{LC1} to V _{LC5}	0		V _{LCD}	V

Note When to use external LCD driving, this parameter is recommended.

- Remarks1.** When to use external LCD driving, keep V_{SS} < V_{LC5} < V_{LC4} < V_{LC3} < V_{LC2} < V_{LC1} ≤ V_{LCD}
2. When power on or power off moment, keep V_{DD} ≤ V_{LCD}
 3. When to use internal LCD driving circuit and not to use D/A converter, keep voltage inputted to AMP_{IN(+)} pin to 1.0V to V_{DD}.

Electrical characteristics (Unless otherwise specified, $T_A = -40$ to $+85^\circ\text{C}$, 4-fold voltage mode : $V_{DD} = 2.7$ to 3.0V or 3-fold voltage mode : $V_{DD} = 2.7$ to 4.0V)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
★ High-level input voltage	V_{IH}		$0.8 V_{DD}$			V
Low-level input voltage	V_{IL}				$0.2 V_{DD}$	V
High-level input current	I_{IH1}	Except Do/DATA, D ₁ to D ₇			1	μA
Low-level input current	I_{IL1}	Except Do/DATA, D ₁ to D ₇			-1	μA
High-level output voltage	V_{OH}	$I_{OUT} = -1.5\text{ mA}$, Except OSC _{OUT}	$V_{DD}-0.5$			V
Low-level output voltage	V_{OL}	$I_{OUT} = 4\text{ mA}$, Except OSC _{OUT}			0.5	V
High-level leakage current	I_{LOH}	Do/DATA, D ₁ to D ₇ $V_{IN/OUT} = V_{DD}$			10	μA
Low-level leakage current	I_{LOL}	Do/DATA, D ₁ to D ₇ $V_{IN/OUT} = V_{SS}$			-10	μA
Common output ON resistance	R_{COM}	$V_{LCn} \rightarrow \text{COM}_n$, $V_{LCD} \geq 3V_{DD}$ $I_{IOL} = 50\ \mu\text{A}$			2	kΩ
Segment output ON resistance	R_{SEG}	$V_{LCn} \rightarrow \text{SEG}_n$, $V_{LCD} \geq 3V_{DD}$ $I_{IOL} = 50\ \mu\text{A}$			4	kΩ
★ Driver voltage (Booster voltage)	V_{LCD}	3-fold voltage mode	$2.7 V_{DD}$		$3.0 V_{DD}$	V
		4-fold voltage mode	$3.6 V_{DD}$		$4.0 V_{DD}$	V
★ Current consumption (V_{DD}) Level condenser mode	I_{DD11}	$f_{OSC} = 32\text{ kHz}$, Display-off data output $V_{DD} = 3.0\text{ V}$, 3-fold voltage mode Not to access to RAM.			95	μA
		$f_{OSC} = 32\text{ kHz}$, Display-off data output $V_{DD} = 3.0\text{ V}$, 4-fold voltage mode Not to access to RAM.			125	μA
★ Current consumption (V_{DD}) LCD driving mode	I_{DD12}	$f_{OSC} = 32\text{ kHz}$, Display-off data output $V_{DD} = 3.0\text{ V}$, 3-fold voltage mode Not to access to RAM.			160	μA
		$f_{OSC} = 32\text{ kHz}$, Display-off data output $V_{DD} = 3.0\text{ V}$, 4-fold voltage mode Not to access to RAM.			250	μA
★ Driver current consumption (V_{DD} , Standby)	I_{DD21}	$V_{DD} = 3.0\text{ V}$			10	μA

Switching characteristics (Unless otherwise specified, $T_A = -40$ to $+85^\circ\text{C}$, $V_{DD} = 2.7$ to 3.3 V)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Oscillation frequency	F_{osc}	Self-oscillation	25	32	38	kHz
Transfer delay time 1	t_{PHL}	SCK↓ → DATA↓			100	ns
Transfer delay time 2	t_{PLH}	SCK↓ → DATA↑			300	ns

- ★ **Remarks 1.** The TYP. value is a reference value when $T_A = +25^\circ\text{C}$.
- 2. The time for one frame is found from the following formula.

$$1 \text{ frame} = 1/f_{osc} \times 8 \times \text{number of duties}$$

(Example)

$f_{osc} = 32$ kHz, $1/53$, then the result is :

$$1 \text{ frame} = 33 \mu\text{s} \times 8 \times 53 = 13.25 \text{ ms} \cong 75.5 \text{ Hz}$$

Required conditions for timing (Unless otherwise specified, T_A = -40 to +85°C, V_{DD} = 2.7 to 3.3 V)

1. Common

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Clock frequency	f _{OSC}	OSC _{IN} external clock	20	32	50	kHz
High-level clock pulse width	t _{WHC1}	OSC _{IN} external clock	10		25	μs
Low-level clock pulse width	t _{WLC1}	OSC _{IN} external clock	10		25	μs
High-level clock pulse width	t _{WHC2}	OSC _{BRI} external clock	400			ns
Low-level clock pulse width	t _{WLC2}	OSC _{BRI} external clock	400			ns
Rise/Fall time	t _r , t _f	OSC _{BRI} external clock			100	ns
Reset pulse width	t _{WRE}	/RESET pin	50			μs

Remark The TYP. value is a reference value when T_A = +25°C.

2. Serial interface

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Shift clock cycle	t _{CYK}	SCK	900			ns
High-level shift clock pulse width	t _{WHK}	SCK	295			ns
Low-level shift clock pulse width	t _{WLK}	SCK	295			ns
Shift clock hold time	t _{HSTBK}	STB↓ → SCK↓	400			ns
Data setup time	t _{DS1}	DATA → SCK↑	40			ns
Data hold time	t _{DH1}	SCK↑ → DATA	40			ns
STB hold time	t _{HKSTB}	SCK↑ → STB↑	400			ns
STB pulse width	t _{WSTB}		210			ns
Wait time ^{Note}	t _{WAIT}	8th CLK↑ → 1st CLK↓	100			ns

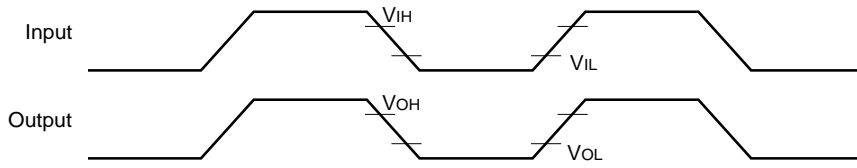
Note See 11.1.3 Transmission (Command/Data read).

3. Parallel interface

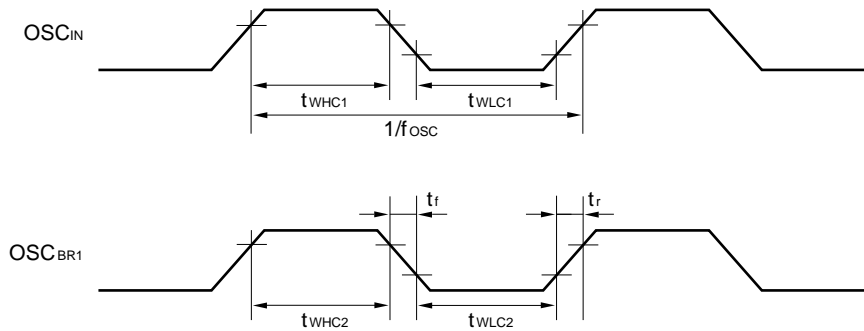
Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Enable cycle time	t _{CYCE}	E↑ → E↑	900			ns
High-level enable pulse width	t _{WHE}	E	295			ns
Low-level enable pulse width	t _{WLE}	E	295			ns
STB pulse width	t _{WSTB}		210			ns
STB hold time	t _{HKSTB}		400			ns
Enable hold time	t _{HSTBK}		400			ns
Data setup time	t _{DS2}	D ₀ to D ₇ → E↑	40			ns
Data hold time	t _{DH2}	D ₀ to D ₇ → E↓	40			ns

Switching characteristics waveforms

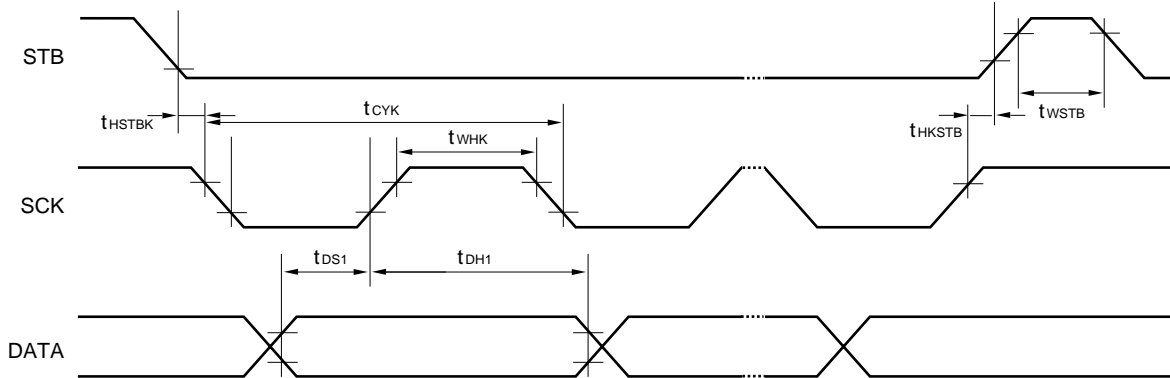
AC measurement point



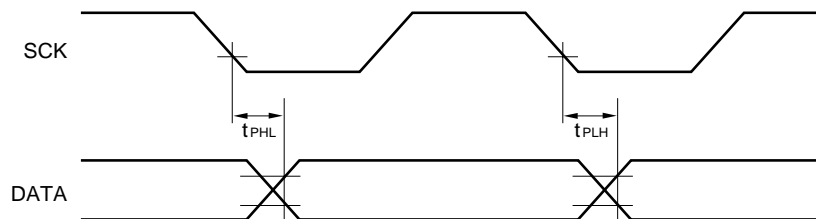
AC characteristics waveform



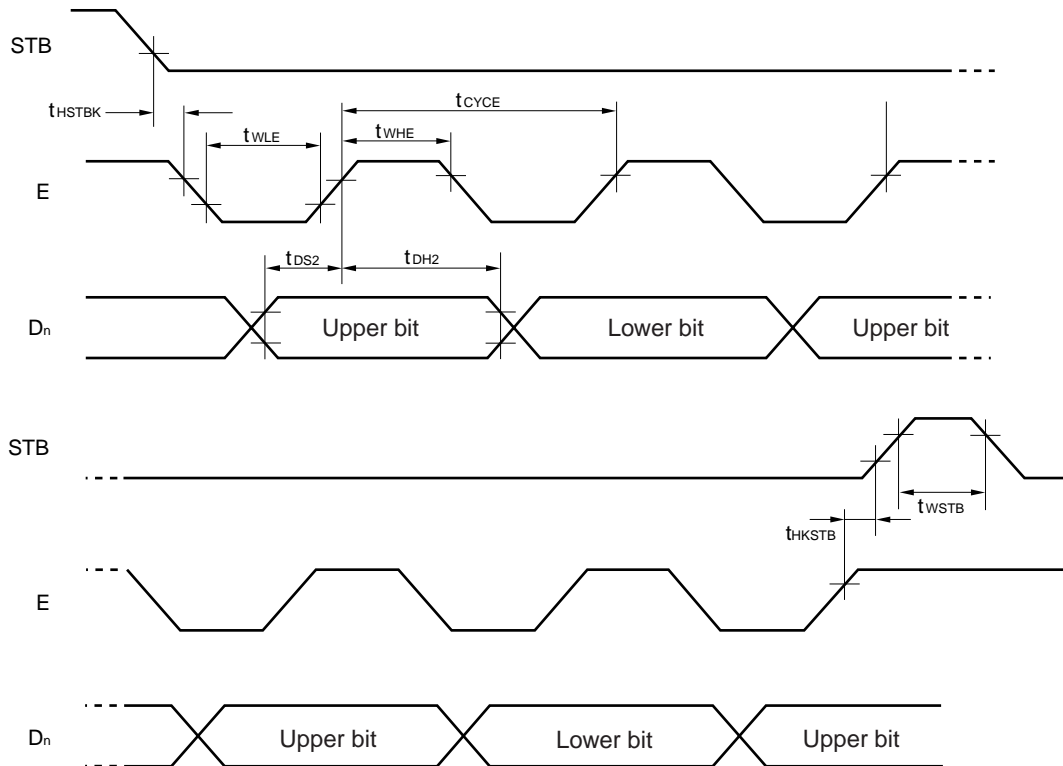
Serial interface (Input)



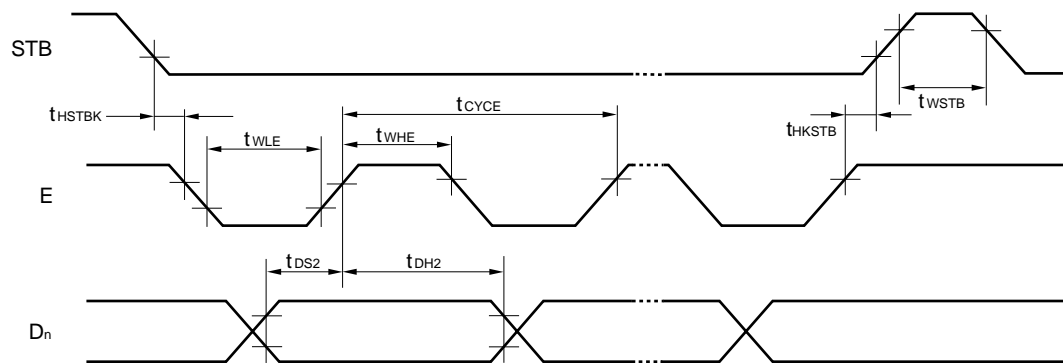
Serial interface (Output)



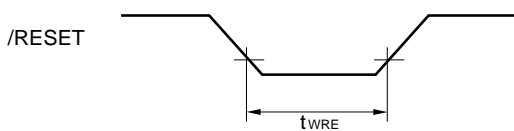
4-bit parallel interface



8-bit parallel interface



Reset



[MEMO]

[MEMO]

NOTES FOR CMOS DEVICES**① PRECAUTION AGAINST ESD FOR SEMICONDUCTORS**

Note:

Strong electric field, when exposed to a MOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop generation of static electricity as much as possible, and quickly dissipate it once, when it has occurred. Environmental control must be adequate. When it is dry, humidifier should be used. It is recommended to avoid using insulators that easily build static electricity. Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work bench and floor should be grounded. The operator should be grounded using wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions need to be taken for PW boards with semiconductor devices on it.

② HANDLING OF UNUSED INPUT PINS FOR CMOS

Note:

No connection for CMOS device inputs can be cause of malfunction. If no connection is provided to the input pins, it is possible that an internal input level may be generated due to noise, etc., hence causing malfunction. CMOS devices behave differently than Bipolar or NMOS devices. Input levels of CMOS devices must be fixed high or low by using a pull-up or pull-down circuitry. Each unused pin should be connected to V_{DD} or GND with a resistor, if it is considered to have a possibility of being an output pin. All handling related to the unused pins must be judged device by device and related specifications governing the devices.

③ STATUS BEFORE INITIALIZATION OF MOS DEVICES

Note:

Power-on does not necessarily define initial status of MOS device. Production process of MOS does not define the initial operation status of the device. Immediately after the power source is turned ON, the devices with reset function have not yet been initialized. Hence, power-on does not guarantee out-pin levels, I/O settings or contents of registers. Device is not initialized until the reset signal is received. Reset operation must be executed immediately after power-on for devices having reset function.

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