DATA SHEET

NEC

MOS INTEGRATED CIRCUIT

μPD160040

384-OUTPUT TFT-LCD SOURCE DRIVER (COMPATIBLE WITH 256-GRAY SCALES)

DESCRIPTION

The μPD160040 is a source driver for TFT-LCDs capable of dealing with displays with 256-gray scales. Data input is based on digital input configured as 8 bits by 6 dots (2 pixels), which can realize a full-color display of 16,777,216 colors by output of 256 values γ-corrected by an internal D/A converter and 8-by-2 external power modules.

Because the output dynamic range is as large as V_{SS2} + 0.2 V to V_{DD2} – 0.2 V, level inversion operation of the LCD's common electrode is rendered unnecessary. Also, to be able to deal with dot-line inversion, n-line inversion and column line inversion when mounted on a single side, this source driver is equipped with a built-in 8-bit D/A converter circuit whose odd output pins and even output pins respectively output gray scale voltages of differing polarity.

FEATURES

- CMOS level input
- 384 outputs
- Input of 8 bits (gray scale data) by 6 dots
- Capable of outputting 256 values by means of 8-by-2 external power modules (16 units) and a D/A converter
- Logic power supply voltage (V_{DD1}): 2.5 to 3.6 V
- Driver power supply voltage (V_{DD2}): 12.5 to 15.5 V (switchable, V_{SEL})
- Output dynamic range: V_{SS2} + 0.2 V to V_{DD2} – 0.2 V
- High-speed data transfer: $f_{CLK.}$ = 55 MHz MAX. (internal data transfer speed when operating at 3.0 V ≤ V_{DD1} ≤ 3.6 V)
  $f_{CLK.}$ = 40 MHz MAX. (internal data transfer speed when operating at 2.5 V ≤ V_{DD1} < 3.0 V)
- Apply for dot-line inversion, n-line inversion and column line inversion
- Output voltage polarity inversion function (POL)
- Output inversion function (POL21, POL 22)
- Output reset control is possible (MODE)
- Through-rate control is possible (SRC)
- Output resistance control is possible (ORC)
- Single bank arrangement is possible (loaded with slim TCP)

ORDERING INFORMATION

Part Number	Package
μPD160040N-xxx	TCP (TAB package)

Remark The TCP's external shape is customized. To order the required shape, so please contact one of our sales representatives.

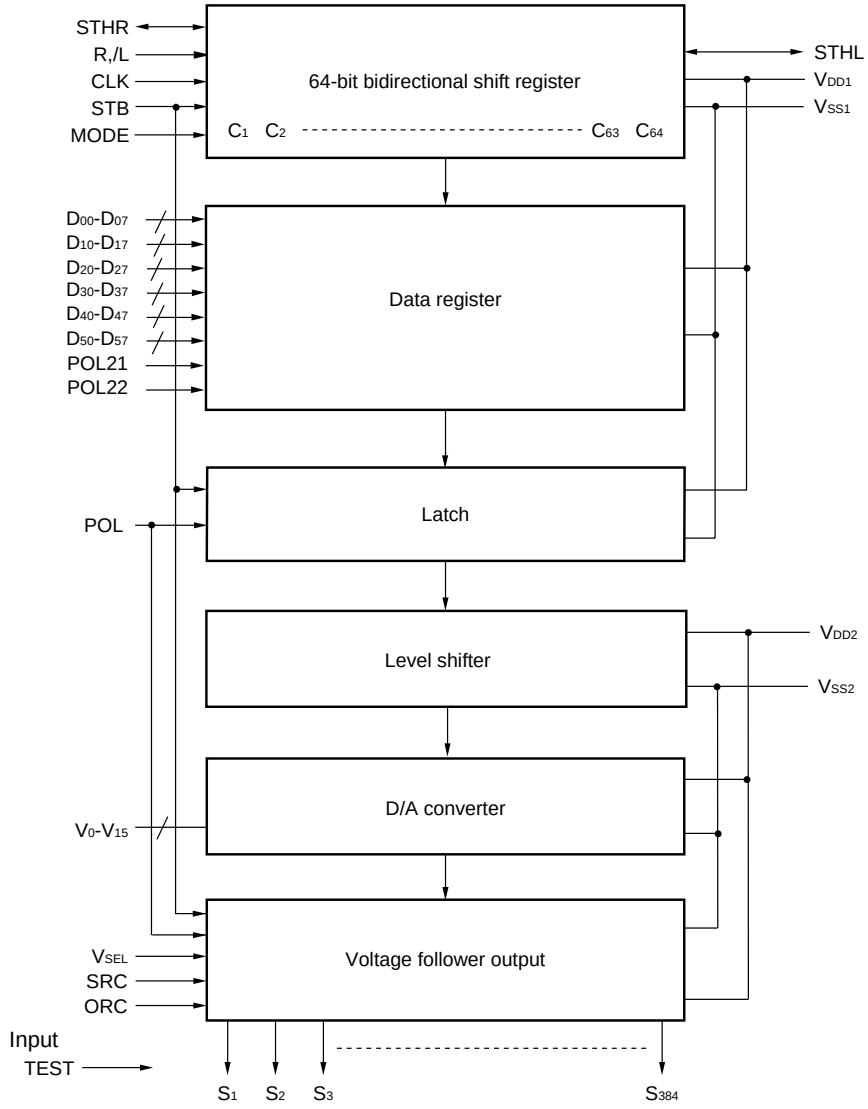
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The mark ★ shows major revised points.

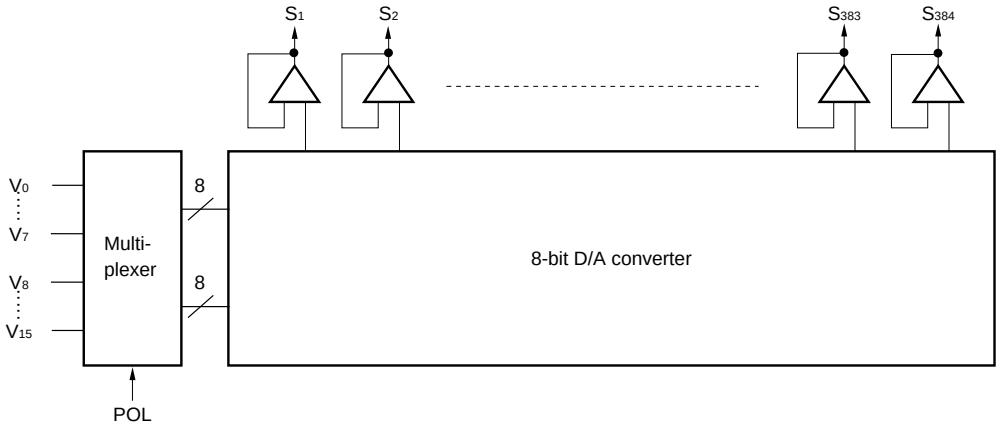
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1. BLOCK DIAGRAM

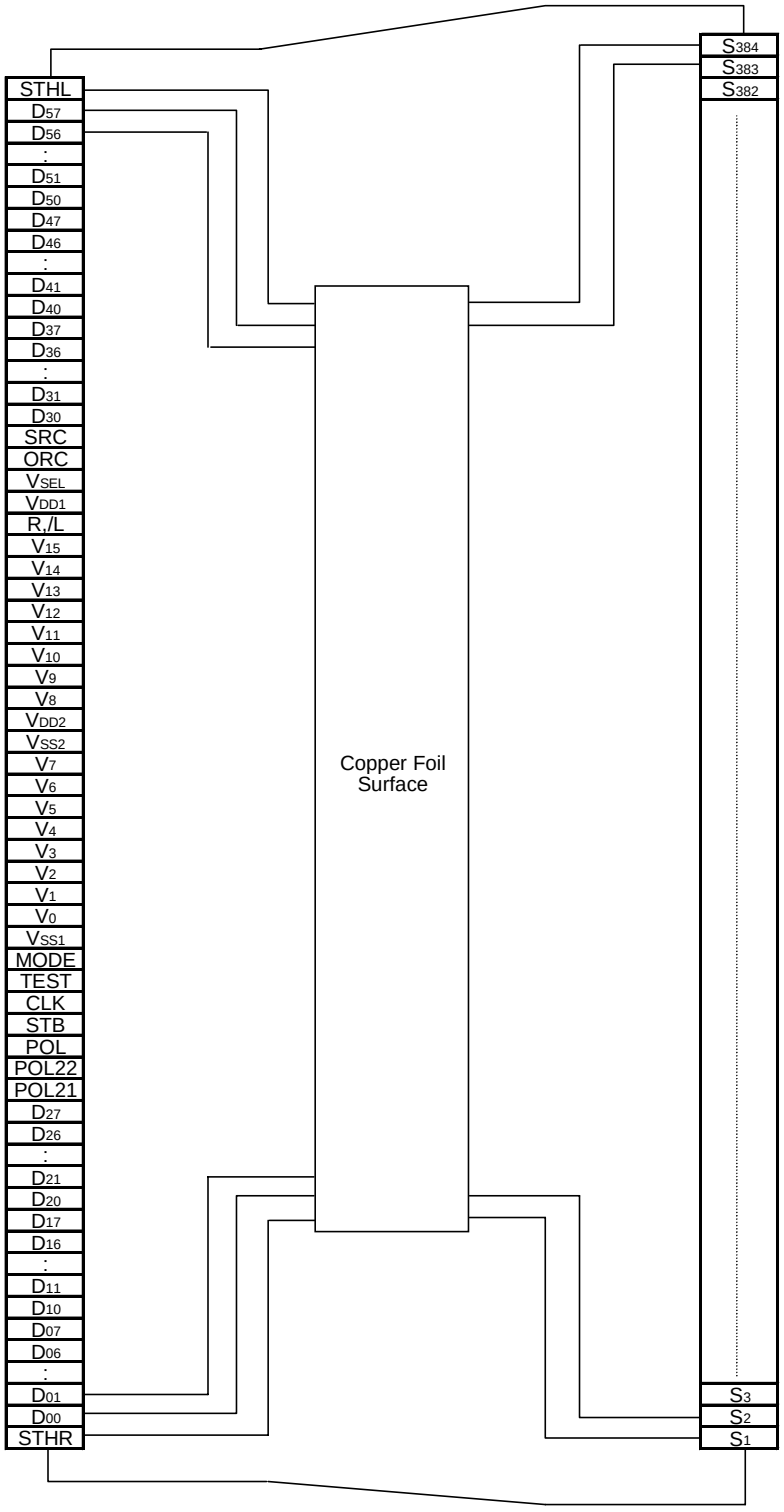


Remark /xxx indicates active low signal.

2. RELATIONSHIP BETWEEN OUTPUT CIRCUIT AND D/A CONVERTER



3. PIN CONFIGURATION (μPD160040N-xxx) (Copper Foil Surface, Face-up)



Remark This figure does not specify the TCP package.

4. PIN FUNCTIONS

(1/2)

Pin Symbol	Pin Name	I/O	Description
S_1 to S_{384}	Driver	Output	The D/A converted 256-gray-scale analog voltage is output.
D_{00} to D_{07} D_{10} to D_{17} D_{20} to D_{27}	Port 1 display data	Input	The display data is input with a width of 48 bits, viz., the gray scale data (8 bits) by 6 dots (2 pixels). D_{X0}: LSB, D_{X7}: MSB
D_{30} to D_{37} D_{40} to D_{47} D_{50} to D_{57}	Port 2 display data	Input	
R,/L	Shift direction control	Input	The shift direction control pin of shift register. The shift directions of the shift registers are as follows. R,/L = H (right shift): STHR input, $S_1 \rightarrow S_{384}$, STHL output R,/L = L (left shift): STHL input, $S_{384} \rightarrow S_1$, STHR output
★ STHR	Right shift start pulse	I/O	These are the start pulse input/output pins when connected in cascade. Loading of display data starts when a H level is read at the rising edge of CLK. A H level should be input at the pulse of one cycle of the clock signal. If the start pulse input is more than 2 CLK, the first 1 CLK of the H-level input is valid. For right shift, STHR is input and STHL is output. For left shift, STHL is input and STHR is output.
★ STHL	Left shift start pulse	I/O	
CLK	Shift clock	Input	The shift clock input pin of shift register. The display data is loaded into the data register at the rising edge. When 66-clock pulses are input after input of the start pulse, input of display data is halted automatically. The contents of the shift register are cleared at the STB's rising edge.
STB	Latch	Input	The contents of the data register are transferred to the latch circuit at the rising edge. In addition, at the falling edge, the gray scale voltage is supplied to the driver. It is necessary to ensure input of one pulse per horizontal period.
SRC	Through rate control	Input	SRC = H: High-through-rate period (large current consumption) SRC = L: Low-through-rate period (small current consumption) SRC is pulled up to the V_{DD1} in the IC.
ORC	Output resistance control	Input	ORC = H: Low output resistance period ORC = L: High output resistance period ORC is pulled up to the V_{DD1} in the IC.
POL	Polarity input	Input	POL = L: The S_{2n-1} output uses V_0-V_7 as the reference supply. The S_{2n} output uses V_8-V_{15} as the reference supply. POL = H: The S_{2n-1} output uses V_8-V_{15} as the reference supply. The S_{2n} output uses V_0-V_7 as the reference supply. S_{2n-1} indicates the odd output and S_{2n} indicates the even output. Input of the POL signal is allowed the setup time ($t_{POL-STB}$) with respect to STB's rising edge. When it switches such as POL = H→L or L→H, all output pins are output reset during STB = H. When it does not switch, all output pins become Hi-Z (high impedance) during STB = H. Refer to **7. RELATIONSHIP BETWEEN MODE, STB, SRC, ORC, POL, AND OUTPUT WAVEFORM** for details.

(2/2)

Pin Symbol	Pin Name	I/O	Description
MODE	Output reset control	Input	MODE = H or open: Output reset MODE = L: No output reset MODE is pulled up to the V_{DD1} in the IC.
POL21, POL22	Data inversion	Input	Select of inversion or no inversion for input data. POL21: Data inversion or no inversion of Port1. POL22: Data inversion or no inversion of Port2 POL21, POL22 = H: Data are inverted in the IC. POL21, POL22 = L: Data are not inverted in the IC.
V_{SEL}	Driver voltage select	Input	The driver voltage can be switched by controlling the stationary bias current of the output amplifier via V_{SEL}. V_{SEL} = H: V_{DD2} = 12.5 to (14.0 V) (large bias current) V_{SEL} = L or open: V_{DD2} = (14.0 V) to 15.0 V (small bias current) LPC is pulled down to the V_{SS1} in the IC.
TEST	Test	Input	Normally, set the TEST pin to H or leave open. This pin is pulled up to V_{DD1} in the IC.
V_0-V_{15}	γ-corrected power supplies	–	Input the γ-corrected power supplies from outside by using operational amplifier. During the gray scale voltage output, be sure to keep the gray scale level power supply at a constant level. Make sure to maintain the following relationships. $V_{DD2} - 0.2\ V \geq V_0 > V_1 > V_2 > V_1 > V_2 > \ldots \ldots > V_6 > V_7 \geq 0.5\ V_{DD2} + 0.5\ V$ $0.5\ V_{DD2} - 0.5\ V \geq V_8 > V_9 > V_{10} > \ldots \ldots > V_{14} > V_{15} \geq V_{SS2} + 0.2\ V$
V_{DD1}	Logic power supply	–	2.5 to 3.6 V
V_{DD2}	Driver power supply	–	12.5 to 15.5 V
V_{SS1}	Logic ground	–	Grounding
V_{SS2}	Driver ground	–	Grounding

Cautions 1. The power start sequence must be V_{DD1}, logic input, and V_{DD2} & V_0-V_{15} in that order. Reverse this sequence to shut down.

2. To stabilize the supply voltage, please be sure to insert a 0.47 μF bypass capacitor between V_{DD1}-V_{SS1} and V_{DD2}-V_{SS2}. Furthermore, for increased precision of the D/A converter, insertion of a bypass capacitor of about 0.1 μF is also advised between the γ-corrected power supply terminals (V_0, V_1, V_2,.. ..., V_{15}) and V_{SS2}.

5. RELATIONSHIP BETWEEN INPUT DATA AND OUTPUT VOLTAGE VALUE

The μPD160040 incorporates a 8-bit D/A converter whose odd output pins and even output pins output respectively gray scale voltages of differing polarity with respect to the LCD's counter electrode voltage. The D/A converter consists of ladder resistors and switches.

The ladder resistors (r_0 to r_{253}) are designed so that the ratio of LCD panel (γ-compensated voltages to V_0'-V_{255}' and V_0"-V_{255}" is almost equivalent as shown in Figure 5–2. For the 2 sets of eight γ-compensated power supplies, V_0-V_7 and V_8-V_{15}, respectively, input gray scale voltages of the same polarity with respect to the 0.5 V_{DD2}.

Figure 5–1 shows the relationship between the driving voltages such as liquid-crystal driving voltages V_{DD2}, V_{SS2} and 0.5 V_{DD2}, and γ-corrected voltages V_0 to V_{15} and the input data. Be sure to maintain the voltage relationships below.

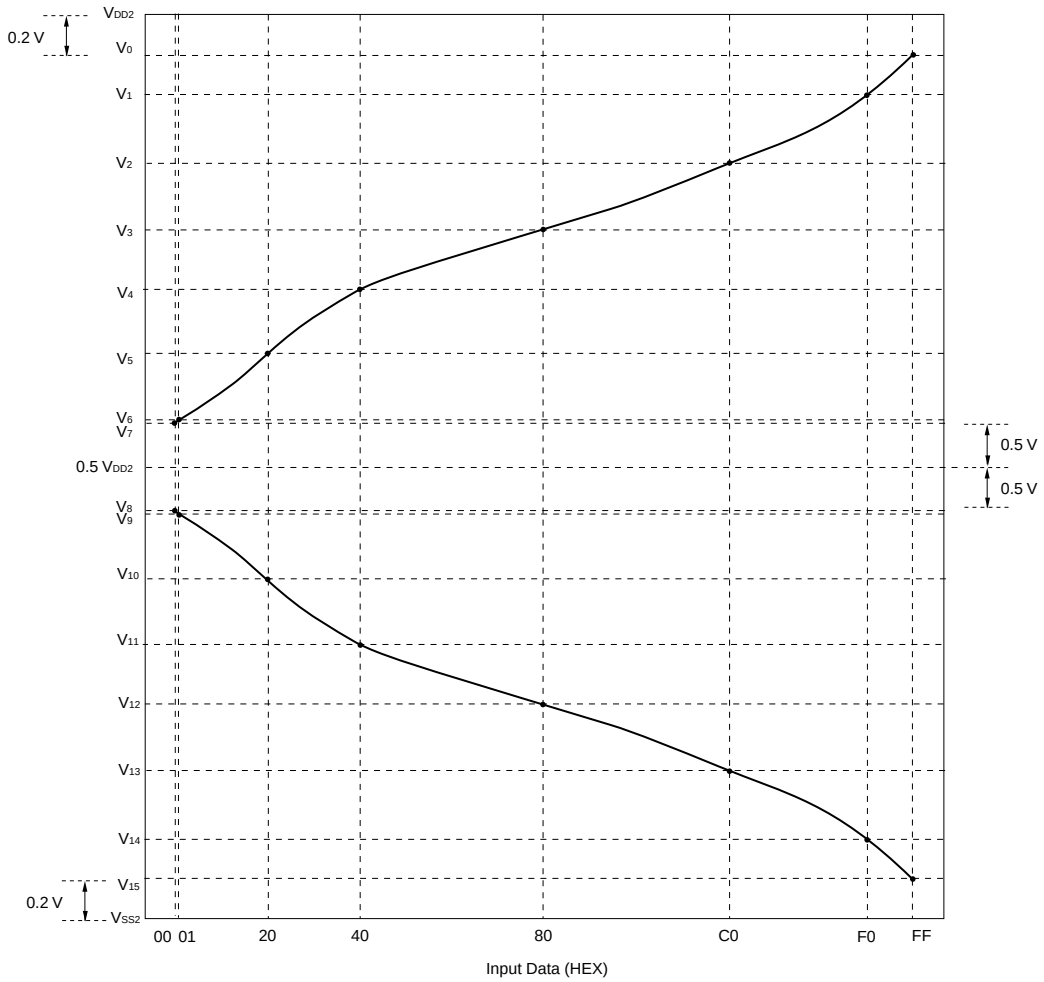
$$V_{DD2} - 0.2\ V \geq V_0 > V_1 > V_2 > V_3 > V_4 > V_5 > V_6 > V_7 \geq 0.5\ V_{DD2} + 0.5\ V$$

$$0.5\ V_{DD2} - 0.5\ V \geq V_8 > V_9 > V_{10} > V_{11} > V_{12} > V_{13} > V_{14} > V_{15} \geq V_{SS2} + 0.2\ V$$

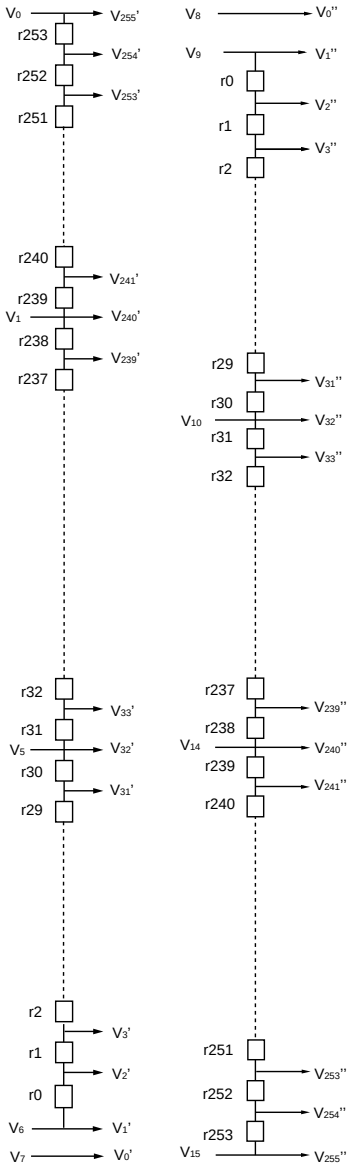
Also, V_6-V_7 and V_8-V_9 are left open in the IC. Be sure to input the gray scale level power supply at a constant level to the all pins, as V_0-V_{15}.

Figures 5–3 shows the relationship between the input data and the output voltage.

Figure 5–1. Relationship between Input Data and γ-corrected Power Supplies



★ **Figure 5–2. γ-Corrected Voltages and Ladder Resistors Ratio**



rn	Ratio1	Ratio2	Value
r0	3.58	0.0084	86
r1	3.58	0.0084	86
r2	3.58	0.0084	86
r3	3.58	0.0084	86
r4	3.58	0.0084	86
r5	3.50	0.0082	84
r6	3.50	0.0082	84
r7	3.42	0.0080	82
r8	3.42	0.0080	82
r9	3.33	0.0078	80
r10	3.25	0.0076	78
r11	3.25	0.0076	78
r12	3.17	0.0074	76
r13	3.08	0.0072	74
r14	3.08	0.0072	74
r15	3.00	0.0070	72
r16	2.92	0.0068	70
r17	2.83	0.0066	68
r18	2.83	0.0066	68
r19	2.75	0.0064	66
r20	2.67	0.0062	64
r21	2.67	0.0062	64
r22	2.58	0.0060	62
r23	2.50	0.0058	60
r24	2.50	0.0058	60
r25	2.42	0.0056	58
r26	2.33	0.0054	56
r27	2.33	0.0054	56
r28	2.25	0.0053	54
r29	2.25	0.0053	54
r30	2.17	0.0051	52
r31	2.17	0.0051	52
r32	2.08	0.0049	50
r33	2.08	0.0049	50
r34	2.00	0.0047	48
r35	2.00	0.0047	48
r36	1.92	0.0045	46
r37	1.92	0.0045	46
r38	1.92	0.0045	46
r39	1.83	0.0043	44
r40	1.83	0.0043	44
r41	1.83	0.0043	44
r42	1.75	0.0041	42
r43	1.75	0.0041	42
r44	1.75	0.0041	42
r45	1.67	0.0039	40
r46	1.67	0.0039	40
r47	1.67	0.0039	40
r48	1.67	0.0039	40
r49	1.58	0.0037	38
r50	1.58	0.0037	38
r51	1.58	0.0037	38
r52	1.58	0.0037	38
r53	1.50	0.0035	36
r54	1.50	0.0035	36
r55	1.50	0.0035	36
r56	1.50	0.0035	36
r57	1.42	0.0033	34
r58	1.42	0.0033	34
r59	1.42	0.0033	34
r60	1.42	0.0033	34
r61	1.42	0.0033	34
r62	1.42	0.0033	34
r63	1.33	0.0031	32

rn	Ratio1	Ratio2	Value
r64	1.33	0.0031	32
r65	1.33	0.0031	32
r66	1.33	0.0031	32
r67	1.33	0.0031	32
r68	1.33	0.0031	32
r69	1.33	0.0031	32
r70	1.25	0.0029	30
r71	1.25	0.0029	30
r72	1.25	0.0029	30
r73	1.25	0.0029	30
r74	1.25	0.0029	30
r75	1.25	0.0029	30
r76	1.25	0.0029	30
r77	1.25	0.0029	30
r78	1.25	0.0029	30
r79	1.25	0.0029	30
r80	1.17	0.0027	28
r81	1.17	0.0027	28
r82	1.17	0.0027	28
r83	1.17	0.0027	28
r84	1.17	0.0027	28
r85	1.17	0.0027	28
r86	1.17	0.0027	28
r87	1.17	0.0027	28
r88	1.17	0.0027	28
r89	1.17	0.0027	28
r90	1.17	0.0027	28
r91	1.17	0.0027	28
r92	1.17	0.0027	28
r93	1.08	0.0025	26
r94	1.08	0.0025	26
r95	1.08	0.0025	26
r96	1.08	0.0025	26
r97	1.08	0.0025	26
r98	1.08	0.0025	26
r99	1.08	0.0025	26
r100	1.08	0.0025	26
r101	1.08	0.0025	26
r102	1.08	0.0025	26
r103	1.08	0.0025	26
r104	1.08	0.0025	26
r105	1.08	0.0025	26
r106	1.08	0.0025	26
r107	1.08	0.0025	26
r108	1.08	0.0025	26
r109	1.08	0.0025	26
r110	1.08	0.0025	26
r111	1.08	0.0025	26
r112	1.08	0.0025	26
r113	1.08	0.0025	26
r114	1.08	0.0025	26
r115	1.08	0.0025	26
r116	1.08	0.0025	26
r117	1.08	0.0025	26
r118	1.08	0.0025	26
r119	2.38	0.0025	26
r120	1.08	0.0025	26
r121	1.08	0.0025	26
r122	1.08	0.0025	26
r123	1.08	0.0025	26
r124	1.08	0.0025	26
r125	1.08	0.0025	26
r126	1.08	0.0025	26
r127	1.08	0.0025	26

rn	Ratio1	Ratio2	Value
r128	1.00	0.0023	24
r129	1.08	0.0025	26
r130	1.00	0.0023	24
r131	1.00	0.0023	24
r132	1.00	0.0023	24
r133	1.00	0.0023	24
r134	1.08	0.0025	26
r135	1.08	0.0025	26
r136	1.08	0.0025	26
r137	1.08	0.0025	26
r138	1.08	0.0025	26
r139	1.08	0.0025	26
r140	1.08	0.0025	26
r141	1.08	0.0025	26
r142	1.08	0.0025	26
r143	1.08	0.0025	26
r144	1.08	0.0025	26
r145	1.08	0.0025	26
r146	1.08	0.0025	26
r147	1.08	0.0025	26
r148	1.08	0.0025	26
r149	1.08	0.0025	26
r150	1.08	0.0025	26
r151	1.08	0.0025	26
r152	1.08	0.0025	26
r153	1.08	0.0025	26
r154	1.08	0.0025	26
r155	1.08	0.0025	26
r156	1.08	0.0025	26
r157	1.08	0.0025	26
r158	1.08	0.0025	26
r159	1.08	0.0025	26
r160	1.08	0.0025	26
r161	1.08	0.0025	26
r162	1.08	0.0025	26
r163	1.08	0.0025	26
r164	1.08	0.0025	26
r165	1.08	0.0025	26
r166	1.08	0.0025	26
r167	1.08	0.0025	26
r168	1.08	0.0025	26
r169	1.08	0.0025	26
r170	1.17	0.0027	28
r171	1.17	0.0027	28
r172	1.17	0.0027	28
r173	1.17	0.0027	28
r174	1.17	0.0027	28
r175	1.17	0.0027	28
r176	1.17	0.0027	28
r177	1.17	0.0027	28
r178	1.17	0.0027	28
r179	1.17	0.0027	28
r180	1.17	0.0027	28
r181	1.17	0.0027	28
r182	1.17	0.0027	28
r183	2.38	0.0027	28
r184	1.25	0.0029	30
r185	1.25	0.0029	30
r186	1.25	0.0029	30
r187	1.25	0.0029	30
r188	1.25	0.0029	30
r189	1.25	0.0029	30
r190	1.25	0.0029	30
r191	1.25	0.0029	30

rn	Ratio1	Ratio2	Value
r192	1.25	0.0029	30
r193	1.25	0.0029	30
r194	1.33	0.0031	32
r195	1.33	0.0031	32
r196	1.33	0.0031	32
r197	1.33	0.0031	32
r198	1.33	0.0031	32
r199	1.33	0.0031	32
r200	1.33	0.0031	32
r201	1.42	0.0033	34
r202	1.42	0.0033	34
r203	1.42	0.0033	34
r204	1.42	0.0033	34
r205	1.42	0.0033	34
r206	1.42	0.0033	34
r207	1.50	0.0035	36
r208	1.50	0.0035	36
r209	1.50	0.0035	36
r210	1.50	0.0035	36
r211	1.50	0.0035	36
r212	1.58	0.0037	38
r213	1.58	0.0037	38
r214	1.58	0.0037	38
r215	1.58	0.0037	38
r216	1.67	0.0039	40
r217	1.67	0.0039	40
r218	1.67	0.0039	40
r219	1.75	0.0041	42
r220	1.75	0.0041	42
r221	1.75	0.0041	42
r222	1.83	0.0043	44
r223	1.83	0.0043	44
r224	1.83	0.0043	44
r225	1.92	0.0045	46
r226	1.92	0.0045	46
r227	2.00	0.0047	48
r228	2.00	0.0047	48
r229	2.08	0.0049	50
r230	2.08	0.0049	50
r231	2.17	0.0051	52
r232	2.17	0.0051	52
r233	2.25	0.0053	54
r234	2.33	0.0054	56
r235	2.33	0.0054	56
r236	2.42	0.0056	58
r237	2.50	0.0058	60
r238	2.58	0.0060	62
r239	2.67	0.0062	64
r240	2.75	0.0064	66
r241	2.83	0.0066	68
r242	2.92	0.0068	70
r243	3.00	0.0070	72
r244	3.17	0.0074	76
r245	3.33	0.0078	80
r246	3.42	0.0080	82
r247	2.38	0.0084	86
r248	3.83	0.0089	92
r249	4.08	0.0095	98
r250	4.33	0.0101	104
r251	4.67	0.0109	112
r252	5.00	0.0117	120
r253	5.50	0.0128	132
Total resistance			10280
Minimum resistance value			24

Remark The resistance ratio1 is a relative ratio in the case of setting the minimum resistance value to 1.

The resistance ratio2 is a relative ratio in the case of setting the total resistance to 1.

Figure 5–3. Relationship between Input Data and Output Voltage (POL21, POL22 = L) (1/2)

★ **(Output voltage 1) V_{DD2} – 0.2 V ≥ V_0 > V_1 > V_2 > V_3 > V_4 > V_5 > V_6 > V_7 ≥ 0.5 V_{DD2} + 0.5 V**

Data	Output voltage1	
00H	V_0'	V7
01H	V_1'	V6
02H	V_2'	V6+(V5-V6) X 86 / 2206
03H	V_3'	V6+(V5-V6) X 172 / 2206
04H	V_4'	V6+(V5-V6) X 258 / 2206
05H	V_5'	V6+(V5-V6) X 344 / 2206
06H	V_6'	V6+(V5-V6) X 430 / 2206
07H	V_7'	V6+(V5-V6) X 514 / 2206
08H	V_8'	V6+(V5-V6) X 598 / 2206
09H	V_9'	V6+(V5-V6) X 680 / 2206
0AH	V_{10}'	V6+(V5-V6) X 762 / 2206
0BH	V_{11}'	V6+(V5-V6) X 842 / 2206
0CH	V_{12}'	V6+(V5-V6) X 920 / 2206
0DH	V_{13}'	V6+(V5-V6) X 998 / 2206
0EH	V_{14}'	V6+(V5-V6) X 1074 / 2206
0FH	V_{15}'	V6+(V5-V6) X 1148 / 2206
10H	V_{16}'	V6+(V5-V6) X 1222 / 2206
11H	V_{17}'	V6+(V5-V6) X 1294 / 2206
12H	V_{18}'	V6+(V5-V6) X 1364 / 2206
13H	V_{19}'	V6+(V5-V6) X 1432 / 2206
14H	V_{20}'	V6+(V5-V6) X 1500 / 2206
15H	V_{21}'	V6+(V5-V6) X 1566 / 2206
16H	V_{22}'	V6+(V5-V6) X 1630 / 2206
17H	V_{23}'	V6+(V5-V6) X 1694 / 2206
18H	V_{24}'	V6+(V5-V6) X 1756 / 2206
19H	V_{25}'	V6+(V5-V6) X 1816 / 2206
1AH	V_{26}'	V6+(V5-V6) X 1876 / 2206
1BH	V_{27}'	V6+(V5-V6) X 1934 / 2206
1CH	V_{28}'	V6+(V5-V6) X 1990 / 2206
1DH	V_{29}'	V6+(V5-V6) X 2046 / 2206
1EH	V_{30}'	V6+(V5-V6) X 2100 / 2206
1FH	V_{31}'	V6+(V5-V6) X 2154 / 2206
20H	V_{32}'	V5
21H	V_{33}'	V5+(V4-V5) X 52 / 1304
22H	V_{34}'	V5+(V4-V5) X 102 / 1304
23H	V_{35}'	V5+(V4-V5) X 152 / 1304
24H	V_{36}'	V5+(V4-V5) X 200 / 1304
25H	V_{37}'	V5+(V4-V5) X 248 / 1304
26H	V_{38}'	V5+(V4-V5) X 294 / 1304
27H	V_{39}'	V5+(V4-V5) X 340 / 1304
28H	V_{40}'	V5+(V4-V5) X 386 / 1304
29H	V_{41}'	V5+(V4-V5) X 430 / 1304
2AH	V_{42}'	V5+(V4-V5) X 474 / 1304
2BH	V_{43}'	V5+(V4-V5) X 518 / 1304
2CH	V_{44}'	V5+(V4-V5) X 560 / 1304
2DH	V_{45}'	V5+(V4-V5) X 602 / 1304
2EH	V_{46}'	V5+(V4-V5) X 644 / 1304
2FH	V_{47}'	V5+(V4-V5) X 684 / 1304
30H	V_{48}'	V5+(V4-V5) X 724 / 1304
31H	V_{49}'	V5+(V4-V5) X 764 / 1304
32H	V_{50}'	V5+(V4-V5) X 804 / 1304
33H	V_{51}'	V5+(V4-V5) X 842 / 1304
34H	V_{52}'	V5+(V4-V5) X 880 / 1304
35H	V_{53}'	V5+(V4-V5) X 918 / 1304
36H	V_{54}'	V5+(V4-V5) X 956 / 1304
37H	V_{55}'	V5+(V4-V5) X 992 / 1304
38H	V_{56}'	V5+(V4-V5) X 1028 / 1304
39H	V_{57}'	V5+(V4-V5) X 1064 / 1304
3AH	V_{58}'	V5+(V4-V5) X 1100 / 1304
3BH	V_{59}'	V5+(V4-V5) X 1134 / 1304
3CH	V_{60}'	V5+(V4-V5) X 1168 / 1304
3DH	V_{61}'	V5+(V4-V5) X 1202 / 1304
3EH	V_{62}'	V5+(V4-V5) X 1236 / 1304
3FH	V_{63}'	V5+(V4-V5) X 1270 / 1304

Data	Output voltage1	
40H	V_{64}'	V4
41H	V_{65}'	V4+(V3-V4) X 32 / 1772
42H	V_{66}'	V4+(V3-V4) X 64 / 1772
43H	V_{67}'	V4+(V3-V4) X 96 / 1772
44H	V_{68}'	V4+(V3-V4) X 128 / 1772
45H	V_{69}'	V4+(V3-V4) X 160 / 1772
46H	V_{70}'	V4+(V3-V4) X 192 / 1772
47H	V_{71}'	V4+(V3-V4) X 224 / 1772
48H	V_{72}'	V4+(V3-V4) X 254 / 1772
49H	V_{73}'	V4+(V3-V4) X 284 / 1772
4AH	V_{74}'	V4+(V3-V4) X 314 / 1772
4BH	V_{75}'	V4+(V3-V4) X 344 / 1772
4CH	V_{76}'	V4+(V3-V4) X 374 / 1772
4DH	V_{77}'	V4+(V3-V4) X 404 / 1772
4EH	V_{78}'	V4+(V3-V4) X 434 / 1772
4FH	V_{79}'	V4+(V3-V4) X 464 / 1772
50H	V_{80}'	V4+(V3-V4) X 494 / 1772
51H	V_{81}'	V4+(V3-V4) X 524 / 1772
52H	V_{82}'	V4+(V3-V4) X 552 / 1772
53H	V_{83}'	V4+(V3-V4) X 580 / 1772
54H	V_{84}'	V4+(V3-V4) X 608 / 1772
55H	V_{85}'	V4+(V3-V4) X 636 / 1772
56H	V_{86}'	V4+(V3-V4) X 664 / 1772
57H	V_{87}'	V4+(V3-V4) X 692 / 1772
58H	V_{88}'	V4+(V3-V4) X 720 / 1772
59H	V_{89}'	V4+(V3-V4) X 748 / 1772
5AH	V_{90}'	V4+(V3-V4) X 776 / 1772
5BH	V_{91}'	V4+(V3-V4) X 804 / 1772
5CH	V_{92}'	V4+(V3-V4) X 832 / 1772
5DH	V_{93}'	V4+(V3-V4) X 860 / 1772
5EH	V_{94}'	V4+(V3-V4) X 888 / 1772
5FH	V_{95}'	V4+(V3-V4) X 914 / 1772
60H	V_{96}'	V4+(V3-V4) X 940 / 1772
61H	V_{97}'	V4+(V3-V4) X 966 / 1772
62H	V_{98}'	V4+(V3-V4) X 992 / 1772
63H	V_{99}'	V4+(V3-V4) X 1018 / 1772
64H	V_{100}'	V4+(V3-V4) X 1044 / 1772
65H	V_{101}'	V4+(V3-V4) X 1070 / 1772
66H	V_{102}'	V4+(V3-V4) X 1096 / 1772
67H	V_{103}'	V4+(V3-V4) X 1122 / 1772
68H	V_{104}'	V4+(V3-V4) X 1148 / 1772
69H	V_{105}'	V4+(V3-V4) X 1174 / 1772
6AH	V_{106}'	V4+(V3-V4) X 1200 / 1772
6BH	V_{107}'	V4+(V3-V4) X 1226 / 1772
6CH	V_{108}'	V4+(V3-V4) X 1252 / 1772
6DH	V_{109}'	V4+(V3-V4) X 1278 / 1772
6EH	V_{110}'	V4+(V3-V4) X 1304 / 1772
6FH	V_{111}'	V4+(V3-V4) X 1330 / 1772
70H	V_{112}'	V4+(V3-V4) X 1356 / 1772
71H	V_{113}'	V4+(V3-V4) X 1382 / 1772
72H	V_{114}'	V4+(V3-V4) X 1408 / 1772
73H	V_{115}'	V4+(V3-V4) X 1434 / 1772
74H	V_{116}'	V4+(V3-V4) X 1460 / 1772
75H	V_{117}'	V4+(V3-V4) X 1486 / 1772
76H	V_{118}'	V4+(V3-V4) X 1512 / 1772
77H	V_{119}'	V4+(V3-V4) X 1538 / 1772
78H	V_{120}'	V4+(V3-V4) X 1564 / 1772
79H	V_{121}'	V4+(V3-V4) X 1590 / 1772
7AH	V_{122}'	V4+(V3-V4) X 1616 / 1772
7BH	V_{123}'	V4+(V3-V4) X 1642 / 1772
7CH	V_{124}'	V4+(V3-V4) X 1668 / 1772
7DH	V_{125}'	V4+(V3-V4) X 1694 / 1772
7EH	V_{126}'	V4+(V3-V4) X 1720 / 1772
7FH	V_{127}'	V4+(V3-V4) X 1746 / 1772

Data	Output voltage1	
80H	V_{128}'	V3
81H	V_{129}'	V3+(V2-V3) X 26 / 1710
82H	V_{130}'	V3+(V2-V3) X 50 / 1710
83H	V_{131}'	V3+(V2-V3) X 76 / 1710
84H	V_{132}'	V3+(V2-V3) X 100 / 1710
85H	V_{133}'	V3+(V2-V3) X 124 / 1710
86H	V_{134}'	V3+(V2-V3) X 148 / 1710
87H	V_{135}'	V3+(V2-V3) X 172 / 1710
88H	V_{136}'	V3+(V2-V3) X 198 / 1710
89H	V_{137}'	V3+(V2-V3) X 224 / 1710
8AH	V_{138}'	V3+(V2-V3) X 250 / 1710
8BH	V_{139}'	V3+(V2-V3) X 276 / 1710
8CH	V_{140}'	V3+(V2-V3) X 302 / 1710
8DH	V_{141}'	V3+(V2-V3) X 328 / 1710
8EH	V_{142}'	V3+(V2-V3) X 354 / 1710
8FH	V_{143}'	V3+(V2-V3) X 380 / 1710
90H	V_{144}'	V3+(V2-V3) X 406 / 1710
91H	V_{145}'	V3+(V2-V3) X 432 / 1710
92H	V_{146}'	V3+(V2-V3) X 458 / 1710
93H	V_{147}'	V3+(V2-V3) X 484 / 1710
94H	V_{148}'	V3+(V2-V3) X 510 / 1710
95H	V_{149}'	V3+(V2-V3) X 536 / 1710
96H	V_{150}'	V3+(V2-V3) X 562 / 1710
97H	V_{151}'	V3+(V2-V3) X 588 / 1710
98H	V_{152}'	V3+(V2-V3) X 614 / 1710
99H	V_{153}'	V3+(V2-V3) X 640 / 1710
9AH	V_{154}'	V3+(V2-V3) X 666 / 1710
9BH	V_{155}'	V3+(V2-V3) X 692 / 1710
9CH	V_{156}'	V3+(V2-V3) X 718 / 1710
9DH	V_{157}'	V3+(V2-V3) X 744 / 1710
9EH	V_{158}'	V3+(V2-V3) X 770 / 1710
9FH	V_{159}'	V3+(V2-V3) X 796 / 1710
A0H	V_{160}'	V3+(V2-V3) X 822 / 1710
A1H	V_{161}'	V3+(V2-V3) X 848 / 1710
A2H	V_{162}'	V3+(V2-V3) X 874 / 1710
A3H	V_{163}'	V3+(V2-V3) X 900 / 1710
A4H	V_{164}'	V3+(V2-V3) X 926 / 1710
A5H	V_{165}'	V3+(V2-V3) X 952 / 1710
A6H	V_{166}'	V3+(V2-V3) X 978 / 1710
A7H	V_{167}'	V3+(V2-V3) X 1004 / 1710
A8H	V_{168}'	V3+(V2-V3) X 1030 / 1710
A9H	V_{169}'	V3+(V2-V3) X 1056 / 1710
AAH	V_{170}'	V3+(V2-V3) X 1082 / 1710
ABH	V_{171}'	V3+(V2-V3) X 1108 / 1710
ACH	V_{172}'	V3+(V2-V3) X 1136 / 1710
ADH	V_{173}'	V3+(V2-V3) X 1164 / 1710
AEH	V_{174}'	V3+(V2-V3) X 1192 / 1710
AFH	V_{175}'	V3+(V2-V3) X 1220 / 1710
B0H	V_{176}'	V3+(V2-V3) X 1248 / 1710
B1H	V_{177}'	V3+(V2-V3) X 1276 / 1710
B2H	V_{178}'	V3+(V2-V3) X 1304 / 1710
B3H	V_{179}'	V3+(V2-V3) X 1332 / 1710
B4H	V_{180}'	V3+(V2-V3) X 1360 / 1710
B5H	V_{181}'	V3+(V2-V3) X 1388 / 1710
B6H	V_{182}'	V3+(V2-V3) X 1416 / 1710
B7H	V_{183}'	V3+(V2-V3) X 1444 / 1710
B8H	V_{184}'	V3+(V2-V3) X 1472 / 1710
B9H	V_{185}'	V3+(V2-V3) X 1500 / 1710
BAH	V_{186}'	V3+(V2-V3) X 1530 / 1710
BBH	V_{187}'	V3+(V2-V3) X 1560 / 1710
BCH	V_{188}'	V3+(V2-V3) X 1590 / 1710
BDH	V_{189}'	V3+(V2-V3) X 1620 / 1710
BEH	V_{190}'	V3+(V2-V3) X 1650 / 1710
BFH	V_{191}'	V3+(V2-V3) X 1680 / 1710

Data	Output voltage1	
C0H	V_{192}'	V2
C1H	V_{193}'	V2+(V1-V2) 30 / 1966
C2H	V_{194}'	V2+(V1-V2) 60 / 1966
C3H	V_{195}'	V2+(V1-V2) 90 / 1966
C4H	V_{196}'	V2+(V1-V2) 122 / 1966
C5H	V_{197}'	V2+(V1-V2) 154 / 1966
C6H	V_{198}'	V2+(V1-V2) 186 / 1966
C7H	V_{199}'	V2+(V1-V2) 218 / 1966
C8H	V_{200}'	V2+(V1-V2) 250 / 1966
C9H	V_{201}'	V2+(V1-V2) 282 / 1966
CAH	V_{202}'	V2+(V1-V2) 314 / 1966
CBH	V_{203}'	V2+(V1-V2) 348 / 1966
CCH	V_{204}'	V2+(V1-V2) 382 / 1966
CDH	V_{205}'	V2+(V1-V2) 416 / 1966
CEH	V_{206}'	V2+(V1-V2) 450 / 1966
CFH	V_{207}'	V2+(V1-V2) 484 / 1966
D0H	V_{208}'	V2+(V1-V2) 518 / 1966
D1H	V_{209}'	V2+(V1-V2) 554 / 1966
D2H	V_{210}'	V2+(V1-V2) 590 / 1966
D3H	V_{211}'	V2+(V1-V2) 626 / 1966
D4H	V_{212}'	V2+(V1-V2) 662 / 1966
D5H	V_{213}'	V2+(V1-V2) 698 / 1966
D6H	V_{214}'	V2+(V1-V2) 736 / 1966
D7H	V_{215}'	V2+(V1-V2) 774 / 1966
D8H	V_{216}'	V2+(V1-V2) 812 / 1966
D9H	V_{217}'	V2+(V1-V2) 850 / 1966
DAH	V_{218}'	V2+(V1-V2) 890 / 1966
DBH	V_{219}'	V2+(V1-V2) 930 / 1966
DCH	V_{220}'	V2+(V1-V2) 970 / 1966
DDH	V_{221}'	V2+(V1-V2) 1012 / 1966
DEH	V_{222}'	V2+(V1-V2) 1054 / 1966
DFH	V_{223}'	V2+(V1-V2) 1096 / 1966
E0H	V_{224}'	V2+(V1-V2) 1140 / 1966
E1H	V_{225}'	V2+(V1-V2) 1184 / 1966
E2H	V_{226}'	V2+(V1-V2) 1228 / 1966
E3H	V_{227}'	V2+(V1-V2) 1274 / 1966
E4H	V_{228}'	V2+(V1-V2) 1320 / 1966
E5H	V_{229}'	V2+(V1-V2) 1368 / 1966
E6H	V_{230}'	V2+(V1-V2) 1416 / 1966
E7H	V_{231}'	V2+(V1-V2) 1466 / 1966
E8H	V_{232}'	V2+(V1-V2) 1516 / 1966
E9H	V_{233}'	V2+(V1-V2) 1568 / 1966
EAH	V_{234}'	V2+(V1-V2) 1620 / 1966
EBH	V_{235}'	V2+(V1-V2) 1674 / 1966
ECH	V_{236}'	V2+(V1-V2) 1730 / 1966
EDH	V_{237}'	V2+(V1-V2) 1786 / 1966
EEH	V_{238}'	V2+(V1-V2) 1844 / 1966
EFH	V_{239}'	V2+(V1-V2) 1904 / 1966
F0H	V_{240}'	V1
F1H	V_{241}'	V1+(V0-V1) 64 / 1322
F2H	V_{242}'	V1+(V0-V1) 130 / 1322
F3H	V_{243}'	V1+(V0-V1) 198 / 1322
F4H	V_{244}'	V1+(V0-V1) 268 / 1322
F5H	V_{245}'	V1+(V0-V1) 340 / 1322
F6H	V_{246}'	V1+(V0-V1) 416 / 1322
F7H	V_{247}'	V1+(V0-V1) 496 / 1322
F8H	V_{248}'	V1+(V0-V1) 578 / 1322
F9H	V_{249}'	V1+(V0-V1) 664 / 1322
FAH	V_{250}'	V1+(V0-V1) 756 / 1322
FBH	V_{251}'	V1+(V0-V1) 854 / 1322
FCH	V_{252}'	V1+(V0-V1) 958 / 1322
FDH	V_{253}'	V1+(V0-V1) 1070 / 1322
FEH	V_{254}'	V1+(V0-V1) 1190 / 1322
FFH	V_{255}'	V0

Figure 5–3. Relationship between Input Data and Output Voltage (POL21, POL22 = L) (2/2)

★ **(Output voltage 2) 0.5 V_{DD2} – 0.5 V ≥ V_8 > V_9 > V_{10} > V_{11} > V_{12} > V_{13} > V_{14} > V_{15} ≥ V_{SS2} + 0.2 V**

Data	Output voltage2		Data	Output voltage2		Data	Output voltage2		Data	Output voltage2	
00H	V_0"	V8	40H	V_{64}"	V12	80H	V_{128}"	V12	C0H	V_{192}"	V13
01H	V_1"	V9	41H	V_{65}"	V12+(V13-V12) X 1740 / 1772	81H	V_{129}"	V13+(V12-V13) X 1684 / 1710	C1H	V_{193}"	V14+(V13-V14) X 1936 / 1966
02H	V_2"	V10+(V9-V10) X 2120 / 2206	42H	V_{66}"	V12+(V13-V12) X 1708 / 1772	82H	V_{130}"	V13+(V12-V13) X 1660 / 1710	C2H	V_{194}"	V14+(V13-V14) X 1906 / 1966
03H	V_3"	V10+(V9-V10) X 2034 / 2206	43H	V_{67}"	V12+(V13-V12) X 1676 / 1772	83H	V_{131}"	V13+(V12-V13) X 1634 / 1710	C3H	V_{195}"	V14+(V13-V14) X 1876 / 1966
04H	V_4"	V10+(V9-V10) X 1948 / 2206	44H	V_{68}"	V12+(V13-V12) X 1644 / 1772	84H	V_{132}"	V13+(V12-V13) X 1610 / 1710	C4H	V_{196}"	V14+(V13-V14) X 1844 / 1966
05H	V_5"	V10+(V9-V10) X 1862 / 2206	45H	V_{69}"	V12+(V13-V12) X 1612 / 1772	85H	V_{133}"	V13+(V12-V13) X 1586 / 1710	C5H	V_{197}"	V14+(V13-V14) X 1812 / 1966
06H	V_6"	V10+(V9-V10) X 1776 / 2206	46H	V_{70}"	V12+(V13-V12) X 1580 / 1772	86H	V_{134}"	V13+(V12-V13) X 1562 / 1710	C6H	V_{198}"	V14+(V13-V14) X 1780 / 1966
07H	V_7"	V10+(V9-V10) X 1692 / 2206	47H	V_{71}"	V12+(V13-V12) X 1548 / 1772	87H	V_{135}"	V13+(V12-V13) X 1538 / 1710	C7H	V_{199}"	V14+(V13-V14) X 1748 / 1966
08H	V_8"	V10+(V9-V10) X 1608 / 2206	48H	V_{72}"	V12+(V13-V12) X 1518 / 1772	88H	V_{136}"	V13+(V12-V13) X 1512 / 1710	C8H	V_{200}"	V14+(V13-V14) X 1716 / 1966
09H	V_9"	V10+(V9-V10) X 1526 / 2206	49H	V_{73}"	V12+(V13-V12) X 1488 / 1772	89H	V_{137}"	V13+(V12-V13) X 1486 / 1710	C9H	V_{201}"	V14+(V13-V14) X 1684 / 1966
0AH	V_{10}"	V10+(V9-V10) X 1444 / 2206	4AH	V_{74}"	V12+(V13-V12) X 1458 / 1772	8AH	V_{138}"	V13+(V12-V13) X 1460 / 1710	CAH	V_{202}"	V14+(V13-V14) X 1652 / 1966
0BH	V_{11}"	V10+(V9-V10) X 1364 / 2206	4BH	V_{75}"	V12+(V13-V12) X 1428 / 1772	8BH	V_{139}"	V13+(V12-V13) X 1434 / 1710	CBH	V_{203}"	V14+(V13-V14) X 1618 / 1966
0CH	V_{12}"	V10+(V9-V10) X 1286 / 2206	4CH	V_{76}"	V12+(V13-V12) X 1398 / 1772	8CH	V_{140}"	V13+(V12-V13) X 1408 / 1710	CCH	V_{204}"	V14+(V13-V14) X 1584 / 1966
0DH	V_{13}"	V10+(V9-V10) X 1208 / 2206	4DH	V_{77}"	V12+(V13-V12) X 1368 / 1772	8DH	V_{141}"	V13+(V12-V13) X 1382 / 1710	CDH	V_{205}"	V14+(V13-V14) X 1550 / 1966
0EH	V_{14}"	V10+(V9-V10) X 1132 / 2206	4EH	V_{78}"	V12+(V13-V12) X 1338 / 1772	8EH	V_{142}"	V13+(V12-V13) X 1356 / 1710	CEH	V_{206}"	V14+(V13-V14) X 1516 / 1966
0FH	V_{15}"	V10+(V9-V10) X 1058 / 2206	4FH	V_{79}"	V12+(V13-V12) X 1308 / 1772	8FH	V_{143}"	V13+(V12-V13) X 1330 / 1710	CFH	V_{207}"	V14+(V13-V14) X 1482 / 1966
10H	V_{16}"	V10+(V9-V10) X 984 / 2206	50H	V_{80}"	V12+(V13-V12) X 1278 / 1772	90H	V_{144}"	V13+(V12-V13) X 1304 / 1710	D0H	V_{208}"	V14+(V13-V14) X 1448 / 1966
11H	V_{17}"	V10+(V9-V10) X 912 / 2206	51H	V_{81}"	V12+(V13-V12) X 1248 / 1772	91H	V_{145}"	V13+(V12-V13) X 1278 / 1710	D1H	V_{209}"	V14+(V13-V14) X 1412 / 1966
12H	V_{18}"	V10+(V9-V10) X 842 / 2206	52H	V_{82}"	V12+(V13-V12) X 1220 / 1772	92H	V_{146}"	V13+(V12-V13) X 1252 / 1710	D2H	V_{210}"	V14+(V13-V14) X 1376 / 1966
13H	V_{19}"	V10+(V9-V10) X 774 / 2206	53H	V_{83}"	V12+(V13-V12) X 1192 / 1772	93H	V_{147}"	V13+(V12-V13) X 1226 / 1710	D3H	V_{211}"	V14+(V13-V14) X 1340 / 1966
14H	V_{20}"	V10+(V9-V10) X 706 / 2206	54H	V_{84}"	V12+(V13-V12) X 1164 / 1772	94H	V_{148}"	V13+(V12-V13) X 1200 / 1710	D4H	V_{212}"	V14+(V13-V14) X 1304 / 1966
15H	V_{21}"	V10+(V9-V10) X 640 / 2206	55H	V_{85}"	V12+(V13-V12) X 1136 / 1772	95H	V_{149}"	V13+(V12-V13) X 1174 / 1710	D5H	V_{213}"	V14+(V13-V14) X 1268 / 1966
16H	V_{22}"	V10+(V9-V10) X 576 / 2206	56H	V_{86}"	V12+(V13-V12) X 1108 / 1772	96H	V_{150}"	V13+(V12-V13) X 1148 / 1710	D6H	V_{214}"	V14+(V13-V14) X 1230 / 1966
17H	V_{23}"	V10+(V9-V10) X 512 / 2206	57H	V_{87}"	V12+(V13-V12) X 1080 / 1772	97H	V_{151}"	V13+(V12-V13) X 1122 / 1710	D7H	V_{215}"	V14+(V13-V14) X 1192 / 1966
18H	V_{24}"	V10+(V9-V10) X 450 / 2206	58H	V_{88}"	V12+(V13-V12) X 1052 / 1772	98H	V_{152}"	V13+(V12-V13) X 1096 / 1710	D8H	V_{216}"	V14+(V13-V14) X 1154 / 1966
19H	V_{25}"	V10+(V9-V10) X 390 / 2206	59H	V_{89}"	V12+(V13-V12) X 1024 / 1772	99H	V_{153}"	V13+(V12-V13) X 1070 / 1710	D9H	V_{217}"	V14+(V13-V14) X 1116 / 1966
1AH	V_{26}"	V10+(V9-V10) X 330 / 2206	5AH	V_{90}"	V12+(V13-V12) X 996 / 1772	9AH	V_{154}"	V13+(V12-V13) X 1044 / 1710	DAH	V_{218}"	V14+(V13-V14) X 1076 / 1966
1BH	V_{27}"	V10+(V9-V10) X 272 / 2206	5BH	V_{91}"	V12+(V13-V12) X 968 / 1772	9BH	V_{155}"	V13+(V12-V13) X 1018 / 1710	DBH	V_{219}"	V14+(V13-V14) X 1036 / 1966
1CH	V_{28}"	V10+(V9-V10) X 216 / 2206	5CH	V_{92}"	V12+(V13-V12) X 940 / 1772	9CH	V_{156}"	V13+(V12-V13) X 992 / 1710	DCH	V_{220}"	V14+(V13-V14) X 996 / 1966
1DH	V_{29}"	V10+(V9-V10) X 160 / 2206	5DH	V_{93}"	V12+(V13-V12) X 912 / 1772	9DH	V_{157}"	V13+(V12-V13) X 966 / 1710	DDH	V_{221}"	V14+(V13-V14) X 954 / 1966
1EH	V_{30}"	V10+(V9-V10) X 106 / 2206	5EH	V_{94}"	V12+(V13-V12) X 884 / 1772	9EH	V_{158}"	V13+(V12-V13) X 940 / 1710	DEH	V_{222}"	V14+(V13-V14) X 912 / 1966
1FH	V_{31}"	V10+(V9-V10) X 52 / 2206	5FH	V_{95}"	V12+(V13-V12) X 858 / 1772	9FH	V_{159}"	V13+(V12-V13) X 914 / 1710	DFH	V_{223}"	V14+(V13-V14) X 870 / 1966
20H	V_{32}"	V10	60H	V_{96}"	V12+(V13-V12) X 832 / 1772	A0H	V_{160}"	V13+(V12-V13) X 888 / 1710	E0H	V_{224}"	V14+(V13-V14) X 826 / 1966
21H	V_{33}"	V11+(V10-V11) X 1252 / 1304	61H	V_{97}"	V12+(V13-V12) X 806 / 1772	A1H	V_{161}"	V13+(V12-V13) X 862 / 1710	E1H	V_{225}"	V14+(V13-V14) X 782 / 1966
22H	V_{34}"	V11+(V10-V11) X 1202 / 1304	62H	V_{98}"	V12+(V13-V12) X 780 / 1772	A2H	V_{162}"	V13+(V12-V13) X 836 / 1710	E2H	V_{226}"	V14+(V13-V14) X 738 / 1966
23H	V_{35}"	V11+(V10-V11) X 1152 / 1304	63H	V_{99}"	V12+(V13-V12) X 754 / 1772	A3H	V_{163}"	V13+(V12-V13) X 810 / 1710	E3H	V_{227}"	V14+(V13-V14) X 692 / 1966
24H	V_{36}"	V11+(V10-V11) X 1104 / 1304	64H	V_{100}"	V12+(V13-V12) X 728 / 1772	A4H	V_{164}"	V13+(V12-V13) X 784 / 1710	E4H	V_{228}"	V14+(V13-V14) X 646 / 1966
25H	V_{37}"	V11+(V10-V11) X 1056 / 1304	65H	V_{101}"	V12+(V13-V12) X 702 / 1772	A5H	V_{165}"	V13+(V12-V13) X 758 / 1710	E5H	V_{229}"	V14+(V13-V14) X 598 / 1966
26H	V_{38}"	V11+(V10-V11) X 1010 / 1304	66H	V_{102}"	V12+(V13-V12) X 676 / 1772	A6H	V_{166}"	V13+(V12-V13) X 732 / 1710	E6H	V_{230}"	V14+(V13-V14) X 550 / 1966
27H	V_{39}"	V11+(V10-V11) X 964 / 1304	67H	V_{103}"	V12+(V13-V12) X 650 / 1772	A7H	V_{167}"	V13+(V12-V13) X 706 / 1710	E7H	V_{231}"	V14+(V13-V14) X 500 / 1966
28H	V_{40}"	V11+(V10-V11) X 918 / 1304	68H	V_{104}"	V12+(V13-V12) X 624 / 1772	A8H	V_{168}"	V13+(V12-V13) X 680 / 1710	E8H	V_{232}"	V14+(V13-V14) X 450 / 1966
29H	V_{41}"	V11+(V10-V11) X 874 / 1304	69H	V_{105}"	V12+(V13-V12) X 598 / 1772	A9H	V_{169}"	V13+(V12-V13) X 654 / 1710	E9H	V_{233}"	V14+(V13-V14) X 398 / 1966
2AH	V_{42}"	V11+(V10-V11) X 830 / 1304	6AH	V_{106}"	V12+(V13-V12) X 572 / 1772	AAH	V_{170}"	V13+(V12-V13) X 628 / 1710	EAH	V_{234}"	V14+(V13-V14) X 346 / 1966
2BH	V_{43}"	V11+(V10-V11) X 786 / 1304	6BH	V_{107}"	V12+(V13-V12) X 546 / 1772	ABH	V_{171}"	V13+(V12-V13) X 602 / 1710	EBH	V_{235}"	V14+(V13-V14) X 292 / 1966
2CH	V_{44}"	V11+(V10-V11) X 744 / 1304	6CH	V_{108}"	V12+(V13-V12) X 520 / 1772	ACH	V_{172}"	V13+(V12-V13) X 574 / 1710	ECH	V_{236}"	V14+(V13-V14) X 236 / 1966
2DH	V_{45}"	V11+(V10-V11) X 702 / 1304	6DH	V_{109}"	V12+(V13-V12) X 494 / 1772	ADH	V_{173}"	V13+(V12-V13) X 546 / 1710	EDH	V_{237}"	V14+(V13-V14) X 180 / 1966
2EH	V_{46}"	V11+(V10-V11) X 660 / 1304	6EH	V_{110}"	V12+(V13-V12) X 468 / 1772	AEH	V_{174}"	V13+(V12-V13) X 518 / 1710	EEH	V_{238}"	V14+(V13-V14) X 122 / 1966
2FH	V_{47}"	V11+(V10-V11) X 620 / 1304	6FH	V_{111}"	V12+(V13-V12) X 442 / 1772	AFH	V_{175}"	V13+(V12-V13) X 490 / 1710	EFH	V_{239}"	V14+(V13-V14) X 62 / 1966
30H	V_{48}"	V11+(V10-V11) X 580 / 1304	70H	V_{112}"	V12+(V13-V12) X 416 / 1772	B0H	V_{176}"	V13+(V12-V13) X 462 / 1710	F0H	V_{240}"	V14
31H	V_{49}"	V11+(V10-V11) X 540 / 1304	71H	V_{113}"	V12+(V13-V12) X 390 / 1772	B1H	V_{177}"	V13+(V12-V13) X 434 / 1710	F1H	V_{241}"	V15+(V14-V15) X 1258 / 1322
32H	V_{50}"	V11+(V10-V11) X 500 / 1304	72H	V_{114}"	V12+(V13-V12) X 364 / 1772	B2H	V_{178}"	V13+(V12-V13) X 406 / 1710	F2H	V_{242}"	V15+(V14-V15) X 1192 / 1322
33H	V_{51}"	V11+(V10-V11) X 462 / 1304	73H	V_{115}"	V12+(V13-V12) X 338 / 1772	B3H	V_{179}"	V13+(V12-V13) X 378 / 1710	F3H	V_{243}"	V15+(V14-V15) X 1124 / 1322
34H	V_{52}"	V11+(V10-V11) X 424 / 1304	74H	V_{116}"	V12+(V13-V12) X 312 / 1772	B4H	V_{180}"	V13+(V12-V13) X 350 / 1710	F4H	V_{244}"	V15+(V14-V15) X 1054 / 1322
35H	V_{53}"	V11+(V10-V11) X 386 / 1304	75H	V_{117}"	V12+(V13-V12) X 286 / 1772	B5H	V_{181}"	V13+(V12-V13) X 322 / 1710	F5H	V_{245}"	V15+(V14-V15) X 982 / 1322
36H	V_{54}"	V11+(V10-V11) X 348 / 1304	76H	V_{118}"	V12+(V13-V12) X 260 / 1772	B6H	V_{182}"	V13+(V12-V13) X 294 / 1710	F6H	V_{246}"	V15+(V14-V15) X 906 / 1322
37H	V_{55}"	V11+(V10-V11) X 312 / 1304	77H	V_{119}"	V12+(V13-V12) X 234 / 1772	B7H	V_{183}"	V13+(V12-V13) X 266 / 1710	F7H	V_{247}"	V15+(V14-V15) X 826 / 1322
38H	V_{56}"	V11+(V10-V11) X 276 / 1304	78H	V_{120}"	V12+(V13-V12) X 208 / 1772	B8H	V_{184}"	V13+(V12-V13) X 238 / 1710	F8H	V_{248}"	V15+(V14-V15) X 744 / 1322
39H	V_{57}"	V11+(V10-V11) X 240 / 1304	79H	V_{121}"	V12+(V13-V12) X 182 / 1772	B9H	V_{185}"	V13+(V12-V13) X 210 / 1710	F9H	V_{249}"	V15+(V14-V15) X 658 / 1322
3AH	V_{58}"	V11+(V10-V11) X 204 / 1304	7AH	V_{122}"	V12+(V13-V12) X 156 / 1772	BAH	V_{186}"	V13+(V12-V13) X 180 / 1710	FAH	V_{250}"	V15+(V14-V15) X 566 / 1322
3BH	V_{59}"	V11+(V10-V11) X 170 / 1304	7BH	V_{123}"	V12+(V13-V12) X 130 / 1772	BBH	V_{187}"	V13+(V12-V13) X 150 / 1710	FBH	V_{251}"	V15+(V14-V15) X 468 / 1322
3CH	V_{60}"	V11+(V10-V11) X 136 / 1304	7CH	V_{124}"	V12+(V13-V12) X 104 / 1772	BCH	V_{188}"	V13+(V12-V13) X 120 / 1710	FCH	V_{252}"	V15+(V14-V15) X 364 / 1322
3DH	V_{61}"	V11+(V10-V11) X 102 / 1304	7DH	V_{125}"	V12+(V13-V12) X 78 / 1772	BDH	V_{189}"	V13+(V12-V13) X 90 / 1710	FDH	V_{253}"	V15+(V14-V15) X 252 / 1322
3EH	V_{62}"	V11+(V10-V11) X 68 / 1304	7EH	V_{126}"	V12+(V13-V12) X 52 / 1772	BEH	V_{190}"	V13+(V12-V13) X 60 / 1710	FEH	V_{254}"	V15+(V14-V15) X 132 / 1322
3FH	V_{63}"	V11+(V10-V11) X 34 / 1304	7FH	V_{127}"	V12+(V13-V12) X 26 / 1772	BFH	V_{191}"	V13+(V12-V13) X 30 / 1710	FFH	V_{255}"	V15

6. RELATIONSHIP BETWEEN INPUT DATA AND OUTPUT PIN

Data format: 8 bits x 2 RGBs (6 dots)

Input width: 48 bits (2-pixel data)

(1) R,/L = H (right shift)

Output	S_1	S_2	S_3	S_4	…	S_{383}	S_{384}
Data	D_{00} to D_{07}	D_{10} to D_{17}	D_{20} to D_{27}	D_{30} to D_{37}	…	D_{40} to D_{47}	D_{50} to D_{57}

(2) R,/L = L (left shift)

Output	S_1	S_2	S_3	S_4	…	S_{383}	S_{384}
Data	D_{00} to D_{07}	D_{10} to D_{17}	D_{20} to D_{27}	D_{30} to D_{37}	…	D_{40} to D_{47}	D_{50} to D_{57}

POL	S_{2n-1} **Note**	S_{2n} **Note**
L	V_0-V_7	V_8-V_{15}
H	V_8-V_{15}	V_0-V_7

Note S_{2n-1} (odd output), S_{2n} (even output), n = 1, 2, ..., 192.

7. RELATIONSHIP BETWEEN MODE, STB, SRC, ORC, POL, AND OUTPUT WAVEFORM

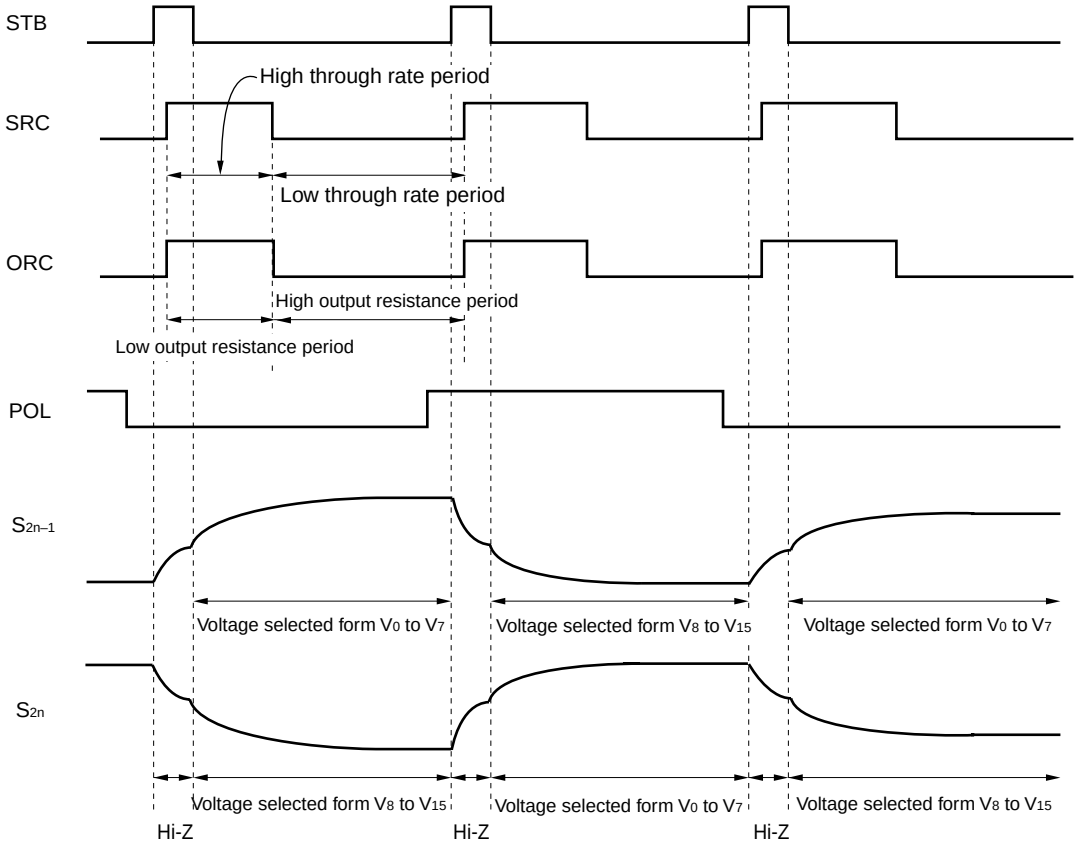
When MODE = H or open and STB = H, all outputs are reset (short) and the gray-scale voltage is output to LCD in synchronization with the falling edge of STB.

When MODE = L and STB = H, all outputs became Hi-Z and the gray-scale voltage is output to the LCD in synchronization with the falling edge of STB.

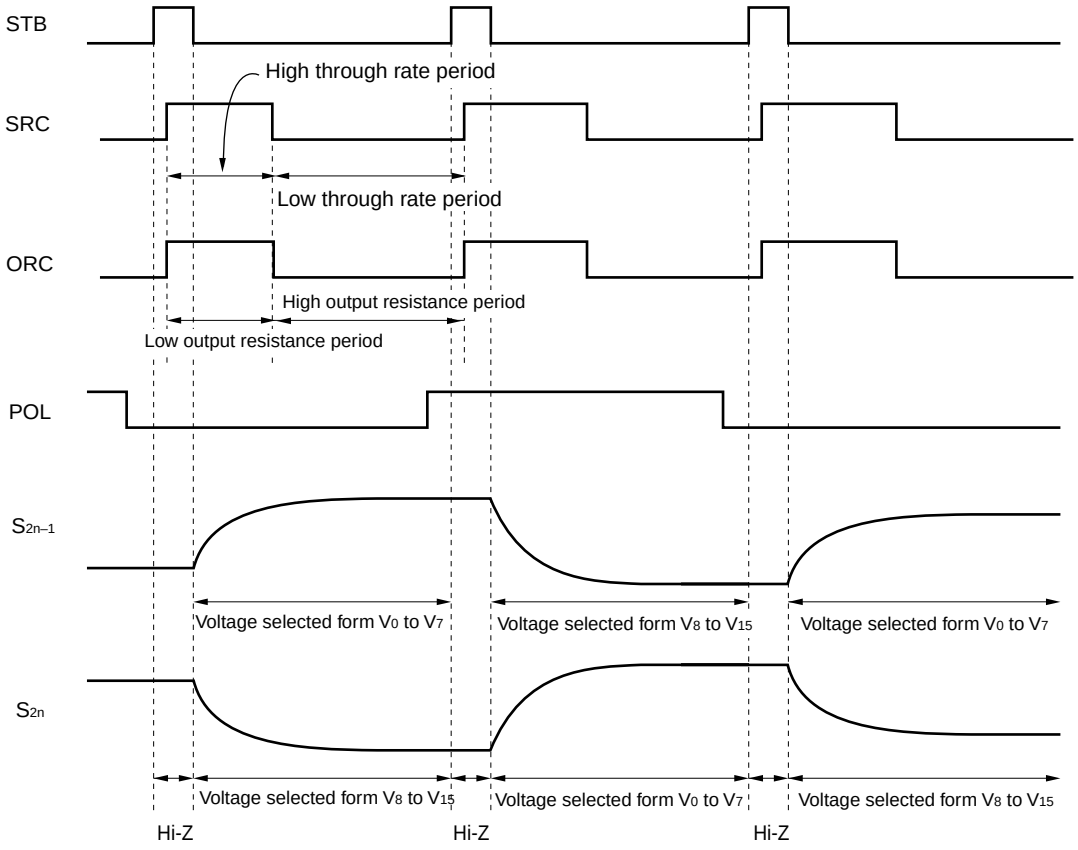
Also, setting the SRC pin to H level allows the bias current value of the output amplifier to rise temporarily, and setting the ORC pin to H level allows the output resistance value of the amplifier to lower temporarily.

For the timing and the processing of STB, SRC, or ORC during a high-level period, We recommend a thorough evaluation of the LCD panel specifications in advance.

(1) MODE = H or open



(2) MODE = L


STB
SRC
High through rate period
Low through rate period
ORC
High output resistance period
Low output resistance period
POL
S2n–1
Voltage selected form V0 to V7
Voltage selected form V8 to V15
Voltage selected form V0 to V7
S2n
Voltage selected form V8 to V15
Voltage selected form V0 to V7
Voltage selected form V8 to V15
Hi-Z
Hi-Z
Hi-Z

8. ELECTRICAL SPECIFICATIONS

Absolute Maximum Ratings (T_A = 25°C, V_{SS1} = V_{SS2} = 0 V)

Parameter	Symbol	Ratings	Unit
Logic part supply voltage	V_{DD1}	–0.5 to +4.0	V
Driver part supply voltage	V_{DD2}	–0.5 to +17.0	V
Logic part input voltage	V_{I1}	–0.5 to V_{DD1} + 0.5	V
Driver part input voltage	V_{I2}	–0.5 to V_{DD2} + 0.5	V
Logic part output voltage	V_{O1}	–0.5 to V_{DD1} + 0.5	V
Driver part output voltage	V_{O2}	–0.5 to V_{DD2} + 0.5	V
Operating ambient temperature	T_A	–10 to +75	°C
Storage temperature	T_{stg}	–55 to +125	°C

Caution Product quality may suffer if the absolute maximum rating is exceeded even momentarily for any parameter. That is, the absolute maximum ratings are rated values at which the product is on the verge of suffering physical damage, and therefore the product must be used under conditions that ensure that the absolute maximum ratings are not exceeded.

Recommended Operating Range (T_A = –10 to +75°C, V_{SS1} = V_{SS2} = 0 V)

	Parameter	Symbol	Condition	MIN.	TYP.	MAX.	Unit
★	Logic part supply voltage	V_{DD1}		2.5		3.6	V
	Driver part supply voltage	V_{DD2}	V_{SEL} = H	12.5	13.0	(14.0)	V
			V_{SEL} = L or open	(14.0)	15.0	15.5	
	High-level input voltage	V_{IH}		0.7 V_{DD1}		V_{DD1}	V
	Low-level input voltage	V_{IL}		0		0.3 V_{DD1}	V
	γ-corrected voltage	V_0-V_7		0.5 V_{DD2} + 0.5		V_{DD2} – 0.2	V
		V_8-V_{15}		0.2		0.5 V_{DD2} – 0.5	V
	Driver part output voltage	V_O		0.2		V_{DD2} – 0.2	V
	Clock frequency	f_{CLK}	3.0 V ≤ V_{DD1} ≤ 3.6 V			55	MHz
			2.5 V ≤ V_{DD1} < 3.0 V			40	MHz

Remark The value enclosed in parentheses is a reference value.

Electrical Characteristics (T_A = –10 to +75°C, V_{DD1} = 2.5 to 3.6 V, V_{DD2} = 12.5 to 15.5 V, V_{SS1} = V_{SS2} = 0 V)

	Parameter	Symbol	Condition	MIN.	TYP.	MAX.	Unit
	Input leakage current	I_{IL}				±1.0	μA
	High-level output voltage	V_{OH}	STHR (STHL), I_{OH} = 0 mA	V_{DD1} – 0.1			V
	Low-level output voltage	V_{OL}	STHR (STHL), I_{OL} = 0 mA			0.1	V
★	γ-corrected resistance	R_γ	V_{DD2} = 15.0 V, V_0-V_7 = V_8-V_{15} = 7.0 V	5.14	10.3	15.4	kΩ
★	Driver output current	I_{VOH}	V_X = 12.0 V, V_{OUT} = 11.0 V Note1			–0.40	mA
		I_{VOL}	V_X = 1.0 V, V_{OUT} = 2.0 V Note1	0.65			mA
★	Output voltage deviation	ΔV_O	T_A = 25°C, V_{SS2} + 1.0 V to V_{DD2} – 1.0 V		±10	±20	mV
★	Output swing voltage difference deviation	ΔV_{P-P1}	V_{DD1} = 3.3 V, V_{OUT} = 7.0 to 8.0 V Note1		±5	±10	mV
		ΔV_{P-P2}	V_{DD2} = 15.0 V, V_{OUT} = 4.0 to 11.0 V Note1		±7	±15	mV
		ΔV_{P-P3}	T_A = 25°C, V_{OUT} = 1.0 to 14.0 V Note1		±10	±20	mV
★	Logic part dynamic current consumption	I_{DD1}	V_{DD1} Notes2,3		1.3	12	mA
★	Driver part dynamic current consumption	I_{DD2}	V_{DD2}, with no load Notes3,4		12	30	mA

Notes 1. V_X refers to the output voltage of analog output pins S_1 to S_{384}.
V_{OUT} refers to the voltage applied to analog output pins S_1 to S_{384}

2. f_{STB} = 64 kHz, f_{CLK} = 54 MHz

3. The TYP. values refer to an all black or all white input pattern. The MAX. value refers to the measured values in the dot checkerboard input pattern.

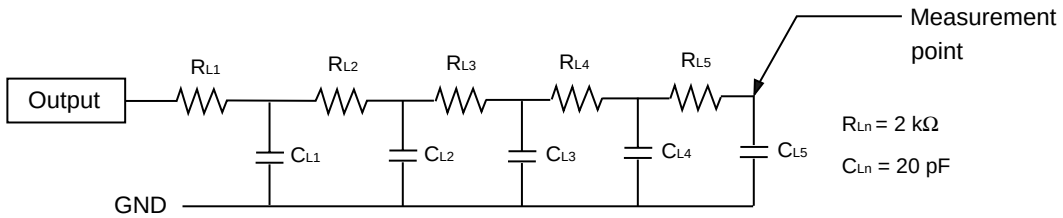
4. Refers to the current consumption per driver when cascades are connected under the assumption of SXGA single-sided mounting (10 units).

Switching Characteristics (T_A = –10 to +75°C, V_{DD1} = 2.5 to 3.6 V, V_{DD2} = 12.5 to 15.5 V, V_{SS1} = V_{SS2} = 0 V)

	Parameter	Symbol	Condition	MIN.	TYP.	MAX.	Unit
	Start pulse delay time	t_{PLH1}	C_L = 15 pF, 3.0 V ≤ V_{DD} ≤ 3.6 V			17	ns
			C_L = 15 pF, 2.5 V ≤ V_{DD} < 3.0 V			24	ns
★	Driver output delay time	t_{PLH2} Note	C_L = 100 pF, R_L = 10 kΩ			5	μs
		t_{PLH3} Note				10	μs
		t_{PHL2} Note				5	μs
		t_{PHL3} Note				10	μs
	Input capacitance	C_{I1}	logic input, except STHR (STHL), T_A = 25°C		5	10	pF
		C_{I2}	STHR (STHL), T_A = 25°C		10	15	pF

Note t_{PLH2}, t_{PHL2} refer to the arrival time from falling edge of STB to target voltage ±10%
t_{PLH3}, t_{PHL3} refer to the arrival time from falling edge of STB to target voltage ±0.02 V (condition: V_O = 3.0 V ↔12.0 V)

★ **<Test Condition>**



Timing Requirements (T_A = –10 to +75°C, V_{DD1} = 2.5 to 3.6 V, V_{SS1} = 0 V, $t_r = t_f$ = 5.0 ns)

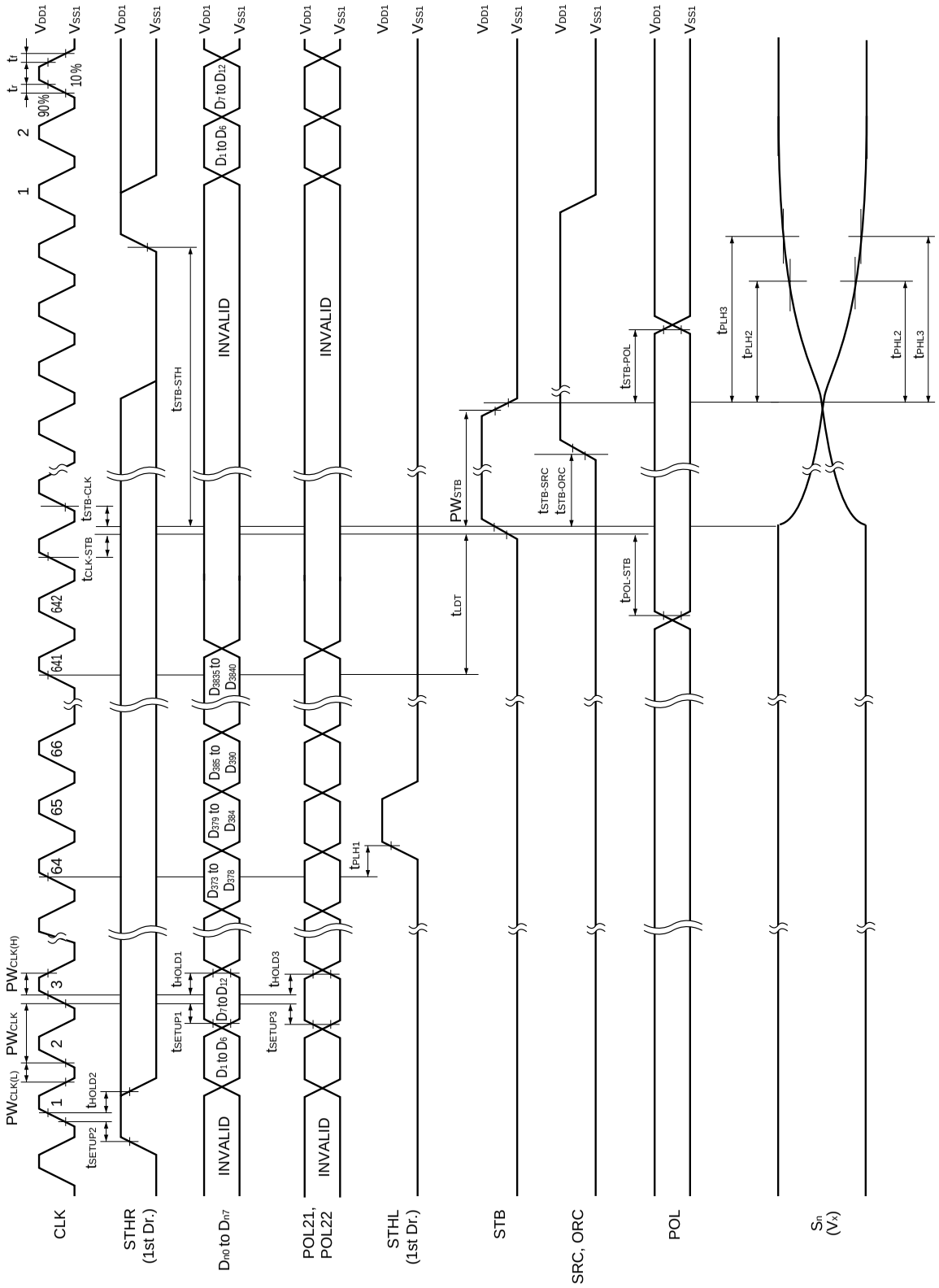
Parameter	Symbol	Condition	MIN.	TYP.	MAX.	Unit
Clock pulse width	PW_{CLK}	3.0 V ≤ V_{DD1} ≤ 3.6 V	18			ns
		2.5 V ≤ V_{DD1} < 3.0 V	25			ns
Clock pulse high period	$PW_{CLK (H)}$	3.0 V ≤ V_{DD1} ≤ 3.6 V	4			ns
		2.5 V ≤ V_{DD1} < 3.0 V	6			ns
Clock pulse low period	$PW_{CLK (L)}$		4			ns
Data setup time	t_{SETUP1}		0			ns
Data hold time	t_{HOLD1}		4			ns
Start pulse setup time	t_{SETUP2}		0			ns
Start pulse hold time	t_{HOLD2}		4			ns
POL21, POL22 setup time	t_{SETUP3}		0			ns
POL21, POL22 hold time	t_{HOLD3}		4			ns
STB pulse width	PW_{STB}		1.0			μs
Last data timing	t_{LDT}		2			CLK
CLK-STB time	$t_{CLK-STB}$	CLK ↑→ STB↑	4			ns
STB-CLK time	$t_{STB-CLK}$	STB ↑→ CLK↑	4			ns
Time between STB and start pulse	$t_{STB-STH}$	STB ↑→ STHR (STHL) ↑	2			CLK
POL-STB time	$t_{POL-STB}$	POL ↑ or ↓→ STB ↑	4			ns
STB-POL time	$t_{STB-POL}$	STB ↓→ POL ↓ or ↑	4			ns
STB-SRC time	$t_{STB-SRC}$	STB ↑ → SRC ↑	0			ns
STB-ORC time	$t_{STB-ORC}$	STB ↓→ ORC ↑	0			ns

Remark Unless otherwise specified, the input level is defined to be V_{IH} = 0.7 V_{DD1}, V_{IL} = 0.3 V_{DD1}.

Switching Characteristic Waveform

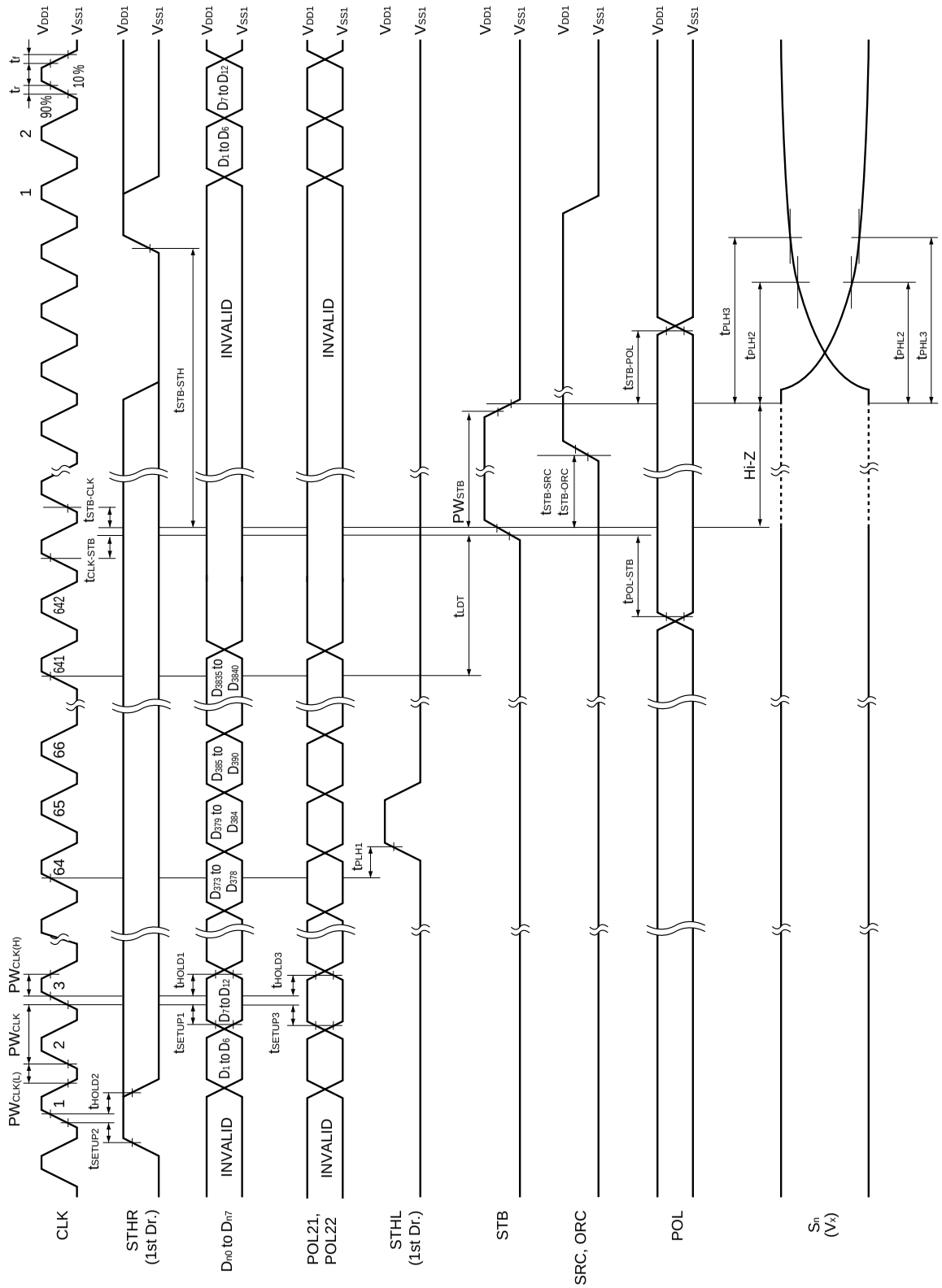
(1) R,/L= H, MODE = H or open

Unless otherwise specified, V_{IH}, V_{IL} are defined to be V_{IH} = 0.7 V_{DD1}, V_{IL} = 0.3 V_{DD1} (numbers clock and display data are example when in SXGA).



(2) R,/L= H, MODE = L

Unless otherwise specified, V_{IH}, V_{IL} are defined to be V_{IH} = 0.7 V_{DD1}, V_{IL} = 0.3 V_{DD1} (Numbers clock and display data are example when in SXGA).



9. RECOMMENDED MOUNTING CONDITIONS

The following conditions must be met for mounting conditions of the μPD160040.

For more details, refer to the **Semiconductor Device Mounting Technology Manual (C10535E).**

Please consult with our sales offices in case other mounting process is used, or in case the mounting is done under different conditions.

μPD160040N-xxx: TCP (TAB Package)

Mounting Condition	Mounting Method	Condition
Thermocompression	Soldering	Heating tool 300 to 350°C, heating for 2 to 3 sec, pressure 100g (per solder).
	ACF (Adhesive Conductive Film)	Temporary bonding 70 to 100°C, pressure 3 to 8 kg/cm^2, time 3 to 5 sec. Real bonding 165 to 180°C, pressure 25 to 45 kg/cm^2, time 30 to 40 sec. (When using the anisotropy conductive film SUMIZAC1003 of Sumitomo Bakelite, Ltd.)

Caution To find out the detailed conditions for mounting the ACF part, please contact the ACF manufacturing company. Be sure to avoid using two or more mounting methods at a time.

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.