DATA SHEET

NEC

MOS INTEGRATED CIRCUIT

μPD160040A

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

DESCRIPTION

The μPD160040A 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})
- High-speed data transfer: f_{CLK} = 55 MHz MAX. (internal data transfer speed when operating at 3.0 V ≤ V_{DD1} ≤ 3.6 V)
  = 40 MHz MAX. (internal data transfer speed when operating at 2.5 V ≤ V_{DD1} < 3.0 V)
- Output dynamic range: V_{SS2} + 0.2 V to V_{DD2} – 0.2 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)
- Slew-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
μPD160040AN-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.

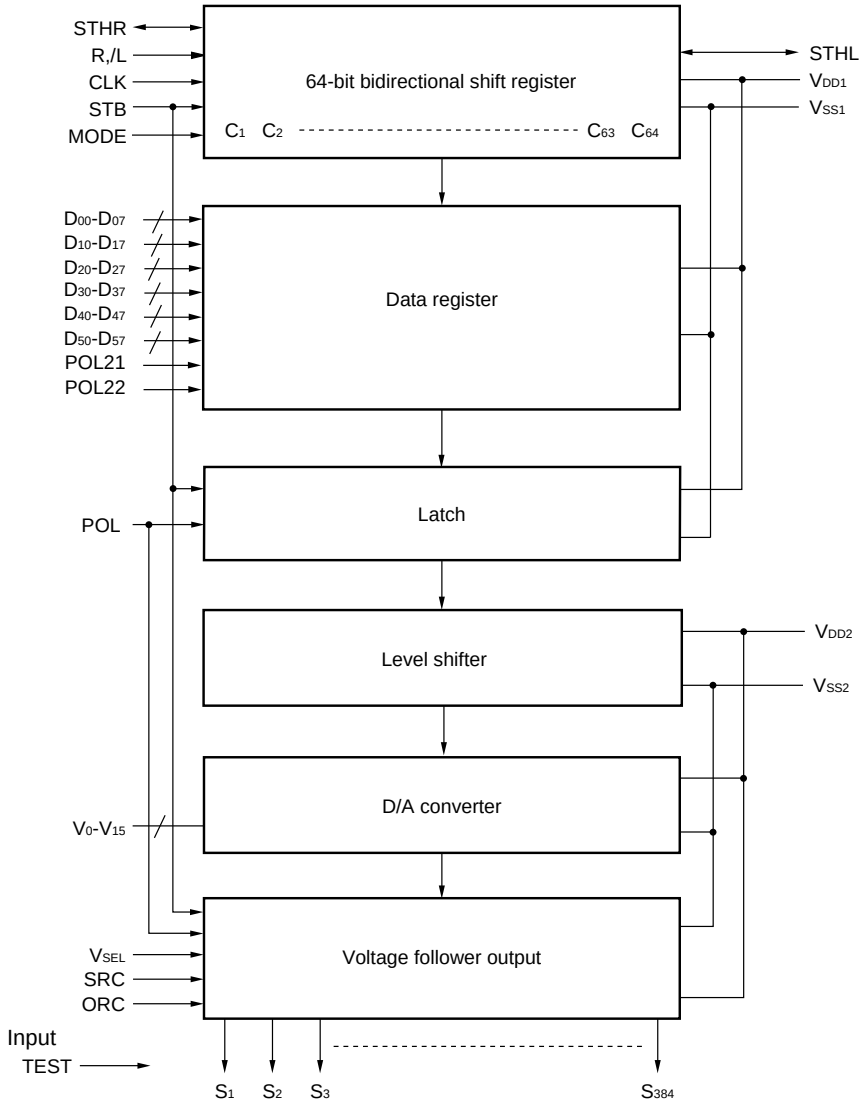
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The mark ★ shows major revised points.

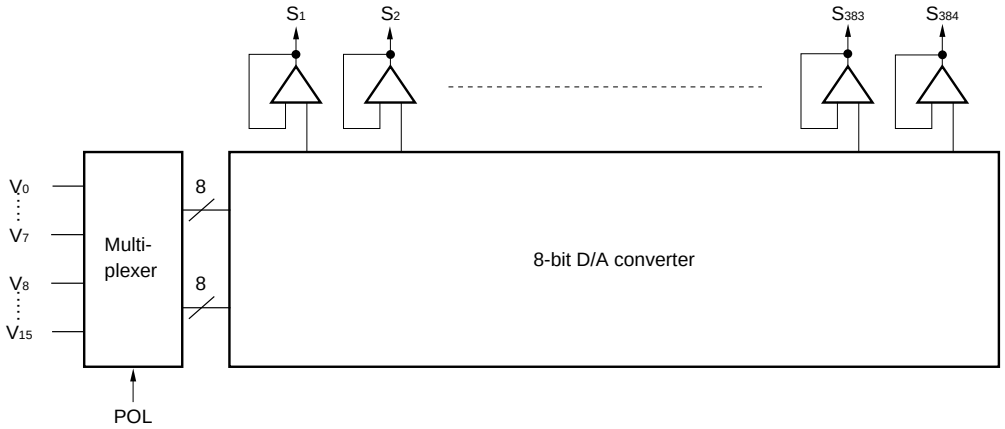
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1. BLOCK DIAGRAM

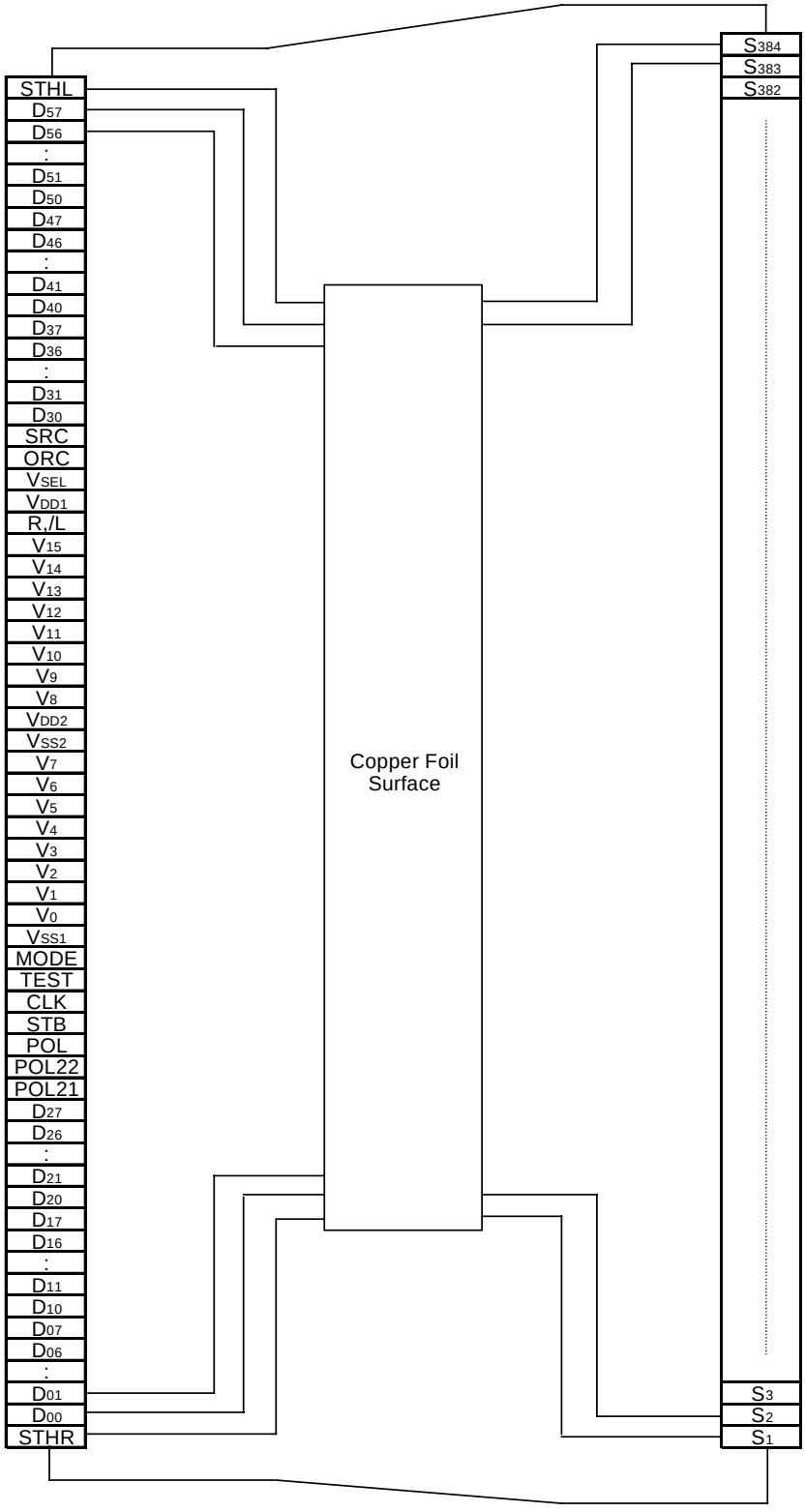


Remark /xxx indicates active low signal.

2. RELATIONSHIP BETWEEN OUTPUT CIRCUIT AND D/A CONVERTER



3. PIN CONFIGURATION (μPD160040AN-xxx: TCP) (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→S_{384}→STHL output R,/L = L (left shift) : STHL input →S_{384}→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 high level is read at the rising edge of CLK. At the rising edge of the 64th clock after the start pulse input, the start pulse output reaches the high level, thus becoming the start pulse of the next-level driver. 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	Slew-rate control	Input	SRC = H: High-slew-rate mode (large current consumption) SRC = L: Low-slew-rate mode (small current consumption) SRC is pulled up to the V_{DD1} in the IC.
ORC	Output resistance control	Input	ORC = H: Low output resistance mode ORC = L: High output resistance mode ORC is pulled up to the V_{DD1} in the IC.
POL	Polarity	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 15.5 V (Small bias current) LPC is pulled down to the V_{SS1} 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 ≥ V_0 > V_1 > V_2 > ..... > V_6 > V_7 ≥ 0.5 V_{DD2} + 0.5 V 0.5 V_{DD2} – 0.5 V ≥ V_8 > V_9 > V_{10} > ..... V_{14} > V_{15} ≥ V_{SS2} + 0.2 V
TEST	Test	I	Normally, set the TEST pin to high level or leave open. This pin is pulled up to V_{DD1} in the IC.
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 μPD160040A 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 (r0 to r253) 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-V_{15} and the input data. Be sure to maintain the voltage relationships below.

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

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

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 5–2 shows γCorrected Voltages and Ladder Resistors Ratio and figure 5–3 shows the relation ship between the input data and the output voltage (POL21, POL22 = L).

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

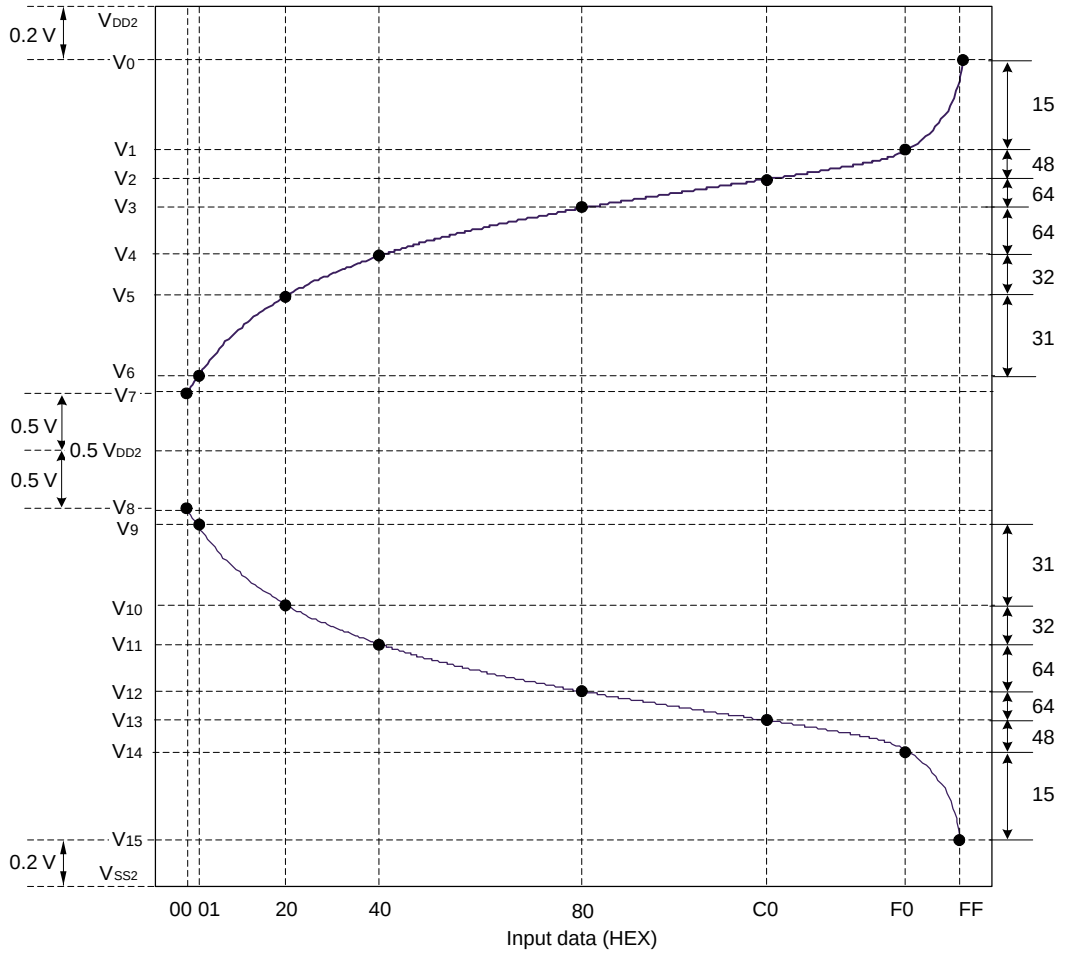
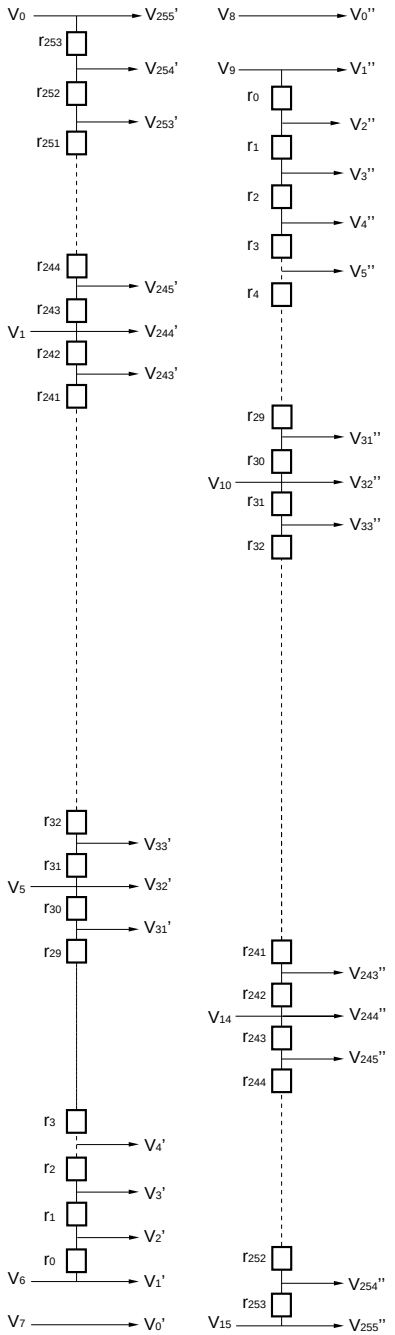


Figure 5–2. γ-Corrected Voltages and Ladder Resistors Ratio



rn	Ratio 1	Ratio 2	Value
r0	46.00	0.0637	644.0
r1	21.43	0.0297	300.0
r2	17.14	0.0237	240.0
r3	14.29	0.0198	200.0
r4	12.14	0.0168	170.0
r5	10.00	0.0139	140.0
r6	9.29	0.0129	130.0
r7	8.57	0.0119	120.0
r8	7.86	0.0109	110.0
r9	7.14	0.0099	100.0
r10	6.43	0.0089	90.0
r11	6.00	0.0083	84.0
r12	5.71	0.0079	80.0
r13	5.29	0.0073	74.0
r14	5.00	0.0069	70.0
r15	4.57	0.0063	64.0
r16	4.29	0.0059	60.0
r17	3.86	0.0053	54.0
r18	3.57	0.0049	50.0
r19	3.14	0.0044	44.0
r20	2.86	0.0040	40.0
r21	2.57	0.0036	36.0
r22	2.43	0.0034	34.0
r23	2.29	0.0032	32.0
r24	2.14	0.0030	30.0
r25	2.00	0.0028	28.0
r26	1.86	0.0026	26.0
r27	1.71	0.0024	24.0
r28	1.57	0.0022	22.0
r29	1.43	0.0020	20.0
r30	1.43	0.0020	20.0
r31	1.29	0.0018	18.0
r32	1.14	0.0016	16.0
r33	1.14	0.0016	16.0
r34	1.14	0.0016	16.0
r35	1.14	0.0016	16.0
r36	1.14	0.0016	16.0
r37	1.14	0.0016	16.0
r38	1.14	0.0016	16.0
r39	1.14	0.0016	16.0
r40	1.14	0.0016	16.0
r41	1.14	0.0016	16.0
r42	1.14	0.0016	16.0
r43	1.14	0.0016	16.0
r44	1.14	0.0016	16.0
r45	1.14	0.0016	16.0
r46	1.00	0.0014	14.0
r47	1.00	0.0014	14.0
r48	1.00	0.0014	14.0
r49	1.00	0.0014	14.0
r50	1.00	0.0014	14.0
r51	1.00	0.0014	14.0
r52	1.00	0.0014	14.0
r53	1.00	0.0014	14.0
r54	1.00	0.0014	14.0
r55	1.00	0.0014	14.0
r56	1.00	0.0014	14.0
r57	1.00	0.0014	14.0
r58	1.00	0.0014	14.0
r59	1.00	0.0014	14.0
r60	1.00	0.0014	14.0
r61	1.00	0.0014	14.0
r62	1.00	0.0014	14.0
r63	1.00	0.0014	14.0

rn	Ratio 1	Ratio 2	Value
r64	1.00	0.0014	14.0
r65	1.00	0.0014	14.0
r66	1.00	0.0014	14.0
r67	1.00	0.0014	14.0
r68	1.00	0.0014	14.0
r69	1.00	0.0014	14.0
r70	1.00	0.0014	14.0
r71	1.00	0.0014	14.0
r72	1.00	0.0014	14.0
r73	1.00	0.0014	14.0
r74	1.00	0.0014	14.0
r75	1.00	0.0014	14.0
r76	1.00	0.0014	14.0
r77	1.00	0.0014	14.0
r78	1.00	0.0014	14.0
r79	1.00	0.0014	14.0
r80	1.00	0.0014	14.0
r81	1.00	0.0014	14.0
r82	1.00	0.0014	14.0
r83	1.00	0.0014	14.0
r84	1.00	0.0014	14.0
r85	1.00	0.0014	14.0
r86	1.00	0.0014	14.0
r87	1.00	0.0014	14.0
r88	1.00	0.0014	14.0
r89	1.00	0.0014	14.0
r90	1.00	0.0014	14.0
r91	1.00	0.0014	14.0
r92	1.00	0.0014	14.0
r93	1.00	0.0014	14.0
r94	1.00	0.0014	14.0
r95	1.00	0.0014	14.0
r96	1.00	0.0014	14.0
r97	1.00	0.0014	14.0
r98	1.00	0.0014	14.0
r99	1.00	0.0014	14.0
r100	1.00	0.0014	14.0
r101	1.00	0.0014	14.0
r102	1.00	0.0014	14.0
r103	1.00	0.0014	14.0
r104	1.00	0.0014	14.0
r105	1.00	0.0014	14.0
r106	1.00	0.0014	14.0
r107	1.00	0.0014	14.0
r108	1.00	0.0014	14.0
r109	1.00	0.0014	14.0
r110	1.14	0.0016	16.0
r111	1.14	0.0016	16.0
r112	1.14	0.0016	16.0
r113	1.14	0.0016	16.0
r114	1.14	0.0016	16.0
r115	1.14	0.0016	16.0
r116	1.14	0.0016	16.0
r117	1.14	0.0016	16.0
r118	1.14	0.0016	16.0
r119	1.14	0.0016	16.0
r120	1.14	0.0016	16.0
r121	1.14	0.0016	16.0
r122	1.14	0.0016	16.0
r123	1.14	0.0016	16.0
r124	1.14	0.0016	16.0
r125	1.14	0.0016	16.0
r126	1.14	0.0016	16.0
r127	1.29	0.0018	18.0

rn	Ratio 1	Ratio 2	Value
r128	1.29	0.0018	18.0
r129	1.29	0.0018	18.0
r130	1.29	0.0018	18.0
r131	1.29	0.0018	18.0
r132	1.29	0.0018	18.0
r133	1.29	0.0018	18.0
r134	1.29	0.0018	18.0
r135	1.29	0.0018	18.0
r136	1.29	0.0018	18.0
r137	1.29	0.0018	18.0
r138	1.29	0.0018	18.0
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r142	1.29	0.0018	18.0
r143	1.29	0.0018	18.0
r144	1.29	0.0018	18.0
r145	1.29	0.0018	18.0
r146	1.29	0.0018	18.0
r147	1.29	0.0018	18.0
r148	1.29	0.0018	18.0
r149	1.29	0.0018	18.0
r150	1.43	0.0020	20.0
r151	1.43	0.0020	20.0
r152	1.43	0.0020	20.0
r153	1.43	0.0020	20.0
r154	1.43	0.0020	20.0
r155	1.43	0.0020	20.0
r156	1.43	0.0020	20.0
r157	1.43	0.0020	20.0
r158	1.43	0.0020	20.0
r159	1.43	0.0020	20.0
r160	1.43	0.0020	20.0
r161	1.43	0.0020	20.0
r162	1.57	0.0022	22.0
r163	1.57	0.0022	22.0
r164	1.57	0.0022	22.0
r165	1.57	0.0022	22.0
r166	1.57	0.0022	22.0
r167	1.57	0.0022	22.0
r168	1.57	0.0022	22.0
r169	1.71	0.0024	24.0
r170	1.71	0.0024	24.0
r171	1.71	0.0024	24.0
r172	1.71	0.0024	24.0
r173	1.71	0.0024	24.0
r174	1.71	0.0024	24.0
r175	1.86	0.0026	26.0
r176	1.86	0.0026	26.0
r177	1.86	0.0026	26.0
r178	1.86	0.0026	26.0
r179	1.86	0.0026	26.0
r180	2.00	0.0028	28.0
r181	2.00	0.0028	28.0
r182	2.00	0.0028	28.0
r183	2.00	0.0028	28.0
r184	2.00	0.0028	28.0
r185	2.00	0.0028	28.0
r186	2.14	0.0030	30.0
r187	2.14	0.0030	30.0
r188	2.14	0.0030	30.0
r189	2.14	0.0030	30.0
r190	2.14	0.0030	30.0
r191	2.29	0.0032	32.0

rn	Ratio 1	Ratio 2	Value
r192	2.29	0.0032	32.0
r193	2.29	0.0032	32.0
r194	2.29	0.0032	32.0
r195	2.29	0.0032	32.0
r196	2.43	0.0034	34.0
r197	2.43	0.0034	34.0
r198	2.43	0.0034	34.0
r199	2.43	0.0034	34.0
r200	2.57	0.0036	36.0
r201	2.57	0.0036	36.0
r202	2.57	0.0036	36.0
r203	2.57	0.0036	36.0
r204	2.71	0.0038	38.0
r205	2.71	0.0038	38.0
r206	2.71	0.0038	38.0
r207	2.86	0.0040	40.0
r208	2.86	0.0040	40.0
r209	2.86	0.0040	40.0
r210	3.00	0.0042	42.0
r211	3.00	0.0042	42.0
r212	3.00	0.0042	42.0
r213	3.14	0.0044	44.0
r214	3.14	0.0044	44.0
r215	3.29	0.0046	46.0
r216	3.29	0.0046	46.0
r217	3.43	0.0047	48.0
r218	3.43	0.0047	48.0
r219	3.57	0.0049	50.0
r220	3.57	0.0049	50.0
r221	3.71	0.0051	52.0
r222	3.86	0.0053	54.0
r223	3.86	0.0053	54.0
r224	4.00	0.0055	56.0
r225	4.14	0.0057	58.0
r226	4.29	0.0059	60.0
r227	4.43	0.0061	62.0
r228	4.57	0.0063	64.0
r229	4.71	0.0065	66.0
r230	4.86	0.0067	68.0
r231	5.00	0.0069	70.0
r232	5.14	0.0071	72.0
r233	5.29	0.0073	74.0
r234	5.43	0.0075	76.0
r235	5.71	0.0079	80.0
r236	5.86	0.0081	82.0
r237	6.14	0.0085	86.0
r238	6.29	0.0087	88.0
r239	6.57	0.0091	92.0
r240	6.86	0.0095	96.0
r241	7.00	0.0097	98.0
r242	7.43	0.0103	104.0
r243	7.86	0.0109	110.0
r244	8.14	0.0113	114.0
r245	8.57	0.0119	120.0
r246	8.57	0.0119	120.0
r247	9.29	0.0129	130.0
r248	9.29	0.0129	130.0
r249	9.29	0.0129	130.0
r250	9.29	0.0129	130.0
r251	9.29	0.0129	130.0
r252	9.29	0.0129	130.0
r253	9.29	0.0129	130.0
Total resistance			10108
Minimum resistance value			14.0

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 voltage1) 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	V0'	V7
01H	V1'	V6
02H	V2'	V6+(V5-V6) X 46.0 / 224.0
03H	V3'	V6+(V5-V6) X 67.4 / 224.0
04H	V4'	V6+(V5-V6) X 84.6 / 224.0
05H	V5'	V6+(V5-V6) X 98.9 / 224.0
06H	V6'	V6+(V5-V6) X111.0 / 224.0
07H	V7'	V6+(V5-V6) X121.0 / 224.0
08H	V8'	V6+(V5-V6) X130.3 / 224.0
09H	V9'	V6+(V5-V6) X138.9 / 224.0
0AH	V10'	V6+(V5-V6) X146.7 / 224.0
0BH	V11'	V6+(V5-V6) X153.9 / 224.0
0CH	V12'	V6+(V5-V6) X160.3 / 224.0
0DH	V13'	V6+(V5-V6) X166.3 / 224.0
0EH	V14'	V6+(V5-V6) X172.0 / 224.0
0FH	V15'	V6+(V5-V6) X177.3 / 224.0
10H	V16'	V6+(V5-V6) X182.3 / 224.0
11H	V17'	V6+(V5-V6) X186.9 / 224.0
12H	V18'	V6+(V5-V6) X191.1 / 224.0
13H	V19'	V6+(V5-V6) X195.0 / 224.0
14H	V20'	V6+(V5-V6) X198.6 / 224.0
15H	V21'	V6+(V5-V6) X201.7 / 224.0
16H	V22'	V6+(V5-V6) X204.6 / 224.0
17H	V23'	V6+(V5-V6) X207.1 / 224.0
18H	V24'	V6+(V5-V6) X209.6 / 224.0
19H	V25'	V6+(V5-V6) X211.9 / 224.0
1AH	V26'	V6+(V5-V6) X214.0 / 224.0
1BH	V27'	V6+(V5-V6) X216.0 / 224.0
1CH	V28'	V6+(V5-V6) X217.9 / 224.0
1DH	V29'	V6+(V5-V6) X219.6 / 224.0
1EH	V30'	V6+(V5-V6) X221.1 / 224.0
1FH	V31'	V6+(V5-V6) X222.6 / 224.0
20H	V32'	V5
21H	V33'	V5+(V4-V5) X 1.3 / 34.3
22H	V34'	V5+(V4-V5) X 2.4 / 34.3
23H	V35'	V5+(V4-V5) X 3.6 / 34.3
24H	V36'	V5+(V4-V5) X 4.7 / 34.3
25H	V37'	V5+(V4-V5) X 5.9 / 34.3
26H	V38'	V5+(V4-V5) X 7.0 / 34.3
27H	V39'	V5+(V4-V5) X 8.1 / 34.3
28H	V40'	V5+(V4-V5) X 9.3 / 34.3
29H	V41'	V5+(V4-V5) X 10.4 / 34.3
2AH	V42'	V5+(V4-V5) X 11.6 / 34.3
2BH	V43'	V5+(V4-V5) X 12.7 / 34.3
2CH	V44'	V5+(V4-V5) X 13.9 / 34.3
2DH	V45'	V5+(V4-V5) X 15.0 / 34.3
2EH	V46'	V5+(V4-V5) X 16.1 / 34.3
2FH	V47'	V5+(V4-V5) X 17.3 / 34.3
30H	V48'	V5+(V4-V5) X 18.3 / 34.3
31H	V49'	V5+(V4-V5) X 19.3 / 34.3
32H	V50'	V5+(V4-V5) X 20.3 / 34.3
33H	V51'	V5+(V4-V5) X 21.3 / 34.3
34H	V52'	V5+(V4-V5) X 22.3 / 34.3
35H	V53'	V5+(V4-V5) X 23.3 / 34.3
36H	V54'	V5+(V4-V5) X 24.3 / 34.3
37H	V55'	V5+(V4-V5) X 25.3 / 34.3
38H	V56'	V5+(V4-V5) X 26.3 / 34.3
39H	V57'	V5+(V4-V5) X 27.3 / 34.3
3AH	V58'	V5+(V4-V5) X 28.3 / 34.3
3BH	V59'	V5+(V4-V5) X 29.3 / 34.3
3CH	V60'	V5+(V4-V5) X 30.3 / 34.3
3DH	V61'	V5+(V4-V5) X 31.3 / 34.3
3EH	V62'	V5+(V4-V5) X 32.3 / 34.3
3FH	V63'	V5+(V4-V5) X 33.3 / 34.3

Data	Output voltage1	
40H	V64'	V4
41H	V65'	V4+(V3-V4) X 1.0 / 66.4
42H	V66'	V4+(V3-V4) X 2.0 / 66.4
43H	V67'	V4+(V3-V4) X 3.0 / 66.4
44H	V68'	V4+(V3-V4) X 4.0 / 66.4
45H	V69'	V4+(V3-V4) X 5.0 / 66.4
46H	V70'	V4+(V3-V4) X 6.0 / 66.4
47H	V71'	V4+(V3-V4) X 7.0 / 66.4
48H	V72'	V4+(V3-V4) X 8.0 / 66.4
49H	V73'	V4+(V3-V4) X 9.0 / 66.4
4AH	V74'	V4+(V3-V4) X10.0 / 66.4
4BH	V75'	V4+(V3-V4) X11.0 / 66.4
4CH	V76'	V4+(V3-V4) X12.0 / 66.4
4DH	V77'	V4+(V3-V4) X13.0 / 66.4
4EH	V78'	V4+(V3-V4) X14.0 / 66.4
4FH	V79'	V4+(V3-V4) X15.0 / 66.4
50H	V80'	V4+(V3-V4) X16.0 / 66.4
51H	V81'	V4+(V3-V4) X17.0 / 66.4
52H	V82'	V4+(V3-V4) X18.0 / 66.4
53H	V83'	V4+(V3-V4) X19.0 / 66.4
54H	V84'	V4+(V3-V4) X20.0 / 66.4
55H	V85'	V4+(V3-V4) X21.0 / 66.4
56H	V86'	V4+(V3-V4) X22.0 / 66.4
57H	V87'	V4+(V3-V4) X23.0 / 66.4
58H	V88'	V4+(V3-V4) X24.0 / 66.4
59H	V89'	V4+(V3-V4) X25.0 / 66.4
5AH	V90'	V4+(V3-V4) X26.0 / 66.4
5BH	V91'	V4+(V3-V4) X27.0 / 66.4
5CH	V92'	V4+(V3-V4) X28.0 / 66.4
5DH	V93'	V4+(V3-V4) X29.0 / 66.4
5EH	V94'	V4+(V3-V4) X30.0 / 66.4
5FH	V95'	V4+(V3-V4) X31.0 / 66.4
60H	V96'	V4+(V3-V4) X32.0 / 66.4
61H	V97'	V4+(V3-V4) X33.0 / 66.4
62H	V98'	V4+(V3-V4) X34.0 / 66.4
63H	V99'	V4+(V3-V4) X35.0 / 66.4
64H	V100'	V4+(V3-V4) X36.0 / 66.4
65H	V101'	V4+(V3-V4) X37.0 / 66.4
66H	V102'	V4+(V3-V4) X38.0 / 66.4
67H	V103'	V4+(V3-V4) X39.0 / 66.4
68H	V104'	V4+(V3-V4) X40.0 / 66.4
69H	V105'	V4+(V3-V4) X41.0 / 66.4
6AH	V106'	V4+(V3-V4) X42.0 / 66.4
6BH	V107'	V4+(V3-V4) X43.0 / 66.4
6CH	V108'	V4+(V3-V4) X44.0 / 66.4
6DH	V109'	V4+(V3-V4) X45.0 / 66.4
6EH	V110'	V4+(V3-V4) X46.0 / 66.4
6FH	V111'	V4+(V3-V4) X47.0 / 66.4
70H	V112'	V4+(V3-V4) X48.1 / 66.4
71H	V113'	V4+(V3-V4) X49.3 / 66.4
72H	V114'	V4+(V3-V4) X50.4 / 66.4
73H	V115'	V4+(V3-V4) X51.6 / 66.4
74H	V116'	V4+(V3-V4) X52.7 / 66.4
75H	V117'	V4+(V3-V4) X53.9 / 66.4
76H	V118'	V4+(V3-V4) X55.0 / 66.4
77H	V119'	V4+(V3-V4) X56.1 / 66.4
78H	V120'	V4+(V3-V4) X57.3 / 66.4
79H	V121'	V4+(V3-V4) X58.4 / 66.4
7AH	V122'	V4+(V3-V4) X59.6 / 66.4
7BH	V123'	V4+(V3-V4) X60.7 / 66.4
7CH	V124'	V4+(V3-V4) X61.9 / 66.4
7DH	V125'	V4+(V3-V4) X63.0 / 66.4
7EH	V126'	V4+(V3-V4) X64.1 / 66.4
7FH	V127'	V4+(V3-V4) X65.3 / 66.4

Data	Output voltage1	
80H	V128'	V3
81H	V129'	V3+(V2-V3) X 1.3 / 100.0
82H	V130'	V3+(V2-V3) X 2.6 / 100.0
83H	V131'	V3+(V2-V3) X 3.9 / 100.0
84H	V132'	V3+(V2-V3) X 5.1 / 100.0
85H	V133'	V3+(V2-V3) X 6.4 / 100.0
86H	V134'	V3+(V2-V3) X 7.7 / 100.0
87H	V135'	V3+(V2-V3) X 9.0 / 100.0
88H	V136'	V3+(V2-V3) X10.3 / 100.0
89H	V137'	V3+(V2-V3) X11.6 / 100.0
8AH	V138'	V3+(V2-V3) X12.9 / 100.0
8BH	V139'	V3+(V2-V3) X14.1 / 100.0
8CH	V140'	V3+(V2-V3) X15.4 / 100.0
8DH	V141'	V3+(V2-V3) X16.7 / 100.0
8EH	V142'	V3+(V2-V3) X18.0 / 100.0
8FH	V143'	V3+(V2-V3) X19.3 / 100.0
90H	V144'	V3+(V2-V3) X20.6 / 100.0
91H	V145'	V3+(V2-V3) X21.9 / 100.0
92H	V146'	V3+(V2-V3) X23.1 / 100.0
93H	V147'	V3+(V2-V3) X24.4 / 100.0
94H	V148'	V3+(V2-V3) X25.7 / 100.0
95H	V149'	V3+(V2-V3) X27.0 / 100.0
96H	V150'	V3+(V2-V3) X28.3 / 100.0
97H	V151'	V3+(V2-V3) X29.6 / 100.0
98H	V152'	V3+(V2-V3) X31.0 / 100.0
99H	V153'	V3+(V2-V3) X32.4 / 100.0
9AH	V154'	V3+(V2-V3) X33.9 / 100.0
9BH	V155'	V3+(V2-V3) X35.3 / 100.0
9CH	V156'	V3+(V2-V3) X36.7 / 100.0
9DH	V157'	V3+(V2-V3) X38.1 / 100.0
9EH	V158'	V3+(V2-V3) X39.6 / 100.0
9FH	V159'	V3+(V2-V3) X41.0 / 100.0
A0H	V160'	V3+(V2-V3) X42.4 100.0
A1H	V161'	V3+(V2-V3) X43.9 / 100.0
A2H	V162'	V3+(V2-V3) X45.3 / 100.0
A3H	V163'	V3+(V2-V3) X46.7 / 100.0
A4H	V164'	V3+(V2-V3) X48.3 / 100.0
A5H	V165'	V3+(V2-V3) X49.9 / 100.0
A6H	V166'	V3+(V2-V3) X51.4 / 100.0
A7H	V167'	V3+(V2-V3) X53.0 / 100.0
A8H	V168'	V3+(V2-V3) X54.6 / 100.0
A9H	V169'	V3+(V2-V3) X56.1 / 100.0
AAH	V170'	V3+(V2-V3) X57.7 / 100.0
ABH	V171'	V3+(V2-V3) X59.4 / 100.0
ACH	V172'	V3+(V2-V3) X61.1 / 100.0
ADH	V173'	V3+(V2-V3) X62.9 / 100.0
AEH	V174'	V3+(V2-V3) X64.6 / 100.0
AFH	V175'	V3+(V2-V3) X66.3 / 100.0
B0H	V176'	V3+(V2-V3) X68.0 / 100.0
B1H	V177'	V3+(V2-V3) X69.9 / 100.0
B2H	V178'	V3+(V2-V3) X71.7 / 100.0
B3H	V179'	V3+(V2-V3) X73.6 / 100.0
B4H	V180'	V3+(V2-V3) X75.4 / 100.0
B5H	V181'	V3+(V2-V3) X77.3 / 100.0
B6H	V182'	V3+(V2-V3) X79.3 / 100.0
B7H	V183'	V3+(V2-V3) X81.3 / 100.0
B8H	V184'	V3+(V2-V3) X83.3 / 100.0
B9H	V185'	V3+(V2-V3) X85.3 / 100.0
BAH	V186'	V3+(V2-V3) X87.3 / 100.0
BBH	V187'	V3+(V2-V3) X89.3 / 100.0
BCH	V188'	V3+(V2-V3) X91.4 / 100.0
BDH	V189'	V3+(V2-V3) X93.6 / 100.0
BEH	V190'	V3+(V2-V3) X95.7 / 100.0
BFH	V191'	V3+(V2-V3) X97.9 / 100.0

Data	Output voltage1	
C0H	V192'	V2
C1H	V193'	V2+(V1-V2) X 2.3 / 171.3
C2H	V194'	V2+(V1-V2) X 4.6 / 171.3
C3H	V195'	V2+(V1-V2) X 6.9 / 171.3
C4H	V196'	V2+(V1-V2) X 9.1 / 171.3
C5H	V197'	V2+(V1-V2) X 11.4 / 171.3
C6H	V198'	V2+(V1-V2) X 13.9 / 171.3
C7H	V199'	V2+(V1-V2) X 16.3 / 171.3
C8H	V200'	V2+(V1-V2) X 18.7 / 171.3
C9H	V201'	V2+(V1-V2) X 21.1 / 171.3
CAH	V202'	V2+(V1-V2) X 23.7 / 171.3
CBH	V203'	V2+(V1-V2) X 26.3 / 171.3
CCH	V204'	V2+(V1-V2) X 28.9 / 171.3
CDH	V205'	V2+(V1-V2) X 31.4 / 171.3
CEH	V206'	V2+(V1-V2) X 34.1 / 171.3
CFH	V207'	V2+(V1-V2) X 36.9 / 171.3
D0H	V208'	V2+(V1-V2) X 39.6 / 171.3
D1H	V209'	V2+(V1-V2) X 42.4 / 171.3
D2H	V210'	V2+(V1-V2) X 45.3 / 171.3
D3H	V211'	V2+(V1-V2) X 48.1 / 171.3
D4H	V212'	V2+(V1-V2) X 51.1 / 171.3
D5H	V213'	V2+(V1-V2) X 54.1 / 171.3
D6H	V214'	V2+(V1-V2) X 57.1 / 171.3
D7H	V215'	V2+(V1-V2) X 60.3 / 171.3
D8H	V216'	V2+(V1-V2) X 63.4 / 171.3
D9H	V217'	V2+(V1-V2) X 66.7 / 171.3
DAH	V218'	V2+(V1-V2) X 70.0 / 171.3
DBH	V219'	V2+(V1-V2) X 73.4 / 171.3
DCH	V220'	V2+(V1-V2) X 76.9 / 171.3
DDH	V221'	V2+(V1-V2) X 80.4 / 171.3
DEH	V222'	V2+(V1-V2) X 84.0 / 171.3
DFH	V223'	V2+(V1-V2) X 87.7 / 171.3
E0H	V224'	V2+(V1-V2) X 91.6 / 171.3
E1H	V225'	V2+(V1-V2) X 95.4 / 171.3
E2H	V226'	V2+(V1-V2) X 99.4 / 171.3
E3H	V227'	V2+(V1-V2) X103.6 / 171.3
E4H	V228'	V2+(V1-V2) X107.9 / 171.3
E5H	V229'	V2+(V1-V2) X112.3 / 171.3
E6H	V230'	V2+(V1-V2) X116.9 / 171.3
E7H	V231'	V2+(V1-V2) X121.6 / 171.3
E8H	V232'	V2+(V1-V2) X126.4 / 171.3
E9H	V233'	V2+(V1-V2) X131.4 / 171.3
EAH	V234'	V2+(V1-V2) X136.6 / 171.3
EBH	V235'	V2+(V1-V2) X141.9 / 171.3
ECH	V236'	V2+(V1-V2) X147.3 / 171.3
EDH	V237'	V2+(V1-V2) X153.0 / 171.3
EEH	V238'	V2+(V1-V2) X158.9 / 171.3
EFH	V239'	V2+(V1-V2) X165.0 / 171.3
F0H	V240'	V1
F1H	V241'	V1+(V0-V1) X 6.6 / 126.0
F2H	V242'	V1+(V0-V1) X 13.4 / 126.0
F3H	V243'	V1+(V0-V1) X 20.4 / 126.0
F4H	V244'	V1+(V0-V1) X 27.9 / 126.0
F5H	V245'	V1+(V0-V1) X 35.7 / 126.0
F6H	V246'	V1+(V0-V1) X 43.9 / 126.0
F7H	V247'	V1+(V0-V1) X 52.4 / 126.0
F8H	V248'	V1+(V0-V1) X 61.0 / 126.0
F9H	V249'	V1+(V0-V1) X 70.3 / 126.0
FAH	V250'	V1+(V0-V1) X 79.6 / 126.0
FBH	V251'	V1+(V0-V1) X 88.9 / 126.0
FCH	V252'	V1+(V0-V1) X 98.1 / 126.0
FDH	V253'	V1+(V0-V1) X107.4 / 126.0
FEH	V254'	V1+(V0-V1) X116.7 / 126.0
FFH	V255'	V0

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

(Output voltage2) 0.5 V_{DD2} – 0.5 V ≥ V_8 > V_9 > V_{10} > V_{11} > V_{12} > V_{13} > V_{14} > V_{15} ≥ 0.5 V_{SS2} +0.2 V

Data	Output voltage2	
00H	V0"	V8
01H	V1"	V9
02H	V2"	V10+(V9-V10) X 178.0 / 224.0
03H	V3"	V10+(V9-V10) X 156.6 / 224.0
04H	V4"	V10+(V9-V10) X 139.4 / 224.0
05H	V5"	V10+(V9-V10) X 125.1 / 224.0
06H	V6"	V10+(V9-V10) X 113.0 / 224.0
07H	V7"	V10+(V9-V10) X 103.0 / 224.0
08H	V8"	V10+(V9-V10) X 93.7 / 224.0
09H	V9"	V10+(V9-V10) X 85.1 / 224.0
0AH	V10"	V10+(V9-V10) X 77.3 / 224.0
0BH	V11"	V10+(V9-V10) X 70.1 / 224.0
0CH	V12"	V10+(V9-V10) X 63.7 / 224.0
0DH	V13"	V10+(V9-V10) X 57.7 / 224.0
0EH	V14"	V10+(V9-V10) X 52.0 / 224.0
0FH	V15"	V10+(V9-V10) X 46.7 / 224.0
10H	V16"	V10+(V9-V10) X 41.7 / 224.0
11H	V17"	V10+(V9-V10) X 37.1 / 224.0
12H	V18"	V10+(V9-V10) X 32.9 / 224.0
13H	V19"	V10+(V9-V10) X 29.0 / 224.0
14H	V20"	V10+(V9-V10) X 25.4 / 224.0
15H	V21"	V10+(V9-V10) X 22.3 / 224.0
16H	V22"	V10+(V9-V10) X 19.4 / 224.0
17H	V23"	V10+(V9-V10) X 16.9 / 224.0
18H	V24"	V10+(V9-V10) X 14.4 / 224.0
19H	V25"	V10+(V9-V10) X 12.1 / 224.0
1AH	V26"	V10+(V9-V10) X 10.0 / 224.0
1BH	V27"	V10+(V9-V10) X 8.0 / 224.0
1CH	V28"	V10+(V9-V10) X 6.1 / 224.0
1DH	V29"	V10+(V9-V10) X 4.4 / 224.0
1EH	V30"	V10+(V9-V10) X 2.9 / 224.0
1FH	V31"	V10+(V9-V10) X 1.4 / 224.0
20H	V32"	V10
21H	V33"	V11+(V10-V11) X 33.0 / 34.3
22H	V34"	V11+(V10-V11) X 31.9 / 34.3
23H	V35"	V11+(V10-V11) X 30.7 / 34.3
24H	V36"	V11+(V10-V11) X 29.6 / 34.3
25H	V37"	V11+(V10-V11) X 28.4 / 34.3
26H	V38"	V11+(V10-V11) X 27.3 / 34.3
27H	V39"	V11+(V10-V11) X 26.1 / 34.3
28H	V40"	V11+(V10-V11) X 25.0 / 34.3
29H	V41"	V11+(V10-V11) X 23.9 / 34.3
2AH	V42"	V11+(V10-V11) X 22.7 / 34.3
2BH	V43"	V11+(V10-V11) X 21.6 / 34.3
2CH	V44"	V11+(V10-V11) X 20.4 / 34.3
2DH	V45"	V11+(V10-V11) X 19.3 / 34.3
2EH	V46"	V11+(V10-V11) X 18.1 / 34.3
2FH	V47"	V11+(V10-V11) X 17.0 / 34.3
30H	V48"	V11+(V10-V11) X 16.0 / 34.3
31H	V49"	V11+(V10-V11) X 15.0 / 34.3
32H	V50"	V11+(V10-V11) X 14.0 / 34.3
33H	V51"	V11+(V10-V11) X 13.0 / 34.3
34H	V52"	V11+(V10-V11) X 12.0 / 34.3
35H	V53"	V11+(V10-V11) X 11.0 / 34.3
36H	V54"	V11+(V10-V11) X 10.0 / 34.3
37H	V55"	V11+(V10-V11) X 9.0 / 34.3
38H	V56"	V11+(V10-V11) X 8.0 / 34.3
39H	V57"	V11+(V10-V11) X 7.0 / 34.3
3AH	V58"	V11+(V10-V11) X 6.0 / 34.3
3BH	V59"	V11+(V10-V11) X 5.0 / 34.3
3CH	V60"	V11+(V10-V11) X 4.0 / 34.3
3DH	V61"	V11+(V10-V11) X 3.0 / 34.3
3EH	V62"	V11+(V10-V11) X 2.0 / 34.3
3FH	V63"	V11+(V10-V11) X 1.0 / 34.3

Data	Output voltage2	
40H	V64"	V11
41H	V65"	V12+(V11-V12) X65.4 / 66.4
42H	V66"	V12+(V11-V12) X64.4 / 66.4
43H	V67"	V12+(V11-V12) X63.4 / 66.4
44H	V68"	V12+(V11-V12) X62.4 / 66.4
45H	V69"	V12+(V11-V12) X61.4 / 66.4
46H	V70"	V12+(V11-V12) X60.4 / 66.4
47H	V71"	V12+(V11-V12) X59.4 / 66.4
48H	V72"	V12+(V11-V12) X58.4 / 66.4
49H	V73"	V12+(V11-V12) X57.4 / 66.4
4AH	V74"	V12+(V11-V12) X56.4 / 66.4
4BH	V75"	V12+(V11-V12) X55.4 / 66.4
4CH	V76"	V12+(V11-V12) X54.4 / 66.4
4DH	V77"	V12+(V11-V12) X53.4 / 66.4
4EH	V78"	V12+(V11-V12) X52.4 / 66.4
4FH	V79"	V12+(V11-V12) X51.4 / 66.4
50H	V80"	V12+(V11-V12) X50.4 / 66.4
51H	V81"	V12+(V11-V12) X49.4 / 66.4
52H	V82"	V12+(V11-V12) X48.4 / 66.4
53H	V83"	V12+(V11-V12) X47.4 / 66.4
54H	V84"	V12+(V11-V12) X46.4 / 66.4
55H	V85"	V12+(V11-V12) X45.4 / 66.4
56H	V86"	V12+(V11-V12) X44.4 / 66.4
57H	V87"	V12+(V11-V12) X43.4 / 66.4
58H	V88"	V12+(V11-V12) X42.4 / 66.4
59H	V89"	V12+(V11-V12) X41.4 / 66.4
5AH	V90"	V12+(V11-V12) X40.4 / 66.4
5BH	V91"	V12+(V11-V12) X39.4 / 66.4
5CH	V92"	V12+(V11-V12) X38.4 / 66.4
5DH	V93"	V12+(V11-V12) X37.4 / 66.4
5EH	V94"	V12+(V11-V12) X36.4 / 66.4
5FH	V95"	V12+(V11-V12) X35.4 / 66.4
60H	V96"	V12+(V11-V12) X34.4 66.4
61H	V97"	V12+(V11-V12) X33.4 / 66.4
62H	V98"	V12+(V11-V12) X32.4 / 66.4
63H	V99"	V12+(V11-V12) X31.4 / 66.4
64H	V100"	V12+(V11-V12) X30.4 / 66.4
65H	V101"	V12+(V11-V12) X29.4 / 66.4
66H	V102"	V12+(V11-V12) X28.4 / 66.4
67H	V103"	V12+(V11-V12) X27.4 / 66.4
68H	V104"	V12+(V11-V12) X26.4 / 66.4
69H	V105"	V12+(V11-V12) X25.4 / 66.4
6AH	V106"	V12+(V11-V12) X24.4 / 66.4
6BH	V107"	V12+(V11-V12) X23.4 / 66.4
6CH	V108"	V12+(V11-V12) X22.4 / 66.4
6DH	V109"	V12+(V11-V12) X21.4 / 66.4
6EH	V110"	V12+(V11-V12) X20.4 / 66.4
6FH	V111"	V12+(V11-V12) X19.4 / 66.4
70H	V112"	V12+(V11-V12) X18.3 / 66.4
71H	V113"	V12+(V11-V12) X17.1 / 66.4
72H	V114"	V12+(V11-V12) X16.0 / 66.4
73H	V115"	V12+(V11-V12) X14.9 / 66.4
74H	V116"	V12+(V11-V12) X13.7 / 66.4
75H	V117"	V12+(V11-V12) X12.6 / 66.4
76H	V118"	V12+(V11-V12) X11.4 / 66.4
77H	V119"	V12+(V11-V12) X10.3 / 66.4
78H	V120"	V12+(V11-V12) X 9.1 / 66.4
79H	V121"	V12+(V11-V12) X 8.0 / 66.4
7AH	V122"	V12+(V11-V12) X 6.9 / 66.4
7BH	V123"	V12+(V11-V12) X 5.7 / 66.4
7CH	V124"	V12+(V11-V12) X 4.6 / 66.4
7DH	V125"	V12+(V11-V12) X 3.4 / 66.4
7EH	V126"	V12+(V11-V12) X 2.3 / 66.4
7FH	V127"	V12+(V11-V12) X 1.1 / 66.4

Data	Output voltage2	
80H	V128"	V12
81H	V129"	V13+(V12-V13) X98.7 / 100.0
82H	V130"	V13+(V12-V13) X97.4 / 100.0
83H	V131"	V13+(V12-V13) X96.1 / 100.0
84H	V132"	V13+(V12-V13) X94.9 / 100.0
85H	V133"	V13+(V12-V13) X93.6 / 100.0
86H	V134"	V13+(V12-V13) X92.3 / 100.0
87H	V135"	V13+(V12-V13) X91.0 / 100.0
88H	V136"	V13+(V12-V13) X89.7 / 100.0
89H	V137"	V13+(V12-V13) X88.4 / 100.0
8AH	V138"	V13+(V12-V13) X87.1 / 100.0
8BH	V139"	V13+(V12-V13) X85.9 / 100.0
8CH	V140"	V13+(V12-V13) X84.6 / 100.0
8DH	V141"	V13+(V12-V13) X83.3 / 100.0
8EH	V142"	V13+(V12-V13) X82.0 / 100.0
8FH	V143"	V13+(V12-V13) X80.7 / 100.0
90H	V144"	V13+(V12-V13) X79.4 / 100.0
91H	V145"	V13+(V12-V13) X78.1 / 100.0
92H	V146"	V13+(V12-V13) X76.9 / 100.0
93H	V147"	V13+(V12-V13) X75.6 / 100.0
94H	V148"	V13+(V12-V13) X74.3 / 100.0
95H	V149"	V13+(V12-V13) X73.0 / 100.0
96H	V150"	V13+(V12-V13) X71.7 / 100.0
97H	V151"	V13+(V12-V13) X70.4 / 100.0
98H	V152"	V13+(V12-V13) X69.0 / 100.0
99H	V153"	V13+(V12-V13) X67.6 / 100.0
9AH	V154"	V13+(V12-V13) X66.1 / 100.0
9BH	V155"	V13+(V12-V13) X64.7 / 100.0
9CH	V156"	V13+(V12-V13) X63.3 / 100.0
9DH	V157"	V13+(V12-V13) X61.9 / 100.0
9EH	V158"	V13+(V12-V13) X60.4 / 100.0
9FH	V159"	V13+(V12-V13) X59.0 / 100.0
A0H	V160"	V13+(V12-V13) X57.6 100.0
A1H	V161"	V13+(V12-V13) X56.1 / 100.0
A2H	V162"	V13+(V12-V13) X54.7 / 100.0
A3H	V163"	V13+(V12-V13) X53.3 / 100.0
A4H	V164"	V13+(V12-V13) X51.7 / 100.0
A5H	V165"	V13+(V12-V13) X50.1 / 100.0
A6H	V166"	V13+(V12-V13) X48.6 / 100.0
A7H	V167"	V13+(V12-V13) X47.0 / 100.0
A8H	V168"	V13+(V12-V13) X45.4 / 100.0
A9H	V169"	V13+(V12-V13) X43.9 / 100.0
AAH	V170"	V13+(V12-V13) X42.3 / 100.0
ABH	V171"	V13+(V12-V13) X40.6 / 100.0
ACH	V172"	V13+(V12-V13) X38.9 / 100.0
ADH	V173"	V13+(V12-V13) X37.1 / 100.0
AEH	V174"	V13+(V12-V13) X35.4 / 100.0
AFH	V175"	V13+(V12-V13) X33.7 / 100.0
B0H	V176"	V13+(V12-V13) X32.0 / 100.0
B1H	V177"	V13+(V12-V13) X30.1 / 100.0
B2H	V178"	V13+(V12-V13) X28.3 / 100.0
B3H	V179"	V13+(V12-V13) X26.4 / 100.0
B4H	V180"	V13+(V12-V13) X24.6 / 100.0
B5H	V181"	V13+(V12-V13) X22.7 / 100.0
B6H	V182"	V13+(V12-V13) X20.7 / 100.0
B7H	V183"	V13+(V12-V13) X18.7 / 100.0
B8H	V184"	V13+(V12-V13) X16.7 / 100.0
B9H	V185"	V13+(V12-V13) X14.7 / 100.0
BAH	V186"	V13+(V12-V13) X12.7 / 100.0
BBH	V187"	V13+(V12-V13) X10.7 / 100.0
BCH	V188"	V13+(V12-V13) X 8.6 / 100.0
BDH	V189"	V13+(V12-V13) X 6.4 / 100.0
BEH	V190"	V13+(V12-V13) X 4.3 / 100.0
BFH	V191"	V13+(V12-V13) X 2.1 / 100.0

Data	Output voltage2	
C0H	V192"	V13
C1H	V193"	V14+(V13-V14) X169.0 / 171.3
C2H	V194"	V14+(V13-V14) X166.7 / 171.3
C3H	V195"	V14+(V13-V14) X164.4 / 171.3
C4H	V196"	V14+(V13-V14) X162.1 / 171.3
C5H	V197"	V14+(V13-V14) X159.9 / 171.3
C6H	V198"	V14+(V13-V14) X157.4 / 171.3
C7H	V199"	V14+(V13-V14) X155.0 / 171.3
C8H	V200"	V14+(V13-V14) X152.6 / 171.3
C9H	V201"	V14+(V13-V14) X150.1 / 171.3
CAH	V202"	V14+(V13-V14) X147.6 / 171.3
CBH	V203"	V14+(V13-V14) X145.0 / 171.3
CCH	V204"	V14+(V13-V14) X142.4 / 171.3
CDH	V205"	V14+(V13-V14) X139.9 / 171.3
CEH	V206"	V14+(V13-V14) X137.1 / 171.3
CFH	V207"	V14+(V13-V14) X134.4 / 171.3
D0H	V208"	V14+(V13-V14) X131.7 / 171.3
D1H	V209"	V14+(V13-V14) X128.9 / 171.3
D2H	V210"	V14+(V13-V14) X126.0 / 171.3
D3H	V211"	V14+(V13-V14) X123.1 / 171.3
D4H	V212"	V14+(V13-V14) X120.1 / 171.3
D5H	V213"	V14+(V13-V14) X117.1 / 171.3
D6H	V214"	V14+(V13-V14) X114.1 / 171.3
D7H	V215"	V14+(V13-V14) X111.0 / 171.3
D8H	V216"	V14+(V13-V14) X107.9 / 171.3
D9H	V217"	V14+(V13-V14) X104.6 / 171.3
DAH	V218"	V14+(V13-V14) X101.3 / 171.3
DBH	V219"	V14+(V13-V14) X 97.9 / 171.3
DCH	V220"	V14+(V13-V14) X 94.4 / 171.3
DDH	V221"	V14+(V13-V14) X 90.9 / 171.3
DEH	V222"	V14+(V13-V14) X 87.3 / 171.3
DFH	V223"	V14+(V13-V14) X 83.6 / 171.3
E0H	V224"	V14+(V13-V14) X 79.7 171.3
E1H	V225"	V14+(V13-V14) X 75.9 / 171.3
E2H	V226"	V14+(V13-V14) X 71.9 / 171.3
E3H	V227"	V14+(V13-V14) X 67.7 / 171.3
E4H	V228"	V14+(V13-V14) X 63.4 / 171.3
E5H	V229"	V14+(V13-V14) X 59.0 / 171.3
E6H	V230"	V14+(V13-V14) X 54.4 / 171.3
E7H	V231"	V14+(V13-V14) X 49.7 / 171.3
E8H	V232"	V14+(V13-V14) X 44.9 / 171.3
E9H	V233"	V14+(V13-V14) X 39.9 / 171.3
EAH	V234"	V14+(V13-V14) X 34.7 / 171.3
EBH	V235"	V14+(V13-V14) X 29.4 / 171.3
ECH	V236"	V14+(V13-V14) X 24.0 / 171.3
EDH	V237"	V14+(V13-V14) X 18.3 / 171.3
EEH	V238"	V14+(V13-V14) X 12.4 / 171.3
EFH	V239"	V14+(V13-V14) X 6.3 / 171.3
F0H	V240"	V14
F1H	V241"	V15+(V14-V15) X119.4 / 126.0
F2H	V242"	V15+(V14-V15) X112.6 / 126.0
F3H	V243"	V15+(V14-V15) X105.6 / 126.0
F4H	V244"	V15+(V14-V15) X 98.1 / 126.0
F5H	V245"	V15+(V14-V15) X 90.3 / 126.0
F6H	V246"	V15+(V14-V15) X 82.1 / 126.0
F7H	V247"	V15+(V14-V15) X 73.6 / 126.0
F8H	V248"	V15+(V14-V15) X 65.0 / 126.0
F9H	V249"	V15+(V14-V15) X 55.7 / 126.0
FAH	V250"	V15+(V14-V15) X 46.4 / 126.0
FBH	V251"	V15+(V14-V15) X 37.1 / 126.0
FCH	V252"	V15+(V14-V15) X 27.9 / 126.0
FDH	V253"	V15+(V14-V15) X 18.6 / 126.0
FEH	V254"	V15+(V14-V15) X 9.3 / 126.0
FFH	V255"	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

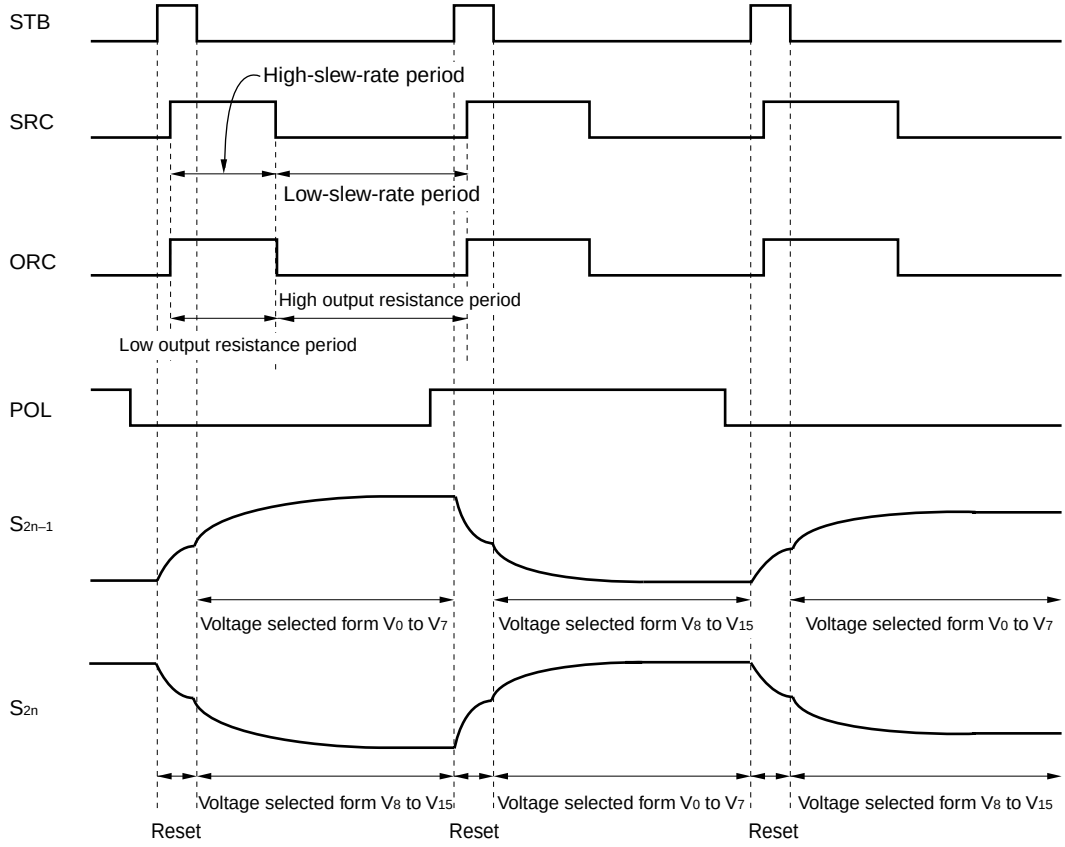
When MODE = H or open and STB is high level, all outputs are reset (shorted) and the gray-scale voltage is output to LCD in synchronization with the falling edge of STB.

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

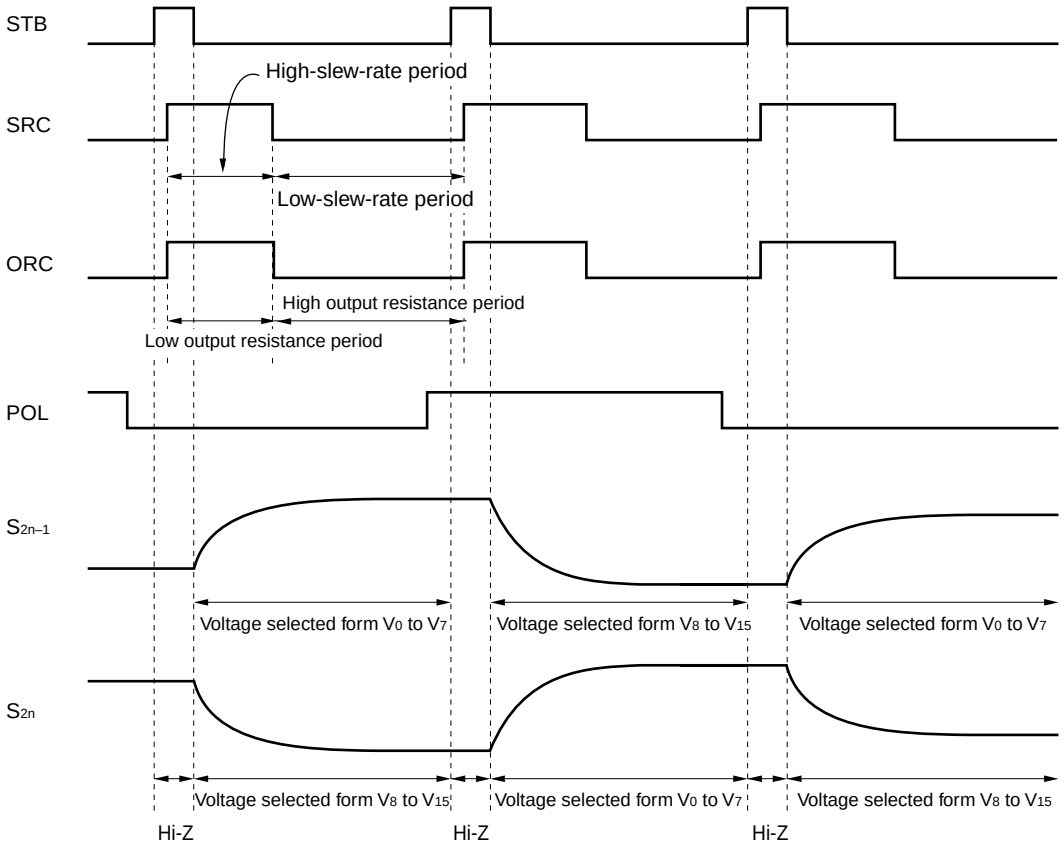
Also, setting the SRC pin to high level allows the bias current value of the output amplifier to rise temporarily, and setting the ORC pin to high level allows the output resistance value of the amplifier to lower temporarily.

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-slew-rate period
Low-slew-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	V
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 power supply static current consumption	I_γ	V_{DD2} = 15.0 V,	V_0, V_8 pins	340	681	1020	μA
		V_0-V_7 = V_8-V_{15} = 7.0 V	V_7, V_{15} pins	–1020	–681	–340	μA
Driver output current	I_{VOH}	V_X = 12 V, V_{OUT} = 11 V **Note1**				–0.40	mA
	I_{VOL}	V_X = 1 V, V_{OUT} = 2 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} **Notes 2,3**			1.3	12	mA
Driver part dynamic current consumption	I_{DD2}	V_{DD2}, with no load **Notes 3,4**			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.

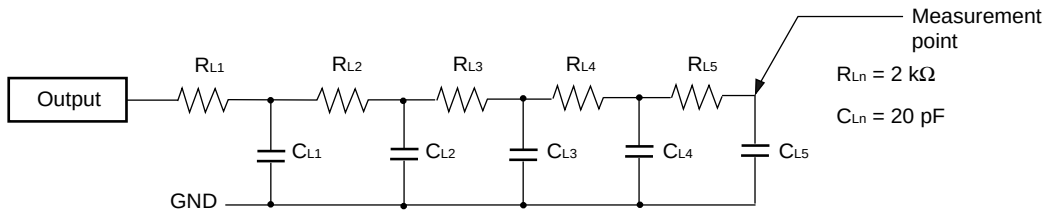
4. Refers to the current consumption per driver when cascades are connected under the assumption of SXGA single-sided mounting (10 units).

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_{DD1} ≤ 3.6 V			17	ns
		C_L = 15 pF, 2.5 V ≤ V_{DD1} < 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)

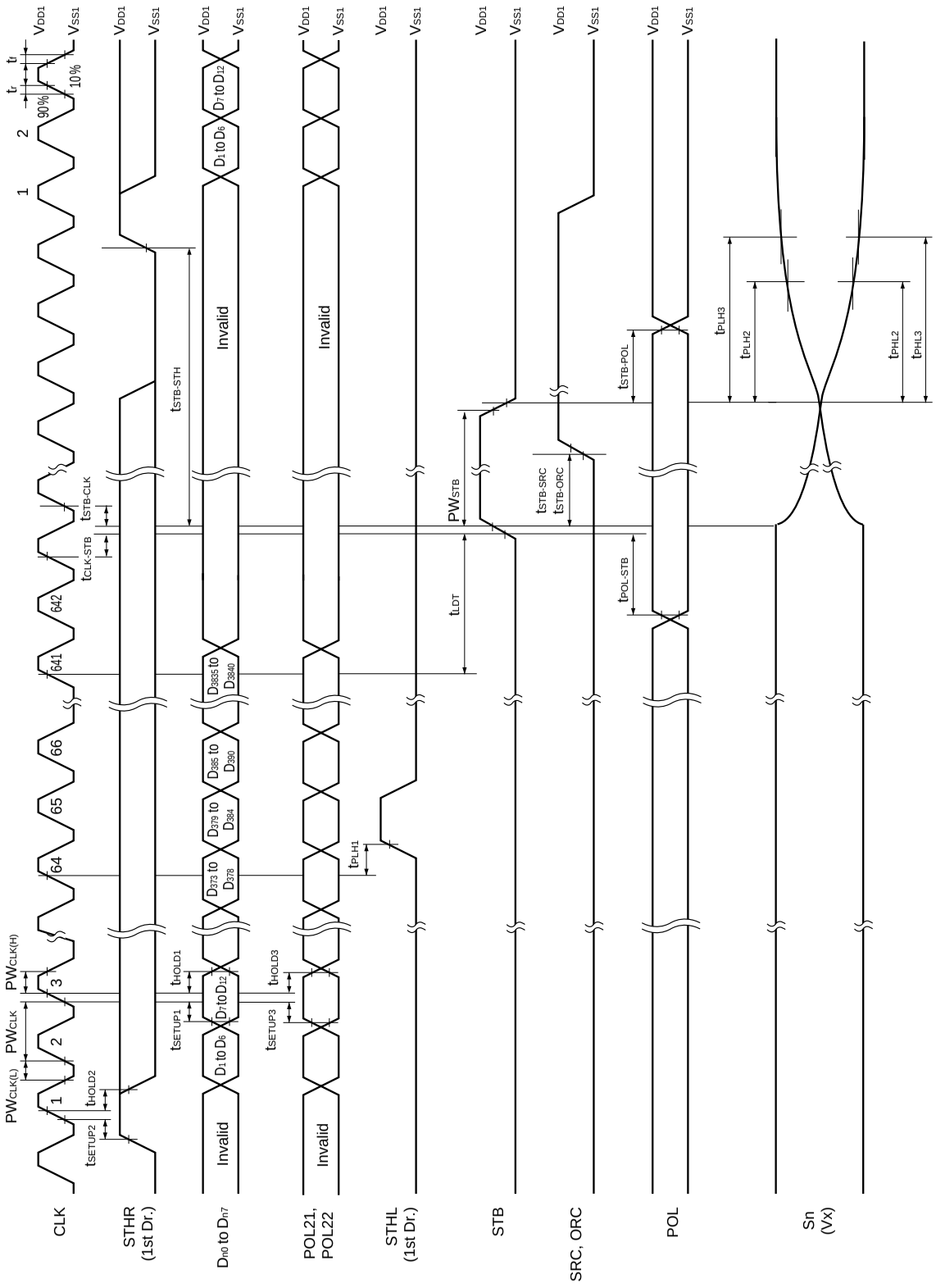
Parameter	Symbol	Condition	MIN.	TYP.	MAX.	Unit
Clock pulse width	PW_{CLK}	3.0 V ≤ V_{DD1} ≤ 3.6 V	18			ns
		2.5 V ≤ V_{DD1} < 3.0 V	25			ns
Clock pulse high period	$PW_{CLK (H)}$	3.0 V ≤ V_{DD1} ≤ 3.6 V	4			ns
		2.5 V ≤ V_{DD1} < 3.0 V	6			ns
Clock pulse low period	$PW_{CLK (L)}$		4			ns
Data setup time	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

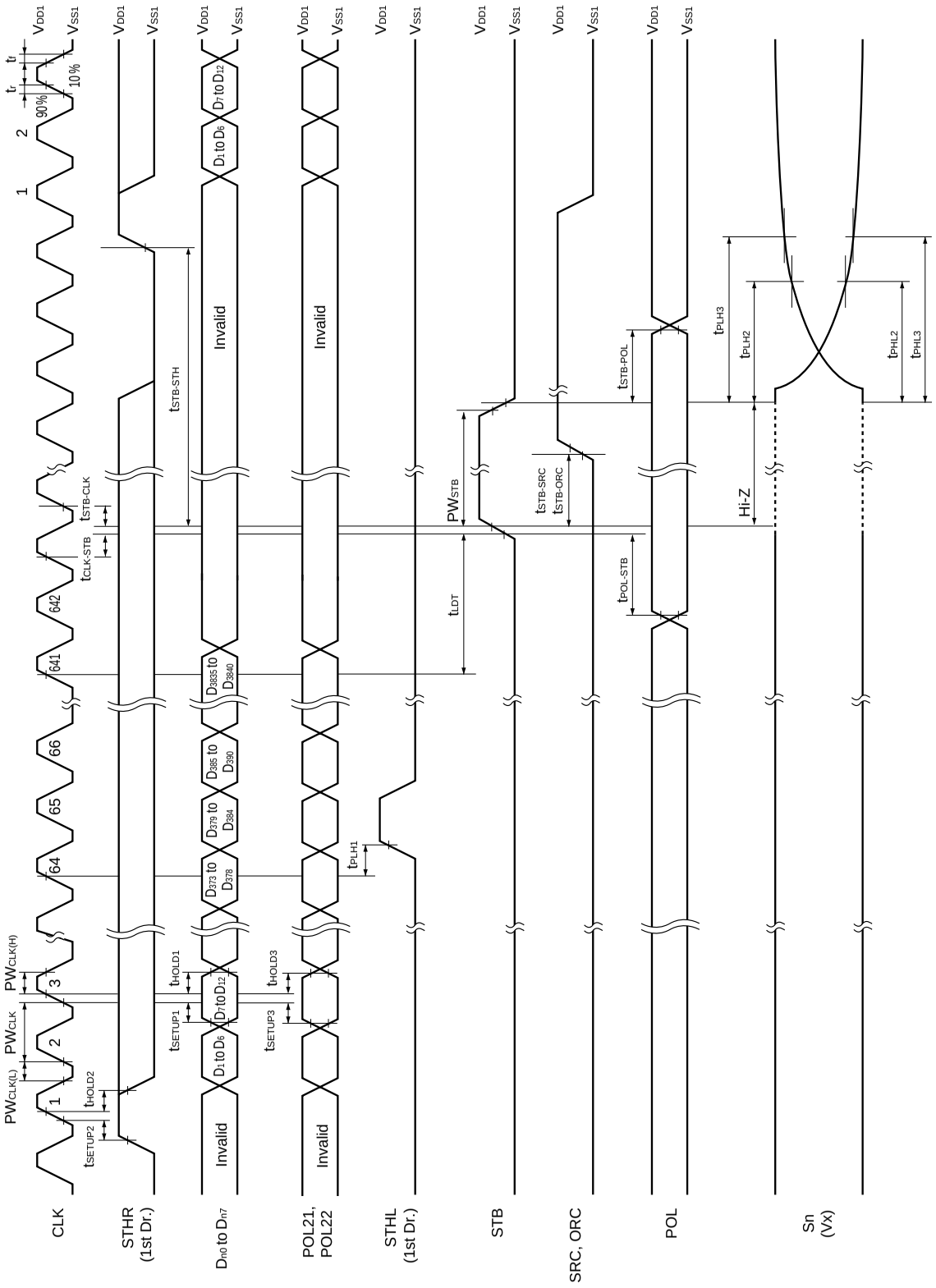
(1) R,/L= H, MODE = H or open

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 μPD160040A.

For more details, refer to the

★ **[Semiconductor Device Mount Manual] (http://www.necel.com/pkg/en/mount/index.html)**

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

μPD160040AN-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.