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April 1st, 2010
Renesas Electronics Corporation

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**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 $V_{SS2} + 0.2 \text{ V}$ to $V_{DD2} - 0.2 \text{ V}$, 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: $f_{CLK} = 55 \text{ MHz MAX.}$ (internal data transfer speed when operating at $3.0 \text{ V} \leq V_{DD1} \leq 3.6 \text{ V}$)
= 40 MHz MAX. (internal data transfer speed when operating at $2.5 \text{ V} \leq V_{DD1} < 3.0 \text{ V}$)
- Output dynamic range: $V_{SS2} + 0.2 \text{ V}$ to $V_{DD2} - 0.2 \text{ V}$
- 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)

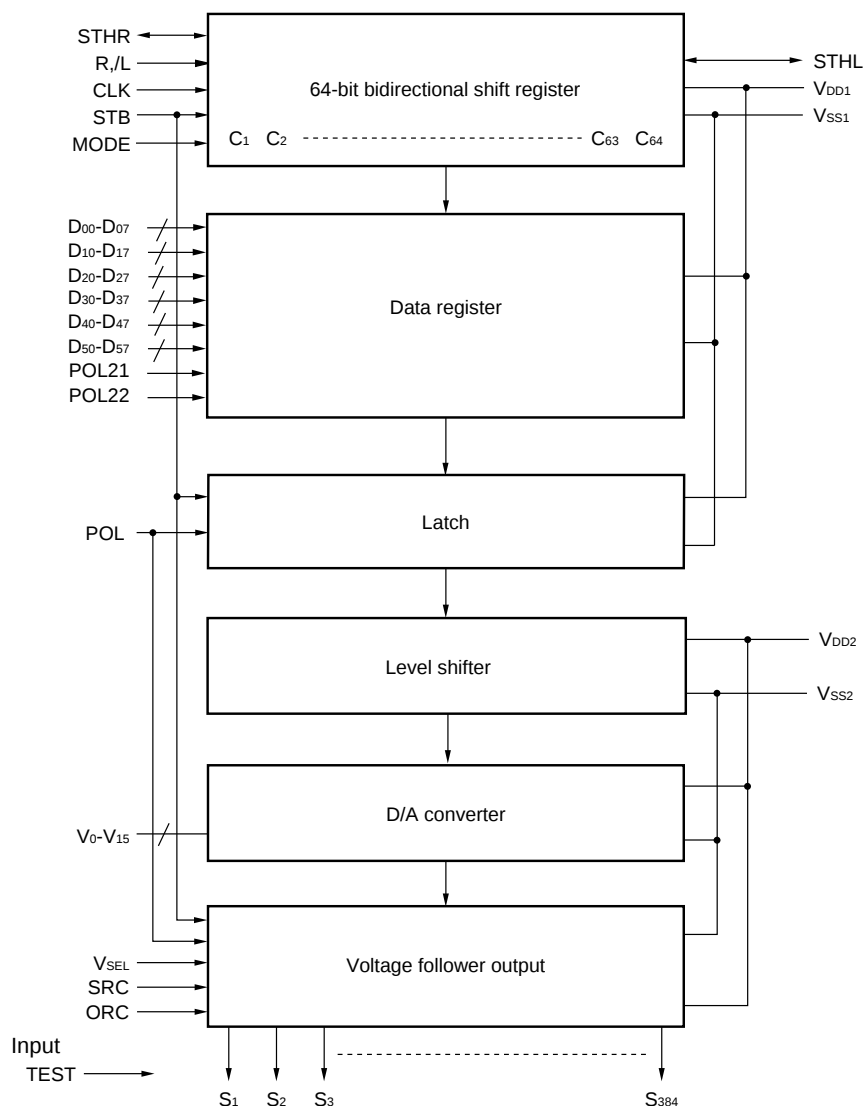
ORDERING INFORMATION

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.

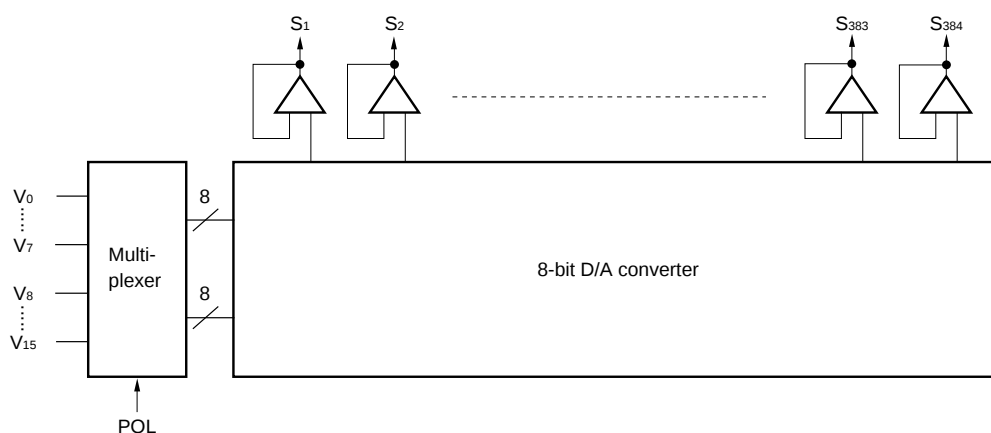
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1. BLOCK DIAGRAM

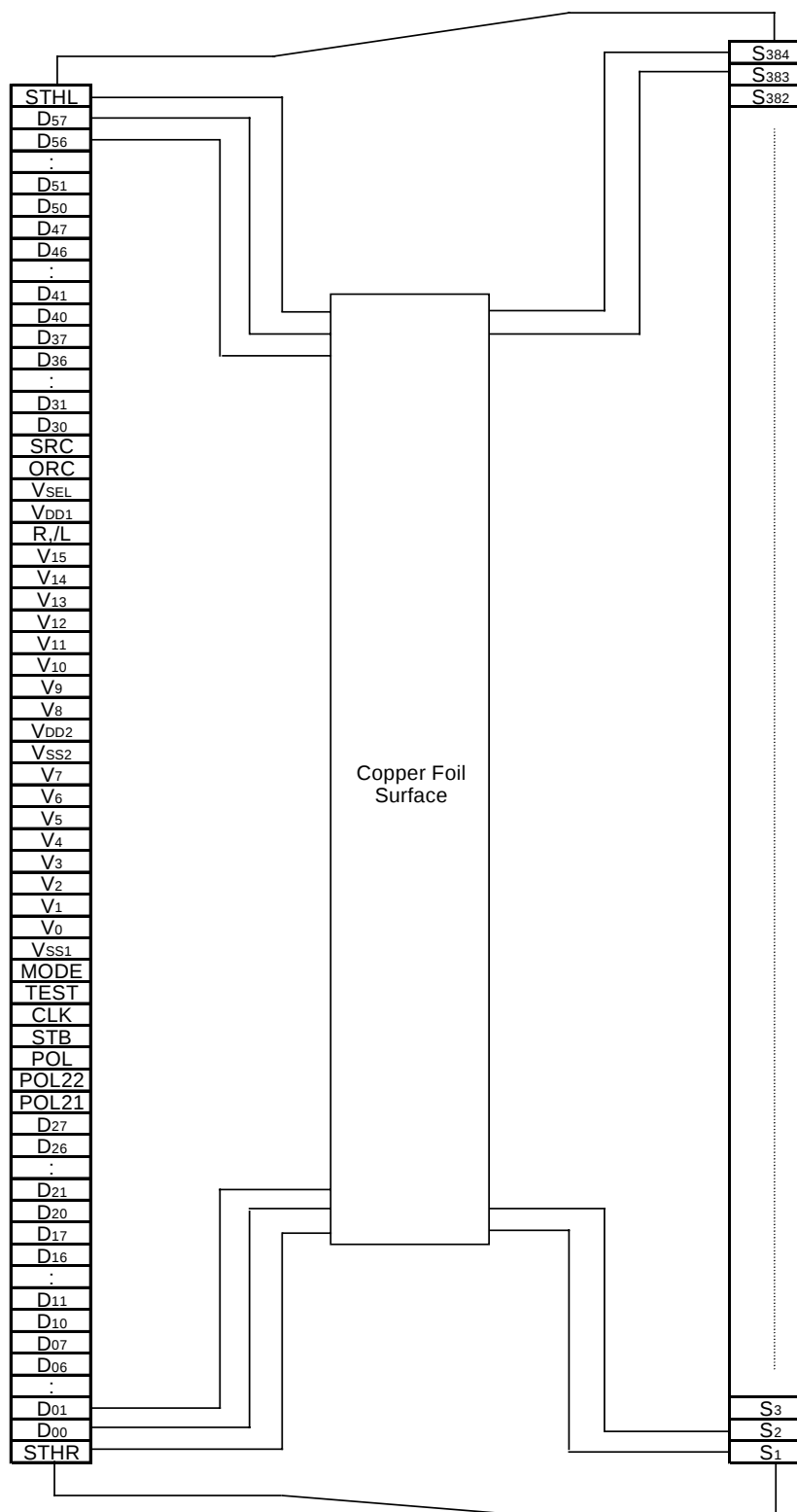


Remark /xxx indicates active low signal.

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	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 ₁₀ to D ₁₇			
D ₂₀ to D ₂₇			
D ₃₀ to D ₃₇			
D ₄₀ to D ₄₇	Port 2 display data	Input	
D ₅₀ to D ₅₇			
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. $V_{DD2} - 0.2 \text{ V} \geq V_0 > V_1 > V_2 > \dots > V_6 > V_7 \geq 0.5 V_{DD2} + 0.5 \text{ V}$ $0.5 V_{DD2} - 0.5 \text{ V} \geq V_8 > V_9 > V_{10} > \dots > V_{14} > V_{15} \geq V_{SS2} + 0.2 \text{ V}$
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.

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

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

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 γ -Corrected 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

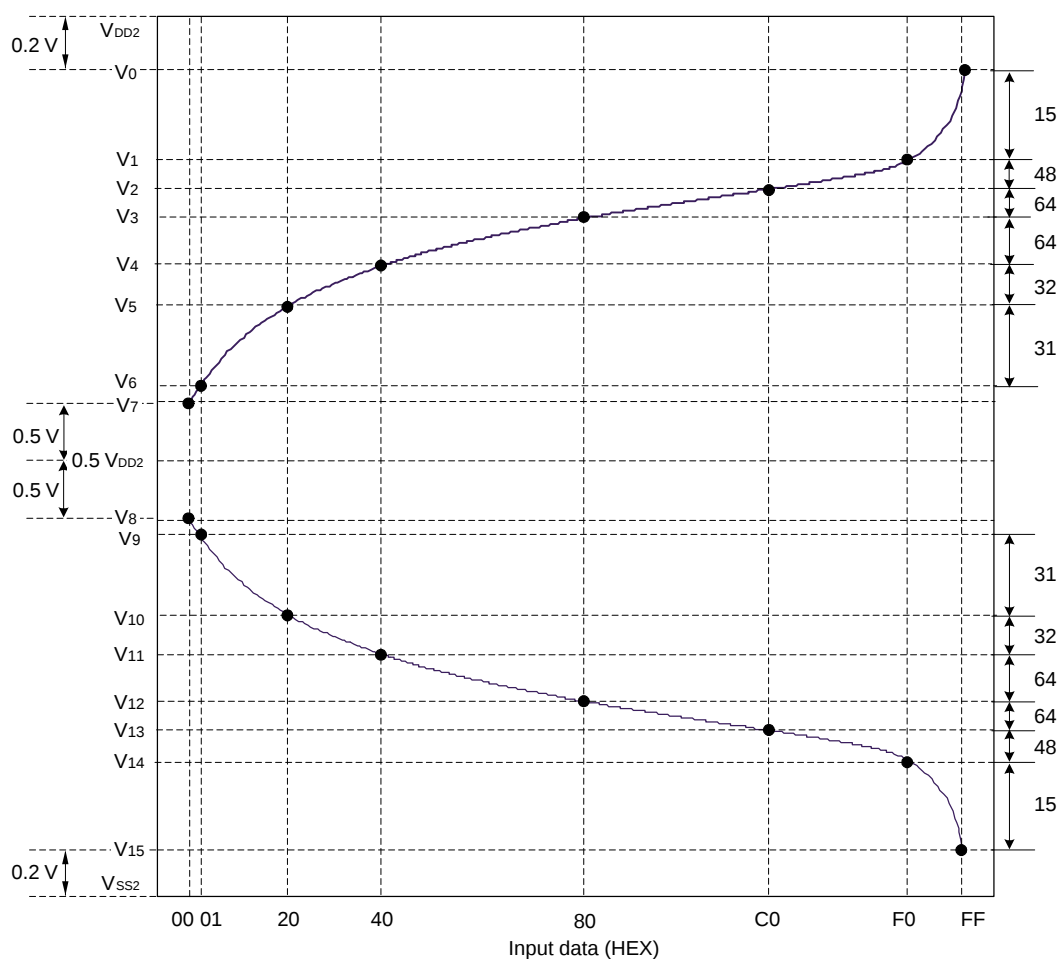
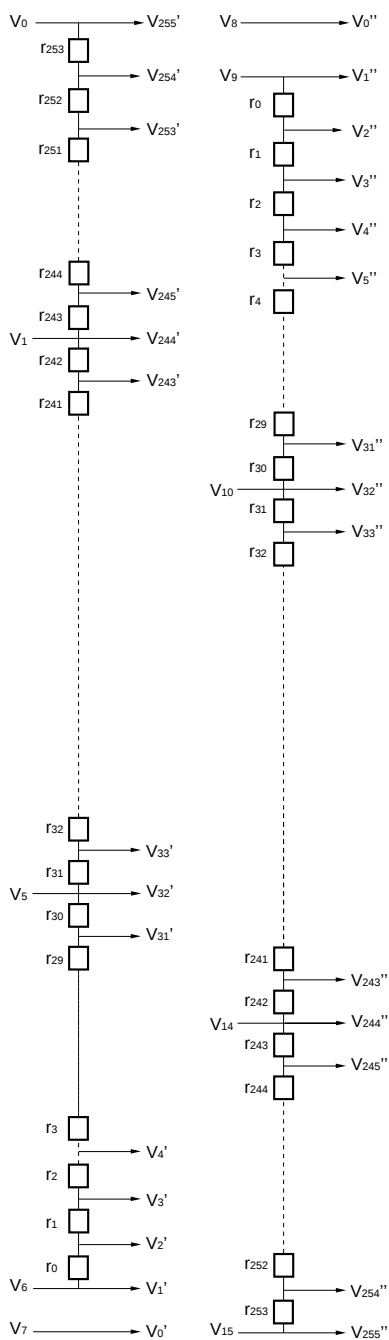


Figure 5-2. γ -Corrected Voltages and Ladder Resistors Ratio

rn	Ratio 1	Ratio 2	Value	rn	Ratio 1	Ratio 2	Value	rn	Ratio 1	Ratio 2	Value	rn	Ratio 1	Ratio 2	Value
r0	46.00	0.0637	644.0	r64	1.00	0.0014	14.0	r128	1.29	0.0018	18.0	r192	2.29	0.0032	32.0
r1	21.43	0.0297	300.0	r65	1.00	0.0014	14.0	r129	1.29	0.0018	18.0	r193	2.29	0.0032	32.0
r2	17.14	0.0237	240.0	r66	1.00	0.0014	14.0	r130	1.29	0.0018	18.0	r194	2.29	0.0032	32.0
r3	14.29	0.0198	200.0	r67	1.00	0.0014	14.0	r131	1.29	0.0018	18.0	r195	2.29	0.0032	32.0
r4	12.14	0.0168	170.0	r68	1.00	0.0014	14.0	r132	1.29	0.0018	18.0	r196	2.43	0.0034	34.0
r5	10.00	0.0139	140.0	r69	1.00	0.0014	14.0	r133	1.29	0.0018	18.0	r197	2.43	0.0034	34.0
r6	9.29	0.0129	130.0	r70	1.00	0.0014	14.0	r134	1.29	0.0018	18.0	r198	2.43	0.0034	34.0
r7	8.57	0.0119	120.0	r71	1.00	0.0014	14.0	r135	1.29	0.0018	18.0	r199	2.43	0.0034	34.0
r8	7.86	0.0109	110.0	r72	1.00	0.0014	14.0	r136	1.29	0.0018	18.0	r200	2.57	0.0036	36.0
r9	7.14	0.0099	100.0	r73	1.00	0.0014	14.0	r137	1.29	0.0018	18.0	r201	2.57	0.0036	36.0
r10	6.43	0.0089	90.0	r74	1.00	0.0014	14.0	r138	1.29	0.0018	18.0	r202	2.57	0.0036	36.0
r11	6.00	0.0083	84.0	r75	1.00	0.0014	14.0	r139	1.29	0.0018	18.0	r203	2.57	0.0036	36.0
r12	5.71	0.0079	80.0	r76	1.00	0.0014	14.0	r140	1.29	0.0018	18.0	r204	2.71	0.0038	38.0
r13	5.29	0.0073	74.0	r77	1.00	0.0014	14.0	r141	1.29	0.0018	18.0	r205	2.71	0.0038	38.0
r14	5.00	0.0069	70.0	r78	1.00	0.0014	14.0	r142	1.29	0.0018	18.0	r206	2.71	0.0038	38.0
r15	4.57	0.0063	64.0	r79	1.00	0.0014	14.0	r143	1.29	0.0018	18.0	r207	2.86	0.0040	40.0
r16	4.29	0.0059	60.0	r80	1.00	0.0014	14.0	r144	1.29	0.0018	18.0	r208	2.86	0.0040	40.0
r17	3.86	0.0053	54.0	r81	1.00	0.0014	14.0	r145	1.29	0.0018	18.0	r209	2.86	0.0040	40.0
r18	3.57	0.0049	50.0	r82	1.00	0.0014	14.0	r146	1.29	0.0018	18.0	r210	3.00	0.0042	42.0
r19	3.14	0.0044	44.0	r83	1.00	0.0014	14.0	r147	1.29	0.0018	18.0	r211	3.00	0.0042	42.0
r20	2.86	0.0040	40.0	r84	1.00	0.0014	14.0	r148	1.29	0.0018	18.0	r212	3.00	0.0042	42.0
r21	2.57	0.0036	36.0	r85	1.00	0.0014	14.0	r149	1.29	0.0018	18.0	r213	3.14	0.0044	44.0
r22	2.43	0.0034	34.0	r86	1.00	0.0014	14.0	r150	1.43	0.0020	20.0	r214	3.14	0.0044	44.0
r23	2.29	0.0032	32.0	r87	1.00	0.0014	14.0	r151	1.43	0.0020	20.0	r215	3.29	0.0046	46.0
r24	2.14	0.0030	30.0	r88	1.00	0.0014	14.0	r152	1.43	0.0020	20.0	r216	3.29	0.0046	46.0
r25	2.00	0.0028	28.0	r89	1.00	0.0014	14.0	r153	1.43	0.0020	20.0	r217	3.43	0.0047	48.0
r26	1.86	0.0026	26.0	r90	1.00	0.0014	14.0	r154	1.43	0.0020	20.0	r218	3.43	0.0047	48.0
r27	1.71	0.0024	24.0	r91	1.00	0.0014	14.0	r155	1.43	0.0020	20.0	r219	3.57	0.0049	50.0
r28	1.57	0.0022	22.0	r92	1.00	0.0014	14.0	r156	1.43	0.0020	20.0	r220	3.57	0.0049	50.0
r29	1.43	0.0020	20.0	r93	1.00	0.0014	14.0	r157	1.43	0.0020	20.0	r221	3.71	0.0051	52.0
r30	1.43	0.0020	20.0	r94	1.00	0.0014	14.0	r158	1.43	0.0020	20.0	r222	3.86	0.0053	54.0
r31	1.29	0.0018	18.0	r95	1.00	0.0014	14.0	r159	1.43	0.0020	20.0	r223	3.86	0.0053	54.0
r32	1.14	0.0016	16.0	r96	1.00	0.0014	14.0	r160	1.43	0.0020	20.0	r224	4.00	0.0055	56.0
r33	1.14	0.0016	16.0	r97	1.00	0.0014	14.0	r161	1.43	0.0020	20.0	r225	4.14	0.0057	58.0
r34	1.14	0.0016	16.0	r98	1.00	0.0014	14.0	r162	1.57	0.0022	22.0	r226	4.29	0.0059	60.0
r35	1.14	0.0016	16.0	r99	1.00	0.0014	14.0	r163	1.57	0.0022	22.0	r227	4.43	0.0061	62.0
r36	1.14	0.0016	16.0	r100	1.00	0.0014	14.0	r164	1.57	0.0022	22.0	r228	4.57	0.0063	64.0
r37	1.14	0.0016	16.0	r101	1.00	0.0014	14.0	r165	1.57	0.0022	22.0	r229	4.71	0.0065	66.0
r38	1.14	0.0016	16.0	r102	1.00	0.0014	14.0	r166	1.57	0.0022	22.0	r230	4.86	0.0067	68.0
r39	1.14	0.0016	16.0	r103	1.00	0.0014	14.0	r167	1.57	0.0022	22.0	r231	5.00	0.0069	70.0
r40	1.14	0.0016	16.0	r104	1.00	0.0014	14.0	r168	1.57	0.0022	22.0	r232	5.14	0.0071	72.0
r41	1.14	0.0016	16.0	r105	1.00	0.0014	14.0	r169	1.71	0.0024	24.0	r233	5.29	0.0073	74.0
r42	1.14	0.0016	16.0	r106	1.00	0.0014	14.0	r170	1.71	0.0024	24.0	r234	5.43	0.0075	76.0
r43	1.14	0.0016	16.0	r107	1.00	0.0014	14.0	r171	1.71	0.0024	24.0	r235	5.71	0.0079	80.0
r44	1.14	0.0016	16.0	r108	1.00	0.0014	14.0	r172	1.71	0.0024	24.0	r236	5.86	0.0081	82.0
r45	1.14	0.0016	16.0	r109	1.00	0.0014	14.0	r173	1.71	0.0024	24.0	r237	6.14	0.0085	86.0
r46	1.00	0.0014	14.0	r110	1.14	0.0016	16.0	r174	1.71	0.0024	24.0	r238	6.29	0.0087	88.0
r47	1.00	0.0014	14.0	r111	1.14	0.0016	16.0	r175	1.86	0.0026	26.0	r239	6.57	0.0091	92.0
r48	1.00	0.0014	14.0	r112	1.14	0.0016	16.0	r176	1.86	0.0026	26.0	r240	6.86	0.0095	96.0
r49	1.00	0.0014	14.0	r113	1.14	0.0016	16.0	r177	1.86	0.0026	26.0	r241	7.00	0.0097	98.0
r50	1.00	0.0014	14.0	r114	1.14	0.0016	16.0	r178	1.86	0.0026	26.0	r242	7.43	0.0103	104.0
r51	1.00	0.0014	14.0	r115	1.14	0.0016	16.0	r179	1.86	0.0026	26.0	r243	7.86	0.0109	110.0
r52	1.00	0.0014	14.0	r116	1.14	0.0016	16.0	r180	2.00	0.0028	28.0	r244	8.14	0.0113	114.0
r53	1.00	0.0014	14.0	r117	1.14	0.0016	16.0	r181	2.00	0.0028	28.0	r245	8.57	0.0119	120.0
r54	1.00	0.0014	14.0	r118	1.14	0.0016	16.0	r182	2.00	0.0028	28.0	r246	8.57	0.0119	120.0
r55	1.00	0.0014	14.0	r119	1.14	0.0016	16.0	r183	2.00	0.0028	28.0	r247	9.29	0.0129	130.0
r56	1.00	0.0014	14.0	r120	1.14	0.0016	16.0	r184	2.00	0.0028	28.0	r248	9.29	0.0129	130.0
r57	1.00	0.0014	14.0	r121	1.14	0.0016	16.0	r185	2.00	0.0028	28.0	r249	9.29	0.0129	130.0
r58	1.00	0.0014	14.0	r122	1.14	0.0016	16.0	r186	2.14	0.0030	30.0	r250	9.29	0.0129	130.0
r59	1.00	0.0014	14.0	r123	1.14	0.0016	16.0	r187	2.14	0.0030	30.0	r251	9.29	0.0129	130.0
r60	1.00	0.0014	14.0	r124	1.14	0.0016	16.0	r188	2.14	0.0030	30.0	r252	9.29	0.0129	130.0
r61	1.00	0.0014	14.0	r125	1.14	0.0016	16.0	r189	2.14	0.0030	30.0	r253	9.29	0.0129	130.0
r62	1.00	0.0014	14.0	r126	1.14	0.0016	16.0	r190	2.14	0.0030	30.0	Total resistance			10108
r63	1.00	0.0014	14.0	r127	1.29	0.0018	18.0	r191	2.29	0.0032	32.0	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) $V_{DD2} - 0.2 \text{ V} \geq V_0 > V_1 > V_2 > V_3 > V_4 > V_5 > V_6 > V_7 \geq 0.5 V_{DD2} + 0.5 \text{ V}$

Data	Output voltage1	Data	Output voltage1	Data	Output voltage1	Data	Output voltage1
00H	V0' V7	40H	V64' V4	80H	V128' V3	C0H	V192' V2
01H	V1' V6	41H	V65' V4+(V3-V4) X 1.0 / 66.4	81H	V129' V3+(V2-V3) X 1.3 / 100.0	C1H	V193' V2+(V1-V2) X 2.3 / 171.3
02H	V2' V6+(V5-V6) X 46.0 / 224.0	42H	V66' V4+(V3-V4) X 2.0 / 66.4	82H	V130' V3+(V2-V3) X 2.6 / 100.0	C2H	V194' V2+(V1-V2) X 4.6 / 171.3
03H	V3' V6+(V5-V6) X 67.4 / 224.0	43H	V67' V4+(V3-V4) X 3.0 / 66.4	83H	V131' V3+(V2-V3) X 3.9 / 100.0	C3H	V195' V2+(V1-V2) X 6.9 / 171.3
04H	V4' V6+(V5-V6) X 84.6 / 224.0	44H	V68' V4+(V3-V4) X 4.0 / 66.4	84H	V132' V3+(V2-V3) X 5.1 / 100.0	C4H	V196' V2+(V1-V2) X 9.1 / 171.3
05H	V5' V6+(V5-V6) X 98.9 / 224.0	45H	V69' V4+(V3-V4) X 5.0 / 66.4	85H	V133' V3+(V2-V3) X 6.4 / 100.0	C5H	V197' V2+(V1-V2) X 13.9 / 171.3
06H	V6' V6+(V5-V6) X111.0 / 224.0	46H	V70' V4+(V3-V4) X 6.0 / 66.4	86H	V134' V3+(V2-V3) X 7.7 / 100.0	C6H	V198' V2+(V1-V2) X 21.1 / 171.3
07H	V7' V6+(V5-V6) X121.0 / 224.0	47H	V71' V4+(V3-V4) X 7.0 / 66.4	87H	V135' V3+(V2-V3) X 9.0 / 100.0	C7H	V199' V2+(V1-V2) X 23.7 / 171.3
08H	V8' V6+(V5-V6) X130.3 / 224.0	48H	V72' V4+(V3-V4) X 8.0 / 66.4	88H	V136' V3+(V2-V3) X10.3 / 100.0	C8H	V200' V2+(V1-V2) X 26.3 / 171.3
09H	V9' V6+(V5-V6) X138.9 / 224.0	49H	V73' V4+(V3-V4) X 9.0 / 66.4	89H	V137' V3+(V2-V3) X11.6 / 100.0	C9H	V201' V2+(V1-V2) X 28.9 / 171.3
0AH	V10' V6+(V5-V6) X146.7 / 224.0	4AH	V74' V4+(V3-V4) X10.0 / 66.4	8AH	V138' V3+(V2-V3) X12.9 / 100.0	CAH	V202' V2+(V1-V2) X 31.4 / 171.3
0BH	V11' V6+(V5-V6) X153.9 / 224.0	4BH	V75' V4+(V3-V4) X11.0 / 66.4	8BH	V139' V3+(V2-V3) X14.1 / 100.0	CBH	V203' V2+(V1-V2) X 34.1 / 171.3
0CH	V12' V6+(V5-V6) X160.3 / 224.0	4CH	V76' V4+(V3-V4) X12.0 / 66.4	8CH	V140' V3+(V2-V3) X15.4 / 100.0	CCH	V204' V2+(V1-V2) X 36.9 / 171.3
0DH	V13' V6+(V5-V6) X166.3 / 224.0	4DH	V77' V4+(V3-V4) X13.0 / 66.4	8DH	V141' V3+(V2-V3) X16.7 / 100.0	CDH	V205' V2+(V1-V2) X 39.6 / 171.3
0EH	V14' V6+(V5-V6) X172.0 / 224.0	4EH	V78' V4+(V3-V4) X14.0 / 66.4	8EH	V142' V3+(V2-V3) X18.0 / 100.0	CEH	V206' V2+(V1-V2) X 42.4 / 171.3
0FH	V15' V6+(V5-V6) X177.3 / 224.0	4FH	V79' V4+(V3-V4) X15.0 / 66.4	8FH	V143' V3+(V2-V3) X19.3 / 100.0	CFH	V207' V2+(V1-V2) X 45.3 / 171.3
10H	V16' V6+(V5-V6) X182.3 / 224.0	50H	V80' V4+(V3-V4) X16.0 / 66.4	90H	V144' V3+(V2-V3) X20.6 / 100.0	D0H	V208' V2+(V1-V2) X 48.1 / 171.3
11H	V17' V6+(V5-V6) X186.9 / 224.0	51H	V81' V4+(V3-V4) X17.0 / 66.4	91H	V145' V3+(V2-V3) X21.9 / 100.0	D1H	V209' V2+(V1-V2) X 51.1 / 171.3
12H	V18' V6+(V5-V6) X191.1 / 224.0	52H	V82' V4+(V3-V4) X18.0 / 66.4	92H	V146' V3+(V2-V3) X23.1 / 100.0	D2H	V210' V2+(V1-V2) X 54.1 / 171.3
13H	V19' V6+(V5-V6) X195.0 / 224.0	53H	V83' V4+(V3-V4) X19.0 / 66.4	93H	V147' V3+(V2-V3) X24.4 / 100.0	D3H	V211' V2+(V1-V2) X 57.1 / 171.3
14H	V20' V6+(V5-V6) X198.6 / 224.0	54H	V84' V4+(V3-V4) X20.0 / 66.4	94H	V148' V3+(V2-V3) X25.7 / 100.0	D4H	V212' V2+(V1-V2) X 60.3 / 171.3
15H	V21' V6+(V5-V6) X201.7 / 224.0	55H	V85' V4+(V3-V4) X21.0 / 66.4	95H	V149' V3+(V2-V3) X27.0 / 100.0	D5H	V213' V2+(V1-V2) X 63.4 / 171.3
16H	V22' V6+(V5-V6) X204.6 / 224.0	56H	V86' V4+(V3-V4) X22.0 / 66.4	96H	V150' V3+(V2-V3) X28.3 / 100.0	D6H	V214' V2+(V1-V2) X 66.7 / 171.3
17H	V23' V6+(V5-V6) X207.1 / 224.0	57H	V87' V4+(V3-V4) X23.0 / 66.4	97H	V151' V3+(V2-V3) X29.6 / 100.0	D7H	V215' V2+(V1-V2) X 70.0 / 171.3
18H	V24' V6+(V5-V6) X209.6 / 224.0	58H	V88' V4+(V3-V4) X24.0 / 66.4	98H	V152' V3+(V2-V3) X31.0 / 100.0	D8H	V216' V2+(V1-V2) X 73.4 / 171.3
19H	V25' V6+(V5-V6) X211.9 / 224.0	59H	V89' V4+(V3-V4) X25.0 / 66.4	99H	V153' V3+(V2-V3) X32.4 / 100.0	D9H	V217' V2+(V1-V2) X 76.9 / 171.3
1AH	V26' V6+(V5-V6) X214.0 / 224.0	5AH	V90' V4+(V3-V4) X26.0 / 66.4	9AH	V154' V3+(V2-V3) X33.9 / 100.0	DAH	V218' V2+(V1-V2) X 80.4 / 171.3
1BH	V27' V6+(V5-V6) X216.0 / 224.0	5BH	V91' V4+(V3-V4) X27.0 / 66.4	9BH	V155' V3+(V2-V3) X35.3 / 100.0	E0H	V219' V2+(V1-V2) X 84.0 / 171.3
1CH	V28' V6+(V5-V6) X217.9 / 224.0	5CH	V92' V4+(V3-V4) X28.0 / 66.4	9CH	V156' V3+(V2-V3) X36.7 / 100.0	E1H	V220' V2+(V1-V2) X 87.7 / 171.3
1DH	V29' V6+(V5-V6) X219.6 / 224.0	5DH	V93' V4+(V3-V4) X29.0 / 66.4	9DH	V157' V3+(V2-V3) X38.1 / 100.0	E2H	V221' V2+(V1-V2) X 91.6 / 171.3
1EH	V30' V6+(V5-V6) X221.1 / 224.0	5EH	V94' V4+(V3-V4) X30.0 / 66.4	9EH	V158' V3+(V2-V3) X39.6 / 100.0	E3H	V222' V2+(V1-V2) X 95.4 / 171.3
1FH	V31' V6+(V5-V6) X222.6 / 224.0	5FH	V95' V4+(V3-V4) X31.0 / 66.4	9FH	V159' V3+(V2-V3) X41.0 / 100.0	E4H	V223' V2+(V1-V2) X 99.4 / 171.3
20H	V32' V5	60H	V96' V4+(V3-V4) X32.0 / 66.4	A0H	V160' V3+(V2-V3) X42.4 / 100.0	E5H	V224' V2+(V1-V2) X103.6 / 171.3
21H	V33' V5+(V4-V5) X 1.3 / 34.3	61H	V97' V4+(V3-V4) X33.0 / 66.4	A1H	V161' V3+(V2-V3) X43.9 / 100.0	E6H	V225' V2+(V1-V2) X107.9 / 171.3
22H	V34' V5+(V4-V5) X 2.4 / 34.3	62H	V98' V4+(V3-V4) X34.0 / 66.4	A2H	V162' V3+(V2-V3) X45.3 / 100.0	E7H	V226' V2+(V1-V2) X112.3 / 171.3
23H	V35' V5+(V4-V5) X 3.6 / 34.3	63H	V99' V4+(V3-V4) X35.0 / 66.4	A3H	V163' V3+(V2-V3) X46.7 / 100.0	E8H	V227' V2+(V1-V2) X116.9 / 171.3
24H	V36' V5+(V4-V5) X 4.7 / 34.3	64H	V100' V4+(V3-V4) X36.0 / 66.4	A4H	V164' V3+(V2-V3) X48.3 / 100.0	E9H	V228' V2+(V1-V2) X121.6 / 171.3
25H	V37' V5+(V4-V5) X 5.9 / 34.3	65H	V101' V4+(V3-V4) X37.0 / 66.4	A5H	V165' V3+(V2-V3) X49.9 / 100.0	EAH	V229' V2+(V1-V2) X126.4 / 171.3
26H	V38' V5+(V4-V5) X 7.0 / 34.3	66H	V102' V4+(V3-V4) X38.0 / 66.4	A6H	V166' V3+(V2-V3) X51.4 / 100.0	EBH	V230' V2+(V1-V2) X131.4 / 171.3
27H	V39' V5+(V4-V5) X 8.1 / 34.3	67H	V103' V4+(V3-V4) X39.0 / 66.4	A7H	V167' V3+(V2-V3) X53.0 / 100.0	EBH	V231' V2+(V1-V2) X136.6 / 171.3
28H	V40' V5+(V4-V5) X 9.3 / 34.3	68H	V104' V4+(V3-V4) X40.0 / 66.4	A8H	V168' V3+(V2-V3) X54.6 / 100.0	EBH	V232' V2+(V1-V2) X141.9 / 171.3
29H	V41' V5+(V4-V5) X 10.4 / 34.3	69H	V105' V4+(V3-V4) X41.0 / 66.4	A9H	V169' V3+(V2-V3) X56.1 / 100.0	EBH	V233' V2+(V1-V2) X147.3 / 171.3
2AH	V42' V5+(V4-V5) X 11.6 / 34.3	6AH	V106' V4+(V3-V4) X42.0 / 66.4	AAH	V170' V3+(V2-V3) X57.7 / 100.0	EDH	V234' V2+(V1-V2) X153.0 / 171.3
2BH	V43' V5+(V4-V5) X 12.7 / 34.3	6BH	V107' V4+(V3-V4) X43.0 / 66.4	ABH	V171' V3+(V2-V3) X59.4 / 100.0	EEH	V235' V2+(V1-V2) X158.9 / 171.3
2CH	V44' V5+(V4-V5) X 13.9 / 34.3	6CH	V108' V4+(V3-V4) X44.0 / 66.4	ACH	V172' V3+(V2-V3) X61.1 / 100.0	EFH	V236' V2+(V1-V2) X165.0 / 171.3
2DH	V45' V5+(V4-V5) X 15.0 / 34.3	6DH	V109' V4+(V3-V4) X45.0 / 66.4	ADH	V173' V3+(V2-V3) X62.9 / 100.0	F0H	V240' V1
2EH	V46' V5+(V4-V5) X 16.1 / 34.3	6EH	V110' V4+(V3-V4) X46.0 / 66.4	AEH	V174' V3+(V2-V3) X64.6 / 100.0	F1H	V241' V1+(V0-V1) X 6.6 / 126.0
2FH	V47' V5+(V4-V5) X 17.3 / 34.3	6FH	V111' V4+(V3-V4) X47.0 / 66.4	AFH	V175' V3+(V2-V3) X66.3 / 100.0	F2H	V242' V1+(V0-V1) X 13.4 / 126.0
30H	V48' V5+(V4-V5) X 18.3 / 34.3	70H	V112' V4+(V3-V4) X48.1 / 66.4	B0H	V176' V3+(V2-V3) X68.0 / 100.0	F3H	V243' V1+(V0-V1) X 20.4 / 126.0
31H	V49' V5+(V4-V5) X 19.3 / 34.3	71H	V113' V4+(V3-V4) X49.3 / 66.4	B1H	V177' V3+(V2-V3) X69.9 / 100.0	F4H	V244' V1+(V0-V1) X 27.9 / 126.0
32H	V50' V5+(V4-V5) X 20.3 / 34.3	72H	V114' V4+(V3-V4) X50.4 / 66.4	B2H	V178' V3+(V2-V3) X71.7 / 100.0	F5H	V245' V1+(V0-V1) X 35.7 / 126.0
33H	V51' V5+(V4-V5) X 21.3 / 34.3	73H	V115' V4+(V3-V4) X51.6 / 66.4	B3H	V179' V3+(V2-V3) X73.6 / 100.0	F6H	V246' V1+(V0-V1) X 43.9 / 126.0
34H	V52' V5+(V4-V5) X 22.3 / 34.3	74H	V116' V4+(V3-V4) X52.7 / 66.4	B4H	V180' V3+(V2-V3) X75.4 / 100.0	F7H	V247' V1+(V0-V1) X 52.4 / 126.0
35H	V53' V5+(V4-V5) X 23.3 / 34.3	75H	V117' V4+(V3-V4) X53.9 / 66.4	B5H	V181' V3+(V2-V3) X77.3 / 100.0	F8H	V248' V1+(V0-V1) X 61.0 / 126.0
36H	V54' V5+(V4-V5) X 24.3 / 34.3	76H	V118' V4+(V3-V4) X55.0 / 66.4	B6H	V182' V3+(V2-V3) X79.3 / 100.0	F9H	V249' V1+(V0-V1) X 70.3 / 126.0
37H	V55' V5+(V4-V5) X 25.3 / 34.3	77H	V119' V4+(V3-V4) X56.1 / 66.4	B7H	V183' V3+(V2-V3) X81.3 / 100.0	FAH	V250' V1+(V0-V1) X 79.6 / 126.0
38H	V56' V5+(V4-V5) X 26.3 / 34.3	78H	V120' V4+(V3-V4) X57.3 / 66.4	B8H	V184' V3+(V2-V3) X83.3 / 100.0	FBH	V251' V1+(V0-V1) X 88.9 / 126.0
39H	V57' V5+(V4-V5) X 27.3 / 34.3	79H	V121' V4+(V3-V4) X58.4 / 66.4	B9H	V185' V3+(V2-V3) X85.3 / 100.0	FCH	V252' V1+(V0-V1) X 98.1 / 126.0
3AH	V58' V5+(V4-V5) X 28.3 / 34.3	7AH	V122' V4+(V3-V4) X59.6 / 66.4	BAH	V186' V3+(V2-V3) X87.3 / 100.0	FDH	V253' V1+(V0-V1) X107.4 / 126.0
3BH	V59' V5+(V4-V5) X 29.3 / 34.3	7BH	V123' V4+(V3-V4) X60.7 / 66.4	BBH	V187' V3+(V2-V3) X89.3 / 100.0	FEH	V254' V1+(V0-V1) X116.7 / 126.0
3CH	V60' V5+(V4-V5) X 30.3 / 34.3	7CH	V124' V4+(V3-V4) X61.9 / 66.4	BCH	V188' V3+(V2-V3) X91.4 / 100.0	FFH	V255' V0
3DH	V61' V5+(V4-V5) X 31.3 / 34.3	7DH	V125' V4+(V3-V4) X63.0 / 66.4	BDH	V189' V3+(V2-V3) X93.6 / 100.0		
3EH	V62' V5+(V4-V5) X 32.3 / 34.3	7EH	V126' V4+(V3-V4) X64.1 / 66.4	BEH	V190' V3+(V2-V3) X95.7 / 100.0		
3FH	V63' V5+(V4-V5) X 33.3 / 34.3	7FH	V127' V4+(V3-V4) X65.3 / 66.4	BFH	V191' V3+(V2-V3) X97.9 / 100.0		

Figure 5-3. Relationship between Input Data and Output Voltage (POL21, POL22 = L) (2/2)
(Output voltage2) $0.5 V_{DD2} - 0.5 V \geq V_8 > V_9 > V_{10} > V_{11} > V_{12} > V_{13} > V_{14} > V_{15} \geq 0.5 V_{SS2} + 0.2 V$

Data	Output voltage2	Data	Output voltage2	Data	Output voltage2	Data	Output voltage2
00H	V0" V8	40H	V64" V11	80H	V128" V12	C0H	V192" V13
01H	V1" V9	41H	V65" V12+(V11-V12) X65.4 / 66.4	81H	V129" V13+(V12-V13) X98.7 / 100.0	C1H	V193" V14+(V13-V14) X169.0 / 171.3
02H	V2" V10+(V9-V10) X 178.0 / 224.0	42H	V66" V12+(V11-V12) X64.4 / 66.4	82H	V130" V13+(V12-V13) X97.4 / 100.0	C2H	V194" V14+(V13-V14) X166.7 / 171.3
03H	V3" V10+(V9-V10) X 156.6 / 224.0	43H	V67" V12+(V11-V12) X63.4 / 66.4	83H	V131" V13+(V12-V13) X96.1 / 100.0	C3H	V195" V14+(V13-V14) X164.4 / 171.3
04H	V4" V10+(V9-V10) X 139.4 / 224.0	44H	V68" V12+(V11-V12) X62.4 / 66.4	84H	V132" V13+(V12-V13) X94.9 / 100.0	C4H	V196" V14+(V13-V14) X162.1 / 171.3
05H	V5" V10+(V9-V10) X 125.1 / 224.0	45H	V69" V12+(V11-V12) X61.4 / 66.4	85H	V133" V13+(V12-V13) X93.6 / 100.0	C5H	V197" V14+(V13-V14) X159.9 / 171.3
06H	V6" V10+(V9-V10) X 113.0 / 224.0	46H	V70" V12+(V11-V12) X60.4 / 66.4	86H	V134" V13+(V12-V13) X92.3 / 100.0	C6H	V198" V14+(V13-V14) X157.4 / 171.3
07H	V7" V10+(V9-V10) X 103.0 / 224.0	47H	V71" V12+(V11-V12) X59.4 / 66.4	87H	V135" V13+(V12-V13) X91.0 / 100.0	C7H	V199" V14+(V13-V14) X155.0 / 171.3
08H	V8" V10+(V9-V10) X 93.7 / 224.0	48H	V72" V12+(V11-V12) X58.4 / 66.4	88H	V140" V13+(V12-V13) X89.7 / 100.0	C8H	V200" V14+(V13-V14) X152.6 / 171.3
09H	V9" V10+(V9-V10) X 85.1 / 224.0	49H	V73" V12+(V11-V12) X57.4 / 66.4	89H	V137" V13+(V12-V13) X88.4 / 100.0	C9H	V201" V14+(V13-V14) X150.1 / 171.3
0AH	V10" V10+(V9-V10) X 77.3 / 224.0	4AH	V74" V12+(V11-V12) X56.4 / 66.4	8AH	V138" V13+(V12-V13) X87.1 / 100.0	CAH	V202" V14+(V13-V14) X147.6 / 171.3
0BH	V11" V10+(V9-V10) X 70.1 / 224.0	4BH	V75" V12+(V11-V12) X55.4 / 66.4	8BH	V139" V13+(V12-V13) X85.9 / 100.0	CBH	V203" V14+(V13-V14) X145.0 / 171.3
0CH	V12" V10+(V9-V10) X 63.7 / 224.0	4CH	V76" V12+(V11-V12) X54.4 / 66.4	8CH	V140" V13+(V12-V13) X84.6 / 100.0	CCH	V204" V14+(V13-V14) X142.4 / 171.3
0DH	V13" V10+(V9-V10) X 57.7 / 224.0	4DH	V77" V12+(V11-V12) X53.4 / 66.4	8DH	V141" V13+(V12-V13) X83.3 / 100.0	CDH	V205" V14+(V13-V14) X139.9 / 171.3
0EH	V14" V10+(V9-V10) X 52.0 / 224.0	4EH	V78" V12+(V11-V12) X52.4 / 66.4	8EH	V142" V13+(V12-V13) X82.0 / 100.0	CEH	V206" V14+(V13-V14) X137.1 / 171.3
0FH	V15" V10+(V9-V10) X 46.7 / 224.0	4FH	V79" V12+(V11-V12) X51.4 / 66.4	8FH	V143" V13+(V12-V13) X80.7 / 100.0	CFH	V207" V14+(V13-V14) X134.4 / 171.3
10H	V16" V10+(V9-V10) X 41.7 / 224.0	50H	V80" V12+(V11-V12) X50.4 / 66.4	90H	V148" V13+(V12-V13) X79.4 / 100.0	D0H	V208" V14+(V13-V14) X131.7 / 171.3
11H	V17" V10+(V9-V10) X 37.1 / 224.0	51H	V81" V12+(V11-V12) X49.4 / 66.4	91H	V145" V13+(V12-V13) X78.1 / 100.0	D1H	V209" V14+(V13-V14) X128.9 / 171.3
12H	V18" V10+(V9-V10) X 32.9 / 224.0	52H	V82" V12+(V11-V12) X48.4 / 66.4	92H	V146" V13+(V12-V13) X76.9 / 100.0	D2H	V210" V14+(V13-V14) X126.0 / 171.3
13H	V19" V10+(V9-V10) X 29.0 / 224.0	53H	V83" V12+(V11-V12) X47.4 / 66.4	93H	V147" V13+(V12-V13) X75.6 / 100.0	D3H	V211" V14+(V13-V14) X123.1 / 171.3
14H	V20" V10+(V9-V10) X 25.4 / 224.0	54H	V84" V12+(V11-V12) X46.4 / 66.4	94H	V148" V13+(V12-V13) X74.3 / 100.0	D4H	V212" V14+(V13-V14) X120.1 / 171.3
15H	V21" V10+(V9-V10) X 22.3 / 224.0	55H	V85" V12+(V11-V12) X45.4 / 66.4	95H	V149" V13+(V12-V13) X73.0 / 100.0	D5H	V213" V14+(V13-V14) X117.1 / 171.3
16H	V22" V10+(V9-V10) X 19.4 / 224.0	56H	V86" V12+(V11-V12) X44.4 / 66.4	96H	V150" V13+(V12-V13) X71.7 / 100.0	D6H	V214" V14+(V13-V14) X114.1 / 171.3
17H	V23" V10+(V9-V10) X 16.9 / 224.0	57H	V87" V12+(V11-V12) X43.4 / 66.4	97H	V151" V13+(V12-V13) X70.4 / 100.0	D7H	V215" V14+(V13-V14) X111.0 / 171.3
18H	V24" V10+(V9-V10) X 14.4 / 224.0	58H	V88" V12+(V11-V12) X42.4 / 66.4	98H	V152" V13+(V12-V13) X69.0 / 100.0	D8H	V216" V14+(V13-V14) X107.9 / 171.3
19H	V25" V10+(V9-V10) X 12.1 / 224.0	59H	V89" V12+(V11-V12) X41.4 / 66.4	99H	V153" V13+(V12-V13) X67.6 / 100.0	D9H	V217" V14+(V13-V14) X104.6 / 171.3
1AH	V26" V10+(V9-V10) X 10.0 / 224.0	5AH	V90" V12+(V11-V12) X40.4 / 66.4	9AH	V154" V13+(V12-V13) X66.1 / 100.0	DAH	V218" V14+(V13-V14) X101.3 / 171.3
1BH	V27" V10+(V9-V10) X 8.0 / 224.0	5BH	V91" V12+(V11-V12) X39.4 / 66.4	9BH	V155" V13+(V12-V13) X64.7 / 100.0	DBH	V219" V14+(V13-V14) X 97.9 / 171.3
1CH	V28" V10+(V9-V10) X 6.1 / 224.0	5CH	V92" V12+(V11-V12) X38.4 / 66.4	9CH	V156" V13+(V12-V13) X63.3 / 100.0	DCH	V220" V14+(V13-V14) X 94.4 / 171.3
1DH	V29" V10+(V9-V10) X 4.4 / 224.0	5DH	V93" V12+(V11-V12) X37.4 / 66.4	9DH	V157" V13+(V12-V13) X61.9 / 100.0	DDH	V221" V14+(V13-V14) X 90.9 / 171.3
1EH	V30" V10+(V9-V10) X 2.9 / 224.0	5EH	V94" V12+(V11-V12) X36.4 / 66.4	9EH	V158" V13+(V12-V13) X60.4 / 100.0	DEH	V222" V14+(V13-V14) X 87.3 / 171.3
1FH	V31" V10+(V9-V10) X 1.4 / 224.0	5FH	V95" V12+(V11-V12) X35.4 / 66.4	9FH	V159" V13+(V12-V13) X59.0 / 100.0	DFH	V223" V14+(V13-V14) X 83.6 / 171.3
20H	V32" V10	60H	V96" V12+(V11-V12) X34.4 / 66.4	A0H	V160" V13+(V12-V13) X57.6 / 100.0	E0H	V224" V14+(V13-V14) X 79.7 / 171.3
21H	V33" V11+(V10-V11) X 33.0 / 34.3	61H	V97" V12+(V11-V12) X33.4 / 66.4	A1H	V161" V13+(V12-V13) X56.1 / 100.0	E1H	V225" V14+(V13-V14) X 75.9 / 171.3
22H	V34" V11+(V10-V11) X 31.9 / 34.3	62H	V98" V12+(V11-V12) X32.4 / 66.4	A2H	V162" V13+(V12-V13) X54.7 / 100.0	E2H	V226" V14+(V13-V14) X 71.9 / 171.3
23H	V35" V11+(V10-V11) X 30.7 / 34.3	63H	V99" V12+(V11-V12) X31.4 / 66.4	A3H	V163" V13+(V12-V13) X53.3 / 100.0	E3H	V227" V14+(V13-V14) X 67.7 / 171.3
24H	V36" V11+(V10-V11) X 29.6 / 34.3	64H	V100" V12+(V11-V12) X30.4 / 66.4	A4H	V164" V13+(V12-V13) X51.7 / 100.0	E4H	V228" V14+(V13-V14) X 63.4 / 171.3
25H	V37" V11+(V10-V11) X 28.4 / 34.3	65H	V101" V12+(V11-V12) X29.4 / 66.4	A5H	V165" V13+(V12-V13) X50.1 / 100.0	E5H	V229" V14+(V13-V14) X 59.0 / 171.3
26H	V38" V11+(V10-V11) X 27.3 / 34.3	66H	V102" V12+(V11-V12) X28.4 / 66.4	A6H	V166" V13+(V12-V13) X48.6 / 100.0	E6H	V230" V14+(V13-V14) X 54.4 / 171.3
27H	V39" V11+(V10-V11) X 26.1 / 34.3	67H	V103" V12+(V11-V12) X27.4 / 66.4	A7H	V167" V13+(V12-V13) X47.0 / 100.0	E7H	V231" V14+(V13-V14) X 49.7 / 171.3
28H	V40" V11+(V10-V11) X 25.0 / 34.3	68H	V104" V12+(V11-V12) X26.4 / 66.4	A8H	V168" V13+(V12-V13) X45.4 / 100.0	E8H	V232" V14+(V13-V14) X 44.9 / 171.3
29H	V41" V11+(V10-V11) X 23.9 / 34.3	69H	V105" V12+(V11-V12) X25.4 / 66.4	A9H	V169" V13+(V12-V13) X43.9 / 100.0	E9H	V233" V14+(V13-V14) X 39.9 / 171.3
2AH	V42" V11+(V10-V11) X 22.7 / 34.3	6AH	V106" V12+(V11-V12) X24.4 / 66.4	AAH	V170" V13+(V12-V13) X42.3 / 100.0	EAH	V234" V14+(V13-V14) X 34.7 / 171.3
2BH	V43" V11+(V10-V11) X 21.6 / 34.3	6BH	V107" V12+(V11-V12) X23.4 / 66.4	ABH	V171" V13+(V12-V13) X40.6 / 100.0	EBH	V235" V14+(V13-V14) X 29.4 / 171.3
2CH	V44" V11+(V10-V11) X 20.4 / 34.3	6CH	V108" V12+(V11-V12) X22.4 / 66.4	ACH	V172" V13+(V12-V13) X38.9 / 100.0	ECH	V236" V14+(V13-V14) X 24.0 / 171.3
2DH	V45" V11+(V10-V11) X 19.3 / 34.3	6DH	V109" V12+(V11-V12) X21.4 / 66.4	ADH	V173" V13+(V12-V13) X37.1 / 100.0	EDH	V237" V14+(V13-V14) X 18.3 / 171.3
2EH	V46" V11+(V10-V11) X 18.1 / 34.3	6EH	V110" V12+(V11-V12) X20.4 / 66.4	AEH	V174" V13+(V12-V13) X35.4 / 100.0	EEH	V238" V14+(V13-V14) X 12.4 / 171.3
2FH	V47" V11+(V10-V11) X 17.0 / 34.3	6FH	V111" V12+(V11-V12) X19.4 / 66.4	AFH	V175" V13+(V12-V13) X33.7 / 100.0	EFH	V239" V14+(V13-V14) X 6.3 / 171.3
30H	V48" V11+(V10-V11) X 16.0 / 34.3	70H	V112" V12+(V11-V12) X18.3 / 66.4	B0H	V176" V13+(V12-V13) X32.0 / 100.0	F0H	V240" V14
31H	V49" V11+(V10-V11) X 15.0 / 34.3	71H	V113" V12+(V11-V12) X17.1 / 66.4	B1H	V177" V13+(V12-V13) X30.1 / 100.0	F1H	V241" V15+(V14-V15) X119.4 / 126.0
32H	V50" V11+(V10-V11) X 14.0 / 34.3	72H	V114" V12+(V11-V12) X16.0 / 66.4	B2H	V178" V13+(V12-V13) X28.3 / 100.0	F2H	V242" V15+(V14-V15) X112.6 / 126.0
33H	V51" V11+(V10-V11) X 13.0 / 34.3	73H	V115" V12+(V11-V12) X14.9 / 66.4	B3H	V179" V13+(V12-V13) X26.4 / 100.0	F3H	V243" V15+(V14-V15) X105.6 / 126.0
34H	V52" V11+(V10-V11) X 12.0 / 34.3	74H	V116" V12+(V11-V12) X13.7 / 66.4	B4H	V180" V13+(V12-V13) X24.6 / 100.0	F4H	V244" V15+(V14-V15) X 98.1 / 126.0
35H	V53" V11+(V10-V11) X 11.0 / 34.3	75H	V117" V12+(V11-V12) X12.6 / 66.4	B5H	V181" V13+(V12-V13) X22.7 / 100.0	F5H	V245" V15+(V14-V15) X 90.3 / 126.0
36H	V54" V11+(V10-V11) X 10.0 / 34.3	76H	V118" V12+(V11-V12) X11.4 / 66.4	B6H	V182" V13+(V12-V13) X20.7 / 100.0	F6H	V246" V15+(V14-V15) X 82.1 / 126.0
37H	V55" V11+(V10-V11) X 9.0 / 34.3	77H	V119" V12+(V11-V12) X10.3 / 66.4	B7H	V183" V13+(V12-V13) X18.7 / 100.0	F7H	V247" V15+(V14-V15) X 73.6 / 126.0
38H	V56" V11+(V10-V11) X 8.0 / 34.3	78H	V120" V12+(V11-V12) X 9.1 / 66.4	B8H	V184" V13+(V12-V13) X16.7 / 100.0	F8H	V248" V15+(V14-V15) X 65.0 / 126.0
39H	V57" V11+(V10-V11) X 7.0 / 34.3	79H	V121" V12+(V11-V12) X 8.0 / 66.4	B9H	V185" V13+(V12-V13) X14.7 / 100.0	F9H	V249" V15+(V14-V15) X 55.7 / 126.0
3AH	V58" V11+(V10-V11) X 6.0 / 34.3	7AH	V122" V12+(V11-V12) X 6.9 / 66.4	BAH	V186" V13+(V12-V13) X12.7 / 100.0	FAH	V250" V15+(V14-V15) X 46.4 / 126.0
3BH	V59" V11+(V10-V11) X 5.0 / 34.3	7BH	V123" V12+(V11-V12) X 5.7 / 66.4	BBH	V187" V13+(V12-V13) X10.7 / 100.0	FBH	V251" V15+(V14-V15) X 37.1 / 126.0
3CH	V60" V11+(V10-V11) X 4.0 / 34.3	7CH	V124" V12+(V11-V12) X 4.6 / 66.4	BCH	V188" V13+(V12-V13) X 8.6 / 100.0	FCH	V252" V15+(V14-V15) X 27.9 / 126.0
3DH	V61" V11+(V10-V11) X 3.0 / 34.3	7DH	V125" V12+(V11-V12) X 3.4 / 66.4	BDH	V189" V13+(V12-V13) X 6.4 / 100.0	FDH	V253" V15+(V14-V15) X 18.6 / 126.0
3EH	V62" V11+(V10-V11) X 2.0 / 34.3	7EH	V126" V12+(V11-V12) X 2.3 / 66.4	BEH	V190" V13+(V12-V13) X 4.3 / 100.0	FEH	V254" V15+(V14-V15) X 9.3 / 126.0
3FH	V63" V11+(V10-V11) X 1.0 / 34.3	7FH	V127" V12+(V11-V12) X 1.1 / 66.4	BFH	V191" V13+(V12-V13) X 2.1 / 100.0	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

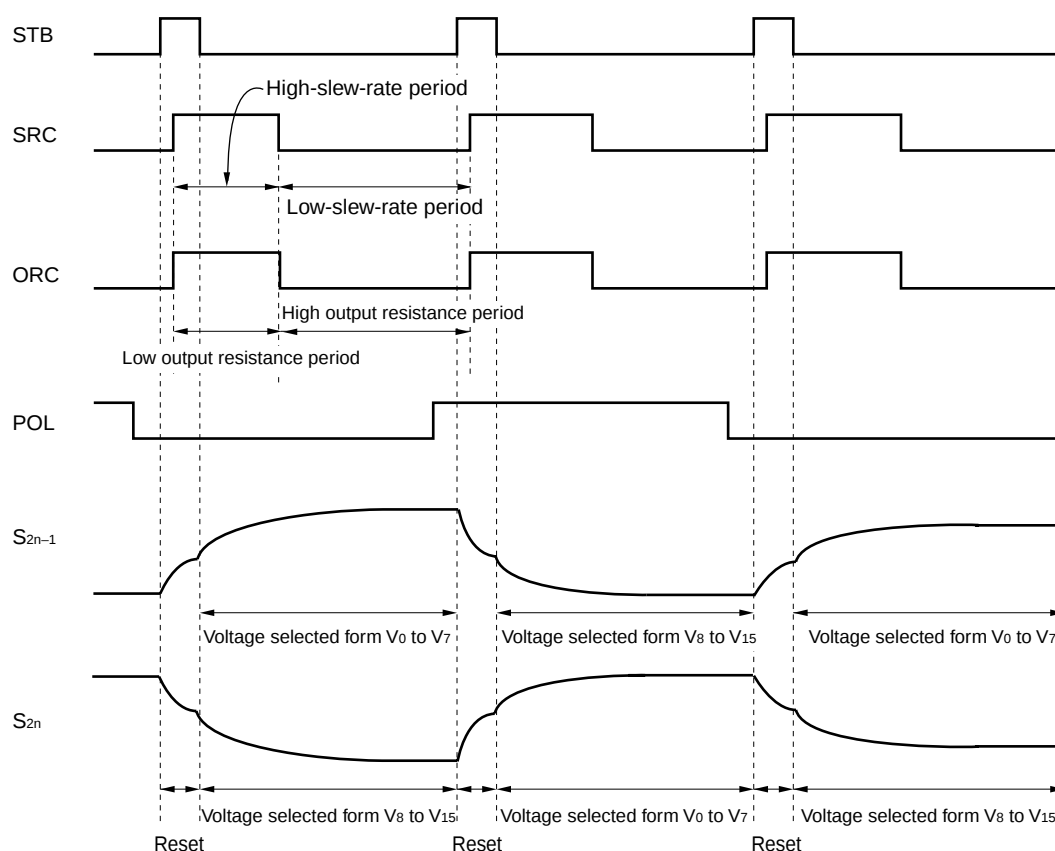
When MODE = H or open and STB is high level, all outputs are reset (shorted) and the gray-scale voltage is output to LCD in synchronization with the falling edge of STB.

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.

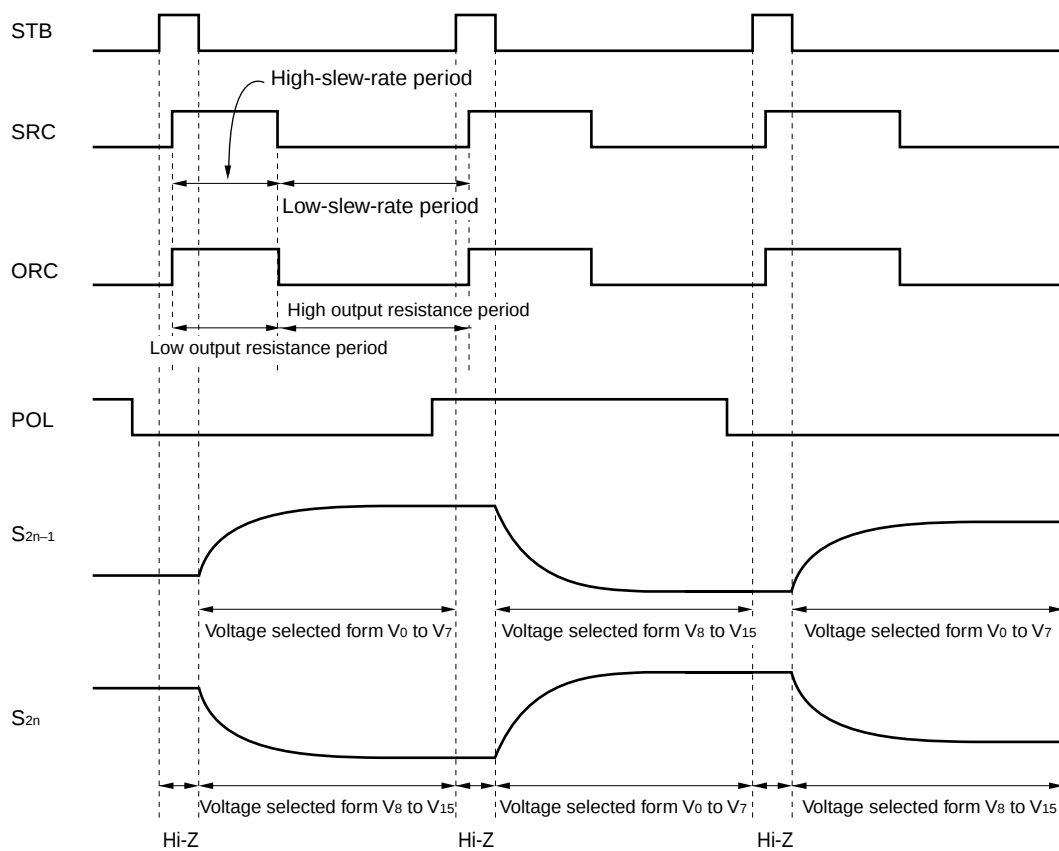
Also, setting the SRC pin to high level allows the bias current value of the output amplifier to rise temporarily, and setting the ORC pin to high level allows the output resistance value of the amplifier to lower temporarily.

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



8. ELECTRICAL SPECIFICATIONS

Absolute Maximum Ratings ($T_A = 25^\circ\text{C}$, $V_{SS1} = V_{SS2} = 0\text{ V}$)

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	$^\circ\text{C}$
Storage temperature	T_{stg}	-55 to +125	$^\circ\text{C}$

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 $+75^\circ\text{C}$, $V_{SS1} = V_{SS2} = 0\text{ V}$)

Parameter	Symbol	Condition	MIN.	TYP.	MAX.	Unit
Logic part supply voltage	V_{DD1}		2.5		3.6	V
Driver part supply voltage	V_{DD2}	$V_{SEL} = \text{H}$	12.5	13.0	(14.0)	V
		$V_{SEL} = \text{L or open}$	(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}	$3.0\text{ V} \leq V_{DD1} \leq 3.6\text{ V}$			55	MHz
		$2.5\text{ V} \leq V_{DD1} < 3.0\text{ V}$			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)

Electrical Characteristics (TA = -40 to +75 °C, VDD1 = 2.5 to 3.3 V, VDD2 = 12.5 to 15.0 V, VSS1 = VSS2 = 0 V)							
Parameter	Symbol	Condition		MIN.	TYP.	MAX.	Unit
Input leakage current	IIL					±1.0	μA
High-level output voltage	VOH	STHR (STHL), IOH = 0 mA		VDD1 - 0.1			V
Low-level output voltage	VOL	STHR (STHL), IOL = 0 mA				0.1	V
γ-corrected power supply static current consumption	Iγ	VDD2 = 15.0 V, V0-V7 = V8-V15 = 7.0 V	V0, V8 pins	340	681	1020	μA
			V7, V15 pins	-1020	-681	-340	μA
Driver output current	IVOH	VX = 12 V, VOUT = 11 V ^{Note1}				-0.40	mA
	IVOL	VX = 1 V, VOUT = 2 V ^{Note1}		0.65			mA
Output voltage deviation	ΔVo	TA = 25°C, VSS2 +1.0 V to VDD2 - 1.0 V			±10	±20	mV
Output swing voltage difference deviation	ΔVP-P1	VDD1 = 3.3 V,	VOUT = 7.0 to 8.0 V ^{Note1}		±5	±10	mV
	ΔVP-P2	VDD2 = 15.0 V,	VOUT = 4.0 to 11.0 V ^{Note1}		±7	±15	mV
	ΔVP-P3	TA = 25°C	VOUT = 1.0 to 14.0 V ^{Note1}		±10	±20	mV
Logic part dynamic current consumption	IDD1	VDD1 ^{Notes 2,3}			1.3	12	mA
Driver part dynamic current consumption	IDD2	VDD2, with no load ^{Notes 3,4}			12	30	mA

Notes 1. V_X refers to the output voltage of analog output pins S₁ to S₃₈₄.

V_{OUT} refers to the voltage applied to analog output pins S₁ to S₃₈₄

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).

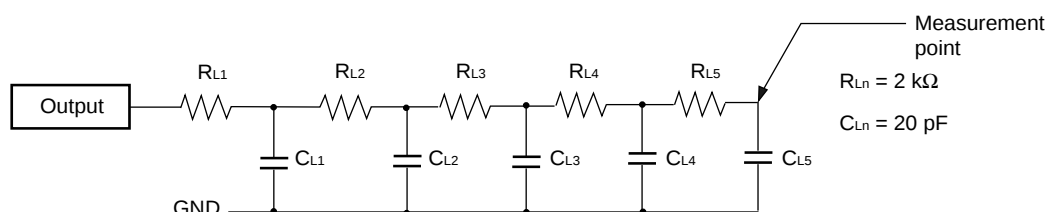
Switching Characteristics (T_A = -10 to +75°C, V_{DD1} = 2.5 to 3.6 V, V_{DD2} = 12.5 to 15.5 V, V_{SS1} = V_{SS2} = 0 V)

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 $+75^\circ\text{C}$, $V_{DD1} = 2.5$ to 3.6 V, $V_{SS1} = 0$ V, $t_r = t_f = 5.0$ ns)

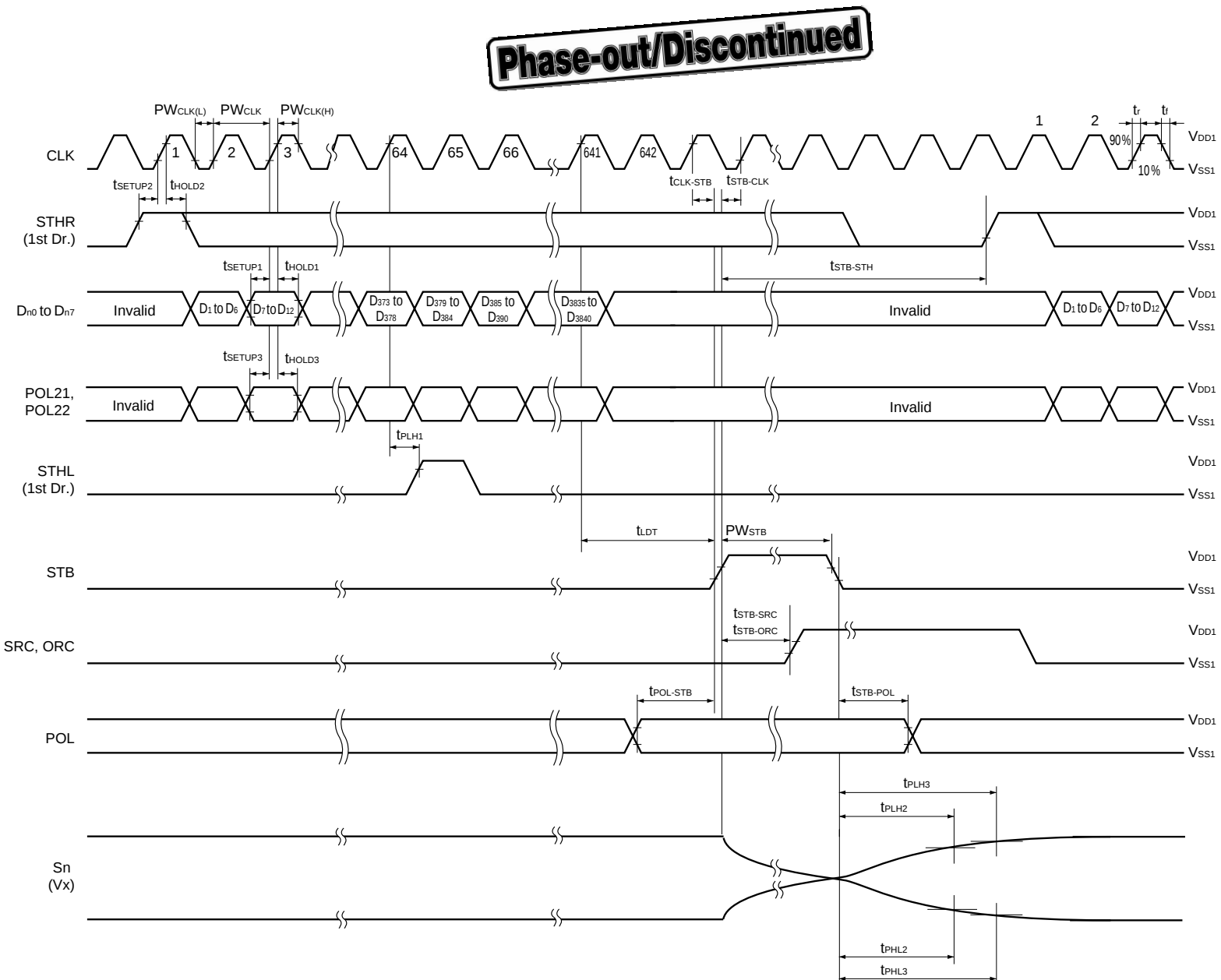
Parameter	Symbol	Condition	MIN.	TYP.	MAX.	Unit
Clock pulse width	PW_{CLK}	$3.0\text{ V} \leq V_{DD1} \leq 3.6\text{ V}$	18			ns
		$2.5\text{ V} \leq V_{DD1} < 3.0\text{ V}$	25			ns
Clock pulse high period	$PW_{CLK(H)}$	$3.0\text{ V} \leq V_{DD1} \leq 3.6\text{ V}$	4			ns
		$2.5\text{ V} \leq V_{DD1} < 3.0\text{ V}$	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	$t_{CLK-STB}$	$CLK \uparrow \rightarrow STB \uparrow$	4			ns
STB-CLK time	$t_{STB-CLK}$	$STB \uparrow \rightarrow CLK \uparrow$	4			ns
Time between STB and start pulse	$t_{STB-STH}$	$STB \uparrow \rightarrow STHR (STHL) \uparrow$	2			CLK
POL-STB time	$t_{POL-STB}$	$POL \uparrow \text{ or } \downarrow \rightarrow STB \uparrow$	4			ns
STB-POL time	$t_{STB-POL}$	$STB \downarrow \rightarrow POL \downarrow \text{ or } \uparrow$	4			ns
STB-SRC time	$t_{STB-SRC}$	$STB \uparrow \rightarrow SRC \uparrow$	0			ns
STB-ORC time	$t_{STB-ORC}$	$STB \downarrow \rightarrow ORC \uparrow$	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

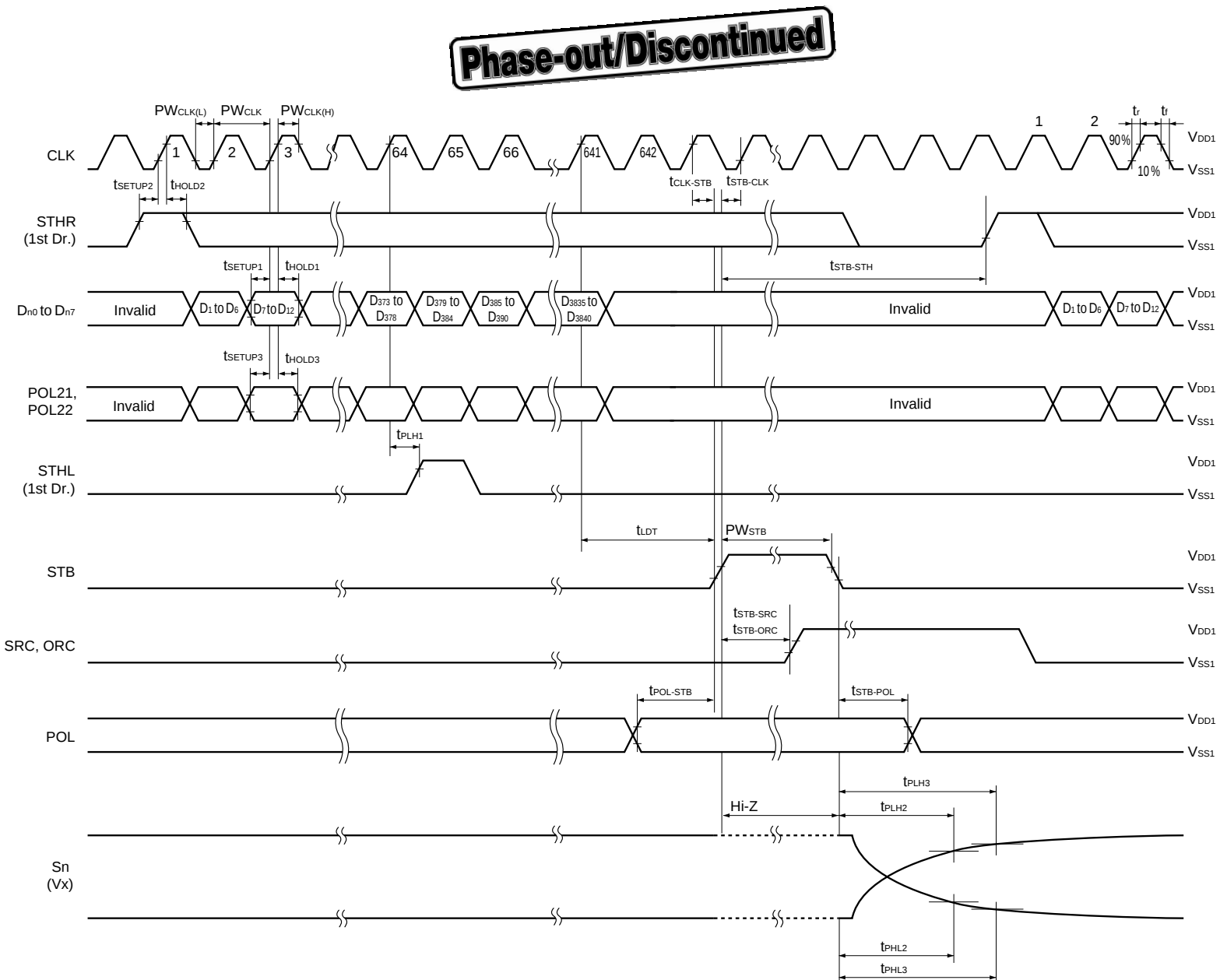
(1) R_L/L = H, MODE = H or open

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/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.

Reference Documents

NEC Semiconductor Device Reliability/Quality Control System (C10983E)

Quality Grades On NEC Semiconductor Devices (C11531E)

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