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April 1st, 2010
Renesas Electronics Corporation

Issued by: Renesas Electronics Corporation (<http://www.renesas.com>)

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

DESCRIPTION

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

Because the output dynamic range is as large as $V_{SS2} + 0.2 \text{ V}$ 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})
- Output dynamic range: $V_{SS2} + 0.2 \text{ V}$ to $V_{DD2} - 0.2 \text{ V}$
- High-speed data transfer: $f_{CLK} = 55 \text{ MHz MAX.}$ (internal data transfer speed when operating at $3.0 \text{ V} \leq V_{DD1} \leq 3.6 \text{ V}$)
 $f_{CLK} = 40 \text{ MHz MAX.}$ (internal data transfer speed when operating at $2.5 \text{ V} \leq V_{DD1} < 3.0 \text{ V}$)
- 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)
- Through-rate control is possible (SRC)
- Output resistance control is possible (ORC)
- Single bank arrangement is possible (loaded with slim TCP)

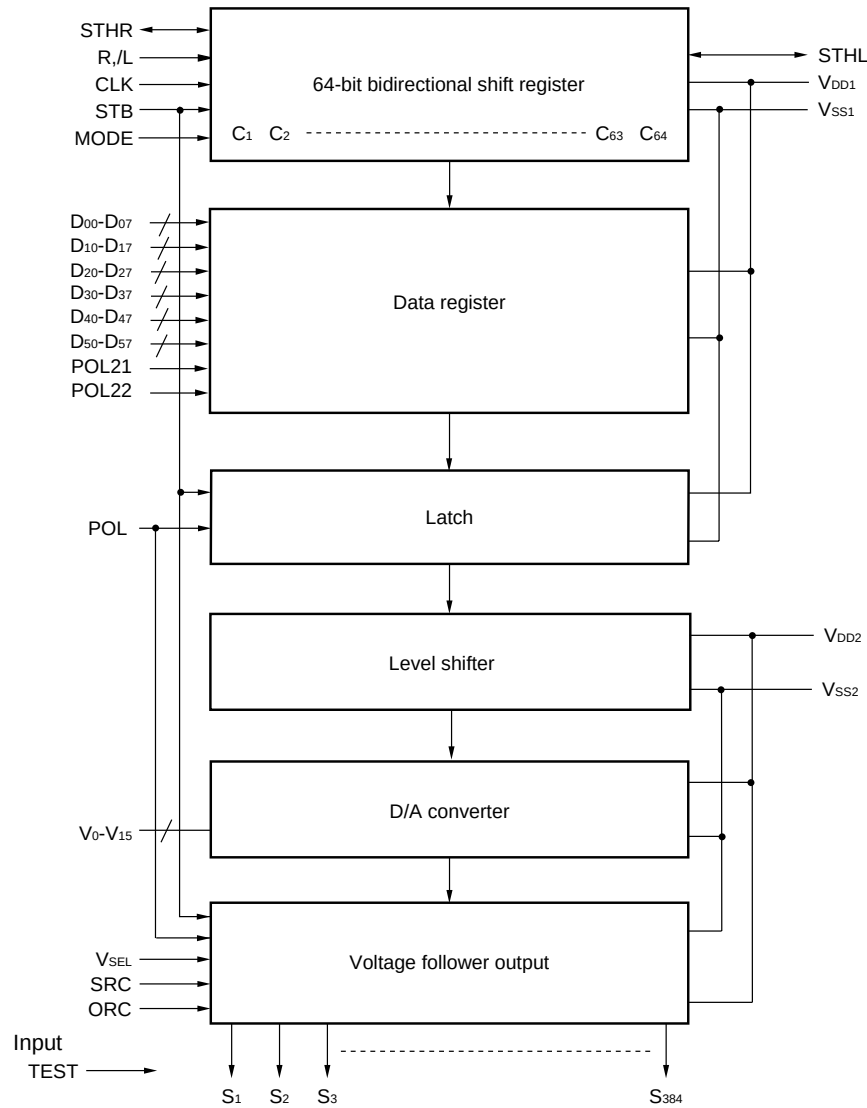
ORDERING INFORMATION

Part Number	Package
μPD160040N-xxx	TCP (TAB package)

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

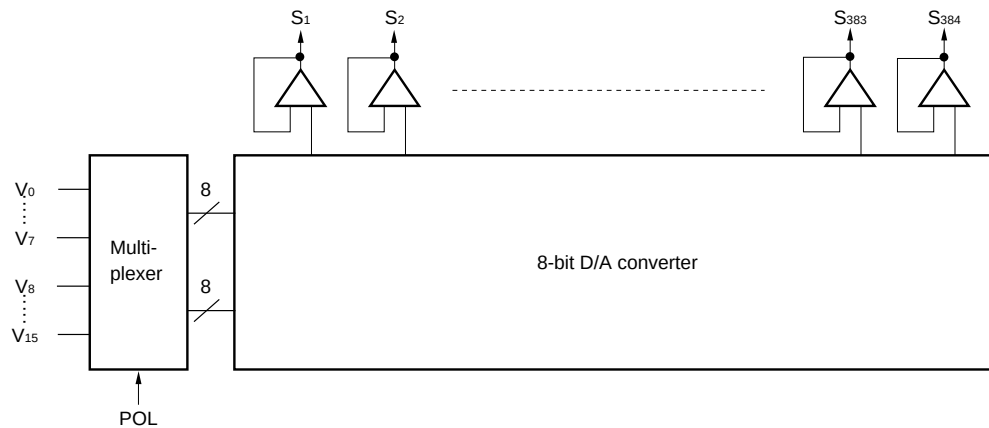
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1. BLOCK DIAGRAM

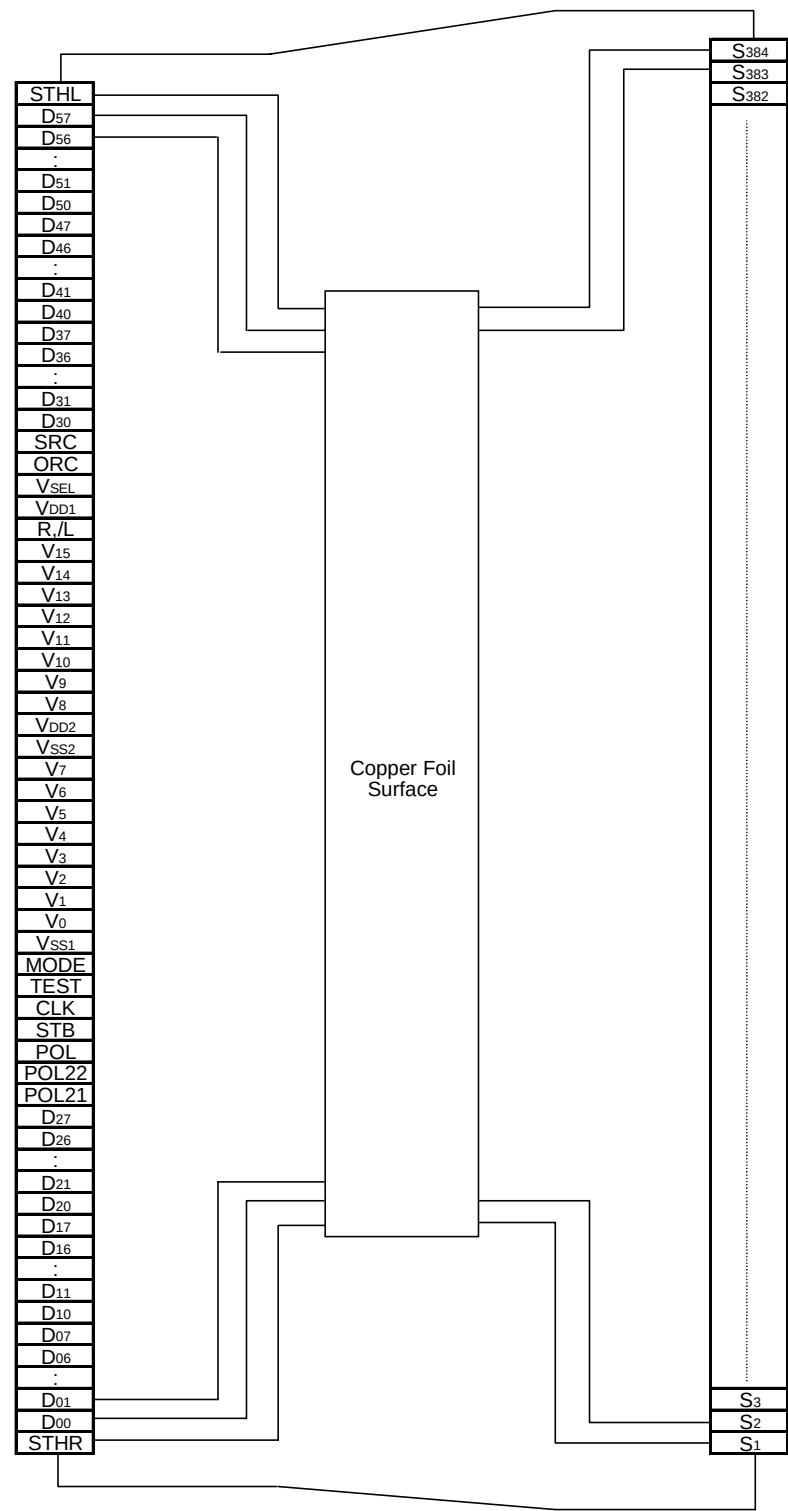


Remark /xxx indicates active low signal.

2. RELATIONSHIP BETWEEN OUTPUT CIRCUIT AND D/A CONVERTER



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



Remark This figure does not specify the TCP package.

4. PIN FUNCTIONS

(1/2)

Pin Symbol	Pin Name	I/O	Description
S ₁ to S ₃₈₄	Driver	Output	The D/A converted 256-gray-scale analog voltage is output.
D ₀₀ to D ₀₇	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 H level is read at the rising edge of CLK. A H level should be input at the pulse of one cycle of the clock signal.
★ STHL	Left shift start pulse	I/O	If the start pulse input is more than 2 CLK, the first 1 CLK of the H-level input is valid. For right shift, STHR is input and STHL is output. For left shift, STHL is input and STHR is output.
CLK	Shift clock	Input	The shift clock input pin of shift register. The display data is loaded into the data register at the rising edge. When 66-clock pulses are input after input of the start pulse, input of display data is halted automatically. The contents of the shift register are cleared at the STB's rising edge.
STB	Latch	Input	The contents of the data register are transferred to the latch circuit at the rising edge. In addition, at the falling edge, the gray scale voltage is supplied to the driver. It is necessary to ensure input of one pulse per horizontal period.
SRC	Through rate control	Input	SRC = H: High-through-rate period (large current consumption) SRC = L: Low-through-rate period (small current consumption) SRC is pulled up to the V _{DD1} in the IC.
ORC	Output resistance control	Input	ORC = H: Low output resistance period ORC = L: High output resistance period ORC is pulled up to the V _{DD1} in the IC.
POL	Polarity input	Input	POL = L: The S _{2n-1} output uses V ₀ -V ₇ as the reference supply. The S _{2n} output uses V ₈ -V ₁₅ as the reference supply. POL = H: The S _{2n-1} output uses V ₈ -V ₁₅ as the reference supply. The S _{2n} output uses V ₀ -V ₇ as the reference supply. S _{2n-1} indicates the odd output and S _{2n} indicates the even output. Input of the POL signal is allowed the setup time (t _{POL-STB}) with respect to STB's rising edge. When it switches such as POL = H→L or L→H, all output pins are output reset during STB = H. When it does not switch, all output pins become Hi-Z (high impedance) during STB = H. Refer to 7. RELATIONSHIP BETWEEN MODE, STB, SRC, ORC, POL, AND OUTPUT WAVEFORM for details.

(2/2)

Pin Symbol	Pin Name	I/O	Description
MODE	Output reset control	Input	MODE = H or open: Output reset MODE = L: No output reset MODE is pulled up to the V_{DD1} in the IC.
POL21, POL22	Data inversion	Input	Select of inversion or no inversion for input data. POL21: Data inversion or no inversion of Port1. POL22: Data inversion or no inversion of Port2 POL21, POL22 = H: Data are inverted in the IC. POL21, POL22 = L: Data are not inverted in the IC.
V _{SEL}	Driver voltage select	Input	The driver voltage can be switched by controlling the stationary bias current of the output amplifier via V _{SEL} . V _{SEL} = H: $V_{DD2} = 12.5$ to (14.0 V) (large bias current) V _{SEL} = L or open: $V_{DD2} = (14.0\text{ V})$ to 15.0 V (small bias current) LPC is pulled down to the V_{SS1} in the IC.
TEST	Test	Input	Normally, set the TEST pin to H or leave open. This pin is pulled up to V_{DD1} in the IC.
V ₀ -V ₁₅	γ-corrected power supplies	–	Input the γ-corrected power supplies from outside by using operational amplifier. During the gray scale voltage output, be sure to keep the gray scale level power supply at a constant level. Make sure to maintain the following relationships. $V_{DD2} - 0.2\text{ V} \geq V_0 > V_1 > V_2 > \dots > V_6 > V_7 \geq 0.5 V_{DD2} + 0.5\text{ V}$ $0.5 V_{DD2} - 0.5\text{ V} \geq V_8 > V_9 > V_{10} > \dots > V_{14} > V_{15} \geq V_{SS2} + 0.2\text{ V}$
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 $0.47\text{ }\mu\text{F}$ 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 $0.1\text{ }\mu\text{F}$ is also advised between the γ-corrected power supply terminals ($V_0, V_1, V_2, \dots, V_{15}$) and V_{SS2} .

5. RELATIONSHIP BETWEEN INPUT DATA AND OUTPUT VOLTAGE VALUE

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

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

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

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

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

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

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

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

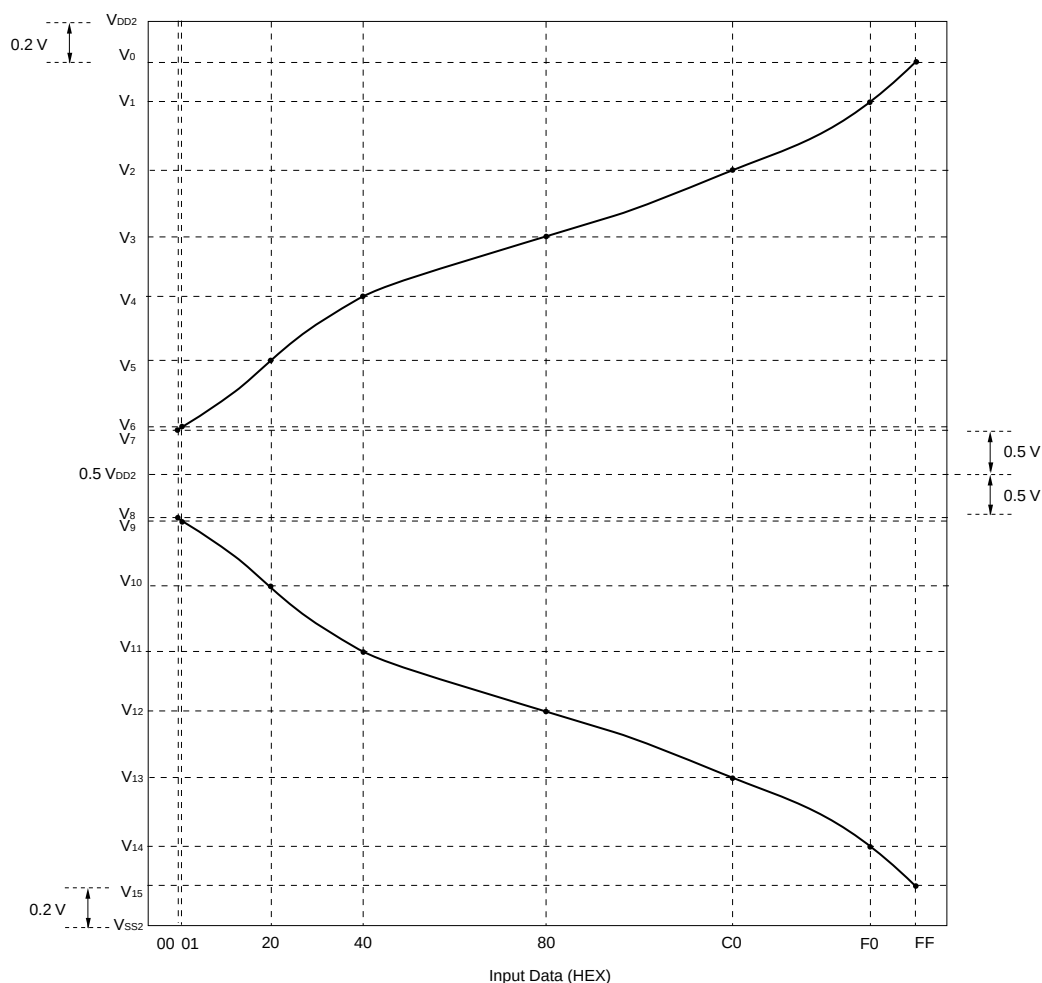
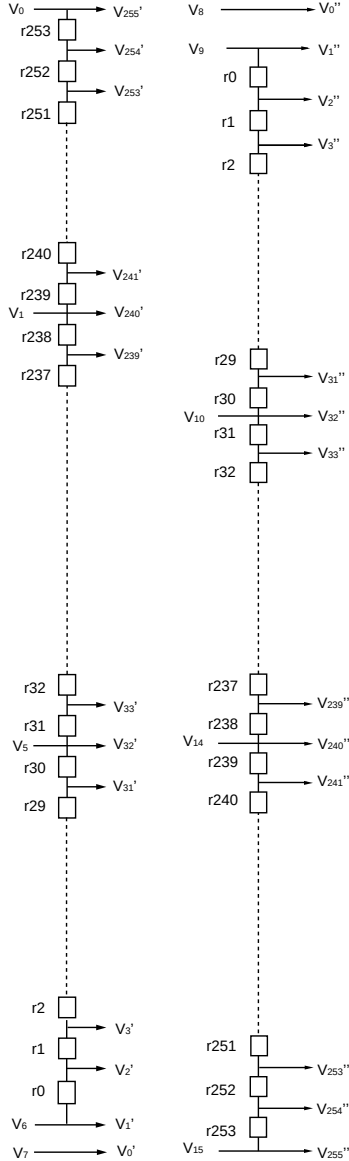




Figure 5-2. γ -Corrected Voltages and Ladder Resistors Ratio



rn	Ratio1	Ratio2	Value	m	Ratio1	Ratio2	Value	r128	Ratio1	Ratio2	Value	rn	Ratio1	Ratio2	Value
r0	3.58	0.0084	86	r64	1.33	0.0031	32	r128	1.00	0.0023	24	r192	1.25	0.0029	30
r1	3.58	0.0084	86	r65	1.33	0.0031	32	r129	1.08	0.0025	26	r193	1.25	0.0029	30
r2	3.58	0.0084	86	r66	1.33	0.0031	32	r130	1.00	0.0023	24	r194	1.33	0.0031	32
r3	3.58	0.0084	86	r67	1.33	0.0031	32	r131	1.00	0.0023	24	r195	1.33	0.0031	32
r4	3.58	0.0084	86	r68	1.33	0.0031	32	r132	1.00	0.0023	24	r196	1.33	0.0031	32
r5	3.50	0.0082	84	r69	1.33	0.0031	32	r133	1.00	0.0023	24	r197	1.33	0.0031	32
r6	3.50	0.0082	84	r70	1.25	0.0029	30	r134	1.08	0.0025	26	r198	1.33	0.0031	32
r7	3.42	0.0080	82	r71	1.25	0.0029	30	r135	1.08	0.0025	26	r199	1.33	0.0031	32
r8	3.42	0.0080	82	r72	1.25	0.0029	30	r136	1.08	0.0025	26	r200	1.33	0.0031	32
r9	3.33	0.0078	80	r73	1.25	0.0029	30	r137	1.08	0.0025	26	r201	1.42	0.0033	34
r10	3.25	0.0076	78	r74	1.25	0.0029	30	r138	1.08	0.0025	26	r202	1.42	0.0033	34
r11	3.25	0.0076	78	r75	1.25	0.0029	30	r139	1.08	0.0025	26	r203	1.42	0.0033	34
r12	3.17	0.0074	76	r76	1.25	0.0029	30	r140	1.08	0.0025	26	r204	1.42	0.0033	34
r13	3.08	0.0072	74	r77	1.25	0.0029	30	r141	1.08	0.0025	26	r205	1.42	0.0033	34
r14	3.08	0.0072	74	r78	1.25	0.0029	30	r142	1.08	0.0025	26	r206	1.42	0.0033	34
r15	3.00	0.0070	72	r79	1.25	0.0029	30	r143	1.08	0.0025	26	r207	1.50	0.0035	36
r16	2.92	0.0068	70	r80	1.17	0.0027	28	r144	1.08	0.0025	26	r208	1.50	0.0035	36
r17	2.83	0.0066	68	r81	1.17	0.0027	28	r145	1.08	0.0025	26	r209	1.50	0.0035	36
r18	2.83	0.0066	68	r82	1.17	0.0027	28	r146	1.08	0.0025	26	r210	1.50	0.0035	36
r19	2.75	0.0064	66	r83	1.17	0.0027	28	r147	1.08	0.0025	26	r211	1.50	0.0035	36
r20	2.67	0.0062	64	r84	1.17	0.0027	28	r148	1.08	0.0025	26	r212	1.58	0.0037	38
r21	2.67	0.0062	64	r85	1.17	0.0027	28	r149	1.08	0.0025	26	r213	1.58	0.0037	38
r22	2.58	0.0060	62	r86	1.17	0.0027	28	r150	1.08	0.0025	26	r214	1.58	0.0037	38
r23	2.50	0.0058	60	r87	1.17	0.0027	28	r151	1.08	0.0025	26	r215	1.58	0.0037	38
r24	2.50	0.0058	60	r88	1.17	0.0027	28	r152	1.08	0.0025	26	r216	1.67	0.0039	40
r25	2.42	0.0056	58	r89	1.17	0.0027	28	r153	1.08	0.0025	26	r217	1.67	0.0039	40
r26	2.33	0.0054	56	r90	1.17	0.0027	28	r154	1.08	0.0025	26	r218	1.67	0.0039	40
r27	2.33	0.0054	56	r91	1.17	0.0027	28	r155	1.08	0.0025	26	r219	1.75	0.0041	42
r28	2.25	0.0053	54	r92	1.17	0.0027	28	r156	1.08	0.0025	26	r220	1.75	0.0041	42
r29	2.25	0.0053	54	r93	1.08	0.0025	26	r157	1.08	0.0025	26	r221	1.75	0.0041	42
r30	2.17	0.0051	52	r94	1.08	0.0025	26	r158	1.08	0.0025	26	r222	1.83	0.0043	44
r31	2.17	0.0051	52	r95	1.08	0.0025	26	r159	1.08	0.0025	26	r223	1.83	0.0043	44
r32	2.08	0.0049	50	r96	1.08	0.0025	26	r160	1.08	0.0025	26	r224	1.83	0.0043	44
r33	2.08	0.0049	50	r97	1.08	0.0025	26	r161	1.08	0.0025	26	r225	1.92	0.0045	46
r34	2.00	0.0047	48	r98	1.08	0.0025	26	r162	1.08	0.0025	26	r226	1.92	0.0045	46
r35	2.00	0.0047	48	r99	1.08	0.0025	26	r163	1.08	0.0025	26	r227	2.00	0.0047	48
r36	1.92	0.0045	46	r100	1.08	0.0025	26	r164	1.08	0.0025	26	r228	2.00	0.0047	48
r37	1.92	0.0045	46	r101	1.08	0.0025	26	r165	1.08	0.0025	26	r229	2.08	0.0049	50
r38	1.92	0.0045	46	r102	1.08	0.0025	26	r166	1.08	0.0025	26	r230	2.08	0.0049	50
r39	1.83	0.0043	44	r103	1.08	0.0025	26	r167	1.08	0.0025	26	r231	2.17	0.0051	52
r40	1.83	0.0043	44	r104	1.08	0.0025	26	r168	1.08	0.0025	26	r232	2.17	0.0051	52
r41	1.83	0.0043	44	r105	1.08	0.0025	26	r169	1.08	0.0025	26	r233	2.25	0.0053	54
r42	1.75	0.0041	42	r106	1.08	0.0025	26	r170	1.17	0.0027	28	r234	2.33	0.0054	56
r43	1.75	0.0041	42	r107	1.08	0.0025	26	r171	1.17	0.0027	28	r235	2.33	0.0054	56
r44	1.75	0.0041	42	r108	1.08	0.0025	26	r172	1.17	0.0027	28	r236	2.42	0.0056	58
r45	1.67	0.0039	40	r109	1.08	0.0025	26	r173	1.17	0.0027	28	r237	2.50	0.0058	60
r46	1.67	0.0039	40	r110	1.08	0.0025	26	r174	1.17	0.0027	28	r238	2.58	0.0060	62
r47	1.67	0.0039	40	r111	1.08	0.0025	26	r175	1.17	0.0027	28	r239	2.67	0.0062	64
r48	1.67	0.0039	40	r112	1.08	0.0025	26	r176	1.17	0.0027	28	r240	2.75	0.0064	66
r49	1.58	0.0037	38	r113	1.08	0.0025	26	r177	1.17	0.0027	28	r241	2.83	0.0066	68
r50	1.58	0.0037	38	r114	1.08	0.0025	26	r178	1.17	0.0027	28	r242	2.92	0.0068	70
r51	1.58	0.0037	38	r115	1.08	0.0025	26	r179	1.17	0.0027	28	r243	3.00	0.0070	72
r52	1.58	0.0037	38	r116	1.08	0.0025	26	r180	1.17	0.0027	28	r244	3.17	0.0074	76
r53	1.50	0.0035	36	r117	1.08	0.0025	26	r181	1.17	0.0027	28	r245	3.33	0.0078	80
r54	1.50	0.0035	36	r118	1.08	0.0025	26	r182	1.17	0.0027	28	r246	3.42	0.0080	82
r55	1.50	0.0035	36	r119	2.38	0.0025	26	r183	2.38	0.0027	28	r247	2.38	0.0084	86
r56	1.50	0.0035	36	r120	1.08	0.0025	26	r184	1.25	0.0029	30	r248	3.83	0.0089	92
r57	1.42	0.0033	34	r121	1.08	0.0025	26	r185	1.25	0.0029	30	r249	4.08	0.0095	98
r58	1.42	0.0033	34	r122	1.08	0.0025	26	r186	1.25	0.0029	30	r250	4.33	0.0101	104
r59	1.42	0.0033	34	r123	1.08	0.0025	26	r187	1.25	0.0029	30	r251	4.67	0.0109	112
r60	1.42	0.0033	34	r124	1.08	0.0025	26	r188	1.25	0.0029	30	r252	5.00	0.0117	120
r61	1.42	0.0033	34	r125	1.08	0.0025	26	r189	1.25	0.0029	30	r253	5.50	0.0128	132
r62	1.42	0.0033	34	r126	1.08	0.0025	26	r190	1.25	0.0029	30	Total resistance		10280	
r63	1.33	0.0031	32	r127	1.08	0.0025	26	r191	1.25	0.0029	30	Minimum resistance value		24	

Remark The resistance ratio1 is a relative ratio in the case of setting the minimum resistance value to 1.
The resistance ratio2 is a relative ratio in the case of setting the total resistance to 1.

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

★

(Output voltage 1) $V_{DD2} - 0.2 \text{ V} \geq V_0 > V_1 > V_2 > V_3 > V_4 > V_5 > V_6 > V_7 \geq 0.5 V_{DD2} + 0.5 \text{ V}$

Data	Output voltage1			Data	Output voltage1			Data	Output voltage1			Data	Output voltage1		
00H	V ₀ ¹	V7		40H	V ₆₄ ¹	V4		80H	V ₁₂₈ ¹	V3		C0H	V ₁₉₂ ¹	V2	
01H	V ₁ ¹	V6		41H	V ₆₅ ¹	V4+(V3-V4) X 32 / 1772		81H	V ₁₂₉ ¹	V3+(V2-V3) X 26 / 1710		C1H	V ₁₉₃ ¹	V2+(V1-V2) 30 / 1966	
02H	V ₂ ¹	V6+(V5-V6) X 86 / 2206		42H	V ₆₆ ¹	V4+(V3-V4) X 64 / 1772		82H	V ₁₃₀ ¹	V3+(V2-V3) X 50 / 1710		C2H	V ₁₉₄ ¹	V2+(V1-V2) 60 / 1966	
03H	V ₃ ¹	V6+(V5-V6) X 172 / 2206		43H	V ₆₇ ¹	V4+(V3-V4) X 96 / 1772		83H	V ₁₃₁ ¹	V3+(V2-V3) X 76 / 1710		C3H	V ₁₉₅ ¹	V2+(V1-V2) 90 / 1966	
04H	V ₄ ¹	V6+(V5-V6) X 258 / 2206		44H	V ₆₈ ¹	V4+(V3-V4) X 128 / 1772		84H	V ₁₃₂ ¹	V3+(V2-V3) X 100 / 1710		C4H	V ₁₉₆ ¹	V2+(V1-V2) 122 / 1966	
05H	V ₅ ¹	V6+(V5-V6) X 344 / 2206		45H	V ₆₉ ¹	V4+(V3-V4) X 160 / 1772		85H	V ₁₃₃ ¹	V3+(V2-V3) X 124 / 1710		C5H	V ₁₉₇ ¹	V2+(V1-V2) 154 / 1966	
06H	V ₆ ¹	V6+(V5-V6) X 430 / 2206		46H	V ₇₀ ¹	V4+(V3-V4) X 192 / 1772		86H	V ₁₃₄ ¹	V3+(V2-V3) X 148 / 1710		C6H	V ₁₉₈ ¹	V2+(V1-V2) 186 / 1966	
07H	V ₇ ¹	V6+(V5-V6) X 514 / 2206		47H	V ₇₁ ¹	V4+(V3-V4) X 224 / 1772		87H	V ₁₃₅ ¹	V3+(V2-V3) X 172 / 1710		C7H	V ₁₉₉ ¹	V2+(V1-V2) 218 / 1966	
08H	V ₈ ¹	V6+(V5-V6) X 598 / 2206		48H	V ₇₂ ¹	V4+(V3-V4) X 254 / 1772		88H	V ₁₃₆ ¹	V3+(V2-V3) X 198 / 1710		C8H	V ₂₀₀ ¹	V2+(V1-V2) 250 / 1966	
09H	V ₉ ¹	V6+(V5-V6) X 680 / 2206		49H	V ₇₃ ¹	V4+(V3-V4) X 284 / 1772		89H	V ₁₃₇ ¹	V3+(V2-V3) X 224 / 1710		C9H	V ₂₀₁ ¹	V2+(V1-V2) 282 / 1966	
0AH	V ₁₀ ¹	V6+(V5-V6) X 762 / 2206		4AH	V ₇₄ ¹	V4+(V3-V4) X 314 / 1772		8AH	V ₁₃₈ ¹	V3+(V2-V3) X 250 / 1710		CAH	V ₂₀₂ ¹	V2+(V1-V2) 314 / 1966	
0BH	V ₁₁ ¹	V6+(V5-V6) X 842 / 2206		4BH	V ₇₅ ¹	V4+(V3-V4) X 344 / 1772		8BH	V ₁₃₉ ¹	V3+(V2-V3) X 276 / 1710		CBH	V ₂₀₃ ¹	V2+(V1-V2) 348 / 1966	
0CH	V ₁₂ ¹	V6+(V5-V6) X 920 / 2206		4CH	V ₇₆ ¹	V4+(V3-V4) X 374 / 1772		8CH	V ₁₄₀ ¹	V3+(V2-V3) X 302 / 1710		CCH	V ₂₀₄ ¹	V2+(V1-V2) 382 / 1966	
0DH	V ₁₃ ¹	V6+(V5-V6) X 998 / 2206		4DH	V ₇₇ ¹	V4+(V3-V4) X 404 / 1772		8DH	V ₁₄₁ ¹	V3+(V2-V3) X 328 / 1710		CDH	V ₂₀₅ ¹	V2+(V1-V2) 416 / 1966	
0EH	V ₁₄ ¹	V6+(V5-V6) X 1074 / 2206		4EH	V ₇₈ ¹	V4+(V3-V4) X 434 / 1772		8EH	V ₁₄₂ ¹	V3+(V2-V3) X 354 / 1710		CEH	V ₂₀₆ ¹	V2+(V1-V2) 450 / 1966	
0FH	V ₁₅ ¹	V6+(V5-V6) X 1148 / 2206		4FH	V ₇₉ ¹	V4+(V3-V4) X 464 / 1772		8FH	V ₁₄₃ ¹	V3+(V2-V3) X 380 / 1710		CFH	V ₂₀₇ ¹	V2+(V1-V2) 484 / 1966	
10H	V ₁₆ ¹	V6+(V5-V6) X 1222 / 2206		50H	V ₈₀ ¹	V4+(V3-V4) X 494 / 1772		90H	V ₁₄₄ ¹	V3+(V2-V3) X 406 / 1710		D0H	V ₂₀₈ ¹	V2+(V1-V2) 518 / 1966	
11H	V ₁₇ ¹	V6+(V5-V6) X 1294 / 2206		51H	V ₈₁ ¹	V4+(V3-V4) X 524 / 1772		91H	V ₁₄₅ ¹	V3+(V2-V3) X 432 / 1710		D1H	V ₂₀₉ ¹	V2+(V1-V2) 554 / 1966	
12H	V ₁₈ ¹	V6+(V5-V6) X 1364 / 2206		52H	V ₈₂ ¹	V4+(V3-V4) X 552 / 1772		92H	V ₁₄₆ ¹	V3+(V2-V3) X 458 / 1710		D2H	V ₂₁₀ ¹	V2+(V1-V2) 590 / 1966	
13H	V ₁₉ ¹	V6+(V5-V6) X 1432 / 2206		53H	V ₈₃ ¹	V4+(V3-V4) X 580 / 1772		93H	V ₁₄₇ ¹	V3+(V2-V3) X 484 / 1710		D3H	V ₂₁₁ ¹	V2+(V1-V2) 626 / 1966	
14H	V ₂₀ ¹	V6+(V5-V6) X 1500 / 2206		54H	V ₈₄ ¹	V4+(V3-V4) X 608 / 1772		94H	V ₁₄₈ ¹	V3+(V2-V3) X 510 / 1710		D4H	V ₂₁₂ ¹	V2+(V1-V2) 662 / 1966	
15H	V ₂₁ ¹	V6+(V5-V6) X 1566 / 2206		55H	V ₈₅ ¹	V4+(V3-V4) X 636 / 1772		95H	V ₁₄₉ ¹	V3+(V2-V3) X 536 / 1710		D5H	V ₂₁₃ ¹	V2+(V1-V2) 698 / 1966	
16H	V ₂₂ ¹	V6+(V5-V6) X 1630 / 2206		56H	V ₈₆ ¹	V4+(V3-V4) X 664 / 1772		96H	V ₁₅₀ ¹	V3+(V2-V3) X 562 / 1710		D6H	V ₂₁₄ ¹	V2+(V1-V2) 736 / 1966	
17H	V ₂₃ ¹	V6+(V5-V6) X 1694 / 2206		57H	V ₈₇ ¹	V4+(V3-V4) X 692 / 1772		97H	V ₁₅₁ ¹	V3+(V2-V3) X 588 / 1710		D7H	V ₂₁₅ ¹	V2+(V1-V2) 774 / 1966	
18H	V ₂₄ ¹	V6+(V5-V6) X 1756 / 2206		58H	V ₈₈ ¹	V4+(V3-V4) X 720 / 1772		98H	V ₁₅₂ ¹	V3+(V2-V3) X 614 / 1710		D8H	V ₂₁₆ ¹	V2+(V1-V2) 812 / 1966	
19H	V ₂₅ ¹	V6+(V5-V6) X 1816 / 2206		59H	V ₈₉ ¹	V4+(V3-V4) X 748 / 1772		99H	V ₁₅₃ ¹	V3+(V2-V3) X 640 / 1710		D9H	V ₂₁₇ ¹	V2+(V1-V2) 850 / 1966	
1AH	V ₂₆ ¹	V6+(V5-V6) X 1876 / 2206		5AH	V ₉₀ ¹	V4+(V3-V4) X 776 / 1772		9AH	V ₁₅₄ ¹	V3+(V2-V3) X 666 / 1710		DAH	V ₂₁₈ ¹	V2+(V1-V2) 890 / 1966	
1BH	V ₂₇ ¹	V6+(V5-V6) X 1934 / 2206		5BH	V ₉₁ ¹	V4+(V3-V4) X 804 / 1772		9BH	V ₁₅₅ ¹	V3+(V2-V3) X 692 / 1710		DBH	V ₂₁₉ ¹	V2+(V1-V2) 930 / 1966	
1CH	V ₂₈ ¹	V6+(V5-V6) X 1990 / 2206		5CH	V ₉₂ ¹	V4+(V3-V4) X 832 / 1772		9CH	V ₁₅₆ ¹	V3+(V2-V3) X 718 / 1710		DCH	V ₂₂₀ ¹	V2+(V1-V2) 970 / 1966	
1DH	V ₂₉ ¹	V6+(V5-V6) X 2046 / 2206		5DH	V ₉₃ ¹	V4+(V3-V4) X 860 / 1772		9DH	V ₁₅₇ ¹	V3+(V2-V3) X 744 / 1710		DDH	V ₂₂₁ ¹	V2+(V1-V2) 1012 / 1966	
1EH	V ₃₀ ¹	V6+(V5-V6) X 2100 / 2206		5EH	V ₉₄ ¹	V4+(V3-V4) X 888 / 1772		9EH	V ₁₅₈ ¹	V3+(V2-V3) X 770 / 1710		DEH	V ₂₂₂ ¹	V2+(V1-V2) 1054 / 1966	
1FH	V ₃₁ ¹	V6+(V5-V6) X 2154 / 2206		5FH	V ₉₅ ¹	V4+(V3-V4) X 914 / 1772		9FH	V ₁₅₉ ¹	V3+(V2-V3) X 796 / 1710		DFH	V ₂₂₃ ¹	V2+(V1-V2) 1096 / 1966	
20H	V ₃₂ ¹	V5		60H	V ₉₆ ¹	V4+(V3-V4) X 940 / 1772		A0H	V ₁₆₀ ¹	V3+(V2-V3) X 822 / 1710		E0H	V ₂₂₄ ¹	V2+(V1-V2) 1140 / 1966	
21H	V ₃₃ ¹	V5+(V4-V5) X 52 / 1304		61H	V ₉₇ ¹	V4+(V3-V4) X 966 / 1772		A1H	V ₁₆₁ ¹	V3+(V2-V3) X 848 / 1710		E1H	V ₂₂₅ ¹	V2+(V1-V2) 1184 / 1966	
22H	V ₃₄ ¹	V5+(V4-V5) X 102 / 1304		62H	V ₉₈ ¹	V4+(V3-V4) X 992 / 1772		A2H	V ₁₆₂ ¹	V3+(V2-V3) X 874 / 1710		E2H	V ₂₂₆ ¹	V2+(V1-V2) 1228 / 1966	
23H	V ₃₅ ¹	V5+(V4-V5) X 152 / 1304		63H	V ₉₉ ¹	V4+(V3-V4) X 1018 / 1772		A3H	V ₁₆₃ ¹	V3+(V2-V3) X 900 / 1710		E3H	V ₂₂₇ ¹	V2+(V1-V2) 1274 / 1966	
24H	V ₃₆ ¹	V5+(V4-V5) X 200 / 1304		64H	V ₁₀₀ ¹	V4+(V3-V4) X 1044 / 1772		A4H	V ₁₆₄ ¹	V3+(V2-V3) X 926 / 1710		E4H	V ₂₂₈ ¹	V2+(V1-V2) 1320 / 1966	
25H	V ₃₇ ¹	V5+(V4-V5) X 248 / 1304		65H	V ₁₀₁ ¹	V4+(V3-V4) X 1070 / 1772		A5H	V ₁₆₅ ¹	V3+(V2-V3) X 952 / 1710		E5H	V ₂₂₉ ¹	V2+(V1-V2) 1368 / 1966	
26H	V ₃₈ ¹	V5+(V4-V5) X 294 / 1304		66H	V ₁₀₂ ¹	V4+(V3-V4) X 1096 / 1772		A6H	V ₁₆₆ ¹	V3+(V2-V3) X 978 / 1710		E6H	V ₂₃₀ ¹	V2+(V1-V2) 1416 / 1966	
27H	V ₃₉ ¹	V5+(V4-V5) X 340 / 1304		67H	V ₁₀₃ ¹	V4+(V3-V4) X 1122 / 1772		A7H	V ₁₆₇ ¹	V3+(V2-V3) X 1004 / 1710		E7H	V ₂₃₁ ¹	V2+(V1-V2) 1466 / 1966	
28H	V ₄₀ ¹	V5+(V4-V5) X 386 / 1304		68H	V ₁₀₄ ¹	V4+(V3-V4) X 1148 / 1772		A8H	V ₁₆₈ ¹	V3+(V2-V3) X 1030 / 1710		E8H	V ₂₃₂ ¹	V2+(V1-V2) 1516 / 1966	
29H	V ₄₁ ¹	V5+(V4-V5) X 430 / 1304		69H	V ₁₀₅ ¹	V4+(V3-V4) X 1174 / 1772		A9H	V ₁₆₉ ¹	V3+(V2-V3) X 1056 / 1710		E9H	V ₂₃₃ ¹	V2+(V1-V2) 1568 / 1966	
2AH	V ₄₂ ¹	V5+(V4-V5) X 474 / 1304		6AH	V ₁₀₆ ¹	V4+(V3-V4) X 1200 / 1772		AAH	V ₁₇₀ ¹	V3+(V2-V3) X 1082 / 1710		EAH	V ₂₃₄ ¹	V2+(V1-V2) 1620 / 1966	
2BH	V ₄₃ ¹	V5+(V4-V5) X 518 / 1304		6BH	V ₁₀₇ ¹	V4+(V3-V4) X 1226 / 1772		ABH	V ₁₇₁ ¹	V3+(V2-V3) X 1108 / 1710		EBH	V ₂₃₅ ¹	V2+(V1-V2) 1674 / 1966	
2CH	V ₄₄ ¹	V5+(V4-V5) X 560 / 1304		6CH	V ₁₀₈ ¹	V4+(V3-V4) X 1252 / 1772		ACH	V ₁₇₂ ¹	V3+(V2-V3) X 1136 / 1710		ECH	V ₂₃₆ ¹	V2+(V1-V2) 1730 / 1966	
2DH	V ₄₅ ¹	V5+(V4-V5) X 602 / 1304		6DH	V ₁₀₉ ¹	V4+(V3-V4) X 1278 / 1772		ADH	V ₁₇₃ ¹	V3+(V2-V3) X 1164 / 1710		EDH	V ₂₃₇ ¹	V2+(V1-V2) 1786 / 1966	
2EH	V ₄₆ ¹	V5+(V4-V5) X 644 / 1304		6EH	V ₁₁₀ ¹	V4+(V3-V4) X 1304 / 1772		AEH	V ₁₇₄ ¹	V3+(V2-V3) X 1192 / 1710		EEH	V ₂₃₈ ¹	V2+(V1-V2) 1844 / 1966	
2FH	V ₄₇ ¹	V5+(V4-V5) X 684 / 1304		6FH	V ₁₁₁ ¹	V4+(V3-V4) X 1330 / 1772		AFH	V ₁₇₅ ¹	V3+(V2-V3) X 1220 / 1710		EFH	V ₂₃₉ ¹	V2+(V1-V2) 1904 / 1966	
30H	V ₄₈ ¹	V5+(V4-V5) X 724 / 1304		70H	V ₁₁₂ ¹	V4+(V3-V4) X 1356 / 1772		B0H	V ₁₇₆ ¹	V3+(V2-V3) X 1248 / 1710		F0H	V ₂₄₀ ¹	V1	
31H	V ₄₉ ¹	V5+(V4-V5) X 764 / 1304		71H	V ₁₁₃ ¹	V4+(V3-V4) X 1382 / 1772									

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

★

(Output voltage 2) $0.5 V_{DD2} - 0.5 V \geq V_8 > V_9 > V_{10} > V_{11} > V_{12} > V_{13} > V_{14} > V_{15} \geq V_{SS2} + 0.2 V$

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

6. RELATIONSHIP BETWEEN INPUT DATA AND OUTPUT PIN

Data format: 8 bits x 2 RGBs (6 dots)
Input width: 48 bits (2-pixel data)

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

Output	S ₁	S ₂	S ₃	S ₄	...	S ₃₈₃	S ₃₈₄
Data	D ₀₀ to D ₀₇	D ₁₀ to D ₁₇	D ₂₀ to D ₂₇	D ₃₀ to D ₃₇	...	D ₄₀ to D ₄₇	D ₅₀ to D ₅₇

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

Output	S ₁	S ₂	S ₃	S ₄	...	S ₃₈₃	S ₃₈₄
Data	D ₀₀ to D ₀₇	D ₁₀ to D ₁₇	D ₂₀ to D ₂₇	D ₃₀ to D ₃₇	...	D ₄₀ to D ₄₇	D ₅₀ to D ₅₇

POL	S _{2n-1} ^{Note}	S _{2n} ^{Note}
L	V ₀ -V ₇	V ₈ -V ₁₅
H	V ₈ -V ₁₅	V ₀ -V ₇

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

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

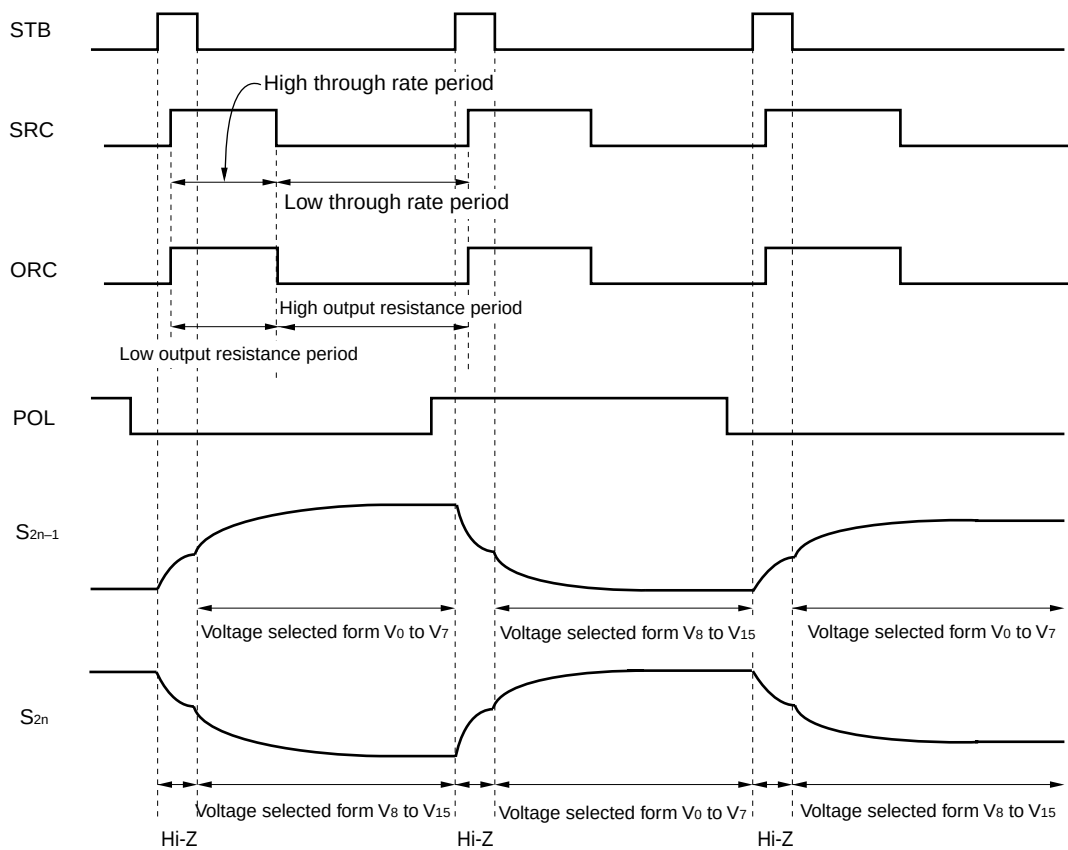
When MODE = H or open and STB = H, all outputs are reset (short) and the gray-scale voltage is output to LCD in synchronization with the falling edge of STB.

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

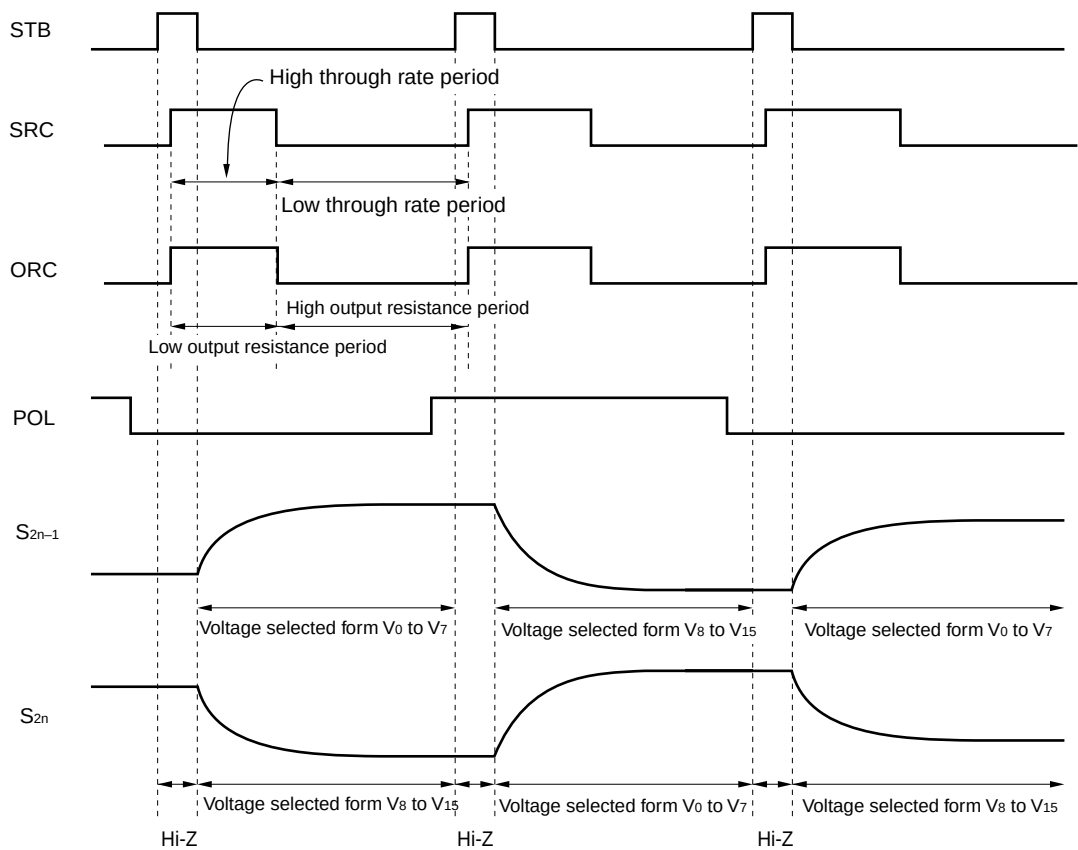
Also, setting the SRC pin to H level allows the bias current value of the output amplifier to rise temporarily, and setting the ORC pin to H level allows the output resistance value of the amplifier to lower temporarily.

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

(1) MODE = H or open



(2) MODE = L



8. ELECTRICAL SPECIFICATIONS

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

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

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

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

Parameter	Symbol	Condition	MIN.	TYP.	MAX.	Unit
★ Logic part supply voltage	V _{DD1}		2.5		3.6	V
Driver part supply voltage	V _{DD2}	V _{SEL} = H	12.5	13.0	(14.0)	V
		V _{SEL} = L or open	(14.0)	15.0	15.5	
High-level input voltage	V _{IH}		0.7 V _{DD1}		V _{DD1}	V
Low-level input voltage	V _{IL}		0		0.3 V _{DD1}	V
γ-corrected voltage	V ₀ –V ₇		0.5 V _{DD2} + 0.5		V _{DD2} − 0.2	V
	V ₈ –V ₁₅		0.2		0.5 V _{DD2} − 0.5	V
Driver part output voltage	V _O		0.2		V _{DD2} − 0.2	V
Clock frequency	f _{CLK}	3.0 V ≤ V _{DD1} ≤ 3.6 V			55	MHz
		2.5 V ≤ V _{DD1} < 3.0 V			40	MHz

Remark The value enclosed in parentheses is a reference value.

Electrical Characteristics ($T_A = -10$ to $+75^\circ\text{C}$, $V_{DD1} = 2.5$ to 3.6 V, $V_{DD2} = 12.5$ to 15.5 V, $V_{SS1} = V_{SS2} = 0$ V)

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

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

V_{OUT} refers to the voltage applied to analog output pins S_1 to S_{384}

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

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

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

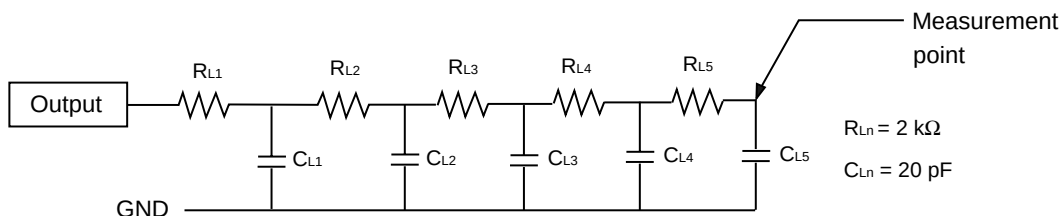
Switching Characteristics ($T_A = -10$ to $+75^\circ\text{C}$, $V_{DD1} = 2.5$ to 3.6 V, $V_{DD2} = 12.5$ to 15.5 V, $V_{SS1} = V_{SS2} = 0$ V)

Parameter	Symbol	Condition	MIN.	TYP.	MAX.	Unit
Start pulse delay time	t_{PLH1}	$C_L = 15$ pF, 3.0 V $\leq V_{DD} \leq 3.6$ V			17	ns
		$C_L = 15$ pF, 2.5 V $\leq V_{DD} < 3.0$ V			24	ns
★ Driver output delay time	t_{PLH2} ^{Note}	$C_L = 100$ pF, $R_L = 10$ k Ω			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), $T_A = 25^\circ\text{C}$		5	10	pF
	C_{i2}	STHR (STHL), $T_A = 25^\circ\text{C}$		10	15	pF

Note t_{PLH2} , t_{PHL2} refer to the arrival time from falling edge of STB to target voltage $\pm 10\%$

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 $\leftrightarrow$ 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)

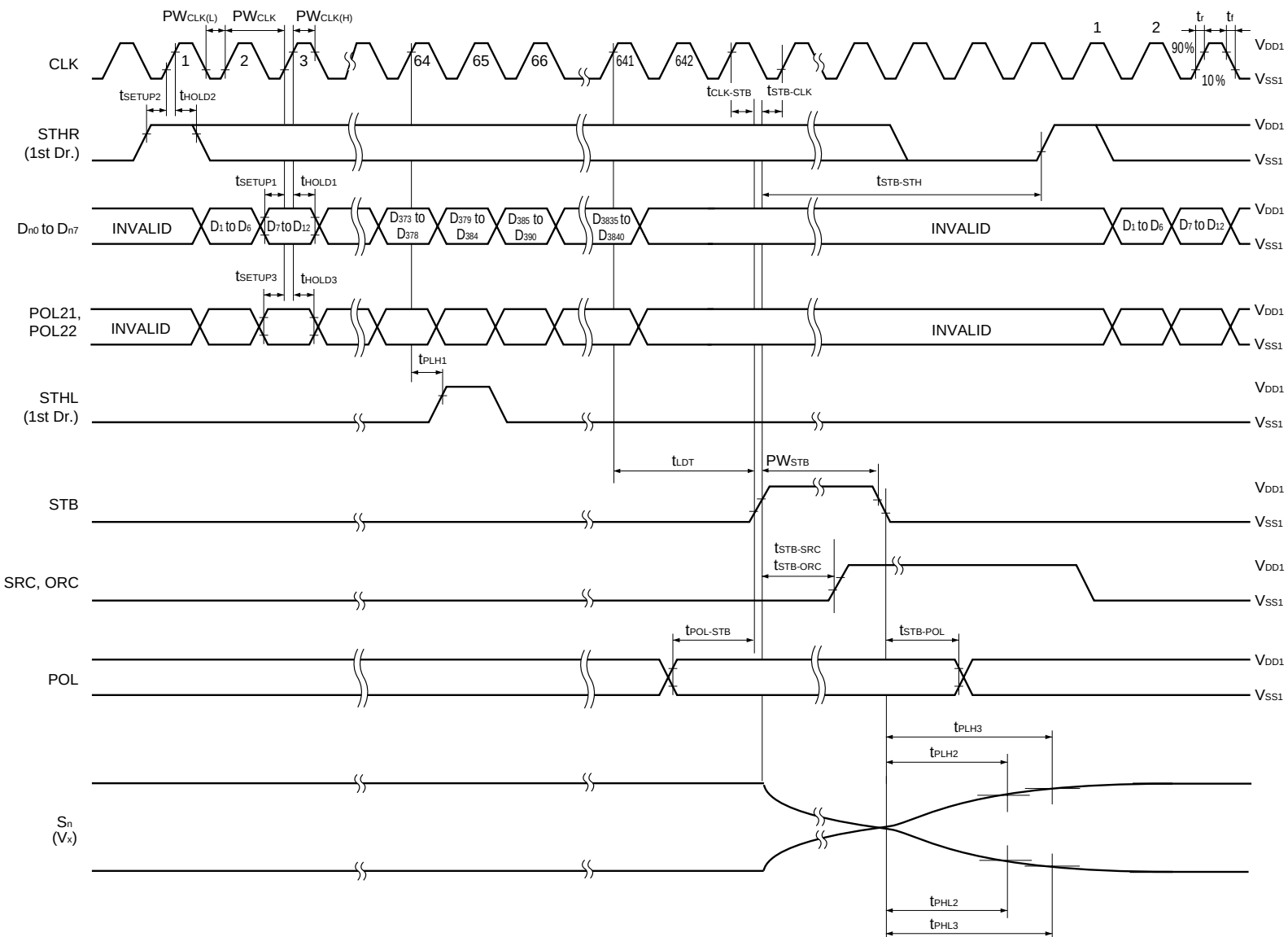
Parameter	Symbol	Condition	MIN.	TYP.	MAX.	Unit
Clock pulse width	PW_{CLK}	$3.0\text{ V} \leq V_{DD1} \leq 3.6\text{ V}$	18			ns
		$2.5\text{ V} \leq V_{DD1} < 3.0\text{ V}$	25			ns
Clock pulse high period	$PW_{CLK(H)}$	$3.0\text{ V} \leq V_{DD1} \leq 3.6\text{ V}$	4			ns
		$2.5\text{ V} \leq V_{DD1}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

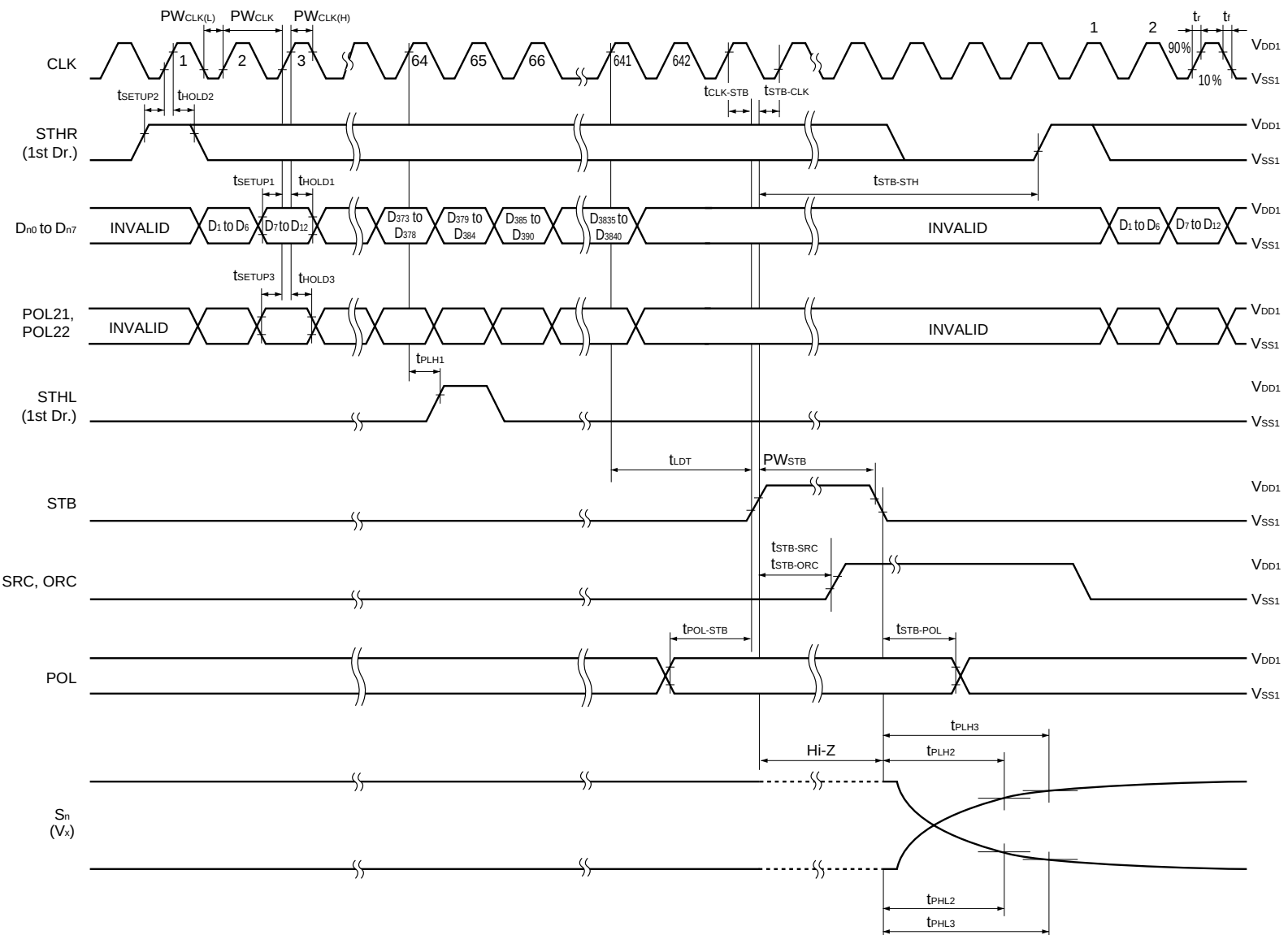
(1) R_L=H, MODE = H or open

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



(2) R_L=H, MODE = L

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



9. RECOMMENDED MOUNTING CONDITIONS

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

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

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

μPD160040N-xxx: TCP (TAB Package)

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

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

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

Note:

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

② HANDLING OF UNUSED INPUT PINS FOR CMOS

Note:

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

③ STATUS BEFORE INITIALIZATION OF MOS DEVICES

Note:

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

Reference Documents

NEC Semiconductor Device Reliability/Quality Control System (C10983E)

Quality Grades On NEC Semiconductor Devices (C11531E)

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