

**384-OUTPUT TFT-LCD SOURCE DRIVER
(COMPATIBLE WITH 256-GRAY SCALE)**
DESCRIPTION

The μ PD160040B is a source driver for TFT-LCDs capable of dealing with displays with 256-gray scale. 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 voltage 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)
- Trough-rate control is possible (SRC)
- Output resistance control is possible (ORC)
- Single bank arrangement is possible (Loaded with slim TCP)

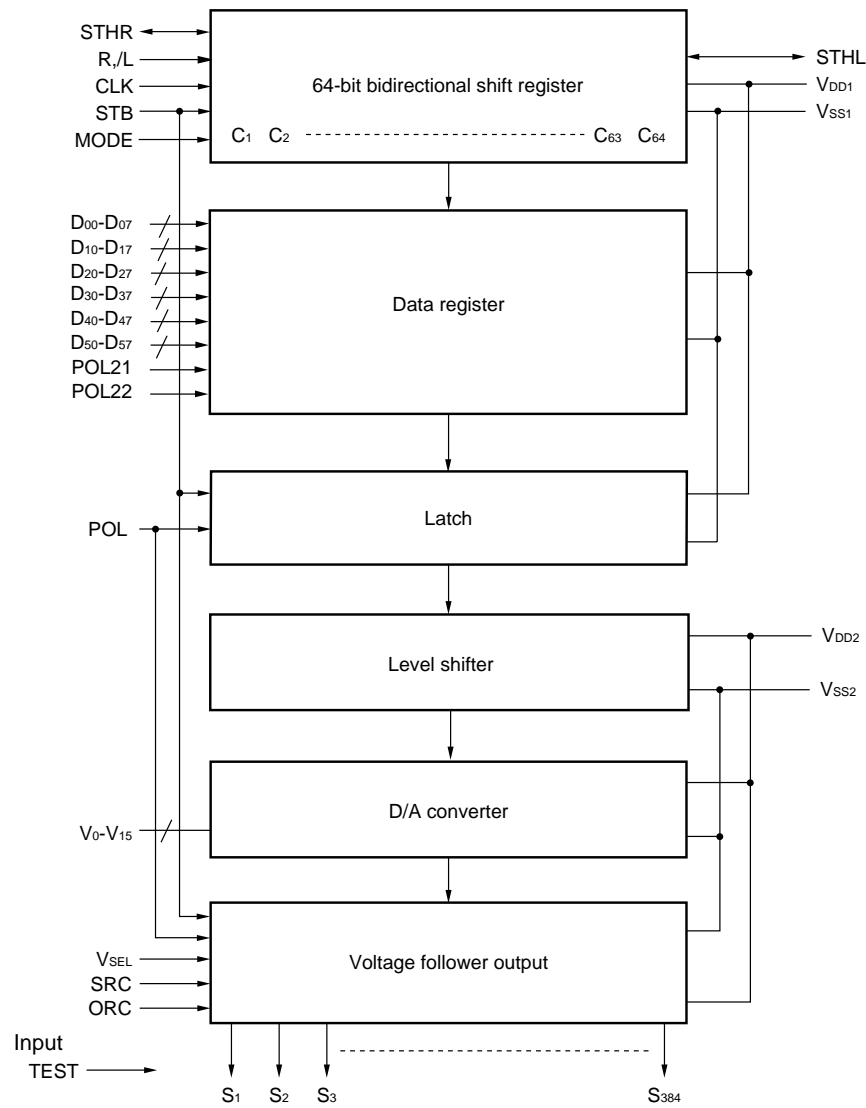
ORDERING INFORMATION

Part Number	Package
μ PD160040BN-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.

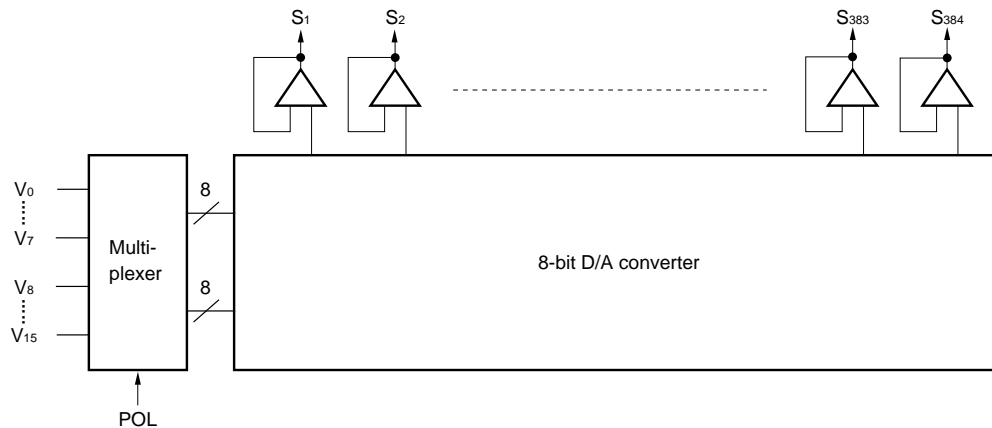
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1. BLOCK DIAGRAM

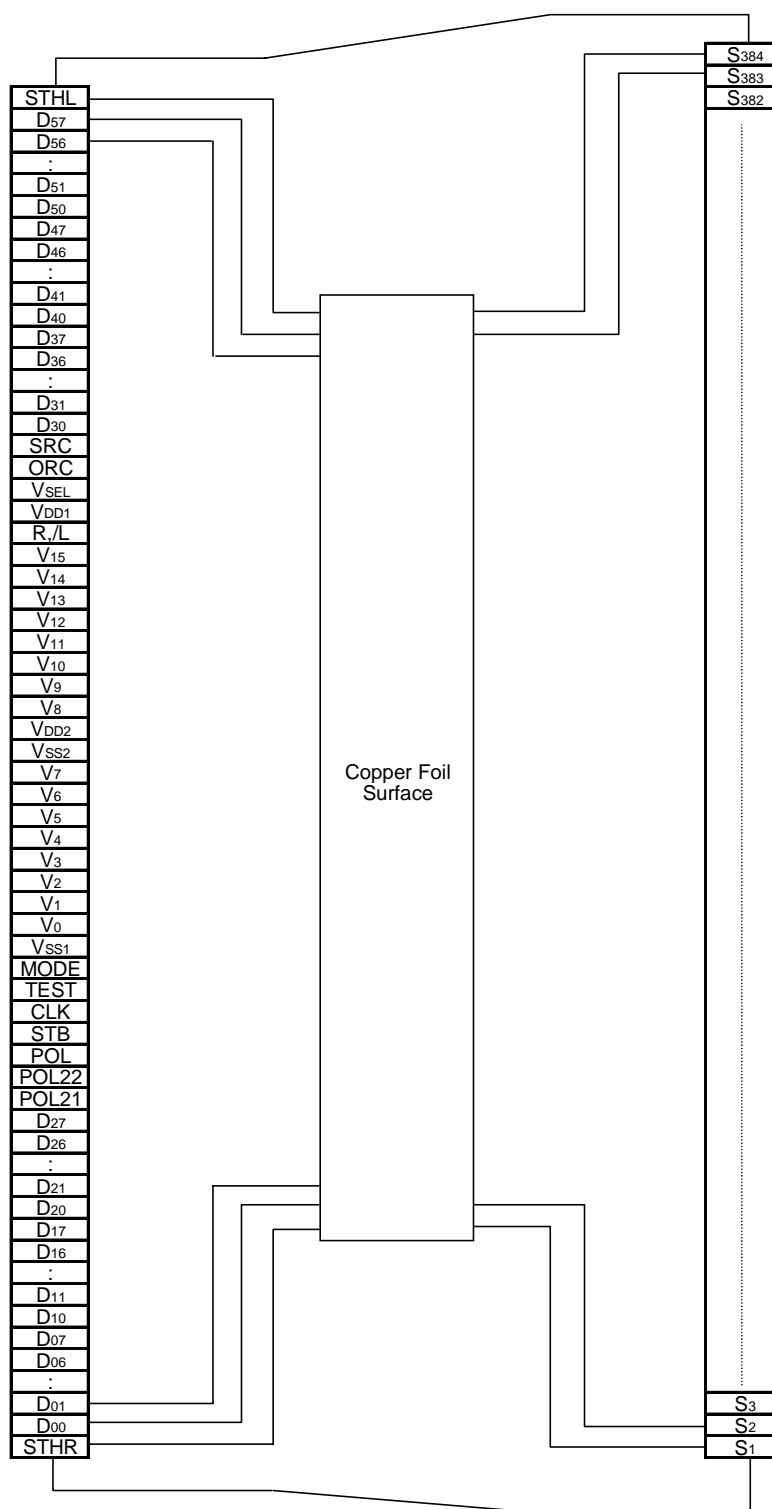


Remark /xxx indicates active low signal.

2. RELATIONSHIP BETWEEN OUTPUT CIRCUIT AND D/A CONVERTER



3. PIN CONFIGURATION (μ PD160040BN-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 mode (large current consumption) SRC = L: Low through 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	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.
VSEL	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 15.5 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. $V_{DD2} - 0.2\text{ V} \geq V_0 > V_1 > V_2 > \dots > V_6 > V_7 \geq 0.5 V_{DD2} + 0.5\text{ V}$ $0.5 V_{DD2} - 0.5\text{ V} \geq V_8 > V_9 > V_{10} > \dots > V_{14} > V_{15} \geq 0.5 V_{SS2} + 0.2\text{ V}$
TEST	Test	Input	Normally, set the TEST pin to H 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.

- 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 μPD160040B 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_{254}) 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.

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

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

Figures 5-2 and 5-3 show the relation ship between the input data and the output voltage and the resistance values of the resistor strings.

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

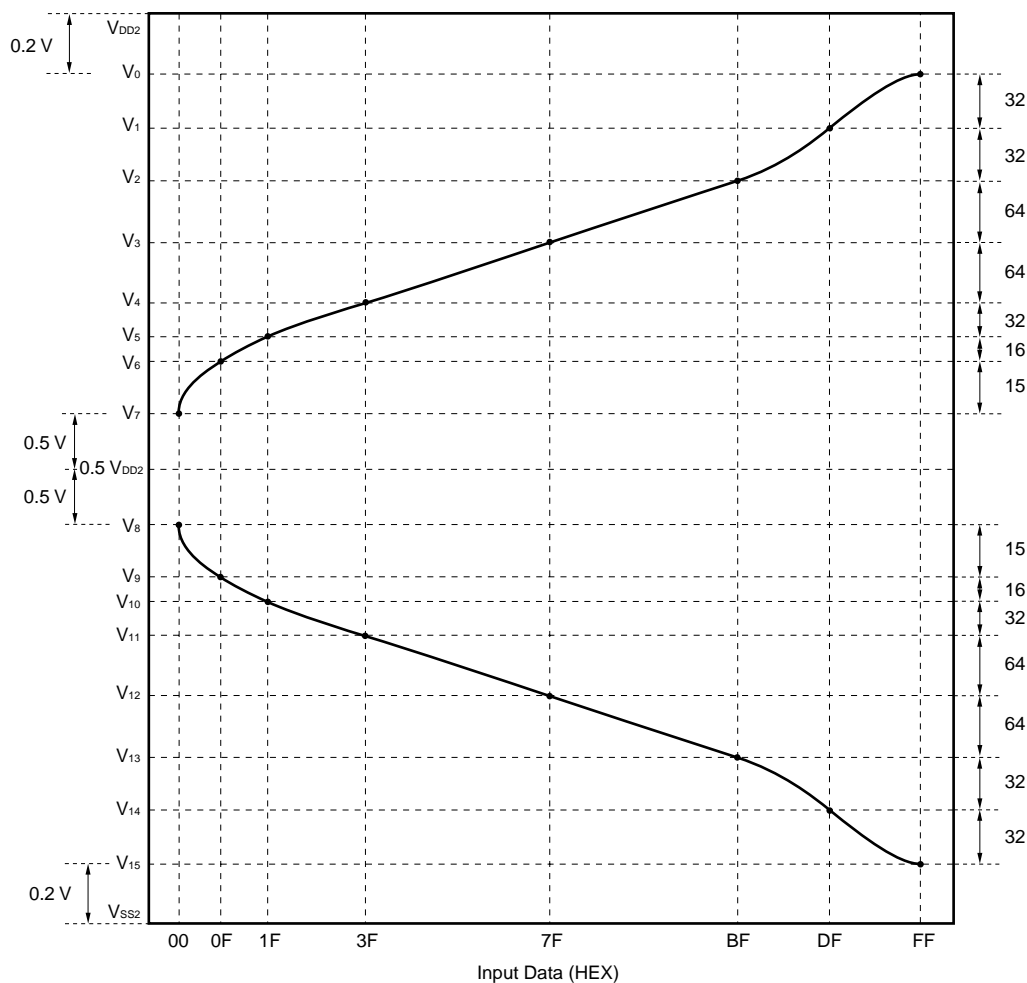
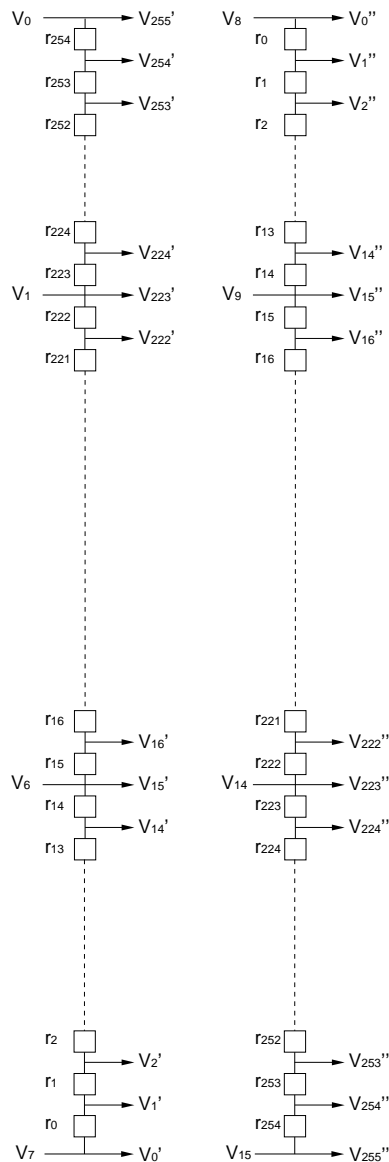


Figure 5-2. γ -Corrected Voltages and Ladder Resistors Ratio



m	Ratio 1	Ratio 2	Value	m	Ratio 1	Ratio 2	Value	m	Ratio 1	Ratio 2	Value	m	Ratio 1	Ratio 2	Value
r0	1.00	0.0014	18	r65	2.33	0.0032	42	r130	1.89	0.0026	34	r195	2.22	0.0031	40
r1	1.11	0.0015	20	r66	2.22	0.0031	40	r131	1.89	0.0026	34	r196	2.22	0.0031	40
r2	1.33	0.0018	24	r67	2.11	0.0029	38	r132	1.78	0.0025	32	r197	2.22	0.0031	40
r3	1.44	0.0020	26	r68	2.00	0.0028	36	r133	1.78	0.0025	32	r198	2.22	0.0031	40
r4	1.67	0.0023	30	r69	2.00	0.0028	36	r134	1.78	0.0025	32	r199	2.22	0.0031	40
r5	1.89	0.0026	34	r70	2.00	0.0028	36	r135	1.78	0.0025	32	r200	2.22	0.0031	40
r6	2.00	0.0028	36	r71	1.89	0.0026	34	r136	1.78	0.0025	32	r201	2.22	0.0031	40
r7	2.11	0.0029	38	r72	2.00	0.0028	36	r137	1.78	0.0025	32	r202	2.33	0.0032	42
r8	2.22	0.0031	40	r73	2.00	0.0028	36	r138	1.78	0.0025	32	r203	2.44	0.0034	44
r9	2.44	0.0034	44	r74	2.00	0.0028	36	r139	1.78	0.0025	32	r204	2.44	0.0034	44
r10	2.56	0.0035	46	r75	2.00	0.0028	36	r140	1.78	0.0025	32	r205	2.56	0.0035	46
r11	2.89	0.0040	52	r76	2.11	0.0029	38	r141	1.78	0.0025	32	r206	2.56	0.0035	46
r12	3.11	0.0043	56	r77	2.22	0.0031	40	r142	1.78	0.0025	32	r207	2.56	0.0035	46
r13	3.22	0.0045	58	r78	2.33	0.0032	42	r143	1.67	0.0023	30	r208	2.78	0.0038	50
r14	3.44	0.0048	62	r79	2.33	0.0032	42	r144	1.67	0.0023	30	r209	2.78	0.0038	50
r15	3.78	0.0052	68	r80	2.33	0.0032	42	r145	1.67	0.0023	30	r210	2.78	0.0038	50
r16	3.78	0.0052	68	r81	2.22	0.0031	40	r146	1.67	0.0023	30	r211	2.78	0.0038	50
r17	3.89	0.0054	70	r82	2.22	0.0031	40	r147	1.67	0.0023	30	r212	2.89	0.0040	52
r18	4.00	0.0055	72	r83	2.22	0.0031	40	r148	1.67	0.0023	30	r213	2.89	0.0040	52
r19	4.00	0.0055	72	r84	2.22	0.0031	40	r149	1.67	0.0023	30	r214	2.89	0.0040	52
r20	4.00	0.0055	72	r85	2.11	0.0029	38	r150	1.67	0.0023	30	r215	2.89	0.0040	52
r21	4.00	0.0055	72	r86	2.11	0.0029	38	r151	1.67	0.0023	30	r216	2.89	0.0040	52
r22	4.00	0.0055	72	r87	2.11	0.0029	38	r152	1.67	0.0023	30	r217	3.00	0.0042	54
r23	4.00	0.0055	72	r88	2.00	0.0028	36	r153	1.78	0.0025	32	r218	3.00	0.0042	54
r24	4.00	0.0055	72	r89	2.00	0.0028	36	r154	1.78	0.0025	32	r219	3.00	0.0042	54
r25	4.00	0.0055	72	r90	1.89	0.0026	34	r155	1.78	0.0025	32	r220	3.00	0.0042	54
r26	4.00	0.0055	72	r91	1.78	0.0025	32	r156	1.78	0.0025	32	r221	3.00	0.0042	54
r27	4.00	0.0055	72	r92	1.78	0.0025	32	r157	1.89	0.0026	34	r222	3.00	0.0042	54
r28	4.00	0.0055	72	r93	1.78	0.0025	32	r158	1.89	0.0026	34	r223	3.11	0.0043	56
r29	4.00	0.0055	72	r94	1.89	0.0026	34	r159	1.89	0.0026	34	r224	3.11	0.0043	56
r30	4.00	0.0055	72	r95	1.89	0.0026	34	r160	1.89	0.0026	34	r225	3.22	0.0045	58
r31	3.89	0.0054	70	r96	1.89	0.0026	34	r161	1.89	0.0026	34	r226	3.22	0.0045	58
r32	3.89	0.0054	70	r97	1.89	0.0026	34	r162	1.89	0.0026	34	r227	3.44	0.0048	62
r33	3.89	0.0054	70	r98	1.78	0.0025	32	r163	1.89	0.0026	34	r228	3.56	0.0049	64
r34	3.89	0.0054	70	r99	1.78	0.0025	32	r164	1.89	0.0026	34	r229	3.67	0.0051	66
r35	3.89	0.0054	70	r100	1.78	0.0025	32	r165	1.89	0.0026	34	r230	3.78	0.0052	68
r36	3.89	0.0054	70	r101	1.78	0.0025	32	r166	1.89	0.0026	34	r231	3.78	0.0052	68
r37	3.89	0.0054	70	r102	1.67	0.0023	30	r167	2.00	0.0028	36	r232	3.78	0.0052	68
r38	3.78	0.0052	68	r103	1.56	0.0022	28	r168	2.11	0.0029	38	r233	3.89	0.0054	70
r39	3.67	0.0051	66	r104	1.56	0.0022	28	r169	2.11	0.0029	38	r234	4.00	0.0055	72
r40	3.67	0.0051	66	r105	1.56	0.0022	28	r170	2.11	0.0029	38	r235	4.22	0.0058	76
r41	3.67	0.0051	66	r106	1.56	0.0022	28	r171	2.11	0.0029	38	r236	4.44	0.0062	80
r42	3.67	0.0051	66	r107	1.56	0.0022	28	r172	2.22	0.0031	40	r237	4.56	0.0063	82
r43	3.56	0.0049	64	r108	1.44	0.0020	26	r173	2.22	0.0031	40	r238	4.56	0.0063	82
r44	3.56	0.0049	64	r109	1.44	0.0020	26	r174	2.22	0.0031	40	r239	4.78	0.0066	86
r45	3.56	0.0049	64	r110	1.44	0.0020	26	r175	2.22	0.0031	40	r240	4.78	0.0066	86
r46	3.44	0.0048	62	r111	1.44	0.0020	26	r176	2.22	0.0031	40	r241	4.89	0.0068	88
r47	3.44	0.0048	62	r112	1.44	0.0020	26	r177	2.22	0.0031	40	r242	5.11	0.0071	92
r48	3.33	0.0046	60	r113	1.44	0.0020	26	r178	2.11	0.0029	38	r243	5.44	0.0075	98
r49	3.22	0.0045	58	r114	1.56	0.0022	28	r179	2.11	0.0029	38	r244	5.89	0.0082	106
r50	3.11	0.0043	56	r115	1.67	0.0023	30	r180	2.00	0.0028	36	r245	6.22	0.0086	112
r51	2.89	0.0040	52	r116	1.67	0.0023	30	r181	2.00	0.0028	36	r246	6.56	0.0091	118
r52	2.78	0.0038	50	r117	1.78	0.0025	32	r182	2.00	0.0028	36	r247	6.78	0.0094	122
r53	2.78	0.0038	50	r118	1.89	0.0026	34	r183	2.00	0.0028	36	r248	7.44	0.0103	134
r54	2.67	0.0037	48	r119	1.89	0.0026	34	r184	2.00	0.0028	36	r249	8.11	0.0112	146
r55	2.44	0.0034	44	r120	1.89	0.0026	34	r185	2.00	0.0028	36	r250	9.56	0.0132	172
r56	2.33	0.0032	42	r121	1.89	0.0026	34	r186	2.00	0.0028	36	r251	10.89	0.0151	196
r57	2.33	0.0032	42	r122	2.00	0.0028	36	r187	2.11	0.0029	38	r252	12.22	0.0169	220
r58	2.33	0.0032	42	r123	2.00	0.0028	36	r188	2.22	0.0031	40	r253	14.89	0.0206	268
r59	2.33	0.0032	42	r124	2.00	0.0028	36	r189	2.22	0.0031	40	r254	22.22	0.0308	400
r60	2.33	0.0032	42	r125	2.00	0.0028	36	r190	2.22	0.0031	40	Total resistance			13004
r61	2.33	0.0032	42	r126	2.00	0.0028	36	r191	2.22	0.0031	40	Minimum resistance value			18
r62	2.33	0.0032	42	r127	2.00	0.0028	36	r192	2.22	0.0031	40				
r63	2.33	0.0032	42	r128	2.00	0.0028	36	r193	2.22	0.0031	40				
r64	2.33	0.0032	42	r129	2.00	0.0028	36	r194	2.22	0.0031	40				

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)

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(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	V0'	V7		40H	V64'	V4+(V3-V4) X 42 / 2196		80H	V128'	V3+(V2-V3) X 36 / 2210		C0H	V192'	V2+(V1-V2) X 40 / 1492	
01H	V1'	V7+(V6-V7) X 18 / 584		41H	V65'	V4+(V3-V4) X 84 / 2196		81H	V129'	V3+(V2-V3) X 72 / 2210		C1H	V193'	V2+(V1-V2) X 80 / 1492	
02H	V2'	V7+(V6-V7) X 38 / 584		42H	V66'	V4+(V3-V4) X 126 / 2196		82H	V130'	V3+(V2-V3) X 108 / 2210		C2H	V194'	V2+(V1-V2) X 120 / 1492	
03H	V3'	V7+(V6-V7) X 62 / 584		43H	V67'	V4+(V3-V4) X 166 / 2196		83H	V131'	V3+(V2-V3) X 142 / 2210		C3H	V195'	V2+(V1-V2) X 160 / 1492	
04H	V4'	V7+(V6-V7) X 88 / 584		44H	V68'	V4+(V3-V4) X 204 / 2196		84H	V132'	V3+(V2-V3) X 176 / 2210		C4H	V196'	V2+(V1-V2) X 200 / 1492	
05H	V5'	V7+(V6-V7) X 118 / 584		45H	V69'	V4+(V3-V4) X 240 / 2196		85H	V133'	V3+(V2-V3) X 208 / 2210		C5H	V197'	V2+(V1-V2) X 240 / 1492	
06H	V6'	V7+(V6-V7) X 152 / 584		46H	V70'	V4+(V3-V4) X 276 / 2196		86H	V134'	V3+(V2-V3) X 240 / 2210		C6H	V198'	V2+(V1-V2) X 280 / 1492	
07H	V7'	V7+(V6-V7) X 188 / 584		47H	V71'	V4+(V3-V4) X 312 / 2196		87H	V135'	V3+(V2-V3) X 272 / 2210		C7H	V199'	V2+(V1-V2) X 320 / 1492	
08H	V8'	V7+(V6-V7) X 226 / 584		48H	V72'	V4+(V3-V4) X 346 / 2196		88H	V136'	V3+(V2-V3) X 304 / 2210		C8H	V200'	V2+(V1-V2) X 360 / 1492	
09H	V9'	V7+(V6-V7) X 266 / 584		49H	V73'	V4+(V3-V4) X 382 / 2196		89H	V137'	V3+(V2-V3) X 336 / 2210		C9H	V201'	V2+(V1-V2) X 400 / 1492	
0AH	V10'	V7+(V6-V7) X 310 / 584		4AH	V74'	V4+(V3-V4) X 418 / 2196		8AH	V138'	V3+(V2-V3) X 368 / 2210		CAH	V202'	V2+(V1-V2) X 440 / 1492	
0BH	V11'	V7+(V6-V7) X 356 / 584		4BH	V75'	V4+(V3-V4) X 454 / 2196		8BH	V139'	V3+(V2-V3) X 400 / 2210		CBH	V203'	V2+(V1-V2) X 482 / 1492	
0CH	V12'	V7+(V6-V7) X 408 / 584		4CH	V76'	V4+(V3-V4) X 490 / 2196		8CH	V140'	V3+(V2-V3) X 432 / 2210		CCH	V204'	V2+(V1-V2) X 526 / 1492	
0DH	V13'	V7+(V6-V7) X 464 / 584		4DH	V77'	V4+(V3-V4) X 528 / 2196		8DH	V141'	V3+(V2-V3) X 464 / 2210		CDH	V205'	V2+(V1-V2) X 570 / 1492	
0EH	V14'	V7+(V6-V7) X 522 / 584		4EH	V78'	V4+(V3-V4) X 568 / 2196		8EH	V142'	V3+(V2-V3) X 496 / 2210		CEH	V206'	V2+(V1-V2) X 616 / 1492	
0FH	V15'	V6		4FH	V79'	V4+(V3-V4) X 610 / 2196		8FH	V143'	V3+(V2-V3) X 528 / 2210		CFH	V207'	V2+(V1-V2) X 662 / 1492	
10H	V16'	V6+(V5-V6) X 68 / 1142		50H	V80'	V4+(V3-V4) X 652 / 2196		90H	V144'	V3+(V2-V3) X 558 / 2210		DOH	V208'	V2+(V1-V2) X 708 / 1492	
11H	V17'	V6+(V5-V6) X 136 / 1142		51H	V81'	V4+(V3-V4) X 694 / 2196		91H	V145'	V3+(V2-V3) X 588 / 2210		D1H	V209'	V2+(V1-V2) X 758 / 1492	
12H	V18'	V6+(V5-V6) X 206 / 1142		52H	V82'	V4+(V3-V4) X 734 / 2196		92H	V146'	V3+(V2-V3) X 618 / 2210		D2H	V210'	V2+(V1-V2) X 808 / 1492	
13H	V19'	V6+(V5-V6) X 278 / 1142		53H	V83'	V4+(V3-V4) X 774 / 2196		93H	V147'	V3+(V2-V3) X 648 / 2210		D3H	V211'	V2+(V1-V2) X 858 / 1492	
14H	V20'	V6+(V5-V6) X 350 / 1142		54H	V84'	V4+(V3-V4) X 814 / 2196		94H	V148'	V3+(V2-V3) X 678 / 2210		D4H	V212'	V2+(V1-V2) X 908 / 1492	
15H	V21'	V6+(V5-V6) X 422 / 1142		55H	V85'	V4+(V3-V4) X 854 / 2196		95H	V149'	V3+(V2-V3) X 708 / 2210		D5H	V213'	V2+(V1-V2) X 960 / 1492	
16H	V22'	V6+(V5-V6) X 494 / 1142		56H	V86'	V4+(V3-V4) X 892 / 2196		96H	V150'	V3+(V2-V3) X 738 / 2210		D6H	V214'	V2+(V1-V2) X 1012 / 1492	
17H	V23'	V6+(V5-V6) X 566 / 1142		57H	V87'	V4+(V3-V4) X 930 / 2196		97H	V151'	V3+(V2-V3) X 768 / 2210		D7H	V215'	V2+(V1-V2) X 1064 / 1492	
18H	V24'	V6+(V5-V6) X 638 / 1142		58H	V88'	V4+(V3-V4) X 968 / 2196		98H	V152'	V3+(V2-V3) X 798 / 2210		D8H	V216'	V2+(V1-V2) X 1116 / 1492	
19H	V25'	V6+(V5-V6) X 710 / 1142		59H	V89'	V4+(V3-V4) X 1004 / 2196		99H	V153'	V3+(V2-V3) X 828 / 2210		D9H	V217'	V2+(V1-V2) X 1168 / 1492	
1AH	V26'	V6+(V5-V6) X 782 / 1142		5AH	V90'	V4+(V3-V4) X 1040 / 2196		9AH	V154'	V3+(V2-V3) X 860 / 2210		DAH	V218'	V2+(V1-V2) X 1222 / 1492	
1BH	V27'	V6+(V5-V6) X 854 / 1142		5BH	V91'	V4+(V3-V4) X 1074 / 2196		9BH	V155'	V3+(V2-V3) X 892 / 2210		DBH	V219'	V2+(V1-V2) X 1276 / 1492	
1CH	V28'	V6+(V5-V6) X 926 / 1142		5CH	V92'	V4+(V3-V4) X 1106 / 2196		9CH	V156'	V3+(V2-V3) X 924 / 2210		DCH	V220'	V2+(V1-V2) X 1330 / 1492	
1DH	V29'	V6+(V5-V6) X 998 / 1142		5DH	V93'	V4+(V3-V4) X 1138 / 2196		9DH	V157'	V3+(V2-V3) X 956 / 2210		DDH	V221'	V2+(V1-V2) X 1384 / 1492	
1EH	V30'	V6+(V5-V6) X 1070 / 1142		5EH	V94'	V4+(V3-V4) X 1170 / 2196		9EH	V158'	V3+(V2-V3) X 990 / 2210		DEH	V222'	V2+(V1-V2) X 1438 / 1492	
1FH	V31'	V5		5FH	V95'	V4+(V3-V4) X 1204 / 2196		9FH	V159'	V3+(V2-V3) X 1024 / 2210		DFH	V223'	V1	
20H	V32'	V5+(V4-V5) X 70 / 1850		60H	V96'	V4+(V3-V4) X 1238 / 2196		A0H	V160'	V3+(V2-V3) X 1058 / 2210		E0H	V224'	V1+(V0-V1) X 56 / 3530	
21H	V33'	V5+(V4-V5) X 140 / 1850		61H	V97'	V4+(V3-V4) X 1272 / 2196		A1H	V161'	V3+(V2-V3) X 1092 / 2210		E1H	V225'	V1+(V0-V1) X 112 / 3530	
22H	V34'	V5+(V4-V5) X 210 / 1850		62H	V98'	V4+(V3-V4) X 1306 / 2196		A2H	V162'	V3+(V2-V3) X 1126 / 2210		E2H	V226'	V1+(V0-V1) X 170 / 3530	
23H	V35'	V5+(V4-V5) X 280 / 1850		63H	V99'	V4+(V3-V4) X 1338 / 2196		A3H	V163'	V3+(V2-V3) X 1160 / 2210		E3H	V227'	V1+(V0-V1) X 228 / 3530	
24H	V36'	V5+(V4-V5) X 350 / 1850		64H	V100'	V4+(V3-V4) X 1370 / 2196		A4H	V164'	V3+(V2-V3) X 1194 / 2210		E4H	V228'	V1+(V0-V1) X 290 / 3530	
25H	V37'	V5+(V4-V5) X 420 / 1850		65H	V101'	V4+(V3-V4) X 1402 / 2196		A5H	V165'	V3+(V2-V3) X 1228 / 2210		E5H	V229'	V1+(V0-V1) X 354 / 3530	
26H	V38'	V5+(V4-V5) X 490 / 1850		66H	V102'	V4+(V3-V4) X 1434 / 2196		A6H	V166'	V3+(V2-V3) X 1262 / 2210		E6H	V230'	V1+(V0-V1) X 420 / 3530	
27H	V39'	V5+(V4-V5) X 558 / 1850		67H	V103'	V4+(V3-V4) X 1464 / 2196		A7H	V167'	V3+(V2-V3) X 1296 / 2210		E7H	V231'	V1+(V0-V1) X 488 / 3530	
28H	V40'	V5+(V4-V5) X 624 / 1850		68H	V104'	V4+(V3-V4) X 1492 / 2196		A8H	V168'	V3+(V2-V3) X 1332 / 2210		E8H	V232'	V1+(V0-V1) X 556 / 3530	
29H	V41'	V5+(V4-V5) X 690 / 1850		69H	V105'	V4+(V3-V4) X 1520 / 2196		A9H	V169'	V3+(V2-V3) X 1370 / 2210		E9H	V233'	V1+(V0-V1) X 624 / 3530	
2AH	V42'	V5+(V4-V5) X 756 / 1850		6AH	V106'	V4+(V3-V4) X 1548 / 2196		AAH	V170'	V3+(V2-V3) X 1408 / 2210		EAH	V234'	V1+(V0-V1) X 694 / 3530	
2BH	V43'	V5+(V4-V5) X 822 / 1850		6BH	V107'	V4+(V3-V4) X 1576 / 2196		ABH	V171'	V3+(V2-V3) X 1446 / 2210		EBH	V235'	V1+(V0-V1) X 766 / 3530	
2CH	V44'	V5+(V4-V5) X 886 / 1850		6CH	V108'	V4+(V3-V4) X 1604 / 2196		ACH	V172'	V3+(V2-V3) X 1484 / 2210		ECH	V236'	V1+(V0-V1) X 842 / 3530	
2DH	V45'	V5+(V4-V5) X 950 / 1850		6DH	V109'	V4+(V3-V4) X 1630 / 2196		ADH	V173'	V3+(V2-V3) X 1524 / 2210		EDH	V237'	V1+(V0-V1) X 922 / 3530	
2EH	V46'	V5+(V4-V5) X 1014 / 1850		6EH	V110'	V4+(V3-V4) X 1656 / 2196		AEH	V174'	V3+(V2-V3) X 1564 / 2210		EEH	V238'	V1+(V0-V1) X 1004 / 3530	
2FH	V47'	V5+(V4-V5) X 1076 / 1850		6FH	V111'	V4+(V3-V4) X 1682 / 2196		AFH	V175'	V3+(V2-V3) X 1604 / 2210		EFH	V239'	V1+(V0-V1) X 1086 / 3530	
30H	V48'	V5+(V4-V5) X 1138 / 1850		70H	V112'	V4+(V3-V4) X 1708 / 2196		BOH	V176'	V3+(V2-V3) X 1644 / 2210		FOH	V240'	V1+(V0-V1) X 1172 / 3530	
31H	V49'	V5+(V4-V5) X 1198 / 1850		71H	V113'	V4+(V3-V4) X 1734 / 2196		B1H	V177'	V3+(V2-V3) X 1684 / 2210		F1H	V241'	V1+(V0-V1) X 1258 / 3530	
32H	V50'	V5+(V4-V5) X 1256 / 1850		72H	V114'	V4+(V3-V4) X 1760 / 2196		B2H	V178'	V3+(V2-V3) X 1724 / 2210		F2H	V242'	V1+(V0-V1) X 1346 / 3530	
33H	V51'	V5+(V4-V5) X 1312 / 1850		73H	V115'	V4+(V3-V4) X 1788 / 2196		B3H	V179'	V3+(V2-V3) X 1762 / 2210		F3H	V243'	V1+(V0-V1) X 1438 / 3530	
34H	V52'	V5+(V4-V5) X 1364 / 1850		74H	V116'	V4+(V3-V4) X 1818 / 2196		B4H	V180'	V3+(V2-V3) X 1800 / 2210		F4H	V244'	V1+(V0-V1) X 1536 / 3530	
35H	V53'	V5+(V4-V5) X 1414 / 1850		75H	V117'	V4+(V3-V4) X 1848 / 2196		B5H	V181'	V3+(V2-V3) X 1836 / 2210		F5H	V245'	V1+(V0-V1) X 1642 / 3530	
36H	V54'	V5+(V4-V5) X 1464 / 1850		76H	V118'	V4+(V3-V4) X 1880 / 2196		B6H	V182'	V3+(V2-V3) X 1872 / 2210		F6H	V246'	V1+(V0-V1) X 1754 / 3530	
37H	V55'	V5+(V4-V5) X 1512 / 1850		77H	V119'	V4+(V3-V4) X 1914 / 2196		B7H	V183'	V3+(V2-V3) X 1908 / 2210		F7H	V247'	V1+(V0-V1) X 1872 / 3530	
38H	V56'	V5+(V4-V5) X 1556 / 1850		78H	V120'	V4+(V3-V4) X 1948 / 2196		B8H	V184'	V3+(V2-V3) X 1944 / 2210		F8H	V248'	V1+(V0-V1) X 1994 / 3530	
39H	V57'	V5+(V4-V5) X 1598 / 1850		79H	V121'	V4+(V3-V4) X 1982 / 2196		B9H	V185'	V3+(V2-V3) X 1980 / 2210		F9H	V249'	V1+(V0-V1) X 2128 / 3530	
3AH	V58'	V5+(V4-V5) X 1640 / 1850		7AH	V122'	V4+(V3-V4) X 2016 / 2196		BAH	V186'	V3+(V2-V3) X 2016 / 2210		FAH	V250'	V1+(V0-V1) X 2274 / 3530	
3BH	V59'	V5+(V4-V5) X 1682 / 1850		7BH	V123'	V4+(V3-V4) X 2052 / 2196		BBH	V187'	V3+(V2-V3) X 2052 / 2210		FBH	V251'	V1+(V0-V1) X 2446 / 3530	
3CH	V60'	V5+(V4-V5) X 1724 / 1850		7CH	V124'	V4+(V3-V4) X 2088 / 2196		BCH	V188'	V3+(V2-V3) X 2090 / 2210		FCH	V252'	V1+(V0-V1) X 2642 / 3530	
3DH	V61'	V5+(V4-V5) X 1766 / 1850		7DH	V125'	V4+(V3-V4) X 2124 / 2196		BDH	V189'	V3+(V2-V3) X 2130 / 2210		FDH	V253'	V1+(V0-V1) X 2862 / 3530	
3EH	V62'	V5+(V4-V5) X 1808 / 1850		7EH	V126'	V4+(V3-V4) X 2160 / 2196		BEH	V190'	V3+(V2-V3) X 2170 / 2210		FEH	V254'	V1+(V0-V1) X 3130 / 3530	
3FH	V63'	V4		7FH	V127'	V3		BFH	V191'	V2		FFH	V255'	V0	

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

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(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					
00H	V0*	V8			40H	V64*	V12+(V13-V12) X	2154 / 2196	80H	V128*	V13+(V12-V13) X	2174 / 2210	C0H	V192*	V14+(V13-V14) X	1452 / 1492
01H	V1*	V9+(V8-V9) X	566 / 584		41H	V65*	V12+(V13-V12) X	2112 / 2196	81H	V129*	V13+(V12-V13) X	2138 / 2210	C1H	V193*	V14+(V13-V14) X	1412 / 1492
02H	V2*	V9+(V8-V9) X	546 / 584		42H	V66*	V12+(V13-V12) X	2070 / 2196	82H	V130*	V13+(V12-V13) X	2102 / 2210	C2H	V194*	V14+(V13-V14) X	1372 / 1492
03H	V3*	V9+(V8-V9) X	522 / 584		43H	V67*	V12+(V13-V12) X	2030 / 2196	83H	V131*	V13+(V12-V13) X	2068 / 2210	C3H	V195*	V14+(V13-V14) X	1332 / 1492
04H	V4*	V9+(V8-V9) X	496 / 584		44H	V68*	V12+(V13-V12) X	1992 / 2196	84H	V132*	V13+(V12-V13) X	2034 / 2210	C4H	V196*	V14+(V13-V14) X	1292 / 1492
05H	V5*	V9+(V8-V9) X	466 / 584		45H	V69*	V12+(V13-V12) X	1956 / 2196	85H	V133*	V13+(V12-V13) X	2002 / 2210	C5H	V197*	V14+(V13-V14) X	1252 / 1492
06H	V6*	V9+(V8-V9) X	432 / 584		46H	V70*	V12+(V13-V12) X	1920 / 2196	86H	V134*	V13+(V12-V13) X	1970 / 2210	C6H	V198*	V14+(V13-V14) X	1212 / 1492
07H	V7*	V9+(V8-V9) X	396 / 584		47H	V71*	V12+(V13-V12) X	1884 / 2196	87H	V135*	V13+(V12-V13) X	1938 / 2210	C7H	V199*	V14+(V13-V14) X	1172 / 1492
08H	V8*	V9+(V8-V9) X	358 / 584		48H	V72*	V12+(V13-V12) X	1850 / 2196	88H	V136*	V13+(V12-V13) X	1906 / 2210	C8H	V200*	V14+(V13-V14) X	1132 / 1492
09H	V9*	V9+(V8-V9) X	318 / 584		49H	V73*	V12+(V13-V12) X	1814 / 2196	89H	V137*	V13+(V12-V13) X	1874 / 2210	C9H	V201*	V14+(V13-V14) X	1092 / 1492
0AH	V10*	V9+(V8-V9) X	274 / 584		4AH	V74*	V12+(V13-V12) X	1778 / 2196	8AH	V138*	V13+(V12-V13) X	1842 / 2210	CAH	V202*	V14+(V13-V14) X	1052 / 1492
0BH	V11*	V9+(V8-V9) X	228 / 584		4BH	V75*	V12+(V13-V12) X	1742 / 2196	8BH	V139*	V13+(V12-V13) X	1810 / 2210	CBH	V203*	V14+(V13-V14) X	1010 / 1492
0CH	V12*	V9+(V8-V9) X	176 / 584		4CH	V76*	V12+(V13-V12) X	1706 / 2196	8CH	V140*	V13+(V12-V13) X	1778 / 2210	CCH	V204*	V14+(V13-V14) X	966 / 1492
0DH	V13*	V9+(V8-V9) X	120 / 584		4DH	V77*	V12+(V13-V12) X	1668 / 2196	8DH	V141*	V13+(V12-V13) X	1746 / 2210	CDH	V205*	V14+(V13-V14) X	922 / 1492
0EH	V14*	V9+(V8-V9) X	62 / 584		4EH	V78*	V12+(V13-V12) X	1628 / 2196	8EH	V142*	V13+(V12-V13) X	1714 / 2210	CEH	V206*	V14+(V13-V14) X	876 / 1492
0FH	V15*	V9			4FH	V79*	V12+(V13-V12) X	1586 / 2196	8FH	V143*	V13+(V12-V13) X	1682 / 2210	CFH	V207*	V14+(V13-V14) X	830 / 1492
10H	V16*	V10+(V9-V10) X	1074 / 1142		50H	V80*	V12+(V13-V12) X	1544 / 2196	90H	V144*	V13+(V12-V13) X	1652 / 2210	D0H	V208*	V14+(V13-V14) X	784 / 1492
11H	V17*	V10+(V9-V10) X	1006 / 1142		51H	V81*	V12+(V13-V12) X	1502 / 2196	91H	V145*	V13+(V12-V13) X	1622 / 2210	D1H	V209*	V14+(V13-V14) X	734 / 1492
12H	V18*	V10+(V9-V10) X	936 / 1142		52H	V82*	V12+(V13-V12) X	1462 / 2196	92H	V146*	V13+(V12-V13) X	1592 / 2210	D2H	V210*	V14+(V13-V14) X	684 / 1492
13H	V19*	V10+(V9-V10) X	864 / 1142		53H	V83*	V12+(V13-V12) X	1422 / 2196	93H	V147*	V13+(V12-V13) X	1562 / 2210	D3H	V211*	V14+(V13-V14) X	634 / 1492
14H	V20*	V10+(V9-V10) X	792 / 1142		54H	V84*	V12+(V13-V12) X	1382 / 2196	94H	V148*	V13+(V12-V13) X	1532 / 2210	D4H	V212*	V14+(V13-V14) X	584 / 1492
15H	V21*	V10+(V9-V10) X	720 / 1142		55H	V85*	V12+(V13-V12) X	1342 / 2196	95H	V149*	V13+(V12-V13) X	1502 / 2210	D5H	V213*	V14+(V13-V14) X	532 / 1492
16H	V22*	V10+(V9-V10) X	648 / 1142		56H	V86*	V12+(V13-V12) X	1304 / 2196	96H	V150*	V13+(V12-V13) X	1472 / 2210	D6H	V214*	V14+(V13-V14) X	480 / 1492
17H	V23*	V10+(V9-V10) X	576 / 1142		57H	V87*	V12+(V13-V12) X	1266 / 2196	97H	V151*	V13+(V12-V13) X	1442 / 2210	D7H	V215*	V14+(V13-V14) X	428 / 1492
18H	V24*	V10+(V9-V10) X	504 / 1142		58H	V88*	V12+(V13-V12) X	1228 / 2196	98H	V152*	V13+(V12-V13) X	1412 / 2210	D8H	V216*	V14+(V13-V14) X	376 / 1492
19H	V25*	V10+(V9-V10) X	432 / 1142		59H	V89*	V12+(V13-V12) X	1192 / 2196	99H	V153*	V13+(V12-V13) X	1382 / 2210	D9H	V217*	V14+(V13-V14) X	324 / 1492
1AH	V26*	V10+(V9-V10) X	360 / 1142		5AH	V90*	V12+(V13-V12) X	1156 / 2196	9AH	V154*	V13+(V12-V13) X	1350 / 2210	DAH	V218*	V14+(V13-V14) X	270 / 1492
1BH	V27*	V10+(V9-V10) X	288 / 1142		5BH	V91*	V12+(V13-V12) X	1122 / 2196	9BH	V155*	V13+(V12-V13) X	1318 / 2210	DBH	V219*	V14+(V13-V14) X	216 / 1492
1CH	V28*	V10+(V9-V10) X	216 / 1142		5CH	V92*	V12+(V13-V12) X	1090 / 2196	9CH	V156*	V13+(V12-V13) X	1286 / 2210	DCH	V220*	V14+(V13-V14) X	162 / 1492
1DH	V29*	V10+(V9-V10) X	144 / 1142		5DH	V93*	V12+(V13-V12) X	1058 / 2196	9DH	V157*	V13+(V12-V13) X	1254 / 2210	DDH	V221*	V14+(V13-V14) X	108 / 1492
1EH	V30*	V10+(V9-V10) X	72 / 1142		5EH	V94*	V12+(V13-V12) X	1026 / 2196	9EH	V158*	V13+(V12-V13) X	1220 / 2210	DEH	V222*	V14+(V13-V14) X	54 / 1492
1FH	V31*	V10			5FH	V95*	V12+(V13-V12) X	992 / 2196	9FH	V159*	V13+(V12-V13) X	1186 / 2210	DFH	V223*	V14	
20H	V32*	V11+(V10-V11) X	1780 / 1850		60H	V96*	V12+(V13-V12) X	958 / 2196	A0H	V160*	V13+(V12-V13) X	1152 / 2210	E0H	V224*	V15+(V14-V15) X	3474 / 3530
21H	V33*	V11+(V10-V11) X	1710 / 1850		61H	V97*	V12+(V13-V12) X	924 / 2196	A1H	V161*	V13+(V12-V13) X	1118 / 2210	E1H	V225*	V15+(V14-V15) X	3418 / 3530
22H	V34*	V11+(V10-V11) X	1640 / 1850		62H	V98*	V12+(V13-V12) X	890 / 2196	A2H	V162*	V13+(V12-V13) X	1084 / 2210	E2H	V226*	V15+(V14-V15) X	3360 / 3530
23H	V35*	V11+(V10-V11) X	1570 / 1850		63H	V99*	V12+(V13-V12) X	858 / 2196	A3H	V163*	V13+(V12-V13) X	1050 / 2210	E3H	V227*	V15+(V14-V15) X	3302 / 3530
24H	V36*	V11+(V10-V11) X	1500 / 1850		64H	V100*	V12+(V13-V12) X	826 / 2196	A4H	V164*	V13+(V12-V13) X	1016 / 2210	E4H	V228*	V15+(V14-V15) X	3240 / 3530
25H	V37*	V11+(V10-V11) X	1430 / 1850		65H	V101*	V12+(V13-V12) X	794 / 2196	A5H	V165*	V13+(V12-V13) X	982 / 2210	E5H	V229*	V15+(V14-V15) X	3176 / 3530
26H	V38*	V11+(V10-V11) X	1360 / 1850		66H	V102*	V12+(V13-V12) X	762 / 2196	A6H	V166*	V13+(V12-V13) X	948 / 2210	E6H	V230*	V15+(V14-V15) X	3110 / 3530
27H	V39*	V11+(V10-V11) X	1292 / 1850		67H	V103*	V12+(V13-V12) X	732 / 2196	A7H	V167*	V13+(V12-V13) X	914 / 2210	E7H	V231*	V15+(V14-V15) X	3042 / 3530
28H	V40*	V11+(V10-V11) X	1226 / 1850		68H	V104*	V12+(V13-V12) X	704 / 2196	A8H	V168*	V13+(V12-V13) X	878 / 2210	E8H	V232*	V15+(V14-V15) X	2974 / 3530
29H	V41*	V11+(V10-V11) X	1160 / 1850		69H	V105*	V12+(V13-V12) X	676 / 2196	A9H	V169*	V13+(V12-V13) X	840 / 2210	E9H	V233*	V15+(V14-V15) X	2906 / 3530
2AH	V42*	V11+(V10-V11) X	1094 / 1850		6AH	V106*	V12+(V13-V12) X	648 / 2196	AAH	V170*	V13+(V12-V13) X	802 / 2210	EAH	V234*	V15+(V14-V15) X	2836 / 3530
2BH	V43*	V11+(V10-V11) X	1028 / 1850		6BH	V107*	V12+(V13-V12) X	620 / 2196	ABH	V171*	V13+(V12-V13) X	764 / 2210	EBH	V235*	V15+(V14-V15) X	2764 / 3530
2CH	V44*	V11+(V10-V11) X	964 / 1850		6CH	V108*	V12+(V13-V12) X	592 / 2196	ACH	V172*	V13+(V12-V13) X	726 / 2210	ECH	V236*	V15+(V14-V15) X	2688 / 3530
2DH	V45*	V11+(V10-V11) X	900 / 1850		6DH	V109*	V12+(V13-V12) X	566 / 2196	ADH	V173*	V13+(V12-V13) X	686 / 2210	EDH	V237*	V15+(V14-V15) X	2608 / 3530
2EH	V46*	V11+(V10-V11) X	836 / 1850		6EH	V110*	V12+(V13-V12) X	540 / 2196	AEH	V174*	V13+(V12-V13) X	646 / 2210	EEH	V238*	V15+(V14-V15) X	2526 / 3530
2FH	V47*	V11+(V10-V11) X	774 / 1850		6FH	V111*	V12+(V13-V12) X	514 / 2196	AFH	V175*	V13+(V12-V13) X	606 / 2210	EFH	V239*	V15+(V14-V15) X	2444 / 3530
30H	V48*	V11+(V10-V11) X	712 / 1850		70H	V112*	V12+(V13-V12) X	488 / 2196	B0H	V176*	V13+(V12-V13) X	566 / 2210	F0H	V240*	V15+(V14-V15) X	2358 / 3530
31H	V49*	V11+(V10-V11) X	652 / 1850		71H	V113*	V12+(V13-V12) X	462 / 2196	B1H	V177*	V13+(V12-V13) X	526 / 2210	F1H	V241*	V15+(V14-V15) X	2272 / 3530
32H	V50*	V11+(V10-V11) X	594 / 1850		72H	V114*	V12+(V13-V12) X	436 / 2196	B2H	V178*	V13+(V12-V13) X	486 / 2210	F2H	V242*	V15+(V14-V15) X	2184 / 3530
33H	V51*	V11+(V10-V11) X	538 / 1850		73H	V115*	V12+(V13-V12) X	408 / 2196	B3H	V179*	V13+(V12-V13) X	448 / 2210	F3H	V243*	V15+(V14-V15) X	2092 / 3530
34H	V52*	V11+(V10-V11) X	486 / 1850		74H	V116*	V12+(V13-V12) X	378 / 2196	BAH	V180*	V13+(V12-V13) X	410 / 2210	F4H	V244*	V15+(V14-V15) X	1994 / 3530
35H	V53*	V11+(V10-V11) X	436 / 1850		75H	V117*	V12+(V13-V12) X	348 / 2196	B5H	V181*	V13+(V12-V13) X	374 / 2210	F5H	V245*	V15+(V14-V15) X	1888 / 3530
36H	V54*	V11+(V10-V11) X	386 / 1850		76H	V118*	V12+(V13-V12) X	316 / 2196	B6H	V182*	V13+(V12-V13) X	338 / 2210	F6H	V246*	V15+(V14-V15) X	1776 / 3530
37H	V55*	V11+(V10-V11) X	338 / 1850		77H	V119*	V12+(V13-V12) X	282 / 2196	B7H	V183*	V13+(V12-V13) X	302 / 2210	F7H	V247*	V15+(V14-V15) X	1658 / 3530
38H	V56*	V11+(V10-V11) X	294 / 1850		78H	V120*	V12+(V13-V12) X	248 / 2196	B8H	V184*	V13+(V12-V13) X	266 / 2210	F8H	V248*	V15+(V14-V15) X	1536 / 3530
39H	V57*	V11+(V10-V11) X	252 / 1850		79H	V121*	V12+(V13-V12) X	214 / 2196	B9H	V185*	V13+(V12-V13) X	230 / 2210	F9H	V249*	V15+(V14-V15) X	1402 / 3530
3AH	V58*	V11+(V10-V11) X	210 / 1850		7AH	V122*	V12+(V13-V12) X	180 / 2196	BAH	V186*	V13+(V12-V13) X	194 / 2210	FAH	V250*	V15+(V14-V15) X	1256 / 3530
3BH	V59*	V11+(V10-V11) X	168 / 1850		7BH	V123*	V12+(V13-V12) X	144 / 2196	BBH	V187*	V13+(V12-V13) X	158 / 2210	FBH	V251*	V15+(V14-V15) X	1084 / 3530
3CH	V60*	V11+(V10-V11) X	126 / 1850		7CH	V124*	V12+(V13-V12) X	108 / 2196	BCH	V188*	V13+(V12-V13) X	120 / 2210	FBH	V252*	V15+(V14-V15) X	888 / 3530
3DH	V61*	V11+(V10-V11) X	84 / 1850		7DH	V125*	V12+(V13-V12) X	72 / 2196	BDH	V189*	V13+(V12-V13) X	80 / 2210	FDH	V253*	V15+(V14-V15) X	668 / 3530
3EH	V62*	V11+(V10-V11) X	42 / 1850		7EH	V126*	V12+(V13-V12) X	36 / 2196	BEH	V190*	V13+(V12-V13) X	40 / 2210	FEH	V254*	V15+(V14-V15) X	400 / 3530
3FH	V63*	V11			7FH	V127*	V12		BFH	V191*	V13		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

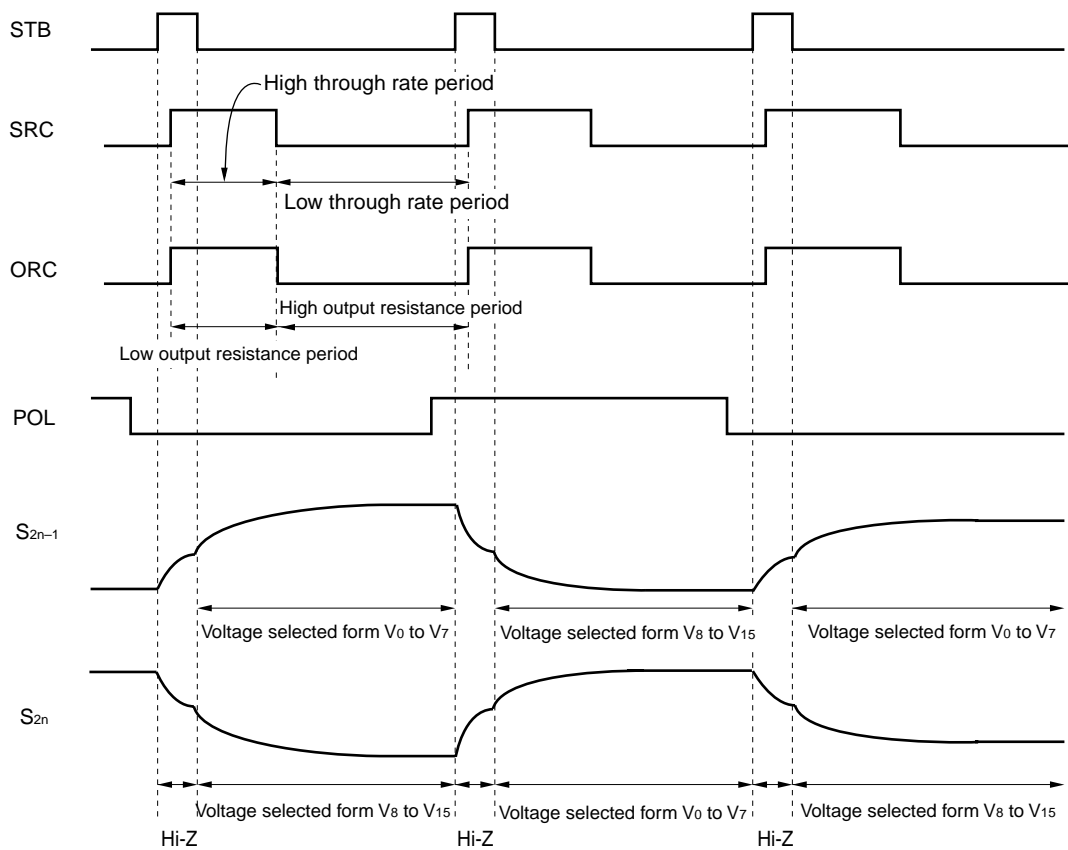
When MODE = H or open and STB = H, all outputs are reset (short) and the gray-scale voltage is output to LCD in synchronization with the falling edge of STB.

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.

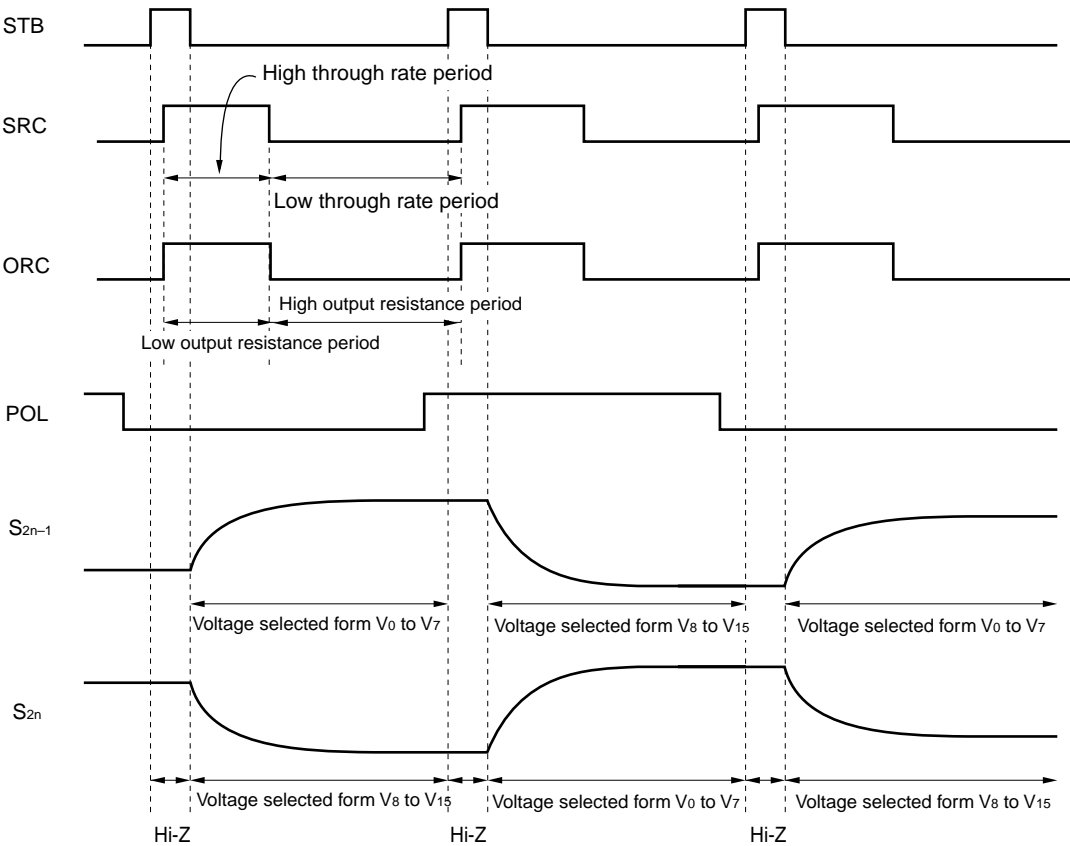
Also, setting the SRC pin to H level allows the bias current value of the output amplifier to rise temporarily, and setting the ORC pin to H level allows the output resistance value of the amplifier to lower temporarily.

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

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 $+75^\circ\text{C}$, $V_{DD1} = 2.5$ 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	6.5	13.0	19.5	$\text{k}\Omega$
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}	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).

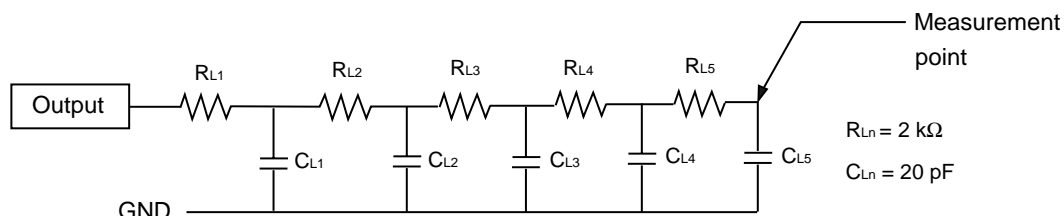
Switching Characteristics ($T_A = -10$ to $+75^\circ\text{C}$, $V_{DD1} = 2.5$ to 3.6 V, $V_{DD2} = 12.5$ to 15.5 V, $V_{SS1} = V_{SS2} = 0$ V)

Parameter	Symbol	Condition	MIN.	TYP.	MAX.	Unit
Start pulse delay time	t_{PLH1}	$C_L = 15$ pF, 3.0 V $\leq V_{DD1} \leq 3.6$ V			17	ns
		$C_L = 15$ pF, 2.5 V $\leq V_{DD1} < 3.0$ 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)

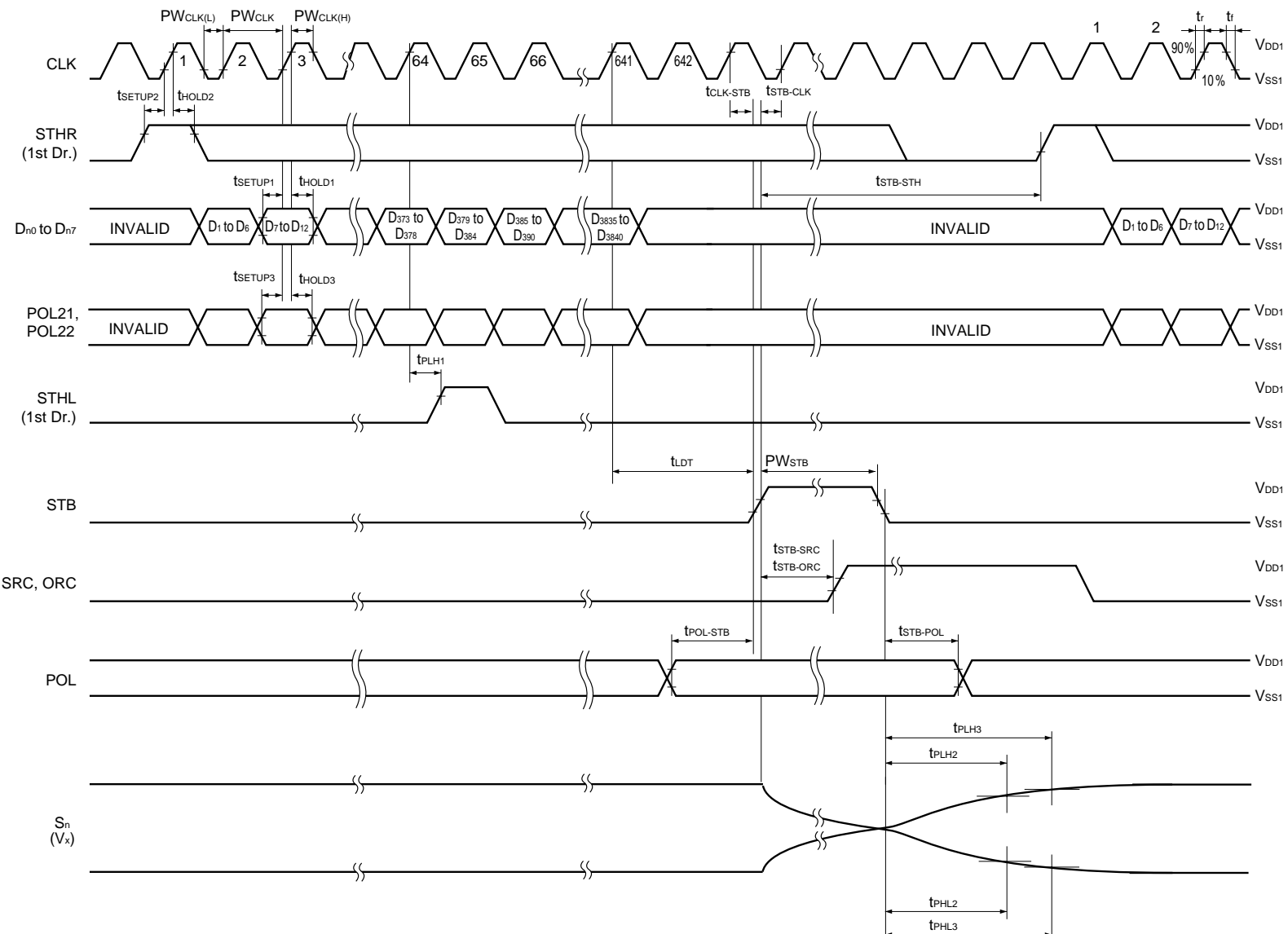
Parameter	Symbol	Condition	MIN.	TYP.	MAX.	Unit
Clock pulse width	PW_{CLK}	$3.0\text{ V} \leq V_{DD1} \leq 3.6\text{ V}$	18			ns
		$2.5\text{ V} \leq V_{DD1} < 3.0\text{ V}$	25			ns
Clock pulse high period	$PW_{CLK(H)}$	$3.0\text{ V} \leq V_{DD1} \leq 3.6\text{ V}$	4			ns
		$2.5\text{ V} \leq V_{DD1}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

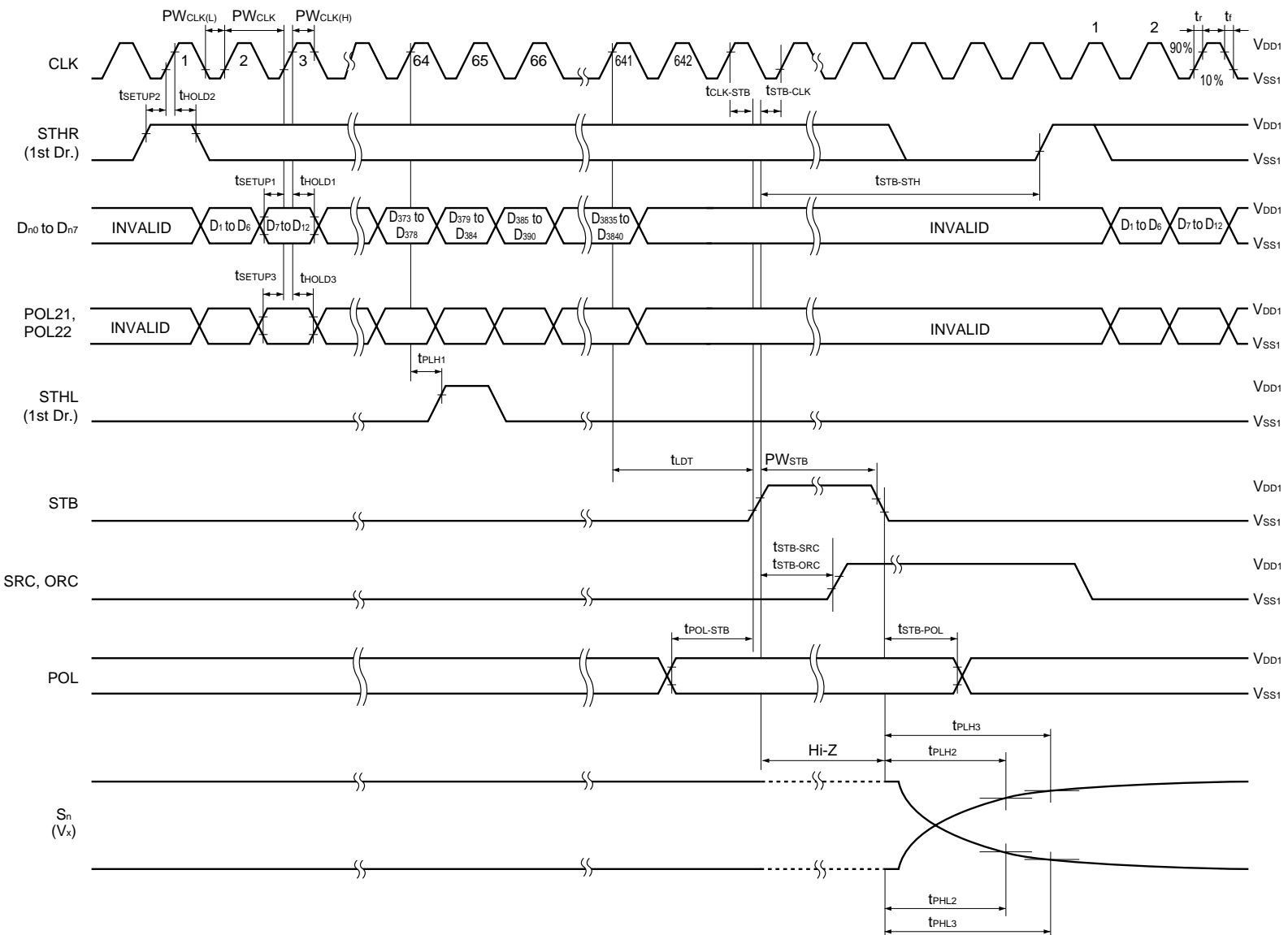
(1) R_L=H, MODE = H or open

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 μPD160040B.

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.

μPD160040BN-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.