DATA SHEET

NEC

MOS INTEGRATED CIRCUIT

μPD160040B

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

DESCRIPTION

The μPD160040B 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 V to V_{DD2} – 0.2 V, level inversion operation of the LCD's common electrode is rendered unnecessary. Also, to be able to deal with dot-line inversion, n-line inversion and column line inversion when mounted on a single side, this source driver is equipped with a built-in 8-bit D/A converter circuit whose odd output pins and even output pins respectively output gray-scale 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 V to V_{DD2} – 0.2 V
- High-speed data transfer: $f_{CLK.}$ = 55 MHz MAX. (internal data transfer speed when operating at 3.0 V ≤ V_{DD1} ≤ 3.6 V)
  $f_{CLK.}$ = 40 MHz MAX. (internal data transfer speed when operating at 2.5 V ≤ V_{DD1} < 3.0 V)
- Apply for dot-line inversion, n-line inversion and column line inversion
- Output voltage polarity inversion function (POL)
- Output inversion function (POL21, POL 22)
- Output reset control is possible (MODE)
- Trough-rate control is possible (SRC)
- Output resistance control is possible (ORC)
- Single bank arrangement is possible (Loaded with slim TCP)

ORDERING INFORMATION

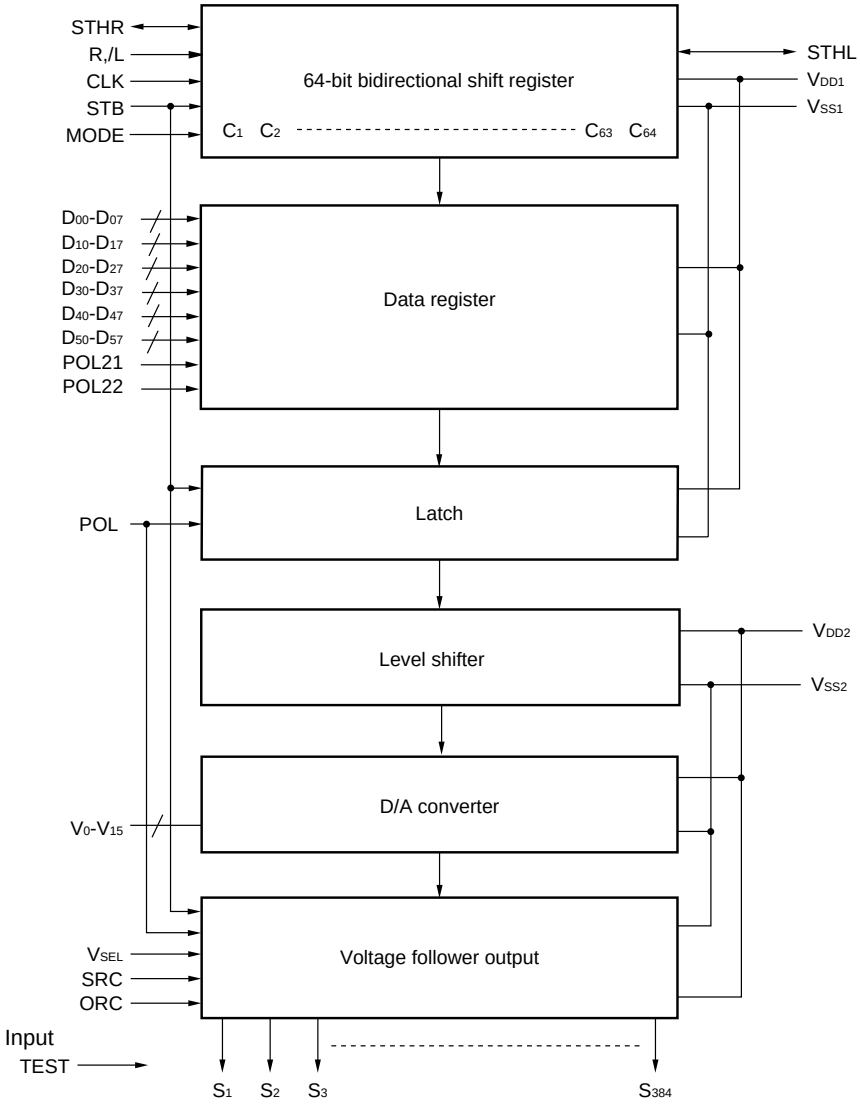
Part Number	Package
μPD160040BN-xxx	TCP (TAB package)

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

Document No. S15953EJ2V0DS00 (2nd edition)
Date Published January 2003 NS CP (K)
Printed in Japan

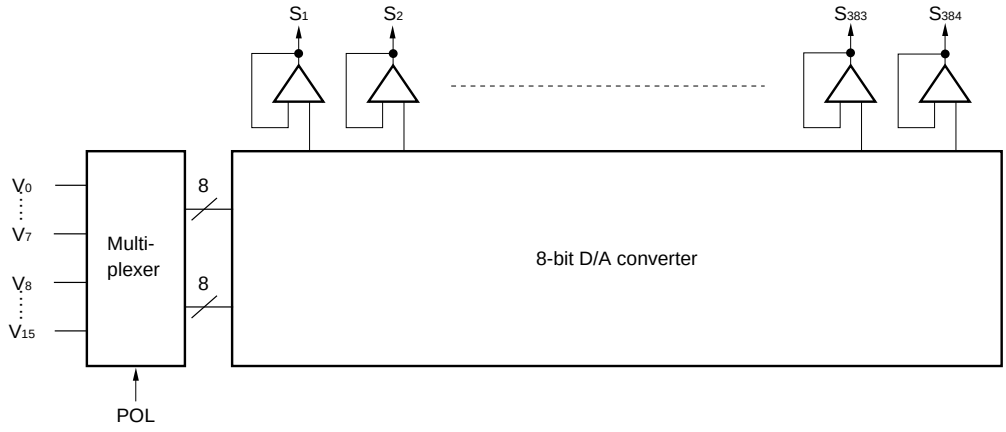
The mark ★ shows major revised points.

1. BLOCK DIAGRAM

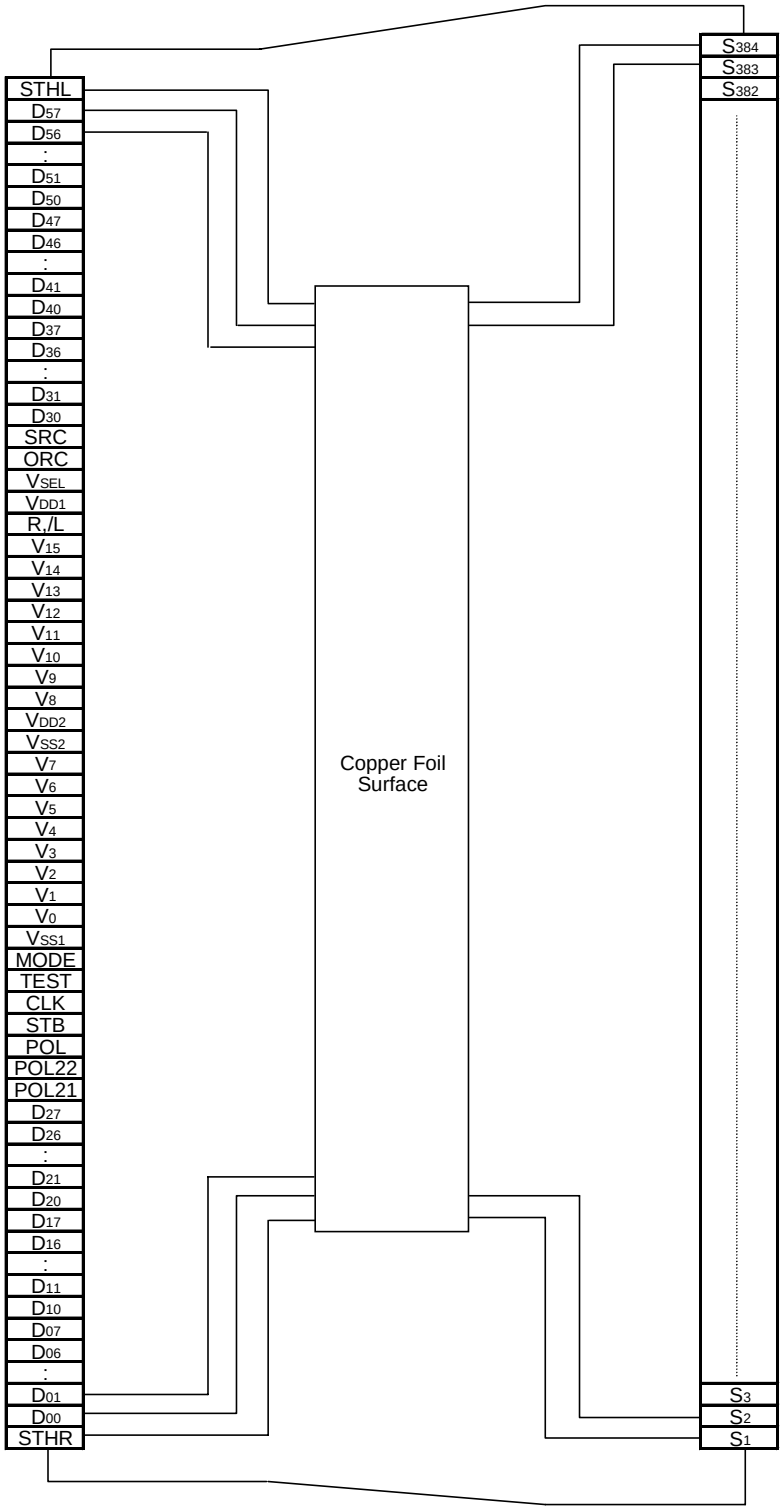


Remark /xxx indicates active low signal.

2. RELATIONSHIP BETWEEN OUTPUT CIRCUIT AND D/A CONVERTER



3. PIN CONFIGURATION (μPD160040BN-xxx) (Copper Foil Surface, Face-up)



Remark This figure does not specify the TCP package.

4. PIN FUNCTIONS

(1/2)

Pin Symbol	Pin Name	I/O	Description
S_1 to S_{384}	Driver	Output	The D/A converted 256-gray-scale analog voltage is output.
D_{00} to D_{07} D_{10} to D_{17} D_{20} to D_{27}	Port 1 display data	Input	The display data is input with a width of 48 bits, viz., the gray scale data (8 bits) by 6 dots (2 pixels). D_{X0}: LSB, D_{X7}: MSB
D_{30} to D_{37} D_{40} to D_{47} D_{50} to D_{57}	Port 2 display data	Input	
R,/L	Shift direction control	Input	The shift direction control pin of shift register. The shift directions of the shift registers are as follows. R,/L = H (right shift): STHR (input) →S_1→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. If the start pulse input is more than 2 CLK, the first 1 CLK of the H-level input is valid. For right shift, STHR is input and STHL is output. For left shift, STHL is input and STHR is output.
★ STHL	Left shift start pulse	I/O	
CLK	Shift clock	Input	The shift clock input pin of shift register. The display data is loaded into the data register at the rising edge. When 66 clock pulses are input after input of the start pulse, input of display data is halted automatically. The contents of the shift register are cleared at the STB's rising edge.
STB	Latch	Input	The contents of the data register are transferred to the latch circuit at the rising edge. In addition, at the falling edge, the gray scale voltage is supplied to the driver. It is necessary to ensure input of one pulse per horizontal period.
SRC	Through rate control	Input	SRC = H: High through rate 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.
V_{SEL}	Driver voltage select	Input	The driver voltage can be switched by controlling the stationary bias current of the output amplifier via V_{SEL}. V_{SEL} = H: V_{DD2} = 12.5 to (14.0 V) (large bias current) V_{SEL} = L or open: V_{DD2} = (14.0 V) to 15.5 V (small bias current) LPC is pulled down to the V_{SS1} in the IC.
V_0-V_{15}	γ-corrected power supplies	–	Input the γ-corrected power supplies from outside by using operational amplifier. During the gray scale voltage output, be sure to keep the gray scale level power supply at a constant level. Make sure to maintain the following relationships. V_{DD2} – 0.2 V ≥ V_0 > V_1 > V_2 > ... ..., > V_6 > V_7 ≥ 0.5 V_{DD2} + 0.5 V 0.5 V_{DD2} – 0.5 V ≥ V_8 > V_9 > V_{10} > ... ..., > V_{14} > V_{15} ≥ 0.5 V_{SS2} + 0.2 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.

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 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.

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

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

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.

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

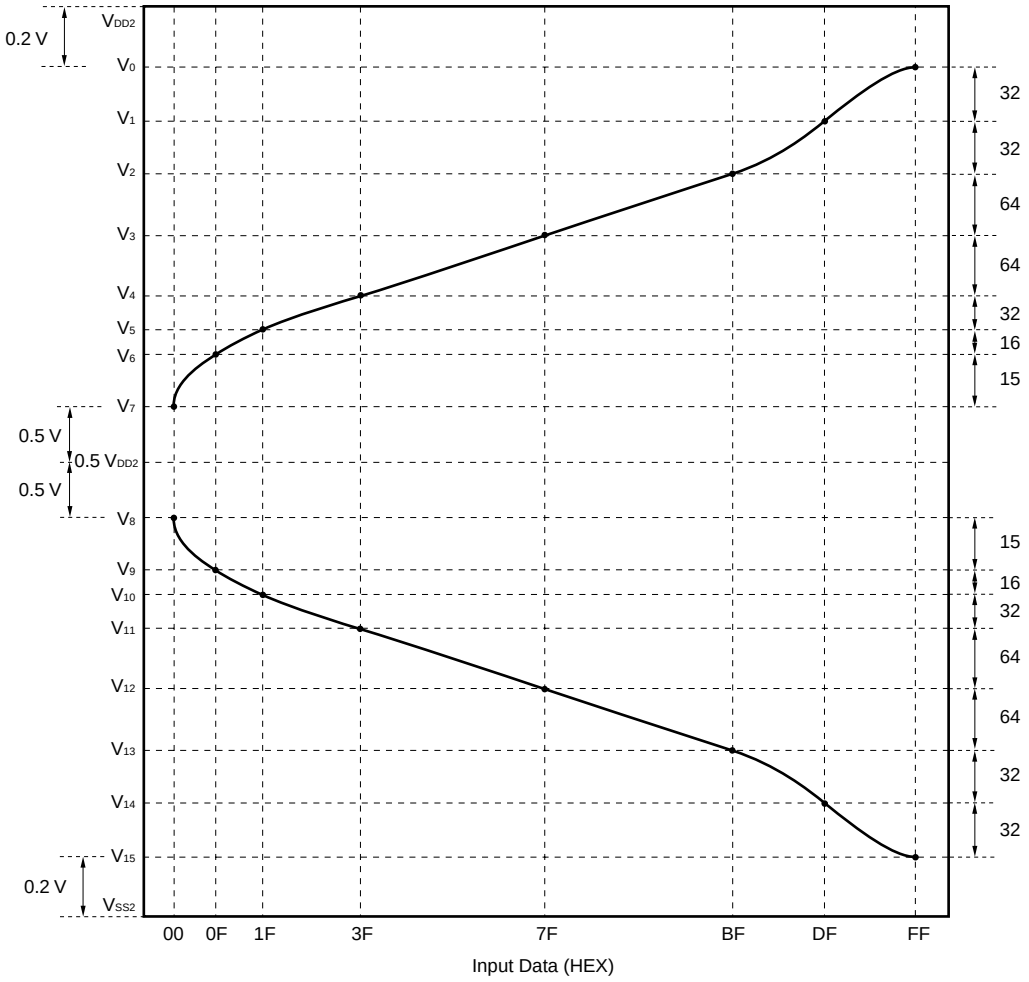
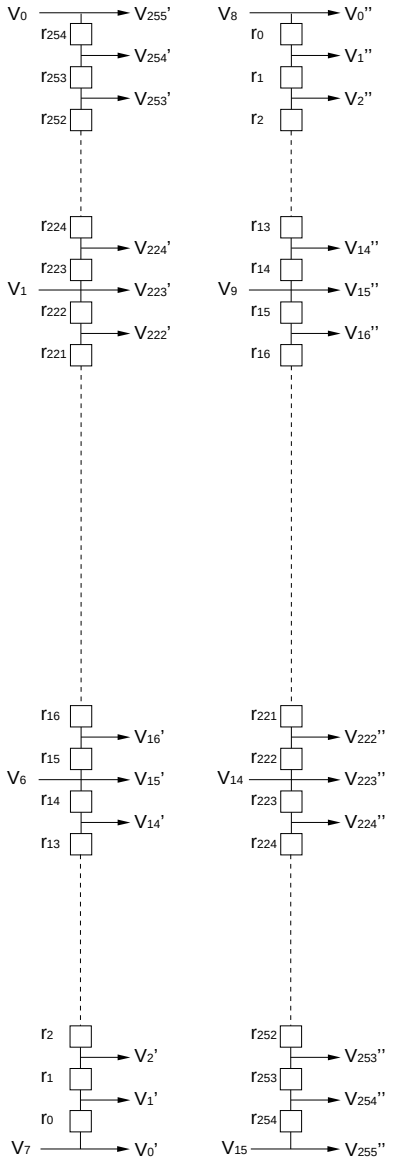


Figure 5–2. γ-Corrected Voltages and Ladder Resistors Ratio



rn	Ratio 1	Ratio 2	Value
r0	1.00	0.0014	18
r1	1.11	0.0015	20
r2	1.33	0.0018	24
r3	1.44	0.0020	26
r4	1.67	0.0023	30
r5	1.89	0.0026	34
r6	2.00	0.0028	36
r7	2.11	0.0029	38
r8	2.22	0.0031	40
r9	2.44	0.0034	44
r10	2.56	0.0035	46
r11	2.89	0.0040	52
r12	3.11	0.0043	56
r13	3.22	0.0045	58
r14	3.44	0.0048	62
r15	3.78	0.0052	68
r16	3.78	0.0052	68
r17	3.89	0.0054	70
r18	4.00	0.0055	72
r19	4.00	0.0055	72
r20	4.00	0.0055	72
r21	4.00	0.0055	72
r22	4.00	0.0055	72
r23	4.00	0.0055	72
r24	4.00	0.0055	72
r25	4.00	0.0055	72
r26	4.00	0.0055	72
r27	4.00	0.0055	72
r28	4.00	0.0055	72
r29	4.00	0.0055	72
r30	4.00	0.0055	72
r31	3.89	0.0054	70
r32	3.89	0.0054	70
r33	3.89	0.0054	70
r34	3.89	0.0054	70
r35	3.89	0.0054	70
r36	3.89	0.0054	70
r37	3.89	0.0054	70
r38	3.78	0.0052	68
r39	3.67	0.0051	66
r40	3.67	0.0051	66
r41	3.67	0.0051	66
r42	3.67	0.0051	66
r43	3.56	0.0049	64
r44	3.56	0.0049	64
r45	3.56	0.0049	64
r46	3.44	0.0048	62
r47	3.44	0.0048	62
r48	3.33	0.0046	60
r49	3.22	0.0045	58
r50	3.11	0.0043	56
r51	2.89	0.0040	52
r52	2.78	0.0038	50
r53	2.78	0.0038	50
r54	2.67	0.0037	48
r55	2.44	0.0034	44
r56	2.33	0.0032	42
r57	2.33	0.0032	42
r58	2.33	0.0032	42
r59	2.33	0.0032	42
r60	2.33	0.0032	42
r61	2.33	0.0032	42
r62	2.33	0.0032	42
r63	2.33	0.0032	42
r64	2.33	0.0032	42

rn	Ratio 1	Ratio 2	Value
r65	2.33	0.0032	42
r66	2.22	0.0031	40
r67	2.11	0.0029	38
r68	2.00	0.0028	36
r69	2.00	0.0028	36
r70	2.00	0.0028	36
r71	1.89	0.0026	34
r72	2.00	0.0028	36
r73	2.00	0.0028	36
r74	2.00	0.0028	36
r75	2.00	0.0028	36
r76	2.11	0.0029	38
r77	2.22	0.0031	40
r78	2.33	0.0032	42
r79	2.33	0.0032	42
r80	2.33	0.0032	42
r81	2.22	0.0031	40
r82	2.22	0.0031	40
r83	2.22	0.0031	40
r84	2.22	0.0031	40
r85	2.11	0.0029	38
r86	2.11	0.0029	38
r87	2.11	0.0029	38
r88	2.00	0.0028	36
r89	2.00	0.0028	36
r90	1.89	0.0026	34
r91	1.78	0.0025	32
r92	1.78	0.0025	32
r93	1.78	0.0025	32
r94	1.89	0.0026	34
r95	1.89	0.0026	34
r96	1.89	0.0026	34
r97	1.89	0.0026	34
r98	1.78	0.0025	32
r99	1.78	0.0025	32
r100	1.78	0.0025	32
r101	1.78	0.0025	32
r102	1.67	0.0023	30
r103	1.56	0.0022	28
r104	1.56	0.0022	28
r105	1.56	0.0022	28
r106	1.56	0.0022	28
r107	1.56	0.0022	28
r108	1.44	0.0020	26
r109	1.44	0.0020	26
r110	1.44	0.0020	26
r111	1.44	0.0020	26
r112	1.44	0.0020	26
r113	1.44	0.0020	26
r114	1.56	0.0022	28
r115	1.67	0.0023	30
r116	1.67	0.0023	30
r117	1.78	0.0025	32
r118	1.89	0.0026	34
r119	1.89	0.0026	34
r120	1.89	0.0026	34
r121	1.89	0.0026	34
r122	2.00	0.0028	36
r123	2.00	0.0028	36
r124	2.00	0.0028	36
r125	2.00	0.0028	36
r126	2.00	0.0028	36
r127	2.00	0.0028	36
r128	2.00	0.0028	36
r129	2.00	0.0028	36

rn	Ratio 1	Ratio 2	Value
r130	1.89	0.0026	34
r131	1.89	0.0026	34
r132	1.78	0.0025	32
r133	1.78	0.0025	32
r134	1.78	0.0025	32
r135	1.78	0.0025	32
r136	1.78	0.0025	32
r137	1.78	0.0025	32
r138	1.78	0.0025	32
r139	1.78	0.0025	32
r140	1.78	0.0025	32
r141	1.78	0.0025	32
r142	1.78	0.0025	32
r143	1.67	0.0023	30
r144	1.67	0.0023	30
r145	1.67	0.0023	30
r146	1.67	0.0023	30
r147	1.67	0.0023	30
r148	1.67	0.0023	30
r149	1.67	0.0023	30
r150	1.67	0.0023	30
r151	1.67	0.0023	30
r152	1.67	0.0023	30
r153	1.78	0.0025	32
r154	1.78	0.0025	32
r155	1.78	0.0025	32
r156	1.78	0.0025	32
r157	1.89	0.0026	34
r158	1.89	0.0026	34
r159	1.89	0.0026	34
r160	1.89	0.0026	34
r161	1.89	0.0026	34
r162	1.89	0.0026	34
r163	1.89	0.0026	34
r164	1.89	0.0026	34
r165	1.89	0.0026	34
r166	1.89	0.0026	34
r167	2.00	0.0028	36
r168	2.11	0.0029	38
r169	2.11	0.0029	38
r170	2.11	0.0029	38
r171	2.11	0.0029	38
r172	2.22	0.0031	40
r173	2.22	0.0031	40
r174	2.22	0.0031	40
r175	2.22	0.0031	40
r176	2.22	0.0031	40
r177	2.22	0.0031	40
r178	2.11	0.0029	38
r179	2.11	0.0029	38
r180	2.00	0.0028	36
r181	2.00	0.0028	36
r182	2.00	0.0028	36
r183	2.00	0.0028	36
r184	2.00	0.0028	36
r185	2.00	0.0028	36
r186	2.00	0.0028	36
r187	2.11	0.0029	38
r188	2.22	0.0031	40
r189	2.22	0.0031	40
r190	2.22	0.0031	40
r191	2.22	0.0031	40
r192	2.22	0.0031	40
r193	2.22	0.0031	40
r194	2.22	0.0031	40

rn	Ratio 1	Ratio 2	Value
r195	2.22	0.0031	40
r196	2.22	0.0031	40
r197	2.22	0.0031	40
r198	2.22	0.0031	40
r199	2.22	0.0031	40
r200	2.22	0.0031	40
r201	2.22	0.0031	40
r202	2.33	0.0032	42
r203	2.44	0.0034	44
r204	2.44	0.0034	44
r205	2.56	0.0035	46
r206	2.56	0.0035	46
r207	2.56	0.0035	46
r208	2.78	0.0038	50
r209	2.78	0.0038	50
r210	2.78	0.0038	50
r211	2.78	0.0038	50
r212	2.89	0.0040	52
r213	2.89	0.0040	52
r214	2.89	0.0040	52
r215	2.89	0.0040	52
r216	2.89	0.0040	52
r217	3.00	0.0042	54
r218	3.00	0.0042	54
r219	3.00	0.0042	54
r220	3.00	0.0042	54
r221	3.00	0.0042	54
r222	3.00	0.0042	54
r223	3.11	0.0043	56
r224	3.11	0.0043	56
r225	3.22	0.0045	58
r226	3.22	0.0045	58
r227	3.44	0.0048	62
r228	3.56	0.0049	64
r229	3.67	0.0051	66
r230	3.78	0.0052	68
r231	3.78	0.0052	68
r232	3.78	0.0052	68
r233	3.89	0.0054	70
r234	4.00	0.0055	72
r235	4.22	0.0058	76
r236	4.44	0.0062	80
r237	4.56	0.0063	82
r238	4.56	0.0063	82
r239	4.78	0.0066	86
r240	4.78	0.0066	86
r241	4.89	0.0068	88
r242	5.11	0.0071	92
r243	5.44	0.0075	98
r244	5.89	0.0082	106
r245	6.22	0.0086	112
r246	6.56	0.0091	118
r247	6.78	0.0094	122
r248	7.44	0.0103	134
r249	8.11	0.0112	146
r250	9.56	0.0132	172
r251	10.89	0.0151	196
r252	12.22	0.0169	220
r253	14.89	0.0206	268
r254	22.22	0.0308	400
Total resistance			13004
Minimum resistance value			18

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

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

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

Data	Output voltage1		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	D0H	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	B0H	V176'	V3+(V2-V3) X 1644 / 2210	F0H	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)

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

Data	Output voltage2	Data	Output voltage2	Data	Output voltage2	Data	Output voltage2
00H	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	B4H	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	FCH	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

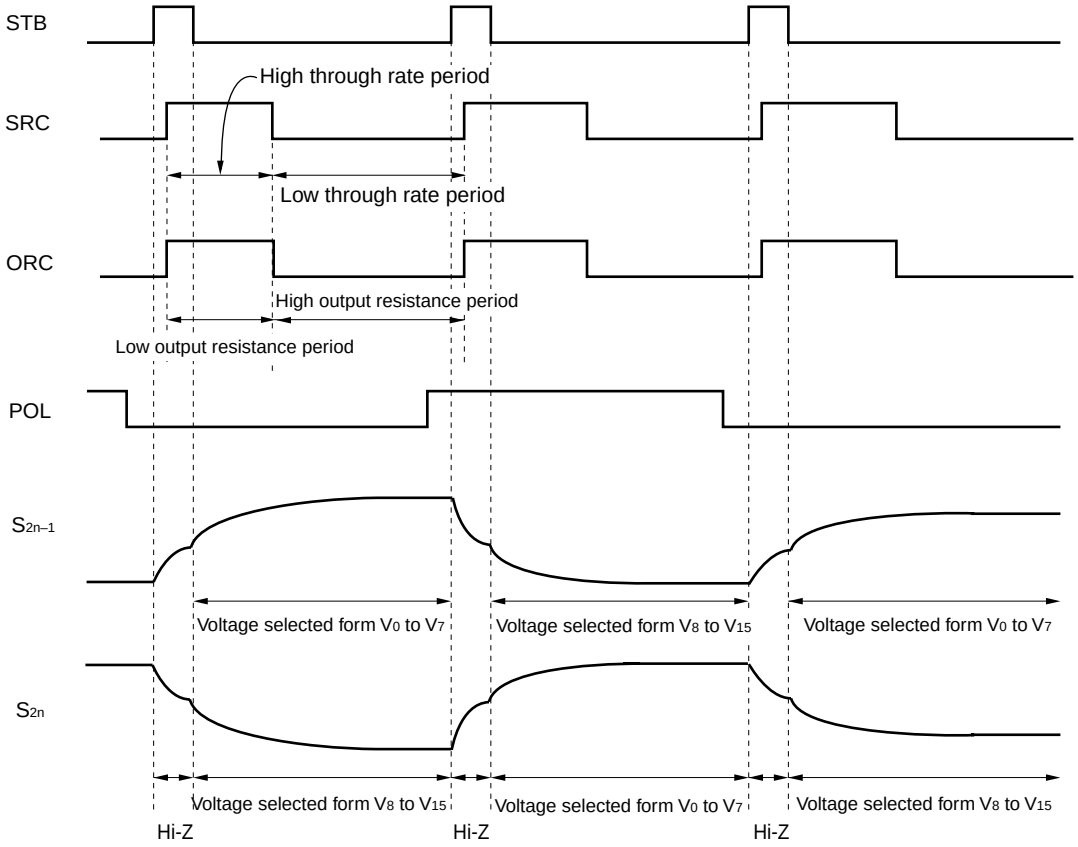
When MODE = H or open and STB = H, all outputs are reset (short) and the gray-scale voltage is output to LCD in synchronization with the falling edge of STB.

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.

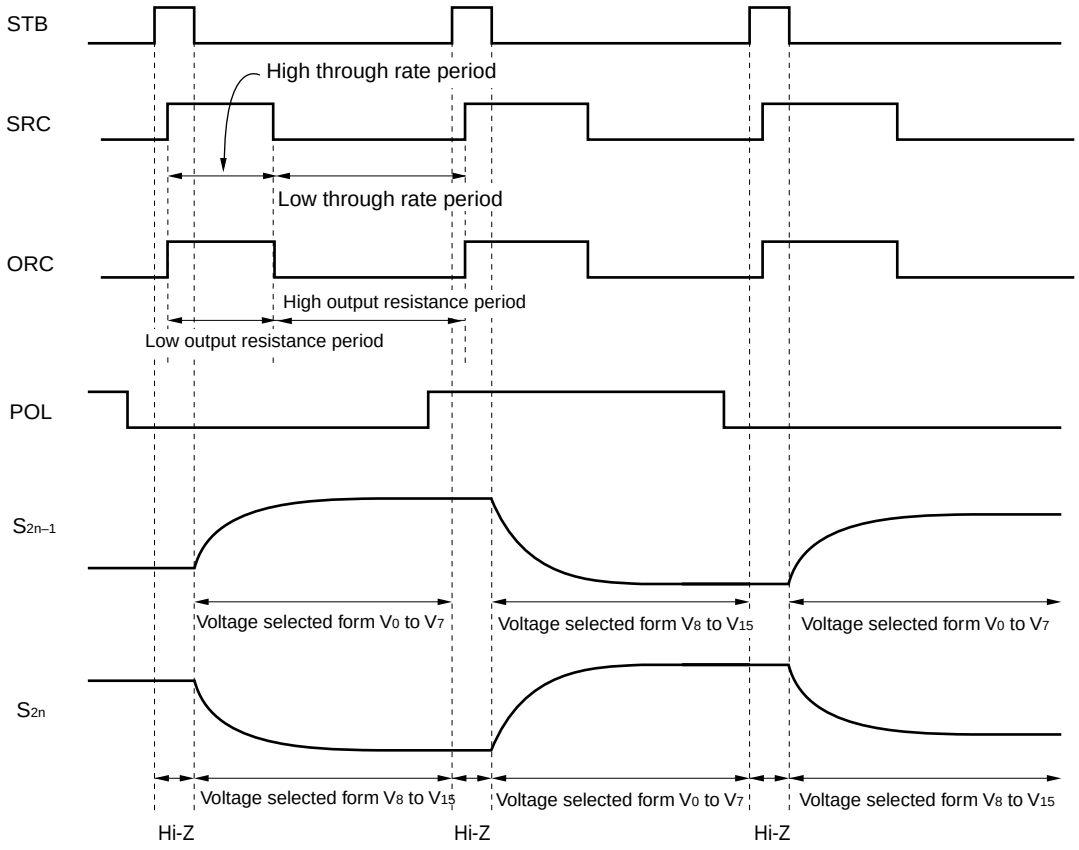
Also, setting the SRC pin to H level allows the bias current value of the output amplifier to rise temporarily, and setting the ORC pin to H level allows the output resistance value of the amplifier to lower temporarily.

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°C, V_{SS1} = V_{SS2} = 0 V)

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

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

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

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

Remark The value enclosed in parentheses is a reference value.

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

Parameter	Symbol	Condition	MIN.	TYP.	MAX.	Unit
Input leakage current	I_{IL}				±1.0	μA
High-level output voltage	V_{OH}	STHR (STHL), I_{OH} = 0 mA	V_{DD1} – 0.1			V
Low-level output voltage	V_{OL}	STHR (STHL), I_{OL} = 0 mA			0.1	V
γ-corrected 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	kΩ
Driver output current	I_{VOH}	V_X = 12.0 V, V_{OUT} = 11.0 V Note1			–0.40	mA
	I_{VOL}	V_X = 1.0 V, V_{OUT} = 2.0 V Note1	0.65			mA
Output voltage deviation	ΔV_O	T_A = 25°C, V_{SS2} + 1.0 V to V_{DD2} – 1.0 V		±10	±20	mV
Output swing voltage difference deviation	ΔV_{P-P1}	V_{DD1} = 3.3 V, V_{OUT} = 7.0 to 8.0 V Note1		±5	±10	mV
	ΔV_{P-P2}	V_{DD2} = 15.0 V, V_{OUT} = 4.0 to 11.0 V Note1		±7	±15	mV
	ΔV_{P-P3}	T_A = 25°C, V_{OUT} = 1.0 to 14.0 V Note1		±10	±20	mV
Logic part dynamic current consumption	I_{DD1}	V_{DD1} Notes 2, 3		1.3	12	mA
Driver part dynamic current consumption	I_{DD2}	V_{DD2}, with no load Notes 3, 4		12	30	mA

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

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

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

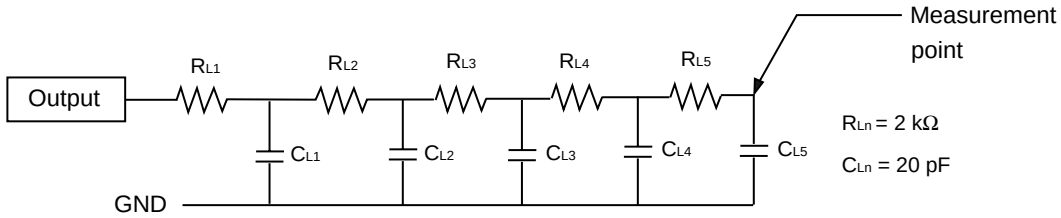
4. Refers to the current consumption per driver when cascades are connected under the assumption of SXGA single-sided mounting (10 units).

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

Parameter	Symbol	Condition	MIN.	TYP.	MAX.	Unit
Start pulse delay time	t_{PLH1}	C_L = 15 pF, 3.0 V ≤ V_{DD1} ≤ 3.6 V			17	ns
		C_L = 15 pF, 2.5 V ≤ V_{DD1} < 3.0 V			24	ns
Driver output delay time	t_{PLH2} Note	C_L = 100 pF, R_L = 10 kΩ			5	μs
	t_{PLH3} Note				10	μs
	t_{PHL2} Note				5	μs
	t_{PHL3} Note				10	μs
Input capacitance	C_{I1}	logic input, except STHR (STHL), T_A = 25°C		5	10	pF
	C_{I2}	STHR (STHL), T_A = 25°C		10	15	pF

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

★ **<Test Condition>**



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

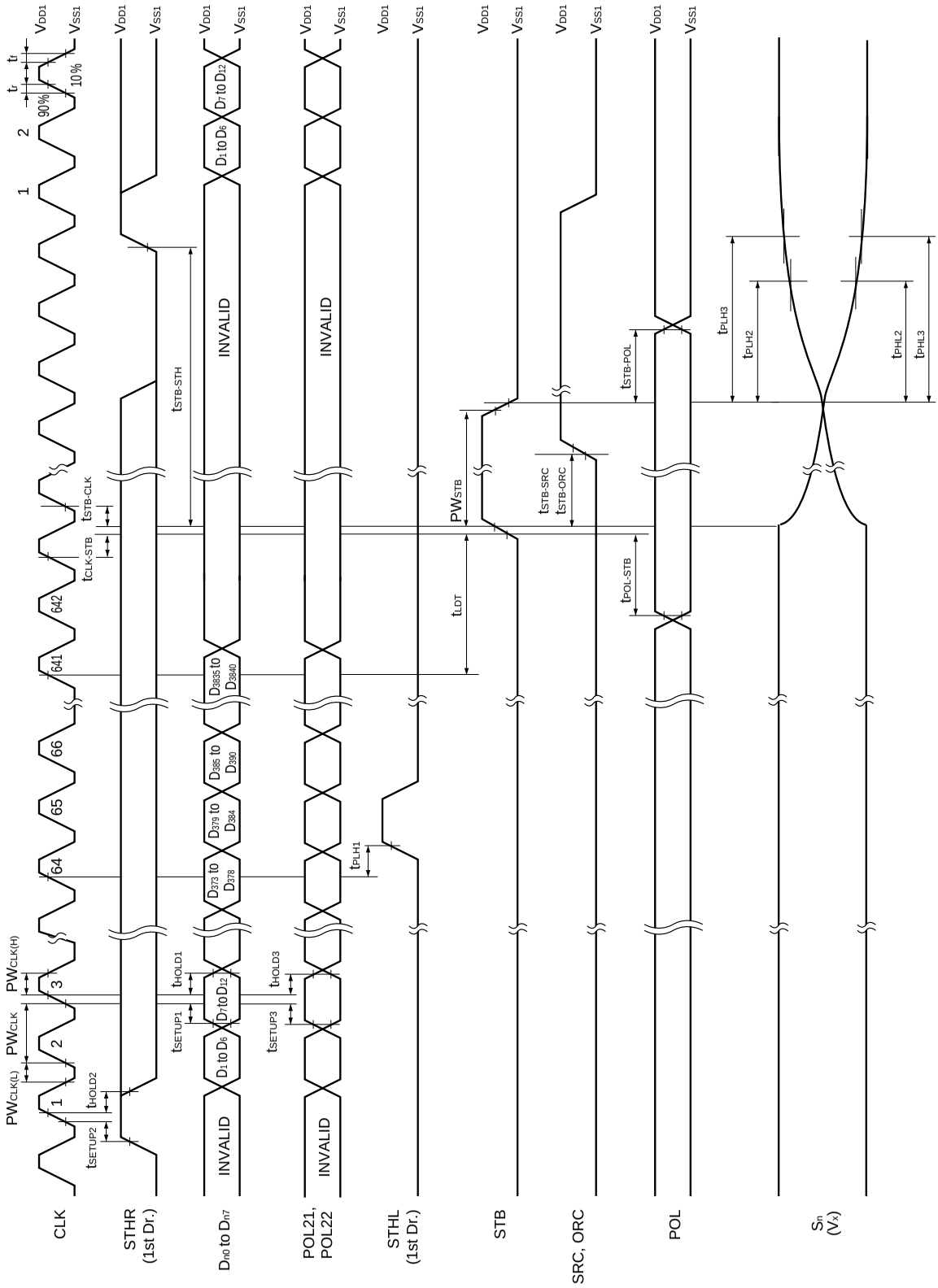
	Parameter	Symbol	Condition	MIN.	TYP.	MAX.	Unit
	Clock pulse width	PW_{CLK}	3.0 V ≤ V_{DD1} ≤ 3.6 V	18			ns
			2.5 V ≤ V_{DD1} < 3.0 V	25			ns
	Clock pulse high period	$PW_{CLK (H)}$	3.0 V ≤ V_{DD1} ≤ 3.6 V	4			ns
			2.5 V ≤ V_{DD1} < 3.0 V	6			ns
	Clock pulse low period	$PW_{CLK (L)}$		4			ns
	Data setup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

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

Switching Characteristic Waveform

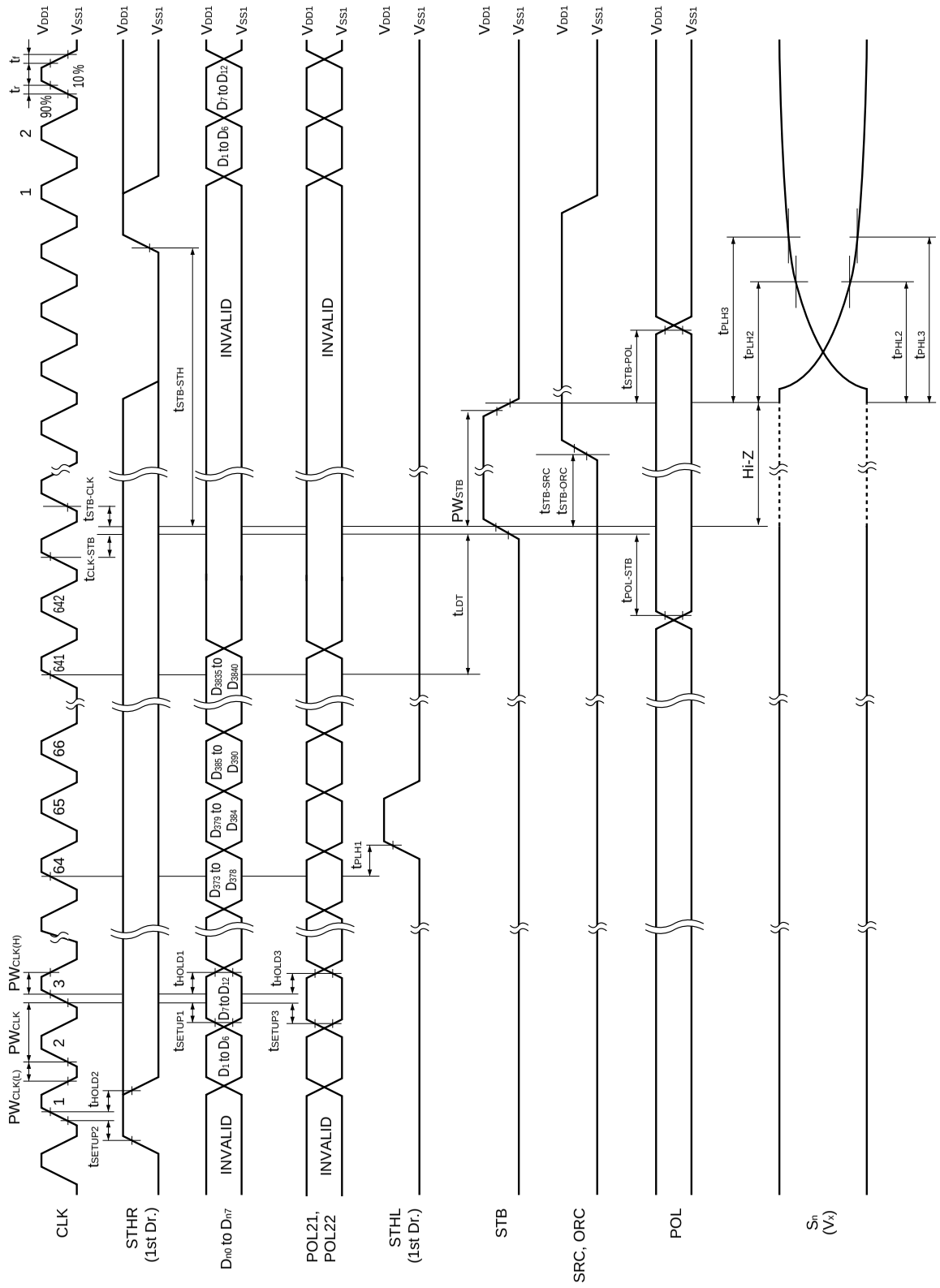
(1) R,/L= H, MODE = H or open

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



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

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



9. RECOMMENDED MOUNTING CONDITIONS

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