NEC

MOS INTEGRATED CIRCUIT

μPD16724

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

DESCRIPTION

The μPD16724 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 9-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. It corresponds to the 2 x 2-dot inversion drive at the time of single-sided mounting. The maximum clock frequency is 55 MHz when driving at 3.0 V.

FEATURES

- CMOS level input
- 480 outputs
- Input of 8 bits (gray scale data) by 6 dots
- Capable of outputting 256 values by means of 9-by-2 external power modules (18 units) and a D/A converter
- ★ • Logic power supply voltage (V_{DD1}): 2.3 to 3.6 V
- Driver power supply voltage (V_{DD2}): 12.0 to 15.0 V (switchable: LPC)
- 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 V_{DD1} = 3.0 V)
- Apply for 2 x 2 dot-line inversion
- Output voltage polarity inversion function (POL)
- Input data inversion function (POL21, POL22)
- Output reset control (MODE1)
- Slew rate control mode switching (MODE2)
- Slew rate control (SRC1, SRC2)
- Bias current control (LPC)

ORDERING INFORMATION

Part Number	Package
μPD16724N-xxx	TCP (TAB package)

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

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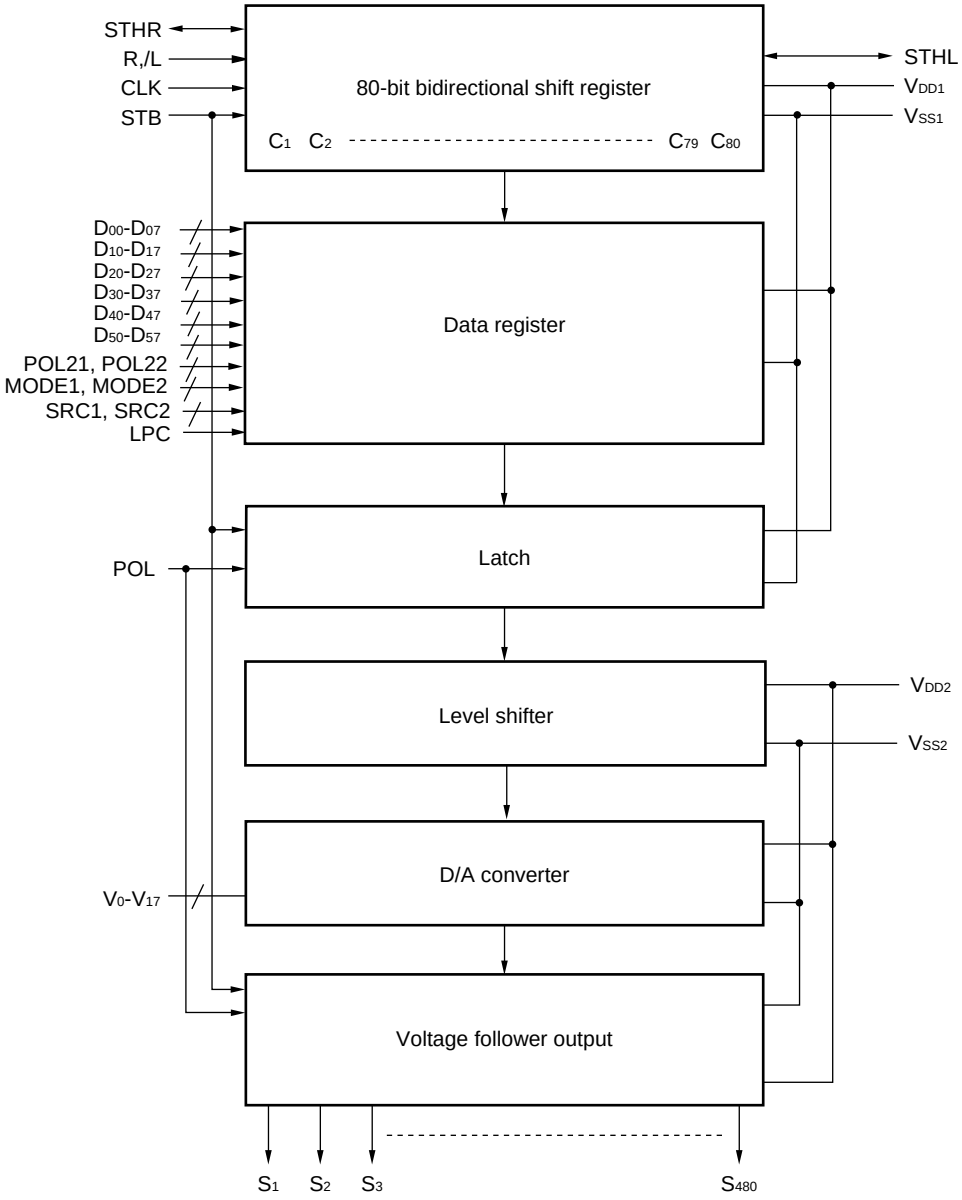
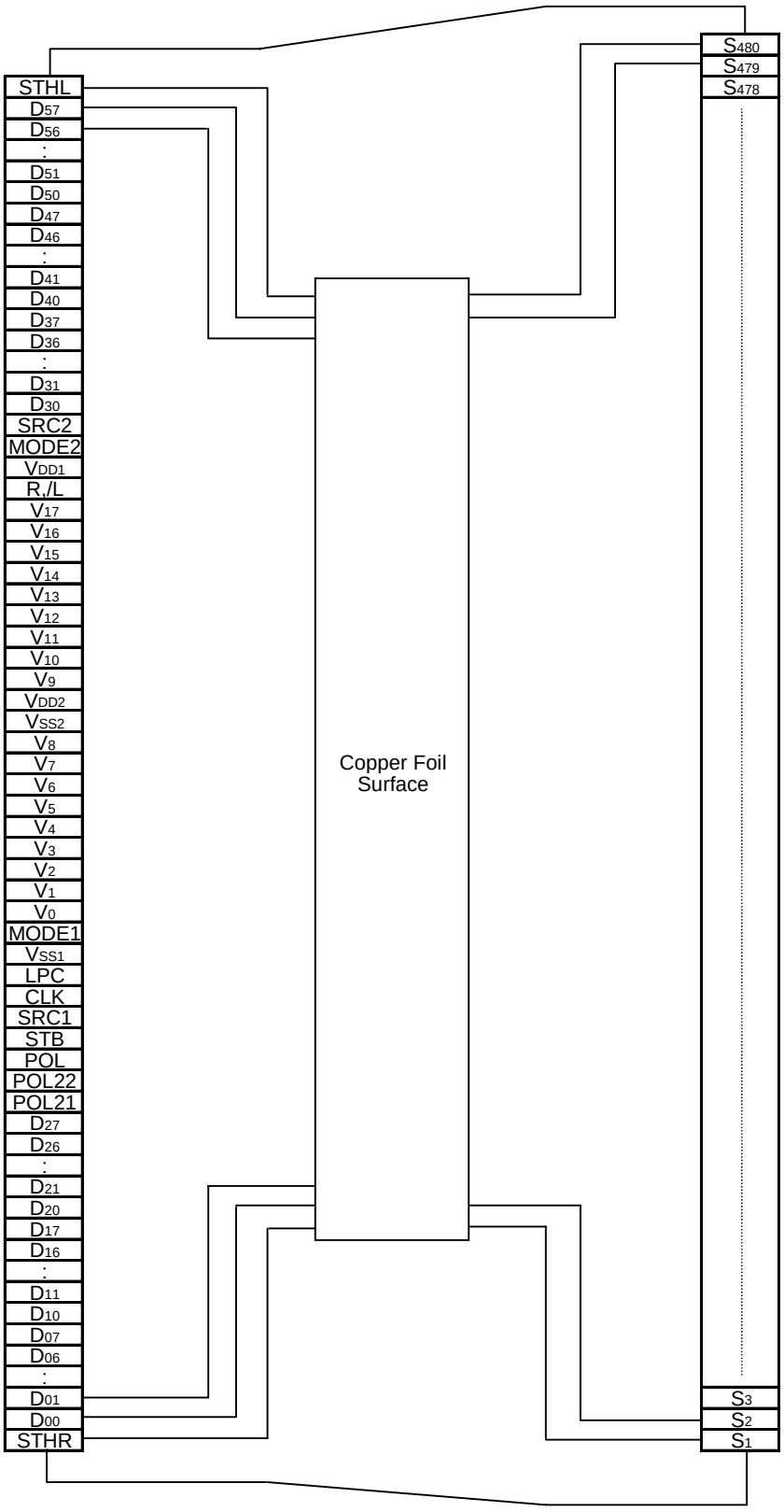
The mark ★ shows major revised points.

★ 1. BLOCK DIAGRAM



Remark /xxx indicates active low signal.

2. PIN CONFIGURATION (μPD16724N-xxx) (Copper Foil Surface, Face-up)



Remark This figure does not specify the TCP package.

3. PIN FUNCTIONS

(1/3)

Pin Symbol	Pin Name	I/O	Description
S_1 to S_{480}	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_{480}→STHL (output) R,/L = L (left shift) : STHL (input) →S_{480}→S_1→STHR (output)
STHR	Right shift start pulse	I/O	These are the start pulse input/output pins when connected in cascade. Loading of display data starts when a high level is read at the rising edge of CLK. A high level should be input as 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 high-level input is valid. At the rising edge of the 80th clock after the start pulse input, the start pulse output reaches the high level, thus becoming the start pulse of the next-level driver. The high-level width outputted is 1 CLK. 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. If 82 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.
SRC1	Slew rate control 1	Input	SRC1 is good at the time of MODE2 = H. SRC1 is pulled up to the V_{DD1} in the IC. SRC1 = H: High slew rate mode (large current consumption) SRC1 = L: Low slew rate mode (small current consumption) Refer to **6. RELATIONSHIP BETWEEN MODE2, SRC1 AND SRC2** for details.
SRC2	Slew rate control 2	Input	SRC2 is good at the time of MODE2 = L or open. SRC2 is pulled down to the V_{SS1} in the IC. SRC2 = H: High slew rate period is twice the STB width from STB rising. SRC2 = L or open: High slew rate period is 3 times the STB width from STB rising. Refer to **6. RELATIONSHIP BETWEEN MODE2, SRC1 AND SRC2** for details.

(2/3)

Pin Symbol	Pin Name	I/O	Description
POL	Polarity input	Input	The relation between POL and output is as follows. POL: L → S_{12n}, S_{12n-3}, S_{12n-4}, S_{12n-7}, S_{12n-8}, S_{12n-11} Note: V_0 to V_8; S_{12n-1}, S_{12n-2}, S_{12n-5}, S_{12n-6}, S_{12n-9}, S_{12n-10} Note: V_9 to V_{17} POL: H → S_{12n}, S_{12n-3}, S_{12n-4}, S_{12n-7}, S_{12n-8}, S_{12n-11} Note: V_9 to V_{17}; S_{12n-1}, S_{12n-2}, S_{12n-5}, S_{12n-6}, S_{12n-9}, S_{12n-10} Note: V_0 to V_8 **Note** n = 1,2, ..., 80 Input of the POL signal is allowed the setup time ($t_{POL-STB}$) with respect to STB's rising edge. MODE1 = H or open: 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 during STB = H. Refer to **7. RELATIONSHIP BETWEEN MODE, STB, SRC, ORC, POL AND OUTPUT WAVEFORM** for details.
MODE1	Output reset control	Input	MODE1 is pulled up to the V_{DD1} in the IC. MODE1 = H or open: During an STB = H period, output is reset between all-output pins. MODE1 = L: During an STB = H period, output is Hi-Z between all-output pins.
MODE2	Slew rate control mode switching	Input	MODE2 is pulled down to the V_{SS1} in the IC. MODE2 = H: High slew rate period is controlled from the outside (SRC1 is good). MODE2 = L or open: High slew rate period is formed inside the IC (SRC2 is good).
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.
LPC	Bias current control	Input	LPC is pulled up to the V_{DD1} in the IC. LPC = H or open: V_{DD2} = 12.0 V to (13.0 V) normal static-current-consumption mode LPC = L: V_{DD2} = (13.0 V) to 15.0 V static-current-consumption cut mode
V_0 to V_{17}	γ-corrected power supplies	Input	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. $V_{DD2} - 0.2\ V \geq V_0 > V_1 > V_2 > \ldots \ldots > V_7 > V_8 \geq 0.5\ V_{DD2} + 0.5\ V$ $0.5\ V_{DD2} - 0.5\ V \geq V_9 > V_{10} > V_{11} > \ldots \ldots > V_{16} > V_{17} \geq 0.5\ V_{SS2} + 0.2\ V$ or $V_{DD2} - 0.2\ V \geq V_8 > V_7 > V_6 > \ldots \ldots > V_1 > V_0 \geq 0.5\ V_{DD2} + 0.5\ V$ $0.5\ V_{DD2} - 0.5\ V \geq V_{17} > V_{16} > V_{15} > \ldots \ldots > V_{10} > V_9 \geq 0.5\ V_{SS2} + 0.2\ V$

Remark Hi-Z: High impedance

(3/3)

Pin Symbol	Pin Name	I/O	Description
V_{DD1}	Logic power supply	–	2.3 to 3.6 V
V_{DD2}	Driver power supply	–	12.0 to 15.0 V
V_{SS1}	Logic ground	–	Grounding
V_{SS2}	Driver ground	–	Grounding

Cautions 1. The power start sequence must be V_{DD1}, logic input, V_{DD2} and V_0-V_{17} 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_{17}) and V_{SS2}.

4. RELATIONSHIP BETWEEN INPUT DATA AND OUTPUT VOLTAGE VALUE

The μPD16724 incorporates a 8-bit D/A converter which can output respectively gray scale voltages of differing polarity with respect to the LCD's counter electrode voltage as shown in Figure 4–1. 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. For the 2 sets of nine γ-compensated power supplies, V_0-V_8 and V_9-V_{17}, respectively, input gray scale voltages of the same polarity with respect to the 0.5 V_{DD2}.

Figure 4–1 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_{17} and the input data. Be sure to maintain the voltage relationships below.

$$V_{DD2} - 0.2\ V \geq V_0 > V_1 > V_2 > V_3 > V_4 > V_5 > V_6 > V_7 > V_8 \geq 0.5\ V_{DD2} + 0.5\ V$$
$$0.5\ V_{DD2} - 0.5\ V \geq V_9 > V_{10} > V_{11} > V_{12} > V_{13} > V_{14} > V_{15} > V_{16} > V_{17} \geq 0.5\ V_{SS2} + 0.2\ V$$

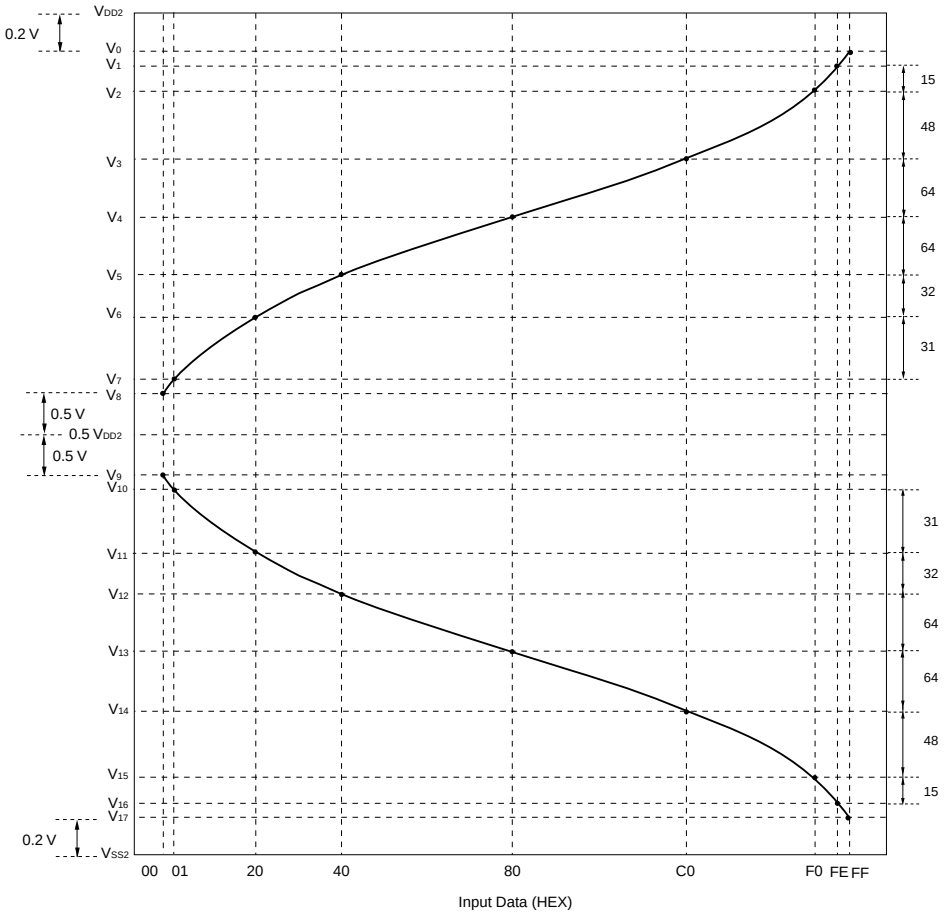
or

$$V_{DD2} - 0.2\ V \geq V_8 > V_7 > V_6 > V_5 > V_4 > V_3 > V_2 > V_1 > V_0 \geq 0.5\ V_{DD2} + 0.5\ V$$
$$0.5\ V_{DD2} - 0.5\ V \geq V_{17} > V_{16} > V_{15} > V_{14} > V_{13} > V_{12} > V_{11} > V_{10} > V_9 \geq 0.5\ V_{SS2} + 0.2\ V$$

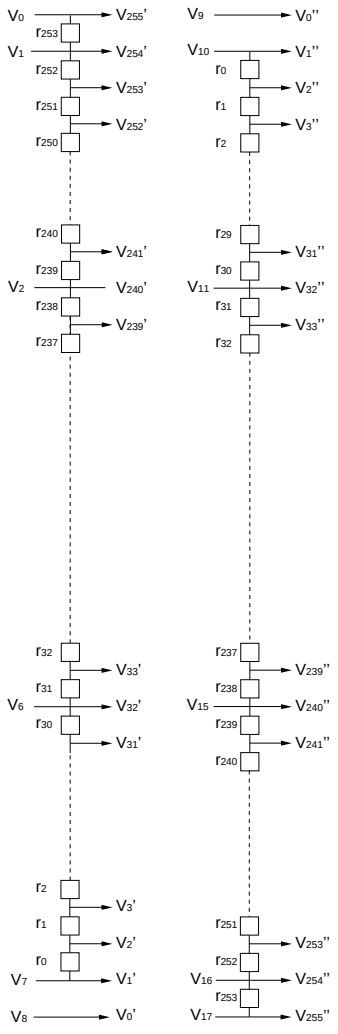
Also, V_7-V_8, V_8-V_9 and V_9-V_{10} are left open in the IC. Be sure to input the gray scale level power supply at a constant level to the all pins.

Figures 4–2 and 4–3 show the relation ship between the input data and the output voltage and the resistance values of the resistor strings.

★ **Figure 4–1. Relationship between Input Data and γ-corrected Power Supplies**



★ **Figure 4–2. γ-corrected Voltages and Ladder Resistors Ratio**



rn	Ratio 1	Ratio 2	Value
r0	3.58	0.0084	129
r1	3.58	0.0084	129
r2	3.58	0.0084	129
r3	3.58	0.0084	129
r4	3.58	0.0084	129
r5	3.50	0.0082	126
r6	3.50	0.0082	126
r7	3.42	0.0080	123
r8	3.42	0.0080	123
r9	3.33	0.0078	120
r10	3.25	0.0076	117
r11	3.25	0.0076	117
r12	3.17	0.0074	114
r13	3.08	0.0072	111
r14	3.08	0.0072	111
r15	3.00	0.0070	108
r16	2.92	0.0068	105
r17	2.83	0.0066	102
r18	2.83	0.0066	102
r19	2.75	0.0064	99
r20	2.67	0.0062	96
r21	2.67	0.0062	96
r22	2.58	0.0060	93
r23	2.50	0.0058	90
r24	2.50	0.0058	90
r25	2.42	0.0056	87
r26	2.33	0.0054	84
r27	2.33	0.0054	84
r28	2.25	0.0053	81
r29	2.25	0.0053	81
r30	2.17	0.0051	78
r31	2.17	0.0051	78
r32	2.08	0.0049	75
r33	2.08	0.0049	75
r34	2.00	0.0047	72
r35	2.00	0.0047	72
r36	1.92	0.0045	69
r37	1.92	0.0045	69
r38	1.92	0.0045	69
r39	1.83	0.0043	66
r40	1.83	0.0043	66
r41	1.83	0.0043	66
r42	1.75	0.0041	63
r43	1.75	0.0041	63
r44	1.75	0.0041	63
r45	1.67	0.0039	60
r46	1.67	0.0039	60
r47	1.67	0.0039	60
r48	1.67	0.0039	60
r49	1.58	0.0037	57
r50	1.58	0.0037	57
r51	1.58	0.0037	57
r52	1.58	0.0037	57
r53	1.50	0.0035	54
r54	1.50	0.0035	54
r55	1.50	0.0035	54
r56	1.50	0.0035	54
r57	1.42	0.0033	51
r58	1.42	0.0033	51
r59	1.42	0.0033	51
r60	1.42	0.0033	51
r61	1.42	0.0033	51
r62	1.42	0.0033	51
r63	1.33	0.0031	48

rn	Ratio 1	Ratio 2	Value
r64	1.33	0.0031	48
r65	1.33	0.0031	48
r66	1.33	0.0031	48
r67	1.33	0.0031	48
r68	1.33	0.0031	48
r69	1.33	0.0031	48
r70	1.25	0.0029	45
r71	1.25	0.0029	45
r72	1.25	0.0029	45
r73	1.25	0.0029	45
r74	1.25	0.0029	45
r75	1.25	0.0029	45
r76	1.25	0.0029	45
r77	1.25	0.0029	45
r78	1.25	0.0029	45
r79	1.25	0.0029	45
r80	1.17	0.0027	42
r81	1.17	0.0027	42
r82	1.17	0.0027	42
r83	1.17	0.0027	42
r84	1.17	0.0027	42
r85	1.17	0.0027	42
r86	1.17	0.0027	42
r87	1.17	0.0027	42
r88	1.17	0.0027	42
r89	1.17	0.0027	42
r90	1.17	0.0027	42
r91	1.17	0.0027	42
r92	1.17	0.0027	42
r93	1.08	0.0025	39
r94	1.08	0.0025	39
r95	1.08	0.0025	39
r96	1.08	0.0025	39
r97	1.08	0.0025	39
r98	1.08	0.0025	39
r99	1.08	0.0025	39
r100	1.08	0.0025	39
r101	1.08	0.0025	39
r102	1.08	0.0025	39
r103	1.08	0.0025	39
r104	1.08	0.0025	39
r105	1.08	0.0025	39
r106	1.08	0.0025	39
r107	1.08	0.0025	39
r108	1.08	0.0025	39
r109	1.08	0.0025	39
r110	1.08	0.0025	39
r111	1.08	0.0025	39
r112	1.08	0.0025	39
r113	1.08	0.0025	39
r114	1.08	0.0025	39
r115	1.08	0.0025	39
r116	1.08	0.0025	39
r117	1.08	0.0025	39
r118	1.08	0.0025	39
r119	1.08	0.0025	39
r120	1.08	0.0025	39
r121	1.08	0.0025	39
r122	1.08	0.0025	39
r123	1.08	0.0025	39
r124	1.08	0.0025	39
r125	1.08	0.0025	39
r126	1.08	0.0025	39
r127	1.08	0.0025	39

rn	Ratio 1	Ratio 2	Value
r128	1.08	0.0025	39
r129	1.08	0.0025	39
r130	1.00	0.0023	36
r131	1.00	0.0023	36
r132	1.00	0.0023	36
r133	1.00	0.0023	36
r134	1.08	0.0025	39
r135	1.08	0.0025	39
r136	1.08	0.0025	39
r137	1.08	0.0025	39
r138	1.08	0.0025	39
r139	1.08	0.0025	39
r140	1.08	0.0025	39
r141	1.08	0.0025	39
r142	1.08	0.0025	39
r143	1.08	0.0025	39
r144	1.08	0.0025	39
r145	1.08	0.0025	39
r146	1.08	0.0025	39
r147	1.08	0.0025	39
r148	1.08	0.0025	39
r149	1.08	0.0025	39
r150	1.08	0.0025	39
r151	1.08	0.0025	39
r152	1.08	0.0025	39
r153	1.08	0.0025	39
r154	1.08	0.0025	39
r155	1.08	0.0025	39
r156	1.08	0.0025	39
r157	1.08	0.0025	39
r158	1.08	0.0025	39
r159	1.08	0.0025	39
r160	1.08	0.0025	39
r161	1.08	0.0025	39
r162	1.08	0.0025	39
r163	1.08	0.0025	39
r164	1.08	0.0025	39
r165	1.08	0.0025	39
r166	1.08	0.0025	39
r167	1.08	0.0025	39
r168	1.08	0.0025	39
r169	1.08	0.0025	39
r170	1.17	0.0027	42
r171	1.17	0.0027	42
r172	1.17	0.0027	42
r173	1.17	0.0027	42
r174	1.17	0.0027	42
r175	1.17	0.0027	42
r176	1.17	0.0027	42
r177	1.17	0.0027	42
r178	1.17	0.0027	42
r179	1.17	0.0027	42
r180	1.17	0.0027	42
r181	1.17	0.0027	42
r182	1.17	0.0027	42
r183	1.17	0.0027	42
r184	1.25	0.0029	45
r185	1.25	0.0029	45
r186	1.25	0.0029	45
r187	1.25	0.0029	45
r188	1.25	0.0029	45
r189	1.25	0.0029	45
r190	1.25	0.0029	45
r191	1.25	0.0029	45

rn	Ratio 1	Ratio 2	Value
r192	1.25	0.0029	45
r193	1.25	0.0029	45
r194	1.33	0.0031	48
r195	1.33	0.0031	48
r196	1.33	0.0031	48
r197	1.33	0.0031	48
r198	1.33	0.0031	48
r199	1.33	0.0031	48
r200	1.33	0.0031	48
r201	1.42	0.0033	51
r202	1.42	0.0033	51
r203	1.42	0.0033	51
r204	1.42	0.0033	51
r205	1.42	0.0033	51
r206	1.42	0.0033	51
r207	1.50	0.0035	54
r208	1.50	0.0035	54
r209	1.50	0.0035	54
r210	1.50	0.0035	54
r211	1.50	0.0035	54
r212	1.58	0.0037	57
r213	1.58	0.0037	57
r214	1.58	0.0037	57
r215	1.58	0.0037	57
r216	1.67	0.0039	60
r217	1.67	0.0039	60
r218	1.67	0.0039	60
r219	1.75	0.0041	63
r220	1.75	0.0041	63
r221	1.75	0.0041	63
r222	1.83	0.0043	66
r223	1.83	0.0043	66
r224	1.83	0.0043	66
r225	1.92	0.0045	69
r226	1.92	0.0045	69
r227	2.00	0.0047	72
r228	2.00	0.0047	72
r229	2.08	0.0049	75
r230	2.08	0.0049	75
r231	2.17	0.0051	78
r232	2.17	0.0051	78
r233	2.25	0.0053	81
r234	2.33	0.0054	84
r235	2.33	0.0054	84
r236	2.42	0.0056	87
r237	2.50	0.0058	90
r238	2.58	0.0060	93
r239	2.67	0.0062	96
r240	2.75	0.0064	99
r241	2.83	0.0066	102
r242	2.92	0.0068	105
r243	3.00	0.0070	108
r244	3.17	0.0074	114
r245	3.33	0.0078	120
r246	3.42	0.0080	123
r247	3.58	0.0084	129
r248	3.83	0.0089	138
r249	4.08	0.0095	147
r250	4.33	0.0101	156
r251	4.67	0.0109	168
r252	5.00	0.0117	180
r253	5.50	0.0128	198
Total resistance			15423
Minimum resistance value			36

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 4–3. Relationship between Input Data and Output Voltage (Positive side 1/2)**

V_{DD2} – 0.2 V ≥ V_0 > V_1 > V_2 > V_3 > V_4 > V_5 > V_6 > V_7 > V_8 ≥ 0.5 V_{DD2} + 0.5 V (POL21, POL22 = L)

Data	Output Voltage		Data	Output Voltage	
00H	V0'	V8	40H	V64'	V5
01H	V1'	V7	41H	V65'	V5+(V4-V5) X 48 / 2658
02H	V2'	V7+(V6-V7) X 129 / 3309	42H	V66'	V5+(V4-V5) X 96 / 2658
03H	V3'	V7+(V6-V7) X 258 / 3309	43H	V67'	V5+(V4-V5) X 144 / 2658
04H	V4'	V7+(V6-V7) X 387 / 3309	44H	V68'	V5+(V4-V5) X 192 / 2658
05H	V5'	V7+(V6-V7) X 516 / 3309	45H	V69'	V5+(V4-V5) X 240 / 2658
06H	V6'	V7+(V6-V7) X 645 / 3309	46H	V70'	V5+(V4-V5) X 288 / 2658
07H	V7'	V7+(V6-V7) X 771 / 3309	47H	V71'	V5+(V4-V5) X 336 / 2658
08H	V8'	V7+(V6-V7) X 897 / 3309	48H	V72'	V5+(V4-V5) X 381 / 2658
09H	V9'	V7+(V6-V7) X 1020 / 3309	49H	V73'	V5+(V4-V5) X 426 / 2658
0AH	V10'	V7+(V6-V7) X 1143 / 3309	4AH	V74'	V5+(V4-V5) X 471 / 2658
0BH	V11'	V7+(V6-V7) X 1263 / 3309	4BH	V75'	V5+(V4-V5) X 516 / 2658
0CH	V12'	V7+(V6-V7) X 1380 / 3309	4CH	V76'	V5+(V4-V5) X 561 / 2658
0DH	V13'	V7+(V6-V7) X 1497 / 3309	4DH	V77'	V5+(V4-V5) X 606 / 2658
0EH	V14'	V7+(V6-V7) X 1611 / 3309	4EH	V78'	V5+(V4-V5) X 651 / 2658
0FH	V15'	V7+(V6-V7) X 1722 / 3309	4FH	V79'	V5+(V4-V5) X 696 / 2658
10H	V16'	V7+(V6-V7) X 1833 / 3309	50H	V80'	V5+(V4-V5) X 741 / 2658
11H	V17'	V7+(V6-V7) X 1941 / 3309	51H	V81'	V5+(V4-V5) X 786 / 2658
12H	V18'	V7+(V6-V7) X 2046 / 3309	52H	V82'	V5+(V4-V5) X 828 / 2658
13H	V19'	V7+(V6-V7) X 2148 / 3309	53H	V83'	V5+(V4-V5) X 870 / 2658
14H	V20'	V7+(V6-V7) X 2250 / 3309	54H	V84'	V5+(V4-V5) X 912 / 2658
15H	V21'	V7+(V6-V7) X 2349 / 3309	55H	V85'	V5+(V4-V5) X 954 / 2658
16H	V22'	V7+(V6-V7) X 2445 / 3309	56H	V86'	V5+(V4-V5) X 996 / 2658
17H	V23'	V7+(V6-V7) X 2541 / 3309	57H	V87'	V5+(V4-V5) X 1038 / 2658
18H	V24'	V7+(V6-V7) X 2634 / 3309	58H	V88'	V5+(V4-V5) X 1080 / 2658
19H	V25'	V7+(V6-V7) X 2724 / 3309	59H	V89'	V5+(V4-V5) X 1122 / 2658
1AH	V26'	V7+(V6-V7) X 2814 / 3309	5AH	V90'	V5+(V4-V5) X 1164 / 2658
1BH	V27'	V7+(V6-V7) X 2901 / 3309	5BH	V91'	V5+(V4-V5) X 1206 / 2658
1CH	V28'	V7+(V6-V7) X 2985 / 3309	5CH	V92'	V5+(V4-V5) X 1248 / 2658
1DH	V29'	V7+(V6-V7) X 3069 / 3309	5DH	V93'	V5+(V4-V5) X 1290 / 2658
1EH	V30'	V7+(V6-V7) X 3150 / 3309	5EH	V94'	V5+(V4-V5) X 1332 / 2658
1FH	V31'	V7+(V6-V7) X 3231 / 3309	5FH	V95'	V5+(V4-V5) X 1371 / 2658
20H	V32'	V6	60H	V96'	V5+(V4-V5) X 1410 / 2658
21H	V33'	V6+(V5-V6) X 78 / 1956	61H	V97'	V5+(V4-V5) X 1449 / 2658
22H	V34'	V6+(V5-V6) X 153 / 1956	62H	V98'	V5+(V4-V5) X 1488 / 2658
23H	V35'	V6+(V5-V6) X 228 / 1956	63H	V99'	V5+(V4-V5) X 1527 / 2658
24H	V36'	V6+(V5-V6) X 300 / 1956	64H	V100'	V5+(V4-V5) X 1566 / 2658
25H	V37'	V6+(V5-V6) X 372 / 1956	65H	V101'	V5+(V4-V5) X 1605 / 2658
26H	V38'	V6+(V5-V6) X 441 / 1956	66H	V102'	V5+(V4-V5) X 1644 / 2658
27H	V39'	V6+(V5-V6) X 510 / 1956	67H	V103'	V5+(V4-V5) X 1683 / 2658
28H	V40'	V6+(V5-V6) X 579 / 1956	68H	V104'	V5+(V4-V5) X 1722 / 2658
29H	V41'	V6+(V5-V6) X 645 / 1956	69H	V105'	V5+(V4-V5) X 1761 / 2658
2AH	V42'	V6+(V5-V6) X 711 / 1956	6AH	V106'	V5+(V4-V5) X 1800 / 2658
2BH	V43'	V6+(V5-V6) X 777 / 1956	6BH	V107'	V5+(V4-V5) X 1839 / 2658
2CH	V44'	V6+(V5-V6) X 840 / 1956	6CH	V108'	V5+(V4-V5) X 1878 / 2658
2DH	V45'	V6+(V5-V6) X 903 / 1956	6DH	V109'	V5+(V4-V5) X 1917 / 2658
2EH	V46'	V6+(V5-V6) X 966 / 1956	6EH	V110'	V5+(V4-V5) X 1956 / 2658
2FH	V47'	V6+(V5-V6) X 1026 / 1956	6FH	V111'	V5+(V4-V5) X 1995 / 2658
30H	V48'	V6+(V5-V6) X 1086 / 1956	70H	V112'	V5+(V4-V5) X 2034 / 2658
31H	V49'	V6+(V5-V6) X 1146 / 1956	71H	V113'	V5+(V4-V5) X 2073 / 2658
32H	V50'	V6+(V5-V6) X 1206 / 1956	72H	V114'	V5+(V4-V5) X 2112 / 2658
33H	V51'	V6+(V5-V6) X 1263 / 1956	73H	V115'	V5+(V4-V5) X 2151 / 2658
34H	V52'	V6+(V5-V6) X 1320 / 1956	74H	V116'	V5+(V4-V5) X 2190 / 2658
35H	V53'	V6+(V5-V6) X 1377 / 1956	75H	V117'	V5+(V4-V5) X 2229 / 2658
36H	V54'	V6+(V5-V6) X 1434 / 1956	76H	V118'	V5+(V4-V5) X 2268 / 2658
37H	V55'	V6+(V5-V6) X 1488 / 1956	77H	V119'	V5+(V4-V5) X 2307 / 2658
38H	V56'	V6+(V5-V6) X 1542 / 1956	78H	V120'	V5+(V4-V5) X 2346 / 2658
39H	V57'	V6+(V5-V6) X 1596 / 1956	79H	V121'	V5+(V4-V5) X 2385 / 2658
3AH	V58'	V6+(V5-V6) X 1650 / 1956	7AH	V122'	V5+(V4-V5) X 2424 / 2658
3BH	V59'	V6+(V5-V6) X 1701 / 1956	7BH	V123'	V5+(V4-V5) X 2463 / 2658
3CH	V60'	V6+(V5-V6) X 1752 / 1956	7CH	V124'	V5+(V4-V5) X 2502 / 2658
3DH	V61'	V6+(V5-V6) X 1803 / 1956	7DH	V125'	V5+(V4-V5) X 2541 / 2658
3EH	V62'	V6+(V5-V6) X 1854 / 1956	7EH	V126'	V5+(V4-V5) X 2580 / 2658
3FH	V63'	V6+(V5-V6) X 1905 / 1956	7FH	V127'	V5+(V4-V5) X 2619 / 2658

★ **Figure 4–3. Relationship between Input Data and Output Voltage (Positive side 2/2)**

V_{DD2} – 0.2 V ≥ V_0 > V_1 > V_2 > V_3 > V_4 > V_5 > V_6 > V_7 > V_8 ≥ 0.5 V_{DD2} + 0.5 V (POL21, POL22 = L)

Data	Output Voltage		Data	Output Voltage	
80H	V128'	V4	C0H	V192'	V3
81H	V129'	V4+(V3-V4) X 39 / 2568	C1H	V193'	V3+(V2-V3) X 45 / 2949
82H	V130'	V4+(V3-V4) X 78 / 2568	C2H	V194'	V3+(V2-V3) X 90 / 2949
83H	V131'	V4+(V3-V4) X 117 / 2568	C3H	V195'	V3+(V2-V3) X 135 / 2949
84H	V132'	V4+(V3-V4) X 153 / 2568	C4H	V196'	V3+(V2-V3) X 183 / 2949
85H	V133'	V4+(V3-V4) X 189 / 2568	C5H	V197'	V3+(V2-V3) X 231 / 2949
86H	V134'	V4+(V3-V4) X 225 / 2568	C6H	V198'	V3+(V2-V3) X 279 / 2949
87H	V135'	V4+(V3-V4) X 261 / 2568	C7H	V199'	V3+(V2-V3) X 327 / 2949
88H	V136'	V4+(V3-V4) X 300 / 2568	C8H	V200'	V3+(V2-V3) X 375 / 2949
89H	V137'	V4+(V3-V4) X 339 / 2568	C9H	V201'	V3+(V2-V3) X 423 / 2949
8AH	V138'	V4+(V3-V4) X 378 / 2568	CAH	V202'	V3+(V2-V3) X 471 / 2949
8BH	V139'	V4+(V3-V4) X 417 / 2568	CBH	V203'	V3+(V2-V3) X 522 / 2949
8CH	V140'	V4+(V3-V4) X 456 / 2568	CCH	V204'	V3+(V2-V3) X 573 / 2949
8DH	V141'	V4+(V3-V4) X 495 / 2568	CDH	V205'	V3+(V2-V3) X 624 / 2949
8EH	V142'	V4+(V3-V4) X 534 / 2568	CEH	V206'	V3+(V2-V3) X 675 / 2949
8FH	V143'	V4+(V3-V4) X 573 / 2568	CFH	V207'	V3+(V2-V3) X 726 / 2949
90H	V144'	V4+(V3-V4) X 612 / 2568	D0H	V208'	V3+(V2-V3) X 777 / 2949
91H	V145'	V4+(V3-V4) X 651 / 2568	D1H	V209'	V3+(V2-V3) X 831 / 2949
92H	V146'	V4+(V3-V4) X 690 / 2568	D2H	V210'	V3+(V2-V3) X 885 / 2949
93H	V147'	V4+(V3-V4) X 729 / 2568	D3H	V211'	V3+(V2-V3) X 939 / 2949
94H	V148'	V4+(V3-V4) X 768 / 2568	D4H	V212'	V3+(V2-V3) X 993 / 2949
95H	V149'	V4+(V3-V4) X 807 / 2568	D5H	V213'	V3+(V2-V3) X 1047 / 2949
96H	V150'	V4+(V3-V4) X 846 / 2568	D6H	V214'	V3+(V2-V3) X 1104 / 2949
97H	V151'	V4+(V3-V4) X 885 / 2568	D7H	V215'	V3+(V2-V3) X 1161 / 2949
98H	V152'	V4+(V3-V4) X 924 / 2568	D8H	V216'	V3+(V2-V3) X 1218 / 2949
99H	V153'	V4+(V3-V4) X 963 / 2568	D9H	V217'	V3+(V2-V3) X 1275 / 2949
9AH	V154'	V4+(V3-V4) X 1002 / 2568	DAH	V218'	V3+(V2-V3) X 1335 / 2949
9BH	V155'	V4+(V3-V4) X 1041 / 2568	DBH	V219'	V3+(V2-V3) X 1395 / 2949
9CH	V156'	V4+(V3-V4) X 1080 / 2568	DCH	V220'	V3+(V2-V3) X 1455 / 2949
9DH	V157'	V4+(V3-V4) X 1119 / 2568	DDH	V221'	V3+(V2-V3) X 1518 / 2949
9EH	V158'	V4+(V3-V4) X 1158 / 2568	DEH	V222'	V3+(V2-V3) X 1581 / 2949
9FH	V159'	V4+(V3-V4) X 1197 / 2568	DFH	V223'	V3+(V2-V3) X 1644 / 2949
A0H	V160'	V4+(V3-V4) X 1236 2568	E0H	V224'	V3+(V2-V3) X 1710 / 2949
A1H	V161'	V4+(V3-V4) X 1275 / 2568	E1H	V225'	V3+(V2-V3) X 1776 / 2949
A2H	V162'	V4+(V3-V4) X 1314 / 2568	E2H	V226'	V3+(V2-V3) X 1842 / 2949
A3H	V163'	V4+(V3-V4) X 1353 / 2568	E3H	V227'	V3+(V2-V3) X 1911 / 2949
A4H	V164'	V4+(V3-V4) X 1392 / 2568	E4H	V228'	V3+(V2-V3) X 1980 / 2949
A5H	V165'	V4+(V3-V4) X 1431 / 2568	E5H	V229'	V3+(V2-V3) X 2052 / 2949
A6H	V166'	V4+(V3-V4) X 1470 / 2568	E6H	V230'	V3+(V2-V3) X 2124 / 2949
A7H	V167'	V4+(V3-V4) X 1509 / 2568	E7H	V231'	V3+(V2-V3) X 2199 / 2949
A8H	V168'	V4+(V3-V4) X 1548 / 2568	E8H	V232'	V3+(V2-V3) X 2274 / 2949
A9H	V169'	V4+(V3-V4) X 1587 / 2568	E9H	V233'	V3+(V2-V3) X 2352 / 2949
AAH	V170'	V4+(V3-V4) X 1626 / 2568	EAH	V234'	V3+(V2-V3) X 2430 / 2949
ABH	V171'	V4+(V3-V4) X 1665 / 2568	EBH	V235'	V3+(V2-V3) X 2511 / 2949
ACH	V172'	V4+(V3-V4) X 1707 / 2568	ECH	V236'	V3+(V2-V3) X 2595 / 2949
ADH	V173'	V4+(V3-V4) X 1749 / 2568	EDH	V237'	V3+(V2-V3) X 2679 / 2949
AEH	V174'	V4+(V3-V4) X 1791 / 2568	EEH	V238'	V3+(V2-V3) X 2766 / 2949
AFH	V175'	V4+(V3-V4) X 1833 / 2568	EFH	V239'	V3+(V2-V3) X 2856 / 2949
B0H	V176'	V4+(V3-V4) X 1875 / 2568	F0H	V240'	V2
B1H	V177'	V4+(V3-V4) X 1917 / 2568	F1H	V241'	V2+(V1-V2) X 96 / 1785
B2H	V178'	V4+(V3-V4) X 1959 / 2568	F2H	V242'	V2+(V1-V2) X 195 / 1785
B3H	V179'	V4+(V3-V4) X 2001 / 2568	F3H	V243'	V2+(V1-V2) X 297 / 1785
B4H	V180'	V4+(V3-V4) X 2043 / 2568	F4H	V244'	V2+(V1-V2) X 402 / 1785
B5H	V181'	V4+(V3-V4) X 2085 / 2568	F5H	V245'	V2+(V1-V2) X 510 / 1785
B6H	V182'	V4+(V3-V4) X 2127 / 2568	F6H	V246'	V2+(V1-V2) X 624 / 1785
B7H	V183'	V4+(V3-V4) X 2169 / 2568	F7H	V247'	V2+(V1-V2) X 744 / 1785
B8H	V184'	V4+(V3-V4) X 2211 / 2568	F8H	V248'	V2+(V1-V2) X 867 / 1785
B9H	V185'	V4+(V3-V4) X 2253 / 2568	F9H	V249'	V2+(V1-V2) X 996 / 1785
BAH	V186'	V4+(V3-V4) X 2298 / 2568	FAH	V250'	V2+(V1-V2) X 1134 / 1785
BBH	V187'	V4+(V3-V4) X 2343 / 2568	FBH	V251'	V2+(V1-V2) X 1281 / 1785
BCH	V188'	V4+(V3-V4) X 2388 / 2568	FCH	V252'	V2+(V1-V2) X 1437 / 1785
BDH	V189'	V4+(V3-V4) X 2433 / 2568	FDH	V253'	V2+(V1-V2) X 1605 / 1785
BEH	V190'	V4+(V3-V4) X 2478 / 2568	FEH	V254'	V1
BFH	V191'	V4+(V3-V4) X 2523 / 2568	FFH	V255'	V0

★ **Figure 4–3. Relationship between Input Data and Output Voltage (Negative side 1/2)**

0.5 V_{DD2} – 0.5 V ≥ V_9 > V_{10} > V_{11} > V_{12} > V_{13} > V_{14} > V_{15} > V_{16} > V_{17} ≥ V_{SS2} + 0.2 V (POL21, POL22 = L)

Data	Output Voltage					Data	Output Voltage				
00H	V0"	V9				40H	V64"	V12			
01H	V1"	V10				41H	V65"	V13+(V12-V13) X	2610	/	2658
02H	V2"	V11+(V10-V11) X	3180	/	3309	42H	V66"	V13+(V12-V13) X	2562	/	2658
03H	V3"	V11+(V10-V11) X	3051	/	3309	43H	V67"	V13+(V12-V13) X	2514	/	2658
04H	V4"	V11+(V10-V11) X	2922	/	3309	44H	V68"	V13+(V12-V13) X	2466	/	2658
05H	V5"	V11+(V10-V11) X	2793	/	3309	45H	V69"	V13+(V12-V13) X	2418	/	2658
06H	V6"	V11+(V10-V11) X	2664	/	3309	46H	V70"	V13+(V12-V13) X	2370	/	2658
07H	V7"	V11+(V10-V11) X	2538	/	3309	47H	V71"	V13+(V12-V13) X	2322	/	2658
08H	V8"	V11+(V10-V11) X	2412	/	3309	48H	V72"	V13+(V12-V13) X	2277	/	2658
09H	V9"	V11+(V10-V11) X	2289	/	3309	49H	V73"	V13+(V12-V13) X	2232	/	2658
0AH	V10"	V11+(V10-V11) X	2166	/	3309	4AH	V74"	V13+(V12-V13) X	2187	/	2658
0BH	V11"	V11+(V10-V11) X	2046	/	3309	4BH	V75"	V13+(V12-V13) X	2142	/	2658
0CH	V12"	V11+(V10-V11) X	1929	/	3309	4CH	V76"	V13+(V12-V13) X	2097	/	2658
0DH	V13"	V11+(V10-V11) X	1812	/	3309	4DH	V77"	V13+(V12-V13) X	2052	/	2658
0EH	V14"	V11+(V10-V11) X	1698	/	3309	4EH	V78"	V13+(V12-V13) X	2007	/	2658
0FH	V15"	V11+(V10-V11) X	1587	/	3309	4FH	V79"	V13+(V12-V13) X	1962	/	2658
10H	V16"	V11+(V10-V11) X	1476	/	3309	50H	V80"	V13+(V12-V13) X	1917	/	2658
11H	V17"	V11+(V10-V11) X	1368	/	3309	51H	V81"	V13+(V12-V13) X	1872	/	2658
12H	V18"	V11+(V10-V11) X	1263	/	3309	52H	V82"	V13+(V12-V13) X	1830	/	2658
13H	V19"	V11+(V10-V11) X	1161	/	3309	53H	V83"	V13+(V12-V13) X	1788	/	2658
14H	V20"	V11+(V10-V11) X	1059	/	3309	54H	V84"	V13+(V12-V13) X	1746	/	2658
15H	V21"	V11+(V10-V11) X	960	/	3309	55H	V85"	V13+(V12-V13) X	1704	/	2658
16H	V22"	V11+(V10-V11) X	864	/	3309	56H	V86"	V13+(V12-V13) X	1662	/	2658
17H	V23"	V11+(V10-V11) X	768	/	3309	57H	V87"	V13+(V12-V13) X	1620	/	2658
18H	V24"	V11+(V10-V11) X	675	/	3309	58H	V88"	V13+(V12-V13) X	1578	/	2658
19H	V25"	V11+(V10-V11) X	585	/	3309	59H	V89"	V13+(V12-V13) X	1536	/	2658
1AH	V26"	V11+(V10-V11) X	495	/	3309	5AH	V90"	V13+(V12-V13) X	1494	/	2658
1BH	V27"	V11+(V10-V11) X	408	/	3309	5BH	V91"	V13+(V12-V13) X	1452	/	2658
1CH	V28"	V11+(V10-V11) X	324	/	3309	5CH	V92"	V13+(V12-V13) X	1410	/	2658
1DH	V29"	V11+(V10-V11) X	240	/	3309	5DH	V93"	V13+(V12-V13) X	1368	/	2658
1EH	V30"	V11+(V10-V11) X	159	/	3309	5EH	V94"	V13+(V12-V13) X	1326	/	2658
1FH	V31"	V11+(V10-V11) X	78	/	3309	5FH	V95"	V13+(V12-V13) X	1287	/	2658
20H	V32"	V11				60H	V96"	V13+(V12-V13) X	1248	/	2658
21H	V33"	V12+(V11-V12) X	1878	/	1956	61H	V97"	V13+(V12-V13) X	1209	/	2658
22H	V34"	V12+(V11-V12) X	1803	/	1956	62H	V98"	V13+(V12-V13) X	1170	/	2658
23H	V35"	V12+(V11-V12) X	1728	/	1956	63H	V99"	V13+(V12-V13) X	1131	/	2658
24H	V36"	V12+(V11-V12) X	1656	/	1956	64H	V100"	V13+(V12-V13) X	1092	/	2658
25H	V37"	V12+(V11-V12) X	1584	/	1956	65H	V101"	V13+(V12-V13) X	1053	/	2658
26H	V38"	V12+(V11-V12) X	1515	/	1956	66H	V102"	V13+(V12-V13) X	1014	/	2658
27H	V39"	V12+(V11-V12) X	1446	/	1956	67H	V103"	V13+(V12-V13) X	975	/	2658
28H	V40"	V12+(V11-V12) X	1377	/	1956	68H	V104"	V13+(V12-V13) X	936	/	2658
29H	V41"	V12+(V11-V12) X	1311	/	1956	69H	V105"	V13+(V12-V13) X	897	/	2658
2AH	V42"	V12+(V11-V12) X	1245	/	1956	6AH	V106"	V13+(V12-V13) X	858	/	2658
2BH	V43"	V12+(V11-V12) X	1179	/	1956	6BH	V107"	V13+(V12-V13) X	819	/	2658
2CH	V44"	V12+(V11-V12) X	1116	/	1956	6CH	V108"	V13+(V12-V13) X	780	/	2658
2DH	V45"	V12+(V11-V12) X	1053	/	1956	6DH	V109"	V13+(V12-V13) X	741	/	2658
2EH	V46"	V12+(V11-V12) X	990	/	1956	6EH	V110"	V13+(V12-V13) X	702	/	2658
2FH	V47"	V12+(V11-V12) X	930	/	1956	6FH	V111"	V13+(V12-V13) X	663	/	2658
30H	V48"	V12+(V11-V12) X	870	/	1956	70H	V112"	V13+(V12-V13) X	624	/	2658
31H	V49"	V12+(V11-V12) X	810	/	1956	71H	V113"	V13+(V12-V13) X	585	/	2658
32H	V50"	V12+(V11-V12) X	750	/	1956	72H	V114"	V13+(V12-V13) X	546	/	2658
33H	V51"	V12+(V11-V12) X	693	/	1956	73H	V115"	V13+(V12-V13) X	507	/	2658
34H	V52"	V12+(V11-V12) X	636	/	1956	74H	V116"	V13+(V12-V13) X	468	/	2658
35H	V53"	V12+(V11-V12) X	579	/	1956	75H	V117"	V13+(V12-V13) X	429	/	2658
36H	V54"	V12+(V11-V12) X	522	/	1956	76H	V118"	V13+(V12-V13) X	390	/	2658
37H	V55"	V12+(V11-V12) X	468	/	1956	77H	V119"	V13+(V12-V13) X	351	/	2658
38H	V56"	V12+(V11-V12) X	414	/	1956	78H	V120"	V13+(V12-V13) X	312	/	2658
39H	V57"	V12+(V11-V12) X	360	/	1956	79H	V121"	V13+(V12-V13) X	273	/	2658
3AH	V58"	V12+(V11-V12) X	306	/	1956	7AH	V122"	V13+(V12-V13) X	234	/	2658
3BH	V59"	V12+(V11-V12) X	255	/	1956	7BH	V123"	V13+(V12-V13) X	195	/	2658
3CH	V60"	V12+(V11-V12) X	204	/	1956	7CH	V124"	V13+(V12-V13) X	156	/	2658
3DH	V61"	V12+(V11-V12) X	153	/	1956	7DH	V125"	V13+(V12-V13) X	117	/	2658
3EH	V62"	V12+(V11-V12) X	102	/	1956	7EH	V126"	V13+(V12-V13) X	78	/	2658
3FH	V63"	V12+(V11-V12) X	51	/	1956	7FH	V127"	V13+(V12-V13) X	39	/	2658

★ **Figure 4–3. Relationship between Input Data and Output Voltage (Negative side 2/2)**

0.5 V_{DD2} – 0.5 V ≥ V_9 > V_{10} > V_{11} > V_{12} > V_{13} > V_{14} > V_{15} > V_{16} > V_{17} ≥ V_{SS2} + 0.2 V (POL21, POL22 = L)

Data	Output Voltage		Data	Output Voltage	
80H	V128"	V13	C0H	V192"	V14
81H	V129"	V14+(V13-V14) X 2529 / 2568	C1H	V193"	V15+(V14-V15) X 2904 / 2949
82H	V130"	V14+(V13-V14) X 2490 / 2568	C2H	V194"	V15+(V14-V15) X 2859 / 2949
83H	V131"	V14+(V13-V14) X 2451 / 2568	C3H	V195"	V15+(V14-V15) X 2814 / 2949
84H	V132"	V14+(V13-V14) X 2415 / 2568	C4H	V196"	V15+(V14-V15) X 2766 / 2949
85H	V133"	V14+(V13-V14) X 2379 / 2568	C5H	V197"	V15+(V14-V15) X 2718 / 2949
86H	V134"	V14+(V13-V14) X 2343 / 2568	C6H	V198"	V15+(V14-V15) X 2670 / 2949
87H	V135"	V14+(V13-V14) X 2307 / 2568	C7H	V199"	V15+(V14-V15) X 2622 / 2949
88H	V136"	V14+(V13-V14) X 2268 / 2568	C8H	V200"	V15+(V14-V15) X 2574 / 2949
89H	V137"	V14+(V13-V14) X 2229 / 2568	C9H	V201"	V15+(V14-V15) X 2526 / 2949
8AH	V138"	V14+(V13-V14) X 2190 / 2568	CAH	V202"	V15+(V14-V15) X 2478 / 2949
8BH	V139"	V14+(V13-V14) X 2151 / 2568	CBH	V203"	V15+(V14-V15) X 2427 / 2949
8CH	V140"	V14+(V13-V14) X 2112 / 2568	CCH	V204"	V15+(V14-V15) X 2376 / 2949
8DH	V141"	V14+(V13-V14) X 2073 / 2568	CDH	V205"	V15+(V14-V15) X 2325 / 2949
8EH	V142"	V14+(V13-V14) X 2034 / 2568	CEH	V206"	V15+(V14-V15) X 2274 / 2949
8FH	V143"	V14+(V13-V14) X 1995 / 2568	CFH	V207"	V15+(V14-V15) X 2223 / 2949
90H	V144"	V14+(V13-V14) X 1956 / 2568	D0H	V208"	V15+(V14-V15) X 2172 / 2949
91H	V145"	V14+(V13-V14) X 1917 / 2568	D1H	V209"	V15+(V14-V15) X 2118 / 2949
92H	V146"	V14+(V13-V14) X 1878 / 2568	D2H	V210"	V15+(V14-V15) X 2064 / 2949
93H	V147"	V14+(V13-V14) X 1839 / 2568	D3H	V211"	V15+(V14-V15) X 2010 / 2949
94H	V148"	V14+(V13-V14) X 1800 / 2568	D4H	V212"	V15+(V14-V15) X 1956 / 2949
95H	V149"	V14+(V13-V14) X 1761 / 2568	D5H	V213"	V15+(V14-V15) X 1902 / 2949
96H	V150"	V14+(V13-V14) X 1722 / 2568	D6H	V214"	V15+(V14-V15) X 1845 / 2949
97H	V151"	V14+(V13-V14) X 1683 / 2568	D7H	V215"	V15+(V14-V15) X 1788 / 2949
98H	V152"	V14+(V13-V14) X 1644 / 2568	D8H	V216"	V15+(V14-V15) X 1731 / 2949
99H	V153"	V14+(V13-V14) X 1605 / 2568	D9H	V217"	V15+(V14-V15) X 1674 / 2949
9AH	V154"	V14+(V13-V14) X 1566 / 2568	DAH	V218"	V15+(V14-V15) X 1614 / 2949
9BH	V155"	V14+(V13-V14) X 1527 / 2568	DBH	V219"	V15+(V14-V15) X 1554 / 2949
9CH	V156"	V14+(V13-V14) X 1488 / 2568	DCH	V220"	V15+(V14-V15) X 1494 / 2949
9DH	V157"	V14+(V13-V14) X 1449 / 2568	DDH	V221"	V15+(V14-V15) X 1431 / 2949
9EH	V158"	V14+(V13-V14) X 1410 / 2568	DEH	V222"	V15+(V14-V15) X 1368 / 2949
9FH	V159"	V14+(V13-V14) X 1371 / 2568	DFH	V223"	V15+(V14-V15) X 1305 / 2949
A0H	V160"	V14+(V13-V14) X 1332 / 2568	E0H	V224"	V15+(V14-V15) X 1239 / 2949
A1H	V161"	V14+(V13-V14) X 1293 / 2568	E1H	V225"	V15+(V14-V15) X 1173 / 2949
A2H	V162"	V14+(V13-V14) X 1254 / 2568	E2H	V226"	V15+(V14-V15) X 1107 / 2949
A3H	V163"	V14+(V13-V14) X 1215 / 2568	E3H	V227"	V15+(V14-V15) X 1038 / 2949
A4H	V164"	V14+(V13-V14) X 1176 / 2568	E4H	V228"	V15+(V14-V15) X 969 / 2949
A5H	V165"	V14+(V13-V14) X 1137 / 2568	E5H	V229"	V15+(V14-V15) X 897 / 2949
A6H	V166"	V14+(V13-V14) X 1098 / 2568	E6H	V230"	V15+(V14-V15) X 825 / 2949
A7H	V167"	V14+(V13-V14) X 1059 / 2568	E7H	V231"	V15+(V14-V15) X 750 / 2949
A8H	V168"	V14+(V13-V14) X 1020 / 2568	E8H	V232"	V15+(V14-V15) X 675 / 2949
A9H	V169"	V14+(V13-V14) X 981 / 2568	E9H	V233"	V15+(V14-V15) X 597 / 2949
AAH	V170"	V14+(V13-V14) X 942 / 2568	EAH	V234"	V15+(V14-V15) X 519 / 2949
ABH	V171"	V14+(V13-V14) X 903 / 2568	EBH	V235"	V15+(V14-V15) X 438 / 2949
ACH	V172"	V14+(V13-V14) X 861 / 2568	ECH	V236"	V15+(V14-V15) X 354 / 2949
ADH	V173"	V14+(V13-V14) X 819 / 2568	EDH	V237"	V15+(V14-V15) X 270 / 2949
AEH	V174"	V14+(V13-V14) X 777 / 2568	EEH	V238"	V15+(V14-V15) X 183 / 2949
AFH	V175"	V14+(V13-V14) X 735 / 2568	EFH	V239"	V15+(V14-V15) X 93 / 2949
B0H	V176"	V14+(V13-V14) X 693 / 2568	F0H	V240"	V15
B1H	V177"	V14+(V13-V14) X 651 / 2568	F1H	V241"	V16+(V15-V16) X 1689 / 1785
B2H	V178"	V14+(V13-V14) X 609 / 2568	F2H	V242"	V16+(V15-V16) X 1590 / 1785
B3H	V179"	V14+(V13-V14) X 567 / 2568	F3H	V243"	V16+(V15-V16) X 1488 / 1785
B4H	V180"	V14+(V13-V14) X 525 / 2568	F4H	V244"	V16+(V15-V16) X 1383 / 1785
B5H	V181"	V14+(V13-V14) X 483 / 2568	F5H	V245"	V16+(V15-V16) X 1275 / 1785
B6H	V182"	V14+(V13-V14) X 441 / 2568	F6H	V246"	V16+(V15-V16) X 1161 / 1785
B7H	V183"	V14+(V13-V14) X 399 / 2568	F7H	V247"	V16+(V15-V16) X 1041 / 1785
B8H	V184"	V14+(V13-V14) X 357 / 2568	F8H	V248"	V16+(V15-V16) X 918 / 1785
B9H	V185"	V14+(V13-V14) X 315 / 2568	F9H	V249"	V16+(V15-V16) X 789 / 1785
BAH	V186"	V14+(V13-V14) X 270 / 2568	FAH	V250"	V16+(V15-V16) X 651 / 1785
BBH	V187"	V14+(V13-V14) X 225 / 2568	FBH	V251"	V16+(V15-V16) X 504 / 1785
BCH	V188"	V14+(V13-V14) X 180 / 2568	FCH	V252"	V16+(V15-V16) X 348 / 1785
BDH	V189"	V14+(V13-V14) X 135 / 2568	FDH	V253"	V16+(V15-V16) X 180 / 1785
BEH	V190"	V14+(V13-V14) X 90 / 2568	FEH	V254"	V16
BFH	V191"	V14+(V13-V14) X 45 / 2568	FFH	V255"	V17

5. 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_{479}	S_{480}
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_{479}	S_{480}
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_{12n}, S_{12n-3}, S_{12n-4}, S_{12n-7}, S_{12n-8}, S_{12n-11} **Note**	S_{12n-1}, S_{12n-2}, S_{12n-5}, S_{12n-6}, S_{12n-9}, S_{12n-10} **Note**
L	V_0 to V_8	V_9 to V_{17}
H	V_9 to V_{17}	V_0 to V_8

Note n = 1, 2, ..., 80

Figure 5–1. Relationship between POL and Output

POL	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	S_{10}	S_{11}	S_{12}	...	S_{477}	S_{478}	S_{479}	S_{480}
L	+	–	–	+	+	–	–	+	+	–	–	+	...	+	–	–	+
L	+	–	–	+	+	–	–	+	+	–	–	+	...	+	–	–	+
H	–	+	+	–	–	+	+	–	–	+	+	–	...	–	+	+	–
H	–	+	+	–	–	+	+	–	–	+	+	–	...	–	+	+	–
L	+	–	–	+	+	–	–	+	+	–	–	+	...	+	–	–	+
L	+	–	–	+	+	–	–	+	+	–	–	+	...	+	–	–	+
H	–	+	+	–	–	+	+	–	–	+	+	–	...	–	+	+	–
H	–	+	+	–	–	+	+	–	–	+	+	–	...	–	+	+	–

6. RELATIONSHIP BETWEEN MODE1, SRC1 AND SRC2

The μPD16724's IC can control the slew rate of output amplifier.

High slew rate period can be chosen from "control from the IC outside", or "forming inside the IC" with MODE2 pin.

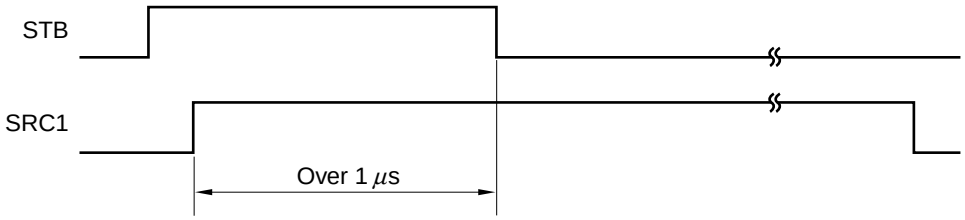
(1) MODE2 = H

SRC1 pin is good and can control a high slew rate period from the outside.

SRC1 = H: High slew rate period

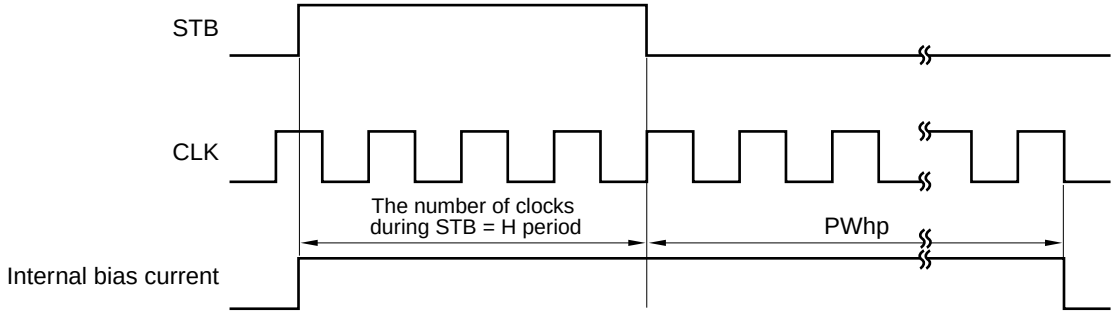
SRC1 = L: Low slew rate period

We recommend setting as "SRC1 = H" from 1 μs or more before STB falling.



(2) MODE2 = L or open

SRC2 pin is good and forms high slew rate period inside the IC.



In this mode, clock stop is prohibition during the STB = H.

SRC2, the CLK number in STB = H period, and the relation of high slew rate period are as follows.

The number of clocks during STB = H period	PWhp (the number of clocks)	
	SRC2 = H	SRC2 = L or open
2 to 15	16	32
16 to 31	32	64
32 to 47	48	96
48 to 63	64	128
64 to 79	80	160
80 to 95	96	192
96 to 111	112	224
from 112	128	256

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

MODE1 = H or open:

When it switches such as POL = H→L or L→H, all output pins are output reset during STB = H and synchronizing with falling of STB, gray-scale voltage is output to LCD. When it does not switch, all output pins become Hi-Z during STB = H.

MODE1 = L:

Regardless of POL changing, all output is Hi-Z during the STB = H and synchronizing with falling of STB, gray-scale voltage is outputted to LCD.

Figure 7–1. MODE1 = H or open

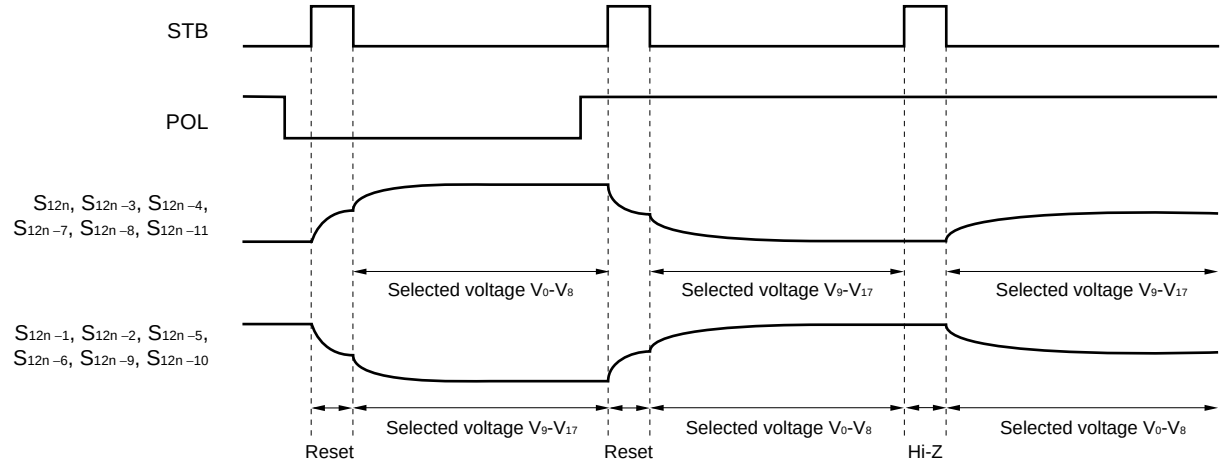
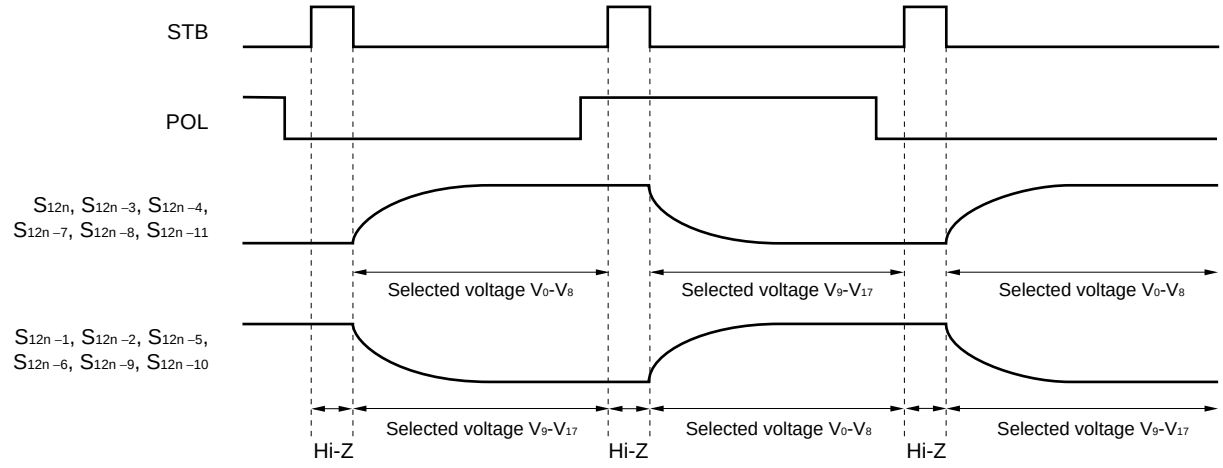


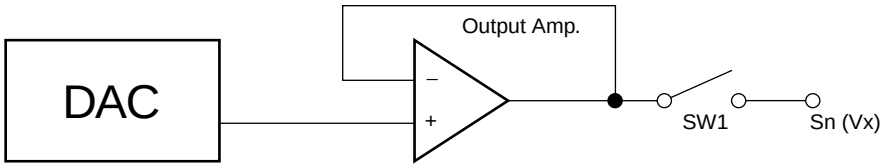
Figure 7–2. MODE1 = L



8. RELATIONSHIP BETWEEN STB, CLK, AND OUTPUT WAVEFORM (MODE1 = L)

At the time of MODE1 = L, synchronizing with the falling edge of STB, it is begun to output gray-scale voltage.

Figure 8–1. Output Circuit Block Diagram

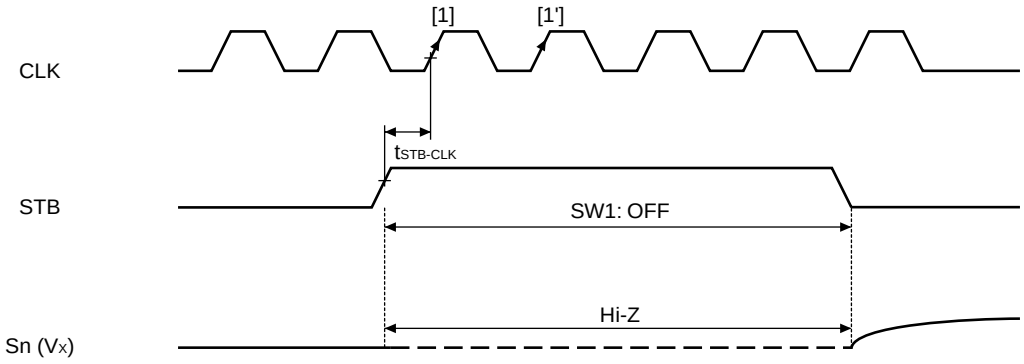


SW1 switches according to the level of STB.

STB = L: SW1 = ON

STB = H: SW1 = OFF

Figure 8–2. Output Circuit Timing Waveform



STB = H is loaded with the rising edge of CLK [1]. However, when not satisfying the specification of $t_{STB-CLK}$, STB = H is loaded with the rising edge of the next CLK [1']. Latch operation of display data is completed with the falling edge of the next CLK which loaded STB= H. Therefore, in order to complete latch operation of display data, it is necessary to input at least 2 CLK in STB = H period. In MORE2 = L or open, please input the CLK number according to the high slew period.

★ 9. CURRENT CONSUMPTION REDUCTION FUNCTION

The μPD16724 has a low power control function (LPC) which can switch the bias current of the output amplifier between two levels.

<Low power control function (LPC)>

The bias current of the output amplifier can be switched between two levels using this pin.

LPC = H or open: Normal power mode

LPC = L: Low power mode

The V_{DD2} of static current consumption can be reduced to two thirds of that in normal mode (LPC = H or open). Input a stable DC current (V_{DD1}/V_{SS1}) to this pin.

Caution Because the low-power control function controls the bias current in the output amplifier and regulate the over-all current consumption of the driver IC, when this occurs, the characteristics of the output amplifier will simultaneously change. Therefore, when using this function, be sure to sufficiently evaluate the picture quality.

10. 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}		2.3	3.3	3.6	V
Driver part supply voltage	V_{DD2}	LPC = H or open	12.0		(13.0)	V
		LPC = L	(13.0)		15.0	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_8		0.5 V_{DD2} + 0.5		V_{DD2} – 0.2	V
	V_9-V_{17}		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}	2.3 V ≤ V_{DD1} < 3.0 V			50	MHz
		3.0 V ≤ V_{DD1} ≤ 3.6 V			55	MHz

Remark The value enclosed in parentheses is a reference value.

Electrical Characteristics (T_A = –10 to +75°C, V_{DD1} = 2.3 to 3.6 V, V_{DD2} = 12.0 to 15.0 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
Pull-up/pull-down resistance	R_{PU}	V_{DD1} = 3.3 V, MODE1, MODE2, SRC1, SRC2, LPC	80	200	500	kΩ
γ-corrected resistance	R_γ	T_A = 25°C, V_{DD2} = 15.0 V, V_0 to V_8 = V_9 to V_{17} = 7.0 V	7.9	15.8	31.6	kΩ
Driver output current	I_{VOH}	V_X = 11.0 V, V_{OUT} = 10.0 V Note1			–40	mA
	I_{VOL}	V_X = 1.0 V, V_{OUT} = 2.0 V Note1	40			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_{DD2} = 15.0 V, T_A = 25°C; V_X = 7.0 to 8.0 V Note1		±5	±10	mV
	ΔV_{P-P2}	V_X = 4.0 to 11.0 V Note1		±7	±15	mV
	ΔV_{P-P3}	V_X = 1.0 to 14.0 V Note1		±10	±20	mV
Logic part dynamic current consumption	I_{DD1}	V_{DD1} Note2		1.0	15.0	mA
Driver part dynamic current consumption	I_{DD2}	V_{DD2}, with no load Note2		12.5	40.0	mA

Notes 1. V_X refers to the output voltage of analog output pins S_1 to S_{480}.

V_{OUT} refers to the voltage applied to analog output pins S_1 to S_{480}

2. f_{STB} = 77 kHz, f_{CLK} = 40 MHz

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.

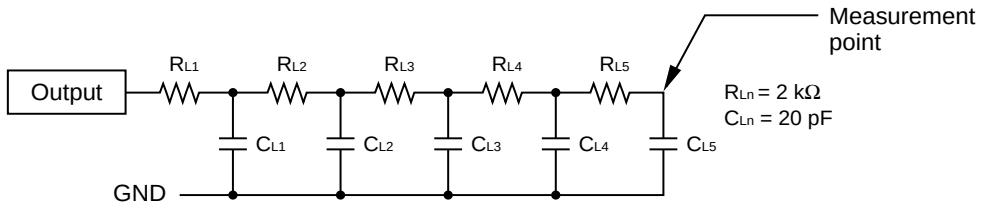
Switching Characteristics (T_A = –10 to +75°C, V_{DD1} = 2.3 to 3.6 V, V_{DD2} = 12.0 to 15.0 V, V_{SS1} = V_{SS2} = 0 V)

Parameter	Symbol	Condition	MIN.	TYP.	MAX.	Unit
Start pulse delay time	t_{PLH1}	C_L = 15 pF, 2.3 V ≤ V_{DD1} < 3.0 V			15	ns
		C_L = 15 pF, 3.0 V ≤ V_{DD1} ≤ 3.6 V			12	ns
Driver output delay time	t_{PLH2} Note	V_{DD2} = 15.0 V, T_A = 25°C, 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% (condition: V_O = 0.2 V ↔14.8 V)

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 ↔13.0 V)

★ **<Test Condition>**



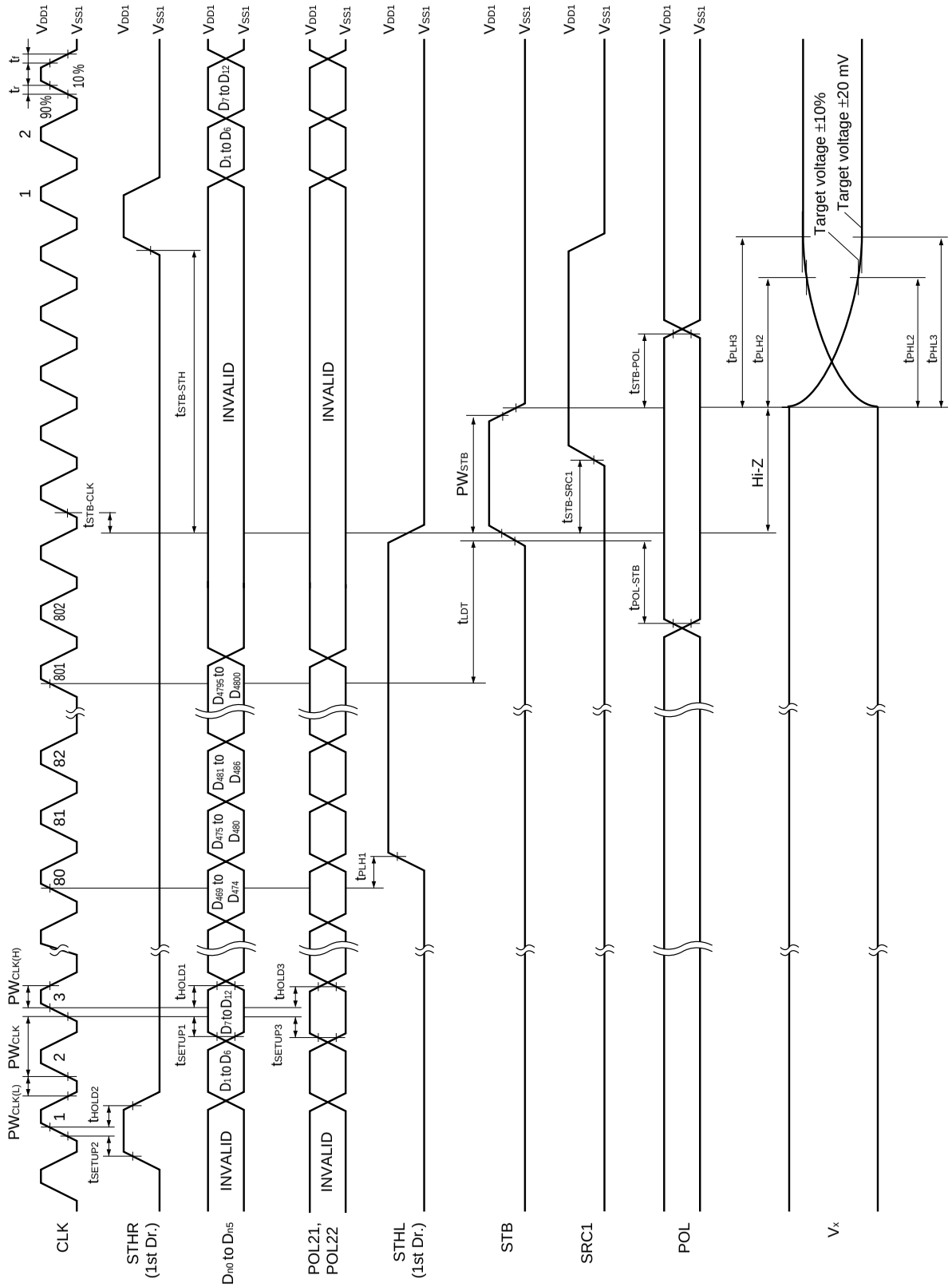
Timing Requirements (T_A = −10 to +75°C, V_{DD1} = 2.3 to 3.6 V, V_{SS1} = 0 V, $t_r = t_f$ = 5.0 ns)

Parameter	Symbol	Condition	MIN.	TYP.	MAX.	Unit
Clock pulse width	PW_{CLK}	2.3 V ≤ V_{DD1} < 3.0 V	20			ns
		3.0 V ≤ V_{DD1} ≤ 3.6 V	17			ns
Clock pulse high period	$PW_{CLK(H)}$	2.3 V ≤ V_{DD1} < 3.0 V	5			ns
		3.0 V ≤ V_{DD1} ≤ 3.6 V	3			ns
Clock pulse low period	$PW_{CLK(L)}$	2.3 V ≤ V_{DD1} < 3.0 V	5			ns
		3.0 V ≤ V_{DD1} ≤ 3.6 V	3			ns
Data setup time	t_{SETUP1}		0			ns
Data hold time	t_{HOLD1}		3			ns
Start pulse setup time	t_{SETUP2}		0			ns
Start pulse hold time	t_{HOLD2}		3			ns
POL21, POL22 setup time	t_{SETUP3}		0			ns
POL21, POL22 hold time	t_{HOLD3}		3			ns
STB pulse width	PW_{STB}		1.0			μs
			2			CLK
Last data timing	t_{LDT}		2			CLK
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	$t_{STB-SRC1}$	STB ↑ → SRC1 ↑	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 (R,/L= H, MODE1 = L, MODE2 = H)

Unless otherwise specified, V_{IH}, V_{IL} are defined to be V_{IH} = 0.7 V_{DD1}, V_{IL} = 0.3 V_{DD1}.



★ 11. RECOMMENDED MOUNTING CONDITIONS

The following conditions must be met for mounting conditions of the μPD16724.

For more details, refer to the **Semiconductor Device Mount Manual (http://www.necel.com/pkg/en/mount/index.html).**

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

μPD16724N-xxx: TCP (TAB Package)

Mounting Condition	Mounting Method	Condition
Thermocompression	Soldering	Heating tool 300 to 350°C, heating for 2 to 3 sec, pressure 100 g (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)

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

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