NEC

MOS INTEGRATED CIRCUIT

μPD16770

420-OUTPUT TFT-LCD SOURCE DRIVER (COMPATIBLE WITH 64-GRAY SCALES)

DESCRIPTION

The μPD16770 is a source driver for TFT-LCDs capable of dealing with displays with 64-gray scales. Data input is based on digital input configured as 6 bits by 6 dots (2 pixels), which can realize a full-color display of 260,000 colors by output of 64 values γ-corrected by an internal D/A converter and 5-by-2 external power modules.

Because the output dynamic range is as large as V_{SS2} + 0.1 V to V_{DD2} – 0.1 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 6-bit D/A converter circuit whose odd output pins and even output pins respectively output gray scale voltages of differing polarity. Assuring a clock frequency of 45 MHz when driving at 2.3 V, this driver is applicable to SXGA+ standard TFT-LCD panels.

FEATURES

- CMOS level input (2.3 to 3.6 V)
- 420 Outputs
- Input of 6 bits (gray scale data) by 6 dots
- Capable of outputting 64 values by means of 5-by-2 external power modules (10 units) and a D/A converter
- Logic power supply voltage (V_{DD1}): 2.3 to 3.6 V
- Driver power supply voltage (V_{DD2}): 8.5 V ± 0.5 V
- High-speed data transfer: f_{CLK} = 45 MHz (internal data transfer speed when operating at V_{DD1} = 2.3 V)
- Output dynamic range V_{SS2} + 0.1 V to V_{DD2} – 0.1 V
- Apply for dot-line inversion, n-line inversion and column line inversion
- Output Voltage polarity inversion function (POL)
- Display data inversion function (Capable of controlling by each input port) (POL21, POL22)
- ★ • Current consumption control function (LPC, HPC, Bcont)
- Slim chip

ORDERING INFORMATION

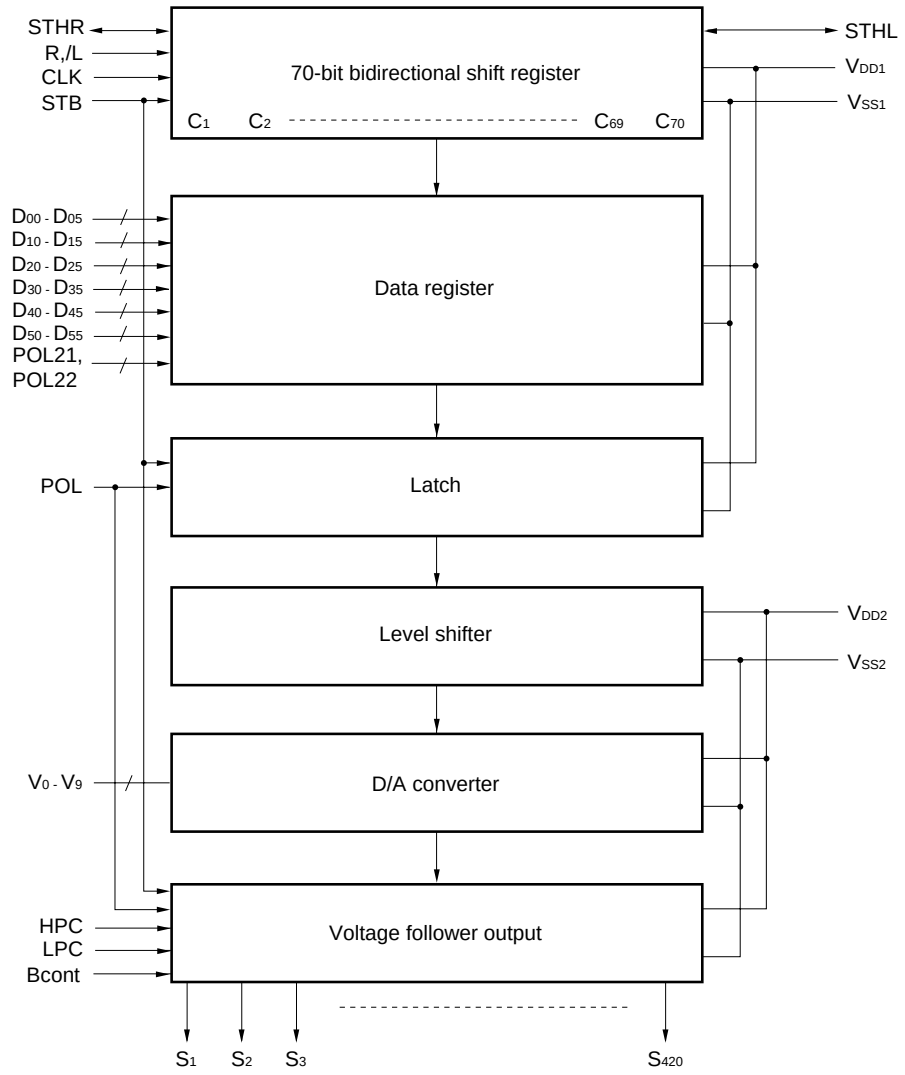
Part Number	Package
μPD16770N -×××	TCP (TAB package)

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

Document No. S14413EJ1V1DS00 (1st edition)
Date Published June 2001 NS CP(K)
Printed in Japan

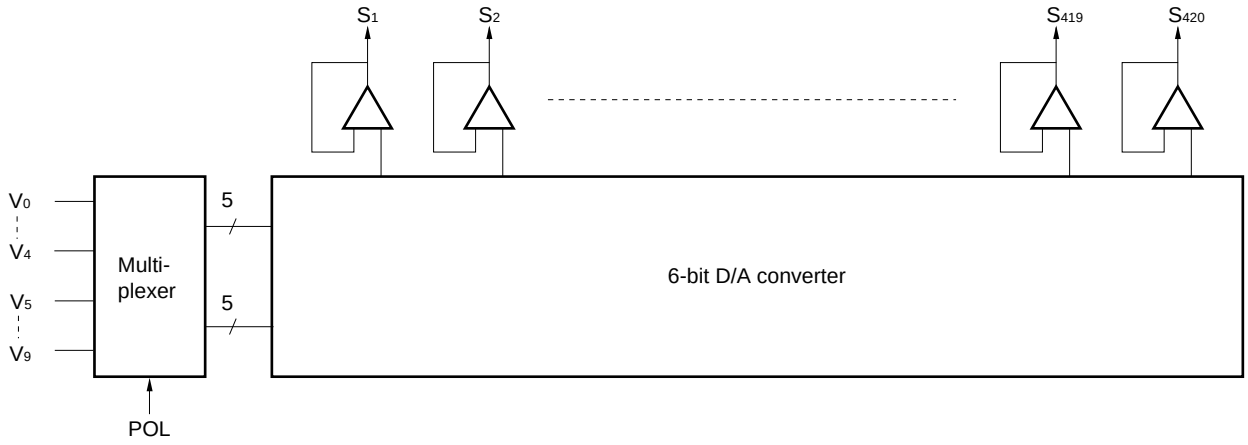
The mark ★ shows major revised points.

1. BLOCK DIAGRAM

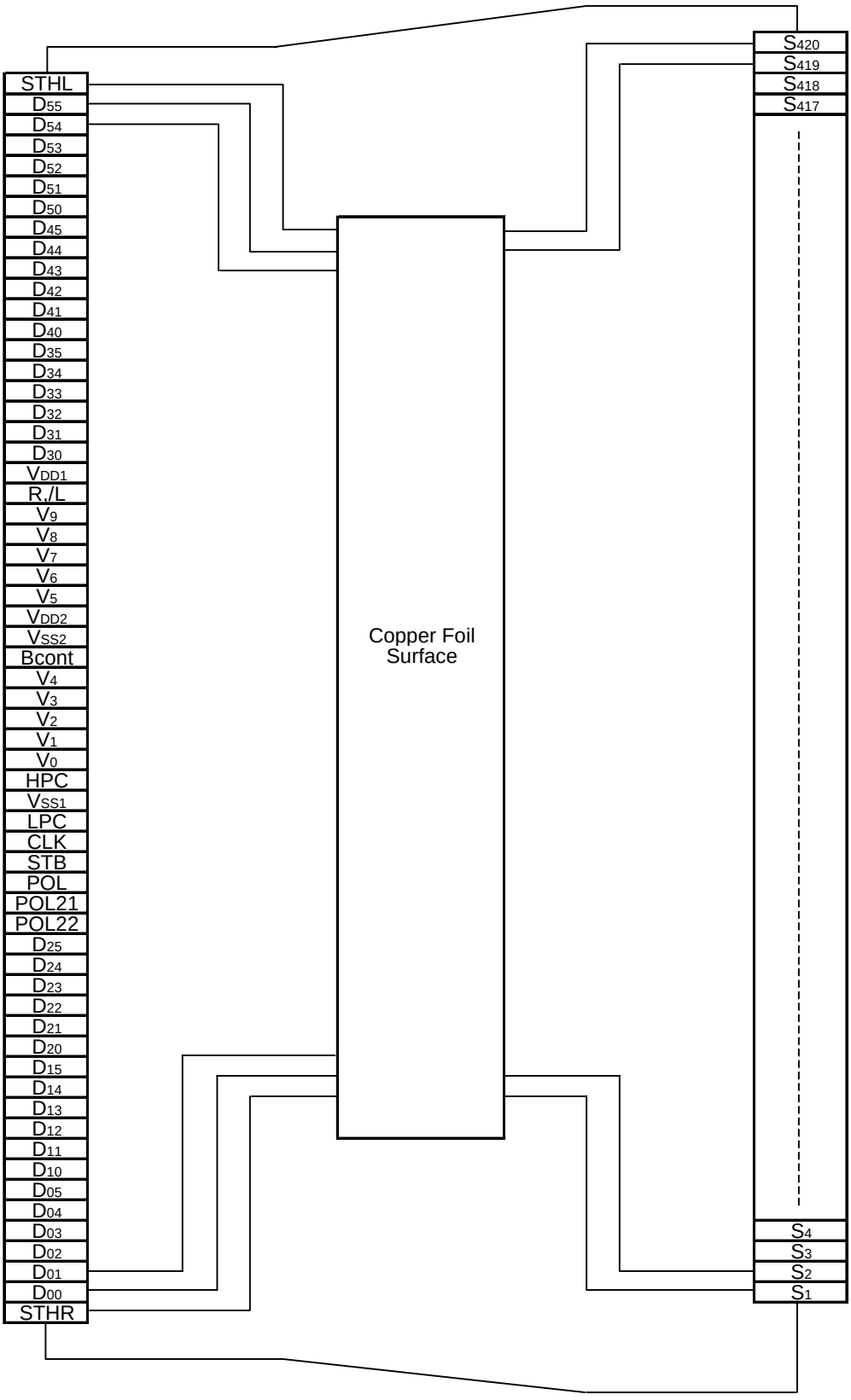


Remark /xxx indicates active low signal.

2. RELATIONSHIP BETWEEN OUTPUT CIRCUIT AND D/A CONVERTER



3. PIN CONFIGURATION (μPD16770N-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_{420}	Driver	O	The D/A converted 64-gray-scale analog voltage is output.
	D_{00} to D_{05}	Display data	I	The display data is input with a width of 36 bits, viz., the gray scale data (6 bits) by 6 dots (2 pixels). D_{X0}: LSB, D_{X5}: MSB
	D_{10} to D_{15}			
	D_{20} to D_{25}			
	D_{30} to D_{35}			
	D_{40} to D_{45}			
	D_{50} to D_{55}			
	R,/L	Shift direction control	I	Refers to the shift direction control. The shift directions of the shift registers are as follows. R,/L = H: STHR input, $S_1 \rightarrow S_{420}$, STHL output R,/L = L: STHL input, $S_{420} \rightarrow S_1$, STHR output
★	STHR	Right shift start pulse	I/O	These refer to the start pulse I/O pins when driver ICs are connected in cascade. Loading of display data starts when H is read at the rising edge of CLK. R,/L = H (right shift): STHR input, STHL output R,/L = L (left shift): STHL input, STHR output The start pulse width (H level) for next-level drivers is 1CLK.
★	STHL	Left shift start pulse	I/O	
★	CLK	Shift clock	I	Refers to the shift register's shift clock input. The display data is loaded into the data register at the rising edge. At the rising edge of the 70th clock after the start pulse input, the start pulse output reaches the high level, thus becoming the start pulse of the next-level driver. If 72-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	I	The contents of the data register are transferred to the latch circuit at the rising edge. And, 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.
	POL	Polarity	I	POL = L: The S_{2n-1} output uses V_0 to V_4 as the reference supply. The S_{2n} output uses V_5 to V_9 as the reference supply. POL = H: The S_{2n-1} output uses V_5 to V_9 as the reference supply. The S_{2n} output uses V_0 to V_4 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.
★	POL21, POL22	Data inversion	I	Data inversion can invert when display data is loaded. POL21: Invert/not invert of display data D_{00} to D_{05}, D_{10} to D_{15}, D_{20} to D_{25}. POL22: Invert/not invert of display data D_{30} to D_{35}, D_{40} to D_{45}, D_{50} to D_{55}. POL21, POL22 = H : Display data is inverted. POL21, POL22 = L : Display data is not inverted.
	LPC	Low power control	I	Controls the write function of the driver section by digitally controlling the bypass current of the output amplifier. This pin is pulled up to the V_{DD1} power supply inside the IC. Refer to **9. BIAS CURRENT CONTROL PIN.**
	HPC	High power control	I	

(2/2)

Pin Symbol	Pin Name	I/O	Description
Bcont	Bias control	I	This pin can be used to finely control the bias current inside the output amplifier. When this fine-control function is not required, leave this pin open. Refer to **9. BIAS CURRENT CONTROL PIN.**
V_0 to V_9	γ-corrected power supplies	–	Input the γ-corrected power supplies from outside by using operational amplifier. Make sure to maintain the following relationships. During the gray scale voltage output, be sure to keep the gray scale level power supply at a constant level. $V_{DD2} - 0.1\ V \geq V_0 > V_1 > V_2 > V_3 > V_4 > 0.5\ V_{DD2} > V_5 > V_6 > V_7 > V_8 > V_9 \geq V_{SS2} + 0.1\ V$
V_{DD1}	Logic power supply	–	2.3 to 3.6 V
V_{DD2}	Driver power supply	–	8.5 V ± 0.5 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 to V_9 in that order. Reverse this sequence to shut down.

2. To stabilize the supply voltage, please be sure to insert a 0.1 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 0.01 μF is also advised between the γ-corrected power supply terminals (V_0, V_1, V_2, ···, V_9) and V_{SS2}.

5. RELATIONSHIP BETWEEN INPUT DATA AND OUTPUT VOLTAGE VALUE

This product incorporates a 6-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 (common electrode) voltage. The D/A converter consists of ladder resistors and switches.

The ladder resistors (r0 to r62) are designed so that the ratio of LCD panel γ-compensated voltages to V_0' to V_{63}' and V_0" to V_{63}" is almost equivalent. For the 2 sets of five γ-compensated power supplies, V_0 to V_4 and V_5 to V_9, respectively, input gray scale voltages of the same polarity with respect to the common voltage. When fine gray scale voltage precision is not necessary, there is no need to connect a voltage follower circuit to the γ-compensated power supplies V_1 to V_3 and V_6 to V_8.

Figure 5-1 shows the relationship between the driving voltages such as liquid-crystal driving voltages V_{DD2} and V_{SS2}, common electrode potential V_{COM}, and γ-corrected voltages V_0 to V_9 and the input data.

Be sure to maintain the voltage relationships as follows:

$V_{DD2} - 0.1\ V \geq V_0 > V_1 > V_2 > V_3 > V_4 > 0.5\ V_{DD2} > V_5 > V_6 > V_7 > V_8 > V_9 \geq V_{SS2} + 0.1\ V$.

Figures 5–2 and 5–3 show the relationship between the input data and the output data and the resistance values of the resistor strings.

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

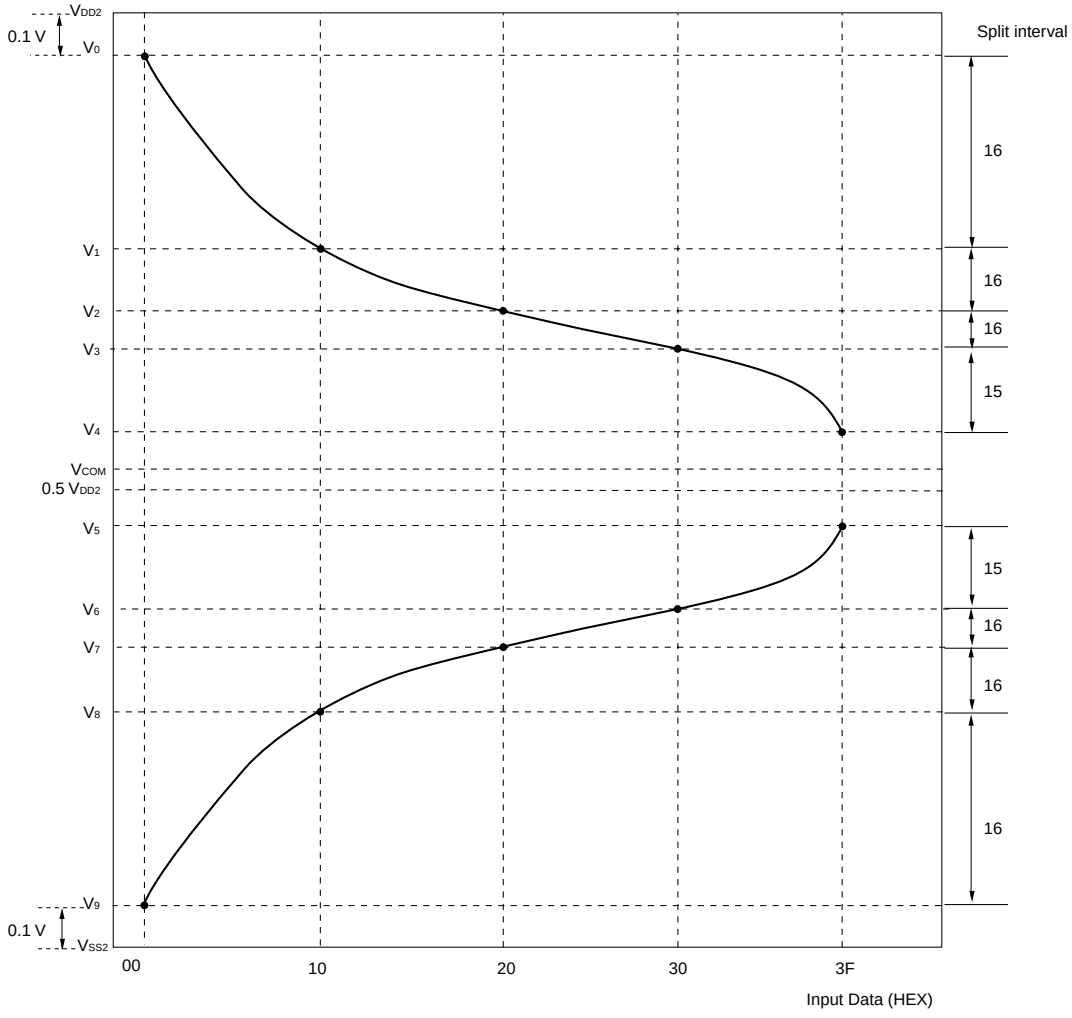
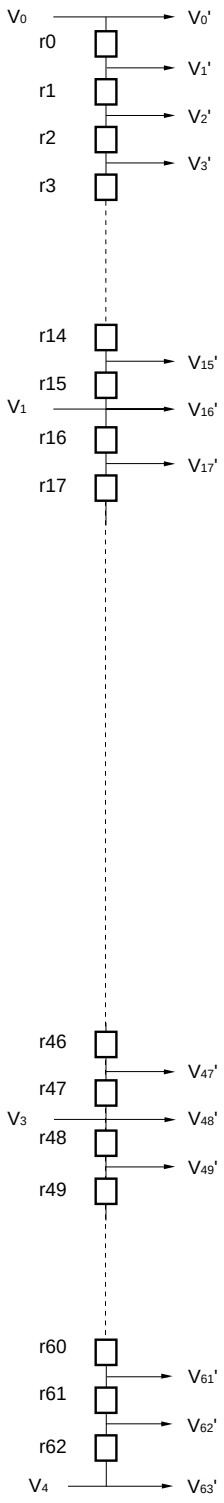


Figure 5–2. Relationship between Input Data and Output voltage

V_{DD2} – 0.1 V ≥ V_0 > V_1 > V_2 > V_3 > V_4 ≥ 0.5 V_{DD2}, POL21, POL22 = L

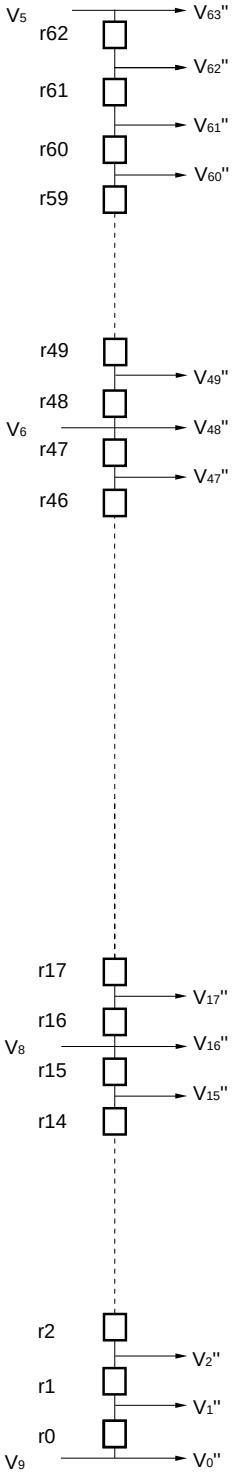


DATA	D_{X5}	D_{X4}	D_{X3}	D_{X2}	D_{X1}	D_{X0}	Output Voltage				r n(Ω)	
00H	0	0	0	0	0	0	V_0'	V_0			r0	800
01H	0	0	0	0	0	1	V_1'	$V_1+(V_0-V_1)\times$	7250 /	8050	r1	750
02H	0	0	0	0	1	0	V_2'	$V_1+(V_0-V_1)\times$	6500 /	8050	r2	700
03H	0	0	0	0	1	1	V_3'	$V_1+(V_0-V_1)\times$	5800 /	8050	r3	650
04H	0	0	0	1	0	0	V_4'	$V_1+(V_0-V_1)\times$	5150 /	8050	r4	600
05H	0	0	0	1	0	1	V_5'	$V_1+(V_0-V_1)\times$	4550 /	8050	r5	550
06H	0	0	0	1	1	0	V_6'	$V_1+(V_0-V_1)\times$	4000 /	8050	r6	550
07H	0	0	0	1	1	1	V_7'	$V_1+(V_0-V_1)\times$	3450 /	8050	r7	500
08H	0	0	1	0	0	0	V_8'	$V_1+(V_0-V_1)\times$	2950 /	8050	r8	500
09H	0	0	1	0	0	1	V_9'	$V_1+(V_0-V_1)\times$	2450 /	8050	r9	400
0AH	0	0	1	0	1	0	V_{10}'	$V_1+(V_0-V_1)\times$	2050 /	8050	r10	400
0BH	0	0	1	0	1	1	V_{11}'	$V_1+(V_0-V_1)\times$	1650 /	8050	r11	350
0CH	0	0	1	1	0	0	V_{12}'	$V_1+(V_0-V_1)\times$	1300 /	8050	r12	350
0DH	0	0	1	1	0	1	V_{13}'	$V_1+(V_0-V_1)\times$	950 /	8050	r13	350
0EH	0	0	1	1	1	0	V_{14}'	$V_1+(V_0-V_1)\times$	600 /	8050	r14	300
0FH	0	0	1	1	1	1	V_{15}'	$V_1+(V_0-V_1)\times$	300 /	8050	r15	300
10H	0	1	0	0	0	0	V_{16}'	V_1			r16	300
11H	0	1	0	0	0	1	V_{17}'	$V_2+(V_1-V_2)\times$	2450 /	2750	r17	250
12H	0	1	0	0	1	0	V_{18}'	$V_2+(V_1-V_2)\times$	2200 /	2750	r18	250
13H	0	1	0	0	1	1	V_{19}'	$V_2+(V_1-V_2)\times$	1950 /	2750	r19	250
14H	0	1	0	1	0	0	V_{20}'	$V_2+(V_1-V_2)\times$	1700 /	2750	r20	200
15H	0	1	0	1	0	1	V_{21}'	$V_2+(V_1-V_2)\times$	1500 /	2750	r21	200
16H	0	1	0	1	1	0	V_{22}'	$V_2+(V_1-V_2)\times$	1300 /	2750	r22	200
17H	0	1	0	1	1	1	V_{23}'	$V_2+(V_1-V_2)\times$	1100 /	2750	r23	150
18H	0	1	1	0	0	0	V_{24}'	$V_2+(V_1-V_2)\times$	950 /	2750	r24	150
19H	0	1	1	0	0	1	V_{25}'	$V_2+(V_1-V_2)\times$	800 /	2750	r25	150
1AH	0	1	1	0	1	0	V_{26}'	$V_2+(V_1-V_2)\times$	650 /	2750	r26	150
1BH	0	1	1	0	1	1	V_{27}'	$V_2+(V_1-V_2)\times$	500 /	2750	r27	100
1CH	0	1	1	1	0	0	V_{28}'	$V_2+(V_1-V_2)\times$	400 /	2750	r28	100
1DH	0	1	1	1	0	1	V_{29}'	$V_2+(V_1-V_2)\times$	300 /	2750	r29	100
1EH	0	1	1	1	1	0	V_{30}'	$V_2+(V_1-V_2)\times$	200 /	2750	r30	100
1FH	0	1	1	1	1	1	V_{31}'	$V_2+(V_1-V_2)\times$	100 /	2750	r31	100
20H	1	0	0	0	0	0	V_{32}'	V_2			r32	100
21H	1	0	0	0	0	1	V_{33}'	$V_3+(V_2-V_3)\times$	1500 /	1600	r33	100
22H	1	0	0	0	1	0	V_{34}'	$V_3+(V_2-V_3)\times$	1400 /	1600	r34	100
23H	1	0	0	0	1	1	V_{35}'	$V_3+(V_2-V_3)\times$	1300 /	1600	r35	100
24H	1	0	0	1	0	0	V_{36}'	$V_3+(V_2-V_3)\times$	1200 /	1600	r36	100
25H	1	0	0	1	0	1	V_{37}'	$V_3+(V_2-V_3)\times$	1100 /	1600	r37	100
26H	1	0	0	1	1	0	V_{38}'	$V_3+(V_2-V_3)\times$	1000 /	1600	r38	100
27H	1	0	0	1	1	1	V_{39}'	$V_3+(V_2-V_3)\times$	900 /	1600	r39	100
28H	1	0	1	0	0	0	V_{40}'	$V_3+(V_2-V_3)\times$	800 /	1600	r40	100
29H	1	0	1	0	0	1	V_{41}'	$V_3+(V_2-V_3)\times$	700 /	1600	r41	100
2AH	1	0	1	0	1	0	V_{42}'	$V_3+(V_2-V_3)\times$	600 /	1600	r42	100
2BH	1	0	1	0	1	1	V_{43}'	$V_3+(V_2-V_3)\times$	500 /	1600	r43	100
2CH	1	0	1	1	0	0	V_{44}'	$V_3+(V_2-V_3)\times$	400 /	1600	r44	100
2DH	1	0	1	1	0	1	V_{45}'	$V_3+(V_2-V_3)\times$	300 /	1600	r45	100
2EH	1	0	1	1	1	0	V_{46}'	$V_3+(V_2-V_3)\times$	200 /	1600	r46	100
2FH	1	0	1	1	1	1	V_{47}'	$V_3+(V_2-V_3)\times$	100 /	1600	r47	100
30H	1	1	0	0	0	0	V_{48}'	V_3			r48	100
31H	1	1	0	0	0	1	V_{49}'	$V_4+(V_3-V_4)\times$	3350 /	3450	r49	100
32H	1	1	0	0	1	0	V_{50}'	$V_4+(V_3-V_4)\times$	3250 /	3450	r50	100
33H	1	1	0	0	1	1	V_{51}'	$V_4+(V_3-V_4)\times$	3150 /	3450	r51	100
34H	1	1	0	1	0	0	V_{52}'	$V_4+(V_3-V_4)\times$	3050 /	3450	r52	100
35H	1	1	0	1	0	1	V_{53}'	$V_4+(V_3-V_4)\times$	2950 /	3450	r53	150
36H	1	1	0	1	1	0	V_{54}'	$V_4+(V_3-V_4)\times$	2800 /	3450	r54	150
37H	1	1	0	1	1	1	V_{55}'	$V_4+(V_3-V_4)\times$	2650 /	3450	r55	150
38H	1	1	1	0	0	0	V_{56}'	$V_4+(V_3-V_4)\times$	2500 /	3450	r56	200
39H	1	1	1	0	0	1	V_{57}'	$V_4+(V_3-V_4)\times$	2300 /	3450	r57	200
3AH	1	1	1	0	1	0	V_{58}'	$V_4+(V_3-V_4)\times$	2100 /	3450	r58	250
3BH	1	1	1	0	1	1	V_{59}'	$V_4+(V_3-V_4)\times$	1850 /	3450	r59	250
3CH	1	1	1	1	0	0	V_{60}'	$V_4+(V_3-V_4)\times$	1600 /	3450	r60	300
3DH	1	1	1	1	0	1	V_{61}'	$V_4+(V_3-V_4)\times$	1300 /	3450	r61	500
3EH	1	1	1	1	1	0	V_{62}'	$V_4+(V_3-V_4)\times$	800 /	3450	r62	800
3FH	1	1	1	1	1	1	V_{63}'	V_4			rtotal	15850

Caution There is no connection between V_4 and V_5 terminal in the chip.

Figure 5–3. Relationship between Input Data and Output voltage

0.5 V_{DD2} ≥V_4 > V_5 > V_6 > V_7 > V_8 > V_9 ≥ V_{SS2} + 0.1 V, POL21, POL22 = L



DATA	D_{X5}	D_{X4}	D_{X3}	D_{X2}	D_{X1}	D_{X0}	Output Voltage				rn	(Ω)
00H	0	0	0	0	0	0	V_0"	V_9			r0	800
01H	0	0	0	0	0	1	V_1"	$V_9+(V_8-V_9)\times$	800 /	8050	r1	750
02H	0	0	0	0	1	0	V_2"	$V_9+(V_8-V_9)\times$	1550 /	8050	r2	700
03H	0	0	0	0	1	1	V_3"	$V_9+(V_8-V_9)\times$	2250 /	8050	r3	650
04H	0	0	0	1	0	0	V_4"	$V_9+(V_8-V_9)\times$	2900 /	8050	r4	600
05H	0	0	0	1	0	1	V_5"	$V_9+(V_8-V_9)\times$	3500 /	8050	r5	550
06H	0	0	0	1	1	0	V_6"	$V_9+(V_8-V_9)\times$	4050 /	8050	r6	550
07H	0	0	0	1	1	1	V_7"	$V_9+(V_8-V_9)\times$	4600 /	8050	r7	500
08H	0	0	1	0	0	0	V_8"	$V_9+(V_8-V_9)\times$	5100 /	8050	r8	500
09H	0	0	1	0	0	1	V_9"	$V_9+(V_8-V_9)\times$	5600 /	8050	r9	400
0AH	0	0	1	0	1	0	V_{10}"	$V_9+(V_8-V_9)\times$	6000 /	8050	r10	400
0BH	0	0	1	0	1	1	V_{11}"	$V_9+(V_8-V_9)\times$	6400 /	8050	r11	350
0CH	0	0	1	1	0	0	V_{12}"	$V_9+(V_8-V_9)\times$	6750 /	8050	r12	350
0DH	0	0	1	1	0	1	V_{13}"	$V_9+(V_8-V_9)\times$	7100 /	8050	r13	350
0EH	0	0	1	1	1	0	V_{14}"	$V_9+(V_8-V_9)\times$	7450 /	8050	r14	300
0FH	0	0	1	1	1	1	V_{15}"	$V_9+(V_8-V_9)\times$	7750 /	8050	r15	300
10H	0	1	0	0	0	0	V_{16}"	V_8			r16	300
11H	0	1	0	0	0	1	V_{17}"	$V_8+(V_7-V_8)\times$	300 /	2750	r17	250
12H	0	1	0	0	1	0	V_{18}"	$V_8+(V_7-V_8)\times$	550 /	2750	r18	250
13H	0	1	0	0	1	1	V_{19}"	$V_8+(V_7-V_8)\times$	800 /	2750	r19	250
14H	0	1	0	1	0	0	V_{20}"	$V_8+(V_7-V_8)\times$	1050 /	2750	r20	200
15H	0	1	0	1	0	1	V_{21}"	$V_8+(V_7-V_8)\times$	1250 /	2750	r21	200
16H	0	1	0	1	1	0	V_{22}"	$V_8+(V_7-V_8)\times$	1450 /	2750	r22	200
17H	0	1	0	1	1	1	V_{23}"	$V_8+(V_7-V_8)\times$	1650 /	2750	r23	150
18H	0	1	1	0	0	0	V_{24}"	$V_8+(V_7-V_8)\times$	1800 /	2750	r24	150
19H	0	1	1	0	0	1	V_{25}"	$V_8+(V_7-V_8)\times$	1950 /	2750	r25	150
1AH	0	1	1	0	1	0	V_{26}"	$V_8+(V_7-V_8)\times$	2100 /	2750	r26	150
1BH	0	1	1	0	1	1	V_{27}"	$V_8+(V_7-V_8)\times$	2250 /	2750	r27	100
1CH	0	1	1	1	0	0	V_{28}"	$V_8+(V_7-V_8)\times$	2350 /	2750	r28	100
1DH	0	1	1	1	0	1	V_{29}"	$V_8+(V_7-V_8)\times$	2450 /	2750	r29	100
1EH	0	1	1	1	1	0	V_{30}"	$V_8+(V_7-V_8)\times$	2550 /	2750	r30	100
1FH	0	1	1	1	1	1	V_{31}"	$V_8+(V_7-V_8)\times$	2650 /	2750	r31	100
20H	1	0	0	0	0	0	V_{32}"	V_7			r32	100
21H	1	0	0	0	0	1	V_{33}"	$V_7+(V_6-V_7)\times$	100 /	1600	r33	100
22H	1	0	0	0	1	0	V_{34}"	$V_7+(V_6-V_7)\times$	200 /	1600	r34	100
23H	1	0	0	0	1	1	V_{35}"	$V_7+(V_6-V_7)\times$	300 /	1600	r35	100
24H	1	0	0	1	0	0	V_{36}"	$V_7+(V_6-V_7)\times$	400 /	1600	r36	100
25H	1	0	0	1	0	1	V_{37}"	$V_7+(V_6-V_7)\times$	500 /	1600	r37	100
26H	1	0	0	1	1	0	V_{38}"	$V_7+(V_6-V_7)\times$	600 /	1600	r38	100
27H	1	0	0	1	1	1	V_{39}"	$V_7+(V_6-V_7)\times$	700 /	1600	r39	100
28H	1	0	1	0	0	0	V_{40}"	$V_7+(V_6-V_7)\times$	800 /	1600	r40	100
29H	1	0	1	0	0	1	V_{41}"	$V_7+(V_6-V_7)\times$	900 /	1600	r41	100
2AH	1	0	1	0	1	0	V_{42}"	$V_7+(V_6-V_7)\times$	1000 /	1600	r42	100
2BH	1	0	1	0	1	1	V_{43}"	$V_7+(V_6-V_7)\times$	1100 /	1600	r43	100
2CH	1	0	1	1	0	0	V_{44}"	$V_7+(V_6-V_7)\times$	1200 /	1600	r44	100
2DH	1	0	1	1	0	1	V_{45}"	$V_7+(V_6-V_7)\times$	1300 /	1600	r45	100
2EH	1	0	1	1	1	0	V_{46}"	$V_7+(V_6-V_7)\times$	1400 /	1600	r46	100
2FH	1	0	1	1	1	1	V_{47}"	$V_7+(V_6-V_7)\times$	1500 /	1600	r47	100
30H	1	1	0	0	0	0	V_{48}"	V_6			r48	100
31H	1	1	0	0	0	1	V_{49}"	$V_6+(V_5-V_6)\times$	100 /	3450	r49	100
32H	1	1	0	0	1	0	V_{50}"	$V_6+(V_5-V_6)\times$	200 /	3450	r50	100
33H	1	1	0	0	1	1	V_{51}"	$V_6+(V_5-V_6)\times$	300 /	3450	r51	100
34H	1	1	0	1	0	0	V_{52}"	$V_6+(V_5-V_6)\times$	400 /	3450	r52	100
35H	1	1	0	1	0	1	V_{53}"	$V_6+(V_5-V_6)\times$	500 /	3450	r53	150
36H	1	1	0	1	1	0	V_{54}"	$V_6+(V_5-V_6)\times$	650 /	3450	r54	150
37H	1	1	0	1	1	1	V_{55}"	$V_6+(V_5-V_6)\times$	800 /	3450	r55	150
38H	1	1	1	0	0	0	V_{56}"	$V_6+(V_5-V_6)\times$	950 /	3450	r56	200
39H	1	1	1	0	0	1	V_{57}"	$V_6+(V_5-V_6)\times$	1150 /	3450	r57	200
3AH	1	1	1	0	1	0	V_{58}"	$V_6+(V_5-V_6)\times$	1350 /	3450	r58	250
3BH	1	1	1	0	1	1	V_{59}"	$V_6+(V_5-V_6)\times$	1600 /	3450	r59	250
3CH	1	1	1	1	0	0	V_{60}"	$V_6+(V_5-V_6)\times$	1850 /	3450	r60	300
3DH	1	1	1	1	0	1	V_{61}"	$V_6+(V_5-V_6)\times$	2150 /	3450	r61	500
3EH	1	1	1	1	1	0	V_{62}"	$V_6+(V_5-V_6)\times$	2650 /	3450	r62	800
3FH	1	1	1	1	1	1	V_{63}"	V_5			rtotal	15850

Caution There is no connection between V_4 and V_5 terminal in the chip.

6. RELATIONSHIP BETWEEN INPUT DATA AND OUTPUT PIN

Data format: 6 bits × 2 RGBs (6 dots)

Input width: 36 bits (2-pixel data)

R,/L = H (Right shift)

Output	S_1	S_2	S_3	S_4	···	S_{419}	S_{420}
Data	D_{00} to D_{05}	D_{10} to D_{15}	D_{20} to D_{25}	D_{30} to D_{35}	···	D_{40} to D_{45}	D_{50} to D_{55}

R,/L = L (Left shift)

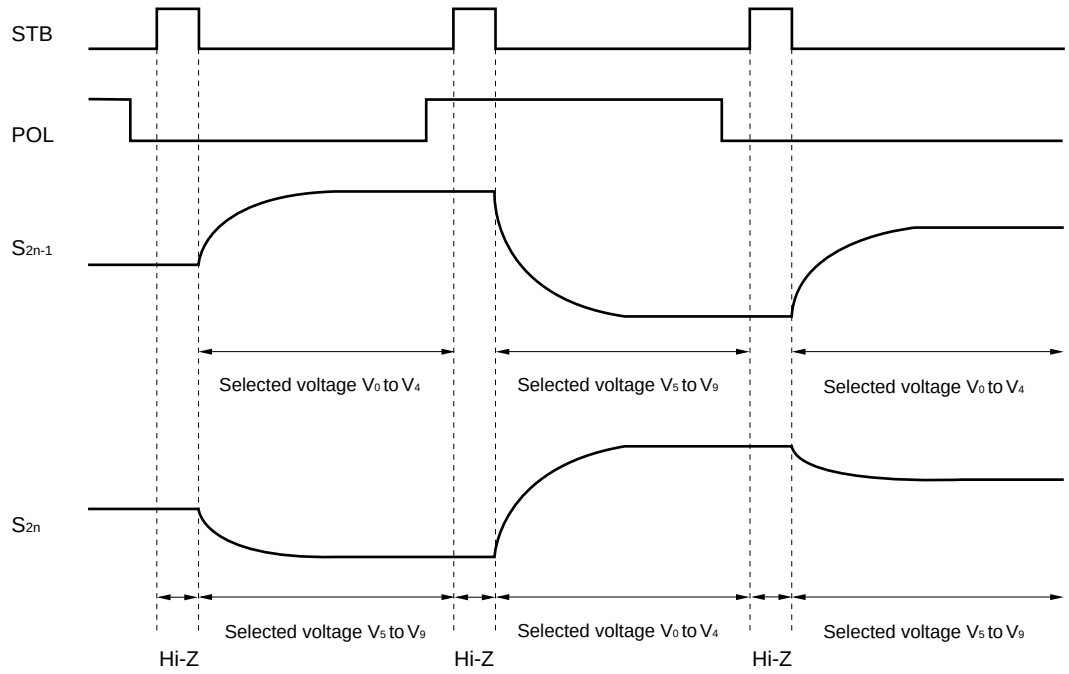
Output	S_1	S_2	S_3	S_4	···	S_{419}	S_{420}
Data	D_{00} to D_{05}	D_{10} to D_{15}	D_{20} to D_{25}	D_{30} to D_{35}	···	D_{40} to D_{45}	D_{50} to D_{55}

POL	S_{2n-1} Note	S_{2n} Note
L	V_0 to V_4	V_5 to V_9
H	V_5 to V_9	V_0 to V_4

Note S_{2n-1} (Odd output), S_{2n} (Even output)

7. RELATIONSHIP BETWEEN STB, POL AND OUTPUT WAVEFORM

The output voltage is written to the LCD panel synchronized with the STB falling edge.



8. RELATIONSHIP BETWEEN STB, CLK, AND OUTPUT WAVEFORM

The output voltage is written to the LCD panel synchronized with the STB falling edge.

Figure 8–1. Output Circuit Block Diagram

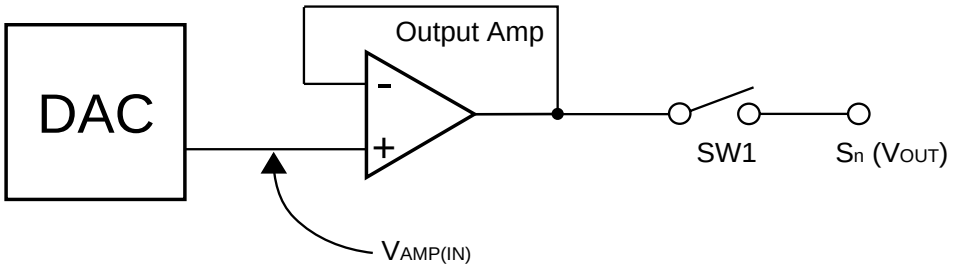
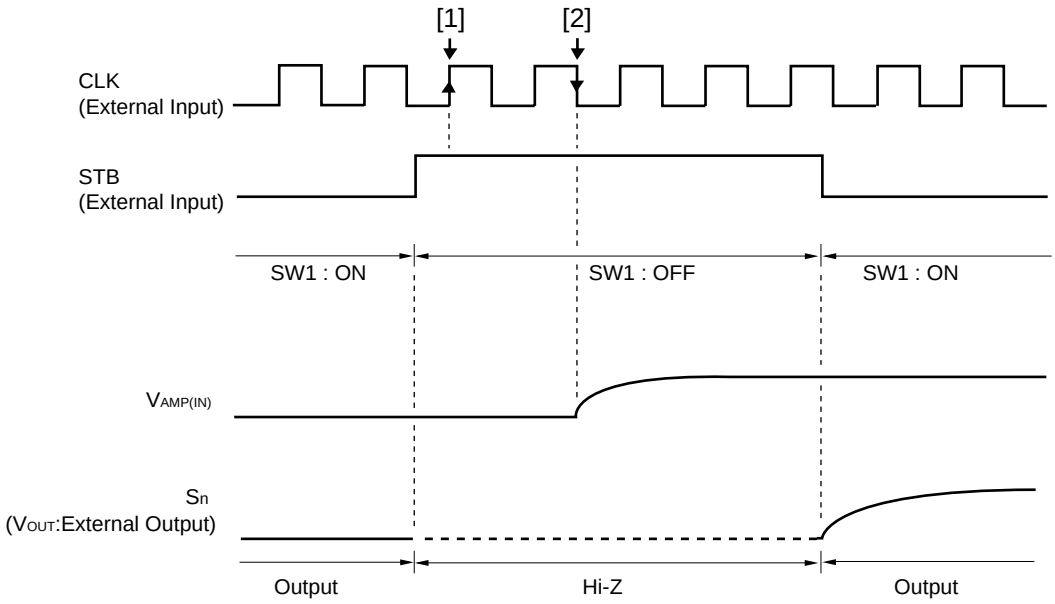


Figure 8–2. Output Circuit Timing Waveform



Remarks 1. STB = L : SW1 = ON, STB = H : SW1 = OFF

2. STB = “H” is acknowledged at timing [1].

3. The display data latch is completed at timing [2] and the input voltage (Vamp (in) : gray-scale level voltage) of the output amplifier changes.

9. BIAS CURRENT CONTROL PIN

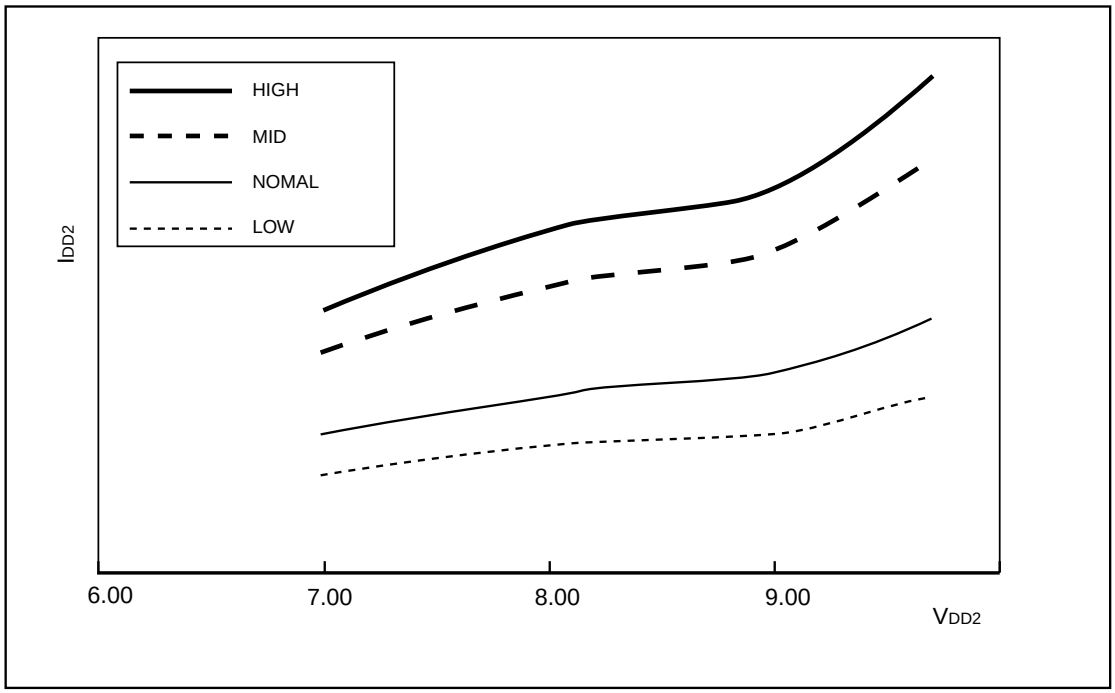
The μPD16770 has a power control function which can switch the bias current of the output amplifier between four levels and a bias control function (Bcont) which can be used to finely control the bias current.

<Power control function>

The bias current of the output amplifier can be switched between four levels using LPC (Low Power Control) pins and HPC (High Power Control) pins.

Power mode	LPC	HPC
High	L	L
Mid	H or open	L
Normal	L	H or open
Low	H or open	H or open

Following graph shows the relationship between each power modes and bias current.

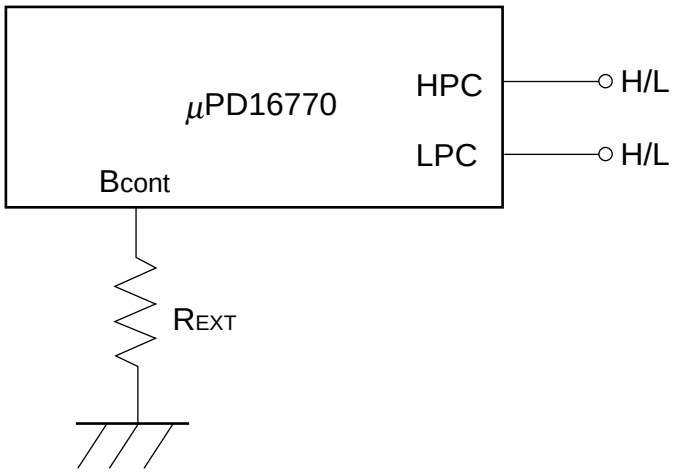


Remark This relationship is founded on results of simulation and don't assuring a characteristics of this product.

<Bias Current Control Function (Bcont)>

It is possible to fine-control the current consumption by using the bias current of the output amplifier control function (Bcont pin). When using this function, connect this pin to the stabilized ground potential (V_{SS2}) via an external resistor (R_{EXT}). When not using this function, leave this pin open.

Figure9–1. Bias Current Control Function (Bcont)



Refer to the table below for the percentage of current regulation when using the bias current control function.

Table9–1. Current Consumption Regulation Percentage Compared to Normal Mode

R_{EXT}	Current Consumption Regulation Percentage	
	LPC = H, HPC = H/open	LPC = H/open, HPC = H/open
∞ (open)	100%	65%
50 kΩ	110%	70%
20 kΩ	115%	80%
10 kΩ	120%	85%

V_{DD1} = 3.3 V
V_{DD2} = 8.7 V

Remark The above current consumption regulation percentages are founded on results of simulation and don't assuring a characteristics of this product.

Caution Because the power and bias-current control functions control 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 these functions, 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	Rating	Unit
Logic Part Supply Voltage	V_{DD1}	–0.5 to +4.0	V
Driver Part Supply Voltage	V_{DD2}	–0.5 to +10.0	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	Conditions	MIN.	TYP.	MAX.	Unit
Logic Part Supply Voltage	V_{DD1}		2.3		3.6	V
Driver Part Supply Voltage	V_{DD2}		8.0	8.5	9.0	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 to V_9		V_{SS2} + 0.1		V_{DD2} – 0.1	V
Driver Part Output Voltage	V_O		V_{SS2} + 0.1		V_{DD2} – 0.1	V
Maximum Clock Frequency	f_{CLK}	V_{DD1} = 2.3 V			45	MHz

★ **Electrical Characteristics (T_A = –10 to +75°C, V_{DD1} = 2.3 to 3.6 V, V_{DD2} = 8.5 V ± 0.5 V, V_{SS1} = V_{SS2} = 0 V, Unless otherwise specified, power mode = normal, Bcont = open)**

	Parameter	Symbol	Conditions		MIN.	TYP.	MAX.	Unit
	Input Leak 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 Supply Current	I_γ	V_{DD2} = 8.5 V, V_0 to V_4 = V_5 to V_9 = 4.0 V	V_0 pin, V_5 pin	126	252	504	μA
				V_4 pin, V_9 pin	–504	–252	–126	μA
★	Driver Output Current	I_{VOH}	V_X = 7.0 V, V_{OUT} = 6.5 V Note				–30	μA
★		I_{VOL}	V_X = 1.0 V, V_{OUT} = 1.5 V Note		30			μA
★	Output Voltage Deviation	ΔV_O	T_A = 25°C			±7	±20	mV
★	Output swing difference deviation	ΔV_{P-P}	V_{DD1} = 3.3 V, V_{DD2} = 8.5 V, V_{OUT} = 2.0 V, 4.25 V, 6.5 V			±2	±15	mV
★	Logic Part Dynamic Current Consumption	I_{DD1}	V_{DD1}			1.0	6.5	mA
★	Driver Part Dynamic Current Consumption	I_{DD2}	V_{DD2}, with no load			3.0	6.5	mA

Note V_X refers to the output voltage of analog output pins S_1 to S_{420}. V_{OUT} refers to the voltage applied to analog output pins S_1 to S_{420}.

Cautions 1. f_{STB} = 64 kHz, f_{CLK} = 40 MHz.

2. 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.

3. 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} = 2.3 to 3.6 V, V_{DD2} = 8.5 V ± 0.5 V, V_{SS1} = V_{SS2} = 0 V, Unless otherwise specified, power mode = normal, Bcont = open)**

	Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
	Start Pulse Delay Time	t_{PLH1}	C_L = 10 pF		10	20	ns
		t_{PHL1}			10	20	ns
★	Driver Output Delay Time	t_{PLH2}	C_L = 75 pF, R_L = 5 kΩ		2.5	5	μs
★		t_{PLH3}			5	8	μs
★		t_{PHL2}			2.5	5	μs
★		t_{PHL3}			5	8	μs
	Input Capacitance	C_{I1}	STHR (STHL) excluded, T_A = 25°C			10	pF
		C_{I2}	STHR (STHL), T_A = 25°C			10	pF

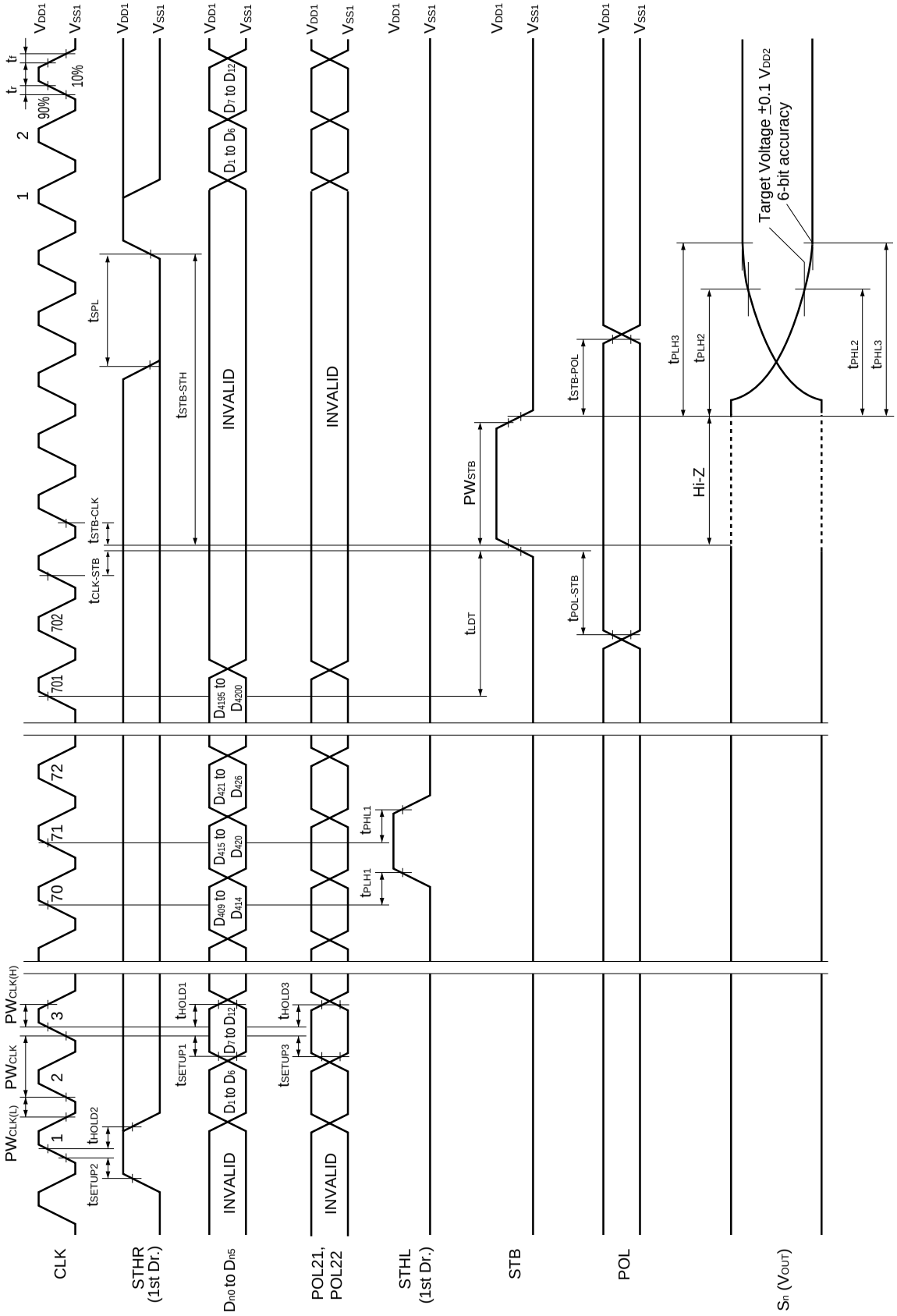
Timing Requirement (T_A = –10 to +75°C, V_{DD1} = 2.3 to 3.6 V, V_{SS1} = 0 V, $t_r = t_f$ = 5.0 ns)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Clock Pulse Width	PW_{CLK}		22			ns
Clock Pulse High Period	$PW_{CLK(H)}$		4			ns
Clock Pulse Low Period	$PW_{CLK(L)}$		4			ns
Data Setup Time	t_{SETUP1}		4			ns
Data Hold Time	t_{HOLD1}		0			ns
Start Pulse Setup Time	t_{SETUP2}		4			ns
Start Pulse Hold Time	t_{HOLD2}		0			ns
POL21/22 Setup Time	t_{SETUP3}		4			ns
POL21/22 Hold Time	t_{HOLD3}		0			ns
★ Start Pulse Low Period	t_{SPL}		1			CLK
STB Pulse Width	PW_{STB}		2			CLK
Last Data Timing	t_{LDT}		2			CLK
CLK-STB Time	$t_{CLK-STB}$	CLK ↑ → STB ↑	6			ns
STB-CLK Time	$t_{STB-CLK}$	STB ↑ → CLK ↑	9			ns
Time Between STB and Start Pulse	$t_{STB-STH}$	STB ↑ → STHR(STHL) ↑	2			CLK
POL-STB Time	$t_{POL-STB}$	POL ↑ or ↓ → STB ↑	–5			ns
STB-POL Time	$t_{STB-POL}$	STB ↓ → POL ↓ or ↑	6			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 Characteristics Waveform (R,/L = H)**

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



11. RECOMMENDED SOLDERING CONDITIONS

The following conditions must be met for soldering conditions of the μPD16770.

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

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

μPD16770N -xxx : TCP (TAB package)

Mounting Condition	Mounting Method	Condition
Thermocompression	Soldering	Heating tool 300 to 350°C: heating for 2 to 3 seconds: 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 seconds. Real bonding 165 to 180°C: pressure 25 to 45 kg/cm^2 : time 30 to 40 seconds. (When using the anisotropy conductive film SUMIZAC1003 of Sumitomo Bakelite, Ltd.)

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

[MEMO]

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 to NEC's Semiconductor Devices (C11531E)

- **The information in this document is current as of May, 2001. The information is subject to change without notice. For actual design-in, refer to the latest publications of NEC's data sheets or data books, etc., for the most up-to-date specifications of NEC semiconductor products. Not all products and/or types are available in every country. Please check with an NEC sales representative for availability and additional information.**
- No part of this document may be copied or reproduced in any form or by any means without prior written consent of NEC. NEC assumes no responsibility for any errors that may appear in this document.
- NEC does not assume any liability for infringement of patents, copyrights or other intellectual property rights of third parties by or arising from the use of NEC semiconductor products listed in this document or any other liability arising from the use of such products. No license, express, implied or otherwise, is granted under any patents, copyrights or other intellectual property rights of NEC or others.
- Descriptions of circuits, software and other related information in this document are provided for illustrative purposes in semiconductor product operation and application examples. The incorporation of these circuits, software and information in the design of customer's equipment shall be done under the full responsibility of customer. NEC assumes no responsibility for any losses incurred by customers or third parties arising from the use of these circuits, software and information.
- While NEC endeavours to enhance the quality, reliability and safety of NEC semiconductor products, customers agree and acknowledge that the possibility of defects thereof cannot be eliminated entirely. To minimize risks of damage to property or injury (including death) to persons arising from defects in NEC semiconductor products, customers must incorporate sufficient safety measures in their design, such as redundancy, fire-containment, and anti-failure features.
- NEC semiconductor products are classified into the following three quality grades:
  "Standard", "Special" and "Specific". The "Specific" quality grade applies only to semiconductor products developed based on a customer-designated "quality assurance program" for a specific application. The recommended applications of a semiconductor product depend on its quality grade, as indicated below. Customers must check the quality grade of each semiconductor product before using it in a particular application.
  "Standard": Computers, office equipment, communications equipment, test and measurement equipment, audio and visual equipment, home electronic appliances, machine tools, personal electronic equipment and industrial robots
  "Special": Transportation equipment (automobiles, trains, ships, etc.), traffic control systems, anti-disaster systems, anti-crime systems, safety equipment and medical equipment (not specifically designed for life support)
  "Specific": Aircraft, aerospace equipment, submersible repeaters, nuclear reactor control systems, life support systems and medical equipment for life support, etc.
  The quality grade of NEC semiconductor products is "Standard" unless otherwise expressly specified in NEC's data sheets or data books, etc. If customers wish to use NEC semiconductor products in applications not intended by NEC, they must contact an NEC sales representative in advance to determine NEC's willingness to support a given application.
  (Note)
  (1) "NEC" as used in this statement means NEC Corporation and also includes its majority-owned subsidiaries.
  (2) "NEC semiconductor products" means any semiconductor product developed or manufactured by or for NEC (as defined above).

M8E 00.4