NEC

MOS INTEGRATED CIRCUIT

μPD160061

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

DESCRIPTION

The μPD160061 is a source driver for TFT-LCD's 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} + 0.2 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 6-bit D/A converter circuit whose odd output pins and even output pins respectively output gray scale voltages of differing polarity. Assuring a maximum clock frequency of 65 MHz when driving at 2.7 V, this driver is applicable to XGA-standard TFT-LCD panels and SXGA TFT-LCD panels.

FEATURES

- CMOS level input (2.3 to 3.6 V)
- 384 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 (R-DAC)
- Logic power supply voltage (V_{DD1}): 2.3 to 3.6 V
- Driver power supply voltage (V_{DD2}): 7.5 to 9.5 V
- High-speed data transfer: f_{CLK} = 65 MHz MAX. (internal data transfer speed when operating at V_{DD1} = 2.7 V)
  40 MHz MAX. (internal data transfer speed when operating at V_{DD1} = 2.3 V)
- Output dynamic range: V_{SS2} + 0.2 V to V_{DD2} – 0.2 V
- Apply for dot-line inversion, n-line inversion and column line inversion
- Output voltage polarity inversion function (POL)
- Input data inversion function (capable of controlling by each input port) (POL21, POL22)
- Apply for heavy load, light load
- Semi slim-chip shaped

ORDERING INFORMATION

Part Number	Package
μPD160061N-xxx	TCP (TAB package)
μPD160061NL-xxx	COF (COF package)

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

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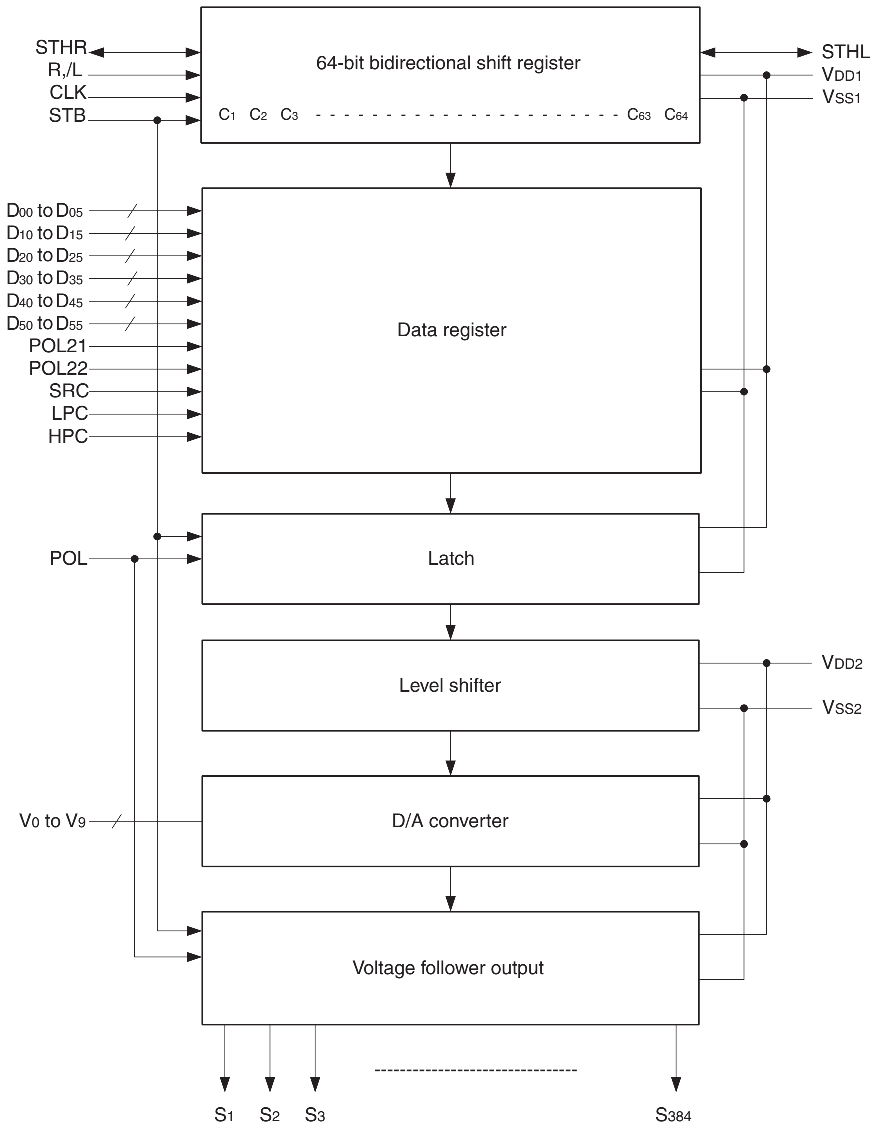
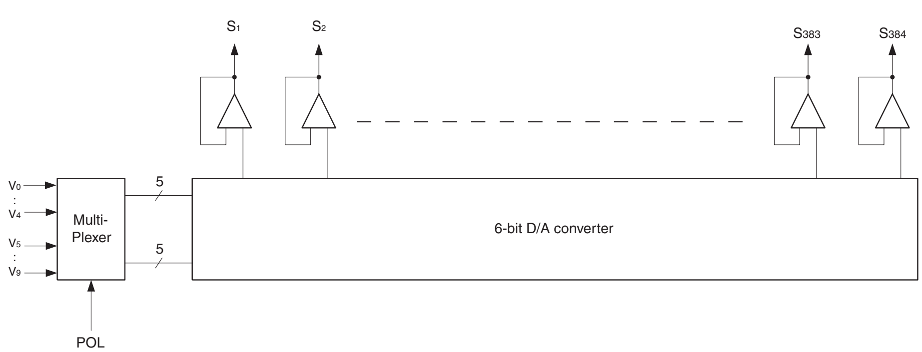
The mark ★ shows major revised points.

1. BLOCK DIAGRAM

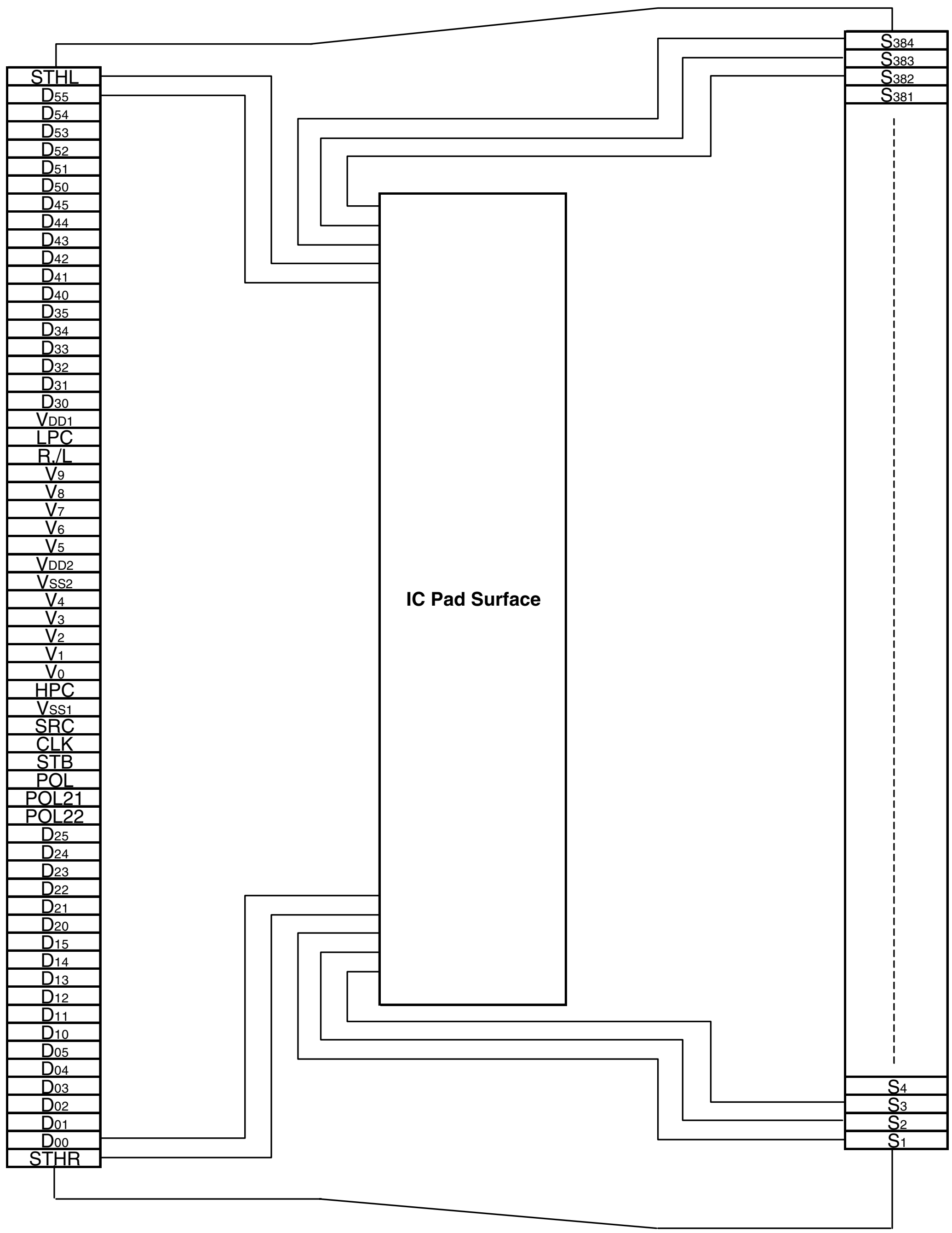


Remark /xxx indicates active low signal.

2. RELATIONSHIP BETWEEN OUTPUT CIRCUIT AND D/A CONVERTER



3. PIN CONFIGURATION (Copper foil surface) (μPD160061N-xxx: TCP (TAB package): Face-up/ μPD160061NL-xxx: COF (COF package): Face-down)



Remark This figure does not specify the TCP or COF package.

4. PIN FUNCTIONS

(1/2)

Pin Symbol	Pin Name	I/O	Description
S_1 to S_{384}	Driver output	Output	The D/A converted 64-gray-scale analog voltage is output.
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}	Display data input	Input	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
R,/L	Shift direction control	Input	These refer to the start pulse I/O pins when driver ICs are connected in cascade. Fetching of display data starts when H is read at the rising edge of CLK. R,/L = H (right shift): STHR input, $S_1 \rightarrow S_{384}$, STHL output R,/L = L (left shift): STHL input, $S_{384} \rightarrow S_1$, STHR output
STHR	Right shift start pulse input/output	I/O	These refer to the start pulse I/O pins when driver ICs are connected in cascade. Fetching of display data starts when H is read at the rising edge of CLK. When right shift: STHR input, STHL output When left shift: STHL input, STHR output A high level should be input as the pulse of one cycle of the clock signal. If the start pulse input is more than 2CLK, the first 1CLK of the high-level input is valid.
STHL	Left shift start pulse input/output		
CLK	Shift clock input	Input	Refers to the shift register's shift clock input. The display data is incorporated into the data register at the rising edge. At the rising edge of the 64th after the start pulse input, the start pulse output reaches the high level, thus becoming the start pulse of the next-level driver. If 66th 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	Input	The contents of the data register are transferred to the latch circuit at the rising edge. And, at the falling edge of the STB, the gray scale voltage is supplied to the driver. When STB = H period, driver output level is Hi-Z (High impedance). It is necessary to ensure input of one pulse per horizontal period.
POL	Polarity input	Input	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 input	Input	Data inversion can invert when display data is loaded. POL21: D_{00} to D_{05}, D_{10} to D_{15}, D_{20} to D_{25}, data inversion can invert display data POL22: D_{30} to D_{35}, D_{40} to D_{45}, D_{50} to D_{55}, data inversion can invert display data POL21, POL22 = H: Data inversion loads display data after inverting it. POL21, POL22 = L: Data inversion does not invert input data.
LPC, HPC	Bias current control input	Input	Please refer to panel loads and driver power supply voltage (V_{DD2}), when set up these pins. Refer to **10. BIAS CURRENT CONTROL BY LPC AND HPC**. LPC pin is pulled down to the V_{SS1} inside the IC, HPC pin is pulled up to the V_{DD1} inside the IC.

(2/2)

Pin Symbol	Pin Name	I/O	Description
SRC	High driving time control	Input	This pin is set up to high drive time of the output amplifier. Please decide the pin setting refer to panel loads and one horizontal period. SRC pin is pulled up to the V_{DD1} inside the IC. SRC = H or open: High drive time 64 CLK (Normally period mode) SRC = L: High drive time 128 CLK (Long time mode) Refer to **9. SRC AND HIGH DRIVE TIME.**
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. $V_{DD2} – 0.2\ V \geq V_0 > V_1 > V_2 > V_3 > V_4 \geq 0.5\ V_{DD2}$ $V_{DD2} – 0.3\ V \geq\ > V_5 > V_6 > V_7 > V_8 > V_9 \geq V_{SS2} + 0.2\ V$
V_{DD1}	Logic power supply	–	2.3 to 3.6 V
V_{DD2}	Driver power supply	–	7.5 to 9.5 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} to V_{SS1} and V_{DD2} to V_{SS2}. Furthermore, for increased precision of the D/A converter, insertion of a bypass capacitor of about 0.01 μF is also recommended between the γ-corrected power supply terminals (V_0, V_1, V_2,....., V_9) and V_{SS}.

5. RELATIONSHIP BETWEEN INPUT DATA AND OUTPUT VOLTAGE VALUE

The μPD160061 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 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, resistor ratio is shown in Figure 5–2. 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 of below.

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

$$0.5\ V_{DD2} - 0.3\ V \geq V_5 > V_6 > V_7 > V_8 > V_9 > V_{SS2} + 0.2\ V$$

Figures 5–2 indicates γ-corrected voltages and ladder resistors ratio. Figures 5–3 indicates the relationship between the input data and output voltage.

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

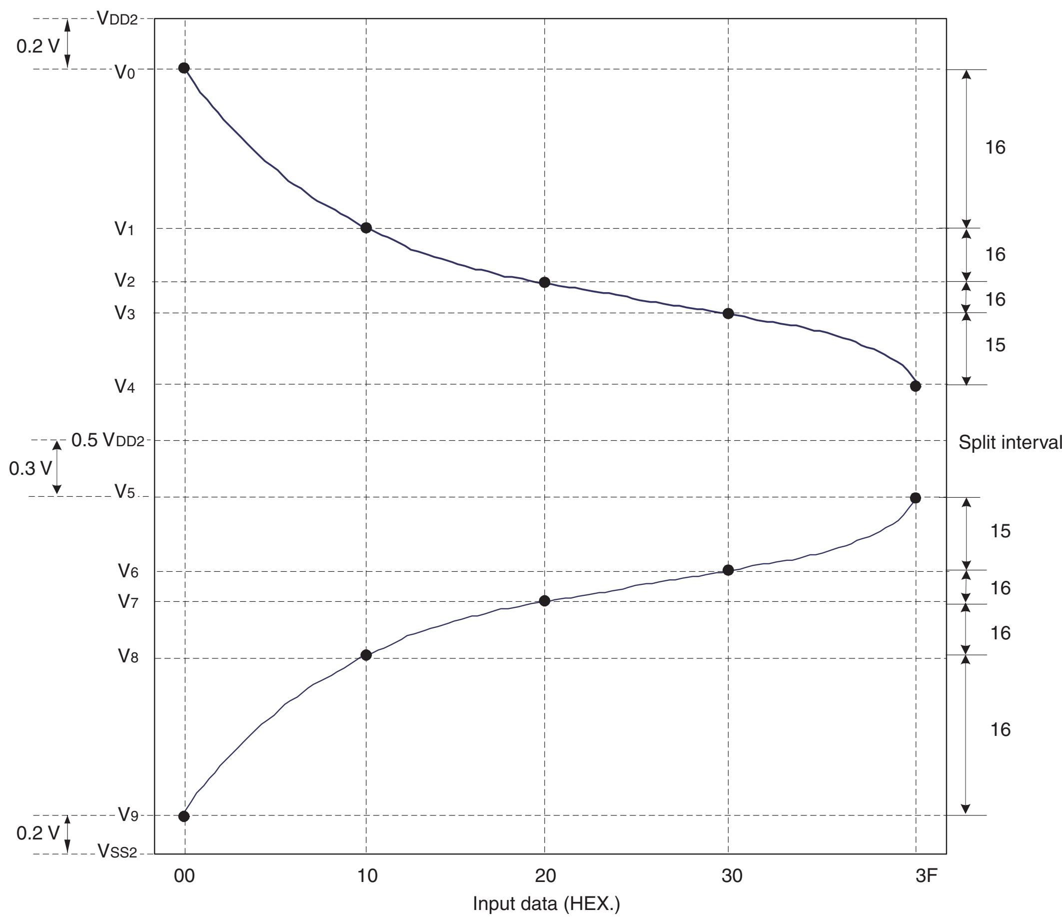
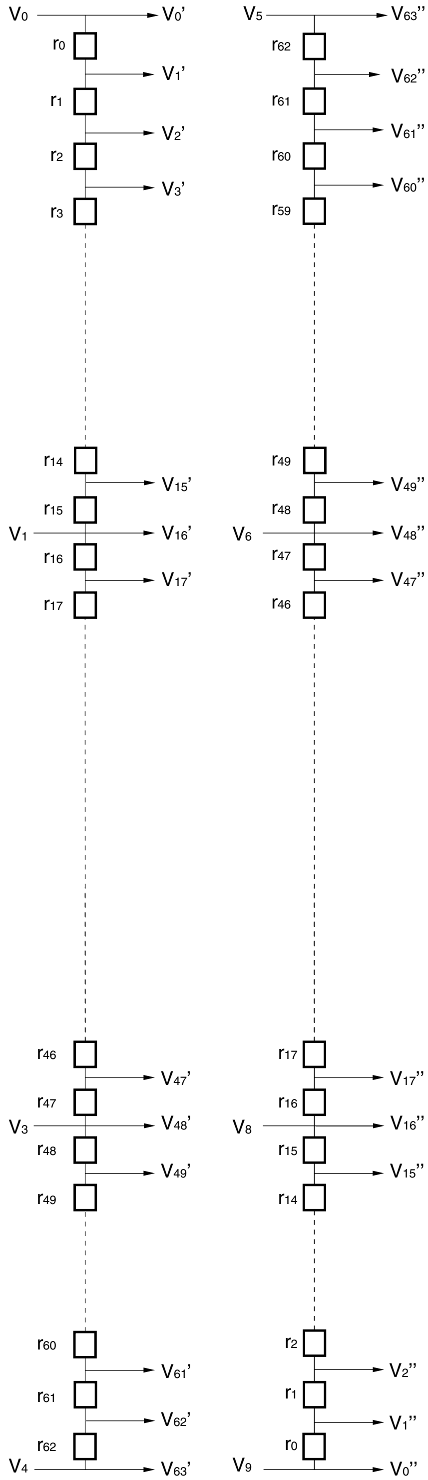


Figure 5–2. γ-corrected Voltages and Ladder Resistors Ratio



rn	Ratio	Value (TYP.)
r0	8.5	800
r1	7.5	750
r2	7.0	700
r3	6.5	650
r4	6.0	600
r5	5.5	550
r6	5.5	550
r7	5.0	500
r8	5.0	500
r9	4.0	400
r10	4.0	400
r11	3.5	350
r12	3.5	350
r13	3.5	350
r14	3.0	300
r15	3.0	300
r16	3.0	300
r17	2.5	250
r18	2.5	250
r19	2.5	250
r20	2.0	200
r21	2.0	200
r22	2.0	200
r23	1.5	150
r24	1.5	150
r25	1.5	150
r26	1.5	150
r27	1.0	100
r28	1.0	100
r29	1.0	100
r30	1.0	100
r31	1.0	100
r32	1.0	100
r33	1.0	100
r34	1.0	100
r35	1.0	100
r36	1.0	100
r37	1.0	100
r38	1.0	100
r39	1.0	100
r40	1.0	100
r41	1.0	100
r42	1.0	100
r43	1.0	100
r44	1.0	100
r45	1.0	100
r46	1.0	100
r47	1.0	100
r48	1.0	100
r49	1.0	100
r50	1.0	100
r51	1.0	100
r52	1.0	100
r53	1.5	150
r54	1.5	150
r55	1.5	150
r56	2.0	200
r57	2.0	200
r58	2.5	250
r59	2.5	250
r60	3.0	300
r61	5.0	500
r62	8.0	800

Cautions 1. There is no connection between V_4 and V_5 terminal in the IC.

2. The resistance ratio is a relative ratio in the case of setting the resistance minimum value to 1.

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

Output Voltage 1: $V_{DD2} - 0.2\ V \geq V_0 > V_1 > V_2 > V_3 > V_4 \geq 0.5\ V_{DD2}$

Output Voltage 2: $0.5\ V_{DD2} - 0.3\ V \geq V_5 > V_6 > V_7 > V_8 > V_9 \geq V_{SS2} + 0.2\ V$

Input Data	Output Voltage 1			Output Voltage 2		
00H	$V_{0'}$	V_0		$V_{0''}$	V_9	
01H	$V_{1'}$	$V_1+(V_0-V_1)\times$	7250 / 8050	$V_{1''}$	$V_9+(V_8-V_9)\times$	800 / 8050
02H	$V_{2'}$	$V_1+(V_0-V_1)\times$	6500 / 8050	$V_{2''}$	$V_9+(V_8-V_9)\times$	1550 / 8050
03H	$V_{3'}$	$V_1+(V_0-V_1)\times$	5800 / 8050	$V_{3''}$	$V_9+(V_8-V_9)\times$	2250 / 8050
04H	$V_{4'}$	$V_1+(V_0-V_1)\times$	5150 / 8050	$V_{4''}$	$V_9+(V_8-V_9)\times$	2900 / 8050
05H	$V_{5'}$	$V_1+(V_0-V_1)\times$	4550 / 8050	$V_{5''}$	$V_9+(V_8-V_9)\times$	3500 / 8050
06H	$V_{6'}$	$V_1+(V_0-V_1)\times$	4000 / 8050	$V_{6''}$	$V_9+(V_8-V_9)\times$	4050 / 8050
07H	$V_{7'}$	$V_1+(V_0-V_1)\times$	3450 / 8050	$V_{7''}$	$V_9+(V_8-V_9)\times$	4600 / 8050
08H	$V_{8'}$	$V_1+(V_0-V_1)\times$	2950 / 8050	$V_{8''}$	$V_9+(V_8-V_9)\times$	5100 / 8050
09H	$V_{9'}$	$V_1+(V_0-V_1)\times$	2450 / 8050	$V_{9''}$	$V_9+(V_8-V_9)\times$	5600 / 8050
0AH	$V_{10'}$	$V_1+(V_0-V_1)\times$	2050 / 8050	$V_{10''}$	$V_9+(V_8-V_9)\times$	6000 / 8050
0BH	$V_{11'}$	$V_1+(V_0-V_1)\times$	1650 / 8050	$V_{11''}$	$V_9+(V_8-V_9)\times$	6400 / 8050
0CH	$V_{12'}$	$V_1+(V_0-V_1)\times$	1300 / 8050	$V_{12''}$	$V_9+(V_8-V_9)\times$	6750 / 8050
0DH	$V_{13'}$	$V_1+(V_0-V_1)\times$	950 / 8050	$V_{13''}$	$V_9+(V_8-V_9)\times$	7100 / 8050
0EH	$V_{14'}$	$V_1+(V_0-V_1)\times$	600 / 8050	$V_{14''}$	$V_9+(V_8-V_9)\times$	7450 / 8050
0FH	$V_{15'}$	$V_1+(V_0-V_1)\times$	300 / 8050	$V_{15''}$	$V_9+(V_8-V_9)\times$	7750 / 8050
10H	$V_{16'}$	V_1		$V_{16''}$	V_8	
11H	$V_{17'}$	$V_2+(V_1-V_2)\times$	2450 / 2750	$V_{17''}$	$V_8+(V_7-V_8)\times$	300 / 2750
12H	$V_{18'}$	$V_2+(V_1-V_2)\times$	2200 / 2750	$V_{18''}$	$V_8+(V_7-V_8)\times$	550 / 2750
13H	$V_{19'}$	$V_2+(V_1-V_2)\times$	1950 / 2750	$V_{19''}$	$V_8+(V_7-V_8)\times$	800 / 2750
14H	$V_{20'}$	$V_2+(V_1-V_2)\times$	1700 / 2750	$V_{20''}$	$V_8+(V_7-V_8)\times$	1050 / 2750
15H	$V_{21'}$	$V_2+(V_1-V_2)\times$	1500 / 2750	$V_{21''}$	$V_8+(V_7-V_8)\times$	1250 / 2750
16H	$V_{22'}$	$V_2+(V_1-V_2)\times$	1300 / 2750	$V_{22''}$	$V_8+(V_7-V_8)\times$	1450 / 2750
17H	$V_{23'}$	$V_2+(V_1-V_2)\times$	1100 / 2750	$V_{23''}$	$V_8+(V_7-V_8)\times$	1650 / 2750
18H	$V_{24'}$	$V_2+(V_1-V_2)\times$	950 / 2750	$V_{24''}$	$V_8+(V_7-V_8)\times$	1800 / 2750
19H	$V_{25'}$	$V_2+(V_1-V_2)\times$	800 / 2750	$V_{25''}$	$V_8+(V_7-V_8)\times$	1950 / 2750
1AH	$V_{26'}$	$V_2+(V_1-V_2)\times$	650 / 2750	$V_{26''}$	$V_8+(V_7-V_8)\times$	2100 / 2750
1BH	$V_{27'}$	$V_2+(V_1-V_2)\times$	500 / 2750	$V_{27''}$	$V_8+(V_7-V_8)\times$	2250 / 2750
1CH	$V_{28'}$	$V_2+(V_1-V_2)\times$	400 / 2750	$V_{28''}$	$V_8+(V_7-V_8)\times$	2350 / 2750
1DH	$V_{29'}$	$V_2+(V_1-V_2)\times$	300 / 2750	$V_{29''}$	$V_8+(V_7-V_8)\times$	2450 / 2750
1EH	$V_{30'}$	$V_2+(V_1-V_2)\times$	200 / 2750	$V_{30''}$	$V_8+(V_7-V_8)\times$	2550 / 2750
1FH	$V_{31'}$	$V_2+(V_1-V_2)\times$	100 / 2750	$V_{31''}$	$V_8+(V_7-V_8)\times$	2650 / 2750
20H	$V_{32'}$	V_2		$V_{32''}$	V_7	
21H	$V_{33'}$	$V_3+(V_2-V_3)\times$	1500 / 1600	$V_{33''}$	$V_7+(V_6-V_7)\times$	100 / 1600
22H	$V_{34'}$	$V_3+(V_2-V_3)\times$	1400 / 1600	$V_{34''}$	$V_7+(V_6-V_7)\times$	200 / 1600
23H	$V_{35'}$	$V_3+(V_2-V_3)\times$	1300 / 1600	$V_{35''}$	$V_7+(V_6-V_7)\times$	300 / 1600
24H	$V_{36'}$	$V_3+(V_2-V_3)\times$	1200 / 1600	$V_{36''}$	$V_7+(V_6-V_7)\times$	400 / 1600
25H	$V_{37'}$	$V_3+(V_2-V_3)\times$	1100 / 1600	$V_{37''}$	$V_7+(V_6-V_7)\times$	500 / 1600
26H	$V_{38'}$	$V_3+(V_2-V_3)\times$	1000 / 1600	$V_{38''}$	$V_7+(V_6-V_7)\times$	600 / 1600
27H	$V_{39'}$	$V_3+(V_2-V_3)\times$	900 / 1600	$V_{39''}$	$V_7+(V_6-V_7)\times$	700 / 1600
28H	$V_{40'}$	$V_3+(V_2-V_3)\times$	800 / 1600	$V_{40''}$	$V_7+(V_6-V_7)\times$	800 / 1600
29H	$V_{41'}$	$V_3+(V_2-V_3)\times$	700 / 1600	$V_{41''}$	$V_7+(V_6-V_7)\times$	900 / 1600
2AH	$V_{42'}$	$V_3+(V_2-V_3)\times$	600 / 1600	$V_{42''}$	$V_7+(V_6-V_7)\times$	1000 / 1600
2BH	$V_{43'}$	$V_3+(V_2-V_3)\times$	500 / 1600	$V_{43''}$	$V_7+(V_6-V_7)\times$	1100 / 1600
2CH	$V_{44'}$	$V_3+(V_2-V_3)\times$	400 / 1600	$V_{44''}$	$V_7+(V_6-V_7)\times$	1200 / 1600
2DH	$V_{45'}$	$V_3+(V_2-V_3)\times$	300 / 1600	$V_{45''}$	$V_7+(V_6-V_7)\times$	1300 / 1600
2EH	$V_{46'}$	$V_3+(V_2-V_3)\times$	200 / 1600	$V_{46''}$	$V_7+(V_6-V_7)\times$	1400 / 1600
2FH	$V_{47'}$	$V_3+(V_2-V_3)\times$	100 / 1600	$V_{47''}$	$V_7+(V_6-V_7)\times$	1500 / 1600
30H	$V_{48'}$	V_3		$V_{48''}$	V_6	
31H	$V_{49'}$	$V_4+(V_3-V_4)\times$	3350 / 3450	$V_{49''}$	$V_6+(V_5-V_6)\times$	100 / 3450
32H	$V_{50'}$	$V_4+(V_3-V_4)\times$	3250 / 3450	$V_{50''}$	$V_6+(V_5-V_6)\times$	200 / 3450
33H	$V_{51'}$	$V_4+(V_3-V_4)\times$	3150 / 3450	$V_{51''}$	$V_6+(V_5-V_6)\times$	300 / 3450
34H	$V_{52'}$	$V_4+(V_3-V_4)\times$	3050 / 3450	$V_{52''}$	$V_6+(V_5-V_6)\times$	400 / 3450
35H	$V_{53'}$	$V_4+(V_3-V_4)\times$	2950 / 3450	$V_{53''}$	$V_6+(V_5-V_6)\times$	500 / 3450
36H	$V_{54'}$	$V_4+(V_3-V_4)\times$	2800 / 3450	$V_{54''}$	$V_6+(V_5-V_6)\times$	650 / 3450
37H	$V_{55'}$	$V_4+(V_3-V_4)\times$	2650 / 3450	$V_{55''}$	$V_6+(V_5-V_6)\times$	800 / 3450
38H	$V_{56'}$	$V_4+(V_3-V_4)\times$	2500 / 3450	$V_{56''}$	$V_6+(V_5-V_6)\times$	950 / 3450
39H	$V_{57'}$	$V_4+(V_3-V_4)\times$	2300 / 3450	$V_{57''}$	$V_6+(V_5-V_6)\times$	1150 / 3450
3AH	$V_{58'}$	$V_4+(V_3-V_4)\times$	2100 / 3450	$V_{58''}$	$V_6+(V_5-V_6)\times$	1350 / 3450
3BH	$V_{59'}$	$V_4+(V_3-V_4)\times$	1850 / 3450	$V_{59''}$	$V_6+(V_5-V_6)\times$	1600 / 3450
3CH	$V_{60'}$	$V_4+(V_3-V_4)\times$	1600 / 3450	$V_{60''}$	$V_6+(V_5-V_6)\times$	1850 / 3450
3DH	$V_{61'}$	$V_4+(V_3-V_4)\times$	1300 / 3450	$V_{61''}$	$V_6+(V_5-V_6)\times$	2150 / 3450
3EH	$V_{62'}$	$V_4+(V_3-V_4)\times$	800 / 3450	$V_{62''}$	$V_6+(V_5-V_6)\times$	2650 / 3450
3FH	$V_{63'}$	V_4		$V_{63''}$	V_5	

6. RELATIONSHIP BETWEEN INPUT DATA AND OUTPUT PIN

Data format : 6 bits x 2 RGBs (6 dots)
Input width : 36 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_{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}

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

Output	S_1	S_2	S_3	S_4	...	S_{383}	S_{384}
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 CLK AND OUTPUT WAVEFORM

Figure 7–1. Input Circuit Block Diagram

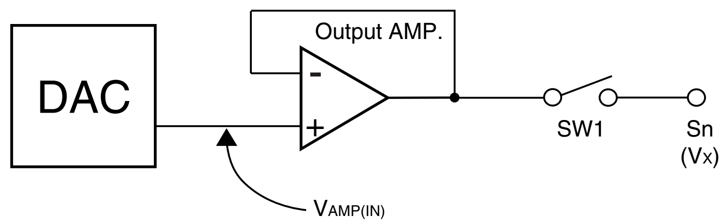
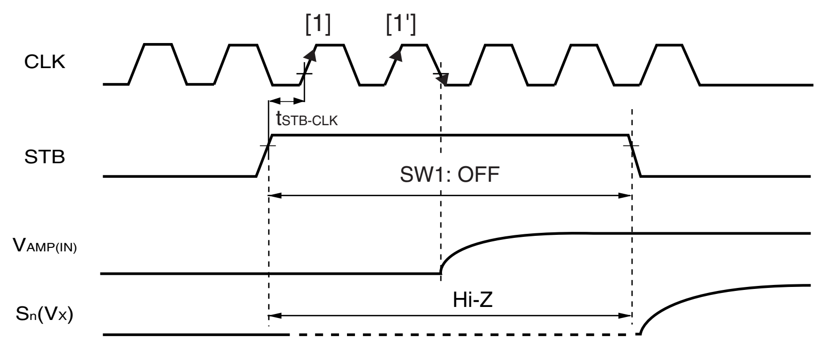


Figure 7–2. Output Circuit Timing Waveform

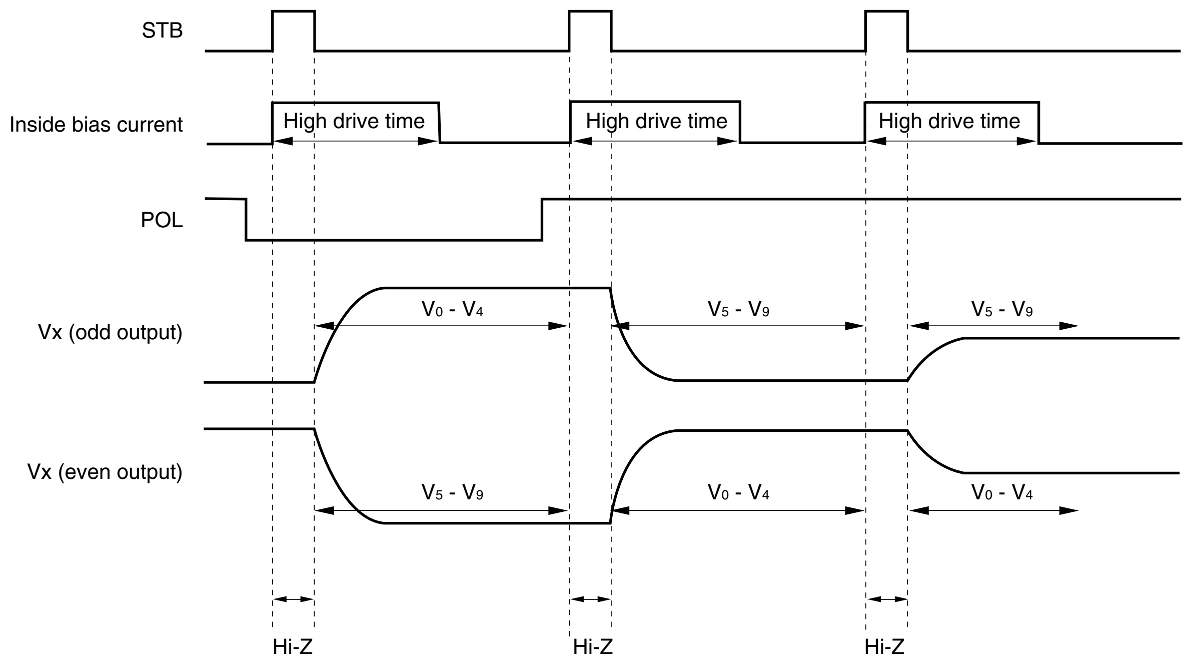


STB = H is loaded with the rising edge of CLK[1]. However, when not satisfying the specification of $f_{STB\text{-}CLK}$, STB = H is loaded with the rising edge of the next CLK[1′]. Latch operation of display data is completed with the falling edge of the next CLK which loaded STB = H. Therefore, in order to complete latch operation of display data, it is necessary to input at least 2 CLK in STB = H period. Besides, after loading STB=H to the timing of [1], it is necessary to continue inputting CLK.

8. RELATIONSHIP BETWEEN STB, POL AND OUTPUT WAVEFORM

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

Therefore, high drive time of the output amplifier as below is determined by the CLK number of the required SRC pin setting. Be sure to avoid using such as extremely changing the CLK frequency (ex. CLK stop).

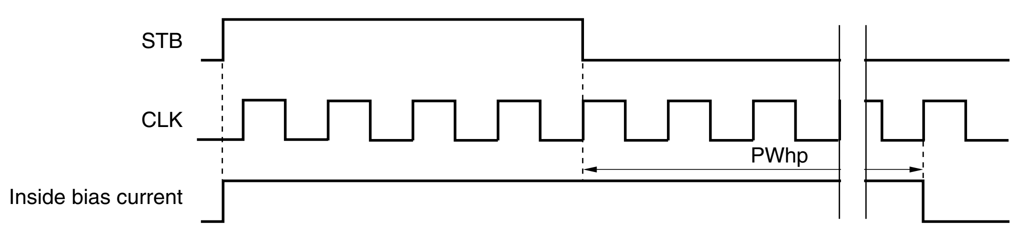


9. SRC AND HIGH DRIVE TIME

The μPD160061 can control high drive time of the output amplifier by SRC pin logic (refer to below figure).

SRC = H or open (high drive time: standard mode): High drive time (PWhp) of the output amplifier is in 64 CLK period from falling edge of the STB.

SRC = L (high drive time: long-term mode): High drive time (PWhp) of the output amplifier is in 128 CLK period from falling edge of the STB.



We recommend a thorough simulation of the output amplifier in advance when set the SRC pin.

10. BIAS CURRENT CONTROL BY LPC AND HPC

The μPD160061 can control the bias current of the output amplifier in high drive period and low drive period.

Bias Current	LPC	HPC
High	H	L
★ Middle	L or open	L
Normal	L or open	H or open
Low	H	H or open

Panel Load
Heavy
↕
Light

We recommend a thorough simulation of the output amplifier in advance, when set the LPC and HPC pins.
Refer to the table below for the example of the combination of setting level and panel load, with driver part supply voltage.

	Example of Condition	LPC	HPC	SRC
Example 1	Load: R_L = 5 kΩ, C_L = 75 pF	L or open	L	H or open
	Driver part supply voltage: V_{DD2} = 7.5 V	Bias current mode: Middle		
Example 2	Load: R_L = 5 kΩ, C_L = 75 pF	L or open	H or open	H or open
	Driver part supply voltage: V_{DD2} = 9.0 V	Bias current mode: Normal		
Example 3	Load: R_L = 40 kΩ, C_L = 80 pF	H	L	L
	Driver part supply voltage: V_{DD2} = 9.0 V	Bias current mode: High		

11. 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	Condition	MIN.	TYP.	MAX.	Unit
Logic Part Supply Voltage	V_{DD1}		2.3		3.6	V
Driver Part Supply Voltage	V_{DD2}		7.5	8.5	9.5	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 to V_4	7.5 V ≤ V_{DD1} ≤ 9.5 V	0.5 V_{DD2}		V_{DD2} – 0.2	V
	V_5 to V_9	7.5 V ≤ V_{DD1} < 8.5 V	0.2		0.5 V_{DD2} – 0.3	V
		8.5 V ≤ V_{DD1} ≤ 9.5 V	0.2		0.5 V_{DD2}	V
Driver Part Output Voltage	V_O		0.2		V_{DD2} – 0.2	V
Clock Frequency	f_{CLK}	2.3 V ≤ V_{DD1} < 2.7 V			40	MHz
		2.7 V ≤ V_{DD1} ≤ 3.6 V			65	MHz

Electrical Characteristics (T_A = –10 to +75°C, V_{DD1} = 2.3 to 3.6 V, V_{DD2} = 7.5 to 9.5 V, V_{SS1} = V_{SS2} = 0 V)

Parameter	Symbol	Condition	MIN.	TYP.	MAX.	Unit
Input Leak Current	I_{IL}	Except LPC, HPC, SRC			±1.0	μA
		LPC, HPC, SRC			±150	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_0 to V_4 = V_5 to V_9 = 4.0 V, V_{DD2} = 8.5 V	7.9	15.8	23.7	kΩ
Driver Output Current	I_{VOH}	V_{DD2} = 8.0 V, V_X = 7.0 V, V_{OUT} = 6.5 V Note1			– 20	μA
	I_{VOL}	V_{DD2} = 8.0 V, V_X = 1.0 V, V_{OUT} = 1.5 V Note1	20			μA
Output Voltage Deviation	ΔV_O	T_A = 25°C,		±10	±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		±3	±15	mV
Logic Part Dynamic Current Consumption Note2, 3, 4	I_{DD1}	V_{DD1}		4	12	mA
Driver Part Dynamic Current Consumption Note2, 4	I_{DD22}	V_{DD2}, with no load		3.5	8	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. Specified at f_{STB} = 65 kHz and 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.

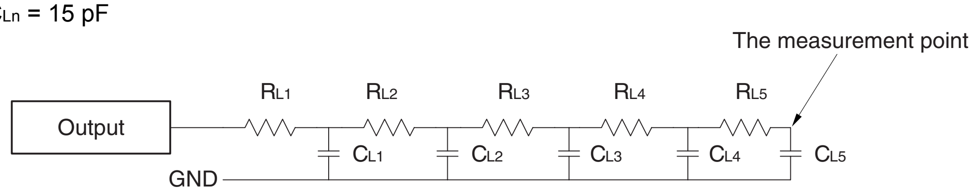
4. Refers to the current consumption per driver when cascades are connected under the assumption of XGA single-sided mounting (8 units).

Switching Characteristics (T_A = –10 to +75°C, V_{DD1} = 2.3 to 3.6 V, V_{DD2} = 7.5 to 9.5 V, V_{SS1} = V_{SS2} = 0 V)

Parameter	Symbol	Condition	MIN.	TYP.	MAX.	Unit
Start Pulse Delay Time	t_{PLH1}	C_L = 15 pF, 2.3 V ≤ V_{DD1} < 2.7 V			20	ns
		C_L = 10 pF, 2.7 V ≤ V_{DD1} ≤ 3.6 V			10.5	ns
	t_{PLH1}	C_L = 10 pF, 2.3 V ≤ V_{DD1} < 2.7 V			20	ns
		C_L = 10 pF, 2.7 V ≤ V_{DD1} ≤ 3.6 V			10.5	ns
Driver Output Delay Time	t_{PLH2}	C_L = 75 pF, R_L = 5 kΩ,			5	μs
★	t_{PLH3}	LPC = L or open,			8	μs
	t_{PHL2}	HPC = H or open,			5	μs
	t_{PHL3}	SRC = H or open			8	μs
Input Capacitance	C_{I1}	Logic input of exclude STHR (STHL), T_A = 25°C			10	pF
	C_{I2}	STHR (STHL), T_A = 25°C			5	pF

<Measurement condition>

R_{Ln} = 1 kΩ, C_{Ln} = 15 pF



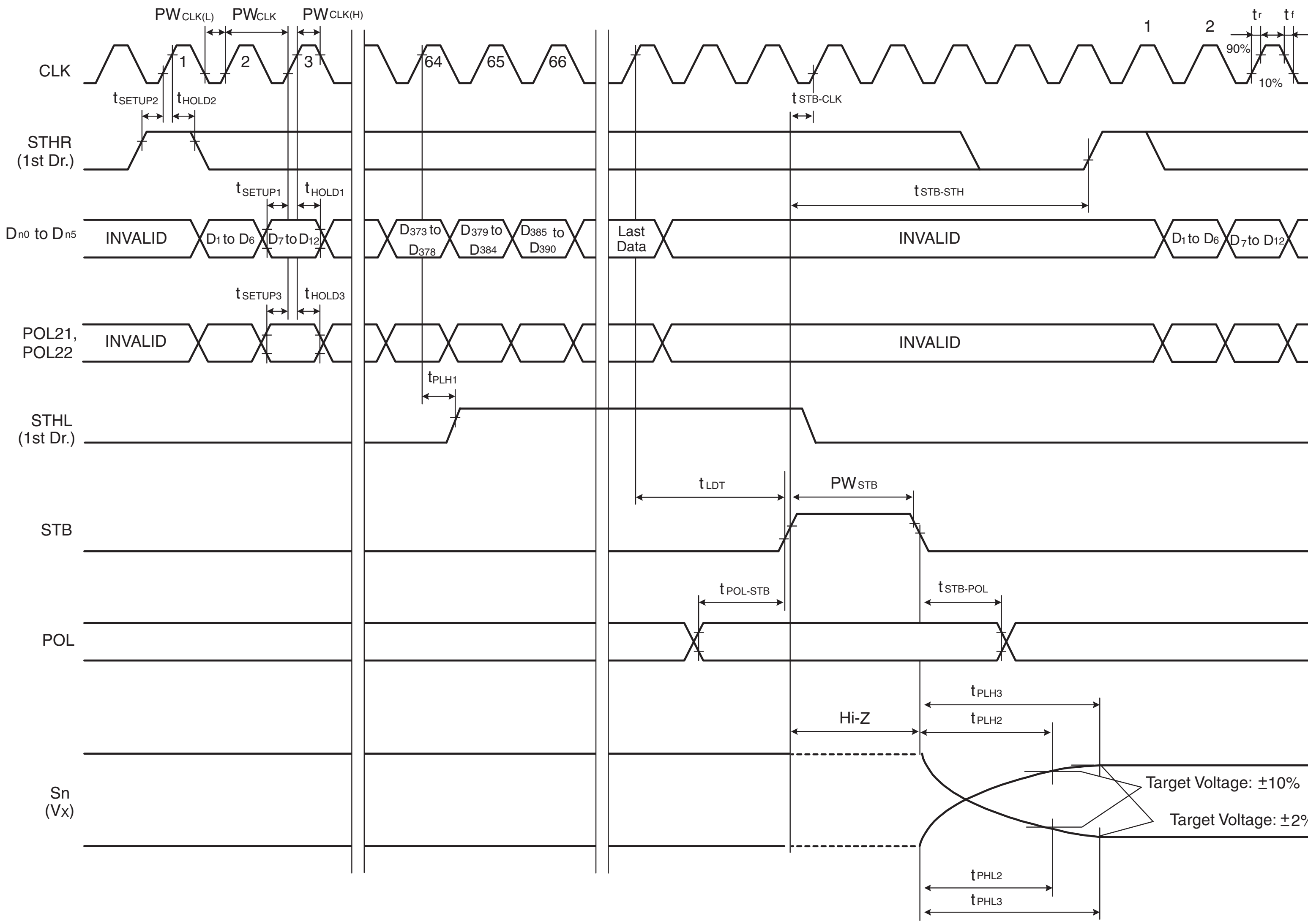
Timing Requirements (T_A = –10 to +75°C, V_{DD1} = 2.3 to 3.6 V, V_{SS1} = 0 V, t_r = t_f = 5.0 ns)

Parameter	Symbol	Condition	MIN.	TYP.	MAX.	Unit
Clock Pulse Width	PW_{CLK}	2.3 V ≤ V_{DD1} < 2.7 V	25			ns
		2.7 V ≤ V_{DD1} ≤ 3.6 V	15			ns
Clock Pulse High Period	$PW_{CLK(H)}$	2.3 V ≤ V_{DD1} < 2.7 V	6			ns
		2.7 V ≤ V_{DD1} ≤ 3.6 V	4			ns
Clock Pulse Low Period	$PW_{CLK(L)}$	2.3 V ≤ V_{DD1} < 2.7 V	6			ns
		2.7 V ≤ V_{DD1} ≤ 3.6 V	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, POL22 Setup Time	t_{SETUP3}		4			ns
POL21, POL22 Hold Time	t_{HOLD3}		0			ns
STB Pulse Width	PW_{STB}		2			CLK
Last Data Timing	t_{LDT}		2			CLK
STB-CLK Time	$t_{STB\text{-}CLK}$	STB ↑→ CLK ↑	9			ns
Time Between STB and Start Pulse	$t_{STB\text{-}STH}$	STB ↑ → STHR(STHL) ↑	2			CLK
POL-STB Time	$t_{POL\text{-}STB}$	POL ↑ or ↓ → STB ↑	–5			ns
STB-POL Time	$t_{STB\text{-}POL}$	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 $V_{IH} = 0.7\ V_{DD1}$, $V_{IL} = 0.3\ V_{DD1}$.



12. RECOMMENDED MOUNTING CONDITIONS

The following conditions must be met for mounting conditions of the μPD160061.

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.

μPD160061N - ×××: TCP (TAB package)

Mounting Condition	Mounting Method	Condition
Thermocompression	Soldering	Heating tool 300 to 350°C, heating for 2 to 3 seconds, 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 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 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 VOLTAGE APPLICATION WAVEFORM AT INPUT PIN

Waveform distortion due to input noise or a reflected wave may cause malfunction. If the input of the CMOS device stays in the area between V_{IL} (MAX) and V_{IH} (MIN) due to noise, etc., the device may malfunction. Take care to prevent chattering noise from entering the device when the input level is fixed, and also in the transition period when the input level passes through the area between V_{IL} (MAX) and V_{IH} (MIN).

② HANDLING OF UNUSED INPUT PINS

Unconnected CMOS device inputs can be cause of malfunction. If an input pin is unconnected, it is possible that an internal input level may be generated due to noise, etc., causing malfunction. CMOS devices behave differently than Bipolar or NMOS devices. Input levels of CMOS devices must be fixed high or low by using pull-up or pull-down circuitry. Each unused pin should be connected to V_{DD} or GND via a resistor if there is a possibility that it will be an output pin. All handling related to unused pins must be judged separately for each device and according to related specifications governing the device.

③ PRECAUTION AGAINST ESD

A 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 when it has occurred. Environmental control must be adequate. When it is dry, a humidifier should be used. It is recommended to avoid using insulators that easily build up 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 benches and floors should be grounded. The operator should be grounded using a wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions need to be taken for PW boards with mounted semiconductor devices.

④ STATUS BEFORE INITIALIZATION

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

Reference Documents

NEC Semiconductor Device Reliability/Quality Control System (C10983E)

Quality Grades On NEC Semiconductor Devices (C11531E)