

### SOURCE DRIVER FOR 240-OUTPUT TFT-LCD (64 GRAY SCALES)

#### DESCRIPTION

The  $\mu$ PD16641 is a source driver for TFT-LCD 64 gray scale displays. Its logic circuit operates at 3.3 V and the driver circuit operates at 3.3 or 5.0 V (selectable). The input data is digital data at 6 bits  $\times$  3 dots, and 260,000 colors can be displayed in 64-value outputs  $\gamma$ -corrected by the internal D/A converter and 11 external power supplies.

Because the clock frequency is 33 MHz<sub>MIN</sub>, the  $\mu$ PD16641 can be used in TFT-LCD panels conforming to the VGA standards.

#### FEATURES

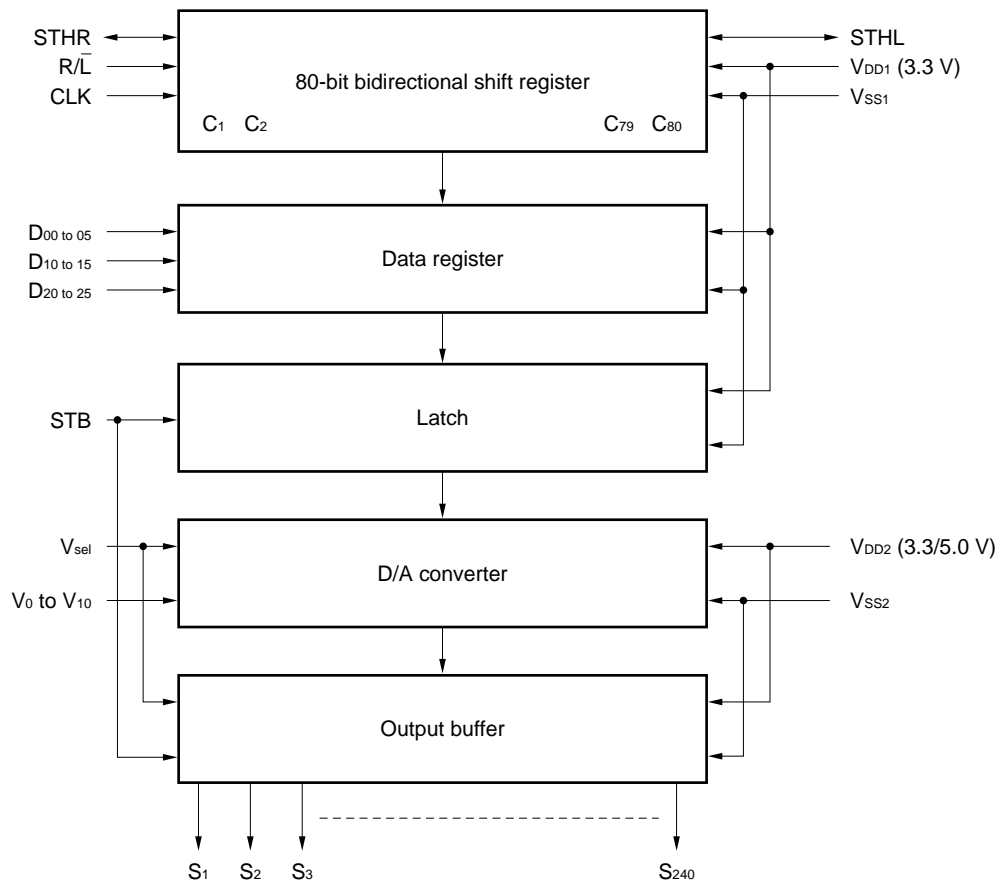
- Precharge-less output buffer
- 64-value output by 11 external power supplies and internal D/A converter
- Level of  $\gamma$ -corrected power supply can be inverted
- Output voltage range: 2.8 V<sub>P-P</sub>MAX. (at supply voltage V<sub>DD2</sub> of driver circuit = 3.0 V)  
4.3 V<sub>P-P</sub>MAX. (at supply voltage V<sub>DD2</sub> of driver circuit = 4.5 V)
- CMOS level input
- 6 bit (gray scale data)  $\times$  3 dot input
- High-speed data transfer: f<sub>max.</sub> = 33 MHz<sub>MIN</sub>. (internal data transfer rate at supply voltage V<sub>DD1</sub> of logic circuit = 3.0 V)
- 240 outputs
- Supply voltage of driver circuit selectable (V<sub>sel</sub> = H: 3.3 V, V<sub>sel</sub> = L: 5.0 V)
- Slim TCP

#### ORDERING INFORMATION

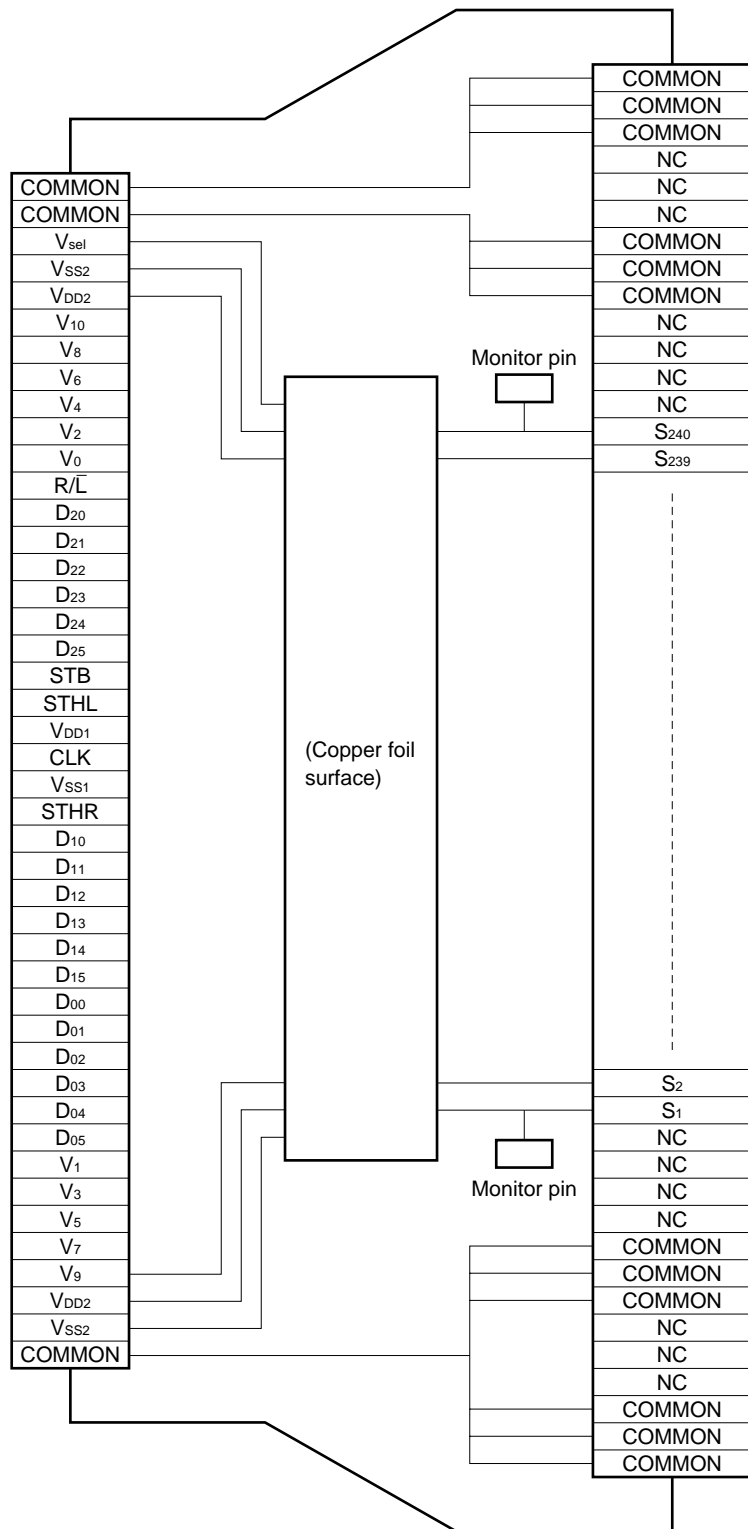
Part No.	Package
$\mu$ PD16641N-xxx	TCP (TAB package)

The TCP is custom-made. For details, consult NEC

1. BLOCK DIAGRAM



2. PIN CONFIGURATION (standard TCP: μPD16641N-xxx)



V<sub>sel</sub> pin is internally pulled up.

Therefore, the number of input pins can be reduced by opening or short-circuiting these pins to V<sub>SS2</sub> by means of TCP wiring.

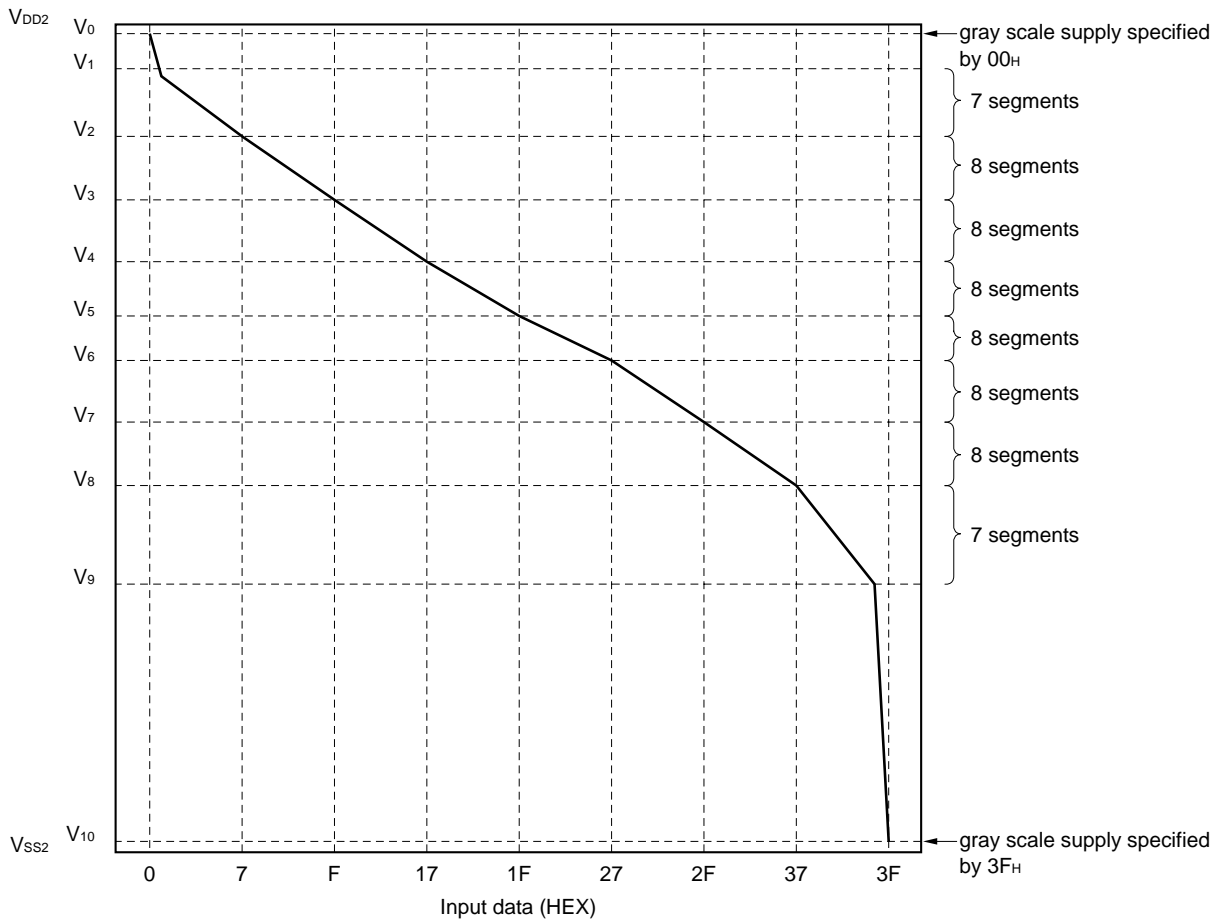
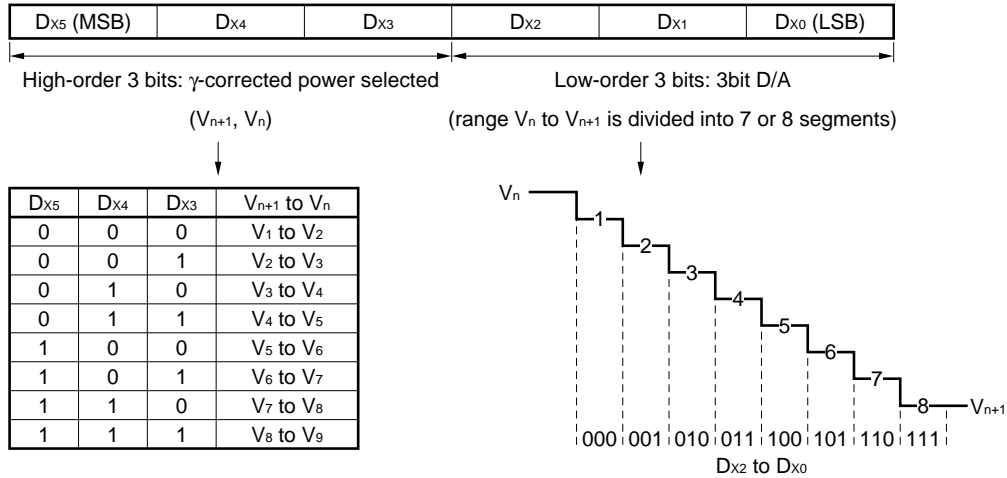
## 3. PIN DESCRIPTION

Pin Symbol	Pin Name	Description
S <sub>1</sub> to S <sub>240</sub>	Driver output	Output 64 gray scale analog voltages converted from digital signals.
D <sub>00</sub> to D <sub>05</sub>	Display data input	Inputs 18-bit-wide display gray scale data (6 bits) × 3 dots (RGB). D <sub>X0</sub> : LSB, D <sub>X5</sub> : MSB
D <sub>10</sub> to D <sub>15</sub>		
D <sub>20</sub> to D <sub>25</sub>		
R/ $\bar{L}$	Shift direction select input	This pin inputs/outputs start pulses when two or more $\mu$ PD16641s are connected in cascade. Shift direction of shift register is as follows: R/ $\bar{L}$ = H : STHR input, S <sub>1</sub> → S <sub>240</sub> , STHL output R/ $\bar{L}$ = L : STHL input, S <sub>240</sub> → S <sub>1</sub> , STHR output
STHR	Right shift start pulse I/O	R/ $\bar{L}$ = H : Inputs start pulse. R/ $\bar{L}$ = L : Outputs start pulse.
STHL	Left shift start pulse I/O	R/ $\bar{L}$ = H : Outputs start pulse. R/ $\bar{L}$ = L : Inputs start pulse.
V <sub>sel</sub>	Driver voltage selection	Selects driver voltage. This pin is internally pulled up to V <sub>DD2</sub> . V <sub>sel</sub> = V <sub>DD2</sub> or OPEN: V <sub>DD2</sub> = 3.3 V ± 0.3 V, V <sub>sel</sub> = L: V <sub>DD2</sub> = 5.0 V ± 0.5 V
CLK	Shift clock input	Inputs shift clock to shift register. Display data is loaded to data register at rising edge of this pin. Start pulse output goes high at rising edge of 80th clock after start pulse has been input, and serves as start pulse to driver in next stage. 80th clock of driver in first stage serves as start pulse of driver in next stage.
STB	Latch input	Contents of data register are latched at rising edge, transferred to D/A converter, and output as analog voltage corresponding to display data. Contents of initial shift register are cleared after STB has been input. One pulse of this signal is input when $\mu$ PD16641 is started, and then device operates normally. For STB input timing, refer to <b>Relations between STB, Start Pulse, and Blanking Period in Switching Characteristic Waveform</b> .
V <sub>0</sub> to V <sub>10</sub>	$\gamma$ -corrected power supply	Inputs $\gamma$ -corrected power from external source. V <sub>SS2</sub> ≤ V <sub>10</sub> ≤ V <sub>9</sub> ≤ V <sub>8</sub> ≤ V <sub>7</sub> ≤ V <sub>6</sub> ≤ V <sub>5</sub> ≤ V <sub>4</sub> ≤ V <sub>3</sub> ≤ V <sub>2</sub> ≤ V <sub>1</sub> ≤ V <sub>0</sub> ≤ V <sub>DD2</sub> V <sub>SS2</sub> ≤ V <sub>0</sub> ≤ V <sub>1</sub> ≤ V <sub>2</sub> ≤ V <sub>3</sub> ≤ V <sub>4</sub> ≤ V <sub>5</sub> ≤ V <sub>6</sub> ≤ V <sub>7</sub> ≤ V <sub>8</sub> ≤ V <sub>9</sub> ≤ V <sub>10</sub> ≤ V <sub>DD2</sub> Maintain gray scale power supply during gray scale voltage output.
V <sub>DD1</sub>	Logic circuit power supply	3.3 V ± 0.3 V
V <sub>DD2</sub>	Driver circuit power supply	V <sub>sel</sub> = V <sub>DD2</sub> or OPEN: V <sub>DD2</sub> = 3.3 V ± 0.3 V V <sub>sel</sub> = L : V <sub>DD2</sub> = 5.0 V ± 0.5 V
V <sub>SS1</sub>	Logic ground	Ground
V <sub>SS2</sub>	Driver ground	Ground

**Caution** Be sure to turn on power in the order V<sub>DD1</sub>, logic input, V<sub>DD2</sub>, and gray scale power (V<sub>0</sub> to V<sub>10</sub>), and turn off power in the reverse order, to prevent the  $\mu$ PD16641 from being damaged by latchup. Be sure to observe this power sequence even during a transition period.

4. RELATION BETWEEN INPUT DATA AND OUTPUT VOLTAGE VALUE

The 11 major points on the  $\gamma$  characteristic curve of the LCD panel are arbitrarily set by external power supplies  $V_0$  through  $V_{10}$ . If the display data is 00H or 3FH, gray scale voltage  $V_0$  or  $V_{10}$  is output. If the display data is in the range 01H to 3EH, the high-order 3 bits select an external powers pair  $V_{n+1}$ ,  $V_n$ . The low-order 3 bits evenly divide the range of  $V_{n+1}$  to  $V_n$  into eight segments by means of D/A conversion (however, the ranges from  $V_9$  to  $V_8$  and from  $V_2$  to  $V_1$  are divided into seven segments) to output a 64 gray scale voltage.

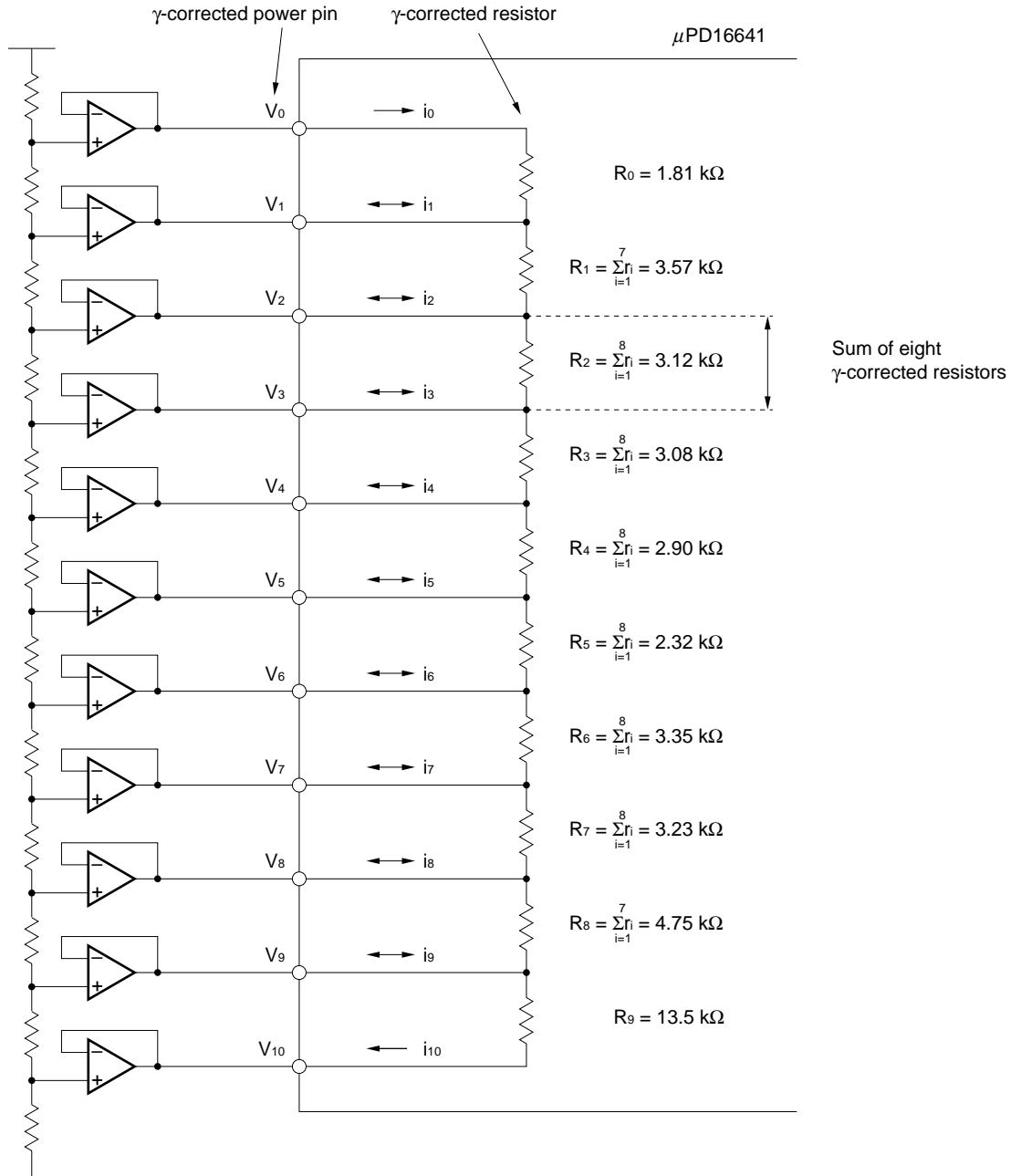


Relation between Input Data and Output Voltage

Input Data	D <sub>X5</sub>	D <sub>X4</sub>	D <sub>X3</sub>	D <sub>X2</sub>	D <sub>X1</sub>	D <sub>X0</sub>	Output Voltage
00 <sub>H</sub>	0	0	0	0	0	0	V <sub>0</sub>
01 <sub>H</sub>	0	0	0	0	0	1	V <sub>2</sub> + (V <sub>1</sub> - V <sub>2</sub> ) × 6/7
02 <sub>H</sub>	0	0	0	0	1	0	V <sub>2</sub> + (V <sub>1</sub> - V <sub>2</sub> ) × 5/7
03 <sub>H</sub>	0	0	0	0	1	1	V <sub>2</sub> + (V <sub>1</sub> - V <sub>2</sub> ) × 4/7
04 <sub>H</sub>	0	0	0	1	0	0	V <sub>2</sub> + (V <sub>1</sub> - V <sub>2</sub> ) × 3/7
05 <sub>H</sub>	0	0	0	1	0	1	V <sub>2</sub> + (V <sub>1</sub> - V <sub>2</sub> ) × 2/7
06 <sub>H</sub>	0	0	0	1	1	0	V <sub>2</sub> + (V <sub>1</sub> - V <sub>2</sub> ) × 1/7
07 <sub>H</sub>	0	0	0	1	1	1	V <sub>2</sub>
08 <sub>H</sub>	0	0	1	0	0	0	V <sub>3</sub> + (V <sub>2</sub> - V <sub>3</sub> ) × 7/8
09 <sub>H</sub>	0	0	1	0	0	1	V <sub>3</sub> + (V <sub>2</sub> - V <sub>3</sub> ) × 6/8
0A <sub>H</sub>	0	0	1	0	1	0	V <sub>3</sub> + (V <sub>2</sub> - V <sub>3</sub> ) × 5/8
0B <sub>H</sub>	0	0	1	0	1	1	V <sub>3</sub> + (V <sub>2</sub> - V <sub>3</sub> ) × 4/8
0C <sub>H</sub>	0	0	1	1	0	0	V <sub>3</sub> + (V <sub>2</sub> - V <sub>3</sub> ) × 3/8
0D <sub>H</sub>	0	0	1	1	0	1	V <sub>3</sub> + (V <sub>2</sub> - V <sub>3</sub> ) × 2/8
0E <sub>H</sub>	0	0	1	1	1	0	V <sub>3</sub> + (V <sub>2</sub> - V <sub>3</sub> ) × 1/8
0F <sub>H</sub>	0	0	1	1	1	1	V <sub>3</sub>
10 <sub>H</sub>	0	1	0	0	0	0	V <sub>4</sub> + (V <sub>3</sub> - V <sub>4</sub> ) × 7/8
11 <sub>H</sub>	0	1	0	0	0	1	V <sub>4</sub> + (V <sub>3</sub> - V <sub>4</sub> ) × 6/8
12 <sub>H</sub>	0	1	0	0	1	0	V <sub>4</sub> + (V <sub>3</sub> - V <sub>4</sub> ) × 5/8
13 <sub>H</sub>	0	1	0	0	1	1	V <sub>4</sub> + (V <sub>3</sub> - V <sub>4</sub> ) × 4/8
14 <sub>H</sub>	0	1	0	1	0	0	V <sub>4</sub> + (V <sub>3</sub> - V <sub>4</sub> ) × 3/8
15 <sub>H</sub>	0	1	0	1	0	1	V <sub>4</sub> + (V <sub>3</sub> - V <sub>4</sub> ) × 2/8
16 <sub>H</sub>	0	1	0	1	1	0	V <sub>4</sub> + (V <sub>3</sub> - V <sub>4</sub> ) × 1/8
17 <sub>H</sub>	0	1	0	1	1	1	V <sub>4</sub>
18 <sub>H</sub>	0	1	1	0	0	0	V <sub>5</sub> + (V <sub>4</sub> - V <sub>5</sub> ) × 7/8
19 <sub>H</sub>	0	1	1	0	0	1	V <sub>5</sub> + (V <sub>4</sub> - V <sub>5</sub> ) × 6/8
1A <sub>H</sub>	0	1	1	0	1	0	V <sub>5</sub> + (V <sub>4</sub> - V <sub>5</sub> ) × 5/8
1B <sub>H</sub>	0	1	1	0	1	1	V <sub>5</sub> + (V <sub>4</sub> - V <sub>5</sub> ) × 4/8
1C <sub>H</sub>	0	1	1	1	0	0	V <sub>5</sub> + (V <sub>4</sub> - V <sub>5</sub> ) × 3/8
1D <sub>H</sub>	0	1	1	1	0	1	V <sub>5</sub> + (V <sub>4</sub> - V <sub>5</sub> ) × 2/8
1E <sub>H</sub>	0	1	1	1	1	0	V <sub>5</sub> + (V <sub>4</sub> - V <sub>5</sub> ) × 1/8
1F <sub>H</sub>	0	1	1	1	1	1	V <sub>5</sub>
20 <sub>H</sub>	1	0	0	0	0	0	V <sub>6</sub> + (V <sub>5</sub> - V <sub>6</sub> ) × 7/8
21 <sub>H</sub>	1	0	0	0	0	1	V <sub>6</sub> + (V <sub>5</sub> - V <sub>6</sub> ) × 6/8
22 <sub>H</sub>	1	0	0	0	1	0	V <sub>6</sub> + (V <sub>5</sub> - V <sub>6</sub> ) × 5/8
23 <sub>H</sub>	1	0	0	0	1	1	V <sub>6</sub> + (V <sub>5</sub> - V <sub>6</sub> ) × 4/8
24 <sub>H</sub>	1	0	0	1	0	0	V <sub>6</sub> + (V <sub>5</sub> - V <sub>6</sub> ) × 3/8
25 <sub>H</sub>	1	0	0	1	0	1	V <sub>6</sub> + (V <sub>5</sub> - V <sub>6</sub> ) × 2/8
26 <sub>H</sub>	1	0	0	1	1	0	V <sub>6</sub> + (V <sub>5</sub> - V <sub>6</sub> ) × 1/8
27 <sub>H</sub>	1	0	0	1	1	1	V <sub>6</sub>
28 <sub>H</sub>	1	0	1	0	0	0	V <sub>7</sub> + (V <sub>6</sub> - V <sub>7</sub> ) × 7/8
29 <sub>H</sub>	1	0	1	0	0	1	V <sub>7</sub> + (V <sub>6</sub> - V <sub>7</sub> ) × 6/8
2A <sub>H</sub>	1	0	1	0	1	0	V <sub>7</sub> + (V <sub>6</sub> - V <sub>7</sub> ) × 5/8
2B <sub>H</sub>	1	0	1	0	1	1	V <sub>7</sub> + (V <sub>6</sub> - V <sub>7</sub> ) × 4/8
2C <sub>H</sub>	1	0	1	1	0	0	V <sub>7</sub> + (V <sub>6</sub> - V <sub>7</sub> ) × 3/8
2D <sub>H</sub>	1	0	1	1	0	1	V <sub>7</sub> + (V <sub>6</sub> - V <sub>7</sub> ) × 2/8
2E <sub>H</sub>	1	0	1	1	1	0	V <sub>7</sub> + (V <sub>6</sub> - V <sub>7</sub> ) × 1/8
2F <sub>H</sub>	1	0	1	1	1	1	V <sub>7</sub>
30 <sub>H</sub>	1	1	0	0	0	0	V <sub>8</sub> + (V <sub>7</sub> - V <sub>8</sub> ) × 7/8
31 <sub>H</sub>	1	1	0	0	0	1	V <sub>8</sub> + (V <sub>7</sub> - V <sub>8</sub> ) × 6/8
32 <sub>H</sub>	1	1	0	0	1	0	V <sub>8</sub> + (V <sub>7</sub> - V <sub>8</sub> ) × 5/8
33 <sub>H</sub>	1	1	0	0	1	1	V <sub>8</sub> + (V <sub>7</sub> - V <sub>8</sub> ) × 4/8
34 <sub>H</sub>	1	1	0	1	0	0	V <sub>8</sub> + (V <sub>7</sub> - V <sub>8</sub> ) × 3/8
35 <sub>H</sub>	1	1	0	1	0	1	V <sub>8</sub> + (V <sub>7</sub> - V <sub>8</sub> ) × 2/8
36 <sub>H</sub>	1	1	0	1	1	0	V <sub>8</sub> + (V <sub>7</sub> - V <sub>8</sub> ) × 1/8
37 <sub>H</sub>	1	1	0	1	1	1	V <sub>8</sub>
38 <sub>H</sub>	1	1	1	0	0	0	V <sub>9</sub> + (V <sub>8</sub> - V <sub>9</sub> ) × 6/7
39 <sub>H</sub>	1	1	1	0	0	1	V <sub>9</sub> + (V <sub>8</sub> - V <sub>9</sub> ) × 5/7
3A <sub>H</sub>	1	1	1	0	1	0	V <sub>9</sub> + (V <sub>8</sub> - V <sub>9</sub> ) × 4/7
3B <sub>H</sub>	1	1	1	0	1	1	V <sub>9</sub> + (V <sub>8</sub> - V <sub>9</sub> ) × 3/7
3C <sub>H</sub>	1	1	1	1	0	0	V <sub>9</sub> + (V <sub>8</sub> - V <sub>9</sub> ) × 2/7
3D <sub>H</sub>	1	1	1	1	0	1	V <sub>9</sub> + (V <sub>8</sub> - V <sub>9</sub> ) × 1/7
3E <sub>H</sub>	1	1	1	1	1	0	V <sub>9</sub>
3F <sub>H</sub>	1	1	1	1	1	1	V <sub>10</sub>

**γ-Corrected Power Circuit**

The reference power supply of the D/A converter consists of a ladder circuit with a total of 64 resistors, and resistance  $\sum r_i$  between  $\gamma$ -corrected power pins differs depending on each pair of  $\gamma$ -corrected power pins. One pair of  $\gamma$ -corrected power pins consists of seven or eight series resistors, and resistance  $\sum r_i$  in the figure below is indicated as the sum of the seven or eight resistors. The resistance ratio between the  $\gamma$ -corrected power pins ( $\sum r_i$  ratio) is designed to be a value relatively close to the ratio of the  $\gamma$ -corrected voltages  $V_1$  through  $V_9$  (gray scale voltages in 8 steps) used in an actual LCD panel. Under ideal conditions where there is no difference between the two, therefore, there is no voltage difference between the voltage of the  $\gamma$ -corrected power supplies and the gray scale voltages in 8 steps of the resistor ladder circuits of the μPD16641, and no current flows into the  $\gamma$ -corrected power pins  $V_1$  through  $V_9$ . As a result, a voltage follower circuit is not necessary.



**Relation between Input Data and Output Data**

Data format : 1 pixel data (6 bits) × RGB (3 dots)

Input width : 18 bits

$R/\bar{L} = H$  (right shift)

Output	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	...	S <sub>239</sub>	S <sub>240</sub>
Data	D <sub>00</sub> to D <sub>05</sub>	D <sub>10</sub> to D <sub>15</sub>	D <sub>20</sub> to D <sub>25</sub>	...	D <sub>10</sub> to D <sub>15</sub>	D <sub>20</sub> to D <sub>25</sub>

$R/\bar{L} = L$  (left shift)

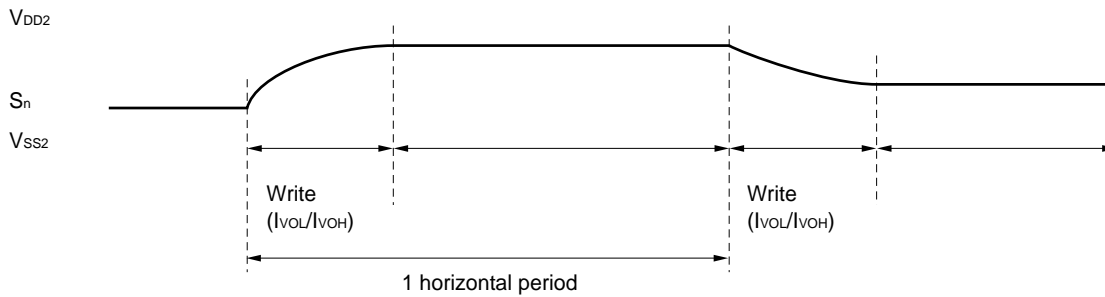
Output	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	...	S <sub>239</sub>	S <sub>240</sub>
Data	D <sub>00</sub> to D <sub>05</sub>	D <sub>10</sub> to D <sub>15</sub>	D <sub>20</sub> to D <sub>25</sub>	...	D <sub>10</sub> to D <sub>15</sub>	D <sub>20</sub> to D <sub>25</sub>

**5. OPERATION OF OUTPUT BUFFER**

The output buffer consists of an operational amplifier circuit that does not perform precharge operation. Therefore, driver output current  $I_{VOH1/2}$  is the charging current to the LCD, and  $I_{VOL1/2}$  is the discharging current.

The chip has the driving capability to charge or discharge a liquid load with  $C_L = 80$  pF to  $3\tau$  in less than  $10\ \mu s$ .

**<LCD panel driving waveform of μPD16641>**





6. ELECTRIC SPECIFICATION

Absolute Maximum Ratings ( $V_{SS1} = V_{SS2} = 0\text{ V}$ )

Parameter	Symbol	Rating	Unit
Supply voltage	$V_{DD1}$	-0.3 to +4.5	V
Supply voltage	$V_{DD2}$	-0.3 to +7.0	V
Input voltage	$V_i$	-0.3 to $V_{DD1,2} + 0.3$	V
Output voltage	$V_o$	-0.3 to $V_{DD1,2} + 0.3$	V
Permissible dissipation	$P_D$	150	mW
Operating temperature range	$T_A$	-10 to +75	°C
Storage temperature range	$T_{stg.}$	-55 to +125	°C

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

Parameter	Symbol	Condition	MIN.	TYP.	MAX.	Unit
Logic supply voltage	$V_{DD1}$		3.0	3.3	3.6	V
Driver supply voltage	$V_{DD2}$	$V_{sel} = H$	3.0	3.3	3.6	V
Driver supply voltage	$V_{DD2}$	$V_{sel} = L$	4.5	5.0	5.5	V
$\gamma$ -corrected power	$V_0$ to $V_{10}$		$V_{SS2} + 0.1$		$V_{DD2} - 0.1$	V
Maximum clock frequency	$f_{max.}$		33			MHz
Output load capacitance	$C_L$				150	pF

Electrical Characteristics (T<sub>A</sub> = -10 to +75°C, V<sub>DD1</sub> = 3.0 to 3.6 V, V<sub>DD2</sub> = 3.0 to 3.6 V or 4.5 to 5.5 V, V<sub>SS1</sub> = V<sub>SS2</sub> = 0 V)

Parameter	Symbol	Condition	MIN.	TYP.	MAX.	Unit		
High-level input voltage	V <sub>IH</sub>	R/L, CLK, STB, STHR (L), D <sub>00-05</sub> , D <sub>10-15</sub> , D <sub>20-25</sub>	0.7V <sub>DD1</sub>		V <sub>DD1</sub>	V		
Low-level input voltage	V <sub>IL</sub>		0		0.3V <sub>DD1</sub>	V		
Input leakage current	I <sub>L</sub>	D <sub>00-05</sub> , D <sub>10-15</sub> , D <sub>20-25</sub> R/L, CLK, STB, STHR (L)			±1.0	μA		
Pull-up resistor	R <sub>PU</sub>	V <sub>sel</sub> , V <sub>DD2</sub> = 5.0 V, V <sub>sel</sub> = 0 V	40	100	250	kΩ		
High-level output voltage	V <sub>OH</sub>	STHR (L), I <sub>o</sub> = -1.0 mA	V <sub>DD1</sub> - 0.5			V		
Low-level output voltage	V <sub>OL</sub>	STHR (L), I <sub>o</sub> = +1.0 mA			0.5	V		
Static current consumption of γ-corrected power (V <sub>DD2</sub> = 3.3 V)	I <sub>Vn1</sub>	V <sub>DD1</sub> = 3.3 V, V <sub>DD2</sub> = 3.3 V V <sub>0</sub> = 3.20 V, V <sub>6</sub> = 1.95 V V <sub>1</sub> = 3.07 V, V <sub>7</sub> = 1.70 V V <sub>2</sub> = 2.80 V, V <sub>8</sub> = 1.46 V V <sub>3</sub> = 2.57 V, V <sub>9</sub> = 1.11 V V <sub>4</sub> = 2.34 V, V <sub>10</sub> = 0.10 V V <sub>5</sub> = 2.12 V, <sup>Note</sup>	V <sub>10</sub>	-200	-150		μA	
			V <sub>9</sub> to V <sub>1</sub>			±10		μA
			V <sub>0</sub>			150	200	μA
Static current consumption of γ-corrected power (V <sub>DD2</sub> = 5.0 V)	I <sub>Vn2</sub>	V <sub>DD1</sub> = 3.3 V, V <sub>DD2</sub> = 5.0 V V <sub>0</sub> = 4.90 V, V <sub>6</sub> = 2.96 V V <sub>1</sub> = 4.69 V, V <sub>7</sub> = 2.58 V V <sub>2</sub> = 4.28 V, V <sub>8</sub> = 2.20 V V <sub>3</sub> = 3.92 V, V <sub>9</sub> = 1.66 V V <sub>4</sub> = 3.56 V, V <sub>10</sub> = 0.1 V V <sub>5</sub> = 3.23 V, <sup>Note</sup>	V <sub>10</sub>	-300	-250		μA	
			V <sub>9</sub> to V <sub>1</sub>			±10		μA
			V <sub>0</sub>			250	300	μA

(V<sub>x</sub> is output voltage of analog output pin S<sub>1</sub> to S<sub>240</sub>. V<sub>OUT</sub> is the voltage applied to analog output pin S<sub>1</sub> to S<sub>240</sub>.)

**Note** Apply ideal voltage to V<sub>1</sub> to V<sub>9</sub> that is calculated from internal resistor.

**Electrical Characteristics (T<sub>A</sub> = -10 to +75°C, V<sub>DD1</sub> = 3.0 to 3.6 V, V<sub>DD2</sub> = 3.0 to 3.6 V or 4.5 to 5.5 V, V<sub>SS1</sub> = V<sub>SS2</sub> = 0 V)**

Parameter	Symbol	Condition	MIN.	TYP.	MAX.	Unit
Driver output current (V <sub>DD2</sub> = 3.3 V)	I <sub>VOH1</sub>	STB = 3.3 V V <sub>OUT</sub> = 2.2 V, V <sub>X</sub> = 3.2 V V <sub>DD1</sub> = V <sub>DD2</sub> = 3.3 V		-0.3	-0.075	mA
	I <sub>VOL1</sub>	STB = 3.3 V V <sub>OUT</sub> = 1.1 V, V <sub>X</sub> = 0.1 V V <sub>DD1</sub> = V <sub>DD2</sub> = 3.3 V	0.075	0.25		mA
Driver output current (V <sub>DD2</sub> = 5.0 V)	I <sub>VOH2</sub>	STB = 5.0 V V <sub>OUT</sub> = 3.9 V, V <sub>X</sub> = 4.9 V V <sub>DD1</sub> = 3.3 V, V <sub>DD2</sub> = 5.0 V		-0.3	-0.1	mA
	I <sub>VOL2</sub>	STB = 5.0 V V <sub>OUT</sub> = 1.1 V, V <sub>X</sub> = 0.1 V V <sub>DD1</sub> = 3.3 V, V <sub>DD2</sub> = 5.0 V	0.1	0.25		mA
Output voltage deviation	ΔV <sub>O</sub>	V <sub>DD1</sub> = 3.3 V, V <sub>DD2</sub> = 3.3 V V <sub>OUT</sub> = 1.65		±20	±25	mV
		V <sub>DD1</sub> = 3.3 V, V <sub>DD2</sub> = 5.0 V V <sub>OUT</sub> = 2.50 V		±20	±25	mV
Output voltage range	V <sub>O</sub>	Input data: 00 <sub>H</sub> to 3F <sub>H</sub>	V <sub>SS2</sub> + 0.1		V <sub>DD2</sub> - 0.1	V
Dynamic logic current consumption	I <sub>DD1</sub>	No load <sup>Note</sup>			2.0	mA
Dynamic driver current consumption	I <sub>DD21</sub>	No load, V <sub>DD2</sub> = 3.3 V ± 0.3 V <sup>Note</sup>			5.0	mA
Dynamic driver current consumption	I <sub>DD22</sub>	No load, V <sub>DD2</sub> = 5.0 V ± 0.5 V <sup>Note</sup>			6.5	mA

**Note** The STB cycle is specified at 31 μs and f<sub>CLK</sub> = 16 MHz. Input data: 1010... (checkerboard pattern)  
Refers to current consumption per driver when cascades are connected under the assumption of VGA single-sided mounting (8 units).

**Switching Characteristics** ( $T_A = -10$  to  $+75^\circ\text{C}$ ,  $V_{DD1} = 3.0$  to  $3.6$  V,  $V_{DD2} = 3.0$  to  $3.6$  V or  $4.5$  to  $5.5$  V,  $V_{SS1} = V_{SS2} = 0$  V,  $t_r = t_f = 3.0$  ns)

Parameter	Symbol	Condition	MIN.	TYP.	MAX.	Unit
Start pulse delay time	$t_{PLH1}$	$C_L = 15$ pF	2.0		17	ns
Start pulse delay time	$t_{PHL1}$	$C_L = 15$ pF	2.0		17	ns
Driver output delay time 1	$t_{PLH21}$	$V_{DD2} = 3.3$ V $2$ kΩ + $75$ pF × 2	Vo: 0.1 V → 3.2 V	6.0	12	μs
Driver output delay time 2	$t_{PLH31}$			8.0	14	μs
Driver output delay time 1	$t_{PHL21}$		Vo: 3.2 V → 0.1 V	6.0	10	μs
Driver output delay time 2	$t_{PHL31}$			8.0	12	μs
Driver output delay time 1	$t_{PLH22}$	$V_{DD2} = 5.0$ V $2$ kΩ + $75$ pF × 2	Vo: 0.1 V → 4.9 V	6.0	10	μs
Driver output delay time 2	$t_{PLH32}$			8.0	12	μs
Driver output delay time 1	$t_{PHL22}$		Vo: 4.9 V → 0.1 V	6.0	8.0	μs
Driver output delay time 2	$t_{PHL32}$			8.0	10	μs
Input capacitance	$C_{I1}$	$V_0$ to $V_{10}$ , $T_A = 25^\circ\text{C}$		100		pF
Input capacitance	$C_{I2}$	STHR (L), $T_A = 25^\circ\text{C}$		10	15	pF
Input capacitance	$C_{I3}$	STHR (L), other than $V_0$ to $V_{10}$ $T_A = 25^\circ\text{C}$		7.0	10	pF

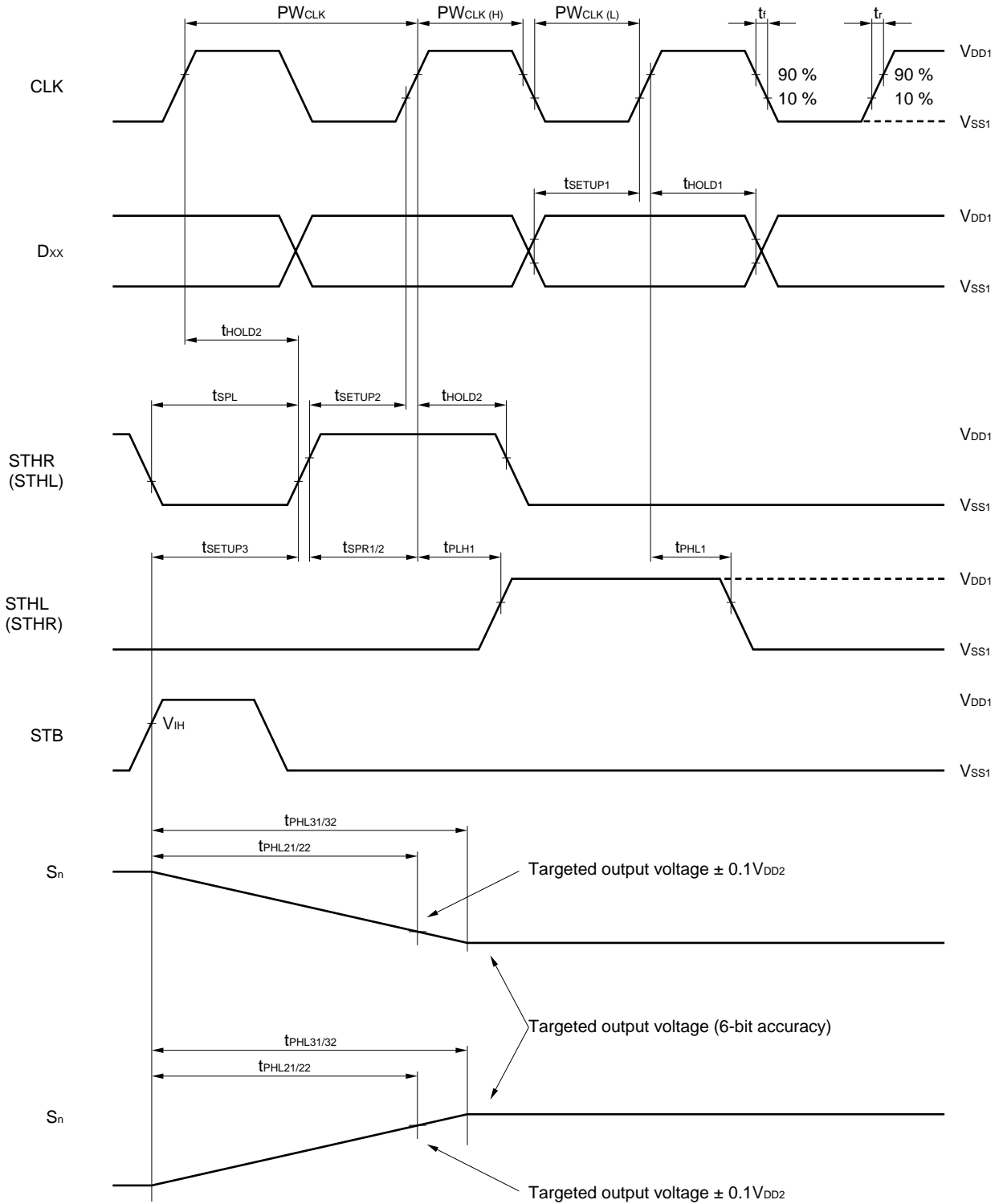
**Timing Requirements** ( $T_A = -10$  to  $+75^\circ\text{C}$ ,  $V_{DD1} = 3.0$  to  $3.6$  V,  $V_{DD2} = 3.0$  to  $3.6$  V or  $4.5$  to  $5.5$  V,  $V_{SS1} = V_{SS2} = 0$  V,  $t_r = t_f = 3.0$  ns)

Parameter	Symbol	Condition	MIN.	TYP.	MAX.	Unit
Clock pulse width	$PW_{CLK}$		22			ns
Clock low period	$PW_{CLK(L)}$		4.0			ns
Clock high period	$PW_{CLK(H)}$		4.0			ns
Data setup time	$t_{SETUP1}$		2.0			ns
Data hold time	$t_{HOLD1}$		2.0			ns
Start pulse setup time	$t_{SETUP2}$		2.0			ns
Start pulse hold time	$t_{HOLD2}$		2.0			ns
Start pulse low period	$t_{SPL}$		2			CLK
Start pulse rise time	$t_{SPR}$		80			CLK
STB setup time	$t_{SETUP3}$		1			CLK
Data invalid period	$t_{INV}$		1			CLK
Final data timing	$t_{LDT}$				1	CLK
CLK-STB time	$t_{CLK-STB}$	CLK ↑ → STB ↑ or ↓	7.0			ns
STB-CLK time	$t_{STB-CLK}$	STB ↑ or ↓ → CLK ↑	7.0			ns

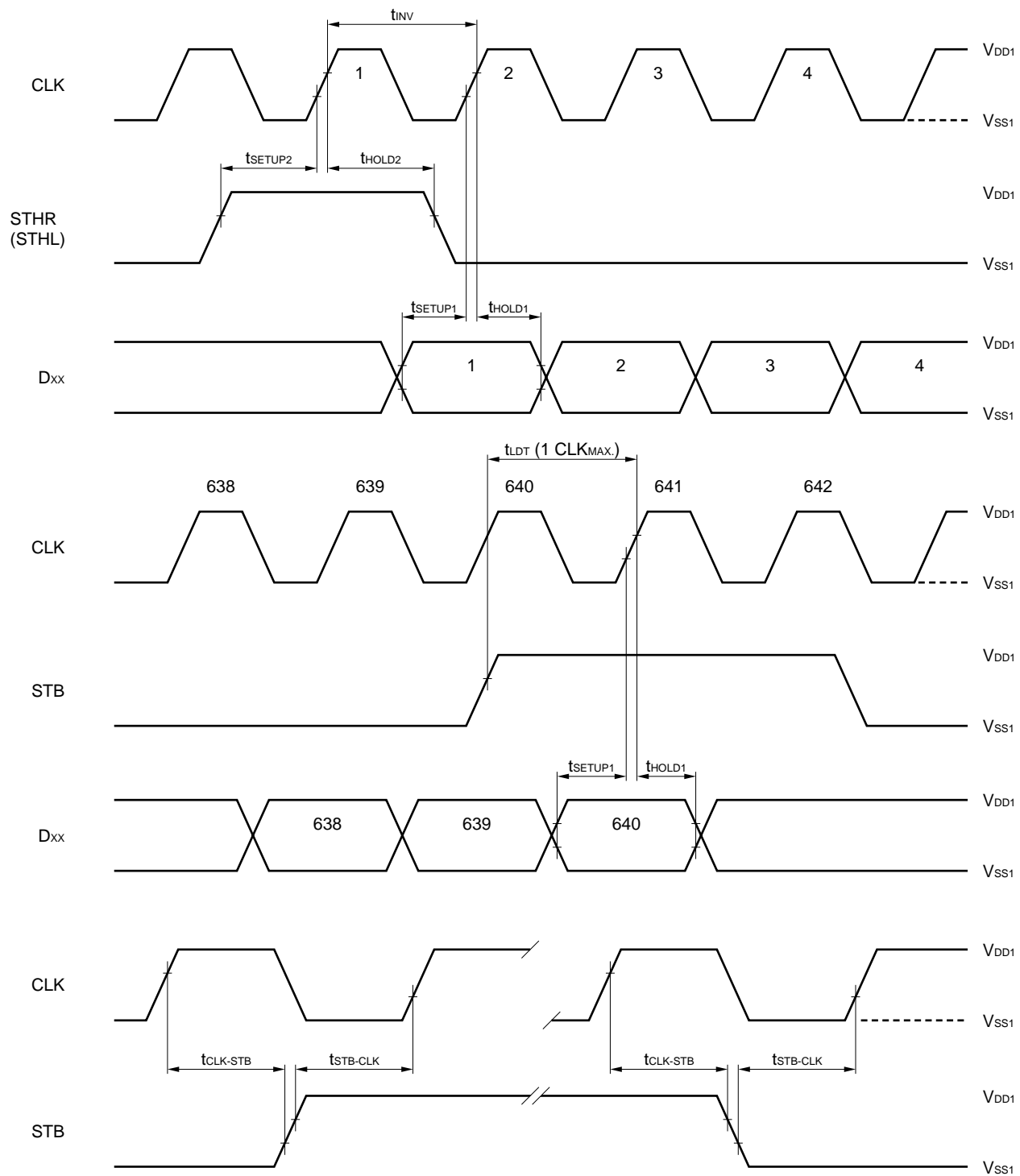
7. SWITCHING CHARACTERISTIC WAVEFORM (R/L = H)

The figures in parenthesis indicate R/L = L

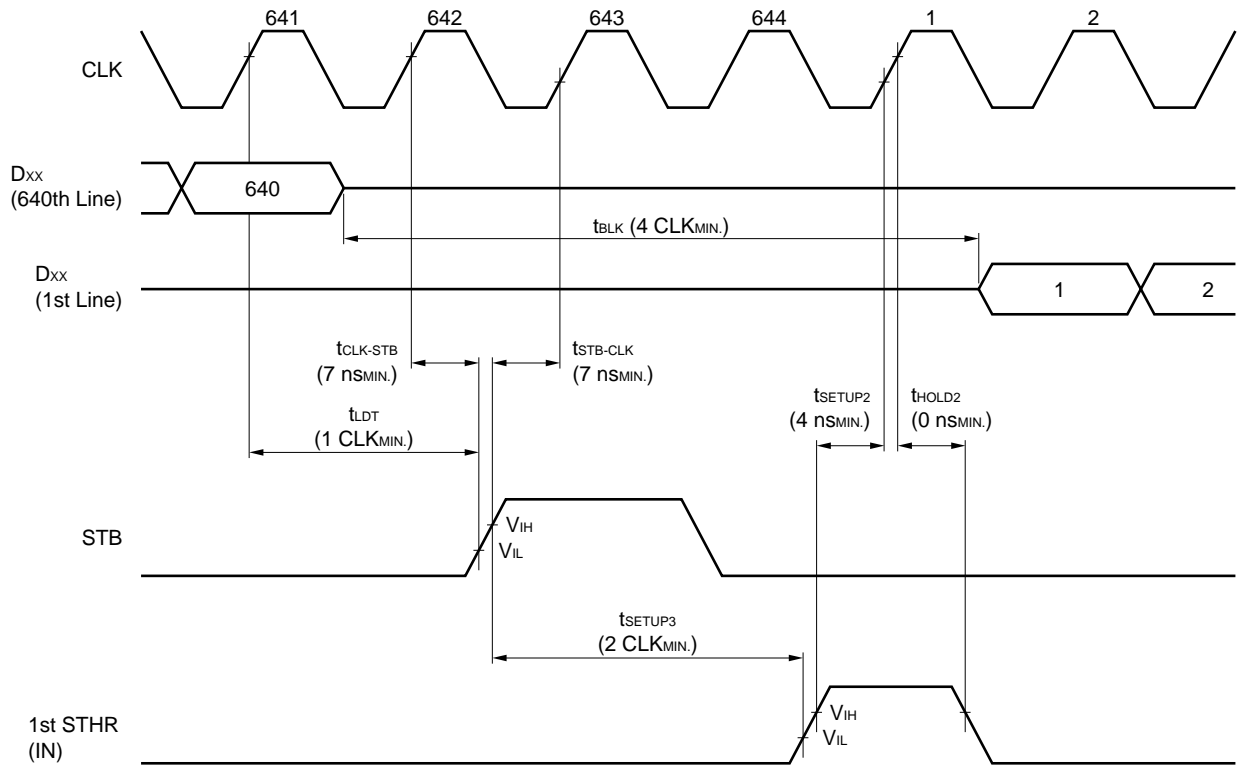
Unless otherwise specified, the input level is  $V_{IH} = 0.7 V_{DD1}$ ,  $V_{IL} = 0.3 V_{DD1}$ .



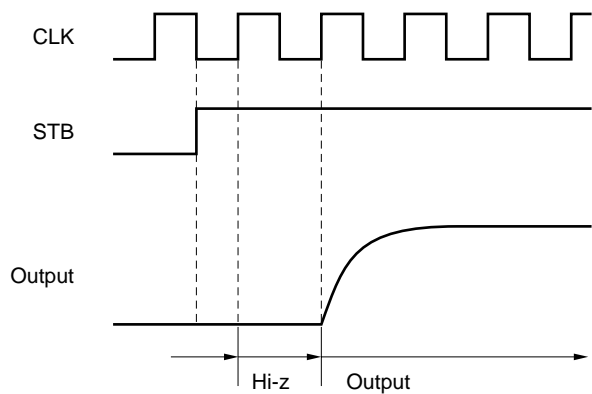
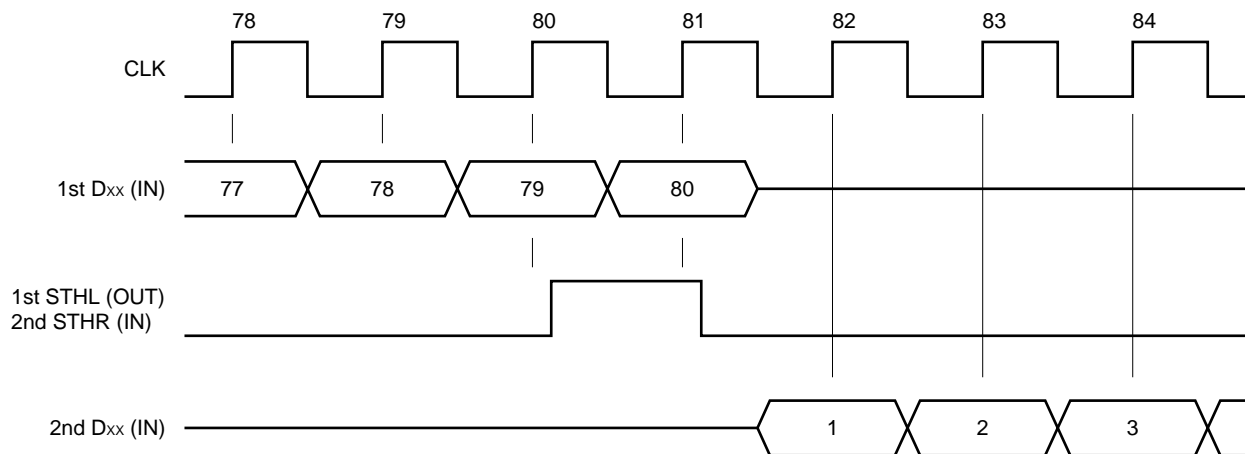
Switching Characteristic Waveform



8. RELATION BETWEEN STB/STHR, STHL AND BLANKING PERIOD



9. DATA INPUT TIMING IN CASCADE CONNECTION





**10. RECOMMENDED MOUNTING CONDITIONS**

Mounting this product under the following conditions is recommended.

For the mounting methods and conditions other than those recommended, consult NEC.

Mounting Conditions	Mounting Method	Conditions
Thermocompression bonding	Soldering	Heating tool: 300 to 350°C, Heating time: 2 to 3 seconds, Pressure: 100 g (per product)
	ACF (sheet adhesive)	Preliminary adhesion: 70 to 100°C, Pressure: 3 to 8 kg/cm <sup>2</sup> , Time: 3 to 5 seconds Real adhesion: 165 to 180°C, Pressure: 25 to 45 kg/cm <sup>2</sup> , Time 30 to 40 seconds (when SUMIZAC1003 of Sumitomo Bakelite is used)

**Note** For the mounting conditions for ACF, consult the ACF manufacturer.  
Do not use two or more mounting methods in combination.

**Reference**

NEC Semiconductor Device Reliability/Quality Control System (C10983E)  
Quality Grades to NEC's Semiconductor Devices (C11531E)

[MEMO]

[MEMO]

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Anti-radioactive design is not implemented in this product.