DATA SHEET

NEC

MOS INTEGRATED CIRCUIT

μPD16640B

300/309-OUTPUT TFT-LCD SOURCE DRIVER (64-GRAY SCALE)

The μPD16640B 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 × 3 dots, and 260,000 colors can be displayed in 64-value outputs γ-corrected by the internal D/A converter and 11 external power supplies.

The clock frequency is 55 MHz MIN. By switching over the number of outputs between 300 and 309, the μPD16640B can be used in TFT-LCD panels conforming to the SVGA/XGA standards.

★ FEATURES

- CMOS level input
- 6 bits (gray scale data) × 3 dots input
- 64-value output by 11 external power supplies and internal D/A converter
- Output voltage range: V_{SS2} + 0.1 V to V_{DD2} – 0.1 V
- High-speed data transfer: $f_{MAX.}$ = 55 MHz MIN. (internal data transfer speed when operating at 3.0 V)
- Precharge-less output buffer
- Level of γ-corrected power supply can be inverted
- Number of outputs selectable (O_{sel} = H: 300 outputs, O_{sel} = L: 309 outputs)
- Supply voltage of driver circuit selectable (V_{sel} = H: 3.3 V, V_{sel} = L: 5.0 V)
- Slim TCP
- Input data inversion function (INV)
- Logic power supply (V_{DD1}): 3.3 V ± 0.3 V
- Driver power supply (V_{DD2}): 3.3 V ± 0.3 V (V_{sel} = H)
  5.0 V ± 0.5 V (V_{sel} = L)

ORDERING INFORMATION

Part Number	Package
μPD16640BN-xxx	TCP (TAB package)

Remark The TCP's external shape is custom-order item. Users are requested to consult with a NEC sales representative.

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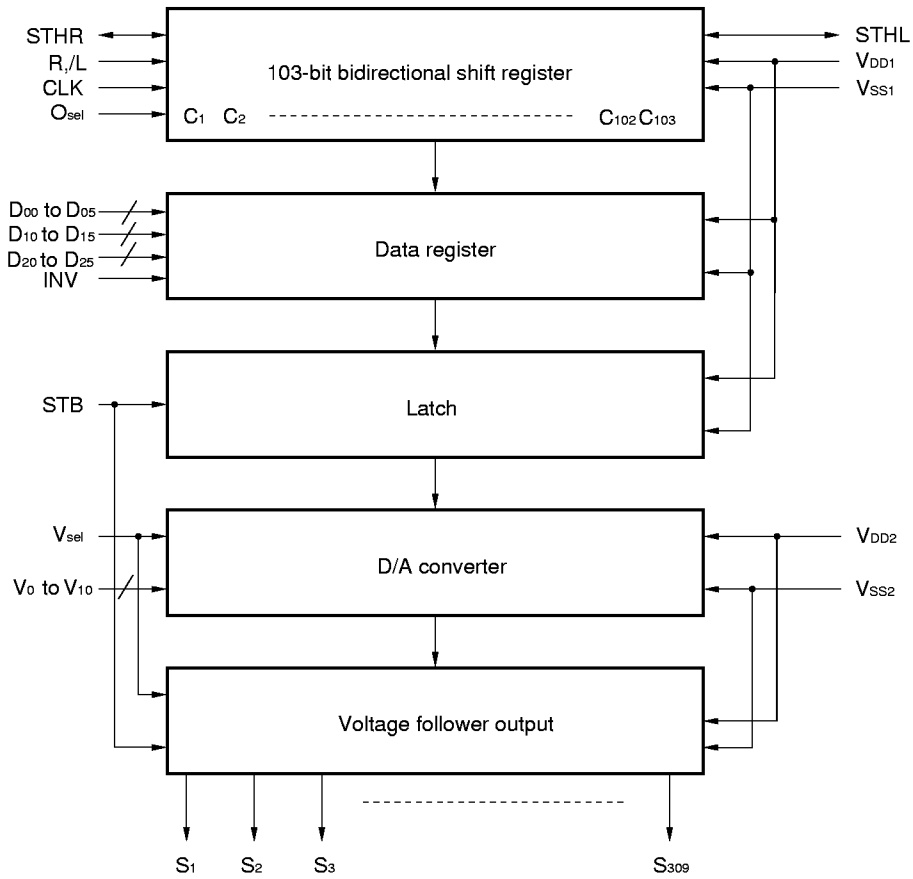
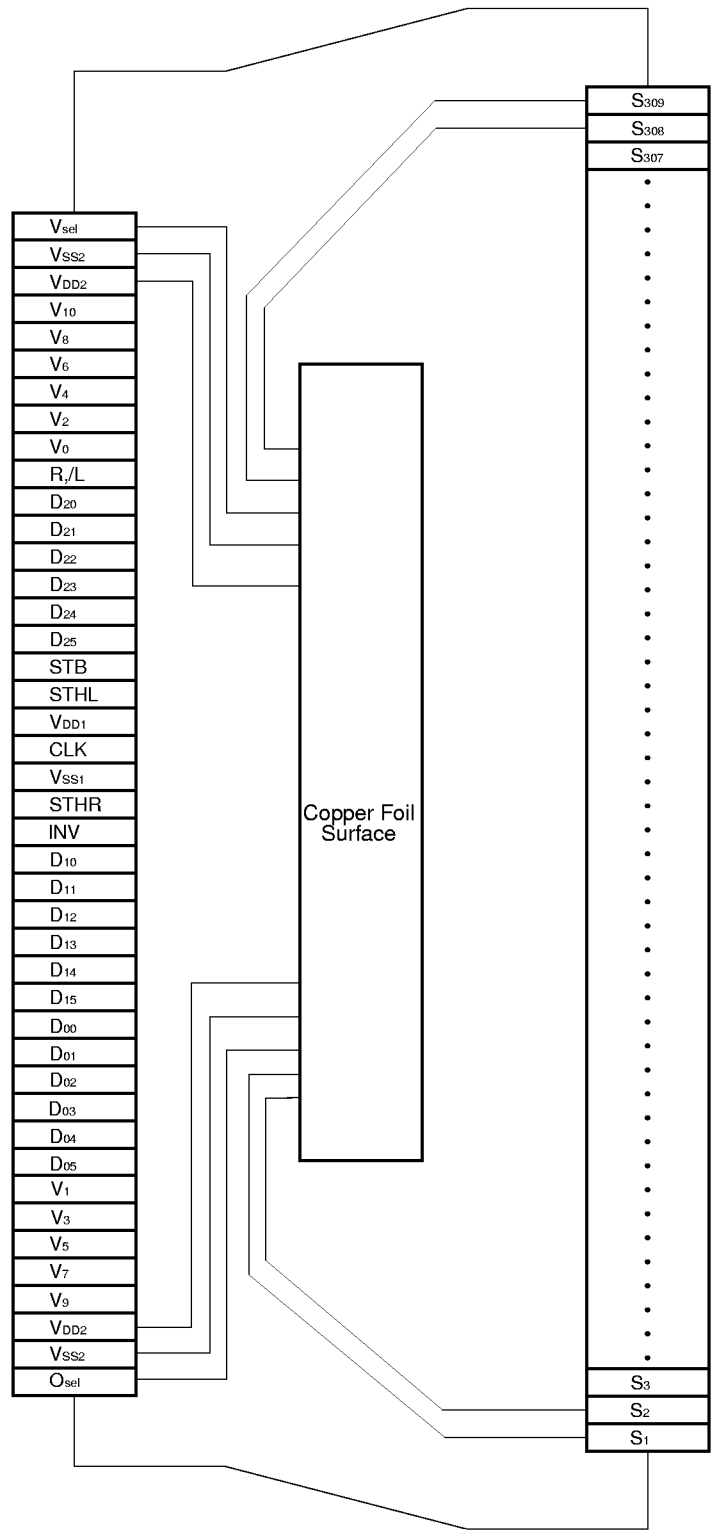
The mark ★ shows major revised points.

★ 1. BLOCK DIAGRAM



Remark /xxx indicates active low signal.

2. PIN CONFIGURATION (μPD16640BN-xxx)



Remark O_{sel} and V_{sel} pins are internally pulled up.

Therefore, the number of input pins can be reduced by opening or short-circuiting these pins to V_{SS2} by means of TCP wiring.

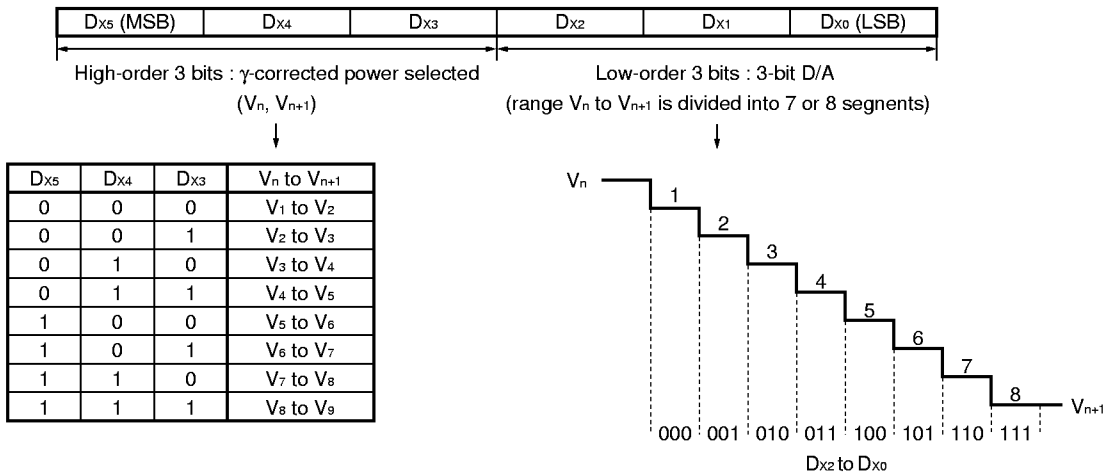
3. PIN DESCRIPTION

Pin Symbol	Pin Name	Description
S_1 to S_{309}	Driver output	Output 64 gray scale analog voltages converted from digital signals. O_{sel} = H: 300 outputs ($S_1 \rightarrow S_{150}$, $S_{160} \rightarrow S_{309}$) O_{sel} = L: 309 outputs ($S_1 \rightarrow S_{309}$) Output pins S_{151} to S_{159} are invalid in 300-output mode.
D_{00} to D_{05} D_{10} to D_{15} D_{20} to D_{25}	Display data input	Inputs 18-bit-wide display gray scale data (6 bits) × 3 dots (RGB). D_{x0}: LSB, D_{x5}: MSB
R,/L	Shift direction select input	This pin inputs/outputs start pulses in cascade mode. Shift direction of shift register is as follows: R/L = H: STHR input, $S_1 \rightarrow S_{309}$, STHL output R/L = L : STHL input, $S_{309} \rightarrow S_1$, STHR output
STHR	Right shift start pulse I/O	R/L = H: Inputs start pulse. R/L = L : Outputs start pulse.
STHL	Left shift start pulse I/O	R/L = H: Outputs start pulse. R/L = L : Inputs start pulse.
O_{sel}	Number of output selection	Selects number of outputs. This pin is internally pulled up by V_{DD1} power supply. O_{sel} = H: 300 outputs O_{sel} = L: 309 outputs
V_{sel}	Driver voltage selection	Selects driver voltage. This pin is internally pulled up by V_{DD2} power supply. V_{sel} = H: V_{DD2} = 3.3 V V_{sel} = L: V_{DD2} = 5.0 V
CLK	Shift clock input	Inputs shift clock to shift register. Display data is loaded to data register at rising edge of this pin. When O_{sel} = H, start pulse output goes high at rising edge of 100th clock after start pulse has been input, and serves as start pulse to driver in next stage. 100th clock of driver in first stage serves as start pulse of driver in next stage. When O_{sel} = L, start pulse output goes high at rising edge of 103rd clock after start pulse has been input, and serves as start pulse to driver in next stage. 103rd 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 internal shift register are cleared after STB has been input. One pulse of this signal is input when μPD16640B is started, and then device operates normally. For STB input timing, refer to **8. Switching Characteristic Waveform.**
★ V_0 to V_{10}	γ-corrected power supply	Inputs γ-corrected power from external source. $V_{SS2} + 0.1\ V \leq V_{10} \leq V_9 \leq V_8 \leq V_7 \leq V_6 \leq V_5 \leq V_4 \leq V_3 \leq V_2 \leq V_1 \leq V_0 \leq V_{DD2} - 0.1\ V$ or $V_{SS2} + 0.1\ V \leq V_0 \leq V_1 \leq V_2 \leq V_3 \leq V_4 \leq V_5 \leq V_6 \leq V_7 \leq V_8 \leq V_9 \leq V_{10} \leq V_{DD2} - 0.1\ V$ Maintain gray scale power supply during gray scale voltage output.
INV	Data inversion input	Input data can be inverted when display data is loaded. INV = H: Inverts and loads input data. INV = L: Does not invert input data.
V_{DD1}	Logic circuit power supply	3.3 V ± 0.3 V
V_{DD2}	Driver circuit power supply	V_{sel} = H: V_{DD2} = 3.3 V ± 0.3 V V_{sel} = L: V_{DD2} = 5.0 V ± 0.5 V
V_{SS1}	Logic ground	Ground
V_{SS2}	Driver ground	Ground

Caution Be sure to turn on power in the order V_{DD1}, logic input, V_{DD2}, and gray scale power (V_0 to V_{10}), and turn off power in the reverse order, to prevent the μPD16640B 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 γ 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-grayscale voltage.



D_{X5}	D_{X4}	D_{X3}	V_n to V_{n+1}
0	0	0	V_1 to V_2
0	0	1	V_2 to V_3
0	1	0	V_3 to V_4
0	1	1	V_4 to V_5
1	0	0	V_5 to V_6
1	0	1	V_6 to V_7
1	1	0	V_7 to V_8
1	1	1	V_8 to V_9

Figure4–1. Relationship between Input Data and γ-corrected Voltage

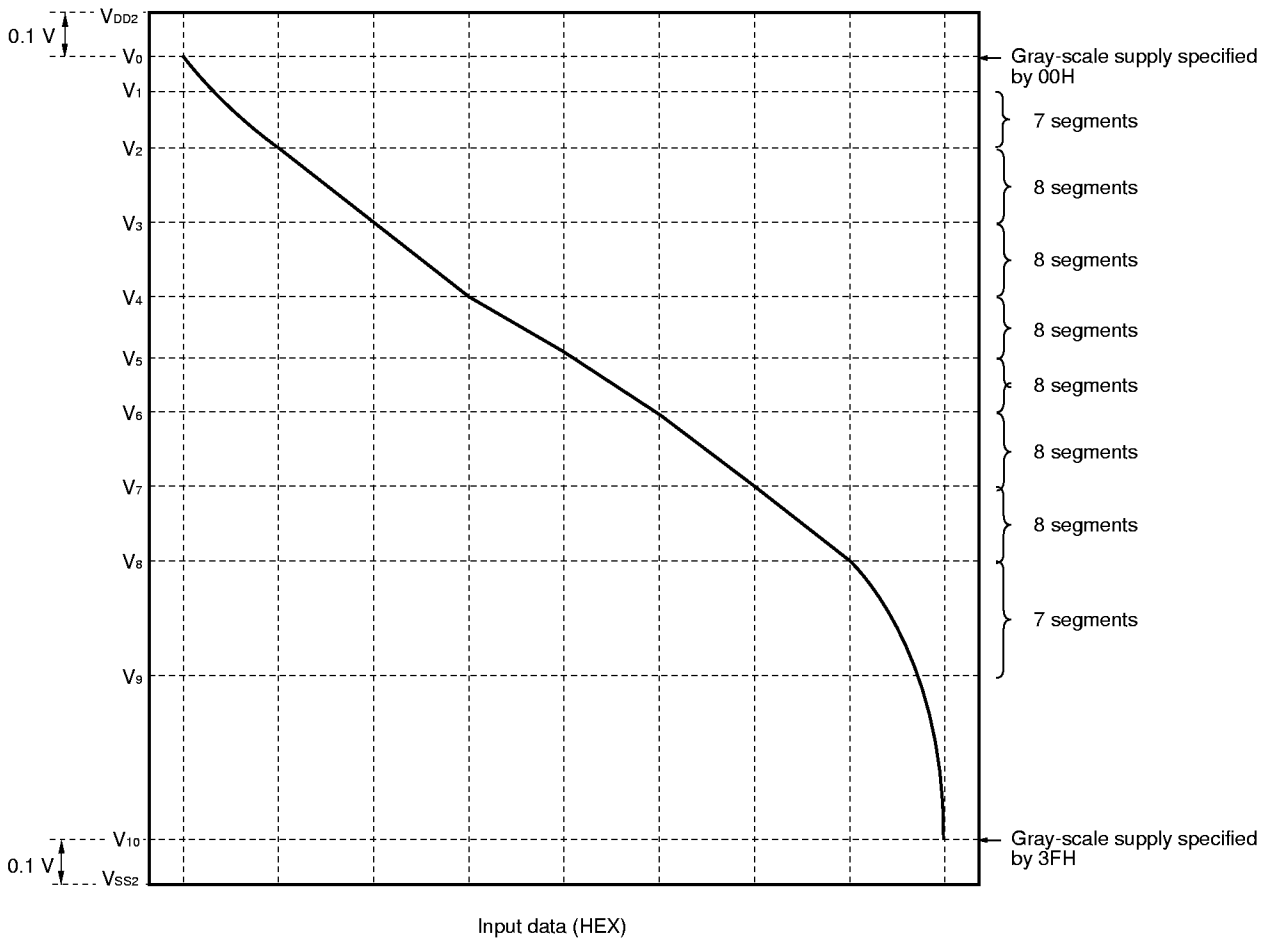


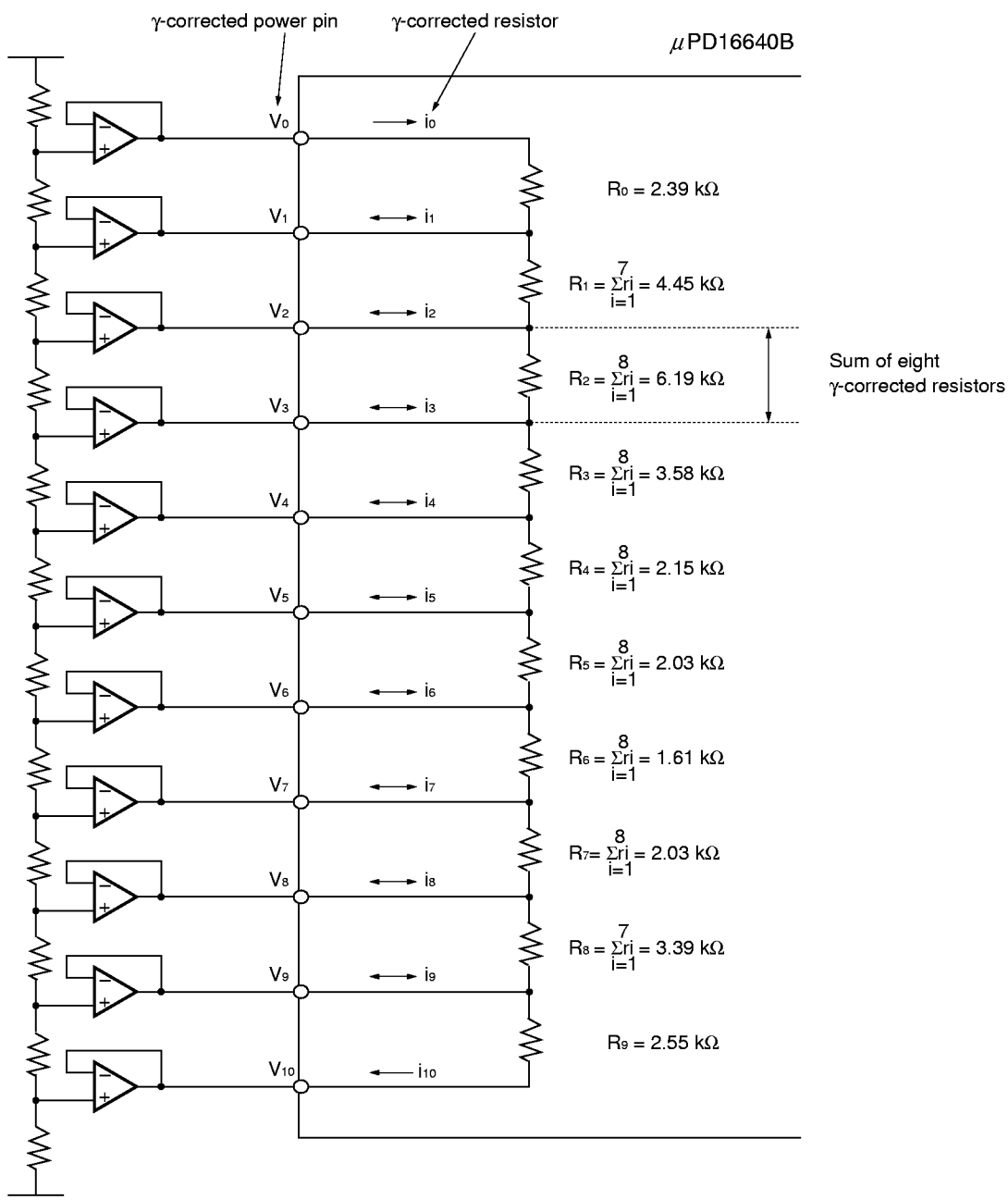
Table4–1. Relation between Input Data and Output Voltage

Input Data	D_{X5}	D_{X4}	D_{X3}	D_{X2}	D_{X1}	D_{X0}	Output Voltage
00H	0	0	0	0	0	0	V_0
01H	0	0	0	0	0	1	$V_2 + (V_1 - V_2) \times 6/7$
02H	0	0	0	0	1	0	$V_2 + (V_1 - V_2) \times 5/7$
03H	0	0	0	0	1	1	$V_2 + (V_1 - V_2) \times 4/7$
04H	0	0	0	1	0	0	$V_2 + (V_1 - V_2) \times 3/7$
05H	0	0	0	1	0	1	$V_2 + (V_1 - V_2) \times 2/7$
06H	0	0	0	1	1	0	$V_2 + (V_1 - V_2) \times 1/7$
07H	0	0	0	1	1	1	V_2
08H	0	0	1	0	0	0	$V_3 + (V_2 - V_3) \times 7/8$
09H	0	0	1	0	0	1	$V_3 + (V_2 - V_3) \times 6/8$
0AH	0	0	1	0	1	0	$V_3 + (V_2 - V_3) \times 5/8$
0BH	0	0	1	0	1	1	$V_3 + (V_2 - V_3) \times 4/8$
0CH	0	0	1	1	0	0	$V_3 + (V_2 - V_3) \times 3/8$
0DH	0	0	1	1	0	1	$V_3 + (V_2 - V_3) \times 2/8$
0EH	0	0	1	1	1	0	$V_3 + (V_2 - V_3) \times 1/8$
0FH	0	0	1	1	1	1	V_3
10H	0	1	0	0	0	0	$V_4 + (V_3 - V_4) \times 7/8$
11H	0	1	0	0	0	1	$V_4 + (V_3 - V_4) \times 6/8$
12H	0	1	0	0	1	0	$V_4 + (V_3 - V_4) \times 5/8$
13H	0	1	0	0	1	1	$V_4 + (V_3 - V_4) \times 4/8$
14H	0	1	0	1	0	0	$V_4 + (V_3 - V_4) \times 3/8$
15H	0	1	0	1	0	1	$V_4 + (V_3 - V_4) \times 2/8$
16H	0	1	0	1	1	0	$V_4 + (V_3 - V_4) \times 1/8$
17H	0	1	0	1	1	1	V_4
18H	0	1	1	0	0	0	$V_5 + (V_4 - V_5) \times 7/8$
19H	0	1	1	0	0	1	$V_5 + (V_4 - V_5) \times 6/8$
1AH	0	1	1	0	1	0	$V_5 + (V_4 - V_5) \times 5/8$
1BH	0	1	1	0	1	1	$V_5 + (V_4 - V_5) \times 4/8$
1CH	0	1	1	1	0	0	$V_5 + (V_4 - V_5) \times 3/8$
1DH	0	1	1	1	0	1	$V_5 + (V_4 - V_5) \times 2/8$
1EH	0	1	1	1	1	0	$V_5 + (V_4 - V_5) \times 1/8$
1FH	0	1	1	1	1	1	V_5
20H	1	0	0	0	0	0	$V_6 + (V_5 - V_6) \times 7/8$
21H	1	0	0	0	0	1	$V_6 + (V_5 - V_6) \times 6/8$
22H	1	0	0	0	1	0	$V_6 + (V_5 - V_6) \times 5/8$
23H	1	0	0	0	1	1	$V_6 + (V_5 - V_6) \times 4/8$
24H	1	0	0	1	0	0	$V_6 + (V_5 - V_6) \times 3/8$
25H	1	0	0	1	0	1	$V_6 + (V_5 - V_6) \times 2/8$
26H	1	0	0	1	1	0	$V_6 + (V_5 - V_6) \times 1/8$
27H	1	0	0	1	1	1	V_6
28H	1	0	1	0	0	0	$V_7 + (V_6 - V_7) \times 7/8$
29H	1	0	1	0	0	1	$V_7 + (V_6 - V_7) \times 6/8$
2AH	1	0	1	0	1	0	$V_7 + (V_6 - V_7) \times 5/8$
2BH	1	0	1	0	1	1	$V_7 + (V_6 - V_7) \times 4/8$
2CH	1	0	1	1	0	0	$V_7 + (V_6 - V_7) \times 3/8$
2DH	1	0	1	1	0	1	$V_7 + (V_6 - V_7) \times 2/8$
2EH	1	0	1	1	1	0	$V_7 + (V_6 - V_7) \times 1/8$
2FH	1	0	1	1	1	1	V_7
30H	1	1	0	0	0	0	$V_8 + (V_7 - V_8) \times 7/8$
31H	1	1	0	0	0	1	$V_8 + (V_7 - V_8) \times 6/8$
32H	1	1	0	0	1	0	$V_8 + (V_7 - V_8) \times 5/8$
33H	1	1	0	0	1	1	$V_8 + (V_7 - V_8) \times 4/8$
34H	1	1	0	1	0	0	$V_8 + (V_7 - V_8) \times 3/8$
35H	1	1	0	1	0	1	$V_8 + (V_7 - V_8) \times 2/8$
36H	1	1	0	1	1	0	$V_8 + (V_7 - V_8) \times 1/8$
37H	1	1	0	1	1	1	V_8
38H	1	1	1	0	0	0	$V_9 + (V_8 - V_9) \times 6/7$
39H	1	1	1	0	0	1	$V_9 + (V_8 - V_9) \times 5/7$
3AH	1	1	1	0	1	0	$V_9 + (V_8 - V_9) \times 4/7$
3BH	1	1	1	0	1	1	$V_9 + (V_8 - V_9) \times 3/7$
3CH	1	1	1	1	0	0	$V_9 + (V_8 - V_9) \times 2/7$
3DH	1	1	1	1	0	1	$V_9 + (V_8 - V_9) \times 1/7$
3EH	1	1	1	1	1	0	V_9
3FH	1	1	1	1	1	1	V_{10}

4.1 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 Σri between γ-corrected power pins differs depending on each pair of γ-corrected power pins. One pair of γ-corrected power pins consists of seven or eight series resistors, and resistance Σri in the figure below is indicated as the sum of the seven or eight resistors. The resistance ratio between the γ-corrected power pins (Σri ratio) is designed to be a value relatively close to the ratio of the γ-corrected voltages V_1 to 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 γ-corrected power supplies and the gray-scale voltages in 8 steps of the resistor ladder circuits of the μ PD16640B, and no current flows into the γ-corrected power pins V_1 to V_9. As a result, a voltage-follower circuit is not necessary.

Figure4–2. γ-Corrected Power Circuit



5. RELATIONSHIP BETWEEN OUTPUT CIRCUIT AND D/A CONVERTER

Data format : 1 pixel data (6 bits) × RGB (3 dots)
Input width : 18 bits

R,/L = H (right shift)

Output	S_1	S_2	S_3	···	S_{308}	S_{309}
Data	D_{00} to D_{05}	D_{10} to D_{15}	D_{20} to D_{25}	···	D_{10} to D_{15}	D_{20} to D_{25}

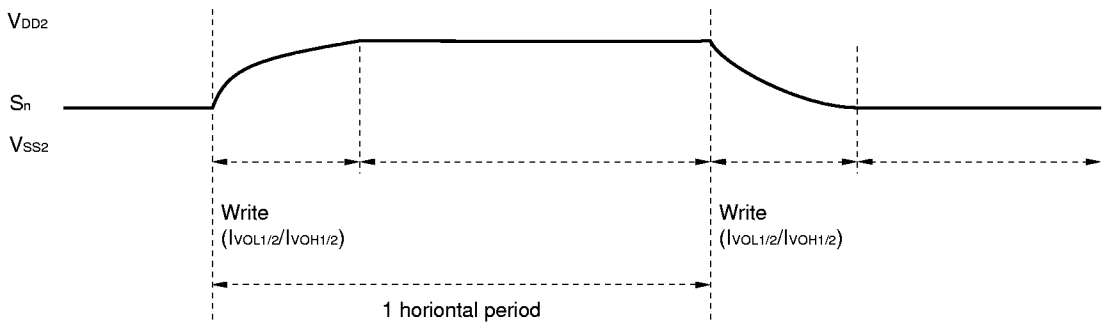
R,/L = L (left shift)

Output	S_1	S_2	S_3	···	S_{308}	S_{309}
Data	D_{00} to D_{05}	D_{10} to D_{15}	D_{20} to D_{25}	···	D_{10} to D_{15}	D_{20} to D_{25}

6. 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.

<LCD panel driving waveform of μPD16640B>



7. ELECTRICAL SPECIFICATIONS

Absolute Maximum Ratings (T_A = 25 °C, V_{SS1} = V_{SS2} = 0 V)

Parameter	Symbol	Ratings	Unit
Logic Power Supply	V_{DD1}	–0.3 to +4.5	V
Driver Power Supply	V_{DD2}	–0.3 to +6.0	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
Operating Ambient Temperature	T_A	–10 to +75	°C
Storage Temperature	T_{stg}	–55 to +125	°C

Caution If the absolute maximum rating of even one of the above parameters is exceeded even momentarily, the quality of the product may be degraded. Absolute maximum ratings, therefore, specify the values exceeding which the product may be physically damaged. Be sure to use the product within the range of the absolute maximum ratings.

Recommended Operating Range (T_A = –10 to +75 °C, V_{SS1} = V_{SS2} = 0 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
		V_{sel} = L	4.5	5.0	5.5	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 Power Voltage	V_0 to V_{10}		V_{SS2} + 0.1		V_{DD2} – 0.1	V
Maximum Clock Frequency	$f_{MAX.}$		55			MHz

Electrical Characteristics (T_A = –10 to +75 °C, V_{DD1} = 3.3 V ± 0.3 V, V_{DD2} = 3.3 V ± 0.3 V or 5.0 V ± 0.5 V, V_{SS1} = V_{SS2} = 0 V)

Parameter	Symbol	Condition		MIN.	TYP.	MAX.	Unit
Input Leakage Current	I_{IL}	R,/L, CLK, STB, INV, STHR(STHL), D_{00} to D_{05}, D_{10} to D_{15}, D_{20} to D_{25}				±1.0	μA
Pull-up Resistor	R_{PU}	V_{DD1} = 3.3 V, O_{sel}, V_{sel}		40	100	250	kΩ
High-Level Output Voltage	V_{OH}	STHR (STHL), I_O = –1.0 mA		V_{DD1} – 0.5			V
Low-Level Output Voltage	V_{OL}	STHR (STHL), I_O = +1.0 mA				0.5	V
Static Current Consumption of γ-Corrected Power (V_{DD2} = 3.3 V or 5.5 V)	I_{Vn1}	V_{DD1} = 3.3 V, V_{DD2} = 3.3 V	V_0 to V_1	100	200	400	μA
			V_1 to V_2	54	109	218	μA
			V_2 to V_3	39	79	158	μA
			V_3 to V_4	68	137	274	μA
			V_4 to V_5	109	219	438	μA
★			V_5 to V_6	116	232	464	μA
			V_6 to V_7	144	288	576	μA
			V_7 to V_8	116	232	464	μA
			V_8 to V_9	72	145	290	μA
			V_9 to V_{10}	92	185	370	μA
Driver Output Current (V_{DD2} = 3.3 V)	I_{VOH1}	STB = 3.3 V, V_{OUT} = 2.7 V, V_X = 3.2 V[Note1], V_{DD1} = V_{DD2} = 3.3 V			–46	–20	μA
	I_{VOL1}	STB = 3.3 V, V_{OUT} = 0.6 V, V_X = 0.1 V[Note1], V_{DD1} = V_{DD2} = 3.3 V		30	62		μA
Driver Output Current (V_{DD2} = 5.0 V)	I_{VOH2}	STB = 5.0 V, V_{OUT} = 4.4 V, V_X = 4.9 V[Note1], V_{DD1} = 3.3 V, V_{DD2} = 5.0 V			–69	–30	μA
	I_{VOL2}	STB = 5.0 V, V_{OUT} = 0.6 V, V_X = 0.1 V[Note1], V_{DD1} = 3.3 V, V_{DD2} = 5.0 V		40	81		μA
Output Voltage Deviation	ΔV_O	V_{DD1} = 3.3 V, V_{DD2} = 3.3 V or 5.0 V, V_{OUT} = 0.5 V[Note1], 0.5 V_{DD2}, V_{DD2} – 0.5 V			±10	±20	mV
Output Voltage Range	V_O	Input data: 00H to 3FH		V_{SS2} + 0.1		V_{DD2} – 0.1	V
Dynamic Logic Current Consumption	I_{DD1}	No load[Note2]			0.5	2.5	mA
Dynamic Driver Current Consumption	I_{DD21}	No load, V_{DD2} = 3.3 V[Note2]				9.0	mA
Dynamic Driver Current Consumption	I_{DD22}	No load, V_{DD2} = 5.0 V[Note2]				9.0	mA

Note1. V_X is output voltage of analog output pin S_1 to S_{309}.
V_{OUT} is the voltage applied to analog output pin S_1 to S_{309}.

2. The STB cycle is specified at 31 μs and f_{CLK} = 16 MHz.

Switching Characteristics (T_A = –10 to +75 °C, V_{DD1} = 3.3 V ± 0.3 V, V_{DD2} = 3.3 V ± 0.3 V or 5.0 V ± 0.5 V, V_{SS1} = V_{SS2} = 0 V)

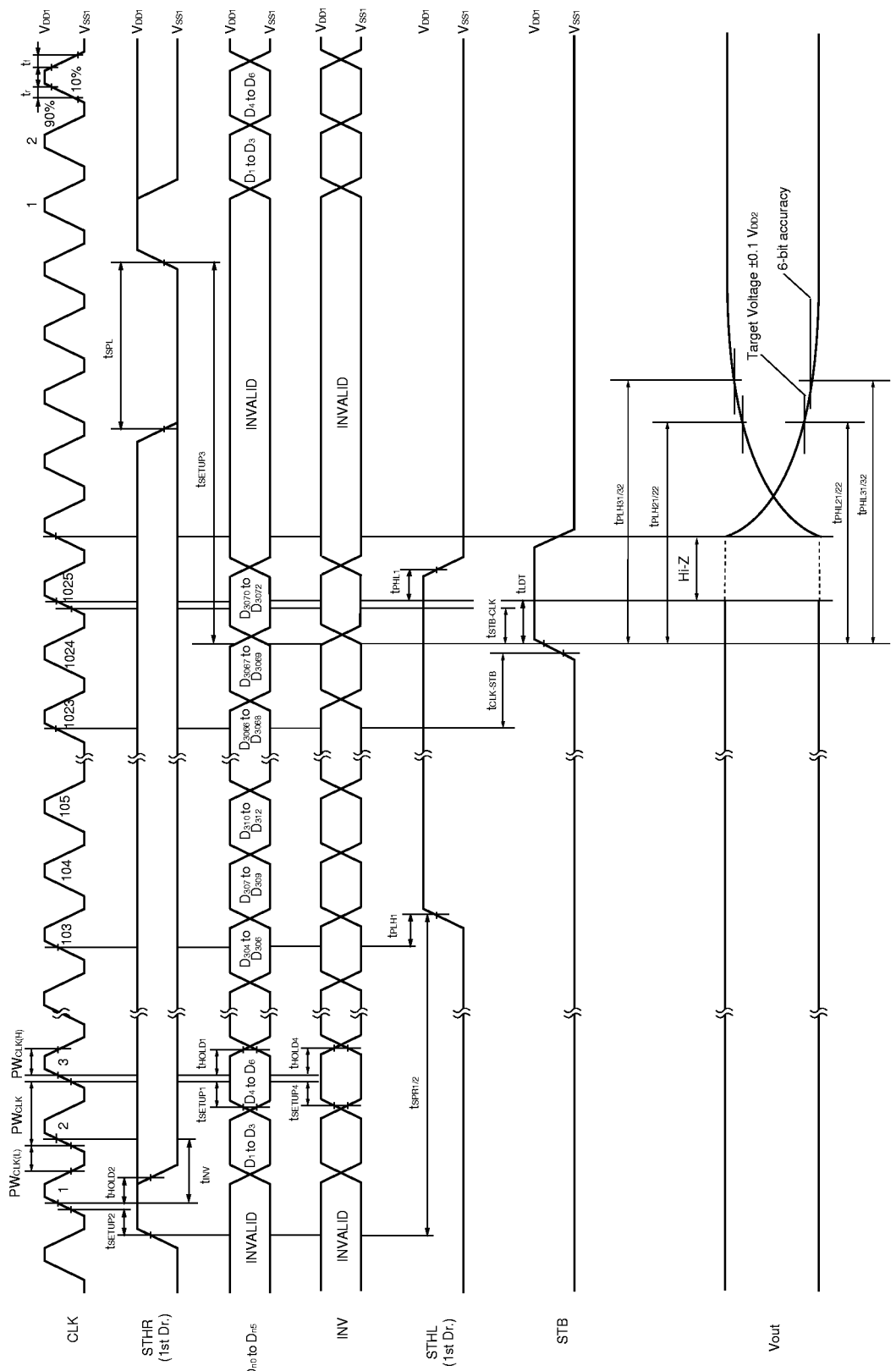
Parameter	Symbol	Condition		MIN.	TYP.	MAX.	Unit
Start Pulse Delay time	t_{PLH1}	C_L = 15 pF				12	ns
	t_{PHL1}					12	ns
Driver Output Delay Time	t_{PLH21}	V_{DD2} = 3.3 V,	V_O: 0.1 V → 3.2 V		3.3		μs
	t_{PLH31}	4 kΩ +24 pF × 2			5.1	10	μs
	t_{PHL21}		V_O: 3.2 V → 0.1 V		4.3		μs
	t_{PHL31}				5.4	10	μs
	t_{PLH22}	V_{DD2} = 5.0 V,	V_O: 0.1 V → 4.9 V		4.2		μs
	t_{PLH32}	4 kΩ +24 pF × 2			5.4	10	μs
	t_{PHL22}		V_O: 4.9 V → 0.1 V		4.9		μs
	t_{PHL32}				6.2	10	μs
Input capacitance	C_{I1}	STHR (STHL), T_A = 25 °C			10	15	pF
	C_{I2}	V_0 to V_{10}, T_A = 25 °C			100		pF
	C_{I3}	STHR (STHL), other than V_0 to V_{10}, T_A = 25 °C			5	10	pF

Timing Requirements (T_A = –10 to +75 °C, V_{DD1} = 3.3 V ± 0.3 V, V_{DD2} = 3.3 V ± 0.3 V or 5.0 V ± 0.5 V, V_{SS1} = V_{SS2} = 0 V)

Parameter	Symbol	Condition	MIN.	TYP.	MAX.	Unit
Clock Pulse Width	PW_{CLK}		18			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
INV Setup time	t_{SETUP4}		4			ns
INV Hold time	t_{HOLD4}		0			ns
Start Pulse Low period	t_{SPL}		2			CLK
Start Pulse Rise Time	t_{SPR1}	O_{sel} = H		100		CLK
Start Pulse Rise Time	t_{SPR2}	O_{sel} = L		103		CLK
STB setup time	t_{SETUP3}		2			CLK
Data Invalid Period	t_{INV}			1		CLK
Last Data Timing	t_{LDT}				1	CLK
CLK-STB Time	$t_{CLK-STB}$	CLK ↑ → STB ↑ or ↓	7			ns
STB-CLK Time	$t_{STB-CLK}$	STB ↑ or ↓ → CLK ↑	7			ns

8. SWITCHING CHARACTERISITIC 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}.)



9. RECOMMENDED SOLDERING CONDITIONS

The following conditions must be met for mounting conditions of the μPD16640B.

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

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

μPD16640BN-xxx : 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 secs. Real bonding 165 to 180°C; pressure 25 to 45 kg/cm^2, time 30 to 40 secs. (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.