

402/384-OUTPUT TFT-LCD SOURCE DRIVER (64 GRAY SCALE)

DESCRIPTION

The μ PD16647 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 5.0 V. The input data is digital data at 6 bits x 3 dots, and 260,000 colors can be displayed in 64-value outputs γ -corrected by the internal D/A converter and 10 external power supplies. The clock frequency is 50 MHz MIN. μ PD16647 can be used in TFT-LCD panels conforming to the SVGA standards.

FEATURES

- CMOS level input
- 402/384 outputs
- 6 bits (gray scale data) x 3 dots input
- 64-value output by 10 external power supplies and internal D/A converter
- Output dynamic range : $V_{SS2} + 0.1$ V to $V_{DD2} - 0.1$ V
- High-speed data transfer: $f_{MAX} = 50$ MHz MIN.(internal data transfer rate at supply voltage V_{DD1} of logic circuit =3.0 V)
- Level of γ -corrected power supply can be inverted
- Input data inversion function (INV)
- Precharge-less output buffer
- Logic supply voltage (V_{DD1}) : 3.3 V \pm 0.3 V
- Driver supply voltage (V_{DD2}) : 5.0 V \pm 0.5 V
- Slim TCP

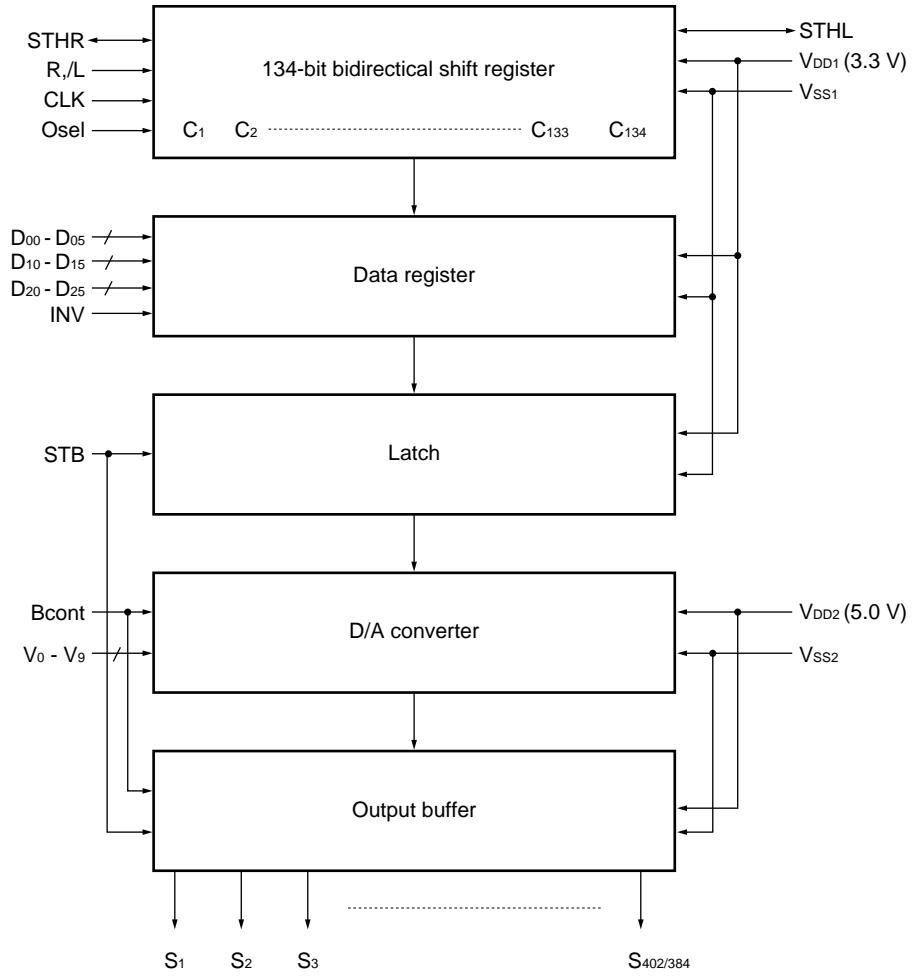
ORDERING INFORMATION

Part Number	Package
μ PD16647N-xxx	TCP (TAB package)

Remark The TCP package is a custom-ordered item. Users are requested to consult with an NEC sales representative.

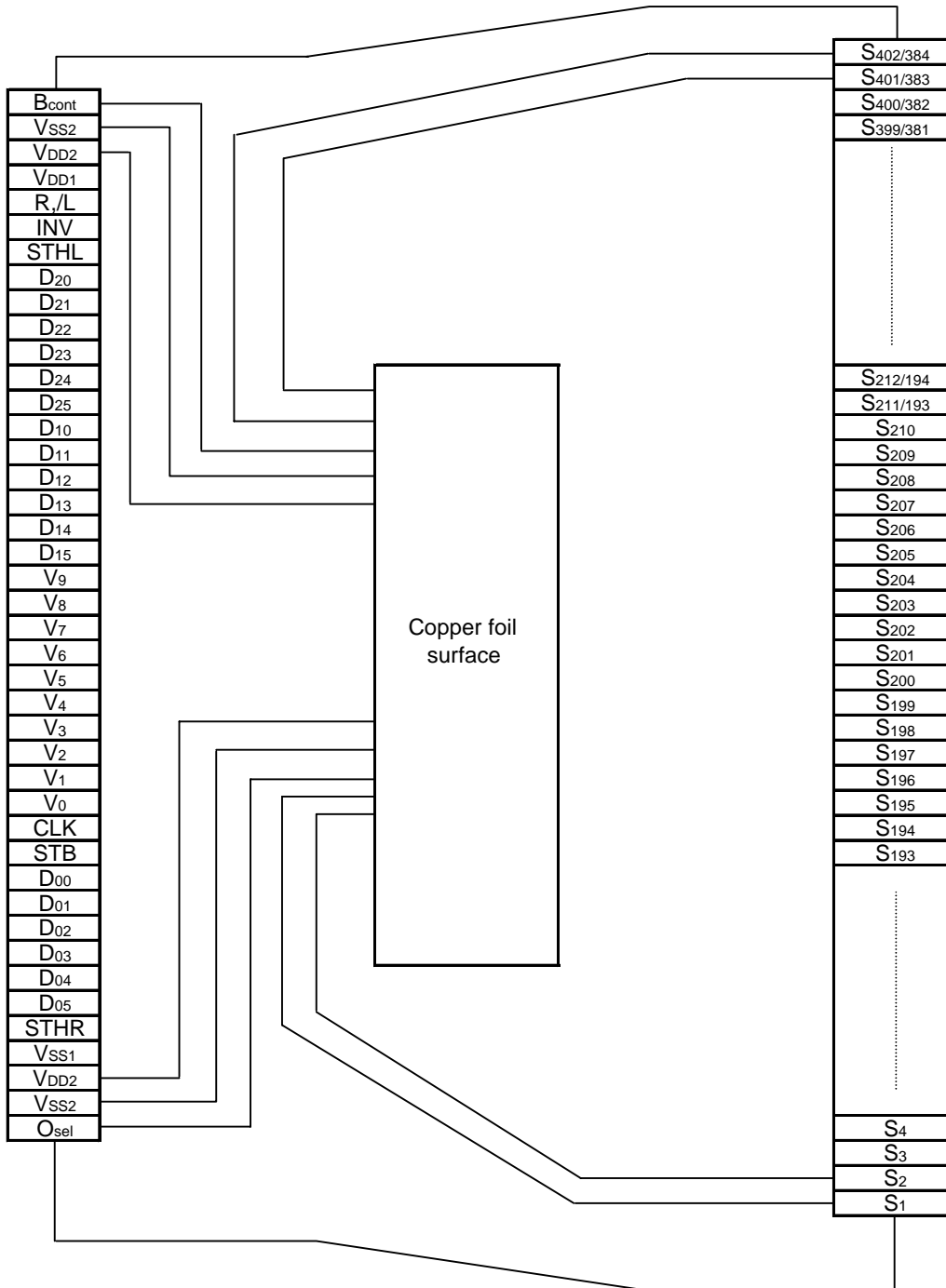
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Not all devices/types available in every country. Please check with local NEC representative for availability and additional information.

1. BLOCK DIAGRAM



Remark /xxx indicates active low signal.

2. PIN CONFIGURATION (μ PD16647N-xxx)



Remark This figure does not specify the TCP package.

3. PIN DESCRIPTION

Pin Symbol	Pin Name	Description
S ₁ to S _{402/384}	Driver output	Output 64 gray-scale analog voltages converted from digital signals. Osel = H or open: 402 outputs (S ₁ to S _{402/384}) Osel = L : 384 outputs (S ₁ to S ₁₉₂ , S _{211/193} to S _{402/384}) S ₁₉₃ to S ₂₁₀ outputs are invalid in 384 outputs.
D ₀₀ to D ₀₅	Display data input	Inputs 18-bit-wide display gray scale data (6 bits) x 3 dots (RGB). D _{X0} : LSB, D _{X5} : MSB
D ₁₀ to D ₁₅		
D ₂₀ to D ₂₅		
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 → S ₄₀₂ , STHL output R, _L = L : STHL input, S ₄₀₂ → 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
Bcont	Bias control	This pin can be used to finely control the bias current inside the output amplifier. In cases when fine-control is necessary, connect this pin to V _{DD2} using a resistor of 10 to 100kΩ (per IC). When this fine-control function is not required, short-circuit this pin to V _{DD2} . Refer to 7. Bias Current Control Function/Bcont .
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 134th clock after start pulse has been input, and serves as start pulse to driver in next stage. 134th 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 μ PD16647 is started, and then device operates normally. For STB input timing, refer to 9. Switching Characteristics Waveform .
Osel	Selection of number of outputs	Selects number of outputs. This pin is internally pulled up to V _{DD1} . Osel = H or open : 402 outputs (S ₁ to S _{402/384}) Osel = L : 384 outputs (S ₁ to S ₁₉₂ , S _{211/193} to S _{402/384})
V ₀ to V ₉	γ-corrected power supply	Inputs γ-corrected power from external source. V _{SS2} ≤ V ₉ ≤ V ₈ ≤ V ₇ ≤ V ₆ ≤ V ₅ ≤ V ₄ ≤ V ₃ ≤ V ₂ ≤ V ₁ ≤ V ₀ ≤ V _{DD2} or V _{SS2} ≤ V ₀ ≤ V ₁ ≤ V ₂ ≤ V ₃ ≤ V ₄ ≤ V ₅ ≤ V ₆ ≤ V ₇ ≤ V ₈ ≤ V ₉ ≤ V _{DD2} 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	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 (V₀ to V₉), and turn off power in the reverse order, to prevent the μ PD16647 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 10 major points on the γ -characteristic curve of the LCD panel are arbitrarily set by external power supplies V_0 through V_9 . If the display data is 00H or 3FH, gray scale voltage V_0 or V_9 is output. If the display data is in the range 01H to 3EH, the high-order 3 bits select an external power 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_8 to V_7 and from V_1 to V_0 are divided into seven segments) to output a 64 gray scale voltage.

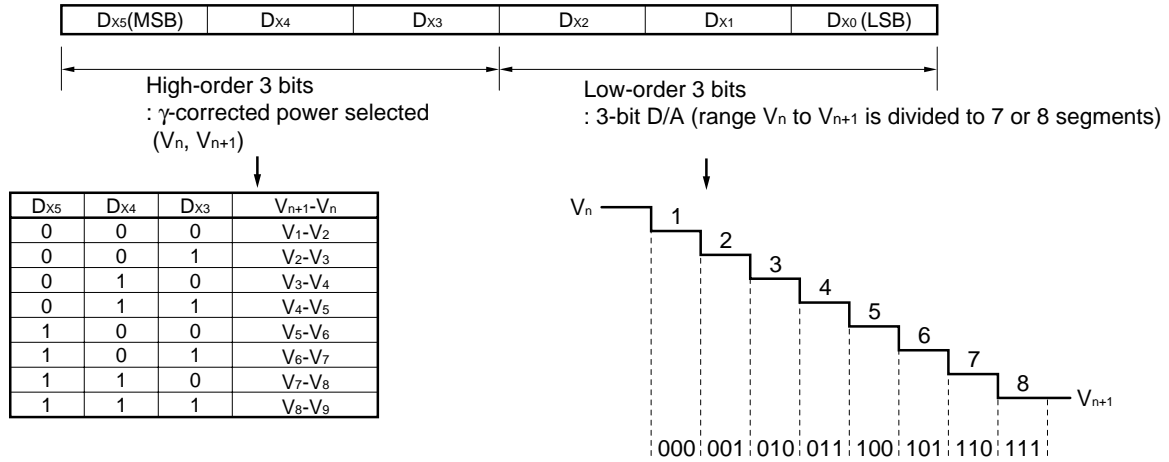


Figure4-1. Relationship between Input Data and γ -corrected Voltage

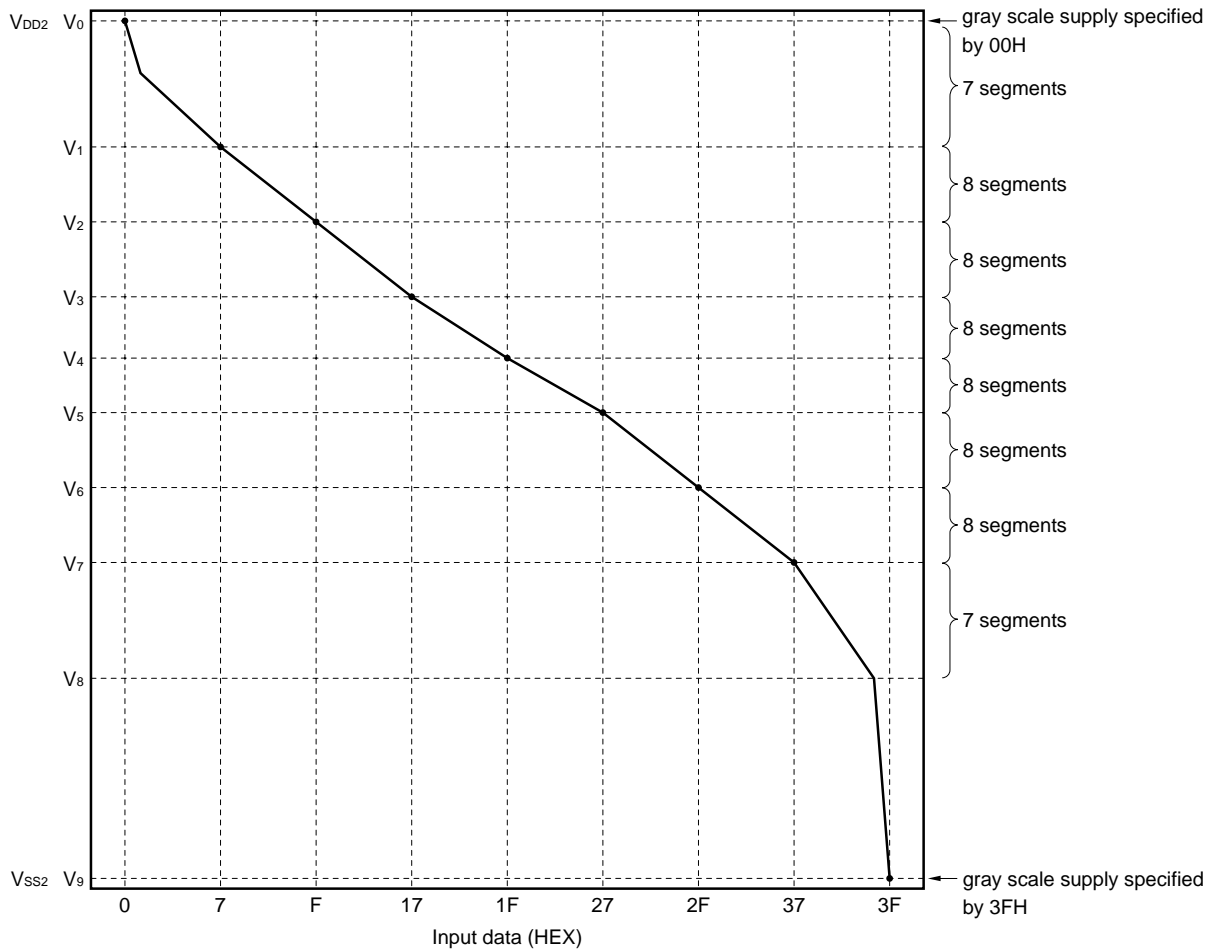


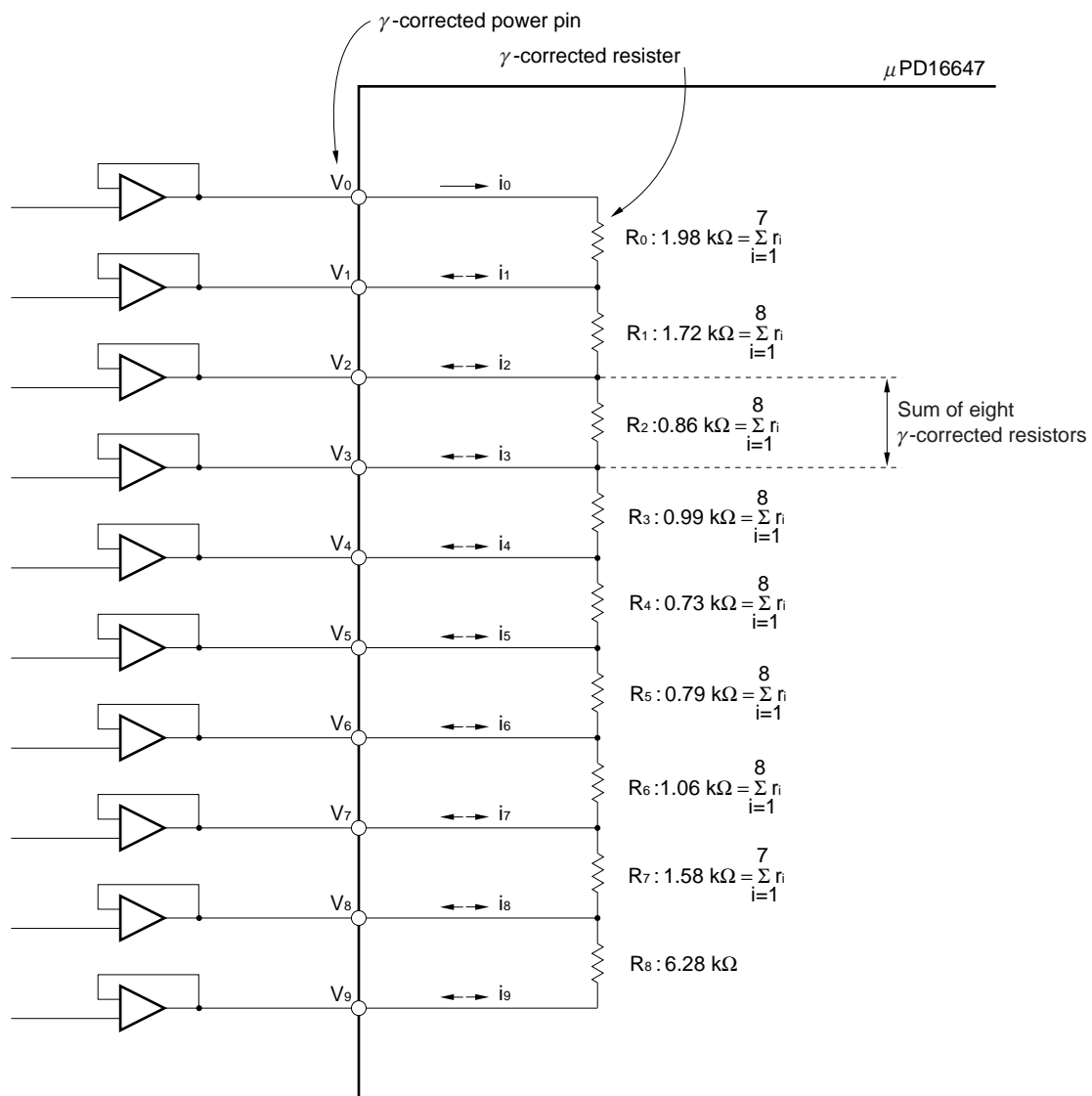
Table 4-1. Relationship between Input Data and Output Voltage

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 ₁ + (V ₀ - V ₁) × 6/7
02H	0	0	0	0	1	0	V ₁ + (V ₀ - V ₁) × 5/7
03H	0	0	0	0	1	1	V ₁ + (V ₀ - V ₁) × 4/7
04H	0	0	0	1	0	0	V ₁ + (V ₀ - V ₁) × 3/7
05H	0	0	0	1	0	1	V ₁ + (V ₀ - V ₁) × 2/7
06H	0	0	0	1	1	0	V ₁ + (V ₀ - V ₁) × 1/7
07H	0	0	0	1	1	1	V ₁
08H	0	0	1	0	0	0	V ₂ + (V ₁ - V ₂) × 7/8
09H	0	0	1	0	0	1	V ₂ + (V ₁ - V ₂) × 6/8
0AH	0	0	1	0	1	0	V ₂ + (V ₁ - V ₂) × 5/8
0BH	0	0	1	0	1	1	V ₂ + (V ₁ - V ₂) × 4/8
0CH	0	0	1	1	0	0	V ₂ + (V ₁ - V ₂) × 3/8
0DH	0	0	1	1	0	1	V ₂ + (V ₁ - V ₂) × 2/8
0EH	0	0	1	1	1	0	V ₂ + (V ₁ - V ₂) × 1/8
0FH	0	0	1	1	1	1	V ₂
10H	0	1	0	0	0	0	V ₃ + (V ₂ - V ₃) × 7/8
11H	0	1	0	0	0	1	V ₃ + (V ₂ - V ₃) × 6/8
12H	0	1	0	0	1	0	V ₃ + (V ₂ - V ₃) × 5/8
13H	0	1	0	0	1	1	V ₃ + (V ₂ - V ₃) × 4/8
14H	0	1	0	1	0	0	V ₃ + (V ₂ - V ₃) × 3/8
15H	0	1	0	1	0	1	V ₃ + (V ₂ - V ₃) × 2/8
16H	0	1	0	1	1	0	V ₃ + (V ₂ - V ₃) × 1/8
17H	0	1	0	1	1	1	V ₃
18H	0	1	1	0	0	0	V ₄ + (V ₃ - V ₄) × 7/8
19H	0	1	1	0	0	1	V ₄ + (V ₃ - V ₄) × 6/8
1AH	0	1	1	0	1	0	V ₄ + (V ₃ - V ₄) × 5/8
1BH	0	1	1	0	1	1	V ₄ + (V ₃ - V ₄) × 4/8
1CH	0	1	1	1	0	0	V ₄ + (V ₃ - V ₄) × 3/8
1DH	0	1	1	1	0	1	V ₄ + (V ₃ - V ₄) × 2/8
1EH	0	1	1	1	1	0	V ₄ + (V ₃ - V ₄) × 1/8
1FH	0	1	1	1	1	1	V ₄
20H	1	0	0	0	0	0	V ₅ + (V ₄ - V ₅) × 7/8
21H	1	0	0	0	0	1	V ₅ + (V ₄ - V ₅) × 6/8
22H	1	0	0	0	1	0	V ₅ + (V ₄ - V ₅) × 5/8
23H	1	0	0	0	1	1	V ₅ + (V ₄ - V ₅) × 4/8
24H	1	0	0	1	0	0	V ₅ + (V ₄ - V ₅) × 3/8
25H	1	0	0	1	0	1	V ₅ + (V ₄ - V ₅) × 2/8
26H	1	0	0	1	1	0	V ₅ + (V ₄ - V ₅) × 1/8
27H	1	0	0	1	1	1	V ₅
28H	1	0	1	0	0	0	V ₆ + (V ₅ - V ₆) × 7/8
29H	1	0	1	0	0	1	V ₆ + (V ₅ - V ₆) × 6/8
2AH	1	0	1	0	1	0	V ₆ + (V ₅ - V ₆) × 5/8
2BH	1	0	1	0	1	1	V ₆ + (V ₅ - V ₆) × 4/8
2CH	1	0	1	1	0	0	V ₆ + (V ₅ - V ₆) × 3/8
2DH	1	0	1	1	0	1	V ₆ + (V ₅ - V ₆) × 2/8
2EH	1	0	1	1	1	0	V ₆ + (V ₅ - V ₆) × 1/8
2FH	1	0	1	1	1	1	V ₆
30H	1	1	0	0	0	0	V ₇ + (V ₆ - V ₇) × 7/8
31H	1	1	0	0	0	1	V ₇ + (V ₆ - V ₇) × 6/8
32H	1	1	0	0	1	0	V ₇ + (V ₆ - V ₇) × 5/8
33H	1	1	0	0	1	1	V ₇ + (V ₆ - V ₇) × 4/8
34H	1	1	0	1	0	0	V ₇ + (V ₆ - V ₇) × 3/8
35H	1	1	0	1	0	1	V ₇ + (V ₆ - V ₇) × 2/8
36H	1	1	0	1	1	0	V ₇ + (V ₆ - V ₇) × 1/8
37H	1	1	0	1	1	1	V ₇
38H	1	1	1	0	0	0	V ₈ + (V ₇ - V ₈) × 6/7
39H	1	1	1	0	0	1	V ₈ + (V ₇ - V ₈) × 5/7
3AH	1	1	1	0	1	0	V ₈ + (V ₇ - V ₈) × 4/7
3BH	1	1	1	0	1	1	V ₈ + (V ₇ - V ₈) × 3/7
3CH	1	1	1	1	0	0	V ₈ + (V ₇ - V ₈) × 2/7
3DH	1	1	1	1	0	1	V ₈ + (V ₇ - V ₈) × 1/7
3EH	1	1	1	1	1	0	V ₈
3FH	1	1	1	1	1	1	V ₈

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 Σr_i 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 Σr_i in the figure below is indicated as the sum of the seven or eight resistors. The resistance ratio between the γ -corrected power pins (Σr_i ratio) is designed to be a value relatively close to the ratio of the γ -corrected voltages V_1 through V_8 (gray scale voltages in 7 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 7 steps of the resistor ladder circuits of the μ PD16647, and no current flows into the γ -corrected power pins V_1 through V_8 . As a result, a voltage follower circuit is not necessary.

Figure4-2. γ -Corrected Power Circuit



5. RELATION BETWEEN INPUT DATA AND OUTPUT VOLTAGE

Data format : 6 bits x RGB (3 dots)

Input width : 18 bits (1 pixel data)

(1) R,/L = H (right shift)

Output	S ₁	S ₂	S ₃	S ₄	...	S _{401/383}	S _{402/384}
Data	D ₀₀ to D ₀₅	D ₁₀ to D ₁₅	D ₂₀ to D ₂₅	D ₀₀ to D ₀₅	...	D ₁₀ to D ₁₅	D ₂₀ to D ₂₅

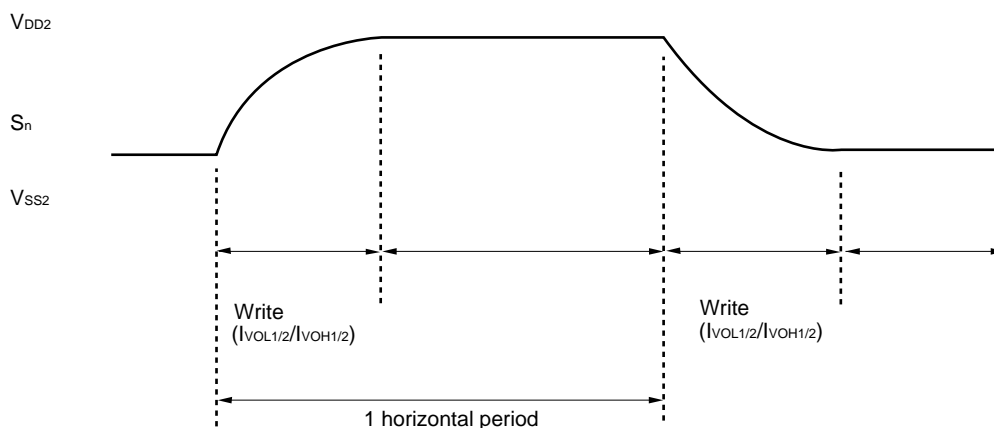
(2) R,/L = L (left shift)

Output	S ₁	S ₂	S ₃	S ₄	...	S _{401/383}	S _{402/384}
Data	D ₀₀ to D ₀₅	D ₁₀ to D ₁₅	D ₂₀ to D ₂₅	D ₀₀ to D ₀₅	...	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.

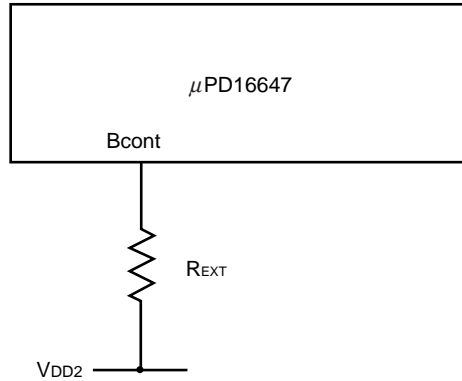
Figure6-1. LCD panel driving waveform of μ PD16647



7. BIAS CURRENT CONTROL FUNCTION/Bcont

It is possible to fine-control the current consumption by using the bias current control function (Bcont pin). When using this function, connect this pin to the stabilized VDD2 potential using an external resistor (REXT). When not using this function, however, short-circuit this pin to VDD2.

Figure7-1. Bias Current Control Function/Bcont



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

Table7-1. Current Consumption Regulation Percentage Compared to Normal Mode

R _{EXT}	Current Consumption Regulation Percentage
SHORT	100 %
10 kΩ	95 %
20 kΩ	91 %
40 kΩ	85 %
80 kΩ	79 %

Remark Be aware that the above current consumption regulation percentages are not product-characteristic guaranteed as they are based on the results of simulation.

Caution Because the low-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.

8. ELECTRICAL SPECIFICATIONS

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

Parameter	Symbol	Ratings	Unit
Logic Supply Voltage	V_{DD1}	-0.3 to +4.5	V
Driver Supply Voltage	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 ($T_A = -10\text{ to }+75\text{ °C}$, $V_{SS1} = V_{SS2} = 0\text{ V}$)

Parameter	Symbol	MIN.	TYP.	MAX.	Unit
Logic Supply Voltage	V_{DD1}	3.0	3.3	3.6	V
Driver Supply Voltage	V_{DD2}	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 Supply Voltage	V_0 to V_9	$V_{SS2} + 0.1$		$V_{DD2} - 0.1$	V
Maximum Clock Frequency	$f_{MAX.}$	50			MHz

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

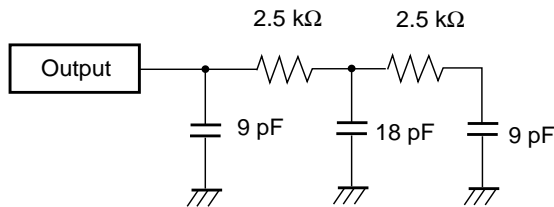
Parameter	Symbol	Condition	MIN.	TYP.	MAX.	Unit	
Input Leakage Current	I _{IL}	D ₀₀ -D ₀₅ , D ₁₀ -D ₁₅ , D ₂₀ -D ₂₅ R, L, STB			±1.0	μ A	
Pull-up Resistor	R _{PU}	V _{DD1} = 3.3 V	40	100	250	kΩ	
High-level Output Voltage	V _{OH}	STHR(STHL), I _o = -1.0 mA	V _{DD1} - 0.5			V	
Low-level Output Voltage	V _{OL}	STHR(STHL), I _o = +1.0 mA			0.5	V	
Static Current Consumption of γ-corrected Power	I _{vn1}	V _{DD1} = 3.3 V, V _n - V _{n+1} = 0.5 V, V _{DD2} = 5.0 V	V ₀ -V ₁	126	253	506	μ A
			V ₁ -V ₂	145	291	582	μ A
			V ₂ -V ₃	289	579	1158	μ A
			V ₃ -V ₄	252	504	1008	μ A
			V ₄ -V ₅	343	686	1372	μ A
			V ₅ -V ₆	315	631	1262	μ A
			V ₆ -V ₇	237	474	948	μ A
			V ₇ -V ₈	158	316	632	μ A
			V ₈ -V ₉	40	80	160	μ A
Driver Output Current	I _{VOH2}	V _{OUT} = 4.4 V, V _X = 4.9 V ^{Note1} V _{DD1} = 3.3 V, V _{DD2} = 5.0 V	(-0.12)		-0.03	mA	
	I _{VOL2}	V _{OUT} = 0.6 V, V _X = 0.1 V ^{Note1} V _{DD1} = 3.3 V, V _{DD2} = 5.0 V	0.04		(0.16)	mA	
Output Voltage Deviation	ΔV _O	V _{DD1} = 3.3 V, V _{DD2} = 5.0 V, V _{OUT} = 2.5 V ^{Note1}		±10	±20	mV	
Output Swing Difference Deviation	ΔV _{P-P}	Input data		(±5)		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, V _{DD2} = 3.3 V ^{Note2}		0.5	2.5	mA	
Dynamic Driver Current Consumption	I _{DD2}	No load, V _{DD2} = 5.0 V ^{Note2}		5.0	10.0	mA	

- Notes 1.** V_X refers to the output voltage of analog output pins S₁ to S_{402/384}.
V_{OUT} refers to the voltage applied to analog output pins S₁ to S_{402/384}.
- 2.** The STB cycle is specified at 31 μ s and f_{CLK} = 16 MHz.

Switching Characteristics (T_A = -10 to +75 °C, V_{DD1} = 3.3 V ± 0.3 V, V_{DD2} = 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		7	12	ns	
	t _{PHL1}			7	12	ns	
Driver Output Delay Time	t _{PLH2}	V _{DD2} = 5.0 V 5 kΩ +36 pF	V _O : 0.1 V → 4.9 V		2.2	10	μs
	t _{PLH3}				2.9	12	μs
	t _{PHL2}	V _O : 4.9 V → 0.1 V		2.6	10	μs	
	t _{PHL3}			3.6	12	μs	
Input Capacitance	C _{I1}	STHR (STHL), T _A = 25 °C		10	20	pF	
	C _{I2}	V ₀ to V ₉ , T _A = 25 °C		100	150	pF	
	C _{I3}	STHR (STHL), other than V ₀ to V ₉ , T _A = 25 °C		10	15	pF	

<Output Load>

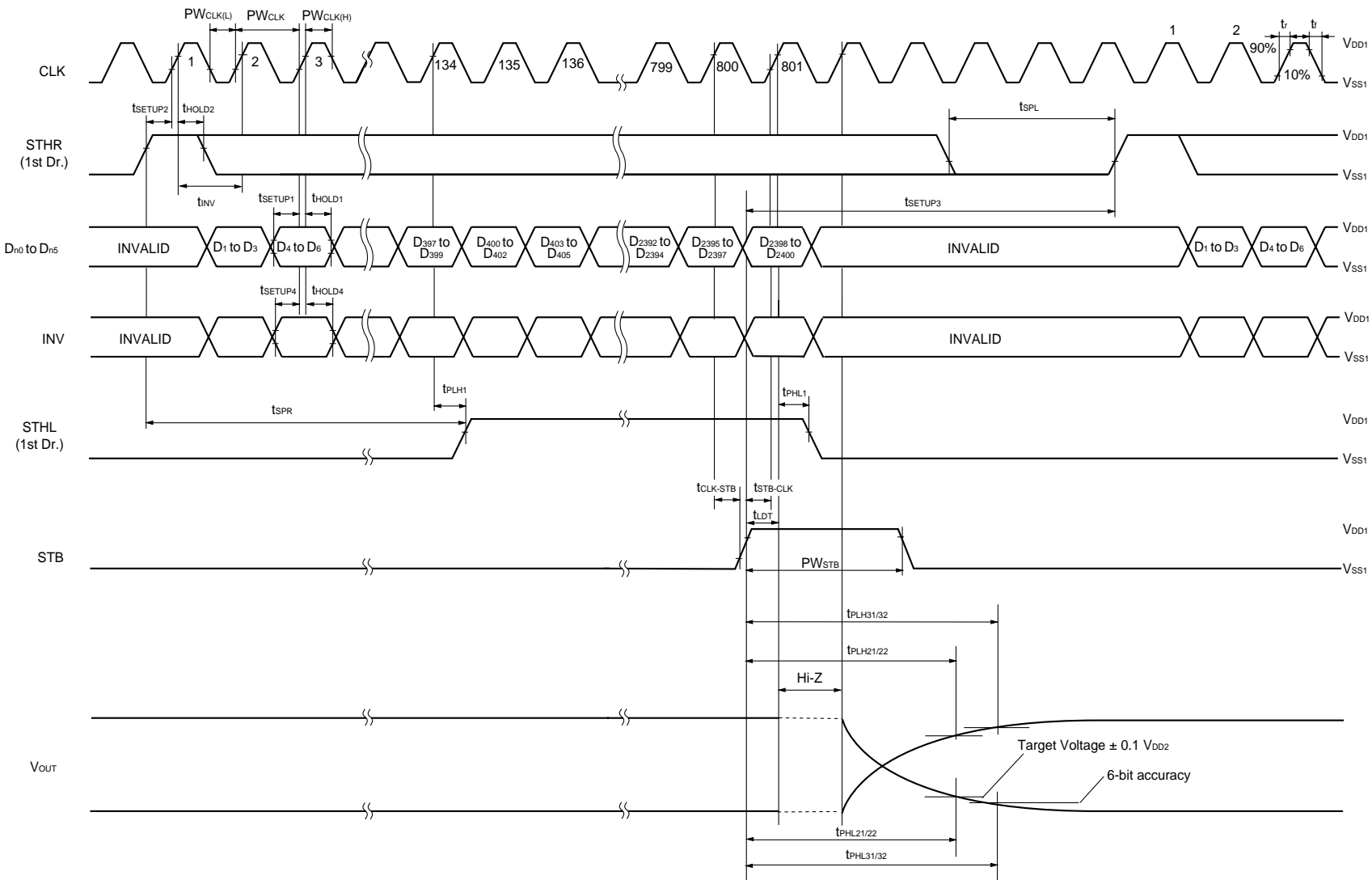


Timing Requirements (T_A = -10 to +75 °C, V_{DD1} = 3.3 V ± 0.3 V, V_{DD2} = 5.0 V ± 0.5 V, V_{SS1} = V_{SS2} = 0 V)

Parameter	Symbol	Condition	MIN.	TYP.	MAX.	Unit
Clock Pulse Width	PW _{CLK}		20			ns
Clock Low Period	PW _{CLK (L)}		4			ns
Clock High Period	PW _{CLK (H)}		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 _{SPR}	384 outputs		128		CLK
		402 outputs		134		CLK
STB Setup Time	t _{SETUP3}		1			CLK
★ STB Pulse Width	PW _{STB}		2			CLK
Data Invalid Period	t _{INV}			1		CLK
Last Data Timing	t _{LDT}				1	CLK
CLK-STB Time	t _{CLK-STB}	CLK ↑ → STB ↑	7			ns
STB-CLK Time	t _{STB-CLK}	STB ↑ → CLK ↑	7			ns

★ 9. SWITCHING CHARACTERISTIC WAVEFORM(R/L=H)

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



10. RECOMMENDED MOUNTING CONDITIONS

The following conditions must be met for mounting conditions of the μ PD16647.

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.

μ PD16647N-xxx : TCP(TAB Package)

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

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

NOTES FOR CMOS DEVICES**① PRECAUTION AGAINST ESD FOR SEMICONDUCTORS**

Note:

Strong electric field, when exposed to a MOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop generation of static electricity as much as possible, and quickly dissipate it once, when it has occurred. Environmental control must be adequate. When it is dry, humidifier should be used. It is recommended to avoid using insulators that easily build static electricity. Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work bench and floor should be grounded. The operator should be grounded using wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions need to be taken for PW boards with semiconductor devices on it.

② HANDLING OF UNUSED INPUT PINS FOR CMOS

Note:

No connection for CMOS device inputs can be cause of malfunction. If no connection is provided to the input pins, it is possible that an internal input level may be generated due to noise, etc., hence causing malfunction. CMOS devices behave differently than Bipolar or NMOS devices. Input levels of CMOS devices must be fixed high or low by using a pull-up or pull-down circuitry. Each unused pin should be connected to V_{DD} or GND with a resistor, if it is considered to have a possibility of being an output pin. All handling related to the unused pins must be judged device by device and related specifications governing the devices.

③ STATUS BEFORE INITIALIZATION OF MOS DEVICES

Note:

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

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

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"Standard", "Special", and "Specific". The Specific quality grade applies only to devices developed based on a customer designated "quality assurance program" for a specific application. The recommended applications of a device depend on its quality grade, as indicated below. Customers must check the quality grade of each device 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 or medical equipment for life support, etc.
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