

MOS INTEGRATED CIRCUIT

μ PD16732A, 16732B

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

DESCRIPTION

The μ PD16732A, 16732B are a source driver for TFT-LCDs capable of dealing with displays with 64-gray scales. Data input is based on digital input configured as 6 bits by 6 dots (2 pixels), which can realize a full-color display of 260,000 colors by output of 64 values γ -corrected by an internal D/A converter and 5-by-2 external power modules. Because the output dynamic range is as large as $V_{SS2} + 0.1$ V to $V_{DD2} - 0.1$ V, level inversion operation of the LCD's common electrode is rendered unnecessary. Also, to be able to deal with dot-line inversion, n-line inversion and column line inversion when mounted on a single side, this source driver is equipped with a built-in 6-bit D/A converter circuit whose odd output pins and even output pins respectively output gray scale voltages of differing polarity. Assuring a maximum clock frequency of 65 MHz when driving at 3.0 V, 45 MHz when driving at 2.3 V, this driver is applicable to XGA-standard TFT-LCD panels and SXGA TFT-LCD panels by input display signal 2 systems (Clock divide).

FEATURES

- CMOS level input (2.3 V to 3.6 V)
- 384 Outputs
- Input of 6 bits (gradation 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)
- High-speed data transfer: $f_{MAX.} = 65$ MHz (internal data transfer speed when operating at $V_{DD1} = 3.0$ V)
- Output dynamic range $V_{SS2} + 0.1$ V to $V_{DD2} - 0.1$ V
- Apply for dot-line inversion, n-line inversion and column line inversion
- Output Voltage polarity inversion function (POL)
- Display data inversion function (POL2)
- Low power control function (LPC)
- Logic power supply voltage (V_{DD1}) : 2.3 V to 3.6 V
- Driver power supply voltage (V_{DD2}) : 8.5 ± 0.5 V
- Different point between μ PD16732A, 16732B : The ladder resistors value(Refer to **5. RELATIONSHIP BETWEEN INPUT DATA AND OUTPUT VOLTAGE VALUE**)

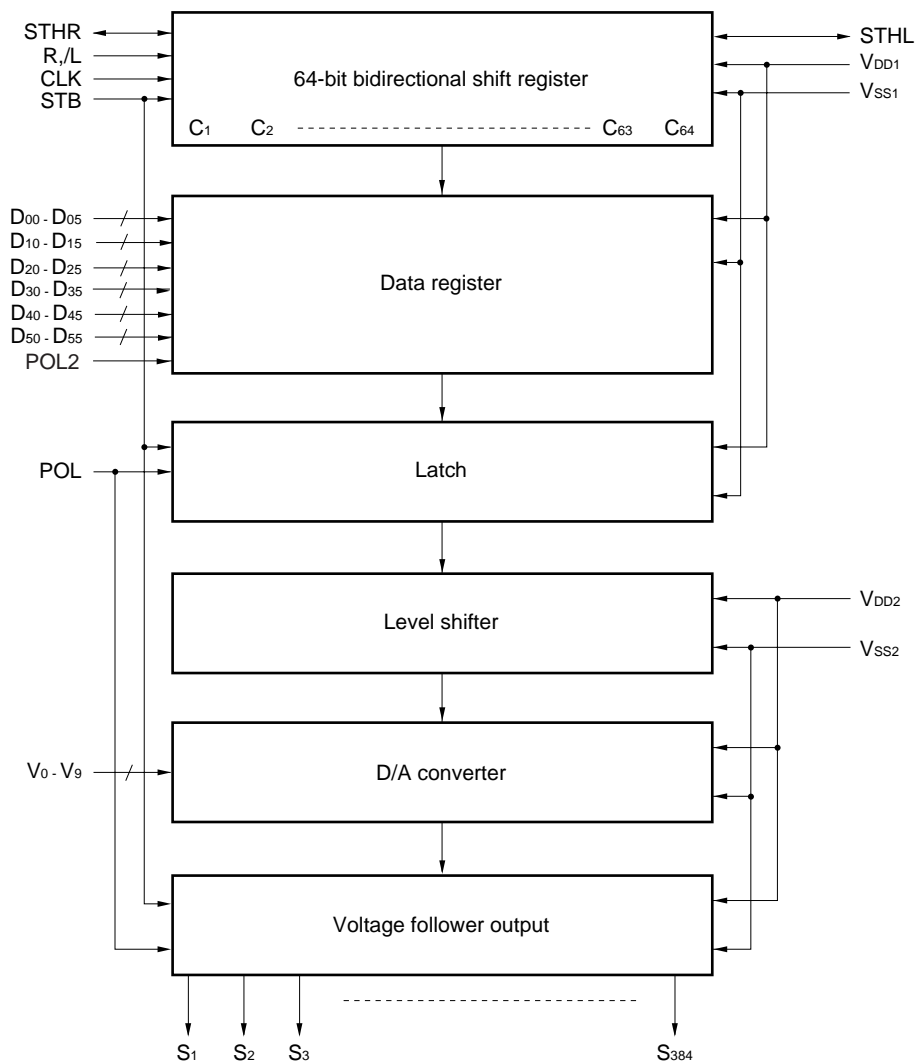
ORDERING INFORMATION

| Part Number | Package |
|---------------------|-------------------|
| μ PD16732AN-xxx | TCP (TAB package) |
| μ PD16732BN-xxx | TCP (TAB package) |

Remark The TCP's external shape is customized. To order the required shape, please contact an NEC salesperson.

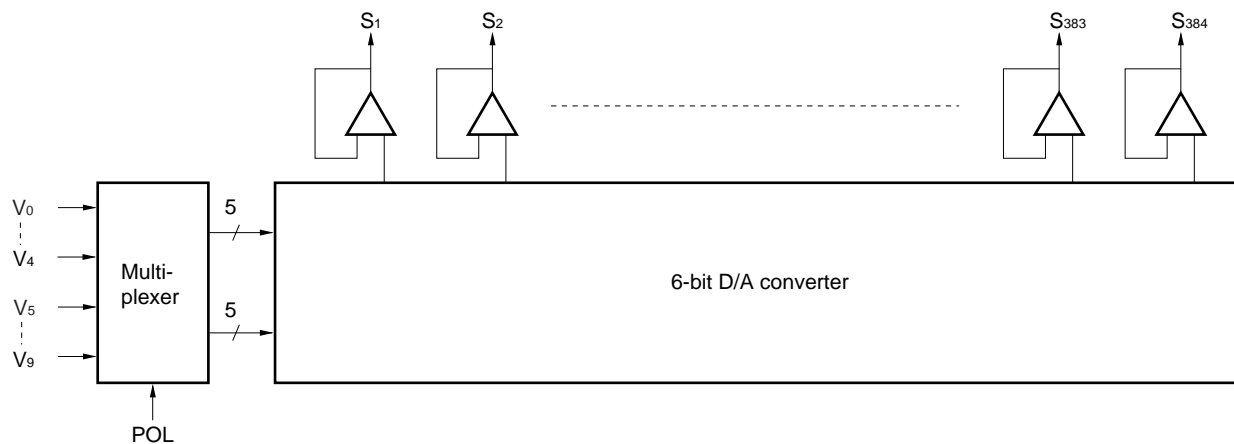
The information in this document is subject to change without notice. Before using this document, please confirm that this is the latest version.
Not all devices/types available in every country. Please check with local NEC representative for availability and additional information.

1. BLOCK DIAGRAM

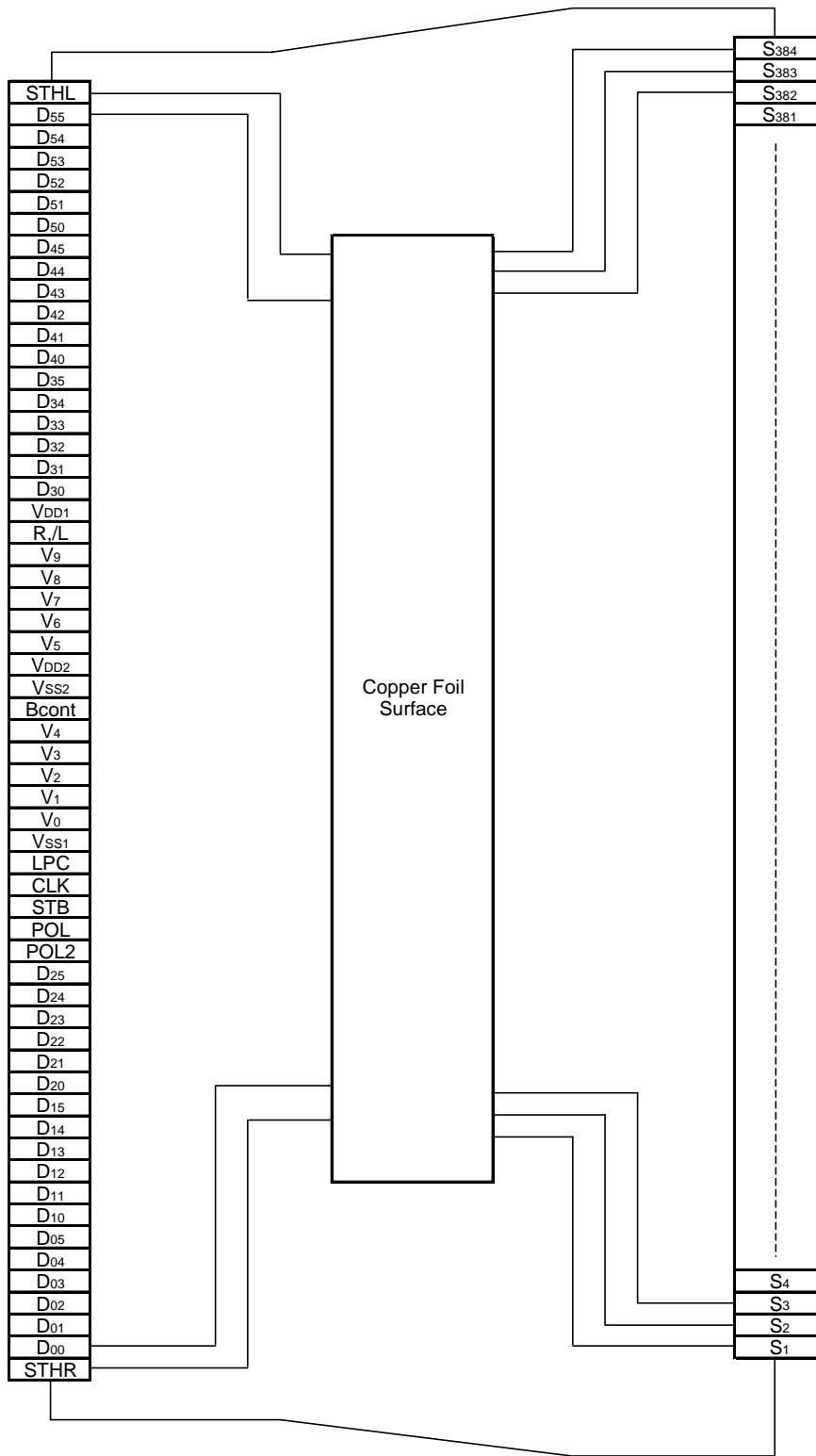


Remark /xxx indicates active low signal.

2. RELATIONSHIP BETWEEN OUTPUT CIRCUIT AND D/A CONVERTER



3. PIN CONFIGURATION (μ PD16732AN-xxx, μ PD16732BN-xxx : TCP (TAB package))



Remark This figure does not specify the TCP package.

4. PIN FUNCTIONS

(1/2)

| Pin Symbol | Pin Name | Description |
|------------------------------------|--------------------------------------|---|
| S ₁ to S ₃₈₄ | Driver output | The D/A converted 64-gray-scale analog voltage is output. |
| D ₀₀ to D ₀₅ | Display data 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 |
| D ₁₀ to D ₁₅ | | |
| D ₂₀ to D ₂₅ | | |
| D ₃₀ to D ₃₅ | | |
| D ₄₀ to D ₄₅ | | |
| D ₅₀ to D ₅₅ | | |
| R _{,L} | | |
| STHR | Right shift start pulse input/output | R,/L = H : Becomes the start pulse input pin. R,/L = L : Becomes the start pulse output pin. |
| STHL | Left shift start pulse input/output | R,/L = H : Becomes the start pulse output pin. R,/L = L : Becomes the start pulse input pin. |
| CLK | Shift clock 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 clock after the start pulse input, the start pulse output reaches the high level, thus becoming the start pulse of the next-level driver. |
| STB | Latch input | The contents of the data register are transferred to the latch circuit at the rising edge. And, at the falling edge, the gray scale voltage is supplied to the driver. It is necessary to ensure input of one pulse per horizontal period. |
| POL | Polarity 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. |
| POL2 | Data inversion | POL2 = H : Display data is inverted. POL2 = L : Display data is not inverted |
| LPC | Low power control input | The current consumption is lowered by controlling the constant current source of the output amplifier. In low power mode (LPC = "L"), the V _{DD2} of static current consumption can be reduced to two thirds of the normal current consumption. This pin is pulled up to the V _{DD1} power supply inside the IC. LPC = H or Open : Normal power mode LPC = L : Low power mode |

★

(2/2)

| Pin Symbol | Pin Name | Description |
|----------------------------------|----------------------------|---|
| 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 the stabilized ground potential (V _{SS2}) via an external resistor of 10 to 100kΩ (per IC). When this fine-control function is not required, leave this pin open. Refer to 9. CURRENT CONSUMPTION REDUCTION FUNCTION |
| V ₀ to V ₉ | γ-corrected power supplies | Input the γ-corrected power supplies from outside by using operational amplifier. Make sure to maintain the following relationships. During the gray scale voltage output, be sure to keep the gray scale level power supply at a constant level. V _{DD2} - 0.1 V > V ₀ > V ₁ > V ₂ > V ₃ > V ₄ > V ₅ > V ₆ > V ₇ > V ₈ > V ₉ > V _{SS2} + 0.1 V |
| V _{DD1} | Logic power supply | 2.3 V to 3.6 V |
| V _{DD2} | Driver power supply | 8.5 V ± 0.5 V |
| V _{SS1} | Logic ground | Grounding |
| V _{SS2} | Driver ground | Grounding |

- Cautions**
- The power start sequence must be V_{DD1}, logic input, and V_{DD2} & V₀ to V₉ in that order.
Reverse this sequence to shut down. (Simultaneous power application to V_{DD2} and V₀ to V₉ is possible.)
 - To stabilize the supply voltage, please be sure to insert a 0.1 μ F bypass capacitor between V_{DD1}-V_{SS1} and V_{DD2}-V_{SS2}. Furthermore, for increased precision of the D/A converter, insertion of a bypass capacitor of about 0.01 μ F is also advised between the γ-corrected power supply terminals (V₀, V₁, V₂, ..., V₉) and V_{SS2}.

5. RELATIONSHIP BETWEEN INPUT DATA AND OUTPUT VOLTAGE VALUE

This product incorporates a 6-bit D/A converter whose odd output pins and even output pins output respectively gray scale voltages of differing polarity with respect to the LCD's counter electrode (common electrode) voltage. The D/A converter consists of ladder resistors and switches.

The ladder resistors (r0 to r62) are designed so that the ratio of LCD panel γ -compensated voltages to $V_{0'}$ to $V_{63'}$ and $V_{0''}$ to $V_{63''}$ is almost equivalent. For the 2 sets of five γ -compensated power supplies, V_0 to V_4 and V_5 to V_9 , respectively, input gray scale voltages of the same polarity with respect to the common voltage. When fine-gray scale voltage precision is not necessary, there is no need to connect a voltage follower circuit to the γ -compensated power supplies V_1 to V_3 and V_6 to V_8 .

Figure 5-1 shows the relationship between the driving voltages such as liquid-crystal driving voltages V_{DD2} and V_{SS2} , common electrode potential V_{COM} , and γ -corrected voltages V_0 to V_9 and the input data. Be sure to maintain the voltage relationships of $V_{DD2} - 0.1\text{ V} > V_0 > V_1 > V_2 > V_3 > V_4 > V_5 > V_6 > V_7 > V_8 > V_9 > V_{SS2} + 0.1\text{ V}$.

Figures 5-2 and 5-3 show the relationship between the input data and the output data. This driver IC is designed for only single-sided mounting. Therefore, please do not use it for γ -corrected power supply level inversion in double-sided mounting.

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

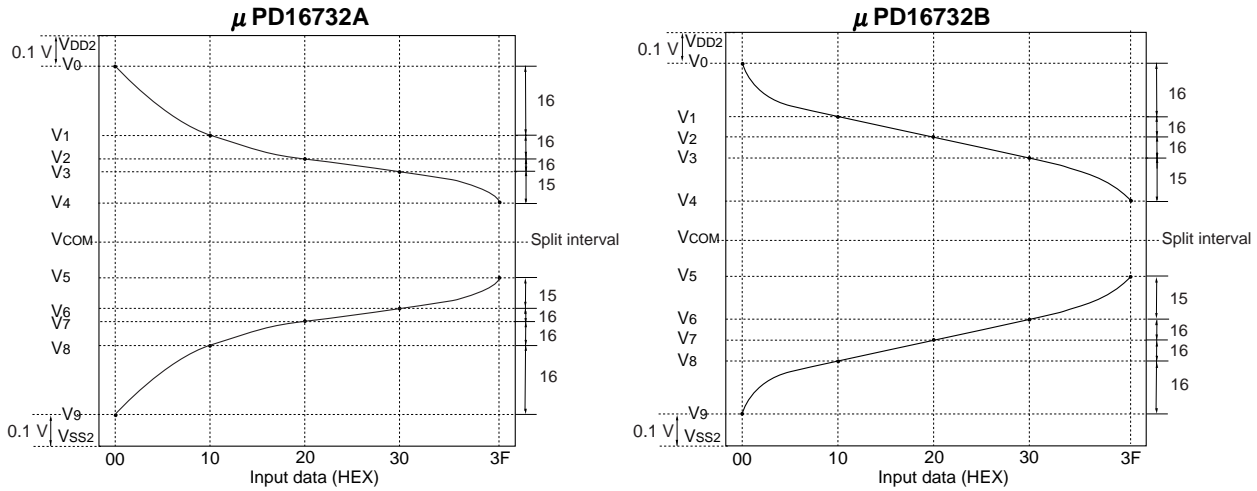


Figure 5–2. Relationship between Input Data and Output Voltage (1/2)

$$V_{DD2} - 0.1\text{ V} > V_0 > V_1 > V_2 > V_3 > V_4 > V_5, \text{POL2} = \text{L}$$

| Data | Dx5 | Dx4 | Dx3 | Dx2 | Dx1 | Dx0 | Output Voltage | | m | (Ω) | |
|------|-----|-----|-----|-----|-----|-----|----------------|-------------|--------|-------|-------|
| | | | | | | | 732A | 732B | | 732A | 732B |
| 00H | 0 | 0 | 0 | 0 | 0 | 0 | V0' | V0 | r0 | 800 | 1766 |
| 01H | 0 | 0 | 0 | 0 | 0 | 1 | V1' | V1+(V0-V1)x | r1 | 750 | 736 |
| 02H | 0 | 0 | 0 | 0 | 1 | 0 | V2' | V1+(V0-V1)x | r2 | 700 | 566 |
| 03H | 0 | 0 | 0 | 0 | 1 | 1 | V3' | V1+(V0-V1)x | r3 | 650 | 509 |
| 04H | 0 | 0 | 0 | 1 | 0 | 0 | V4' | V1+(V0-V1)x | r4 | 600 | 396 |
| 05H | 0 | 0 | 0 | 1 | 0 | 1 | V5' | V1+(V0-V1)x | r5 | 550 | 340 |
| 06H | 0 | 0 | 0 | 1 | 1 | 0 | V6' | V1+(V0-V1)x | r6 | 550 | 283 |
| 07H | 0 | 0 | 0 | 1 | 1 | 1 | V7' | V1+(V0-V1)x | r7 | 500 | 283 |
| 08H | 0 | 0 | 1 | 0 | 0 | 0 | V8' | V1+(V0-V1)x | r8 | 500 | 226 |
| 09H | 0 | 0 | 1 | 0 | 0 | 1 | V9' | V1+(V0-V1)x | r9 | 400 | 226 |
| 0AH | 0 | 0 | 1 | 0 | 1 | 0 | V10' | V1+(V0-V1)x | r10 | 400 | 170 |
| 0BH | 0 | 0 | 1 | 0 | 1 | 1 | V11' | V1+(V0-V1)x | r11 | 350 | 170 |
| 0CH | 0 | 0 | 1 | 1 | 0 | 0 | V12' | V1+(V0-V1)x | r12 | 350 | 170 |
| 0DH | 0 | 0 | 1 | 1 | 0 | 1 | V13' | V1+(V0-V1)x | r13 | 350 | 170 |
| 0EH | 0 | 0 | 1 | 1 | 1 | 0 | V14' | V1+(V0-V1)x | r14 | 300 | 170 |
| 0FH | 0 | 0 | 1 | 1 | 1 | 1 | V15' | V1+(V0-V1)x | r15 | 300 | 170 |
| 10H | 0 | 1 | 0 | 0 | 0 | 0 | V16' | V1 | r16 | 300 | 152 |
| 11H | 0 | 1 | 0 | 0 | 0 | 1 | V17' | V2+(V1-V2)x | r17 | 250 | 152 |
| 12H | 0 | 1 | 0 | 0 | 1 | 0 | V18' | V2+(V1-V2)x | r18 | 250 | 152 |
| 13H | 0 | 1 | 0 | 0 | 1 | 1 | V19' | V2+(V1-V2)x | r19 | 250 | 152 |
| 14H | 0 | 1 | 0 | 1 | 0 | 0 | V20' | V2+(V1-V2)x | r20 | 200 | 152 |
| 15H | 0 | 1 | 0 | 1 | 0 | 1 | V21' | V2+(V1-V2)x | r21 | 200 | 152 |
| 16H | 0 | 1 | 0 | 1 | 1 | 0 | V22' | V2+(V1-V2)x | r22 | 200 | 152 |
| 17H | 0 | 1 | 0 | 1 | 1 | 1 | V23' | V2+(V1-V2)x | r23 | 150 | 152 |
| 18H | 0 | 1 | 1 | 0 | 0 | 0 | V24' | V2+(V1-V2)x | r24 | 150 | 152 |
| 19H | 0 | 1 | 1 | 0 | 0 | 1 | V25' | V2+(V1-V2)x | r25 | 150 | 152 |
| 1AH | 0 | 1 | 1 | 0 | 1 | 0 | V26' | V2+(V1-V2)x | r26 | 150 | 152 |
| 1BH | 0 | 1 | 1 | 0 | 1 | 1 | V27' | V2+(V1-V2)x | r27 | 100 | 152 |
| 1CH | 0 | 1 | 1 | 1 | 0 | 0 | V28' | V2+(V1-V2)x | r28 | 100 | 152 |
| 1DH | 0 | 1 | 1 | 1 | 0 | 1 | V29' | V2+(V1-V2)x | r29 | 100 | 152 |
| 1EH | 0 | 1 | 1 | 1 | 1 | 0 | V30' | V2+(V1-V2)x | r30 | 100 | 152 |
| 1FH | 0 | 1 | 1 | 1 | 1 | 1 | V31' | V2+(V1-V2)x | r31 | 100 | 152 |
| 20H | 1 | 0 | 0 | 0 | 0 | 0 | V32' | V2 | r32 | 100 | 156 |
| 21H | 1 | 0 | 0 | 0 | 0 | 1 | V33' | V3+(V2-V3)x | r33 | 100 | 156 |
| 22H | 1 | 0 | 0 | 0 | 1 | 0 | V34' | V3+(V2-V3)x | r34 | 100 | 156 |
| 23H | 1 | 0 | 0 | 0 | 1 | 1 | V35' | V3+(V2-V3)x | r35 | 100 | 156 |
| 24H | 1 | 0 | 0 | 1 | 0 | 0 | V36' | V3+(V2-V3)x | r36 | 100 | 156 |
| 25H | 1 | 0 | 0 | 1 | 0 | 1 | V37' | V3+(V2-V3)x | r37 | 100 | 156 |
| 26H | 1 | 0 | 0 | 1 | 1 | 0 | V38' | V3+(V2-V3)x | r38 | 100 | 156 |
| 27H | 1 | 0 | 0 | 1 | 1 | 1 | V39' | V3+(V2-V3)x | r39 | 100 | 156 |
| 28H | 1 | 0 | 1 | 0 | 0 | 0 | V40' | V3+(V2-V3)x | r40 | 100 | 156 |
| 29H | 1 | 0 | 1 | 0 | 0 | 1 | V41' | V3+(V2-V3)x | r41 | 100 | 156 |
| 2AH | 1 | 0 | 1 | 0 | 1 | 0 | V42' | V3+(V2-V3)x | r42 | 100 | 156 |
| 2BH | 1 | 0 | 1 | 0 | 1 | 1 | V43' | V3+(V2-V3)x | r43 | 100 | 156 |
| 2CH | 1 | 0 | 1 | 1 | 0 | 0 | V44' | V3+(V2-V3)x | r44 | 100 | 156 |
| 2DH | 1 | 0 | 1 | 1 | 0 | 1 | V45' | V3+(V2-V3)x | r45 | 100 | 156 |
| 2EH | 1 | 0 | 1 | 1 | 1 | 0 | V46' | V3+(V2-V3)x | r46 | 100 | 156 |
| 2FH | 1 | 0 | 1 | 1 | 1 | 1 | V47' | V3+(V2-V3)x | r47 | 100 | 156 |
| 30H | 1 | 1 | 0 | 0 | 0 | 0 | V48' | V3 | r48 | 100 | 175 |
| 31H | 1 | 1 | 0 | 0 | 0 | 1 | V49' | V4+(V3-V4)x | r49 | 100 | 175 |
| 32H | 1 | 1 | 0 | 0 | 1 | 0 | V50' | V4+(V3-V4)x | r50 | 100 | 175 |
| 33H | 1 | 1 | 0 | 0 | 1 | 1 | V51' | V4+(V3-V4)x | r51 | 100 | 175 |
| 34H | 1 | 1 | 0 | 1 | 0 | 0 | V52' | V4+(V3-V4)x | r52 | 100 | 175 |
| 35H | 1 | 1 | 0 | 1 | 0 | 1 | V53' | V4+(V3-V4)x | r53 | 150 | 232 |
| 36H | 1 | 1 | 0 | 1 | 1 | 0 | V54' | V4+(V3-V4)x | r54 | 150 | 232 |
| 37H | 1 | 1 | 0 | 1 | 1 | 1 | V55' | V4+(V3-V4)x | r55 | 150 | 232 |
| 38H | 1 | 1 | 1 | 0 | 0 | 0 | V56' | V4+(V3-V4)x | r56 | 200 | 232 |
| 39H | 1 | 1 | 1 | 0 | 0 | 1 | V57' | V4+(V3-V4)x | r57 | 200 | 289 |
| 3AH | 1 | 1 | 1 | 0 | 1 | 0 | V58' | V4+(V3-V4)x | r58 | 250 | 345 |
| 3BH | 1 | 1 | 1 | 0 | 1 | 1 | V59' | V4+(V3-V4)x | r59 | 250 | 402 |
| 3CH | 1 | 1 | 1 | 1 | 0 | 0 | V60' | V4+(V3-V4)x | r60 | 300 | 402 |
| 3DH | 1 | 1 | 1 | 1 | 0 | 1 | V61' | V4+(V3-V4)x | r61 | 500 | 459 |
| 3EH | 1 | 1 | 1 | 1 | 1 | 0 | V62' | V4+(V3-V4)x | r62 | 800 | 872 |
| 3FH | 1 | 1 | 1 | 1 | 1 | 1 | V63' | V4 | rtotal | 15850 | 15851 |

Caution There is no connection between V4 and V5 terminal in the chip.

Figure 5-3. Relationship between Input Data and Output Voltage (2/2)

$V_4 > V_5 > V_6 > V_7 > V_8 > V_9 > V_{SS2} + 0.1 V$, POL2 = L

| Data | Dx5 | Dx4 | Dx3 | Dx2 | Dx1 | Dxo | Output Voltage | |
|------|-----|-----|-----|-----|-----|-----|----------------|--|
| | | | | | | | 732A | 732B |
| 00H | 0 | 0 | 0 | 0 | 0 | 0 | V_0'' | V_9 |
| 01H | 0 | 0 | 0 | 0 | 0 | 1 | V_1'' | $V_9+(V_8-V_9) \times \frac{800}{8050}$ |
| 02H | 0 | 0 | 0 | 0 | 1 | 0 | V_2'' | $V_9+(V_8-V_9) \times \frac{1550}{8050}$ |
| 03H | 0 | 0 | 0 | 0 | 1 | 1 | V_3'' | $V_9+(V_8-V_9) \times \frac{2250}{8050}$ |
| 04H | 0 | 0 | 0 | 1 | 0 | 0 | V_4'' | $V_9+(V_8-V_9) \times \frac{2900}{8050}$ |
| 05H | 0 | 0 | 0 | 1 | 0 | 1 | V_5'' | $V_9+(V_8-V_9) \times \frac{3500}{8050}$ |
| 06H | 0 | 0 | 0 | 1 | 1 | 0 | V_6'' | $V_9+(V_8-V_9) \times \frac{4050}{8050}$ |
| 07H | 0 | 0 | 0 | 1 | 1 | 1 | V_7'' | $V_9+(V_8-V_9) \times \frac{4600}{8050}$ |
| 08H | 0 | 0 | 1 | 0 | 0 | 0 | V_8'' | $V_9+(V_8-V_9) \times \frac{5100}{8050}$ |
| 09H | 0 | 0 | 1 | 0 | 0 | 1 | V_9'' | $V_9+(V_8-V_9) \times \frac{5600}{8050}$ |
| 0AH | 0 | 0 | 1 | 0 | 1 | 0 | V_{10}'' | $V_9+(V_8-V_9) \times \frac{6000}{8050}$ |
| 0BH | 0 | 0 | 1 | 0 | 1 | 1 | V_{11}'' | $V_9+(V_8-V_9) \times \frac{6400}{8050}$ |
| 0CH | 0 | 0 | 1 | 1 | 0 | 0 | V_{12}'' | $V_9+(V_8-V_9) \times \frac{6750}{8050}$ |
| 0DH | 0 | 0 | 1 | 1 | 0 | 1 | V_{13}'' | $V_9+(V_8-V_9) \times \frac{7100}{8050}$ |
| 0EH | 0 | 0 | 1 | 1 | 1 | 0 | V_{14}'' | $V_9+(V_8-V_9) \times \frac{7450}{8050}$ |
| 0FH | 0 | 0 | 1 | 1 | 1 | 1 | V_{15}'' | $V_9+(V_8-V_9) \times \frac{7750}{8050}$ |
| 10H | 0 | 1 | 0 | 0 | 0 | 0 | V_{16}'' | V_8 |
| 11H | 0 | 1 | 0 | 0 | 0 | 1 | V_{17}'' | $V_8+(V_7-V_8) \times \frac{300}{2750}$ |
| 12H | 0 | 1 | 0 | 0 | 1 | 0 | V_{18}'' | $V_8+(V_7-V_8) \times \frac{550}{2750}$ |
| 13H | 0 | 1 | 0 | 0 | 1 | 1 | V_{19}'' | $V_8+(V_7-V_8) \times \frac{800}{2750}$ |
| 14H | 0 | 1 | 0 | 1 | 0 | 0 | V_{20}'' | $V_8+(V_7-V_8) \times \frac{1050}{2750}$ |
| 15H | 0 | 1 | 0 | 1 | 0 | 1 | V_{21}'' | $V_8+(V_7-V_8) \times \frac{1250}{2750}$ |
| 16H | 0 | 1 | 0 | 1 | 1 | 0 | V_{22}'' | $V_8+(V_7-V_8) \times \frac{1450}{2750}$ |
| 17H | 0 | 1 | 0 | 1 | 1 | 1 | V_{23}'' | $V_8+(V_7-V_8) \times \frac{1650}{2750}$ |
| 18H | 0 | 1 | 1 | 0 | 0 | 0 | V_{24}'' | $V_8+(V_7-V_8) \times \frac{1800}{2750}$ |
| 19H | 0 | 1 | 1 | 0 | 0 | 1 | V_{25}'' | $V_8+(V_7-V_8) \times \frac{1950}{2750}$ |
| 1AH | 0 | 1 | 1 | 0 | 1 | 0 | V_{26}'' | $V_8+(V_7-V_8) \times \frac{2100}{2750}$ |
| 1BH | 0 | 1 | 1 | 0 | 1 | 1 | V_{27}'' | $V_8+(V_7-V_8) \times \frac{2250}{2750}$ |
| 1CH | 0 | 1 | 1 | 1 | 0 | 0 | V_{28}'' | $V_8+(V_7-V_8) \times \frac{2350}{2750}$ |
| 1DH | 0 | 1 | 1 | 1 | 0 | 1 | V_{29}'' | $V_8+(V_7-V_8) \times \frac{2450}{2750}$ |
| 1EH | 0 | 1 | 1 | 1 | 1 | 0 | V_{30}'' | $V_8+(V_7-V_8) \times \frac{2550}{2750}$ |
| 1FH | 0 | 1 | 1 | 1 | 1 | 1 | V_{31}'' | $V_8+(V_7-V_8) \times \frac{2650}{2750}$ |
| 20H | 1 | 0 | 0 | 0 | 0 | 0 | V_{32}'' | V_7 |
| 21H | 1 | 0 | 0 | 0 | 0 | 1 | V_{33}'' | $V_7+(V_6-V_7) \times \frac{100}{1600}$ |
| 22H | 1 | 0 | 0 | 0 | 1 | 0 | V_{34}'' | $V_7+(V_6-V_7) \times \frac{200}{1600}$ |
| 23H | 1 | 0 | 0 | 0 | 1 | 1 | V_{35}'' | $V_7+(V_6-V_7) \times \frac{300}{1600}$ |
| 24H | 1 | 0 | 0 | 1 | 0 | 0 | V_{36}'' | $V_7+(V_6-V_7) \times \frac{400}{1600}$ |
| 25H | 1 | 0 | 0 | 1 | 0 | 1 | V_{37}'' | $V_7+(V_6-V_7) \times \frac{500}{1600}$ |
| 26H | 1 | 0 | 0 | 1 | 1 | 0 | V_{38}'' | $V_7+(V_6-V_7) \times \frac{600}{1600}$ |
| 27H | 1 | 0 | 0 | 1 | 1 | 1 | V_{39}'' | $V_7+(V_6-V_7) \times \frac{700}{1600}$ |
| 28H | 1 | 0 | 1 | 0 | 0 | 0 | V_{40}'' | $V_7+(V_6-V_7) \times \frac{800}{1600}$ |
| 29H | 1 | 0 | 1 | 0 | 0 | 1 | V_{41}'' | $V_7+(V_6-V_7) \times \frac{900}{1600}$ |
| 2AH | 1 | 0 | 1 | 0 | 1 | 0 | V_{42}'' | $V_7+(V_6-V_7) \times \frac{1000}{1600}$ |
| 2BH | 1 | 0 | 1 | 0 | 1 | 1 | V_{43}'' | $V_7+(V_6-V_7) \times \frac{1100}{1600}$ |
| 2CH | 1 | 0 | 1 | 1 | 0 | 0 | V_{44}'' | $V_7+(V_6-V_7) \times \frac{1200}{1600}$ |
| 2DH | 1 | 0 | 1 | 1 | 0 | 1 | V_{45}'' | $V_7+(V_6-V_7) \times \frac{1300}{1600}$ |
| 2EH | 1 | 0 | 1 | 1 | 1 | 0 | V_{46}'' | $V_7+(V_6-V_7) \times \frac{1400}{1600}$ |
| 2FH | 1 | 0 | 1 | 1 | 1 | 1 | V_{47}'' | $V_7+(V_6-V_7) \times \frac{1500}{1600}$ |
| 30H | 1 | 1 | 0 | 0 | 0 | 0 | V_{48}'' | V_6 |
| 31H | 1 | 1 | 0 | 0 | 0 | 1 | V_{49}'' | $V_6+(V_5-V_6) \times \frac{100}{3450}$ |
| 32H | 1 | 1 | 0 | 0 | 1 | 0 | V_{50}'' | $V_6+(V_5-V_6) \times \frac{200}{3450}$ |
| 33H | 1 | 1 | 0 | 0 | 1 | 1 | V_{51}'' | $V_6+(V_5-V_6) \times \frac{300}{3450}$ |
| 34H | 1 | 1 | 0 | 1 | 0 | 0 | V_{52}'' | $V_6+(V_5-V_6) \times \frac{400}{3450}$ |
| 35H | 1 | 1 | 0 | 1 | 0 | 1 | V_{53}'' | $V_6+(V_5-V_6) \times \frac{500}{3450}$ |
| 36H | 1 | 1 | 0 | 1 | 1 | 0 | V_{54}'' | $V_6+(V_5-V_6) \times \frac{650}{3450}$ |
| 37H | 1 | 1 | 0 | 1 | 1 | 1 | V_{55}'' | $V_6+(V_5-V_6) \times \frac{800}{3450}$ |
| 38H | 1 | 1 | 1 | 0 | 0 | 0 | V_{56}'' | $V_6+(V_5-V_6) \times \frac{950}{3450}$ |
| 39H | 1 | 1 | 1 | 0 | 0 | 1 | V_{57}'' | $V_6+(V_5-V_6) \times \frac{1150}{3450}$ |
| 3AH | 1 | 1 | 1 | 0 | 1 | 0 | V_{58}'' | $V_6+(V_5-V_6) \times \frac{1350}{3450}$ |
| 3BH | 1 | 1 | 1 | 0 | 1 | 1 | V_{59}'' | $V_6+(V_5-V_6) \times \frac{1600}{3450}$ |
| 3CH | 1 | 1 | 1 | 1 | 0 | 0 | V_{60}'' | $V_6+(V_5-V_6) \times \frac{1850}{3450}$ |
| 3DH | 1 | 1 | 1 | 1 | 0 | 1 | V_{61}'' | $V_6+(V_5-V_6) \times \frac{2150}{3450}$ |
| 3EH | 1 | 1 | 1 | 1 | 1 | 0 | V_{62}'' | $V_6+(V_5-V_6) \times \frac{2650}{3450}$ |
| 3FH | 1 | 1 | 1 | 1 | 1 | 1 | V_{63}'' | V_5 |

| rn | (Ω) | |
|--------|-------|-------|
| | 732A | 732B |
| r0 | 800 | 1766 |
| r1 | 750 | 736 |
| r2 | 700 | 566 |
| r3 | 650 | 509 |
| r4 | 600 | 396 |
| r5 | 550 | 340 |
| r6 | 550 | 283 |
| r7 | 500 | 283 |
| r8 | 500 | 226 |
| r9 | 400 | 226 |
| r10 | 400 | 170 |
| r11 | 350 | 170 |
| r12 | 350 | 170 |
| r13 | 350 | 170 |
| r14 | 300 | 170 |
| r15 | 300 | 170 |
| r16 | 300 | 152 |
| r17 | 250 | 152 |
| r18 | 250 | 152 |
| r19 | 250 | 152 |
| r20 | 200 | 152 |
| r21 | 200 | 152 |
| r22 | 200 | 152 |
| r23 | 150 | 152 |
| r24 | 150 | 152 |
| r25 | 150 | 152 |
| r26 | 150 | 152 |
| r27 | 100 | 152 |
| r28 | 100 | 152 |
| r29 | 100 | 152 |
| r30 | 100 | 152 |
| r31 | 100 | 152 |
| r32 | 100 | 156 |
| r33 | 100 | 156 |
| r34 | 100 | 156 |
| r35 | 100 | 156 |
| r36 | 100 | 156 |
| r37 | 100 | 156 |
| r38 | 100 | 156 |
| r39 | 100 | 156 |
| r40 | 100 | 156 |
| r41 | 100 | 156 |
| r42 | 100 | 156 |
| r43 | 100 | 156 |
| r44 | 100 | 156 |
| r45 | 100 | 156 |
| r46 | 100 | 156 |
| r47 | 100 | 156 |
| r48 | 100 | 175 |
| r49 | 100 | 175 |
| r50 | 100 | 175 |
| r51 | 100 | 175 |
| r52 | 100 | 175 |
| r53 | 150 | 232 |
| r54 | 150 | 232 |
| r55 | 150 | 232 |
| r56 | 200 | 232 |
| r57 | 200 | 289 |
| r58 | 250 | 345 |
| r59 | 250 | 402 |
| r60 | 300 | 402 |
| r61 | 500 | 459 |
| r62 | 800 | 872 |
| rtotal | 15850 | 15851 |

Caution There is no connection between V4 and V5 terminal in the chip.

6. RELATIONSHIP BETWEEN INPUT DATA AND OUTPUT PIN

Data format: 6 bits × 2 RGBs (6 dots)

Input width: 36 bits (2-pixel data)

R,/L = H (Right shift)

| | | | | | | | |
|--------|------------------------------------|------------------------------------|------------------------------------|------------------------------------|-----|------------------------------------|------------------------------------|
| Output | S ₁ | S ₂ | S ₃ | S ₄ | ... | S 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 |

R,/L = L (Left shift)

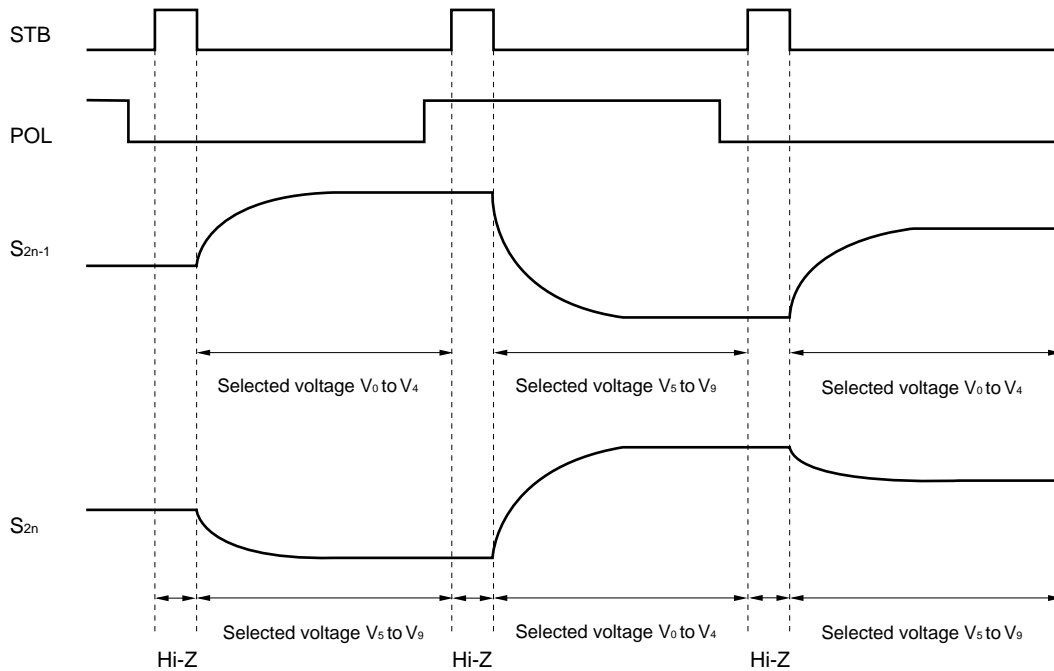
| | | | | | | | |
|--------|------------------------------------|------------------------------------|------------------------------------|------------------------------------|-----|------------------------------------|------------------------------------|
| Output | S ₁ | S ₂ | S ₃ | S ₄ | ... | S ₃₈₃ | 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, POL AND OUTPUT WAVEFORM

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



8. RELATIONSHIP BETWEEN STB, CLK, AND OUTPUT WAVEFORM

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

Figure 8-1. Output Circuit Block Diagram

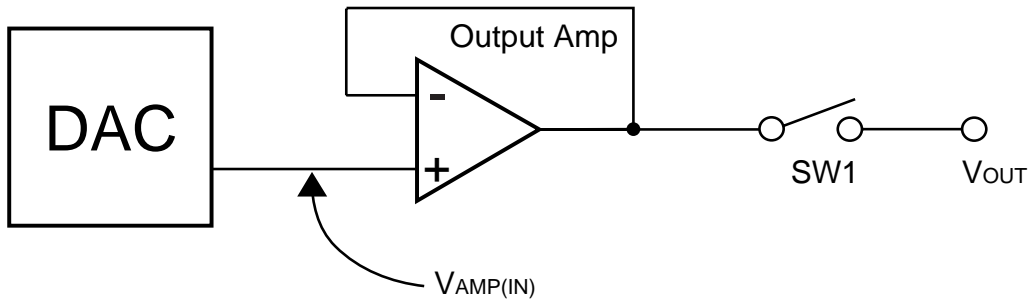
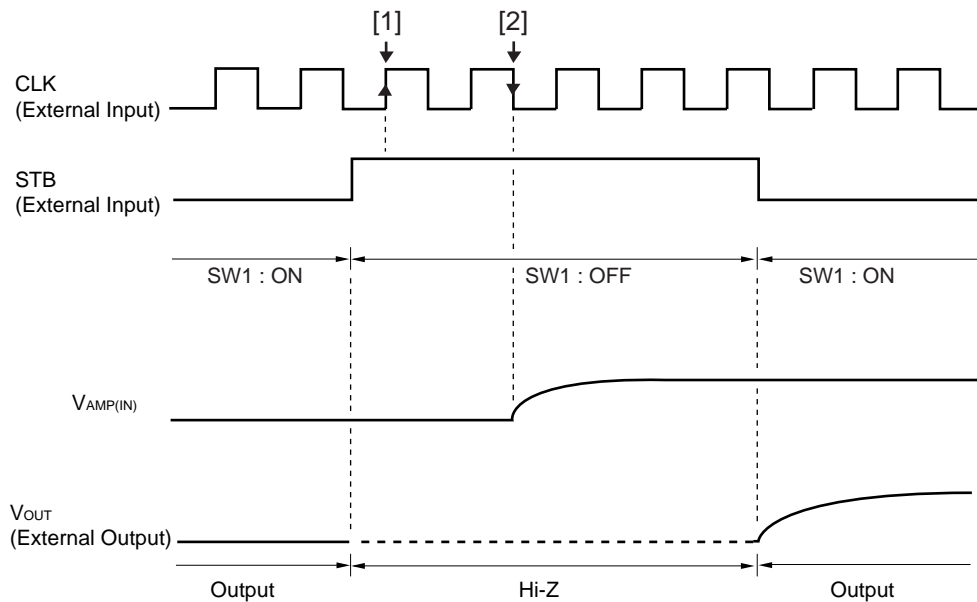


Figure 8-2. Output Circuit Timing Waveform



- Remarks 1.** STB = L : SW1 = ON
 STB = H : SW1 = OFF
- 2.** STB = "H" is acknowledged at timing [1].
- 3.** The display data latch is completed at timing [2] and the input voltage (Vamp (in) : gray-scale level voltage) of the output amplifier changes.

9. CURRENT CONSUMPTION REDUCTION FUNCTION

The μ PD16732A and 16732B have a low power control function (LPC) which can switch the bias current of the output amplifier between two levels and a bias control function (Bcont) which can be used to finely control the bias current.

<Low power control function (LPC)>

The bias current of the output amplifier can be switched between two levels using this pin. (Bcont: Open)

LPC = H or Open: Normal power mode

LPC = L: Low power mode

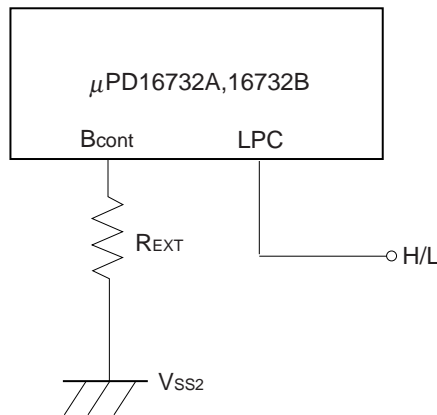
- ★ The V_{DD2} of static current consumption can be reduced to two thirds of that in normal mode. Input a stable DC current (V_{DD1}/V_{SS1}) to this pin.

<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 ground potential (V_{SS2}) via an external resistor (R_{EXT}). When not using this function, leave this pin open.

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

Figure9-1. Bias Current Control Function (Bcont)



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

★ **Talbe9-1. Current Consumption Regulation Percentage Compared to Normal Mode**

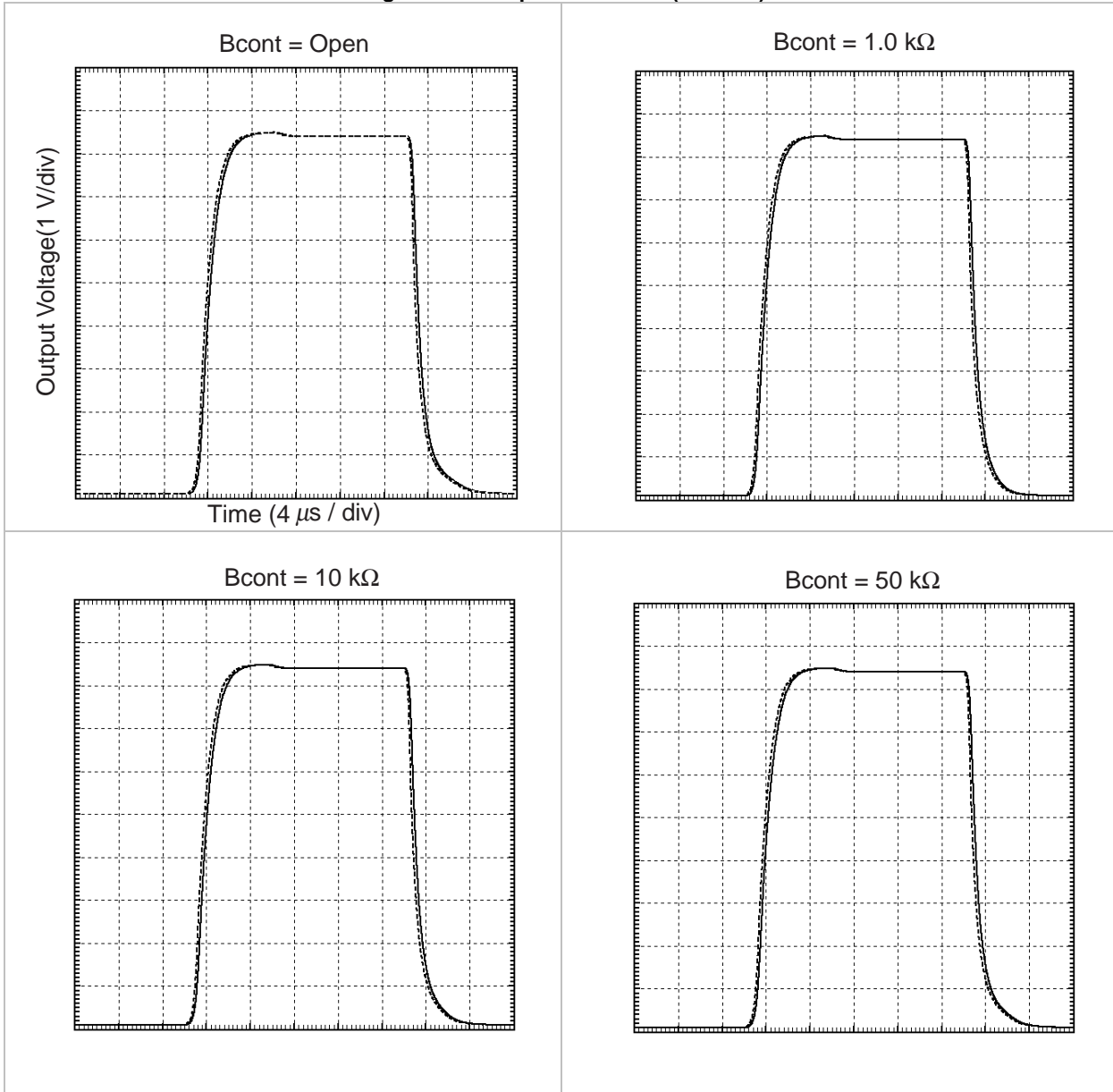
| R_{EXT} | Current Consumption Regulation Percentage | |
|-----------------|---|---------|
| | LPC = H | LPC = L |
| ∞ (Open) | 100 % | 65 % |
| 50 kΩ | 110 % | 70 % |
| 20 kΩ | 115 % | 80 % |
| 10 kΩ | 120 % | 85 % |

$V_{DD1} = 3.3 \text{ V}$
 $V_{DD2} = 8.7 \text{ V}$
 $LPC = 3.3 \text{ V}/0 \text{ V}$

Remark 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.

Figure9-2. Output wave form (LPC = L)



----- [1]
 _____ [2]

<Test Condition>

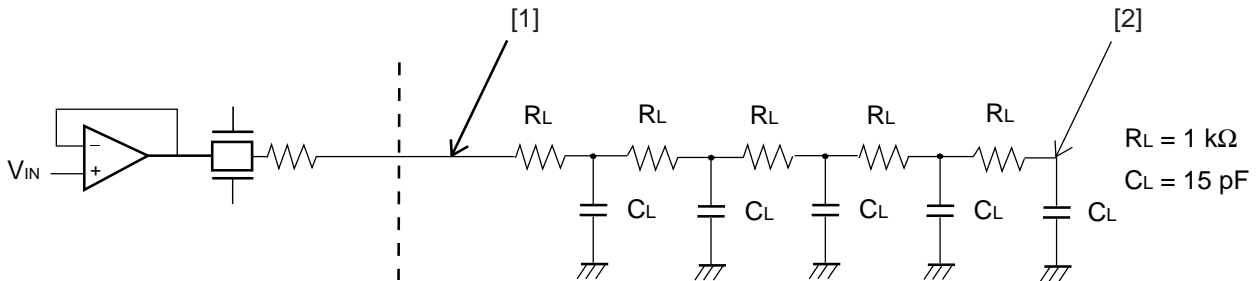
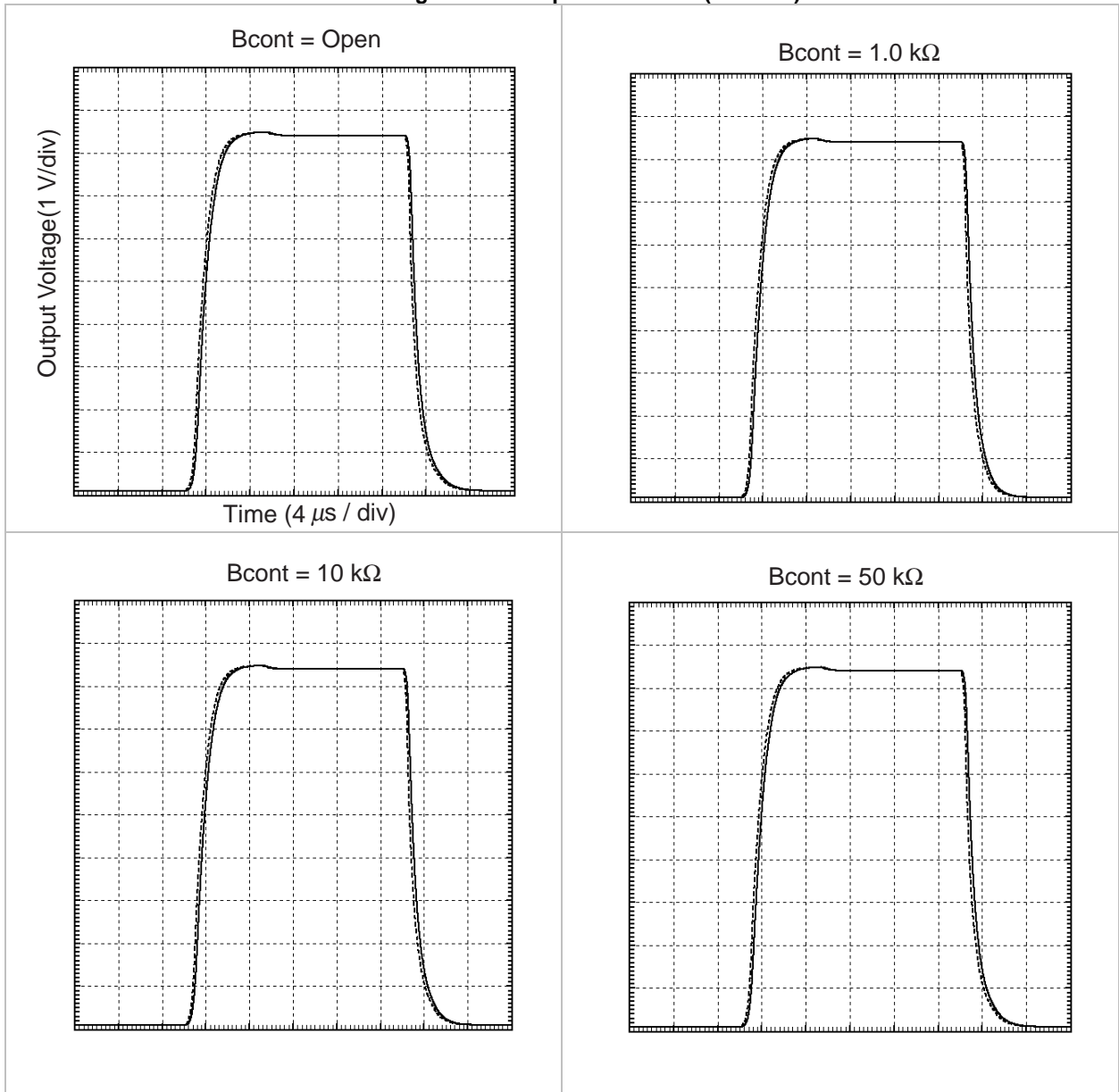


Figure9-3. Output wave form (LPC = H)



10. ELECTRICAL SPECIFICATIONS

Absolute Maximum Ratings ($T_A = +25\text{ }^\circ\text{C}$, $V_{SS1} = V_{SS2} = 0\text{ V}$)

| 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 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 ($T_A = -10\text{ to }+75\text{ }^\circ\text{C}$, $V_{SS1} = V_{SS2} = 0\text{ V}$)

| Parameter | Symbol | Conditions | MIN. | TYP. | MAX. | Unit |
|-----------------------------|----------------|--|-----------------|------|-----------------|------|
| Logic Part Supply Voltage | V_{DD1} | | 2.3 | | 3.6 | V |
| Driver Part Supply Voltage | V_{DD2} | | 8.0 | 8.5 | 9.0 | V |
| High-Level Input Voltage | V_{IH} | | $0.7 V_{DD1}$ | | V_{DD1} | V |
| Low-Level Input Voltage | V_{IL} | | 0 | | $0.3 V_{DD1}$ | V |
| γ -Corrected Voltage | V_0 to V_9 | | $V_{SS2} + 0.1$ | | $V_{DD2} - 0.1$ | V |
| Driver Part Output Voltage | V_O | | $V_{SS2} + 0.1$ | | $V_{DD2} - 0.1$ | V |
| Maximum Clock Frequency | $f_{MAX.}$ | $V_{DD1} = 2.3\text{ V to }3.6\text{ V}$ | 45 | | | MHz |
| | | $V_{DD1} = 3.0\text{ V to }3.6\text{ V}$ | 65 | | | MHz |

Electrical Characteristics ($T_A = -10$ to $+75$ °C, $V_{DD1} = 2.3$ V to 3.6 V, $V_{DD2} = 8.5$ V \pm 0.5 V, $V_{SS1} = V_{SS2} = 0$ V, Unless otherwise specified, the input level is defined to be LPC = H or Open, Bcont = Open)

| Parameter | Symbol | Condition | MIN. | TYP. | MAX. | Unit | |
|---|------------------|---|----------------------|---------|-----------------|---------|---------|
| Input Leak Current | I_{IL} | | | | ± 1.0 | μA | |
| High-Level Output Voltage | V_{OH} | STHR (STHL), $I_{OH} = 0$ mA | $V_{DD1} - 0.1$ | | | V | |
| Low-Level Output Voltage | V_{OL} | STHR (STHL), $I_{OL} = 0$ mA | | | 0.1 | V | |
| γ -Corrected Supply Current | I_γ | V_0 to $V_4 =$ | V_0 pin, V_5 pin | 126 | 252 | 504 | μA |
| | | V_5 to $V_9 = 4.0$ V | V_4 pin, V_9 pin | -504 | -252 | -126 | μA |
| Driver Output Current | I_{VOH} | $V_X = 7.0$ V, $V_{OUT} = 6.5$ V ^{Note} | | | -30 | μA | |
| | I_{VOL} | $V_X = 1.0$ V, $V_{OUT} = 1.5$ V ^{Note} | 30 | | | μA | |
| Output Voltage Deviation | ΔV_O | $V_{DD1} = 3.3$ V, $V_{DD2} = 8.5$ V, $V_{OUT} = 2.0$ V, 4.25 V, 6.5 V | | ± 7 | ± 20 | mV | |
| Output swing difference deviation | ΔV_{P-P} | | | ± 2 | ± 15 | mV | |
| Output Voltage Range | V_O | All Input data | 0.1 | | $V_{DD2} - 0.1$ | V | |
| Logic Part Dynamic Current Consumption | I_{DD1} | V_{DD1} , with no load | | 3.0 | 6.0 | mA | |
| Driver Part Dynamic Current Consumption | I_{DD21} | $V_{DD2} = 8.5$ V \pm 0.5 V, with no load LPC = H, Bcont = Open | | 3.0 | 6.0 | mA | |
| | I_{DD22} | $V_{DD2} = 8.5$ V \pm 0.5 V, with no load LPC = L, Bcont = Open | | 2.0 | 4.0 | mA | |

Notes1. V_X refers to the output voltage of analog output pins S_1 to S_{384} .

2. V_{OUT} refers to the voltage applied to analog output pins S_1 to S_{384} .

Cautions 1. The STB cycle is defined to be 20 μs at $f_{CLK} = 40$ MHz.

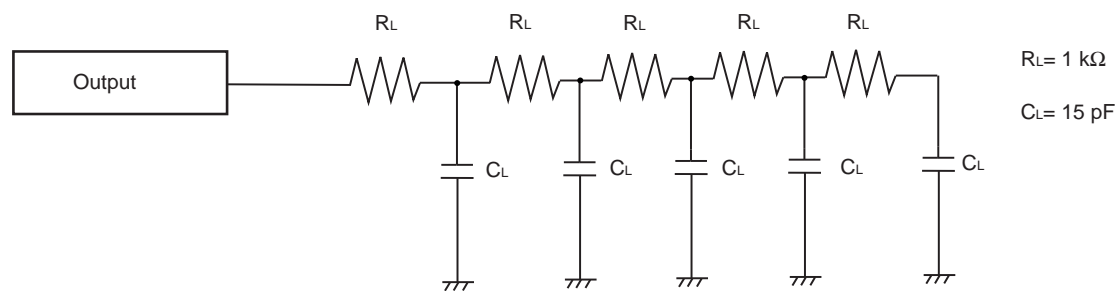
2. The TYP. values refer to an all black or all white input pattern. The MAX. value refers to the measured values in the dot checkerboard input pattern.

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

Switching Characteristics ($T_A = -10$ to $+75$ °C, $V_{DD1} = 2.3$ V to 3.6 V, $V_{DD2} = 8.5$ V \pm 0.5 V, $V_{SS1} = V_{SS2} = 0$ V,
Unless otherwise specified, the input level is defined to be LPC = H or Open,
Bcont = Open)

| Parameter | Symbol | Condition | MIN. | TYP. | MAX. | Unit |
|--------------------------|------------|--|------|------|------|------|
| Start Pulse Delay Time | t_{PLH1} | $C_L = 10$ pF, $V_{DD1} = 2.3$ V to 3.6 V | | 10 | 17 | ns |
| | | $C_L = 10$ pF, $V_{DD1} = 3.0$ V to 3.6 V | | 7 | 10.5 | ns |
| Driver Output Delay Time | t_{PLH2} | $C_L = 75$ pF, $R_L = 5$ kΩ | | 2.5 | 5 | μ s |
| | t_{PLH3} | | | 5 | 8 | μ s |
| | t_{PHL2} | | | 2.5 | 5 | μ s |
| | t_{PHL3} | | | 5 | 8 | μ s |
| Input Capacitance | C_{i1} | STHR (STHL) excluded, $T_A = +25$ °C | | 5 | 10 | pF |
| | C_{i2} | STHR (STHL), $T_A = +25$ °C | | 8 | 10 | pF |

<Measurement Condition>

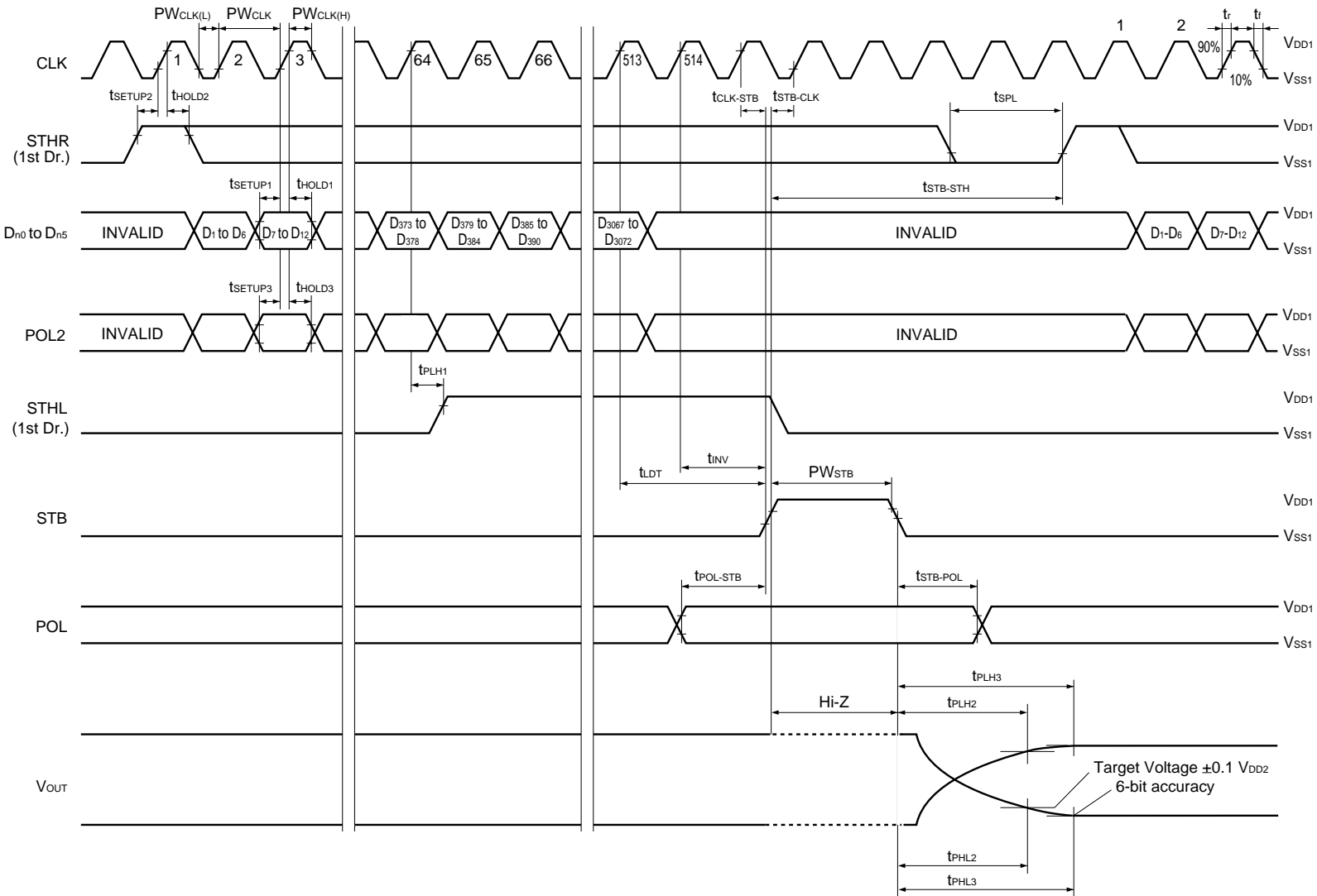


Timing Requirement ($T_A = -10$ to $+75$ °C, $V_{DD1} = 2.3$ V to 3.6 V, $V_{SS1} = V_{SS2} = 0$ V, $t_r = t_f = 8.0$ ns)

| Parameter | Symbol | Condition | MIN. | TYP. | MAX. | Unit |
|----------------------------------|----------------------|--|------|------|------|------|
| Clock Pulse Width | PW _{CLK} | V _{DD1} = 2.3 V to 3.6 V | 22 | | | ns |
| | | V _{DD1} = 3.0 V to 3.6 V | 15 | | | ns |
| Clock Pulse High Period | PW _{CLK(H)} | | 4 | | | ns |
| Clock Pulse Low Period | PW _{CLK(L)} | V _{DD1} = 2.3 V to 3.6 V | 6 | | | ns |
| | | V _{DD1} = 3.0 V to 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 |
| POL2 Setup Time | t _{SETUP3} | | 4 | | | ns |
| POL2 Hold Time | t _{HOLD3} | | 0 | | | ns |
| Start Pulse Low Period | t _{SPL} | | 6 | | | ns |
| STB Pulse Width | PW _{STB} | | 2 | | | CLK |
| | | | | | 4 | μs |
| Data Invalid Period | t _{INV} | | 1 | | | CLK |
| Last Data Timing | t _{LDT} | | 2 | | | CLK |
| CLK-STB Time | t _{CLK-STB} | CLK ↑ → STB ↑ | 6 | | | ns |
| STB-CLK Time | t _{STB-CLK} | STB ↑ → CLK ↑ V _{DD1} = 2.3 V to 3.6 V | 9 | | | ns |
| | | STB ↑ → CLK ↑ V _{DD1} = 3.0 V to 3.6 V | 6 | | | ns |
| Time Between STB and Start Pulse | t _{STB-STH} | STB ↑ → STHR(STHL) ↑ | 2 | | | CLK |
| POL-STB Time | t _{POL-STB} | POL ↑ or ↓ → STB ↑ | -5 | | | ns |
| ★ STB-POL Time | t _{STB-POL} | STB ↓ → POL ↓ or ↑ | 6 | | | ns |

★ 11. SWITCHING CHARACTERISTICS WAVEFORM

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



12. RECOMMENDED SOLDERING CONDITIONS

The following conditions must be met for soldering conditions of the μ PD16732A, 16732B.

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

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

μ PD16732AN-xxx, μ PD16732BN-xxx : TCP (TAB package)

| Mounting Condition | Mounting Method | Condition |
|--------------------|--------------------------------------|---|
| Thermocompression | Soldering | Heating tool 300 to 350°C: heating for 2 to 3 seconds: pressure 100g (per solder) |
| | ACF (Adhesive Conductive Film) | Temporary bonding 70 to 100°C: pressure 3 to 8 kg/cm ² : time 3 to 5 seconds. Real bonding 165 to 180°C: pressure 25 to 45 kg/cm ² : time 30 to 40 seconds. (When using the anisotropy conductive film SUMIZAC1003 of Sumitomo Bakelite, Ltd.) |

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

[MEMO]

[MEMO]

[MEMO]

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

Note:

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

② HANDLING OF UNUSED INPUT PINS FOR CMOS

Note:

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

③ STATUS BEFORE INITIALIZATION OF MOS DEVICES

Note:

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

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

- **The information in this document is subject to change without notice. Before using this document, please confirm that this is the latest version.**
 - No part of this document may be copied or reproduced in any form or by any means without the prior written consent of NEC Corporation. NEC Corporation assumes no responsibility for any errors which may appear in this document.
 - NEC Corporation does not assume any liability for infringement of patents, copyrights or other intellectual property rights of third parties by or arising from use of a device described herein or any other liability arising from use of such device. No license, either express, implied or otherwise, is granted under any patents, copyrights or other intellectual property rights of NEC Corporation or others.
 - Descriptions of circuits, software, and other related information in this document are provided for illustrative purposes in semiconductor product operation and application examples. The incorporation of these circuits, software, and information in the design of the customer's equipment shall be done under the full responsibility of the customer. NEC Corporation assumes no responsibility for any losses incurred by the customer or third parties arising from the use of these circuits, software, and information.
 - While NEC Corporation has been making continuous effort to enhance the reliability of its semiconductor devices, the possibility of defects cannot be eliminated entirely. To minimize risks of damage or injury to persons or property arising from a defect in an NEC semiconductor device, customers must incorporate sufficient safety measures in its design, such as redundancy, fire-containment, and anti-failure features.
 - NEC devices are classified into the following three quality grades:
"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.
- The quality grade of NEC devices is "Standard" unless otherwise specified in NEC's Data Sheets or Data Books. If customers intend to use NEC devices for applications other than those specified for Standard quality grade, they should contact an NEC sales representative in advance.