

TOSHIBA CMOS DIGITAL INTEGRATED CIRCUIT SILICON MONOLITHIC

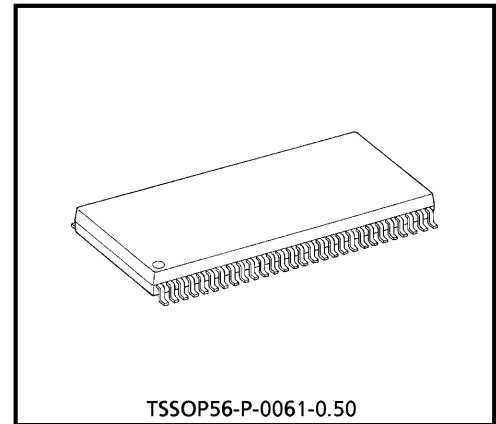
TC74VCX16835FT**LOW-VOLTAGE 18-BIT UNIVERSAL BUS DRIVER
WITH 3.6 V TOLERANT INPUTS AND OUTPUTS**

The TC74VCX16835FT is a high performance CMOS 18-bit UNIVERSAL BUS DRIVER. Designed for use in 1.8, 2.5 or 3.3 Volt systems, it achieves high speed operation while maintaining the CMOS low power dissipation.

It is also designed with over voltage tolerant inputs and outputs up to 3.6 V.

Data flow from A to Y is controlled by the output-enable (\overline{OE}) input. The device operates in the transparent mode when the latch-enable (LE) input is high. When LE is low, the A data is latched if the clock (CLK) input is held at a high or low logic level. If LE is low, the A data is stored in the latch/flip-flop on the low-to-high transition of CLK. When \overline{OE} is high, the outputs are in the high-impedance state.

All inputs are equipped with protection circuits against static discharge.



TSSOP56-P-0061-0.50

Weight : 0.25 g (Typ.)

FEATURES

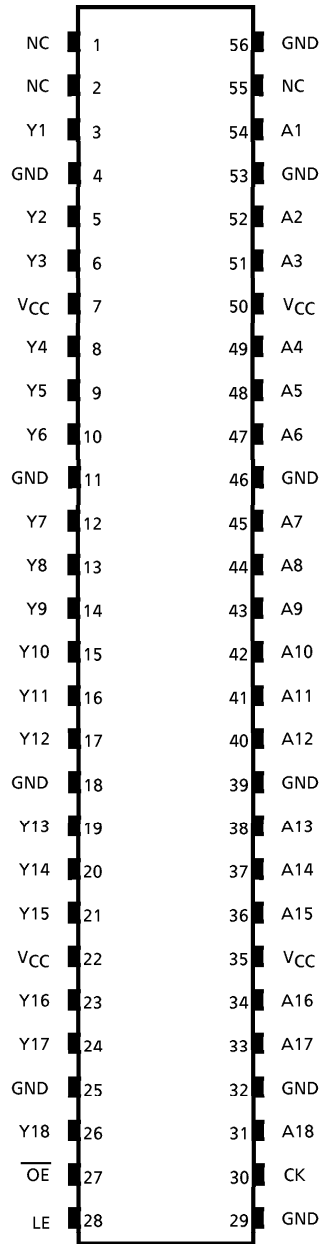
- Low Voltage Operation : $V_{CC} = 1.8\sim 3.6\text{ V}$
- High Speed Operation : $t_{pd} = 3.3\text{ ns (max) at } V_{CC} = 3.0\sim 3.6\text{ V}$
 : $t_{pd} = 4.2\text{ ns (max) at } V_{CC} = 2.3\sim 2.7\text{ V}$
 : $t_{pd} = 8.4\text{ ns (max) at } V_{CC} = 1.8\text{ V}$
- 3.6 V Tolerant inputs and outputs.
- Output Current : $I_{OH}/I_{OL} = \pm 24\text{ mA (min) at } V_{CC} = 3.0\text{ V}$
 : $I_{OH}/I_{OL} = \pm 18\text{ mA (min) at } V_{CC} = 2.3\text{ V}$
 : $I_{OH}/I_{OL} = \pm 6\text{ mA (min) at } V_{CC} = 1.8\text{ V}$
- Latch-up Performance : $\pm 300\text{ mA}$
- ESD Performance : Human Body Model $> \pm 2000\text{ V}$
 : Machine Model $> \pm 200\text{ V}$
- Package : TSSOP
 (Thin Shrink Small Outline Package)
- Power Down Protection is provided on all inputs and outputs.
- Supports live insertion / withdrawal (Note 1)

(Note 1) : To ensure the high-impedance state during power up or power down, \overline{OE} should be tied to V_{CC} through a pullup resistor; the minimum value of the resistor is determined by the current-sourcing capability of the driver.

980910EBA2

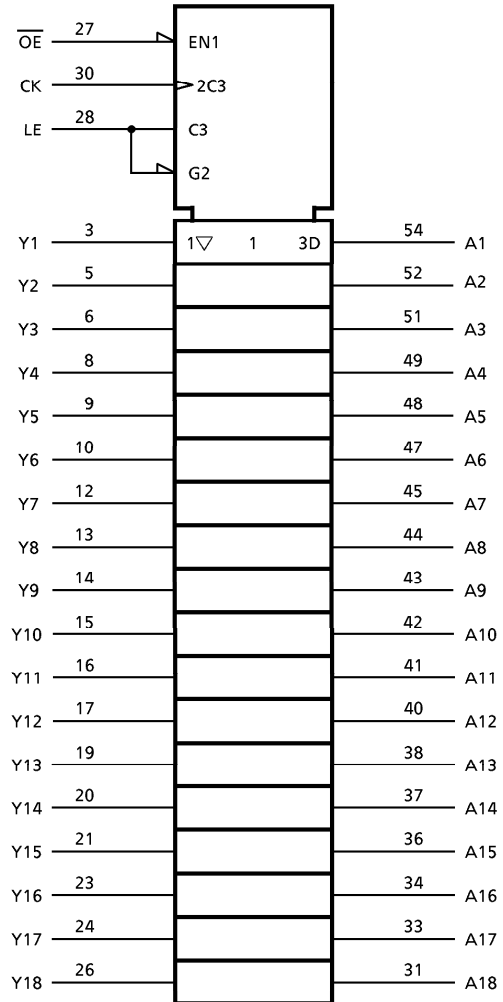
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PIN ASSIGNMENT





(TOP VIEW)

SYMBOL

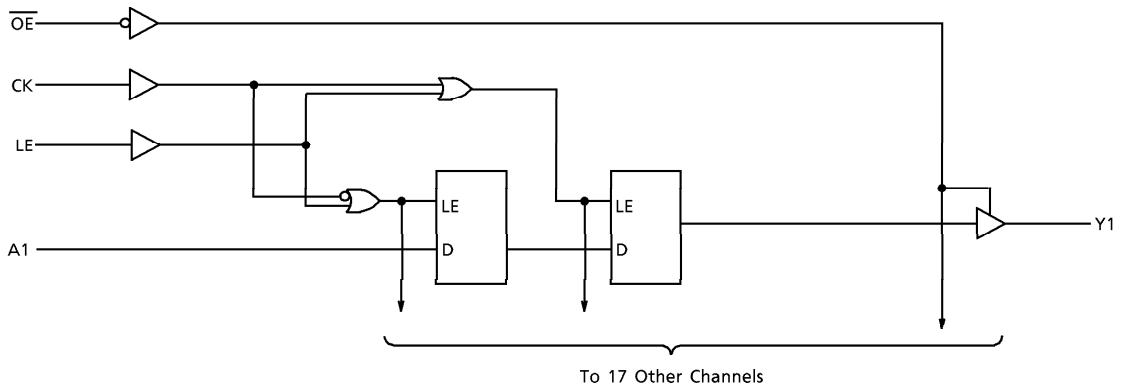


TRUTH TABLE

| INPUTS | | | | OUTPUTS Y |
|-----------------|----|---|---|--------------|
| \overline{OE} | LE | CK | A | |
| H | X | X | X | Z |
| L | H | X | L | L |
| L | H | X | H | H |
| L | L |  | L | L |
| L | L |  | H | H |
| L | L | H | X | Y0 * |
| L | L | L | X | Y0 * |

(*) : Output level before the indicated steady-state input conditions were established, provided that CK was high or low before LE went low.

SYSTEM DIAGRAM



MAXIMUM RATINGS

| PARAMETER | SYMBOL | RATING | UNIT |
|---|--------------------|-------------------------------|------|
| Power Supply Voltage | V_{CC} | -0.5~4.6 | V |
| DC Input Voltage | V_{IN} | -0.5~4.6 | V |
| DC Output Voltage | V_{OUT} | -0.5~4.6 (Note 2) | V |
| | | -0.5~ V_{CC} + 0.5 (Note 3) | |
| Input Diode Current | I_{IK} | -50 | mA |
| Output Diode Current | I_{OK} | ±50 (Note 4) | mA |
| DC Output Current | I_{OUT} | ±50 | mA |
| Power Dissipation | P_D | 400 | mW |
| DC V_{CC} / Ground Current Per Supply Pin | I_{CC} / I_{GND} | ±100 | mA |
| Storage Temperature | T_{stg} | -65~150 | °C |

(Note 2) : Off-State

(Note 3) : High or Low State. I_{OUT} absolute maximum rating must be observed.

(Note 4) : $V_{OUT} < GND$, $V_{OUT} > V_{CC}$

RECOMMENDED OPERATING RANGE

| PARAMETER | SYMBOL | RATING | UNIT |
|--------------------------|-------------------|----------------------|------|
| Supply Voltage | V_{CC} | 1.8~3.6 | V |
| | | 1.2~3.6 (Note 5) | |
| Input Voltage | V_{IN} | -0.3~3.6 | V |
| Output Voltage | $V_{I/O}$ | 0~3.6 (Note 6) | V |
| | | 0~ V_{CC} (Note 7) | |
| Output Current | I_{OH} / I_{OL} | ±24 (Note 8) | mA |
| | | ±18 (Note 9) | |
| | | ±6 (Note 10) | |
| Operating Temperature | T_{opr} | -40~85 | °C |
| Input Rise And Fall Time | dt/dv | 0~10 (Note 11) | ns/V |

(Note 5) : Data Retention Only

(Note 6) : Off-State

(Note 7) : High or Low State

(Note 8) : $V_{CC} = 3.0\sim 3.6\text{ V}$

(Note 9) : $V_{CC} = 2.3\sim 2.7\text{ V}$

(Note 10) : $V_{CC} = 1.8\text{ V}$

(Note 11) : $V_{IN} = 0.8\sim 2.0\text{ V}$, $V_{CC} = 3.0\text{ V}$

ELECTRICAL CHARACTERISTICS

DC characteristics (Ta = -40~85°C, 2.7 V < V_{CC} ≤ 3.6 V)

| PARAMETER | | SYMBOL | TEST CONDITION | | V _{CC} (V) | MIN | MAX | UNIT |
|---------------------------------------|-----------|------------------|--|---------------------------|---------------------|-----------------------|--------|------|
| | | | | | | | | |
| Input Voltage | "H" Level | V _{IH} | | | 2.7~3.6 | 2.0 | — | V |
| | "L" Level | V _{IL} | | | 2.7~3.6 | — | 0.8 | |
| Output Voltage | "H" Level | V _{OH} | V _{IN} = V _{IH} or V _{IL} | I _{OH} = -100 μA | 2.7~3.6 | V _{CC} - 0.2 | — | V |
| | | | | I _{OH} = -12 mA | 2.7 | 2.2 | — | |
| | | | | I _{OH} = -18 mA | 3.0 | 2.4 | — | |
| | | | | I _{OH} = -24 mA | 3.0 | 2.2 | — | |
| | "L" Level | V _{OL} | V _{IN} = V _{IH} or V _{IL} | I _{OL} = 100 μA | 2.7~3.6 | — | 0.2 | |
| | | | | I _{OL} = 12 mA | 2.7 | — | 0.4 | |
| | | | | I _{OL} = 18 mA | 3.0 | — | 0.4 | |
| | | | | I _{OL} = 24 mA | 3.0 | — | 0.55 | |
| Input Leakage Current | | I _{IN} | V _{IN} = 0~3.6 V | | 2.7~3.6 | — | ± 5.0 | μA |
| 3-State Output Off-State Current | | I _{OZ} | V _{IN} = V _{IH} or V _{IL} V _{OUT} = 0~3.6 V | | 2.7~3.6 | — | ± 10.0 | μA |
| Power Off Leakage Current | | I _{OFF} | V _{IN} , V _{OUT} = 0~3.6 V | | 0 | — | 10.0 | μA |
| Quiescent Supply Current | | I _{CC} | V _{IN} = V _{CC} or GND | | 2.7~3.6 | — | 20.0 | μA |
| | | | V _{CC} ≤ (V _{IN} , V _{OUT}) ≤ 3.6 V | | 2.7~3.6 | — | ± 20.0 | |
| Increase In I _{CC} Per Input | | ΔI _{CC} | V _{IH} = V _{CC} - 0.6 V | | 2.7~3.6 | — | 750 | μA |

ELECTRICAL CHARACTERISTICS

DC characteristics (Ta = -40~85°C, 2.3 V ≤ V_{CC} ≤ 2.7 V)

| PARAMETER | | SYMBOL | TEST CONDITION | | V _{CC} (V) | MIN | MAX | UNIT |
|----------------------------------|-----------|------------------|--|---------------------------|---------------------|-----------------------|--------|------|
| | | | | | | | | |
| Input Voltage | "H" Level | V _{IH} | | | 2.3~2.7 | 1.6 | — | V |
| | "L" Level | V _{IL} | | | 2.3~2.7 | — | 0.7 | |
| Output Voltage | "H" Level | V _{OH} | V _{IN} = V _{IH} or V _{IL} | I _{OH} = -100 μA | 2.3~2.7 | V _{CC} - 0.2 | — | V |
| | | | | I _{OH} = -6 mA | 2.3 | 2.0 | — | |
| | | | | I _{OH} = -12 mA | 2.3 | 1.8 | — | |
| | | | | I _{OH} = -18 mA | 2.3 | 1.7 | — | |
| | "L" Level | V _{OL} | V _{IN} = V _{IH} or V _{IL} | I _{OL} = 100 μA | 2.3~2.7 | — | 0.2 | |
| | | | | I _{OL} = 12 mA | 2.3 | — | 0.4 | |
| | | | | I _{OL} = 18 mA | 2.3 | — | 0.6 | |
| | | | | | | | | |
| Input Leakage Current | | I _{IN} | V _{IN} = 0~3.6 V | | 2.3~2.7 | — | ± 5.0 | μA |
| 3-State Output Off-State Current | | I _{OZ} | V _{IN} = V _{IH} or V _{IL} V _{OUT} = 0~3.6 V | | 2.3~2.7 | — | ± 10.0 | μA |
| Power Off Leakage Current | | I _{OFF} | V _{IN} , V _{OUT} = 0~3.6 V | | 0 | — | 10.0 | μA |
| Quiescent Supply Current | | I _{CC} | V _{IN} = V _{CC} or GND | | 2.3~2.7 | — | 20.0 | μA |
| | | | V _{CC} ≤ (V _{IN} , V _{OUT}) ≤ 3.6 V | | 2.3~2.7 | — | ± 20.0 | |

ELECTRICAL CHARACTERISTICS

DC characteristics (Ta = -40~85°C, 1.8 V ≤ VCC < 2.3 V)

| PARAMETER | | SYMBOL | TEST CONDITION | | VCC (V) | MIN | MAX | UNIT |
|----------------------------------|-----------|------------------|--|---------------------------|---------|-----------------------|-----------------------|------|
| | | | | | | | | |
| Input Voltage | "H" Level | V _{IH} | | | 1.8~2.3 | 0.7 × V _{CC} | — | V |
| | "L" Level | V _{IL} | | | 1.8~2.3 | — | 0.2 × V _{CC} | |
| Output Voltage | "H" Level | V _{OH} | V _{IN} = V _{IH} or V _{IL} | I _{OH} = -100 μA | 1.8 | V _{CC} - 0.2 | — | V |
| | | | | I _{OH} = -6 mA | 1.8 | 1.4 | — | |
| | "L" Level | V _{OL} | V _{IN} = V _{IH} or V _{IL} | I _{OL} = 100 μA | 1.8 | — | 0.2 | |
| | | | | I _{OL} = 6 mA | 1.8 | — | 0.3 | |
| Input Leakage Current | | I _{IN} | V _{IN} = 0~3.6 V | | 1.8 | — | ± 5.0 | μA |
| 3-State Output Off-State Current | | I _{OZ} | V _{IN} = V _{IH} or V _{IL} V _{OUT} = 0~3.6 V | | 1.8 | — | ± 10.0 | μA |
| Power Off Leakage Current | | I _{OFF} | V _{IN} , V _{OUT} = 0~3.6 V | | 0 | — | 10.0 | μA |
| Quiescent Supply Current | | I _{CC} | V _{IN} = V _{CC} or GND | | 1.8 | — | 20.0 | μA |
| | | | V _{CC} ≤ (V _{IN} , V _{OUT}) ≤ 3.6 V | | 1.8 | — | ± 20.0 | |

AC characteristics (Ta = -40~85°C, Input $t_r = t_f = 2.0$ ns, $C_L = 30$ pF, $R_L = 500$ Ω)

| PARAMETER | SYMBOL | TEST CONDITION | VCC (V) | MIN | MAX | UNIT |
|------------------------------------|--|----------------|-----------|-----|-----|------|
| | | | | | | |
| Maximum Clock Frequency | f _{MAX} | (Fig.1, 3) | 1.8 | 100 | — | MHz |
| | | | 2.5 ± 0.2 | 200 | — | |
| | | | 3.3 ± 0.3 | 250 | — | |
| Propagation Delay Time (An-Yn) | t _{pLH} t _{pHL} | (Fig.1, 2) | 1.8 | 1.5 | 8.4 | ns |
| | | | 2.5 ± 0.2 | 0.8 | 4.2 | |
| | | | 3.3 ± 0.3 | 0.6 | 3.3 | |
| Propagation Delay Time (CK-Yn) | t _{pLH} t _{pHL} | (Fig.1, 3) | 1.8 | 2.0 | 9.2 | ns |
| | | | 2.5 ± 0.2 | 1.5 | 5.2 | |
| | | | 3.3 ± 0.3 | 1.4 | 4.2 | |
| Propagation Delay Time (LE-Yn) | t _{pLH} t _{pHL} | (Fig.1, 4) | 1.8 | 1.5 | 9.8 | ns |
| | | | 2.5 ± 0.2 | 0.8 | 4.9 | |
| | | | 3.3 ± 0.3 | 0.6 | 3.8 | |
| Output Enable Time | t _{pZL} t _{pZH} | (Fig.1, 5) | 1.8 | 1.5 | 9.8 | ns |
| | | | 2.5 ± 0.2 | 0.8 | 4.9 | |
| | | | 3.3 ± 0.3 | 0.6 | 3.8 | |
| Output Disable Time | t _{pLZ} t _{pHZ} | (Fig.1, 5) | 1.8 | 1.5 | 7.6 | ns |
| | | | 2.5 ± 0.2 | 0.8 | 4.5 | |
| | | | 3.3 ± 0.3 | 0.6 | 3.9 | |
| Minimum Pulse Width | t _w (H) t _w (L) | (Fig.1, 3, 4) | 1.8 | 4.0 | — | ns |
| | | | 2.5 ± 0.2 | 1.5 | — | |
| | | | 3.3 ± 0.3 | 1.5 | — | |
| Minimum Set-up Time (An-CK, An-LE) | t _s | (Fig.1, 3, 4) | 1.8 | 2.5 | — | ns |
| | | | 2.5 ± 0.2 | 1.5 | — | |
| | | | 3.3 ± 0.3 | 1.5 | — | |
| Minimum Hold Time (An-CK, An-LE) | t _h | (Fig.1, 3, 4) | 1.8 | 1.0 | — | ns |
| | | | 2.5 ± 0.2 | 0.7 | — | |
| | | | 3.3 ± 0.3 | 0.7 | — | |
| Output to Output Skew | t _{osLH} t _{osHL} | (Note 12) | 1.8 | — | 0.5 | ns |
| | | | 2.5 ± 0.2 | — | 0.5 | |
| | | | 3.3 ± 0.3 | — | 0.5 | |

(Note 12) : Parameter guaranteed by design.

$$(t_{osLH} = |t_{pLHm} - t_{pLHn}|, t_{osHL} = |t_{pHLm} - t_{pHLn}|)$$

AC characteristics (Ta = 0~85°C, Input $t_r = t_f = 2.0$ ns, $C_L = 0$ pF, $R_L = 500 \Omega$)

| PARAMETER | SYMBOL | TEST CONDITION | V_{CC} (V) | MIN | MAX | UNIT |
|---|------------------------|----------------|----------------|-----|-----|------|
| | | | | | | |
| Propagation Delay Time (An-Yn) (Note 13) | t_{pLH} t_{pHL} | (Fig.1, 2) | 3.3 ± 0.15 | 0.9 | 2.0 | ns |
| Propagation Delay Time (CK-Yn) (Note 13) | t_{pLH} t_{pHL} | (Fig.1, 3) | 3.3 ± 0.15 | 1.5 | 2.9 | ns |
| Propagation Delay Time (LE-Yn) (Note 13) | t_{pLH} t_{pHL} | (Fig.1, 4) | 3.3 ± 0.15 | 0.7 | 2.6 | ns |
| Output Enable Time (Note 13) | t_{pZL} t_{pZH} | (Fig.1, 5) | 3.3 ± 0.15 | 0.7 | 2.6 | ns |
| Output Disable Time (Note 13) | t_{pLZ} t_{pHZ} | (Fig.1, 5) | 3.3 ± 0.15 | 0.7 | 2.7 | ns |
| Minimum Set-up Time (An-CK, An-LE) (Note 13) | t_s | (Fig.1, 3, 4) | 3.3 ± 0.15 | 1.5 | — | ns |
| Minimum Hold Time (An-CK, An-LE) (Note 13) | t_h | (Fig.1, 3, 4) | 3.3 ± 0.15 | 0.7 | — | ns |

(Note 13) : TOSHIBA SPICE simulation data.

AC characteristics (Ta = 0~85°C, Input $t_r = t_f = 2.0$ ns, $C_L = 50$ pF, $R_L = 500 \Omega$)

| PARAMETER | SYMBOL | TEST CONDITION | V_{CC} (V) | MIN | MAX | UNIT |
|---------------------------------------|------------------------|----------------|----------------|-----|-----|------|
| | | | | | | |
| Propagation Delay Time (An-Yn) | t_{pLH} t_{pHL} | (Fig.1, 2) | 3.3 ± 0.15 | 1.0 | 3.6 | ns |
| Propagation Delay Time (CK-Yn) | t_{pLH} t_{pHL} | (Fig.1, 3) | 3.3 ± 0.15 | 1.7 | 4.5 | ns |
| Propagation Delay Time (LE-Yn) | t_{pLH} t_{pHL} | (Fig.1, 4) | 3.3 ± 0.15 | 1.0 | 4.1 | ns |
| Output Enable Time | t_{pZL} t_{pZH} | (Fig.1, 5) | 3.3 ± 0.15 | 1.0 | 4.1 | ns |
| Output Disable Time | t_{pLZ} t_{pHZ} | (Fig.1, 5) | 3.3 ± 0.15 | 1.0 | 4.2 | ns |
| Minimum Set-up Time (An-CK, An-LE) | t_s | (Fig.1, 3, 4) | 3.3 ± 0.15 | 1.5 | — | ns |
| Minimum Hold Time (An-CK, An-LE) | t_h | (Fig.1, 3, 4) | 3.3 ± 0.15 | 0.7 | — | ns |

Dynamic switching characteristics (Ta = 25°C, Input tr = tf = 2.0 ns, CL = 30 pF)

| PARAMETER | SYMBOL | TEST CONDITION | VCC (V) | TYP. | UNIT |
|----------------------------------|--------|--|---------|-------|------|
| | | | | | |
| Quiet Output Maximum Dynamic VOL | VOLP | V _{IH} = 1.8 V, V _{IL} = 0 V (Note 14) | 1.8 | 0.35 | V |
| | | V _{IH} = 2.5 V, V _{IL} = 0 V (Note 14) | 2.5 | 0.7 | |
| | | V _{IH} = 3.3 V, V _{IL} = 0 V (Note 14) | 3.3 | 0.9 | |
| Quiet Output Minimum Dynamic VOL | VOLV | V _{IH} = 1.8 V, V _{IL} = 0 V (Note 14) | 1.8 | -0.35 | V |
| | | V _{IH} = 2.5 V, V _{IL} = 0 V (Note 14) | 2.5 | -0.7 | |
| | | V _{IH} = 3.3 V, V _{IL} = 0 V (Note 14) | 3.3 | -0.9 | |
| Quiet Output Minimum Dynamic VOH | VOHV | V _{IH} = 1.8 V, V _{IL} = 0 V (Note 14) | 1.8 | 1.3 | V |
| | | V _{IH} = 2.5 V, V _{IL} = 0 V (Note 14) | 2.5 | 1.7 | |
| | | V _{IH} = 3.3 V, V _{IL} = 0 V (Note 14) | 3.3 | 2.0 | |

(Note 14) : Parameter guaranteed by design.

Capacitive characteristics (Ta = 25°C)

| PARAMETER | SYMBOL | TEST CONDITION | VCC (V) | TYP. | UNIT |
|-------------------------------|------------------|------------------------------------|---------------|------|------|
| | | | | | |
| Input Capacitance | C _{IN} | | 1.8, 2.5, 3.3 | 6 | pF |
| Output Capacitance | C _{OUT} | | 1.8, 2.5, 3.3 | 7 | pF |
| Power Dissipation Capacitance | C _{PD} | f _{IN} = 10 MHz (Note 15) | 1.8, 2.5, 3.3 | 20 | pF |

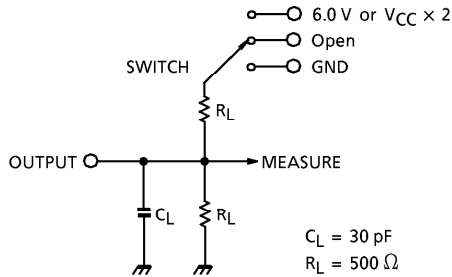
(Note 15) : C_{PD} is defined as the value of the internal equivalent capacitance which is calculated from the operating current consumption without load.

Average operating current can be obtained by the equation :

$$I_{CC}(\text{opr.}) = C_{PD} \cdot V_{CC} \cdot f_{IN} + I_{CC} / 18 \text{ (per bit)}$$

TEST CIRCUIT

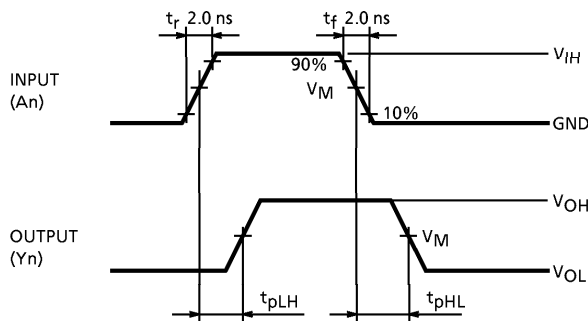
Fig.1



| PARAMETER | SWITCH |
|--------------------|--|
| t_{pLH}, t_{pHL} | Open |
| t_{pLZ}, t_{pZL} | 6.0 V @ $V_{CC} = 3.3 \pm 0.3$ V $V_{CC} \times 2$ @ $V_{CC} = 2.5 \pm 0.2$ V @ $V_{CC} = 1.8$ V |
| t_{pHZ}, t_{pZH} | GND |

AC WAVEFORM

Fig.2 t_{pLH}, t_{pHL}



| SYMBOL | V_{CC} | | |
|----------|------------------|-------------------|-------------------|
| | 3.3 ± 0.3 V | 2.5 ± 0.2 V | 1.8 V |
| V_{IH} | 2.7 V | V_{CC} | V_{CC} |
| V_M | 1.5 V | $V_{CC} / 2$ | $V_{CC} / 2$ |
| V_X | $V_{OL} + 0.3$ V | $V_{OL} + 0.15$ V | $V_{OL} + 0.15$ V |
| V_Y | $V_{OH} - 0.3$ V | $V_{OH} - 0.15$ V | $V_{OH} - 0.15$ V |

Fig.3 $t_{pLH}, t_{pHL}, t_w, t_s, t_h$

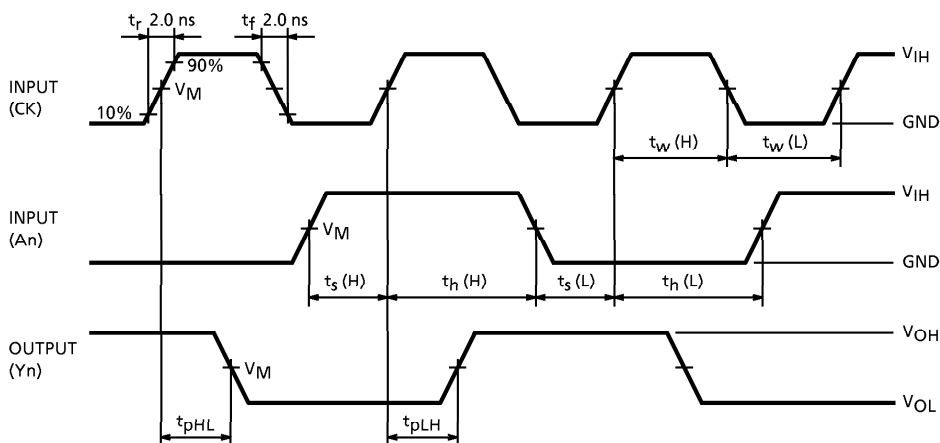


Fig.4 t_{pLH} , t_{pHL} , t_w , t_s , t_h

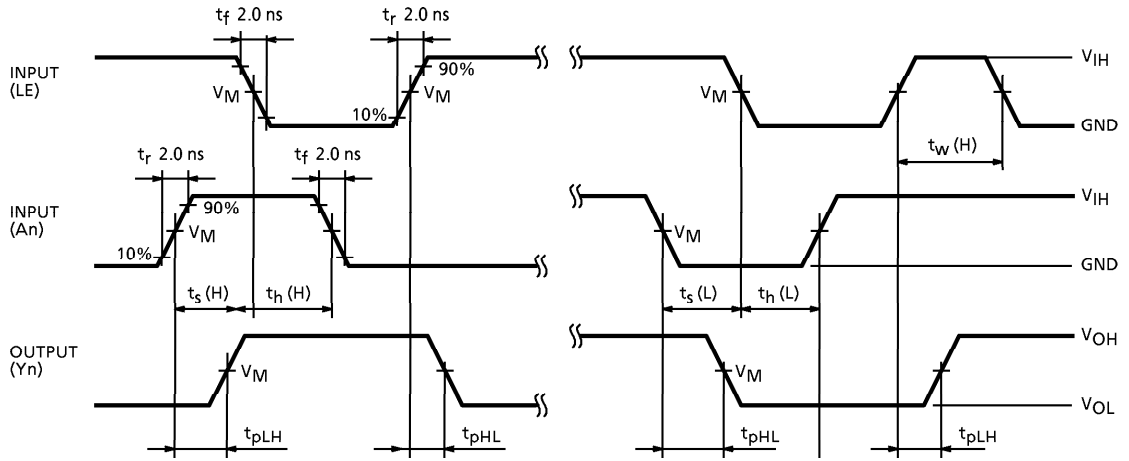
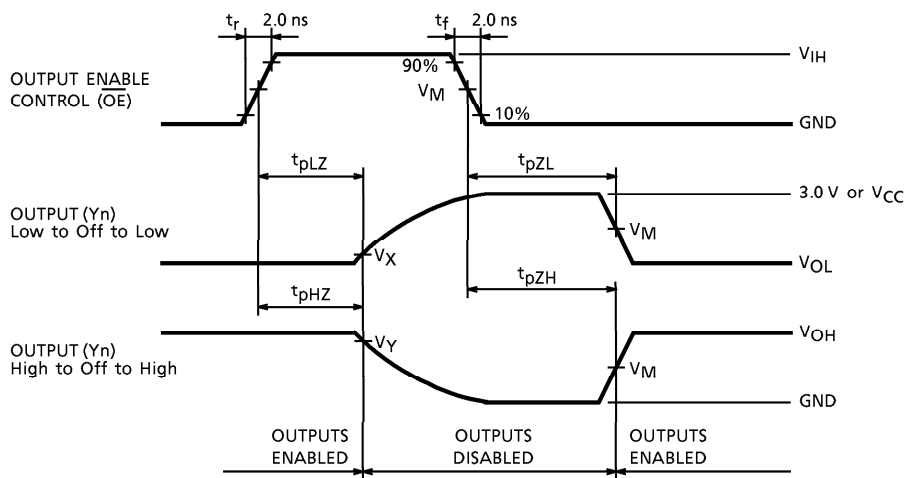


Fig.5 t_{pLZ} , t_{pHZ} , t_{pZL} , t_{pZH}



IBIS CHARACTERISTICS (Typ.)

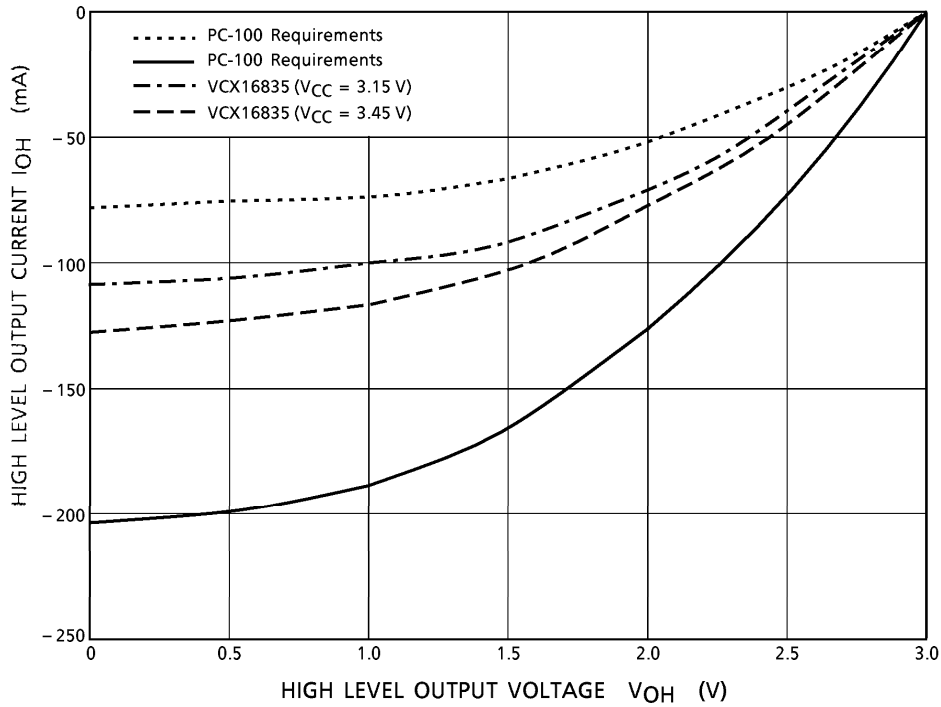


Fig.6 I/V Characteristics-Pullup

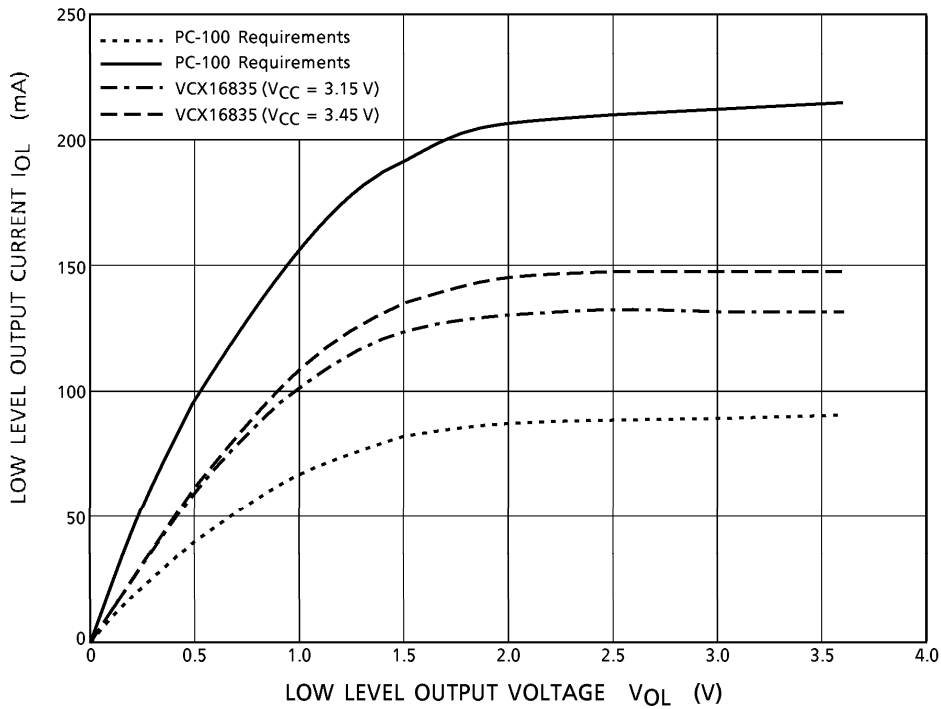
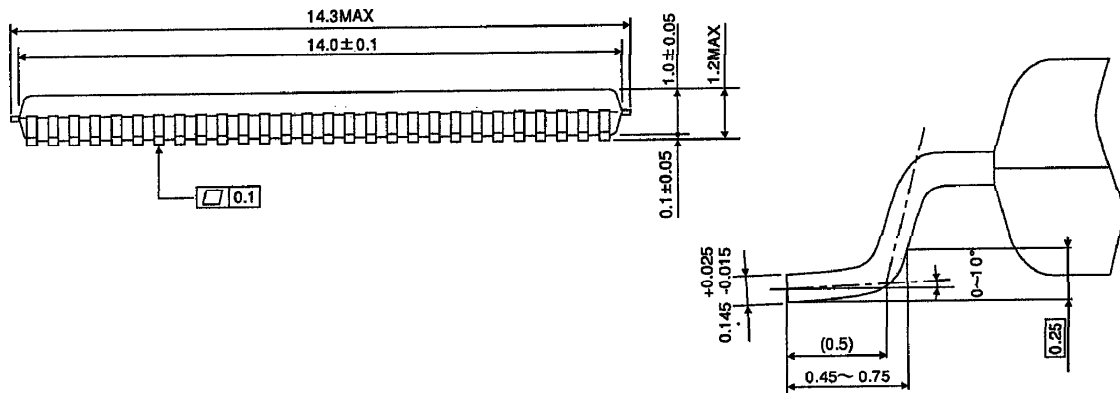
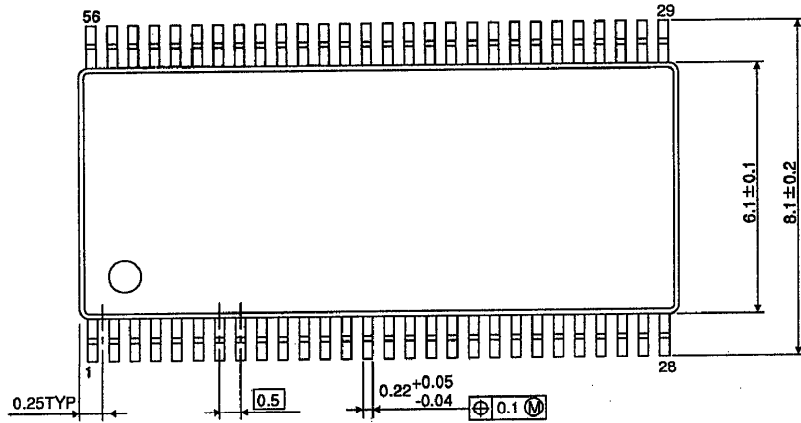


Fig.7 I/V Characteristics-Pulldown

PACKAGE DIMENSIONS

TSSOP56-P-0061-0.50

Unit : mm



Weight : 0.25 g (Typ.)