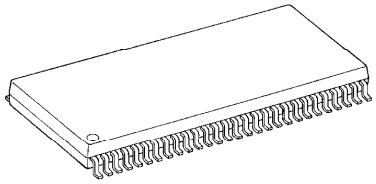
TOSHIBA CMOS DIGITAL INTEGRATED CIRCUIT SILICON MONOLITHIC

# TC74VCX16823FT

## LOW-VOLTAGE 18-BIT D-TYPE FLIP-FLOP WITH 3.6 V TOLERANT INPUTS AND OUTPUTS

The TC74VCX16823FT is a high performance CMOS 18-bit D-TYPE FLIP-FLOP. 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 3.6V.
The TC74VCX16823FT can be used as two 9-bit flip-flops or one 18-bit flip-flop. With the clock-enable ($\overline{CKEN}$) input low, the D-type flip-flops enter data on the low-to-high transitions of the clock. Taking $\overline{CKEN}$ high disables the clock buffer, thus latching the outputs. Taking the clear ($\overline{CLR}$) input low causes the Q outputs to go low independently of the clock.
When the $\overline{OE}$ input is high, the outputs are in a high impedance state. This device is designed to be used with 3 – state memory address drivers, etc.
All inputs are equipped with protection circuits against static discharge.



TSSOP56-P-0061-0.50

Weight : 0.25 g (Typ.)

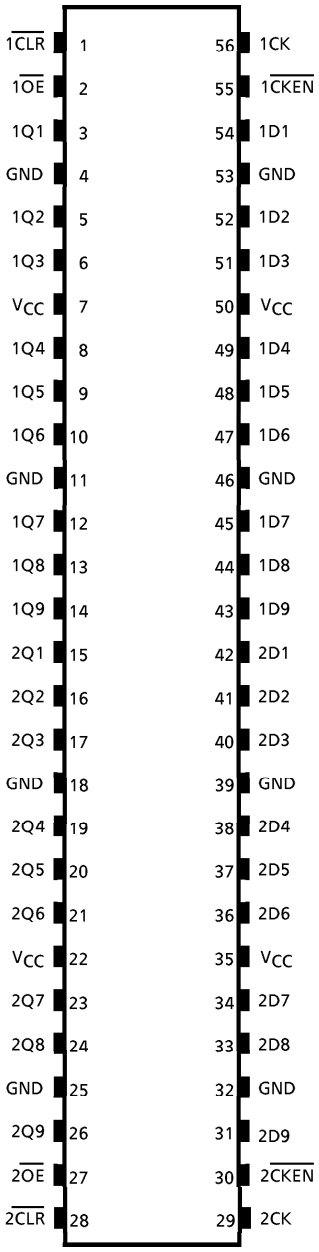
### FEATURES

- Low Voltage Operation : $V_{CC}$ = 1.8~3.6 V
- High Speed Operation : $t_{pd}$ = 3.5 ns (max) at $V_{CC}$ = 3.0~3.6 V
  : $t_{pd}$ = 4.4 ns (max) at $V_{CC}$ = 2.3~2.7 V
  : $t_{pd}$ = 8.8 ns (max) at $V_{CC}$ = 1.8 V
- 3.6V Tolerant inputs and outputs.
- Output Current : $I_{OH}$ / $I_{OL}$ = ±24 mA (min) at $V_{CC}$ = 3.0 V
  : $I_{OH}$ / $I_{OL}$ = ±18 mA (min) at $V_{CC}$ = 2.3 V
  : $I_{OH}$ / $I_{OL}$ = ±6 mA (min) at $V_{CC}$ = 1.8 V
- Latch-up Performance : ±300 mA
- ESD Performance : Human Body Model > ±2000 V
  : Machine Model > ±200 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.

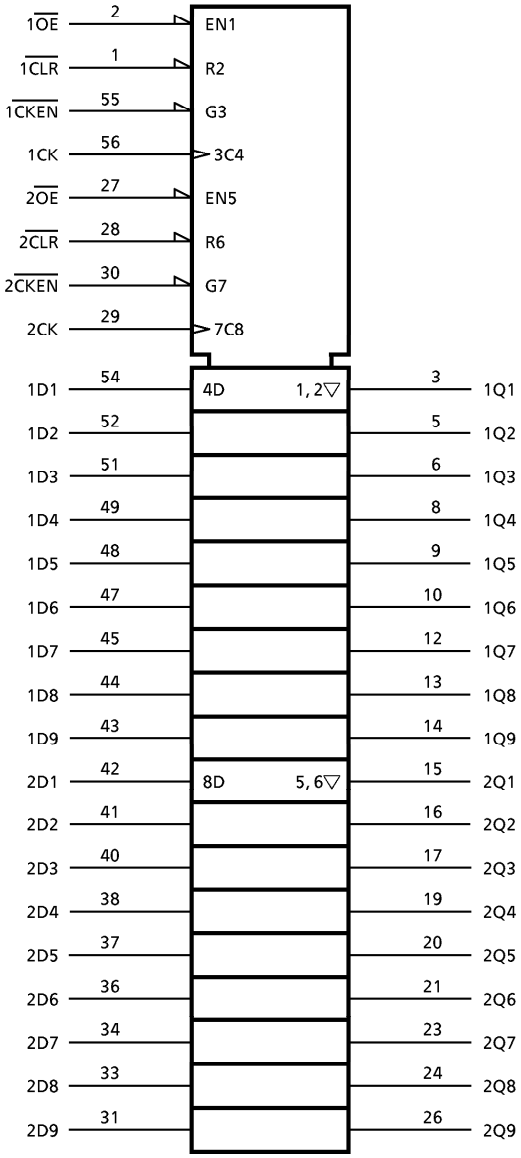
980910EBA2

## PIN ASSIGNMENT




(TOP VIEW)

## SYMBOL



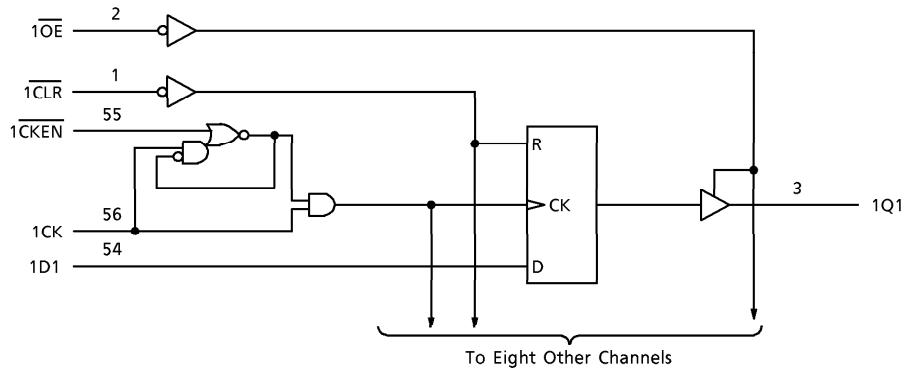

980910EBA2'

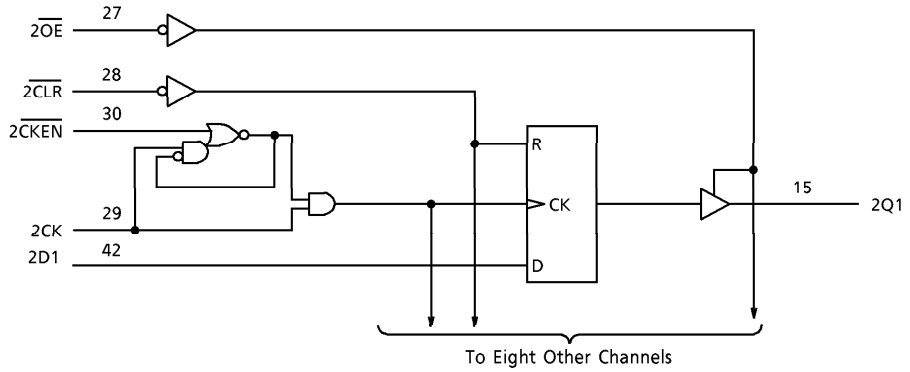
**TRUTH TABLE** (each 9-bit flip flop)

| INPUTS | | | | | OUTPUTS |
|---|---|---|---|---|---|
| $\overline{OE}$ | $\overline{CLR}$ | $\overline{CKEN}$ | CK | D | Q |
| L | L | X | X | X | L |
| L | H | L | ↑ | H | H |
| L | H | L | ↑ | L | L |
| L | H | L | ↓ | X | Q0 |
| L | H | H | X | X | Q0 |
| H | X | X | X | X | Z |

X : Don't Care
Z : High impedance
Qn : No change

**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 1) | V |
| | | −0.5~$V_{CC}$ + 0.5 (Note 2) | |
| Input Diode Current | $I_{IK}$ | −50 | mA |
| Output Diode Current | $I_{OK}$ | ±50 (Note 3) | 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 1) : Off-State
(Note 2) : High or Low State. $I_{OUT}$ absolute maximum rating must be observed.
(Note 3) : $V_{OUT}$ < 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 4) | |
| Input Voltage | $V_{IN}$ | −0.3~3.6 | V |
| Output Voltage | $V_{OUT}$ | 0~3.6 (Note 5) | V |
| | | 0~ $V_{CC}$ (Note 6) | |
| Output Current | $I_{OH}$ / $I_{OL}$ | ±24 (Note 7) | mA |
| | | ±18 (Note 8) | |
| | | ±6 (Note 9) | |
| Operating Temperature | $T_{opr}$ | −40~85 | °C |
| Input Rise And Fall Time | dt / dv | 0~10 (Note 10) | ns / V |

(Note 4) : Data Retention Only
(Note 5) : Off-State
(Note 6) : High or Low State
(Note 7) : $V_{CC}$ = 3.0~3.6 V
(Note 8) : $V_{CC}$ = 2.3~2.7 V
(Note 9) : $V_{CC}$ = 1.8 V
(Note 10) : $V_{IN}$ = 0.8~2.0 V, $V_{CC}$ = 3.0 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 $V_{IL}$<br>$V_{OUT}$ = 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 | | $\Delta I_{CC}$ | $V_{IH}$ = $V_{CC}$ − 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 $V_{IL}$<br>$V_{OUT}$ = 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 ≦ $V_{CC}$ < 2.3 V)

| PARAMETER | | SYMBOL | TEST CONDITION | | $V_{CC}$ (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 $V_{IL}$<br>$V_{OUT}$ = 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 | $V_{CC}$ (V) | MIN | MAX | UNIT |
|---|---|---|---|---|---|---|
| Maximum Clock Frequency | $f_{MAX}$ | (Fig.1, 2) | 1.8 | 100 | — | MHz |
| | | | 2.5 ± 0.2 | 200 | — | |
| | | | 3.3 ± 0.3 | 250 | — | |
| Propagation Delay Time (CK-Q) | $t_{pLH}$ $t_{pHL}$ | (Fig.1, 2) | 1.8 | 1.5 | 8.8 | ns |
| | | | 2.5 ± 0.2 | 0.8 | 4.4 | |
| | | | 3.3 ± 0.3 | 0.6 | 3.5 | |
| Propagation Delay Time ($\overline{CLR}$-Q) | $t_{pHL}$ | (Fig.1, 3) | 1.8 | 1.5 | 9.2 | ns |
| | | | 2.5 ± 0.2 | 0.8 | 4.6 | |
| | | | 3.3 ± 0.3 | 0.6 | 3.7 | |
| 3-State Output Enable Time | $t_{pZL}$ $t_{pZH}$ | (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 | |
| 3-State Output Disable Time | $t_{pLZ}$ $t_{pHZ}$ | (Fig.1, 4) | 1.8 | 1.5 | 7.6 | ns |
| | | | 2.5 ± 0.2 | 0.8 | 4.2 | |
| | | | 3.3 ± 0.3 | 0.6 | 3.7 | |
| Minimum Pulse Width (CK, $\overline{CLR}$) | $t_{w}$ (H) $t_{w}$ (L) | (Fig.1, 2, 3) | 1.8 | 4.0 | — | ns |
| | | | 2.5 ± 0.2 | 1.5 | — | |
| | | | 3.3 ± 0.3 | 1.5 | — | |
| Minimum Set-up Time (D, $\overline{CKEN}$) | $t_s$ | (Fig.1, 2, 5) | 1.8 | 2.5 | — | ns |
| | | | 2.5 ± 0.2 | 1.5 | — | |
| | | | 3.3 ± 0.3 | 1.5 | — | |
| Minimum Hold Time (D, $\overline{CKEN}$) | $t_h$ | (Fig.1, 2, 5) | 1.8 | 1.0 | — | ns |
| | | | 2.5 ± 0.2 | 1.0 | — | |
| | | | 3.3 ± 0.3 | 1.0 | — | |
| Minimum Removal Time | $t_{rem}$ | (Fig.1, 6) | 1.8 | 4.0 | — | ns |
| | | | 2.5 ± 0.2 | 2.0 | — | |
| | | | 3.3 ± 0.3 | 2.0 | — | |
| Output to Output Skew | $t_{osLH}$ $t_{osHL}$ | (Note 11) | 1.8 | — | 0.5 | ns |
| | | | 2.5 ± 0.2 | — | 0.5 | |
| | | | 3.3 ± 0.3 | — | 0.5 | |

For $C_L$ = 50 pF, add approximately 300 ps to the AC maximum specification.

(Note 11) : Parameter guaranteed by design.
($t_{osLH} = |t_{pLHm} - t_{pLHn}|$, $t_{osHL} = |t_{pHLm} - t_{pHLn}|$)

Dynamic switching characteristics (Ta = 25°C, Input $t_r = t_f$ = 2.0 ns, $C_L$ = 30 pF)

| PARAMETER | SYMBOL | TEST CONDITION | $V_{CC}$ (V) | TYP. | UNIT |
|---|---|---|---|---|---|
| Quiet Output Maximum Dynamic $V_{OL}$ | $V_{OLP}$ | $V_{IH}$ = 1.8 V, $V_{IL}$ = 0 V (Note 12) | 1.8 | 0.25 | V |
| | | $V_{IH}$ = 2.5 V, $V_{IL}$ = 0 V (Note 12) | 2.5 | 0.6 | |
| | | $V_{IH}$ = 3.3 V, $V_{IL}$ = 0 V (Note 12) | 3.3 | 0.8 | |
| Quiet Output Minimum Dynamic $V_{OL}$ | $V_{OLV}$ | $V_{IH}$ = 1.8 V, $V_{IL}$ = 0 V (Note 12) | 1.8 | −0.25 | V |
| | | $V_{IH}$ = 2.5 V, $V_{IL}$ = 0 V (Note 12) | 2.5 | −0.6 | |
| | | $V_{IH}$ = 3.3 V, $V_{IL}$ = 0 V (Note 12) | 3.3 | −0.8 | |
| Quiet Output Minimum Dynamic $V_{OH}$ | $V_{OHV}$ | $V_{IH}$ = 1.8 V, $V_{IL}$ = 0 V (Note 12) | 1.8 | 1.5 | V |
| | | $V_{IH}$ = 2.5 V, $V_{IL}$ = 0 V (Note 12) | 2.5 | 1.9 | |
| | | $V_{IH}$ = 3.3 V, $V_{IL}$ = 0 V (Note 12) | 3.3 | 2.2 | |

(Note 12) : Parameter guaranteed by design.

Capacitive characteristics (Ta = 25°C)

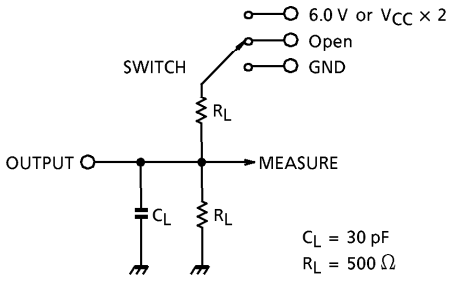
| PARAMETER | SYMBOL | TEST CONDITION | $V_{CC}$ (V) | TYP. | UNIT |
|---|---|---|---|---|---|
| Input Capacitance | $C_{IN}$ | | 1.8, 2.5, 3.3 | 6 | pF |
| Output Capacitance | $C_O$ | | 1.8, 2.5, 3.3 | 7 | pF |
| Power Dissipation Capacitance | $C_{PD}$ | $f_{IN}$ = 10 MHz (Note 13) | 1.8, 2.5, 3.3 | 20 | pF |

(Note 13) : $C_{PD}$ 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 :

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

**TEST CIRCUIT**

Fig.1




| PARAMETER | SWITCH |
|---|---|
| $t_{pLH}$, $t_{pHL}$ | Open |
| $t_{pLZ}$, $t_{pZL}$ | 6.0 V @$V_{CC}$ = 3.3 ± 0.3 V<br>$V_{CC}$ × 2 @$V_{CC}$ = 2.5 ± 0.2 V<br>@$V_{CC}$ = 1.8 V |
| $t_{pHZ}$, $t_{pZH}$ | GND |

**AC WAVEFORM**

Fig.2 $t_{pLH}$, $t_{pHL}$, $t_w$, $t_s$, $t_h$

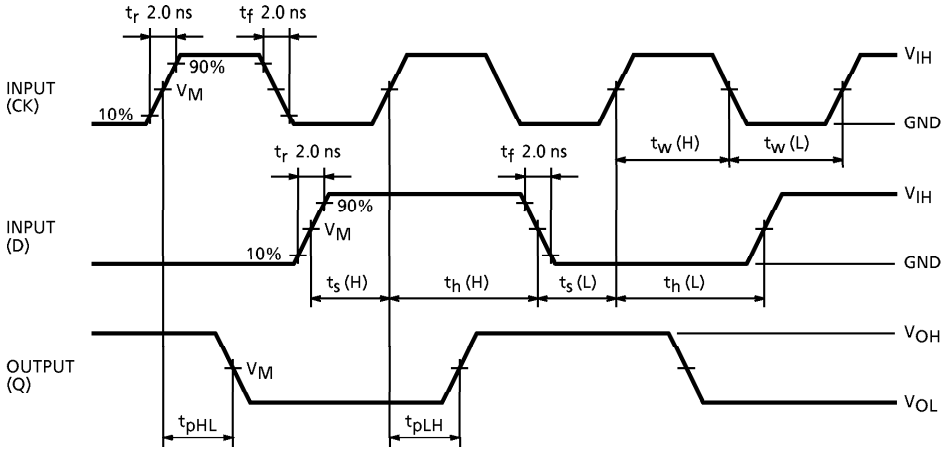



Fig.3 $t_{pHL}$

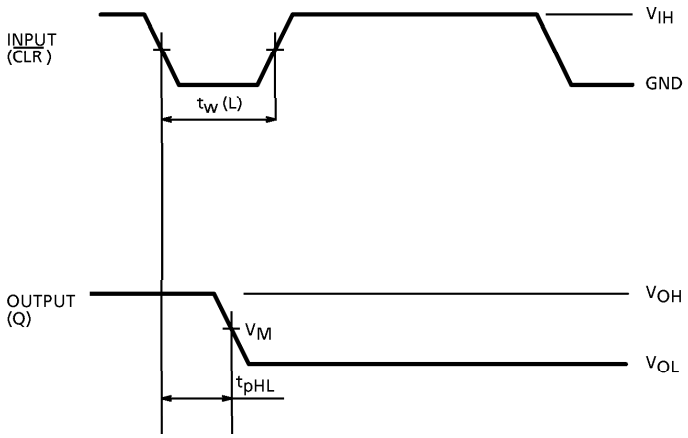
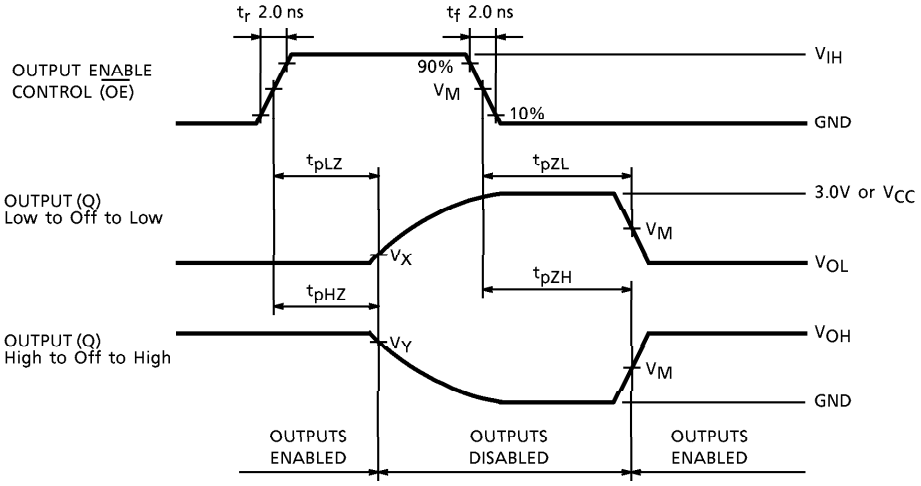


Fig.4 $t_{pLZ}$, $t_{pHZ}$, $t_{pZL}$, $t_{pZH}$




| 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.5 $t_s$, $t_h$

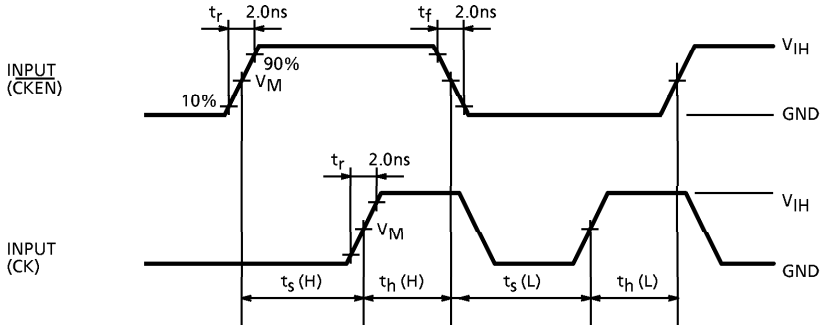
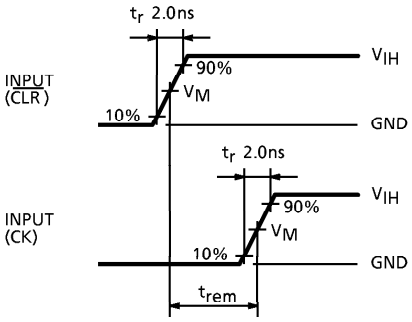
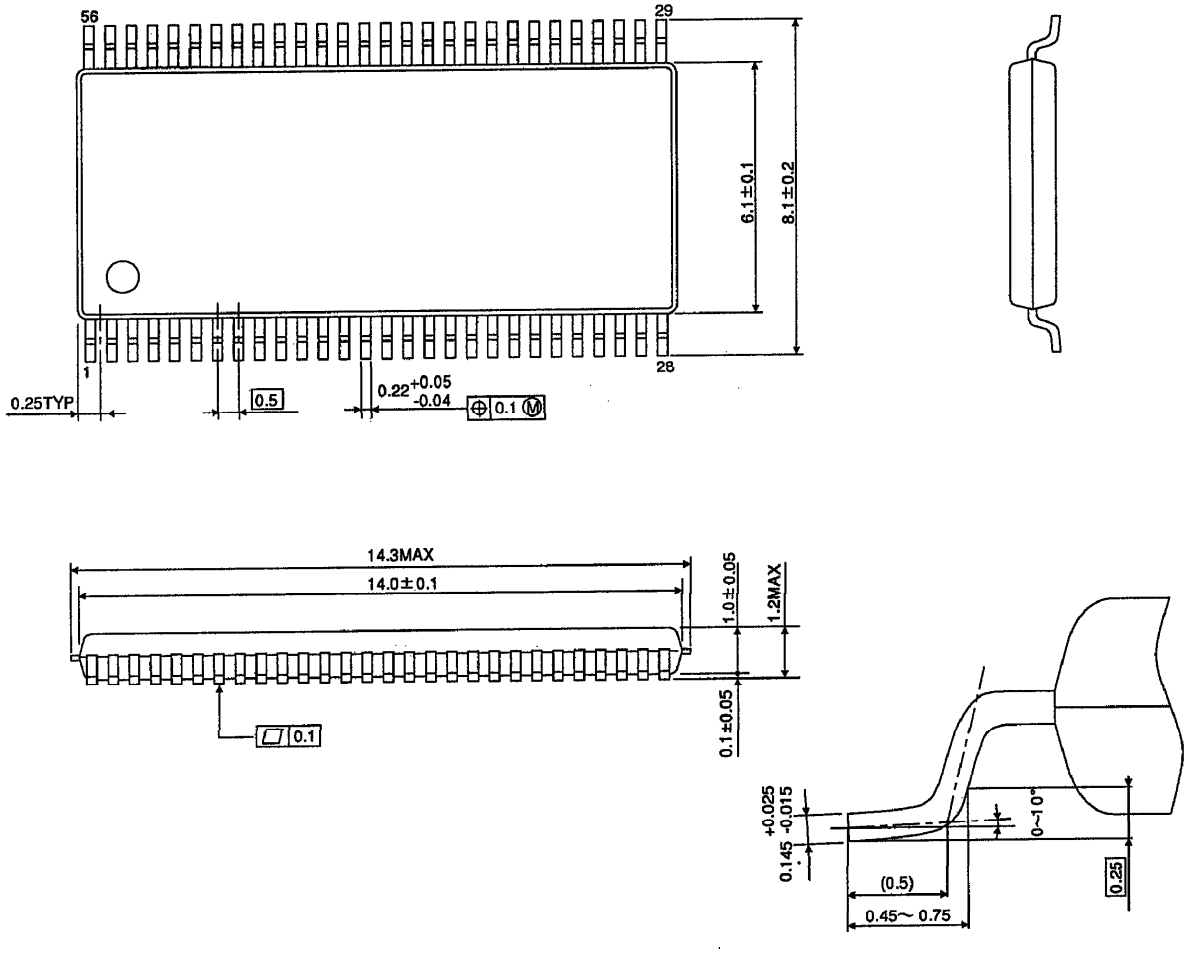



Fig.6 $t_{rem}$



**PACKAGE DIMENSIONS**

TSSOP56-P-0061-0.50 Unit : mm




Weight : 0.25 g (Typ.)