TOSHIBA CMOS Digital Integrated Circuit Silicon Monolithic

# T C 7 M A 2 5 7 F K

## Low Voltage Quad 2-Channel Multiplexer with 3.6 V Tolerant Inputs and Outputs

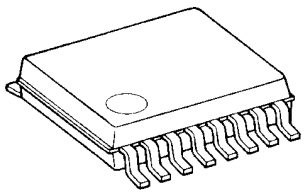
The TC7MA257FK is a high performance CMOS multiplexer. Designed for use in 1.8 , 2.5 or 3.3 V systems, it achieves high speed operation while maintaining the CMOS low power dissipation.

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

It consists of four 2-input digital multiplexers with common SELECT and $\overline{\text{OUTPUTENABLE}}$ ($\overline{\text{OE}}$).

If $\overline{\text{OE}}$ is set high the outputs are held in a high-impedance state. The SELECT decoding determines whether the A or B inputs get routed to their corresponding Y outputs.

All inputs are equipped with protection circuits against static discharge.



VSSOP16-P-0030-0.50

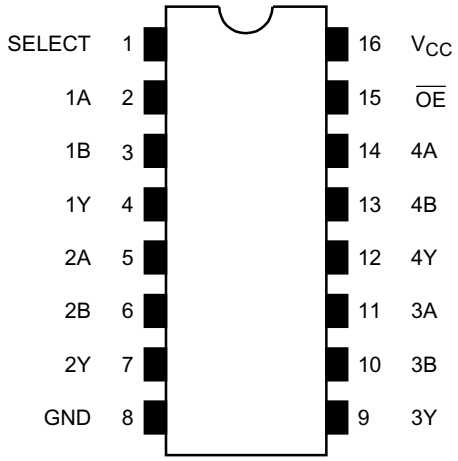
Weight: 0.02 g (typ.)

## Features

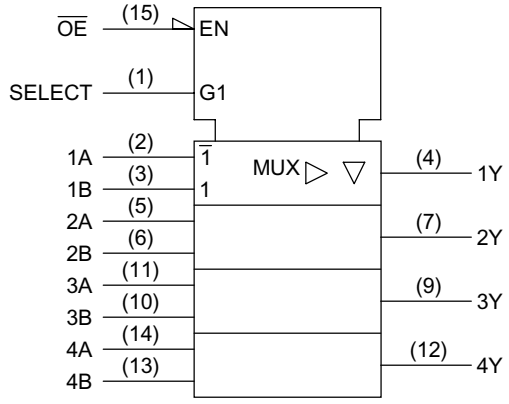
- Low voltage operation: $V_{CC}$ = 1.8~3.6 V
- High speed operation: $t_{pd}$ = 3.0 ns (max) ($V_{CC}$ = 3.0~3.6 V)
  $t_{pd}$ = 4.0 ns (max) ($V_{CC}$ = 2.3~2.7 V)
  $t_{pd}$ = 8.0 ns (max) ($V_{CC}$ = 1.8 V)
- 3.6 V tolerant inputs and outputs.
- Output current: $I_{OH}/I_{OL}$ = ±24 mA (min) ($V_{CC}$ = 3.0 V)
  $I_{OH}/I_{OL}$ = ±18 mA (min) ($V_{CC}$ = 2.3 V)
  $I_{OH}/I_{OL}$ = ±6 mA (min) ($V_{CC}$ = 1.8 V)
- Latch-up performance: ±300 mA
- ESD performance: Machine model > ±200 V
  Human body model > ±2000 V
- Package: VSSOP (US16)
- Power down protection is provided on all inputs and outputs.
- Supports live insertion/withdrawal (*)

*: To ensure the high-impedance state during power up or power down, $\overline{\text{OE}}$ 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.

## Pin Assignment (top view)




## IEC Logic Symbol



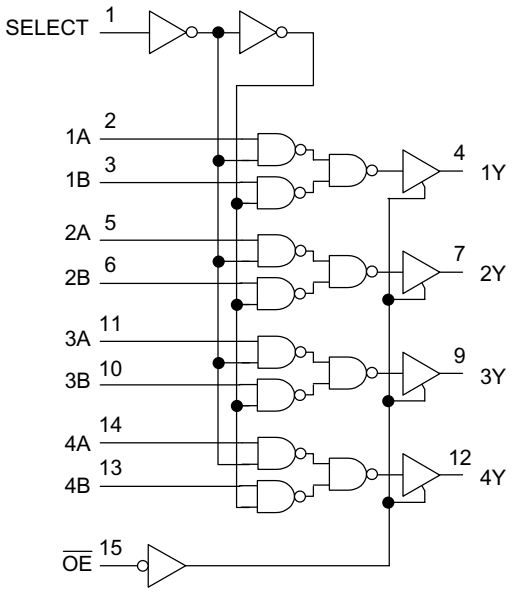

## Truth Table

| Inputs | | | | Outputs |
|---|---|---|---|---|
| $\overline{OE}$ | SELECT | A | B | Y |
| H | X | X | X | Z |
| L | L | L | X | L |
| L | L | H | X | H |
| L | H | X | L | L |
| L | H | X | H | H |

X: Don’t care

Z: High impedance

## System Diagram



## Maximum Ratings

| Characteristics | 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 (Note1) | V |
| | | −0.5~$V_{CC}$ + 0.5 (Note2) | |
| Input diode current | $I_{IK}$ | −50 | mA |
| Output diode current | $I_{OK}$ | ±50 (Note3) | mA |
| DC output current | $I_{OUT}$ | ±50 | mA |
| Power dissipation | $P_D$ | 180 | mW |
| DC $V_{CC}$/ground current | $I_{CC}/I_{GND}$ | ±100 | mA |
| Storage temperature | $T_{stg}$ | −65~150 | °C |

Note1: Off-state

Note2: High or low state. $I_{OUT}$ absolute maximum rating must be observed.

Note3: $V_{OUT} < GND$, $V_{OUT} > V_{CC}$

## Recommended Operating Range

| Characteristics | Symbol | Rating | Unit |
|---|---|---|---|
| Supply voltage | $V_{CC}$ | 1.8~3.6 | V |
| | | 1.2~3.6 (Note4) | |
| Input voltage | $V_{IN}$ | −0.3~3.6 | V |
| Output voltage | $V_{OUT}$ | 0~3.6 (Note5) | V |
| | | 0~$V_{CC}$ (Note6) | |
| Output current | $I_{OH}/I_{OL}$ | ±24 (Note7) | mA |
| | | ±18 (Note8) | |
| | | ±6 (Note9) | |
| Operating temperature | $T_{opr}$ | −40~85 | °C |
| Input rise and fall time | dt/dv | 0~10 (Note10) | ns/V |

Note4: Data retention only

Note5: Off-state

Note6: High or low state

Note7: $V_{CC}$ = 3.0~3.6 V

Note8: $V_{CC}$ = 2.3~2.7 V

Note9: $V_{CC}$ = 1.8 V

Note10: $V_{IN}$ = 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)

| Characteristics | | Symbol | Test Condition | | $V_{CC}$ (V) | Min | Max | Unit |
|---|---|---|---|---|---|---|---|---|
| Input voltage | High level | $V_{IH}$ | — | | 2.7~3.6 | 2.0 | — | V |
| | Low level | $V_{IL}$ | — | | 2.7~3.6 | — | 0.8 | |
| Output voltage | High 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 | — | |
| | Low 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 | |

### DC Characteristics (Ta = –40~85°C, 2.3 V ≦ $V_{CC}$ ≦ 2.7 V)

| Characteristics | | Symbol | Test Condition | | $V_{CC}$ (V) | Min | Max | Unit |
|---|---|---|---|---|---|---|---|---|
| Input voltage | High level | $V_{IH}$ | — | | 2.3~2.7 | 1.6 | — | V |
| | Low level | $V_{IL}$ | — | | 2.3~2.7 | — | 0.7 | |
| Output voltage | High 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 | — | |
| | Low 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 | |

## DC Characteristics (Ta = –40~85°C, 1.8 V ≦ $V_{CC}$ < 2.3 V)

| Characteristics | | Symbol | Test Condition | | $V_{CC}$ (V) | Min | Max | Unit |
|---|---|---|---|---|---|---|---|---|
| Input voltage | High level | $V_{IH}$ | — | | 1.8~2.3 | 0.7 × $V_{CC}$ | — | V |
| | Low level | $V_{IL}$ | — | | 1.8~2.3 | — | 0.2 × $V_{CC}$ | |
| Output voltage | High 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 | — | |
| | Low 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 | | 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 | | 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)

| Characteristics | Symbol | Test Condition | $V_{CC}$ (V) | Min | Max | Unit |
|---|---|---|---|---|---|---|
| Propagation delay time (A, B-Y) | $t_{pLH}$ $t_{pHL}$ | Figure 1, Figure 2 | 1.8 | 1.0 | 8.0 | ns |
| | | | 2.5 ± 0.2 | 0.8 | 4.0 | |
| | | | 3.3 ± 0.3 | 0.6 | 3.0 | |
| Propagation delay time (SELECT-Y) | $t_{pLH}$ $t_{pHL}$ | Figure 1, Figure 2 | 1.8 | 1.0 | 9.6 | ns |
| | | | 2.5 ± 0.2 | 0.8 | 4.8 | |
| | | | 3.3 ± 0.3 | 0.6 | 4.0 | |
| 3-state output enable time | $t_{pZL}$ $t_{pZH}$ | Figure 1, Figure 3 | 1.8 | 1.0 | 9.2 | ns |
| | | | 2.5 ± 0.2 | 0.8 | 4.6 | |
| | | | 3.3 ± 0.3 | 0.6 | 3.5 | |
| 3-state output disable time | $t_{pLZ}$ $t_{pHZ}$ | Figure 1, Figure 3 | 1.8 | 1.0 | 6.8 | ns |
| | | | 2.5 ± 0.2 | 0.8 | 3.8 | |
| | | | 3.3 ± 0.3 | 0.6 | 3.5 | |
| Output to output skew | $t_{osLH}$ $t_{osHL}$ | (Note11) | 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.

Note11: This parameter is 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)

| Characteristics | 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 (Note12) | 1.8 | 0.25 | V |
| | | $V_{IH}$ = 2.5 V, $V_{IL}$ = 0 V (Note12) | 2.5 | 0.6 | |
| | | $V_{IH}$ = 3.3 V, $V_{IL}$ = 0 V (Note12) | 3.3 | 0.8 | |
| Quiet output minimum dynamic $V_{OL}$ | $V_{OLV}$ | $V_{IH}$ = 1.8 V, $V_{IL}$ = 0 V (Note12) | 1.8 | −0.25 | V |
| | | $V_{IH}$ = 2.5 V, $V_{IL}$ = 0 V (Note12) | 2.5 | −0.6 | |
| | | $V_{IH}$ = 3.3 V, $V_{IL}$ = 0 V (Note12) | 3.3 | −0.8 | |
| Quiet output minimum dynamic $V_{OH}$ | $V_{OHV}$ | $V_{IH}$ = 1.8 V, $V_{IL}$ = 0 V (Note12) | 1.8 | 1.5 | V |
| | | $V_{IH}$ = 2.5 V, $V_{IL}$ = 0 V (Note12) | 2.5 | 1.9 | |
| | | $V_{IH}$ = 3.3 V, $V_{IL}$ = 0 V (Note12) | 3.3 | 2.2 | |

Note12: This parameter is guaranteed by design.

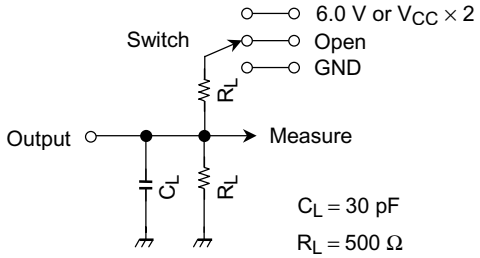
## Capacitive Characteristics (Ta = 25°C)

| Characteristics | 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 (Note13) | 1.8, 2.5, 3.3 | 20 | pF |

Note13: $C_{PD}$ 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:

$I_{CC\ (opr)} = C_{PD} \cdot V_{CC} \cdot f_{IN} + I_{CC}$

## AC Test Circuit




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

**Figure 1**

## AC Waveform

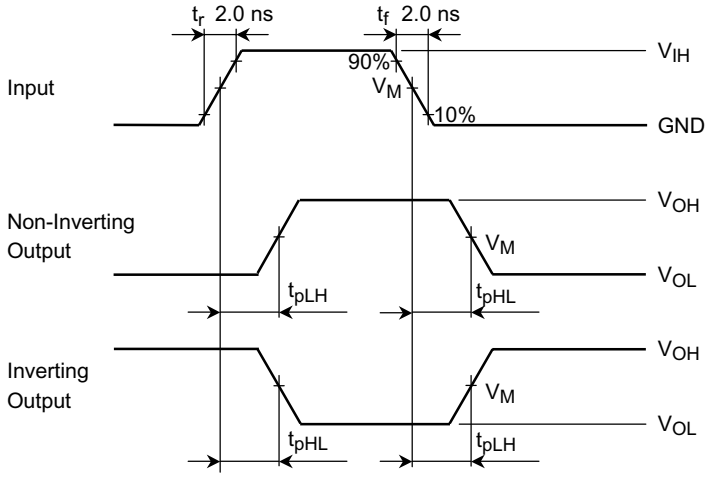
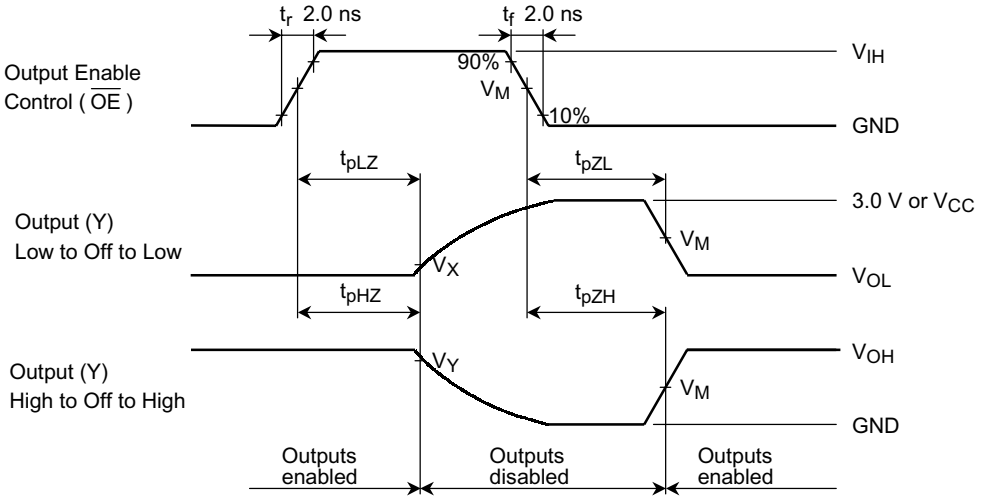



**Figure 2 $t_{pLH}$, $t_{pHL}$**

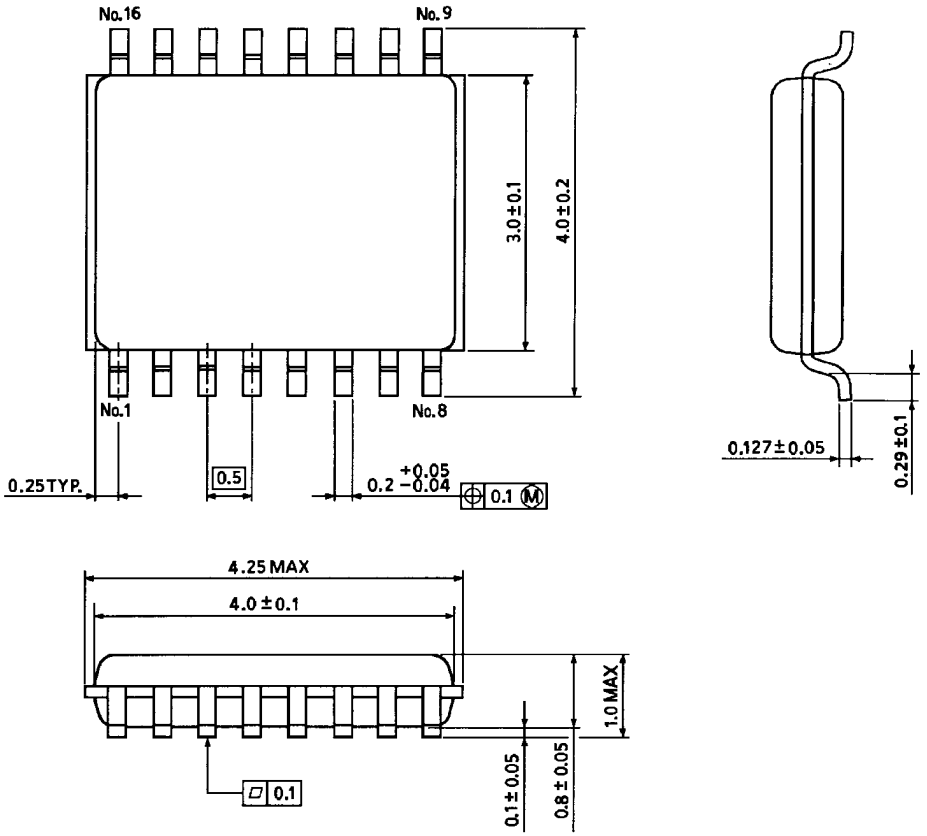



| Symbol | $V_{CC}$ | | |
|---|---|---|---|
| | 3.3 ± 0.3 V | 2.5 ± 0.2 V | 1.8 V |
| $V_{IH}$ | 2.7 V | $V_{CC}$ | $V_{CC}$ |
| $V_M$ | 1.5 V | $V_{CC}/2$ | $V_{CC}/2$ |
| $V_X$ | $V_{OL}$ + 0.3 V | $V_{OL}$ + 0.15 V | $V_{OL}$ + 0.15 V |
| $V_Y$ | $V_{OH}$ − 0.3 V | $V_{OH}$ − 0.15 V | $V_{OH}$ − 0.15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

**Figure 3 $t_{pLZ}$, $t_{pHZ}$, $t_{pZL}$, $t_{pZH}$**

## Package Dimensions

VSSOP16-P-0030-0.50 Unit : mm




Weight: 0.02 g (typ.)