TOSHIBA CMOS Digital Integrated Circuit Silicon Monolithic

# TC7MA157FK

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

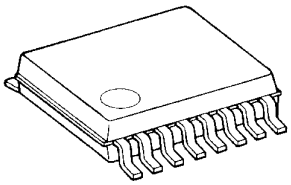
The TC7MA157FK is a high performance CMOS multiplexer which is guaranteed to operate from 1.2-V to 3.6-V. Designed for use in 1.5 V, 1.8 V, 2.5 V or 3.3 V systems, it achieves high. speed operation while maintaining the CMOS low power dissipation.

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 strobe inputs.

When the $\overline{ST}$ input is held "H" level, selection of data is inhibited and all the outputs become "L" level. 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.



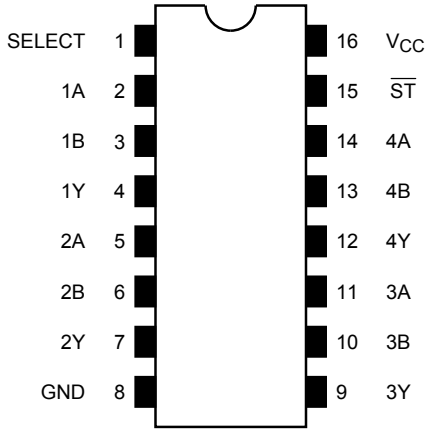
VSSOP16-P-0030-0.50

Weight: 0.02 g (typ.)

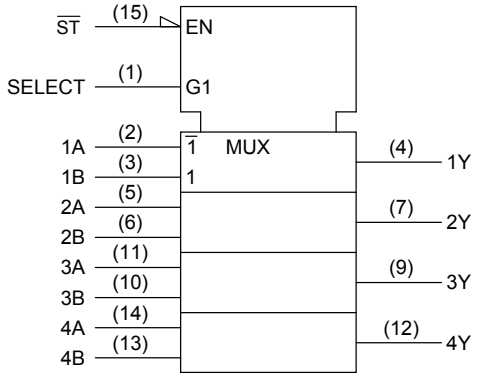
## Features

- Low voltage operation: $V_{CC}$ = 1.2~3.6 V
- High speed operation: $t_{pd}$ = 3.0 ns (max) ($V_{CC}$ = 3.0~3.6 V)
  $t_{pd}$ = 3.5 ns (max) ($V_{CC}$ = 2.3~2.7 V)
  $t_{pd}$ = 7.0 ns (max) ($V_{CC}$ = 1.65~1.95 V)
  $t_{pd}$ = 14.0 ns (max) ($V_{CC}$ = 1.4~1.6 V)
  $t_{pd}$ = 35.0 ns (max) ($V_{CC}$ = 1.2 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) ($V_{CC}$ = 1.65 V)
  $I_{OH}/I_{OL}$ = ±2 mA (min) ($V_{CC}$ = 1.4 V)
- Latch-up performance: −300 mA
- ESD performance: Machine model ≥ ±200 V
  Human body model ≥ ±2000 V
- Package: VSSOP (US)
- Power down protection is provided on all inputs and outputs.

## Pin Assignment (top view)




## IEC Logic Symbol

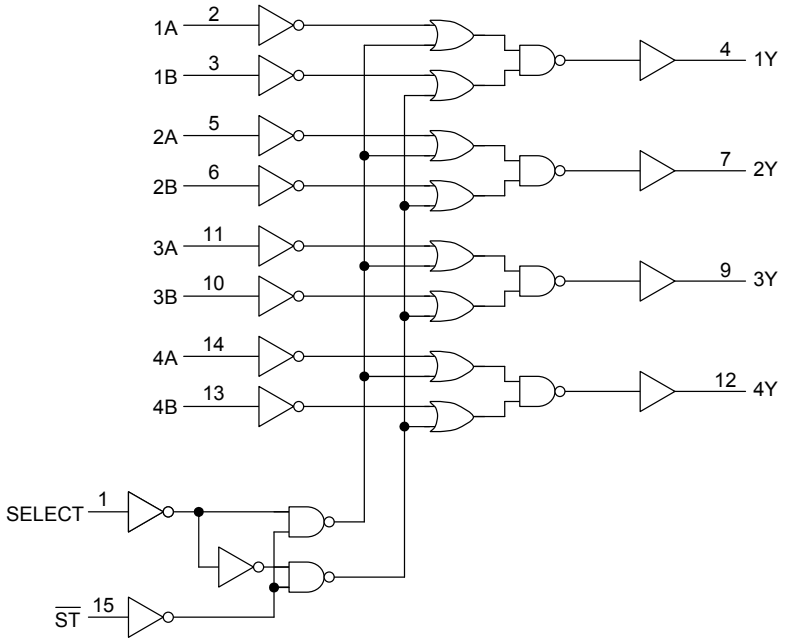



## Truth Table

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

X: Don’t care

## System Diagram




## Absolute Maximum Ratings (Note 1)

| 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 (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 | $P_D$ | 180 | mW |
| DC $V_{CC}$/ground current | $I_{CC}/I_{GND}$ | ±100 | mA |
| Storage temperature | $T_{stg}$ | −65~150 | °C |

Note 1: Exceeding any of the absolute maximum ratings, even briefly, lead to deterioration in IC performance or even destruction.
Using continuously under heavy loads (e.g. the application of high temperature/current/voltage and the significant change in temperature, etc.) may cause this product to decrease in the reliability significantly even if the operating conditions (i.e. operating temperature/current/voltage, etc.) are within the absolute maximum ratings and the operating ranges.
Please design the appropriate reliability upon reviewing the Toshiba Semiconductor Reliability Handbook (“Handling Precautions”/“Derating Concept and Methods”) and individual reliability data (i.e. reliability test report and estimated failure rate, etc).

Note 2: $V_{CC}$ = 0 V

Note 3: High or low state. $I_{OUT}$ absolute maximum rating must be observed.

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

## Operating Ranges (Note 1)

| Characteristics | Symbol | Rating | Unit |
|---|---|---|---|
| Supply voltage | $V_{CC}$ | 1.2~3.6 | V |
| Input voltage | $V_{IN}$ | −0.3~3.6 | V |
| Output voltage | $V_{OUT}$ | 0~3.6 (Note 2) | V |
| | | 0~$V_{CC}$ (Note 3) | |
| Output current | $I_{OH}/I_{OL}$ | ±24 (Note 4) | mA |
| | | ±18 (Note 5) | |
| | | ±6 (Note 6) | |
| | | ±2 (Note 7) | |
| Operating temperature | $T_{opr}$ | −40~85 | °C |
| Input rise and fall time | dt/dv | 0~10 (Note 8) | ns/V |

Note 1: The operating ranges must be maintained to ensure the normal operation of the device. Unused inputs must be tied to either VCC or GND.

Note 2: $V_{CC}$ = 0 V

Note 3: High or low state

Note 4: $V_{CC}$ = 3.0~3.6 V

Note 5: $V_{CC}$ = 2.3~2.7 V

Note 6: $V_{CC}$ = 1.65~1.95 V

Note 7: $V_{CC}$ = 1.4~1.6 V

Note 8: $V_{IN}$ = 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 |
| 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 |
| | | | $V_{CC}$ ≦ $V_{IN}$ ≦ 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 |
| 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 |
| | | | $V_{CC}$ ≦ $V_{IN}$ ≦ 3.6 V | | 2.3~2.7 | — | ±20.0 | |

## DC Characteristics (Ta = –40~85°C, 1.65 V ≦ $V_{CC}$ < 2.3 V)

| Characteristics | | Symbol | Test Condition | | $V_{CC}$ (V) | Min | Max | Unit |
|---|---|---|---|---|---|---|---|---|
| Input voltage | High level | $V_{IH}$ | — | | 1.65~2.3 | 0.65 × $V_{CC}$ | — | V |
| | Low level | $V_{IL}$ | — | | 1.65~2.3 | — | 0.2 × $V_{CC}$ | |
| Output voltage | High level | $V_{OH}$ | $V_{IN}$ = $V_{IH}$ or $V_{IL}$ | $I_{OH}$ = –100 μA | 1.65~2.3 | $V_{CC}$ – 0.2 | — | V |
| | | | | $I_{OH}$ = –6 mA | 1.65 | 1.25 | — | |
| | Low level | $V_{OL}$ | $V_{IN}$ = $V_{IH}$ or $V_{IL}$ | $I_{OL}$ = 100 μA | 1.65~2.3 | — | 0.2 | |
| | | | | $I_{OL}$ = 6 mA | 1.65 | — | 0.3 | |
| Input leakage current | | $I_{IN}$ | $V_{IN}$ = 0~3.6 V | | 1.65~2.3 | — | ±5.0 | 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 | | 1.65~2.3 | — | 20.0 | μA |
| | | | $V_{CC}$ ≦ $V_{IN}$ ≦ 3.6 V | | 1.65~2.3 | — | ±20.0 | |

## DC Characteristics (Ta = –40~85°C, 1.4 V ≦ $V_{CC}$ ≦ 1.65 V)

| Characteristics | | Symbol | Test Condition | | $V_{CC}$ (V) | Min | Max | Unit |
|---|---|---|---|---|---|---|---|---|
| Input voltage | High level | $V_{IH}$ | — | | 1.4~1.65 | 0.65 × $V_{CC}$ | — | V |
| | Low level | $V_{IL}$ | — | | 1.4~1.65 | — | 0.05 × $V_{CC}$ | |
| Output voltage | High level | $V_{OH}$ | $V_{IN}$ = $V_{IH}$ or $V_{IL}$ | $I_{OH}$ = –100 μA | 1.4~1.65 | $V_{CC}$ – 0.2 | — | V |
| | | | | $I_{OH}$ = –2 mA | 1.4 | 1.05 | — | |
| | Low level | $V_{OL}$ | $V_{IN}$ = $V_{IH}$ or $V_{IL}$ | $I_{OL}$ = 100 μA | 1.4~1.65 | — | 0.05 | |
| | | | | $I_{OL}$ = 2 mA | 1.4 | — | 0.35 | |
| Input leakage current | | $I_{IN}$ | $V_{IN}$ = 0~3.6 V | | 1.4~1.65 | — | ±5.0 | 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 | | 1.4~1.65 | — | 20.0 | μA |
| | | | $V_{CC}$ ≦ $V_{IN}$ ≦ 3.6 V | | 1.4~1.65 | — | ±20.0 | |

## DC Characteristics (Ta = –40~85°C, 1.2 V ≦ $V_{CC}$ < 1.4 V)

| Characteristics | | Symbol | Test Condition | | $V_{CC}$ (V) | Min | Max | Unit |
|---|---|---|---|---|---|---|---|---|
| Input voltage | High level | $V_{IH}$ | — | | 1.2~1.4 | 0.8 × $V_{CC}$ | — | V |
| | Low level | $V_{IL}$ | — | | 1.2~1.4 | — | 0.05 × $V_{CC}$ | |
| Output voltage | High level | $V_{OH}$ | $V_{IN}$ = $V_{IH}$ or $V_{IL}$ | $I_{OH}$ = –100 μA | 1.2 | $V_{CC}$ – 0.1 | — | V |
| | Low level | $V_{OL}$ | $V_{IN}$ = $V_{IH}$ or $V_{IL}$ | $I_{OL}$ = 100 μA | 1.2 | — | 0.05 | |
| Input leakage current | | $I_{IN}$ | $V_{IN}$ = 0~3.6 V | | 1.2 | — | ±5.0 | 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 | | 1.2 | — | 20.0 | μA |
| | | | $V_{CC}$ ≦ $V_{IN}$ ≦ 3.6 V | | 1.2 | — | ±20.0 | |

## AC Characteristics (Ta = –40~85°C, Input: $t_r = t_f = 2.0$ ns)

| Characteristics | Symbol | Test Condition | | $V_{CC}$ (V) | Min | Max | Unit |
|---|---|---|---|---|---|---|---|
| Propagation delay time (A, B-Y) | $t_{pLH}$ $t_{pHL}$ | Figure 1, Figure 2 | $C_L$ = 15 pF, $R_L$ = 2 kΩ | 1.2 | 3.0 | 35.0 | ns |
| | | | | 1.5 ± 0.1 | 2.0 | 14.0 | |
| | | | $C_L$ = 30 pF, $R_L$ = 500 Ω | 1.8 ± 0.15 | 1.5 | 7.0 | |
| | | | | 2.5 ± 0.2 | 0.8 | 3.5 | |
| | | | | 3.3 ± 0.3 | 0.6 | 3.0 | |
| Propagation delay time (SELECT-Y) | $t_{pLH}$ $t_{pHL}$ | Figure 1, Figure 2 | $C_L$ = 15 pF, $R_L$ = 2 kΩ | 1.2 | 3.0 | 45.0 | ns |
| | | | | 1.5 ± 0.1 | 2.0 | 18.0 | |
| | | | $C_L$ = 30 pF, $R_L$ = 500 Ω | 1.8 ± 0.15 | 1.5 | 9.0 | |
| | | | | 2.5 ± 0.2 | 0.8 | 4.5 | |
| | | | | 3.3 ± 0.3 | 0.6 | 3.5 | |
| Propagation delay time ($\overline{ST}$ -Y) | $t_{pLH}$ $t_{pHL}$ | Figure 1, Figure 2 | $C_L$ = 15 pF, $R_L$ = 2 kΩ | 1.2 | 3.0 | 45.0 | ns |
| | | | | 1.5 ± 0.1 | 2.0 | 18.0 | |
| | | | $C_L$ = 30 pF, $R_L$ = 500 Ω | 1.8 ± 0.15 | 1.5 | 9.0 | |
| | | | | 2.5 ± 0.2 | 0.8 | 4.5 | |
| | | | | 3.3 ± 0.3 | 0.6 | 3.5 | |
| Output to output skew | $t_{osLH}$ $t_{osHL}$ | (Note) | $C_L$ = 15 pF, $R_L$ = 2 kΩ | 1.2 | — | 1.5 | ns |
| | | | | 1.5 ± 0.1 | — | 1.5 | |
| | | | $C_L$ = 30 pF, $R_L$ = 500 Ω | 1.8 ± 0.15 | — | 0.5 | |
| | | | | 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: 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 (Note) | 1.8 | 0.25 | V |
| | | $V_{IH}$ = 2.5 V, $V_{IL}$ = 0 V (Note) | 2.5 | 0.6 | |
| | | $V_{IH}$ = 3.3 V, $V_{IL}$ = 0 V (Note) | 3.3 | 0.8 | |
| Quiet output minimum dynamic $V_{OL}$ | $V_{OLV}$ | $V_{IH}$ = 1.8 V, $V_{IL}$ = 0 V (Note) | 1.8 | −0.25 | V |
| | | $V_{IH}$ = 2.5 V, $V_{IL}$ = 0 V (Note) | 2.5 | −0.6 | |
| | | $V_{IH}$ = 3.3 V, $V_{IL}$ = 0 V (Note) | 3.3 | −0.8 | |
| Quiet output minimum dynamic $V_{OH}$ | $V_{OHV}$ | $V_{IH}$ = 1.8 V, $V_{IL}$ = 0 V (Note) | 1.8 | 1.5 | V |
| | | $V_{IH}$ = 2.5 V, $V_{IL}$ = 0 V (Note) | 2.5 | 1.9 | |
| | | $V_{IH}$ = 3.3 V, $V_{IL}$ = 0 V (Note) | 3.3 | 2.2 | |

Note: This parameter is guaranteed by design.

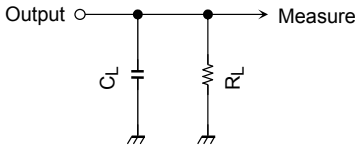
## Capacitive Characteristics (Ta = 25°C)

| Characteristics | Symbol | Test Condition | $V_{CC}$ (V) | Typ. | Unit |
|---|---|---|---|---|---|
| Input capacitance | $C_{IN}$ | — | 1.8, 2.5, 3.3 | 6 | pF |
| Power dissipation capacitance | $C_{PD}$ | $f_{IN}$ = 10 MHz (Note) | 1.8, 2.5, 3.3 | 20 | pF |

Note: $C_{PD}$ 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:

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

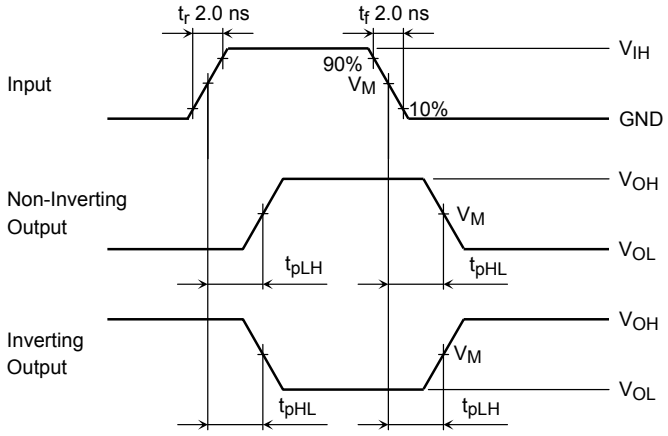
## AC Test Circuit




| Symbol | $V_{CC}$ | |
|---|---|---|
| | 3.3 ± 0.3 V<br>2.5 ± 0.2 V<br>1.8 ± 0.15 V | 1.5 ± 0.1 V<br>1.2V |
| $R_L$ | 500 Ω | 2 kΩ |
| $C_L$ | 30 pF | 15 pF |

**Figure 1**

## AC Waveform

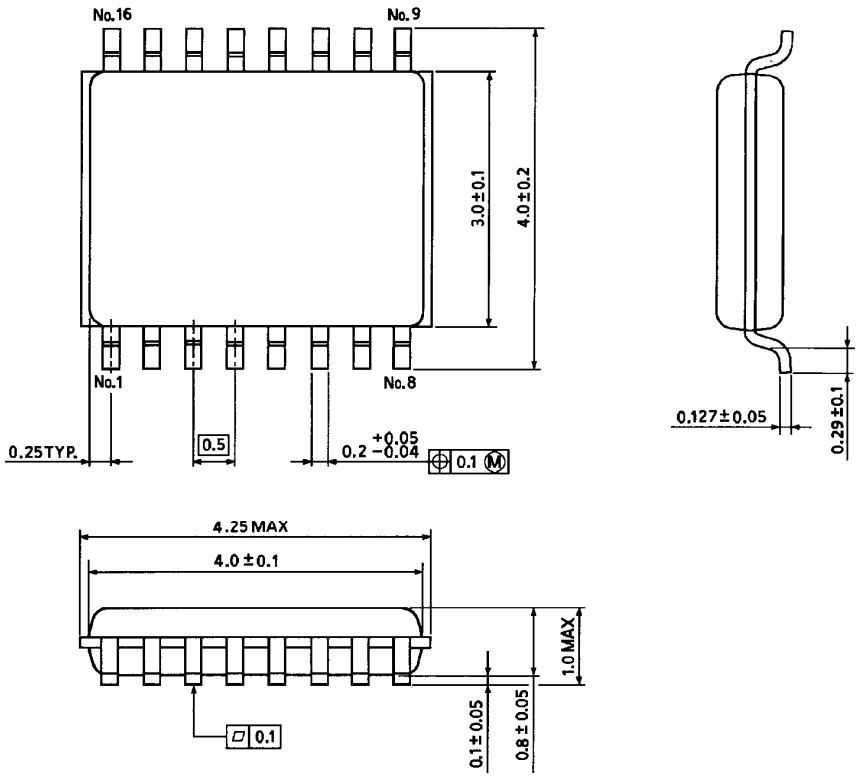



| Symbol | $V_{CC}$ | | | | |
|---|---|---|---|---|---|
| | 3.3 ± 0.3 V | 2.5 ± 0.2 V | 1.8 ± 0.15 V | 1.5 ± 0.1 V | 1.2 V |
| $V_{IH}$ | 2.7 V | $V_{CC}$ | $V_{CC}$ | $V_{CC}$ | $V_{CC}$ |
| $V_M$ | 1.5 V | $V_{CC}/2$ | $V_{CC}/2$ | $V_{CC}/2$ | $V_{CC}/2$ |

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

## Package Dimensions

VSSOP16-P-0030-0.50 Unit : mm




Weight: 0.02 g (typ.)

## RESTRICTIONS ON PRODUCT USE

20070701-EN GENERAL

- The information contained herein is subject to change without notice.
- TOSHIBA is continually working to improve the quality and reliability of its products. Nevertheless, semiconductor devices in general can malfunction or fail due to their inherent electrical sensitivity and vulnerability to physical stress. It is the responsibility of the buyer, when utilizing TOSHIBA products, to comply with the standards of safety in making a safe design for the entire system, and to avoid situations in which a malfunction or failure of such TOSHIBA products could cause loss of human life, bodily injury or damage to property.
  In developing your designs, please ensure that TOSHIBA products are used within specified operating ranges as set forth in the most recent TOSHIBA products specifications. Also, please keep in mind the precautions and conditions set forth in the “Handling Guide for Semiconductor Devices,” or “TOSHIBA Semiconductor Reliability Handbook” etc.
- The TOSHIBA products listed in this document are intended for usage in general electronics applications (computer, personal equipment, office equipment, measuring equipment, industrial robotics, domestic appliances, etc.).These TOSHIBA products are neither intended nor warranted for usage in equipment that requires extraordinarily high quality and/or reliability or a malfunction or failure of which may cause loss of human life or bodily injury (“Unintended Usage”). Unintended Usage include atomic energy control instruments, airplane or spaceship instruments, transportation instruments, traffic signal instruments, combustion control instruments, medical instruments, all types of safety devices, etc.. Unintended Usage of TOSHIBA products listed in his document shall be made at the customer’s own risk.
- The products described in this document shall not be used or embedded to any downstream products of which manufacture, use and/or sale are prohibited under any applicable laws and regulations.
- The information contained herein is presented only as a guide for the applications of our products. No responsibility is assumed by TOSHIBA for any infringements of patents or other rights of the third parties which may result from its use. No license is granted by implication or otherwise under any patents or other rights of TOSHIBA or the third parties.
- Please contact your sales representative for product-by-product details in this document regarding RoHS compatibility. Please use these products in this document in compliance with all applicable laws and regulations that regulate the inclusion or use of controlled substances. Toshiba assumes no liability for damage or losses occurring as a result of noncompliance with applicable laws and regulations.