

# TC7MA374FK

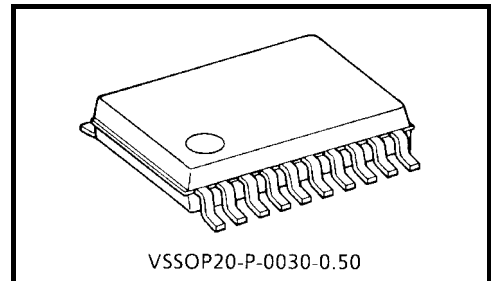
## Low-Voltage Octal D-Type Flip-Flop with 3.6 V Tolerant Inputs and Outputs

The TC7MA374FK is a high performance CMOS octal D-type flip-flop 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.

This 8 bit D-type flip-flop is controlled by a clock input (CK) and an output enable input ( $\overline{OE}$ ). When  $\overline{OE}$  input is high, the eight outputs are in a high impedance state.

All inputs are equipped with protection circuits against static discharge.

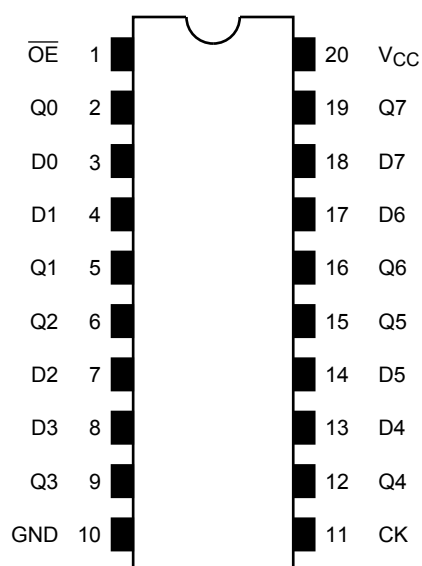


Weight: 0.03 g (typ.)

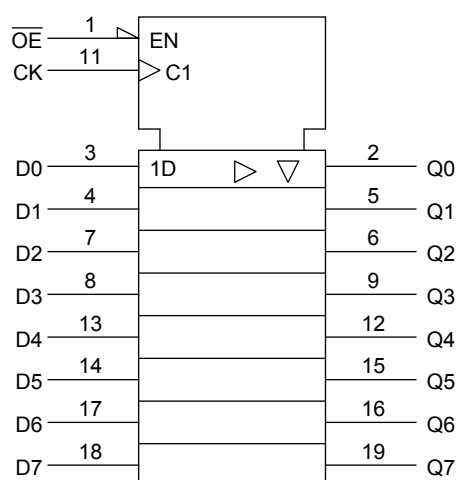
### Features

- Low voltage operation:  $V_{CC} = 1.2\sim 3.6\text{ V}$
- High speed operation:  $t_{pd} = 4.2\text{ ns (max)}$  ( $V_{CC} = 3.0\sim 3.6\text{ V}$ )  
 $t_{pd} = 4.8\text{ ns (max)}$  ( $V_{CC} = 2.3\sim 2.7\text{ V}$ )  
 $t_{pd} = 9.6\text{ ns (max)}$  ( $V_{CC} = 1.65\sim 1.95\text{ V}$ )  
 $t_{pd} = 19.2\text{ ns (max)}$  ( $V_{CC} = 1.4\sim 1.6\text{ V}$ )  
 $t_{pd} = 48.0\text{ ns (max)}$  ( $V_{CC} = 1.2\text{ V}$ )
- 3.6 V tolerant inputs and outputs.
- Output current:  $I_{OH}/I_{OL} = \pm 24\text{ mA (min)}$  ( $V_{CC} = 3.0\text{ V}$ )  
 $I_{OH}/I_{OL} = \pm 18\text{ mA (min)}$  ( $V_{CC} = 2.3\text{ V}$ )  
 $I_{OH}/I_{OL} = \pm 6\text{ mA (min)}$  ( $V_{CC} = 1.65\text{ V}$ )  
 $I_{OH}/I_{OL} = \pm 2\text{ mA (min)}$  ( $V_{CC} = 1.4\text{ V}$ )
- Latch-up performance:  $-300\text{ mA}$
- ESD performance: Machine model  $\geq \pm 200\text{ V}$   
Human body model  $\geq \pm 2000\text{ V}$
- Package: VSSOP (US)
- Power down protection is provided on all inputs and outputs.

## Pin Assignment (top view)



## IEC Logic Level



## Truth Table

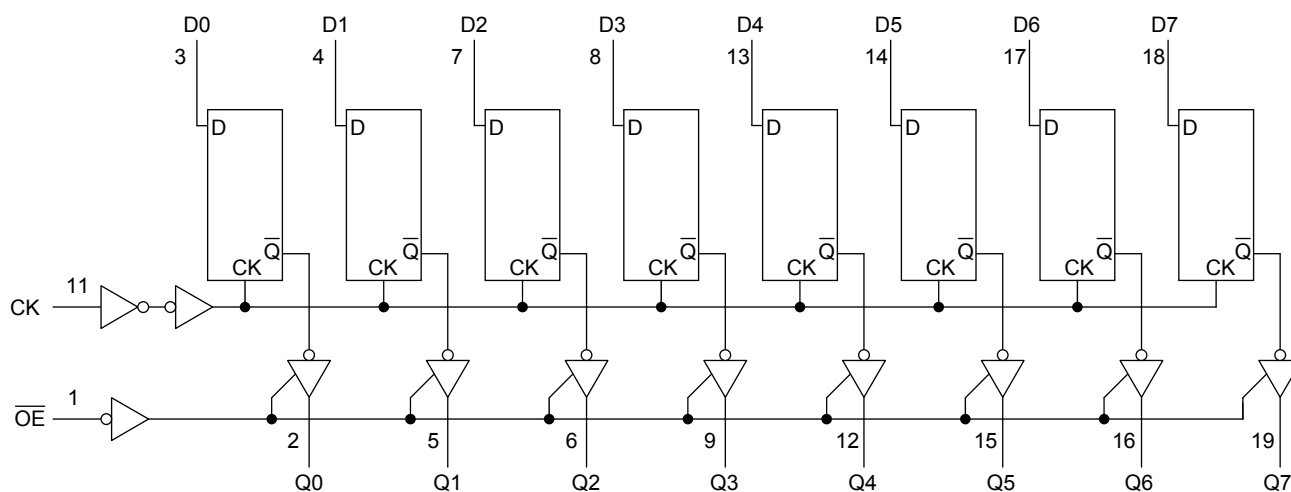
| Inputs          |    |   | Outputs |
|-----------------|----|---|---------|
| $\overline{OE}$ | CK | D |         |
| H               | X  | X | Z       |
| L               |    | X | $Q_n$   |
| L               |    | L | L       |
| L               |    | H | H       |

X: Don't care

Z: High impedance

$Q_n$ : No change

## 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  $V_{CC}$  or GND.

Note 2: Off-state

Note 3: High or low state

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

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

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

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

Note 8:  $V_{IN} = 0.8\sim 2.0$  V,  $V_{CC} = 3.0$  V

## Electrical Characteristics

DC Characteristics ( $T_a = -40 \sim 85^\circ\text{C}$ ,  $2.7\text{ V} < V_{CC} \leq 3.6\text{ V}$ )

| Characteristics                  |                  | Symbol                                                          | Test Condition                                                                     |                           | V <sub>CC</sub> (V) | Min                   | Max  | Unit |
|----------------------------------|------------------|-----------------------------------------------------------------|------------------------------------------------------------------------------------|---------------------------|---------------------|-----------------------|------|------|
| Input voltage                    | High level       | V <sub>IH</sub>                                                 | —                                                                                  |                           | 2.7~3.6             | 2.0                   | —    | V    |
|                                  | Low level        | V <sub>IL</sub>                                                 | —                                                                                  |                           | 2.7~3.6             | —                     | 0.8  |      |
| Output voltage                   | High level       | V <sub>OH</sub>                                                 | V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>                               | I <sub>OH</sub> = -100 μA | 2.7~3.6             | V <sub>CC</sub> - 0.2 | —    | V    |
|                                  |                  |                                                                 |                                                                                    | I <sub>OH</sub> = -12 mA  | 2.7                 | 2.2                   | —    |      |
|                                  |                  |                                                                 |                                                                                    | I <sub>OH</sub> = -18 mA  | 3.0                 | 2.4                   | —    |      |
|                                  |                  |                                                                 |                                                                                    | I <sub>OH</sub> = -24 mA  | 3.0                 | 2.2                   | —    |      |
|                                  | Low level        | V <sub>OL</sub>                                                 | V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>                               | I <sub>OL</sub> = 100 μA  | 2.7~3.6             | —                     | 0.2  |      |
|                                  |                  |                                                                 |                                                                                    | I <sub>OL</sub> = 12 mA   | 2.7                 | —                     | 0.4  |      |
|                                  |                  |                                                                 |                                                                                    | I <sub>OL</sub> = 18 mA   | 3.0                 | —                     | 0.4  |      |
|                                  |                  |                                                                 |                                                                                    | I <sub>OL</sub> = 24 mA   | 3.0                 | —                     | 0.55 |      |
| Input leakage current            |                  | I <sub>IN</sub>                                                 | V <sub>IN</sub> = 0~3.6 V                                                          | 2.7~3.6                   | —                   | ±5.0                  | μA   |      |
| 3-state output off-state current |                  | I <sub>OZ</sub>                                                 | V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub><br>V <sub>OUT</sub> = 0~3.6 V | 2.7~3.6                   | —                   | ±10.0                 | μA   |      |
| Power off leakage current        |                  | I <sub>OFF</sub>                                                | V <sub>IN</sub> , V <sub>OUT</sub> = 0~3.6 V                                       | 0                         | —                   | 10.0                  | μA   |      |
| Quiescent supply current         | I <sub>CC</sub>  | V <sub>IN</sub> = V <sub>CC</sub> or GND                        | 2.7~3.6                                                                            | —                         | 20.0                | μA                    |      |      |
|                                  |                  | V <sub>CC</sub> ≤ (V <sub>IN</sub> , V <sub>OUT</sub> ) ≤ 3.6 V | 2.7~3.6                                                                            | —                         | ±20.0               |                       |      |      |
|                                  | ΔI <sub>CC</sub> | V <sub>IH</sub> = V <sub>CC</sub> - 0.6 V (per input)           | 2.7~3.6                                                                            | —                         | 750                 |                       |      |      |

DC Characteristics ( $T_a = -40 \sim 85^\circ\text{C}$ ,  $2.3\text{ V} \leq V_{CC} \leq 2.7\text{ V}$ )

| Characteristics                  |            | Symbol           | Test Condition                                                                     |                           | V <sub>CC</sub> (V) | Min                   | Max   | Unit |
|----------------------------------|------------|------------------|------------------------------------------------------------------------------------|---------------------------|---------------------|-----------------------|-------|------|
| Input voltage                    | High level | V <sub>IH</sub>  | —                                                                                  |                           | 2.3~2.7             | 1.6                   | —     | V    |
|                                  | Low level  | V <sub>IL</sub>  | —                                                                                  |                           | 2.3~2.7             | —                     | 0.7   |      |
| Output voltage                   | High level | V <sub>OH</sub>  | V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>                               | I <sub>OH</sub> = -100 μA | 2.3~2.7             | V <sub>CC</sub> - 0.2 | —     | V    |
|                                  |            |                  |                                                                                    | I <sub>OH</sub> = -6 mA   | 2.3                 | 2.0                   | —     |      |
|                                  |            |                  |                                                                                    | I <sub>OH</sub> = -12 mA  | 2.3                 | 1.8                   | —     |      |
|                                  |            |                  |                                                                                    | I <sub>OH</sub> = -18 mA  | 2.3                 | 1.7                   | —     |      |
|                                  | Low level  | V <sub>OL</sub>  | V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>                               | I <sub>OL</sub> = 100 μA  | 2.3~2.7             | —                     | 0.2   |      |
|                                  |            |                  |                                                                                    | I <sub>OL</sub> = 12 mA   | 2.3                 | —                     | 0.4   |      |
|                                  |            |                  |                                                                                    | I <sub>OL</sub> = 18 mA   | 2.3                 | —                     | 0.6   |      |
| Input leakage current            |            | I <sub>IN</sub>  | V <sub>IN</sub> = 0~3.6 V                                                          |                           | 2.3~2.7             | —                     | ±5.0  | μA   |
| 3-state output off-state current |            | I <sub>OZ</sub>  | V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub><br>V <sub>OUT</sub> = 0~3.6 V |                           | 2.3~2.7             | —                     | ±10.0 | μA   |
| Power off leakage current        |            | I <sub>OFF</sub> | V <sub>IN</sub> , V <sub>OUT</sub> = 0~3.6 V                                       |                           | 0                   | —                     | 10.0  | μA   |
| Quiescent supply current         |            | I <sub>CC</sub>  | V <sub>IN</sub> = V <sub>CC</sub> or GND                                           |                           | 2.3~2.7             | —                     | 20.0  | μA   |
|                                  |            |                  | V <sub>CC</sub> ≤ (V <sub>IN</sub> , V <sub>OUT</sub> ) ≤ 3.6 V                    |                           | 2.3~2.7             | —                     | ±20.0 |      |

DC Characteristics ( $T_a = -40 \sim 85^\circ\text{C}$ ,  $1.65 \text{ V} \leq V_{CC} < 2.3 \text{ V}$ )

| Characteristics                  |            | Symbol           | Test Condition                                                                     |                           | V <sub>CC</sub> (V) | Min                    | Max                   | Unit |
|----------------------------------|------------|------------------|------------------------------------------------------------------------------------|---------------------------|---------------------|------------------------|-----------------------|------|
| Input voltage                    | High level | V <sub>IH</sub>  | —                                                                                  |                           | 1.65~2.3            | 0.65 × V <sub>CC</sub> | —                     | V    |
|                                  | Low level  | V <sub>IL</sub>  | —                                                                                  |                           | 1.65~2.3            | —                      | 0.2 × V <sub>CC</sub> |      |
| Output voltage                   | High level | V <sub>OH</sub>  | V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>                               | I <sub>OH</sub> = -100 μA | 1.65~2.3            | V <sub>CC</sub> - 0.2  | —                     | V    |
|                                  |            |                  |                                                                                    | I <sub>OH</sub> = -6 mA   | 1.65                | 1.25                   | —                     |      |
|                                  | Low level  | V <sub>OL</sub>  | V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>                               | I <sub>OL</sub> = 100 μA  | 1.65~2.3            | —                      | 0.2                   |      |
|                                  |            |                  |                                                                                    | I <sub>OL</sub> = 6 mA    | 1.65                | —                      | 0.3                   |      |
| Input leakage current            |            | I <sub>IN</sub>  | V <sub>IN</sub> = 0~3.6 V                                                          |                           | 1.65~2.3            | —                      | ±5.0                  | μA   |
| 3-state output off-state current |            | I <sub>OZ</sub>  | V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub><br>V <sub>OUT</sub> = 0~3.6 V |                           | 1.65~2.3            | —                      | ±10.0                 | μA   |
| Power off leakage current        |            | I <sub>OFF</sub> | V <sub>IN</sub> , V <sub>OUT</sub> = 0~3.6 V                                       |                           | 0                   | —                      | 10.0                  | μA   |
| Quiescent supply current         |            | I <sub>CC</sub>  | V <sub>IN</sub> = V <sub>CC</sub> or GND                                           |                           | 1.65~2.3            | —                      | 20.0                  | μA   |
|                                  |            |                  | V <sub>CC</sub> ≤ (V <sub>IN</sub> , V <sub>OUT</sub> ) ≤ 3.6 V                    |                           | 1.65~2.3            | —                      | ±20.0                 |      |

DC Characteristics ( $T_a = -40 \sim 85^\circ\text{C}$ ,  $1.4 \text{ V} \leq V_{CC} < 1.65 \text{ V}$ )

| Characteristics                  |            | Symbol           | Test Condition                                                                     |                           | V <sub>CC</sub> (V) | Min                    | Max                    | Unit |
|----------------------------------|------------|------------------|------------------------------------------------------------------------------------|---------------------------|---------------------|------------------------|------------------------|------|
| Input voltage                    | High level | V <sub>IH</sub>  | —                                                                                  |                           | 1.4~1.65            | 0.65 × V <sub>CC</sub> | —                      | V    |
|                                  | Low level  | V <sub>IL</sub>  | —                                                                                  |                           | 1.4~1.65            | —                      | 0.05 × V <sub>CC</sub> |      |
| Output voltage                   | High level | V <sub>OH</sub>  | V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>                               | I <sub>OH</sub> = −100 μA | 1.4~1.65            | V <sub>CC</sub> − 0.2  | —                      | V    |
|                                  |            |                  |                                                                                    | I <sub>OH</sub> = −2 mA   | 1.4                 | 1.05                   | —                      |      |
|                                  | Low level  | V <sub>OL</sub>  | V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>                               | I <sub>OL</sub> = 100 μA  | 1.4~1.65            | —                      | 0.05                   |      |
|                                  |            |                  |                                                                                    | I <sub>OL</sub> = 2 mA    | 1.4                 | —                      | 0.35                   |      |
| Input leakage current            |            | I <sub>IN</sub>  | V <sub>IN</sub> = 0~3.6 V                                                          |                           | 1.4~1.65            | —                      | ±5.0                   | μA   |
| 3-state output off-state current |            | I <sub>OZ</sub>  | V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub><br>V <sub>OUT</sub> = 0~3.6 V |                           | 1.4~1.65            | —                      | ±10.0                  | μA   |
| Power off leakage current        |            | I <sub>OFF</sub> | V <sub>IN</sub> , V <sub>OUT</sub> = 0~3.6 V                                       |                           | 0                   | —                      | 10.0                   | μA   |
| Quiescent supply current         |            | I <sub>CC</sub>  | V <sub>IN</sub> = V <sub>CC</sub> or GND                                           |                           | 1.4~1.65            | —                      | 20.0                   | μA   |
|                                  |            |                  | V <sub>CC</sub> ≤ (V <sub>IN</sub> , V <sub>OUT</sub> ) ≤ 3.6 V                    |                           | 1.4~1.65            | —                      | ±20.0                  |      |

DC Characteristics ( $T_a = -40 \sim 85^\circ\text{C}$ ,  $1.2\text{ V} \leq V_{CC} < 1.4\text{ V}$ )

| Characteristics                  |            | Symbol           | Test Condition                                                                     |                                      | V <sub>CC</sub> (V) | Min                 | Max                  | Unit          |
|----------------------------------|------------|------------------|------------------------------------------------------------------------------------|--------------------------------------|---------------------|---------------------|----------------------|---------------|
|                                  |            |                  |                                                                                    |                                      |                     |                     |                      |               |
| Input voltage                    | High level | V <sub>IH</sub>  | —                                                                                  |                                      | 1.2~1.4             | $0.8 \times V_{CC}$ | —                    | V             |
|                                  | Low level  | V <sub>IL</sub>  | —                                                                                  |                                      | 1.2~1.4             | —                   | $0.05 \times V_{CC}$ |               |
| Output voltage                   | High level | V <sub>OH</sub>  | V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>                               | I <sub>OH</sub> = -100 $\mu\text{A}$ | 1.2                 | $V_{CC} - 0.1$      | —                    | V             |
|                                  | Low level  | V <sub>OL</sub>  | V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>                               | I <sub>OL</sub> = 100 $\mu\text{A}$  | 1.2                 | —                   | 0.05                 |               |
| Input leakage current            |            | I <sub>IN</sub>  | V <sub>IN</sub> = 0~3.6 V                                                          |                                      | 1.2                 | —                   | $\pm 5.0$            | $\mu\text{A}$ |
| 3-state output off-state current |            | I <sub>OZ</sub>  | V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub><br>V <sub>OUT</sub> = 0~3.6 V |                                      | 1.2                 | —                   | $\pm 10.0$           | $\mu\text{A}$ |
| Power off leakage current        |            | I <sub>OFF</sub> | V <sub>IN</sub> , V <sub>OUT</sub> = 0~3.6 V                                       |                                      | 0                   | —                   | 10.0                 | $\mu\text{A}$ |
| Quiescent supply current         |            | I <sub>CC</sub>  | V <sub>IN</sub> = V <sub>CC</sub> or GND                                           |                                      | 1.2                 | —                   | 20.0                 | $\mu\text{A}$ |
|                                  |            |                  | $V_{CC} \leq (V_{IN}, V_{OUT}) \leq 3.6\text{ V}$                                  |                                      | 1.2                 | —                   | $\pm 20.0$           |               |

AC Characteristics (Ta = -40~85°C, Input: t<sub>r</sub> = t<sub>f</sub> = 2.0 ns)

| Characteristics               | Symbol                                   | Test Condition     |                                                | V <sub>CC</sub> (V) | Min | Max  | Unit |
|-------------------------------|------------------------------------------|--------------------|------------------------------------------------|---------------------|-----|------|------|
|                               |                                          |                    |                                                |                     |     |      |      |
| Maximum clock frequency       | f <sub>max</sub>                         | Figure 1, Figure 2 | C <sub>L</sub> = 15 pF, R <sub>L</sub> = 2 kΩ  | 1.2                 | 40  | —    | MHz  |
|                               |                                          |                    |                                                | 1.5 ± 0.1           | 80  | —    |      |
|                               |                                          |                    | C <sub>L</sub> = 30 pF, R <sub>L</sub> = 500 Ω | 1.8 ± 0.15          | 100 | —    |      |
|                               |                                          |                    |                                                | 2.5 ± 0.2           | 200 | —    |      |
|                               |                                          |                    |                                                | 3.3 ± 0.3           | 250 | —    |      |
| Propagation delay time (CK-Q) | t <sub>pLH</sub><br>t <sub>pHL</sub>     | Figure 1, Figure 2 | C <sub>L</sub> = 15 pF, R <sub>L</sub> = 2 kΩ  | 1.2                 | 1.5 | 48.0 | ns   |
|                               |                                          |                    |                                                | 1.5 ± 0.1           | 1.0 | 19.2 |      |
|                               |                                          |                    | C <sub>L</sub> = 30 pF, R <sub>L</sub> = 500 Ω | 1.8 ± 0.15          | 1.5 | 9.6  |      |
|                               |                                          |                    |                                                | 2.5 ± 0.2           | 0.8 | 4.8  |      |
|                               |                                          |                    |                                                | 3.3 ± 0.3           | 0.6 | 4.2  |      |
| 3-state output enable time    | t <sub>pZL</sub><br>t <sub>pZH</sub>     | Figure 1, Figure 3 | C <sub>L</sub> = 15 pF, R <sub>L</sub> = 2 kΩ  | 1.2                 | 1.5 | 49.0 | ns   |
|                               |                                          |                    |                                                | 1.5 ± 0.1           | 1.0 | 19.6 |      |
|                               |                                          |                    | C <sub>L</sub> = 30 pF, R <sub>L</sub> = 500 Ω | 1.8 ± 0.15          | 1.5 | 9.8  |      |
|                               |                                          |                    |                                                | 2.5 ± 0.2           | 0.8 | 5.5  |      |
|                               |                                          |                    |                                                | 3.3 ± 0.3           | 0.6 | 4.5  |      |
| 3-state output disable time   | t <sub>pLZ</sub><br>t <sub>pHZ</sub>     | Figure 1, Figure 3 | C <sub>L</sub> = 15 pF, R <sub>L</sub> = 2 kΩ  | 1.2                 | 1.5 | 32.5 | ns   |
|                               |                                          |                    |                                                | 1.5 ± 0.1           | 1.0 | 13.0 |      |
|                               |                                          |                    | C <sub>L</sub> = 30 pF, R <sub>L</sub> = 500 Ω | 1.8 ± 0.15          | 1.5 | 6.5  |      |
|                               |                                          |                    |                                                | 2.5 ± 0.2           | 0.8 | 3.6  |      |
|                               |                                          |                    |                                                | 3.3 ± 0.3           | 0.6 | 3.3  |      |
| Minimum pulse width (CK)      | t <sub>w</sub> (H)<br>t <sub>w</sub> (L) | Figure 1, Figure 2 | C <sub>L</sub> = 15 pF, R <sub>L</sub> = 2 kΩ  | 1.2                 | 24  | —    | ns   |
|                               |                                          |                    |                                                | 1.5 ± 0.1           | 8.0 | —    |      |
|                               |                                          |                    | C <sub>L</sub> = 30 pF, R <sub>L</sub> = 500 Ω | 1.8 ± 0.15          | 4.0 | —    |      |
|                               |                                          |                    |                                                | 2.5 ± 0.2           | 1.5 | —    |      |
|                               |                                          |                    |                                                | 3.3 ± 0.3           | 1.5 | —    |      |
| Minimum set-up time           | t <sub>s</sub>                           | Figure 1, Figure 2 | C <sub>L</sub> = 15 pF, R <sub>L</sub> = 2 kΩ  | 1.2                 | 20  | —    | ns   |
|                               |                                          |                    |                                                | 1.5 ± 0.1           | 7.5 | —    |      |
|                               |                                          |                    | C <sub>L</sub> = 30 pF, R <sub>L</sub> = 500 Ω | 1.8 ± 0.15          | 2.5 | —    |      |
|                               |                                          |                    |                                                | 2.5 ± 0.2           | 1.5 | —    |      |
|                               |                                          |                    |                                                | 3.3 ± 0.3           | 1.5 | —    |      |
| Minimum hold time             | t <sub>h</sub>                           | Figure 1, Figure 2 | C <sub>L</sub> = 15 pF, R <sub>L</sub> = 2 kΩ  | 1.2                 | 8.0 | —    | ns   |
|                               |                                          |                    |                                                | 1.5 ± 0.1           | 3.0 | —    |      |
|                               |                                          |                    | C <sub>L</sub> = 30 pF, R <sub>L</sub> = 500 Ω | 1.8 ± 0.15          | 1.0 | —    |      |
|                               |                                          |                    |                                                | 2.5 ± 0.2           | 1.0 | —    |      |
|                               |                                          |                    |                                                | 3.3 ± 0.3           | 1.0 | —    |      |
| Output to output skew         | t <sub>osLH</sub><br>t <sub>osHL</sub>   | (Note)             | C <sub>L</sub> = 15 pF, R <sub>L</sub> = 2 kΩ  | 1.2                 | —   | 1.5  | ns   |
|                               |                                          |                    |                                                | 1.5 ± 0.1           | —   | 1.5  |      |
|                               |                                          |                    | C <sub>L</sub> = 30 pF, R <sub>L</sub> = 500 Ω | 1.8 ± 0.15          | —   | 0.5  |      |
|                               |                                          |                    |                                                | 2.5 ± 0.2           | —   | 0.5  |      |
|                               |                                          |                    |                                                | 3.3 ± 0.3           | —   | 0.5  |      |

For C<sub>L</sub> = 50 pF, add approximately 300 ps to the AC maximum specification.

Note: This parameter is guaranteed by design. (t<sub>osLH</sub> = |t<sub>pLHm</sub> - t<sub>pLHn</sub>|, t<sub>osHL</sub> = |t<sub>pHLm</sub> - t<sub>pHLn</sub>|)

**Dynamic Switching Characteristics (Ta = 25°C, Input:  $t_r = t_f = 2.0$  ns,  $C_L = 30$  pF)**

| Characteristics                              | Symbol           | Test Condition                                        | V <sub>CC</sub> (V) | Typ.  | Unit |
|----------------------------------------------|------------------|-------------------------------------------------------|---------------------|-------|------|
|                                              |                  |                                                       |                     |       |      |
| Quiet output maximum dynamic V <sub>OL</sub> | V <sub>OLP</sub> | V <sub>IH</sub> = 1.8 V, V <sub>IL</sub> = 0 V (Note) | 1.8                 | 0.25  | V    |
|                                              |                  | V <sub>IH</sub> = 2.5 V, V <sub>IL</sub> = 0 V (Note) | 2.5                 | 0.6   |      |
|                                              |                  | V <sub>IH</sub> = 3.3 V, V <sub>IL</sub> = 0 V (Note) | 3.3                 | 0.8   |      |
| Quiet output minimum dynamic V <sub>OL</sub> | V <sub>OLV</sub> | V <sub>IH</sub> = 1.8 V, V <sub>IL</sub> = 0 V (Note) | 1.8                 | -0.25 | V    |
|                                              |                  | V <sub>IH</sub> = 2.5 V, V <sub>IL</sub> = 0 V (Note) | 2.5                 | -0.6  |      |
|                                              |                  | V <sub>IH</sub> = 3.3 V, V <sub>IL</sub> = 0 V (Note) | 3.3                 | -0.8  |      |
| Quiet output minimum dynamic V <sub>OH</sub> | V <sub>OHV</sub> | V <sub>IH</sub> = 1.8 V, V <sub>IL</sub> = 0 V (Note) | 1.8                 | 1.5   | V    |
|                                              |                  | V <sub>IH</sub> = 2.5 V, V <sub>IL</sub> = 0 V (Note) | 2.5                 | 1.9   |      |
|                                              |                  | V <sub>IH</sub> = 3.3 V, V <sub>IL</sub> = 0 V (Note) | 3.3                 | 2.2   |      |

Note: This parameter is guaranteed by design.

**Capacitive Characteristics (Ta = 25°C)**

| Characteristics               | Symbol          | Test Condition                  | V <sub>CC</sub> (V) | Typ. | Unit |
|-------------------------------|-----------------|---------------------------------|---------------------|------|------|
|                               |                 |                                 |                     |      |      |
| Input capacitance             | C <sub>IN</sub> | —                               | 1.8, 2.5, 3.3       | 6    | pF   |
| Output capacitance            | C <sub>O</sub>  | —                               | 1.8, 2.5, 3.3       | 7    | pF   |
| Power dissipation capacitance | C <sub>PD</sub> | f <sub>IN</sub> = 10 MHz (Note) | 1.8, 2.5, 3.3       | 20   | pF   |

Note: C<sub>PD</sub> 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:

$$I_{CC}(\text{opr}) = C_{PD} \cdot V_{CC} \cdot f_{IN} + I_{CC}/8 \text{ (per bit)}$$

AC Test Circuit

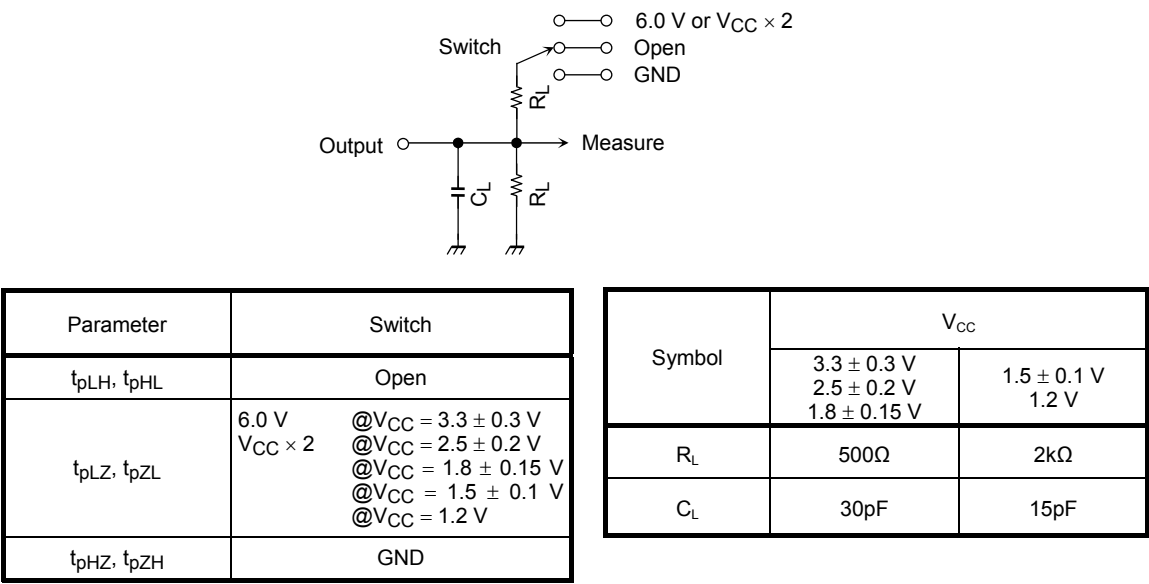


Figure 1

AC Waveform

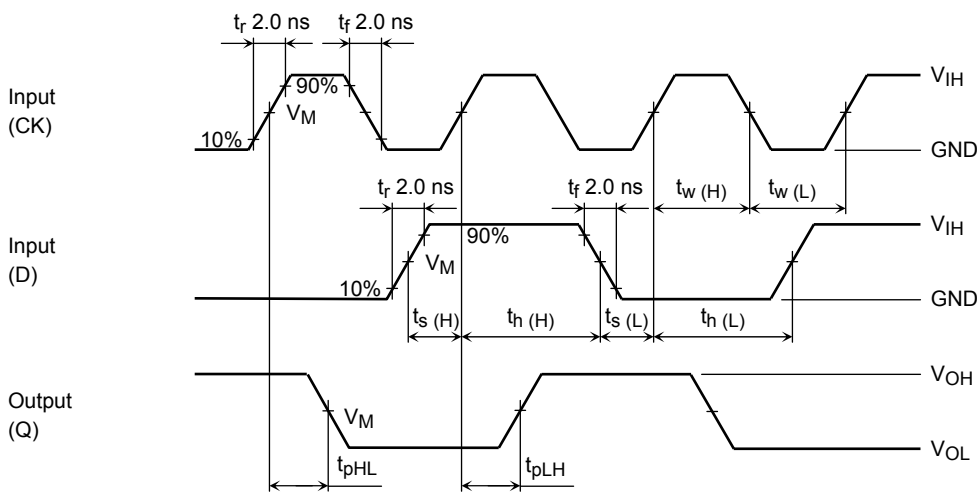
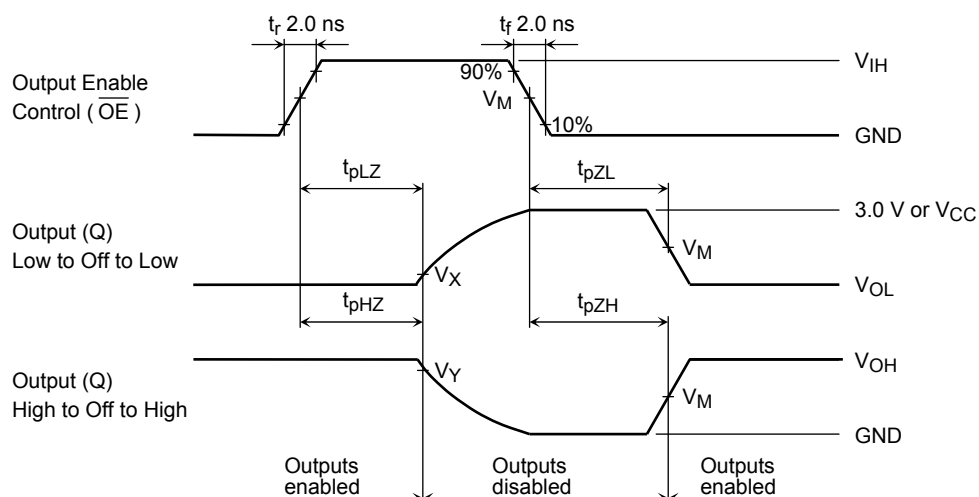


Figure 2  $t_{pLH}$ ,  $t_{pHL}$ ,  $t_w$ ,  $t_s$ ,  $t_h$



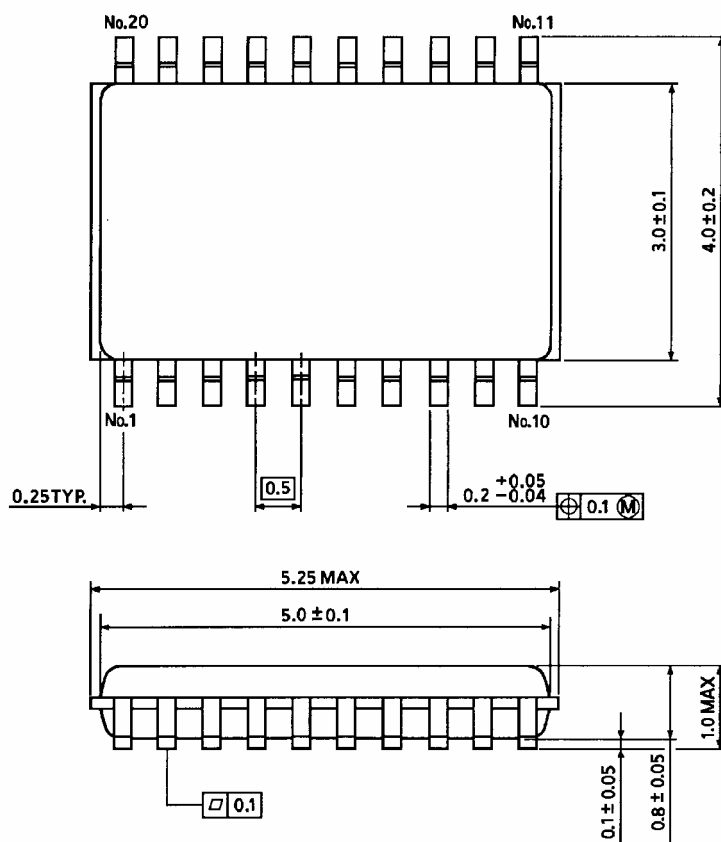
**Figure 3**  $t_{pLZ}$ ,  $t_{pHZ}$ ,  $t_{pZL}$ ,  $t_{pZH}$

| Symbol   | $V_{CC}$                 |                           |                           |                          |                          |
|----------|--------------------------|---------------------------|---------------------------|--------------------------|--------------------------|
|          | $3.3 \pm 0.3 \text{ V}$  | $2.5 \pm 0.2 \text{ V}$   | $1.8 \pm 0.15 \text{ V}$  | $1.5 \pm 0.1 \text{ V}$  | $1.2 \text{ V}$          |
| $V_{IH}$ | 2.7 V                    | $V_{CC}$                  | $V_{CC}$                  | $V_{CC}$                 | $V_{CC}$                 |
| $V_M$    | 1.5 V                    | $V_{CC}/2$                | $V_{CC}/2$                | $V_{CC}/2$               | $V_{CC}/2$               |
| $V_X$    | $V_{OL} + 0.3 \text{ V}$ | $V_{OL} + 0.15 \text{ V}$ | $V_{OL} + 0.15 \text{ V}$ | $V_{OL} + 0.1 \text{ V}$ | $V_{OL} + 0.1 \text{ V}$ |
| $V_Y$    | $V_{OH} - 0.3 \text{ V}$ | $V_{OH} - 0.15 \text{ V}$ | $V_{OH} - 0.15 \text{ V}$ | $V_{OH} - 0.1 \text{ V}$ | $V_{OH} - 0.1 \text{ V}$ |

## Package Dimensions

VSSOP20-P-0030-0.50

Unit : mm



Weight: 0.03 g (typ.)

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20070701-EN GENERAL

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