

TOSHIBA CMOS Digital Integrated Circuit Silicon Monolithic

# TC7MA573FK

Low-Voltage Octal D-Type Latch with 3.6 V Tolerant Inputs and Outputs

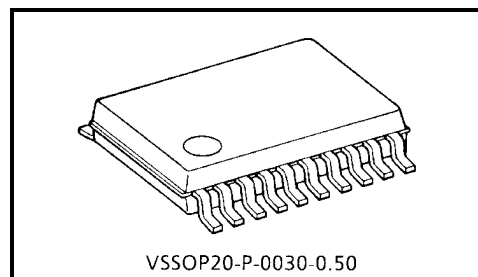
The TC7MA573FK is a high performance CMOS octal D-type latch. Designed for use in 1.8 V, 2.5 V or 3.3 V systems, it achieves high speed operation while maintaining the CMOS low power dissipation.

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

This 8 bit D-type latch is controlled by a latch enable input (LE) and an output enable input ( $\overline{OE}$ ).

When the  $\overline{OE}$  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

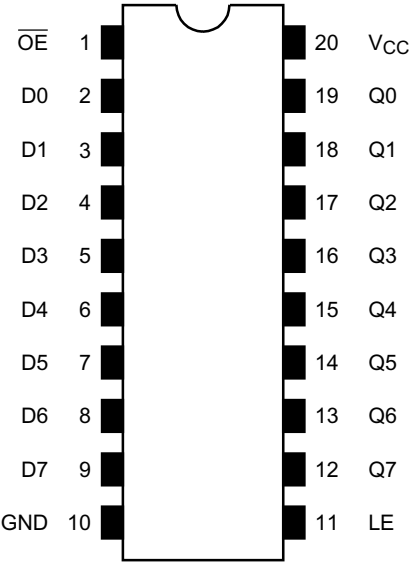
- Low voltage operation:  $V_{CC} = 1.8 \sim 3.6$  V
- High speed operation:  $t_{pd} = 4.2$  ns (max) ( $V_{CC} = 3.0 \sim 3.6$  V)  
 $t_{pd} = 4.7$  ns (max) ( $V_{CC} = 2.3 \sim 2.7$  V)  
 $t_{pd} = 9.4$  ns (max) ( $V_{CC} = 1.8$  V)
- 3.6 V tolerant inputs and outputs.
- Output current:  $I_{OH}/I_{OL} = \pm 24$  mA (min) ( $V_{CC} = 3.0$  V)  
 $I_{OH}/I_{OL} = \pm 18$  mA (min) ( $V_{CC} = 2.3$  V)  
 $I_{OH}/I_{OL} = \pm 6$  mA (min) ( $V_{CC} = 1.8$  V)
- Latch-up performance:  $\pm 300$  mA
- ESD performance: Machine model  $> \pm 200$   
Human body model  $> \pm 2000$  V
- Package: VSSOP (US20)
- 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,  $\overline{OE}$  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.

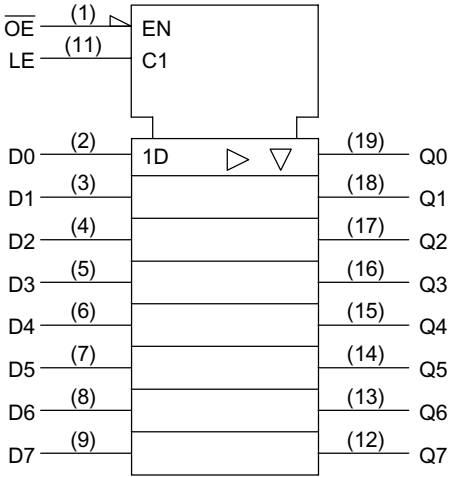
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Pin Assignment (top view)



IEC Logic Level



Truth Table

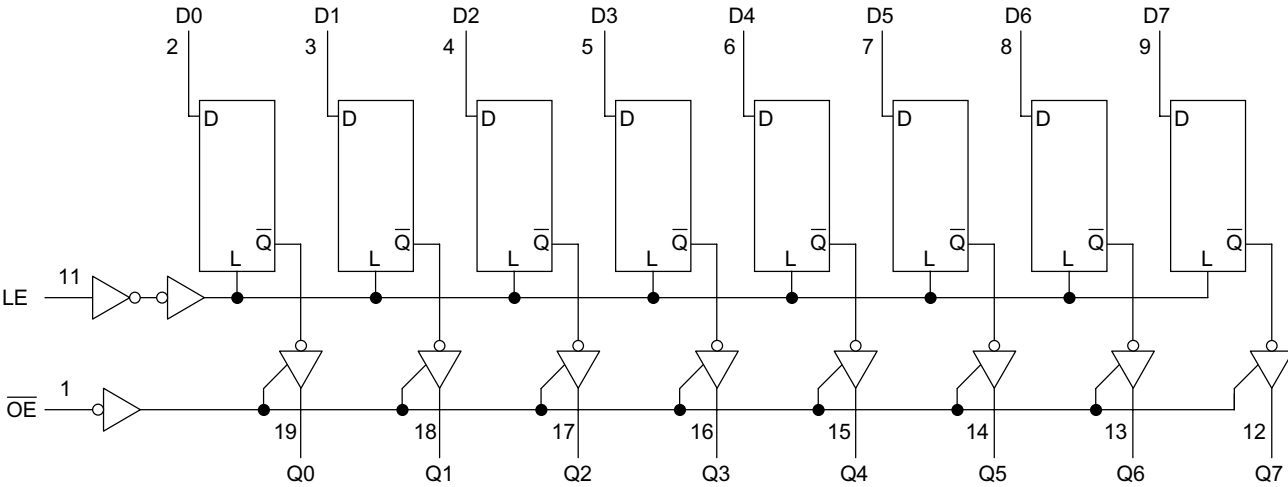
| Inputs          |    |   | Outputs |
|-----------------|----|---|---------|
| $\overline{OE}$ | LE | D |         |
| H               | X  | X | Z       |
| L               | L  | X | $Q_n$   |
| L               | H  | L | L       |
| L               | H  | H | H       |

X: Don't care

Z: High impedance

$Q_n$ : Q outputs are latched at the time when the LE inputs is taken to a low logic level.

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

Note8:  $V_{CC} = 2.3\sim 2.7$  V

Note9:  $V_{CC} = 1.8$  V

Note10:  $V_{IN} = 0.8\sim 2.0$  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 ( $T_a = -40 \sim 85^\circ\text{C}$ ,  $1.8\text{ V} \leq V_{CC} < 2.3\text{ V}$ )

| Characteristics                  |            | Symbol           | Test Condition                                                                     |                           | V <sub>CC</sub> (V) | Min                   | Max                   | Unit |
|----------------------------------|------------|------------------|------------------------------------------------------------------------------------|---------------------------|---------------------|-----------------------|-----------------------|------|
| Input voltage                    | High level | V <sub>IH</sub>  | —                                                                                  |                           | 1.8~2.3             | 0.7 × V <sub>CC</sub> | —                     | V    |
|                                  | Low level  | V <sub>IL</sub>  | —                                                                                  |                           | 1.8~2.3             | —                     | 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 | 1.8                 | V <sub>CC</sub> - 0.2 | —                     | V    |
|                                  |            |                  |                                                                                    | I <sub>OH</sub> = -6 mA   | 1.8                 | 1.4                   | —                     |      |
|                                  | 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  | 1.8                 | —                     | 0.2                   |      |
|                                  |            |                  |                                                                                    | I <sub>OL</sub> = 6 mA    | 1.8                 | —                     | 0.3                   |      |
| Input leakage current            |            | I <sub>IN</sub>  | V <sub>IN</sub> = 0~3.6 V                                                          |                           | 1.8                 | —                     | ±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 |                           | 1.8                 | —                     | ±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                                           |                           | 1.8                 | —                     | 20.0                  | μA   |
|                                  |            |                  | V <sub>CC</sub> ≤ (V <sub>IN</sub> , V <sub>OUT</sub> ) ≤ 3.6 V                    |                           | 1.8                 | —                     | ±20.0                 |      |

AC Characteristics (Ta = -40~85°C, Input: t<sub>r</sub> = t<sub>f</sub> = 2.0 ns, C<sub>L</sub> = 30 pF, R<sub>L</sub> = 500 Ω)

| Characteristics               | Symbol                                 | Test Condition     | V <sub>CC</sub> (V) | Min | Max | Unit |
|-------------------------------|----------------------------------------|--------------------|---------------------|-----|-----|------|
|                               |                                        |                    |                     |     |     |      |
| Propagation delay time (D-Q)  | t <sub>pLH</sub><br>t <sub>pHL</sub>   | Figure 1, Figure 2 | 1.8                 | 1.5 | 9.4 | ns   |
|                               |                                        |                    | 2.5 ± 0.2           | 0.8 | 4.7 |      |
|                               |                                        |                    | 3.3 ± 0.3           | 0.6 | 4.2 |      |
| Propagation delay time (LE-Q) | t <sub>pLH</sub><br>t <sub>pHL</sub>   | Figure 1, Figure 2 | 1.8                 | 1.5 | 9.8 | ns   |
|                               |                                        |                    | 2.5 ± 0.2           | 0.8 | 4.9 |      |
|                               |                                        |                    | 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 | 1.8                 | 1.5 | 9.8 | ns   |
|                               |                                        |                    | 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 | 1.8                 | 1.5 | 6.5 | ns   |
|                               |                                        |                    | 2.5 ± 0.2           | 0.8 | 3.6 |      |
|                               |                                        |                    | 3.3 ± 0.3           | 0.6 | 3.3 |      |
| Minimum pulse width           | t <sub>w</sub> (H)                     | Figure 1, Figure 2 | 1.8                 | 4.0 | —   | ns   |
|                               |                                        |                    | 2.5 ± 0.2           | 1.5 | —   |      |
|                               |                                        |                    | 3.3 ± 0.3           | 1.5 | —   |      |
| Minimum set-up time           | t <sub>s</sub>                         | Figure 1, Figure 2 | 1.8                 | 2.5 | —   | ns   |
|                               |                                        |                    | 2.5 ± 0.2           | 1.5 | —   |      |
|                               |                                        |                    | 3.3 ± 0.3           | 1.5 | —   |      |
| Minimum hold time             | t <sub>h</sub>                         | Figure 1, Figure 2 | 1.8                 | 1.0 | —   | ns   |
|                               |                                        |                    | 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> | (Note11)           | 1.8                 | —   | 0.5 | ns   |
|                               |                                        |                    | 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.

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 <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 (Note12) | 1.8                 | 0.25  | V    |
|                                              |                  | V <sub>IH</sub> = 2.5 V, V <sub>IL</sub> = 0 V (Note12) | 2.5                 | 0.6   |      |
|                                              |                  | V <sub>IH</sub> = 3.3 V, V <sub>IL</sub> = 0 V (Note12) | 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 (Note12) | 1.8                 | -0.25 | V    |
|                                              |                  | V <sub>IH</sub> = 2.5 V, V <sub>IL</sub> = 0 V (Note12) | 2.5                 | -0.6  |      |
|                                              |                  | V <sub>IH</sub> = 3.3 V, V <sub>IL</sub> = 0 V (Note12) | 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 (Note12) | 1.8                 | 1.5   | V    |
|                                              |                  | V <sub>IH</sub> = 2.5 V, V <sub>IL</sub> = 0 V (Note12) | 2.5                 | 1.9   |      |
|                                              |                  | V <sub>IH</sub> = 3.3 V, V <sub>IL</sub> = 0 V (Note12) | 3.3                 | 2.2   |      |

Note12: This parameter is guaranteed by design.

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

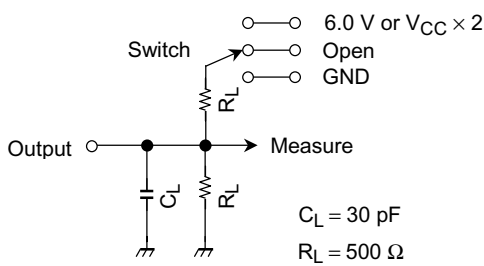
| Characteristics               | Symbol          | Test Condition                    | V <sub>CC</sub> (V) | Typ. | Unit |
|-------------------------------|-----------------|-----------------------------------|---------------------|------|------|
|                               |                 |                                   |                     |      |      |
| 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 (Note13) | 1.8, 2.5, 3.3       | 20   | pF   |

Note13: 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



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

Figure 1

AC Waveform

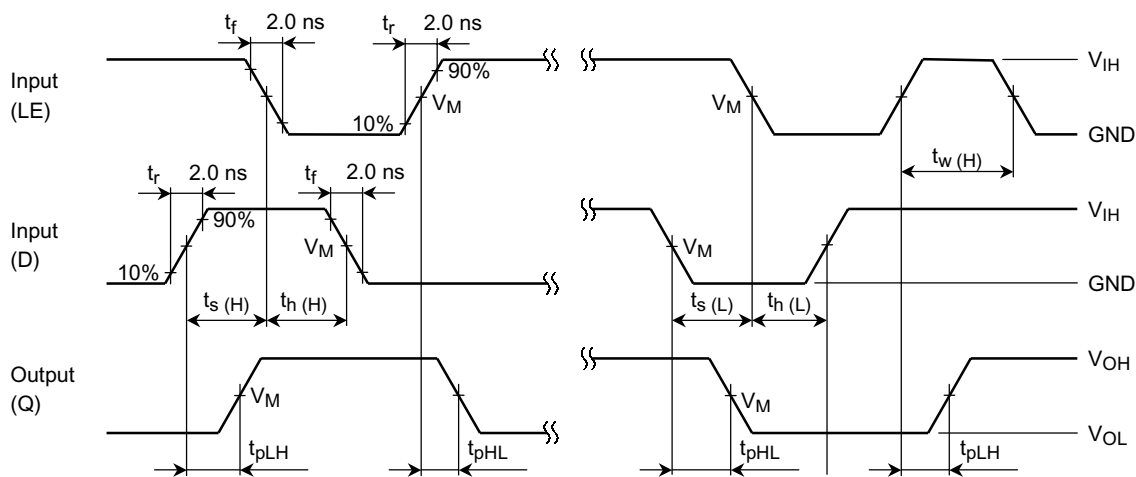
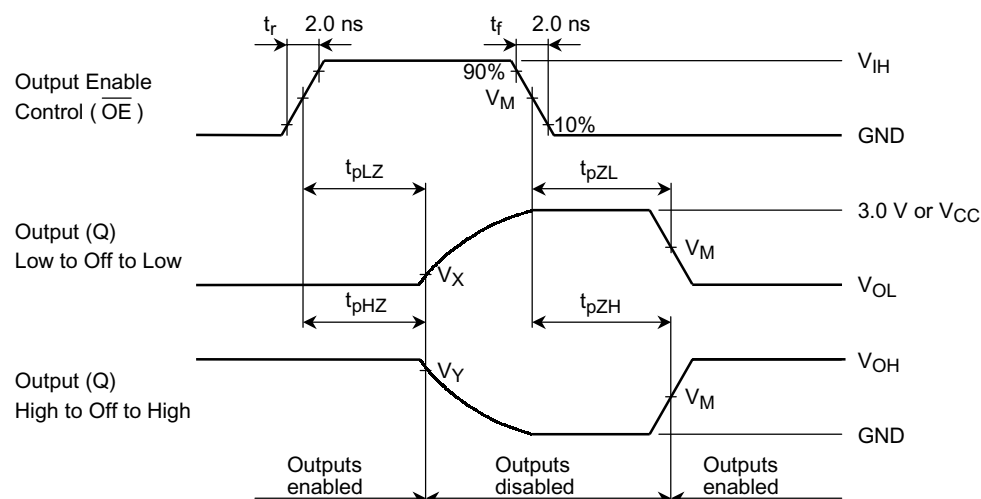


Figure 2  $t_{pLH}$ ,  $t_{pHL}$ ,  $t_w$ ,  $t_s$ ,  $t_h$



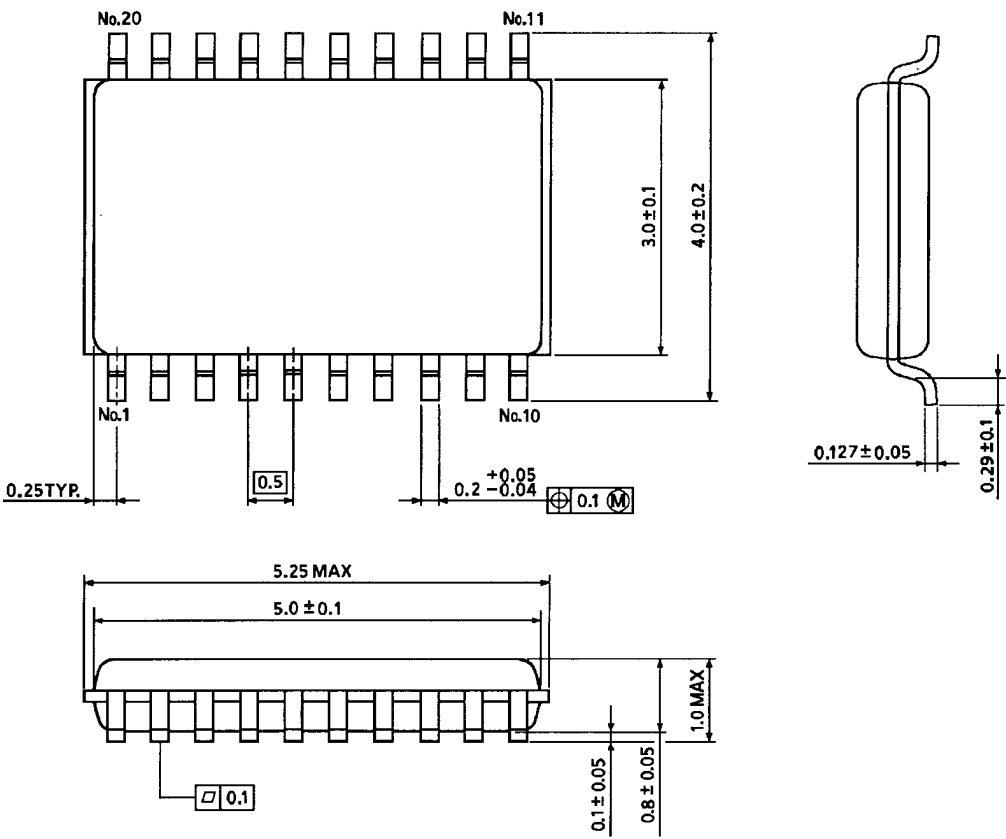
| Symbol   | $V_{CC}$                 |                           |                           |
|----------|--------------------------|---------------------------|---------------------------|
|          | $3.3 \pm 0.3 \text{ V}$  | $2.5 \pm 0.2 \text{ V}$   | $1.8 \text{ V}$           |
| $V_{IH}$ |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

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

Package Dimensions

VSSOP20-P-0030-0.50

Unit : mm



Weight: 0.03 g (typ.)