

TOSHIBA CMOS Digital Integrated Circuit Silicon Monolithic

TC74VCX373FT, TC74VCX373FK

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

The TC74VCX373 is a high performance CMOS octal D-type latch 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.

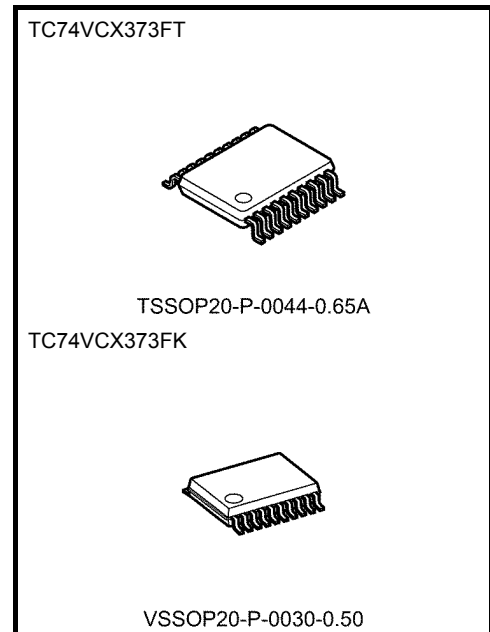
The 8 bit D-type latch is controlled by a latch enable input (LE) and an output enable input (\overline{OE}).

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.

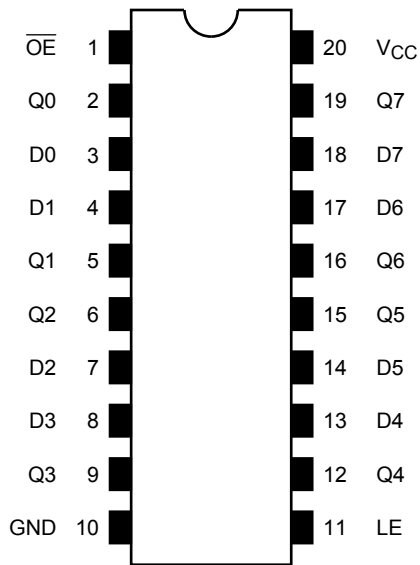
Features

- Low voltage operation: $V_{CC} = 1.2\sim 3.6\text{ V}$
- High speed operation: $t_{pd} = 4.2\text{ ns (max) (}V_{CC} = 3.0\sim 3.6\text{ V)}$
 $t_{pd} = 4.7\text{ ns (max) (}V_{CC} = 2.3\sim 2.7\text{ V)}$
 $t_{pd} = 9.4\text{ ns (max) (}V_{CC} = 1.65\sim 1.95\text{ V)}$
 $t_{pd} = 18.8\text{ ns (max) (}V_{CC} = 1.4\sim 1.6\text{ V)}$
 $t_{pd} = 47.0\text{ ns (max) (}V_{CC} = 1.2\text{ V)}$
- 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 mA
- ESD performance: Machine model $\geq \pm 200\text{ V}$
Human body model $\geq \pm 2000\text{ V}$
- Package: TSSOP and VSSOP (US)
- Power down protection is provided on all inputs and outputs.

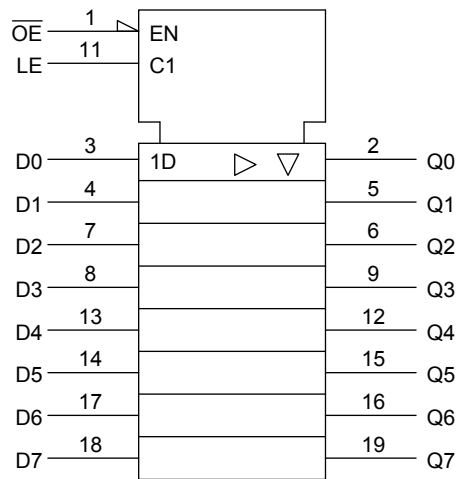


| | |
|----------------------|-----------------|
| Weight | |
| TSSOP20-P-0044-0.65A | : 0.08 g (typ.) |
| VSSOP20-P-0030-0.50 | : 0.03 g (typ.) |

Pin Assignment (top view)



IEC Logic Level



Truth Table

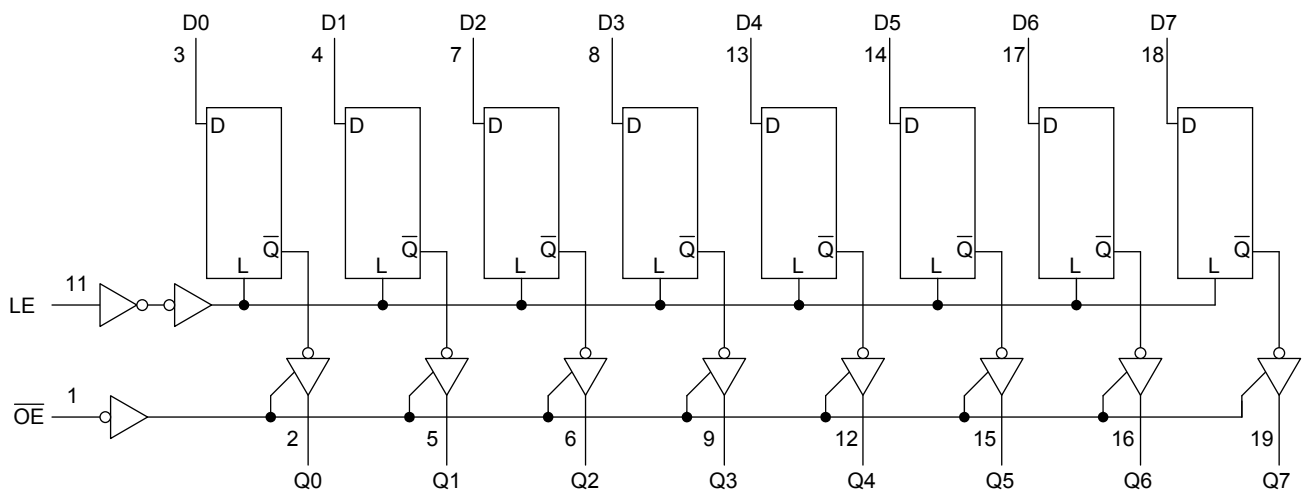
| Inputs | | | Outputs |
|-----------------|----|---|---------|
| \overline{OE} | LE | D | |
| H | X | X | Z |
| L | L | X | Q_n |
| L | H | L | L |
| L | H | H | H |

X: Don't care

Z: High impedance

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

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: Off-state

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 (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} 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 | |
| | | ΔI _{CC} | V _{IH} = V _{CC} - 0.6 V (per input) | | 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 | |
| 3-state output off-state current | | I _{OZ} | V _{IN} = V _{IH} or V _{IL} 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, 1.65 V ≤ VCC < 2.3 V)

| Characteristics | | Symbol | Test Condition | | VCC (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 |
| 3-state output off-state current | | I _{OZ} | V _{IN} = V _{IH} or V _{IL} V _{OUT} = 0~3.6 V | | 1.65~2.3 | — | ±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 | | 1.65~2.3 | — | 20.0 | μA |
| | | | V _{CC} ≤ (V _{IN} , V _{OUT}) ≤ 3.6 V | | 1.65~2.3 | — | ±20.0 | |

DC Characteristics (Ta = -40~85°C, 1.4 V ≤ VCC < 1.65 V)

| Characteristics | | Symbol | Test Condition | | VCC (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 |
| 3-state output off-state current | | I _{OZ} | V _{IN} = V _{IH} or V _{IL} V _{OUT} = 0~3.6 V | | 1.4~1.65 | — | ±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 | | 1.4~1.65 | — | 20.0 | μA |
| | | | V _{CC} ≤ (V _{IN} , V _{OUT}) ≤ 3.6 V | | 1.4~1.65 | — | ±20.0 | |

DC Characteristics (Ta = -40~85°C, 1.2 V ≤ VCC < 1.4 V)

| Characteristics | | Symbol | Test Condition | | VCC (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 |
| 3-state output off-state current | | I _{OZ} | V _{IN} = V _{IH} or V _{IL} V _{OUT} = 0~3.6 V | | 1.2 | — | ±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 | | 1.2 | — | 20.0 | μA |
| | | | V _{CC} ≧ (V _{IN} , V _{OUT}) ≧ 3.6 V | | 1.2 | — | ±20.0 | |

AC Characteristics (Ta = -40~85°C, Input: tr = tf = 2.0 ns) (Note 1)

| Characteristics | Symbol | Test Condition | | VCC (V) | Min | Max | Unit |
|-------------------------------|----------------|--------------------|------------------------|------------|-----|------|------|
| | | | | | | | |
| Propagation delay time (D-Q) | tpLH tpHL | Figure 1, Figure 2 | CL = 15 pF, RL = 2 kΩ | 1.2 | 1.5 | 47.0 | ns |
| | | | | 1.5 ± 0.1 | 1.0 | 18.8 | |
| | | | CL = 30 pF, RL = 500 Ω | 1.8 ± 0.15 | 1.5 | 9.4 | |
| | | | | 2.5 ± 0.2 | 0.8 | 4.7 | |
| Propagation delay time (LE-Q) | tpLH tpHL | Figure 1, Figure 2 | CL = 15 pF, RL = 2 kΩ | 1.2 | 1.5 | 49.0 | ns |
| | | | | 1.5 ± 0.1 | 1.0 | 19.6 | |
| | | | CL = 30 pF, RL = 500 Ω | 1.8 ± 0.15 | 1.5 | 9.8 | |
| | | | | 2.5 ± 0.2 | 0.8 | 4.9 | |
| 3-state output enable time | tpZL tpZH | Figure 1, Figure 3 | CL = 15 pF, RL = 2 kΩ | 1.2 | 1.5 | 49.0 | ns |
| | | | | 1.5 ± 0.1 | 1.0 | 19.6 | |
| | | | CL = 30 pF, RL = 500 Ω | 1.8 ± 0.15 | 1.5 | 9.8 | |
| | | | | 2.5 ± 0.2 | 0.8 | 5.5 | |
| 3-state output disable time | tpLZ tpHZ | Figure 1, Figure 3 | CL = 15 pF, RL = 2 kΩ | 1.2 | 1.5 | 32.5 | ns |
| | | | | 1.5 ± 0.1 | 1.0 | 13.0 | |
| | | | CL = 30 pF, RL = 500 Ω | 1.8 ± 0.15 | 1.5 | 6.5 | |
| | | | | 2.5 ± 0.2 | 0.8 | 3.6 | |
| Minimum pulse width (LE) | tw (H) | Figure 1, Figure 2 | CL = 15 pF, RL = 2 kΩ | 1.2 | 24 | — | ns |
| | | | | 1.5 ± 0.1 | 8.0 | — | |
| | | | CL = 30 pF, RL = 500 Ω | 1.8 ± 0.15 | 4.0 | — | |
| | | | | 2.5 ± 0.2 | 1.5 | — | |
| Minimum set-up time | ts | Figure 1, Figure 2 | CL = 15 pF, RL = 2 kΩ | 1.2 | 20 | — | ns |
| | | | | 1.5 ± 0.1 | 7.5 | — | |
| | | | CL = 30 pF, RL = 500 Ω | 1.8 ± 0.15 | 2.5 | — | |
| | | | | 2.5 ± 0.2 | 1.5 | — | |
| Minimum hold time | th | Figure 1, Figure 2 | CL = 15 pF, RL = 2 kΩ | 1.2 | 8.0 | — | ns |
| | | | | 1.5 ± 0.1 | 3.0 | — | |
| | | | CL = 30 pF, RL = 500 Ω | 1.8 ± 0.15 | 1.0 | — | |
| | | | | 2.5 ± 0.2 | 1.0 | — | |
| Output to output skew | tosLH tosHL | (Note 2) | CL = 15 pF, RL = 2 kΩ | 1.2 | — | 1.5 | ns |
| | | | | 1.5 ± 0.1 | — | 1.5 | |
| | | | CL = 30 pF, RL = 500 Ω | 1.8 ± 0.15 | — | 0.5 | |
| | | | | 2.5 ± 0.2 | — | 0.5 | |
| | | | | 3.3 ± 0.3 | — | 0.5 | |

Note 1: For CL = 50 pF, add approximately 300 ps to the AC maximum specification.

Note 2: This parameter is guaranteed by design. (tosLH = |tpLHm - tpLHn|, tosHL = |tpHLm - tpHLn|)

Dynamic Switching Characteristics (Ta = 25°C, Input: tr = tf = 2.0 ns, CL = 30 pF)

| Characteristics | Symbol | Test Condition | VCC (V) | Typ. | Unit |
|----------------------------------|--------|-------------------------------|---------|-------|------|
| | | | | | |
| Quiet output maximum dynamic VOL | VOLP | VIH = 1.8 V, VIL = 0 V (Note) | 1.8 | 0.25 | V |
| | | VIH = 2.5 V, VIL = 0 V (Note) | 2.5 | 0.6 | |
| | | VIH = 3.3 V, VIL = 0 V (Note) | 3.3 | 0.8 | |
| Quiet output minimum dynamic VOL | VOLV | VIH = 1.8 V, VIL = 0 V (Note) | 1.8 | -0.25 | V |
| | | VIH = 2.5 V, VIL = 0 V (Note) | 2.5 | -0.6 | |
| | | VIH = 3.3 V, VIL = 0 V (Note) | 3.3 | -0.8 | |
| Quiet output minimum dynamic VOH | VOHV | VIH = 1.8 V, VIL = 0 V (Note) | 1.8 | 1.5 | V |
| | | VIH = 2.5 V, VIL = 0 V (Note) | 2.5 | 1.9 | |
| | | VIH = 3.3 V, VIL = 0 V (Note) | 3.3 | 2.2 | |

Note: This parameter is guaranteed by design.

Capacitive Characteristics (Ta = 25°C)

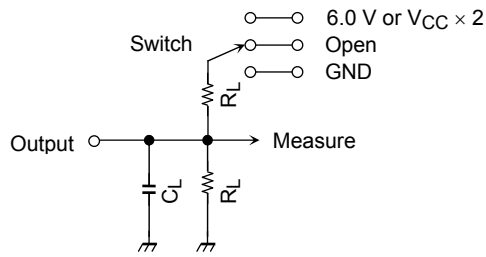
| Characteristics | Symbol | Test Condition | VCC (V) | Typ. | Unit |
|-------------------------------|--------|---------------------|---------------|------|------|
| | | | | | |
| Input capacitance | CIN | — | 1.8, 2.5, 3.3 | 6 | pF |
| Output capacitance | CO | — | 1.8, 2.5, 3.3 | 7 | pF |
| Power dissipation capacitance | CPD | fIN = 10 MHz (Note) | 1.8, 2.5, 3.3 | 20 | pF |

Note: CPD 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:

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

AC Test Circuit



| Parameter | Switch |
|--------------------|---|
| t_{pLH}, t_{pHL} | Open |
| t_{pLZ}, t_{pZL} | 6.0 V $V_{CC} \times 2$ @ $V_{CC} = 3.3 \pm 0.3$ V @ $V_{CC} = 2.5 \pm 0.2$ V @ $V_{CC} = 1.8 \pm 0.15$ V @ $V_{CC} = 1.5 \pm 0.1$ V @ $V_{CC} = 1.2$ V |
| t_{pHZ}, t_{pZH} | GND |

| Symbol | V_{CC} | |
|--------|--------------|--|
| | | 3.3 ± 0.3 V 2.5 ± 0.2 V 1.8 ± 0.15 V |
| R_L | 500 Ω | 2k Ω |
| C_L | 30pF | 15pF |

Figure 1

AC Waveform

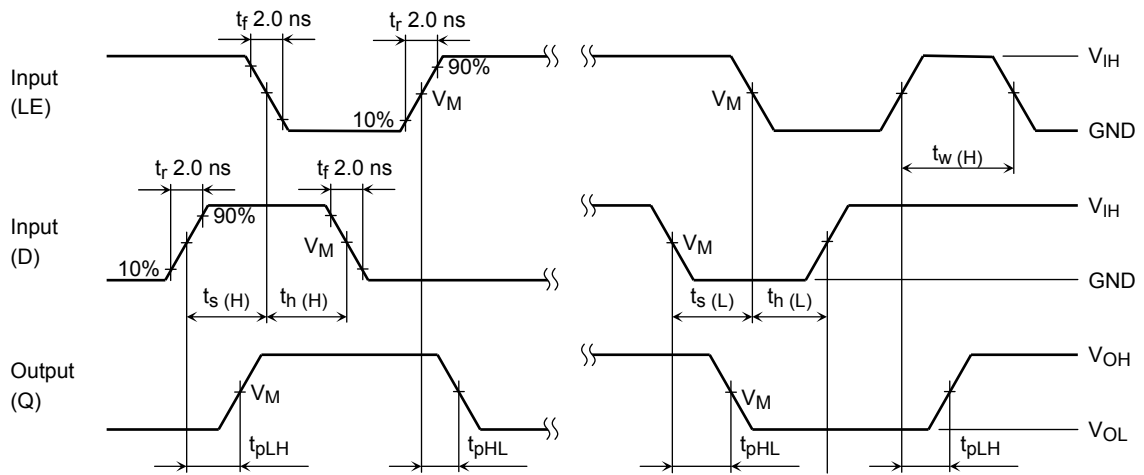


Figure 2 $t_{pLH}, t_{pHL}, t_w, t_s, t_h$

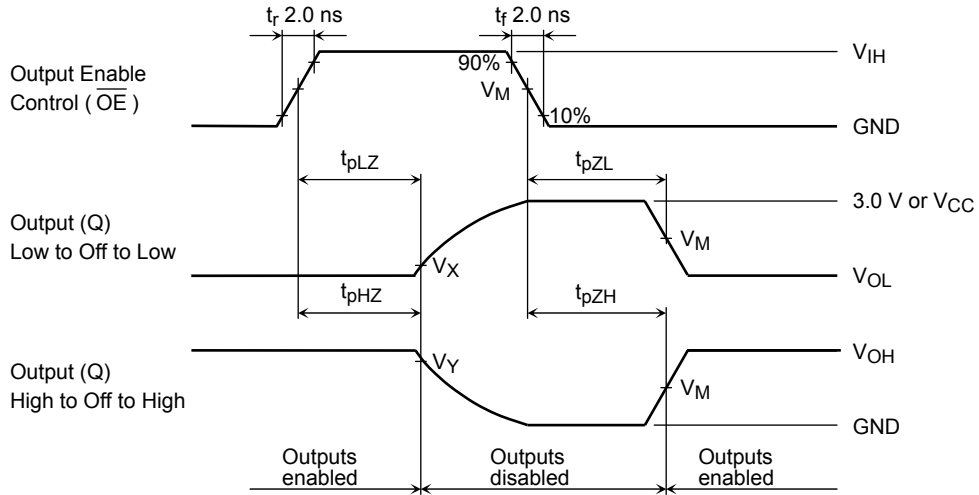


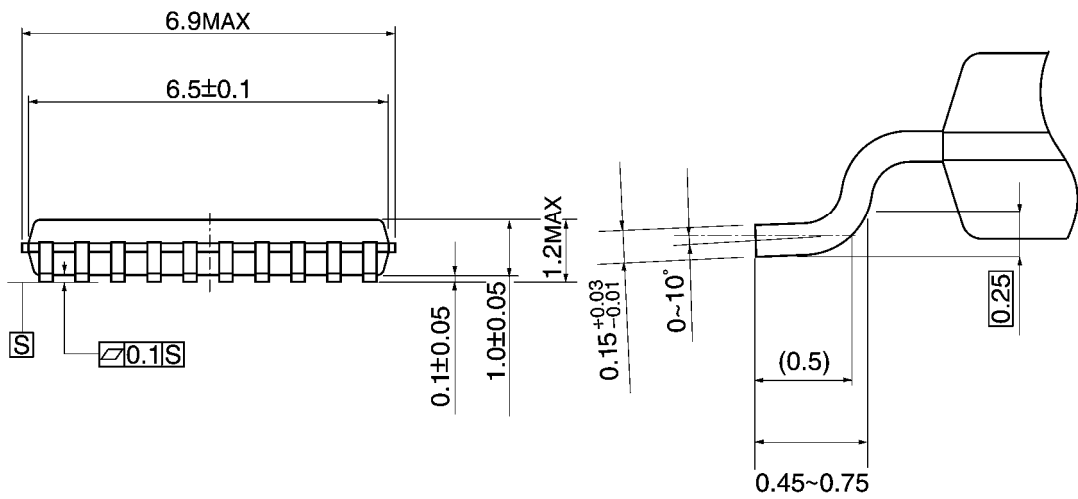
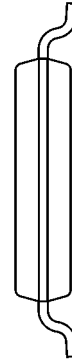
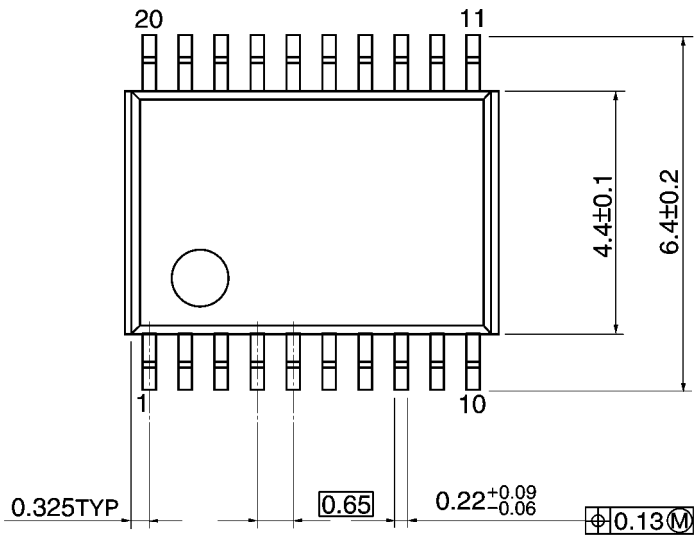
Figure 3 t_{pLZ} , t_{pHZ} , t_{pZL} , t_{pZH}

| 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 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

TSSOP20-P-0044-0.65A

Unit: mm

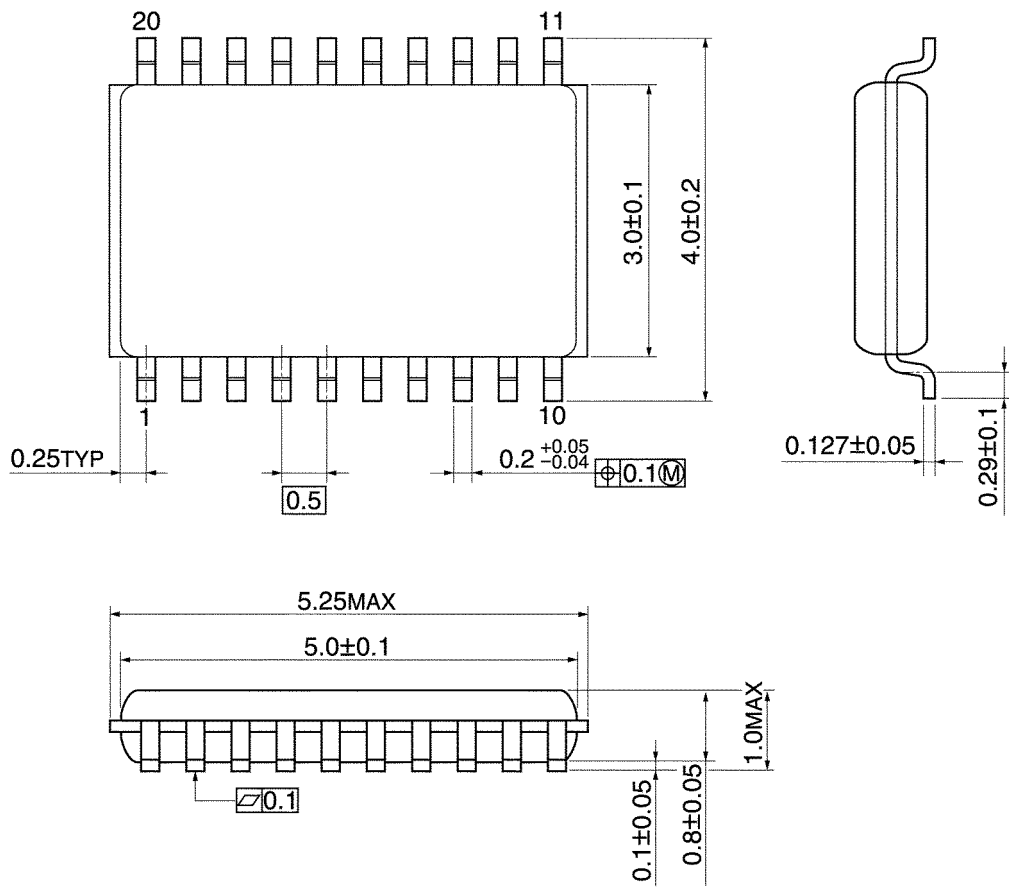


Weight: 0.08 g (typ.)

Package Dimensions

VSSOP20-P-0030-0.50

Unit: mm



Weight: 0.03 g (typ.)

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