

TOSHIBA CMOS Digital Integrated Circuit Silicon Monolithic

# TC7MAR2245FK

Low-Voltage Octal Bus Transceiver with 3.6 V Tolerant Inputs and Outputs

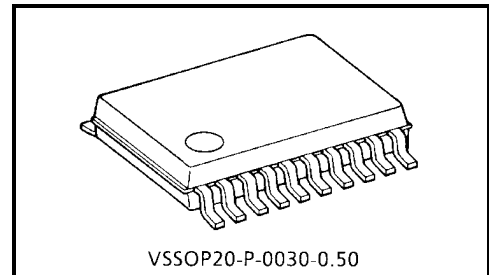
The TC7MAR2245FK is a high performance CMOS octal bus transceiver. Designed for use in 1.8, 2.5 or 3.3 V systems, it achieves high speed operation while maintaining the CMOS low power dissipation.

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

The direction of data transmission is determined by the level of the DIR inputs. The  $\overline{OE}$  inputs can be used to disable the device so that the busses are effectively isolated.

The 26- $\Omega$  series resistor helps reducing output overshoot and undershoot without external resistor.

All inputs are equipped with protection circuits against static discharge.



VSSOP20-P-0030-0.50

Weight: 0.03 g (typ.)

## Features

- 26- $\Omega$  series resistors on outputs.
- Low voltage operation:  $V_{CC} = 1.8 \sim 3.6$  V
- High speed operation:
  - $t_{pd} = 4.4$  ns (max) ( $V_{CC} = 3.0 \sim 3.6$  V)
  - $t_{pd} = 5.6$  ns (max) ( $V_{CC} = 2.3 \sim 2.7$  V)
  - $t_{pd} = 9.8$  ns (max) ( $V_{CC} = 1.8$  V)
- 3.6 V tolerant inputs and outputs.
- Bidirectional interface between 2.5 V and 3.3 V signals. (\*1)
- Power down protection is provided on all inputs and outputs. (\*2)
- Supports live insertion/withdrawal (\*3)
- Output current:  $I_{OH}/I_{OL} = \pm 12$  mA (min) ( $V_{CC} = 3.0$  V)  
 $I_{OH}/I_{OL} = \pm 8$  mA (min) ( $V_{CC} = 2.3$  V)  
 $I_{OH}/I_{OL} = \pm 4$  mA (min) ( $V_{CC} = 1.8$  V)
- Latch-up performance:  $\pm 300$  mA
- ESD performance:
  - Machine model  $> \pm 200$  V
  - Human body model  $> \pm 2000$  V
- Package: VSSOP (US20)

\*1: Do not apply a signal to any bus terminal when it is in the output mode. Damage may result.

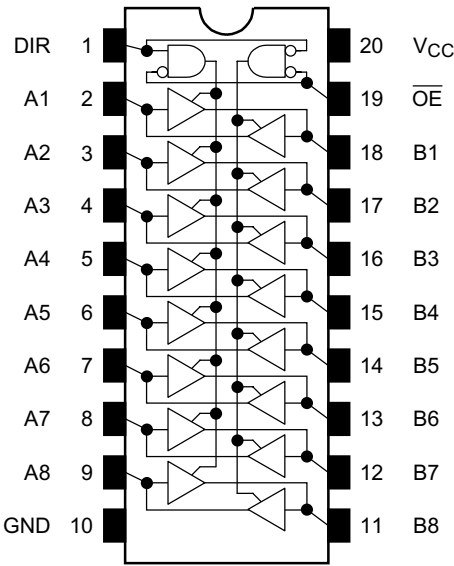
\*2: All floating (high impedance) bus terminal must have their input level fixed by means of pull up or pull down resistors.

\*3: 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.

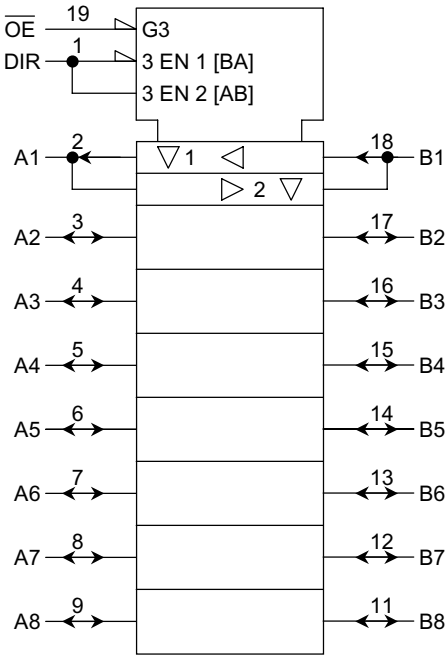
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Pin Assignment (top view)



IEC Logic Symbol



Truth Table

| Inputs |     | Outputs | Function |        |
|--------|-----|---------|----------|--------|
| OE     | DIR |         | A-Bus    | B-Bus  |
| L      | L   | A = B   | Output   | Input  |
| L      | H   | B = A   | Input    | Output |
| H      | X   | Z       | Z        |        |

X: Don't care

Z: High impedance

## Maximum Ratings

| Characteristics                          | Symbol           | Rating                       | Unit |
|------------------------------------------|------------------|------------------------------|------|
| Power supply voltage                     | $V_{CC}$         | -0.5~4.6                     | V    |
| DC input voltage (DIR, $\overline{OE}$ ) | $V_{IN}$         | -0.5~4.6                     | V    |
| DC bus I/O voltage                       | $V_{I/O}$        | -0.5~4.6 (Note1)             | V    |
|                                          |                  | -0.5~ $V_{CC} + 0.5$ (Note2) |      |
| Input diode current                      | $I_{IK}$         | -50                          | mA   |
| Output diode current                     | $I_{OK}$         | $\pm 50$ (Note3)             | mA   |
| DC output current                        | $I_{OUT}$        | $\pm 50$                     | mA   |
| Power dissipation                        | $P_D$            | 180                          | mW   |
| DC $V_{CC}$ /ground current              | $I_{CC}/I_{GND}$ | $\pm 100$                    | 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 (DIR, $\overline{OE}$ ) | $V_{IN}$        | -0.3~3.6            | V    |
| Bus I/O voltage                       | $V_{I/O}$       | 0~3.6 (Note5)       | V    |
|                                       |                 | 0~ $V_{CC}$ (Note6) |      |
| Output current                        | $I_{OH}/I_{OL}$ | $\pm 12$ (Note7)    | mA   |
|                                       |                 | $\pm 8$ (Note8)     |      |
|                                       |                 | $\pm 4$ (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> = -6 mA   | 2.7                 | 2.2                   | —     |      |
|                                       |            |                  |                                                                                    | I <sub>OH</sub> = -8 mA   | 3.0                 | 2.4                   | —     |      |
|                                       |            |                  |                                                                                    | I <sub>OH</sub> = -12 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> = 6 mA    | 2.7                 | —                     | 0.4   |      |
|                                       |            |                  |                                                                                    | I <sub>OL</sub> = 8 mA    | 3.0                 | —                     | 0.55  |      |
|                                       |            |                  |                                                                                    | I <sub>OL</sub> = 12 mA   | 3.0                 | —                     | 0.8   |      |
| 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 |      |
| Increase in I <sub>CC</sub> per input |            | ΔI <sub>CC</sub> | V <sub>IH</sub> = V <sub>CC</sub> - 0.6 V                                          |                           | 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> = -4 mA   | 2.3                 | 2.0                   | —     |      |
|                                  |            |                  |                                                                                    | I <sub>OH</sub> = -6 mA   | 2.3                 | 1.8                   | —     |      |
|                                  |            |                  |                                                                                    | I <sub>OH</sub> = -8 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> = 6 mA    | 2.3                 | —                     | 0.4   |      |
|                                  |            |                  |                                                                                    | I <sub>OL</sub> = 8 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×<br>V <sub>CC</sub>  | —                       | V    |
|                                  | Low level  | V <sub>IL</sub>  | —                                                                                  |                           | 1.8~2.3             | —                        | 0.2×<br>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><br>− 0.2 | —                       | V    |
|                                  |            |                  |                                                                                    | I <sub>OH</sub> = −4 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> = 4 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 ( $T_a = -40 \sim 85^\circ\text{C}$ , Input:  $t_r = t_f = 2.0\text{ ns}$ ,  $C_L = 30\text{ pF}$ ,  $R_L = 500\ \Omega$ )

| Characteristics             |  | Symbol                                 | Test Condition     |  | V <sub>CC</sub> (V) | Min | Max | Unit |
|-----------------------------|--|----------------------------------------|--------------------|--|---------------------|-----|-----|------|
| Propagation delay time      |  | t <sub>pLH</sub><br>t <sub>pHL</sub>   | Figure 1, Figure 2 |  | 1.8                 | 1.5 | 9.8 | ns   |
|                             |  |                                        |                    |  | $2.5 \pm 0.2$       | 0.8 | 5.6 |      |
|                             |  |                                        |                    |  | $3.3 \pm 0.3$       | 0.6 | 4.4 |      |
| 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   |
|                             |  |                                        |                    |  | $2.5 \pm 0.2$       | 0.8 | 6.6 |      |
|                             |  |                                        |                    |  | $3.3 \pm 0.3$       | 0.6 | 5.0 |      |
| 3-state output disable time |  | t <sub>pLZ</sub><br>t <sub>pHZ</sub>   | Figure 1, Figure 3 |  | 1.8                 | 1.5 | 8.5 | ns   |
|                             |  |                                        |                    |  | $2.5 \pm 0.2$       | 0.8 | 4.7 |      |
|                             |  |                                        |                    |  | $3.3 \pm 0.3$       | 0.6 | 4.2 |      |
| Output to output skew       |  | t <sub>osLH</sub><br>t <sub>osHL</sub> | (Note11)           |  | 1.8                 | —   | 0.5 | ns   |
|                             |  |                                        |                    |  | $2.5 \pm 0.2$       | —   | 0.5 |      |
|                             |  |                                        |                    |  | $3.3 \pm 0.3$       | —   | 0.5 |      |

For  $C_L = 50\text{ pF}$ , 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                 | 0.15  | V    |
|                                              |                  | V <sub>IH</sub> = 2.5 V, V <sub>IL</sub> = 0 V (Note12) | 2.5                 | 0.25  |      |
|                                              |                  | V <sub>IH</sub> = 3.3 V, V <sub>IL</sub> = 0 V (Note12) | 3.3                 | 0.35  |      |
| 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                 | -0.15 | V    |
|                                              |                  | V <sub>IH</sub> = 2.5 V, V <sub>IL</sub> = 0 V (Note12) | 2.5                 | -0.25 |      |
|                                              |                  | V <sub>IH</sub> = 3.3 V, V <sub>IL</sub> = 0 V (Note12) | 3.3                 | -0.35 |      |
| 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                 | 1.55  | V    |
|                                              |                  | V <sub>IH</sub> = 2.5 V, V <sub>IL</sub> = 0 V (Note12) | 2.5                 | 2.05  |      |
|                                              |                  | V <sub>IH</sub> = 3.3 V, V <sub>IL</sub> = 0 V (Note12) | 3.3                 | 2.65  |      |

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>  | DIR, $\overline{\text{OE}}$       | 1.8, 2.5, 3.3       | 6    | pF   |
| Bus I/O capacitance           | C <sub>I/O</sub> | An, Bn                            | 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

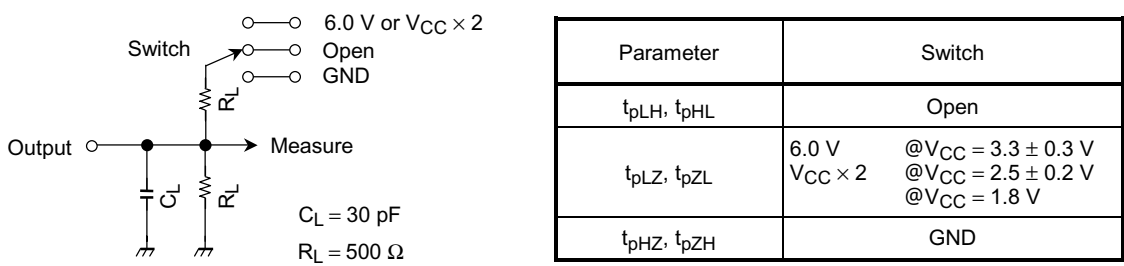


Figure 1

AC Waveform

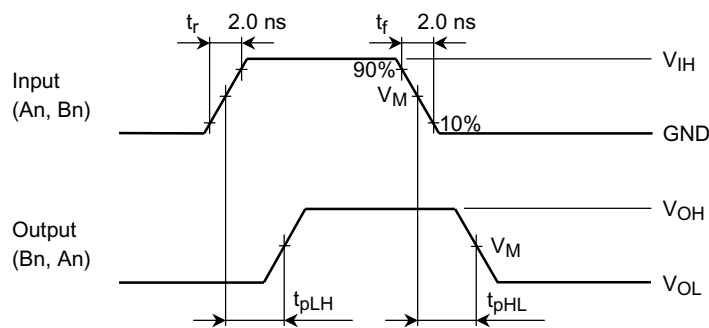
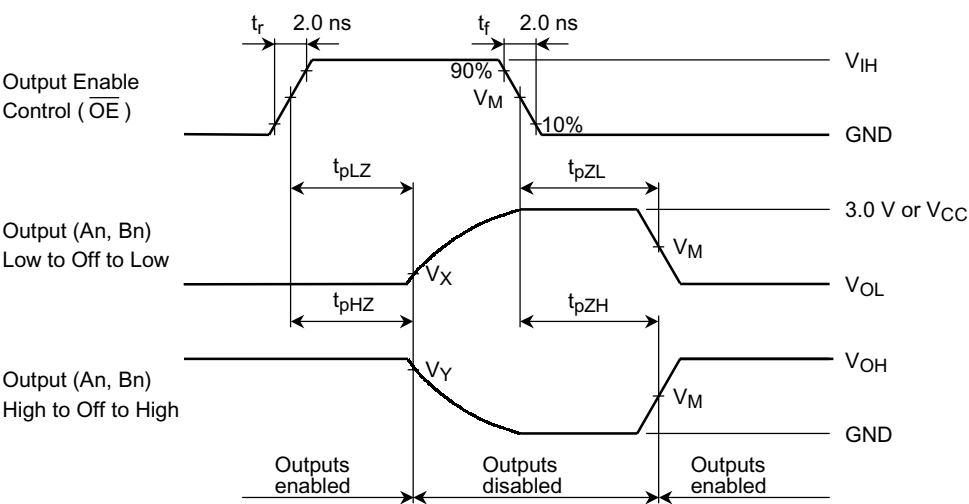


Figure 2  $t_{pLH}$ ,  $t_{pHL}$



| 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    $t_{pLZ}$ ,  $t_{pHZ}$ ,  $t_{pZL}$ ,  $t_{pZH}$

## VSSOP20-P-0030-0.50

Unit : mm

