

TOSHIBA CMOS Digital Integrated Circuit Silicon Monolithic

## TC7MZ138FK

Low Voltage 3-to-8 Line Decoder with 5 V Tolerant Inputs and Outputs

The TC7MZ138FK is a high performance CMOS 3-to-8 decoder.

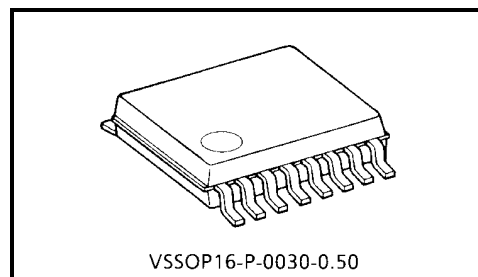
Designed for use in 3.3 V systems, it achieves high speed operation while maintaining the CMOS low power dissipation.

The device is designed for low-voltage (3.3 V) VCC applications, but it could be used to interface to 5 V supply environment for inputs.

When the device is enabled, 3 binary select inputs (A, B and C) determine which one of the outputs ( $\bar{Y}_0 - \bar{Y}_7$ ) will go low.

When enable input G1 is held low or either  $\bar{G}_2A$  or  $\bar{G}_2B$  is held high, decoding function is inhibited and all outputs go high. G1,  $\bar{G}_2A$ , and  $\bar{G}_2B$  inputs are provided to ease cascade connection and for use as an address decoder for memory systems.

All inputs are equipped with protection circuits against static discharge.



VSSOP16-P-0030-0.50

Weight: 0.02 g (typ.)

### Features

- Low voltage operation:  $V_{CC} = 2.0 \sim 3.6$  V
- High speed operation:  $t_{pd} = 6.0$  ns (max) ( $V_{CC} = 3.0 \sim 3.6$  V)
- Output current:  $|I_{OH}|/I_{OL} = 24$  mA (min) ( $V_{CC} = 3.0$  V)
- Latch-up performance:  $\pm 500$  mA
- Package: VSSOP (US16)
- Power down protection is provided on all inputs and outputs.
- Pin and function compatible with the 74 series (74AC/VHC/HC/F/ALS/LS etc.) 138 type.

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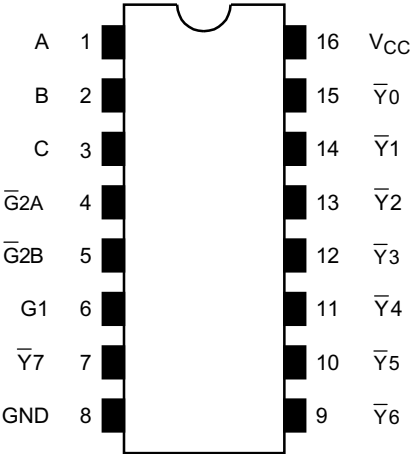
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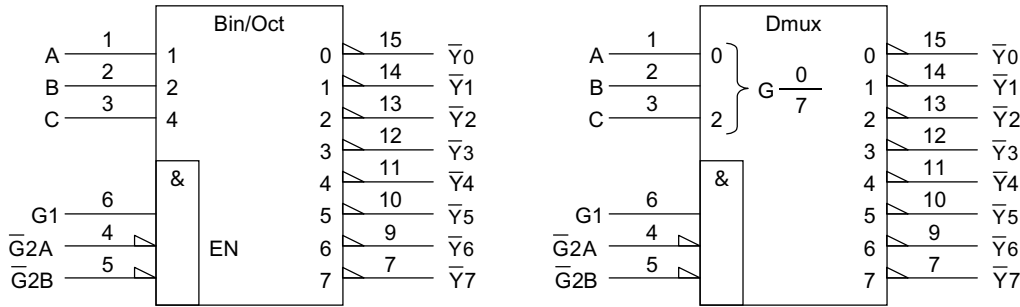
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Pin Assignment (top view)



IEC Logic Symbol

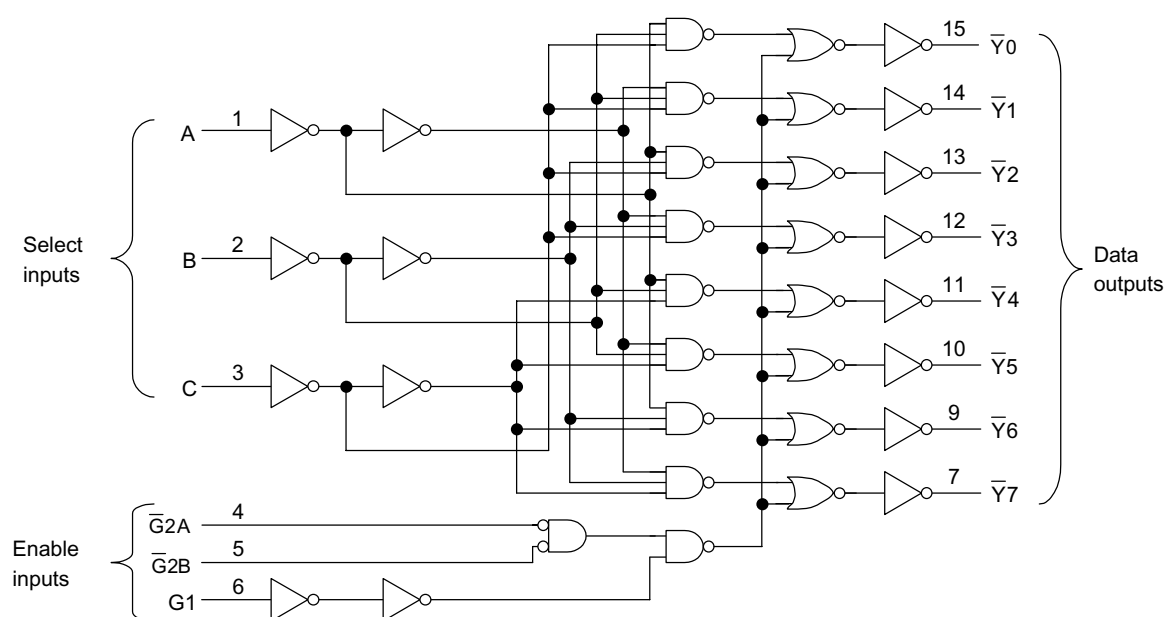


Truth Table

| Inputs |                  |                  |        |   |   | Outputs         |                 |                 |                 |                 |                 |                 |                 | Selected Output |
|--------|------------------|------------------|--------|---|---|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Enable |                  |                  | Select |   |   | $\overline{Y}0$ | $\overline{Y}1$ | $\overline{Y}2$ | $\overline{Y}3$ | $\overline{Y}4$ | $\overline{Y}5$ | $\overline{Y}6$ | $\overline{Y}7$ |                 |
| G1     | $\overline{G}2A$ | $\overline{G}2B$ | C      | B | A |                 |                 |                 |                 |                 |                 |                 |                 |                 |
| L      | X                | X                | X      | X | X | H               | H               | H               | H               | H               | H               | H               | H               | None            |
| X      | H                | X                | X      | X | X | H               | H               | H               | H               | H               | H               | H               | H               | None            |
| X      | X                | H                | X      | X | X | H               | H               | H               | H               | H               | H               | H               | H               | None            |
| H      | L                | L                | L      | L | L | L               | H               | H               | H               | H               | H               | H               | H               | $\overline{Y}0$ |
| H      | L                | L                | L      | L | H | H               | L               | H               | H               | H               | H               | H               | H               | $\overline{Y}1$ |
| H      | L                | L                | L      | H | L | H               | H               | L               | H               | H               | H               | H               | H               | $\overline{Y}2$ |
| H      | L                | L                | L      | H | H | H               | H               | H               | L               | H               | H               | H               | H               | $\overline{Y}3$ |
| H      | L                | L                | H      | L | L | H               | H               | H               | H               | L               | H               | H               | H               | $\overline{Y}4$ |
| H      | L                | L                | H      | L | H | H               | H               | H               | H               | H               | L               | H               | H               | $\overline{Y}5$ |
| H      | L                | L                | H      | H | L | H               | H               | H               | H               | H               | H               | L               | H               | $\overline{Y}6$ |
| H      | L                | L                | H      | H | H | H               | H               | H               | H               | H               | H               | H               | L               | $\overline{Y}7$ |

X: Don't care

## System Diagram



## Maximum Ratings

| Characteristics             | Symbol           | Rating                       | Unit |
|-----------------------------|------------------|------------------------------|------|
| Supply voltage range        | $V_{CC}$         | -0.5~7.0                     | V    |
| DC input voltage            | $V_{IN}$         | -0.5~7.0                     | V    |
| DC output voltage           | $V_{OUT}$        | -0.5~7.0 (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:  $V_{CC} = 0$  V

Note2: High or low state.  $I_{OUT}$  absolute maximum rating must be observed.

Note3:  $V_{OUT} < GND$ ,  $V_{OUT} > V_{CC}$

## Recommended Operating Conditions

| Characteristics          | Symbol          | Rating              | Unit |
|--------------------------|-----------------|---------------------|------|
| Supply voltage           | $V_{CC}$        | 2.0~3.6             | V    |
|                          |                 | 1.5~3.6 (Note4)     |      |
| Input voltage            | $V_{IN}$        | 0~5.5               | V    |
| Output voltage           | $V_{OUT}$       | 0~5.5 (Note5)       | V    |
|                          |                 | 0~ $V_{CC}$ (Note6) |      |
| Output current           | $I_{OH}/I_{OL}$ | $\pm 24$ (Note7)    | mA   |
|                          |                 | $\pm 12$ (Note8)    |      |
| Operating temperature    | $T_{opr}$       | -40~85              | °C   |
| Input rise and fall time | dt/dv           | 0~10 (Note9)        | ns/V |

Note4: Data retention only

Note5:  $V_{CC} = 0$  V

Note6: High or low state

Note7:  $V_{CC} = 3.0\sim 3.6$  V

Note8:  $V_{CC} = 2.7\sim 3.0$  V

Note9:  $V_{IN} = 0.8\sim 2.0$  V,  $V_{CC} = 3.0$  V

## Electrical Characteristics

DC Characteristics ( $T_a = -40\sim 85^\circ\text{C}$ )

| 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> = 16 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> = 0~5.5 V                            | 2.7~3.6                   | —                   | ±5.0                  | μA   |      |
| Power off leakage current             |            | I <sub>OFF</sub> | V <sub>IN</sub> /V <sub>OUT</sub> = 5.5 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                   | —                   | 10.0                  | μA   |      |
|                                       |            |                  | V <sub>IN</sub> = 3.6~5.5 V                          | 2.7~3.6                   | —                   | ±10.0                 |      |      |
| 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                   | —                   | 500                   |      |      |

## AC Characteristics (Ta = -40~85°C)

| Characteristics                                      | Symbol     | Test Condition     | V <sub>CC</sub> (V) | Min | Max | Unit |
|--|------------|--------------------|---------------------|-----|-----|------|
|  |            |                    |                     |     |     |      |
| Propagation delay time<br>(A, B, C- $\bar{Y}$ )      | $t_{pLH}$  | Figure 1, Figure 2 | 2.7                 | —   | 7.0 | ns   |
|  | $t_{pHL}$  |                    | 3.3 ± 0.3           | 1.5 | 6.0 |      |
| Propagation delay time<br>(G1- $\bar{Y}$ )           | $t_{pLH}$  | Figure 1, Figure 2 | 2.7                 | —   | 8.0 | ns   |
|  | $t_{pHL}$  |                    | 3.3 ± 0.3           | 1.5 | 7.0 |      |
| Propagation delay time<br>( $\bar{G}2$ - $\bar{Y}$ ) | $t_{pLH}$  | Figure 1, Figure 2 | 2.7                 | —   | 7.0 | ns   |
|  | $t_{pHL}$  |                    | 3.3 ± 0.3           | 1.5 | 6.0 |      |
| Output to output skew                                | $t_{osLH}$ | (Note10)           | 2.7                 | —   | —   | ns   |
|  | $t_{osHL}$ |                    | 3.3 ± 0.3           | —   | 1.0 |      |

Note10: 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:  $t_r = t_f = 2.5$  ns,  $C_L = 50$  pF,  $R_L = 500$  Ω)

| Characteristics              | Symbol          | Test Condition   |  | Typ. | Unit |   |
|------------------------------|-----------------|------------------|--|------|------|---|
|                              |                 |                  | V <sub>CC</sub> (V)                            |      |      |   |
| Quiet output maximum dynamic | V <sub>OL</sub> | V <sub>OLP</sub> | V <sub>IH</sub> = 3.3 V, V <sub>IL</sub> = 0 V | 3.3  | 0.8  | V |
| Quiet output minimum dynamic | V <sub>OL</sub> | V <sub>OLV</sub> | V <sub>IH</sub> = 3.3 V, V <sub>IL</sub> = 0 V | 3.3  | 0.8  | V |

## Capacitive Characteristics (Ta = 25°C)

| Characteristics               | Symbol    | Test Condition             | V <sub>CC</sub> (V) | Typ. | Unit |
|-------------------------------|-----------|----------------------------|---------------------|------|------|
|                               |           |                            |                     |      |      |
| Input capacitance             | $C_{IN}$  | —                          | 3.3                 | 7    | pF   |
| Output capacitance            | $C_{OUT}$ | —                          | 0                   | 8    | pF   |
| Power dissipation capacitance | $C_{PD}$  | $f_{IN} = 10$ MHz (Note11) | 3.3                 | 25   | pF   |

Note11:  $C_{PD}$  is defined as the value of the internal equivalent capacitance which is calculated from the operating current consumption without load.

Average operating current can be obtained by the equation:

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

AC Test Circuit

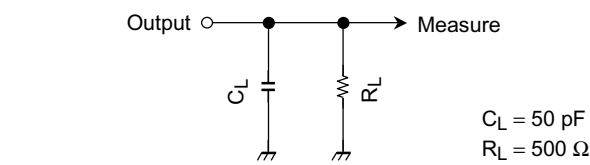


Figure 1

AC Waveform

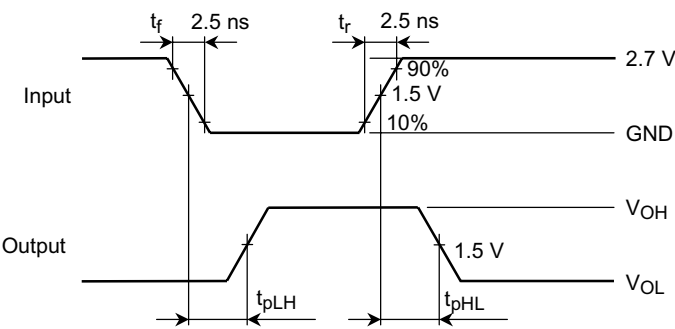
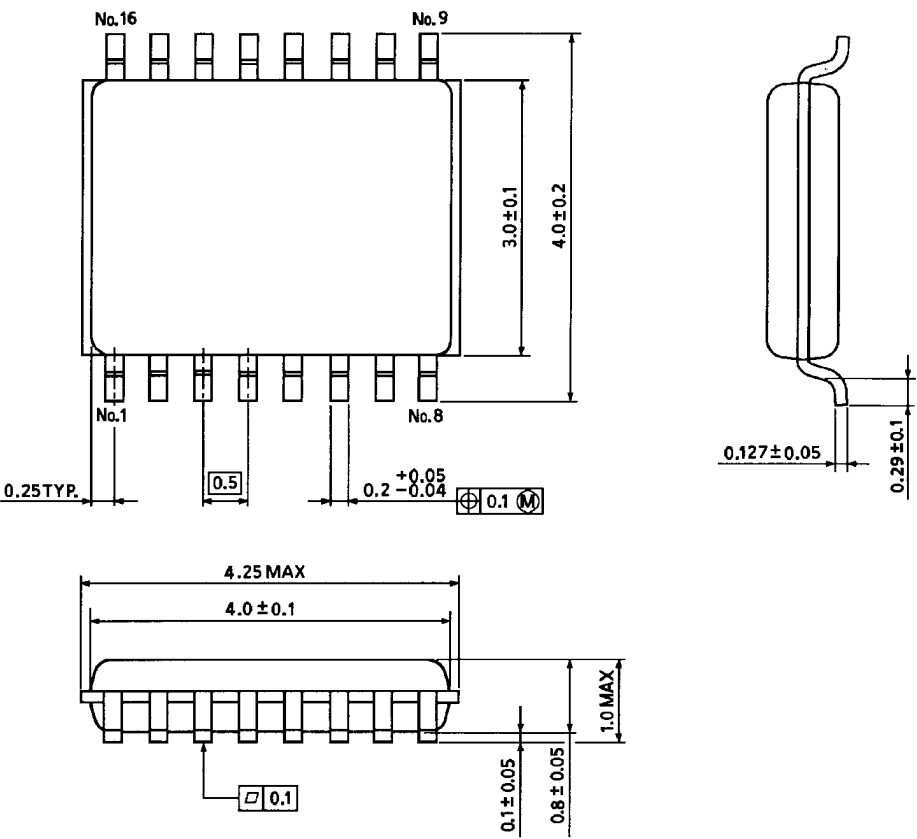


Figure 2  $t_{pLH}$ ,  $t_{pHL}$

Package Dimensions

VSSOP16-P-0030-0.50

Unit : mm



Weight: 0.02 g (typ.)