

Preliminary TOSHIBA CMOS Digital Integrated Circuit Silicon Monolithic

TC7MA138FK

Low Voltage 3-to-8 Line Decoder with 3.6 V Tolerant Inputs and Outputs

The TC7MA138FK is a high performance CMOS 3-to-8 decoder. 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.

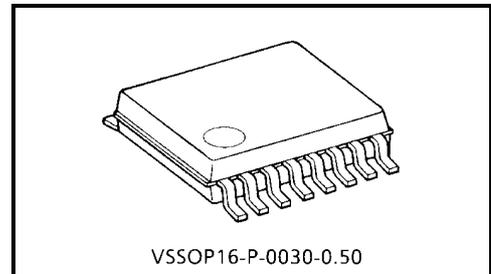
It is also designed with over voltage tolerant inputs and outputs up to 3.6 V.

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: $V_{CC} = 1.8 \sim 3.6$ V
- High speed operation: $t_{pd} = \text{TBD (max)} (V_{CC} = 3.0 \sim 3.6$ V)
 $t_{pd} = \text{TBD (max)} (V_{CC} = 2.3 \sim 2.7$ V)
 $t_{pd} = \text{TBD (max)} (V_{CC} = 1.8$ 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: ± 300 mA
- ESD performance: Machine model $> \pm 200$ V
Human body model $> \pm 2000$ V
- Package: VSSOP (US16)
- Power down protection is provided on all inputs and outputs.

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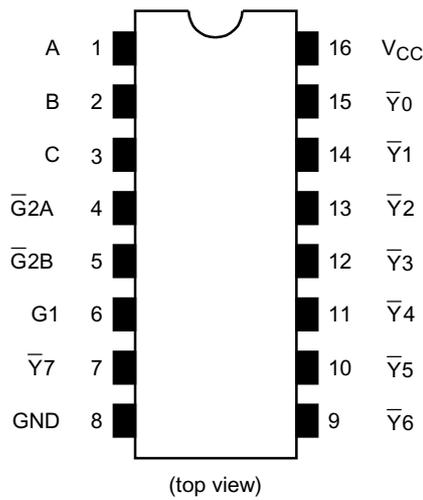
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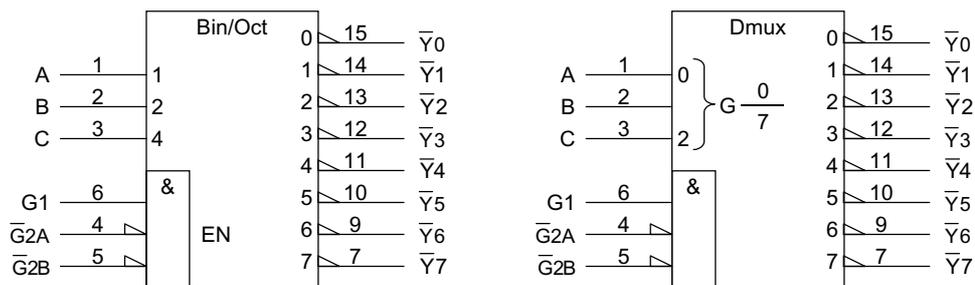
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Pin Assignment (top view)



IEC Logic Symbol

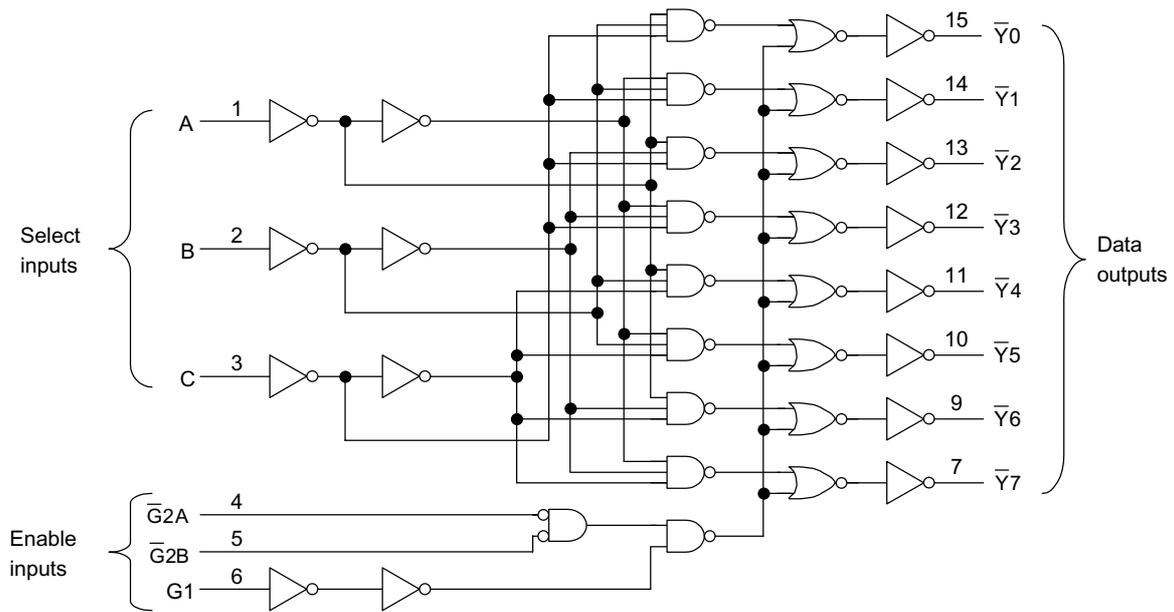


Truth Table

| Inputs | | | | | | Outputs | | | | | | | | Selected Output |
|--------|-------------|-------------|--------|---|---|------------|------------|------------|------------|------------|------------|------------|------------|-----------------|
| Enable | | | Select | | | $\bar{Y}0$ | $\bar{Y}1$ | $\bar{Y}2$ | $\bar{Y}3$ | $\bar{Y}4$ | $\bar{Y}5$ | $\bar{Y}6$ | $\bar{Y}7$ | |
| G1 | $\bar{G}2A$ | $\bar{G}2B$ | 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 | $\bar{Y}0$ |
| H | L | L | L | L | H | H | L | H | H | H | H | H | H | $\bar{Y}1$ |
| H | L | L | L | H | L | H | H | L | H | H | H | H | H | $\bar{Y}2$ |
| H | L | L | L | H | H | H | H | H | L | H | H | H | H | $\bar{Y}3$ |
| H | L | L | H | L | L | H | H | H | H | L | H | H | H | $\bar{Y}4$ |
| H | L | L | H | L | H | H | H | H | H | H | L | H | H | $\bar{Y}5$ |
| H | L | L | H | H | L | H | H | H | H | H | H | L | H | $\bar{Y}6$ |
| H | L | L | H | H | H | H | H | H | H | H | H | H | L | $\bar{Y}7$ |

X: Don't care

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 | $^{\circ}C$ |

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 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: $V_{CC} = 0$ V

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_{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} | $I_{OH} = -100\ \mu\text{A}$ | 2.7~3.6 | $V_{CC} - 0.2$ | — | V |
| | | | | $I_{OH} = -12\ \text{mA}$ | 2.7 | 2.2 | — | |
| | | | | $I_{OH} = -18\ \text{mA}$ | 3.0 | 2.4 | — | |
| | | | | $I_{OH} = -24\ \text{mA}$ | 3.0 | 2.2 | — | |
| | Low level | V_{OL} | $V_{IN} = V_{IH}$ or V_{IL} | $I_{OL} = 100\ \mu\text{A}$ | 2.7~3.6 | — | 0.2 | |
| | | | | $I_{OL} = 12\ \text{mA}$ | 2.7 | — | 0.4 | |
| | | | | $I_{OL} = 18\ \text{mA}$ | 3.0 | — | 0.4 | |
| | | | | $I_{OL} = 24\ \text{mA}$ | 3.0 | — | 0.55 | |
| Input leakage current | | I_{IN} | $V_{IN} = 0\sim 3.6\text{ V}$ | 2.7~3.6 | — | ± 5.0 | μA | |
| Power off leakage current | | I_{OFF} | $V_{IN}, V_{OUT} = 0\sim 3.6\text{ V}$ | 0 | — | 10.0 | μA | |
| Quiescent supply current | | I_{CC} | $V_{IN} = V_{CC}$ or GND | 2.7~3.6 | — | 20.0 | μA | |
| | | | $V_{CC} \leq V_{IN} \leq 3.6\text{ V}$ | 2.7~3.6 | — | ± 20.0 | | |
| Increase in I_{CC} per input | | ΔI_{CC} | $V_{IH} = V_{CC} - 0.6\text{ V}$ | 2.7~3.6 | — | 750 | | |

DC Characteristics (Ta = -40~85°C, 2.3 V ≤ VCC ≤ 2.7 V)

| Characteristics | | Symbol | Test Condition | | VCC (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 | — | |
| | 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 | | 2.3~2.7 | — | ±5.0 | 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} ≤ 3.6 V | | 2.3~2.7 | — | ±20.0 | |

DC Characteristics (Ta = -40~85°C, 1.8 V ≤ VCC < 2.3 V)

| Characteristics | | Symbol | Test Condition | | VCC (V) | Min | Max | Unit |
|---------------------------|------------|------------------|--|---------------------------|---------|-----------------------|-----------------------|------|
| | | | | | | | | |
| Input voltage | High level | V _{IH} | — | | 1.8~2.3 | 0.7 × V _{CC} | — | V |
| | Low level | V _{IL} | — | | 1.8~2.3 | — | 0.2 × V _{CC} | |
| Output voltage | High level | V _{OH} | V _{IN} = V _{IH} or V _{IL} | I _{OH} = -100 μA | 1.8 | V _{CC} - 0.2 | — | V |
| | | | | I _{OH} = -6 mA | 1.8 | 1.4 | — | |
| | Low level | V _{OL} | V _{IN} = V _{IH} or V _{IL} | I _{OL} = 100 μA | 1.8 | — | 0.2 | |
| | | | | I _{OL} = 6 mA | 1.8 | — | 0.3 | |
| Input leakage current | | I _{IN} | V _{IN} = 0~3.6 V | | 1.8 | — | ±5.0 | 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 | | 1.8 | — | 20.0 | μA |
| | | | V _{CC} ≤ V _{IN} ≤ 3.6 V | | 1.8 | — | ±20.0 | |

AC Characteristics (Ta = -40~85°C, Input: tr = tf = 2.0 ns, CL = 30 pF, RL = 500 Ω)

| Characteristics | Symbol | Test Condition | VCC (V) | Min | Max | Unit |
|---|--------------------------------------|--------------------|-----------|-----|-----|------|
| | | | | | | |
| Propagation delay time (A, B, C- \bar{Y}) | t _{pLH} t _{pHL} | Figure 1, Figure 2 | 1.8 | 1.0 | TBD | ns |
| | | | 2.5 ± 0.2 | 0.8 | TBD | |
| | | | 3.3 ± 0.3 | 0.6 | TBD | |
| Propagation delay time (G1, \bar{Y}) | t _{pLH} t _{pHL} | Figure 1, Figure 3 | 1.8 | 1.0 | TBD | ns |
| | | | 2.5 ± 0.2 | 0.8 | TBD | |
| | | | 3.3 ± 0.3 | 0.6 | TBD | |
| Propagation delay time ($\bar{G}2$, \bar{Y}) | t _{pLH} t _{pHL} | Figure 1, Figure 3 | 1.8 | 1.0 | TBD | ns |
| | | | 2.5 ± 0.2 | 0.8 | TBD | |
| | | | 3.3 ± 0.3 | 0.6 | TBD | |

For C_L = 50 pF, add approximately 300 ps to the AC maximum specification.

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 V _{OL} | V _{OLP} | V _{IH} = 1.8 V, V _{IL} = 0 V (Note11) | 1.8 | 0.25 | V |
| | | V _{IH} = 2.5 V, V _{IL} = 0 V (Note11) | 2.5 | 0.6 | |
| | | V _{IH} = 3.3 V, V _{IL} = 0 V (Note11) | 3.3 | 0.8 | |
| Quiet output minimum dynamic V _{OL} | V _{OLV} | V _{IH} = 1.8 V, V _{IL} = 0 V (Note11) | 1.8 | -0.25 | V |
| | | V _{IH} = 2.5 V, V _{IL} = 0 V (Note11) | 2.5 | -0.6 | |
| | | V _{IH} = 3.3 V, V _{IL} = 0 V (Note11) | 3.3 | -0.8 | |
| Quiet output minimum dynamic V _{OH} | V _{OHV} | V _{IH} = 1.8 V, V _{IL} = 0 V (Note11) | 1.8 | 1.5 | V |
| | | V _{IH} = 2.5 V, V _{IL} = 0 V (Note11) | 2.5 | 1.9 | |
| | | V _{IH} = 3.3 V, V _{IL} = 0 V (Note11) | 3.3 | 2.2 | |

Note11: This parameter is guaranteed by design.

Capacitive Characteristics (Ta = 25°C)

| Characteristics | Symbol | Test Condition | VCC (V) | Typ. | Unit |
|-------------------------------|-----------------|-----------------------------------|---------------|------|------|
| | | | | | |
| Input capacitance | C _{IN} | — | 1.8, 2.5, 3.3 | 6 | pF |
| Power dissipation capacitance | C _{PD} | f _{IN} = 10 MHz (Note12) | 1.8, 2.5, 3.3 | 20 | pF |

Note12: 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

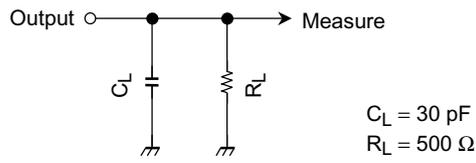
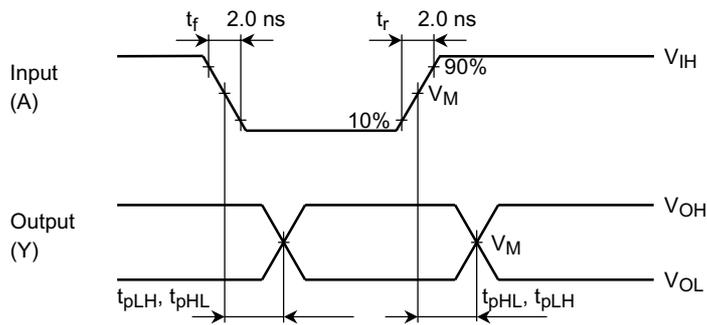


Figure 1

AC Waveform



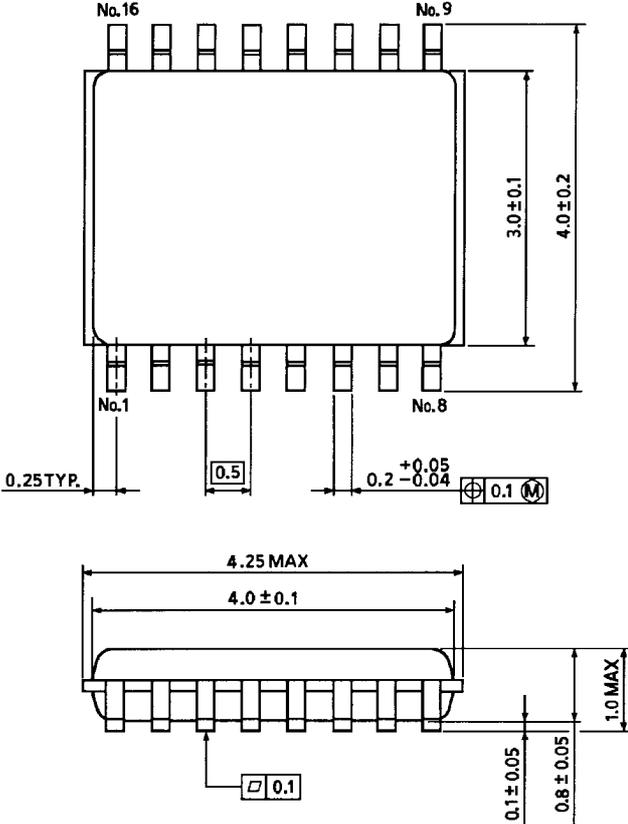
| Symbol | V_{CC} | | |
|----------|-------------------------|-------------------------|------------|
| | $3.3 \pm 0.3 \text{ V}$ | $2.5 \pm 0.2 \text{ V}$ | 1.8 V |
| V_{IH} | 2.7 V | V_{CC} | V_{CC} |
| V_M | 1.5 V | $V_{CC}/2$ | $V_{CC}/2$ |

Figure 2 t_{pLH}, t_{pHL}

Package Dimensions

VSSOP16-P-0030-0.50

Unit : mm



Weight: 0.02 g (typ.)