CMOS Digital Integrated Circuits Silicon Monolithic

# TC7SZ05F

## 1. Functional Description

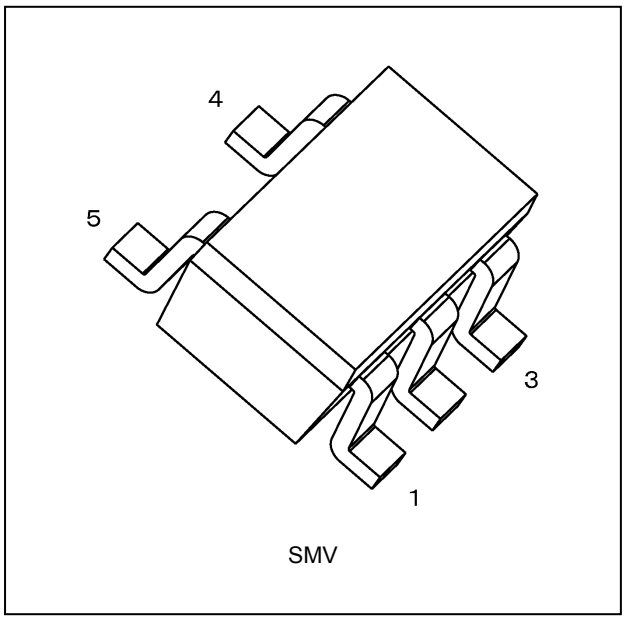
- Inverter (Open Drain)

## 2. Features

(1) AEC-Q100 (Rev. H) (Note 1)
(2) Wide operating temperature range: $T_{opr}$ = -40 to 125 °C (Note 2)
(3) High output current: ±24 mA (min) at $V_{CC}$ = 3.0 V
(4) Super high speed operation: $t_{PZL}$ = 1.9 ns (typ.) at $V_{CC}$ = 5.0 V, $C_L$ = 50 pF
(5) Operation voltage range: $V_{CC}$ = 1.65 to 5.5 V
(6) 5.5 V tolerant inputs
(7) 5.5 V power down protection output
(8) Matches the performance of TC74LCX series when operated at 3.3 V $V_{CC}$

Note 1: This device is compliant with the reliability requirements of AEC-Q100. For details, contact your Toshiba sales representative.
Note 2: For devices with the ordering part number ending in J(CT. $T_{opr}$ = -40 to 85 °C for the other devices.

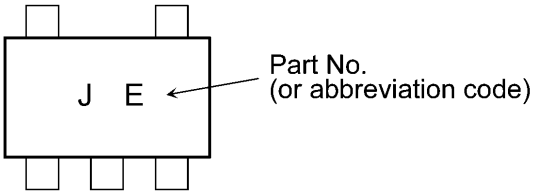
## 3. Packaging



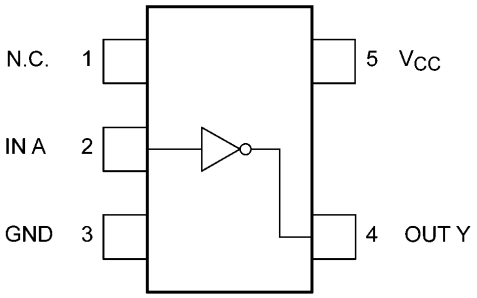

SMV

Start of commercial production
1998-08

## 4. Marking and Pin Assignment




Marking




Pin Assignment (Top view)

## 5. IEC Logic Symbol


## 6. Truth Table

| A | Y |
|---|---|
| L | Z |
| H | L |

Z: High impedance

## 7. Absolute Maximum Ratings (Note) (Unless otherwise specified, $T_a$ = 25 °C)

| Characteristics | Symbol | Note | Rating | Unit |
|---|---|---|---|---|
| Supply voltage | $V_{CC}$ | | -0.5 to 6.0 | V |
| Input voltage | $V_{IN}$ | | -0.5 to 6.0 | V |
| DC output voltage | $V_{OUT}$ | (Note 1) | -0.5 to 6.0 | V |
| Input diode current | $I_{IK}$ | | -20 | mA |
| Output diode current | $I_{OK}$ | (Note 2) | -20 | mA |
| DC output current | $I_{OUT}$ | | 50 | mA |
| $V_{CC}$/ground current | $I_{CC}$ | | ±50 | mA |
| Power dissipation | $P_D$ | | 200 | mW |
| Storage temperature | $T_{stg}$ | | -65 to 150 | °C |

Note: 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 1: $I_{OUT}$ absolute maximum rating must be observed.

Note 2: $V_{OUT}$ < GND

## 8. Operating Ranges (Note)

| Characteristics | Symbol | Note | Test Condition | Rating | Unit |
|---|---|---|---|---|---|
| Supply voltage | $V_{CC}$ | | — | 1.65 to 5.5 | V |
| | | (Note 1) | — | 1.5 to 5.5 | |
| Input voltage | $V_{IN}$ | | — | 0 to 5.5 | V |
| Output voltage | $V_{OUT}$ | | — | 0 to 5.5 | V |
| Operating temperature | $T_{opr}$ | (Note 2) | — | -40 to 125 | °C |
| | | (Note 3) | — | -40 to 85 | |
| Input rise and fall time | dt/dv | | $V_{CC}$ = 1.8 ± 0.15 V, 2.5 ± 0.2 V | 0 to 20 | ns/V |
| | | | $V_{CC}$ = 3.3 ± 0.3 V | 0 to 10 | |
| | | | $V_{CC}$ = 5.0 ± 0.5 V | 0 to 5 | |

Note: 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 1: Data retention only

Note 2: For devices with the ordering part number ending in J(CT.

Note 3: For devices except those with the ordering part number ending in J(CT.

## 9. Electrical Characteristics

### 9.1. DC Characteristics (Unless otherwise specified, $T_a$ = 25 °C)

| Characteristics | Symbol | Test Condition | | $V_{CC}$ (V) | Min | Typ. | Max | Unit |
|---|---|---|---|---|---|---|---|---|
| High-level input voltage | $V_{IH}$ | — | | 1.65 to 1.95 | $V_{CC}$ × 0.75 | — | — | V |
| | | | | 2.3 to 5.5 | $V_{CC}$ × 0.7 | — | — | |
| Low-level input voltage | $V_{IL}$ | — | | 1.65 to 1.95 | — | — | $V_{CC}$ × 0.25 | V |
| | | | | 2.3 to 5.5 | — | — | $V_{CC}$ × 0.3 | |
| Low-level output voltage | $V_{OL}$ | $V_{IN}$ = $V_{IH}$ | $I_{OL}$ = 100 μA | 1.65 | — | 0.0 | 0.1 | V |
| | | | | 2.3 | — | 0.0 | 0.1 | |
| | | | | 3.0 | — | 0.0 | 0.1 | |
| | | | | 4.5 | — | 0.0 | 0.1 | |
| | | | $I_{OL}$ = 8 mA | 2.3 | — | 0.1 | 0.3 | |
| | | | $I_{OL}$ = 16 mA | 3.0 | — | 0.15 | 0.4 | |
| | | | $I_{OL}$ = 24 mA | 3.0 | — | 0.22 | 0.55 | |
| | | | $I_{OL}$ = 32 mA | 4.5 | — | 0.22 | 0.55 | |
| 3-state output OFF-state leakage current | $I_{OZ}$ | $V_{IN}$ = $V_{IL}$<br>$V_{OUT}$ = 0 to 5.5 V | | 1.65 to 5.5 | — | — | ±5 | μA |
| Input leakage current | $I_{IN}$ | $V_{IN}$ = 5.5 V or GND | | 0 to 5.5 | — | — | ±1 | μA |
| Power-OFF leakage current | $I_{OFF}$ | $V_{IN}$ or $V_{OUT}$ = 5.5 V | | 0 | — | — | 1 | μA |
| Quiescent supply current | $I_{CC}$ | $V_{IN}$ = $V_{CC}$ or GND | | 5.5 | — | — | 2 | μA |

## 9.2. DC Characteristics (Unless otherwise specified, $T_a$ = -40 to 85 °C)

| Characteristics | Symbol | Test Condition | | $V_{CC}$ (V) | Min | Max | Unit |
|---|---|---|---|---|---|---|---|
| High-level input voltage | $V_{IH}$ | — | | 1.65 to 1.95 | $V_{CC}$ × 0.75 | — | V |
| | | | | 2.3 to 5.5 | $V_{CC}$ × 0.7 | — | |
| Low-level input voltage | $V_{IL}$ | — | | 1.65 to 1.95 | — | $V_{CC}$ × 0.25 | V |
| | | | | 2.3 to 5.5 | — | $V_{CC}$ × 0.3 | |
| Low-level output voltage | $V_{OL}$ | $V_{IN}$ = $V_{IH}$ | $I_{OL}$ = 100 μA | 1.65 | — | 0.1 | V |
| | | | | 2.3 | — | 0.1 | |
| | | | | 3.0 | — | 0.1 | |
| | | | | 4.5 | — | 0.1 | |
| | | | $I_{OL}$ = 8 mA | 2.3 | — | 0.3 | |
| | | | $I_{OL}$ = 16 mA | 3.0 | — | 0.4 | |
| | | | $I_{OL}$ = 24 mA | 3.0 | — | 0.55 | |
| | | | $I_{OL}$ = 32 mA | 4.5 | — | 0.55 | |
| 3-state output OFF-state leakage current | $I_{OZ}$ | $V_{IN}$ = $V_{IL}$<br>$V_{OUT}$ = 0 to 5.5 V | | 1.65 to 5.5 | — | ±10 | μA |
| Input leakage current | $I_{IN}$ | $V_{IN}$ = 5.5 V or GND | | 0 to 5.5 | — | ±10 | μA |
| Power-OFF leakage current | $I_{OFF}$ | $V_{IN}$ or $V_{OUT}$ = 5.5 V | | 0 | — | 10 | μA |
| Quiescent supply current | $I_{CC}$ | $V_{IN}$ = $V_{CC}$ or GND | | 5.5 | — | 20 | μA |

## 9.3. DC Characteristics (Note) (Unless otherwise specified, $T_a$ = -40 to 125 °C)

| Characteristics | Symbol | Test Condition | | $V_{CC}$ (V) | Min | Max | Unit |
|---|---|---|---|---|---|---|---|
| High-level input voltage | $V_{IH}$ | — | | 1.65 to 1.95 | $V_{CC}$ × 0.75 | — | V |
| | | | | 2.3 to 5.5 | $V_{CC}$ × 0.7 | — | |
| Low-level input voltage | $V_{IL}$ | — | | 1.65 to 1.95 | — | $V_{CC}$ × 0.25 | V |
| | | | | 2.3 to 5.5 | — | $V_{CC}$ × 0.3 | |
| Low-level output voltage | $V_{OL}$ | $V_{IN}$ = $V_{IH}$ | $I_{OL}$ = 100 μA | 1.65 | — | 0.1 | V |
| | | | | 2.3 | — | 0.1 | |
| | | | | 3.0 | — | 0.1 | |
| | | | | 4.5 | — | 0.1 | |
| | | | $I_{OL}$ = 8 mA | 2.3 | — | 0.45 | |
| | | | $I_{OL}$ = 16 mA | 3.0 | — | 0.6 | |
| | | | $I_{OL}$ = 24 mA | 3.0 | — | 0.8 | |
| | | | $I_{OL}$ = 32 mA | 4.5 | — | 0.8 | |
| 3-state output OFF-state leakage current | $I_{OZ}$ | $V_{IN}$ = $V_{IL}$<br>$V_{OUT}$ = 0 to 5.5 V | | 1.65 to 5.5 | — | ±20 | μA |
| Input leakage current | $I_{IN}$ | $V_{IN}$ = 5.5 V or GND | | 0 to 5.5 | — | ±20 | μA |
| Power-OFF leakage current | $I_{OFF}$ | $V_{IN}$ or $V_{OUT}$ = 5.5 V | | 0 | — | 100 | μA |
| Quiescent supply current | $I_{CC}$ | $V_{IN}$ = $V_{CC}$ or GND | | 5.5 | — | 200 | μA |

Note: For devices with the ordering part number ending in J(CT.

## 9.4. AC Characteristics (Unless otherwise specified, $T_a$ = 25 °C, Input: $t_r = t_f$ = 3 ns)

| Characteristics | Symbol | Note | Test Condition | $V_{CC}$ (V) | $C_L$ (pF) | Min | Typ. | Max | Unit |
|---|---|---|---|---|---|---|---|---|---|
| Propagation delay time | $t_{PZL}$ | | $R_L$ = 500 Ω | 1.8 ± 0.15 | 50 | 1.5 | 4.6 | 10.5 | ns |
| | | | | 2.5 ± 0.2 | | 0.8 | 3.0 | 7.0 | |
| | | | | 3.3 ± 0.3 | | 0.8 | 2.4 | 5.0 | |
| | | | | 5.0 ± 0.5 | | 0.5 | 1.9 | 4.3 | |
| Propagation delay time | $t_{PLZ}$ | | $R_L$ = 500 Ω | 1.8 ± 0.15 | 50 | 1.5 | 4.1 | 10.5 | ns |
| | | | | 2.5 ± 0.2 | | 0.8 | 2.5 | 7.0 | |
| | | | | 3.3 ± 0.3 | | 0.8 | 2.1 | 5.0 | |
| | | | | 5.0 ± 0.5 | | 0.5 | 1.2 | 4.3 | |
| Input capacitance | $C_{IN}$ | | — | 0 to 5.5 | — | — | 4 | — | pF |
| Power dissipation capacitance | $C_{PD}$ | (Note 1) | — | 3.3 | — | — | 3.6 | — | pF |
| | | | | 5.5 | | — | 6.5 | — | |

Note 1: $C_{PD}$ 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.

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

## 9.5. AC Characteristics (Unless otherwise specified, $T_a$ = -40 to 85 °C, Input: $t_r = t_f$ = 3 ns)

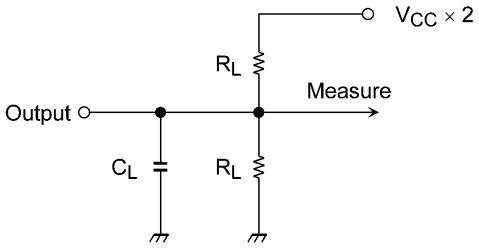
| Characteristics | Symbol | Test Condition | $V_{CC}$ (V) | $C_L$ (pF) | Min | Max | Unit |
|---|---|---|---|---|---|---|---|
| Propagation delay time | $t_{PZL}$ | $R_L$ = 500 Ω | 1.8 ± 0.15 | 50 | 1.5 | 11.0 | ns |
| | | | 2.5 ± 0.2 | | 0.8 | 7.5 | |
| | | | 3.3 ± 0.3 | | 0.8 | 5.2 | |
| | | | 5.0 ± 0.5 | | 0.5 | 4.5 | |
| Propagation delay time | $t_{PLZ}$ | $R_L$ = 500 Ω | 1.8 ± 0.15 | 50 | 1.5 | 11.0 | ns |
| | | | 2.5 ± 0.2 | | 0.8 | 7.5 | |
| | | | 3.3 ± 0.3 | | 0.8 | 5.2 | |
| | | | 5.0 ± 0.5 | | 0.5 | 4.5 | |

## 9.6. AC Characteristics (Note) (Unless otherwise specified, $T_a$ = -40 to 125 °C, Input: $t_r = t_f$ = 3 ns)

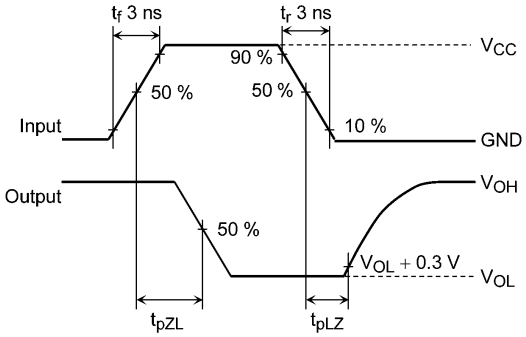
| Characteristics | Symbol | Test Condition | $V_{CC}$ (V) | $C_L$ (pF) | Min | Max | Unit |
|---|---|---|---|---|---|---|---|
| Propagation delay time | $t_{PZL}$ | $R_L$ = 500 Ω | 1.8 ± 0.15 | 50 | 1.5 | 12.5 | ns |
| | | | 2.5 ± 0.2 | | 0.8 | 8.5 | |
| | | | 3.3 ± 0.3 | | 0.8 | 6.0 | |
| | | | 5.0 ± 0.5 | | 0.5 | 5.0 | |
| Propagation delay time | $t_{PLZ}$ | $R_L$ = 500 Ω | 1.8 ± 0.15 | 50 | 1.5 | 12.5 | ns |
| | | | 2.5 ± 0.2 | | 0.8 | 8.5 | |
| | | | 3.3 ± 0.3 | | 0.8 | 6.0 | |
| | | | 5.0 ± 0.5 | | 0.5 | 5.0 | |

Note: For devices with the ordering part number ending in J(CT.

## 9.7. AC Characteristics Measurement Circuit and AC Waveform



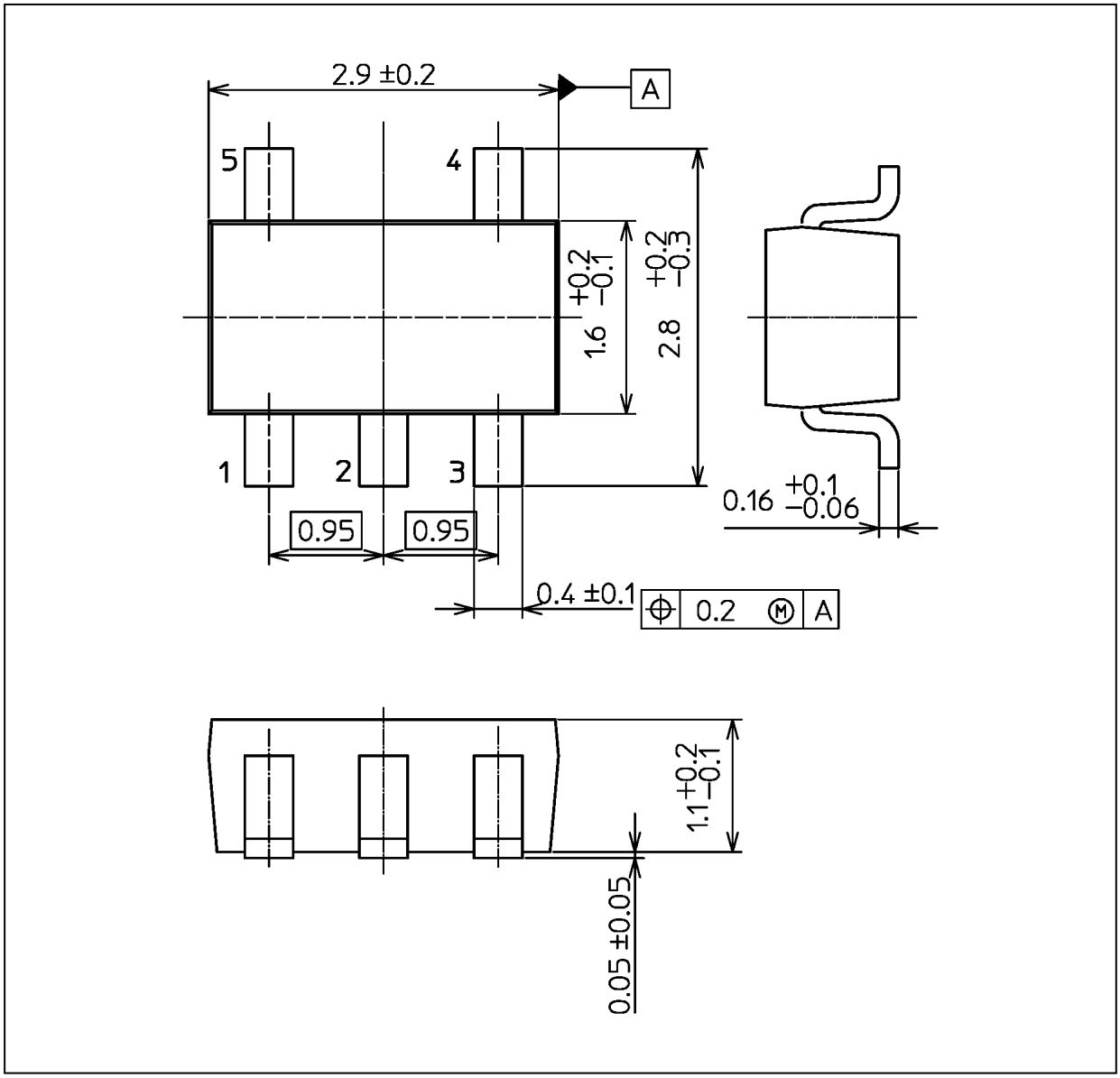

AC Characteristics Measurement Circuit




AC Waveform

## Package Dimensions

Unit: mm




Weight: 14 mg (typ.)

| Package Name(s) |
|---|
| JEDEC: SOT-25 |
| Nickname: SMV |

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