TOSHIBA CMOS Linear Integrated Circuit Silicon Monolithic

# TCTH0xxxE Series

## Thermoflagger™ (Over Temperature Detection IC)

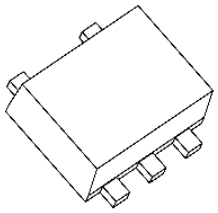
The TCTH0xxxE series are the CMOS process IC outputs abnormal-state signal on detecting over temperature as the resistor value changing of external PTC Thermistor.

Output current to PTC thermistor is 1 μA (Typ.) and whole current consumption is 1.8 μA (Typ.), low consumption operation is realised. (TCTH01xxE)

Selectable Push-pull type, or Open-drain type for FLAG signal output by product.

Also, Selectable Auto retry type if PTC thermistor temperature goes down back to lower than threshold, or Latch the abnormal signal type.

IC package is ESV (1.6 mm x 1.6 mm x 0.55 mm).



ESV

Weight: 2.98 mg (Typ.)

## Application (Ex)

- Notebook PC, Mobile equipment, home appliance, Industry equipment etc. for over temperature detection.

## Feature

- Selectable PTCO output current $I_{PTCO}$ = 1 μA (TCTH01xxE, Typ.)
  $I_{PTCO}$ = 10 μA (TCTH02xxE, Typ.)
- High PTCO output current accuracy ±8 % ($V_{DD}$ = 3.3 V, 25 °C)
- Low current consumption $I_{DD}$= 1.8 μA (TCTH01xxE, Typ.)
  $I_{DD}$= 11.3 μA (TCTH02xxE, Typ.)
- FLAG signal latch function (TCTH0x2xE)
- FLAG signal output (PTCGOOD)
  TCTH0xxAE: Push-pull type
  TCTH0xxBE: Open-drain type
- Standard package ESV (SOT-553) (1.6 mm x 1.6 mm x 0.55 mm)



Start of commercial production
2023-02

# 1. Absolute Maximum Ratings (Ta = 25 °C)

| Characteristics | Symbol | Ratings | | Unit |
|---|---|---|---|---|
| Supply Voltage | $V_{DD}$ | -0.3 to 6.0 | | V |
| PTCO Voltage | $V_{PTCO}$ | -0.3 to $V_{DD}$ + 0.3 ≤ 6.0 | | V |
| PTCGOOD Voltage | $V_{PTCGOOD}$ | TCTH0xxAE | -0.3 to $V_{DD}$ + 0.3 ≤ 6.0 | V |
| | | TCTH0xxBE | -0.3 to 6.0 | V |
| RESET Voltage | $V_{RESET}$ | -0.3 to $V_{DD}$ + 0.3 ≤ 6.0 | | V |
| Power dissipation | $P_D$ | 150 (Note 1)<br>320 (Note 2) | | mW |
| Junction Temperature | $T_j$ | 150 | | °C |
| Storage Temperature | $T_{stg}$ | -55 to 150 | | °C |

Note: Using continuously under heavy loads (e.g. the application of high temperature/current/voltage and the significant changing in temperature, etc.) may cause this product to reduce the reliability significantly even if the operating conditions (i.e. operating temperature/current/voltage, etc.) are within the absolute maximum ratings. Please design appropriatly 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).

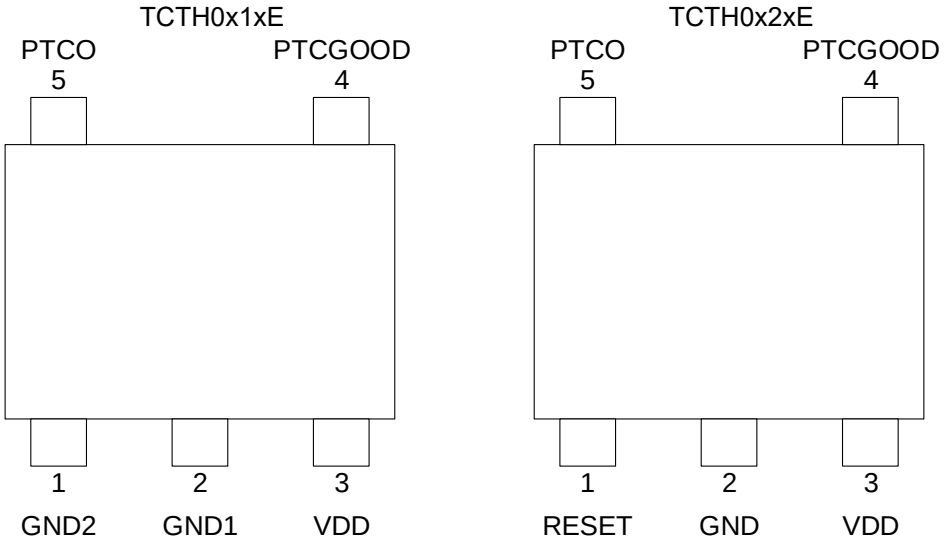
Note 1: Unit Rating
Note 2: Rating at mounting on a board
(FR4 board dimension: 30 mm x 30 mm x 0.8 mm)

# 2. Operating Ranges

| Characteristics | Symbol | Operating Ranges | | Unit |
|---|---|---|---|---|
| Supply Voltage | $V_{DD}$ | 1.7 to 5.5 | | V |
| PTCGOOD Output Voltage | $V_{PTCGOOD}$ | TCTH0xxAE | 0 to $V_{DD}$ | V |
| | | TCTH0xxBE | 0 to 5.5 | V |
| RESET Voltage | $V_{RESET}$ | 0 to $V_{DD}$ | | V |
| Operation Temperature | $T_{opr}$ | -40 to 125 | | °C |

Note3: There is possibility for significant negative affect for reliability, if this product used long time on the state includes limit or very close condition on Operating ranges. Exposure to such conditions may adversely impact product reliability lifetime average junction temperature of 107 ºC.

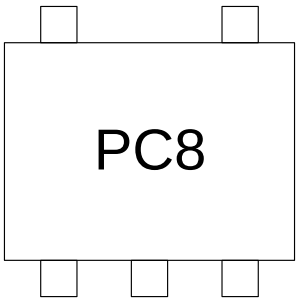
## 3. Pin Assignment (Top view)




Note4: All GND pin must connect to the system GND.

## 4. Top Marking (Top view)

Example: TCTH022BE

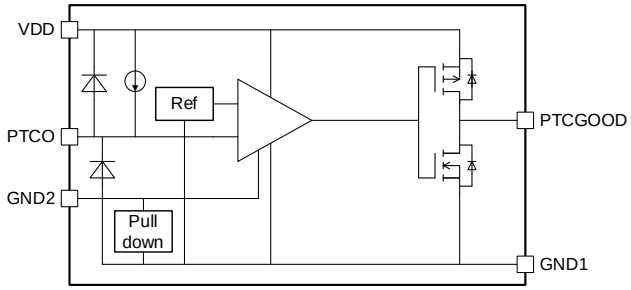


## 5. List for Product name, Output type, Top marking

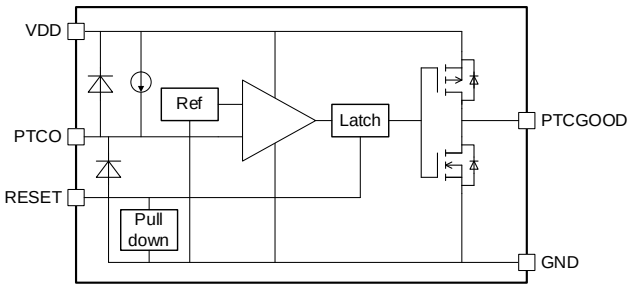
| Product name | PTCO output current | FLAG signal latch function | Output type | Top Marking |
|---|---|---|---|---|
| TCTH011AE | 1 μA (Typ.) | – | Push-pull | PC1 |
| TCTH012AE | 1 μA (Typ.) | ✓ included | Push-pull | PC2 |
| TCTH021AE | 10 μA (Typ.) | – | Push-pull | PC3 |
| TCTH022AE | 10 μA (Typ.) | ✓ included | Push-pull | PC4 |
| TCTH011BE | 1 μA (Typ.) | – | Open-drain | PC5 |
| TCTH012BE | 1 μA (Typ.) | ✓ included | Open-drain | PC6 |
| TCTH021BE | 10 μA (Typ.) | – | Open-drain | PC7 |
| TCTH022BE | 10 μA (Typ.) | ✓ included | Open-drain | PC8 |

## 6. Block diagram

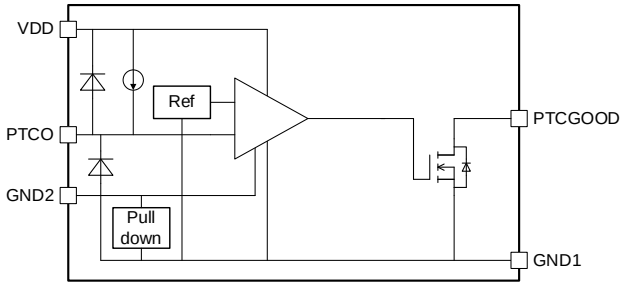
**TCTH0x1AE**



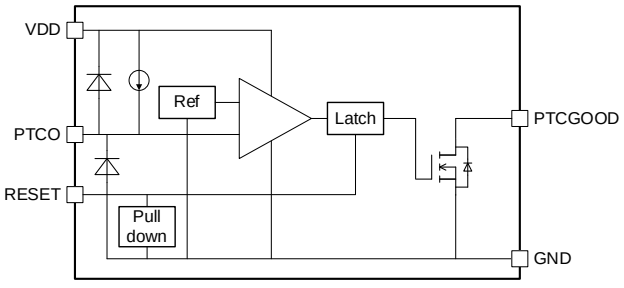

**TCTH0x2AE**




**TCTH0x1BE**




**TCTH0x2BE**



## 7. Pin Description

| Pin name | Description |
|---|---|
| VDD | Power supply pin. |
| GND | Ground level pin. |
| RESET | Reset pin release Latching function for FLAG signal. |
| PTCO | Constant-current output pin.<br>Single or several pcs of PTC thermistor(s) for temperature detecting is(are) to be connected in series between PTCO and GND.<br>Do not apply a voltage exceeding 1 V from outside. If a high voltage is applied from the outside for a long time, the Detect Voltage ($V_{DET}$) characteristics may be changed. |
| PTCGOOD | FLAG signal output pin. |

## 8. Operation list

8-1. TCTH0x1AE (without RESET)

| $V_{DD}$ | $V_{PTCO}$ | PTCGOOD |
|---|---|---|
| $V_{DD} < V_{UVLO}$ | X | Indefinite |
| $V_{DD} \geq V_{UVLO}$ | $V_{PTCO} < V_{DET}$ | H |
| $V_{DD} \geq V_{UVLO}$ | $V_{PTCO} \geq V_{DET}$ | L |

X : Don't care,

8-2. TCTH0x1BE (without RESET)

| $V_{DD}$ | $V_{PTCO}$ | PTCGOOD |
|---|---|---|
| $V_{DD} < V_{UVLO}$ | X | Indefinite |
| $V_{DD} \geq V_{UVLO}$ | $V_{PTCO} < V_{DET}$ | Hi-Z |
| $V_{DD} \geq V_{UVLO}$ | $V_{PTCO} \geq V_{DET}$ | L |

X : Don't care,
Hi-Z : High-impedance

8-3. TCTH0x2AE (RESET included)

| $V_{DD}$ | RESET | $V_{PTCO}$ | PTCGOOD |
|---|---|---|---|
| $V_{DD} < V_{UVLO}$ | X | X | Indefinite |
| $V_{DD} \geq V_{UVLO}$ | H | X | H |
| $V_{DD} \geq V_{UVLO}$ | L | $V_{PTCO} < V_{DET}$ | H |
| $V_{DD} \geq V_{UVLO}$ | L | $V_{PTCO} \geq V_{DET}$ | L (Latch) |

X : Don't care,

8-4. TCTH0x2BE (RESET included)

| $V_{DD}$ | RESET | $V_{PTCO}$ | PTCGOOD |
|---|---|---|---|
| $V_{DD} < V_{UVLO}$ | X | X | Indefinite |
| $V_{DD} \geq V_{UVLO}$ | H | X | Hi-Z |
| $V_{DD} \geq V_{UVLO}$ | L | $V_{PTCO} < V_{DET}$ | Hi-Z |
| $V_{DD} \geq V_{UVLO}$ | L | $V_{PTCO} \geq V_{DET}$ | L (Latch) |

X : Don't care,
Hi-Z : High-impedance

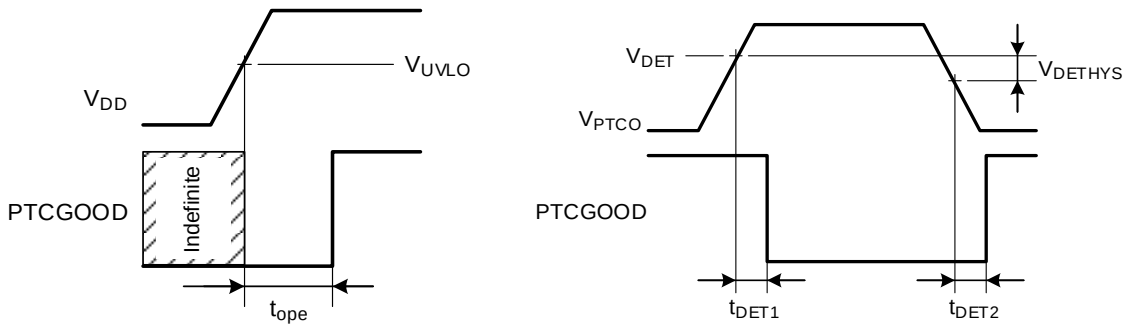
PTCGOOD latch will be released if the RESET inputs "H" or re-input using the $V_{DD}$.

## 9. Electrical characteristics

(Unless otherwise specified, $V_{DD}$ = 3.3 V)

| Characteristics | symbol | Test Condition | $T_j$ = 25 °C | | | $T_j$ = -40 to 125 °C (Note 5) | | Unit |
|---|---|---|---|---|---|---|---|---|
| | | | Min. | Typ. | Max. | Min. | Max. | |
| PTCO output current | $I_{PTCO}$ | TCTH01xxE, $V_{DD}$ = 3.3 V | 0.92 | 1.00 | 1.08 | 0.76 | 1.27 | μA |
| | | TCTH01xxE, $V_{DD}$ = 1.7 V to 5.5V | 0.80 | 1.00 | 1.22 | 0.72 | 1.32 | μA |
| | | TCTH02xxE, $V_{DD}$ = 3.3 V | 9.2 | 10.0 | 10.8 | 7.6 | 12.7 | μA |
| | | TCTH02xxE, $V_{DD}$ = 1.7 V to 5.5 V | 8.0 | 10.0 | 12.2 | 7.2 | 13.2 | μA |
| Detect Voltage | $V_{DET}$ | | 0.42 | 0.50 | 0.58 | 0.36 | 0.64 | V |
| Hysteresis Voltage | $V_{DETHYS}$ | TCTH0x1xE | — | 0.1 | — | — | — | V |
| Response time | $t_{DET1}$ | PTCO terminal voltage : 1 V to 10 mV | — | 17 | — | — | — | μs |
| | $t_{DET2}$ | PTCO terminal voltage : 1 V to 10 mV, TCTH0x1xE | — | 214 | — | — | — | μs |
| Current Consumption | $I_{DD1U}$ | TCTH01xxE | — | 1.8 | 2.4 | — | 2.6 | μA |
| | $I_{DD10U}$ | TCTH02xxE | — | 11.3 | 14.7 | — | 16.5 | μA |
| UVLO voltage | $V_{UVLO}$ | | — | 1.5 | — | — | — | V |
| Operation MASK time | $t_{ope}$ | | — | 20 | — | — | — | μs |
| Threshold of RESET pin High level | $V_{IHRESET}$ | | 0.84 | — | $V_{DD}$ | 1.00 | $V_{DD}$ | V |
| Pull-down current at RESET pin | $I_{RESET}$ | | — | 0.04 | — | — | — | μA |
| PTCGOOD High level output voltage | $V_{OH}$ | TCTH0xxAE, $I_{PTCGOOD}$ = -4 mA | 3.03 | — | — | — | — | V |
| PTCGOOD Low level output voltage | $V_{OL}$ | $I_{PTCGOOD}$ = 4 mA | — | — | 0.2 | — | — | V |

Note 5: These parameters are guaranteed by design.



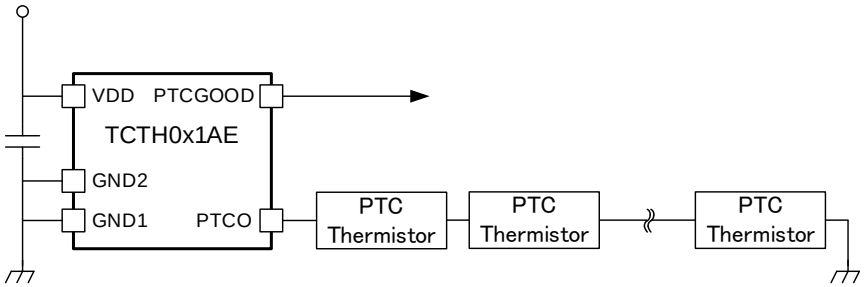

**$t_{ope}$, $t_{DET1}$, $t_{DET2}$ Waveforms**

# 10. Application Note

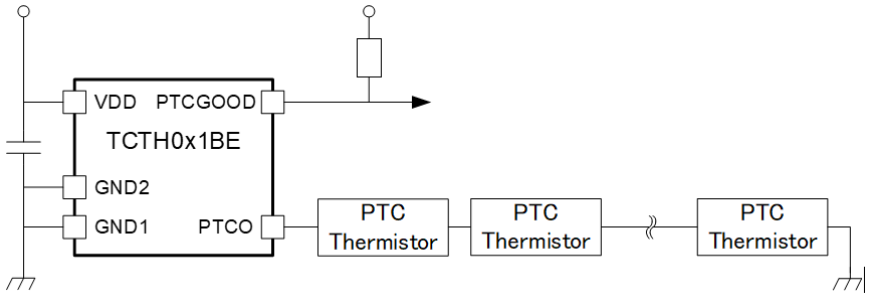
## 10.1. Operation description (TCTH0x1AE, TCTH0x1BE)

PTCO output current and PTC Thermistor(s) resistance, externally placed near the heat source determines the voltage level on PTCO pin. When this terminal-voltage exceeds the specified voltage, immediately PTCGOOD pin outputs “Low”.
When PTCO pin voltage become lower than the specified voltage, automatically returns and PTCGOOD pin outputs “High” (TCTH0x1AE), or “High-impedance” (TCTH0x1BE).
Detecting temperature varies on selection of PTC thermistor(s). If the detection on higher temperature than this IC operation range is necessary, take care the PCB designing and keep enough distance between PTC Thermistor(s) and this IC to avoid heat propagation to this IC.

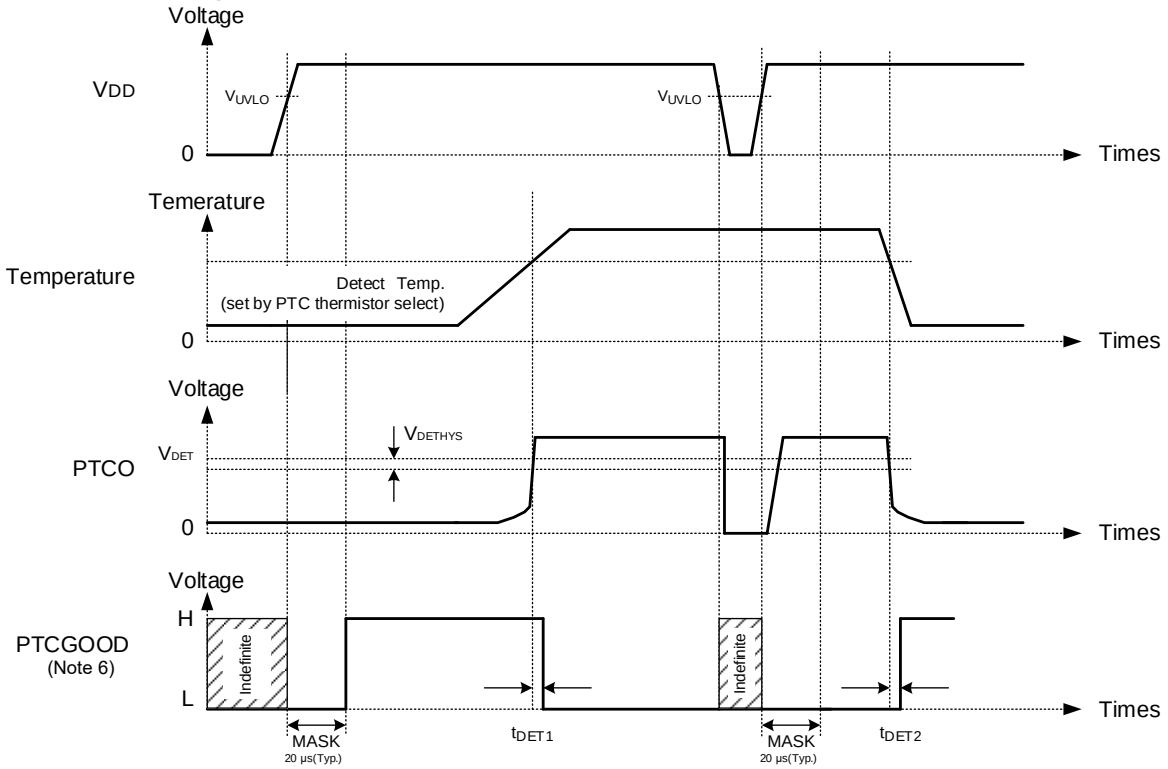
**TCTH0x1AE**




**TCTH0x1BE**




**TCTH0x1xE Timing chart**

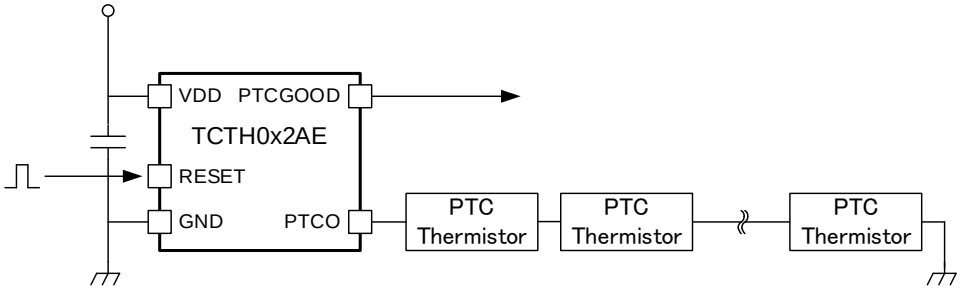



Note 6: TCTH0x1BE is using Open-drain output.
Therefore, PTCGOOD pin of TCTH0x1BE outputs High-impedance instead of “High”.

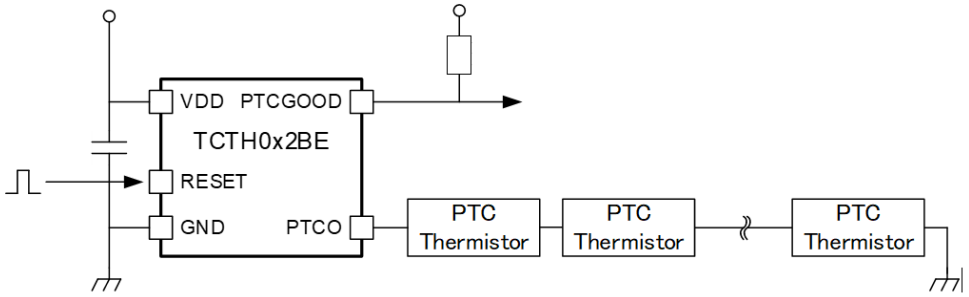
## 10.2. Operation description (TCTH0x2AE, TCTH0x2BE)

PTCO output current and PTC Thermistor(s) resistance, externally placed near the heat source determines the voltage level on PTCO pin. When this terminal-voltage exceeds the specified voltage, immediately PTCGOOD pin outputs “Low” and keep the output state.
Input the “High” signal into RESET pin, to cancel this PTCGOOD latch signal.
If “High” signal is input to RESET pin, this device is in reset state, PTCGOOD pin outputs “High” (TCTH0x2AE), or “High-impedance” (TCTH0x2BE).
Detecting temperature varies on selection of PTC thermistor(s). If the detection on higher temperature than this IC operation range is necessary, take care the PCB designing and keep enough distance between PTC Thermistor(s) and this IC to avoid heat propagation to this IC.

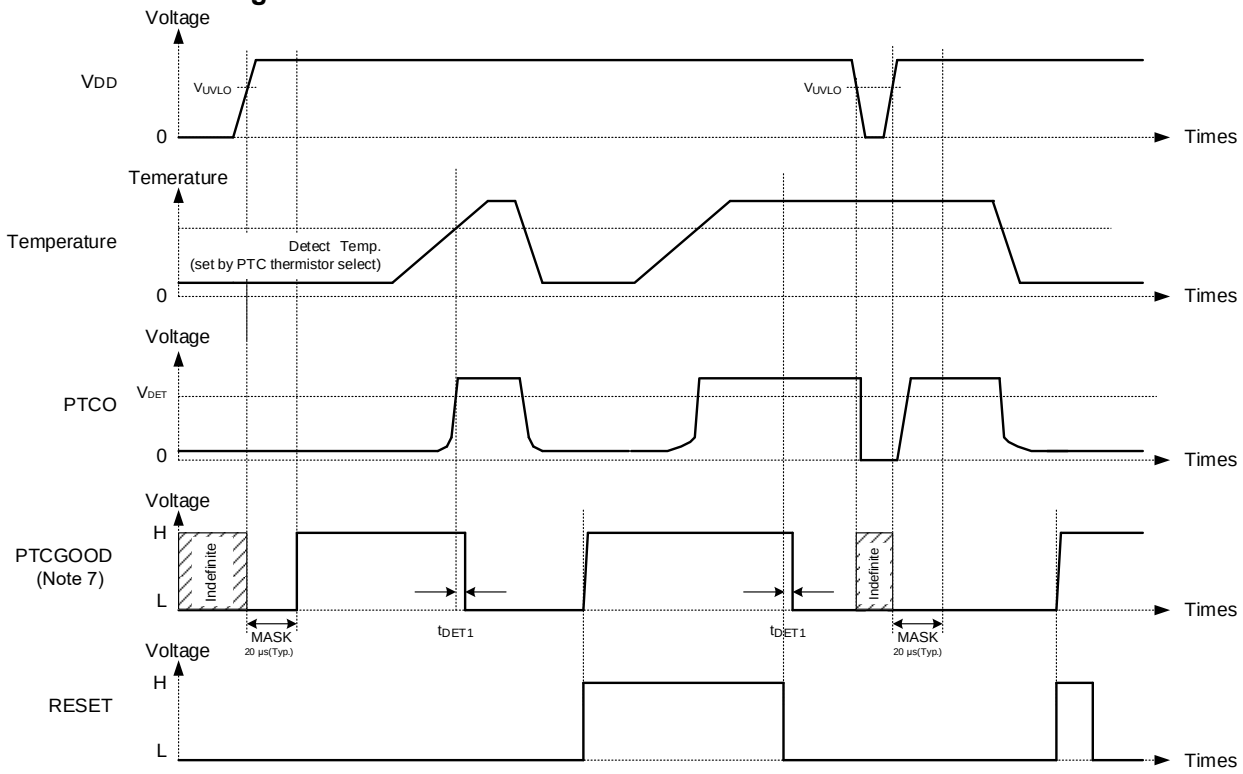
**TCTH0x2AE**




**TCTH0x2BE**




**TCTH0x2xE Timing chart**




Note 7: TCTH0x2BE is using Open-drain output.
Therefore, PTCGOOD pin of TCTH0x2BE outputs High-impedance instead of “High”.

## 10.3. How to choose PTC thermistor

The resistor value of PTC thermistor is increased when the temperature exceeds threshold. PTCO voltage ($V_{PTCO}$) generates with PTC thermistor characteristics and PTCO output current. PTCGOOD outputs “Low” when PTC PTCO voltage is higher than the detect voltage ($V_{DET}$).
There are 2 types of products, have different PTCO output current. Select PTC thermistor matches each PTCO output current. Refer to the following.

### 10.3.1. Usage with single PTC thermistor

Refer to the following to select a PTC thermistor for IC detecting when resistance of PTC thermistor becomes α times the one on normal conditions.

$$\frac{V_{DET}\ (Max.)}{I_{PTCO}\ (Min.) \times \alpha} < \text{PTC thermistor resistance at normal operation} < \frac{V_{DET}\ (Min.)}{I_{PTCO}\ (Max.) \times \beta}$$

α: The rate of changing PTC thermistor resistance $\left(\alpha = \frac{\text{resistance at over temperature operation}}{\text{resistance at normal operation}}\right)$

β: $V_{DET}$ margin coefficient, Set with guideline as $10 \leq \beta \leq \alpha/4$
Note: Design for PTC thermistor resistance variation and margins.

Ex.) Reference PTC thermistor resistance for single pc.

| Product name | PTCO output current (Typ.) | PTC thermistor resistance (25 °C) | |
|---|---|---|---|
| | | α = 50, β = 10 | α = 100, β = 10 |
| TCTH01xxE | 1 μA | 17.8 kΩ to 27 kΩ | 9.1 kΩ to 27 kΩ |
| TCTH02xxE | 10 μA | 1.78 kΩ to 2.7 kΩ | 910 Ω to 2.7 kΩ |

### 10.3.2. Using several (N pcs) PTC thermistors

When using several PTC thermistors, select the thermistors with same resistance value at 25 °C. if using different thermistors in same system, the IC does not correctly detect the setting temperature as blow.
Maximum number of PTC thermistors can be connected is around 30 pcs.

Ex.) Refer next formula to select the PTC thermistors, to detect with this IC when the resistor value changed to α times when one of the PTC thermistors is overheated, using N pcs of PTC thermistors have same resistor value at 25 °C.

$$\frac{V_{DET}\ (Max.)}{I_{PTCO}\ (Min.) \times (\alpha + N - 1)} < \text{PTC thermistor resistance at normal operation} < \frac{V_{DET}\ (Min.)}{I_{PTCO}\ (Max.) \times \beta \times N}$$

N: PTC thermistor quantity
α: The rate of changing PTC thermistor resistance $\left(\alpha = \frac{\text{resistance at over temperature operation}}{\text{resistance at normal operation}}\right)$
Set α to be at least (4 + N/2) × β or more, as guideline.
β: $V_{DET}$ margin coefficient, set β to be N + 10 as guideline.
Note: Design for PTC thermistor resistance variation and margins.

If in a condition that multiple PTC thermistors are to be overheated at the same time, the combined resistance after overheating should be considered to set the system, to avoid false positive of the IC on the temperature below detecting temperature.

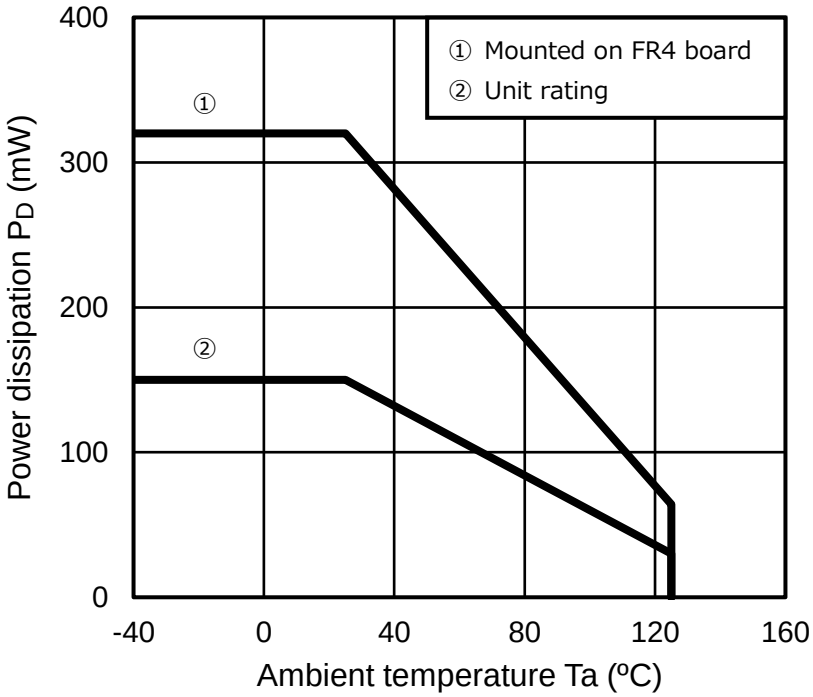
Ex.) Reference PTC thermistor resistance using several (N) pcs.

| Product name | PTCO output current (Typ.) | PTC thermistor resistance (25 °C) | |
|---|---|---|---|
| | | N = 10, α = 180, β = 20 | N = 10, α = 300, β = 20 (when α is increased) |
| TCTH01xxE | 1 μA | 4.7 kΩ to 9.4 kΩ | 2.8 kΩ to 9.4 kΩ |
| TCTH02xxE | 10 μA | 470 Ω to 940 Ω | 280 Ω to 940 Ω |

## 10.4. Power Dissipation

Both unit and board mounted power dissipation ratings for TCTH0 series are available in the Absolute Maximum Ratings table.
Power dissipation is measured on the board shown below.

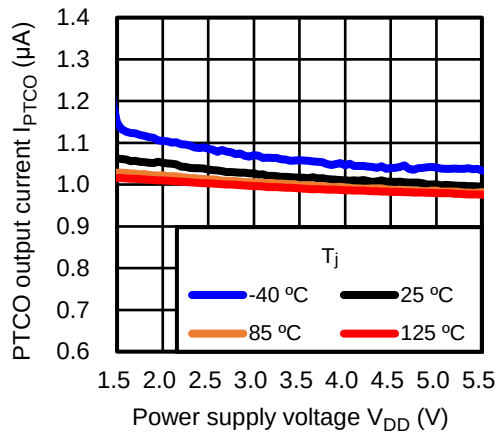
[The Board Condition]
FR4 board dimension: 30 mm × 30 mm × 0.8 mm



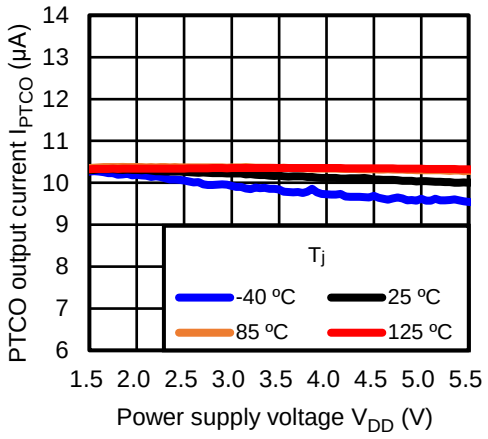
## 11. Representative Typical Characteristics

Unless otherwise specified, $V_{DD}$ = 3.3 V, $V_{PTCO}$ = 0.61 V, $T_j$ = 25 °C

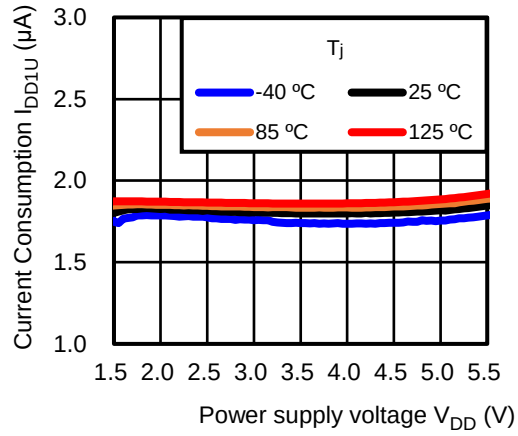
PTCO output current $I_{PTCO}$
TCTH01xxE



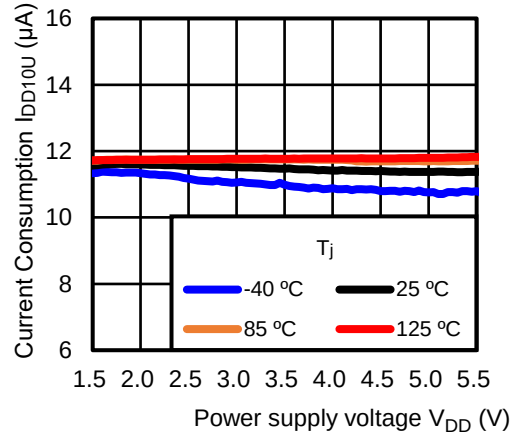

PTCO output current $I_{PTCO}$
TCTH02xxE



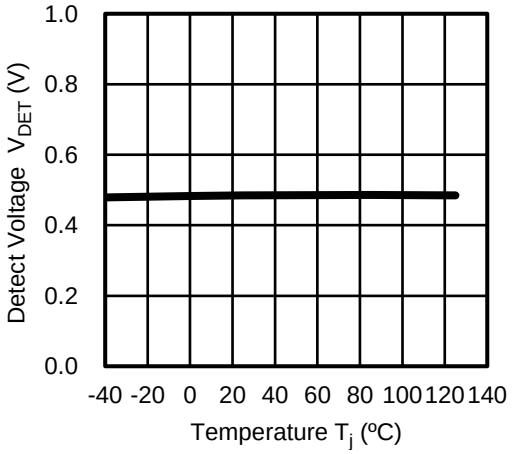

Current Consumption $I_{DD1U}$
TCTH01xxE

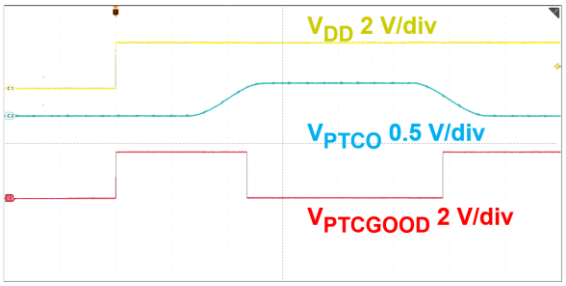
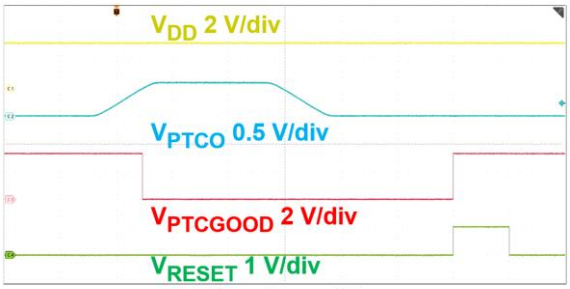



Current Consumption $I_{DD10U}$
TCTH02xxE




Detect Voltage $V_{DET}$

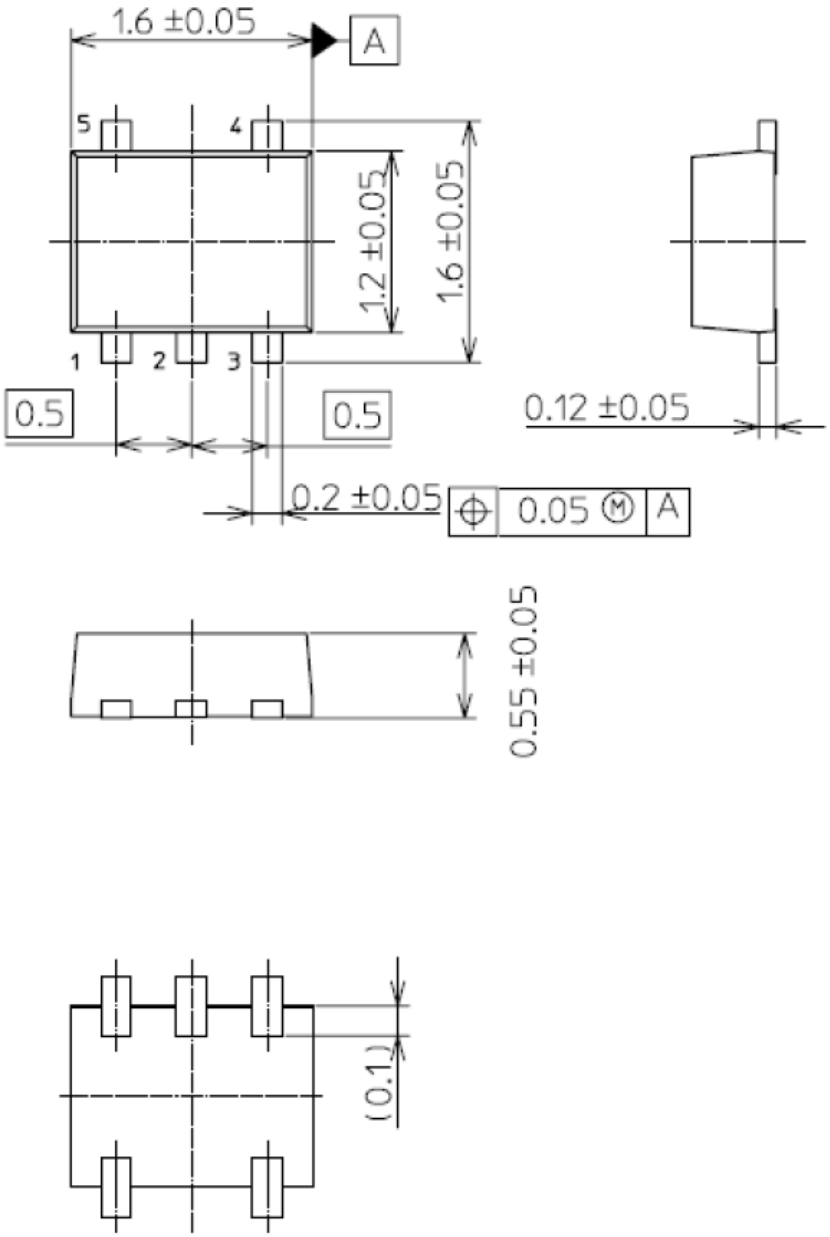


| TCTH0x1xE Operation | TCTH0x2xE Operation |
|---|---|
| $V_{DD}$ = 3.3 V, $V_{PTCO}$ = 0 V to 0.61 V | $V_{DD}$ = 3.3 V, $V_{PTCO}$ = 0 V to 0.61 V, $V_{RESET}$ = 0 V to 1 V |
|  |  |
| **Time 10 ms/div** | **Time 10 ms/div** |

Note: The above characteristics curves are presented for reference only and not guaranteed by production test, unless otherwise noted.

## 12. Package Dimension

ESV(SOT-553) Unit: mm




Weight: 2.98 mg (Typ.)

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