

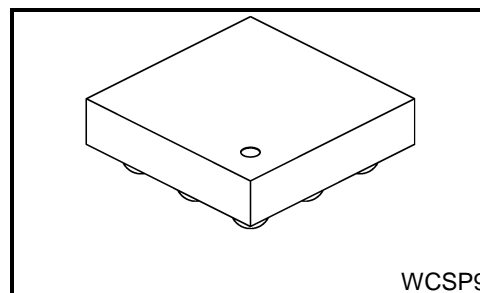
# TCK304G

## 28 V, Single input – Single Output Load Switch IC with Over Voltage Protection

The TCK304G is 28 V high input voltage Single Inputs-Single Output load switch ICs. It has Over Voltage

Protection function featuring low switch ON resistance, high output current and wide input voltage operation. Switch ON resistance is only 73 mΩ at 4.5 V, - 1.0 A load conditions. And these feature a slew rate control driver, thermal shutdown and Flag function. Also it can block reverse current if switch turned off. Output current is available up to 3 A. Thus this is suitable for power management such as Battery Charge application.

This device is available in 0.5mm pitch ultra small package WCSP9 (1.5 mm x 1.5 mm, t: 0.5 mm (Typ.)). Thus this devices is ideal for portable applications that require high-density board assembly such as cellular phone.

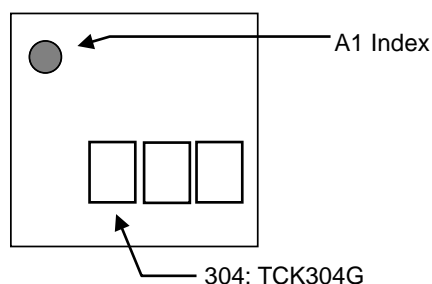


Weight : 3.5 mg ( Typ.)

### Feature

- High input voltage:  $V_{IN} (Max) = 28 V$
- High output current:  $I_{OUT} (DC) = 3.0 A$
- Low ON resistance :  $R_{ON} = 73 m\Omega (Typ.)$  at  $V_{IN} = 4.5 V$ ,  $I_{OUT} = - 1.0 A$
- Over Voltage Lockout : 6.6 V (Typ.)
- Under Voltage Lockout: 2.9 V (Typ.)
- FLAG indicates
- Internal 15ms startup hold
- Reverse current blocking (SW OFF state)
- Inrush current reducing circuit
- Thermal Shutdown function
- Small package: 0.5 mm pitch WCSP9 ( 1.5 mm x 1.5 mm, t: 0.5 mm(Typ.)) ,  $P_D = 1.65 W$

### Top marking



Start of commercial production  
2015-09

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

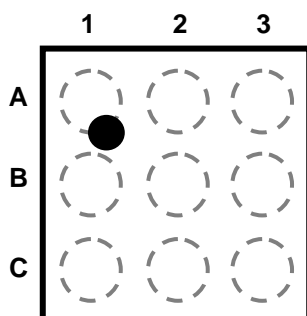
| Characteristics             | Symbol                            | Rating        |              | Unit |
|-----------------------------|-----------------------------------|---------------|--------------|------|
| Input voltage               | V <sub>IN</sub>                   | -0.3 to 30    |              | V    |
| Control voltage             | V <sub>CT</sub> , V <sub>CE</sub> | -0.3 to 6     |              | V    |
| Output voltage              | V <sub>OUT</sub>                  | -0.3 to 18    |              | V    |
| Flag voltage                | V <sub>FLAG</sub>                 | -0.3 to 6     |              | V    |
| Output current              | I <sub>OUT</sub>                  | DC            | 3.0          | A    |
|                             |                                   | Pulse         | 4.0 (Note 1) |      |
| Power dissipation           | P <sub>D</sub>                    | 1.65 (Note 2) |              | W    |
| Operating temperature range | T <sub>opr</sub>                  | -40 to 85     |              | °C   |
| Junction temperature        | T <sub>j</sub>                    | 150           |              | °C   |
| Storage temperature         | T <sub>stg</sub>                  | -55 to 150    |              | °C   |

Note: 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. 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).

Note1: 1 ms pulse, 1% duty cycle

Note2: Rating at mounting on a board: FR4 board. ( 40 mm × 40 mm × 1.6 mm, Cu 4 layer )

## Pin Assignment (Top view/Bottom bump)



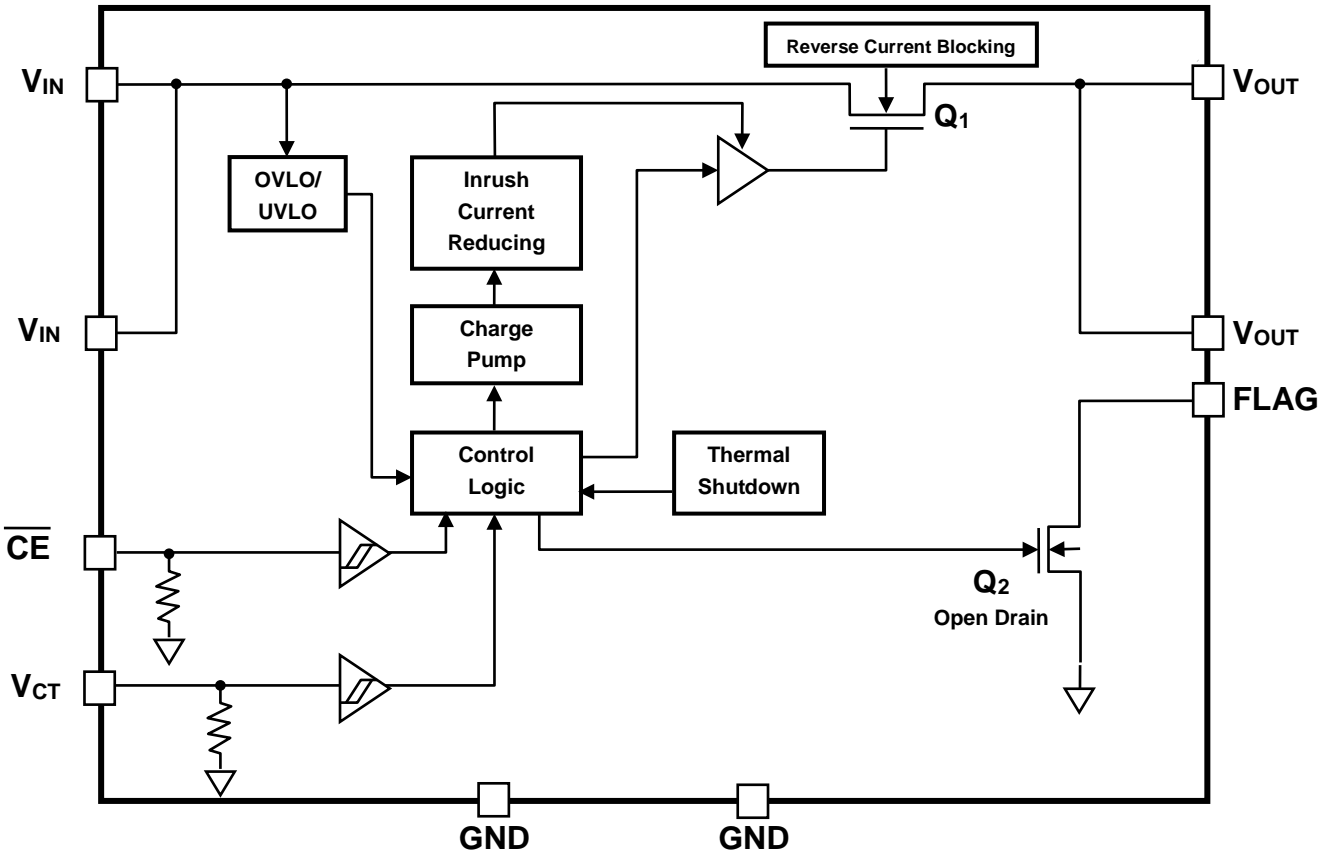
|   | 1               | 2               | 3                      |
|---|-----------------|-----------------|------------------------|
| A | FLAG            | V <sub>CT</sub> | $\overline{\text{CE}}$ |
| B | V <sub>IN</sub> | GND             | V <sub>OUT</sub>       |
| C | V <sub>IN</sub> | GND             | V <sub>OUT</sub>       |

## Product list

| Part number | Over voltage lockout | $\overline{\text{CE}}$ function | VCT function | VCT resistance |
|-------------|----------------------|---------------------------------|--------------|----------------|
| TCK304G     | 6.6 V (Typ.)         | Active High                     | Active Low   | Pull down      |

Please ask your local retailer about the devices with other OVLO, logic function and pull down resistance.

Block Diagram



PIN Description

| PIN    | Name      | Description  |
|--------|-----------|--|
| A1     | FLAG      | Open drain acknowledge signal output. When input voltage is in regular range ( $V_{UVL} < V_{IN} < V_{OVL}$ ), $Q_2$ turn ON. FLAG output turn to be high impedance in irregular input voltage range, CE Low state and thermal shutdown operation. |
| A2     | $V_{CT}$  | Switch Control function. It is internally connected to GND (Pull down).  |
| A3     | CE        | Chip Enable function. It is internally connected to GND(Pull down)   |
| B1, C1 | $V_{IN}$  | Input. It has Over Voltage Lock Out (OVLO) and Under Voltage Lock Out function (UVLO).   |
| B2, C2 | GND       | Ground   |
| B3, C3 | $V_{OUT}$ | Output   |

Operation Logic Table

TCK304G

|                    |                       | CE "Low" | CE "High"   |
|--------------------|-----------------------|----------|---|
| $V_{CT}$<br>"HIGH" | $Q_1$ (Main Switch)   | OFF      | OFF   |
|                    | $Q_2$ (FLAG out)      | OFF      | ON (When $V_{UVL} < V_{IN} < V_{OVL}$ ),<br>OFF (When $V_{UVL} > V_{IN}$ , or $V_{IN} > V_{OVL}$ ),<br>OFF (Thermal shut down = active) |
|                    | Reverse current block | Active   | Active  |
| $V_{CT}$<br>"LOW"  | $Q_1$ (Main Switch)   | OFF      | ON  |
|                    | $Q_2$ (FLAG out)      | OFF      | ON (When $V_{UVL} < V_{IN} < V_{OVL}$ ),<br>OFF (When $V_{UVL} > V_{IN}$ , or $V_{IN} > V_{OVL}$ ),<br>OFF (Thermal shut down = active) |
|                    | Reverse current block | Active   | Disable   |

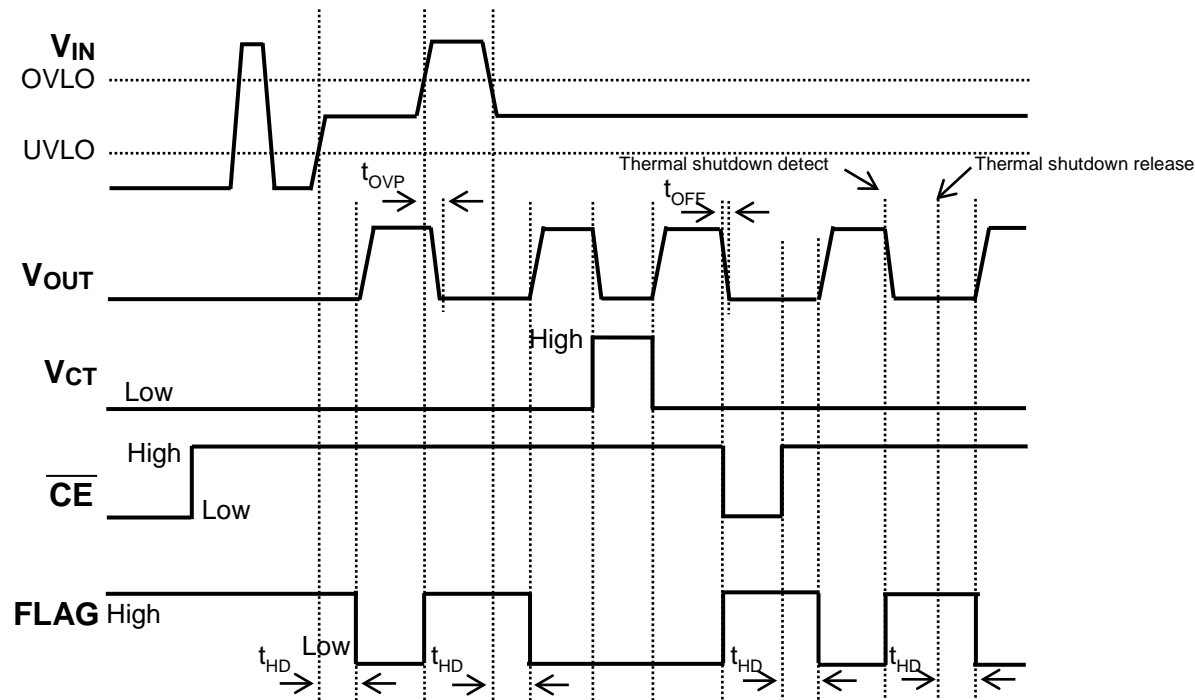
## DC Characteristics (Ta = -40 to 85°C)

| Characteristics   | Symbol               | Test Condition  | Ta = 25°C |                             |     | Ta = -40 to 85°C |     | Unit |
|---|----------------------|---|-----------|-----------------------------|-----|------------------|-----|------|
|   |                      |   | Min       | Typ.                        | Max | Min              | Max |      |
| Input voltage   | V <sub>IN</sub>      | —   | 2.3       | —                           | 28  | 2.3              | 28  | V    |
| $\overline{\text{CE}}$ , V <sub>CT</sub> High-level input voltage | V <sub>IH</sub>      | V <sub>IN</sub> = 2.3 to 28 V   | 1.6       | —                           | —   | 1.6              | —   | V    |
| $\overline{\text{CE}}$ , V <sub>CT</sub> Low-level input voltage  | V <sub>IL</sub>      | V <sub>IN</sub> = 2.3 to 28 V   | —         | —                           | 0.3 | —                | 0.3 | V    |
| Over voltage lock out (OVLO) rising threshold                     | V <sub>OVLO_RI</sub> | —   | —         | 6.6                         | —   | 5.9              | 7.3 | V    |
| Over voltage lock out (OVLO) falling threshold                    | V <sub>OVLO_FA</sub> | —   | —         | V <sub>OVLO_RI</sub> - 0.35 | —   | —                | —   | V    |
| Under voltage lock out (UVLO) rising threshold                    | V <sub>UVLO_RI</sub> | —   | —         | 2.9                         | —   | 2.3              | 3.5 | V    |
| Under voltage lock out (UVLO) falling threshold                   | V <sub>UVLO_FA</sub> | —   | —         | V <sub>UVLO_RI</sub> - 0.3  | —   | —                | —   | V    |
| Quiescent current (ON state)                                      | I <sub>Q(ON)</sub>   | $\overline{\text{CE}}$ = 3.0 V, V <sub>CT</sub> = Open<br>I <sub>OUT</sub> = 0 mA, V <sub>IN</sub> = 5.0 V  | —         | 130                         | —   | —                | 190 | μA   |
| Quiescent current (OFF state)                                     | I <sub>Q(OFF1)</sub> | $\overline{\text{CE}}$ = 3.0 V, V <sub>CT</sub> = 3.0 V,<br>V <sub>IN</sub> = 5.0 V, V <sub>OUT</sub> = 0 V | —         | 75                          | —   | —                | 115 | μA   |
| Input Shutdown Current  | I <sub>Q(OFF2)</sub> | $\overline{\text{CE}}$ = Open, V <sub>CT</sub> = Open,<br>V <sub>IN</sub> = 5.0 V, V <sub>OUT</sub> = 0 V   | —         | 1.3                         | —   | —                | 10  | μA   |
| Switch OFF state current  | I <sub>OFF</sub>     | $\overline{\text{CE}}$ = Open, V <sub>CT</sub> = Open,<br>V <sub>IN</sub> = Open, V <sub>OUT</sub> = 5.0 V  | —         | 0.1                         | —   | —                | 1   | μA   |
| Reverse blocking current  | I <sub>RB</sub>      | V <sub>OUT</sub> = 5.0 V,<br>V <sub>IN</sub> = 0 V, V <sub>CT</sub> = 3.0 V                                 | —         | 0.1                         | —   | —                | 10  | μA   |
| On resistance   | R <sub>ON</sub>      | I <sub>OUT</sub> = -1.0 A, V <sub>IN</sub> = 4.5 V  | —         | 73                          | —   | —                | 140 | mΩ   |
| FLAG Leak current   | I <sub>LEAK</sub>    | V <sub>IO</sub> = 5.0 V   | —         | —                           | 2   | —                | 2   | μA   |
| FLAG Output low voltage   | V <sub>OL</sub>      | I <sub>SINK</sub> = 1 mA, V <sub>IO</sub> = 5.0 V   | —         | —                           | 0.4 | —                | 0.4 | V    |
| $\overline{\text{CE}}$ built-in resistance                        | R <sub>CE</sub>      | —   | —         | 530                         | —   | —                | —   | kΩ   |
| V <sub>CT</sub> built-in resistance                               | R <sub>VCT</sub>     | —   | —         | 530                         | —   | —                | —   |      |

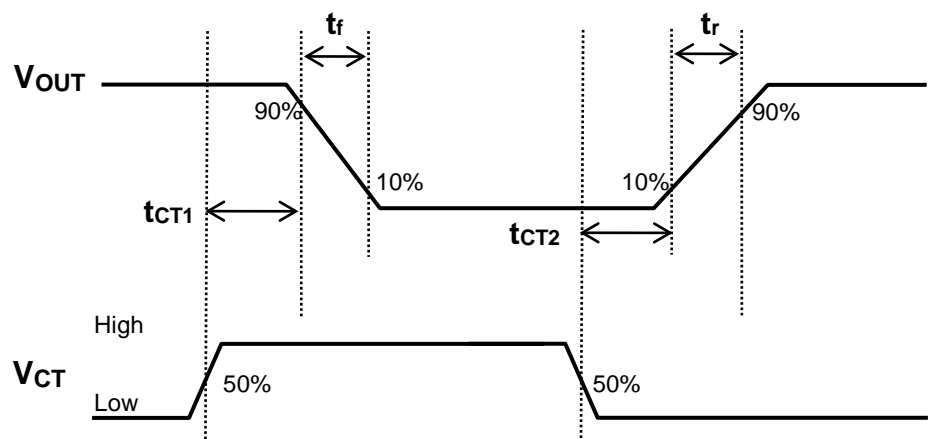
## AC Characteristics (Ta = 25°C)

| Characteristics                                | Symbol           | Test Condition (Figure 1, 2)  | Min | Typ. | Max | Unit |
|--|------------------|---|-----|------|-----|------|
| Hold time                                      | t <sub>HD</sub>  | V <sub>UVL</sub> < V <sub>IN</sub> (5 V) < V <sub>OVLO</sub> , R <sub>L</sub> = 50 Ω<br>Initial start up V <sub>OUT</sub> off state to charge-pump on state | —   | 15   | —   | ms   |
| V <sub>OUT</sub> OVP off time                  | t <sub>OVP</sub> | V <sub>IN</sub> > V <sub>OVLO_RI</sub> , V <sub>IN</sub> rising = 2 V/μs,<br>R <sub>L</sub> = 50 Ω, V <sub>OUT</sub> to 80% of V <sub>OVLO_RI</sub>         | —   | 3    | —   | μs   |
| V <sub>OUT</sub> off time                      | t <sub>OFF</sub> | V <sub>UVL</sub> < V <sub>IN</sub> (5 V) < V <sub>OVLO</sub> , R <sub>L</sub> = 50 Ω,<br>V <sub>OUT</sub> to 80% of V <sub>IN</sub>                         | —   | 2    | —   | μs   |
| V <sub>OUT</sub> rise time                     | t <sub>r</sub>   | V <sub>IN</sub> = 5.0 V, R <sub>L</sub> = 50 Ω, C <sub>L</sub> = 1.0 μF   | —   | 2    | —   | ms   |
| V <sub>OUT</sub> fall time                     | t <sub>f</sub>   | V <sub>IN</sub> = 5.0 V, R <sub>L</sub> = 50 Ω, C <sub>L</sub> = 1.0 μF   | —   | 0.12 | —   | ms   |
| V <sub>CT</sub> delay time (Enable to Disable) | t <sub>CT1</sub> | V <sub>IN</sub> = 5.0 V, R <sub>L</sub> = 50 Ω  | —   | 0.5  | —   | μs   |
| V <sub>CT</sub> delay time (Disable to Enable) | t <sub>CT2</sub> | V <sub>IN</sub> = 5.0 V, R <sub>L</sub> = 50 Ω  | —   | 3.2  | —   | ms   |

**Timing chart**



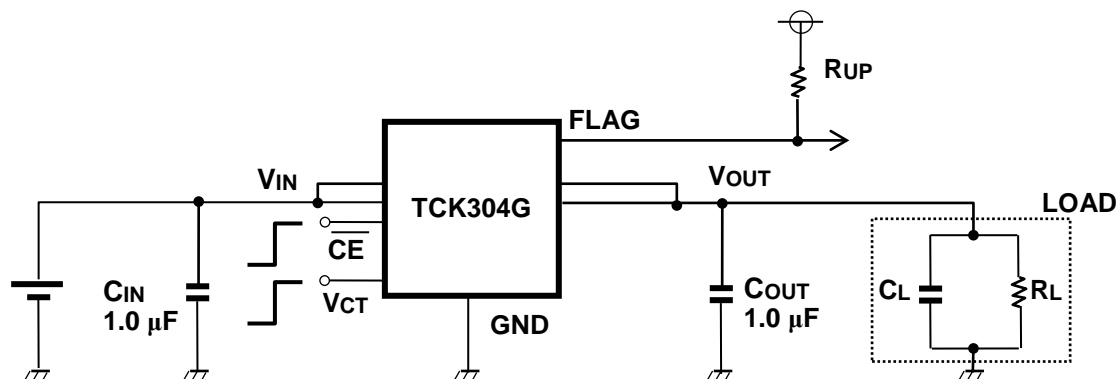
**Figure 1:  $t_{HD}$ ,  $t_{OVP}$ ,  $t_{OFF}$**



**Figure 2:  $t_r$ ,  $t_{ct1}$ ,  $t_{ct2}$**

## Application Note

### 1. Application circuit example (top view)



#### 1) Input and Output capacitor

An input capacitor ( $C_{IN}$ ) and an output capacitor ( $C_{OUT}$ ) are necessary for the stable operation of TCK304G. And it is effective to reduce voltage overshoot or undershoot due to sharp changes in output current and also for improved stability of the power supply. When used, place  $C_{IN}$  and  $C_{OUT}$  more than  $1.0\mu\text{F}$  as close to  $V_{IN}$  pin to improve stability of the power supply.

#### 2) Control pin

Control pins for TCK304G is operated by the control voltage and Schmitt trigger. It can be used even if the control voltage is higher than the input voltage.

### 2. Reverse current blocking

Reverse current blocking (SW OFF state) function is designed in this product. This function is active at output n-ch MOSEFT turned off.

However these does not assure for the suppression of uprising device operation. In use of these products, please read through and understand dissipation idea for absolute maximum ratings from the above mention or our 'Semiconductor Reliability Handbook'. Then use these products under absolute maximum ratings in any condition. Furthermore, Toshiba recommend inserting failsafe system into the design.

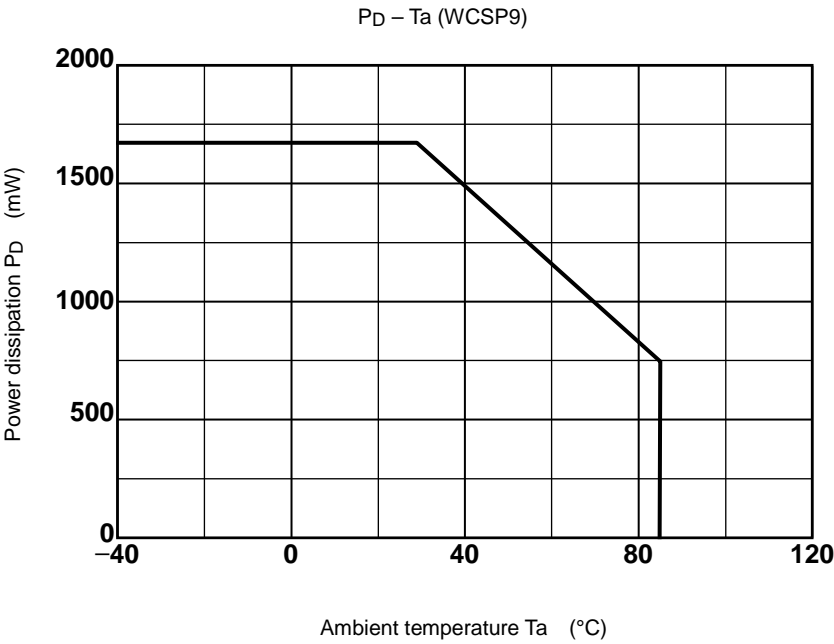
### 3. Thermal shut down function

Thermal shutdown function is designed in these products, but these does not assure for the suppression of uprising device operation. In use of these products, please read through and understand dissipation idea for absolute maximum ratings from the above mention or our 'Semiconductor Reliability Handbook'. Then use these products under absolute maximum ratings in any condition. Furthermore, Toshiba recommend inserting failsafe system into the design.

4. Power Dissipation

Board-mounted power dissipation ratings for TCK304G are available in the Absolute Maximum Ratings table.  
Power dissipation is measured on the board condition shown below.

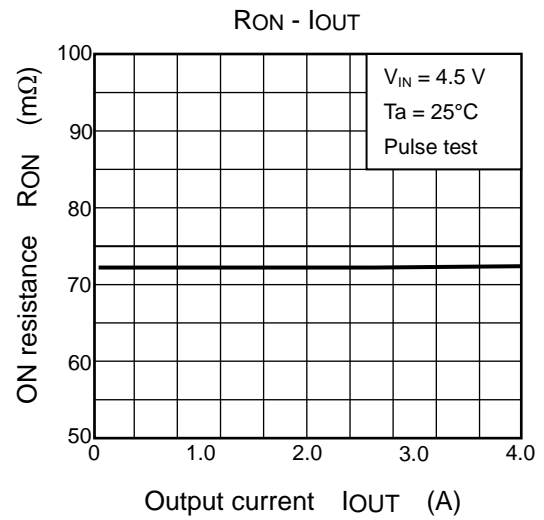
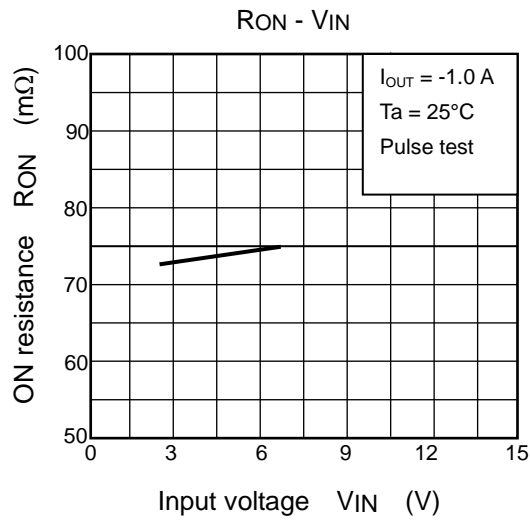
[The Board Condition]  
Board material: Glass epoxy (FR4)  
Board dimension: 40 mm x 40 mm (Cu 4 layer)



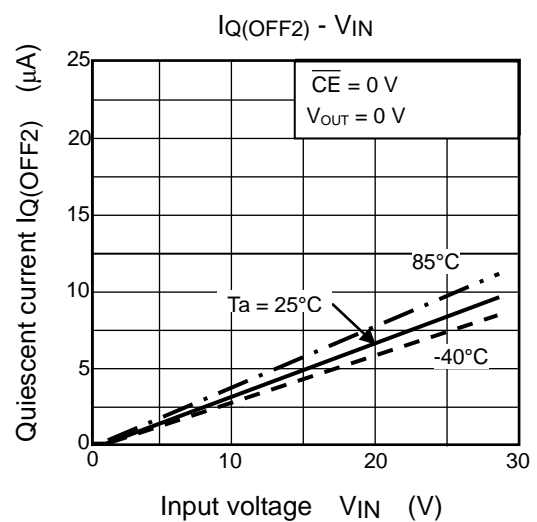
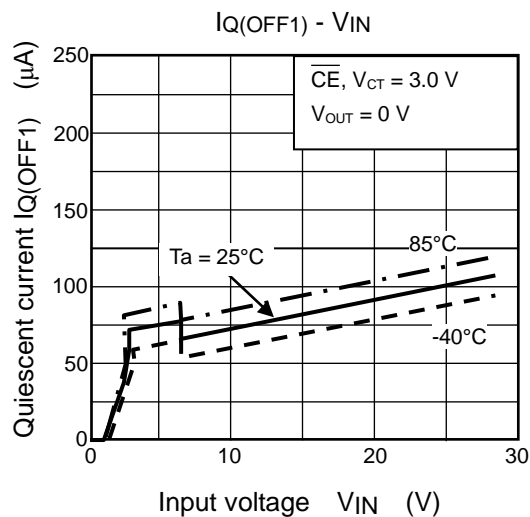
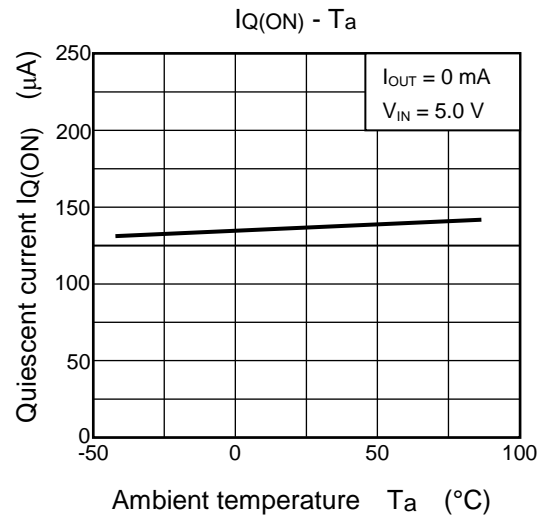
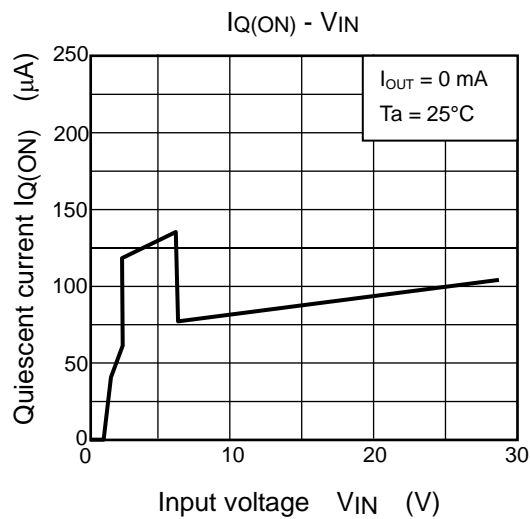
Please allow sufficient margin when designing a board pattern to fit the expected power dissipation. Also take into consideration the ambient temperature, input voltage, output current etc and applying the appropriate derating for allowable power dissipation during operation.

## Representative Typical Characteristics

### 1) ON resistance



### 2) Quiescent current

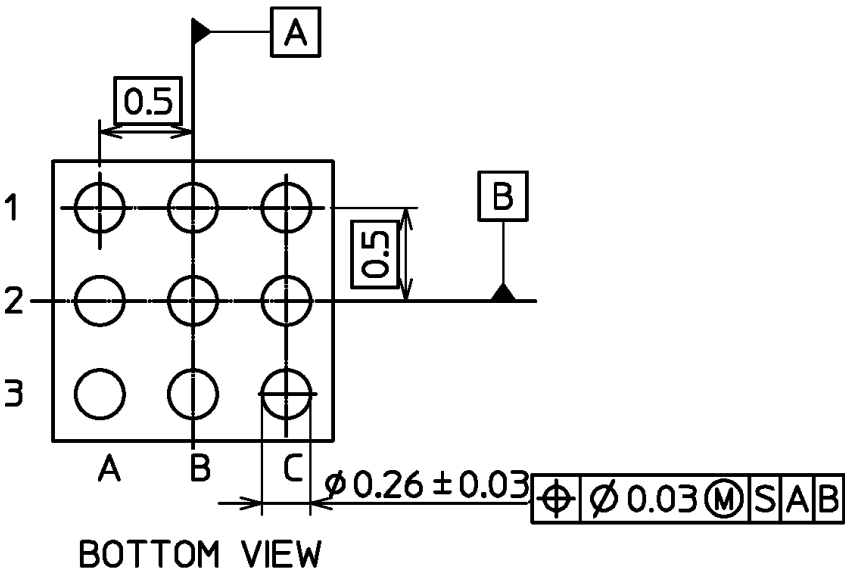
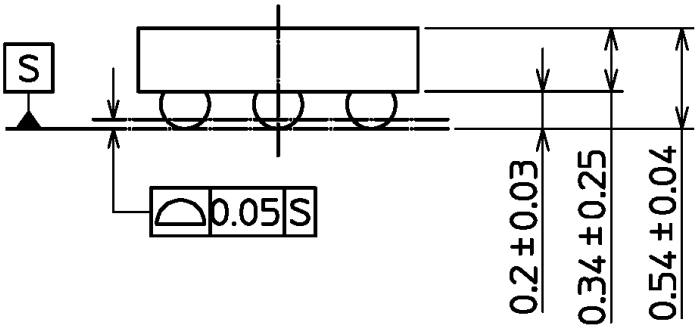
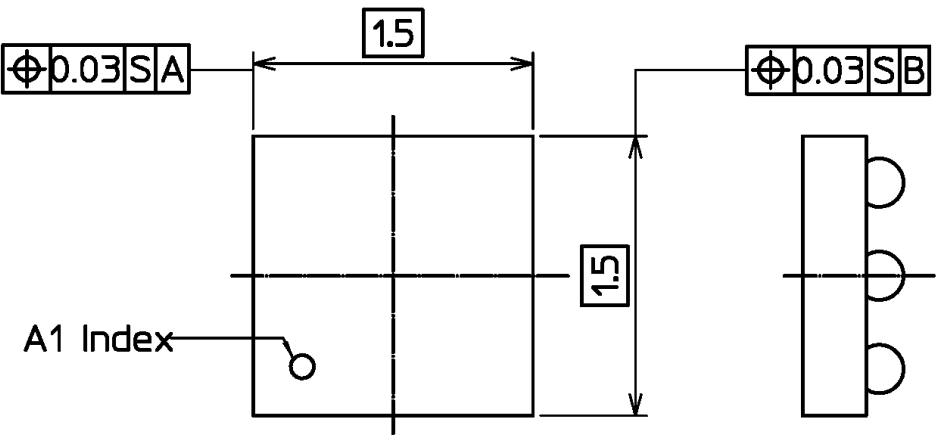




Package Dimensions

WCSP9

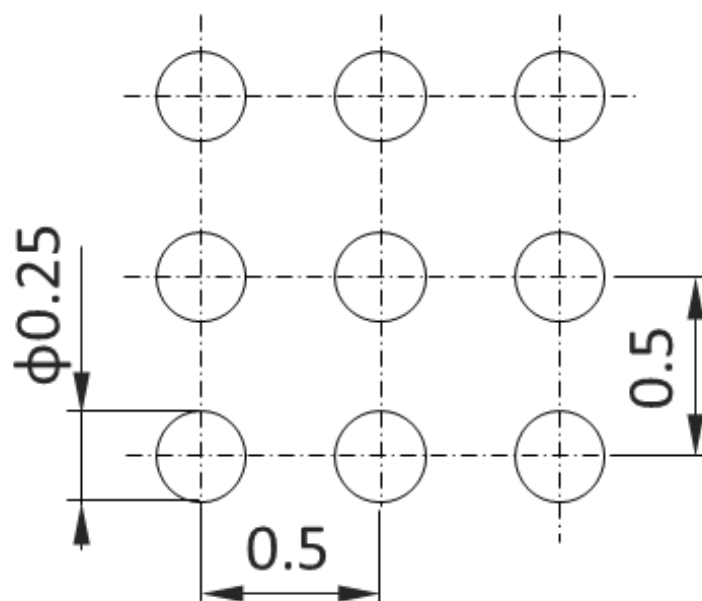
Unit: mm



Weight : 3.5 mg ( Typ.)

Land pattern dimensions (for reference only)

Unit: mm



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