

# TLP2704

## 1. Applications

- Intelligent Power Module Signal Isolation
- Factory Automation (FA)
- Industrial Inverters

## 2. General

The TLP2704 consists of an infrared LED optically coupled with an integrated high-gain, high-speed photodetector and is housed in the SO6L package. It supports operating temperatures of up to 125 °C.

The SO6L package meets the reinforced insulation class requirements of international safety standards.

The photodetector has an internal Faraday shield that provides a guaranteed common-mode transient immunity of  $\pm 20$  kV/ $\mu$ s.

The TLP2704 guarantees minimum and maximum of propagation delay time, pulse width distortion. Therefore it is suitable for isolation interface between IPM and control IC circuits in motor control application.

## 3. Features

- (1) Inverter logic type (open collector output)
- (2) Package: SO6L
- (3) Operating temperature: -40 to 125 °C
- (4) Supply voltage: -0.5 to 30 V
- (5) Threshold input current: 5.0 mA (max)
- (6) Supply current: 1.3 mA (max)
- (7) Propagation delay time:  $t_{pHL} = 400$  ns (max),  $t_{pLH} = 550$  ns (max)
- (8) Pulse width distortion: 400 ns (max)
- (9) Common-mode transient immunity:  $\pm 20$  kV/ $\mu$ s (min)
- (10) Isolation voltage: 5000 Vrms (min)
- (11) Safety standards

UL-recognized: UL 1577, File No.E67349

cUL-recognized: CSA Component Acceptance Service No.5A File No.E67349

VDE-approved: EN IEC 60747-5-5, EN IEC 62368-1 (**Note 1**)

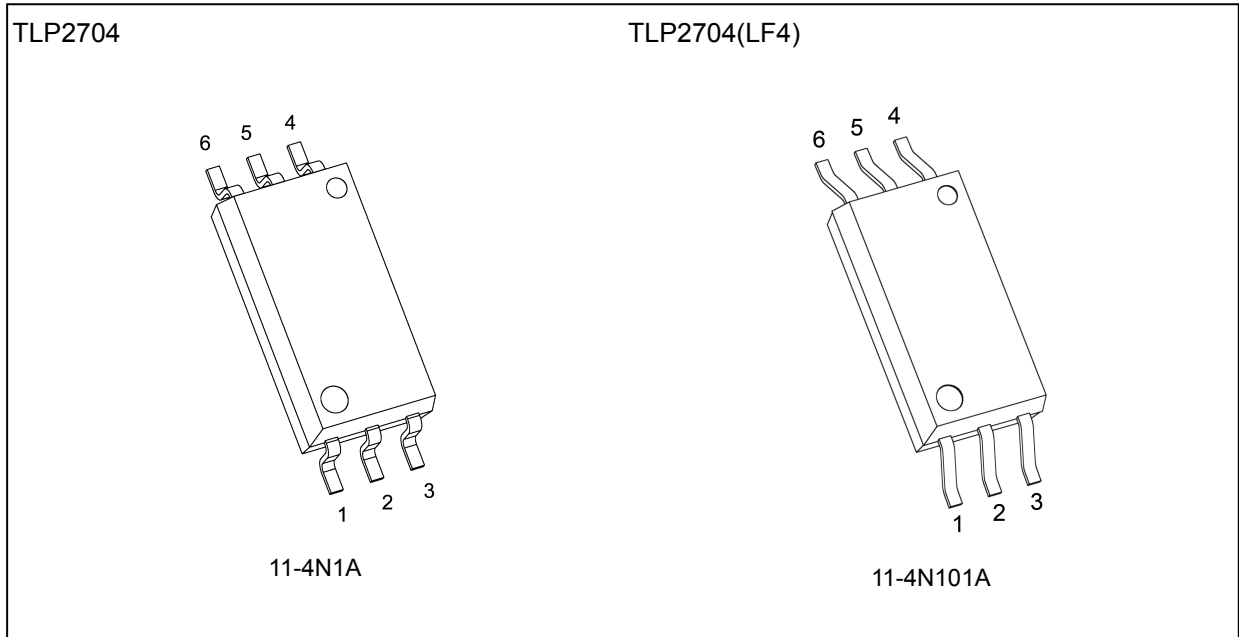
CQC-approved: GB4943.1 Japan and Thailand Factory

Note 1: When a VDE approved type is needed, please designate the **Option (D4)**.

Start of commercial production

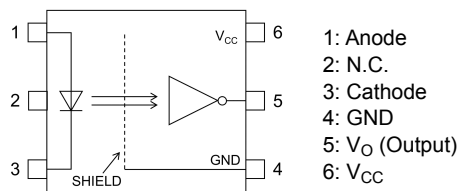
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## 4. Packaging (Note)

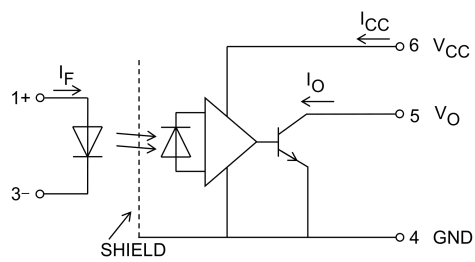


Note: Lead-formed product: (LF4)

## 5. Pin Assignment



## 6. Internal Circuit (Note)



Note: A 0.1  $\mu\text{F}$  bypass capacitor must be connected between pin 6 and pin 4.

## 7. Principle of Operation

### 7.1. Truth Table

| Input | LED | Output |
|-------|-----|--------|
| H     | ON  | L      |
| L     | OFF | H      |

### 7.2. Mechanical Parameters

| Characteristics              | Min | Unit |
|------------------------------|-----|------|
| Creepage distances           | 8.0 | mm   |
| Clearance distances          | 8.0 |      |
| Internal isolation thickness | 0.4 |      |

## 8. Absolute Maximum Ratings (Note) (Unless otherwise specified, $T_a = 25\text{ °C}$ )

|          | Characteristics  | Symbol                      | Note     | Rating     | Unit  |
|----------|--|-----------------------------|----------|------------|-------|
| LED      | Input forward current  | $I_F$                       |          | 20         | mA    |
|          | Input forward current derating ( $T_a \geq 116\text{ °C}$ )                | $\Delta I_F/\Delta T_a$     |          | -0.6       | mA/°C |
|          | Input forward current (pulsed)   | $I_{FP}$                    | (Note 1) | 50         | mA    |
|          | Input forward current derating (pulsed) ( $T_a \geq 110\text{ °C}$ )       | $\Delta I_{FP}/\Delta T_a$  |          | -1.25      | mA/°C |
|          | Peak transient input forward current                                       | $I_{FPT}$                   | (Note 2) | 1          | A     |
|          | Peak transient input forward current derating ( $T_a \geq 110\text{ °C}$ ) | $\Delta I_{FPT}/\Delta T_a$ |          | -25        | mA/°C |
|          | Input power dissipation  | $P_D$                       |          | 40         | mW    |
|          | Input power dissipation derating ( $T_a \geq 110\text{ °C}$ )              | $\Delta P_D/\Delta T_a$     |          | -1.0       | mW/°C |
|          | Input reverse voltage  | $V_R$                       |          | 5          | V     |
| Detector | Output current   | $I_O$                       |          | 15         | mA    |
|          | Output current derating ( $T_a \geq 110\text{ °C}$ )                       | $\Delta I_O/\Delta T_a$     |          | 0.38       | mA/°C |
|          | Output voltage   | $V_O$                       |          | -0.5 to 30 | V     |
|          | Supply voltage   | $V_{CC}$                    |          | -0.5 to 30 |       |
|          | Output power dissipation   | $P_O$                       |          | 80         | mW    |
|          | Output power dissipation derating ( $T_a \geq 110\text{ °C}$ )             | $\Delta P_O/\Delta T_a$     |          | -2.0       | mW/°C |
| Common   | Operating temperature  | $T_{opr}$                   |          | -40 to 125 | °C    |
|          | Storage temperature  | $T_{stg}$                   |          | -55 to 125 |       |
|          | Lead soldering temperature (10 s)  | $T_{sol}$                   |          | 260        |       |
|          | Isolation voltage AC, 60 s, R.H. $\leq 60\%$                               | $BV_S$                      | (Note 3) | 5000       |       |

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).

Note 1: Pulse width (PW)  $\leq 1\text{ ms}$ , duty = 50 %

Note 2: Pulse width (PW)  $\leq 1\text{ }\mu\text{s}$ , 300 pps

Note 3: This device is considered as a two-terminal device: Pins 1, 2 and 3 are shorted together, and pins 4, 5 and 6 are shorted together.

## 9. Recommended Operating Conditions (Note)

| Characteristics         | Symbol       | Note     | Min | Typ. | Max | Unit |
|-------------------------|--------------|----------|-----|------|-----|------|
| Input on-state current  | $I_{F(ON)}$  | (Note 1) | 7.5 | —    | 15  | mA   |
| Input off-state voltage | $V_{F(OFF)}$ |          | 0   | —    | 0.8 | V    |
| Supply voltage          | $V_{CC}$     | (Note 2) | 4.5 | —    | 30  | V    |
| Operating temperature   | $T_{opr}$    | (Note 2) | -40 | —    | 125 | °C   |

Note: The recommended operating conditions are given as a design guide necessary to obtain the intended performance of the device. Each parameter is an independent value. When creating a system design using this device, the electrical characteristics specified in this data sheet should also be considered.

Note : A ceramic capacitor (0.1  $\mu$ F) should be connected between pin 6 and pin 4 to stabilize the operation of a high-gain linear amplifier. Otherwise, this photocoupler may not switch properly. The bypass capacitor should be placed within 1 cm of each pin.

Note 1: The rise and fall times of the input on-current should be less than 0.5  $\mu$ s.

Note 2: Denotes the operating range, not the recommended operating condition.

## 10. Electrical Characteristics (Note) (Unless otherwise specified, $T_a = -40$ to $125$ °C, $V_{CC} = 4.5$ to $30$ V)

| Characteristics                               | Symbol                    | Note | Test Circuit | Test Condition                 | Min  | Typ. | Max | Unit    |
|---|---------------------------|------|--------------|--------------------------------|------|------|-----|---------|
| Input forward voltage                         | $V_F$                     |      | —            | $I_F = 10$ mA, $T_a = 25$ °C   | 1.45 | 1.55 | 1.7 | V       |
| Input forward voltage temperature coefficient | $\Delta V_F / \Delta T_a$ |      | —            | $I_F = 10$ mA                  | —    | -1.8 | —   | mV/°C   |
| Input reverse current                         | $I_R$                     |      | —            | $V_R = 5$ V, $T_a = 25$ °C     | —    | —    | 10  | $\mu$ A |
| Input capacitance                             | $C_t$                     |      | —            | $V = 0$ V, $f = 1$ MHz         | —    | 60   | —   | pF      |
| High-level output current                     | $I_{OH}$                  |      | Fig.13.1.1   | $V_F = 0.8$ V, $V_O < V_{CC}$  | —    | —    | 50  | $\mu$ A |
| Low-level output voltage                      | $V_{OL}$                  |      | Fig.13.1.2   | $I_F = 10$ mA, $I_O = 2.4$ mA  | —    | —    | 0.6 | V       |
| High-level supply current                     | $I_{CCH}$                 |      | Fig.13.1.3   | $I_F = 0$ mA                   | —    | —    | 1.3 | mA      |
| Low-level supply current                      | $I_{CCL}$                 |      | Fig.13.1.4   | $I_F = 10$ mA                  | —    | —    | 1.3 |         |
| Output current                                | $I_O$                     |      | Fig.13.1.5   | $I_F = 10$ mA, $V_O = 0.6$ V   | 4.0  | —    | —   | mA      |
| Threshold input current (H/L)                 | $I_{FHL}$                 |      | —            | $I_O = 0.75$ mA, $V_O < 0.8$ V | —    | —    | 5.0 |         |
| Threshold input voltage (L/H)                 | $V_{FLH}$                 |      | —            | $I_O = 0.75$ mA, $V_O > 2.0$ V | 0.8  | —    | —   | V       |

Note: All typical values are at  $T_a = 25$  °C.

## 11. Isolation Characteristics (Unless otherwise specified, $T_a = 25$ °C)

| Characteristics                     | Symbol | Note     | Test Condition                  | Min       | Typ.      | Max | Unit     |
|-------------------------------------|--------|----------|---------------------------------|-----------|-----------|-----|----------|
| Total capacitance (input to output) | $C_S$  | (Note 1) | $V_S = 0$ V, $f = 1$ MHz        | —         | 0.8       | —   | pF       |
| Isolation resistance                | $R_S$  | (Note 1) | $V_S = 500$ V, R.H. $\leq 60$ % | $10^{12}$ | $10^{14}$ | —   | $\Omega$ |
| Isolation voltage                   | $BV_S$ | (Note 1) | AC, 60 s                        | 5000      | —         | —   | Vrms     |

Note 1: This device is considered as a two-terminal device: Pins 1, 2 and 3 are shorted together, and pins 4, 5 and 6 are shorted together.

## 12. Switching Characteristics (Note) (Unless otherwise specified, $T_a = -40$ to $125$ °C, $V_{CC} = 15$ V)

| Characteristics                              | Symbol                | Note                  | Test Circuit | Test Condition   | Min      | Typ.     | Max | Unit        |
|--|-----------------------|-----------------------|--------------|--|----------|----------|-----|-------------|
| Propagation delay time (H/L)                 | $t_{pHL}$             | (Note 1)              | Fig.13.1.6   | $I_F = 0 \rightarrow 10$ mA, $R_L = 20$ k $\Omega$ ,<br>$C_L = 100$ pF   | 30       | 150      | 400 | ns          |
|  |                       |                       |              | $I_F = 0 \rightarrow 10$ mA, $R_L = 20$ k $\Omega$ ,<br>$C_L = 10$ pF  | —        | 70       | —   |             |
| Propagation delay time (L/H)                 | $t_{pLH}$             | (Note 1)              |              | $I_F = 10 \rightarrow 0$ mA, $R_L = 20$ k $\Omega$ ,<br>$C_L = 100$ pF   | 150      | 350      | 550 |             |
|  |                       |                       |              | $I_F = 10 \rightarrow 0$ mA, $R_L = 20$ k $\Omega$ ,<br>$C_L = 10$ pF  | —        | 110      | —   |             |
| Pulse width distortion                       | $ t_{pHL} - t_{pLH} $ | (Note 1)              |              | $I_F = 10$ mA, $R_L = 20$ k $\Omega$ ,<br>$C_L = 100$ pF   | —        | —        | 400 |             |
| Propagation delay skew<br>(device to device) | $t_{psk}$             | (Note 1),<br>(Note 2) |              |  | -50      | —        | 450 |             |
| High-level common-mode<br>transient immunity | $CM_H$                |                       | Fig.13.1.7   | $V_{CM} = 1500$ V <sub>p-p</sub> , $I_F = 0$ mA,<br>$R_L = 20$ k $\Omega$ , $T_a = 25$ °C,<br>$C_L = 10$ pF or 100 pF  | $\pm 20$ | $\pm 25$ | —   | kV/ $\mu$ s |
| Low-level common-mode<br>transient immunity  | $CM_L$                |                       |              | $V_{CM} = 1500$ V <sub>p-p</sub> , $I_F = 10$ mA,<br>$R_L = 20$ k $\Omega$ , $T_a = 25$ °C,<br>$C_L = 10$ pF or 100 pF | $\pm 20$ | $\pm 25$ | —   |             |

Note: All typical values are at  $T_a = 25$  °C.

Note 1: Input signal ( $f = 10$  kHz, duty = 10 %, input current  $t_r = t_f = 5$  ns or less )

Note 2: The propagation delay skew,  $t_{psk}$ , is defined as the propagation delay time of the largest or smallest  $t_{pLH}$  minus the largest or smallest  $t_{pHL}$  of multiple samples. Evaluations of these samples are conducted under identical test conditions (supply voltage, input current, temperature, etc.).

## 13. Test Circuits and Characteristics Curves

### 13.1. Test Circuits

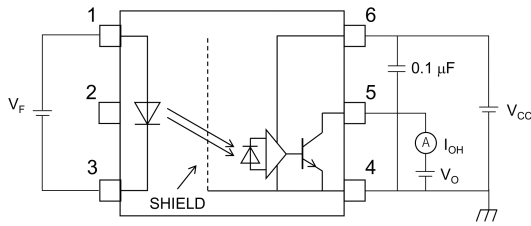


Fig. 13.1.1  $I_{OH}$  Test Circuit

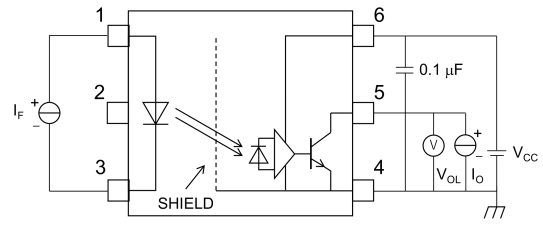


Fig. 13.1.2  $V_{OL}$  Test Circuit

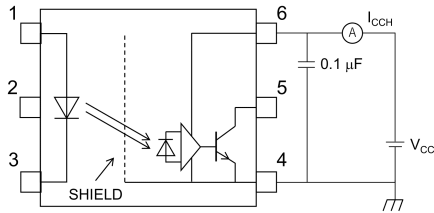


Fig. 13.1.3  $I_{CCH}$  Test Circuit

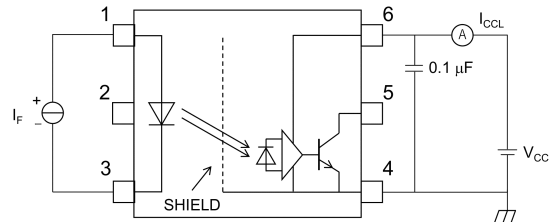


Fig. 13.1.4  $I_{CCL}$  Test Circuit

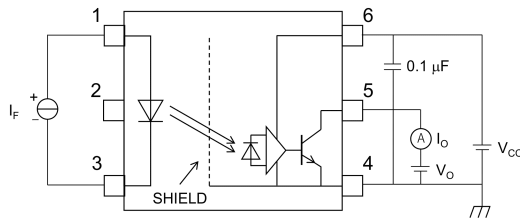
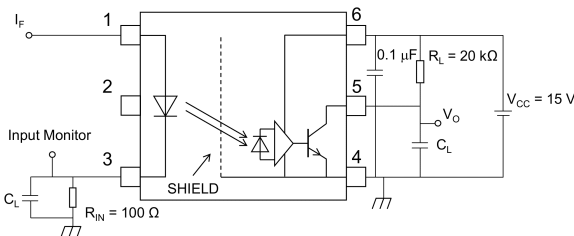


Fig. 13.1.5  $I_O$  Test Circuit

$I_F = 10 \text{ mA}$  (Pulse Generator)  
 $(f = 10 \text{ kHz, duty} = 10 \%, t_r = t_f = 5 \text{ ns or less})$



$C_L$  is 15 pF or less, which includes probe and stray wiring capacitance.

Fig. 13.1.6 Switching Time Test Circuit and Waveform

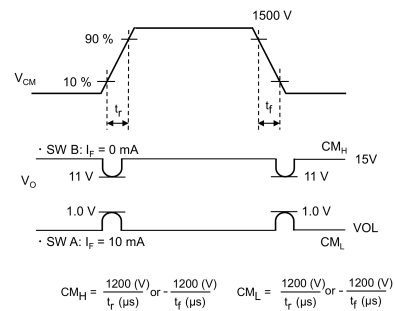
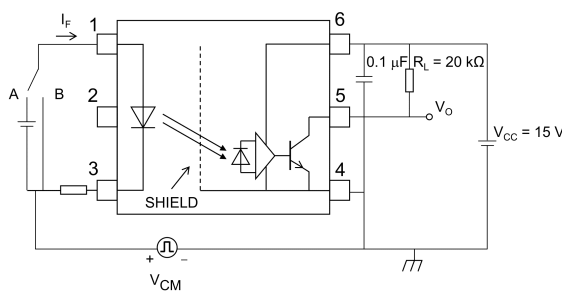
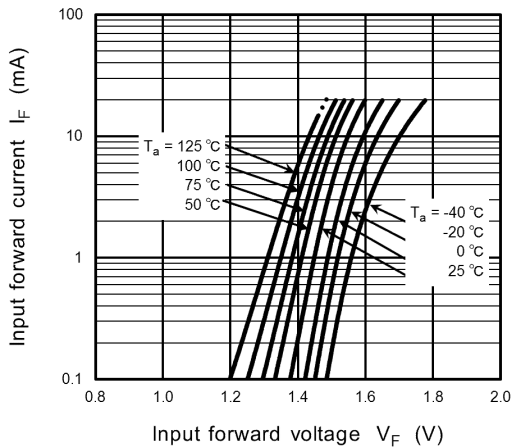
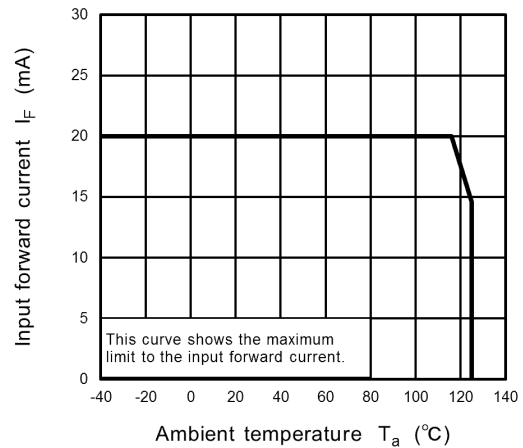


Fig. 13.1.7 Common-Mode Transient Immunity Test Circuit and Waveform

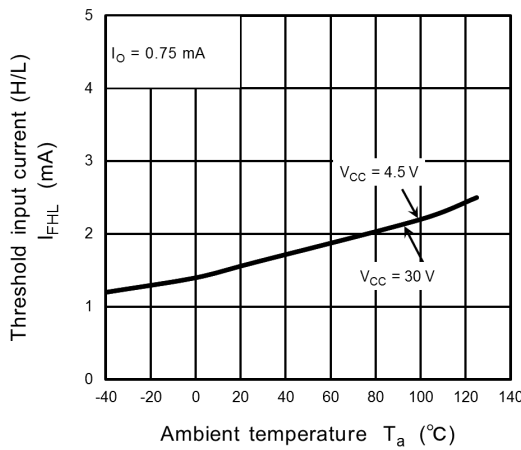
## 13.2. Characteristics Curves (Note)



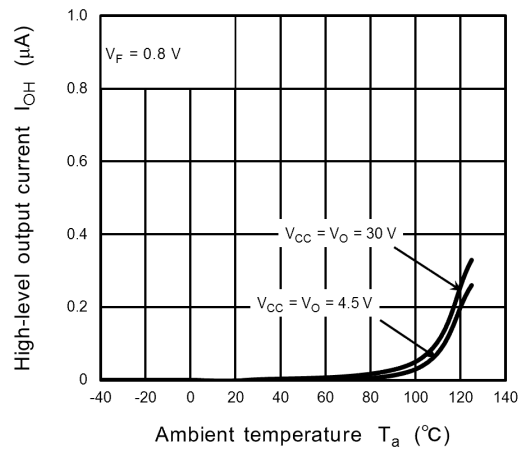
**Fig. 13.2.1**  $I_F - V_F$



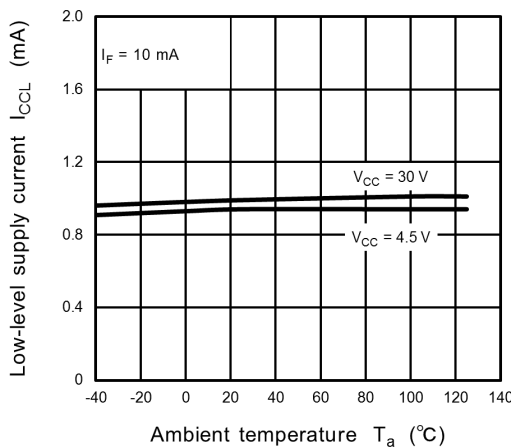
**Fig. 13.2.2**  $I_F - T_a$



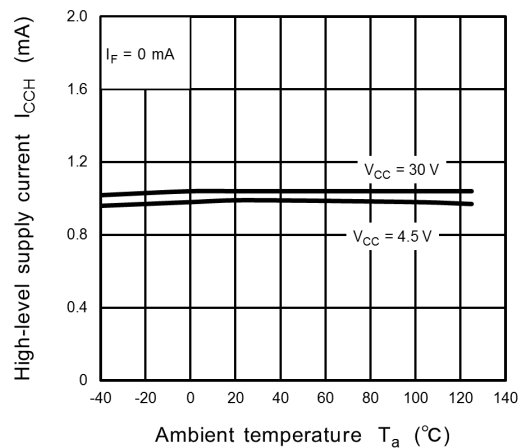
**Fig. 13.2.3**  $I_{FHL} - T_a$



**Fig. 13.2.4**  $I_{OH} - T_a$



**Fig. 13.2.5**  $I_{CCL} - T_a$



**Fig. 13.2.6**  $I_{CCH} - T_a$

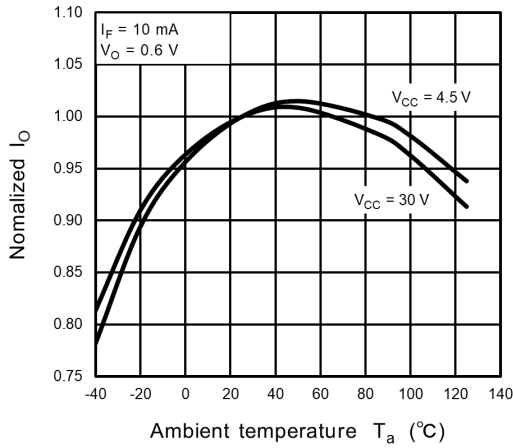


Fig. 13.2.7  $I_O - T_a$

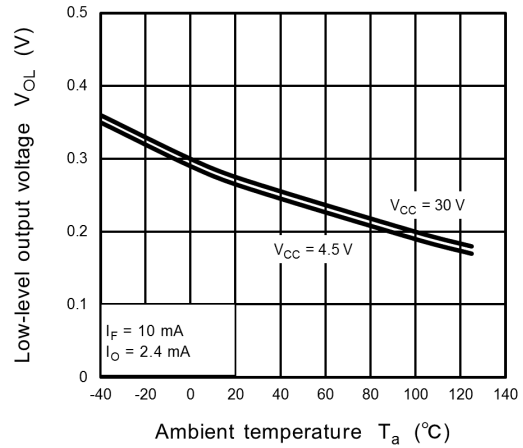


Fig. 13.2.8  $V_{OL} - T_a$

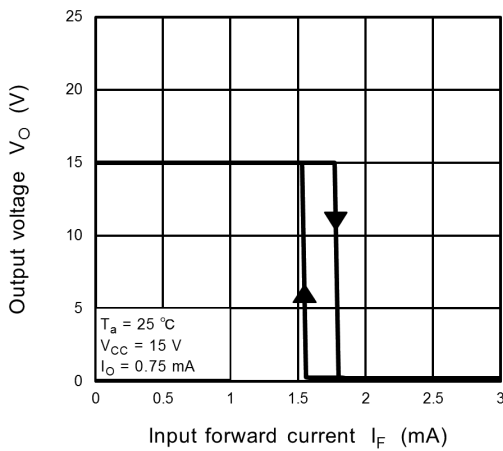


Fig. 13.2.9  $V_O - I_F$

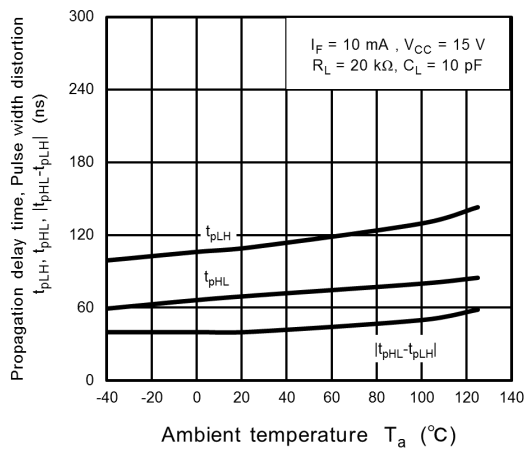


Fig. 13.2.10  $t_{pLH}, t_{pHL}, |t_{pHL} - t_{pLH}| - T_a$

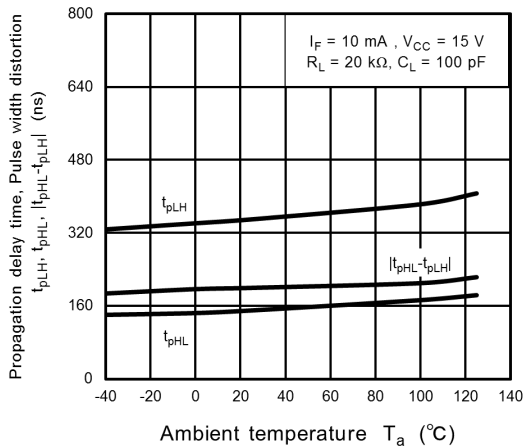


Fig. 13.2.11  $t_{pLH}, t_{pHL}, |t_{pHL} - t_{pLH}| - T_a$

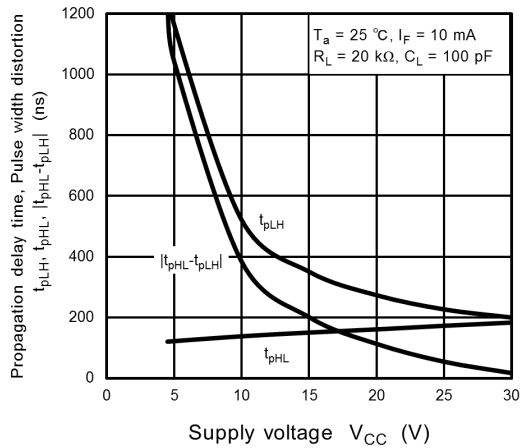
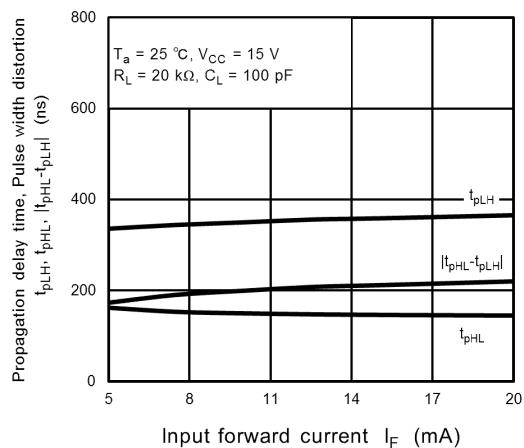


Fig. 13.2.12  $t_{pLH}, t_{pHL}, |t_{pHL} - t_{pLH}| - V_{CC}$



**Fig. 13.2.13**  $t_{pLH}, t_{pHL}, |t_{pHL} - t_{pLH}| - I_F$

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

## 14. Soldering and Storage

### 14.1. Precautions for Soldering

The soldering temperature should be controlled as closely as possible to the conditions shown below, irrespective of whether a soldering iron or a reflow soldering method is used.

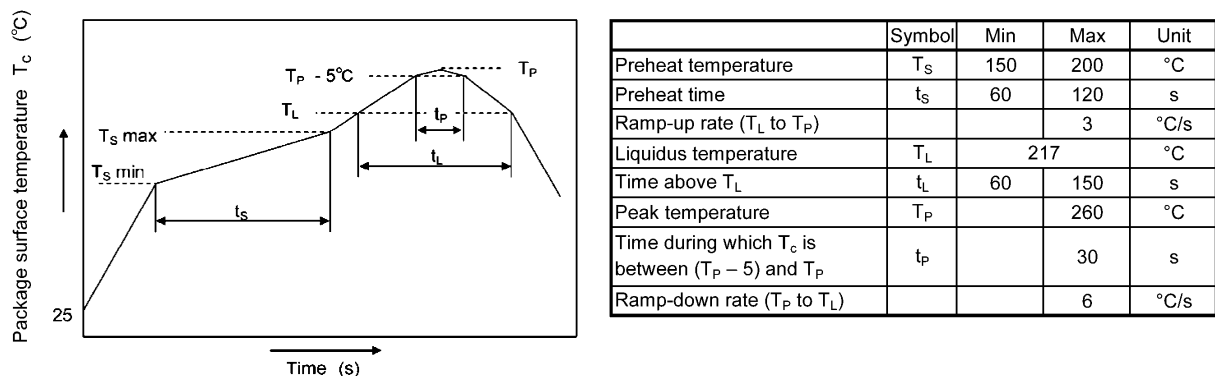
- When using soldering reflow.

The soldering temperature profile is based on the package surface temperature.

(See the figure shown below, which is based on the package surface temperature.)

Reflow soldering must be performed once or twice.

The mounting should be completed with the interval from the first to the last mountings being 2 weeks.



**Fig. 14.1.1 An Example of a Temperature Profile When Lead(Pb)-Free Solder Is Used**

- When using soldering flow  
Preheat the device at a temperature of 150 °C (package surface temperature) for 60 to 120 seconds.  
Mounting condition of 260 °C within 10 seconds is recommended.  
Flow soldering must be performed once.
- When using soldering Iron  
Complete soldering within 10 seconds for lead temperature not exceeding 260 °C or within 3 seconds not exceeding 350 °C  
Heating by soldering iron must be done only once per lead.

### 14.2. Precautions for General Storage

- Avoid storage locations where devices may be exposed to moisture or direct sunlight.
- Follow the precautions printed on the packing label of the device for transportation and storage.
- Keep the storage location temperature and humidity within a range of 5 °C to 35 °C and 45 % to 75 %, respectively.
- Do not store the products in locations with poisonous gases (especially corrosive gases) or in dusty conditions.
- Store the products in locations with minimal temperature fluctuations. Rapid temperature changes during storage can cause condensation, resulting in lead oxidation or corrosion, which will deteriorate the solderability of the leads.
- When restoring devices after removal from their packing, use anti-static containers.
- Do not allow loads to be applied directly to devices while they are in storage.

## 15. Land Pattern Dimensions (for reference only)

Unit: mm

TLP2704

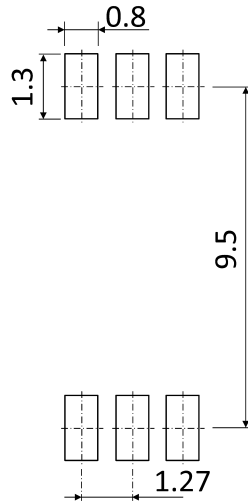


Fig. 15.1 Lead Forming Option (standard)

TLP2704(LF4)

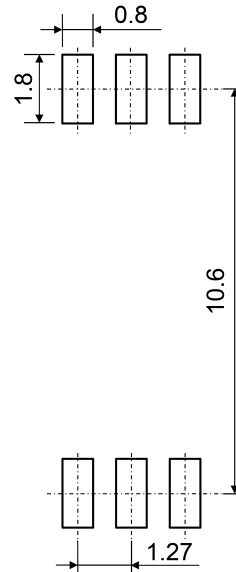
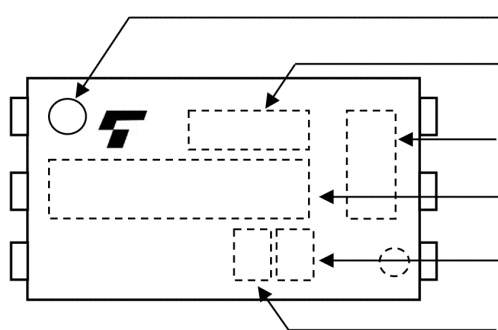


Fig. 15.2 Lead Forming Option (LF4)

## 16. Marking



Pin No. 1

Lot No.

Special indication

Part No. (Note)

Process Lot No.

Country / Region of origin  
e.g.) J: Japan, T: Thailand

Note: TLP2704

## 17. EN IEC 60747-5-5 Option (D4) Specification

- Part number: TLP2704 (Note)
- The following part naming conventions are used for the devices that have been qualified according to option (D4) of EN IEC 60747.

Example: TLP2704(D4-TP,E)

D4: EN IEC 60747 option

TP: Tape type

E: [[G]]/RoHS COMPATIBLE (Note 1)

Note: Use TOSHIBA standard type number for safety standard application.

e.g., TLP2704(D4-TP,E → TLP2704

Note 1: Please contact your Toshiba sales representative for details on environmental information such as the product's RoHS compatibility.

RoHS is the Directive 2011/65/EU of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment.

| Description   | Symbol   | Rating  | Unit              |
|---|--|---|-------------------|
| Application classification<br>for rated mains voltage ≤ 600 Vrms<br>for rated mains voltage ≤ 1000 Vrms   |  | I-IV<br>I-III   | —                 |
| Climatic classification   |  | 40 / 125 / 21   | —                 |
| Pollution degree  |  | 2   | —                 |
| Maximum operating insulation voltage  | V <sub>IORM</sub>                                    | 1230  | V <sub>peak</sub> |
| Input to output test voltage, Method A<br>V <sub>pr</sub> = 1.6 × V <sub>IORM</sub> , type and sample test<br>t <sub>p</sub> = 10 s, partial discharge < 5 pC   | V <sub>pr</sub>                                      | 1970  | V <sub>peak</sub> |
| Input to output test voltage, Method B<br>V <sub>pr</sub> = 1.875 × V <sub>IORM</sub> , 100 % production test<br>t <sub>p</sub> = 1 s, partial discharge < 5 pC   | V <sub>pr</sub>                                      | 2310  | V <sub>peak</sub> |
| Highest permissible overvoltage<br>(transient overvoltage, t <sub>pr</sub> = 60 s)  | V <sub>TR</sub>                                      | 8000  | V <sub>peak</sub> |
| Safety limiting values (max. permissible ratings in case of fault,<br>also refer to thermal derating curve)<br>current (input current I <sub>F</sub> , P <sub>so</sub> = 0)<br>power (output or total power dissipation)<br>temperature | I <sub>si</sub><br>P <sub>so</sub><br>T <sub>s</sub> | 300<br>700<br>150   | mA<br>mW<br>°C    |
| Insulation resistance<br>V <sub>IO</sub> = 500 V, T <sub>a</sub> = 25 °C<br>V <sub>IO</sub> = 500 V, T <sub>a</sub> = 100 °C<br>V <sub>IO</sub> = 500 V, T <sub>a</sub> = T <sub>s</sub>  | R <sub>si</sub>                                      | ≥ 10 <sup>12</sup><br>≥ 10 <sup>11</sup><br>≥ 10 <sup>9</sup> | Ω                 |

Fig. 17.1 EN IEC 60747 Insulation Characteristics

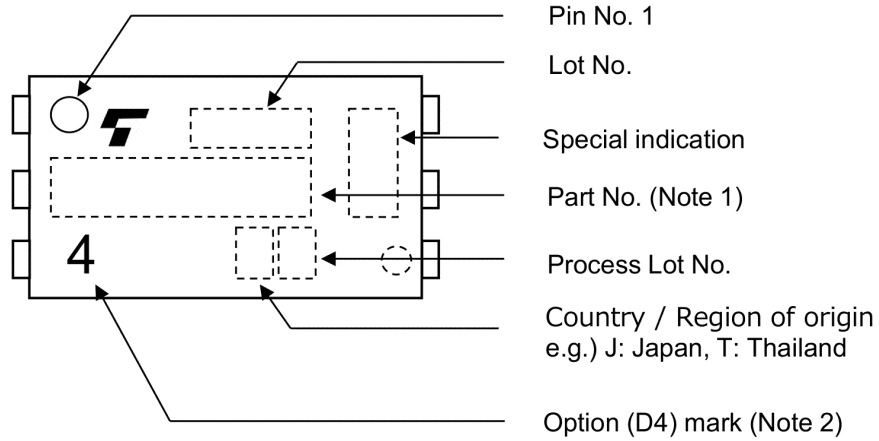
|                              |     |        |
|------------------------------|-----|--------|
| Minimum creepage distance    | Cr  | 8.0 mm |
| Minimum clearance            | Cl  | 8.0 mm |
| Minimum insulation thickness | ti  | 0.4 mm |
| Comparative tracking index   | CTI | 500    |

**Fig. 17.2 Insulation Related Specifications (Note)**

Note: This photocoupler is suitable for **safe electrical isolation** only within the safety limit data. Maintenance of the safety data shall be ensured by means of protective circuits.



**Fig. 17.3 Marking on Packing**



**Fig. 17.4 Marking Example**

Note1: TLP2704

Note2: The above marking is applied to the photocouplers that have been qualified according to option (D4) of EN IEC 60747.

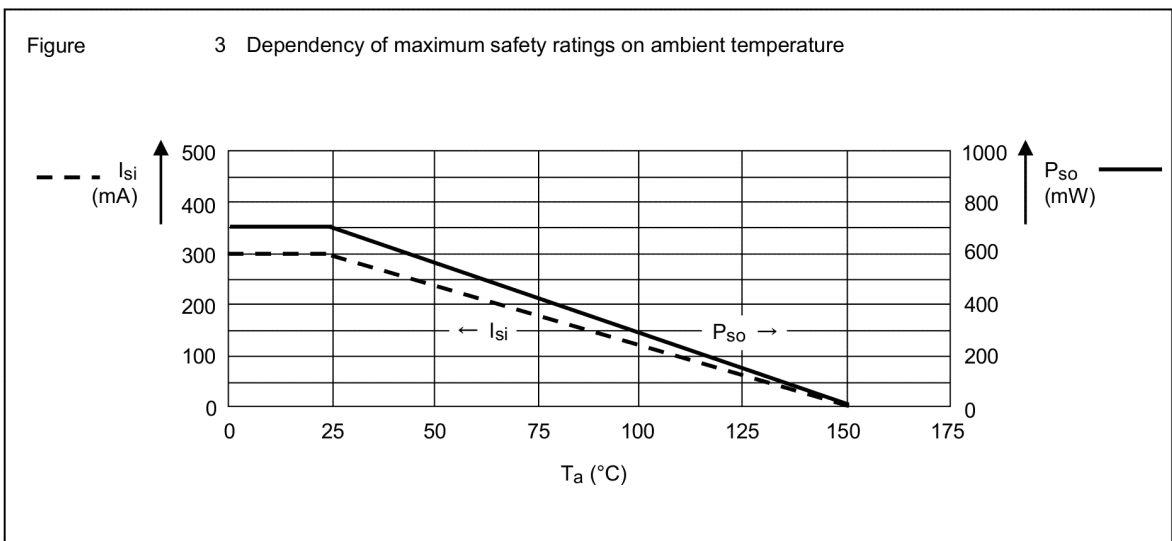
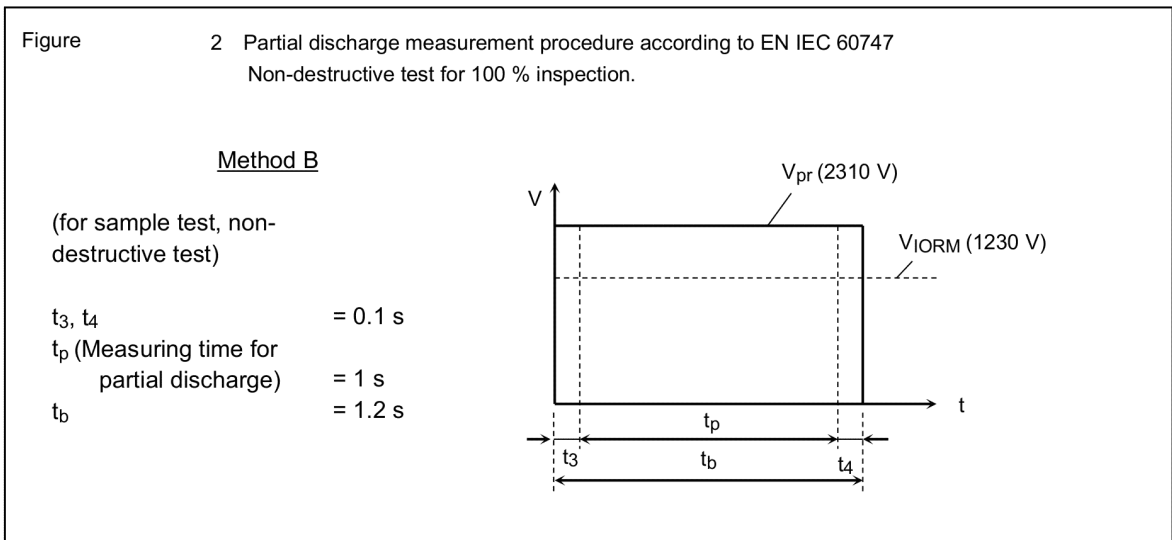
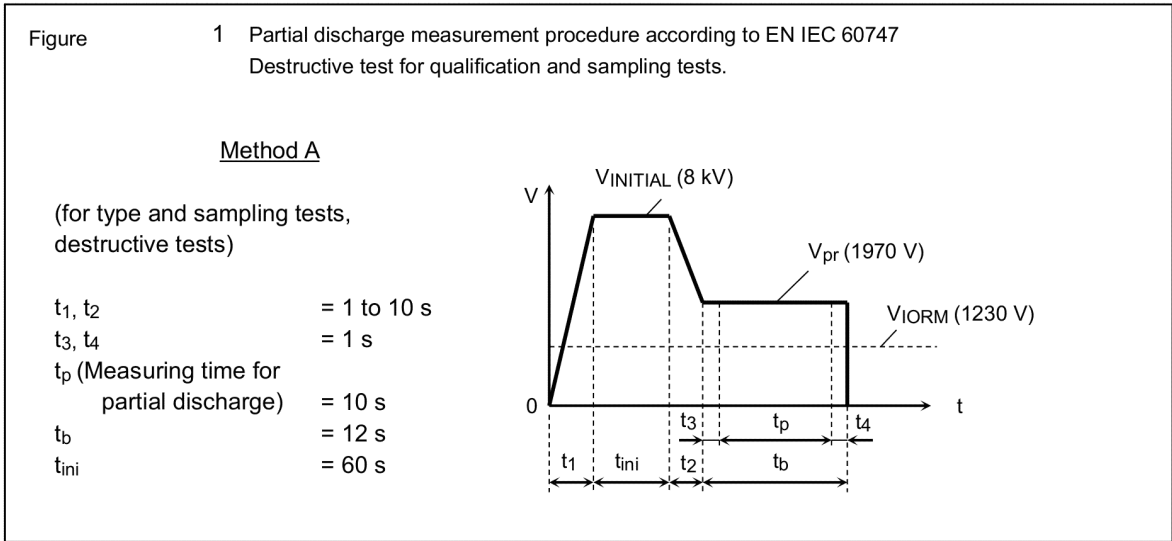


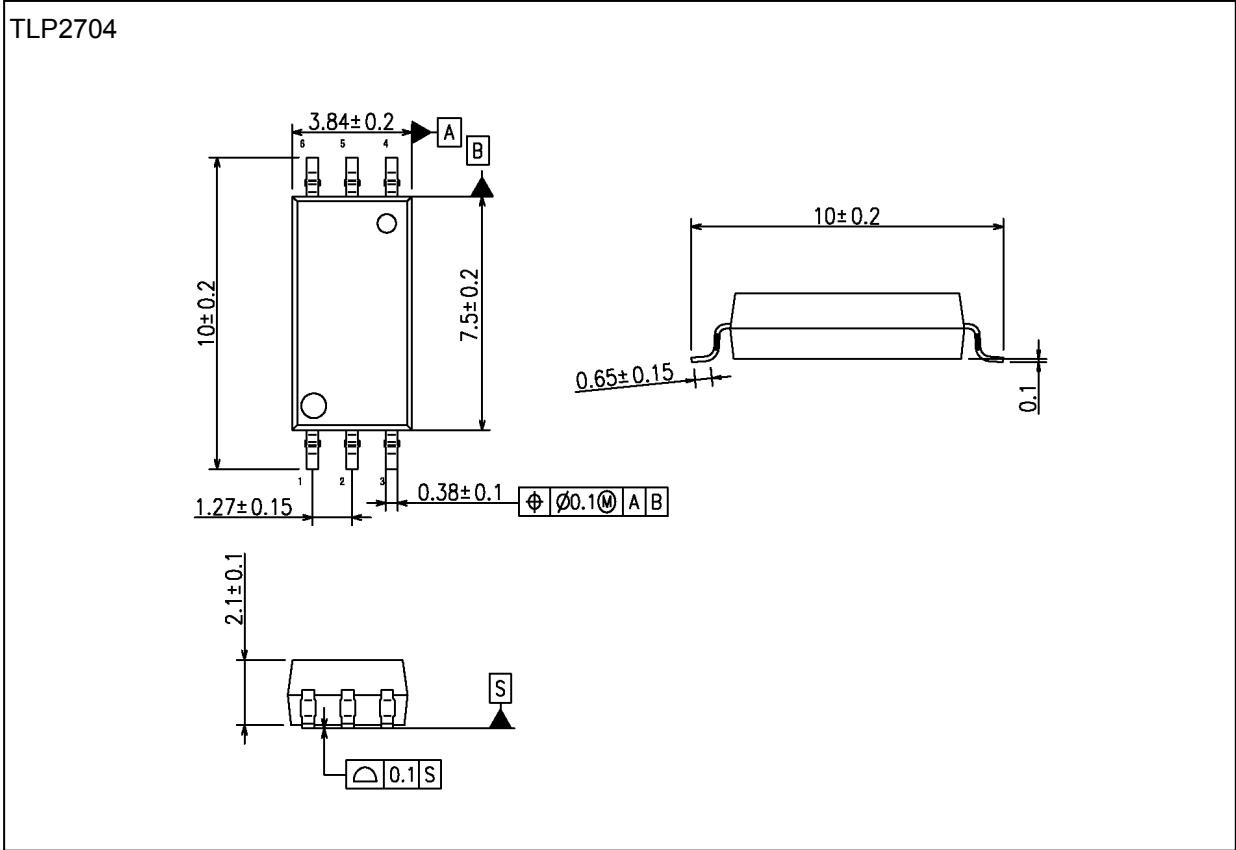
Fig. 17.5 Measurement Procedure

## 18. Ordering Information (Example of Item Name)

| Item Name        | Packaging         | VDE Option   | Packing (MOQ)            |
|------------------|-------------------|--------------|--------------------------|
| TLP2704(E        |                   |              | Magazine (125 pcs)       |
| TLP2704(TP,E     |                   |              | Tape and reel (1500 pcs) |
| TLP2704(D4,E     |                   | EN 60747-5-5 | Magazine (125 pcs)       |
| TLP2704(D4-TP,E  |                   | EN 60747-5-5 | Tape and reel (1500 pcs) |
| TLP2704(LF4,E    | LF4, Wide forming |              | Magazine (125 pcs)       |
| TLP2704(TP4,E    | LF4, Wide forming |              | Tape and reel (1500 pcs) |
| TLP2704(D4-LF4,E | LF4, Wide forming | EN 60747-5-5 | Magazine (125 pcs)       |
| TLP2704(D4-TP4,E | LF4, Wide forming | EN 60747-5-5 | Tape and reel (1500 pcs) |

Package Dimensions

Unit: mm

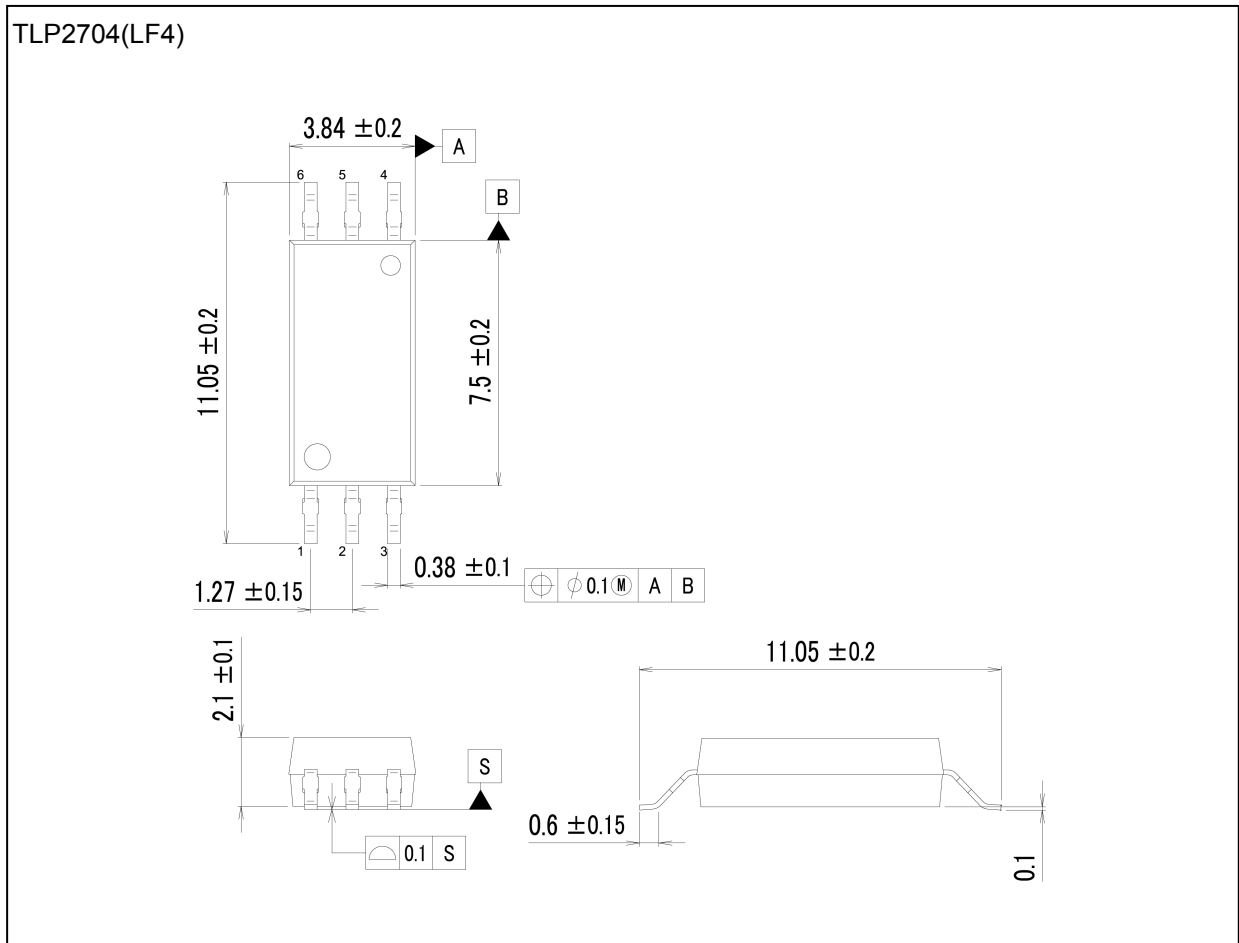


Weight: 0.126 g (typ.)

| Package Name(s)  |
|------------------|
| TOSHIBA: 11-4N1A |

## Package Dimensions

Unit: mm



Weight: 0.126 g (typ.)

| Package Name(s)    |
|--------------------|
| TOSHIBA: 11-4N101A |

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