Photocouplers Optically Isolation Amplifiers

# TLP7920,TLP7920F

## 1. Applications

- Motor phase and rail current sensing
- Power inverter current and voltage sensing

## 2. General

The TLP7920 and TLP7920F of isolation amplifiers is designed for current sensing in electronic motor drives. In a typical implementation, motor currents flow through an external resistor and the resulting analog voltage drop is sensed by the TLP7920 or TLP7920F.

## 3. Features

(1) Output side supply voltage: 3.0 to 5.5 V
(2) Output side supply current: 6.2 mA (typ.)
(3) Operating temperature range: -40 to 105 ℃
(4) Common-mode transient immunity: 15 kV/μs (min)
(5) 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 Factory

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

Start of commercial production
2015-09

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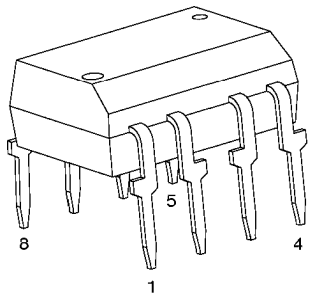
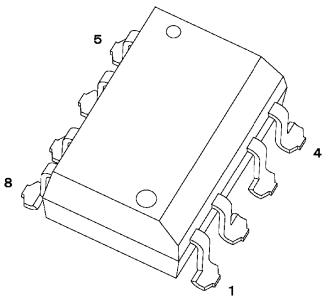
## 4. Packaging (Note)

TLP7920



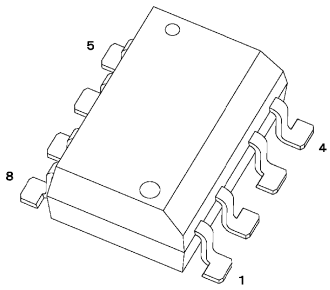

11-10C4S

TLP7920(LF1,TP1)



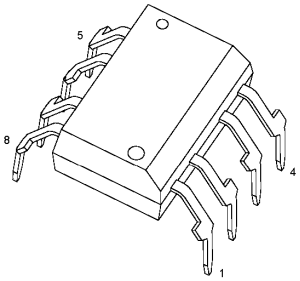

11-10C401S

TLP7920(LF5,TP5)



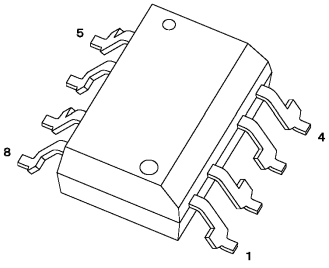

11-10C405S

TLP7920F




11-10C402S

TLP7920F(LF4,TP4)




11-10C404S

Note: Through-hole type: TLP7920, TLP7920F
Lead forming option: (LF1),(LF4),(LF5)
Taping option: (TP1),(TP4),(TP5)

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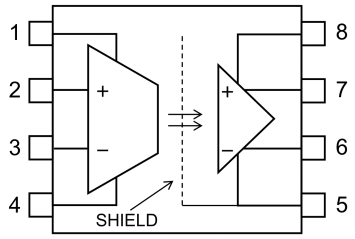
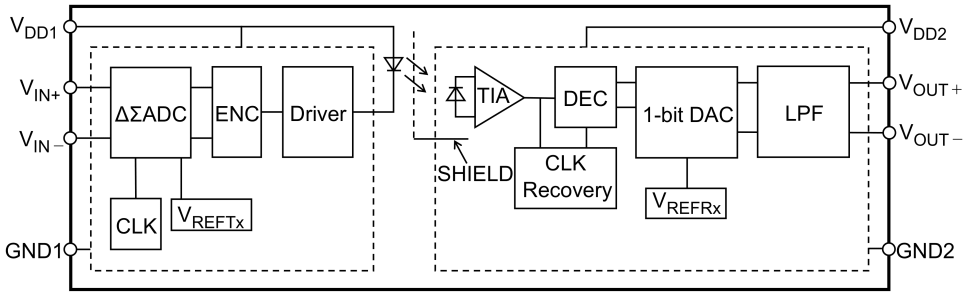
## 5. Pin Assignment




### 5.1. Pin Functions

| Pin No. | Symbol | Description |
|---|---|---|
| 1 | $V_{DD1}$ | Input side supply voltage |
| 2 | $V_{IN+}$ | Positive input |
| 3 | $V_{IN-}$ | Negative input |
| 4 | GND1 | Input side ground |
| 5 | GND2 | Output side ground |
| 6 | $V_{OUT-}$ | Negative output |
| 7 | $V_{OUT+}$ | Positive output |
| 8 | $V_{DD2}$ | Output side supply voltage |

## 6. Internal Circuit (Note)




Note: A 0.1 μF bypass capacitor must be connected between 1 and 4 pins and between 5 and 8 pins.

## 7. Principle of Operation

### 7.1. Mechanical Parameters

| Characteristics | 7.62-mm Pitch TLP7920 | 10.16-mm Pitch TLP7920F | Unit |
|---|---|---|---|
| Creepage distances | 7.0 (min) | 8.0 (min) | mm |
| Clearance | 7.0 (min) | 8.0 (min) | |
| Internal isolation thickness | 0.4 (min) | 0.4 (min) | |

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

| Characteristics | | Symbol | Note | Rating | Unit |
|---|---|---|---|---|---|
| Supply voltages | | $V_{DD1}$, $V_{DD2}$ | | -0.5 to 6 | V |
| Steady-state input voltages | | $V_{IN+}$, $V_{IN-}$ | | -0.5 to $V_{DD1}$ + 0.5 | |
| Two-second transient input voltages | | $V_{IN+}$, $V_{IN-}$ | | -0.5 to 6 | |
| Input power dissipation | | $P_D$ | (Note 1) | 72 | mW |
| Output voltages | | $V_{OUT+}$, $V_{OUT-}$ | | -0.5 to 6 | V |
| Output power dissipation | | $P_O$ | (Note 1) | 60 | mW |
| Operating temperature | | $T_{opr}$ | | -40 to 105 | °C |
| Storage temperature | | $T_{stg}$ | | -55 to 125 | °C |
| Lead soldering temperature | (10 s) | $T_{sol}$ | (Note 2) | 260 | °C |
| Isolation voltage | AC, 60 s, R.H. ≤ 60 % | $BV_S$ | (Note 3) | 5000 | Vrms |

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: Ceramic capacitors (0.1 μF) should be connected between 1 and 4 pins and between 5 and 8 pins to stabilize the operation. Otherwise, this photocoupler may not switch properly. The bypass capacitors should be placed as close as possible to each pin.

Note 1: Input power dissipation derating($T_a$≥ 114.2 °C): -6.7 mW/°C
Output power dissipation derating($T_a$≥ 116.0 °C): -6.7 mW/°C

Note 2: ≥ 2 mm below seating plane.

Note 3: This device is considered as a two-terminal device: Pins 1, 2, 3 and 4 are shorted together, and pins 5, 6, 7 and 8 are shorted together.

## 9. Recommended Operating Conditions (Note)

| Characteristics | Symbol | Note | Min | Typ. | Max | Unit |
|---|---|---|---|---|---|---|
| Input side supply voltage | $V_{DD1}$ | | 4.5 | 5 | 5.5 | V |
| Output side supply voltage | $V_{DD2}$ | | 3.0 | — | 5.5 | |
| Analog input voltage | $V_{IN+}$, $V_{IN-}$ | (Note 1), (Note 2) | -200 | — | 200 | mV |
| Ambient temperature | $T_a$ | | -40 | — | 105 | °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 1: FSR = ±300 mV

Note 2: When either $V_{IN+}$ or $V_{IN-}$ or both are equal to or greater than $V_{DD1}$ - 2 V (e.g., if $V_{DD1}$ = 5 V, when $V_{IN+}$ and/or $V_{IN-}$ are equal to or greater than 5 V - 2 V = 3 V), isolation amplifiers go into one of the test modes. Do not raise either $V_{IN+}$ or $V_{IN-}$ above this voltage to keep the device in functional mode.

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## 10. Electrical Characteristics

### 10.1. DC Characteristics (Unless otherwise specified, $T_a$ = -40 to 105 °C, $V_{DD1}$ = 4.5 to 5.5 V, $V_{DD2}$ = 3.0 to 5.5 V, $V_{IN+}$ = -200 to 200 mV, $V_{IN-}$ = 0 V)

| Characteristics | Symbol | Note | Test Condition | Min | Typ. | Max | Unit |
|---|---|---|---|---|---|---|---|
| Input offset voltage | $V_{OS}$ | | $T_a$ = 25 °C | -0.7 | 0.73 | 2.1 | mV |
| Input offset voltage drift vs ambient temperature | $\lvert dV_{OS}/dT_a \rvert$ | | | — | 3 | 10 | μV/°C |
| Input offset voltage drift vs input side supply voltage | $\lvert dV_{OS}/dV_{DD1} \rvert$ | | | — | 120 | — | μV/V |
| Gain (Rank B) | $G_0$ | (Note 1) | $T_a$ = 25 °C | — | — | — | V/V |
| Gain (Rank A) | $G_1$ | | $T_a$ = 25 °C | — | — | — | |
| Gain (None) | $G_3$ | | $T_a$ = 25 °C | — | — | — | |
| Gain drift vs ambient temperature | $\lvert dG/dT_a \rvert$ | | | — | 0.00012 | — | V/V/°C |
| $V_{OUT}$ non-linearity (±200 mV) | $NL_{200}$ | (Note 2) | $V_{IN+}$ = -200 to 200 mV, $T_a$ = 25 °C | — | 0.02 | 0.13 | % |
| $V_{OUT}$ non-linearity (±200 mV) drift vs ambient temperature | $\lvert dNL_{200}/dT_a \rvert$ | | | — | 0.00007 | — | %/°C |
| $V_{OUT}$ non-linearity (±100 mV) | $NL_{100}$ | (Note 2) | $V_{IN+}$ = -100 to 100 mV, $T_a$ = 25 °C | — | 0.01 | 0.06 | % |
| High-level output voltage | $V_{OH}$ | | $V_{IN+}$ = 400 mV, $T_a$ = 25 °C | — | 2.497 | — | V |
| Low-level output voltage | $V_{OL}$ | | $V_{IN+}$ = -400 mV, $T_a$ = 25 °C | — | 0.0009 | — | |
| Input common-mode rejection ratio | $CMRR_{IN}$ | | | — | 80 | — | dB |
| Input bias current | $I_{IN+}$ | | $V_{IN+}$ = 0 V, $T_a$ = 25 °C | -1 | -0.055 | — | μA |
| Input side supply current ($V_{DD1}$) | $I_{DD1}$ | | $V_{IN+}$ = 0 V | — | 8.6 | 12 | mA |
| Output side supply current ($V_{DD2}$) | $I_{DD2}$ | | $V_{IN+}$ = 0 V | — | 6.2 | 10 | mA |
| Equivalent input resistance | $R_{IN}$ | | | — | 80 | — | kΩ |

Note 1: See Chapter 10.1.1 for gain rank values.

Note 2: The slope of the optimum line is derived by the method of least squares between differential input voltage ($V_{IN+}$ - $V_{IN-}$) and differential output voltage ($V_{OUT+}$ - $V_{OUT-}$). Nonlinearity is defined as a fraction of the half of the peak-to-peak value of differential output voltage deviation divided by the full-scale differential output voltage (OVR).

#### 10.1.1. Gain Rank (Note) (Unless otherwise specified, $T_a$ = 25 °C)

| Rank | Gain Rank Marking | Gain (Min) | Gain (Typ.) | Gain (Max) | Unit |
|---|---|---|---|---|---|
| None (±3 %) | Blank, A, B | 7.95 | 8.2 | 8.44 | V/V |
| Rank A (±1 %) | A, B | 8.12 | 8.2 | 8.28 | |
| Rank B (±0.5 %) | B | 8.16 | 8.2 | 8.24 | |

Note: The gain is defined as the slope of the optimum line derived by the method of least squares between differential input voltage ($V_{IN+}$ - $V_{IN-}$) and differential output voltage ($V_{OUT+}$ - $V_{OUT-}$) in the recommended voltage range.

Note: Specify both the part number and a rank in this format when ordering.
Example: TLP7920(B,F(O
For safety standard certification, however, specify the part number alone.
Example: TLP7920(B,F(O → TLP7920

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### 10.2. AC Characteristics (Note) (Unless otherwise specified, $T_a$ = -40 to 105 °C, $V_{DD1}$ = 4.5 to 5.5 V, $V_{DD2}$ = 3.0 to 5.5 V)

| Characteristics | Symbol | Test Condition | Min | Typ. | Max | Unit |
|---|---|---|---|---|---|---|
| $V_{OUT}$ bandwidth (-3 dB) | $f_{-3dB}$ | $V_{IN+}$ = 400 $mV_{p-p}$, sine wave | 140 | 230 | — | kHz |
| $V_{IN}$ to $V_{OUT}$ propagation delay time (10 %-10 %) | $t_{pD10}$ | $V_{IN+}$ = 0 to 200 mV/μs step<br>$C_L$ = 15 pF | — | 1.9 | 2.3 | μs |
| $V_{IN}$ to $V_{OUT}$ propagation delay time (50 %-50 %) | $t_{pD50}$ | | — | 2.3 | 2.6 | |
| $V_{IN}$ to $V_{OUT}$ propagation delay time (90 %-90 %) | $t_{pD90}$ | | — | 2.8 | 3.3 | |
| $V_{OUT}$ rise time | $t_r$ | | — | 1.7 | — | |
| $V_{OUT}$ fall time | $t_f$ | | — | 1.7 | — | |
| Common-mode transient immunity | CMTI | $V_{CM}$ = 1 kV, $T_a$ = 25 °C | 15 | 20 | — | kV/μs |

Note: All typical values are at $T_a$ = 25 °C.
$C_L$ is approximately 15 pF which includes probe and stray wiring capacitance.

## 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 | — | 1.0 | — | pF |
| Isolation resistance | $R_S$ | | $V_S$ = 500 V, R.H. ≤ 60 % | $1 \times 10^{12}$ | $10^{14}$ | — | Ω |
| Isolation voltage | $BV_S$ | | AC, 60 s | 5000 | — | — | Vrms |

Note 1: This device is considered as a two-terminal device: Pins 1, 2, 3 and 4 are shorted together, and pins 5, 6, 7 and 8 are shorted together.

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## 12. Characteristics Curves (Note)

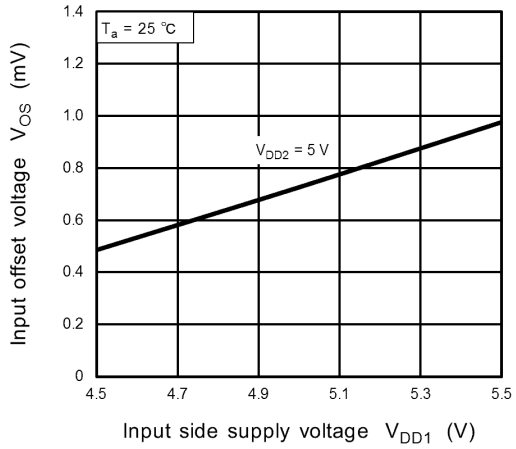


Fig. 12.1 $V_{OS}$ - $V_{DD1}$

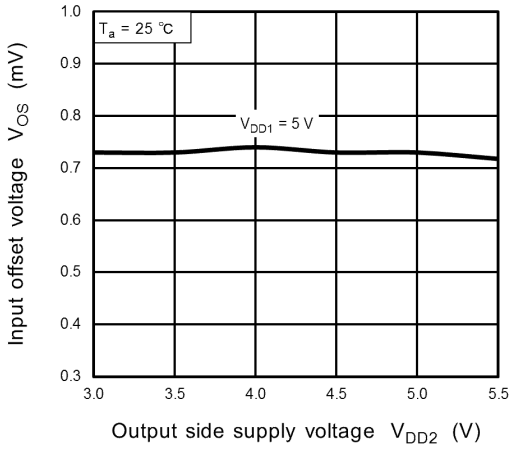


Fig. 12.2 $V_{OS}$ - $V_{DD2}$

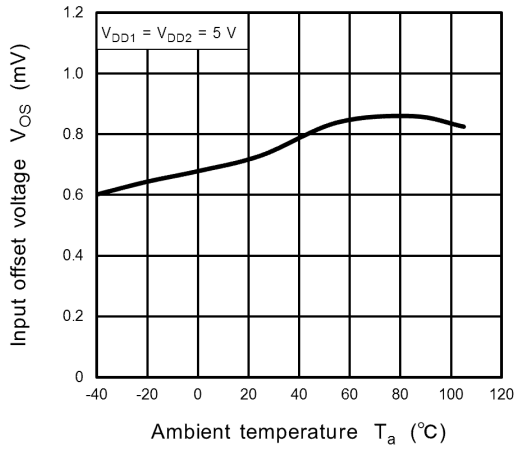


Fig. 12.3 $V_{OS}$ - $T_a$

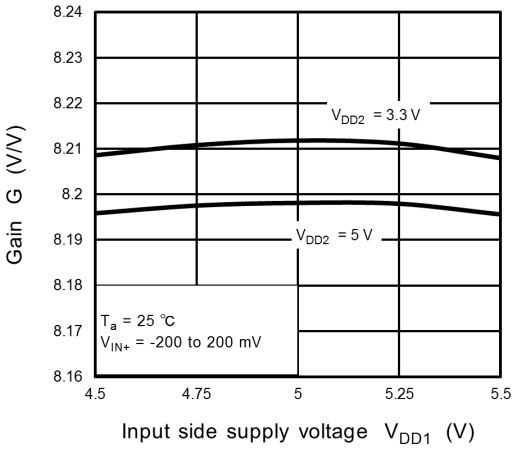


Fig. 12.4 G - $V_{DD1}$

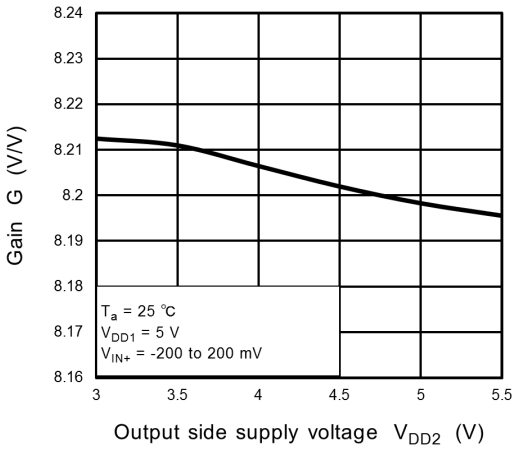


Fig. 12.5 G - $V_{DD2}$

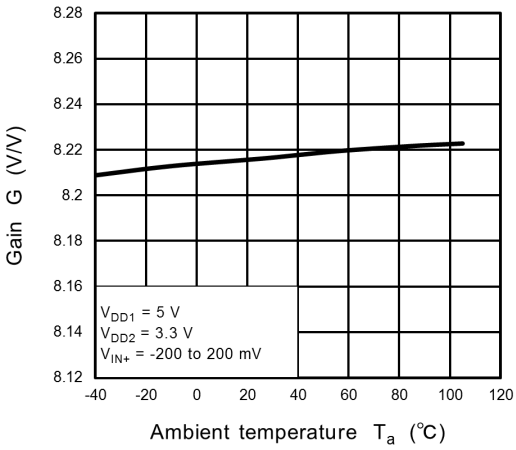


Fig. 12.6 G - $T_a$

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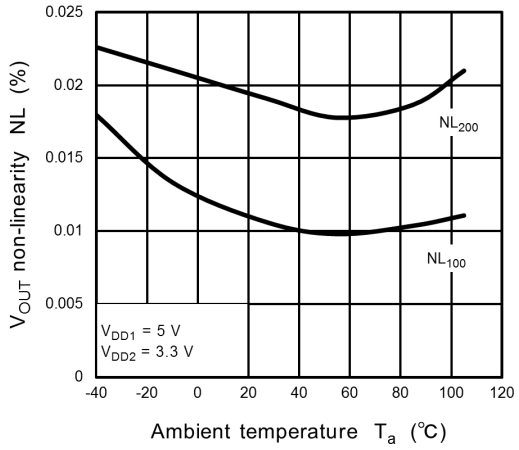


**Fig. 12.7 NL - $T_a$**

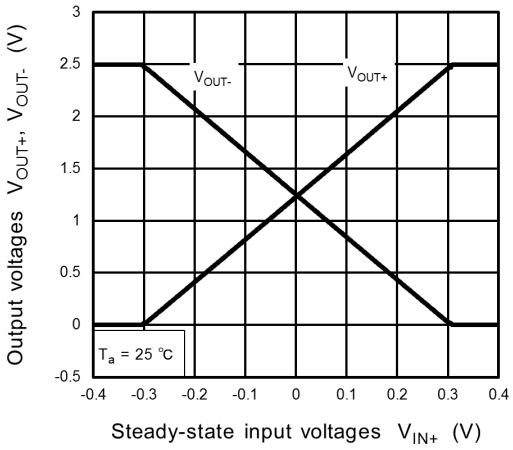


**Fig. 12.8 $V_{OUT}$ - $V_{IN+}$**

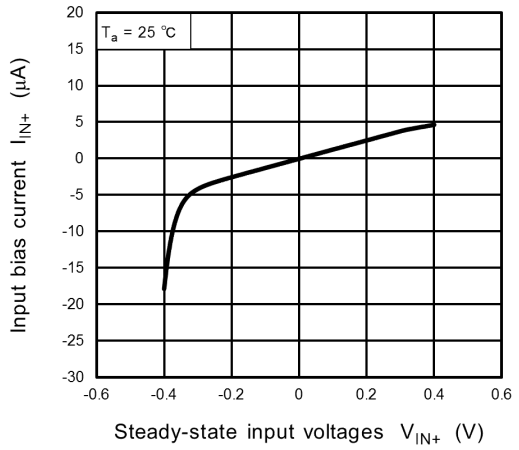


**Fig. 12.9 $I_{IN+}$ - $V_{IN+}$**

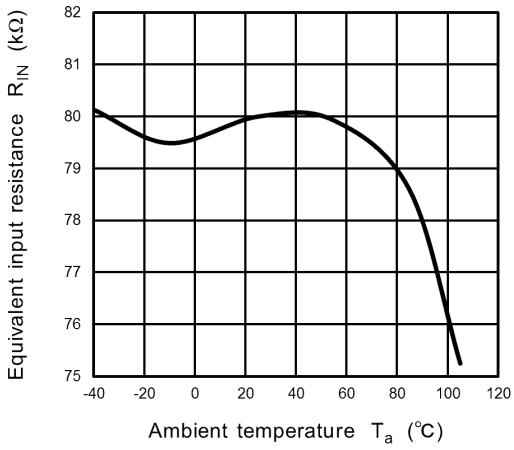


**Fig. 12.10 $R_{IN}$ - $T_a$**

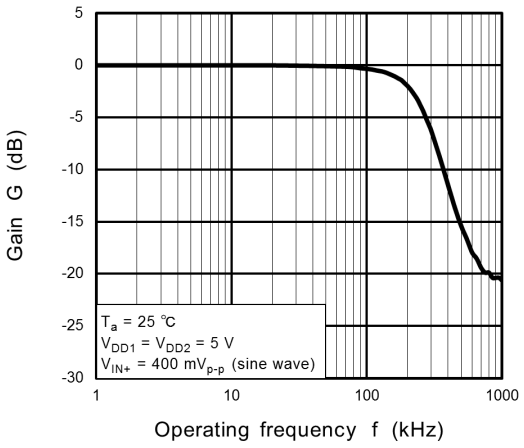


**Fig. 12.11 G[dB] - f**

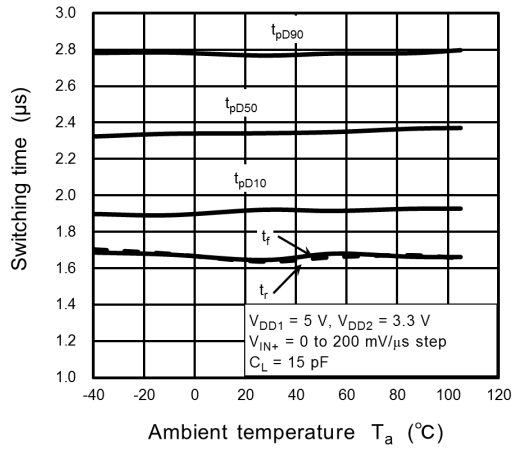


**Fig. 12.12 Switching time - $T_a$**

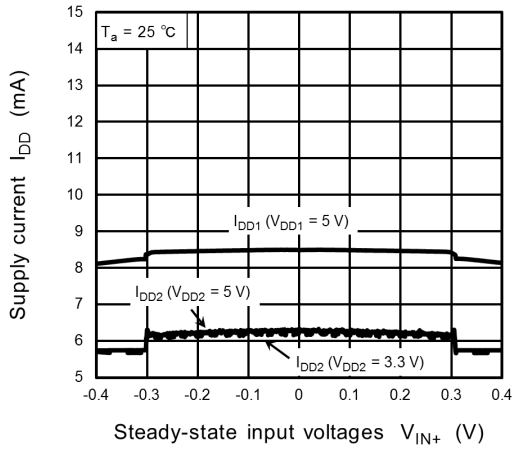


**Fig. 12.13 $I_{DD}$ - $V_{IN+}$**

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

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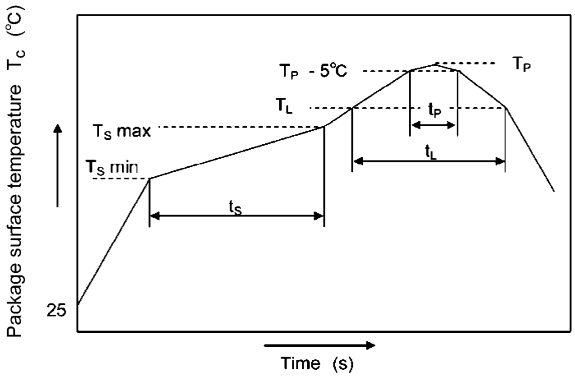
# 13. Soldering and Storage

## 13.1. 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.




| | Symbol | Min | Max | Unit |
|---|---|---|---|---|
| Preheat temperature | $T_S$ | 150 | 200 | °C |
| Preheat time | $t_S$ | 60 | 120 | s |
| Ramp-up rate ($T_L$ to $T_P$) | | | 3 | °C/s |
| Liquidus temperature | $T_L$ | 217 | | °C |
| Time above $T_L$ | $t_L$ | 60 | 150 | s |
| Peak temperature | $T_P$ | | 260 | °C |
| Time during which $T_c$ is between ($T_P$ – 5) and $T_P$ | $t_P$ | | 30 | s |
| Ramp-down rate ($T_P$ to $T_L$) | | | 6 | °C/s |

**Fig. 13.1.1 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.

## 13.2. 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.

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

Unit：mm

TLP7920

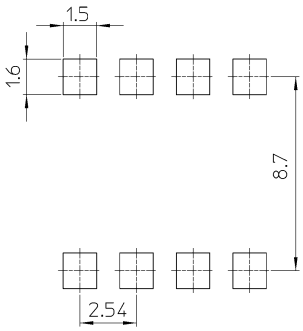



Fig. 14.1 Lead forming and taping option (LF1), (TP1), (LF5), (TP5)

TLP7920F

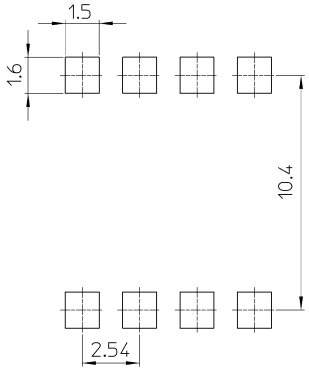
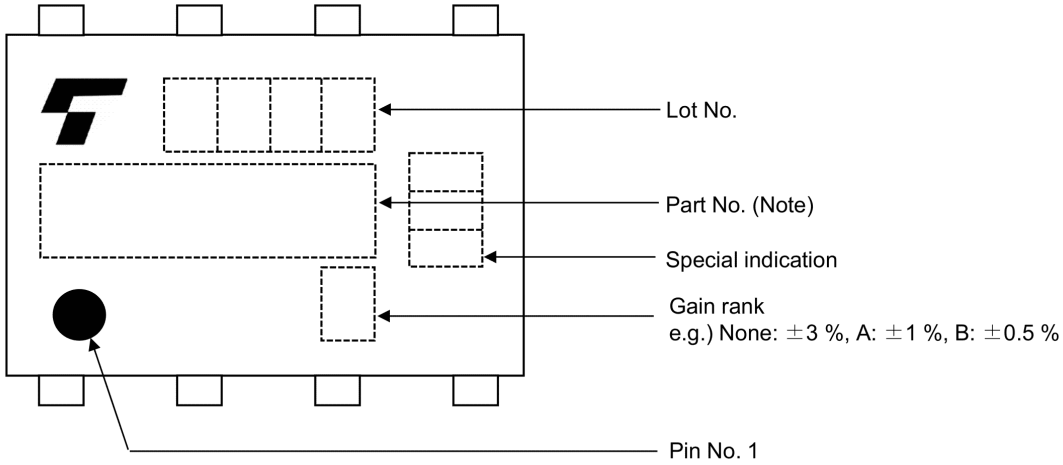



Fig. 14.2 Lead forming and taping option (LF4), (TP4)

## 15. Marking




Note: TLP7920 / TLP7920F

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

- Example: TLP7920 **(Note 1)**
- The following part naming conventions are used for the devices that have been qualified according to option (D4) of EN IEC 60747.

Example: TLP7920(D4ATP1,F(O

D4: EN IEC 60747 option
A: Gain Rank
TP1: Tape type
F: [[G]]/RoHS COMPATIBLE **(Note 2)**
(O: Domestic ID (Country / Region of origin: Japan)

Note 1: Use TOSHIBA standard type number for safety standard application.
e.g., TLP7920(D4ATP1,F(O → TLP7920

Note 2: 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><br>for rated mains voltage ≤ 600 Vrms<br>for rated mains voltage ≤ 1000 Vrms | | | <br><br>I-IV<br>I-III | — |
| Climatic classification | | | 40 / 105 / 21 | — |
| Pollution degree | | | 2 | — |
| Maximum operating insulation voltage | TLPxxx type | $V_{IORM}$ | 890 | Vpeak |
| | TLPxxxF type | | 1140 | |
| Input to output test voltage, Method A<br>$V_{pr}$ = 1.6 × $V_{IORM}$, type and sample test<br>$t_p$ = 10 s, partial discharge < 5 pC | TLPxxx type | $V_{pr}$ | 1424 | Vpeak |
| | TLPxxxF type | | 1824 | |
| Input to output test voltage, Method B<br>$V_{pr}$ = 1.875 × $V_{IORM}$, 100 % production test<br>$t_p$ = 1 s, partial discharge < 5 pC | TLPxxx type | $V_{pr}$ | 1670 | Vpeak |
| | TLPxxxF type | | 2140 | |
| Highest permissible overvoltage<br>(transient overvoltage, $t_{pr}$ = 60 s) | | $V_{TR}$ | 8000 | Vpeak |
| Safety limiting values (max. permissible ratings in case of fault, also refer to thermal derating curve)<br>current (input current $I_F$, $P_{SO}$ = 0)<br>power (output or total power dissipation)<br>temperature | | <br>$I_{si}$<br>$P_{SO}$<br>$T_S$ | <br>400<br>700<br>150 | <br>mA<br>mW<br>°C |
| Insulation resistance | $V_{IO}$ = 500 V, $T_a$ = 25 °C<br>$V_{IO}$ = 500 V, $T_a$ = 100 °C<br>$V_{IO}$ = 500 V, $T_a$ = $T_S$ | $R_{si}$ | ≥ $10^{12}$<br>≥ $10^{11}$<br>≥ $10^{9}$ | Ω |

**Fig. 16.1 EN IEC 60747 Insulation Characteristics**

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**Table Insulation Related Specifications (Note)**

| Insulation Related Parameters | Symbol | TLP7920 | TLP7920F |
|---|---|---|---|
| Minimum creepage distance | Cr | 7.0 mm | 8.0 mm |
| Minimum clearance | Cl | 7.0 mm | 8.0 mm |
| Minimum insulation thickness | ti | 0.4 mm | 0.4 mm |
| Comparative tracking index | CTI | 250 | 250 |

Note: If a printed circuit is incorporated, the creepage distance and clearance may be reduced below this value. (e.g., at a standard distance between soldering eye centers of 7.5 mm). If this is not permissible, the user shall take suitable measures.

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. 16.2 Marking on Packing for EN IEC 60747**

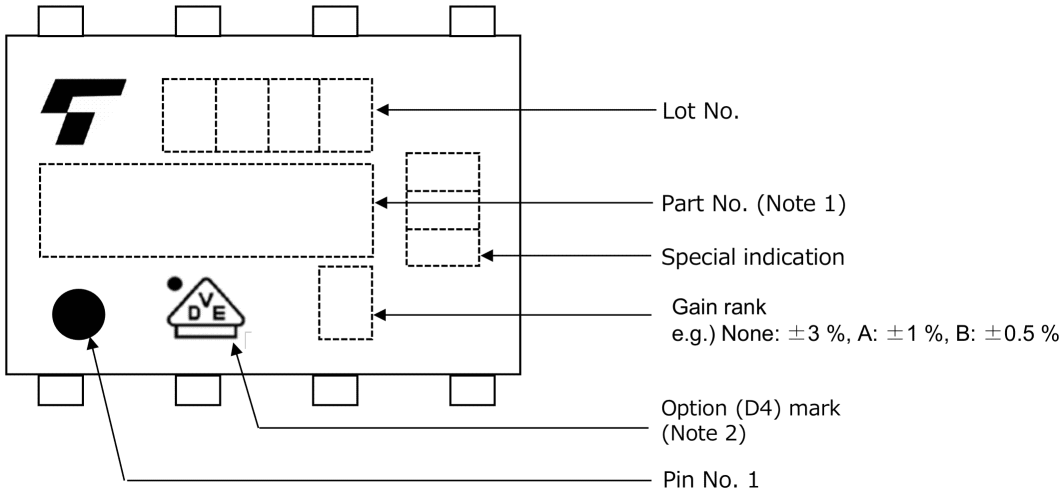



**Fig. 16.3 Marking Example**

Note 1: TLP7920 / TLP7920F

Note 2: The above marking is applied to the photocouplers that have been qualified according to option (D4) of EN IEC 60747.

Figure 1 Partial discharge measurement procedure according to EN IEC 60747
Destructive test for qualification and sampling tests.

Method A

(for type and sampling tests, destructive tests)

| | |
|---|---|
| $t_1$, $t_2$ | = 1 to 10 s |
| $t_3$, $t_4$ | = 1 s |
| $t_p$ (Measuring time for partial discharge) | = 10 s |
| $t_b$ | = 12 s |
| $t_{ini}$ | = 60 s |

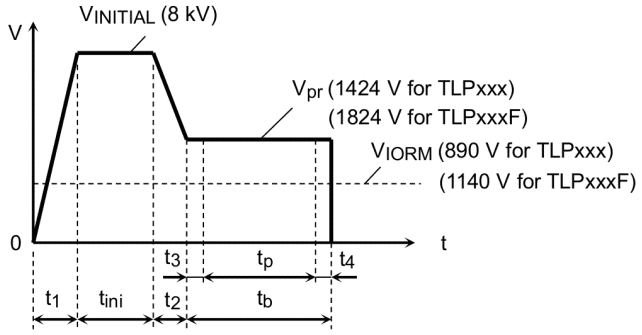



Figure 2 Partial discharge measurement procedure according to EN IEC 60747
Non-destructive test for 100 % inspection.

Method B

(for sample test, non-destructive test)

| | |
|---|---|
| $t_3$, $t_4$ | = 0.1 s |
| $t_p$ (Measuring time for partial discharge) | = 1 s |
| $t_b$ | = 1.2 s |

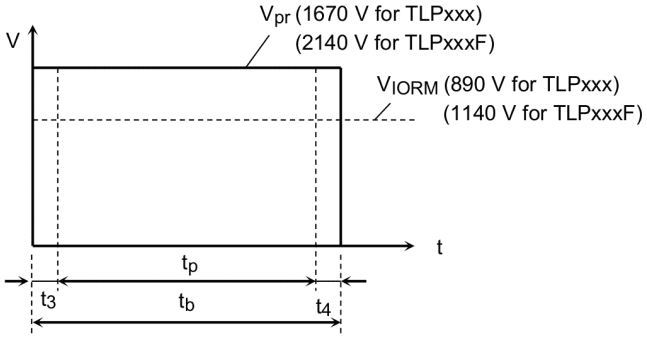



Figure 3 Dependency of maximum safety ratings on ambient temperature

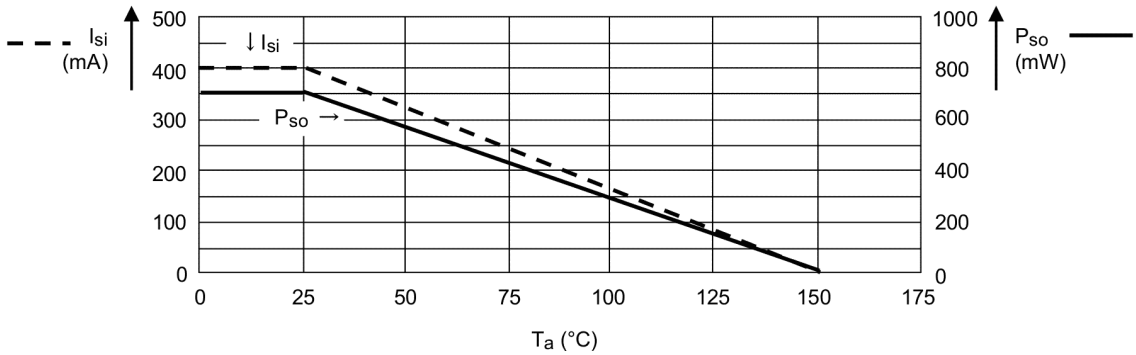
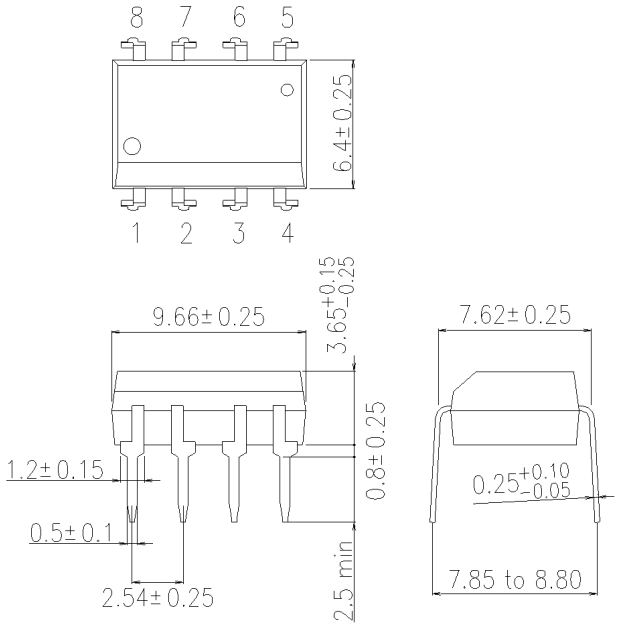



**Fig. 16.4 Measurement Procedure**

## Package Dimensions

Unit: mm

TLP7920



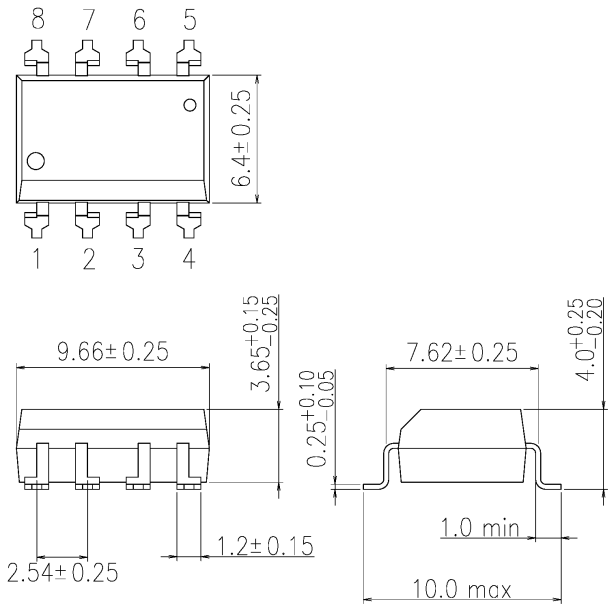

Weight: 0.54 g (typ.)

| Package Name(s) |
|---|
| TOSHIBA: 11-10C4S |

## Package Dimensions

Unit: mm

TLP7920(LF1,TP1)



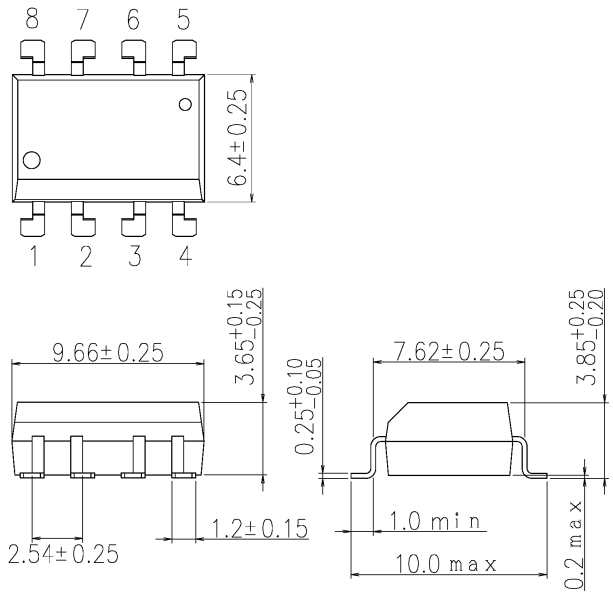

Weight: 0.53 g (typ.)

| Package Name(s) |
| --- |
| TOSHIBA: 11-10C401S |

## Package Dimensions

Unit: mm

TLP7920(LF5,TP5)




Weight: 0.53 g (typ.)

| Package Name(s) |
| --- |
| TOSHIBA: 11-10C405S |

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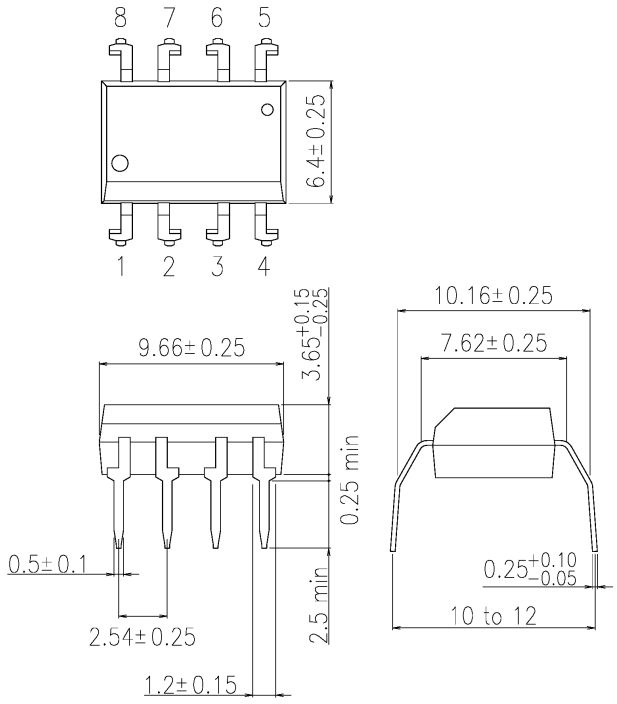
## Package Dimensions

Unit: mm

TLP7920F



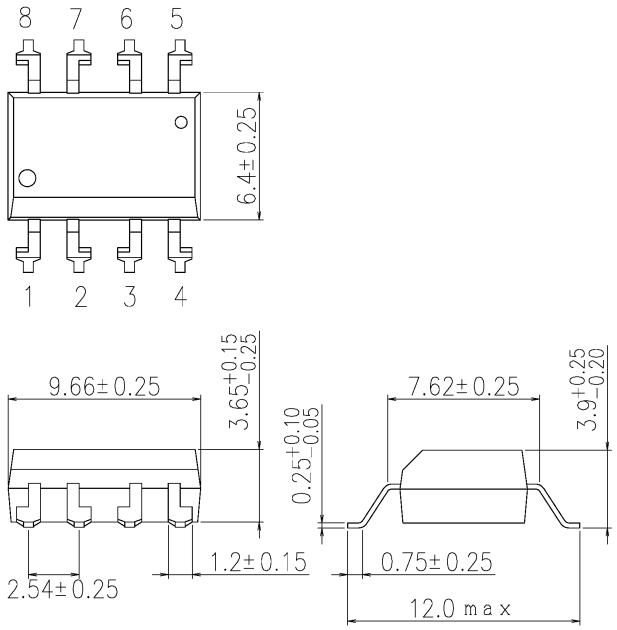

Weight: 0.54 g (typ.)

| Package Name(s) |
| --- |
| TOSHIBA: 11-10C402S |

## Package Dimensions

Unit: mm

TLP7920F(LF4,TP4)




Weight: 0.53 g (typ.)

| Package Name(s) |
|---|
| TOSHIBA: 11-10C404S |

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