

# TLP250H, TLP250HF

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## 1. Applications

- Industrial Inverters
- Air Conditioner Inverters
- IGBT Gate Drivers
- MOSFET Gate Drivers
- Induction Cooktop and Home Appliances

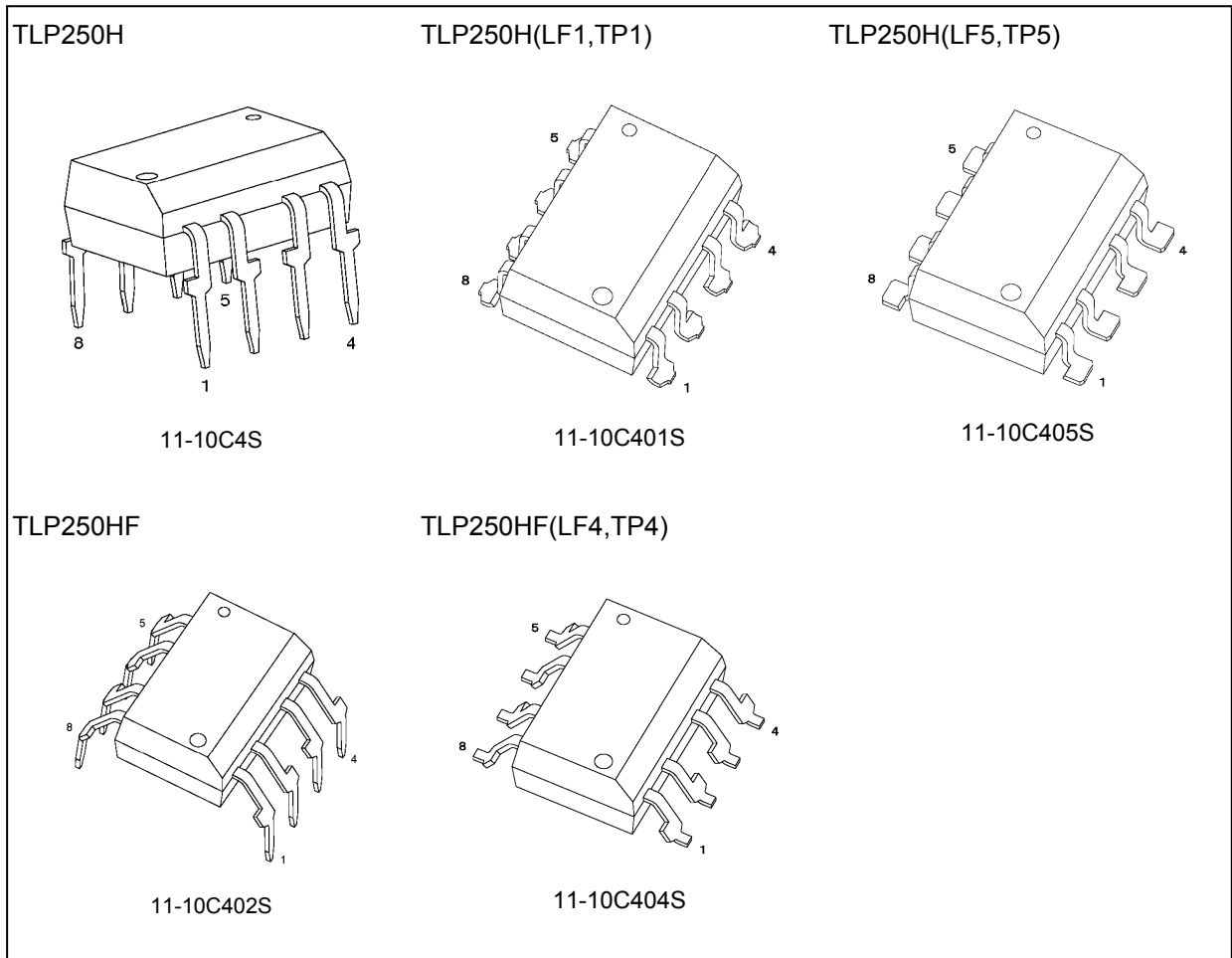
## 2. General

The TLP250H is a photocoupler in a DIP8 package that consists of a GaAs infrared light-emitting diode (LED) optically coupled to an integrated high-gain, high-speed photodetector IC chip. It provides guaranteed performance and specifications at temperatures up to 125 °C. The TLP250H has an internal Faraday shield that provides a guaranteed Common-mode transient immunity of  $\pm 40$  kV/ $\mu$ s. It has a totem-pole output that can both sink and source current. The TLP250H is ideal for IGBT and power MOSFET gate drive.

## 3. Features

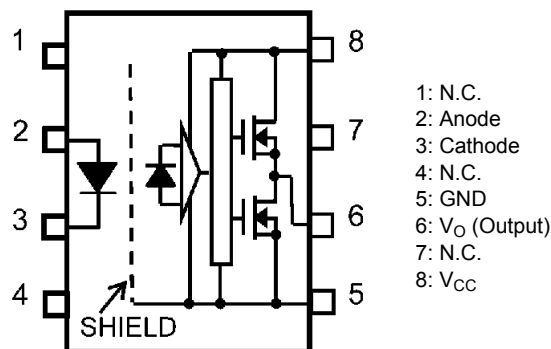
- (1) Buffer logic type (totem pole output)
  - (2) Output peak current:  $\pm 2.5$  A (max)
  - (3) Operating temperature: -40 to 125 °C
  - (4) Supply current: 3 mA (max)
  - (5) Supply voltage: 10 to 30 V
  - (6) Threshold input current: 5 mA (max)
  - (7) Propagation delay time: 500 ns (max)
  - (8) Common-mode transient immunity:  $\pm 40$  kV/ $\mu$ s (min)
  - (9) Isolation voltage: 3750 Vrms (min)
  - (10) Safety standards
    - UL-approved: UL1577, File No.E67349
    - cUL-approved: CSA Component Acceptance Service No.5A File No.E67349
    - VDE-approved: EN60747-5-5, EN60065 or EN60950-1 (**Note 1**)
- Note 1: When a VDE approved type is needed, please designate the **Option (D4)**.

**4. Packaging (Note)**

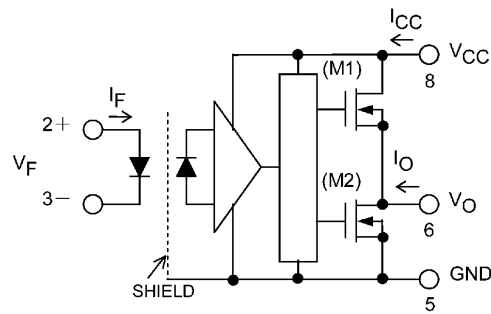


Note: Through-hole type: TLP250H, TLP250HF  
 Lead forming option: (LF1), (LF4), (LF5)  
 Taping option: (TP1), (TP4), (TP5)

**5. Pin Assignment**



**6. Internal Circuit (Note)**



Note: A 0.1- $\mu$ F bypass capacitor must be connected between pin 8 and pin 5.

**7. Principle of Operation**

**7.1. Truth Table**

Input	LED	M1	M2	Output
H	ON	ON	OFF	H
L	OFF	OFF	ON	L

**7.2. Mechanical Parameters**

Characteristics	7.62-mm Pitch TLP250H	10.16-mm Pitch TLP250HF	Unit
Creepage distances	7.0 (min)	8.0 (min)	mm
Clearance distances	7.0 (min)	8.0 (min)	
Internal isolation thickness	0.4 (min)	0.4 (min)	

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

	Characteristics	Symbol	Note	Rating	Unit
LED	Input forward current	$I_F$		20	mA
	Input forward current derating ( $T_a \geq 110\text{ }^\circ\text{C}$ )	$\Delta I_F / \Delta T_a$		-0.54	mA/ $^\circ\text{C}$
	Peak transient input forward current	$I_{FPT}$	(Note 1)	1	A
	Peak transient input forward current derating ( $T_a \geq 110\text{ }^\circ\text{C}$ )	$\Delta I_{FPT} / \Delta T_a$		-25	mA/ $^\circ\text{C}$
	Input reverse voltage	$V_R$		6	V
	Input power dissipation	$P_D$		40	mW
	Input power dissipation derating ( $T_a \geq 110\text{ }^\circ\text{C}$ )	$\Delta P_D / \Delta T_a$		-1.0	mW/ $^\circ\text{C}$
Detector	Peak high-level output current ( $T_a = -40\text{ to }125\text{ }^\circ\text{C}$ )	$I_{OPH}$	(Note 2)	-2.5	A
	Peak low-level output current ( $T_a = -40\text{ to }125\text{ }^\circ\text{C}$ )	$I_{OPL}$	(Note 2)	+2.5	
	Output voltage	$V_O$		35	V
	Supply voltage	$V_{CC}$		35	
	Output power dissipation	$P_O$		260	mW
	Output power dissipation derating ( $T_a \geq 110\text{ }^\circ\text{C}$ )	$\Delta P_O / \Delta T_a$		-2.0	mW/ $^\circ\text{C}$
Common	Operating temperature	$T_{opr}$		-40 to 125	$^\circ\text{C}$
	Storage temperature	$T_{stg}$		-55 to 150	
	Lead soldering temperature (10 s)	$T_{sol}$	(Note 3)	260	
	Isolation voltage AC, 60 s, R.H. $\leq 60\%$	$BV_S$	(Note 4)	3750	

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)  $\leq 1\text{ }\mu\text{s}$ , 300 pps

Note 2: Exponential waveform. Pulse width  $\leq 0.2\text{ }\mu\text{s}$ ,  $f \leq 15\text{ kHz}$ ,  $V_{CC} = 20\text{ V}$ ,  $T_a = -40\text{ to }125\text{ }^\circ\text{C}$   
 Exponential waveform. Pulse width  $\leq 0.08\text{ }\mu\text{s}$ ,  $f \leq 25\text{ kHz}$ ,  $V_{CC} = 15\text{ V}$ ,  $T_a = -40\text{ to }125\text{ }^\circ\text{C}$

Note 3:  $\geq 2\text{ mm}$  below seating plane.

Note 4: 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 on-state current	$I_{F(ON)}$	(Note 1)	6.5	—	10	mA
Input off-state voltage	$V_{F(OFF)}$		0	—	0.8	V
Supply voltage	$V_{CC}$	(Note 2)	10	—	30	
Peak high-level output current	$I_{OPH}$		—	—	-2.0	A
Peak low-level output current	$I_{OPL}$		—	—	+2.0	
Operating frequency	f	(Note 3)	—	—	250	kHz

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 datasheet should also be considered.

Note: A ceramic capacitor (0.1  $\mu$ F) should be connected between pin 8 and pin 5 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: If the rising slope of the supply voltage ( $V_{CC}$ ) for the detector is steep, stable operation of the internal circuits cannot be guaranteed.

Be sure to set 3.0 V/ $\mu$ s or less for a rising slope of the  $V_{CC}$ .

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.

Note 3: Exponential waveform.  $I_{OPH} \geq -0.65$  A ( $\leq 80$  ns),  $I_{OPL} \leq 0.65$  A ( $\leq 80$  ns),  $T_a = 125$  °C,  $V_{CC} = 20$  V

**10. Electrical Characteristics (Note)(Unless otherwise specified,  $T_a = -40$  to  $125$  °C)**

Characteristics	Symbol	Note	Test Circuit	Test Condition	Min	Typ.	Max	Unit
Input forward voltage	$V_F$			$I_F = 10$ mA, $T_a = 25$ °C	1.4	1.57	1.8	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, $T_a = 25$ °C	—	45	—	pF
Peak high-level output current	$I_{OPH}$	(Note 1)	Fig. 12.1.1	$I_F = 5$ mA, $V_{CC} = 30$ V, $V_{8-6} = -3.5$ V	—	-2.2	-1.0	A
				$I_F = 5$ mA, $V_{CC} = 15$ V, $V_{8-6} = -7.0$ V	—	-3.4	-2.0	
Peak low-level output current	$I_{OPL}$	(Note 1)	Fig. 12.1.2	$I_F = 0$ mA, $V_{CC} = 30$ V, $V_{6-5} = 2.5$ V	1.0	2.4	—	A
				$I_F = 0$ mA, $V_{CC} = 15$ V, $V_{6-5} = 7.0$ V	2.0	3.5	—	
High-level output voltage	$V_{OH}$		Fig. 12.1.3	$I_F = 5$ mA, $R_L = 200$ $\Omega$ , $V_{CC1} = +15$ V, $V_{EE1} = -15$ V	11.0	13.7	—	V
Low-level output voltage	$V_{OL}$		Fig. 12.1.4	$V_F = 0.8$ V, $R_L = 200$ $\Omega$ , $V_{CC1} = +15$ V, $V_{EE1} = -15$ V	—	-14.9	-12.5	
High-level supply current	$I_{CCH}$		Fig. 12.1.5	$I_F = 10$ mA, $V_{CC} = 30$ V, $V_O =$ Open	—	1.9	3.0	mA
Low-level supply current	$I_{CCL}$		Fig. 12.1.6	$I_F = 0$ mA, $V_{CC} = 30$ V, $V_O =$ Open	—	1.8	3.0	
Threshold input current (L/H)	$I_{FLH}$			$V_{CC} = 15$ V, $V_O > 1$ V	—	1.0	5	V
Threshold input voltage (H/L)	$V_{FHL}$			$V_{CC} = 15$ V, $V_O < 1$ V	0.8	1.47	—	
Supply voltage	$V_{CC}$			—	10	—	30	
UVLO threshold voltage	$V_{UVLO+}$			$I_F = 5$ mA, $V_O > 2.5$ V	7.5	8.7	9.5	
	$V_{UVLO-}$			$I_F = 5$ mA, $V_O < 2.5$ V	7.5	8.4	9.5	
UVLO hysteresis	$UVLO_{HYS}$			—	—	0.3	—	

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

Note: This device is designed for low power consumption, making it more sensitive to ESD than its predecessors. Extra care should be taken in the design of circuitry and pc board implementation to avoid ESD problems.

Note 1:  $I_O$  application time  $\leq 50$   $\mu$ s, single pulse.

**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	—	0.35	—	pF
Isolation resistance	$R_S$	(Note 1)	$V_S = 500$ V, R.H. $\leq 60$ %	$1 \times 10^{12}$	$10^{14}$	—	$\Omega$
Isolation voltage	$BV_S$	(Note 1)	AC, 60 s	3750	—	—	Vrms
			AC, 1 s in oil	—	10000	—	
			DC, 60 s in oil	—	10000	—	Vdc

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.

**12. Switching Characteristics (Note)(Unless otherwise specified,  $T_a = -40$  to  $125$  °C)**

Characteristics	Symbol	Note	Test Circuit	Test Condition	Min	Typ.	Max	Unit
Propagation delay time (L/H)	$t_{pLH}$	(Note 1)	Fig. 12.1.7	$I_F = 0 \rightarrow 10$ mA, $V_{CC} = 30$ V, $R_g = 20$ $\Omega$ , $C_g = 10$ nF	100	—	500	ns
Propagation delay time (H/L)	$t_{pHL}$	(Note 1)		$I_F = 10 \rightarrow 0$ mA, $V_{CC} = 30$ V, $R_g = 20$ $\Omega$ , $C_g = 10$ nF	100	—	500	
Pulse width distortion	$ t_{pHL} - t_{pLH} $	(Note 1)		$I_F = 0 \leftrightarrow 10$ mA, $V_{CC} = 30$ V, $R_g = 20$ $\Omega$ , $C_g = 10$ nF	—	—	50	
Propagation delay skew (device to device)	$t_{psk}$	(Note 1), (Note 4)		$I_F = 0 \leftrightarrow 10$ mA, $V_{CC} = 30$ V, $R_g = 20$ $\Omega$ , $C_g = 10$ nF	-150	—	150	
Rise time	$t_r$	(Note 1)		$I_F = 0 \rightarrow 10$ mA, $V_{CC} = 30$ V, $R_g = 20$ $\Omega$ , $C_g = 10$ nF	—	50	—	
Fall time	$t_f$	(Note 1)		$I_F = 10 \rightarrow 0$ mA, $V_{CC} = 30$ V, $R_g = 20$ $\Omega$ , $C_g = 10$ nF	—	50	—	
Common-mode transient immunity at output high	$CM_H$	(Note 2)	Fig. 12.1.8	$V_{CM} = 1000$ V <sub>p-p</sub> , $I_F = 10$ mA, $V_{CC} = 30$ V, $T_a = 25$ °C, $V_{O(min)} = 26$ V	$\pm 40$	—	—	kV/ $\mu$ s
Common-mode transient immunity at output low	$CM_L$	(Note 3)		$V_{CM} = 1000$ V <sub>p-p</sub> , $I_F = 0$ mA, $V_{CC} = 30$ V, $T_a = 25$ °C, $V_{O(max)} = 1$ V	$\pm 40$	—	—	

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

Note 1: Input signal ( $f = 250$  kHz, duty = 50 %,  $t_r = t_f = 5$  ns or less).

$C_L$  is approximately 15 pF which includes probe and stray wiring capacitance.

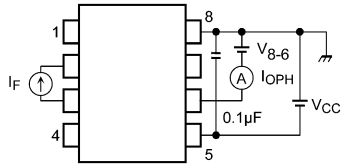
Note 2:  $CM_H$  is the maximum rate of rise of the common mode voltage that can be sustained with the output voltage in the logic high state ( $V_O > 26$  V).

Note 3:  $CM_L$  is the maximum rate of fall of the common mode voltage that can be sustained with the output voltage in the logic low state ( $V_O < 1$  V).

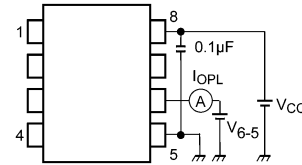
Note 4: The propagation delay skew,  $t_{psk}$ , is equal to the magnitude of the worst-case difference in  $t_{pHL}$  and/or  $t_{pLH}$  that will be seen between units at the same given conditions (supply voltage, input current, temperature, etc).

**13. Test Circuits and Characteristics Curves**

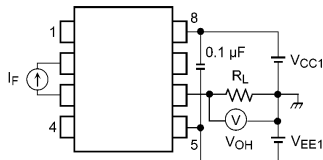
**13.1. Test Circuits**



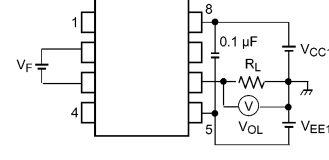
**Fig. 13.1.1 I<sub>OPH</sub> Test Circuit**



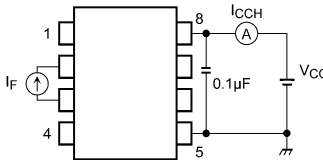
**Fig. 13.1.2 I<sub>OPL</sub> Test Circuit**



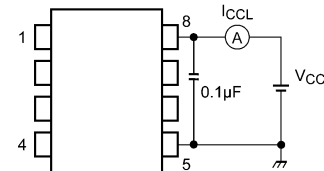
**Fig. 13.1.3 V<sub>OH</sub> Test Circuit**



**Fig. 13.1.4 V<sub>OL</sub> Test Circuit**



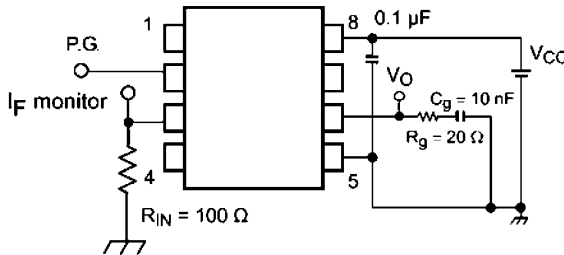
**Fig. 13.1.5 I<sub>CCH</sub> Test Circuit**



**Fig. 13.1.6 I<sub>CCL</sub> Test Circuit**

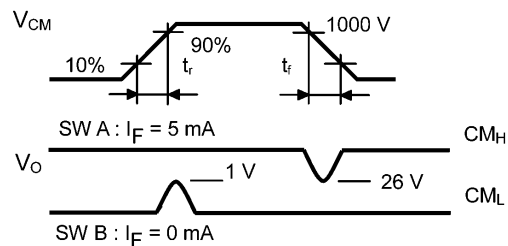
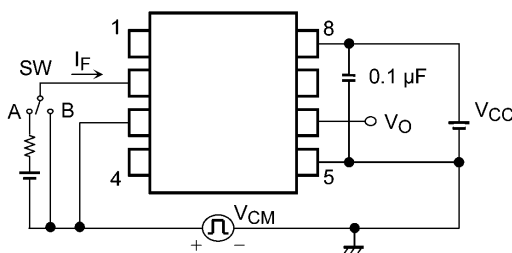
I<sub>F</sub> = 10 mA (P.G.)

(f = 250 kHz, duty = 50 %, t<sub>r</sub> = t<sub>f</sub> 5 ns or less)



P.G.: Pulse generator

**Fig. 13.1.7 Switching Time Test Circuit and Waveform**



$$CM_L = \frac{800(V)}{t_r(\mu s)} \quad CM_H = -\frac{800(V)}{t_f(\mu s)}$$

CM<sub>L</sub> (CM<sub>H</sub>) is the maximum rate of rise (fall) of the common mode voltage that can be sustained with the output voltage in the low (high) state.

**Fig. 13.1.8 Common-Mode Transient Immunity Test Circuit and Waveform**



## 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.

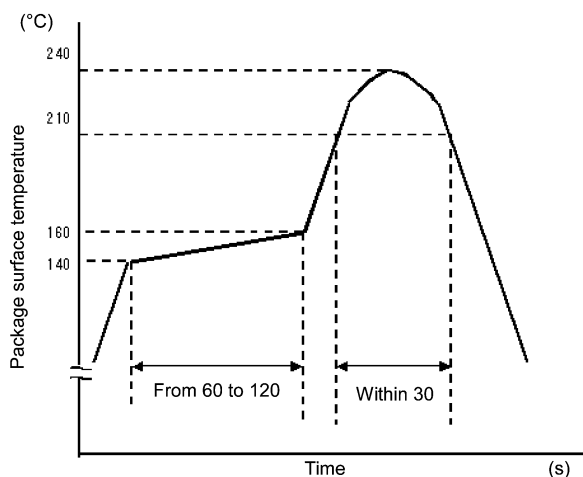
- When using soldering reflow.

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

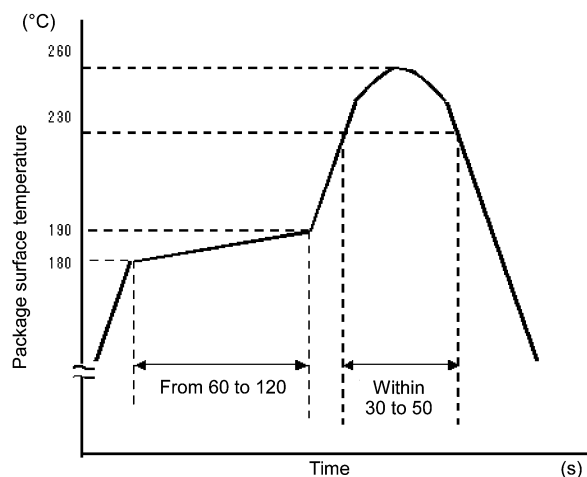
(See the figure shown below, which is based on the package surface temperature.)

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 Sn-Pb Eutectic Solder Is Used**



**Fig. 14.1.2 An Example of a Temperature Profile When Lead(Pb)-Free Solder Is Used**

- When using soldering flow (Applicable to both eutectic solder and Lead(Pb)-Free solder)  
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.

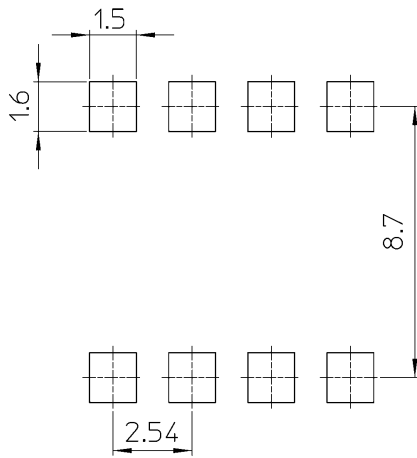
### 14.2. Precautions for General Storage

- 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.
- If devices have been stored for more than two years under normal storage conditions, it is recommended that you check the leads for ease of soldering prior to use.

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

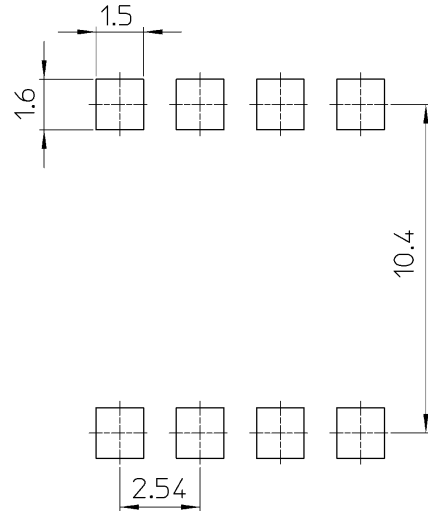
Unit: mm

TLP250H



**Fig. 15.1 Lead forming and taping option (LF1), (TP1), (LF5), (TP5)**

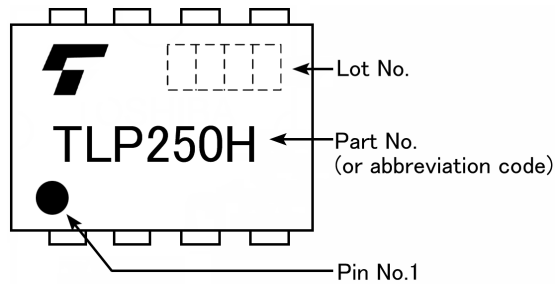
TLP250HF



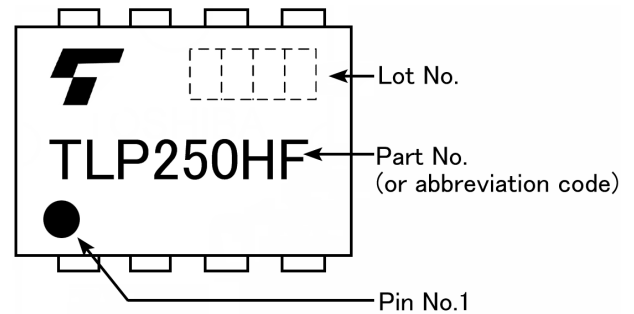
**Fig. 15.2 Lead forming and taping option (LF4), (TP4)**

**16. Marking (Note)**

TLP250H



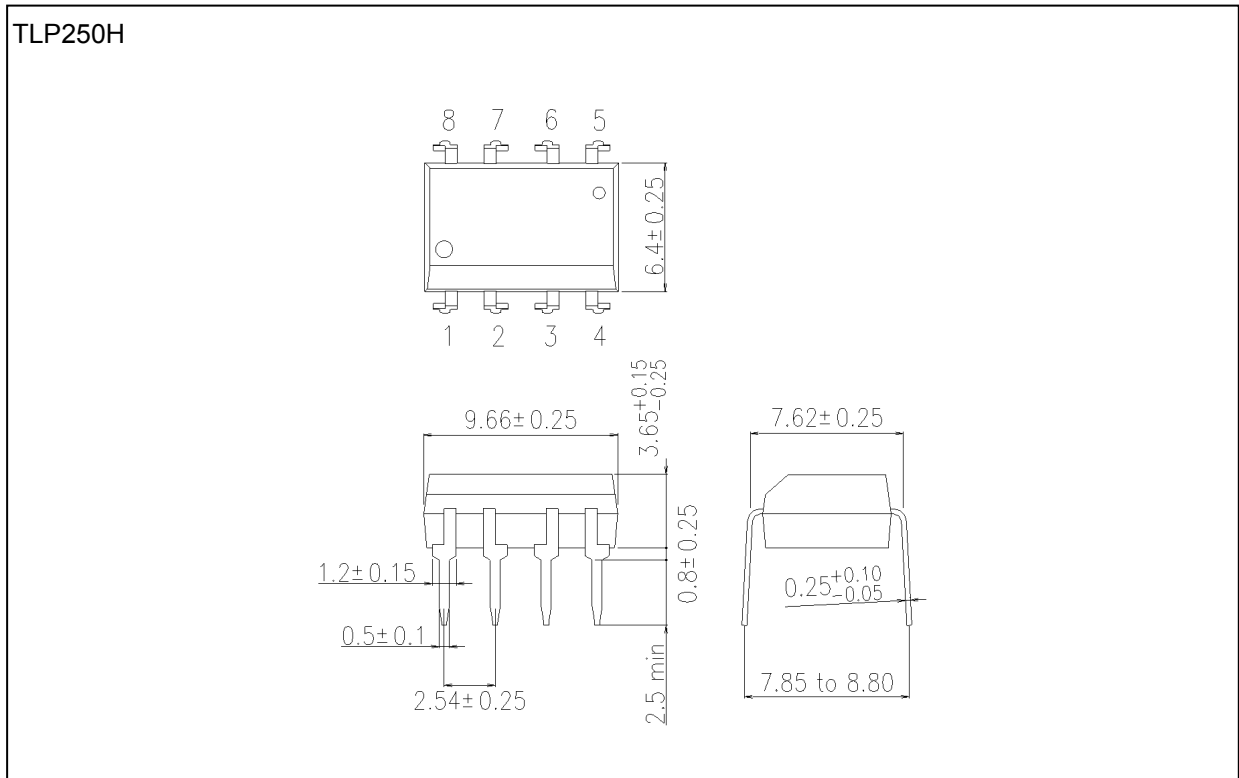
TLP250HF



Note: A different marking is used for photocouplers that have been qualified according to option (D4) of EN60747.

**Package Dimensions**

Unit: mm

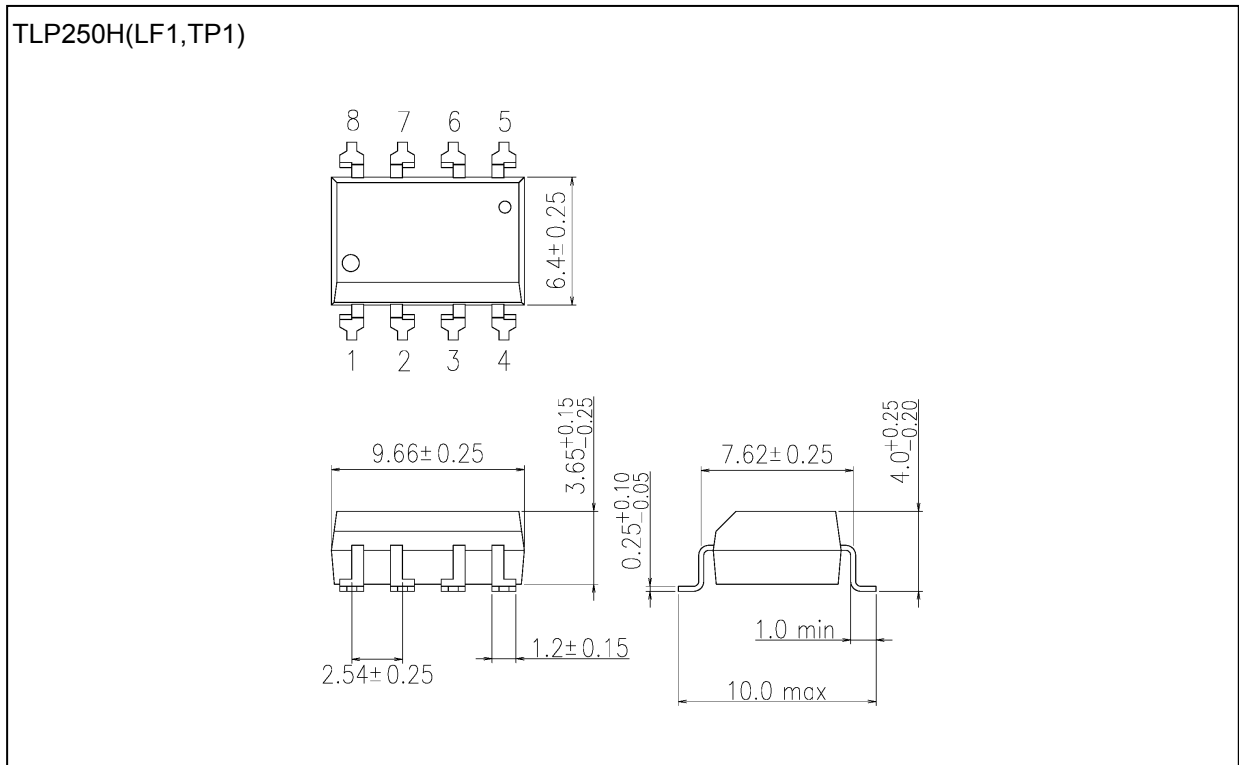


Weight: 0.54 g (typ.)

Package Name(s)
TOSHIBA: 11-10C4S

**Package Dimensions**

Unit: mm

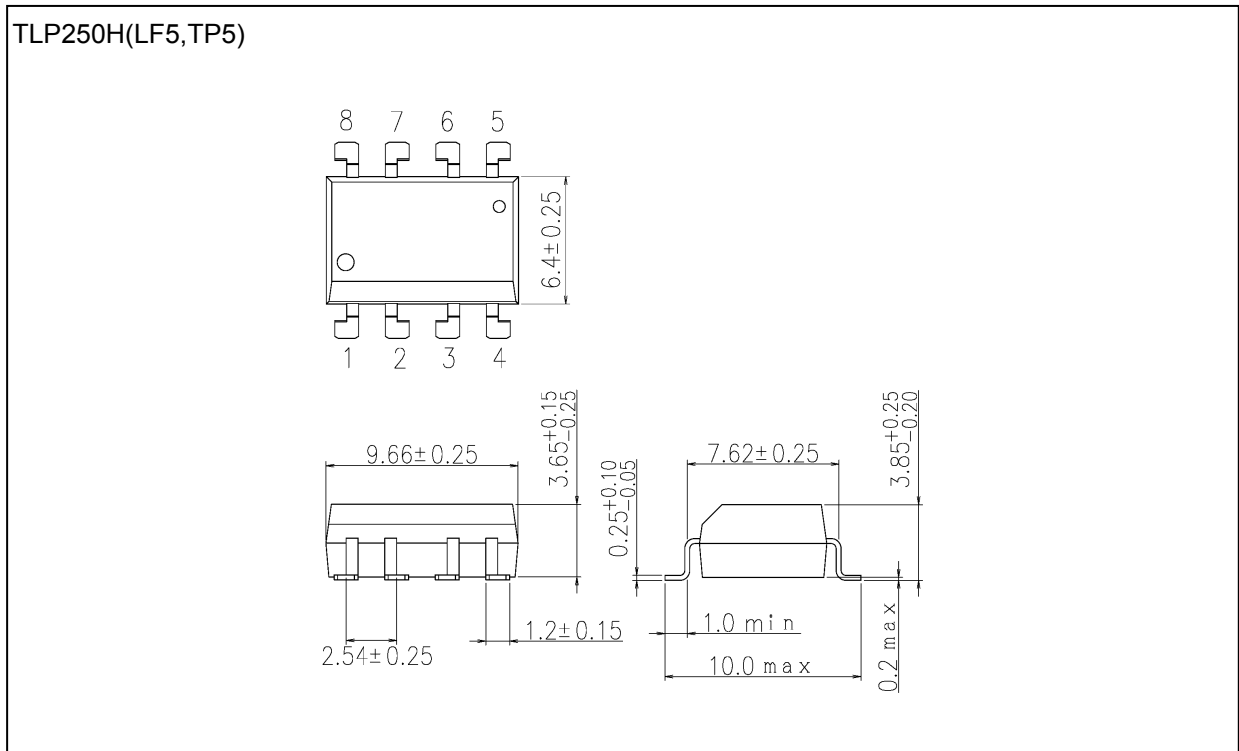


Weight: 0.53 g (typ.)

Package Name(s)
TOSHIBA: 11-10C401S

**Package Dimensions**

Unit: mm

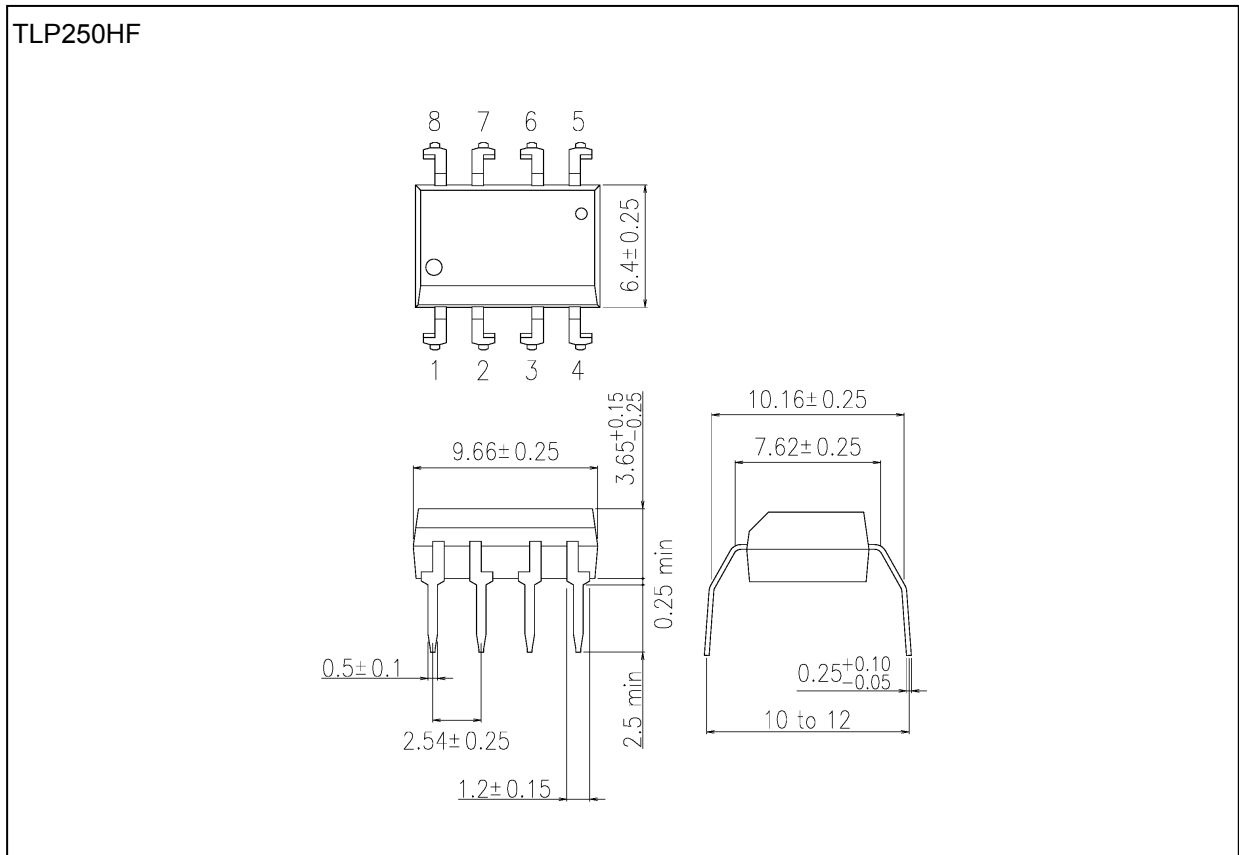


Weight: 0.53 g (typ.)

Package Name(s)
TOSHIBA: 11-10C405S

**Package Dimensions**

Unit: mm

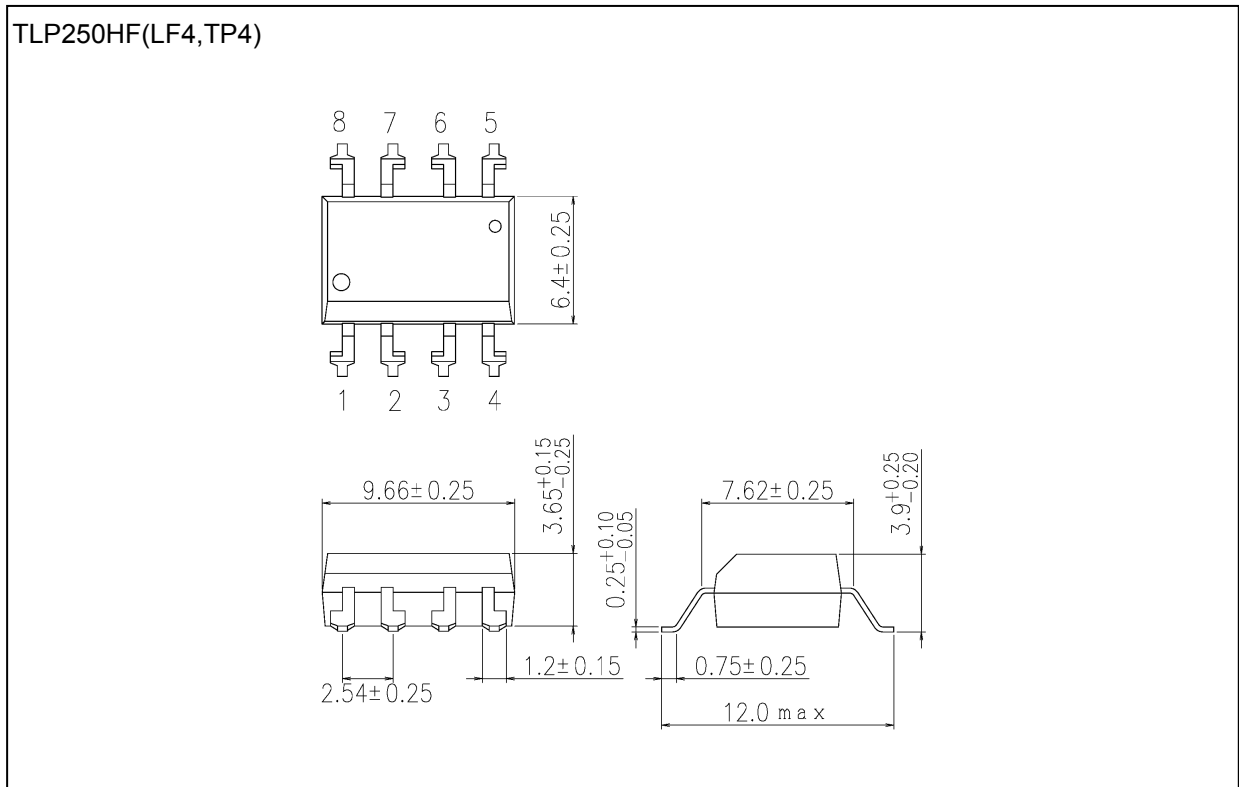


Weight: 0.54 g (typ.)

Package Name(s)
TOSHIBA: 11-10C402S

**Package Dimensions**

Unit: mm



Weight: 0.53 g (typ.)

Package Name(s)
TOSHIBA: 11-10C404S

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