Photocouplers   GaAℓAs Infrared LED & Photo IC

TLP2168

1. Applications

- Plasma Display Panels (PDPs)
- Factory Automation (FA)
- Measuring Instruments

2. General

The TLP2168 consists of high-intensity GaAℓAs infrared light-emitting diodes (LEDs) optically coupled to a high-gain, high-speed photoreceptor chip. The TLP2168 guarantees operation at up to 125 ℃ and on supplies from 2.7 V to 5.5 V. It is offered in the SO8 package. With two LED-photoreceptor pairs, the TLP2168 helps save board space. An internal noise shield provides superior common-mode rejection for improved noise immunity.

3. Features

(1)   Inverter logic type (open collector output)

(2)   Package: SO8

(3)   Operating temperature: -40 to 125 ℃

(4)   Supply voltage: 2.7 to 5.5 V

(5)   Data transfer rate: 20 MBd (typ.)(NRZ)

(6)   Threshold input current: 5.0 mA (max)

(7)   Supply current: 8 mA (max)

(8)   Common-mode transient immunity: ±15 kV/μs (min)

(9)   Isolation voltage: 2500 Vrms (min)

(10)   Safety standards

　　　UL-approved: UL1577, File No.E67349

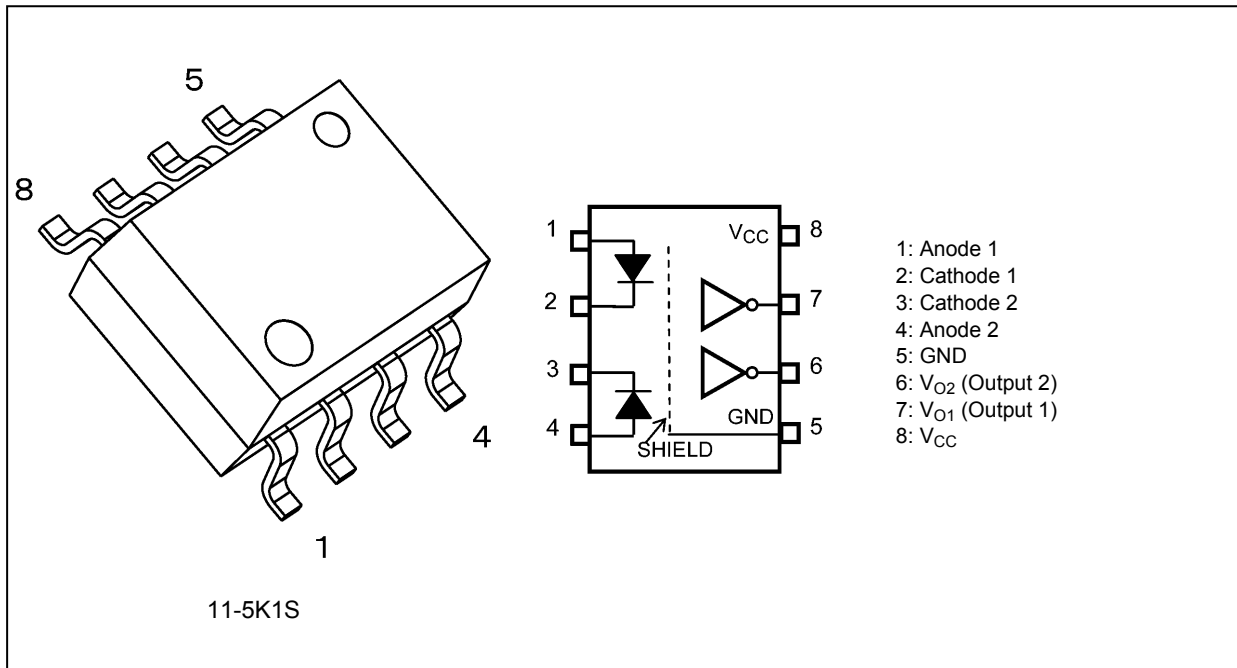　　　cUL-approved: CSA Component Acceptance Service No.5A File No.E67349

　　　VDE-approved: EN60747-5-5 **(Note 1)**

Note 1: When an EN60747-5-5 approved type is needed, please designate the **Option (V4)**.
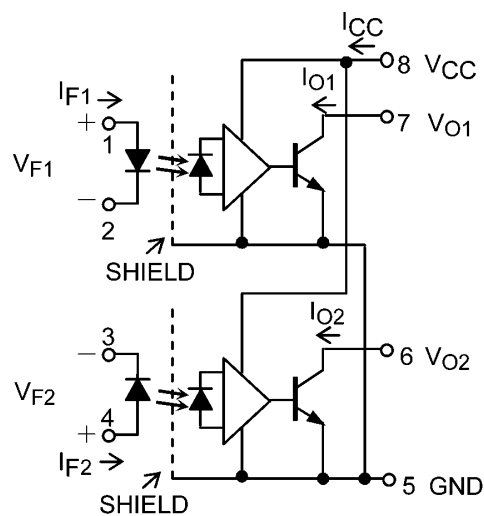
4. Packaging and Pin Configuration

1: Anode 1
2: Cathode 1
3: Cathode 2
4: Anode 2
5: GND
6: V_{O2} (Output 2)
7: V_{O1} (Output 1)
8: V_{CC}

11-5K1S

5. Internal Circuit

6. Principle of Operation

6.1. Truth Table

Input	LED 1 (2)	Output 1 (2)
H	ON	L
L	OFF	H

6.2. Mechanical Parameters

Characteristics	Min	Unit
Creepage distances	4.0	mm
Clearance distances	4.0	
Internal isolation thickness	—	

7. Absolute Maximum Ratings (Note) (Unless otherwise specified, T_a = 25 ℃)

	Characteristics		Symbol	Note	Rating	Unit
LED	Input forward current		I_F	(Note 1)	25	mA
	Input forward current derating	($T_a \geq$ 110 ℃)	$\Delta I_F/\Delta T_a$	(Note 1)	-0.67	mA/℃
	Input forward current (pulsed)		I_{FP}	(Note 1), (Note 2)	40	mA
	Input forward current derating (pulsed)	($T_a \geq$ 110 ℃)	$\Delta I_{FP}/\Delta T_a$	(Note 1)	-1.0	mA/℃
	Input reverse voltage		V_R	(Note 1)	5	V
	Input power dissipation		P_D	(Note 1)	40	mW
Detector	Output current		I_O	(Note 1)	25	mA
	Output voltage		V_O	(Note 1)	6	V
	Supply voltage		V_{CC}		6	V
	Output power dissipation		P_O	(Note 1)	40	mW
	Output power dissipation derating	($T_a \geq$ 110 ℃)	$\Delta P_O/\Delta T_a$	(Note 1)	-1	mW/℃
Common	Operating temperature		T_{opr}		-40 to 125	℃
	Storage temperature		T_{stg}		-55 to 150	℃
	Lead soldering temperature	(10 s)	T_{sol}		260	℃
	Isolation voltage	AC, 60 s, R.H. $\leq$ 60 %	BV_S	(Note 3)	2500	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 1: Each channel

Note 2: Pulse width (PW) $\leq$ 1 ms, duty = 50 %

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.

8. Recommended Operating Conditions (Note)

Characteristics	Symbol	Note	Min	Typ.	Max	Unit
Input on-state current	$I_{F(ON)}$	(Note 1), (Note 2)	7.5	—	14	mA
Input off-state voltage	$V_{F(OFF)}$	(Note 1)	0	—	0.8	V
Supply voltage	V_{CC}	(Note 3)	2.7	3.3/5.0	5.5	
Operating temperature	T_{opr}		-40	—	125	℃

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 μF) 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 1: Each channel

Note 2: The rise and fall times of the input on-current should be less than 0.5 μs.

Note 3: Denotes the operating range, not the recommended operating condition.

9. Electrical Characteristics (Note)
(Unless otherwise specified, T_a = -40 to 125 ℃, V_{CC} = 2.7 to 5.5 V)

Characteristics	Symbol	Note	Test Circuit	Test Condition	Min	Typ.	Max	Unit
Input forward voltage	V_F	(Note 1)	—	I_F = 10 mA, T_a = 25 ℃	1.4	1.57	1.8	V
Input forward voltage temperature coefficient	$\Delta V_F/\Delta T_a$	(Note 1)	—	I_F = 10 mA	—	-2.0	—	mV/℃
Input reverse current	I_R	(Note 1)	—	V_R = 5 V, T_a = 25 ℃	—	—	10	μA
Input capacitance	C_t	(Note 1)	—	V = 0 V, f = 1 MHz, T_a = 25 ℃	—	60	—	pF
High-level output current	I_{OH}	(Note 1)	Fig. 12.1.1	V_F = 0.8 V, V_O = 5.5 V, V_{CC} = 5.5 V	—	—	50	μA
				V_F = 0.8 V, V_O = 5.5 V, V_{CC} = 5.5 V, T_a = 25 ℃	—	—	10	
Low-level output voltage	V_{OL}	(Note 1)	Fig. 12.1.2	I_F = 10 mA, I_O = 13 mA (Sinking)	—	0.2	0.6	V
Low-level supply current	I_{CCL}		Fig. 12.1.3	I_{F1} = I_{F2} = 10 mA	—	3.8	8	mA
High-level supply current	I_{CCH}		Fig. 12.1.4	I_F = 0 mA	—	3.4	8	
Threshold input current (H/L)	I_{FHL}	(Note 1)	—	I_O = 13 mA (Sinking), V_O < 0.6 V	—	1.0	5.0	

Note: All typical values are at T_a = 25 ℃.
Note 1: Each channel

10. Isolation Characteristics (Unless otherwise specified, T_a = 25 ℃)

Characteristics	Symbol	Note	Test Conditions	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. ≤ 60 %	1×10^{12}	10^{14}	—	Ω
Isolation voltage	BV_S	(Note 1)	AC, 60 s	2500	—	—	Vrms
			AC, 1 s in oil	—	5000	—	
			DC, 60 s in oil	—	5000	—	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.

11. Switching Characteristics (Note)
   (Unless otherwise specified, T_a = -40 to 125 ℃, V_{CC} = 2.7 to 5.5 V (Each channel))

Characteristics	Symbol	Note	Test Circuit	Test Condition	Min	Typ.	Max	Unit
Propagation delay time (H/L)	t_{pHL}	(Note 1)	Fig. 12.1.5	I_F = 0 → 7.5 mA, R_L = 350 Ω, C_L = 15 pF	—	35	60	ns
Propagation delay time (L/H)	t_{pLH}	(Note 1)		I_F = 7.5 → 0 mA, R_L = 350 Ω, C_L = 15 pF	—	35	60	
Pulse width distortion	$\lvert t_{pHL}-t_{pLH}\rvert$	(Note 1)		I_F = 0 ←→ 7.5 mA, R_L = 350 Ω, C_L = 15 pF	—	—	35	
Propagation delay skew (device to device)	t_{psk}	(Note 1), (Note 2)			-40	—	40	
Fall time	t_f	(Note 1)		I_F = 0 → 7.5 mA, R_L = 350 Ω, C_L = 15 pF	—	30	—	
Rise time	t_r	(Note 1)		I_F = 7.5 → 0 mA, R_L = 350 Ω, C_L = 15 pF	—	30	—	
Common-mode transient immunity at output high	CM_H		Fig. 12.1.6	V_{CM} = 1000 V_{p-p}, I_F = 0 mA, V_{CC} = 5 V, T_a = 25 ℃	15	—	—	kV/μs
Common-mode transient immunity at output low	CM_L			V_{CM} = 1000 V_{p-p}, I_F = 10 mA, V_{CC} = 5 V, T_a = 25 ℃	-15	—	—	

Note: All typical values are at T_a = 25 ℃.

Note 1: f = 5 MHz, duty = 50%, input current t_r = t_f = 5 ns or less, C_L is approximately 15 pF which includes probe and stray wiring capacitance.

Note 2: 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).

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12. Test Circuits and Characteristics Curves

12.1. Test Circuits
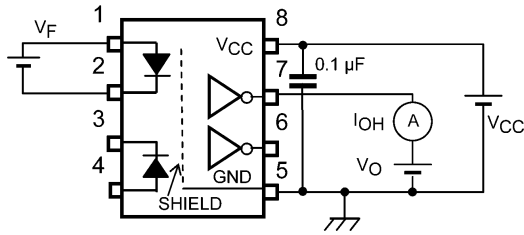
Fig. 12.1.1 I_{OH} Test Circuit
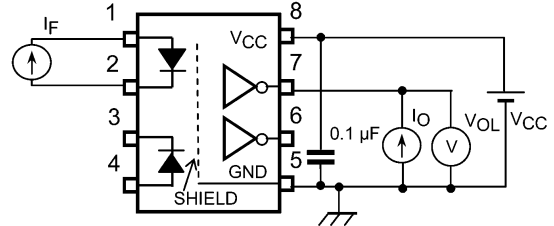
Fig. 12.1.2 V_{OL} Test Circuit
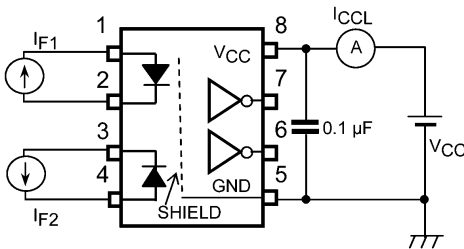
Fig. 12.1.3 I_{CCL} Test Circuit
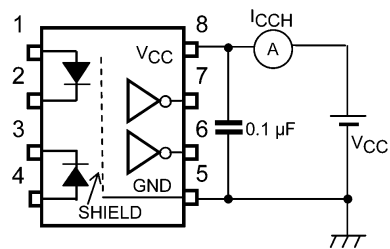
Fig. 12.1.4 I_{CCH} Test Circuit

Fig. 12.1.5 Switching Time Test Circuit and Waveform

Fig. 12.1.6 Common-Mode Transient Immunity and Waveform
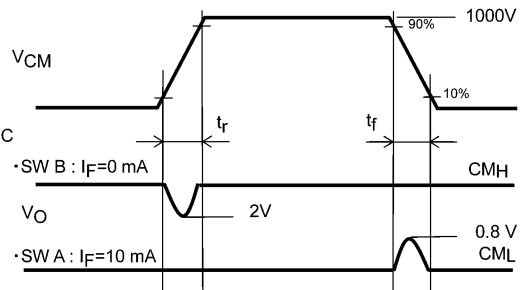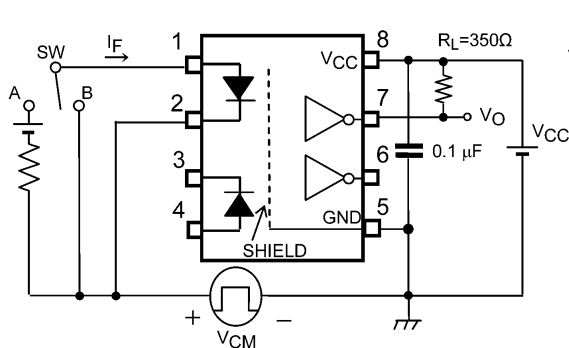
$$CM_H = \frac{800(V)}{t_r\,(\mu s)} \qquad CM_L = -\frac{800(V)}{t_f\,(\mu s)}$$

12.2. Characteristics Curves (Note)
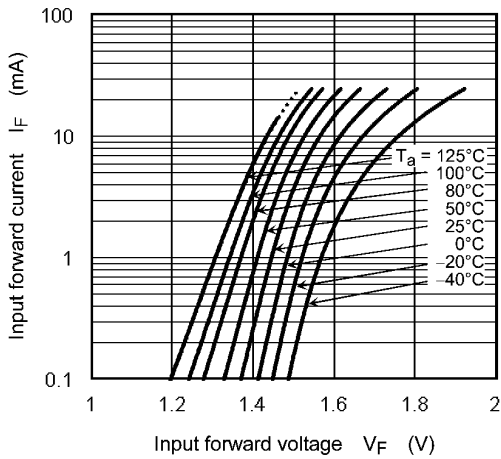
Fig. 12.2.1   I_F - V_F
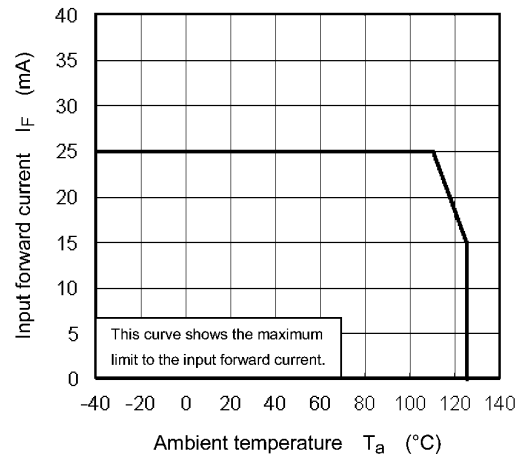
Fig. 12.2.2   I_F - T_a
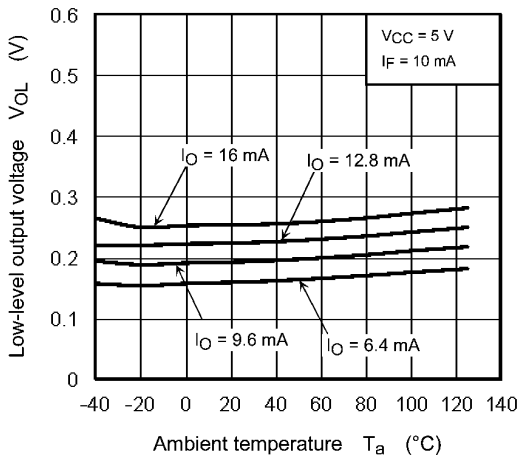
Fig. 12.2.3   V_OL - T_a
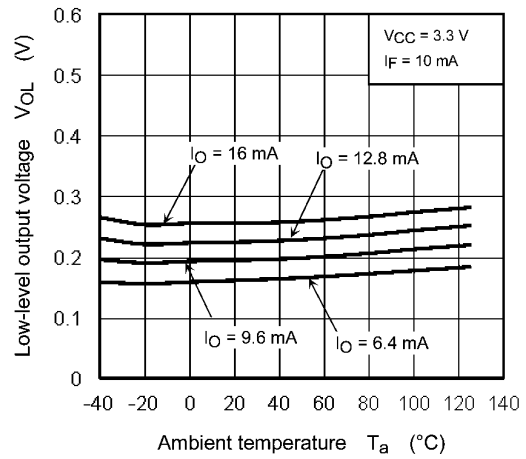
Fig. 12.2.4   V_OL - T_a
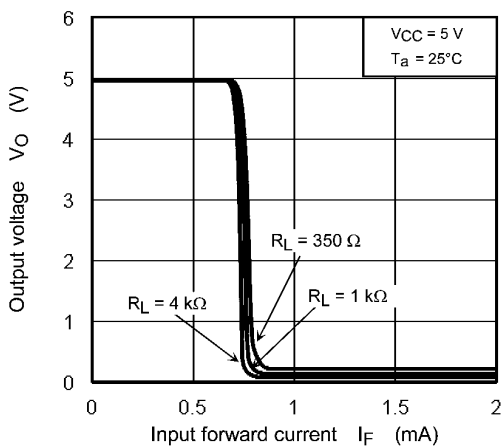
Fig. 12.2.5   V_O - I_F
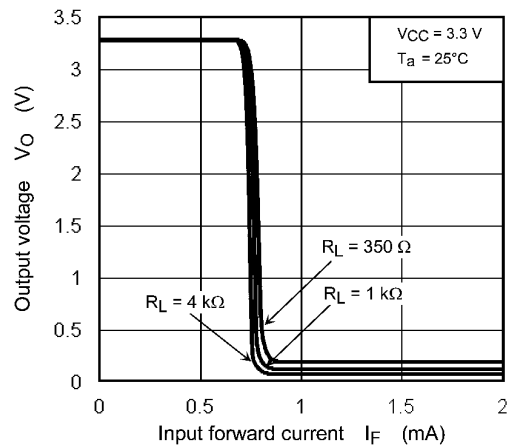
Fig. 12.2.6   V_O - I_F
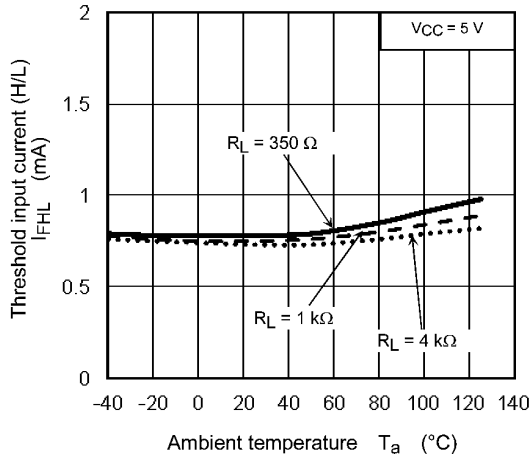
Fig. 12.2.7   I$_{FHL}$ - T$_a$
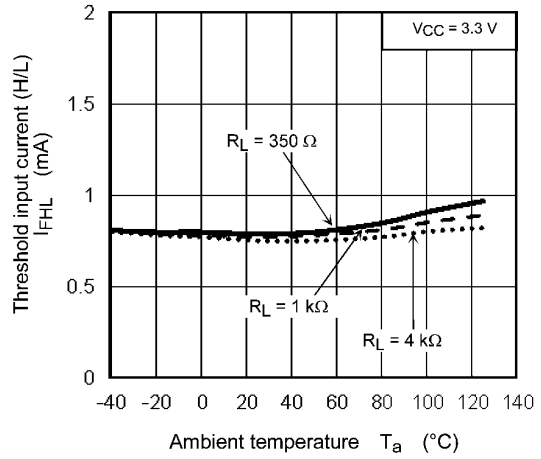
Fig. 12.2.8   I$_{FHL}$ - T$_a$
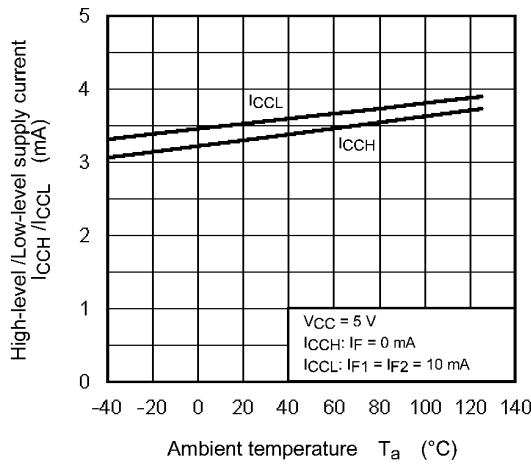
Fig. 12.2.9   I$_{CCH}$ / I$_{CCL}$ - T$_a$
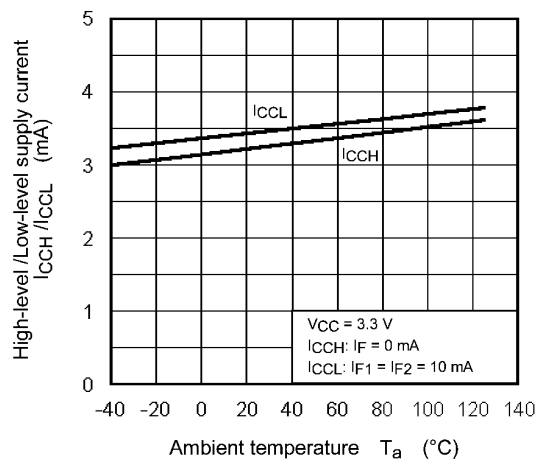
Fig. 12.2.10   I$_{CCH}$ / I$_{CCL}$ - T$_a$
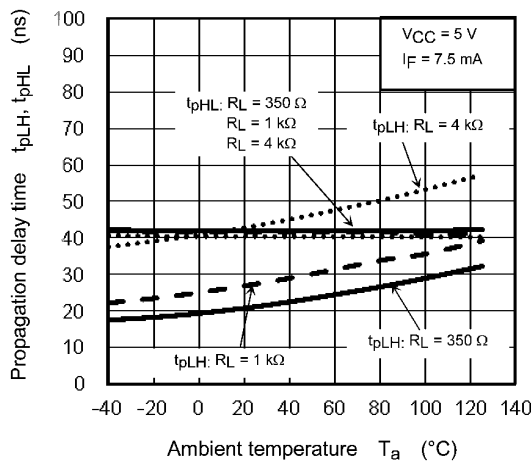
Fig. 12.2.11   t$_{pLH}$ / t$_{pHL}$ - T$_a$
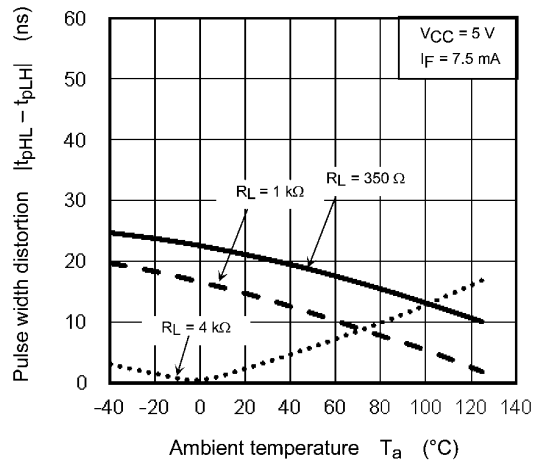
Fig. 12.2.12 |t$_{pHL}$-t$_{pLH}$| - T$_a$

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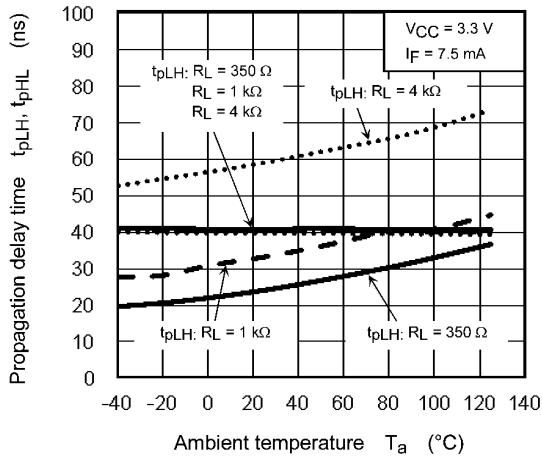
Fig. 12.2.13 t_pLH / t_pHL - T_a
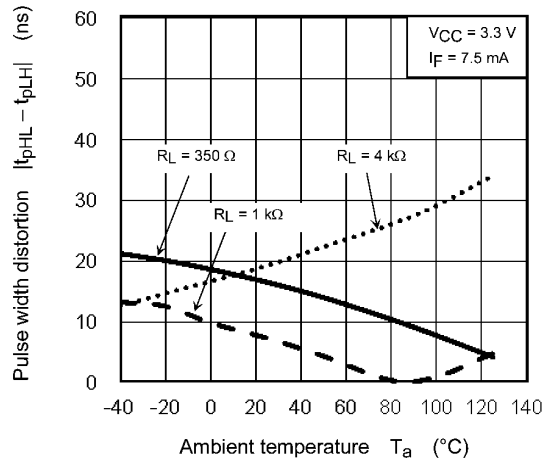
Fig. 12.2.14 |t_pHL-t_pLH| - T_a
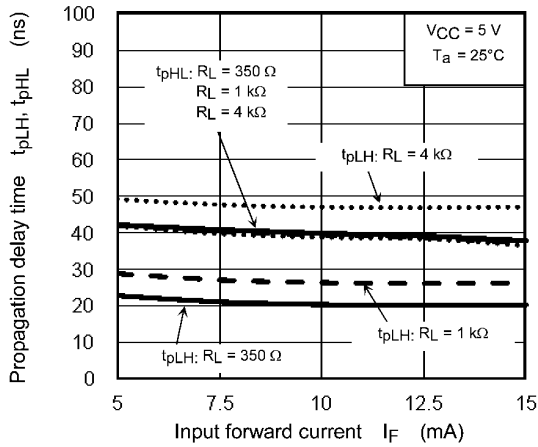
Fig. 12.2.15 t_pLH / t_pHL - I_F
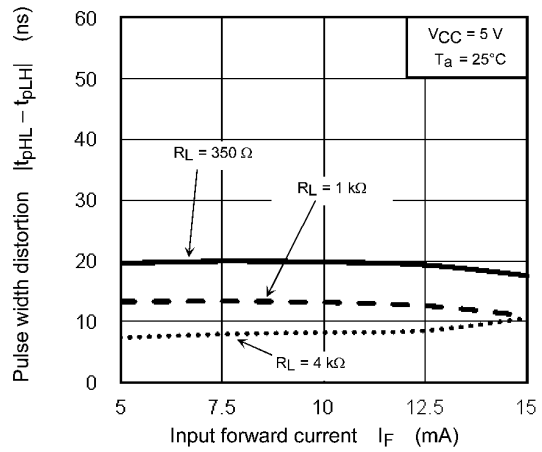
Fig. 12.2.16 |t_pHL-t_pLH| - I_F
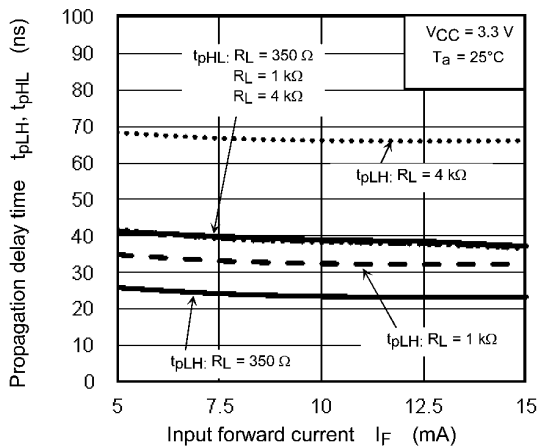
Fig. 12.2.17 t_pLH / t_pHL - I_F
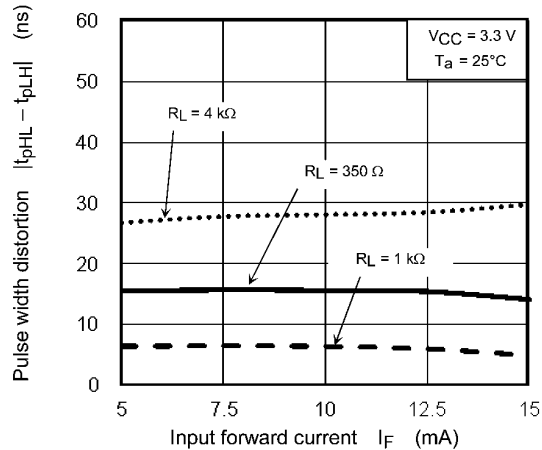
Fig. 12.2.18 |t_pHL-t_pLH| - I_F

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

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
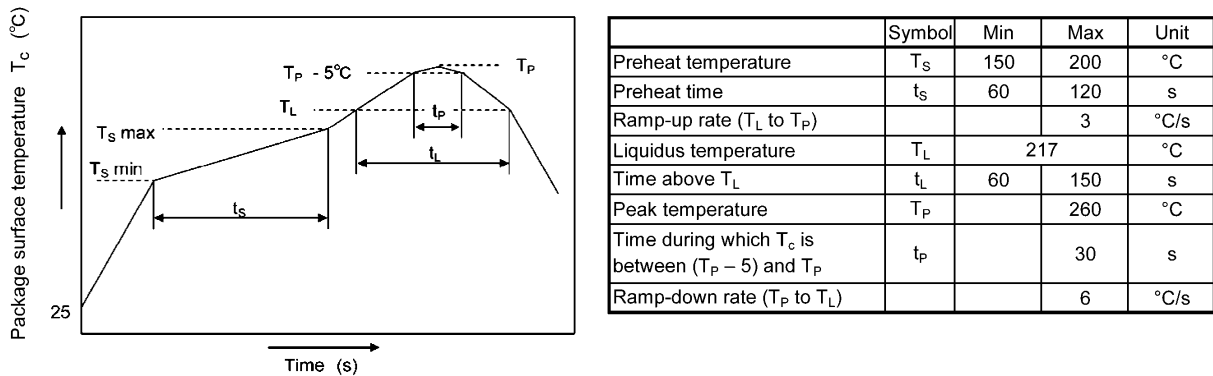
Fig. 13.1.1   An Example of a Temperature Profile When Lead(Pb)-free Solder Is Used

- 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.
- 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.

14. Land Pattern Dimensions (for reference only)

0.8

1.2

5.5

1.27   1.27

Unit: mm

15. Marking

P2168

Lot No.

Part No. (or abbreviation code)

Pin No. 1
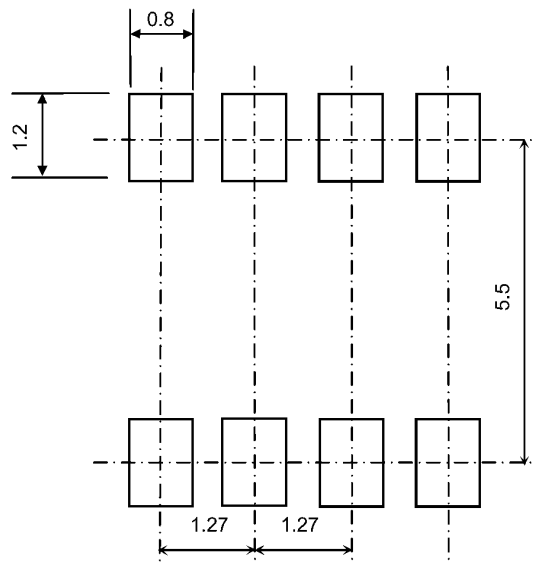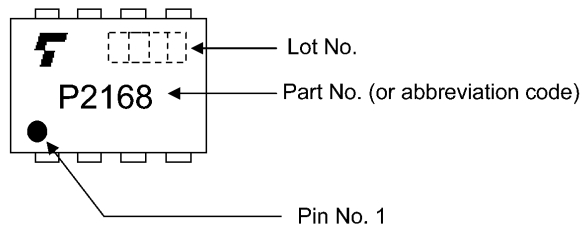
16. EN60747-5-5 Option (V4) Specification

· Part number: TLP2168 **(Note 1)**

· The following part naming conventions are used for the devices that have been qualified according to option (V4) of EN60747.
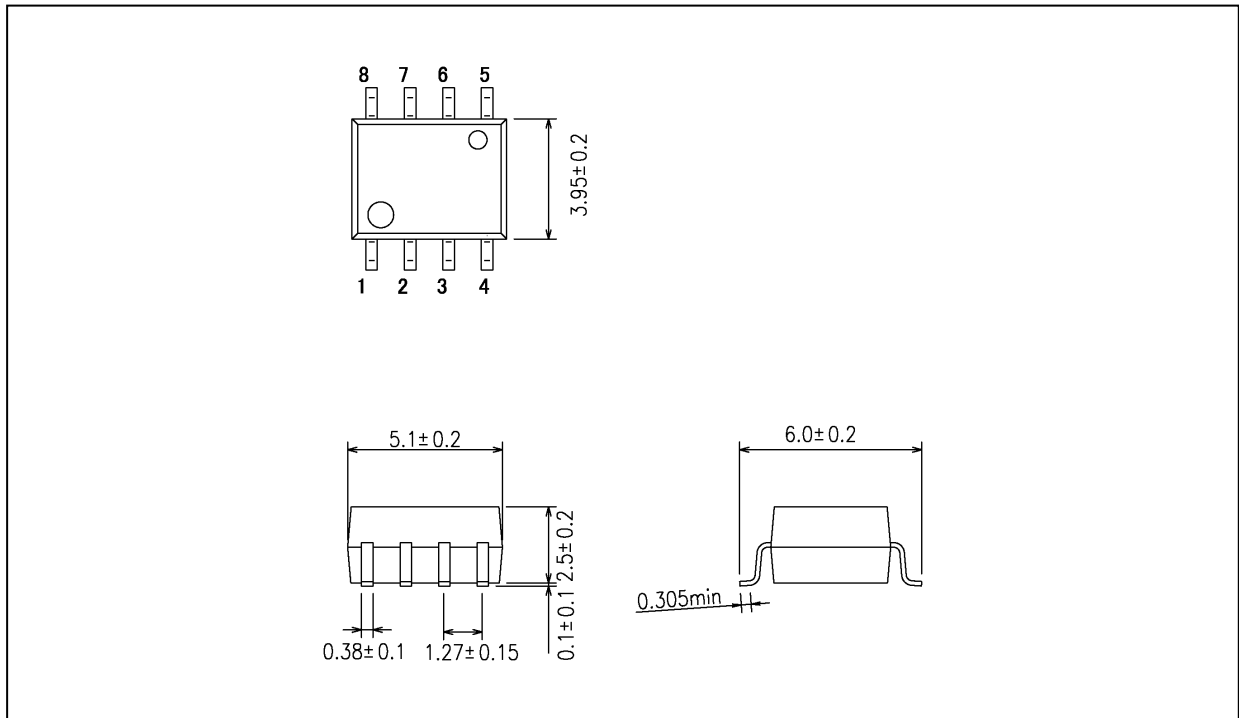
Example: TLP2168(V4-TP,F)

V4: EN60747 option

TP: Tape type

F: [[G]]/RoHS COMPATIBLE **(Note 2)**

Note 1: Use TOSHIBA standard type number for safety standard application.

e.g., TLP2168(V4-TP,F) → TLP2168

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 electronics equipment.

Description	Symbol	Rating	Unit
Application classification for rated mains voltage $\leq$ 150 Vrms for rated mains voltage $\leq$ 300 Vrms		 I-IV I-III	—
Climatic classification		40 / 125 / 21	—
Pollution degree		2	—
Maximum operating insulation voltage	V_{IORM}	565	Vpeak
Input to output test voltage, Method A V_{pr} = 1.6 × V_{IORM}, type and sample test t_p = 10 s, partial discharge < 5 pC	V_{pr}	904	Vpeak
Input to output test voltage, Method B V_{pr} = 1.875 × V_{IORM}, 100 % production test t_p = 1 s, partial discharge < 5 pC	V_{pr}	1059	Vpeak
Highest permissible overvoltage (transient overvoltage, t_{pr} = 60 s)	V_{TR}	4000	Vpeak
Safety limiting values (max. permissible ratings in case of fault, also refer to thermal derating curve) current (input current I_F, P_{so} = 0) power (output or total power dissipation) temperature	 I_{si} P_{so} T_s	 250 400 150	 mA mW °C
Insulation resistance V_{IO} = 500 V, T_a = 25 °C V_{IO} = 500 V, T_a = 100 °C V_{IO} = 500 V, T_a = T_s	R_{si}	$\geq 10^{12}$ $\geq 10^{11}$ $\geq 10^{9}$	Ω

Fig. 16.1   EN60747 Isolation Characteristics

Fig. 16.2   Marking on Packing

Lot No.

Part No.
(or abbreviation code)

Option (V4) mark

Pin No.1
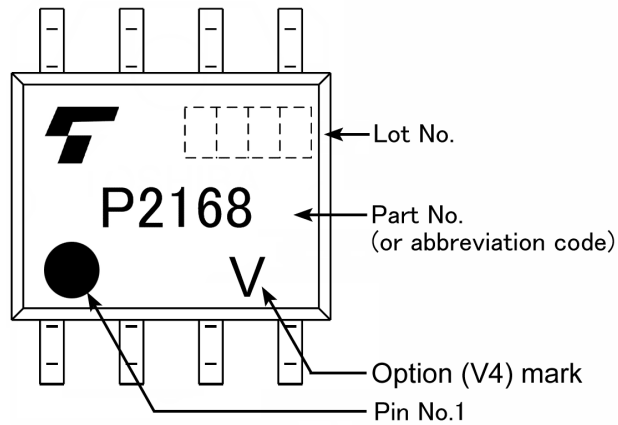
Fig. 16.3   Marking Example(Note 1)

Note 1: The above marking is applied to the photocouplers that have been qualified according to option (V4) of EN60747.

TOSHIBA   TLP2168

Figure   1   Partial discharge measurement procedure according to EN60747
                    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

$V_{INITIAL}$ (4 kV)
V_{pr} (904 V)
V_{IORM} (565 V)

Figure   2   Partial discharge measurement procedure according to EN60747
                    Non-destructive test for100 % 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

V_{pr} (1059 V)
V_{IORM} (565 V)

Figure   3   Dependency of maximum safety ratings on ambient temperature

I_{si} (mA)
P_{so} (mW)
T_a (°C)

Fig. 16.4   Measurement Procedure

Package Dimensions

Unit: mm

Weight: 0.11 g (typ.)

Package Name(s)
TOSHIBA: 11-5K1S

RESTRICTIONS ON PRODUCT USE

X-ON Electronics

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