

# PS9531, PS9531L1, PS9531L2, PS9531L3

R08DS0114EJ0100

Rev.1.00

Nov 29, 2013

2.5 A OUTPUT CURRENT, HIGH CMR, IGBT GATE DRIVE, 8-PIN DIP PHOTOCOUPLER

## DESCRIPTION

The PS9531, PS9531L1, PS9531L2 and PS9531L3 are optically coupled isolators containing a GaAlAs LED on the input side and a photo diode, a signal processing circuit and a power output transistor on the output side on one chip.

The PS9531 Series is designed specifically for high common mode transient immunity (CMR), high output current and high switching speed.

The PS9531 Series is suitable for driving IGBTs and MOS FETs.

The PS9531 Series is in a plastic DIP (Dual In-line Package).

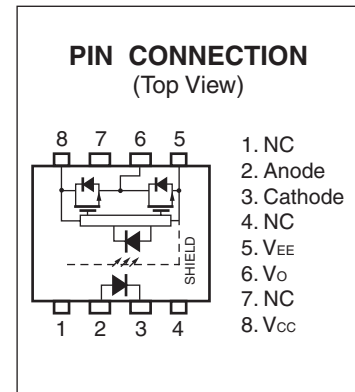
The PS9531L1 is lead bending type for long creepage distance.

The PS9531L2 is lead bending type for long creepage distance (Gull-wing) for surface mount.

The PS9531L3 is lead bending type (Gull-wing) for surface mounting.

## FEATURES

- Long creepage distance (8 mm MIN.: PS9531L1, PS9531L2)
- Large peak output current (2.5 A MAX., 2.0 A MIN.)
- High speed switching ( $t_{PLH}$ ,  $t_{PHL}$  = 175 ns MAX.)
- UVLO (Under Voltage Lock Out) protection with hysteresis
- High common mode transient immunity ( $CM_H$ ,  $CM_L$  =  $\pm 50$  kV/ $\mu$ s MIN.)
- Embossed tape product : PS9531L2-E3: 1 000 pcs/reel  
: PS9531L3-E3: 1 000 pcs/reel
- Pb-Free product
- <R> • Safety standards
  - UL approved: No. E72422
  - CSA approved: No. CA 101391 (CA5A, CAN/CSA-C22.2 60065, 60950)
  - SEMKO approved (EN 60065, EN 60950)
  - DIN EN 60747-5-5 (VDE 0884-5) approved (Option)



## APPLICATIONS

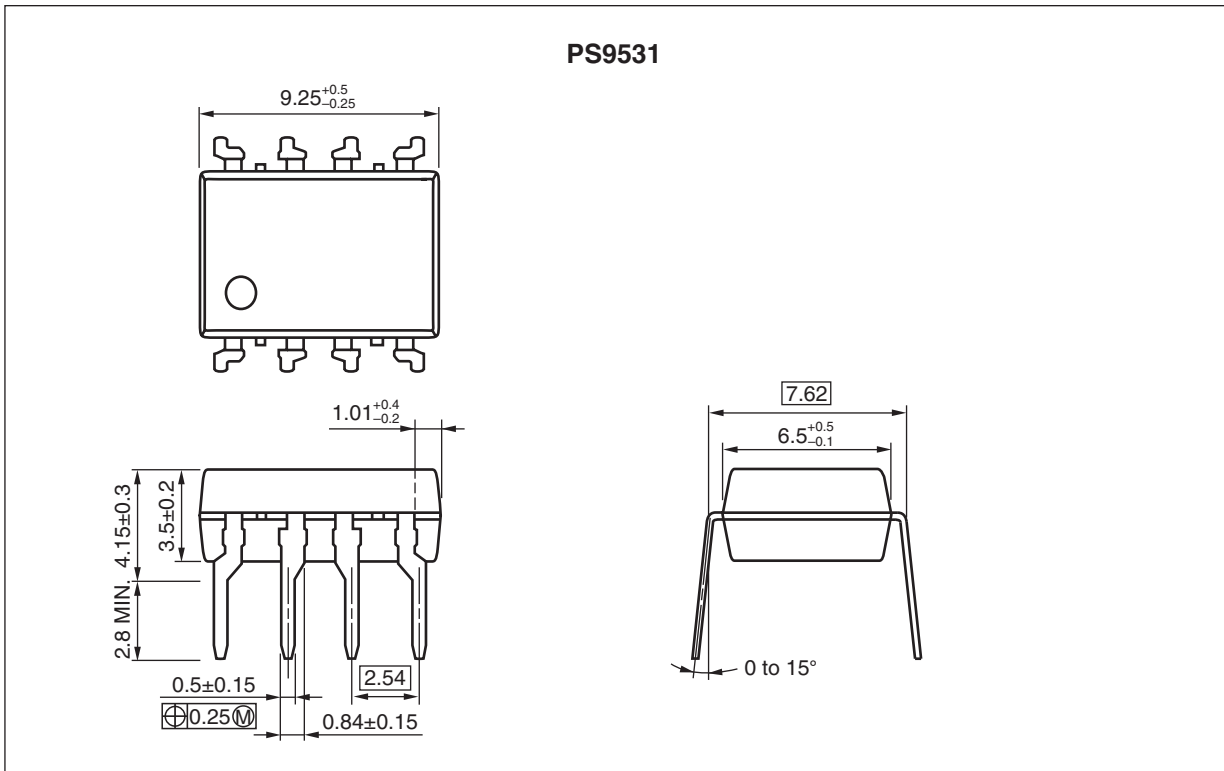
- IGBT, Power MOS FET Gate Driver
- Industrial inverter
- IH (Induction Heating)

The mark <R> shows major revised points.

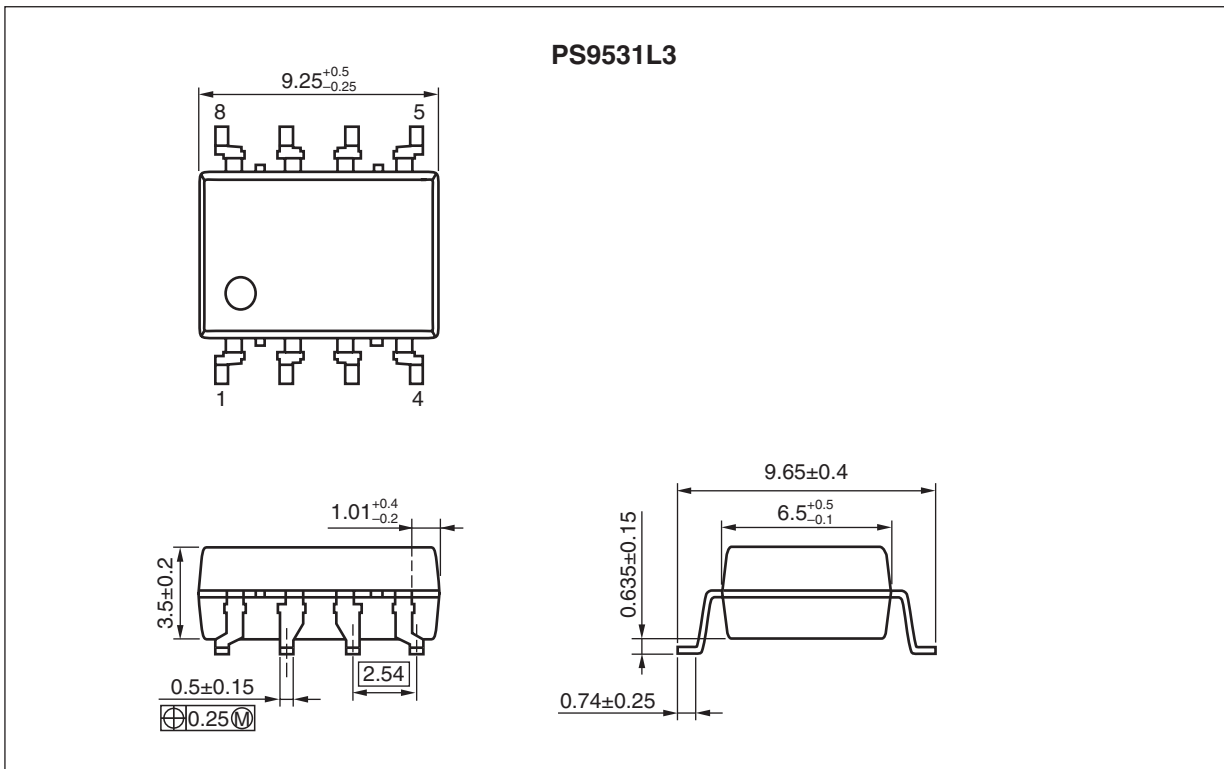
The revised points can be easily searched by copying an "<R>" in the PDF file and specifying it in the "Find what:" field.

**PACKAGE DIMENSIONS (UNIT: mm)**

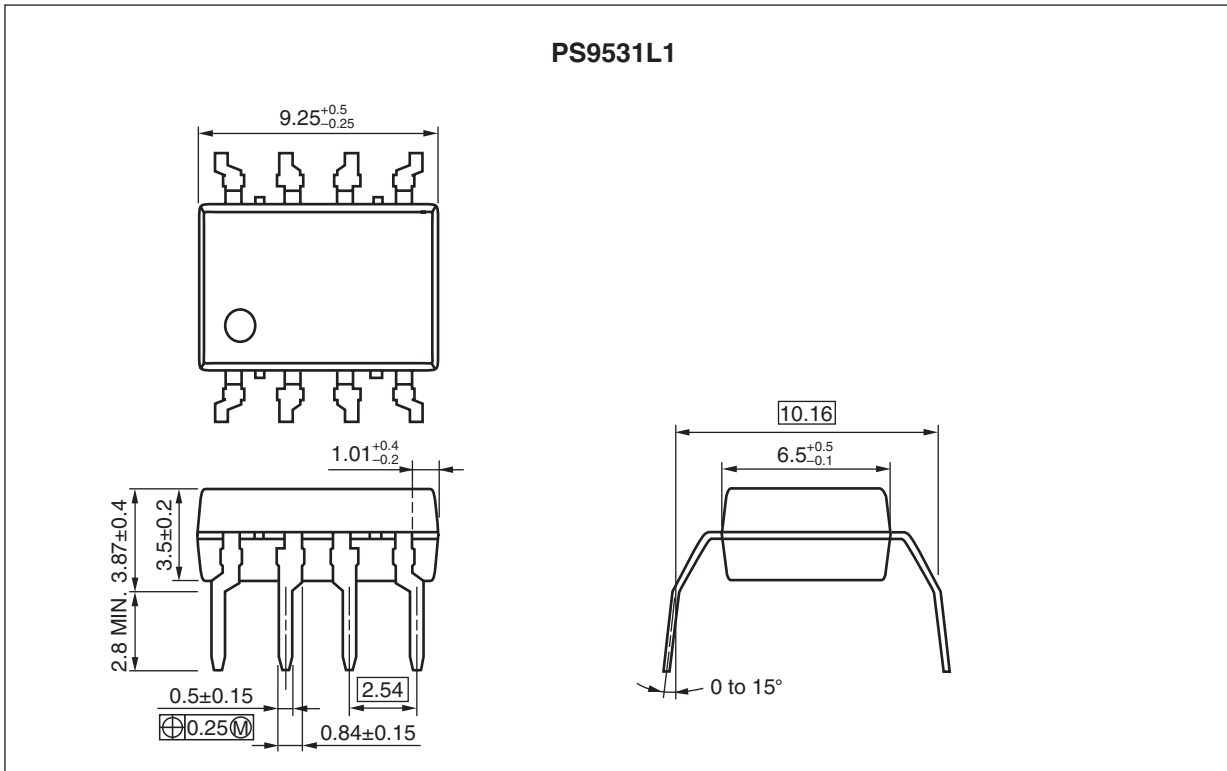
**DIP Type**



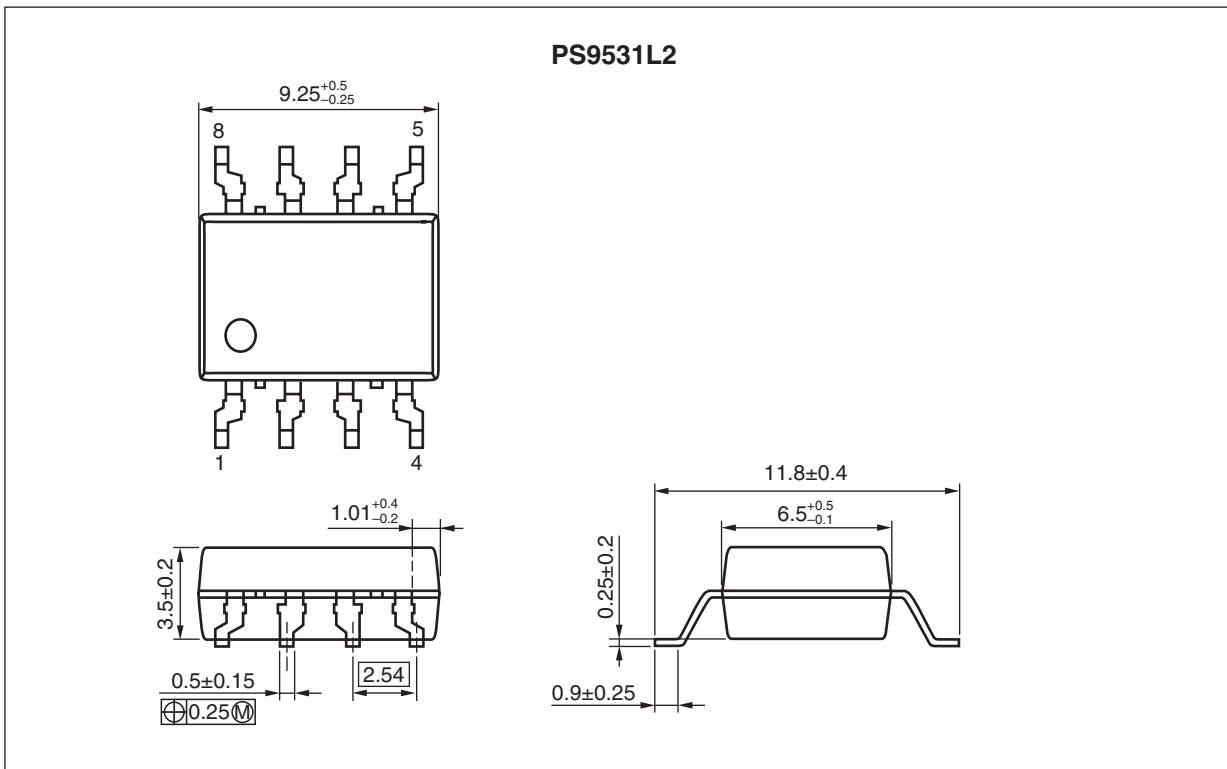
**Lead Bending Type (Gull-wing) For Surface Mount**



Lead Bending Type For Long Creepage Distance



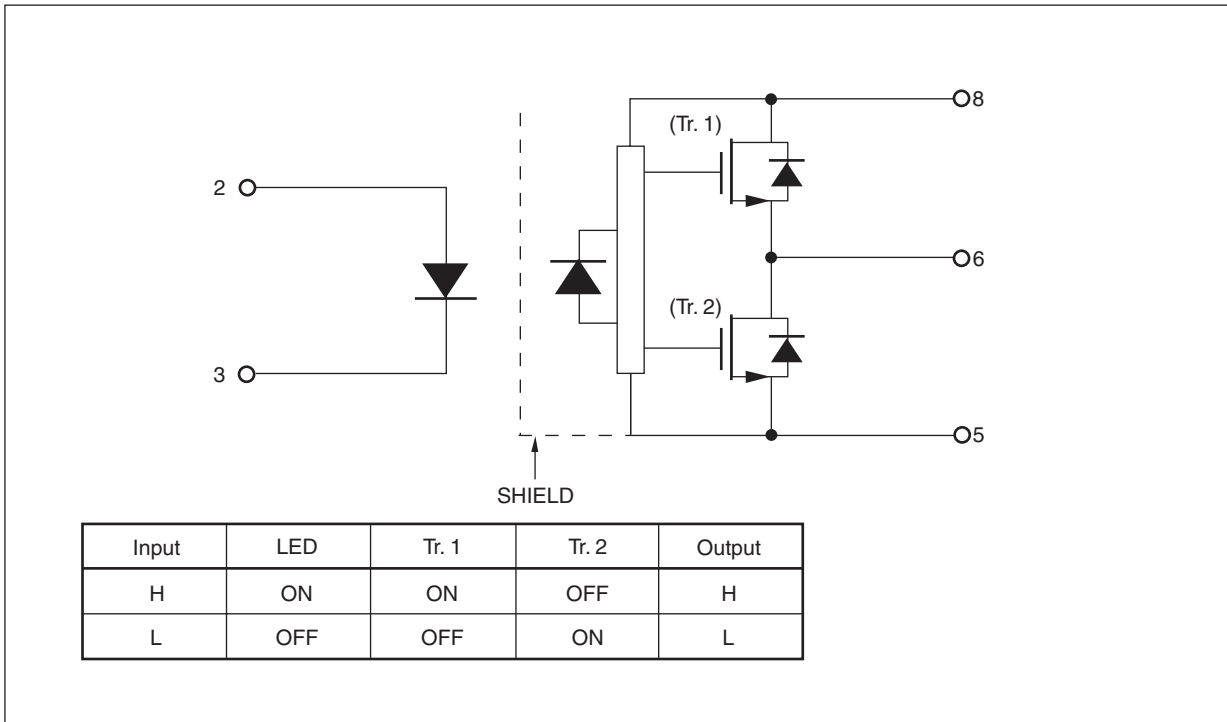
Lead Bending Type (Gull-wing) For Long Creepage Distance (Surface Mount)



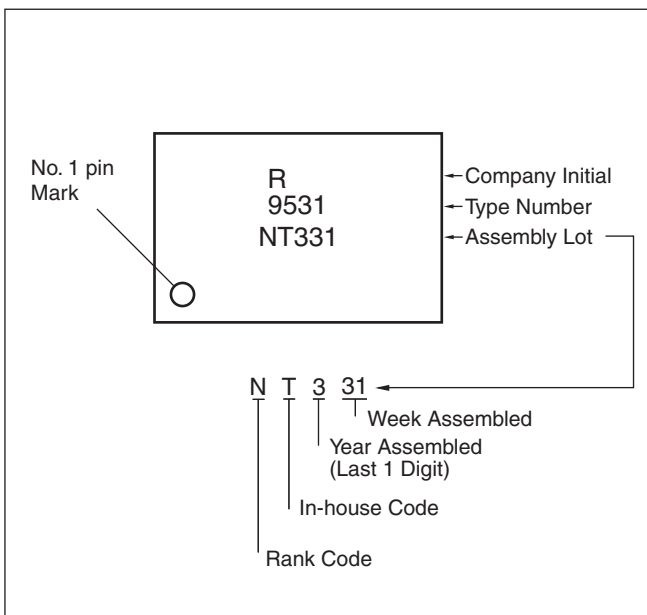
## PHOTOCOUPLER CONSTRUCTION

Parameter	PS9531, PS9531L3	PS9531L1, PS9531L2
Air Distance (MIN.)	7 mm	8 mm
Outer Creepage Distance (MIN.)	7 mm	8 mm
Isolation Distance (MIN.)	0.4 mm	0.4 mm

## FUNCTIONAL DIAGRAM



## MARKING EXAMPLE



**ORDERING INFORMATION**

Part Number	Order Number	Solder Plating Specification	Packing Style	Safety Standard Approval	Application Part Number <sup>*1</sup>			
PS9531	PS9531-AX	Pb-Free (Ni/Pd/Au)	50 Magazine Cases	Standard products (UL, CSA, SEMKO approved)	PS9531			
PS9531L1	PS9531L1-AX				PS9531L1			
PS9531L2	PS9531L2-AX				PS9531L2			
PS9531L3	PS9531L3-AX				PS9531L3			
PS9531L2-E3	PS9531L2-E3-AX		Embossed Tape 1 000 pcs/reel		PS9531L2			
PS9531L3-E3	PS9531L3-E3-AX				PS9531L3			
PS9531-V	PS9531-V-AX		50 Magazine Cases		UL, CSA, SEMKO, DIN EN 60747-5-5 (VDE 0884-5) approved	PS9531		
PS9531L1-V	PS9531L1-V-AX					PS9531L1		
PS9531L2-V	PS9531L2-V-AX					PS9531L2		
PS9531L3-V	PS9531L3-V-AX					PS9531L3		
PS9531L2-V-E3	PS9531L2-V-E3-AX					Embossed Tape 1 000 pcs/reel		PS9531L2
PS9531L3-V-E3	PS9531L3-V-E3-AX							PS9531L3

Note: \*1. For the application of the Safety Standard, following part number should be used.

**ABSOLUTE MAXIMUM RATINGS ( $T_A = 25^\circ\text{C}$ , unless otherwise specified)**

Parameter		Symbol	Ratings	Unit
Diode	Forward Current	$I_F$	25	mA
	Peak Transient Forward Current (Pulse Width < 1 $\mu\text{s}$ )	$I_{F(\text{TRAN})}$	1.0	A
	Reverse Voltage	$V_R$	5	V
	Power Dissipation *1	$P_D$	45	mW
Detector	High Level Peak Output Current *2	$I_{OH(\text{PEAK})}$	2.5	A
	Low Level Peak Output Current *2	$I_{OL(\text{PEAK})}$	2.5	A
	Supply Voltage	$(V_{CC} - V_{EE})$	0 to 35	V
	Output Voltage	$V_O$	0 to $V_{CC}$	V
	Power Dissipation *3	$P_C$	250	mW
Isolation Voltage *4		BV	5 000	Vr.m.s.
Operating Frequency		f	50	kHz
Operating Ambient Temperature		$T_A$	-40 to +125	$^\circ\text{C}$
Storage Temperature		$T_{\text{stg}}$	-55 to +150	$^\circ\text{C}$

Notes: \*1. Reduced to 1.5 mW/ $^\circ\text{C}$  at  $T_A = 110^\circ\text{C}$  or more.

\*2. Maximum pulse width = 10  $\mu\text{s}$ , Maximum duty cycle = 0.2%

\*3. Reduced to 3.9 mW/ $^\circ\text{C}$  at  $T_A = 90^\circ\text{C}$  or more.

\*4. AC voltage for 1 minute at  $T_A = 25^\circ\text{C}$ , RH = 60% between input and output.

Pins 1-4 shorted together, 5-8 shorted together.

**RECOMMENDED OPERATING CONDITIONS**

Parameter	Symbol	MIN.	TYP.	MAX.	Unit
Supply Voltage	$(V_{CC} - V_{EE})$	15		30	V
Forward Current (ON)	$I_{F(\text{ON})}$	8	10	12	mA
Forward Voltage (OFF)	$V_{F(\text{OFF})}$	-2		0.8	V
Operating Ambient Temperature	$T_A$	-40		125	$^\circ\text{C}$

**ELECTRICAL CHARACTERISTICS (at RECOMMENDED OPERATING CONDITIONS, V<sub>EE</sub> = GND, unless otherwise specified)**

Parameter		Symbol	Conditions	MIN.	TYP.* <sup>1</sup>	MAX.	Unit
Diode	Forward Voltage	V <sub>F</sub>	I <sub>F</sub> = 10 mA, T <sub>A</sub> = 25°C	1.35	1.56	1.75	V
	Reverse Current	I <sub>R</sub>	V <sub>R</sub> = 3 V, T <sub>A</sub> = 25°C			10	μA
	Input Capacitance	C <sub>IN</sub>	f = 1 MHz, V <sub>F</sub> = 0 V		30		pF
Detector	High Level Output Current	I <sub>OH</sub>	V <sub>O</sub> = (V <sub>CC</sub> - 4 V) <sup>*2</sup>	0.5	2.2		A
			V <sub>O</sub> = (V <sub>CC</sub> - 15 V) <sup>*3</sup>	2.0			
	Low Level Output Current	I <sub>OL</sub>	V <sub>O</sub> = (V <sub>EE</sub> + 2.5 V) <sup>*2</sup>	0.5	2.4		A
			V <sub>O</sub> = (V <sub>EE</sub> + 15 V) <sup>*3</sup>	2.0			
	High Level Output Voltage	V <sub>OH</sub>	I <sub>O</sub> = -100 mA <sup>*4</sup>	V <sub>CC</sub> - 3.0	V <sub>CC</sub> - 1.3		V
	Low Level Output Voltage	V <sub>OL</sub>	I <sub>O</sub> = 100 mA		0.2	0.5	V
	High Level Supply Current	I <sub>CCH</sub>	V <sub>O</sub> = Open		1.7	2.2	mA
	Low Level Supply Current	I <sub>CCL</sub>	V <sub>O</sub> = Open		1.7	2.2	mA
	UVLO Threshold	V <sub>UVLO+</sub>	V <sub>O</sub> > 5 V, I <sub>F</sub> = 10 mA	10.8	12.3	13.4	V
		V <sub>UVLO-</sub>		9.5	11.0	12.5	
UVLO Hysteresis	UVLO <sub>HYS</sub>	V <sub>O</sub> > 5 V, I <sub>F</sub> = 10 mA	0.4	1.3		V	
Coupled	Threshold Input Current (L → H)	I <sub>FLH</sub>	I <sub>O</sub> = 0 mA, V <sub>O</sub> > 5 V		2.0	4.0	mA
	Threshold Input Voltage (H → L)	V <sub>FHL</sub>	I <sub>O</sub> = 0 mA, V <sub>O</sub> < 5 V	0.8			V

Notes: \*1. Typical values at T<sub>A</sub> = 25°C, V<sub>CC</sub> - V<sub>EE</sub> = 30 V.

\*2. Maximum pulse width = 50 μs, Maximum duty cycle = 0.5%.

\*3. Maximum pulse width = 10 μs, Maximum duty cycle = 0.2%.

\*4. V<sub>OH</sub> is measured with the DC load current in this testing (Maximum pulse width = 2 ms, Maximum duty cycle = 20%).

**SWITCHING CHARACTERISTICS (at RECOMMENDED OPERATING CONDITIONS, V<sub>EE</sub> = GND, unless otherwise specified)**

Parameter	Symbol	Conditions	MIN.	TYP.* <sup>1</sup>	MAX.	Unit	
Propagation Delay Time (L → H)	t <sub>PLH</sub>	R <sub>g</sub> = 10 Ω, C <sub>g</sub> = 10 nF, f = 10 kHz, Duty Cycle = 50%, I <sub>F</sub> = 10 mA		80	175	ns	
Propagation Delay Time (H → L)	t <sub>PHL</sub>			100	175	ns	
Pulse Width Distortion (PWD)	t <sub>PHL</sub> - t <sub>PLH</sub>				20	75	ns
Propagation Delay Time (Difference Between Any Two Products)	t <sub>PHL</sub> - t <sub>PLH</sub>			-90		90	ns
Rise Time	t <sub>r</sub>				40		ns
Fall Time	t <sub>f</sub>				40		ns
Common Mode Transient Immunity at High Level Output	CM <sub>H</sub>		T <sub>A</sub> = 25°C, I <sub>F</sub> = 10 mA, V <sub>CC</sub> = 30 V, V <sub>CM</sub> = 1.5 kV	50			kV/μs
Common Mode Transient Immunity at Low Level Output	CM <sub>L</sub>	T <sub>A</sub> = 25°C, I <sub>F</sub> = 0 mA, V <sub>CC</sub> = 30 V, V <sub>CM</sub> = 1.5 kV	50			kV/μs	

Note: \*1. Typical values at T<sub>A</sub> = 25°C, V<sub>CC</sub> - V<sub>EE</sub> = 30 V.

TEST CIRCUIT

Fig. 1 I<sub>OH</sub> Test Circuit

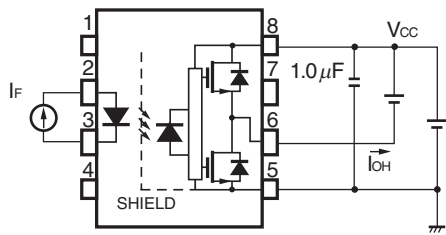


Fig. 2 I<sub>OL</sub> Test Circuit

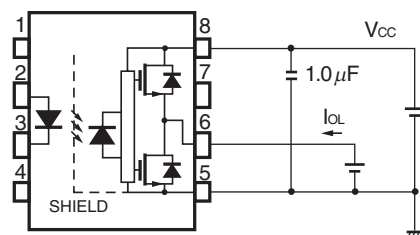


Fig. 3 V<sub>OH</sub> Test Circuit

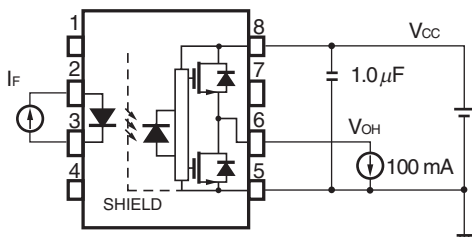


Fig. 4 V<sub>OL</sub> Test Circuit

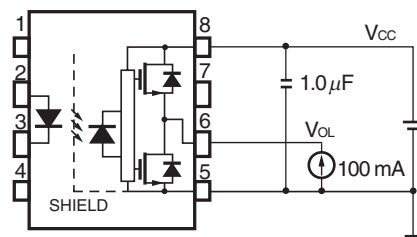


Fig. 5 I<sub>CCH</sub>/I<sub>CCL</sub> Test Circuit

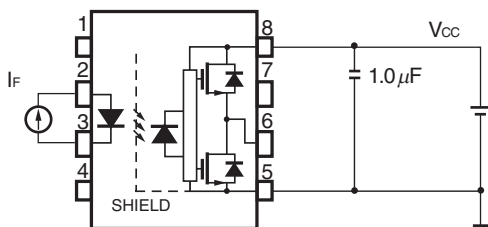


Fig. 6 UVLO Test Circuit

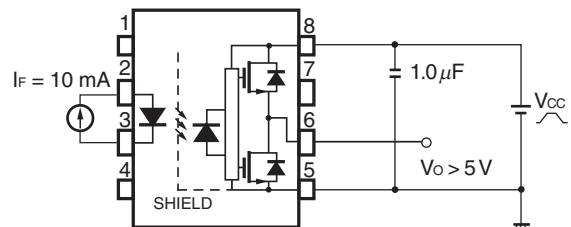




Fig. 7 I<sub>FLH</sub> Test Circuit

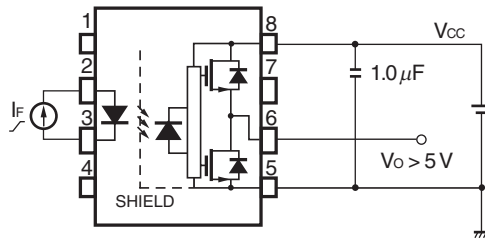


Fig. 8 t<sub>PLH</sub>, t<sub>PHL</sub>, t<sub>r</sub>, t<sub>f</sub> Test Circuit and Wave Forms

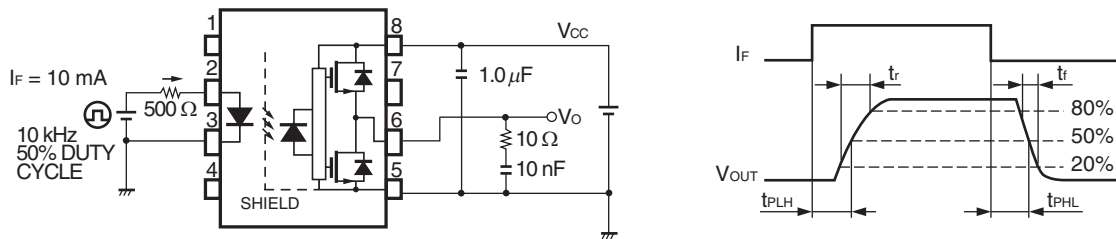
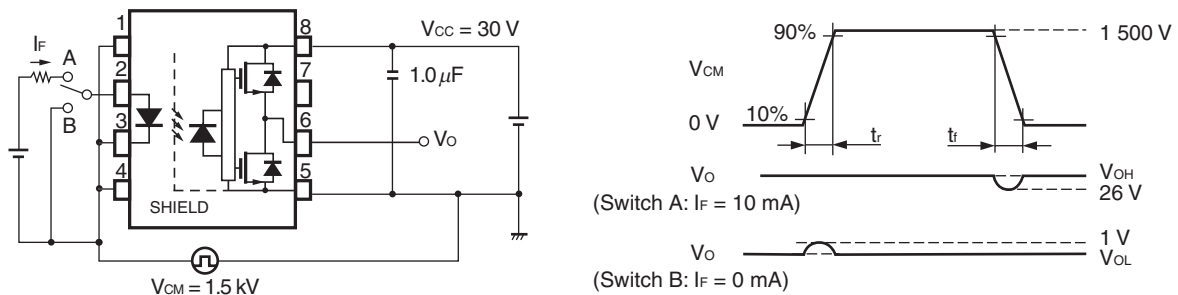
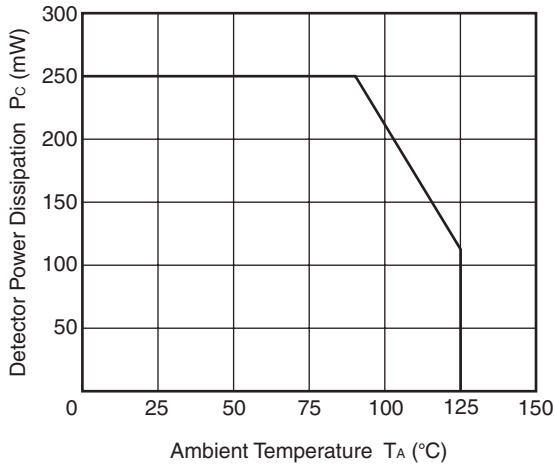


Fig. 9 CMR Test Circuit and Wave Forms

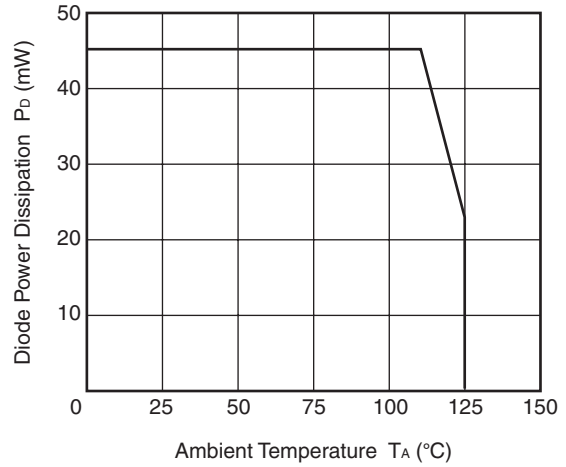


**TYPICAL CHARACTERISTICS ( $T_A = 25^\circ\text{C}$ , unless otherwise specified)**

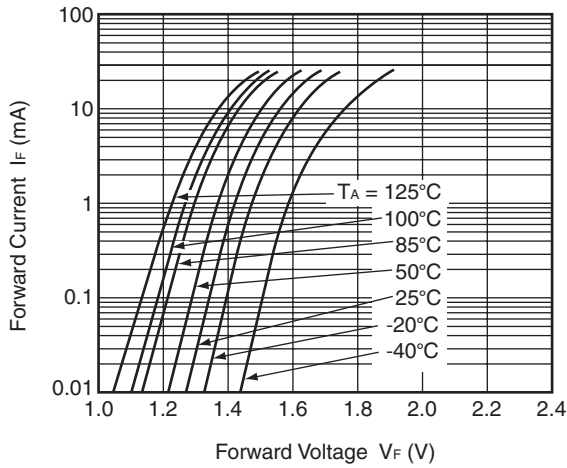
**DETECTOR POWER DISSIPATION vs. AMBIENT TEMPERATURE**



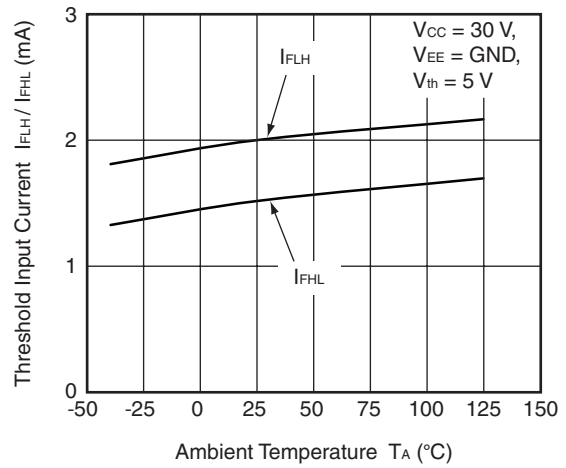
**DIODE POWER DISSIPATION vs. AMBIENT TEMPERATURE**



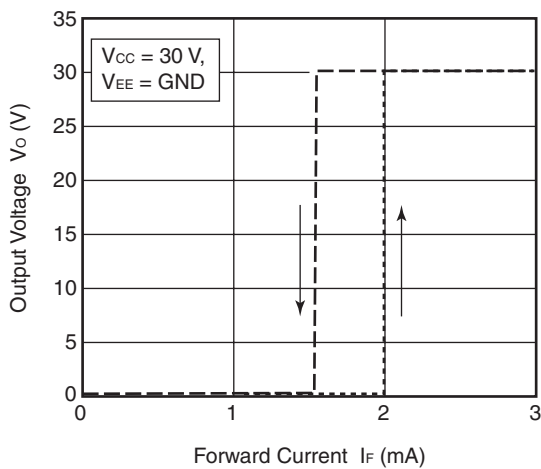
**FORWARD CURRENT vs. FORWARD VOLTAGE**



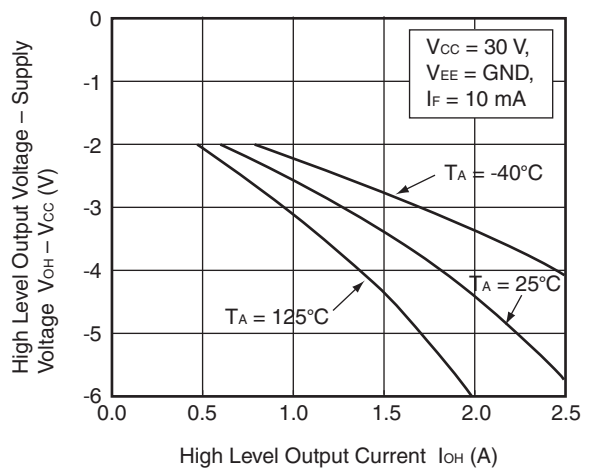
**THRESHOLD INPUT CURRENT vs. AMBIENT TEMPERATURE**



**OUTPUT VOLTAGE vs. FORWARD CURRENT**

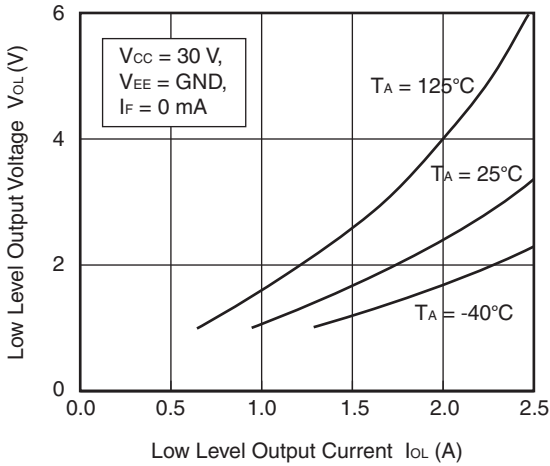


**HIGH LEVEL OUTPUT VOLTAGE – SUPPLY VOLTAGE vs. HIGH LEVEL OUTPUT CURRENT**

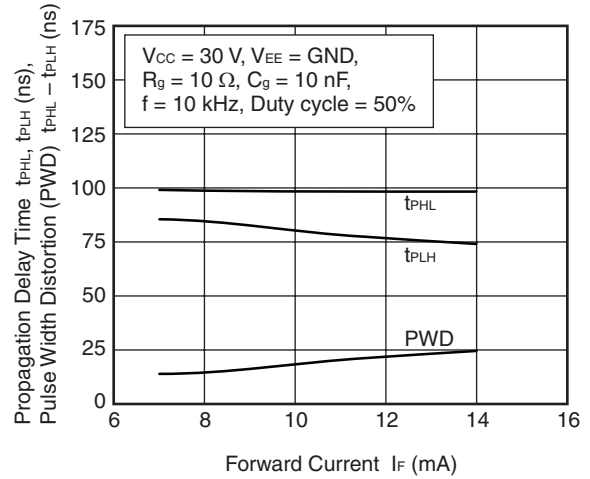


**Remark** The graphs indicate nominal characteristics.

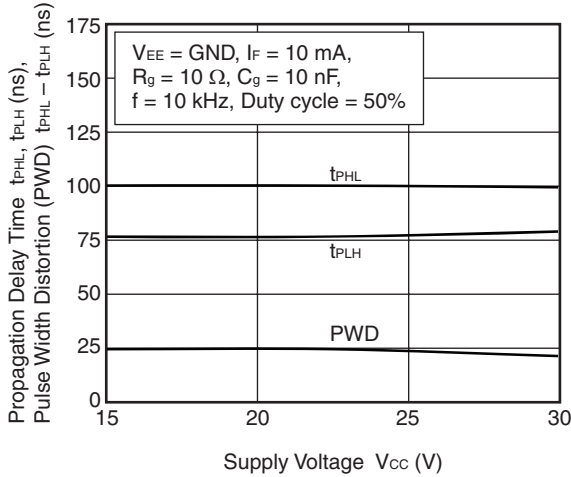
LOW LEVEL OUTPUT VOLTAGE vs. LOW LEVEL OUTPUT CURRENT



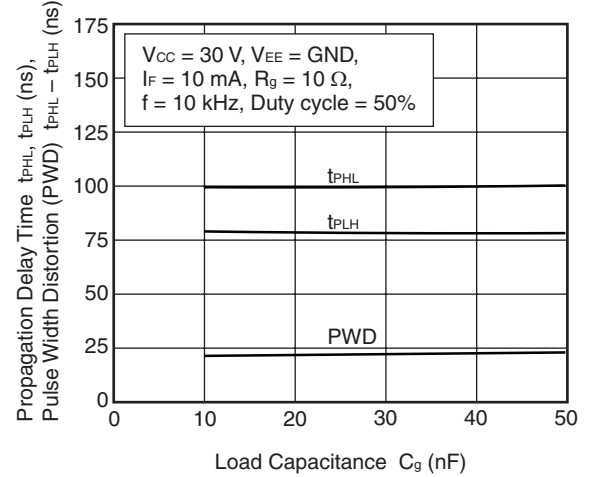
PROPAGATION DELAY TIME, PULSE WIDTH DISTORTION vs. FORWARD CURRENT



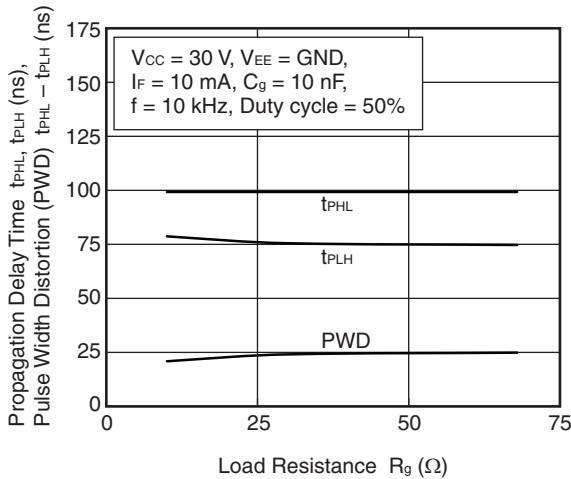
PROPAGATION DELAY TIME, PULSE WIDTH DISTORTION vs. SUPPLY VOLTAGE



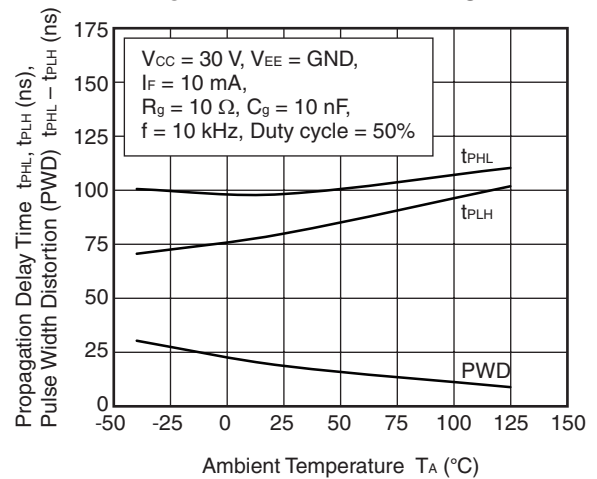
PROPAGATION DELAY TIME, PULSE WIDTH DISTORTION vs. LOAD CAPACITANCE



PROPAGATION DELAY TIME, PULSE WIDTH DISTORTION vs. LOAD RESISTANCE

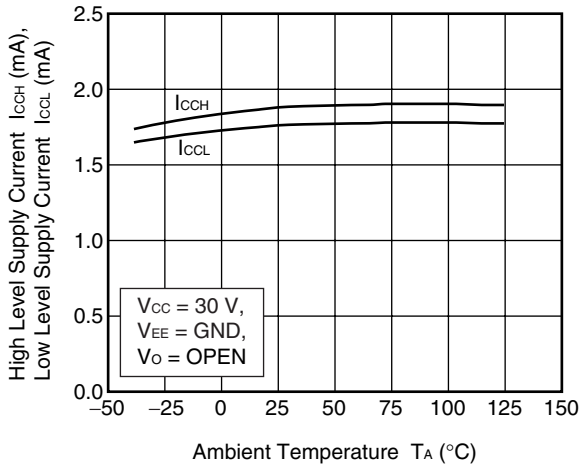


PROPAGATION DELAY TIME, PULSE WIDTH DISTORTION vs. AMBIENT TEMPERATURE

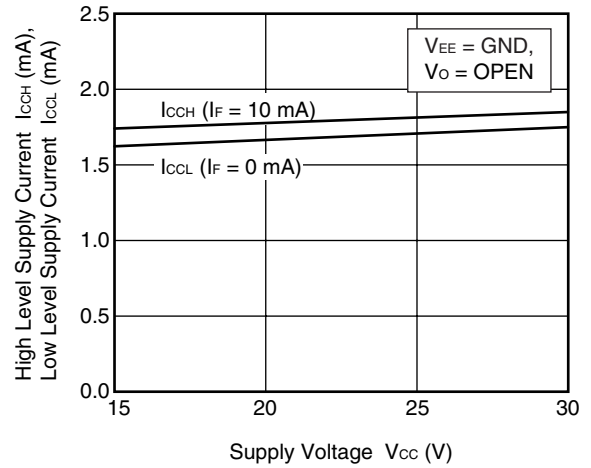


**Remark** The graphs indicate nominal characteristics.

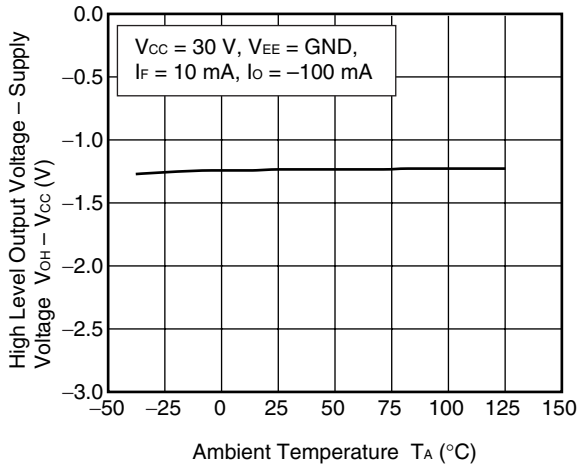
SUPPLY CURRENT vs. AMBIENT TEMPERATURE



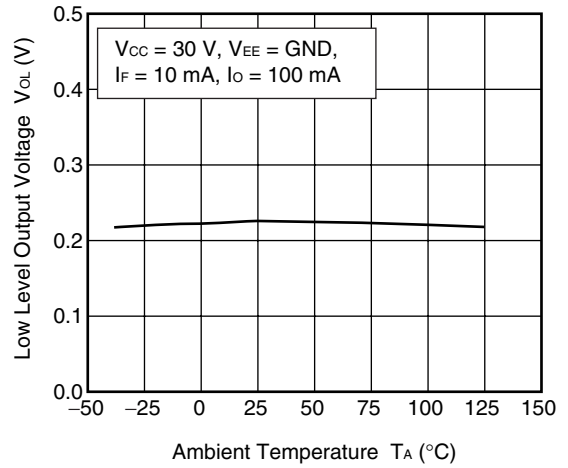
SUPPLY CURRENT vs. SUPPLY VOLTAGE



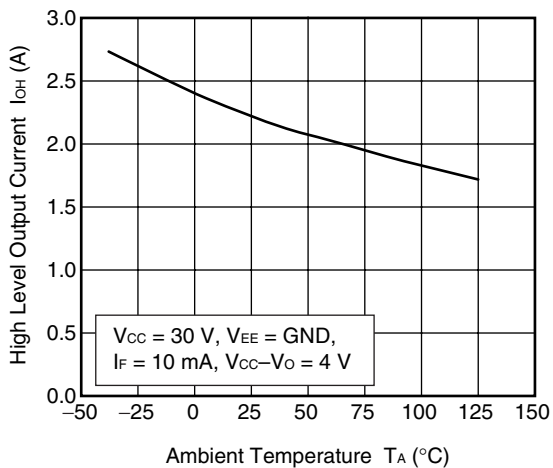
HIGH LEVEL OUTPUT VOLTAGE – SUPPLY VOLTAGE vs. AMBIENT TEMPERATURE



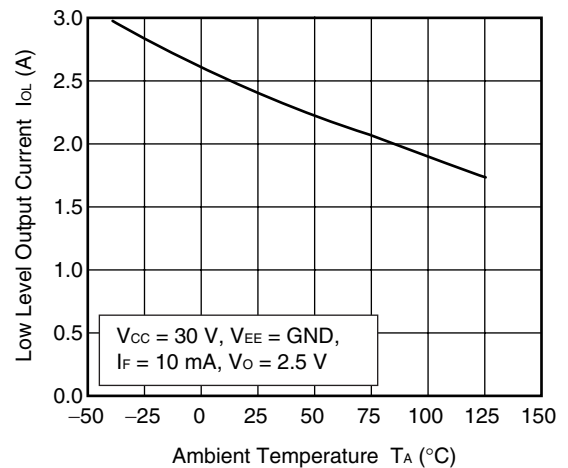
LOW LEVEL OUTPUT VOLTAGE vs. AMBIENT TEMPERATURE



HIGH LEVEL OUTPUT CURRENT vs. AMBIENT TEMPERATURE

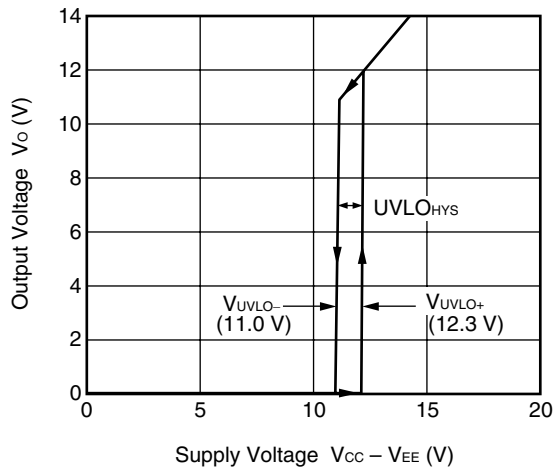


LOW LEVEL OUTPUT CURRENT vs. AMBIENT TEMPERATURE



**Remark** The graphs indicate nominal characteristics.

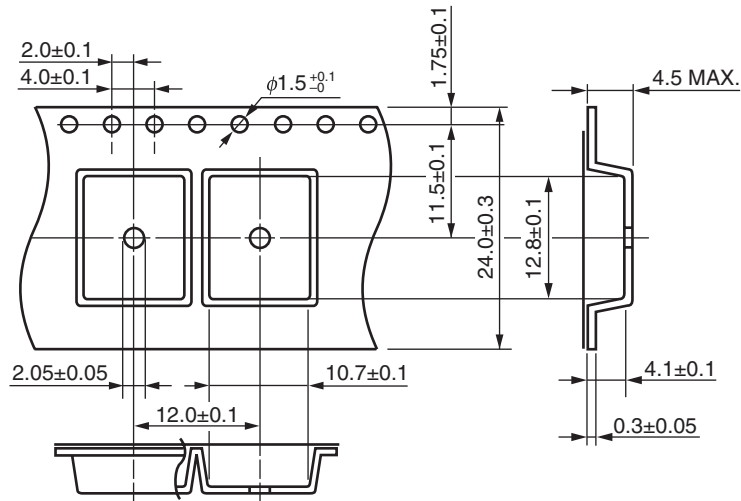
OUTPUT VOLTAGE vs. SUPPLY VOLTAGE



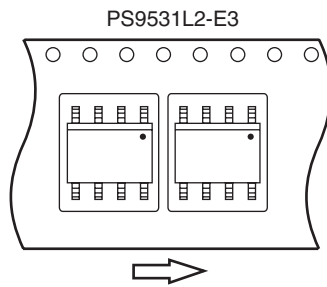
**Remark** The graphs indicate nominal characteristics.

**TAPING SPECIFICATIONS (UNIT: mm)**

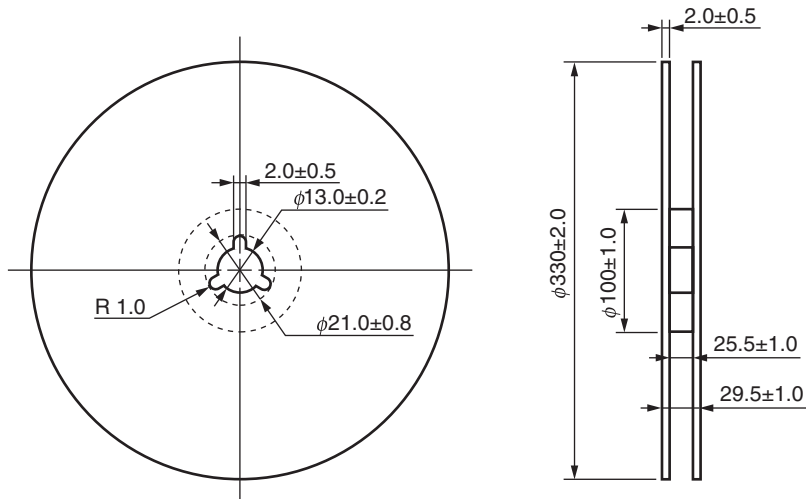
Outline and Dimensions (Tape)



Tape Direction

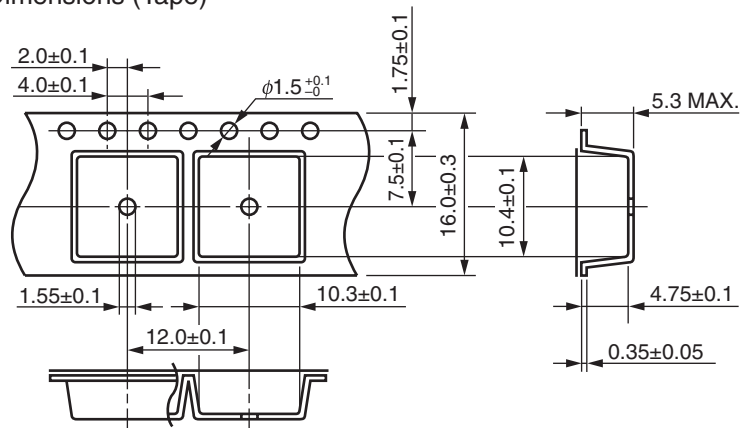


Outline and Dimensions (Reel)

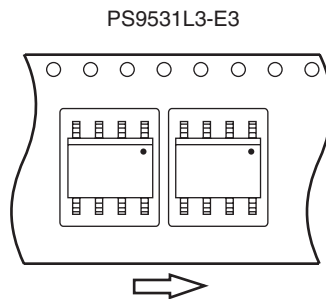


Packing: 1 000 pcs/reel

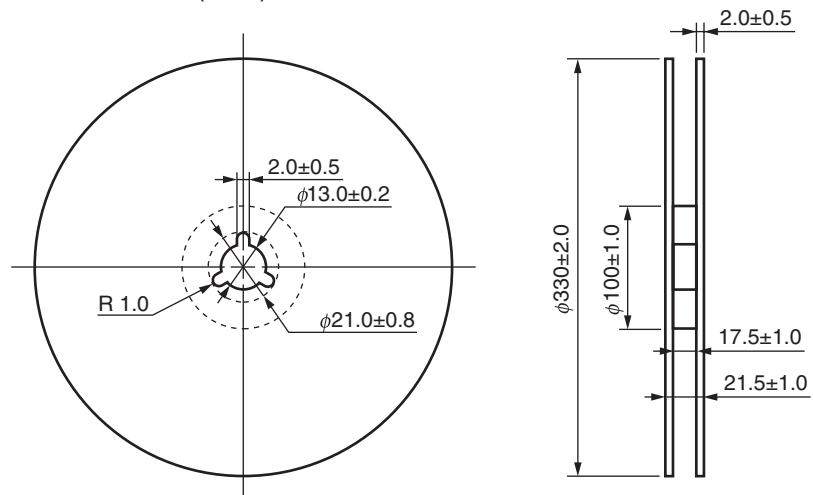
Outline and Dimensions (Tape)



Tape Direction

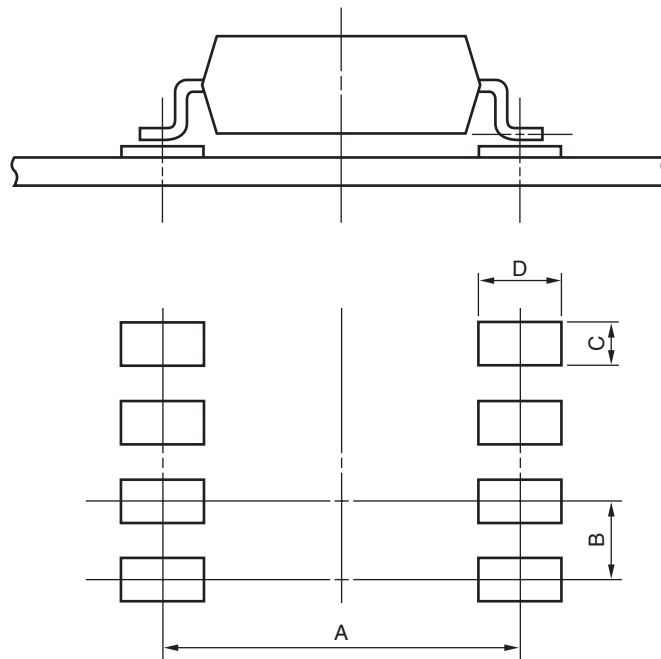


Outline and Dimensions (Reel)



Packing: 1 000 pcs/reel

**RECOMMENDED MOUNT PAD DIMENSIONS (UNIT: mm)**



Part Number	Lead Bending	A	B	C	D
PS9531L2	lead bending type (Gull-wing) for long creepage distance (surface mount)	10.2	2.54	1.7	2.2
PS9531L3	lead bending type (Gull-wing) for surface mount	9.0	2.54	1.7	2.0



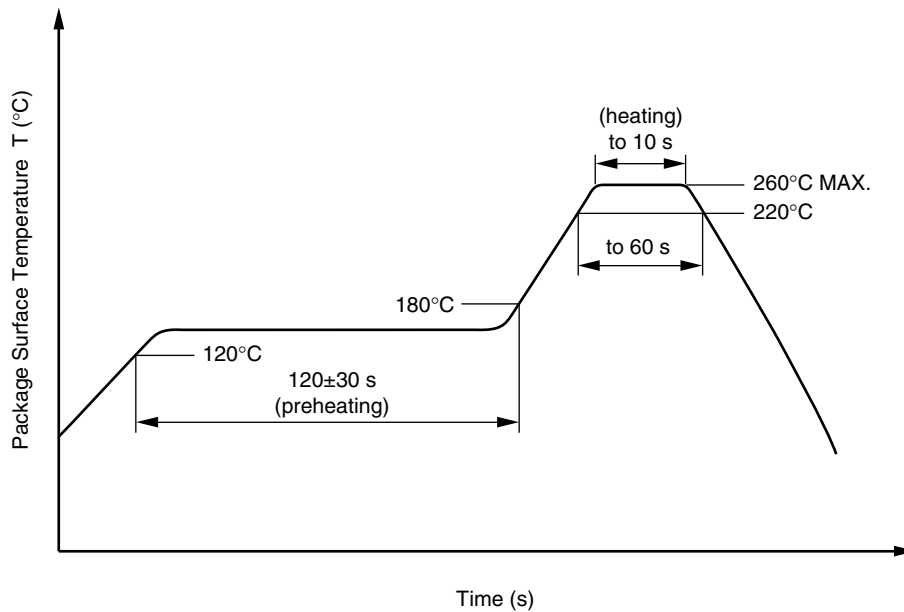
## NOTES ON HANDLING

### 1. Recommended soldering conditions

#### (1) Infrared reflow soldering

- Peak reflow temperature 260°C or below (package surface temperature)
- Time of peak reflow temperature 10 seconds or less
- Time of temperature higher than 220°C 60 seconds or less
- Time to preheat temperature from 120 to 180°C 120±30 s
- Number of reflows Three
- Flux Rosin flux containing small amount of chlorine (The flux with a maximum chlorine content of 0.2 Wt% is recommended.)

Recommended Temperature Profile of Infrared Reflow



#### (2) Wave soldering

- Temperature 260°C or below (molten solder temperature)
- Time 10 seconds or less
- Preheating conditions 120°C or below (package surface temperature)
- Number of times One (Allowed to be dipped in solder including plastic mold portion.)
- Flux Rosin flux containing small amount of chlorine (The flux with a maximum chlorine content of 0.2 Wt% is recommended.)

#### (3) Soldering by Soldering Iron

- Peak Temperature (lead part temperature) 350°C or below
- Time (each pins) 3 seconds or less
- Flux Rosin flux containing small amount of chlorine (The flux with a maximum chlorine content of 0.2 Wt% is recommended.)

(a) Soldering of leads should be made at the point 1.5 to 2.0 mm from the root of the lead

(4) Cautions

- Fluxes

Avoid removing the residual flux with freon-based and chlorine-based cleaning solvent.

2. Cautions regarding noise

Be aware that when voltage is applied suddenly between the photocoupler's input and output at startup, the output transistor may enter the on state, even if the voltage is within the absolute maximum ratings.

## **USAGE CAUTIONS**

1. This product is weak for static electricity by designed with high-speed integrated circuit so protect against static electricity when handling.
2. Board designing
  - (1) By-pass capacitor of more than 1.0  $\mu\text{F}$  is used between VCC and GND near device. Also, ensure that the distance between the leads of the photocoupler and capacitor is no more than 10 mm.
  - (2) When designing the printed wiring board, ensure that the pattern of the IGBT collectors/emitters is not too close to the input block pattern of the photocoupler.

If the pattern is too close to the input block and coupling occurs, a sudden fluctuation in the voltage on the IGBT output side might affect the photocoupler's LED input, leading to malfunction or degradation of characteristics.

(If the pattern needs to be close to the input block, to prevent the LED from lighting during the off state due to the abovementioned coupling, design the input-side circuit so that the bias of the LED is reversed, within the range of the recommended operating conditions, and be sure to thoroughly evaluate operation.)
  - (3) Pins 1, 4 (which is an NC<sup>\*1</sup> pin) can either be connected directly to the GND pin on the LED side or left open. Pin 7, which is an NC<sup>\*1</sup> pin, can either be connected directly to Pin 6 or the GND pin on the output side (photo diode side), or left open.

Unconnected pins should not be used as a bypass for signals or for any other similar purpose because this may degrade the internal noise environment of the device.

\*1 NC: Non-Connection (No Connection)
3. Make sure the rise/fall time of the forward current is 0.5  $\mu\text{s}$  or less.
4. In order to avoid malfunctions, make sure the rise/fall slope of the supply voltage is 3 V/ $\mu\text{s}$  or less.
5. Avoid storage at a high temperature and high humidity.

## SPECIFICATION OF VDE MARKS LICENSE DOCUMENT

Parameter	Symbol	Spec.	Unit
Climatic test class (IEC 60068-1/DIN EN 60068-1)		40/125/21	
Dielectric strength maximum operating isolation voltage	$U_{IORM}$	1 130	$V_{peak}$
Test voltage (partial discharge test, procedure a for type test and random test) $U_{pr} = 1.6 \times U_{IORM}, P_d < 5 \text{ pC}$	$U_{pr}$	1 808	$V_{peak}$
Test voltage (partial discharge test, procedure b for all devices) $U_{pr} = 1.875 \times U_{IORM}, P_d < 5 \text{ pC}$	$U_{pr}$	2 119	$V_{peak}$
Highest permissible overvoltage	$U_{TR}$	8 000	$V_{peak}$
Degree of pollution (DIN EN 60664-1 VDE 0110 Part 1)		2	
Comparative tracking index (IEC 60112/DIN EN 60112 (VDE 0303 Part 11))	CTI	175	
Material group (DIN EN 60664-1 VDE 0110 Part 1)		III a	
Storage temperature range	$T_{stg}$	-55 to +150	°C
Operating temperature range	$T_A$	-40 to +125	°C
Isolation resistance, minimum value $V_{IO} = 500 \text{ V dc at } T_A = 25^\circ\text{C}$	Ris MIN.	$10^{12}$	$\Omega$
$V_{IO} = 500 \text{ V dc at } T_A \text{ MAX. at least } 100^\circ\text{C}$	Ris MIN.	$10^{11}$	$\Omega$
Safety maximum ratings (maximum permissible in case of fault, see thermal derating curve)			
Package temperature	$T_{si}$	175	°C
Current (input current $I_F$ , $P_{si} = 0$ )	$I_{si}$	400	mA
Power (output or total power dissipation)	$P_{si}$	700	mW
Isolation resistance $V_{IO} = 500 \text{ V dc at } T_A = T_{si}$	Ris MIN.	$10^9$	$\Omega$

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<b>Revision History</b>	<b>PS9531, PS9531L1, PS9531L2, PS9531L3 Data Sheet</b>
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Rev.	Date	Description	
		Page	Summary
0.01	Jul 08, 2013	–	First Edition issued
1.00	Nov 29, 2013	Throughout	Preliminary Data Sheet -> Data Sheet
		Throughout	Safety standards approved

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