How to replace mechanical relays with photorelays

Overview

Compared with mechanical relays, photorelays are superior in terms of long life, low current drive, and high-speed response. They are applied to a variety of end-products, including semiconductor tester contact switching and security device contact output. Our lineup includes products for semiconductor testers featuring ultra-small packages, low R_{ON}, and low C_{OFF}, as well as a wide range of packages and general-purpose products featuring large currents and high off-voltages. This document describes tips and precautions for replacing mechanical relays with photorelays.

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1. What is photorelay?

1.1 Structure of photorelay

The photorelay is equipped with infrared LEDs on the input side and Photo Diode Array (hereinafter called "PDA") and MOSFETs on the output side. The input and output sides are electrically isolated with resin.

Fig. 1.1.1 shows an example of the internal structure of the 2.54SOP4 package, which is one of the packages deployed by the photorelay. The LED on the input side and the PDA on the output side is placed as face-to-face, and is insulated with silicone resin.

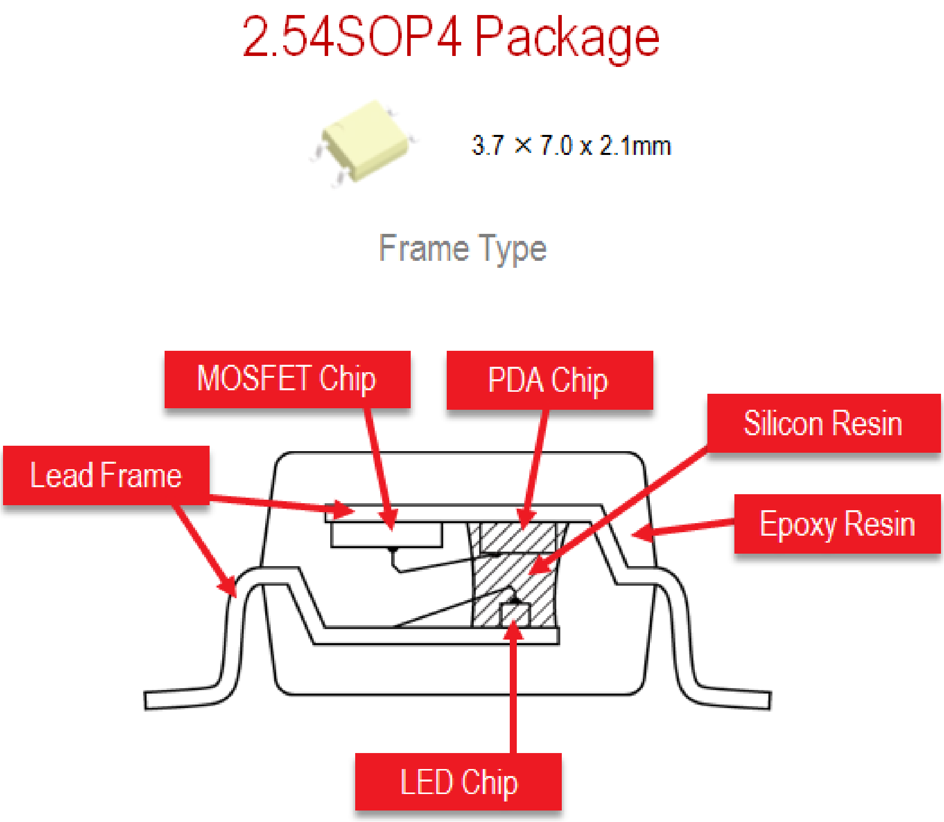


Fig. 1.1.1 Example of Internal Structure

1.2 Principle of photorelay operation

The photorelay is operated by applying current to the LED on the input side. Then the PDA on the output side receives infrared light from the LED and generates electromotive force. This electromotive force drives each MOSFET gate and thus turns on the MOSFETs.

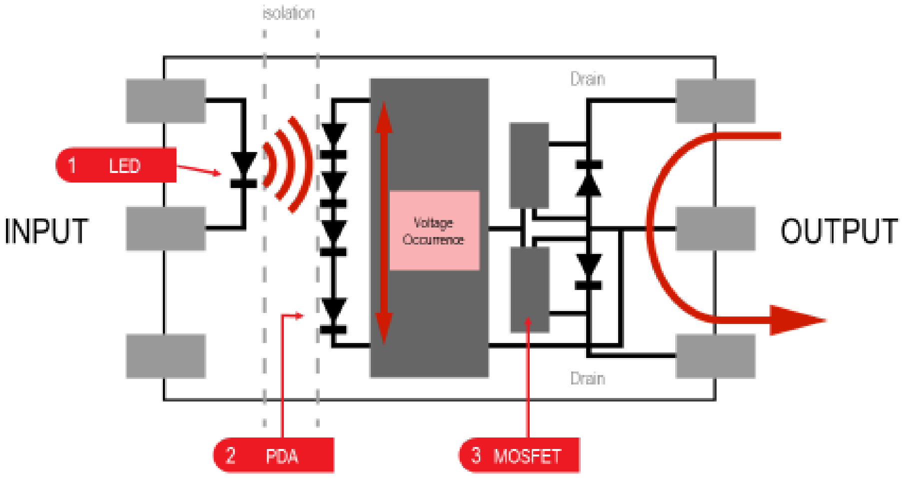


Fig. 1.2.1 Principle of photorelay operation

1.3 Contact structure of photorelay

Form A is a contact type, the output side is turned on when a certain amount of current is applied to the input side. This contact type is also called normally open type. It is denoted as 1a and represents 1-pole a-contact relay and 2-pole a-contact relay, denoted as 2a.

On the other hand, when a certain amount of current is applied to the input side, the output side of Form B contact type keeps off state, and when the current on the input side falls below a certain level, the output side turns to on state. This contact type is also known as normally closed. It is denoted as 1b and represents 1-pole b-contact relay and 2-pole b-contact relay, denoted as 2b.

The photorelay uses enhancement-type MOSFETs for form A and depletion-type MOSFETs for form B.

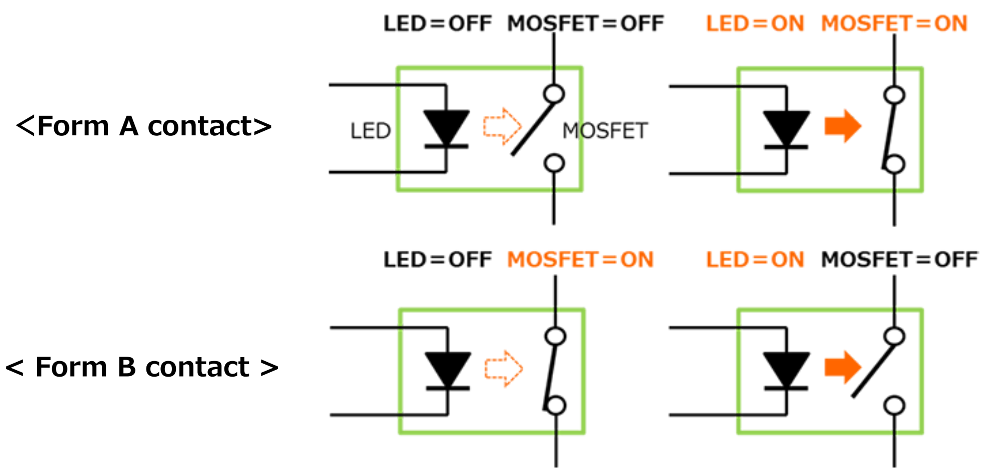


Fig. 1.3.1 Contact structure

2. Electrical characteristics of mechanical relays and photorelays

2.1 Comparison of electrical characteristics items

Each characteristic of the mechanical relay and photorelay can be linked as shown in the following table.

Mechanical Relay Characteristic		Explanation	Equivalent Photorelay Characteristic
Rated Coil Voltage and (Coil) Nominal Current		Voltage, intended by design, applied to the coil for operation and the resulting value of current flow in the coil	Input forward current (I_F), Input forward voltage (V_F), Recommended input forward current (I_F)
Contact Form		Contact type and the number of contacts in the circuit e.g.: Normally Open × 1 Contact (1a) Normally Close × 1 Contact (1b) Transfer Contact × 1 Contact (1c)	Contact type and the number of contacts in the circuit e.g.: Normally ON × 1 Contact (1a) Normally OFF × 1 Contact (1b)
Contact Resistance		Total resistance when the contacts meet	ON-state resistance (R_{ON})
Contact Capacity		Voltage and current that the device can handle in the ON state	OFF-state output terminal voltage (V_{OFF}), ON-state current (I_{ON} , I_{ONP})
Maximum Allowable Switching Power		Upper limit of power within which the part can be turned on and off properly	Output power dissipation (P_O)
Maximum Allowable Switching Voltage		Maximum open circuit voltage Requires derating according to operation load and current	OFF-state output terminal voltage (V_{OFF})
Maximum Allowable Switching Current		Maximum current that the contacts can handle Requires derating according to operation load and voltage	ON-state current (I_{ON}, I_{ONP})
Switching (Time) Characteristics	Operation Time	Coil contact time after the rated coil voltage is added with the coil. (Bounce time not included)	Turn-on Time (t_{ON})
	Release Time	Coil contact time after the rated coil voltage is removed from the coil. (Bounce time not included)	Turn-off Time (t_{OFF})
Lifetime	Mechanical Life	Minimum number of operation cycles the relay can undergo with no load on the contacts.	Estimates the operable time from the LED lifetime data and the maximum trigger LED current
	Electrical Life	Minimum number of operation cycles the relay can undergo with a specified load on the contacts.	Estimates the operable time from the LED lifetime data and the maximum trigger LED current
Operating Temperature		Ambient temperature of the environment at which the relay is operated.	Operating temperature (T_{opr})

2.2 Example of Toshiba photorelay data sheet descriptions

Input forward current
Max allowable forward current at 25°C that can be input into the LED without damage.
Please note to design within this spec.

OFF-state output terminal voltage
Max voltage which can be applied between the MOSFETs output pins in the OFF-state. It provides an indication as to the power source used.

ON-state current
Max current which can flow between the MOSFETs output pins in the ON-state.
Design for both DC and AC currents are to be kept within this value.
I_{ON}(max) changes with ambient temperature.

ON-state current (pulsed)
Max current which can flow instantaneously between the MOSFETs output pins in the ON-state.
Design for both DC and AC currents are to be kept within this value.
I_{ONP}(max) changes with ambient temperature.

Isolation Voltage
Resistance between the input and output pins at the specified voltage for 1 minute.
The limit within which isolation breakdown does not occur.

Absolute Maximum Ratings (Note) (Unless otherwise specified, T_a = 25 °C)

	Characteristics		Symbol	Note	Rating	Unit
LED	Input forward current		I_F		30	mA
	Input forward current derating	($T_a \geq$ 25 °C)	$\Delta I_F/\Delta T_a$		-0.3	mA/°C
	Input reverse voltage		V_R		5	V
	Junction temperature		T_j		125	°C
Detector	OFF-state output terminal voltage		V_{OFF}		40	V
	ON-state current		I_{ON}		120	mA
	ON-state current derating	($T_a \geq$ 25 °C)	$\Delta I_{ON}/\Delta T_a$		-1.2	mA/°C
	ON-state current (pulsed)	(t = 100 ms, Duty = 1/10)	I_{ONP}		360	mA
	Junction temperature		T_j		125	°C
Common	Storage temperature		T_{stg}		-40 to 125	°C
	Operating temperature		T_{opr}		-40 to 110	
	Lead soldering temperature	(10 s)	T_{sol}		260	
	Isolation voltage	AC, 60 s, R.H. ≤ 60 %	BV_S	(Note 1)	500	Vrms

Output Capacitance
Electrostatic capacitance between the MOSFET's output pins (capacitance of the PN junction between the two drains).
There is leakage through this "capacitor" when LED is OFF.

Trigger LED Current
Min value of the input current IF necessary to turn the output MOSFET into the ON-state

ON-state Resistance
Resistance between the MOSFET output pins when the MOSFET turns on at a specified input LED current.

Turn-ON Time
Time required for output waveform to drop to 10% upon turning on the LED

Turn-OFF Time
Time required for output waveform to return to 90% upon turning off the LED

Electrical Characteristics (Unless otherwise specified, T_a = 25 °C)

	Characteristics	Symbol	Note	Test Condition	Min	Typ.	Max	Unit
LED	Input forward voltage	V_F		I_F = 10 mA	1.1	1.27	1.4	V
	Input reverse current	I_R		V_R = 5 V	—	—	10	μA
	Input capacitance	C_t		V = 0 V, f = 1 MHz	—	30	—	pF
Detector	OFF-state current	I_{OFF}		V_{OFF} = 40 V	—	—	1	nA
	Output capacitance	C_{OFF}		V = 0 V, f = 100 MHz, t < 1 s	—	0.45	0.8	pF

Coupled Electrical Characteristics (Unless otherwise specified, T_a = 25 °C)

Characteristics	Symbol	Note	Test Condition	Min	Typ.	Max	Unit
Trigger LED current	I_{FT}		I_{ON} = 100 mA		—	3	mA
Return LED current	I_{FC}		I_{OFF} = 10 μA	0.1	—	—	
ON-state resistance	R_{ON}		I_{ON} = 120 mA, I_F = 5 mA, t < 1 s	—	12	14	Ω

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	—	pF
Isolation resistance	R_S	(Note 1)	V_S = 500 V, R.H. ≤ 60 %	—	10^{14}	—	Ω
Isolation voltage	BV_S	(Note 1)	AC, 60 s	500	—	—	Vrms
			AC, 1 s in oil	—	1000	—	
			DC, 60 s, in oil	—	1000	—	Vdc

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

Switching Characteristics (Unless otherwise specified, T_a = 25 °C)

Characteristics	Symbol	Note	Test Condition	Min	Typ.	Max	Unit
Turn-on time	t_{ON}		See Fig. 11.1 R_L = 200 Ω, V_{DD} = 20 V, I_F = 5 mA		—	200	μs
Turn-off time	t_{OFF}				—	300	

3. Selection of photorelays

The replacement of mechanical relays with photorelays is recommended by a variety of advantages, including high reliability, compactness, high speed, low noise, and silence. This section describes the procedure for selecting photorelays when replacing mechanical relays.

3.1 Selection of contact type

Many normally open x 1 contact (1a) and normally closed x 1 contact (1b) are available for the photorelay operation method and the number of contacts. You can also select 1a1b that combines these.

3.2 Selection of contact capacity (voltage)

The contact voltage of a mechanical relay corresponds to the OFF-state output terminal voltage (V_{OFF}) in a photorelay. Select a product with a V_{OFF} which is greater than the voltage currently applied to the mechanical relay in use. Our photorelay's V_{OFF} lineup ranges from 20 to 600 V.

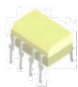
3.3 Selection of contact capacity (current)

The contact current of a mechanical relay is equivalent to the on-state current (I_{ON} or I_{ONP}) in a photorelay. As for the on-state current, it is necessary to derate it depending on the operating temperature. Select an appropriate product that will be within the maximum rating of the operating temperature.

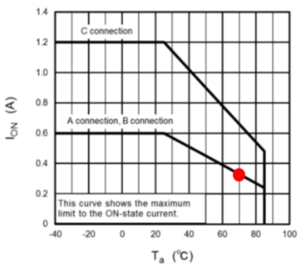
◆ Example of on-state current selection by ambient temperature

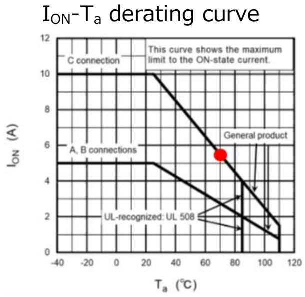
(1) Confirm current rating of the photorelay in the range of operating temperature (e.g. T_a = -20 to 70 ℃)

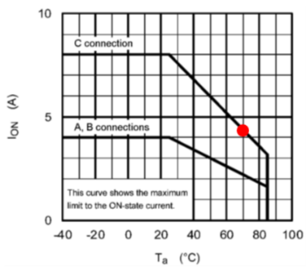
- TLP3549 ($\Delta I_{ON}/\Delta T_a$ = -6mA/℃)
  Current rating: 0.33A (A connection (AC operation) at T_a=70℃ on the derating curve)
- TLP3543A ($\Delta I_{ON}/\Delta T_a$ = -100mA/℃)
  Current rating : 5.5A (C connection (DC operation) at T_a=70℃ on the derating curve)
- TLP3106 ($\Delta I_{ON}/\Delta T_a$ = -80mA/℃)
  Current rating : 4.4A (C connection (DC operation) at T_a=70℃ on the derating curve)

TLP3549

TLP3543A

TLP3106


TLP3549
I_{ON}-T_a derating curve


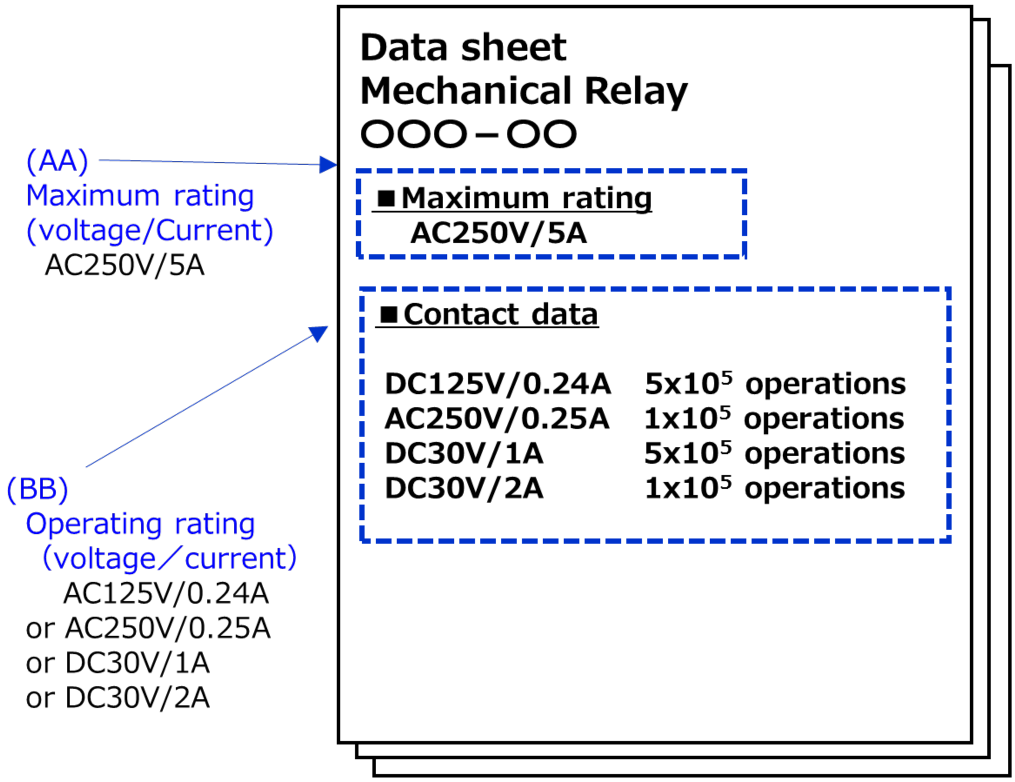
TLP3543A
I_{ON}-T_a derating curve


TLP3106
I_{ON}-T_a derating curve


(2) Confirm if the current rating of photorelay in the range of operating temperature is bigger than the operating current.

3.4 Example of procedure for finding the appropriate photorelay from the information of the mechanical relay

■Example of data sheet of Mechanical relay



- Mechanical relay has two kinds of the ratings in voltage/current.
  (AA): Maximum rating
  (BB): Operating rating
  (with condition of contact times)
- Generally the operating rating (BB) with contact life times will be used in circuit design.
- For this example, maximum rating is AC250V/5A. But if the number of operations assumes as 1 x 10^5, the operating rating is AC250/0.25A or DC30V/2A.
- Though there is no product at the condition of AC250V/5A, but we can recommend the following photorelays at this operation rating.

■Suitable photorelay (e.g.)

(AC operation)

- TLP3549 (600V/0.6A, DIP8)

(DC operation)

- TLP3543A (30V/5A, DIP6)
- TLP3106 (30V/4A, 2.54SOP6)

4. Design considerations

4.1 On-state resistance (R_{ON})

Mechanical relays have characteristics equivalent to contact resistance. The photorelay has a resistance when turned on (Fig. 4.1.1). This is a different value for each part number, and can be checked with each datasheet. The current-voltage characteristics of output terminals of the photorelay are expressed in I_{ON}-V_{ON} curve. The larger the slope of the line, the smaller the on-resistance (Fig. 4.1.2). The on-resistance of MOSFET used for output has a trade-off relationship with the withstand voltage (load voltage). Higher withstand voltage MOSFETs tend to be higher on-resistance and power dissipation. When the withstand voltage is lowered, the on-resistance becomes lower.

On-resistance value is affected by changes in the ambient temperature (Fig. 4.1.3). It is desirable to select the photorelay with the smallest on-resistance after sufficiently ensuring the withstand voltage margin for the load voltage to be applied.

When the ambient temperature rises, the on-resistance value increases and thus power consumption increases. To prevent MOSFET breakdown due to heat generation caused by increased power consumption, the rating is set so that a load current exceeding a certain level is not applied under high temperatures.

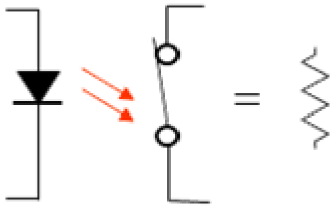


Fig. 4.1.1 On-state resistance

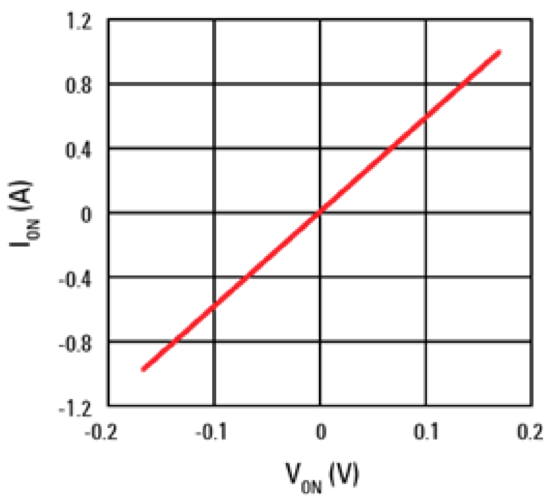


Fig. 4.1.2 Example of I_{ON}-V_{ON} characteristic

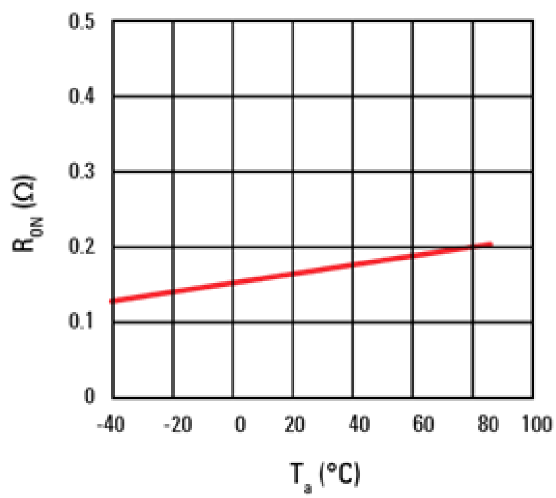


Fig. 4.1.3 Example of R_{ON}-T_a characteristic

4.2 Output Capacitance (C_{OFF})

Output capacitance (C_{OFF}) at the output terminals is seen when the photorelay is off (Fig. 4.2.1). The major difference from mechanical relays is this characteristic, and care must be taken when replacing mechanical relays. Fig.4.2.2 shows examples of operations caused by on-state resistances and output capacitances.

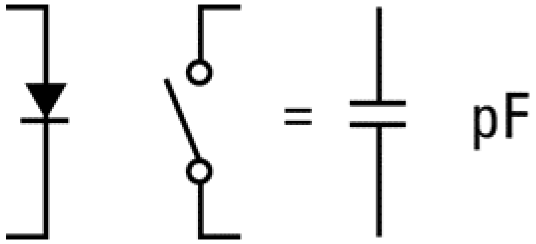


Fig. 4.2.1 Off-state capacitance

- C_{OFF} is the capacitance between MOSFET pins when no current is applied to the LEDs (output is off, in case of form a type).
- "Impedance" describes a measure of opposition to alternating current (AC) circuits, which is called "resistance" in the form of a DC circuits. Impedances of a capacitance become smaller as higher frequencies and largerer capacitance, then current flows more easily.
- In case of form a type, when the input side of the photorelay is off, the leakage current at the output side should be small, and reducing this capacitance will help to suppress the leakage current (especially when controlling high-frequency signals).

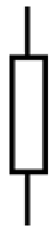
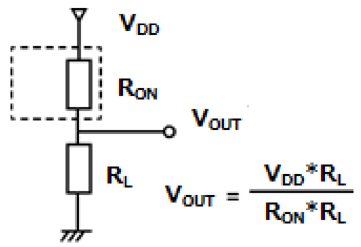
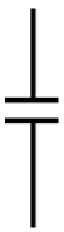
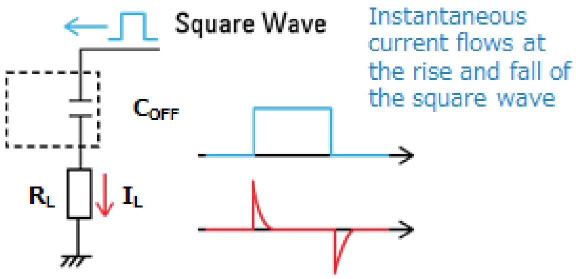
Mode	Equivalent Circuit	Operation Example
LED : ON	Resistor 	
LED : OFF	Capacitor 	

Fig. 4.2.2 On-state resistance and output capacitance

4.3 Switching time (t_{ON}/t_{OFF})

Depending on the product, but the switching time is up to 2.0 ms and the minimum is 0.2 ms.

The switching time is affected by input forward current to the LED and the ambient temperature of the photorelay. When the input current is higher, the LED emission intensity becoms higher and it contributes faster turn-on time (t_{ON}) (Fig. 4.3.1). As for the ambient temperature, t_{ON} becomes slower as the LED emission intensity decreases and the PDA performance decreases as the temperature increases (Fig. 4.3.2). It is necessary to consider these two factors when circuit design.

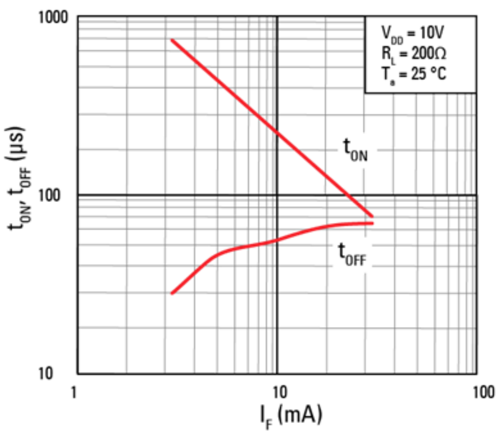


Fig. 4.3.1 Example of
LED forward current (I_F) - switching time (t_{ON}, t_{OFF})

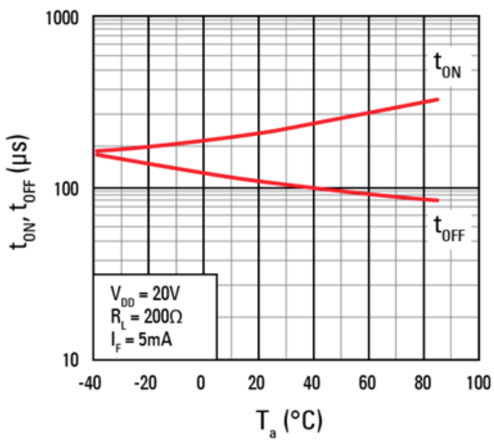


Fig. 4.3.2 Example of
ambient temperature (T_a) - switching time (t_{ON}, t_{OFF})

4.4 I_F setting

To turn on the contact of the photorelay, an input forward current (I_F) which is greater than or equal to trigger LED current (I_{FT}) descried in the datasheet should be applied. For details, I_F should be set based on the maximum trigger LED current $I_{FT(max)}$ and also should be considered following factors:

$$I_{F(ON)} = I_{FT(\max)} \cdot \alpha_1 \cdot \alpha_2 \cdot (\alpha_3)$$

α1: LED degradation rate (coefficient)	Set α1 from the average (X)-3σ curve (e.g. Fig. 4.4.1). The higher the ambient temperature and/or I_F value, the degradation rate is grater. Note: As degradation rate is varied by using LED types, please contact us for more information.
α2: I_{FT}-T_a characteristic (coefficient)	Set α2 from I_{FT}-T_a curve shown on the datasheet (e.g. Fig. 4.4.2).
α3: Drive factor	Power supply fluctuations, acceptable design tolerance

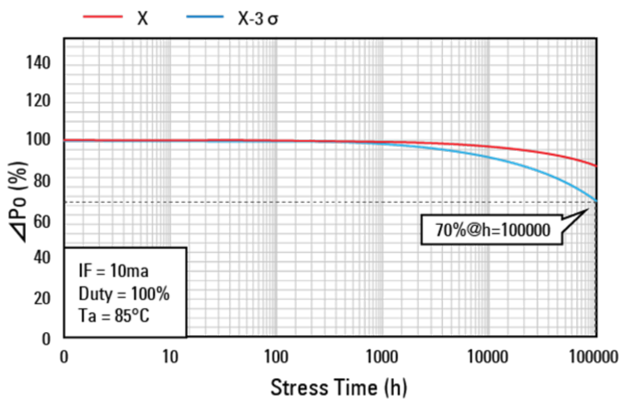


Fig. 4.4.1 Examples of estimated aging data

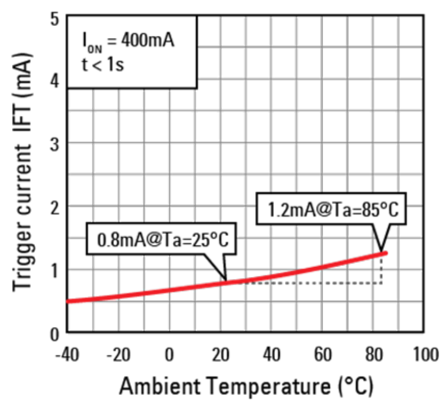


Fig. 4.4.2 Example of ambient temperature dependency of I_{FT}

e.g.) When a photorelay with maximum I_{FT} is 3 mA@T_a = 25 °C, operating temperature T_a = 85 °C, and expected life of 100,000 hours,

α1: When the rate of change of the LED is 70%,
α1 is 100% (initial value) ÷ 70 % = 1.43 times

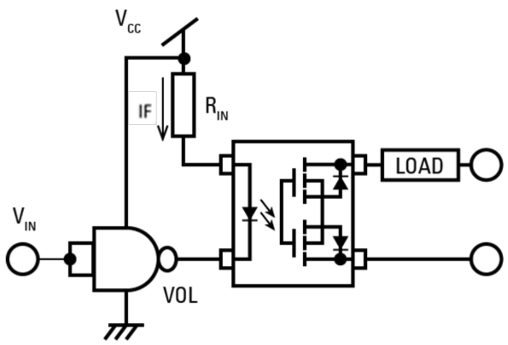
α2: Taking into account changes in I_{FT} due to ambient temperature rise,
α2 is 1.2mA (85°C) ÷ 0.8mA (25°C) = 1.5 times

$$I_{F(ON)} = 3\ (mA) \times 1.43 \times 1.5 = 6.53\ (mA)$$

Therefore, I_F should be set at least 6.53 mA.

Precautions when applying voltage (calculating LED current limit resistance)

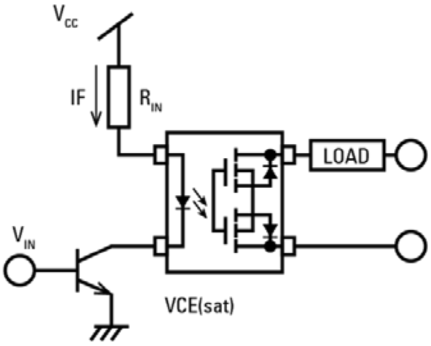
Determine the limit resistance to be connected in series to the LED based on the design $I_{F(ON)}$ obtained on the previous page. V_F at the design $I_{F(ON)}$, V_F dependency on the operating temperature (V_F becomes larger at lower temperatures), and the voltage drop at the signal-input device (device for LED drive) must be considered. For each maximum value, consider the maximum value stated in the datasheet. At this time, also confirm that the I_F must not exceed to the maximum absolute rating. In addition, make sure that the power supply (V_{CC}) and the device for LED drive have the capability of supplying current equal to or greater than the design $I_{F(ON)}$.



$$R_{IN} \leq \frac{Vcc(MIN) - VF(MAX) - VOL(MAX)}{\text{Design } IF(ON)}$$

$$^{*}R_{IN} > \frac{Vcc(MAX) - VF(MIN) - VOL}{IF(max)}$$

Fig. 4.4.3 Calculation of current limit resistor ①



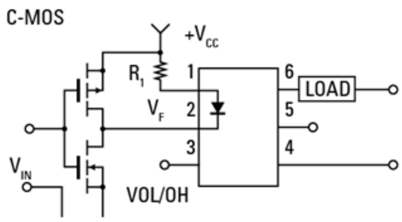
$$R_{IN} \leq \frac{Vcc(Min) - VF(MAX) - VCE(sat)(MAX)}{\text{Design } IF(ON)}$$

$$^{*}R_{IN} > \frac{Vcc(MAX) - VF(MIN) - VCE(sat)}{IF(max)}$$

Fig. 4.4.4 Calculation of current limit resistor ②

Typical photorelay drive circuit

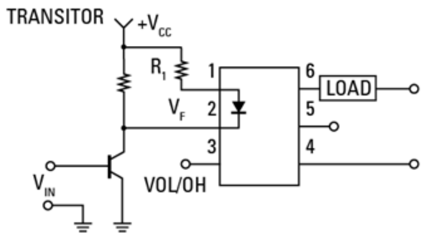
The CMOS drive circuit has excellent noise immunity because the LED is off and the high-side FET is on (almost short). If noise is generated in the transistor drive circuit, insert a resistance of several 10 kΩ in parallel with the LED.



Calculation of LED current limiting resistor required for proper operation of the photorelay

Current Limiting Resistor

$$R_1 = \frac{V_{CC} - V_{OL} - V_{F(ON)}}{5 - 20\text{mA}}$$



Calculation of LED forward voltage VF required for proper return operation of the photorelay

Return Voltage (LED forward direction)

$$V_{F(OFF)} = V_{CC} - I_F R_1 - V_{OH} < 0.8\text{V}$$

Fig. 4.4.5 Example of photorelay drive circuit

5. Trouble and countermeasure examples

5.1 Applying overvoltage or overcurrent to the output side

Output failure due to external surge: Cause

In some cases, inductive impulse noise, ESD surge, etc. may be superimposed on the load power supply line which is connected to the photorelay output side, then output side elements may be damaged (short or open).

● Short-circuit in the output elements ⇒ Load is operating even though the LED is off (the output keeps on).

● Open-circuit in the output elements ⇒ Load does not operate even if the LED is on (the output does not on).

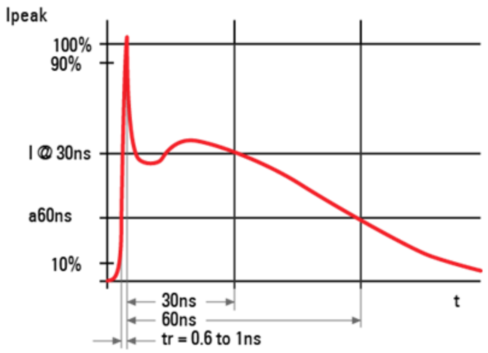


Fig. 5.1.1 Examples of an ESD noise waveforms (in ns order)

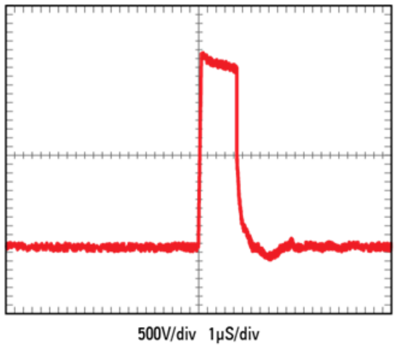


Fig. 5.1.2 Example of an impulse noise waveform (in μs order)

Output failure due to external surge: Countermeasures

■ Insert a varistor

Varistors normally operate as a capacitor (when the current is small).
When a large current flows due to an overvoltage, the varistor acts as a resistor and protects subsequent circuits by applying short-circuit current.

■ Selection method

Select a varistor whose limiting voltage does not exceed the off-state voltage (V_{OFF}) of photorelay.

・ For ESD: Anti-static chip type mutilayer varistors are common.
・ For use with commercial AC power supply: See Fig. 5.1.3.

Power Supply Voltage	Recommended Varistor Rated Voltage	Photorelay V_{OFF}	Surge current tolerance
AC100V line	220～270V	400-600V	Above 1000A
AC200V line	430～470V	600V	Above 1000A

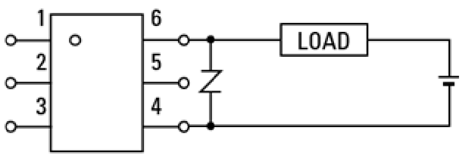


Fig. 5.1.3 Example of varistor selection and circuit using varistor

Output elements malfunction due to back EMF voltage: Cause

If a photorelay is switched from on to off when an inductive load is used, the current will suddenly change from $I_L = (V_{CC}/L) \cdot t$ to zero cause of existing of inductance (L), resulting in a large current change ($-dI_L/dt$). Because the voltage across the inductive load is $E = L \cdot (dI_L/dt)$, a high back-EMF voltage of $L \cdot (dI_L/dt)$ is generated with the power supply side: V_{CC} as the starting point.

If this voltage exceeds the off-state voltage of photorelay, the photorelay may fail.

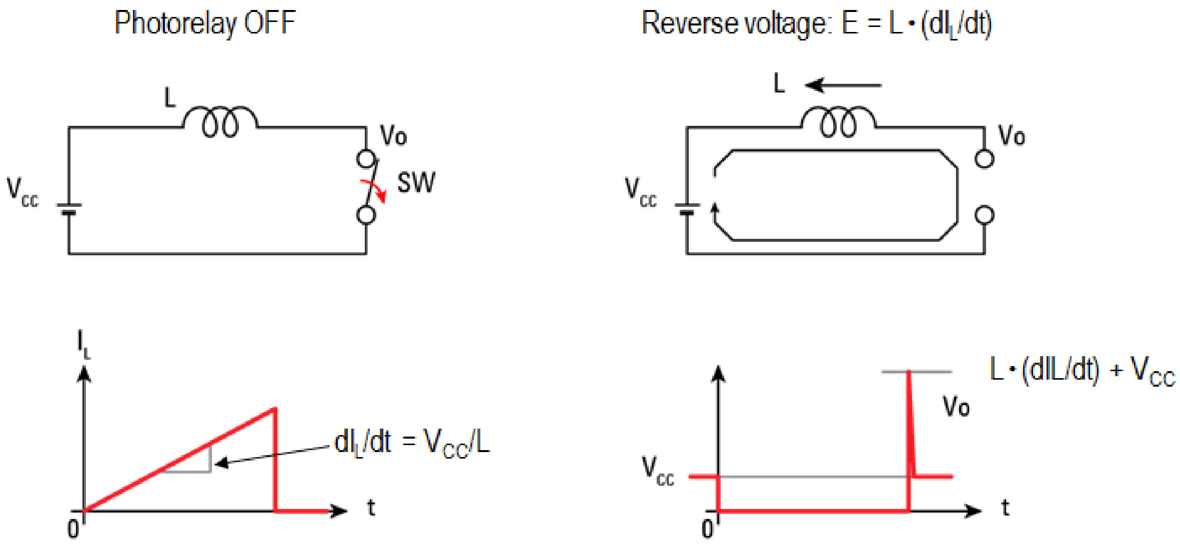
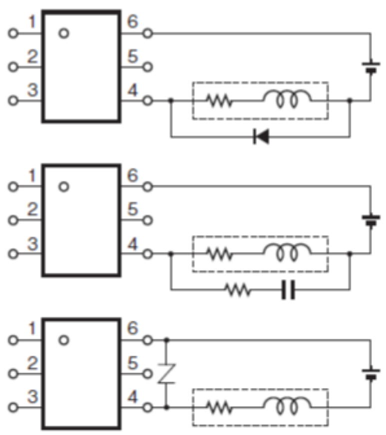


Fig. 5.1.4 Example of failure due to back electromotive voltage

Output elements malfunction due to back EMF voltage: Countermeasures

To prevent applying overvoltage from inductive loads to the photorelay output side, it is recommended that protection devices / circuit are installed. The point is to keep the overvoltage from exceeding the off-state voltage (V_{OFF}).



Provide energy path through a diode.

Absorb energy by a snubber circuit.

The overvoltage is suppressed by a varistor.

Fig. 5.1.5 Examples of protection circuits against back EMF voltage

Note: If protection devices such as diodes, snubbers (C-R), and varistors are to be installed to the output circuit, they must be placed near the load or photorelay. If the distance is too far, the protection will be less effective.

Output elements malfcunction due to inrush current: Cause

Inrush current occurs when the power is turned on to the load controlled by the photorelay. The inrush current values vary depending on the load type. The characteristics of each load are shown below.

1. Heater load (resistive load)

   Basically, no inrush current is generated. Depending on the type of heater, the resistance value may change depending on the temperature. In this case, note that an inrush current is generated because the resistance value is low at room temperature. If the inrush current exceeds the maximum rating of pulse on-state current of the photorelay, the output device may be damaged.

   <Type of heater through which inrush current flows>

   - Pure metal type heater (approx. 3 to 5 times the rated current)
   - Ceramic heaters (approx. 3 to 5 times the rated current)
   - Lamp heater (approx. 10 to 15 times the rated current)

2. Lamp load

   Incandescent and halogen lamps (including lamp heaters) carry about 10 to 15 times the rated current. If inrush current exceeding the photorelay's pulse on-state current rating flows repeatedly, it may cause output elements malfunction.

3. Motor load

   When starting an inductive load such as a motor, an inrush current of about 5 to 10 times the rated current flows. If an inrush current exceeding the photorelay's pulse on-state current rating flows repeatedly, it may cause output elements malfunction.

4. Transformer load

   The transformer load generates an excitation current which is 10 to 20 times the rated current for a a short time (10 to 500 ms) when the primary power is on.
   If an excitation current exceeding the photorelay's pulse on-state current rating is applied to the photorelay, the output elements may be damaged.

Output elements malfunction due to inrush current: Countermeasures

Select suitable photorelay having higher pulse on-state current rating than the inrush current generated from the load.

Detector	OFF-state output terminal voltage		V_{OFF}		60	V
	ON-state current (A connection)		I_{ON}	(Note 1)	5	A
	ON-state current (B connection)				5	
	ON-state current (C connection)				10	
	ON-state current derating (A connection)	($T_a \geq 25$ °C)	$\Delta I_{ON}/\Delta T_a$	(Note 1)	-50	mA/°C
	ON-state current derating (B connection)	($T_a \geq 25$ °C)			-50	
	ON-state current derating (C connection)	($T_a \geq 25$ °C)			-100	
	ON-state current (pulsed)	(t = 100 ms, duty = 1/10)	I_{ONP}		15	A

Table 5.1.1 Example of datasheet description

5.2 Design of the output side is not fully considered

Example of Failure

Using a photorelay with an on-state current rating of 500mA

Mr. A designed with a current margin of 80 %, and the circuit was designed at 400mA, and a prototype could work at the laboratory (the air conditioning of the laboratory was set at 25 °C). However, the set does not work during mass production.

⇒ He did not understand that there was a temperature derating in the on-state current.

Absolute Maximum Ratings (Unless otherwise specified, $T_a = 25°C$)

	Characteristics		Symbol	Note	Rating	Unit
LED	Input forward current		I_F		30	mA
	Input forward current derating	($T_a \geq 25$ °C)	$\Delta I_F/\Delta T_a$		-0.3	mA/°C
	Input forward current (pulsed)	(100 μs pulse, 100 pps)	I_{FP}		1	A
	Input reverse voltage		V_R		6	V
	Input power dissipation		P_D		50	mW
	Junction temperature		T_j		125	°C
Detector	OFF-state output terminal voltage		V_{OFF}		60	V
	ON-state current		I_{ON}		500	mA
	ON-state current derating	($T_a \geq 25$ °C)	$\Delta I_{ON}/\Delta T_a$		-5.0	mA/°C
	ON-state current (pulsed)	(t = 100 ms, Duty = 1/10)	I_{ONP}		1.5	A
	Output power dissipation		P_O		300	mW
	Junction temperature		T_j		125	°C

Table 5.2.1 Example of datasheet description

Cause of the Failure

The ambient temperature of the photorelay rose to 60 ℃ in the mass production. Therefore, derating of the photorelay's on-state current is required depending on the ambient temperature. As shown in Fig. 5.2.1, the rated on-state current at an ambient temperature of 60°C is reduced compared to the rated on-state current at 25 °C; 500mA-(5mA × (60°C-25°C)) = 325mA

As a result, a thermal runaway occurred due to 400mA flow, exceeding the rated on-state current in thish high temperature, causing MOSFETs to fail.

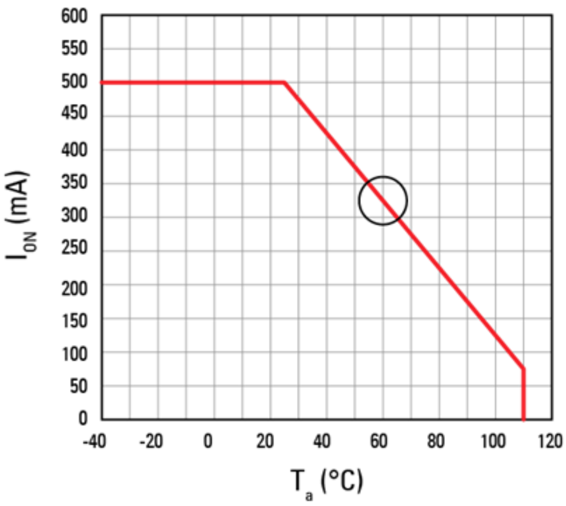


Fig. 5.2.1 Example of on-current derating curve

Revision History

Version information	Date	Corresponding pages	Contents of change
Rev. 1.0	2020-02-12	-	First edition

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