

<注意事項>

Specifications

注 意 事 項

Specifications (Precautions and Prohibitions)

● 安全上の注意事項

Safety Precautions

- 1) 本製品は一般的な電子機器 (AV 機器、OA 機器、通信機器、家電製品、アミューズメント機器等) への使用を意図して設計・製造されております。従いまして、極めて高度な信頼性が要求され、その故障や誤動作が人の生命、身体への損害又はその他の重大な損害の発生に関わるような機器又は装置 (医療機器、輸送機器、航空宇宙機、原子力制御、燃料制御、カーアクセサリを含む車載機器、各種安全装置等) へのご使用を検討される際は事前に弊社営業窓口までご相談願いますようお願い致します。いかなる場合であっても、本製品の不具合により、人の生命、身体への損害及びその他の重大な損害の発生が予見される場合は下記の方法により、フル設計への配慮を十分行い、安全性を確保されますようお願い致します。

The products are designed and produced for application in ordinary electronic equipment (AV equipment, OA equipment, telecommunication equipment, home appliances, amusement equipment, etc.).

If the products are to be used in devices requiring extremely high reliability (medical equipment, transport equipment, aircraft/spacecraft, nuclear power controllers, fuel controllers, car equipment including car accessories, safety devices, etc.) and whose malfunction or operational error may endanger human life and sufficient fail-safe measures, please consult with the Company's sales staff in advance. If product malfunctions may result in serious damage, including that to human life, sufficient fail-safe measures must be taken, including the following:

- ①保護回路及び保護装置を設けてシステムとしての安全性を確保する。

Installation of protection circuits or other protective devices to improve system safety

- ②冗長回路等を設けて単一故障では危険が生じないようにシステムとしての安全を確保する。

Installation of redundant circuits in the case of single-circuit failure

- 2) 本製品は一般電子機器に標準的な用途で使用されることを意図して設計・製造されており、下記のような特殊環境での使用を配慮した設計はなされておられません。従いまして、下記特殊環境でのご使用は本製品の性能に影響を与える恐れがありますので、貴社におかれましては十分に性能、信頼性等をご確認の上ご使用ください。

The products are designed for use in a standard environment and not in any special environments.

Application of the products in a special environment can deteriorate product performance.

Accordingly, verification and confirmation of product performance, prior to use, is recommended if used under the following conditions:

- ①水・油・薬液・有機溶剤等の液体中でのご使用。

Use in various types of liquid, including water, oils, chemicals, and organic solvents

- ②直射日光・屋外暴露、塵埃中でのご使用。

Use outdoors where the products are exposed to direct sunlight, or in dusty places

- ③潮風、Cl₂、H₂S、NH₃、SO₂、NO₂等の腐食性ガスの多い場所でのご使用。

Use in places where the products are exposed to sea winds or corrosive gases, including Cl₂, H₂S, NH₃, SO₂, and NO₂

DESIGN



CHECK



APPROVAL



DATE: 2005/09/22

SPECIFICATION No. : CASE0018

REV. A

ROHM CO., LTD.

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Specifications (Precautions and Prohibitions)

- ④静電気や電磁波の強い環境でのご使用。
Use in places where the products are exposed to static electricity or electromagnetic waves
 - ⑤発熱部品に近接した取付け及び当製品に近接してビニール配線等、可燃物を配置する場合。
Use in proximity to heat-producing components, plastic cords, or other flammable items
 - ⑥本製品を樹脂等で封止、コーティングしてのご使用。
Use involving sealing or coating the products with resin or other coating materials
 - ⑦無洗浄半田付けや半田付け後のフラックス洗浄で水及び水溶性洗浄剤をご使用の場合。
Use involving unclean solder or use of water or water-soluble cleaning agents for cleaning after soldering
 - ⑧本製品が結露するような場所でのご使用。
Use of the products in places subject to dew condensation
- 3) 本製品は耐放射線設計はなされておられません。
The products are not radiation resistant.
- 4) 本仕様書の記載内容を逸脱して本製品をご使用されたことによって生じた不具合につきましては弊社では保証致し兼ねますのでご了承下さい。
The Company is not responsible for any problems resulting from use of the products under conditions not recommended herein.
- 5) 本製品の安全性について疑義が生じた場合は速やかに弊社へご連絡戴くと共に貴社にて技術検討戴けます様お願いします。
The Company should be notified of any product safety issues. Moreover, product safety issues should be periodically monitored by the customer.

● 応用回路、外付け回路等に関する注意事項

Precautions Regarding Application Examples and External Circuits

- 1) 本製品の外付け回路定数を変更してご使用になる際は静特性のみならず、過渡特性も含め外付け部品及び当社部品のパラメータ等を考慮して十分なマージンをみて決定して下さい。また、特許に関しましては弊社では十分な確認はできておりませんのでご了承願います。
If change is made to the constant of an external circuit, allow a sufficient margin due to variations of the characteristics of the products and external components, including transient characteristics, as well as static characteristics. Please be informed that the Company has not conducted investigations on whether or not particular changes in the application examples or external circuits would result in the infringement of patent rights of a third party.
- 2) 記載されております応用回路例やその定数などの情報につきましては、本製品の標準的な動作や使い方を説明するものです。従いまして、量産設計をされる場合には、外部諸条件を考慮していただきます様お願いいたします。
The application examples, their constants, and other types of information contained herein are applicable only when the products are used in accordance with standard methods. Therefore, if mass production is intended, sufficient consideration to external conditions must be made.

注 意 事 項

Specifications (Precautions and Prohibitions)

● 外国為替管理法に関する注意事項

Precautions Regarding Foreign Exchange and Foreign Trade Control Law

- 1) 当社は本製品が外国為替及び外国貿易管理法に定める規制対象貨物又は技術に該当するか否かを判定しておりませんので本製品及びそれを使用した貴社製品等を海外に持ち出し又は非住居者に提供する場合は関連法規に基づき適正な手続きを実施戴くようお願い致します。
The Company has not determined whether or not the products are considered "a controlled product or technology" as specified in the Foreign Exchange and Foreign Trade Control Law.
Accordingly, if exportation of the products, either separately or integrated in another company's products, is intended, or giving the products to persons who are not residents is planned, additional steps are required, based upon the appropriate regulations.

● 工業所有権に関する注意事項

Prohibitions Regarding Industrial Property

- 1) 本仕様書には弊社の著作権、ノウハウに関わる内容も含まれておりますので、本製品の使用目的以外にはこれを用いないようお願いいたします。また、弊社の事前承諾を得ずにこれを複製、又は第三者に開示することはご遠慮下さい。
These Specifications contain information related to the Company's industrial property. Any use of them other than pertaining to the usage of appropriate products is not permitted. Duplication of these Specifications and its disclosure to a third party without the Company's permission is prohibited.
- 2) 本仕様書に掲載されております本製品に関する応用回路例、情報及び諸データは、あくまでも一例を示すものであり、これらに関する第三者の知的所有権及びその他の権利について権利侵害がないことの保証を示すものではございません。従いまして、(1)上記第三者の知的財産権侵害の責任、及び (2)本製品の使用により発生するその他の責任、につきましては弊社ではその責を負いかねますのであらかじめご了承下さい。
Information and data on products, including application examples, contained in these specifications are simply for reference; the Company does not guarantee any industrial property rights, intellectual property rights, or any other rights of a third party regarding this information or data. Accordingly, the Company does not bear any responsibility for: (1) infringement of the intellectual property rights of a third party (2) any problems incurred by the use of the products listed herein.
- 3) 本製品の販売は本製品自体の使用、販売及びその他の処分を除き、本製品について弊社が所有または管理している工業所有権、等の知的財産権及びその他のあらゆる権利について明示的にも黙示的にも、その実施また利用を貴社に許諾するものではありません。
The Company prohibits the purchaser of its products to exercise or use the intellectual property rights, industrial property rights, or any other rights that either belong to or are controlled by the Company, other than the right to use, sell, or dispose of the products.

注 意 事 項
Specifications (Precautions and Prohibitions)

● 使用上の注意事項

Precautions on Use of Products

- 1) 本製品のご使用にあたっては貴社製品に実装された状態で必ず評価及び確認を実施下さい。
Verification and confirmation of performance characteristics of products, after on-board mounting, is advised.
- 2) パルス等の過渡的な負荷（短時間での大きな負荷）が加わる場合は、貴社製品に本製品を実装した状態で必ずその評価及び確認を実施して下さい。また、定常時での負荷条件において定格電力以上の負荷を印加されますと、本製品の性能又は信頼性が損なわれる恐れがあるため必ず定格電力以下で使用して下さい。
In particular, if a transient load (a large amount of load applied in a short period of time, such as pulse) is applied, confirmation of performance characteristics after on-board mounting is strongly recommended.
Avoid applying power exceeding normal rated power; exceeding the power rating under steady-state loading condition may negatively affect product performance and reliability.
- 3) ハロゲン系（塩素系、臭素系等）の活性度の高いフラックスを使用する場合、フラックスの残さにより本製品の性能又は信頼性への影響が考えられますので、事前に貴社にてご確認下さい。
When a highly active halogenous (chlorine, bromine, etc.) flux is used, the remainder of flux may negatively affect product performance and reliability.
- 4) 半田付けは手半田、フロー半田を原則とさせて戴きます。なおリフロー半田には対応しておりません。
In principle, the hand and flow soldering method must be used. It is not suitable for reflow solder.
- 5) パッケージは合成樹脂を使用しております。
Compound resin is used for package.
- 6) 入力および出力は電気で行います。
Input and output is done by electric signal.

● 保管上の注意事項

Precautions Regarding Product Storage

- 1) 本製品を下記の環境又は条件で保管されますと性能劣化や半田付け性等の性能に影響を与える恐れがありますのでこのような環境及び条件での保管は避けて下さい。
Product performance and soldered connections may deteriorate if the products are stored in the following places:
 - ①潮風、Cl₂、H₂S、NH₃、SO₂、NO₂等の腐食性ガスの多い場所での保管。
Where the products are exposed to sea winds or corrosive gases, including Cl₂, H₂S, NH₃, SO₂, and NO₂
 - ②推奨温度、湿度以外での保管。
Where the temperature or humidity exceeds those recommended by the Company
- 2) 半田付け性等の性能は当社出荷より1年間とし、上記保管方法を遵守された場合に限りらせて戴きます。
The guaranteed period of solder connections and product performance is within one year from shipment by the Company, provided that the above-mentioned storage conditions have been satisfied.

注 意 事 項
Specifications (Precautions and Prohibitions)

● その他の注意事項
Other Matters

- 1) 本仕様書に貴社受領印をご捺印の上、一部を弊社にご返却下さい。
本仕様書表紙に記載の発行日より3ヶ月を経過してもご返却頂けない場合は誠に勝手ながらその記載内容についてご承認頂けたものと扱わせて戴きます。
Please sign these Specifications and return one copy to the Company.
If a copy is not returned within three months after the issued date specified on the front page of these Specifications, the Company will consider the Specifications accepted.
- 2) 本仕様書の記載内容に疑義が生じた場合は双方の協議の上、速やかに解決にあたるものと致します。
If any matter related to these Specifications needs to be clarified, discussions shall be held promptly between the two parties concerned to determine the issue.
- 3) ご使用にあたっては、別紙「センサ取り扱い注意事項」をご参照下さい。
Please read the Handling Precautions for Sensor as attached when you design.

1. 形 名 R P I - 5 7 9 N 1
Part number

2. 構 造 G a A s 赤外発光ダイオード、シリコンプレーナ形フォトトランジスタ 樹脂ケースタイプ
Construction GaAs Infrared light emitting diode, silicon planar type phototransistor

3. 用 途 各種制御機器
Application All kinds of controller

4. 外形寸法 図 - 1
Outline dimensions Fig-1

5. 絶対最大定格 (T_a = 25°C)
Absolute max. ratings

入力側 (発光ダイオード)
Input (infrared light emitting diode)

順電流 I_F 50 mA
Forward current

逆電圧 V_R 5 V
Reverse voltage

許容損失 P_D 80 mW
Power dissipation

出力側 (フォトトランジスタ)
Output (Phototransistor)

コレクターエミッタ間電圧 V_{CEO} . . . 30 V
Collector-emitter voltage

エミッターコレクタ間電圧 V_{ECO} . . . 4.5 V
Emitter-collector voltage

コレクタ電流 I_C . . . 30 mA
Collector current

コレクタ損失 P_C . . . 80 mW
Collector power dissipation

動作温度 T_{opr} -25 ~ +85 °C
Operating temperature

保存温度 T_{stg} -40 ~ +85 °C
Storage temperature

半田付け温度 T_{sol} 260 °C、3 sec
Soldering temperature
(リード根本より 1 mm 以上)
(1 mm from the body bottom)

6. 電氣的・光学的特性 (T_a = 25°C)

Electrical optical characteristics

1) 入力側

Input characteristics

項 目 Item	記号 Symbol	最小値 Min.	標準値 Typ.	最大値 Max.	単位 Unit	条 件 Condition
順 電 圧 Forward voltage	V _F	—	1.3	1.6	V	I _F = 50 mA
逆 電 流 Reverse current	I _R	—	—	10	μA	V _R = 10 V

2) 出力側

Output characteristics

項 目 Item	記号 Symbol	最小値 Min.	標準値 Typ.	最大値 Max.	単位 Unit	条 件 Condition
暗 電 流 Dark current	I _{CEO}	—	—	0.5	μA	V _{CE} = 10 V
ピーク感度波長 Peak sensitivity wavelength	λ _p	—	800	—	nm	—

3) 伝達特性

Transfer characteristics

項 目 Item	記号 Symbol	最小値 Min.	標準値 Typ.	最大値 Max.	単位 Unit	条 件 Condition
コレクタ電流 Collector current	I _C	0.5	—	—	mA	V _{CE} = 5 V I _F = 20 mA
コレクタ-エミッタ間飽和電圧 Collector-emitter saturation voltage	V _{CE} (sat)	—	0.1	0.5	V	I _F = 20 mA I _C = 0.1 mA
応答時間 Response time	上昇時間 Rise time	tr	—	10	—	V _{CC} = 5 V I _F = 20 mA R _L = 100 Ω
	下降時間 Fall time	tf	—	10	—	

7. 使用している赤外発光ダイオードの電氣的・光学的特性

Electrical optical characteristics using infrared light emitting diode.

項 目 Item	記号 Symbol	標準値 Typ.	単位 Unit	条 件 Condition
遮断周波数 Cut-off frequency	f _c	1	MHz	I _F = 50 mA
ピーク発光波長 Peak light emitting wavelength	λ _p	950	nm	I _F = 50 mA

※非干渉性発光ダイオードを使用。

Non-coherent Infrared light emitting diode used.

8. 使用しているフォトトランジスタの電気的光学的特性
Electrical optical characteristics using phototransistor.

項 目 Item	記号 Symbol	標準値 Typ.	単位 Unit	条 件 Condition
最大感度波長 Peak sensitivity wavelength	λp	800	nm	—
応答時間 Response time	t_r, t_f	10	μs	$V_{cc} = 5 V$ $I_c = 1 mA$ $R_L = 100 \Omega$

※耐電磁波/耐重荷電粒子線設計はしてありません。

This product is not designed to be protected against electromagnetic wave.

9. 重量 約 0.69 g / 個
Weight About 0.69 g/piece

10. 推奨回路

Recommended circuit

過負荷等からフォトインタラプタを保護するため、順電流制限抵抗 R_{If} と負荷抵抗 R_L はフォトインタラプターGND間(カソード-GND間、エミッター-GND間)に実装する事を推奨いたします。

To protect photointerrupter from over-load ,we recommend putting R_{If} and R_L Photointerrupter and GND (Cathode-GND, Emitter-GND).

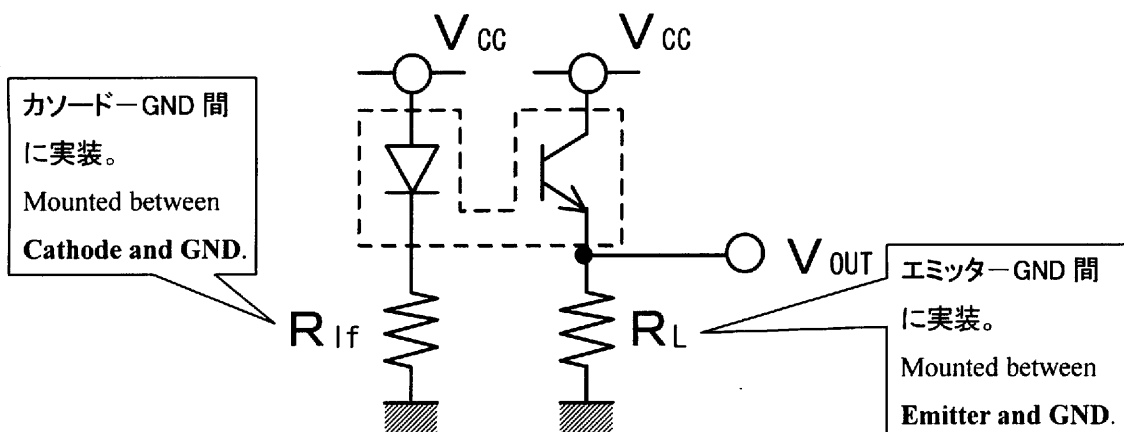


図-1 外形寸法図
Fig-1 Outline dimension

単位 : mm
Unit

注) 1. 指示無き寸法公差は ± 0.2 とする。

Unspecified tolerance shall be ± 0.2 .

2. リード寸法は根本で満足するものとする。

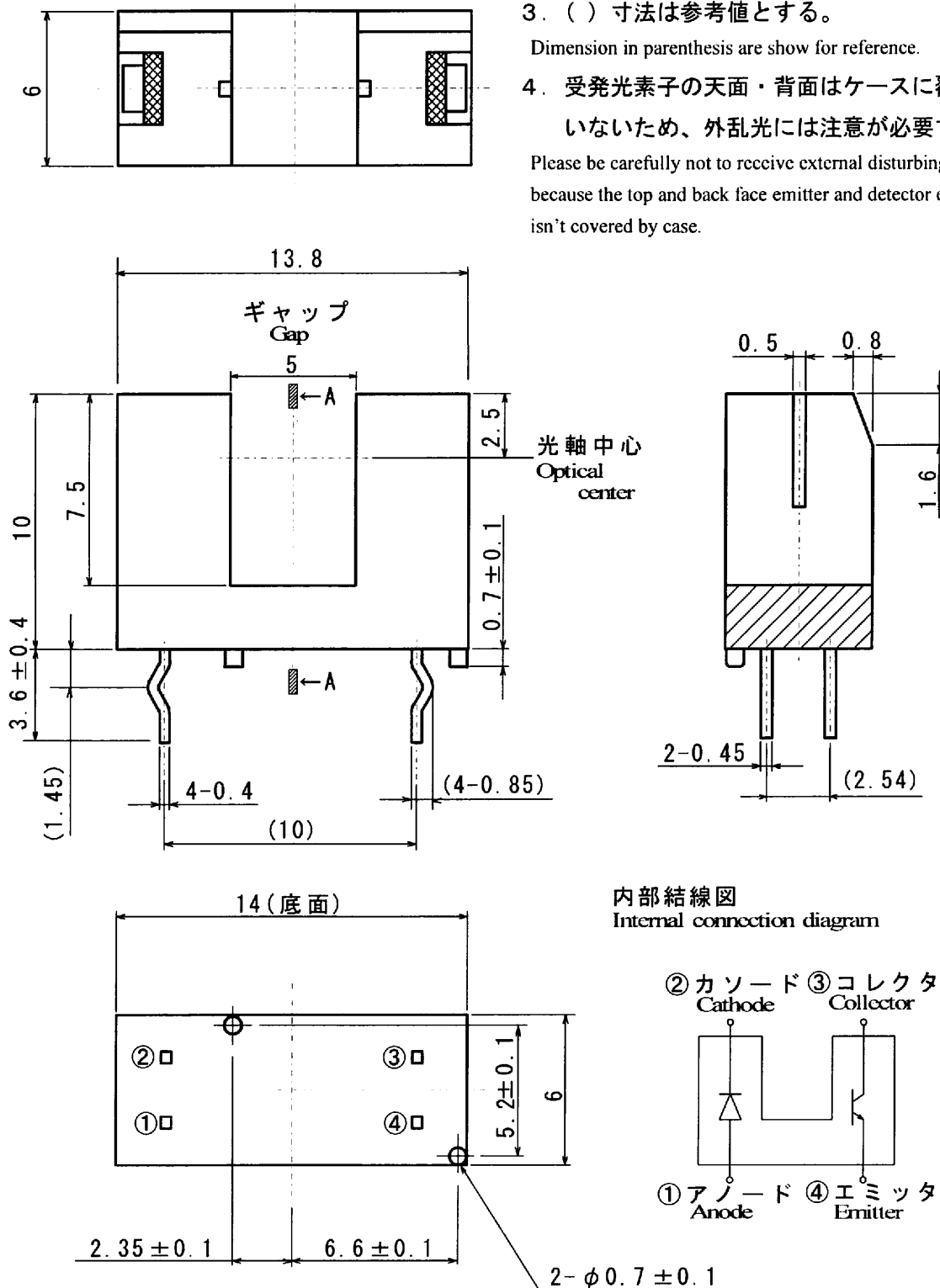
Measurement in the bracket is that of lead pin at base the mold.

3. () 寸法は参考値とする。

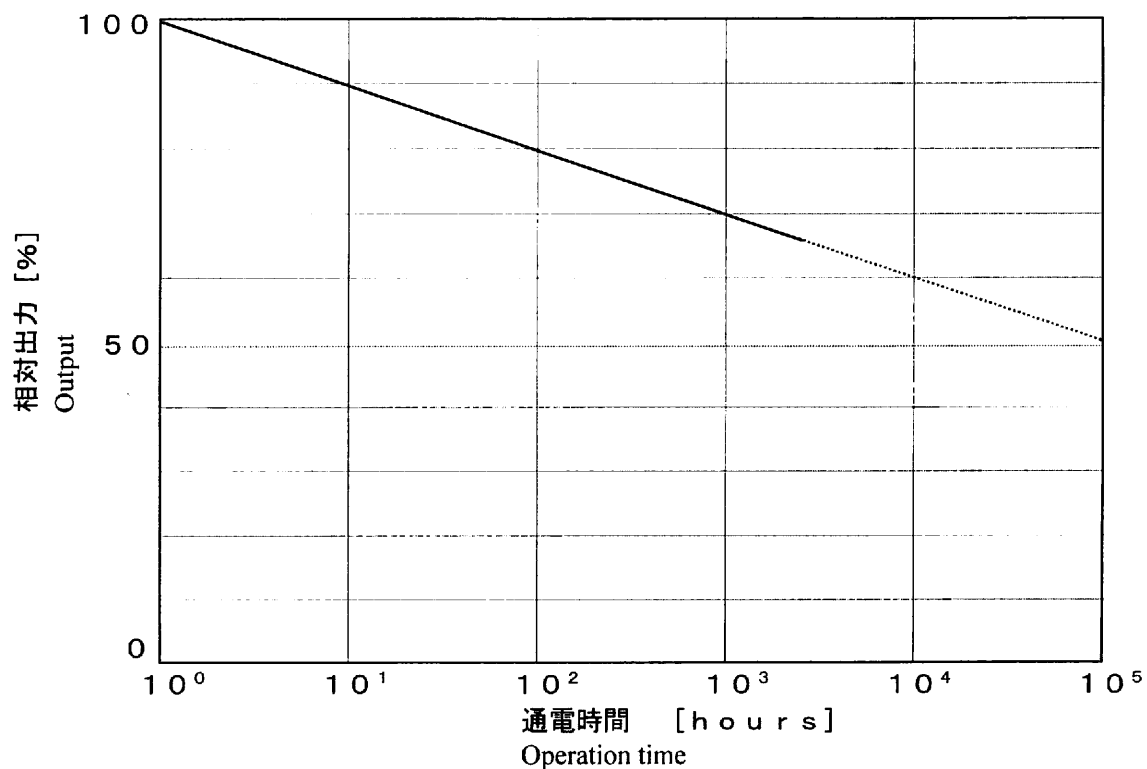
Dimension in parenthesis are show for reference.

4. 受発光素子の天面・背面はケースに覆われていないため、外乱光には注意が必要です。

Please be carefully not to receive external disturbing light because the top and back face emitter and detector element isn't covered by case.



形 名 Part number	RPI-579N1
データ名 Data	経時変化特性 Operation life
条 件 Condition	$I_F = 20 \text{ mA}$ $V_{CE} = 5 \text{ V}$ $T_a = 25 \text{ }^\circ\text{C}$

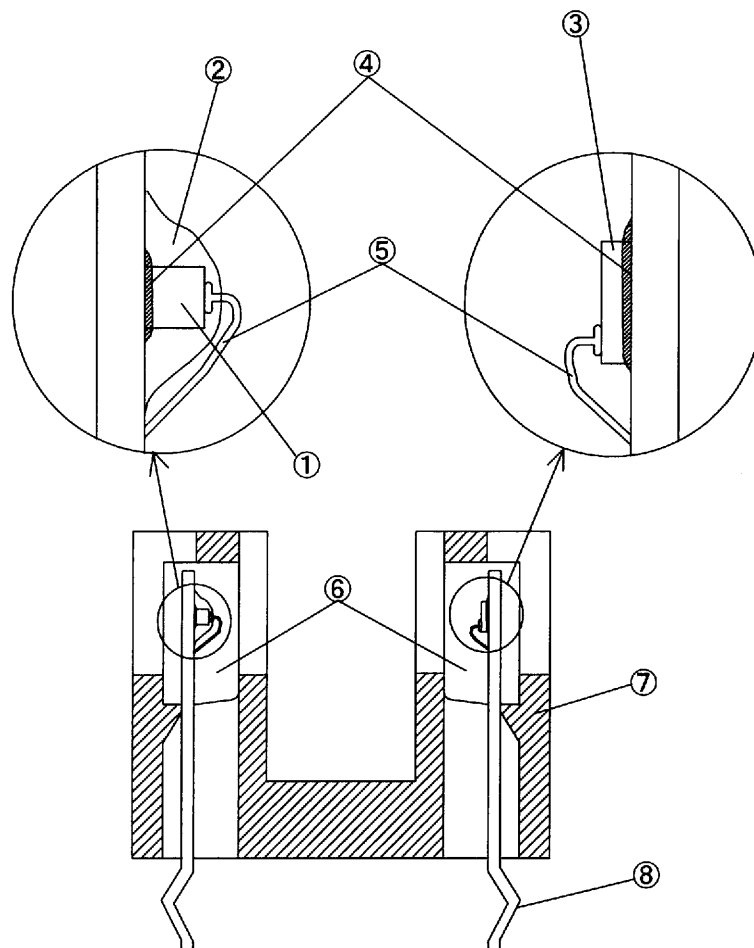


注意：データは出力の最大低下率を示しています。商品設計にあたっては、設計マージンを十分考慮下さい。

This curve is maximum degradation. In circuit designing, make allowance for the degradation of the light emitting diode output.

構造図

Structure fig.



No.	名称 Name	材質 Material
①	赤外LED Infrared light emitting diode	G a A s
②	シリコン Silicone	シリコン Silicone
③	フォトトランジスタ Phototransistor	S i
④	銀ペースト Conductive epoxy resin	A g + エポキシ樹脂 Ag+Epoxy resin
⑤	金線 Bonding wire	A u
⑥	モールド樹脂 Mold resin	エポキシ樹脂 Epoxy resin
⑦	樹脂ケース Case	P B T (94-V0)
⑧	リード Lead	F e

包装方法 Packaging requirements

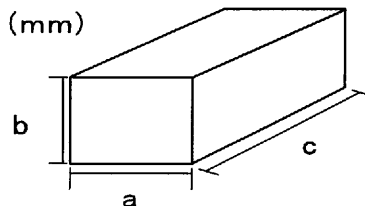
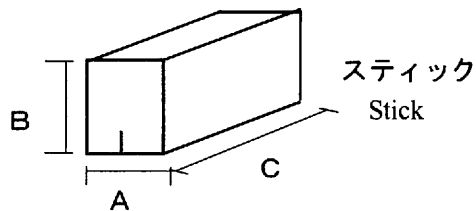
1. 包装 Packaging

- (1) スティックに40pcs包装する。
A stick of 40pcs.

スティックは、 $(A) \times (B) \times (C) = 8.0 \times 16.7 \times 580$ (mm)
Stick size: $(A) \times (B) \times (C) = 8.0 \times 16.7 \times 580$ (mm)

- (2) スティック25本を紙箱に包装する。
A paper box pack of 25sticks.

紙箱は、 $(a) \times (b) \times (c) = 100 \times 55 \times 590$ (mm)
Paper box size: $(a) \times (b) \times (c) = 100 \times 55 \times 590$ (mm)



2. 表示 Label indication

紙箱に製品形名 包装数量 製造ロット番号 検査者印を表示します。
The following information shall be described on a boxlabel; ROHM type number, packaging quantity, lot number, inspection stamp.

【表示例】 Example

形名 Type number	RPI-579N1	QRコード形名 QR cord	
バーコード Bar cord	1000 pcs 0507 06320W		ロットNo. Lot number
包装数量 Packaging quantity			検査者印 Inspection stamp
バーコード Bar cord	JAPAN Excellence in Electronics		

【ロット番号表示例】 Example of lot number marking

05	07	06320	W	製造工場記号 Factory mark
				ロットの追番 Serial number of lot
				製造週 Manufacture week
				製造西暦年 Manufacture year

3. 製造工場 Factory

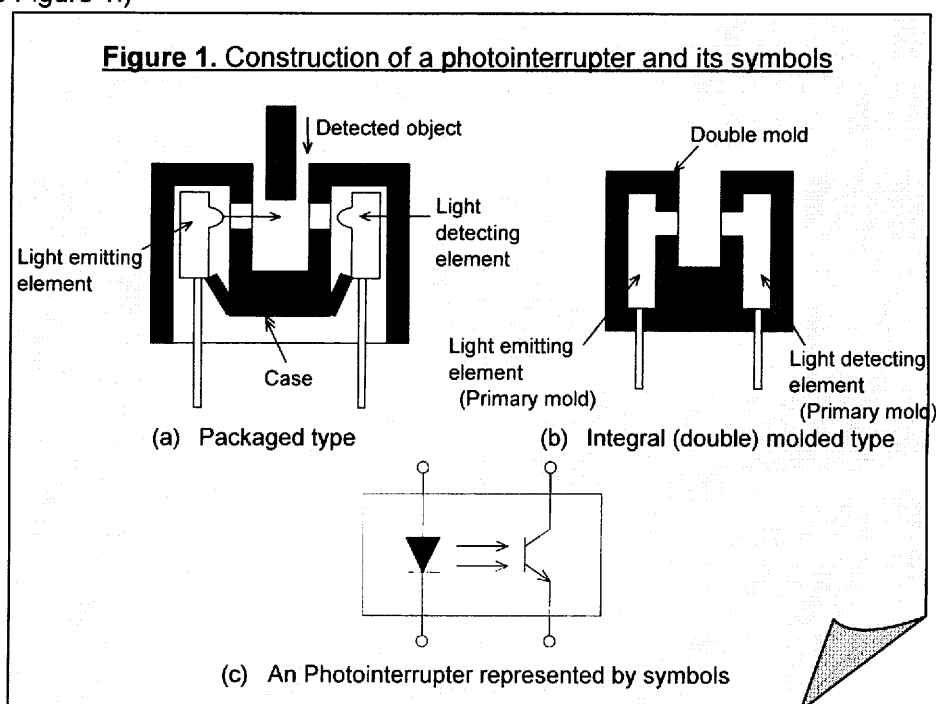
- ・ ローム・ワコー株式会社
ROHM・WAKO CO.,LTD.
- ・ ROHM SEMICONDUCTOR (CHINA) CO.,LTD.

Handling Precautions for Sensor

A photointerrupter is a packaged product that consists of a pair of light emitting and detecting elements facing each other. Photointerrupters are also called transmission photodetectors since objects are detected when they pass through the area between the two elements to block the light beam. ROHM calls such transmission type detectors "interrupters."

Photointerrupters use GaAs infrared LEDs that feature strong light emission and a long service life as a light emitting element, and use mainly single-phototransistors or photo ICs as a light detecting element.

Photointerrupters, in a broad sense, are divided into packaged (housed) types and double molded types. (See Figure 1.)

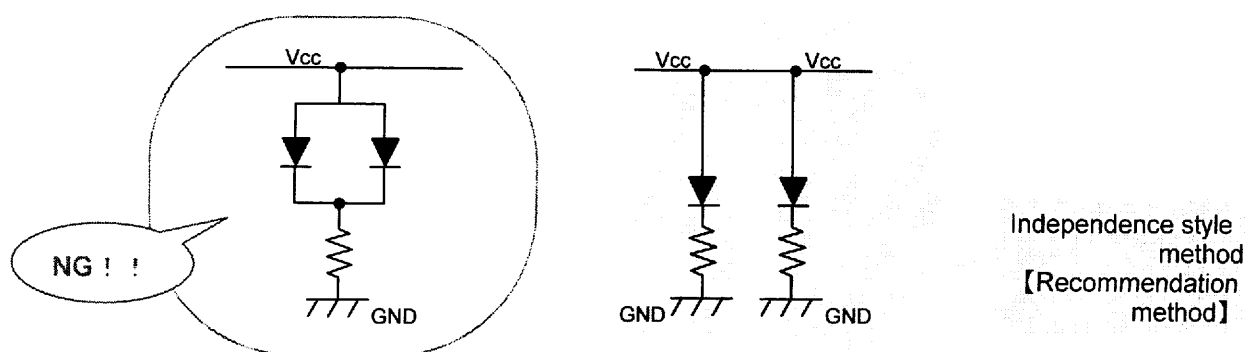


A packaged type photointerrupter, used most commonly, is contained in a molded (injection molded) case, which contains a pair of light emitting and light detecting elements. A double molded type, on the other hand, is a product developed responding to the recent needs of compact-size photointerrupters.

For improved light emitting/detecting efficiency, the resin used for the molds of our photointerrupters' light emitting/detecting elements is epoxy resin of a high degree of purity, with the minimal use of fillers. Because of this, compared with resins used in ICs and transistors, it may exhibit slightly poor performance in thermal resistance, mechanical strength, and solvent resistance. Therefore, you should consider the following points when designing, handling or packaging the photointerrupters.

1. Precautions for Circuit Designing

- A.
 - The load resistance on the phototransistor side should be determined by the customer since the working current in an infrared LED varies from one application to another. If the load resistance is improperly selected, problems such as the malfunction of assembled sets will occur.
 - The main point is the testimation of the Maximum and the minimum radiation strength. That is the maximum dark current, threshold voltage and a half-strength of radiation strength.
 - To prevent this, in circuit designing, you should always read the information attached as "Reference Material 1," which describes the method of determining a correct load resistance value.
- B. The phototransistor will not work when using only one resistance for two parallel phototransistors.



2. Lead Forming

- (1) Lead pins should be formed as clamped with a bending tool. Avoid bending lead pins by using their root sections as a fulcrum.
- (2) Lead pins should be bent at a distance of at least 2 mm from their root sections.
- (3) Lead forming should be conducted prior to soldering.
- (4) Repeatedly bending lead pins at the same points should be avoided.

3. Lead Cutting

Cutting leads at high temperatures may cause wire breakage. Always conduct lead cutting at ordinary temperatures.

4. Mounting

- (1) Lead pins must have the same pitch as that of the fitting holes on the substrate. Do not bend lead pins to expand or reduce the pin pitch when mounting ICs to a substrate.
- (2) If a holder etc. is used to position ICs, consider the dimensional tolerances of the holder, the substrate, and the product to prevent the stress to the lead pins.

※ Note) Note the thermal inflation coefficient of each material in use.

In preheating and soldering, the holder inflates due to heat and then shrinks, which applies stress to the lead pins and possibly causes wire breakage.

5. Soldering

The recommended soldering conditions are given below:

Item	Conditions	Soldering temperature	Operation time
Solder dipping	Conducted at a distance of 1.2mm from the resin	Preheating below 85°C (Max 30 SEC) 260°C or lower	3 seconds or shorter
Soldering iron	Conducted at a distance of 1.2mm from the resin Wattage: 30 W or lower Tip diameter: 3 mm or shorter	300°C or lower	3 seconds or shorter
Reflow soldering	Reflow soldering is not permitted.		

- * Use rosin-based flux only. Note that strongly acid or alkaline flux may cause corrosion.
- * The surface mount devices require special attention. Please check requested time control after opening sealed bag, land pattern, the thickness of solder paste screen etc.

6. About PCB division

- The case insertion type is weaker than double mold type ; due to its structure , it is weak to stresses (bending • drop)

Hence, please do not use hands directly when removing each PCB as shown on picture.

Please use proper equipments to avoid any stresses to PCB(components.)



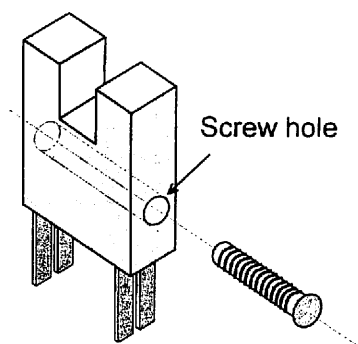
- After soldering, please do not make any strength test to the case insertion type. It may causes terminal breakage and/or case removals.



7. Attention in products mounting

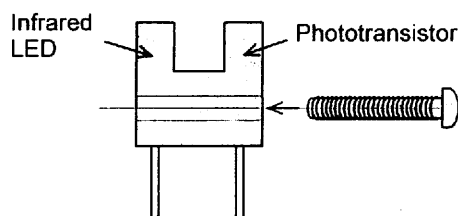
Double molded interrupter

- R P I - 1 3 1
- R P I - 2 4 3
- R P I - 2 4 6



As for the above type, there is the possibility that makes electrically short-circuit between parts to Metal mounting plate, when tighten at the time of attachment and torque be strong. Especially attention to the following point and please use.

- ① Screw M1.4 screw head $\phi 2.5$ mm
(Plastic production recommendation)
- ② Tightening torque $0.049\text{N}\cdot\text{m} \sim 0.078\text{N}\cdot\text{m}$
(Attention to strong tightening)
- ③ Insertion direction Insert a screw from the phototransistor side.
- ④ Metal mounting plate Do not short-circuit to VCC and GND.



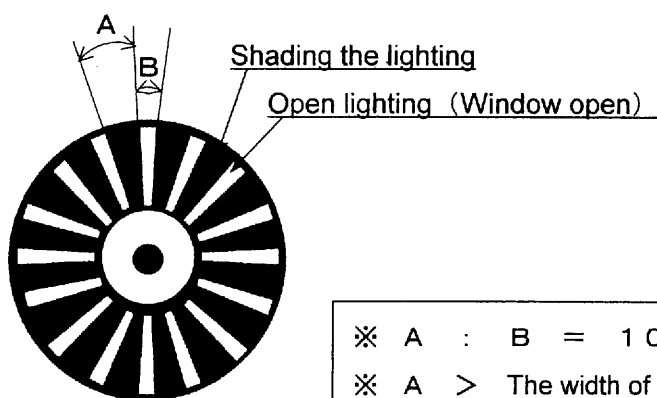
8. Rules of the speed operating and the response time

You need to be careful about the response time of photo interrupter during the high-speed switching.

In case of using photo interrupter as positioning control chip by on – off with μ SEC order, you should take a margin according to the response time that is written on Date Book.

In case of using photo interrupter at high-speed, you should lower the resistance value to control. Consequently you should lower the resistance value of infrared side and send more electric current.

When you use the slit as shade the light, you should make the shade part 3~10% bigger against the width of slit of interrupter.



Thank you if you would contact to the following, if there is the question/question etc. regarding this case.

ROHM CO., LTD.

Quality Control Dept. DISPLAY Div

Manager TETSURO YAMASHITA

Charge AKIO TSUJI

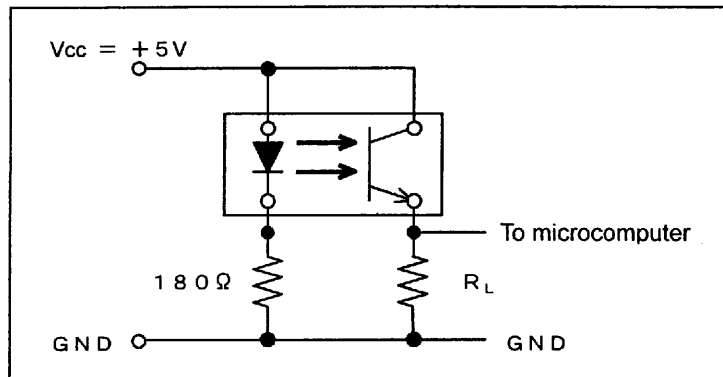
TEL : (075) 321 - 1294

✉ E-mail : display@rohm.co.jp

<Reference Material 1>

Load Resistance Calculation Example

I. Customer's Circuit



II. Forward Current I_F in Customer's Circuit

$$I_F = \frac{5.0V - 1.3V}{180\Omega} = 20.6mA$$

Infrared Emitting Diode
 $V_F = 1.3V$

III. Minimum Value of Collector Current I_C in Customer's Circuit

ROHM SPEC . . . $V_{CC} 5V$ $I_C \text{ Min } 0.2mA$

$I_F 20mA$

Customer's circuit . . . $V_{CC} 5V$

$I_F 20.6mA$

- Minimum value of collector current I_C when I_F is 20.6 mA

$$I_C = 0.2mA \times \frac{20.6mA}{20mA} = 0.21mA$$

- Taking into consideration the changes in characteristics due to aging*, the light emitting capacity of an infrared LED decreases approx. 50% if used for 10 years.

$$I_C \text{ Min} = 0.21 \times 0.5 = 0.105mA$$

$$\underline{I_C \text{ Min} = 0.105mA}$$

* The characteristics of the infrared LED used for photointerrupters changes due to aging and therefore there is a limitation in its service life. If the input current is maintained lower than the rated input, the officially announced service life of an infrared LED is 100,000 hours, assuming that the life of an infrared LED completes when its light emitting capacity is decreased to 50% of its initial value. Therefore, a sufficient allowance must be provided in designing photointerrupters.

- If the threshold voltage in customer's circuit is

$$\left\{ \begin{array}{l} V_{Hi} \ 3.8V \text{ or higher and} \\ V_{Lo} \ 1.0V \text{ or lower (our estimation value),} \end{array} \right\}$$

then the load resistor R_L must be the one that satisfies it.

IV. Minimum Value of Load Resistance R_L

$$\begin{aligned}
 V_{Hi} &< I_{C \text{ Min}} \times R_L \text{ Min}) \\
 3.8V &< 0.105mA \times R_L \text{ Min} \\
 R_L \text{ Min} &> \frac{3.8V}{0.000105A} \\
 R_L \text{ Min} &> 36k\Omega
 \end{aligned}$$

V. Maximum Value of Load Resistance R_L

Assume that the maximum value of dark current I_{ceo} ($I_{ceo \text{ max}}$) is $10 \mu A$, then:

$$\begin{aligned}
 V_{OL} &> I_{CEO \text{ Max}} \times R_L \text{ Max} \\
 1.0V &> 10\mu A \times R_L \text{ Max} \\
 R_L \text{ Max} &< \frac{1.0V}{0.000010A} \\
 R_L \text{ Max} &< 100k\Omega
 \end{aligned}$$

VI. From the above calculations, the following load resistance range is obtained:

$$36k\Omega < R < 100k\Omega$$