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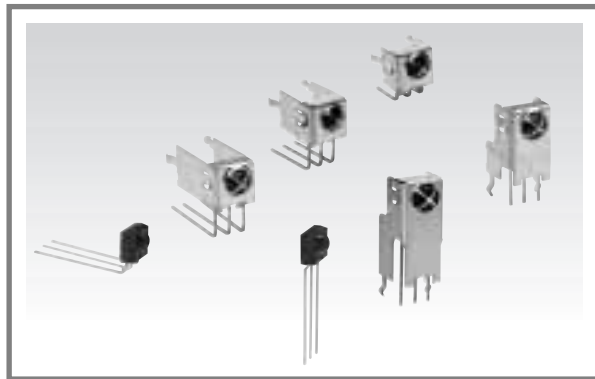

Contact us

Tel: +86-755-8981 8866 Fax: +86-755-8427 6832
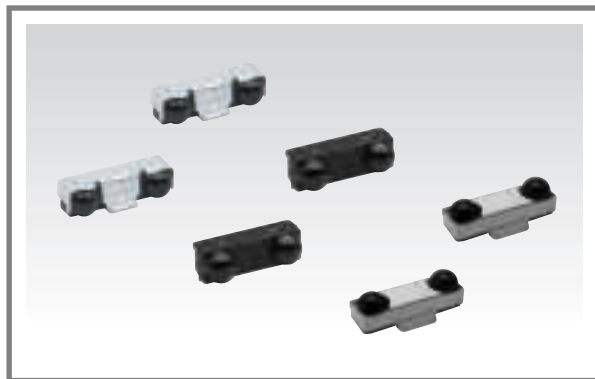Email & Skype: info@chipsmall.com Web: www.chipsmall.com
Address: A1208, Overseas Decoration Building, #122 Zhenhua RD., Futian, Shenzhen, China
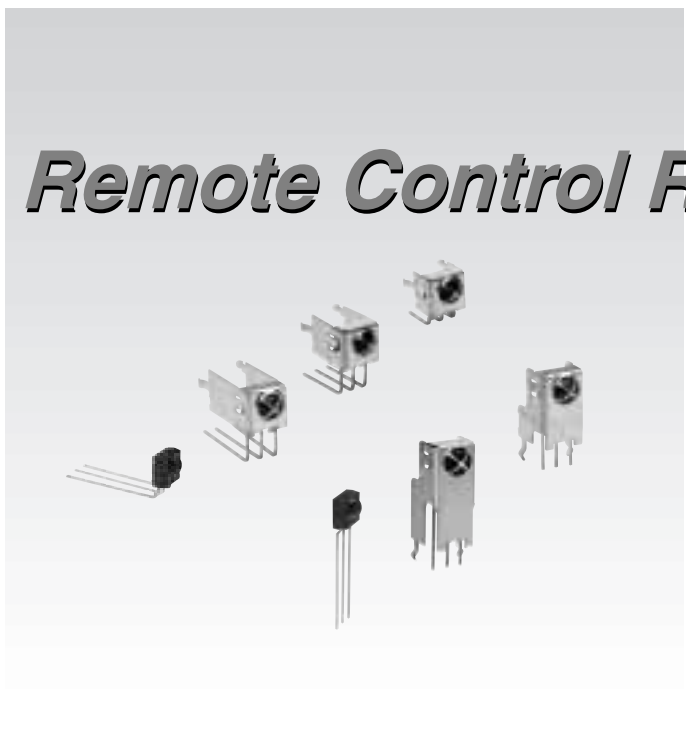
Photo Link Modules

Remote Control Receiver Module
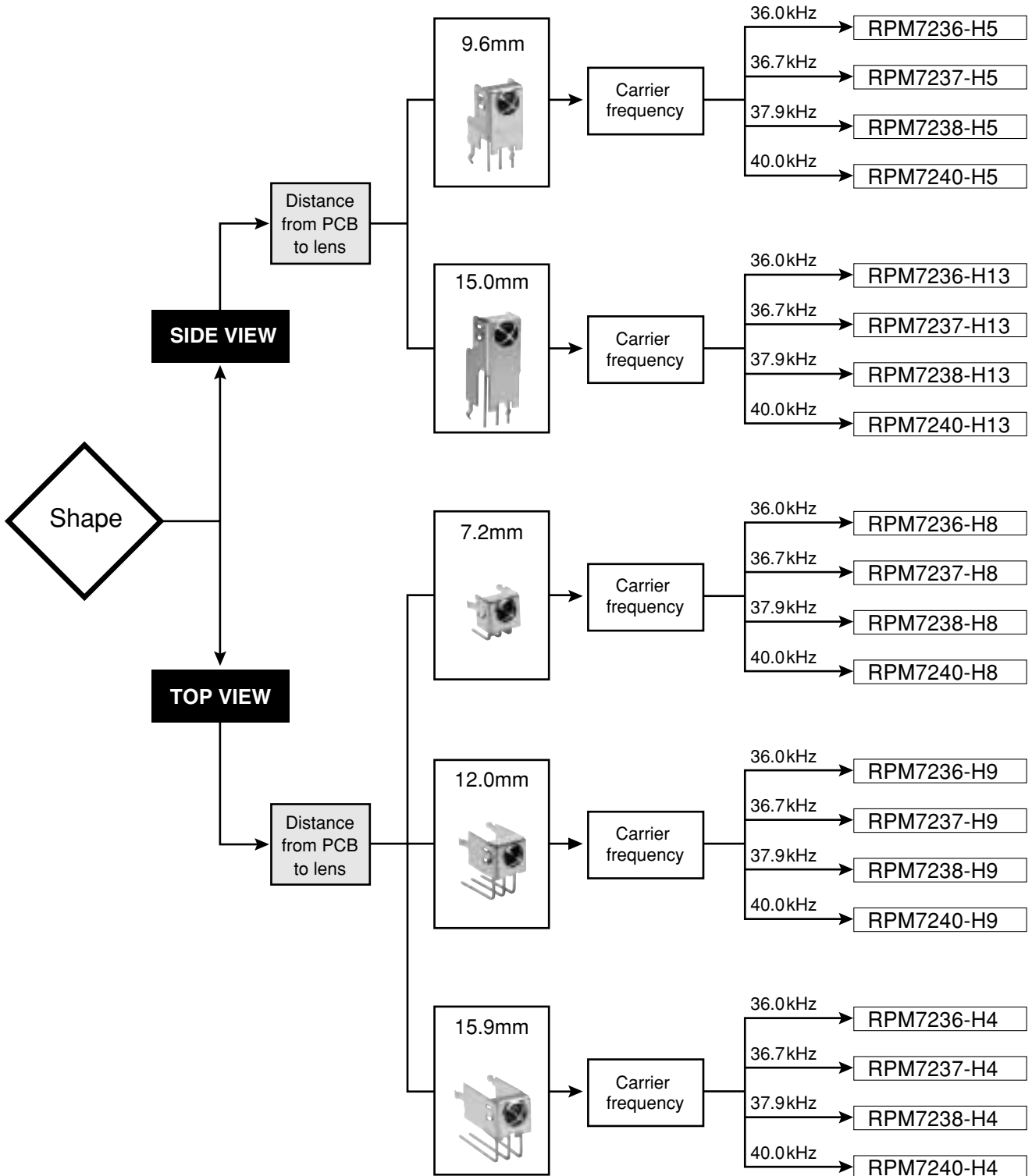
IrDA Infrared Communication Module

ROHM CO., LTD.

Remote Control Receiver Module

Remote Control Receiver Module

■Contents

■Remote Control Receiver Module Selection Guide

Remote Control Receiver Module (at 3.0 to 3.3V)

Shape

SIDE VIEW

Distance from PCB to lens

9.6mm

Carrier frequency
- 36.0kHz → RPM7236-H5
- 36.7kHz → RPM7237-H5
- 37.9kHz → RPM7238-H5
- 40.0kHz → RPM7240-H5

15.0mm

Carrier frequency
- 36.0kHz → RPM7236-H13
- 36.7kHz → RPM7237-H13
- 37.9kHz → RPM7238-H13
- 40.0kHz → RPM7240-H13

TOP VIEW

Distance from PCB to lens

7.2mm

Carrier frequency
- 36.0kHz → RPM7236-H8
- 36.7kHz → RPM7237-H8
- 37.9kHz → RPM7238-H8
- 40.0kHz → RPM7240-H8

12.0mm

Carrier frequency
- 36.0kHz → RPM7236-H9
- 36.7kHz → RPM7237-H9
- 37.9kHz → RPM7238-H9
- 40.0kHz → RPM7240-H9

15.9mm

Carrier frequency
- 36.0kHz → RPM7236-H4
- 36.7kHz → RPM7237-H4
- 37.9kHz → RPM7238-H4
- 40.0kHz → RPM7240-H4

1

Remote Control Receiver Module (at 5.0V)

Shape

SIDE VIEW

TOP VIEW

SIDE VIEW → Distance from PCB to lens

5.5mm → Carrier frequency
- 36.0kHz → RPM7136
- 36.7kHz → RPM7137
- 37.9kHz → RPM7138
- 40.0kHz → RPM7140
- 56.9kHz → RPM7157

9.6mm → Carrier frequency
- 36.0kHz → RPM7136-H5
- 36.7kHz → RPM7137-H5
- 37.9kHz → RPM7138-H5
- 40.0kHz → RPM7140-H5
- 56.9kHz → RPM7157-H5

15.0mm → Carrier frequency
- 36.0kHz → RPM7136-H13
- 36.7kHz → RPM7137-H13
- 37.9kHz → RPM7138-H13
- 40.0kHz → RPM7140-H13
- 56.9kHz → RPM7157-H13

TOP VIEW → Distance from PCB to lens

4.8mm → Carrier frequency
- 36.0kHz → RPM7136-V4
- 36.7kHz → RPM7137-V4
- 37.9kHz → RPM7138-V4
- 40.0kHz → RPM7140-V4
- 56.9kHz → RPM7157-V4

7.2mm → Carrier frequency
- 36.0kHz → RPM7136-H8
- 36.7kHz → RPM7137-H8
- 37.9kHz → RPM7138-H8
- 40.0kHz → RPM7140-H8
- 56.9kHz → RPM7157-H8

12.0mm → Carrier frequency
- 36.0kHz → RPM7136-H9
- 36.7kHz → RPM7137-H9
- 37.9kHz → RPM7138-H9
- 40.0kHz → RPM7140-H9
- 56.9kHz → RPM7157-H9

15.9mm → Carrier frequency
- 36.0kHz → RPM7136-H4
- 36.7kHz → RPM7137-H4
- 37.9kHz → RPM7138-H4
- 40.0kHz → RPM7140-H4
- 56.9kHz → RPM7157-H4

■Electrical and Optical Characteristics of RPM7200 Series

Absolute Maximum Ratings (Ta=25°C)

Parameter	Symbol	Limits	Unit
Supply Voltage	V_{CC}	6.3	V
Storage Temperature Range	Tstg	-30~+100	°C
Operating Temperature Range	Topr	-10~+75	°C
Solder Temperature	Tsol	260*	°C

* Within 5s and 3mm of the route of the lead.

Recommended Operating Conditions (Ta=25°C)

Parameter	Symbol	Min.	Typ.	Max.	Unit
Supply Voltage	V_{CC}	2.7	3.0	3.6	V

Electrical Characteristics (Ta=25°C and Vcc=3V unless otherwise specified)

Parameter	Symbol	Min.	Typ.	Max.	Unit	Conditions
Current Consumption	Icc	—	0.3	0.5	mA	With no external light or input
Effective Distance on Axis	L	8	15	—	m	*1 External light condition Ee<10 lx
High Level Output Voltage	V_H	2.5	—	—	V	*1
Low Level Output Voltage	V_L	—	—	0.5	V	*1 Isink=200µA max.
ON Pulse Width	Ton	400	600	800	µs	*1 External light condition Ee<10 lx
OFF Pulse Width	Toff	400	600	800	µs	*1 External light condition Ee<10 lx
Horizontal Half Angle	θ1/2	—	45	—	deg	*2
Vertical Half Angle	θ1/2	—	35	—	deg	*2

*1. Burst waves (600/600µs) are transmitted by a standard transmitter,
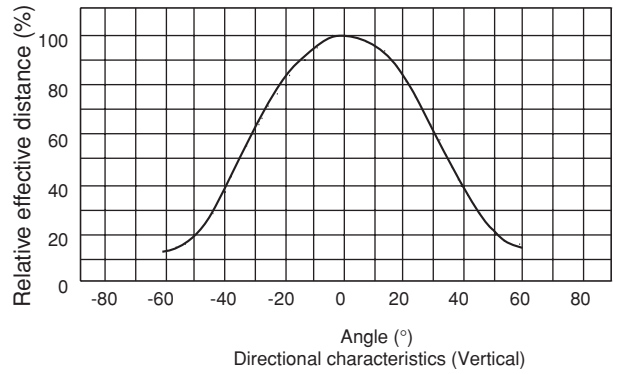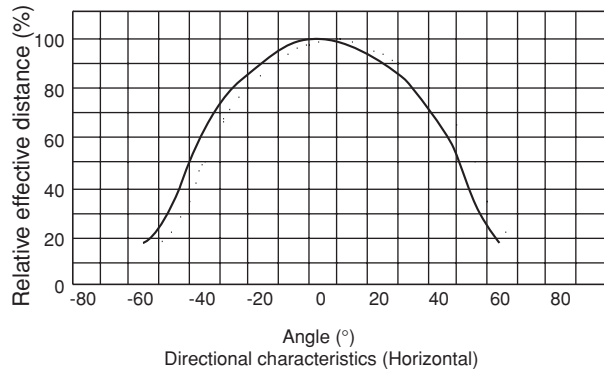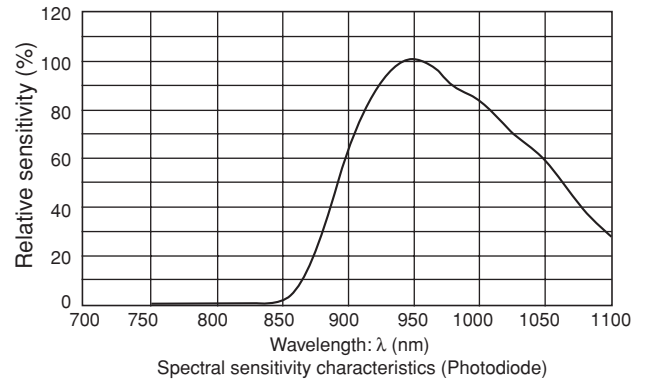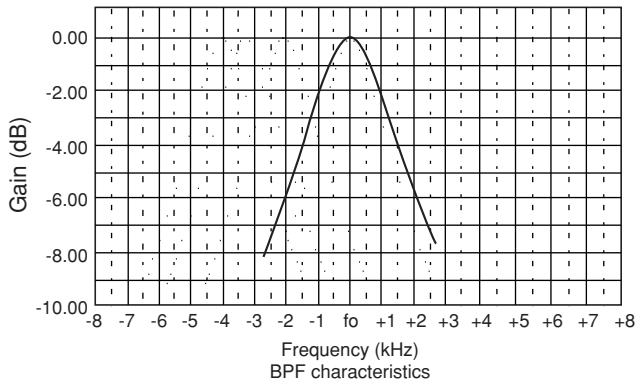   and the 100th and later pulses are measured.
*2. A directional angle where the effective distance is half the linear arrival distance.

Shape	Side View		Top View		
Package	RSIP-A3 (H5)	RSIP-A3 (H13)	RSIP-A3 (H8)	RSIP-A3 (H9)	RSIP-A3 (H4)
Hight (PCB to LENS)	9.6mm	15.0mm	7.2mm	12.0mm	15.9mm

Carrier Frequency

36.0kHz	RPM7236-H5	RPM7236-H13	RPM7236-H8	RPM7236-H9	RPM7236-H4
36.7kHz	RPM7237-H5	RPM7237-H13	RPM7237-H8	RPM7237-H9	RPM7237-H4
37.9kHz	RPM7238-H5	RPM7238-H13	RPM7238-H8	RPM7238-H9	RPM7238-H4
40.0kHz	RPM7240-H5	RPM7240-H13	RPM7240-H8	RPM7240-H9	RPM7240-H4

■Typical Characteristics of RPM7200 Series

Gain (dB) vs Frequency (kHz)

BPF characteristics

Relative sensitivity (%) vs Wavelength: λ (nm)

Spectral sensitivity characteristics (Photodiode)

Relative effective distance (%) vs Angle (°)

Directional characteristics (Horizontal)

Relative effective distance (%) vs Angle (°)

Directional characteristics (Vertical)

4

■Electrical and Optical Characteristics of RPM7100 Series

Absolute Maximum Ratings (Ta=25°C)

Parameter	Symbol	Limits	Unit
Supply voltage	V_{CC}	6.3	V
Storage Temperature Range	Tstg	-30~+100	°C
Operating Temperature Range	Topr	-10~+75	°C
Solder Temperature	Tsol	260*	°C

* Within 5s and 3mm of the route of the lead.

Recommended Operating Conditions (Ta=25°C)

Parameter	Symbol	Min.	Typ.	Max.	Unit
Supply Voltage	V_{CC}	4.5	5.0	5.5	V

Electrical Characteristics (Ta=25°C and Vcc=5V unless otherwise specified)

Parameter	Symbol	Min.	Typ.	Max.	Unit	Conditions
Current Consumption	Icc	—	0.95	1.5	mA	With no external light or input
Effective Distance on Axis	L	8	15	—	m	*1 External light condition Ee<10 lx
High Level Output Voltage	V_H	4.5	—	—	V	*1
Low Level Output Voltage	V_L	—	—	0.5	V	*1 Isink=200µA max.
ON Pulse Width	Ton	400	600	800	µs	*1 External light condition Ee<10 lx
OFF Pulse Width	Toff	400	600	800	µs	*1 External light condition Ee<10 lx
Horizontal Half Angle	θ1/2	—	45	—	deg	*2
Vertical Half Angle	θ1/2	—	35	—	deg	*2

*1. Burst waves (600/600µs) are transmitted by a standard transmitter,
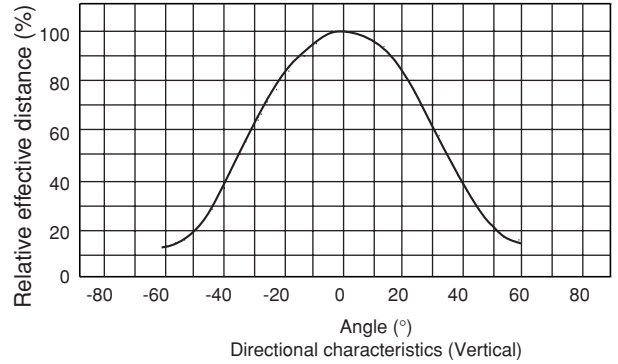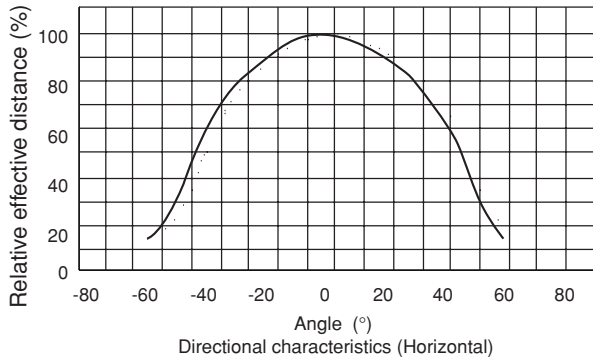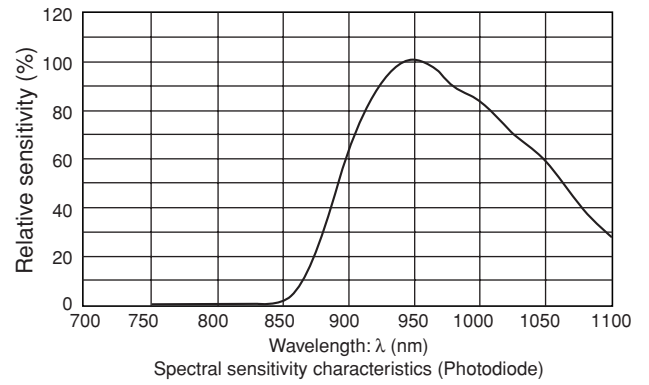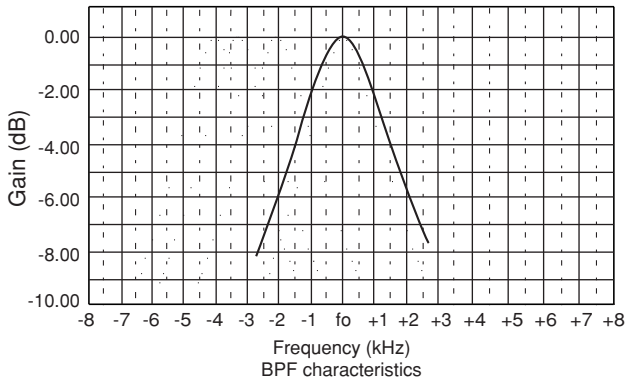   and the 100th and later pulses are measured.
*2. A directional angle where the effective distance is half the linear arrival distance.

Shape	Side View			Top View			
Package	RSIP-A3	RSIP-A3 (H5)	RSIP-A3 (H13)	RSIP-A3 V4	RSIP-A3 (H8)	RSIP-A3 (H9)	RSIP-A3 (H4)
Hight (PCB to LENS)	5.5mm	9.6mm	15.0mm	4.8mm	7.2mm	12.0mm	15.9mm

Carrier Frequency

36.0kHz	RPM7136	RPM7136-H5	RPM7136-H13	RPM7136-V4	RPM7136-H8	RPM7136-H9	RPM7136-H4
36.7kHz	RPM7137	RPM7137-H5	RPM7137-H13	RPM7137-V4	RPM7137-H8	RPM7137-H9	RPM7137-H4
37.9kHz	RPM7138	RPM7138-H5	RPM7138-H13	RPM7138-V4	RPM7138-H8	RPM7138-H9	RPM7138-H4
40.0kHz	RPM7140	RPM7140-H5	RPM7140-H13	RPM7140-V4	RPM7140-H8	RPM7140-H9	RPM7140-H4
56.9kHz	RPM7157	RPM7157-H5	RPM7157-H13	RPM7157-V4	RPM7157-H8	RPM7157-H9	RPM7157-H4

■Typical Characteristics of RPM7100 Series

BPF characteristics

Spectral sensitivity characteristics (Photodiode)

Directional characteristics (Horizontal)
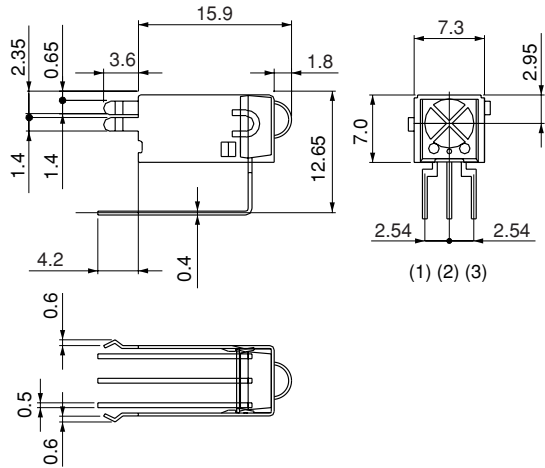

Directional characteristics (Vertical)
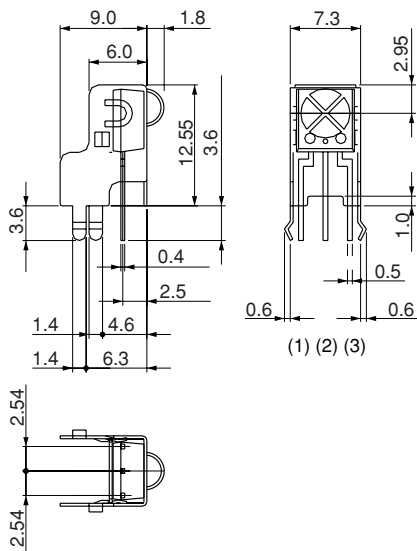
■External Dimensions (Unit: mm)
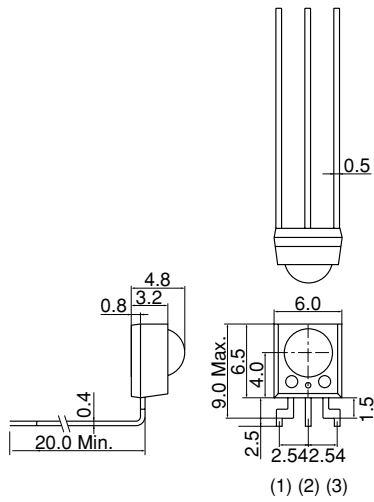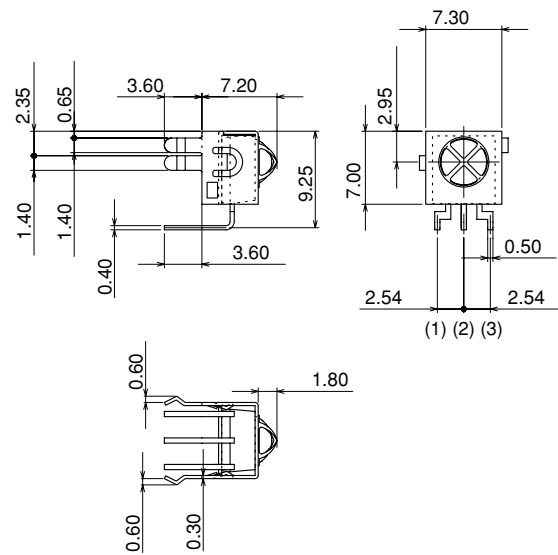
●RSIP-A3 (H13)
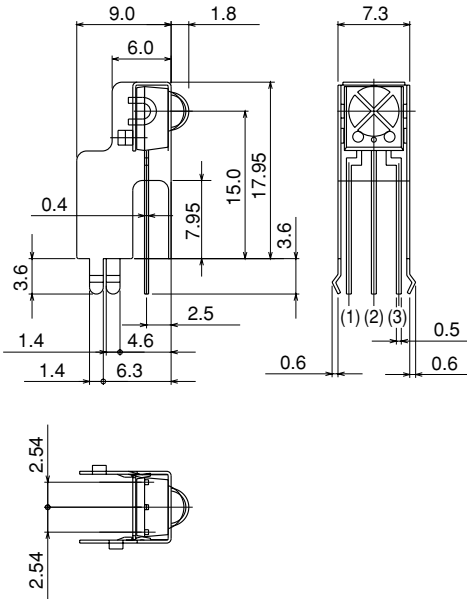
●RSIP-A3 (H4)

●RSIP-A3 (H5)

●RSIP-A3

Pin number	
(1)	Rout
(2)	GND
(3)	Vcc

7
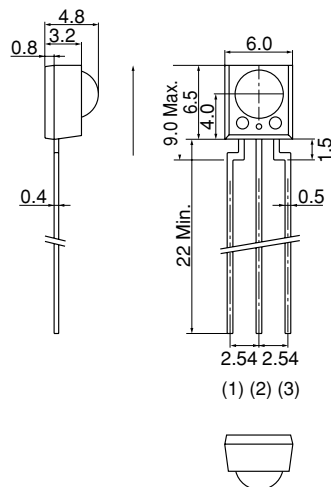
Remote Control Receiver Module

●RSIP-A3 V4

●RSIP-A3 (H8)

●RSIP-A3 (H9)
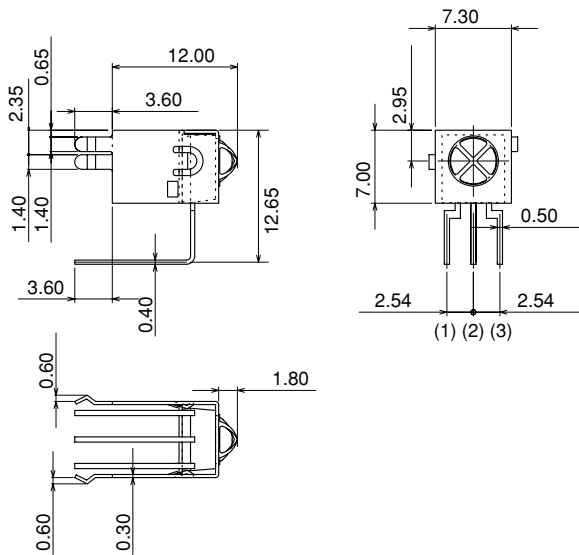
Pin number	
(1)	Rout
(2)	GND
(3)	Vcc

1. Basic Knowledge of Remote Control

1) Remote Control Receiver Module

The Remote Control Receiver Module is an optical communications module that uses infrared rays for TV sets and audio equipment.

Conventional models were of cubic structure (1.5×1.5cm) incorporating a PCB mounted with a PIN photodiode, receiver IC, and capacitors and covered with a shield casing. Since ROHM released a one-package model, however, mold resin models of one-package structure have been mainstream products.

ROHM provides the RPM7100-Hx Series (operating at 5V) and the RPM7200-Hx Series (operating at 3.0V). Both of them are of two-chip structure incorporating a PIN photodiode and receiver IC.

ROHM's Remote Control Receiver Module prevents malfunctions caused by power line noise by taking measures for a reduction in power supply ripples, thus suiting a variety of power supply environments flexibly.
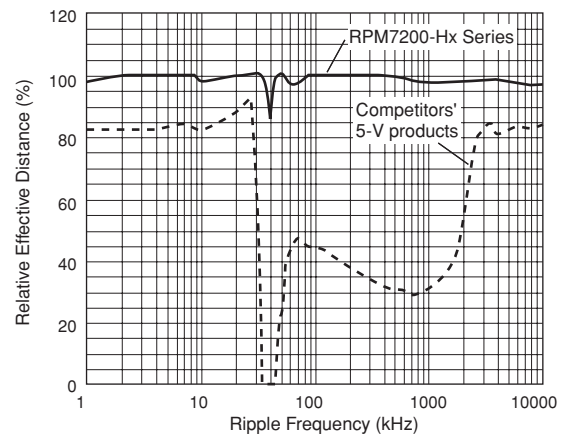
Fig. 1 Relative Effective Distance vs. Power Supply Ripple Frequency of RPM7200-Hx

2) Remote Control Optical Signal

The remote control uses an infrared optical signal.
Infrared rays are invisible and longer in wavelength than visible light.
Remote control models use a dominant wavelength around 950nm.

3) Reason for Use of Infrared Rays

The remote control is overwhelmingly used indoors under light emitted from lighting apparatus, which includes quantities of visible light components. In order to prevent such light from becoming a noise source, the remote control uses infrared rays, which is rarely included in the light emitted from the lighting apparatus.

In other words, the remote control uses infrared rays in order to improve the signal-to-noise ratio. The RPM7100-Hx Series and RPM7200-Hx Series eliminate optical noise by providing the resin packages with a filter function that shuts off visible light.
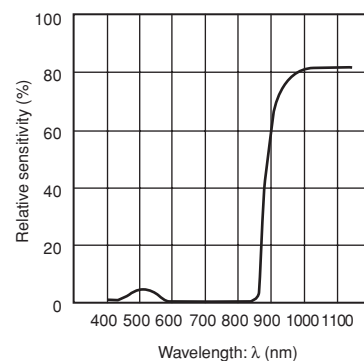
Fig. 2 Relative Sensitivity of RPM7100-Hx/RPM7200-Hx

2. Remote Control Receiver Module and Data Communication

1) Structure of Remote Control Receiver Module

Holder casing

Mold resin

Photodiode

Signal processing IC
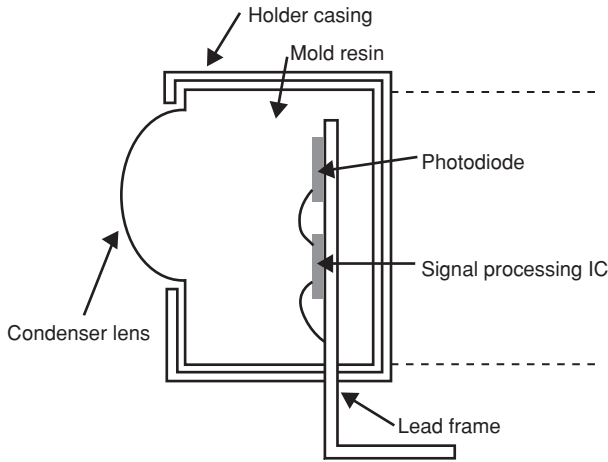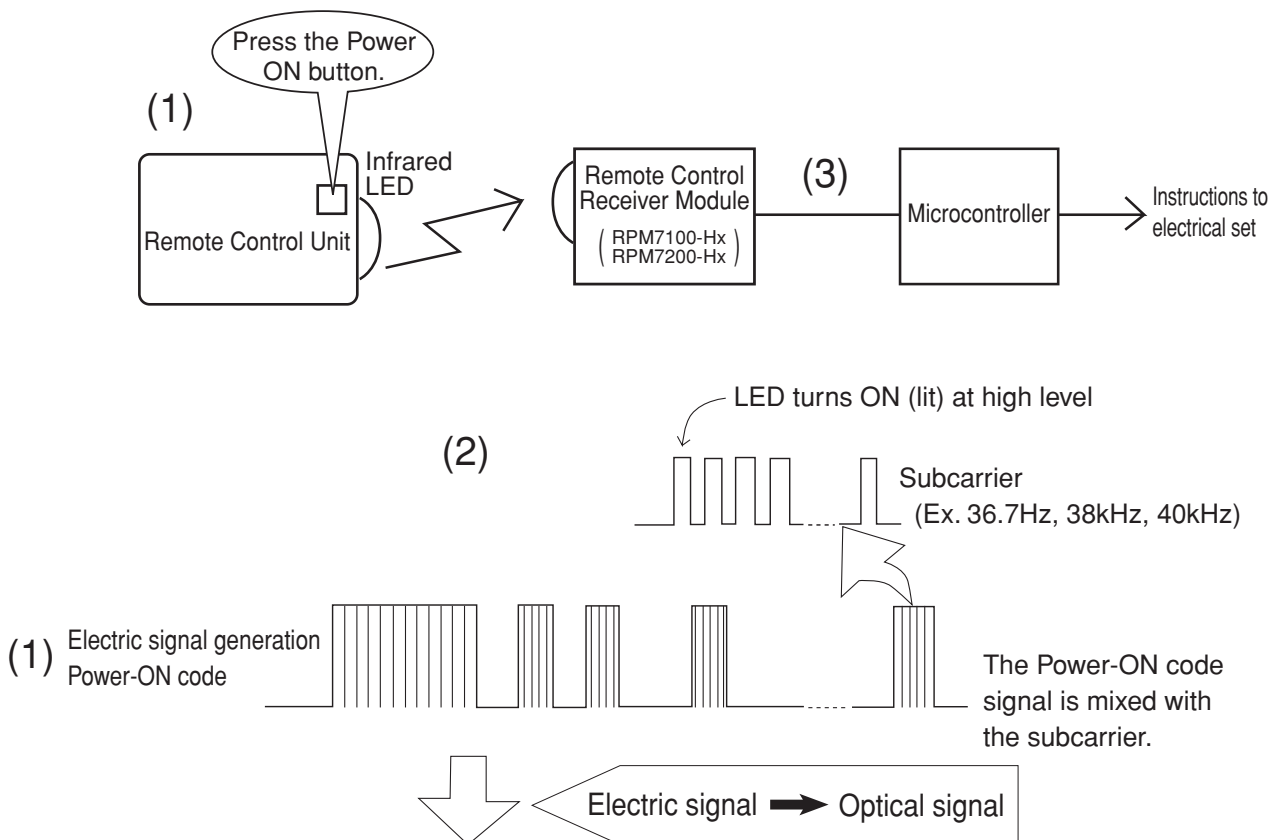
Condenser lens

Lead frame

Fig. 3 Structure of RPM7100-Hx/RPM7200-Hx

The photodiode and the signal processing IC are die-bonded to the metal lead frame. Then gold wires are bonded for necessary wiring.
The parts are sealed with mold resin to shut off visible optical noise, and the whole structure except the condenser lens is covered with a metal shield casing.

2) Remote Control System Signal Flow

The Remote Control Receiver Module receives an optical signal from the Remote Control Unit and changes the signal into an electric signal.
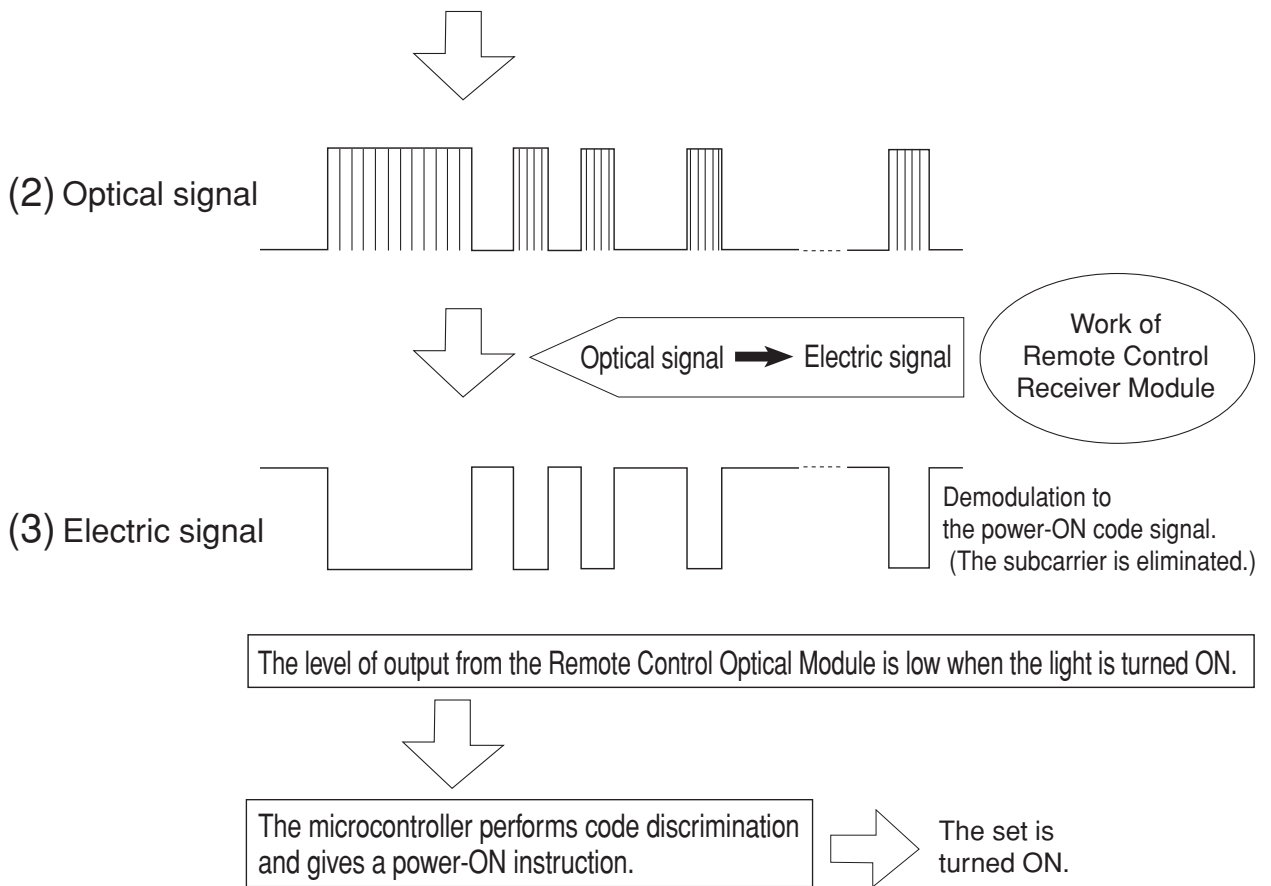
(1)

Press the Power ON button.

Infrared LED

Remote Control Unit

Remote Control Receiver Module
(RPM7100-Hx)
(RPM7200-Hx)

(3)

Microcontroller

Instructions to electrical set

(2)

LED turns ON (lit) at high level

Subcarrier
(Ex. 36.7Hz, 38kHz, 40kHz)

(1) Electric signal generation
Power-ON code

The Power-ON code signal is mixed with the subcarrier.

Electric signal ➡ Optical signal

Remote Control Receiver Module

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(2) Optical signal

Optical signal ➡ Electric signal

Work of Remote Control Receiver Module

(3) Electric signal

Demodulation to the power-ON code signal. (The subcarrier is eliminated.)

The level of output from the Remote Control Optical Module is low when the light is turned ON.

The microcontroller performs code discrimination and gives a power-ON instruction.

The set is turned ON.

Fig. 4

3. Block Diagram and Work of Remote Control Receiver Module

1) Block Diagram of Remote Control Receiver Module

Photodiode

IV

Amplifier

BPF

Detection

Comparator

V$_{CC}$

R$_{ON}$

GND

RPM7100-Hx/RPM7200-Hx
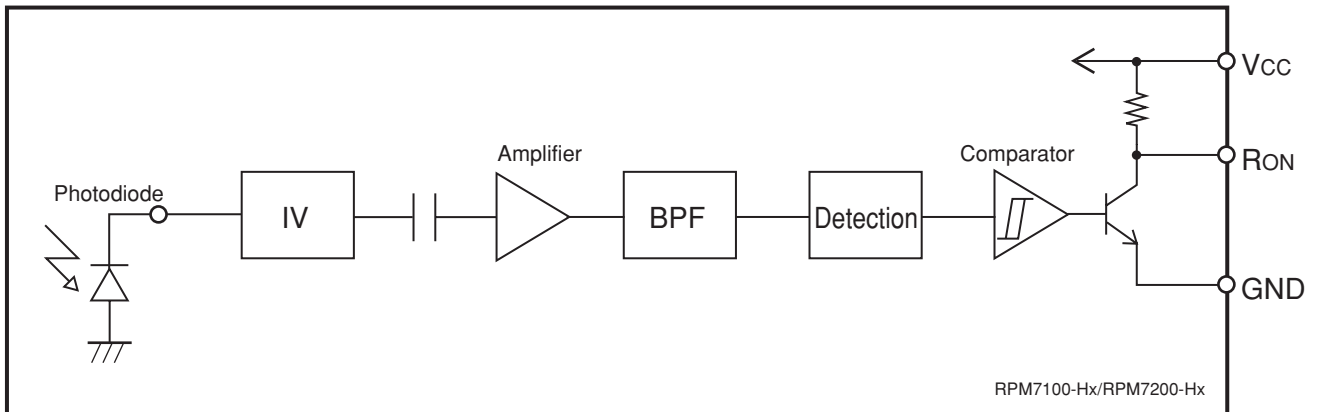
Fig. 5 Block Diagram

2) Work of Each Blocks

• Photodiode

The photodiode receives an optical signal transmitted from the remote control unit and converts the optical signal into a current signal. The mold resin of the Remote Control Receiver Module has a function to shut off visible light, thus allowing only the optical signal to pass. Figure 6 shows the spectral sensitivity characteristics of the mold resin and photodiode.

• IV

The optical signal received by the photodiode and converted into the current signal is further converted into a voltage signal. An automatic gain control function is provided to suppress excessively strong optical signal input so that the signal will be within the permissible range of the circuits.

• Amplifier

The IV block amplifies the voltage signal converted from the current signal to optimum amplitude for the later stages where the signal is further processed. If the input is excessively high, the amplitude will be limited in the IV block.
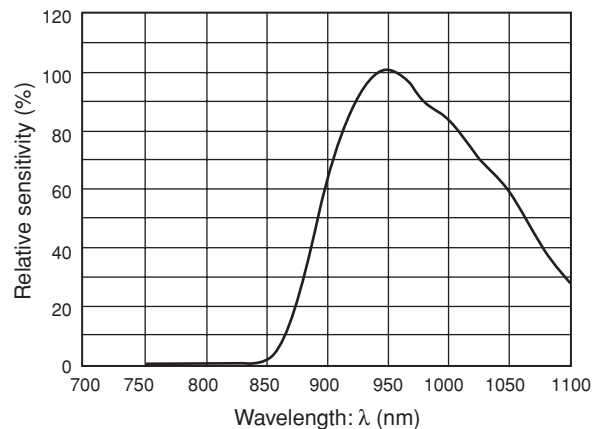
Fig. 6 Relative Spectral Sensitivity Characteristics of RPM7100-Hx/RPM7200-Hx
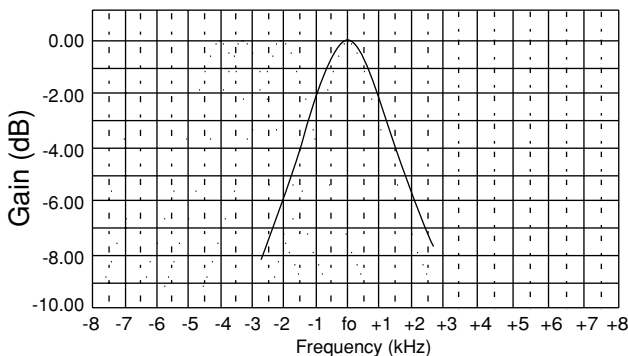
• BPF (Band Pass Filter)

The remote transmission signal is modulated by the subcarrier. The BPF is incorporated in order to extract only pure signal components from the signal (including noise) received.

Fig. 7 BPF Characteristics of RPM7100-Hx/RPM7200-Hx

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• Detection

This block has a detector and integrator.
The detector automatically determines the level of detection (a) according to the level of BPF output, and sets the timing of integration.
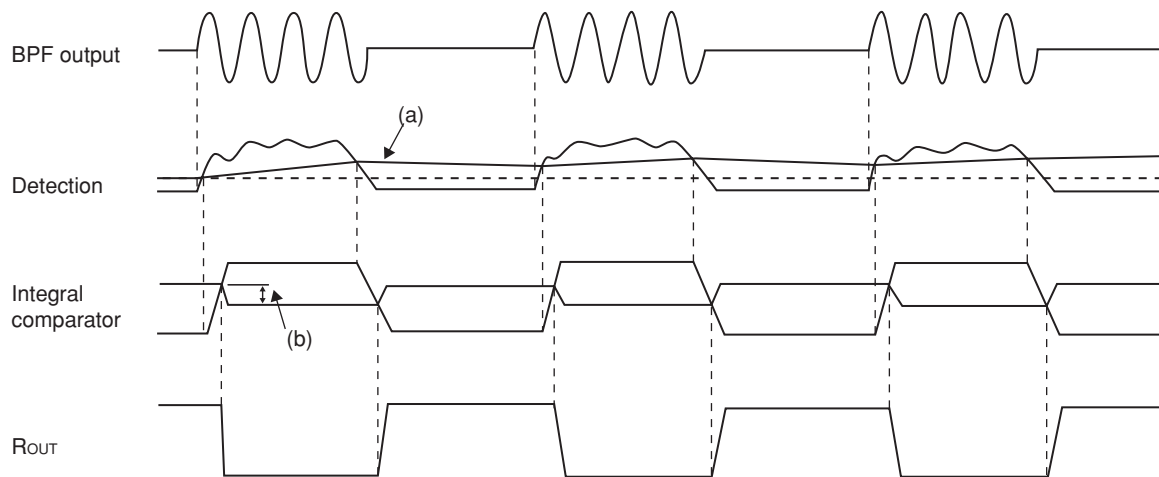

Fig. 8 Waveform Shaping of RPM7100-Hx/RPM7200-Hx

Only the pure signal is extracted from the input signal that includes noise, at which time the level of detection is automatically adjusted according to the output amplitude of the BPF.

• Comparator

The output of the detection block is converted into a binary. The hysteresis (b) prevents chattering that results from noise.

4. Remote Control Transmission Signal

Various methods are used for signal transmission, because there are no unified standards. The same PPM (pulse position modulation) code is used to discriminate 1 and 0 according to the pulse time interval.
The amplitude of the subcarrier is modified according to the pulse train. Therefore, the subcarrier frequency range is between 33 and 57kHz.
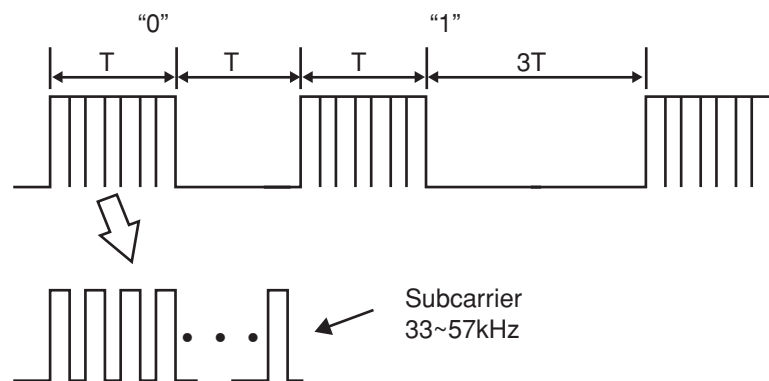
"0"   "1"

T   T   T   3T

Subcarrier
33~57kHz

Fig. 9

《Overview of AEHA's (Association for Electric Home Appliances) Format》

Application: Applicable to infrared remote control systems for home appliances with a subcarrier range up to 40kHz employed to transmit data.

Subcarrier: 33kHz and 40kHz max.

Signal format: A frame includes a leader, custom code, parity, data code, and trailer, the outline of which is shown below.

Custom
code   Parity
Leader   Data code   Trailer

(a) Signal
    configuration

1 byte

Leader   "0"   "1"   Trailer

(b) Pulse shape

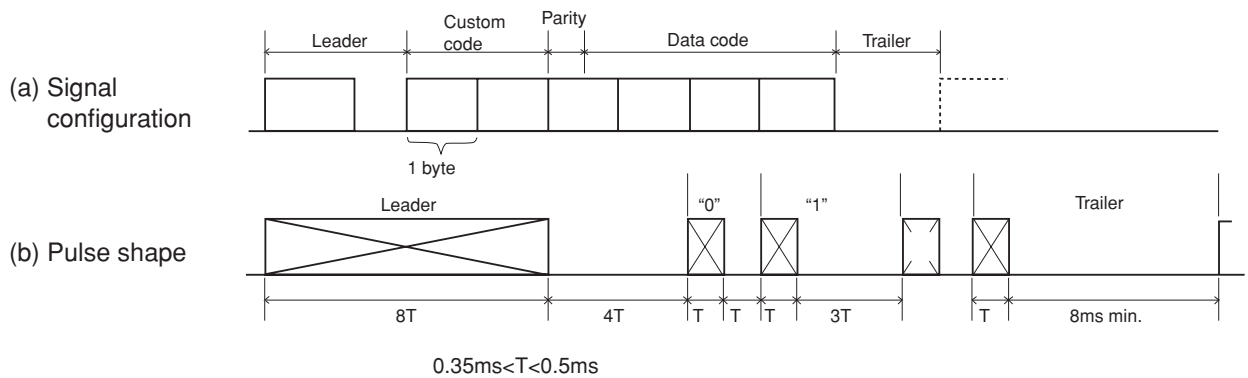8T   4T   T T T   3T   T   8ms min.

0.35ms<T<0.5ms

Fig. 10

In this format, the leader is used for the discrimination of the start of transmission, the custom code is registered and used to prevent the remote control and controlled equipment from malfunctioning, and the parity bit along with the custom code is used to confirm that the signal is addressed to the equipment in use. The trailer is used to discriminate the completion of transmission.

With the diffusion of infrared remote control systems for home appliances, certain standards apply to each manufacturer's signal transmission method in the AEHA's format with the method officially registered, thus preventing the remote control and controlled equipment from malfunctioning.

The transmission format presently in use takes individual measures for the prevention of malfunctions. For example, a method is used to transmit the data code three times and read the data code only when the leader code is received correctly at least twice in the three transmissions. Another method is also used to transmit front and back signals and judge the data only after the front and back signals coincide.

5. Precautions for Designing Transmitter Side

1) Transmitter
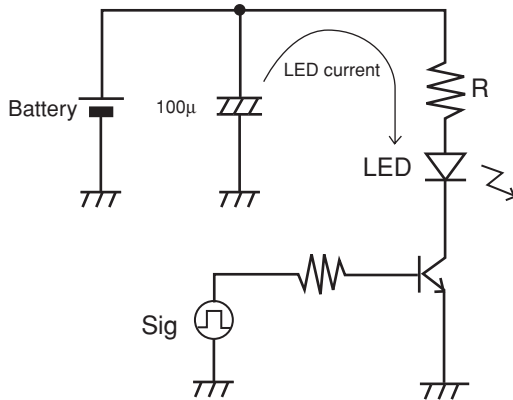
«Transmitter circuit example»

Fig. 13

The resister R is used to set the forward current of the LED and adjusts the optical output power of the transmitter.

The LED is used usually 5mm in diameter and of high-intensity type.
(Optical wavelength (λ)=940 or 950nm)

The electrolytic capacitor C provides the LED current.

Precautions for Transmission Frequency

Check that the subcarrier frequency of the transmitter coincides with the center frequency of the Remote Control Receiver Module, or otherwise the effective distance may be reduced or no receiving may be possible.

2) Transmission Format

• Leader Pulse

The Remote Control Receiver Module covers a wide input range, and automatically makes receiving sensitivity by using leader pulses. The pulse immediately after the start of input may fluctuate (i.e., the receiving pulse width of output may be wider than the transmission pulse width) if there is no leader pulse.
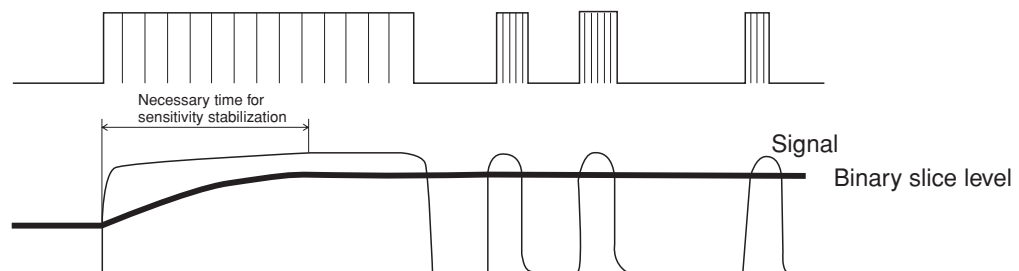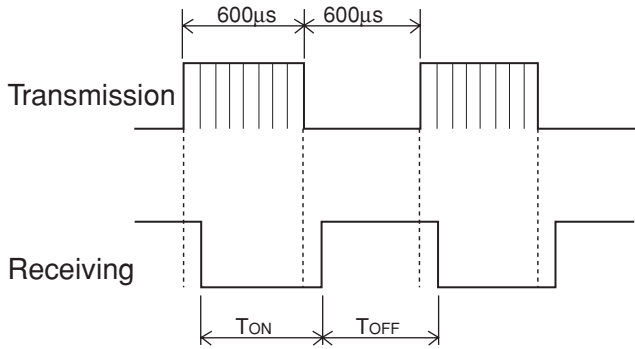

Fig. 14 Automatic Sensitivity Adjustment

• Transmission Pulse Width

Specifications of output pulse width of Remote Control Receiver Module (Transmission pulse width: 600μs)

Output pulse width	MIN	TYP	MAX	Unit
T_{ON}/T_{OFF}	400	600	800	μs

The receiving output pulse fluctuate ±200μs according to the transmission signal.
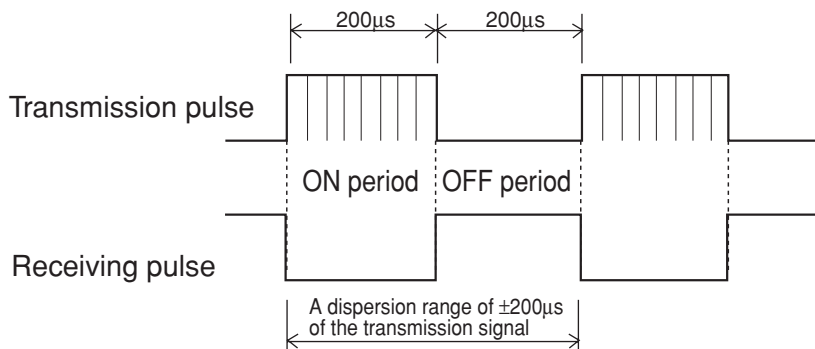
Fig. 15

Transmission pulse width (ON/OFF): Both 200μs

Fig. 16

In the worst case, the dispersion pulse range of output may be 0 to 400μs and no receiving may be possible.

• Countermeasure against Dispersion of Receiving Output Pulses

Take the transmission pulse width as wide as possible (for both ON and OFF periods)
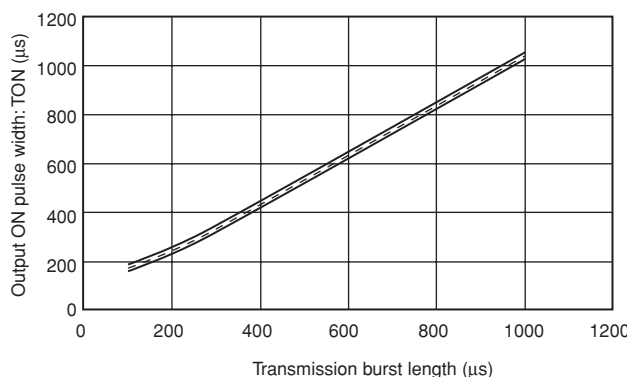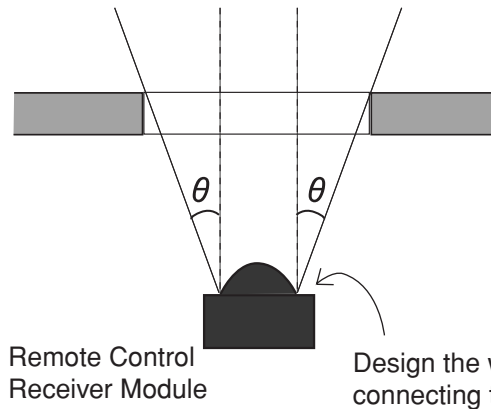

Fig. 17 Output ON Pulse Width vs. Transmission Burst Length
of RPM7100-Hx/RPM7200-Hx

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6. Precautions for Designing Receiver Side

1) Design of Beam Spread Angle

### • Installation of Sensor Window and Remote Control Receiver Module

If the specified beam spread angle is $\theta 1$, design the sensor window to satisfy the following condition, as shown in the figure on the right-hand side: $\theta > \theta 1$.

If the angle is specified from the lens top, there will be no optical signal incidence at the edge of the lens. Therefore, the Remote Control Receiver Module will not fully demonstrate its performance.

Remote Control Receiver Module

Design the window at the angle connecting the lens edge and window edge.

Fig. 18 Sensor Window of RPM7100-Hx/RPM7200-Hx

• Light Guide Tube
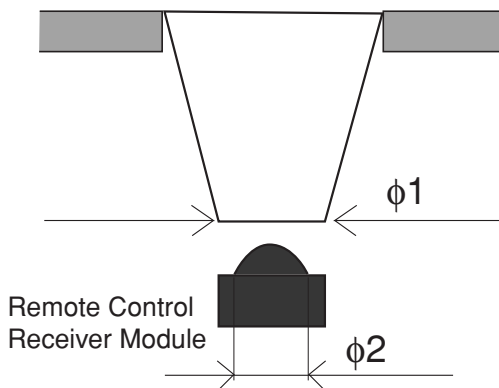
Apply the condition below, on the condition that the diameter of light guide tube on the Remote Control Receiver Module is $\phi 1$ and that of the lens of the Remote Control Receiver is $\phi 2$.

$$\phi 1 > \phi 2$$

The maximum sensitivity is obtained by beaming the optical signal at the whole surface of the lens.

Remote Control Receiver Module

Fig. 19 Light Guide Tube of RPM7100-Hx/RPM7200-Hx

2) Environment-resistive Noise Design

Environments where the Remote Control Receiver Module is used have quantities of noise sources. The Remote Control Receiver Module has very high sensitivity to receive minute optical signals. Therefore, the Remote Control Receiver Module takes a variety of countermeasures against each noise source. If there is an interference of excessive noise, however, the Remote Control Receiver Module may malfunction.
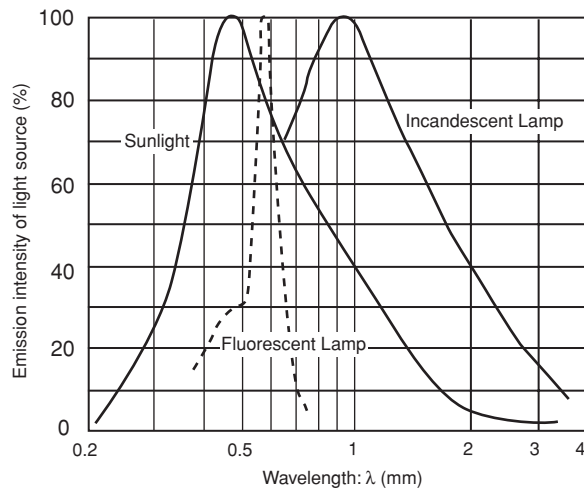
• Various Types of Optical Noise

Fig. 20 Optical Noise Wavelength Characteristics

Rapid Fluorescent Lamp

The light emission frequency of a standard fluorescent lamp is 100Hz or 120Hz in most of the countries. It depends on the goverment policy. Although the light emission frequency is sufficiently lower than the subcarrier frequency of the remote control, the harmonics may cause a malfunction (i.e., a reduction in the effective distance may result).

High Frequency Modulation Type Fluorescent Lamp

In order to reduce the flickering of light, the light emission frequency of an inverter fluorescent lamp is modified. The frequency is around 45kHz, which is close to the subcarrier of the remote controller and becomes noise that cannot be eliminated with ease.
With the incidence of inverter fluorescent light, the effective distance will be shorter in comparison with the case of the rapid fluorescent lamp.

Incandescent Lamp and Sunlight

These light sources have DC noise but including a large quantity of infrared components used for the remote control. The incidence of the noise results in a reduction in effective distance.

• Countermeasures of Set for Optical Noise

Lighting apparatus becomes an optical noise source. In many cases, this noise source is radiated from the upper side. Therefore, at the time of designing the window of the set, limit the incidence of light from the upper side.

• Other Noise Sources

Power Supply Noise

Power supply noise may wrap around from the digital block of the set or may result due to the insufficient smoothing of the power supply circuit. If there are power supply ripples, the effective distance may be reduced. The RPM7100-Hx and RPM7200-Hx Series are designed to reduce the droppage of effective distance to the minimum.

Electromagnetic Noise

The following ones may be sources of electromagnetic noise.
• CRT noise
• LCD (driver) noise (i.e., horizontal synchronizing signal at 38kHz)
• Fluorescent lamp
• Noise radiated from power supply circuit

3) Grounding and Pattern Designing

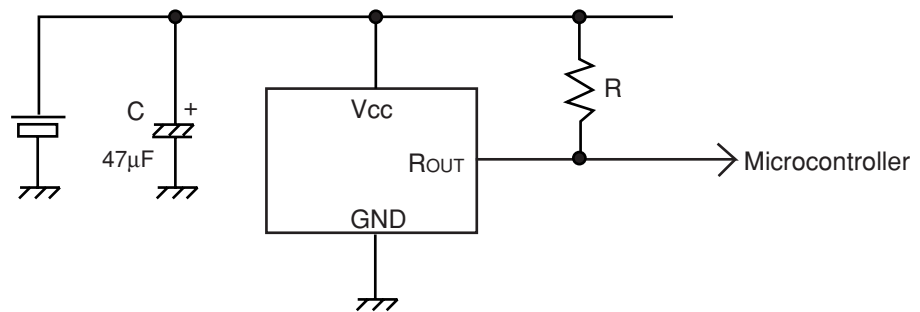• Output pull-up resistance

«Circuit diagram»

Fig. 21 Pull-up Circuit Diagram

The pull-up resistance connected to the output must limit the absorption current of Remote Control Receiving Module to a range not exceeding a specified value, or otherwise the low-level voltage will be in excess of the specified value.

$$R > \frac{Vcc-VOL}{Isink}$$

Isink: Specified Absorption Current Max.

Model	Isink (μA)
RPM7100-Hx Series	400
RPM7200-Hx Series	200

• Holder Grounding
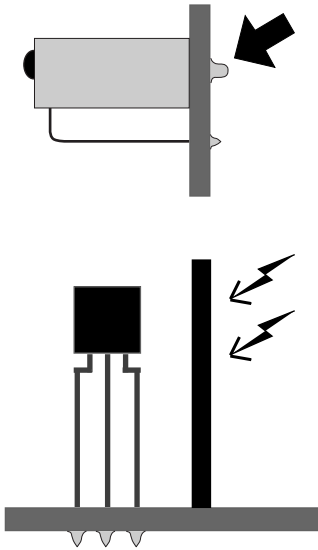
Be sure to connect the holder to the ground pattern.

The Remote Control Receiver Module is highly sensitive. In order to protect the influence of external noise, ground the casing.

RPM7100-Hx Series Holderless Model

The installation of a grounded metal shield in the direction of external noise is effective to avoid the influence of the external noise.

Fig. 22 Shield

• Vcc and Ground Pattern Designing

The Remote Control Receiver Module is highly sensitive in order to receive an infrared signal that is far away. Although a sufficient countermeasure against power ripples is taken, the user should take a further countermeasure in preparation for unforeseen malfunctions.

«Good example»

Noise is reduced as much as possible within the digital block loop.

Noise

Noise

There is little influence because the common impedance is low.

Increase the occupied ground area to lower the common impedance.

V_{DD}

Digital block

GND

V_{CC}

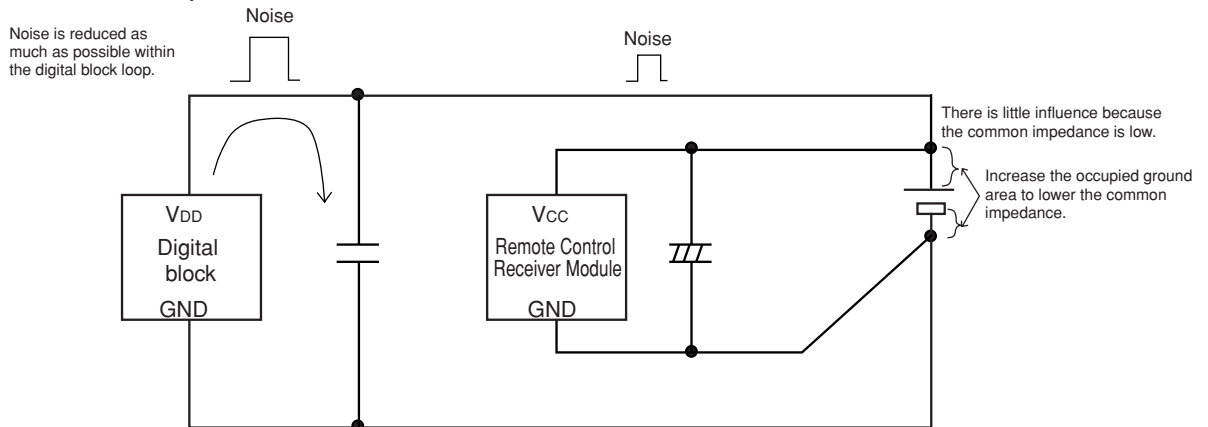Remote Control Receiver Module

GND

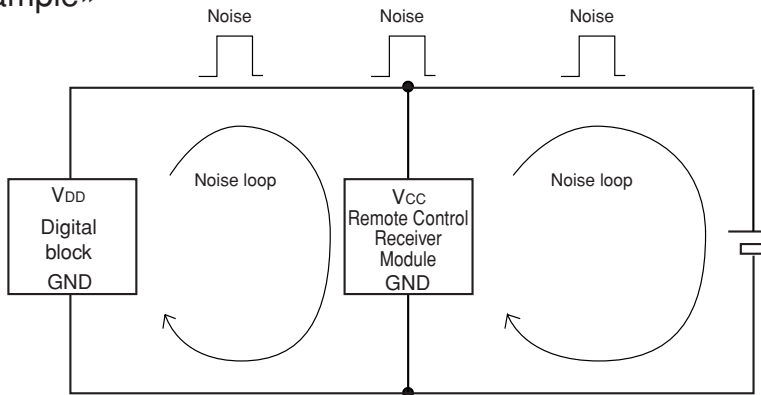Fig. 23 Countermeasure against Line Noise

«Bad Example»

Fig. 24 Countermeasures against Line Noise (Not Good)

In the above wiring pattern, the power noise of the digital block has an adverse influence on the power supply pattern of the Remote Control Receiver Module.

7. Receiving Discrimination Method to Expand Effective Distance
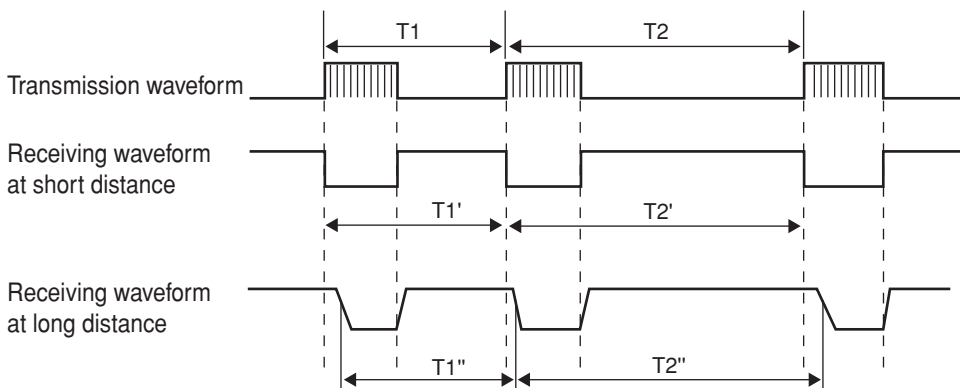
1) Wide Pulse Width Jitter

Fig. 25 Jitter Countermeasures

If the communications distance is long or angled or has the incidence of optical noise, the output pulse jitters will become larger at the limit of receiving, thus increasing the errors of the pulse intervals T1 and T2. In order to correct the errors, T1" and T2" are provided with margins according to the software discrimination of receiving, thus making it possible to increase the effective distance.
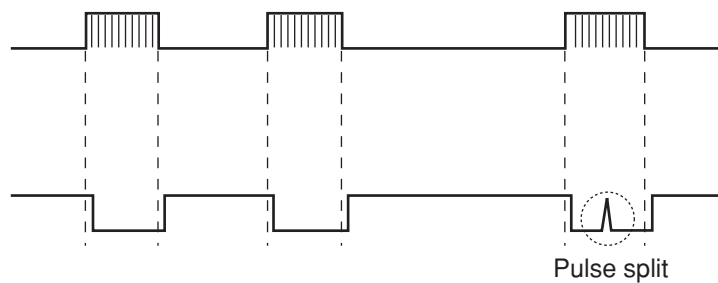
2) Pulse Split

Fig. 26 ON Pulse Split

| Incidence of excessive external noise | ➤ | A pulse split may be caused by external noise, such as optical noise or electromagnetic noise. |

If a pulse is split midway, write a receiving discriminative program to ignore the split pulse so that a sufficient effective distance will be secured.

8. Measures for Preventing Malfunctions

If there is strong external noise (e.g., optical noise, electromagnetic noise, or power supply ripples), noise pulses may be generated from the output terminal regardless of whether the input signal exists or not.
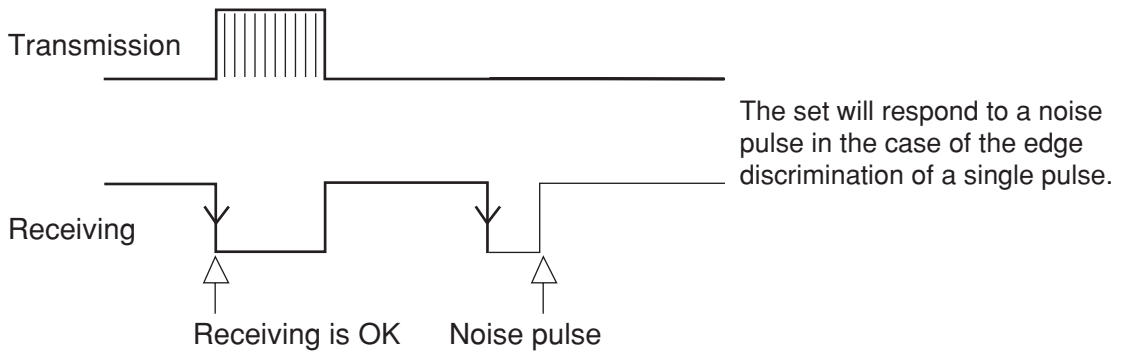
1) Receiving Code Discrimination

By always discriminating the receiving of a number of bits in combination as a code, the malfunctioning of the unit can be prevented.

In the above case, it is ideal to use the lead pulse and the code.

2) Falling Edge Discrimination of Single Pulse

Noise pulses may be generated in the output due to the influence of external noise. Therefore, the discrimination of receiving with a non-coded signal (e.g., the falling edge of a single pulse only) is not recommendable.

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«Bad Example»

Transmission

The set will respond to a noise pulse in the case of the edge discrimination of a single pulse.

Receiving

Receiving is OK   Noise pulse

The noise cannot be discriminated from the signal.

Fig. 27 Single Transmission Pulse

3) Subcarrier

• Coincidence of Subcarrier

Make sure that the subcarrier coincides with the center frequency of the Remote Control Receiver Module, or otherwise the effective distance may be shorter or the Remote Control Receiver Module may fail to receive the signal.

• Constant Duty of Subcarrier

Make sure that the duty of the subcarrier is constant. The discontinuance of the duty may cause a receiving output pulse split and result in a receiving error.

Transmission waveform (Good)

Transmission waveform (Bad)

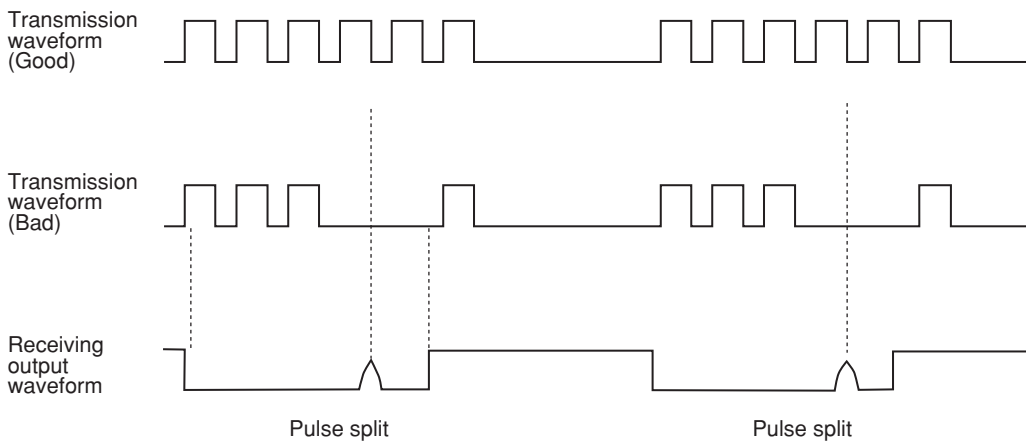Receiving output waveform

Pulse split   Pulse split

Fig. 28 Duty Discontinuance Period