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Innovations Embedded

Optical Sensors

- Remote Controls
- Copiers
- Cell Phones

White Paper

ROHM Marketing USA

Presented by ROHM Semiconductor

Using Infrared Technology for Sensing and Remote Control Applications

Introduction

Infrared (IR) technology addresses a broad variety of wireless applications, especially in the areas of sensing and remote control. Today's newest products such as cell phones, digital cameras, and DVD players as well as remote controls for every market segment rely on IR sensing and control devices. ROHM Semiconductor has been driving technology advances that have led to a growing number of IR sensing and communication applications for over 40 years.

About Optical Sensors

To understand infrared technology, the best starting point is the electromagnetic spectrum. The frequency range and wavelengths of the entire spectrum are shown in Figure 1. The IR portion of the electromagnetic spectrum is usually divided into three regions: the near-, mid- and far- infrared. The wavelengths for these regions are shown in Table 1. Infrared wavelengths range from red to violet. The frequencies are higher than microwave but shorter than visible light.

Focusing on near infrared devices and applications, PhotoOptic technologies are used for optical sensing and optical communications with numerous general market applications, since light is less complex than RF when implemented as the signal source. Optical sensors are used in industrial, consumer and other applications for sensing movement, position, proximity, ambient light, speed, and direction.

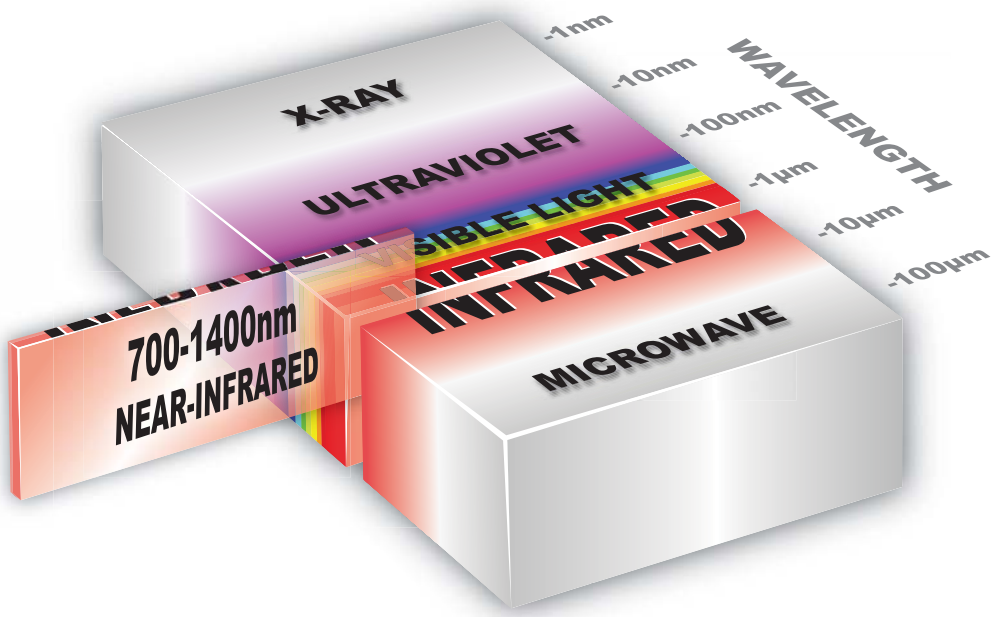


Figure 1. Infrared signals are near the middle of the electromagnetic spectrum, above radio and well below gamma ray.

IR-A: 700nm–1400nm (0-7µm – 1.4µm)	Near - fiber optic, IR sensors
IR-B: 1400nm–3000 nm (1.4µm – 3µm)	Mid - heat sensing
IR-C: 3000nm–1mm (3µm – 1000µm)	Far - thermal imaging

Table 1. Wavelengths and frequencies for the IR spectrum

Optical wireless communication uses IR data transmission for short range applications such as computer peripherals and PDAs (personal digital assistants). For optical communication, a modulated IR light beam transmitted by an emitter LED is received by a silicon photodiode. Infrared Data Association (IrDA) standards provide the protocol for these types of communication. Since IR does not penetrate walls, it does not interfere with other signals in indoor environments. IR technology is the most commonly used technique for remotely controlling appliances.

Some general applications for IR components include:

- *Office Automation (OA) equipment such as copiers, fax machines and printers*
- *Vending machines*
- *Gaming products*
- *Home entertainment products*
- *Medical / health care equipment*
- *Banking terminals such as ATMs*
- *Testing equipment such as IC/LSI testers, encoders and more*

Types of IR Devices

To address the variety of sensing applications, products take advantage of several IR technologies. These include:

- *IR Emitters*
- *IR Receivers (sensors)*
- *Photointerrupters & Photo Reflectors*
- *Tilt Sensors*
- *IrDA Communication Modules, and*
- *Remote Control Module Receivers*

A brief explanation of each shows the commonalities and differences.

An *IR Emitter* is a light emitting diode (LED). Different types of IR LEDs are specified based on their packaging and special features, such as output optical power, wavelength, and response time.

IR Receivers are also called sensors since they detect the wavelength and spectral radiation of the light from the IR emitter. IR receivers are specified by optic features, packaging, special circuitry such as an ambient light filter, wide viewing angle, and more.

A *photointerrupter* is a photosensor that integrates an optical receiver and emitter in a single U-shaped package. In a transmission type photointerrupter, the light emitting and detecting elements are placed facing each other (Figure 2). Shape and size are two of the main differentiating features of a photointerrupter.

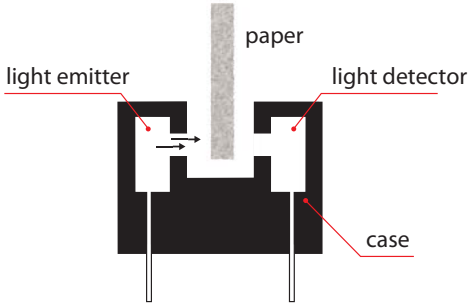


Figure 2. A photointerrupter integrates an emitter and receiver in a single package.

As shown in Figure 3, product characteristics are determined by the slit and gap - the width or distance from emitter to receiver/sensor. The vertical or horizontal slit width is the window opening for collimating, also

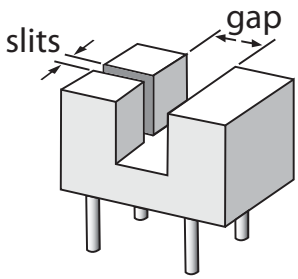


Figure 3. Photointerrupters are specified by gap and slit dimensions as well as outputs.

called the beam width. Besides the slit and gap, additional selection criteria include the output type, such as analog, digital, and dual-phase output signals. Typical

applications include: printers, counters, opto encoders, directional movement detection, and more.

Photo reflectors or reflective type sensors are side-by-side emitter-sensor (photointerrupter) devices that detect reflected beams from a surface. Figure 4 shows a typical photo reflector design. Key electrical characteristics are: transfer gain rate, sensor collector current vs. IR LED current, wavelength, and response switching time. Reflective type sensors can be used in proximity sensing applications.

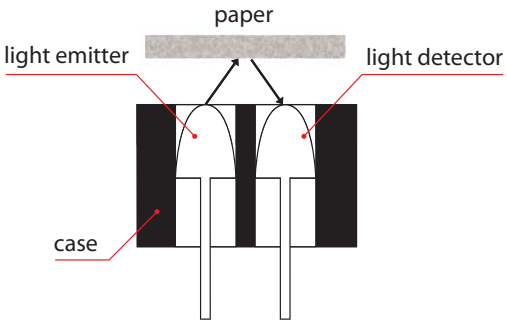


Figure 4. Reflective type photo sensors detect light reflected by a target object.

Tilt sensors represent a special type of sensing design for PhotoOptics. Figure 5 shows image rotation as part of the sensing commonly used in portable products with displays such as cameras and cell phones.

Figure 5. With careful design consideration, optical tilt sensors can provide four-direction detection. Source: ROHM Semiconductor.

IrDA communication modules used in local networks have three different forms:

- *IrDA-SIR (slow speed) infrared supporting data rates up to 115Kbps*
- *IrDA-MIR (medium speed) infrared supporting data rates up to 1.15Mbps*
- *IrDA-FIR (fast speed) infrared supporting data rates up to 4Mbps*

To address common applications such as wireless optical communications for mobile devices, communication modules frequently are offered in surface mount device (SMD) packages and support SIR, MIR or FIR data rates.

Remote control module receivers operate at a variety of carrier frequencies (typically in the 30 to 60kHz range). Units with a dual lens provide a higher degree and wider range of sensitivity. The small size and (typical) surface mount design make them ideal for embedding in numerous applications. Lead frame versions are also offered. Units with an integrated photo IC have improved anti-noise characteristics.

Typical applications include:

- *Audio Visual devices such as audio amplifiers, TVs, VCRs, and CD/DVD/MD players*
- *Multimedia equipment*
- *Home appliances such as air conditioners, fans, and lighting products*
- *CATV set top boxes*
- *Toys*
- *Any equipment with a wireless remote control*

Specific IR Applications

IR sensors have numerous applications in several market segments. A brief summary of markets and applications includes:

Security – movement/motion detection, fire alarms/ smoke detectors

Industrial (including automotive) - measurement, counters, motor encoders

Medical - blood/oxygen/temperature measurement

Consumer - TVs/STBs, proximity sensors, cell phones, tilt sensors, ATMs/kiosks, and cameras

Computers - keyboards/mice

Printers - paper/media/door detection

Game and Toys – remote control modules

Using IR in Wireless Applications

As a wireless technology, IR has advantages and disadvantages when compared to RF and industrial, scientific, and medical (ISM) (902-928MHz) band technologies. Advantages include:

1. *Higher security: beam directionality helps ensure that data isn't detected or leaked to nearby devices as it's transmitted*
2. *High noise immunity: not as susceptible to signal interference from other devices*
3. *Few international regulatory constraints*
4. *Relatively low power requirements: ideal for laptops, cell phones, and personal digital assistants*
5. *Simple design implementation*

The disadvantages of IR technology are:

1. *Line of sight: transmitters and receivers must be almost directly aligned*
2. *Blocked by common materials: people, walls, plants, and other objects can block transmission*
3. *Short range: performance drops off with longer distances*
4. *Light and weather sensitive: direct sunlight, rain, fog, dust, and pollution can affect transmission*
5. *Speed: data rate transmission is lower than typical wired and RF transmission*

Despite these disadvantages, many applications are well-suited to IR technology. IrDA infrared communication modules feature a number of advantages, such as: high communication speed, high level of security, increased design freedom (compatibility for future redesigning of feature set), and more.

ROHM Semiconductor IR Solutions

ROHM Semiconductor offers several products to address each type of IR device technology. A few key products demonstrate a broad range of capabilities with a special focus on packaging.

IR Emitters

ROHM Semiconductor IR optical sensor technology covers infrared light emitting diodes (LEDs). Several products are available in both surface mount (SMD) and through-hole (THD) configurations. Breakthrough IR wavelength emitter technology has resulted in the development of IR emitters that operate near 850nm. As shown in Figure 6, phototransistors have a wide bandwidth but with a peak sensitivity at around 800nm. The 850nm level is much closer to this peak sensitivity (compared with conventional emitters that operate close to 950nm), resulting in higher output efficiency and an energy savings of 66%.

The new SIM-040ST demonstrates an improved peak wavelength (870nm) and high IR power output (maximum of 100mW/sr) in a 1.6 x 2.25 x 3.1mm SMD package. The SIM-030ST with similar performance is offered in an even thinner (0.9mm) and smaller (2.3 x 1.95mm) form factor.

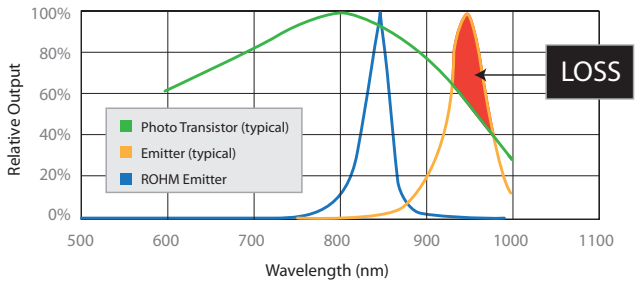


Figure 6. Unlike conventional IR emitters that operate near 950nm, the 850nm operation of ROHM Semiconductor's IR wavelength emitter technology is much closer to the wavelength of phototransistors resulting in reduced energy losses.

IR Phototransistors/Sensors

ROHM Semiconductor IR phototransistors feature high gain and high collector current in a variety of packaging options. For example, the SCM-014TB is a top-view molded type with lens designed for automatic mounting and SMD reflow assembly, while the SML-810TB is a molded type lens design compatible with reverse

mounting. The RPM-012PB is a high sensitivity, side-view sensor offered in an ultra-small 2 x 3 x 2mm surface mount package featuring an ambient light filter, making it an ideal match with the SIM-012SB photo-emitter.

Photointerrupters

ROHM Semiconductor offers photointerrupters in both transmission and reflective type designs. Transmission type photointerrupters such as the RPI-0128/128 are available in an ultra-compact (2.5 x 1.6 x 1.8mm) SMD molded package (see Figure 7). At the same time, the sensors maintain a tight 1.2mm gap. Compared to current photointerrupters, this new package provides approximately a 31.4% reduction in volume and a 28% reduction in mass.

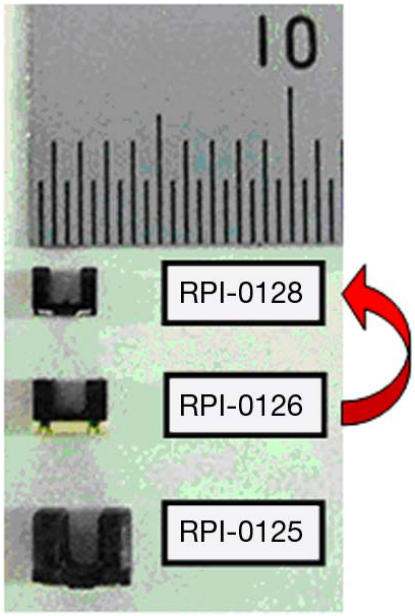


Figure 7. RPI-0128 is smaller and lighter than its predecessors, the RPI-0126 and RPI-0125.

Moreover, utilization of double-mold construction (a primary mold with the lens followed by a secondary mold, see Figure 8) and 850nm IR wavelength emitter technology result in high sensitivity, improved signal accuracy, and the highest collector output current in the industry.

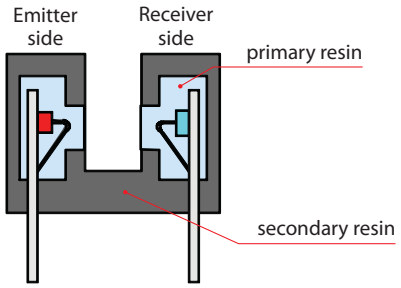


Figure 8. Double-mold construction contributes to increased output in the RPI-2501 and other ROHM Semiconductor optical sensors.

RPI-151 is a two-phase photointerrupter integrating two sensors in a single package (refer to Figure 9). In addition to increased space savings, it can detect both the speed and direction of a motor with greater accuracy than conventional photo-optical solutions utilizing two separate sensors.

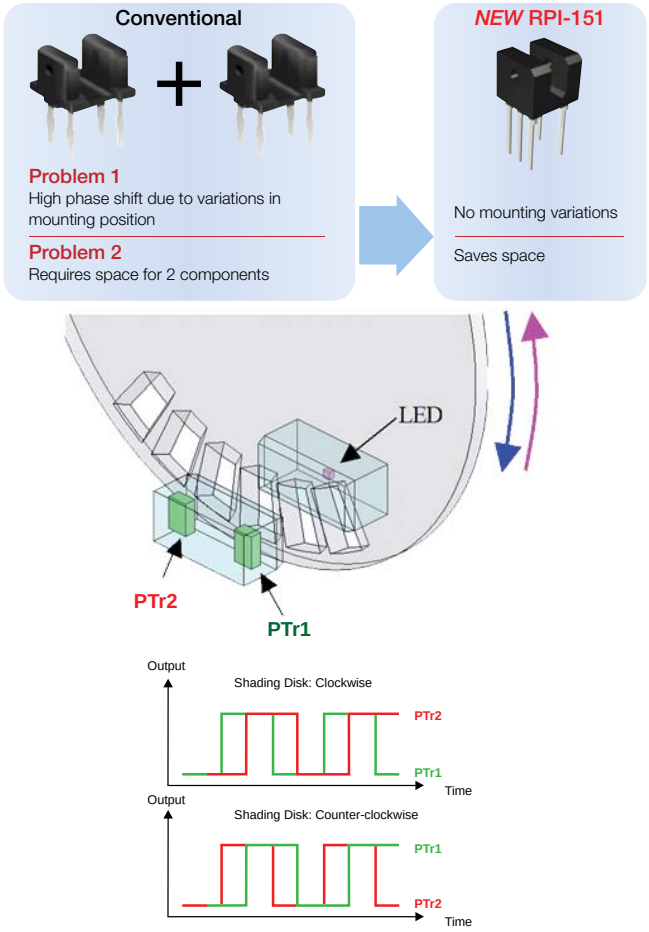
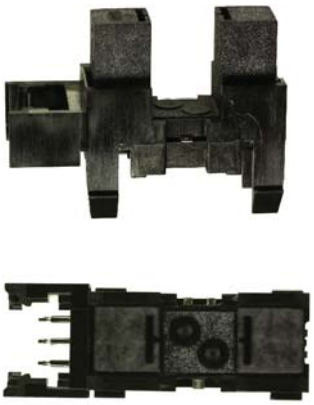


Figure 9. RPI-151 can detect both the spin speed and spin direction of a motor.

The RPI-2501 is a photointerrupter with an integral receptacle housing connector assembly. The clip-mounted package includes a MINI CT connector (1.5 mm pitch) to conveniently connect to the PC board and other circuitry, eliminating the need for a secondary circuit board or soldering.



RPI-2501 photointerrupter

Reflective type sensors are offered in both through-hole and SMD package types and have a focal length (sensing reflection distance) of 3-6mm. The main differentiating feature is the peak emitting wavelength - the RPR220C1 features a wavelength of 940nm, while the RPR-220UC30 and RPR-220PC30N are 630nm and 470nm, respectively.

Tilt Sensors

Optimized for digital camera applications, the RPI-1040 is an optical surface mount 4-way detection sensor consisting of an IR LED and two phototransistors (see Figure 10). The 3.1 x 3.1 x 0.8mm package - the thinnest in the industry - includes a novel light shield that ensures silent operation, avoiding noise frequently exhibited by other designs during rotation. In addition, the tilt sensor is not susceptible to vibration or external energy (RF, magnetic) fields. Ideal applications include orientation/fall/shock detection and image rotation.

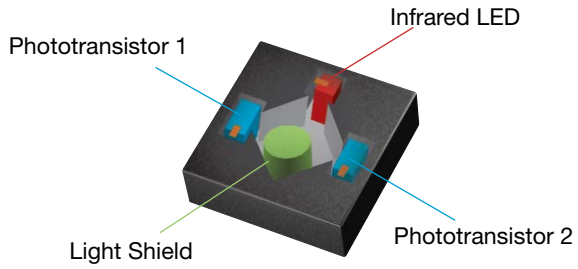
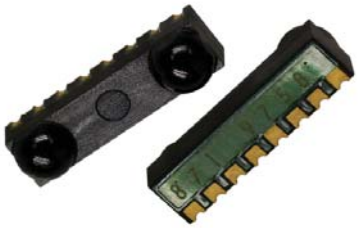


Figure 10. The RPI-1040 integrates an IR LED, two phototransistors, and a light shield into a single package.

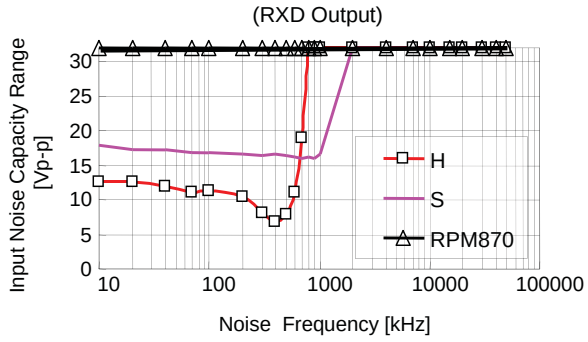
IrDA Communication Modules

ROHM Semiconductor's IrDA communication modules are among the smallest in the industry. Offered for SIR, MIR and FIR data rates, these units feature ultra-low power consumption. Some models offer adjustable LED current.



RPM871 IrDA communication module

For example, the RPM871 is a micro infrared module based on the IrDA1.2 (Low Power) standard. This SIR-compliant product can operate at distances up to 60cm and includes an infrared LED, PIN photodiode, and LSI circuitry in an ultra-compact, 8-pin package. In addition to low power consumption (73µA typ.), the module features a power down function that reduces current consumption to 0.01µA during standby.



Remote Control Receiver Modules

ROHM Semiconductor offers remote control receiver modules integrating two receivers in an ultra-compact surface mount design. 3V and 5V lead frame products are also available featuring excellent anti-noise characteristics, as well as surface mount side and top view types.

RPM5540 remote control receiver module

For example, the RPM5540 series of ultra-compact (3 x 8 x 2mm) surface mount remote control receiver modules is available in both top view (H12) and side view (H14) configurations and is 1/16th the size of conventional products. In addition, the dual-receiver design utilizes a 40kHz carrier frequency, operates from a 5V supply, and features a current consumption of only 0.95mA (typ).

Conclusion

To address the increasingly broad range of IR applications, ROHM Semiconductor has established an extensive portfolio of IR sensor and remote control products that combine the latest IR technologies with unique ultra-compact packaging.

In addition, 40 years of IR sensor support and ongoing advancements in the fields of LEDs and sensors allow ROHM to meet current and future customer requirements. The wide product lineup includes both integrated as well as discrete solutions for standard and custom applications.

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