HAMAMATSU

PHOTON IS OUR BUSINESS

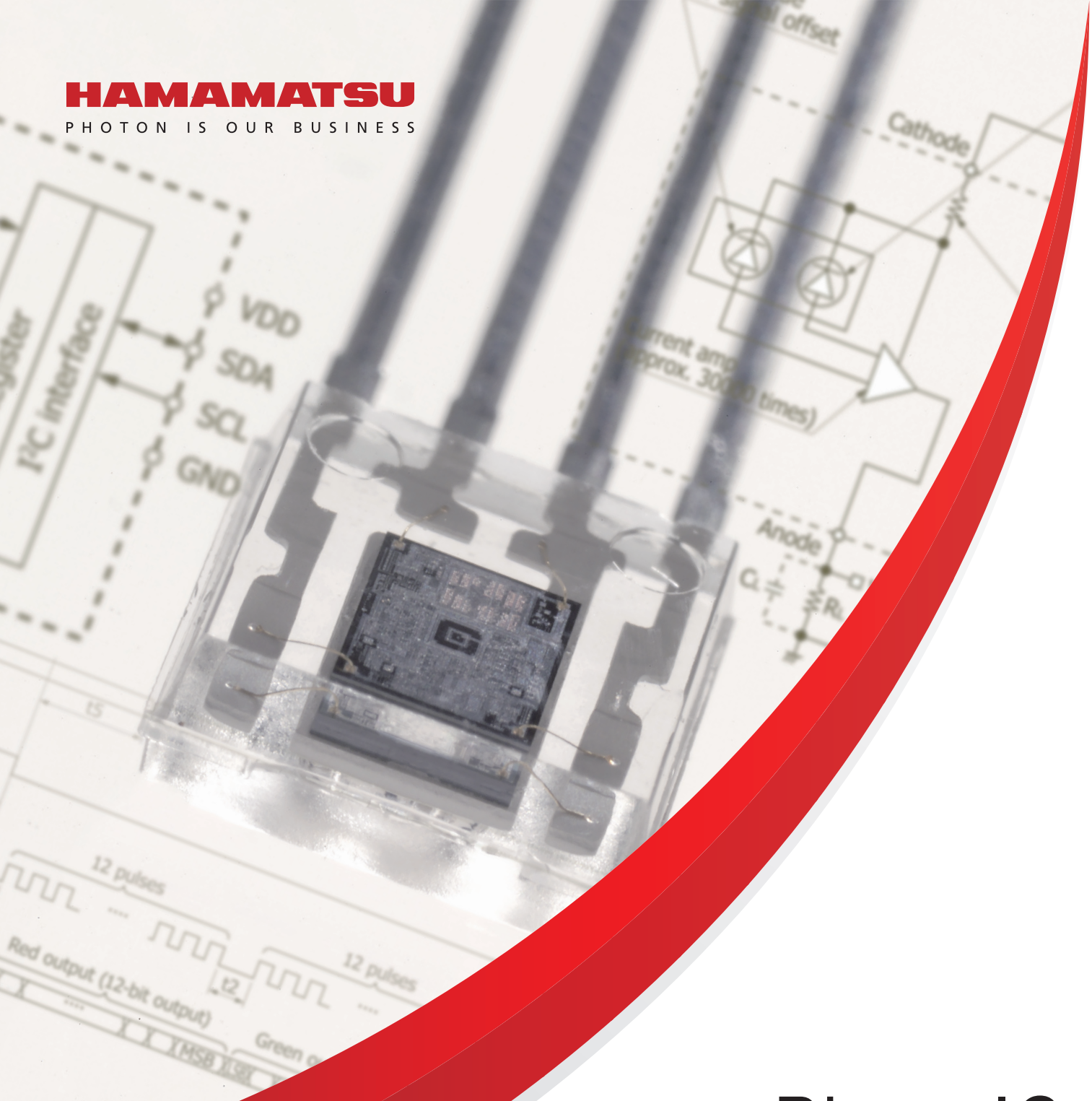


Photo IC

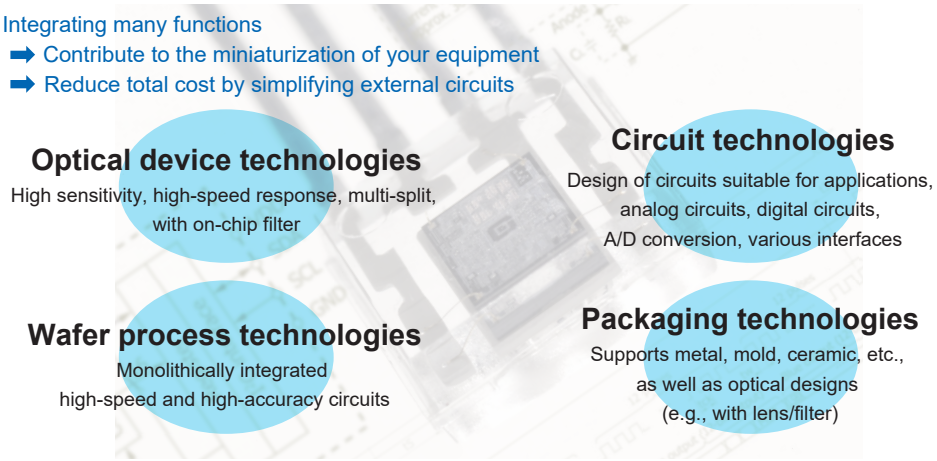
CONTENTS

Aug. 2024

What is a photo IC?

Photo ICs are optical devices that combine an opto-semiconductor and a signal processing circuit into one package. Hamamatsu combines optical device technology, circuit technology, wafer process technology, and packaging technology to produce photo ICs suitable for a variety of applications.

We have established an integrated system from circuit and package design to wafer process, assembly, and inspection, and we also conduct various analyses and evaluations including reliability tests. We also offer photo ICs with custom specifications to suit your requests.



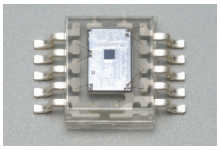
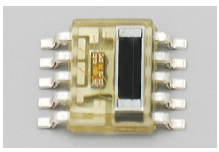
• Features

Photo ICs offer the following features compared to circuits configured with discrete parts:

- Compact and lightweight
- Resistant to electromagnetic induction noise
- High reliability
- Excellent mass productivity
- High cost performance

• Structure types

There are two types of photo ICs, monolithic and hybrid. When designing customized photo ICs, we propose the most suitable type in consideration of the balance between performance and cost.

Monolithic type photo IC	Forming the photosensor and signal processing circuit on the same chip 	• Compact size • Resistant to noise and not affected by unnecessary parasitic parameters due to the short wiring that connects a photosensor and a signal processing circuit ➡ Stable operation
Hybrid type photo IC	Connecting the photosensor and signal processing circuit in one package 	• Photosensor's shape and characteristics can be easily changed (high degree of design freedom is possible) • Combination with a light emitter (LED, etc.) available

• Applications

Hamamatsu photo ICs are used in a variety of applications, including ambient light (illuminance and color) detection, plastic optical fiber communications, optical switches, encoders, etc. We can also provide photo ICs that meet FA and automotive standards.

Consumers

■ **Human body sensing**
- Light modulation photo IC

■ **Detection of ambient light**
- Photo IC diodes (illuminance)
- Color sensors (color)

■ **Detection of printer printing start timing**
- Photo IC for laser beam synchronous detection

In-vehicle

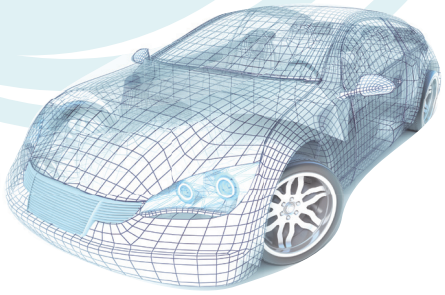
■ **In-vehicle network (MOST)**
- Photo IC for optical link

■ **Auto light**
- Photo IC diodes

■ **Anti-glare mirror**
- Light-to-frequency converter photo IC

■ **LiDAR**
- Photosensors with front-end IC

■ **Human machine interface**
- Photo IC for encoder
- Schmitt trigger circuit photo IC



Industry

■ **Industrial networks**
- Photo IC for optical link

■ **Object detection, safety light curtain**
- Photo IC for optical switch
- Light modulation photo IC
- Schmitt trigger circuit photo IC

■ **Distance measurement**
- Photosensors with front-end IC

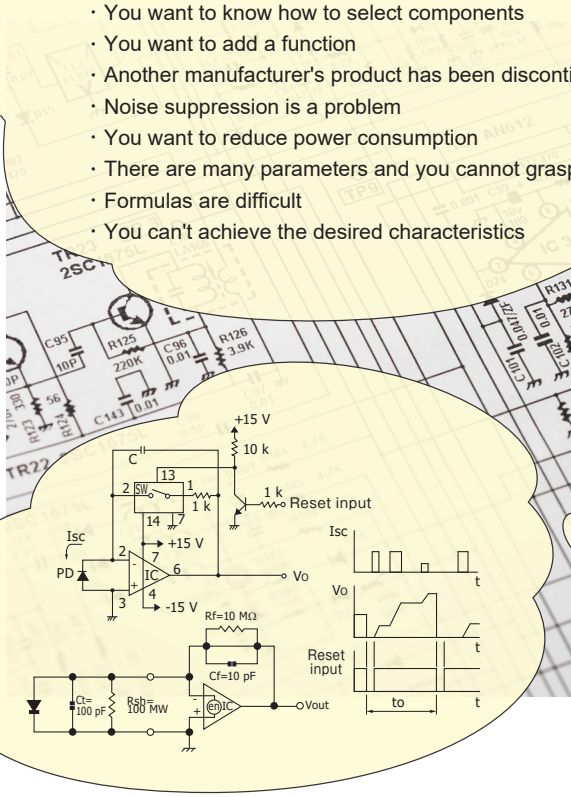
■ **Position/rotation detection**
- Photo IC for encoder

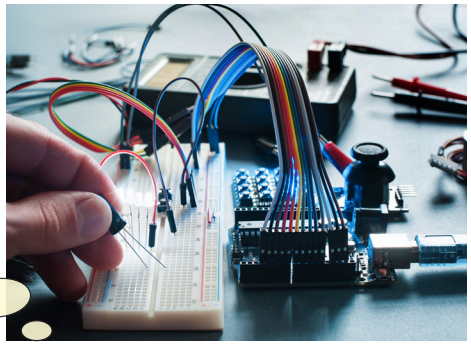
Custom products available

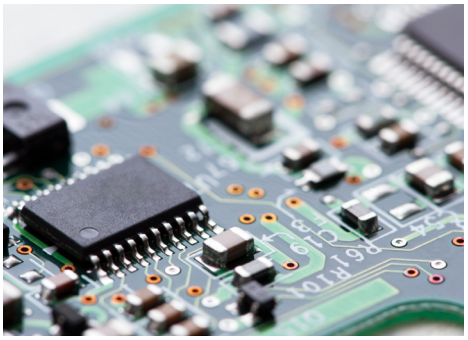
Hamamatsu accepts custom orders for photo ICs. In addition to adding functions, increasing reliability, and reducing costs, we can also offer alternatives to discontinued products from other manufacturers. Utilizing our extensive track record and know-how in opto-semiconductors, we consistently handle proposals, designs, prototypes, and mass production.

Do you have any concerns or requests such as those below?

- You don't know how to use opto-semiconductors
- You don't know what type of detection circuit is optimal
- Your circuit is not stable
- You want to reduce mounting space
- You want to reduce the number of components
- Your circuit oscillates
- You want to know how to select components
- You want to add a function
- Another manufacturer's product has been discontinued
- Noise suppression is a problem
- You want to reduce power consumption
- There are many parameters and you cannot grasp them
- Formulas are difficult
- You can't achieve the desired characteristics



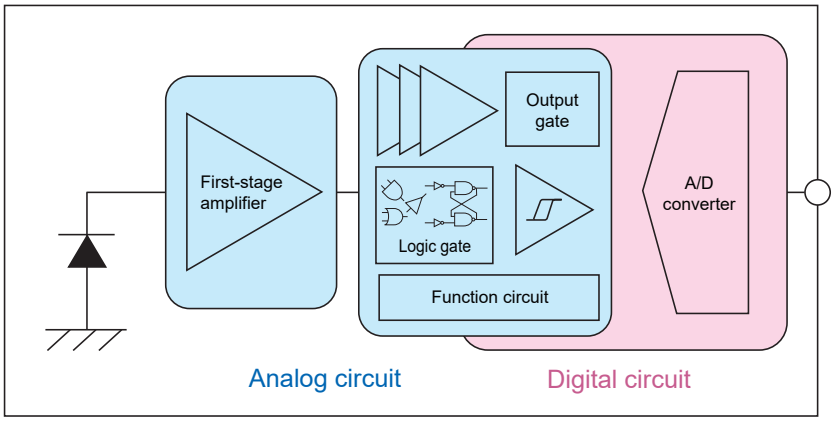




We offer photo ICs with custom specifications to suit your requests

• Circuit technologies

With a wealth of knowledge about photosensors, Hamamatsu can design circuits to meet your requirements. In addition to the first-stage amplifier suitable for the photosensors, we support analog circuits and digital circuits.



■ First-stage amplifier

• Current amplifier • Voltage amplifier • Current-to-voltage amplifier • Current-to-frequency converter	• Transimpedance amplifier • Charge amplifier • Chopper amplifier • Instrumentation amplifier, etc.	• Wide band • High sensitivity • Background light removal • Gain adjustment • Low offset • Low voltage, etc.

■ Circuit example

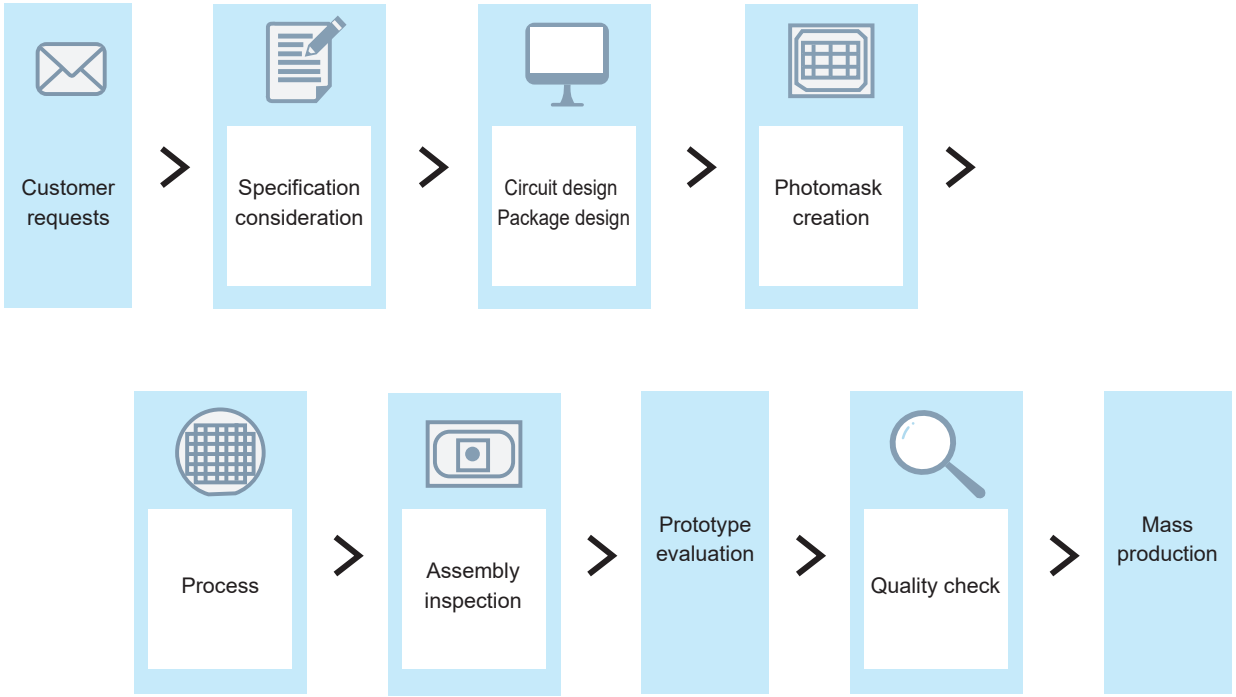
Comparator	• Wide band • With hysteresis
Filter	• Active filter • Low-pass filter • High-pass filter
Detection circuit	• Edge detection circuit • Sample hold circuit • Peak detection circuit • Bottom detection circuit
Voltage amplifier	• Buffer amplifier • Linear amplifier • Limiting amplifier
Other circuits	• Temperature detection circuit • Light level monitor circuit • LED driver circuit
Power supply system	• Reference voltage source • Current source • Regulator
Output method	• Open drain • Open collector

Input/output interface	• TTL • CMOS • LVDS • PECL • CML
Signal processing	• Various logic gates • Counter • Timer circuit • Oscillator • Timing generator • A/D converter
Serial communication interface	• I^2C • SPI

◇ Laser trimming process can correct for characteristic variations

• Procedural flow from custom order to delivery

Hamamatsu has established a comprehensive production system ranging from photo IC design to wafer process, assembly, inspection, and mass production at our ISO9000 and ISO14000 compliant domestic factories. We also offer strong support for various analyses and evaluation systems such as reliability testing.



Main Factory
(Si process, MEMS process, module manufacturing)

Mitsue Factory
(Assembly)

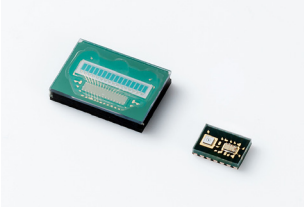
Shingai Factory
(Assembly)

Miyakoda Factory
(Compound process, semiconductor laser manufacturing)

Photo IC product examples

Ideal for detecting pulse signals

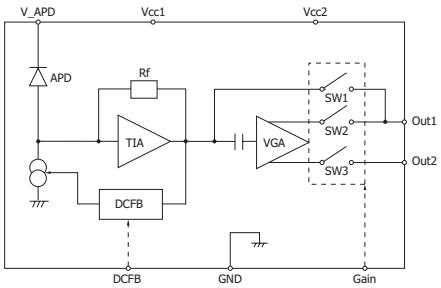
Photosensors with front-end IC



These are photo ICs in which an APD and transimpedance amplifiers (TIAs) are integrated. They achieve high sensitivity, low noise, and high-speed response, making them suitable for distance measurement. They consist of our APD and our unique circuit, and adopt a design that is not easily affected by the usage environment such as background light. They are hybrid type photo ICs and can be used for custom products with built-in APD and APD array with different photosensitive area sizes.

■ Product examples

S15658-01CT



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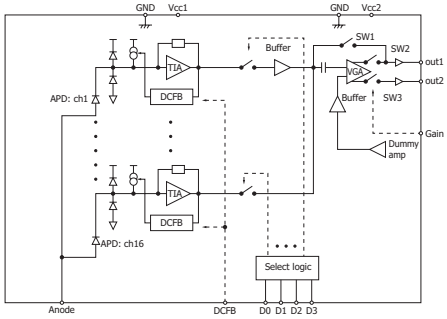
S13645-01CR



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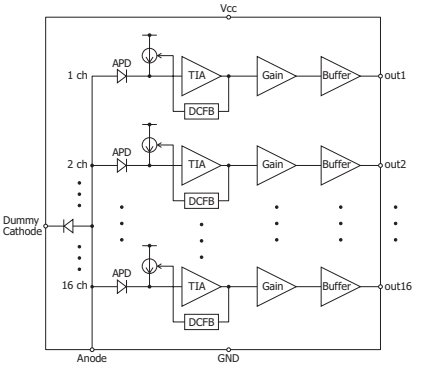

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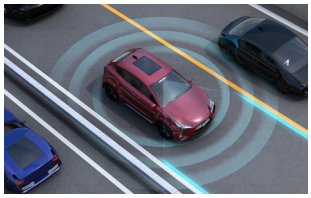
▶ Hamamatsu photo IC technologies

- Transimpedance amplifier to bring out the characteristics of APDs ➡ Optimizes gain and bandwidth
- DC feedback circuit which automatically removes DC offset components generated by TIA ➡ Less susceptible to background light
- Logic circuit for gain switching function
- Circuit technology that achieves a stable output even when excessive light enters the photo IC
- Circuit design to reduce ringing of output waveforms that cause malfunctions when detecting pulse signals
- APD array can be built-in
- Serial output type that outputs from any pixel specified in the selection logic and parallel output type that can measure all pixels simultaneously
- Circuit design with consideration for resistance to high voltages unique to APDs and for effects of element heating on APD characteristics

■ Application examples

AGV
(automated guided vehicle)



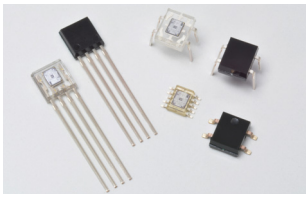
Autonomous driving,
LiDAR

Robot cleaner

Laser rangefinder

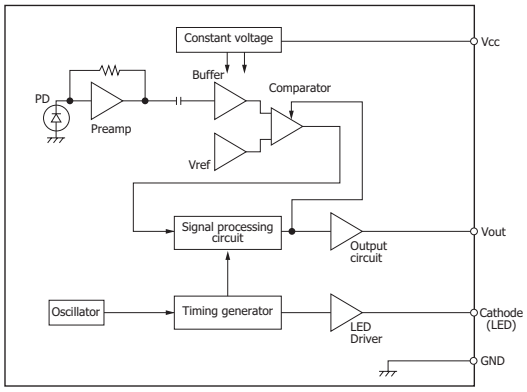
Enables object detection
with few malfunctionseven under background light

Light modulation photo IC



These are photo ICs that can detect objects with high sensitivity and few malfunctions even under background light. By connecting LED, they can be used as a transmissive type (photointerruptor) or reflective type (photoreflector) optical switches that combine a photosensor and a light emitter.
In addition to background light countermeasures, light modulation photo ICs employ a synchronous detection method that pulse-modulates the signal light and detects the signal in synchronization with that timing. This reduces the effect of noise from light entering asynchronously.
They are monolithic type photo ICs, and a photodiode and an amplifier are connected within the chip, minimizing the effects of parasitic parameters and noise on amplifier performance.

■ Product example



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▶ Hamamatsu photo IC technologies

- Preamplifier (AC amplifier circuit) with expanded dynamic range for DC and low frequency background light without impairing signal detection sensitivity
- Capacitance coupling to remove the effects of low-frequency background light and the DC offset of the preamplifier
- Comparator with hysteresis to prevent chattering (malfunction) caused by minute fluctuations in incident light
- Oscillator and timing generator that synchronize the timing of LED drive and digital signal processing
- Dedicated logic circuit (signal processing circuit) for synchronous detection
- LED drive circuit (open collector drive) that drives external LED by LED driving pulses generated in timing generators

■ Application examples

Safety light curtain

Auto faucet

Achieves low-cost optical link systems

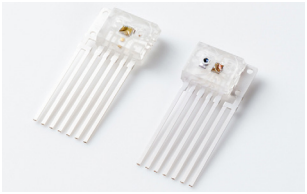
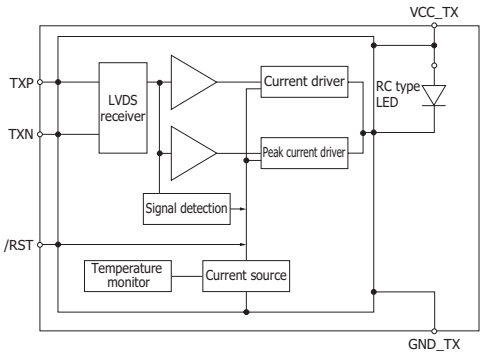


Photo IC for optical link

These are transmitter/receiver photo ICs for plastic optical fiber communications. The transmitter photo ICs are equipped with an LED with a wavelength of 650 nm and a drive IC with a temperature compensation function. They support a wide operating temperature range and provide stable light output. The receiver photo ICs consist of a Si PIN photodiode and a signal processing circuit. The adoption of a fully differential structure using a dummy photodiode reduces the effects of external noise, achieving high sensitivity. It has a sleep function that reduces power consumption during a waiting time, and switches to standby mode when there is no input.
To customize these photo ICs, select an LED and a Si photodiode to match the fiber you are using. Customization is possible for both hybrid types and monolithic types.

■ Product examples

Transmitter photo IC



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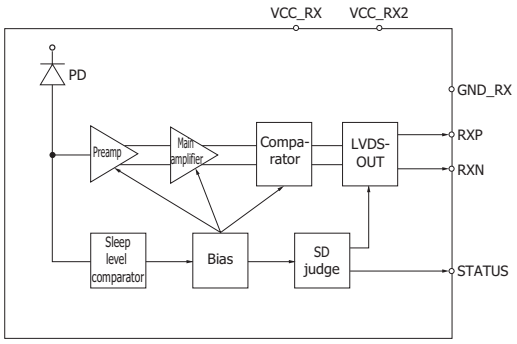
Receiver photo IC



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▶ Hamamatsu photo IC technologies

- Peaking circuit to correct the light output waveform response
- Temperature sensing circuit and LED driver circuit to correct LED temperature fluctuations
- Low distortion circuit with stable output for temperature/supply voltage fluctuations
- Fully differential circuit (dummy photodiode is used to eliminate external noise and power supply noise)

- Transimpedance amplifiers with optimized gain and band
- Signal detection circuit for sleep function
- Power supply isolation to avoid “swinging back” on the power line that causes jitter
- Supports output interfaces such as LVDS, PECL, and CML

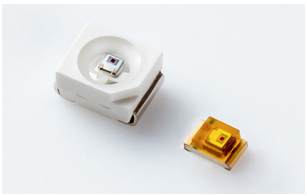
■ Application examples

In-vehicle network

Communication between devices

Two-terminal sensors as easy to use as photodiodes, capable of high-current output

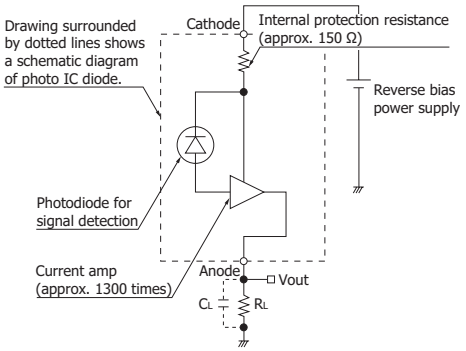
Photo IC diodes



These photo ICs amplify and output the photocurrent generated by a photodiode. Highly sensitive and stable operation is possible, and they can be used in the same way as reverse-biased photodiodes.
Two types are available, infrared type and visual-sensitive compensation type. The visual-sensitive compensation type consists of two photodiodes with different on-chip filters and a current amplifier (subtracted amplifier circuit). They achieve spectral response close to human eye sensitivity and can be used as illuminance sensors.

■ Product examples

Infrared type



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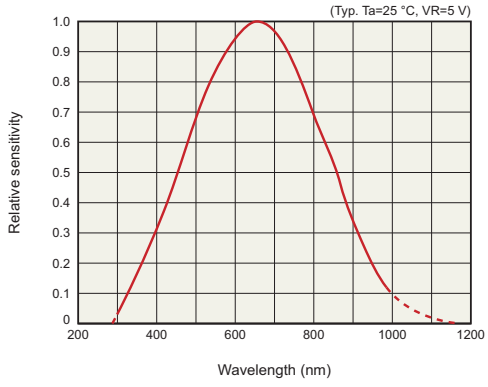
Spectral response example



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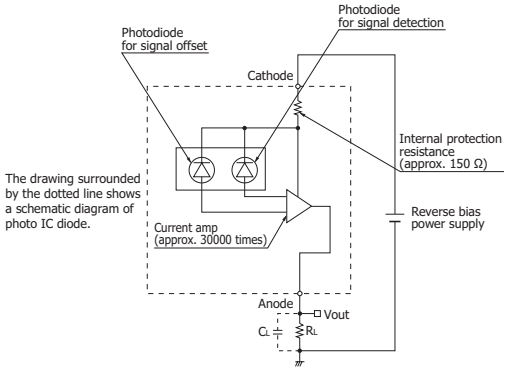
Visual-sensitive compensation type



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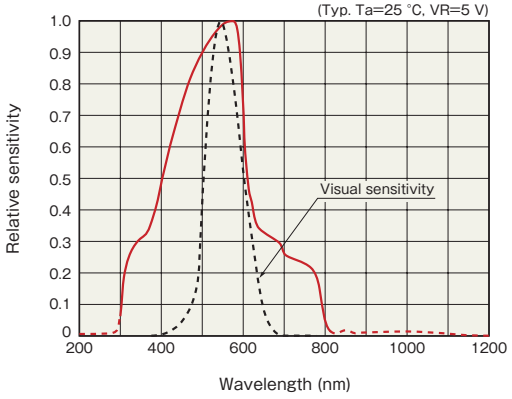
Spectral response example



KPICB0239EA

▶ Hamamatsu photo IC technologies

- Current amplifier realizing a wide operating temperature range and highly sensitive, stable operation
- Subtraction amplifier circuit for spectral response close to human eye sensitivity in combination with on-chip filters

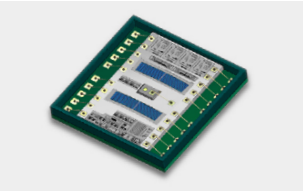
■ Application examples

Automatic lighting

Auto lights in automobiles

For optical encoders

Photo IC for encoder



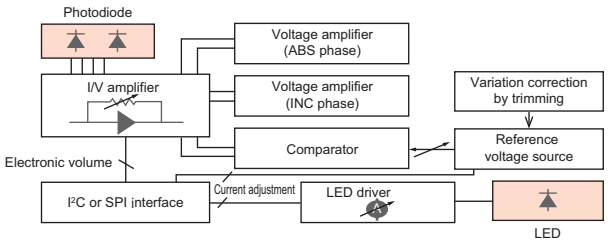
These are photo ICs for configuring optical encoders. The following customization is available to meet your encoder specifications:

- Special photodiode pattern
- Emitter/receiver integrated type combining a photodiode and an LED
- Reduced mounting space realized by miniaturization (monolithic type)
- I²C interface

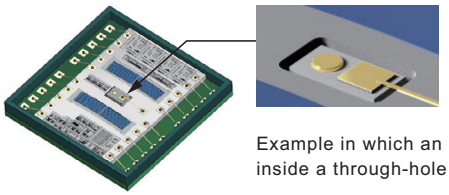
■ Product example

LED integrated photo IC (monolithic type)

Block diagram

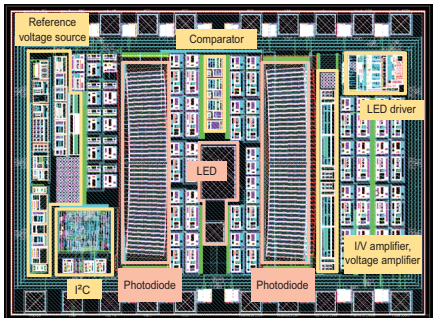


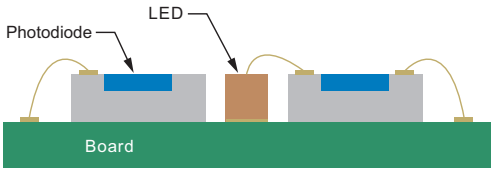
Custom processing example



Example in which an LED is mounted inside a through-hole of a Si photodiode

Photo IC chip example



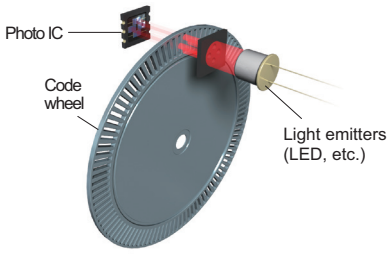


Cross section

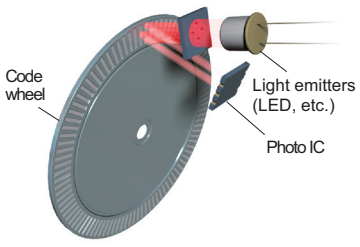
▶ Hamamatsu photo IC technologies

- Detection circuit (preamplifier) to detect rotation/position/speed
- Analog output (amplifier output) or digital output (comparator output)
- I²C interface or SPI for multifunction capability

■ Application examples



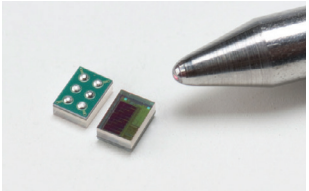
Transmissive encoder



Reflective encoder

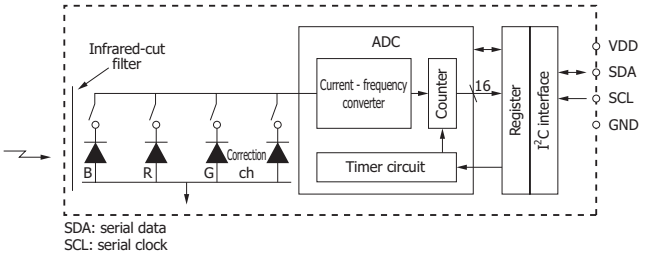
Information transfer between ICs via two signal lines

I²C-compatible color sensors



These are color sensors compatible with I²C (Inter-Integrated Circuit) interface. They have a built-in photodiode with an on-chip filter that is sensitive to Red (λp=615 nm), Green (λp=530 nm), and Blue (λp=460 nm) lights. The I²C interface can be connected to a microcontroller. The detection results are output with a 16-bit digital value for each color. The sensitivity and integration time are adjustable so that photometry can be performed under a variety of conditions.

■ Product example



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▶ Hamamatsu photo IC technologies

- Photometry over a wide dynamic range
- Square wave output with oscillation frequency proportional to incident light level (duty ratio: 50%), current-to-frequency conversion circuit that can be directly connected to the logic circuit input
- Timer circuit with built-in oscillator outputting internal clock and integration time
- Counter circuit that counts the output frequency within the integration time
- A/D converter that converts detection results to 16-bit digital values
- Register circuit to store counter data and I²C interface data
- I²C interface for transmitting and receiving data to and from the outside

■ Application examples

Backlight monitor (backlight dimming)

Printer printing monitor

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