Designing Miniature Optical Switches With the VCNT2025X01 and VCNT2030

By Christoph Schweda

Reflective sensors are used to simplify the interaction between people and machines elegantly and intuitively. The sensors are usually hidden behind infrared (IR) transmissive covers and trigger a signal when a finger or another object touches the surface of the cover. Optical sensors make it easy to design a button that feels naturally smart and works reliably. The principle of operation is as simple as it is effective.

1. The sensor consists of an emitter that emits infrared light on one side
2. An approaching finger or any other object gets irradiated
3. The reflected signal generates a photocurrent at the detector on the other side

They operate invisible to the human eye, there are no moving parts, no friction, and there is virtually no wear. In addition, optical sensors can be configured and calibrated to handle moisture, water, dirt, and scratches on the surface of the cover, and work just as well with gloves on.

Vishay offers many variants of reflective sensors with unique characteristics and individual strengths. The company's latest analog reflective sensors are the VCNT2025X01 and VCNT2030.

VCNT2025X01

- IRED
- Automotive qualified
- Optical IR pass filter

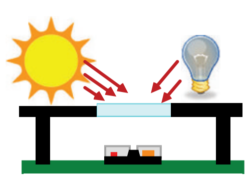
VCNT2030

- VCSEL
- Smallest package
- Low current consumption

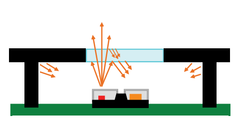
As with any sensor designed into an application, there are key challenges to keep in mind to ensure that everything works as intended. With optical sensors, these are mainly environmental and mechanical challenges within the application housing

ENVIRONMENTAL CHALLENGES

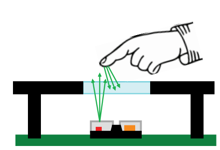
AMBIENT NOISE

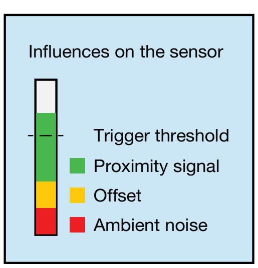


OFFSET



PROXIMITY SIGNAL





Ambient noise: external disturbances such as sunlight and common light sources cause noise at the detector.

Offset: reflections from the surrounding aperture, dirt, water, moisture, or scratches on the cover's surface induce an offset photocurrent that adds up with the proximity signal to the total amplitude of the output signal.

If not considered in the design phase, the noise signal can reach an amplitude that may exceed a predefined threshold and cause false detections. Therefore, the sensor should be designed to minimize such environmental influences to keep a healthy signal to noise ratio.

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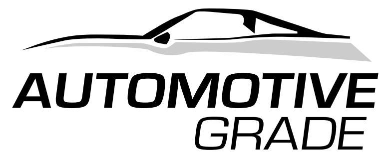
MECHANICAL CHALLENGES

For aesthetic reasons, the sensors are usually placed underneath IR transmissive covers, or an optical sensor's viewing hole size must often be minimal. Additionally, the sensor must take up as little space as possible to closely place multiple buttons next to each other.

This leads to tight mechanical constraints for the package dimensions of the sensor on the one hand and to precise requirements for the angular emission / viewing characteristics on the other.

VCNT2025X01: AUTOMOTIVE TOUCH SWITCH THAT WORKS UNDER DIRECT SUNLIGHT

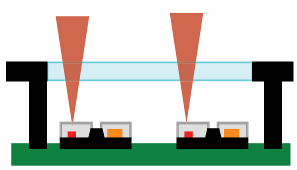


Buttons realized as optical sensors can be used anywhere in the car because of their small space requirements. High demands on reliability are required to cope with the fluctuating conditions in an automotive environment. Both temperature and the influence of sunlight must be taken into account. Here the automotive qualified VCNT2025X01 is a good choice with its high temperature range and its IR pass filter.

The sensor can be shielded and oriented with an optimized aperture to protect it against interfering sunlight. In addition, the sensor package is designed to filter out all interfering light wavelengths. This means that the sensor is only sensitive to light in the wavelength range of the emitter and already ignores a large part of the ambient noise.

The sensor can be further improved with the DC light suppression circuitry with a high pass filter at the detector, as shown in Fig. 1. This ensures that only the pulsed emitter signal is detected and amplified.

VCNT2030: OPTICAL BUTTON PANEL IN A CONFINED SPACE



The VCNT2030 is the sensor of choice when the design requires multiple buttons to be implemented in a confined space. The sensors' emitter uses a vertical cavity surface emitting laser (VCSEL) with high radiant intensity and high optical power. The narrow emission angle of the VCSEL significantly reduces the offset caused by a cover, making it particularly suitable for operation under transparent materials. In addition, the radiation pattern and the small dimensions of the sensor allow for very close side by side placement. So close, in fact, that the width of a finger acts as a limiting factor.

Due to the radiation pattern of the VCSEL, a sweet spot for the cover can be found where it produces only a minimal offset. This sweet spot is best derived from a distance curve.

The distance curve below shows the relative output signal of the VCNT2030 against the distance of a mirror or a cover glass. Up to a distance of about 2 mm, the signal remains adequately low. This means a cover glass should best be kept in this range up to a distance of 2 mm to keep the offset minimal, improving the signal to noise ratio as discussed above.

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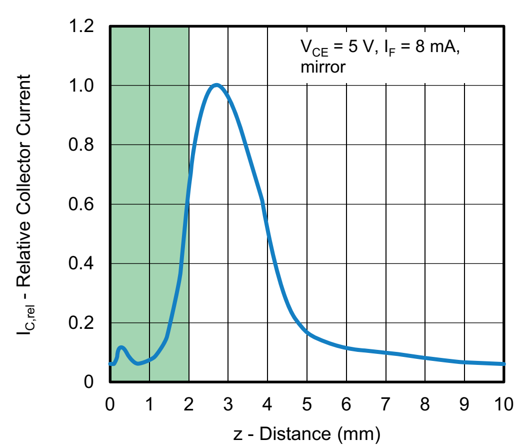

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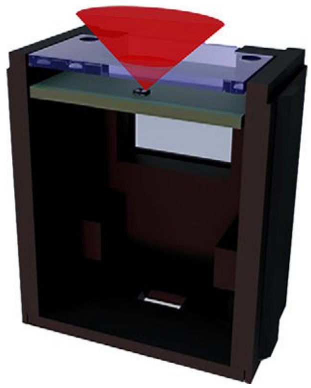
VCNT2025X01: A BUTTON FOR HARSH INDUSTRIAL OR MEDICAL ENVIRONMENTS



The aim is to design a button that is robust and can be used in a harsh industrial or medical application. An optical button would make cleaning easy, since the smooth surface has no cracks where dirt could penetrate. On the other hand, the sensor must not be triggered by liquids or dirt. Instead, a press should be detected even if the finger is placed imprecisely and not directly over the sensor.

The optical button is less sensitive to contaminations on the cover's surface due to the IR emitter's broad emission angle, allowing a wider distribution of the radiation power over a larger area. Besides that, the wider emission enables the detection of fingers that are not placed directly above the sensor. On the other hand, gloves, often used in such an environment, make no difference and will equally be detected by the sensor.

The model to the right shows a simplified, successful real-life implementation of a button design that meets these requirements. The sensor operates under a 2 mm thick, IR transmissive, polycarbonate cover spaced 3 mm from the sensor's top. The aperture is designed large enough for the wide emission angle of the VCNT2025X01 in order to minimize offset noise. To be insensitive to sunlight, the circuit topology shown in Fig. 1 is used. The emitter is pulsed with 5 kHz. A further high pass filter is designed so that the cut-off frequency is below this frequency, but effectively attenuates the usual mains hum at 50 Hz.

The V_O's output signal can be directly connected to an ADC for further processing. A calibration routine enables the sensor to ignore offsets caused by the aperture. All this allows for an extremely robust design that is very difficult to false trigger through external effects, making it very reliable.

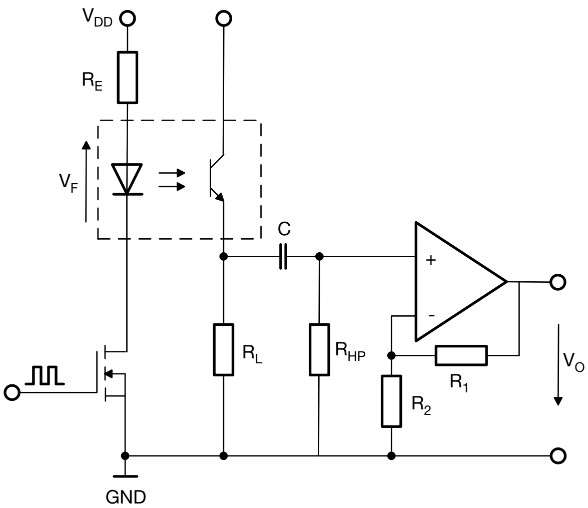


Fig. 1 - General Circuit Topology for Optical Sensors With a Transistor Output

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