VISHAY

The DNA of tech.®

VISHAY SEMICONDUCTORS

www.vishay.com

Optical Sensors | White Paper

Single and Multibutton Applications With the VCNL36828P VCSEL-Based Proximity Sensor

By Stephen Widenmeyer

Industrial and consumer applications feature an increasing amount of functionality encompassed in a single device. To provide access to these functions via a user input, there is a growing need for flexibility in the placement of buttons within a confined space. As a result of this increased miniaturization, touchless applications with IR emitter based proximity sensors are becoming even more difficult to design-in due to their wide field of view (FOV). The latest proximity sensors in Vishay's portfolio are able to overcome these challenges due to their integrated vertical cavity surface emitting laser (VCSEL) with a narrow emission profile VCSEL, and use of the latest package technology optimized to take up as little space as possible on the PCB.

APPLICATION POSSIBILITIES

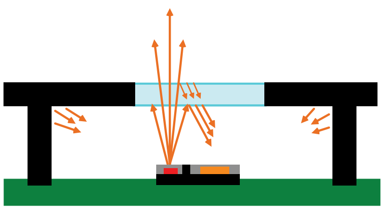
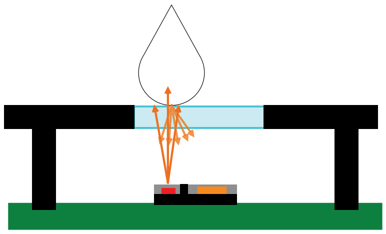
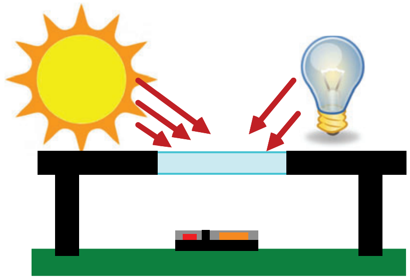


Typical single and multibutton applications include:

- Elevator buttons
- Soap dispensers
- Coffee / vending machines
- HMI interfaces on IoT devices like thermostats or home automation displays

DESIGN CHALLENGES

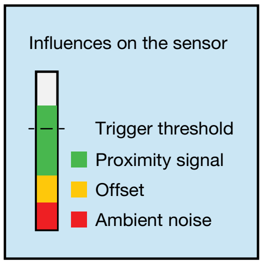
During the design of a touchless application, the general challenges of proximity sensors - as well as the more specific challenges of a multibutton applications - have to be faced.

OFFSET COUNTS: A GENERAL PROXIMITY SENSOR CHALLENGE		
INFLUENCES DEFINED BY APPLICATION DESIGN	EXTERNAL INFLUENCES ON THE APPLICATION	
Reflections due to cover and housing	Water droplet, dirt, scratches	Ambient noise
		

WHITE PAPER

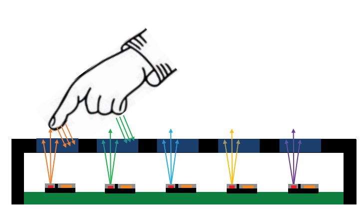
For technical questions, contact: sensorstechsupport@vishay.com

Single and Multibutton Applications With the VCNL36828P VCSEL-Based Proximity Sensor



Offset counts are the main challenge within proximity sensor application designs, and they can have a variety of sources. Offset counts that occur due to the design - such as internal reflections by the housing material or reflections from the applied cover material - can be mitigated during the design phase. Offset counts that occur during the use of the application - like ambient light disturbances or the influence of dust, water, or scratches on the cover - need to be considered during the implementation phase but cannot be avoided during the design phase. These offset counts lead to a decrease in dynamic range and in the worst case, false activation of the application. Reducing the number of offset counts is a key challenge for all proximity applications. By implementing some design guidelines to mitigate these effects, the offset counts can be kept to a minimum and the overall performance of the application can be improved.

FALSE TRIGGERING: A TOUCHLESS MULTIBUTTON CHALLENGE



Within space-constrained applications, the challenge is to design in as many buttons as possible, as close to each other as possible. Therefore, the prevention of false detections is a key challenge in avoiding false activations of the application. During the design phase, the differences in the reflectivity of the detectable object, as well as the required detection distance, need to be considered.

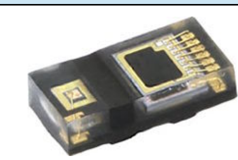
A horizontal alignment of the sensors is recommended to avoid false activation due to the wrist of the user's hand. When the sensors are lined up vertically, additional considerations, like time-based differentiation of the results or multiplexing between the sensors, should be taken into account to prevent false triggers.

VCNL36828P: TOUCHLESS SWITCHING WITH VCSEL-BASED PROXIMITY SENSORS IN CONSUMER AND IOT APPLICATIONS

The VCNL36828P can overcome these design-in challenges and can be used as a reliable and sensitive touchless button. The VCNL36828P is a VCSEL-based proximity sensor that provides a combined solution of an CMOS-based photodiode, amplifier, and analog to digital signal converting circuits - all within one package. Integrating all of these components into a single package decreases the space constraints on PCBs, which is particularly beneficial for touchless applications with several button inputs.

KEY BENEFITS: VCNL36828P

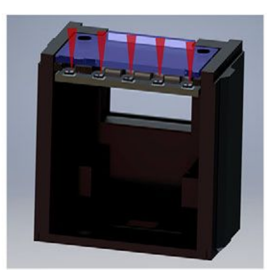
Package dimensions	2.0 mm x 1.0 mm x 0.5 mm
Supply voltage	1.8 V compatible
VCSEL emission angle	± 4°
I^2C addresses	x2
Lowest possible power consumption (1)	5 µA

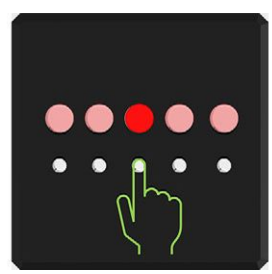


Note

(1) Based on smallest VCSEL on / off period (PS_Period) and smallest VCSEL driving current

HOW TO DESGIN A TOUCHLESS SWITCHING APPLICATION WITH THE VCNL36828P





The above demonstration mimics an IoT home automation thermostat, in which several buttons are placed in close vicinity to each other underneath an IR-coated material. Within the demo, up to five sensors are designed closely to one another in a horizontal alignment with a distance of 7.5 mm between the sensors. The limitation between two buttons is no longer given by the sensors, and instead is defined by the smallest possible distance with regard to the reflective object size, i.e. the fingertip size. Based on the demonstration, the design-in of the typical necessary engineering steps of a touchless proximity application should be discussed.

Single and Multibutton Applications With the VCNL36828P VCSEL-Based Proximity Sensor

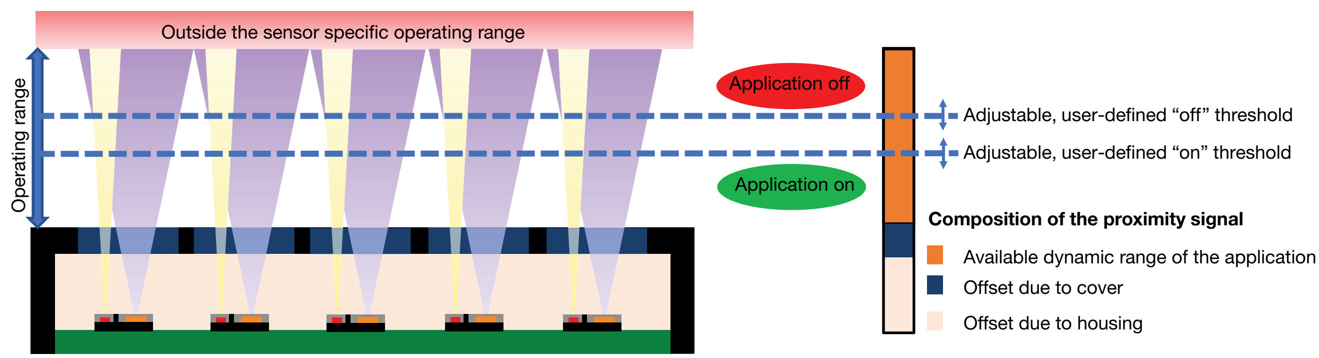
MAIN ENGINEERING STEPS	
MECHANICAL AND OPTICAL IMPLEMENTATION	ELECTRICAL IMPLEMENTATION AND PROTOTYPING
• Define FOV and distance between buttons • Define distance between sensor and cover material • Define transmissivity of the cover material	• Define power consumption and sensitivity settings • Implement delta count approach and offset calibration routine • Define high/low threshold

The implemented low power mode can reduce the power consumption down to 5 µA at a V_{DD} of 1.8 V. This makes the VCNL36828P perfectly suitable for low power IoT applications. The low power mode can be activated via the internal registers.

The sensitivity of every proximity sensor is adjustable via the internal registers of the integration time (measurement rate) and the applied VCSEL driving current. The overall possible operating range is defined by the maximum sensitivity of the sensor. Within this operating range, low and high thresholds can be defined in a way that the desired object with the lowest reflectivity and smallest size is still able to activate the application reliably. Typical touchless button threshold levels are in the range of up to 2 cm above the cover, which are still able to be detected by the sensor. Within the application, a user-defined high threshold is determined to activate the application, whereas the defined low threshold deactivates the application. A hysteresis between the high and low thresholds prevents false triggers, and ensures the reliability of the system.

The combination of a narrow VCSEL emission profile (± 4°) and small package size makes an application FOV down to a hole diameter of 2 mm possible. Both characteristics help to prevent false triggers along the way, since only a finger directly above the sensor is able to trigger it.

The distance between the cover material and the sensor determines how many offset counts are generated. Within proximity applications, the amount of generated offset counts should always be kept as low as possible. Therefore, the cover should be placed as close as possible to the sensor. The placement of the cover within or close to the saturation area of the sensor should be avoided. It is recommended to define the sweet spot during the prototyping phase, since every cover material behaves differently. Within the demonstration, a distance of 3 mm between the cover and top of the sensor has been proven to be suitable.



In combination with a calibration routine, the delta count approach can be used to make the application more reliable and ensures a robust behavior against tolerances. Within real-life designs, the offset counts can change over time, which will accordingly diminish the defined dynamic range of the application. In a worst-case scenario, this drift can even lead to a false activation of the application. With the help of a calibration routine, this offset count change can be determined during an open-air measurement, where no object is in front of the sensor. With the help of the internal crosstalk cancelation registers, the determined offset counts can be directly deducted internally from the actual proximity counts generated by the object. By defining the threshold levels as relative counts (delta counts) instead of fixed values, the adjustment of the thresholds is flexible without changing the software code.

In combination with the calibration routine, the delta count approach can help to retrieve the predefined dynamic range of the application. This is a simple way to enhance the reliability of a proximity application.