

INTELLIGENT OPTO SENSOR DESIGNER'S NOTEBOOK



Proximity Detection

*contributed by Joe Smith
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ABSTRACT

The ability for an electronic device to sense the closeness of an object can be a powerful tool that can lead to increased power efficiency and customer satisfaction. This application note will discuss some of the benefits of implementing proximity detection as well as some considerations to keep in mind during the design.

WHAT IS PROXIMITY DETECTION

Proximity detection enables a system to make a decision based on the proximity of an object to the proximity sensor. The purpose of proximity detection in most applications is to enable or disable system features when a system user is determined to be within a specified proximity range.

This specified range that determines a proximity event is a convenient way to categorize proximity detection applications. Short range applications are interested in seeing whether a user is within the range of a few centimeters, while long range applications base decisions on whether a user is within the range of about a meter. Short range applications are typically portable devices that rely on the user putting the device to their head, such as one would with a mobile phone when making a phone call. Long range applications, however are typically non-portable devices which rely on a user approaching them to activate.

WHY PROXIMITY DETECTION

The primary benefit driving proximity detection is increased power efficiency. Correct use of a proximity detection system can increase battery run time in a portable device or minimize the power usage of a plug-in device.

Many government entities are enforcing higher power efficiency standards on consumer electronics. Additionally, many consumers have an increased expectation of power saving features within their electronic devices and often base purchasing decisions on the scope of these features. For these reasons, proximity detection can be a strategic, value adding feature to implement into many possible applications.

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HOW IT WORKS

There are several methods for detecting the proximity of an object, but they are all based upon a common idea. This idea is that an emitter can emit energy which will be reflected off of an object, and that a sensor can then gather the reflected energy and pass it to a system that could then make a proximity decision. This high level system description describes, how sonar, radar and even how human vision can detect the proximity of an object. The variables that differentiate these technologies are the type of energy being emitted and reflected, and the complexity of the analyzing and deciding system.

This system also describes proximity detection as it relates to an optical system. In this case, the energy emitted is light of a particular wavelength from an emitter. This light is reflected off of an object and is read by an optical sensor, where it is converted to a signal, which can then be interpreted to signify whether or not a proximity event has occurred.

THE TAOS SOLUTION

TAOS has developed integrated ALS/proximity detection devices, which check for object proximity between ALS integration cycles. This integrated approach allows a system to make decisions based on the ambient lux measurements as well as whether or not a proximity event has occurred.

To accomplish this, the device has two modes of operation: ALS mode and proximity mode. During ALS mode, the device gathers data across two channels (a broadband channel and an IR channel). The ratio of these channels indicates the photopic ambient light (lux). Please see the TAOS application note "**DN26: Ambient Light Sensing**", for more information regarding TAOS' ambient light sensing solution.

In proximity mode, the device outputs a pulsed signal which drives an IR emitter. If an object is near the emitter, the IR energy will be reflected toward the sensor. The returning signal contains both the reflected IR energy as well as ambient light, which the sensor converts to a signal. The device subtracts the IR energy from the ambient light and charges a capacitor towards a threshold. The device determines the strength of the proximity event by counting the number of emitter pulses that are required to reach that threshold. This proximity strength information is then made available for the user to access.

DESIGN CONSIDERATIONS

When designing a proximity detection system, there are certain considerations to keep in mind.

PROXIMITY DISTANCE

The first decision to make is what distance would signify a proximity event. This will drive your optical system requirements. The goal is that your emitter outputs energy sufficient to reach any object within this range, be reflected and return to the sensor. When calculating how much energy will reach the sensor, several things need to be considered.

First, the distance from the object to the sensor will affect the returned energy based on the inverse square law. Light intensity is inversely proportional to the square of the distance that light must travel. Since this light must travel to the object and back, this distance is doubled.

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Additionally, as the energy from the emitter strikes the object, some of it will be absorbed by the object, resulting in less energy available to return to the sensor. This absorption is wavelength dependant so it could be improved by experimenting with different emitters which emit energies at different wavelengths. Whether or not this can be improved, it should be considered when designing the optical system.

The amount of reflected energy will depend also on the surface of the object. Reflected energy can be of two forms. The first is specular. Specular reflection is reflection in which the angle between the incoming energy and a line normal to the surface equals the angle between the reflected energy and a line normal to the surface. When a LASER is directed at an ideal mirror, the reflection is specular. Alternatively, diffuse reflection is reflection in which the reflected energy is scattered in many directions and no one direction exhibits more reflected energy than any other. Nearly all surfaces exhibit both specular and diffuse reflection. In proximity sensing, specular reflection is ideal if it directs the reflected energy towards the sensor. It is important to keep in mind that different surfaces will reflect energy differently.

CROSSTALK

A Crosstalk signal is a signal that the sensor perceives that was not reflected off of the intended source, but rather traveled directly to the sensor. This can lead to the false detection of a proximity event. Crosstalk signals can be caused by insufficient isolation of the sensor and emitter in the case of direct crosstalk. Additionally the board or the cover glass could act as a waveguide allowing a crosstalk signal to reach the sensor. This situation can be remedied by interrupting the waveguide path by adding a slit in the board or a notch in the cover glass. In most cases crosstalk can be avoided by optically isolating the sensor from the emitter with a baffle.

LED SELECTION

There are many parameters to keep in mind when selecting an LED for proximity detection. Among these parameters are the output power, the maximum forward current, the viewing angle and the peak wavelength.

Generally, it is important that the energy be in a region that will not disrupt the user. Using an IR emitter with a peak wavelength of 850nm is a good choice because it cannot be detected by the user, is readily available and it is near the peak response of the IR channel of the TAOS sensor.

In a short-range application, it is typically not necessary for the LED to have much output power, unless the energy is being greatly attenuated. More care should be taken when designing a system for a long range application. For IR emitters, the output power is expressed as radiant intensity, I_e , the units of which are milliwatts per steradian (mW/sr). Since a steradian is defined as a solid angle where the area of the side that is opposite the vertex equals the square of the distance from the vertex. In other words, if an IR emitter is characterized as having a radiant intensity of 20 mW/sr, then 20mW of radiant power (or flux) will strike a circular area of 1m^2 , 1m away from the emitter. This would represent an irradiance of $20\text{mW}/\text{m}^2$ at a distance of 1m or an irradiance of $5\text{mW}/\text{m}^2$ at 2m.

Scaling this irradiance by the distance and by the active diode area of the device will return the radiant power that the device will actually receive. This can be correlated to a given response from TAOS devices, by scaling the irradiance response (available in all TAOS datasheets for a particular monochromatic light source) to the peak wavelength of the emitter. This process is further explained in the TAOS application note "***DN23: Photo Sensor Response Part I: Sensitivity to Wavelength***".

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For more information regarding units of measurement with respect to optical systems, please see "*TAOS DN21: Radiometric and Photometric Measurements with TAOS Photo Sensors*".

OPTICAL DESIGN EXAMPLE

The TAOS TSL2711 is a digital output integrated ALS/proximity sensor. An evaluation module (EVM) is currently available, which demonstrates the part as it would be used in a portable device.

The emitter chosen for this demo, has a peak wavelength of 850nm and outputs at least 16mW/sr with a forward current of 100mA. In this design, the emitter will be pulsed at 34mA with a 50% duty cycle and 4 μ s on-time. According to the datasheet for the emitter, this corresponds to about 5mW/sr or 5mW/cm² at a distance of 1cm. If the desired distance is 6cm, the total optical path would be 12cm. At 12cm, the irradiance is 35 μ W/cm².

The TSL2711 has an active photodiode area of 466 μ m². Thus the radiant power at the striking the active photo diode area of the TSL2711 is 1.6 μ W.

TSL2711 EVM Proximity Strength over Distance

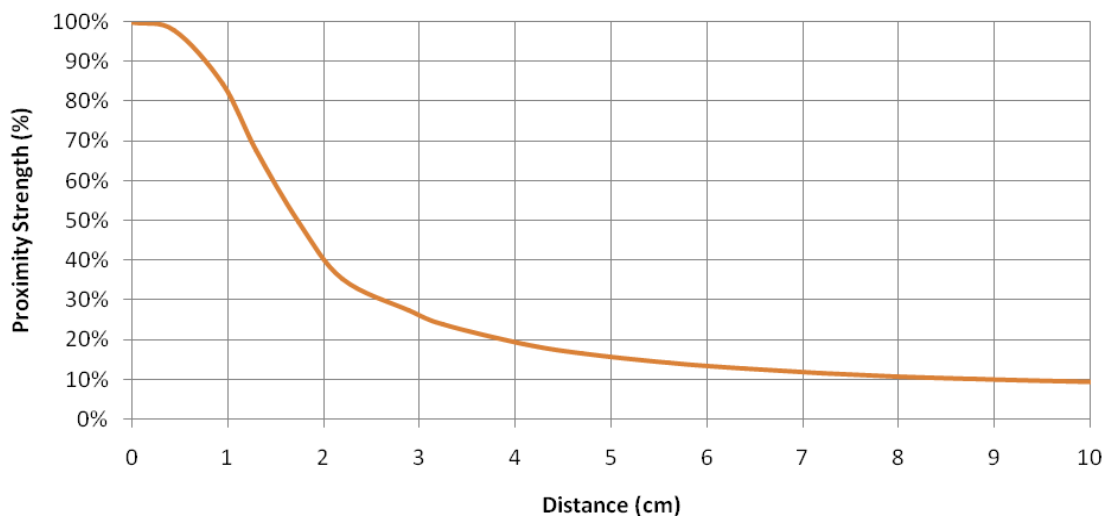


Figure 1. Proximity Strength vs. Distance of Kodak 18% Gray paper

The data in figure 1 was taken by measuring the proximity strength of a signal being reflected off of a Kodak 18% gray card over varying distances. For the device tested, a threshold could be set at around 13% of the full-scale value in order to detect a proximity event at 6cm. Given the slope of the curve at 6cm, this configuration would be most suitable for a close range application where a proximity event would occur within 2cm. To increase the proximity event distance, more IR radiation would need to be emitted, thus more current must be supplied to the IR emitter.

CONCLUSION

Proximity detection can be a useful tool in the design of energy efficient devices. Utilizing TAOS integrated ALS/proximity detection sensors, such as the TSL2711, together with TAOS's industry leading expertise, will ensure that your design is successful.

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