Application Note

AN000607

Behind OLED Proximity Design Considerations

Minimizing Crosstalk and Emitter Placement

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Content Guide

1 Introduction

ams proximity sensors function by pulsing an IR emitter, which can be either an Infrared Light Emitting Diode (IR-LED) or a Vertical Cavity Surface Emitting Laser (VCSEL), and measuring the reflected energy returned from a target. The amount of reflected energy is inversely proportional to the target distance and proportional to the target size and reflectance. The trend toward narrow bezel and no bezel smart phone designs presents new challenges beyond those that occur with traditional proximity system designs that use IR ink apertures on a wide bezel. The narrow bezel and no bezel designs usually require that the proximity sensor be placed Behind the OLED (BOLED). This application note will describe options for the implementation of BOLED proximity systems.

2 Proximity Behind OLED

Traditional proximity sensor modules consist of an emitter and detector within a single device and includes an isolation barrier between the two. These modules are great when used with a bezel behind IR-ink apertures, but in a BOLED application, they limit the flexibility of emitter type, emitter location, number of emitters, etc. A photodiode in a smaller package, paired with a discrete emitter (IR-LED or VCSEL) may be a better choice to overcome any flexibility limitations. A popular choice from **ams** is the TCS3708. This is a small device, in an FN package, that is ideally suited for BOLED applications. However, special design considerations are necessary to achieve optimal proximity sensing performance.

Figure 1 shows the TCS3708 proximity sensor in the clear mold FN package. This package, which is small and thin, is ideal for placement behind an OLED display. However, the clear mold will allow light to enter from undesired directions (primarily the sides of the device) resulting in an unacceptable amount of crosstalk.

Figure 1:
Discrete Proximity Sensor Device

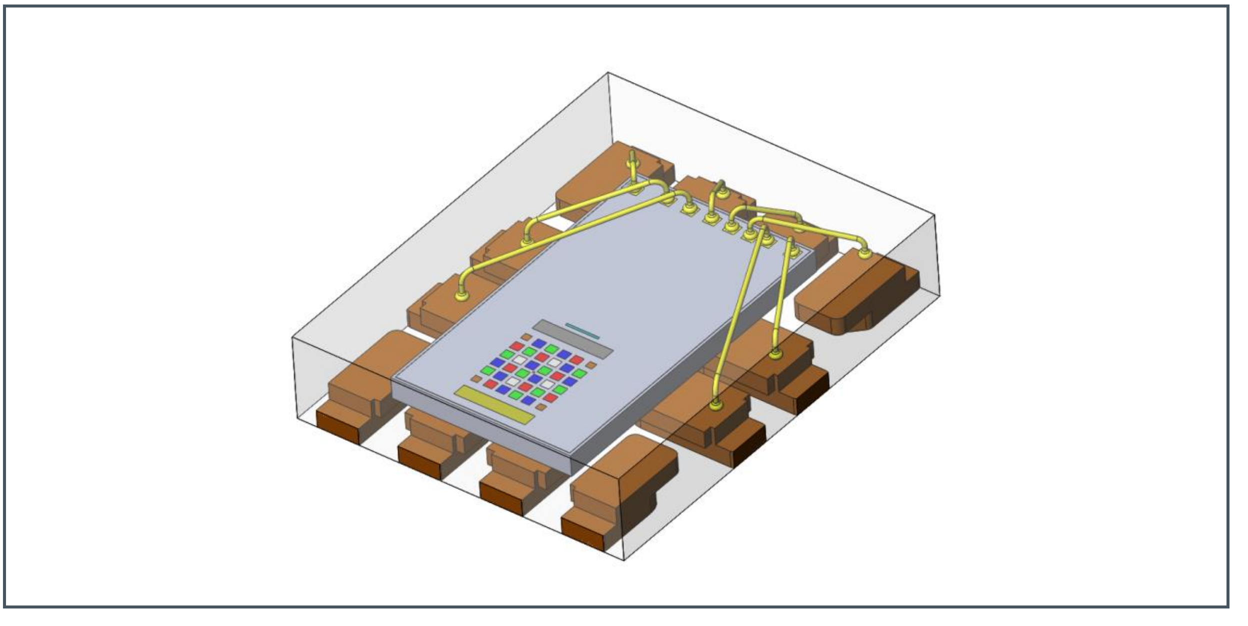
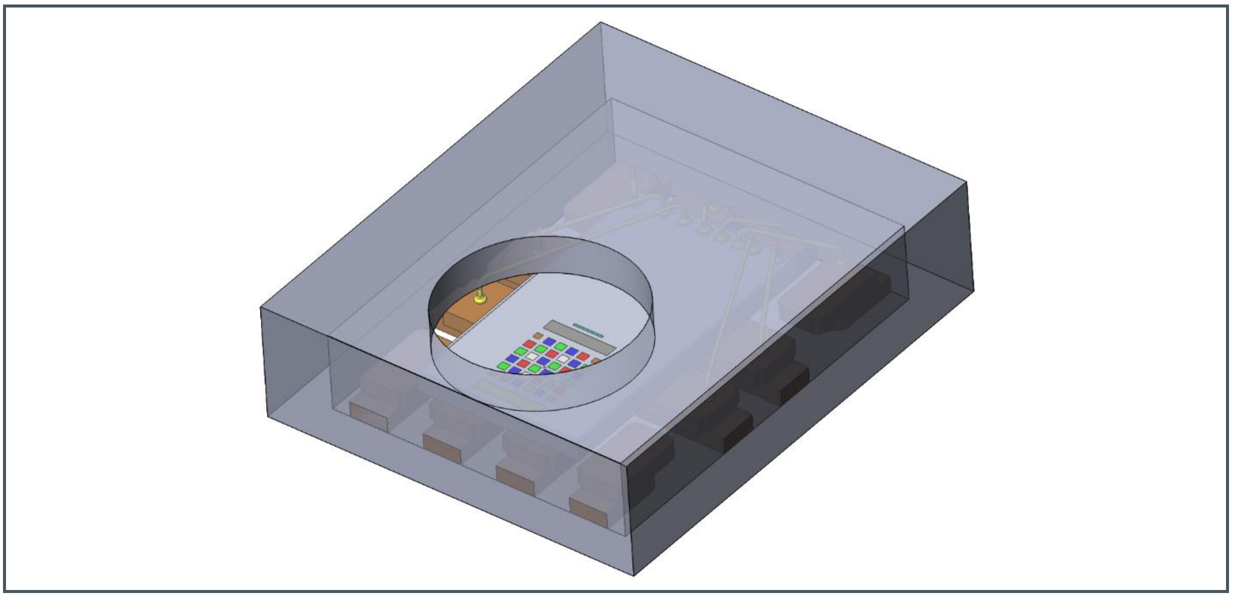


Figure 2 shows the TCS3708 proximity device covered by an opaque, non-reflective black rubber boot with an appropriately sized aperture over the photodiode area. The boot should fill the air gap (which should be as small as possible) between the proximity sensor and the bottom side of the OLED. This boot will only allow light to enter through the aperture to reach the photodiode, eliminating nearly all of the crosstalk energy that would have otherwise entered through the clear mold from the sides of the device. The material chosen for this should be a soft, flexible rubber or neoprene.

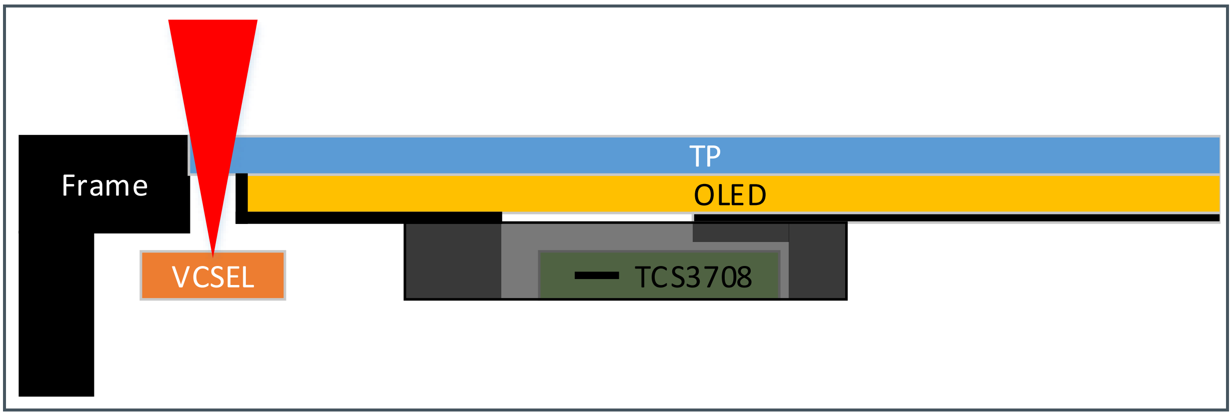
Figure 2:
Discrete Proximity Device Covered by a Rubber Boot



The IR transmissivity of an OLED display is inherently low, primarily due to the required layers of metallization that are present. In order to get the most reflected IR energy through the display to the photodiode, any non-essential, IR-blocking materials on the bottom side of the display (protective barriers, copper, glue, etc.), must be removed to essentially create an aperture on the bottom side of the display. The design and the shape of this aperture should be optimized to maximize proximity signal and to minimize crosstalk. An optimized display aperture is one that is aligned with the device's package (or rubber boot) aperture and is the same shape but slightly oversized. The ideal aperture design for the sensor will consider the sensor's Field-Of-View (FOV), boot thickness, air gap, mechanical tolerances, assembly tolerances, etc. The same guidelines above apply to the emitter Field-Of-Illumination (FOI).

The second component in the proximity detection system is the IR emitter. This could be either an IR-LED or a VCSEL. A key consideration in this type of an application is choosing the best location for the emitter. A narrow bezel area that would support the placement of an IR-inked aperture for the emitter would be the ideal case. For a full no-bezel design, most mobile phones will have a narrow channel between the display and the frame, which provides an acceptable location as long as the mechanical and placement tolerances can be properly managed. Figure 3 illustrates this concept. Note that the area around the emitter needs to be covered with an opaque, non-reflective material (shown in black) to minimize stray light.

Figure 3:
Emitter in the Display/Frame Gap.

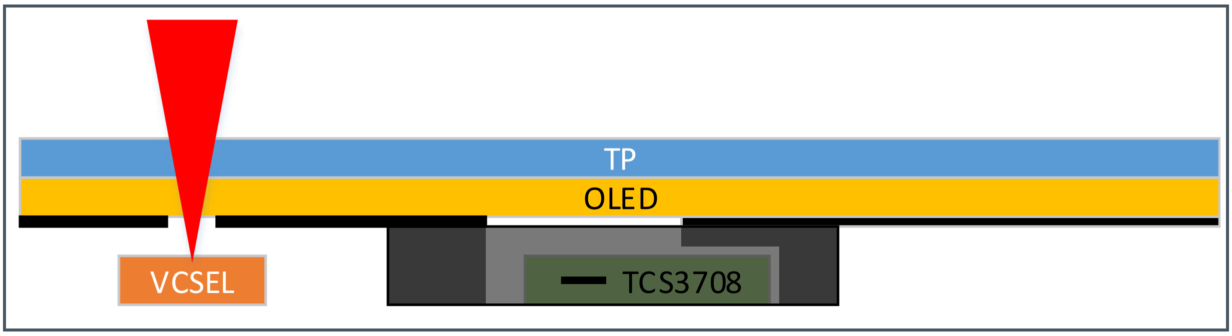


There are several advantages to placing the emitter in this location:

1. The emitted IR energy does not pass through the OLED so the outgoing IR pulses are not subjected to the low IR transmissivity of the OLED.
2. There will not be any issue of screen distortion that could occur when the emitter is placed behind the OLED.
3. Reduced crosstalk compared to BOLED designs where the emitter is behind the OLED and the IR energy enters and exits the OLED display.

A much more challenging architecture involves placing the emitter behind the OLED display, as shown in Figure 4. This configuration has the advantage of not requiring any bezel at all, however the output energy and emitter pulse timing must be carefully controlled in order to achieve an adequate proximity response while avoiding visible screen distortion. Note that a circular aperture of appropriate size on the bottom side of the display will be required.

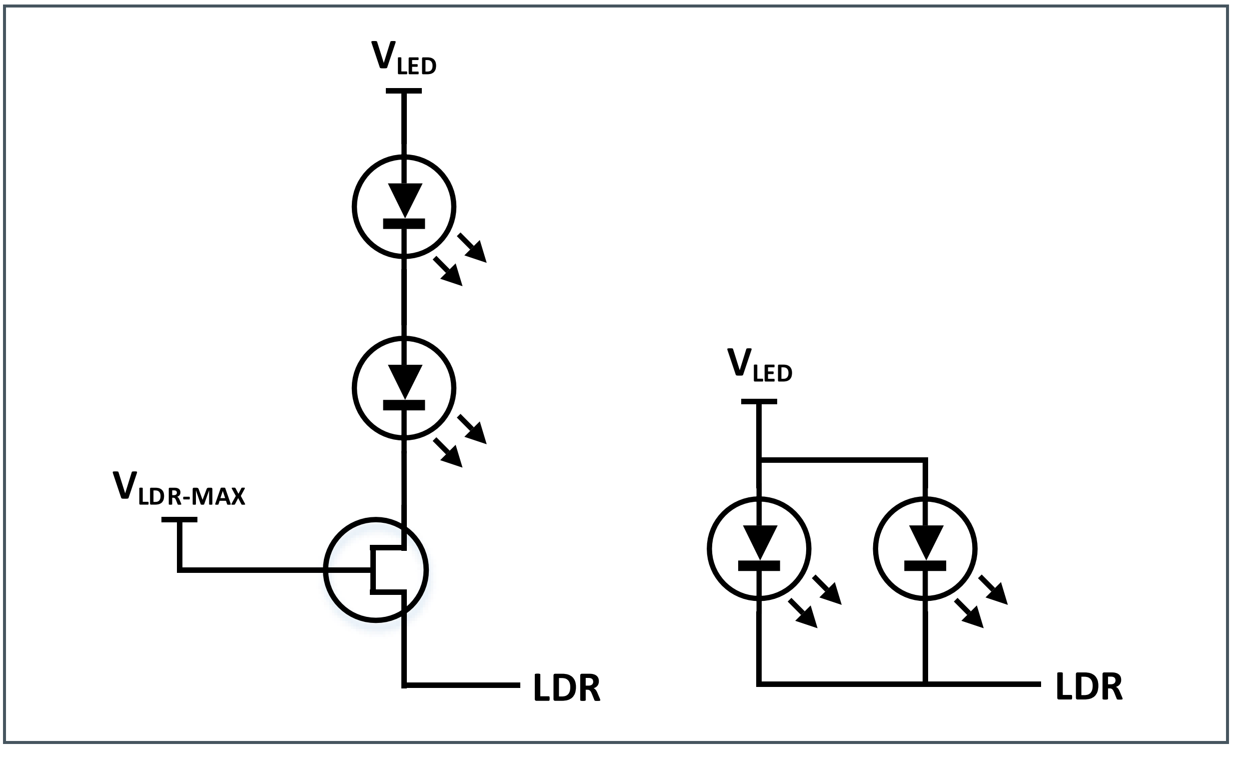
Figure 4:
Emitter Behind the OLED



For displays that have a blanking time, with an associated hardware timing signal, the TCS3708 has a Sync input feature (patent pending) which allows an external pulse to be used to trigger the start of the proximity cycle. Using this feature, the proximity pulses can be triggered to occur during a specific time when visual screen distortion is less likely to be noticeable. It may be necessary to add a delay to the Sync signal to precisely trigger the proximity cycle. This delay will vary depending on the display itself and on exactly where the emitter is placed under the display. A clock that is synchronized to the screen blanking should be used to generate the Sync signal, in order to avoid any negative effects caused by drifting. For displays that have programmable blanking interval timing built in, this delay may not be necessary.

It may be that the best result occurs when multiple emitters are used. Multiple emitters can be connected in parallel or in series. If connected in parallel, it is important to carefully match the device-to-device power output in order to prevent brightness differences between the emitters. Unbalanced emitters, connected in parallel, could result in the higher power emitter causing a visible screen distortion. When connected in series, a higher V_{LED} may be required due to the series V_F of multiple emitters. In this case, a transistor circuit would be required to prevent the LDR pin from exceeding the LDR absolute maximum voltage. Figure 5 shows simplified examples of basic multiple emitter implementations. In an application, the actual design will be determined by system constraints (available voltages, emitter type, etc.) and system requirements (ESD protection, etc.).

Figure 5:
Multiple Emitter Examples



As with any discrete proximity implementation, placement optimizations (i.e. the distance between the emitter and sensor) will be required to determine the tradeoffs between detect/release curves, black hair response and contamination response. Simulations can help for comparisons, but the best approach is to build prototypes and experiment.

3 Summary

Implementing a proximity sensor behind an OLED display is not a simple task. The wide variety of OLED displays that are available means that each design requires a customized solution to match the operational characteristics of the display used. Using **ams** evaluation boards to build prototype systems that can be fine-tuned to meet system design requirements is the best approach to achieve a successful system design.

4 Revision Information

Changes from previous version to current revision v1-00	Page
Initial version	

- Page and figure numbers for the previous version may differ from page and figure numbers in the current revision.
- Correction of typographical errors is not explicitly mentioned.

5 Legal Information

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