Technical Disclosure Commons

Defensive Publications Series

August 2020

# Light-Guiding Structure For Under-Display Sensor Modules

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# Light-Guiding Structure For Under-Display Sensor Modules

**Abstract:**

This publication describes techniques and apparatuses for the use of a light-guiding structure to route electromagnetic signals emitted by an under-display sensor module to a bezel area of a mobile device for transmission and, likewise, route electromagnetic signals received in a bezel area to an under-display sensor module. In aspects, the light-guiding structure is a light guide plate, a curved light-guiding body, or optical fibers. The techniques and apparatuses provide increased efficiency of under-display sensor modules by avoiding signal loss caused by eliminating the need to transmit and receive electrical signals through the display panel structure of a display panel module.

**Keywords:**

Sensor module, under-display sensor, mobile device, smartphone, transmission efficiency, bezel, light guide plate, light-routing structure, light-guiding structure, light guide plate, optical fibers, electromagnetic waves, light signals, display panel module, display

## Background:

The increasing use of mobile devices for gaming, productivity, entertainment, and video communication has resulted in consumer demand for devices with larger screen sizes. To provide a larger screen size without enlarging the mobile device itself, a manufacturer may increase the screen-to-body ratio of the device. Increasing the screen-to-body ratio requires expanding the active area of the display panel module of the mobile device closer to the outer edge of the mobile device, resulting in a smaller bezel area.

One or more sensor modules may be provided in the bezel area, for instance, thermographic cameras (*e.g.*, infrared cameras), proximity sensors, ambient light sensors, radar chips, dot projectors, flood illuminators, and the like. The display panel module may include an orifice (*e.g.*, a hole punch) defined in the bezel for a sensor module located in the bezel area to transmit/receive through.

As a result of the limited bezel space available, in some mobile devices one or more of the sensor modules are positioned under the display panel module of the mobile device. In such a configuration, the "under-display" sensor module emits and receives electromagnetic signals through the display panel module (*e.g.*, between pixels). As a result of interference as the electromagnetic signals pass through the display panel module, under-display sensor modules may experience decreased performance, for example, low transmittance (around 3%).

**Description:**

This publication describes techniques and apparatuses for the use of a light-guiding structure to route electromagnetic signals (*e.g.*, emitted infrared radiation, emitted light, emitted radar waves) emitted by an under-display sensor module to a bezel area for transmission, and, likewise, to route electromagnetic signals (*e.g.*, reflected infrared radiation, ambient light, reflected radar waves) received in a bezel area to an under-display sensor module. The techniques and apparatuses provide increased efficiency of under-display sensor modules.

The term "mobile device," as used in this disclosure, refers to a portable device that has both computational and communication capabilities (*e.g.*, mobile phone, smartphone, camera, tablet computer, laptop computer, convertibles, smartwatches, intelligent glasses, and so forth). While in this publication, an example mobile device is described as a smartphone; other types of mobile devices can also implement the methods described in this publication. The term "electromagnetic signal," as used in this disclosure refers to signals in the electromagnetic spectrum. While in this publication, an example electromagnetic signal is described as a light signal; other types of electromagnetic signals can also be transmitted/received by an under-display sensor module utilizing the methods described in this publication.

A mobile device includes an active display area ("active area") above the pixels of the display panel module and an inactive area of the display panel module that is free of pixels. The inactive area may be referred to as a "bezel area" and may include a bezel defined around the edge of the active area. The bezel hides display panel structure (*e.g.*, electronic components, power signal lines) located in the pixel-free inactive area of the display panel module.

The light-guiding structure is utilized to route light signals to a bezel area for transmission. Likewise, the light-guiding structure is utilized to route light signals received in the bezel area to an under-display sensor module. In a first aspect, the light-guiding structure is a light guide plate. While the light guide plate is referred to as a "plate," other, non-plate shapes are also envisioned. A light guide plate is an optical module that functions to direct (refract) a light signal generated by a light source that is received at a first light incident surface to a second light incident surface from which it is emitted. The light source may be an emitter of a sensor module, for example, a proximity sensor module placed under the display panel module of a device. A proximity sensor module may emit an infrared light utilized, for example, to detect the proximity of an object (*e.g.*, a user's head during a phone call).

Illustrated in Figure 1 is a partial, schematic view of a display panel module of a mobile device. A cover glass layer is provided on the upper surface of the display panel module. A cover glass layer covers both the active area and the pixel-free inactive area of the display panel module. An opaque material ink (*e.g.*, a bezel) may be applied to the under surface of the cover glass layer in a bezel area. The cover glass layer, along with one or more polarizer layers and/or touch sensor layers, is bonded, utilizing an optically clear adhesive, to the upper surface of a display panel structure of the display panel module. The display panel structure includes light-emitting red, green, and blue pixels ("pixels").

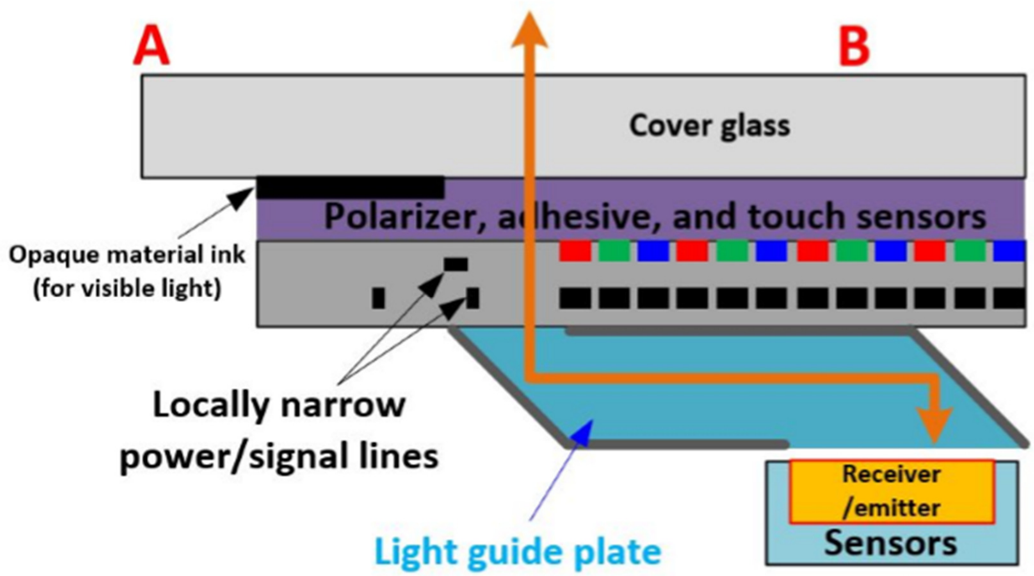


**Figure 1: Light guide plate as a light guiding structure**

Referring to the light guide plate illustrated in Figure 1, the light guide plate has a body that defines a first light incident surface adjacent the sensor module under the active area of the display panel module and a second light incident surface adjacent the inactive area of the display panel module. The body also includes a first oblique reflection surface and a second oblique reflection surface that change the path of the light passing through the light guide plate body. The light guide plate extends from the sensor module to the bezel area. The light signal, emitted by the emitter of the sensor module, enters the light guide plate at the first light incident surface, is reflected by the first oblique reflection surface towards the second oblique reflection surface, is reflected by the second oblique reflection surface towards the second light incident surface, and is emitted from the second light incidence surface and into the inactive area of the display panel module. The light signal emitted from the second light incident surface passes through a gap in the bezel area of a display panel module defined between the outer edge of the light-emitting pixels and the inner edge of a bezel (opaque material ink) and out of the display panel module. Reversely, a light signal emitted by, or reflected from, an outside source external to the smartphone, may pass through the gap region and enter the light guide plate at the second light incident surface, be reflected by the second oblique reflection surface toward the first oblique reflection surface, be reflected by the first oblique reflection surface toward the first light incident surface, then be received by sensor module. Transmission efficiency, using this technique is expected to be roughly 10%.

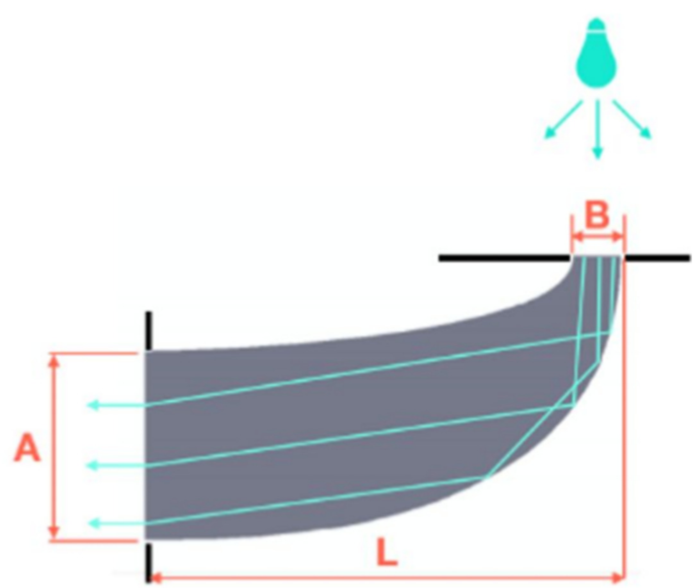


**Figure 2: Curved light-guiding structure**

Referring now to Figure 2, illustrated is a curved light-guiding structure (colored gray) configured for receiving a light signal from a light signal source (teal) (*e.g.*, ambient light signals from a lightbulb, reflected radar signals). In aspects, the light-guiding structure has two light incident surfaces and a curved light-reflecting wall. A first light incident surface (B) is configured for receiving the light signal through the bezel area of the display module, and likewise, emit light signals out of the same light incident surface. A second light incident surface (A) is configured for transmitting light signals to an under-display sensor receiver, and likewise, receiving light signals emitted by an emitter of an under-display sensor module. In aspects, a light-guiding structure may include a reflective curved wall, configured for guiding light signals received through one light incident surface to the opposite light incident surface (*e.g.*, from light incident surface B to light incident surface A, or vice versa). The length (L) of the light guiding structure will depend on the distance between the first and second light incident surfaces.

In another other aspect (not illustrated), the light-guiding structure may be one or more optical fibers. Light signals can be guided from a first end of an optical fiber to a second end of the optical fiber, for example, ambient light received by one end of an optical fiber located in the bezel, could be guided to a sensor module at the other end of the optical fiber underneath the display module and vice versa.

In summary, this publication describes the techniques and apparatuses for directing light signals to an under-display sensor module and, similarly, route light signals from an under-display sensor module to an opening in the bezel area of a mobile device.

**References:**

[1] Patent Publication: US 20110175852 A1. Light-based touch screen using elliptical and parabolic reflectors. Priority Date: November 4, 2002.

[2] Patent Publication: US 20180260602 A1. Devices with peripheral task bar display zone and under-LCD screen optical sensor module for on-screen fingerprint sensing. Priority Date: March 7, 2017.