Emitters and Detectors for Infrared (IR) Touchscreens

Application note

1. Introduction

Touchscreens as a popular user interface are more and more common. Applications span from public information systems to customer self-service terminals. Thus, as a logical step, more and more devices today feature this kind of user interface, e.g. bank automatic teller machines (ATMs), personal digital assistants (PDAs), mobile phones and PC displays. The widespread popularity is actively supported by standard computer based operating systems, like e.g. Windows® 7.

The rapid development of CMOS imaging sensors and the development of high power infrared (IR) emitters in slim packages have led to a series of new optical touchscreen technologies. Many of them contain proprietary technology and solutions. Tab. 1 presents a general overview of different technologies and their features.
This paper will give an overview on IR-based touchscreen technologies with a special focus on infrared emitting diodes (IREDs) and photodetectors to be used in such applications. It shall help touchscreen designers to select suitable IR components for their system and provide some general optoelectronic guidelines.

Traditionally, IR touchscreens have faced three criticisms: Size, cost, and ambient light sensitivity. The first two concerns stem from traditional matrix-based systems. However, new technology and slim packages enable a significant decrease in bezel height combined with a decrease in cost. Camera-based systems go even further by reducing significantly the number of parts at the cost of added computing and software

Feature	Resistive	Capacitive	Surface acoustic wave	IR matrix-based	IR camera-based	IR projector-based	In-cell optical
Clarity of image quality	-	o	+	++	++	++	++
Resolution	+	+	o	-	++	++	++
Cost effective for larger screens	-	-	-	-	++	++	+
Resistance to vandalism	-	-	+	+	+	++	o
Stable calibration	-	+	+	++	++	++	++
Easy to manufacture	+	o	o	+	+	+	+
Retrofit possibility	++	o	-	++	++	-	-
Any object can create a touch	o	-	o	++	++	++	-
Touch accuracy	o	+	+	o	++	++	+
Multitouch capability	-	+	o	+	+	+	+
Ambient light insensitivity	+	+	+	-	o	-	-
Sealable, resistance to dust	+	+	-	+	++	+	o
Main market	s	m	m	m/l	m/l	l	s

Table 1: Summary of touchscreen technologies and their features.
(++: excellent, +: good, o: ok, -: does not perform well/does not have this function, screen size: s: small (2" – 10"), m: medium (12" – 30"), l: large (>32"))

complexity.
The third constraint, the ambient light sensitivity, remains a very relevant design challenge. There are several methods to deal with this, both optically and electrically. This will be discussed, among other issues, in 'General Design Considerations' in section four.
At the end a brief product selection guide provides information for a rapid and successful design-in.

2. Overview of IR Touchscreen Principles

Generally speaking, IR touchscreens have several desirable attributes that are not all present in competing technologies. The object used to generate the 'touch' can have almost any shape and size and be made of almost any material. This is in contrast to most other touchscreen technologies where some sort of stylus is required.
As IR touchscreens are a solid state technology they have no moving mechanical parts or anything placed on top of the display to reduce the brightness. The latter fact ensures crystal clear image quality and robustness over time. This is especially important as many device or display vendors sell their products on the customers perceived display quality. During the past years several different technologies for IR touchscreens have come up on the market. The major ones will be explained in the following sections.

2.1 IR Matrix-based Touchscreens

The traditional IR matrix touchscreen technology is based on the interruption of a light path in an invisible light grid in front of the screen. A simplified schematic is presented in Fig. 1.

In this concept an array of emitters (IREDs) is employed and covered behind two adjacent bezels of the screen frame and

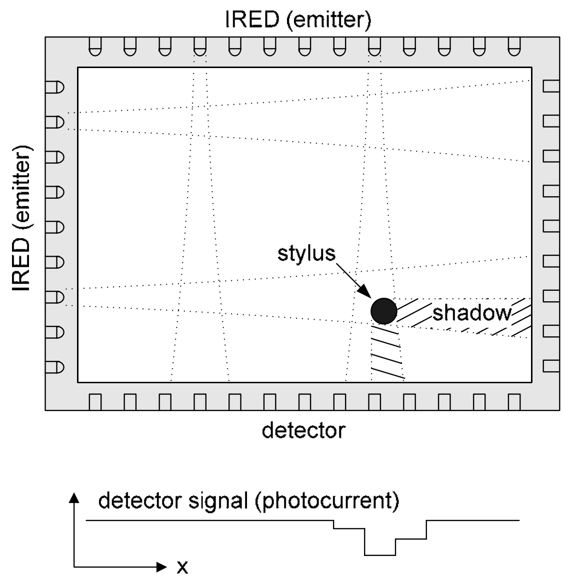


Fig. 1: Concept of an IR matrix-based touchscreen. The influence of a stylus on the photocurrent of individual detector elements is sketched below.

creates the invisible optical grid. The opposite bezels contain the respective detector arrays (typically phototransistors or -diodes). This arrangement shields the active parts from environmental influences and maintains the quality and brightness of the image. Additionally it enables screen retrofits, and is in fact completely independent of the screen for all practical purposes.

If an obstacle (e.g. a stylus or finger tip) appears inside the grid matrix it interrupts the light beams and causes a reduction of the measured photocurrent in the corresponding detectors. Based on this information the x- and y-coordinates can be easily obtained.

The IR-matrix based principle is suitable to recognize static operations as well as motions. It is not really suitable for high resolution motion detection, e.g. handwriting recognition.

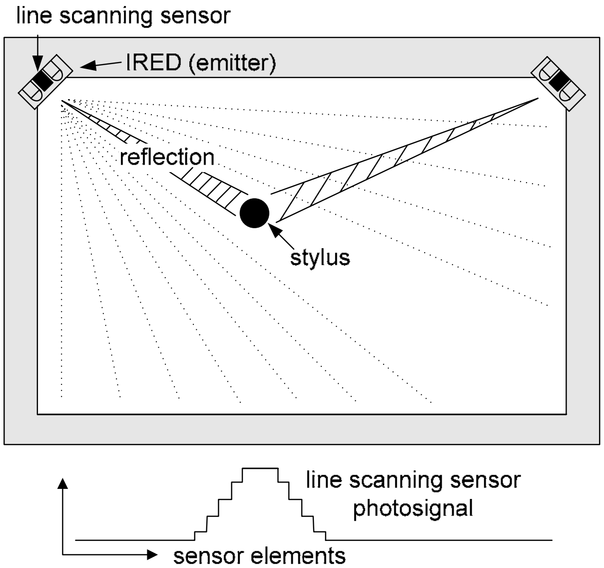


Fig. 2: Reflection type principle of a camera-based touchscreen. The influence of a stylus in the light path on the cell's signal of the line scanning sensor is sketched in the graph.

2.2 Camera-based Touchscreens

Very recent developments are camera-based touchscreen setups. This technology is growing in popularity, due to its scalability, versatility and affordability, especially for larger units. One typical setup is presented in Fig. 2.

The system usually consists of two or more IR line-scanning optical sensors, like used in barcode or flat-bed scanners. Each one is mounted in the upper left and right corner of the screen bezel. The sensors monitor the complete screen which is illuminated with infrared light.
The infrared illumination of the screen area is done by IREDs positioned in the upper left and right corners, next to the line scanning sensors, but optically isolated to avoid crosstalk. Each of these IRED assemblies illuminates the complete 90° angular range of the screen.

The reflection of a stylus or object (e.g. finger) triggers a rise in the signal of the relevant detector cells. By special computational algorithms (e.g. triangulation) based on the readout of the two line scanning sensors the exact coordinates and even the size of the touching object or finger tip can be calculated via software.

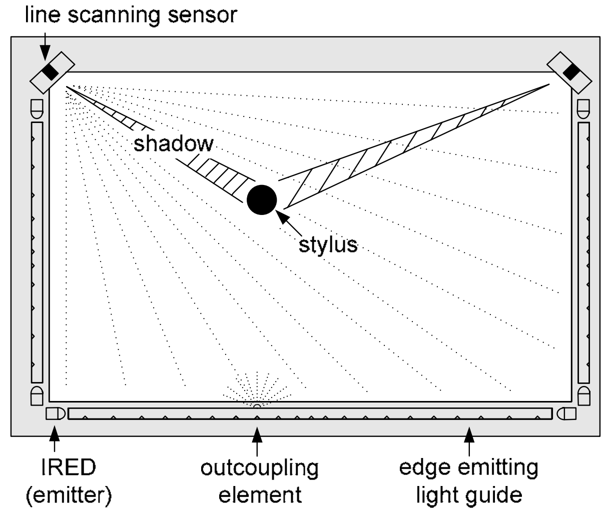


Fig. 3: Camera-based touchscreen realization with an edge emitting light guide. The light guide provides a diffuse illumination of the screen.

2.3 Camera-based with Light Guide

In a different arrangement, a light guide based infrared lighting system is mounted at the cameras opposite field of view, inside the bezel (see Fig. 3). Practical realizations of this backlighting system include high power IREDs which couple light into both ends of an edge emitting optical light guide element. This light guide is mounted around the screen and provides an IR light curtain. In this case the touch of a stylus or object shows up as a shadow generating a drop in the relevant detector cells' signal. Again, special computational algorithms are needed to do the calculation of the location resp. size of the object.

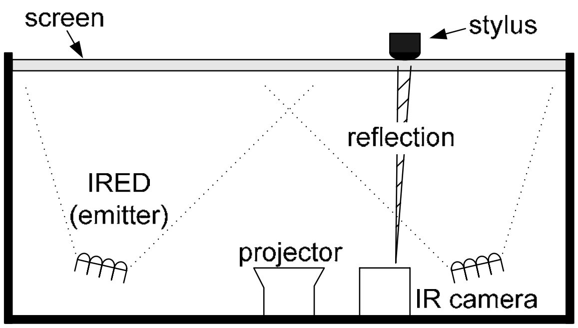


Fig. 4: Principle of projector-based touchscreen realization. The depicted system works with diffuse illumination (DI).

2.4 Projector-based Touchscreens

Another group of systems are based on a projector concept. Due to the setup their main application is in large screens for overview or presentation purposes. The principle of such a technique is presented in Fig. 4.

Usually the visible image is projected from the backside onto a diffuse screen. One or several IR sensitive cameras are mounted behind the screen to monitor the reflected IR image of the screen.
To illuminate the screen with IR radiation there are various options. One makes use of diffuse illumination (DI) from IR-sources behind the screen. If a stylus or finger touches the screen, a reflection occurs and the IR camera detects the bright spot.

2.5 Projector-based with FTIR

Fig. 5 presents a similar version which works on the principle of frustrated total internal reflection (FTIR).

This setup uses the waveguide properties of e.g. the acrylic glass as a part of the screen to distribute the IR radiation. Usually a pressure sensitive polymer layer is added on top to display the projected image, as acrylic glass is almost transparent to the visible image. IR light is coupled into the acrylic

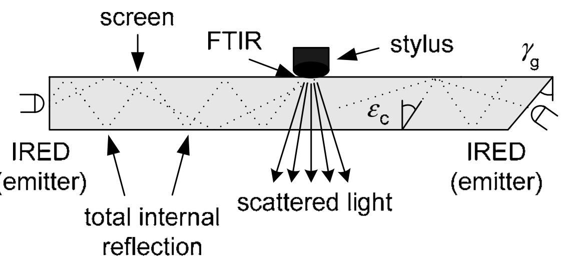


Fig. 5: Principle of a FTIR-based touch detection system. Different IRED coupling options are sketched.

waveguide usually by several IREDs located on all sides of the screen. The light is captured inside the waveguide by total internal reflection.
If pressure or a touch is applied on the polymer/acrylic surface due to a stylus or an object (e.g. finger) light is coupled by FTIR into the polymer (or into the finger if no polymer is used), from where it is scattered and remitted towards the IR sensitive camera located in the rear part of the screen. This technique is desired for applications where IR emission through the screen should be avoided, e.g. in touch screens used in TV studios to avoid interferences or saturation of TV camera pictures by IR light.

It should be mentioned that FTIR combined with camera sensors is also used in the biometrics industry, most notably in fingerprint scanning applications.

2.6 In-Cell Optical Sensing

The in-cell optical sensing principle is an integrated solution. Inside each pixel cell in a LCD display there is typically a phototransistor integrated. The principle works without a designated light source. In a bright environment the phototransistor sees the shadow of the finger tip, whereas in a dark or dim lit ambience the reflections of the backlight generates the signal. The absence of an active illumination is also the drawback of this principle, especially a black screen in dark environments.

3. Application Specific Design Guidelines

3.1 Matrix-based Design

Newly developed slim and cost effective emitter resp. detector packages allow a significant reduction of bezel height, overcoming one of the main drawbacks of this traditional concept.
The number of employed IREDs depends mainly on screen size and required resolution. For simple applications their spacing might be as wide as one IRED per inch.

In most enhanced large screen systems an IR controller sequentially pulses the IREDs. This is important to avoid any simultaneous crosstalk between different emitters.
If sequential operation is not feasible there are some other measures necessary to counterfight unintended crosstalk (although intended optical crosstalk into neighboring detectors is necessary to increase the resolution beyond the IRED spacing).
The most important and best measure is the proper mechanical design to achieve a good optical shadowing. The combination with a narrow-angled detector is also an appropriate action to minimize ambient light issues.

Suitable emitter/detector products with narrow half-angle and small package height for matrix-based touchscreens can be found in Tab. 2 at the end of this note. These slim products enable a cost effective and appealing design.

3.2 Camera-based with Direct Illumination

Depending on the optical design and working principle of camera-based touchscreens, either diffuse wide-angle IREDs for direct illumination or emitters for coupling light into a light guide are advisable.
To extract the signal from ambient IR-noise the usual operation is in pulsed mode by comparing two scans. The first, the reference scan (without IR illumination) is compared with the signal scan (with IR illumination). Based on the difference the touch event can be extracted.

Suitable components for the former setup are either pairs of SFH4050 or SFH4655, which can illuminate the complete 90° field of view. The slim package is an excellent fit for a compact design.

3.3 Camera-based with Light Guide Illumination

An efficient system requires a homogeneous and diffuse illumination of the area above the screen due to an. e.g. edge emitting light guide. The selection of an IRED for coupling into a light guide element depends on a number of criteria. Most important is the design of the light guide (fiber), especially the distribution of the outcoupling elements along the light guide. The spacing of these elements is either uniform or gets narrower with increasing distance from the IRED coupling site. The latter variation is usually designed for standard wide-angle components, whereas the first prefers emitters with a more focused beam to achieve the homogeneous and diffuse outcoupling along the light guide. In general, only customized solutions provide an optimized illumination along the light guide.
However, for coupling light from the emitter into waveguides there are some general guidelines (see also the OSRAM application note “Light Guides” for a more detailed discussion). First of all, the air-gap between the emitter and the light guide needs to be minimized. Even better options include holes in the acrylic glass for the emitter. To get a good optical contact an index matching can significantly reduce the Fresnel-losses (typ. at least 2 x 4 % at the emitter – air-gap – glass interfaces). A second issue concerns the type of coupling, e.g. butt coupling (perpendicular to the plain cut light guide surface) or angled coupling. The first type usually employs standard wide-angle

devices, whereas the latter uses narrow-angle IREDs, necessary to achieve total internal reflection. It is worth to mention that the emitting light guides radiation characteristics depend on the design of the outcoupling structures and the emitter's radiation characteristics in combination with the coupling arrangement. To support design activities OSRAM provides raytrace models, available at the OSRAM website.
For narrow-angle applications, the e.g. MIDLED® SFH46XX series provides a viable solution, whereas the TOPLED® SFH42XX without lens family is an excellent choice for standard wide-angle requirements. Both feature slim packages and a flat-top to minimize the air-gap between the fiber and the IRED.

3.4 Projector-based with Diffuse Illumination

In projector-based touchscreens with IR illumination from the backside it is desirable to achieve a diffuse and homogenous illumination. Suitable high power products are the DRAGON IRED series (SFH423X). In large projector applications it is recommended to split the screen into subscreens and use several IRED-arrays for illumination purpose. Alternatively high power IRED-based modules with homogenous and diffuse fields are recommended, like the OSRAM OSTAR® Observation product family (SFH47XX).

3.5 Projector-based with FTIR

The FTIR principle features different aspects. The mathematics behind is based on Snell's law: $n_1 \cdot sin(\varepsilon_1) = n_2 \cdot sin(\varepsilon_2)$, with ε as the angle between the surface normal and the light path and n as the refractive index of the material (see Fig. 6 for an illustration). Using Snell's law, the boundary condition for total internal reflection at the glass – air interface is around ε_c = 42° (assuming a refractive index of around n_2 = 1.49 for acrylic glass).

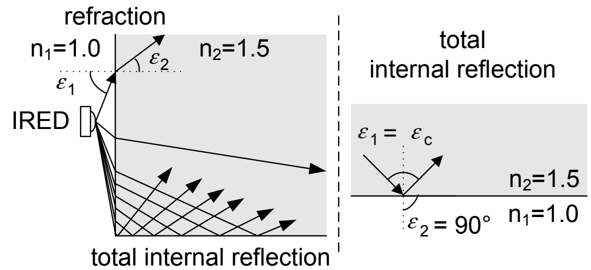


Fig. 6: Definition of Snell's law and critical angle ε_c for total internal reflection. The left schematic also illustrates that under certain conditions all light coupled into the light guide is subject to total internal reflection.

To achieve efficient FTIR a high number of total internal reflections per unit length inside the acrylic glass are desirable.

Direct coupling (also called butt coupling, like depicted on the left side in Fig. 5), employs IREDs with a wide half-angle to achieve this target.
However, to increase the level of internal reflections (increasing the light density to achieve a more efficient FTIR) it might be preferable to couple light into the acrylic glass under angled conditions. This can be achieved efficiently by either tilting the standard wide-angle emitter by e.g. 45° or by an inclined glass edge (see also Fig. 5, coupling from the right side). A suitable arrangement is e.g. cutting the glass edge up to around $\gamma_g \approx 35°$. To ensure a maximum of total internal reflections simultaneously with a high power density, components with a high radiant intensity and narrow half-angle are recommended. Under above conditions, emitters with a half-angle of up to around 15° are preferable.
Compared to wide-angle emitters, narrow-angle IREDs might require a tighter component spacing to avoid 'dark' spots close to the coupling location.

To ensure a high coupling efficiency and minimal Fresnel-losses (which typ. add up to at least 2 x 4 % at the emitter – air-gap – glass interfaces) a plain cut glass surface is

mandatory. To minimize irritations caused by unintentional radiation (scattering) out of the glass at the coupling interface a baffle might be useful. Furthermore it is recommended to minimize the air-gap between the IRED and the acrylic glass.
The MIDLED® product family (SFH 46XX) with its 15° half-angle and flat top is an excellent candidate, whereas for wide-angle components the DRAGON or TOP-/SIDELED® products fulfil the above criteria. For simple applications the spacing might be one to two IREDs per inch.

3.6 In-Cell Optical Sensing

Typically, this design does not feature active IR illumination. However, to overcome the main drawback of this principle the SMARTLED® family (SFH4050) of IREDs with its slim package might be a potential solution for integration without compromising the slim overall design.

4. General Design Guidelines

4.1 Emitter Wavelength

Infrared LEDs for camera-based applications are usually available in two wavelengths: Around 850 nm and 940 nm. The following general guidelines will help you to choose the proper wavelength for your application:

Using an 850 nm IRED results in a higher sensitivity for CMOS cameras. But due to factors described below, 940 nm IRED emitters might be preferable. Additionally, detectors with 'day-light blocking filter' (black resin) often have their maximum at around 900 nm as well. Thus, 940 nm IREDs may be used with discrete phototransistors/-diodes. The detector's data sheet should be consulted to find the best match.

Although human eyes are nominally insensitive to wavelengths above 800 nm according to the CIE V(λ) curves, it has been shown that a red glow is perceived in 850 nm IREDs at high power levels. This effect is around 50 – 100 times lower at 940 nm, therefore this wavelength should be chosen if a faint red glow is visible to the user and definitely undesired in the application.

Eye safety standards should be observed at all times. An application note specifically on this topic is available from OSRAM ("Eye Safety of Infrared Light Emitting Diodes").

4.2 Suppression of Ambient Light

The influence of ambient light on the detector signal may be suppressed and reduced in several ways.

The most important technique is to block visible light in a way that the detector is only sensitive to a narrow wavelength range in the IR region. OSRAM offers to the designer a range of products with so called '*daylight blocking filter*'. OSRAM silicon-detectors with daylight blocking filter are sensitive within the narrow 800 nm - 1100 nm wavelength range. These components are characterized by their black (visible-absorbing, IR-transmitting) packages.
This measure generally provides sufficient ambient visible light suppression for most applications. Please refer to the product selection guide for further details and availability.
Note that usage of devices with daylight blocking filter is recommended in every case to avoid detector saturation.

However, there are additional sources of IR light which might interfere with the signal of interest. The following gives a brief overview of possible distortions and sketches a more demanding solution, if the conventional 'daylight blocking filter' is not sufficient.

4.3 Suppression of Infrared Noise

Minimizing and counterfighting unintended infrared light, which acts as noise in the detector, is the main design challenge.

Using visible LED sources (e.g. monitor backlighting) in IR touchscreen solutions is recommended, as these LEDs have no IR content. In contrast most conventional (non-LED based) light sources emit also in the IR spectral range. E.g. sunlight and incandescent bulbs contain components of equal or even higher amplitudes in the visible as well as IR wavelengths range[1].

For applications where intense incandescent or halogen illumination is expected, some additional electrical-domain effort is advised to enhance the signal-to-noise ratio.
There are several steps with increasing complexity to counterfight the IR noise topic. The implementation depends on the signal compared to the IR noise level.
The simplest version is the operation of the emitter and detector in a pulsed and synchronized operation. An AC-coupling of the detector signal might efficiently filter out the present DC-components of the ambient light. If the IR background noise becomes more dominant, a more complex implementation is necessary. This measure compares two subsequent measurements. The first, called the reference (without IR illumination) is compared with the second, the signal (with IR illumination). Based on the difference signal the touch event can be extracted.
The most demanding solution is the inclusion of a lock-in amplifier type circuitry, which demands a modulated emitter signal. In this case the IRED is modulated with a carrier frequency and the signal is detected through a frequency synchronous receiver, either in a homodyne or heterodyne structure. Alternatively, digital signal processing allows a direct detection by employing computational algorithms (e.g. Fourier-type). Such a system can be made immune even to severe IR ambient light (noise). The selection of the right modulation frequency and the implementation of a narrow band-/lowpass filter are key elements for a high signal-to-noise ratio.

Similar considerations should be undertaken for camera/line scan systems. In this case, it is recommended as a first measure to insert a narrow optical bandpass filter (matching the IRED wavelength) in front of the camera. This increases significantly the signal-to-noise ratio.

4.4 Scalability Issues

Camera-based and projector-based solutions have the advantage of easy scalability. An increase in resolution is commonly achieved by utilizing a sensor with higher resolution. Additionally, the optical power from the emitters might be increased to keep the signal-to-noise ratio stable.

In a more general sense, every free space beam tends to broaden over distance. This leads to a decrease of the irradiance over distance.
The half-angle value is an appropriate approximation concerning the broadening and propagation of light in free space in the so called far field regime[2].

Mathematically the irradiance $E_e(r)$ in the far field drops with the basic relationship $E_e(r) \sim 1/r^2$. As a conclusion: A doubling in distance r reduces the irradiance by a factor of four. Note that the irradiance depends on the distance and also on the angle (normal to the surface of the emitter). The irradiance E_e is related to the radiant intensity I_e (stated in the data sheet of the optical source) by the equation $I_e = E_e \cdot r^2$.

[1] IR noise may contain many frequency components from various light sources:
- DC (e.g. in sunlight, incandescent or halogen lamps)
- Mains frequency (50/60 Hz) and driver caused harmonics (e.g. in incandescent and halogen lamps)
- Frequencies depending on the driver/power supply (e.g. up to kHz range in fluorescent lamps)

[2] The transition distance between the near- and far field depends, among other issues, on the package type. For non-lensed types the transition is usually within the first centimeter. Devices with a domed lens and narrow angle might have a transition distance of up to 25 cm. The main difference between near- and far field lies in the shape and distribution of the radiation characteristics. For proper modelling OSRAM provides raytrace files if accurate information is necessary. An important issue for practical applications might be that the detector should be located within the far field. By using non-lensed emitters this is ensured for almost all applications.

In some enhanced applications it might be worth to consider an external lens in front of the emitter to create a slim IR curtain only above the screen. This might also be advantageous concerning power saving issues, as it allows reducing the IRED drive current.

Exemplary Calculation

The following simple calculation illustrates above relations in a matrix-type application. The emitter is a SFH4650-V (90 mW/sr at 100 mA), the detector a phototransistor SFH309FA-4. The detector is located axially on the opposite screen side, inside the bezel. Unfavorable ambient IR light conditions incident on the detector are assumed to be an equivalent irradiance of 25 µW/cm^2 (e.g. shadowing the detector behind the bezel and bright incandescent light bulbs near the screen).

To achieve a signal-to-noise ratio (*SNR*) of at least 6 at the detector, an E_e = 0.15 mW/cm^2 is required (for a comfortable I_{PCE} ≈ 0.45 mA). Using $I_e = E_e \cdot r^2$ yields for a 7-inch screen (9.1 cm x 15.5 cm) a necessary radiant intensity of 12 mW/sr (vertically emitting) and 36 mW/sr (horizontally). According to the data sheet a drive current I_F of 13 mA resp. 40 mA is required.

Increasing the screen size from 7-inch to 14-inch and keeping the *SNR* stable results in an increase in the required radiant intensity by a factor of four (roughly quadrupling the operating current – in this particular case it is necessary to operate under pulsed conditions).

In the above 7-inch screen example, the crosstalk from a neighboring IRED (spaced 2 cm apart) is around 25 % of the signal for the vertical grid (the angular arrangement causes the radiation characteristics to drop to 60 % resp. the detector's sensitivity to 40 %). This value rises to over 80 % if the screen size doubles. This demonstrates the importance of sequentially pulsed operation of larger matrix-based touchscreens. As an alternative, a proper mechanical design which shadows the detectors from neighboring light, especially with increasing screen sizes resp. resolution is advised. More focused emitter / detector pairs are recommended anyway to avoid x-y crosstalk and reduce interference from ambient light.

4.5 Power Supply Considerations

If the electrical power supply is limited (e.g. battery powered applications or USB connected touchscreens with a max. 500 mA supply) it is recommended to operate the IREDs in pulsed mode. Synchronization with the detector is advised for better signal-to-noise ratio and lower overall power consumption. Please note that in pulsed operation the IREDs can be operated at higher drive currents resulting in higher optical peak powers compared to continuous operation. Please refer to the data sheet for details.

5. Product Selection Guide

Tab. 2 - 7 present a short product selection guide which highlights products and product families of OSRAM which are suitable for IR touchscreen applications. For many package variations top- or side-emitting options are available.

Please note that this guide provides just a general overview. For more detailed information and the latest products and updates please visit www.osram-os.com.

6. Literature

[1] OSRAM-OS: http://www.osram-os.com.

[2] G. Kaindl: *Exploring multi-touch interaction.* VDM Verlag Dr. Müller, 2010.

[3] Interactive Displays Conference: http://www.int-displays.com.

[4] LLFY-Network: http://www.ledlightforyou.com

Emitters

Part Number	Photograph	Wavelength	Package / Package Height *)	Typ. Radiant Intensity, I_e / Half-Angle, φ
SFH4650 SFH4655		850 nm	MIDLED® (top-/sidelooker) 2.35 mm	50 mW/sr (100 mA) ± 15°
SFH4258		850 nm	POWER TOPLED® with Lens 3.0 mm	90 mW/sr (100mA) ± 15°
SFH4059 SFH4059S		850 nm	CHIPLED 1.7 mm	100 mW/sr (70 mA) 190 mW/sr (70 mA) ± 10°
SFH4450		850 nm	REFLED 1.8 mm	40 mW/sr (70 mA) ± 17°
SFH4555		850 nm	5 mm radial 5 mm	500 mW/sr (100 mA) ± 5°
SFH4640 SFH4645		940 nm	MIDLED® (top-/sidelooker) 2.35 mm	60 mW/sr (100 mA) ± 15°
SFH4248		940 nm	POWER TOPLED® with Lens 3.0 mm	100 mW/sr (100 mA) ± 15°
SFH4045		940 nm	CHIPLED sidelooker 1.8 mm	90 mW/sr (70 mA) ± 9°
SFH4545		940 nm	5 mm radial 5 mm	500 mW/sr (100 mA) ± 5°

Detectors with daylight blocking filter

Part Number	Photograph	Detector Type	Package / Package Height *)	Half-Angle, φ / Photocurrent, I_{PC}
SFH309FA		Phototransistor	3 mm radial 3 mm	± 12° 0.8…10 mA/(mW/cm^2)
SFH313FA		Phototransistor	5 mm radial 5 mm	± 10° >5…>20 mA/(mW/cm^2)
SFH3015FA		Phototransistor	CHIPLED sidelooker 1.8 mm	± 13° 1.6…8 mA/(mW/cm^2)
SFH3600 **) SFH3605 **)		Phototransistor	MIDLED® (top-/sidelooker) 2.35 mm	± 20° 1.0…5 mA/(mW/cm^2)

*Table 2: Selection guide (part I): Suitable OSRAM emitter and detector products for **matrix-based touchscreen** applications.*
**) application specific package height, e.g. relevant concerning bezel height.*
***) not available with daylight blocking filter.*

Emitters

Part Number	Photograph	Wavelength	Package / Package Height *)	Typ. Radiant Intensity, I_e / Half-Angle, φ
SFH4250 SFH4250S		850 nm	POWER TOPLED® 3.0 mm	15 mW/sr (100 mA) 25 mW/sr (70 mA) ± 60° wide angle[3]
SFH4240		940 nm	POWER TOPLED® 3.0 mm	15 mW/sr (100 mA) ± 60° wide angle[3]
SFH4255		850 nm	SIDELED® 4.2 mm	15 mW/sr (100 mA) ± 60° wide angle[3]
SFH4244		940 nm	SIDELED® 4.2 mm	11 mW/sr (70 mA) ± 60° wide angle[3]
SFH4050		850 nm	SMARTLED® 0.8 mm	7 mW/sr (100 mA) ± 80° wide angle[3]
SFH4650 SFH4655		850 nm	MIDLED® (top-/sidelooker) 2.35 mm	50 mW/sr (100 mA) ± 15° narrow angle[3]
SFH4640 SFH4645		940 nm	MIDLED® (top-/sidelooker) 2.35 mm	60 mW/sr (100 mA) ± 15° narrow angle[3]
SFH4059 SFH4059S		850 nm	CHIPLED 1.7 mm	100 mW/sr (70 mA) 190 mW/sr (70 mA) ± 10° narrow angle[3]
SFH4450		850 nm	REFLED 1.8 mm	40 mW/sr (70 mA) ± 17° narrow angle[3]
SFH4045		940 nm	CHIPLED sidelooker 1.8 mm	90 mW/sr (70 mA) ± 9° narrow angle[3]

*Table 3: Selection guide (part II): Suitable OSRAM emitter products for **camera-based touchscreen** applications with **light guide illumination.***

[3] the selection of narrow- or wide-angle type emitter depends, among others, on the light guides emitting/illuminating characteristics.

**) application specific package height, e.g. relevant concerning bezel height.*

Emitters

Part Number	Photograph	Wavelength	Package / Package Heigth *)	Typ. Radiant Intensity, I_e / Half-Angle, φ
SFH4650 SFH4655		850 nm	MIDLED® (top-/sidelooker) 2.35 mm	50 mW/sr (100 mA) ± 15°
SFH4640 SFH4645		940 nm	MIDLED® (top-/sidelooker) 2.35 mm	60 mW/sr (100 mA) ± 15°
SFH4050		850 nm	SMARTLED® 0.8 mm	7 mW/sr (100 mA) ± 80°
SFH4053		850 nm	CHIPLED 0.45 mm	6 mW/sr (70 mA) ± 70°
SFH4058		850 nm	CHIPLED 1.7 mm	15 mW/sr (70 mA) ± 40°
SFH4450		850 nm	REFLED 1.8 mm	40 mW/sr (70 mA) ± 17°

*Table 4: Selection guide (part III): Suitable OSRAM emitter products for **camera-based touchscreen** applications with **direct illumination**.*

Emitters

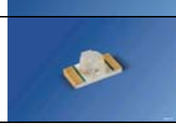
Part Number	Photograph	Wavelength	Package / Package Height	Typ. Radiant Intensity, I_e / Half-Angle, φ
SFH4050		850 nm	SMARTLED® 0.65 mm	7 mW/sr (100 mA) ± 80°
SFH4053		850 nm	CHIPLED 0.45 mm	6 mW/sr (70 mA) ± 70°
SFH4058		850 nm	CHIPLED 1.1 mm	15 mW/sr (70 mA) ± 40°

*Table 5: Selection guide (part IV): Suitable OSRAM emitter products for **in-cell** optical sensing touchscreens with integrated illumination.*

**) application specific package height, e.g. relevant concerning bezel height.*

Emitters

Part Number	Photograph	Wavelength	Package / Package Height *)	Typ. Radiant Intensity, I_e / Half-Angle, φ
SFH4232		850 nm	DRAGON LED 6.2 mm	180 mW/sr (1 A) ± 60° butt/angled coupling[4]
SFH4233		940 nm	DRAGON LED 6.2 mm	170 mW/sr (1 A) ± 60° butt/angled coupling[4]
SFH4250 SFH4250S		850 nm	POWER TOPLED® 3.0 mm	15 mW/sr (100 mA) 25 mW/sr (70 mA) ± 60° butt/angled coupling[4]
SFH4255		850 nm	SIDELED® 4.2 mm	15 mW/sr (100 mA) ± 60° butt/angled coupling[4]
SFH4240		940 nm	POWER TOPLED® 3.0 mm	15 mW/sr (100 mA) ± 60° butt/angled coupling[4]
SFH4244		940 nm	SIDELED® 4.2 mm	11 mW/sr (70 mA) ± 60° butt/angled coupling[4]
SFH4258		850 nm	POWER TOPLED® with Lens 3.0 mm	90 mW/sr (100mA) ± 15° inclined glass coupling[4]
SFH4650 SFH4655		850 nm	MIDLED® (top-/sidelooker) 2.35 mm	50 mW/sr (100 mA) ± 15° inclined glass coupling[4]
SFH4248		940 nm	POWER TOPLED® with Lens 3.0 mm	100 mW/sr (100 mA) ± 15° inclined glass coupling[4]
SFH4640 SFH4645		940 nm	MIDLED® (top-/sidelooker) 2.35 mm	60 mW/sr (100 mA) ± 15° inclined glass coupling[4]
SFH4450		850 nm	REFLED 1.8 mm	40 mW/sr (70 mA) ± 17° inclined glass coupling[4]
SFH4045		940 nm	CHIPLED sidelooker 1.8 mm	90 mW/sr (70 mA) ± 9° inclined glass coupling[4]

Table 6: Selection guide (part VI): Several suitable OSRAM emitter products for ***projector-based touchscreen*** *applications with* ***FTIR illumination****.*

[4] the selection of narrow- or wide-angle type emitter depends, among others, on the coupling arrangement.

**) application specific package height, e.g. relevant concerning bezel height.*

Emitters

Part Number	Photograph	Wavelength	Package	Typ. Radiant Intensity, I_e / Half-Angle, φ
SFH4740		850 nm	OSTAR® Observation	1200 mW/sr (1 A) ± 60°
SFH4750		850 nm	OSTAR® Lighting	1000 mW/sr (1 A) ± 70°
SFH4751		940 nm	OSTAR® Lighting	900 mW/sr (1 A) ± 70°
SFH4232		850 nm	DRAGON LED	180 mW/sr (1 A) ± 60°
SFH4235		850 nm	DRAGON LED	320 mW/sr (1 A) ± 60°
SFH4233		940 nm	DRAGON LED	170 mW/sr (1 A) ± 60°

Table 6: Selection guide (part V): Several suitable OSRAM emitter products for ***projector-based touchscreen*** *applications with* ***diffuse illumination (DI)****.*

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About Osram Opto Semiconductors

Osram Opto Semiconductors GmbH, Regensburg, is a wholly owned subsidiary of Osram GmbH, one of the world's three largest lamp manufacturers, and offers its customers a range of solutions based on semiconductor technology for lighting, sensor and visualisation applications. The company operates facilities in Regensburg (Germany), Sunnyvale (USA) and Penang (Malaysia). Further information is available at www.osram-os.com.