

## IR OSLUX<sup>®</sup> – SFH 4780S in iris recognition applications

### Application Note

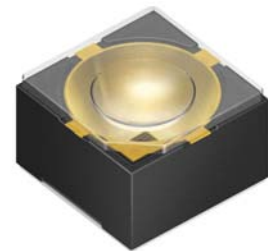


**Valid for:**  
OSLUX<sup>®</sup> SFH 4780S

### Abstract

This application note describes the use of the OSLUX<sup>®</sup> SFH 4780S in iris recognition (iris scanning) applications.

In the first part of this application note the basics of iris recognition are briefly discussed. The second part deals with the use of the SFH 4780S, a component especially designed for iris scanning applications. In an iris recognition system the illumination module with its characteristics has direct influence on the overall quality of the obtained iris picture / data and subsequently on the user experience.



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## A. Iris recognition system

Personal authentication is becoming a key requirement for various electronic devices. Besides of the pin number, today most systems are based on so called biometric “properties”.

Biometrics can include fingerprints, facial features, retina, iris, voice, fingerprint, palm-prints, vein structures, handwritten signatures and hand geometry. All these biometrics have various advantages and disadvantages. However, only iris recognition claims to be a “hard-to-spoof” system in combination with an ultra-low false acceptance rate (i.e. one in a million). Additionally, it also features greater speed, simplicity and accuracy compared to other biometric systems. [1]

The traits of iris recognition systems rely on the unique patterns of the human iris which are used to identify or verify the identity of an individual.

In general, an iris recognition system consists of only a few components (see Figure 1):

- Illumination module, containing the SFH 4780S
- Camera (including the image sensor and the lens)
- Optical bandpass filter in front of the camera to increase the signal-to-noise ratio in high brightness environments
- Software algorithm including pattern extraction

As everything can be mounted behind a glass cover it results in a very rugged system with a small footprint (compared to e.g. the size of a fingerprint ID sensor). The optical system is the heart of the hardware. Using the right emitter is especially important as it defines the quality of the obtained iris scan data.

Figure 1: System setup and the required hardware components for an iris recognition system

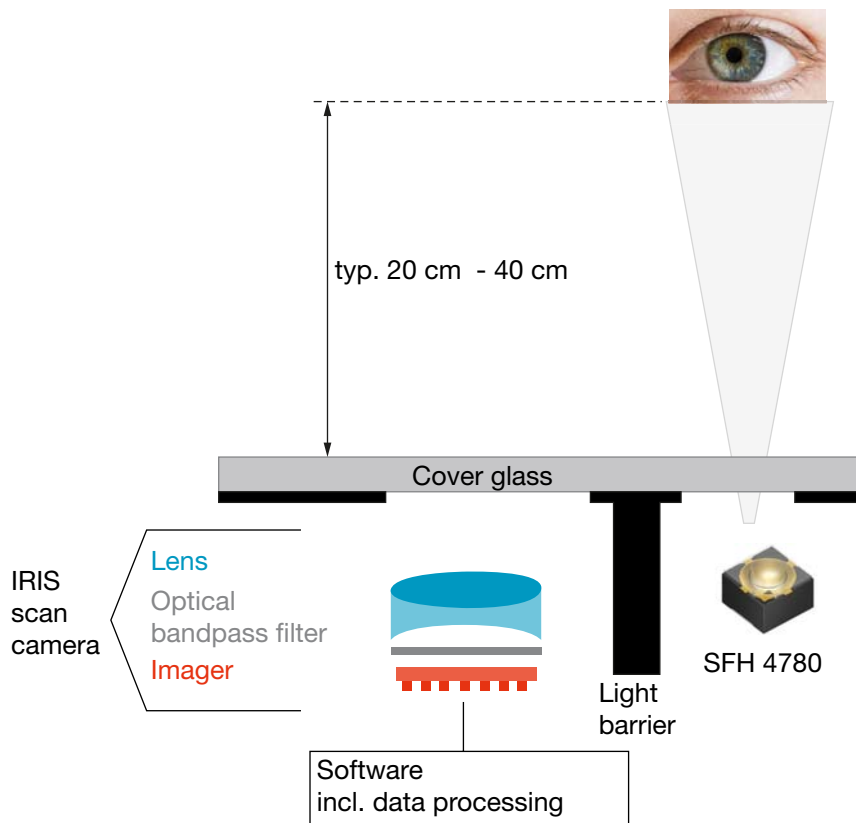
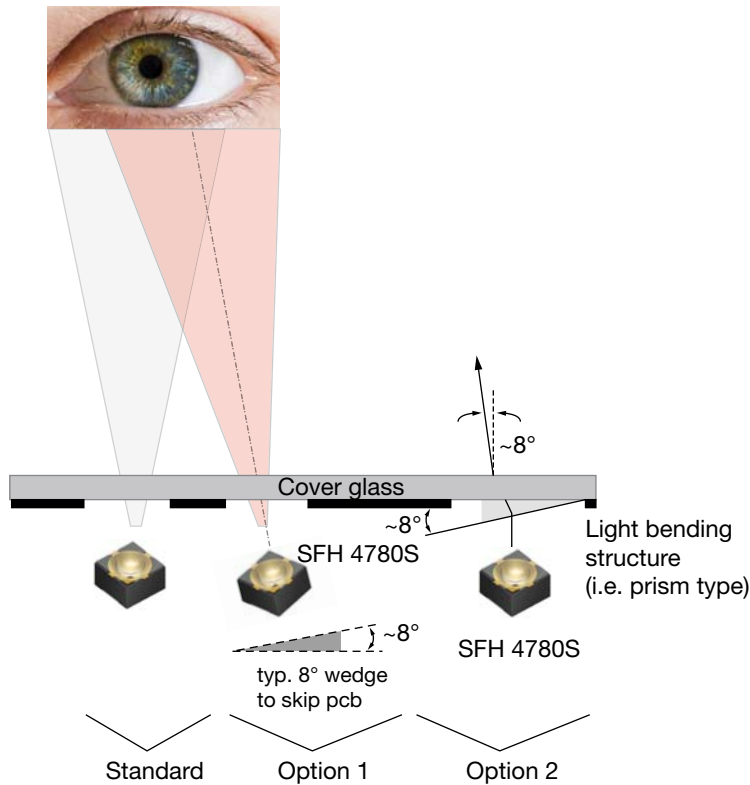


Figure 2: Two options to arrange an 8° tilt of the SFH 4780S illumination module



**The hardware / optical system**

As empiric data suggests there are various suitable wavelengths for an iris scan system, depending on eye color. In general, two wavelengths look suitable, depending on the color of the human iris. For blue and green eyes infrared is a good illumination wavelength, however a visible wavelength might be superior to unveil the richness of iris details. For dark iris colors (the majority of eyes globally) visible wavelengths are not suitable at all (see Figure 3). Here an infrared wavelength is required to unveil the details of the iris. [1] [3]

Figure 3: Suitable wavelengths for iris scanning. 810 nm presents the best solution for all eye colors. Additionally the specular reflection of the corneal is low at 810 nm

	<p>Dark / brown eyes:</p> <ul style="list-style-type: none"> <li>- infrared is best</li> <li>- visible is not suitable (poor extraction of iris details)</li> </ul>	
	<p>Blue / green eyes:</p> <ul style="list-style-type: none"> <li>- infrared is good</li> <li>- visible is best</li> </ul>	

Best solution for all eye colours:  
OSRAM Opto Semiconductors  
SFH 4780S  
810 nm emitter

To simplify and optimize the overall system a single high-power 810 nm illumination module is best suited for all possible eye colors to unveil the rich structures of the human iris. It also allows the use of narrow optical bandpass filters in the camera module to maximize the signal-to-noise ratio of the iris scan pattern in high-brightness environments (e.g. sunlight). Usually the optical bandpass is either integrated into the camera module or positioned on top of the camera (below the cover glass).

A single 810 nm emitter is a clear advantage compared to the more “old-fashioned” (traditional) approach of using e.g. two emitters to create a broadband illumination source between 700 nm and 900 nm.

Additionally, to get the best signal quality and to avoid unintended direct reflections from the surface of the eye a slightly tilted emitter in the range of 5° to 10° (e.g. 8°) might be favorable, depending on the overall system design. To achieve this tilt, the SFH 4780S can be mounted on a tilted PCB (see option 1 in Figure 1B) or a light bending wedge made e.g. made out of glass or other materials. Also, special foils can be fixed on top of the IR-LED to achieve the required light bending (see option 2 in Figure 1B).

In general the radiation characteristics of the SFH 4780S already matches the single eye iris scanning requirements. Adding a proper optics can create any desired illumination pattern in case it is required.

### **Iris recognition software**

A suitable (custom) software extracts the unique pattern of the human eyes, encodes them (e.g. into a 2048 bit code) and conducts a matching procedure (to e.g. grant access). This all can be performed within a second or less, faster and more secure than a four-digit password-based system. Typical camera features are: Resolution > 1 Mpixel, > 10 pixel / mm.

## **B. SFH 4780S**

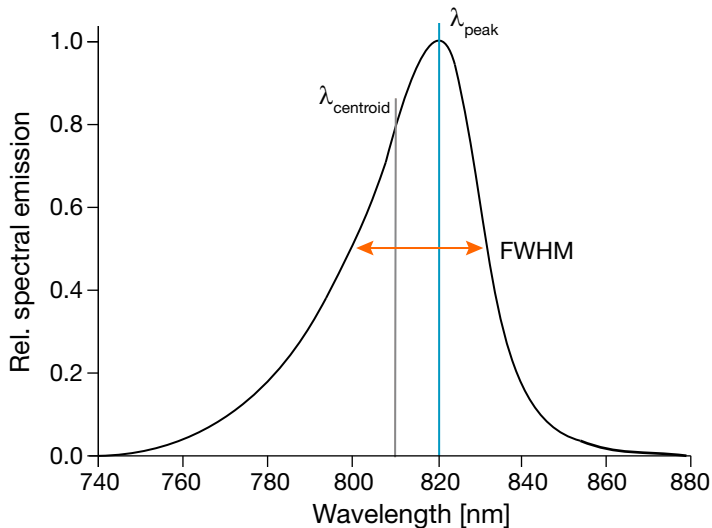
The SFH 4780S is a high-power, narrow-angle 810 nm emitter. It features the unique OSRAM Opto Semiconductors nanostack technology to match the iris-scanning requirements, such as

- High irradiance level: high quality pictures even in bright sunlight conditions
- Narrow emitting angle: focus illumination on the eye area between 10 cm to 40 cm
- Infrared wavelength of 810 nm: minimized corneal specular reflections
- Narrow spectral width (FWHM ~ 30 nm): allows narrow optical filters for high iris picture quality
- Black and compact component body: suitable for harmonic/ discreet industrial design

## Wavelength

The SFH 4780S features a typical centroid wavelength of 810 nm (see also Figure 4), to match best the requirements for iris illumination for all eye colors.

Figure 4: Definition of wavelength parameters for the SFH 4780S.  $\lambda_{\text{peak}} \neq \lambda_{\text{centroid}}$  (due to the asymmetric spectrum)



Further wavelength specifications are:

- **Peak wavelength** ( $\lambda_{\text{peak}}$ ) is the peak wavelength of the spectral density curve (in most applications it is of little significance). This is typically 820 nm for the SFH 4780S.
- **Full-width at half-maximum** (FWHM,  $\Delta\lambda$ ): sometimes also called spectral bandwidth. It is the wavelength distance between the spectral points where the spectral density  $S(\lambda)$  is 50 % of the peak value. This is typically around 30 nm for the SFH 4780S (see Figure 6 for more details).
- **Center wavelength** ( $\lambda_{0.5\text{ m}}$ ) is the wavelength halfway between the two spectral density of 50 % of the peak value. This typically around 815 nm.
- **Centroid wavelength** ( $\lambda_{\text{centroid}}$ ) is the mean wavelength (see equation 1). It divides the spectrum in two equal parts. It is the most important definition for non-visual systems (like iris recognition) and relevant for this kind of application.

$$\lambda_{\text{centroid}} = \frac{\int_{\lambda_1}^{\lambda_2} \lambda \cdot S(\lambda) d\lambda}{\int_{\lambda_1}^{\lambda_2} S(\lambda) d\lambda} \quad (1)$$

For a symmetrical spectrum  $\lambda_{\text{peak}}$ ,  $\lambda_{0.5\text{ m}}$  and  $\lambda_{\text{centroid}}$  are identical. However, the high efficient SFH 4780S features a slightly asymmetrical spectrum.

The SFH 4780S has very tight wavelength specifications and no secondary peak, e.g.  $\lambda_{\text{centroid}}$  is typically within  $\pm 13$  nm. Additionally, the device features a low

temperature dependent wavelength drift (typ. 0.25 nm/K). Figure 5 and 6 present the typical wavelength behavior ( $\lambda_{\text{centroid}}$  and FWHM) vs. ambient temperature and drive current.

Using short pulses minimizes temperature dependent wavelength shift as well as spectral broadening due to internal heating of the LED (e.g. pulse width < 300  $\mu\text{s}$  and repetition rate > 2 ms).

Figure 5: Dependence of the centroid wavelength on ambient temperature and drive current. Operating condition is a single 1  $\mu\text{s}$  pulse

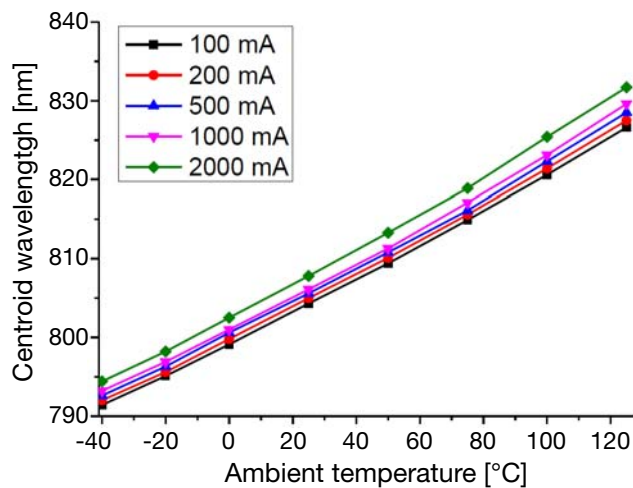
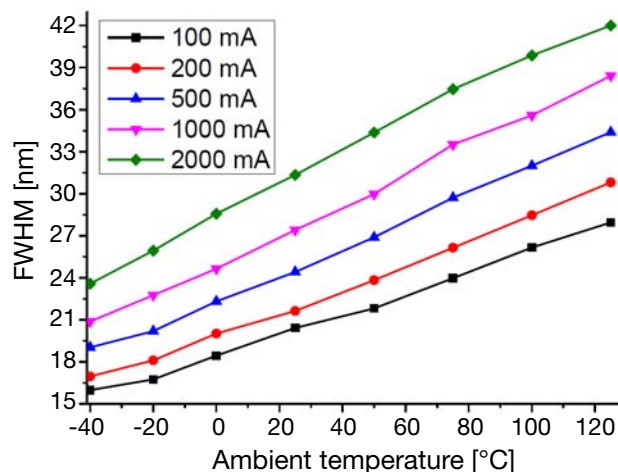
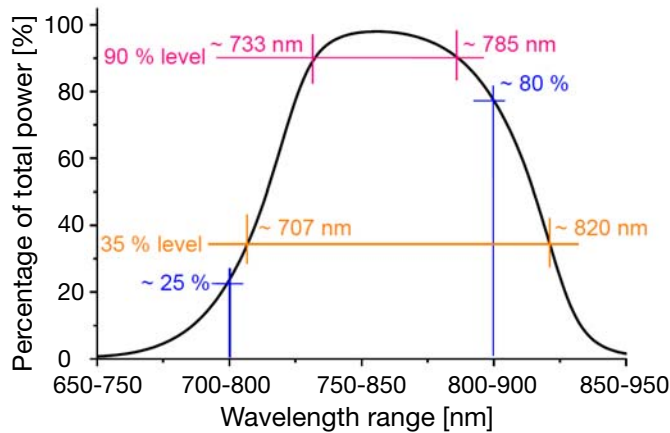


Figure 6: Dependence of the FWHM on ambient temperature and drive current. Operating condition is a single 1  $\mu\text{s}$  pulse. The “harder” the IR-LED is driven the broader the spectrum becomes



Although technically no longer state-of-the-art, some iris-recognition requirements have interest in the percentage of total optical power within any given 100 nm bandwidth (e.g. NIST mobileID “best practices report” (SP 500-280)). Figure 7 illustrates this data for a centroid wavelength of 810 nm. At least 35 % of the total power per 100 nm wide subband are within 707 nm / 807 nm up to 820 nm / 920 nm range.<sup>1</sup>

Figure 7: Percentage of optical power within a given 100 nm wavelength range. This is for a standard SFH 4780S with centroid wavelength of 810 nm and FWHM of 30 nm. Thermal effects are not considered



As the data in Figure 7 suggests, the SFH 4780S is an excellent single emitter fit for the NIST mobileID “best practices report” (SP 500 – 280) recommendation. It is also an excellent candidate for the requirements from the Universal Identification Authority of India (UIDAI) and its requirements.<sup>2</sup>

### Optical bandpass filter

To determine the required passband of the optical bandpass filter the following typical key factors need to be considered:

- Centroid wavelength (810 nm  $\pm$ 13 nm)
- Operating condition (on-time and drive current)
- Ambient/ junction temperature
- Angular dependent shift of optical filter passband

Note that the FWHM (the actual spectral shape and width) depends on junction temperature and drive current of the IR-LED. Figure 6 in combination with Figure 6 and Figure 9 give a good indication of the basic relationships.

1. Note that the data does not include the typical manufacturing distribution ( $\lambda_{\text{centroid}} \pm 13 \text{ nm}$ ) as well as spectral changes due to ambient respectively the components junction temperature.

2. Please note that this requirements are not 100% fulfilled by the SFH 4780S. OSRAM Opto Semiconductors considers the properties of the SFH 4780S in combination with a suitable camera/ software to be superior to the UIDAI requirements.



Figure 8: Spectrum of the SFH 4780S (black line) with FWHM = 30 nm, centered around  $\lambda_{\text{centroid}}$ . Total optical power accumulated from low wavelength up to the actual filter cut-off wavelength is indicated by the dark blue line (ideal shortpass filter). The light blue line indicates the total optical power accumulated down to the actual filter cut-off wavelength (ideal longpass filter). To transmit e.g. 75 % of total optical energy an optical shortpass filter can cut-off  $\lambda_{\text{cut-off-upper}} = \lambda_{\text{centroid}} + 9$  nm (not considering filter losses)

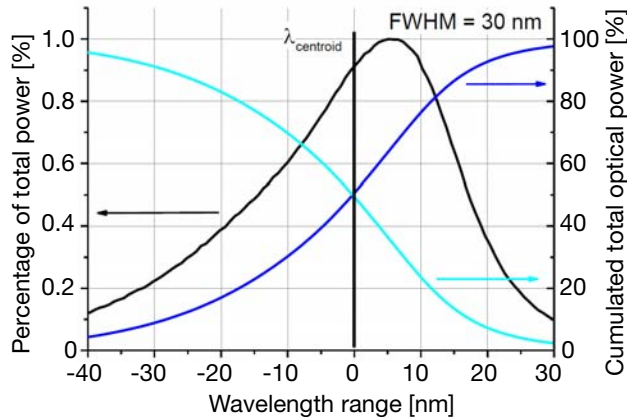


Figure 9: Spectrum of the SFH 4780S (black line) with FWHM = 42 nm, centered around  $\lambda_{\text{centroid}}$ . Total optical power accumulated from low wavelength up to the actual filter cut-off wavelength is indicated by the dark blue line (ideal shortpass filter). The light blue line indicates the total optical power accumulated down to the actual filter cut-off wavelength (ideal longpass filter). To transmit e.g. 75 % of total optical energy and optical shortpass filter can cut-off at  $\lambda_{\text{cut-off-upper}} = \lambda_{\text{centroid}} + 12$  nm (not considering filter losses)

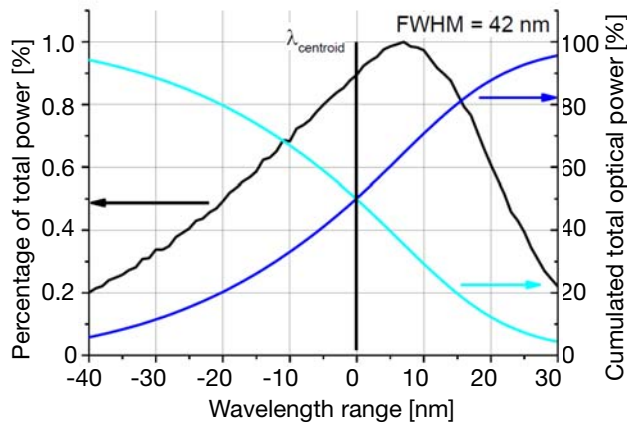
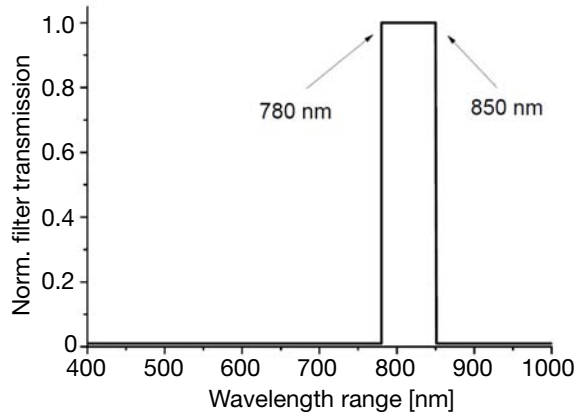


Figure 10: Optical bandpass filter for SFH 4780S with operating conditions of 1 A/ 10 ms. The design ensures that 75 % of total optical power is transmitted at the ambient temperature extremes of -20 °C and 65 °C. Note that good connection to a heat sink (low  $R_{th}$ ) is mandatory as  $T_j$  has direct influence on the passband (upper cut-off wavelength). No guardband/ angle of incidence effect considered



The following example provides a basic approach to calculate the required optical filter passband (by using the following operating condition):

- $I_F = 1$  A, 10 ms on-time with low duty-cycle  
 $T_j \sim 55$  °C (at  $T_a = 25$  °C)  
FWHM  $\sim 30$  nm (at  $T_a = 25$  °C)
- $T_a = -20$  °C...+ 65 °C
- good heat sink (low  $R_{th}$ )
- $TC_\lambda = 0.25$  nm/K
- $TC_{I_e} = -0.3$  %/K (temperature coefficient of  $I_e$ )
- $\lambda_{centroid}$  distribution  $\pm 13$  nm
- transmission (optical bandpass filter):  
>75 % at the ambient temperature extremes (- 20 °C and 65 °C)

At - 20 °C the actual output power is increased by  $\sim 13$  % versus  $T_a = 25$  °C. Thus the required transmission at the lower cut-off wavelength needs to match > 62 % to transmit 75 % of the optical power at 25 °C. Assuming a FWHM  $\sim 25$  nm, the actual lower cut-off wavelength can be estimated to be:

- $\lambda_{cut\_off\_lower} = 810$  nm
  - 13 nm (centroid distribution)
  - 0.25 nm/K  $\cdot$  45 K (thermal shift)
  - 6 nm (cut-off to transmit > 62 %)
  - =  $\sim 780$  nm

At 65 °C ambient temperature the optical power is reduced by ~ 12 %, thus the overall required transmission at this temperature to still match 75 % overall needs to be around 87 %. By using of Figure 8 and Figure 9 (FWHM ~ 35 nm at  $T_a = 65$  °C) the upper cut-off wavelength can be estimated to be:

- $\lambda_{\text{cut\_off\_upper}} = 810$  nm
  - + 13 nm (centroid distribution)
  - + 0.25 nm/K · 40 K (thermal shift)
  - + 17 nm (cut-off to transmit > 87 %)
  - = ~ 850 nm

This results in a required filter transmission function according to Figure 10 (total passband width ~ 70 nm). For a high  $R_{\text{th}}$  connection or operation with higher duty-cycle, the IR-LED's junction might heat-up to higher degrees and subsequently the upper cut-off wavelength might be shifted to longer wavelengths by an additional ~ 10 nm (if heated up to the maximum junction temperature of 145 °C).

A derived passband specification must additionally consider the filter shift due to tilted rays hitting the filter (e.g. an angle of incidence (AOI) of  $\pm 15^\circ$  results typical in a blue shift of the filter characteristics of 15 nm).

### Eye / face illumination

The SFH 4780S features a high radiant intensity  $I_e$  combined with a narrow angular characteristic (half-angle typically  $\pm 10^\circ$ ). This feature ensures a high irradiance  $E_e$  level at the users face / eye / target.<sup>3</sup> Note that the illumination of the target is radial symmetric due to design.

Figure 11 presents graphs which indicate the irradiance distribution versus. distance between the SFH 4780S operated with 1 A / 10 ms (nominal data sheet conditions,  $I_e = 2.9$  W/sr) and a face / target. The graphs are done by averaging the  $E_e$  value over 1 cm<sup>2</sup> area.

Note that the influence of cover glasses or steering / beamshaping optics is not considered here.

### Thermal consideration

The SFH 4780S features a low  $R_{\text{th}}$  package.

However, to utilize the full potential of the device, especially under high duty cycle respectively DC operation, requires some good thermal management.

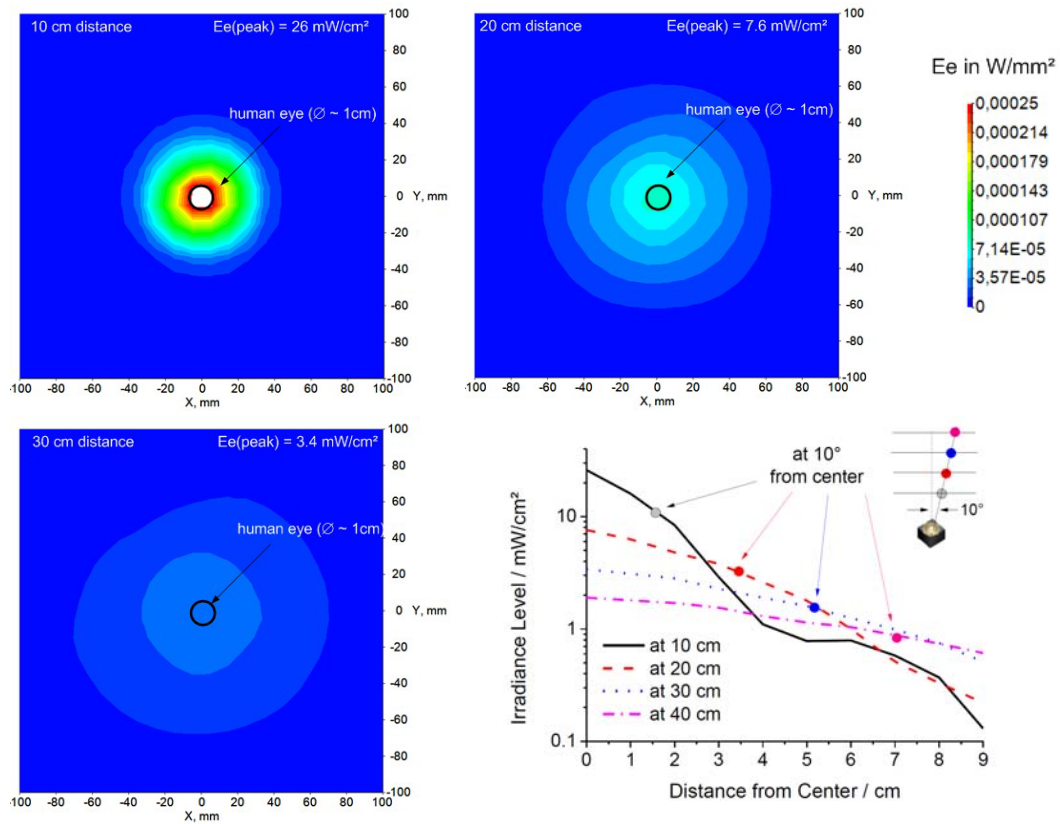
The typical heat transfer time from junction-to-solder-point is in the range of between 1 ms to below 10 ms. Thus for pulses > 10 ms or shorter pulses with high duty-cycle a good thermal heat buffer is recommended. Practical solutions

3. Please note that the testing procedure of the SFH 4780S is done to mimic the application: For IE test a circular detector with diameter of 1.12 cm is located in 31.6 cm distance (0.001 sr measurement). This setup is in excellent agreement with the typical iris scanning application.

might feature a direct connection between the PCB where the SFH 4780S is mounted on and the metal frame of the mobile housing or other metal structure to support the heat transfer to the ambient. This is especially important as otherwise an increased junction temperature might require to limit the maximum drive current at higher ambient temperatures. In addition an increased junction temperature automatically leads to a reduced optical output power vs. time (at a given drive current).

Figure 11: Irradiance distribution of a target at different distances (10 cm, 20 cm, 30 cm, 40 cm). The simulation is based on an  $I_e$  value of the SFH 4780S of 2.9 W/sr.

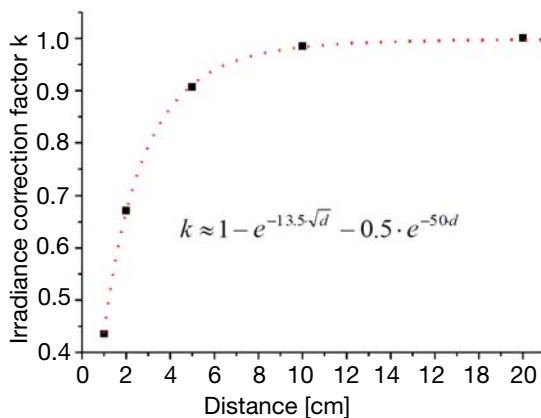
The calculated irradiance level is averaged over an area of 1 cm<sup>2</sup> (i.e. not presenting the absolute peak irradiance). Additionally a typical eye diameter of 1 cm is indicated within the graphs



### Red glow

During high-power operation, dependent on the drive mode (pulse-on time, duty cycle), the radiation of the IR-LED might be visible during operation. Depending on the individual user this can be observed as a dark red glowing of the device. During iris recognition this can be used as an indicator that the system works. Additionally it gives the user some idea where to focus his eyes in order to improve the overall system performance. Note that placing the IR-LED behind cover glasses or special optical bandpasses (inks, filters) does not change this user experience significantly.

Figure 12: Irradiance correction coefficient k vs. viewing distance for the SFH 4780S



### Eye safety

For the SFH 4780S used for iris recognition the IEC-62471 standard is relevant.<sup>4</sup> In general three exposure limits are given for IR-A radiation:

- infrared radiation hazard exposure limits for the eye (cornea)
- thermal hazard exposure limit for skin ( $t < 10$  s)
- retinal hazard exposure limit

To calculate the irradiance for any given distance  $d$  equation 2 can be used:

$$E_e = k \cdot \frac{I_e}{d^2} \quad (2)$$

Note: The distance dependent irradiance correction factor  $k$  in equation 2 is  $k \sim 1.0$  for distances  $> 5$  cm from the SFH 4780S top surface. For distances below 5.0 cm the correction factor is  $k < 1.0$  (see Figure 12). Empirically  $k$  can be expressed as (for the SFH 4780S):

$$k \approx 1 - e^{-13,5 \cdot \sqrt{d}} - 0,5 \cdot e^{-50 \cdot d} \quad (3)$$

For repetitively pulsed IR-LEDs the weighted radiant exposure  $E_{e,time,avg}$  ( $t_{avg,max} = 0.25$  s) shall be compared with the continuous wave exposure limits (EL) by using the time averaged values of the pulsed emission as long as  $E_e$  of the single pulse does not exceed any limit on its own.

$$E_{e, avg} = E_{e, pulse} \cdot D = E_{e, pulse} \cdot \frac{t_{pulse}}{t_{period}} \quad (4)$$

4. Please note that the following discussion is based on  $T_a = 25$  °C. At lower temperatures the limits can be higher, please refer to the IEC-62471 standard.

With  $D$  as the duty cycle,  $t_{\text{pulse}}$  as the pulse on time and  $t_{\text{period}}$  the repetition time ( $t_{\text{period,max}} = 250$  ms). To consider the nearest distance the following extract from [4] might be helpful:

*“For analysis of the retinal exposure for small sources, such as a small diameter optical fiber, the closest distance at which the human eye can sharply focus is about 100 – 200 mm. A viewing distance of 100 mm requires extreme near-point accommodation and really applies only to small children and to very myopic individuals. Therefore, 100 mm viewing distance is generally only applied for worst-case assessment of pointsource divergent beam lasers. For evaluation of both the retinal thermal hazard and the blue-light photochemical hazard, a closest viewing distance of 200 mm from the source can be assumed to represent the worst-case exposure. At shorter distances, the image of a light source would be out of focus and blurred. In most situations, such short viewing conditions are unrealistic. A 20 cm worst case assessment distance is realistic for conventional lamp sources (including LEDs).”*

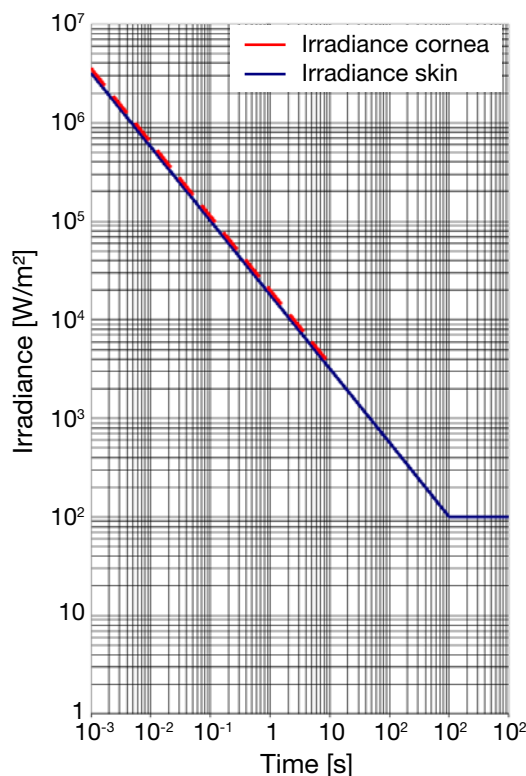
### Cornea limit

The IEC-62471 standard defines the irradiance limit  $E_{e,\text{lim}(\text{cornea})}$  for the cornea exposure as (valid for exposure times  $t \leq 1000$  s).

$$E_{e,\text{lim}(\text{cornea})} \leq 18000 \cdot t^{-0,75} \cdot \frac{W}{m^2} \quad (5)$$

Figure 13 presents the irradiance exposure limits for the cornea limit case.

Figure 13: Irradiance exposure limits as a function of exposure time (cornea, skin)



- **Example 1:** SFH 4780S biased with 500 mA (DC) for 9 s, assuming  $I_e = 2.2 \text{ W/sr}$  (estimated maximum  $I_e$  level at 500 mA). According to equation 5 / Figure 13  $E_{e,lim(\text{cornea})} = 3464 \text{ W/m}^2$ . This level is reached at a distance from the SFH 4780S of around 2.5 cm (considering the correction factor  $k = 0.75$ , the actual  $E_e$  level at 2.5 cm is 25 % below this limit, resulting in an actual eye safe threshold of around 2.0 cm (not considering any optics / cover glass which cause additional losses).
- **Example 2:** SFH 4780S biased with 500 mA, 50 ms pulse-on time ( $I_e = 2.2 \text{ W/sr}$ ), four pulses per second, and total operating time of 9 s. The limit according to equation 5 / Figure 13 once again is  $3464 \text{ W/m}^2$ . At a distance of 2.5 cm  $E_{e,avg}$  is around  $528 \text{ W/m}^2$  (with  $k \sim 0.75$ ). At 0.6 cm distance ( $k \sim 0.28$ ) the  $E_{e,avg} = 3409 \text{ W/m}^2$ , thus reaching the limit concerning eye safe operation.

### Skin limit

Compared to the cornea limit this case can be neglected as the limits for skin are more relaxed. However, it might be possible to get in direct contact with the light source. In this case, the skin is only irritated at a small spot (typ.  $\varnothing \sim 3 \text{ mm}$ ). Additionally, heat transfer inside the skin due to perfusion and the cooling effect from a cover glass might prevent the skin from reaching the critical temperature (e.g.  $47 \text{ }^\circ\text{C}$  for 10 s [2]) at all. For reference, the limit in equation 6 is valid for exposure times  $\leq 10 \text{ s}$  only (as the impact of longer exposure times is sensed by humans and lead to a turn-away reaction).

$$E_{e, lim(\text{skin})} = 20000 \cdot t^{-0,75} \cdot \frac{W}{m^2} \quad (6)$$

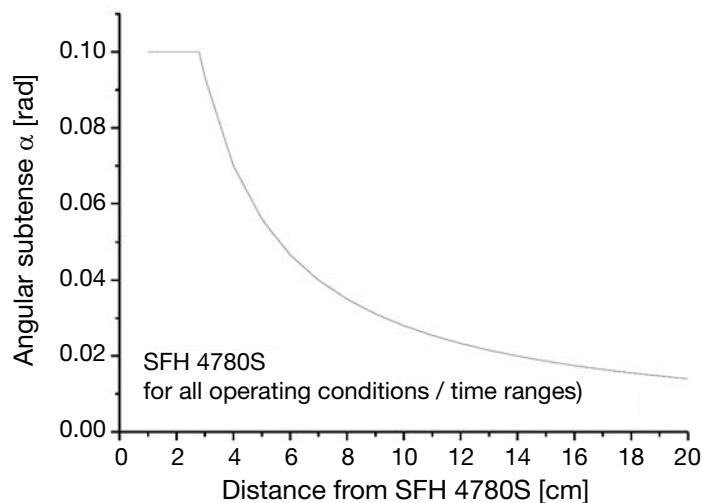
### Retina limit

To get a better understanding on the limits concerning the retina some pre-considerations need to be taken. To calculate the radiance of the SFH 4780S the following equation 7 can be used:

$$L_e \approx \frac{I_e}{Z^2} = \frac{I_e}{(2,8 \text{ mm})^2} \quad (7)$$

with  $Z$  as the mean source extension (i.e. virtual emitter size). For the SFH 4780S the virtual emitter size can be estimated to be around  $Z \sim 2.8 \text{ mm}$  (by applying the law of the conservation of the radiance, IEC 62471-2). An additional parameter,  $\alpha$  (in rad), the angular subtense, can be calculated by

$$\alpha = \frac{Z}{d} \approx \frac{2,8 \text{ mm}}{d} \quad (8)$$

Figure 14: Angular subtense index  $\alpha$  versus viewing distance from SFH 4780S.

In any way, the upper limit of  $\alpha = 0.1$  rad.

As the thermal stress depends on the wavelength, the so-called burn-hazard weighting function  $R(\lambda)$  is defined as:

$$R(\lambda) = 10^{[(700 - \lambda)/500]} \quad (9)$$

for the SFH 4780S  $R(\lambda)$  becomes

$$R_{SFH4780S}(810\text{ nm}) \approx 0,6 \quad (10)$$

Finally, the actual burn-hazard weighted radiance level  $L_R$  from the SFH 4780S can be calculated to be:

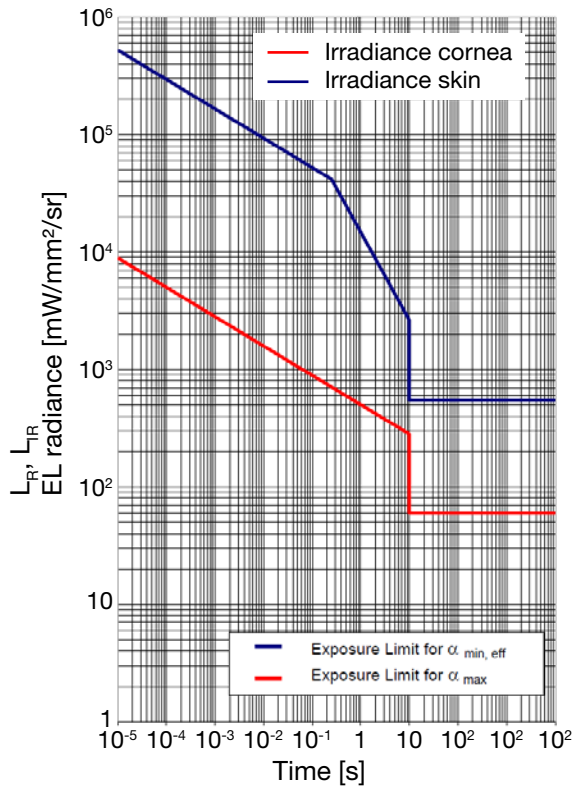
$$L_R = \sum_{\lambda = 300\text{ nm}}^{1400\text{ nm}} L_{\lambda} R(\lambda) \cdot \Delta\lambda \approx L_e \cdot R(\lambda) = \frac{0,6 \cdot I_e}{(2,8\text{ mm})^2} \quad (11)$$

At last,  $L_{R,lim}$ , the retinal thermal hazard exposure limit (EL) for exposure is defined as:

$$L_{R,lim}(\leq 10\text{ sec}) \leq \frac{(50000\text{ W})/m^2/sr}{\alpha \cdot t^{0,25}} \quad (12)$$



Figure 15: Exposure limit ( $L_R$ ) versus exposure time (retina) for different angular subtens ( $\alpha_{max} = 0.1 \text{ rad}$ ,  $\alpha_{min}$  according to IEC-62471)



$$L_{R, lim}( > 10 \text{ sec} ) \leq \frac{(6000 \text{ W}) / \text{m}^2 / \text{sr}}{\alpha} \quad (13)$$

- Example 1:** SFH 4780S biased with 500 mA (DC) for  $t = 9 \text{ s}$ , assuming  $I_e = 2.2 \text{ W/sr}$  (estimated maximum  $I_e$  level at 500 mA). The limit according to equation 12 ( $\alpha = 0.1 \text{ rad}$ , for distances  $< 2.8 \text{ cm}$ ) is  $288.7 \text{ kW}/(\text{m}^2\text{sr})$ . This compares favorably to the actual  $L_R = 168 \text{ kW}/(\text{m}^2\text{sr})$  from to equation 11. This essentially means that this operating condition is eye safe concerning the retina case.
- Example 2:** SFH 4780S biased with 500 mA, 50 ms pulse-on time ( $I_e = 2.2 \text{ W/sr}$ ), four pulses a second, and total operating time of 9 s. The limit according to equation 12 (with  $\alpha = 0.1 \text{ rad}$  at  $< 2.8 \text{ cm}$  distance) is  $288.7 \text{ kW}/(\text{m}^2\text{sr})$ . Comparing this with the actual average radiance of  $34 \text{ kW}/(\text{m}^2\text{sr})$  indicates that this operating condition causes no harm to the human retina.

**General considerations**

As seen, eye safety can be a concern for this kind of high-power, high-radiant intensity devices. However, certain operating conditions (drive current, pulse width, duty cycle) and the use of cover glasses / optics in front of the SFH 4780S

might alter the overall radiation level in a way that it complies with the IEC-62471 standard.

In case eye safety is a concern it is recommended to use a proximity sensor, e.g. SFH 7776 or directly the SFH 4780S in connection with e.g. SFH 7771 to ensure that the high-power operation of the IR-LED is disabled / reduced to reasonable levels in case “something” is close to the SFH 4780S. In this context one might highlight again the fact that for the retinal exposure case the human eye is not able to focus on elements as close as 1 cm [2].

Please note that eye safety classification of the final product, using IR-LEDs, is the responsibility of the final equipment manufacturer. In doubt, consult specialists to ensure eye safety in the application.

For further details on this topics please refer to the OSRAM Opto Semiconductors application note “[Eye safety of IREDS used in lamp applications](#)” and the relevant local standards.

## C. Summary

The SFH 4780S is a component specially designed to optimize iris recognition systems. The high-power, narrow-angle features make the SFH 4780S ideally suited for the next generation of mobile devices as it unifies compact design and high performance for maximum user experience.

## D. Literature

- [1] John Daugman, “How iris recognition works,” IEEE Trans. on Circuits and Systems for Video Technology, 14(1): 21–30, January 2004.
- [2] Intl. Commission on Non-Ionizing Radiation Protection (ICNIRP), “ICNIRP GUIDELINES ON LIMITS OF EXPOSURE TO INCOHERENT VISIBLE AND INFRARED RADIATION,” Health Physics, 105(1):74-96; 2013.
- [3] Intl. Commission Standard, “Information technology – Biometric data interchange formats – Part 6: Iris image data,” 2nd Ed.; ISO/IEC 19794-6:2011(E); 2011.



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OSRAM, Munich, Germany is one of the two leading light manufacturers in the world. Its subsidiary, OSRAM Opto Semiconductors GmbH in Regensburg (Germany), offers its customers solutions based on semiconductor technology for lighting, sensor and visualization applications. OSRAM Opto Semiconductors has production sites in Regensburg (Germany), Penang (Malaysia) and Wuxi (China). Its headquarters for North America is in Sunnyvale (USA), and for Asia in Hong Kong. OSRAM Opto Semiconductors also has sales offices throughout the world. For more information go to [www.osram-os.com](http://www.osram-os.com).

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