SFH 7773
(IR-LED + Proximity Sensor + Ambient Light Sensor)

Application note preliminary

1. Introduction

The SFH 7773 combines a digital ambient light sensor and a proximity sensor (emitter + detector) within one package. Additionally the sensor provides an I^2C-bus interface and an interrupt pin to connect it to an e.g. microcontroller.

This application note describes the basic technical features and the components operation, allowing the user to achieve the full functionality of the sensor. At the end a simple software code illustrates an example for the implementation of the SFH 7773 into a mobile phone environment.
Please note that this guide is only a brief introduction. For more detailed information and the latest products and updates please visit www.osram-os.com or contact your local sales office to get technical assistance during your design-in phase.

2. Applications

Typical application areas are mobile phones, PDAs, notebooks, cameras and other consumer products. Common tasks for the integrated ambient light sensor are display brightness adjustments, whereas the proximity sensor is usually employed to detect objects and motions. This single component integrates several distinct functionalities and greatly simplifies the design-in process in consumer as well as industrial applications. The dark black look of the SFH 7773 makes it ideally suitable for implementation behind a cover glass.
The ultra-low power consumption of the SFH 7773 makes the devices especially suited for mobile applications, where conservation of battery power is a critical point.

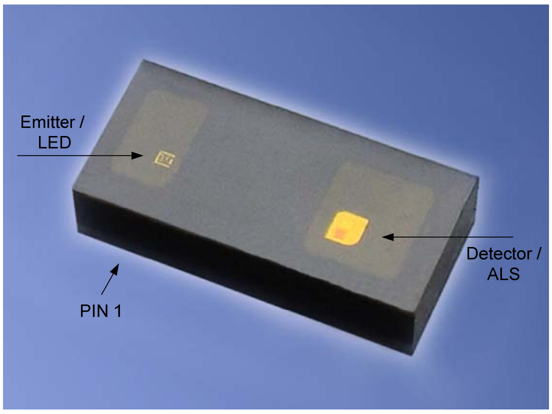


Fig. 1: Photography and orientation of the SFH 7773.

3. The SFH 7773

The SFH 7773 (see Fig. 1) consists of an 850 nm infrared (IR) LED and an ultra-low power ASIC which performs the signal processing and provides the I^2C-bus interface as well as an interrupt alert function. Additionally the ASIC contains the two photodiodes for proximity resp. ambient light sensing. The functional block diagram can be found in Fig. 2. The pinning of the devices is stated in Tab. 1. The key features of the SFH 7773 include:

Proximity Sensor (PS)
- detection-range up to 150 mm
- optimized for the integrated 850nm emitter
- superior ambient light suppression (> 50 klx)
- immunity to crosstalk
- fast access to PS signal
- high power (stacked) emitter version for extended detection range are available on request

Ambient Light Sensor (ALS)
- 0.03 lx – 65 000 lx
- excellent linearity

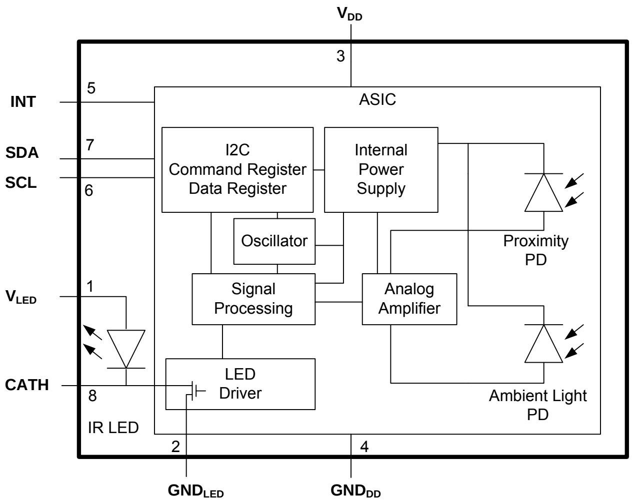


Fig. 2: SFH 7773 functional block diagram.

Pin No.	Pin Label	Description
1	V_{LED}	LED Supply Voltage
2	GND_{LED}	Ground V_{LED} - LED Driver
3	V_{DD}	Digital Supply Voltage
4	GND_{DD}	Ground (Digital)
5	INT	Interrupt Pin
6	SCL	I^2C-Bus Clock Line
7	SDA	I^2C-Bus Data Line
8	CATH	Must not be Connected

Tab. 1: Pin configuration of the SFH 7773

- spectral sensitivity to mimic the human eye (V-lambda)

I^2C-Bus Interface
- Slave Address 0111 000X
- 100kHz / 400kHz and 3.4MHz mode
- programmable operation modes (*stand-by, triggered, free-running*)
- low current consumption (< 5µA) in *stand-by* mode
- configurable interrupt output with programmable threshold levels for PS and ALS

4. Ambient Light Sensor

The ambient light sensor is intended to provide ambient light measurement, e.g. to control and adjust the display brightness. To support this functionality the SFH 7773 provides a convenient user interface.

The ambient light sensor delivers output values in the range from 0 to 65535 (16 bit). Low output values correspond to a low illumination of the sensor, while high values indicate high illumination. The range of the ambient light sensor sensitivity can be set by the user and covers more than 4 ½ decades. Two threshold levels for the ambient light sensor can be set via the I^2C-bus, a lower and an upper threshold. In the case of exceeding these thresholds an interrupt is generated automatically, allowing e.g. the microcontroller to act accordingly (see Sec. 8.3 for the relevant registers and settings).

4.1 Spectral Sensitivity of the ALS

The human eye's wavelength range of significant sensitivity is between 400 nm and 700 nm with its peak at around 555 nm (often called V-lambda characteristic).
The spectral sensitivity of the SFH 7773 aims to mimic the sensitivity of the human eye as close as possible and provides a real improvement compared to standard silicon-photodetectors (see Fig. 3).
Fig. 4 compares the ALS count readings with different light sources and relates them to the human eye sensitivity (V-lambda), assuming the same illuminance value. Values are normalized to the standard light source A (2856 K). Due to the high IR and UV suppression the sensor shows only minor deviation compared to the perception of the human eye for different light sources. Please note that the use of coloured cover glasses might influence the accuracy, depending on the spectral transmission characteristics (visible plus infrared range) of the cover glasses.

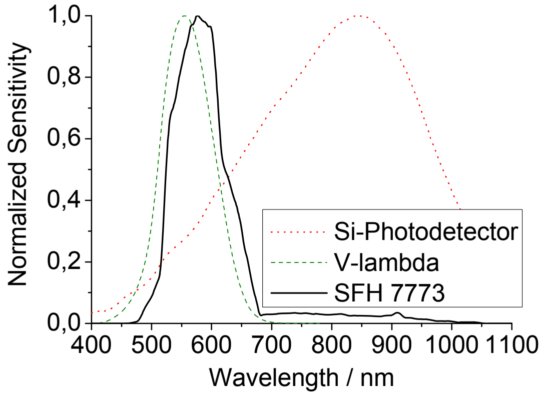


Fig. 3: Spectral sensitivity of the SFH 7773 vs. the human eye (V-lambda) and standard Si-photodetectors.

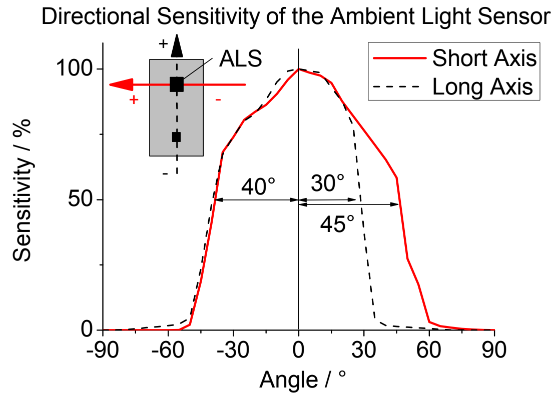


Fig. 5: Directional characteristics of the ambient light sensor.

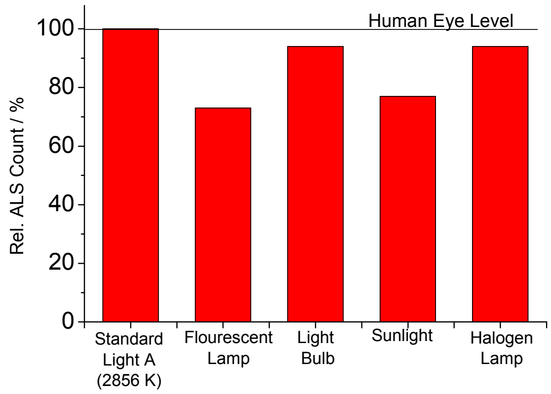


Fig. 4: Ambient light sensor accuracy vs. different light sources. Normalized to 100 lux and standard light A.

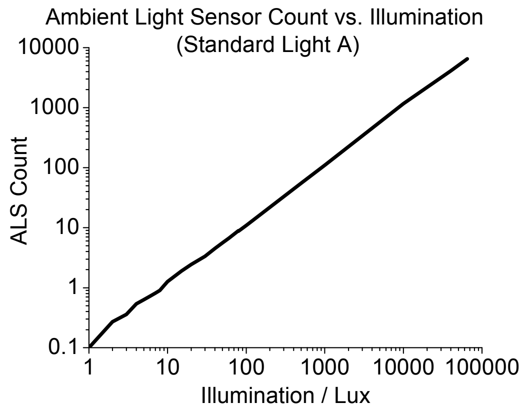


Fig. 6: Ambient light sensor count vs. illumination (integration time = 100 ms).

t_{int}	ALS Range	ALS Resolution
10 ms	3.0 lx - 65535 lx	1.00 lx/count
20 ms	1.5 lx - 32767 lx	0.50 lx/count
50 ms	0.60 lx - 13106 lx	0.20 lx/count
100 ms	0.30 lx - 6553 lx	0.10 lx/count
200 ms	0.15 lx - 3277 lx	0.05 lx/count
500 ms	0.06 lx - 1311 lx	0.02 lx/count
1000 ms	0.03 lx - 655 lx	0.01 lx/count

Tab. 2: ALS integration time settings t_{int} and their relation to ALS range and resolution (default: t_{int} = 100 ms).

4.2 Directivity of the ALS

Fig. 5 presents the directivity of the ALS. This is an important point for considering the design of a potential cover glass (please refer to Sec. 10.1 for more details).

4.3 Sensitivity Range of the ALS

The range of the ALS can be programmed by the user via the ALS integration time (register 0x26). Per default (integration time = 100 ms) the range covers 0.3 lx to 6.5 klx with a resolution of typ. 0.1 lx/count. A doubling of the integration time changes the sensitivity range by a factor of two. Please

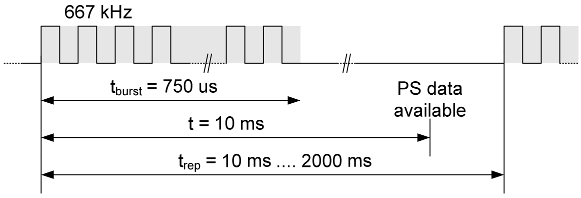


Fig. 7: LED drive current and timing during one proximity measurement cycle (PS integration time t_{burst} is set to 750 us).

refer to Tab. 2. Also note: To access the ALS integration time register (0x26) the integration time access register (0x20) has to be set accordingly.
Please note: To achieve flicker-free measurements (e.g. 50 / 60 Hz driven light bulbs) integration times with a multiple of 50 ms are recommended (i.e. 50 ms, 100 ms aso.). By choosing 10 ms or 20 ms OSRAM recommends averaging several measurements to achieve flicker-free ALS values.

4.4 Output Count and Linearity of the ALS

The sensors output count is linear vs. the illumination level E_V over a wide range (see Fig. 6). This conversion between the ALS count and the illumination is typ. 0.1 lx/count (standard light A) for the default ALS integration time of 100 ms (please refer to Tab. 2 for different ALS integration time settings). For an exact absolute calibration it is recommended that the user performs a measurement within the application for each device. Deviation from the linearity is usually within ± 5 % (normalized to 100 lx).

5. Proximity Sensor

The proximity sensor delivers output values within the range from 0 up to 254 (8 bit, pseudo-logarithmic). Low output values correspond to low irradiance of the sensor, while high values indicate high irradiance. A threshold level for an interrupt alert can be set via the I2C-bus (see Sec. 8.3 for the relevant registers and settings).

5.1 Functionality of the PS

To achieve the outstanding high ambient light suppression, the SFH 7773 uses 667 kHz LED bursts with a programmable duration (default value of the PS integration time t_{burst} is 750 us). The PS integration time can be set via register 0x27 (please refer to Sec. 8.3 for details). Fig. 7 illustrates the burst signal during a complete measurement cycle. After the initial e.g. I^2C-bus triggered request, the proximity data are available after 10 ms. Measurement repetition time in the free running mode can be selected between 10 ms and 2000 ms. The proximity measurement operates at 850 nm.

5.2 Proximity Count and Detection Range

The maximum switching range depends – among target properties like size and reflectivity - on the IR-LED pulse current in combination with the setting of the PS integration time t_{burst}. To reach a maximum detection range the recommended values are for the LED drive current are 100 mA, 150 mA or 200 mA with a PS integration time t_{burst} of 750 us or 1000 us. Fig. 8 and 9 present the proximity values vs. target distance for a 100 x 100 mm^2 Kodak White (90 %) target (no cover glass). As indicated by Fig. 8 and 9 the typ. maximum detection range for the SFH 7773 is in the range of up to 100 mm (by using 200 mA LED current and a PS integration time of 750 us – 1000 us and setting a threshold level for the interrupt alert at 80 - 100 counts). However, OSRAM recommends for the SFH 7773 to set the threshold level not below 80 counts to avoid interference with noise.

As a general rule OSRAM recommends for a robust design the setting of the threshold levels to be up to around 10 times above any noise level. The factor 10 corresponds to around 60 counts in PS signal due to the pseudo-logarithmic relationship.

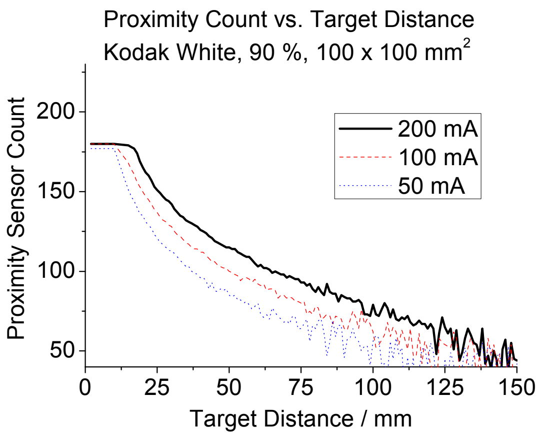


Fig. 8: Proximity sensor signal count vs. target distance and LED drive current (integration time t_{burst} = 750 us).

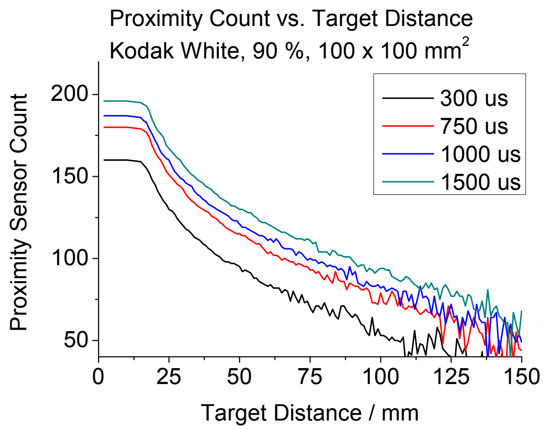


Fig. 9: Proximity sensor signal count vs. target distance and integration time (LED drive current = 200 mA).

As a rule of thumb, 30 counts result in almost a quadrupling in irradiance (PS signal level) whereas 10 counts represent roughly a factor of 1.55 in analog signal level.

The digital proximity count signal is correlated to the detected irradiance E_e. There is an approximate logarithmic relationship between the digital PS signal the analog signal level (irradiance):

$$E_e \approx \left(10^{0.017\cdot counts+0.11-370.4\frac{1}{s}\cdot t_{burst}}\right)\frac{\mu W}{cm^2} \quad \text{Eq. (1)}$$

The sensor's design ensures that a touch of human skin directly onto the sensor (no airgap) delivers the maximum sensor count (which depends on LED drive current and integration time). This ensures that even in this rare case a reliable operation is ensured.

5.3 Radiation Characteristics of the PS-LED

Fig. 10 presents the radiation characteristics of the IR-LED. The characteristics might influence the design of the cover glass (aperture). The directional sensitivity of the proximity sensor photodiode (detector) is

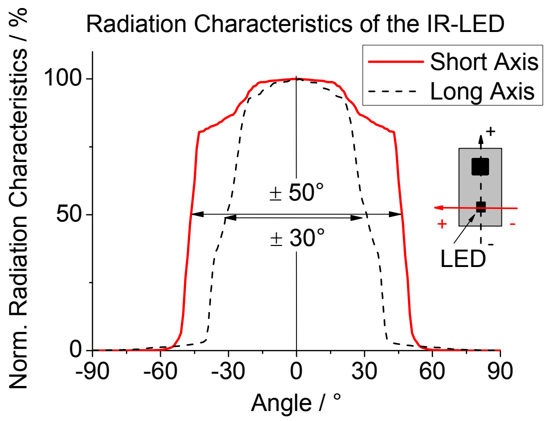


Fig. 10: Radiation characteristics of the proximity sensor LED.

very similar to the emitter's radiation characteristics.

Please refer to Sec. 10.1 for a more detailed discussion.

5.4 Crosstalk

In general, most proximity sensors are hidden behind a cover glass. However, the cover glass causes reflections which might make it impossible for the sensor to differentiate between a target reflection (e.g. human skin) and the reflections from the

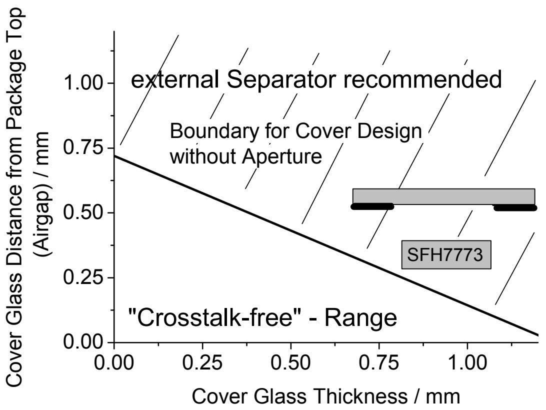


Fig. 11: Crosstalk-free range: Cover glass thickness vs. airgap. The device is "crosstalk-free" for e.g. 0.2 mm cover glass and an airgap of 0.5 mm. To achieve optimized performance a two-hole aperture design is recommended (see Fig. 12).

cover glass. A common and proven solution is the use of an external separator to avoid the reflections from the cover glass. However, such a separator causes additional design-in effort.

Due to its design the SFH 7773 is crosstalk-insensitive for a range of typical applications. Fig. 11 and 12 present this range as a function of cover glass thickness vs. the spacing between the bottom of the cover glass and the SFH 7773 (airgap). Typical applications where the SFH 7773 works without an external separator are e.g. 0.8 mm cover glass and an airgap of 0.7 mm. Note that the crosstalk-free range depends on the actual design of the cover glass aperture. To utilize the full potential of the SFH 7773 it is recommended to use an aperture design within the cover glass (please refer to Sec. 10.1 for more details). Beyond the "crosstalk-free" indicated area a separator is recommended. In any case it is recommended to verify the actual design. Please note that beyond the proposed "crosstalk-free"-range the sensor works as well, but might experience a certain offset-level, dependent, among other issues, on the type of glass. Please note that coloured (dark) cover glasses might reduce the "crosstalk-free"-range, depending on the type/quality of the cover glass. Experimental verification of the behaviour is mandatory here.

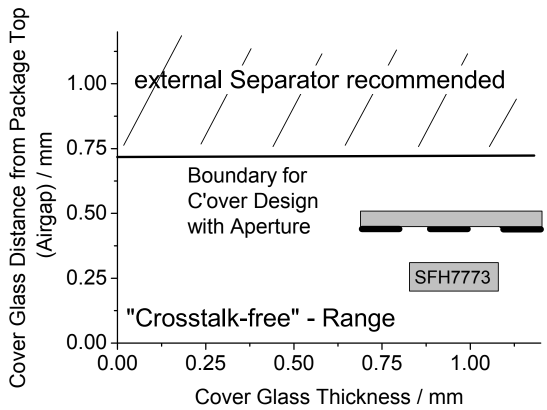


Fig. 12: Crosstalk-free range: Cover glass thickness vs. airgap. The device is "crosstalk-free" for e.g. 1.0 mm cover glass and an airgap of 0.7 mm.

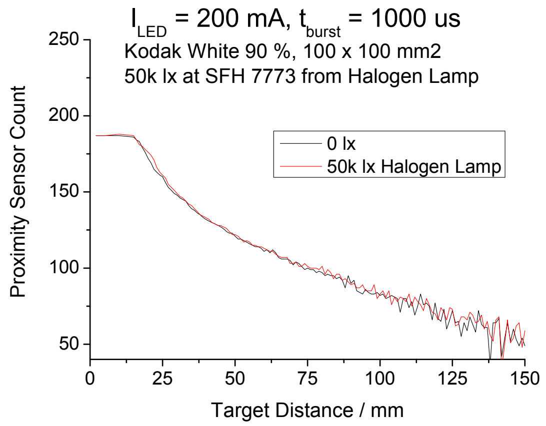


Fig. 13: Proximity signal in different ambient light conditions. Even in a high brightness environment (50k lx on SFH 7773, I_{LED} = 200 mA) the sensor shows no significant changes.

5.5. Ambient Light Suppression of the PS-Signal

Due to its design the SFH 7773 features an excellent immunity of the proximity measurement against even ultra-high

Mode	Bit Rate
Standard mode (Sm)	$\leq$ 100 kbit/s
Fast mode (Fm)	$\leq$ 400 kbit/s
High speed mode (Hs)	$\leq$ 3.4 Mbit/s

Tab. 3: The I^2C-bus protocol speed mode compatibility of the SFH 7773.

ambient light levels. Fig. 13 demonstrates this outstanding feature. Even in environments of 50 klx the proximity signal is completely unaffected (refer to Fig. 13) by even illumination with a halogen lamp which contains a high level of IR radiation.

6. Current Consumption

The following equations give an idea on the total power consumption of the SFH 7773 during operation.

By operating the PS in the free-running mode, the current consumption (including LED current, I_{LED}) can be approximated by the following Eq. (depending on the measurement interval time t_{rep_PS} and the PS integration time t_{burst}):

$$I_{AVG\_PS} = 0.5 \cdot t_{burst} \frac{(I_{LED} + 100mA)}{t_{rep\_PS}} \qquad \text{Eq. (2)}$$

The current consumption during operation of the ALS depends on the ALS integration time t_{int} as well as the repletion time t_{rep_ALS} can be approximated by:

$$I_{AVG\_ALS} = 1mA \cdot \frac{t_{int}}{t_{rep\_ALS}} \qquad \text{Eq. (3)}$$

Example for total PS current consumption:
I_{LED} = 100 mA, t_{burst} = 300 us and t_{rep} = 100 ms => I_{AVG_PS} = 300 µA.

This compares to a stand-by current consumption of less than 5 µA (typ. 2-3 µA).

7. Operating Modes

The SFH 7773 can be operated in three different modes, in which the proximity resp. the ambient light function can be used independently from each other. The three basic modes are:

free-running: The sensor measures continuously and writes the results into the relevant registers, ready to be read via the I^2C-bus interface. Optionally the interrupt alert function with the user-defined threshold levels (PS and/or ALS) will be executed if such an event takes place.
triggered: The measurements are initiated via I^2C-bus instruction. Data are available after processing is finished (10 ms total delay time for PS, 100 ms for ALS).
stand-by: The initial state after power-up. The SFH 7773 is in low power mode (I_{DD} < 5 µA), no operations are carried out, but the device is ready to respond to I^2C-bus commands.
additionally, there is the off-state:
off: The SFH 7773 is inactive, supply current is below 2 µA. The SDA, SCL and INT pins are in Z-state (high impedance). All register entries are reset to the default values.

The transition time between the modes, t_{trans}, is < 10 ms. The delay time between standby and start of measurement is < 10 ms. The voltage V_{DD} to switch the SFH 7773 into the off-state is < 1.4 V. To reach the stand-by mode at least 2.0 V are required.

8. I^2C – Bus Communication

The address of the SFH 7773 is 0x38.

8.1 I²C - Bus Environment

The SFH 7773 is a digital ambient light and proximity sensor. The communication is performed via a 2-wire I²C bus interface, so the device can be integrated into a typical multi-master / multi-slave I²C bus environment. A typical I²C bus network consists of a master and different I²C bus slave devices. For a more detailed discussion on the topic of I^2C-bus please refer to [2].

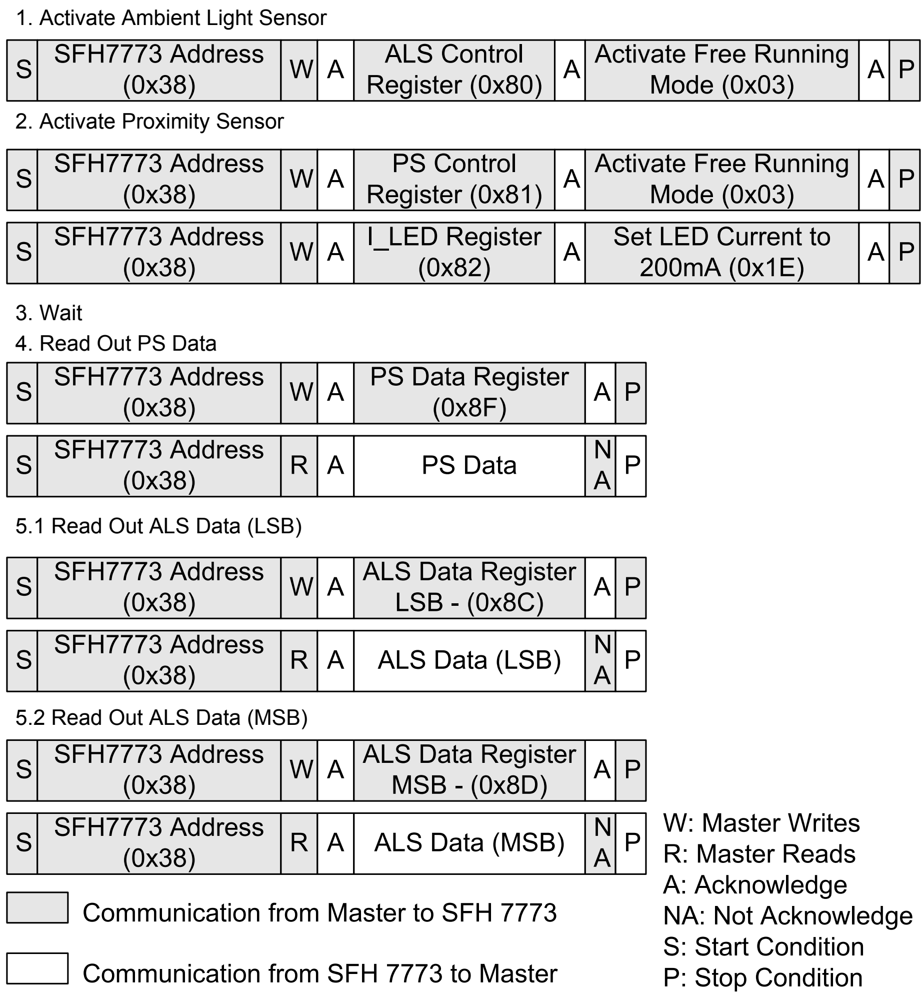


Fig. 14: I^2C-bus communication for the example described below.

The built-in I^2C-bus interface is compatible with all common I^2C-bus modes (see Tab. 3). The logic voltage (V_{IO}) of the SFH 7773 ranges from 1.6 V – 2.0 V (according to I^2C-bus specification [2]).

8.2 I²C - Bus Communication

By embedding the SFH 7773 in an I²C-bus network and after applying V_{DD} = 2.5 V, the communication can start as follows (Fig. 14 illustrates this I²C-bus conversation):

1. Activation of the ALS:
The default mode of the sensor is STAND-BY and the SFH 7773 needs to be activated by the master (e.g. microcontroller).

Each I²C bus communication begins with a start command “S” of the Master (SDA line is changing from “1” to “0” during SCL line stays “1”) followed by the address of the slave (SFH 7773 address is 0x38). After the 7bit slave address the read (1) and write (0) R/W bit of the master will follow. The R/W bit controls the communication direction between the master and the addressed slave. The slave is responding the proper communication with an acknowledge command. Acknowledge “A” (or not acknowledge “NA”) is performed from the receiver by pulling the SDA line down (or leave in “1” state).
For the activation of the sensor the master needs to write an activation command (0x03) into the corresponding control

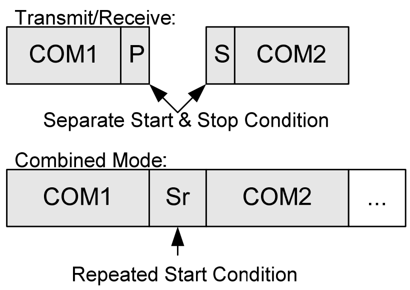


Fig. 15: Combined mode structure.

register for the ALS (0x80). Each command needs to be acknowledged by the slave. After activation the master ends the communication with a STOP command "P" (SDA line is changing from LOW to HIGH during SCL line stays HIGH). In this example the measurement interval time is kept at the default value (500 ms).

2. Activation of the PS:
For the activation of the PS sensor the master needs to write the activation command (0x03) into the corresponding control register (0x81). By writing 0x1E into the I_LED register (0x82) the LED current is set to 200 mA. The measurement interval is left at the default value (100 ms). After activation the master ends the communication with a STOP command.

3. Wait time:
After activation, the sensor will change from STAND-BY to FREE-RUNNING mode. After a delay of 100 ms for ALS / 10 ms for PS the first measurement value is available and can be read via the I²C-bus.

4. PS value: reading data
The PS value is accessible via the output register (0x8F). After reading the 8-bit word, the communication can be ended by the master with a not acknowledge "NA" and the stop command "P". The PS output reading of the SFH 7773 can then be converted from hexadecimal to decimal.

5. ALS value: reading data (LSB and MSB)
The sensor's 16bit ALS measurement value is composed of 2 bytes (LSB & MSB). The bytes are accessible via the two output registers (0x8C, 0x8D). After addressing the LSB (least significant byte) resp. the MSB (most significant byte) output register, the communication direction has got to be changed from the slave to the master by repeating the address and the R/W byte with a changed R/W bit. After reading LSB and MSB, the communication is ended by the master with a not acknowledge "NA" and the stop condition "P". The conversion of the ALS output data of the SFH 7773 from hexadecimal to decimal can easily be calculated:

ALS_DATA_LSB = F0 (1111 0000)
ALS_DATA_MSB = 83 (1000 0011)

Final result (hexadecimal): 83 F0 counts
Final result (decimal): 33776 counts, which correspond to around 30.4 klx (based on a conversion factor of typ. 0.9 lux/count).

After finishing the measurement, the SFH 7773 mode may be changed to STAND-BY via the control register.

Combined mode
To ensure interference free communication the I²C-bus combined mode should be used. Instead of performing two independent read or write commands (COM 1 & COM 2) the commands can be combined by a repeated start condition "Sr" (Fig. 15 illustrates the combined mode structure).
The start and repeated start commands ("Sr") are the same: the SDA line is changing from "1" to "0" during SCL line "1". The "Sr" condition is placed behind "A" or "NA". The combined mode is not limited to 2 read/write commands, so the addressing of the sensor and reading/writing of multiple register values can be performed within one block.

Block read mode
The Block read mode of the SFH 7773 can be used to read all output registers in cyclic manner.

I²C Addr.	Type	Name	Description
0x20	RW	INT_ACCESS	Integration time access
0x26	RW	ALS_INT_TIME	ALS integration time
0x27	RW	PS_INT_TIME	PS integration time (burst length)
0x80	RW	ALS CONTROL	SW reset , ALS operation mode control
0x81	RW	PS CONTROL	PS operation mode control
0x82	RW	I_LED	Setting LED pulse current
0x83	-	-	*not intended for use*
0x84	RW	ALS & PS TRIG	Forced mode ALS and PS measurement triggering
0x85	RW	PS INTERVAL	PS measurement rate in stand-alone mode
0x86	RW	ALS INTERVAL	ALS measurement rate in stand-alone mode
0x8A	R	PART_ID	Part number and revision IDs
0x8B	R	MAN_ID	Manufacturer ID
0x8C	R	ALS_DATA_LSB	ALS measurement data, least significant bits
0x8D	R	ALS_DATA_MSB	ALS measurement data, most significant bits
0x8E	R	ALS_PS STATUS	Status of meas. data (ALS and PS)
0x8F	R	PS_DATA	PS measurement data
0x90	-	-	*not intended for use*
0x91	-	-	*not intended for use*
0x92	RW	INT_SET	Interrupt settings
0x93	RW	PS_THR LED	PS interrupt threshold level
0x94	-	-	*not intended for use*
0x95	-	-	*not intended for use*
0x96	RW	ALS UP_THR LSB	ALS interrupt upper threshold level, least significant bits
0x97	RW	ALS UP_THR MSB	ALS interrupt upper threshold level, most significant bits
0x98	RW	ALS LO_THR LSB	ALS interrupt lower threshold level, least significant bits
0x99	RW	ALS LO_THR MSB	ALS interrupt lower threshold level, most significant bits

Tab. 4: SFH 7773 control and data registers.

After addressing and reading an output register (e.g. LSB) in normal mode, the master is not placing the stop condition, but sends an acknowledge and continues to read the output registers. The SFH 7773 will automatically increase the register address and the content of the next sensor output register can be read following the register addresses:

80→81→…→98→99→80→81→...

For register addresses and content see Sec. 8.3 and Tab. 3.

The block read mode can be ended by placing a not acknowledge (NA) with the subsequent stop condition from the master.

8.3 Registers

The SFH 7773 has 21 different registers (see Tab. 4). Additionally there are 5 more registers which are not intended to be used by the user - but they are addressed automatically by block read/write procedures.

The following pages will describe the registers and their structure resp. content.

INTEGRATION TIME ACCESS: Allows access to reg. 0x26, 0x27 (ALS_INT_TIME, PS_INT_TIME)

Note: After setting bit '0' there must be a stop condition to confirm writing. It is recommended to set the bit '0' back to '0' after the changes in the integration registers 0x26 and 0x27 have been made.

R/W-Register 0x81								
Bit	7	6	5	4	3	2	1	0
	not used							Integration Time Access:
default	XXXXXXX							0 Not Accessible
								1 Accessible

ALS INTEGRATION TIME: Ambient light measurement integration time:

The ALS integration time is responsible for setting the ALS sensitivity range and the lx/count value. An increase of the ALS integration time by a factor of 10 increases also the ALS sensitivity level by a factor of 10. The default setting of 100 ms results in a range from approximately 0.3 lx to 6553 lx with a resolution of 0.1 lx/count.

0x26 is only accessible if the access-bit in register 0x20 is set to '1'. It is recommended to set this access bit back to '0' after changes have been made. When reading or writing in block-read/-write mode, it is recommended to start at register 0x26 and stop at 0x27, as there are other registers accessible which are not intended to be accessible by the user. Afterwards set 0x20 back to '0'.

R/W-Register 0x26								
Bit	7	6	5	4	3	2	1	0
	not used					ALS INTEGRATION TIME		
default	XXXXX					**000 100 ms**		
						001 200 ms		
						010 500 ms		
						011 1000 ms		
						100 10 ms		
						101 20 ms		
						110 50 ms		
						111 50 ms		

PS INTEGRATION TIME (BURST LENGTH): Proximity measurement integration time

An increase in PS integration time results in an increased PS signal level. E.g. an increase in PS integration time by a factor of 10 increases the PS counts by around 50 counts (due to pseudo-logarithmic relationship).

0x27 is only accessible if access-bit in register 0x20 is set to '1'. It is recommended to set this access bit back to '0' after changes have been made. When reading or writing in block-read/-write mode, it is recommended to start at register 0x26 and stop at 0x27, as there are other registers accessible which are not intended to be accessible by the user. Afterwards set 0x20 back to '0'.

R/W-Register 0x27								
Bit	7	6	5	4	3	2	1	0
	not used					PS INTEGRATION TIME		
default	XXXXX					**100 750 us**		
						000 100 us		
						001 200 us		
						010 300 us		
						011 500 us		
						100 750 us		
						101 1000 us		
						110 1500 us		
						111 2500 us		

ALS CONTROL: Software reset and control of ambient light sensor

SW reset (bit #2 „1") sets all registers to default (same as POWER-UP). Afterwards it is automatically set back to „0" by the SFH7773.

R/W-Register 0x80								
Bit	7	6	5	4	3	2	1	0
	not used					complete SW reset	mode of ambient light sensor	
default	00000					0	**00 STAND-BY**	
						1 SW reset	00 STAND-BY	
							01 STAND-BY	
							10 TRIGGERED (by MCU)	
							11 FREE-RUNNING (internally triggered)	

PS CONTROL: Control of proximity sensor

R/W-Register 0x81								
Bit	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
	not used						**mode of Proximity Sensor**	
default	**XXXXXX**						**00 STAND-BY**	
							00 STAND-BY	
							01 STAND-BY	
							10 TRIGGERED by MCU	
							11 FREE-RUNNING (internally triggered)	

I_LED: Emitter (LED) current setting

R/W-Register 0x82								
Bit	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
	activation of LEDs		**Not used**			**setting LED pulse current**		
Default	**00**		**011**			**011 50 mA**		
	00 LED active					000 5 mA		
	bit #7 and #6					001 10 mA		
	must not be changed					010 20 mA		
	to other values					011 50 mA		
						100 100 mA		
						101 150 mA		
						110 200 mA		

ALS & PS TRIG: MCU-triggered measurement (for ambient light sensor and proximity sensor)

If „1“ is set a new measurement will start after I^2C stop command from MCU. As soon as the measurement is finished the corresponding bit of the register will automatically be set to „0“ by the SFH7773.

R/W-Register 0x84								
Bit	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
	not used						**trigger ambient light**	**trigger proximity**
default	**XXXXXX**						1	1

PS INTERVAL: Proximity measurement: time interval setting (repetition time) for FREE-RUNNING mode

R/W-Register 0x85								
Bit	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
	not used				**time-interval**			
default	**XXXX**				**0101 100 ms**			
					0000 10 ms			
					0001 20 ms			
					0010 30 ms			
					0011 50 ms			
					0100 70 ms			
					0101 100 ms			
					0110 200 ms			
					0111 500 ms			
					1000 1000 ms			
					1001 2000 ms			

ALS INTERVAL: Ambient light measurement: time interval setting (repetition time) for FREE-RUNNING mode

R/W-Register 0x86								
Bit	7	6	5	4	3	2	1	0
	not used					time-interval		
default	XXXXX					010 500 ms		
						000 100 ms		
						001 200 ms		
						010 500 ms		
						011 1000 ms		
						100 2000 ms		

PART_ID: Part number and revision Identification

R-Register 0x8A								
Bit	7	6	5	4	3	2	1	0
	Part number ID				Revision ID			
	1001				0100			

MAN_ID: Manufacturer Identification

R-Register 0x8B								
Bit	7	6	5	4	3	2	1	0
	Manufacturer Identification							
	0000				0011			

ALS_DATA_LSB: Ambient light measurement data (0x8C: LSB)

The result of the ambient light sensor is a 16bit word with MSB and LSB. It is stored in two registers. The binary data can be converted directly to decimal „lx“ values (max. 65535lx).

R-Register 0x8C								
Bit	7	6	5	4	3	2	1	0
	LSB data							
default	00000000							

ALS_DATA_MSB: Ambient light measurement data (0x8D: MSB)

R-Register 0x8D								
Bit	7	6	5	4	3	2	1	0
	MSB data							
default	00000000							

ALS_PS STATUS: Status of measurement data for ambient light sensor (ALS) and proximity sensor (PS)

After the measurement data is available in the register (0x8E), the corresponding statusbit (bit #6 for ALS; bit #0 for PS) is set to „1“. After data has been read by the MCU the statusbit is automatically reset to “0” by the SFH 7773.

Bit #7 is set „1“, if the measured ALS value is outside the threshold level settings (register 0x96... 0x99). Bit #1 is set to “1” if the measured PS value is above the threshold level (register 0x93). The status of register 0x8E will always be updated if new measurement data is available.

R-Register 0x8E								
Bit	7	6	5	4	3	2	1	0
	ALS Threshold	ALS data	Not used				PS LED threshold	PS LED data
default	00		0000				00	

PS_DATA: Proximity measurement data (8bit, logarithmic scale)

R-Register 0x8F								
Bit	7	6	5	4	3	2	1	0
	data							
default	00000000							

INT_SET: Interrupt register / INT output.

In bit #6 and #5 the trigger source for the last interrupt event is stated. Data from status register (0x8E) are used. In latched mode (set by bit #3) this remains unchanged until the interrupt register has been read by the MCU. Afterwards the bits are reset automatically to "0" by the SFH 7773. In unlatched mode it is updated after every measurement. The output polarity of the interrupt function can be changed by bit #2. The interrupt can be triggered by an ambient light sensor event and / or by a proximity sensor event (bit #1 and bit #0). Z-state means the output is in high-impedance state.

R/W-Register 0x92								
Bit	7	6	5	4	3	2	1	0
	not used	Interrupt trigger source		not used	Output mode	Output polarity	Interrupt mode (triggered by..)	
R/W	not used	R only		not used	R/W	R/W	R/W	
default	X	00		X	1	0	00	
		00 ALS			0 latched	0 active L	00 Z state	
		01 PS			1 not latched	1 active H	01 only PS	
		No other values allowed					10 only ALS	
							11 PS and ALS	

PS_THR LED: Threshold level for proximity sensor

RW-Register 0x93								
Bit	7	6	5	4	3	2	1	0
	data							
default	11111111							

ALS UP_THR LSB: Upper threshold level for ambient light sensor (LSB)

RW-Register 0x96								
Bit	7	6	5	4	3	2	1	0
	LSB data (upper threshold)							
default	11111111							

ALS UP_THR MSB: Upper threshold level for ambient light sensor (MSB)

RW-Register 0x97								
Bit	7	6	5	4	3	2	1	0
	MSB data (upper threshold)							
default	11111111							

ALS_LO_THR LSB: Lower threshold level for ambient light sensor (LSB)

RW-Register 0x98								
Bit	7	6	5	4	3	2	1	0
	LSB data (upper threshold)							
default	11111111							

ALS_LO_THR MSB: Lower threshold level for ambient light sensor (MSB)

RW-Register 0x99								
Bit	7	6	5	4	3	2	1	0
	LSB data (upper threshold)							
default	11111111							

9. Interrupt Alert

The SFH 7773 provides an interrupt pin, which can be configured completely by the user. The register 0x92 allows configuring the interrupt as active low or active high. Additionally, the interrupt function can be configured to operate in latched or normal mode. In normal mode the interrupt event/signal is updated after every measurement, whereas in the latched mode it is guaranteed that even short peaks are detected (e.g. the interrupt is held as long as the microcontroller reads out the interrupt register).

The interrupt can be set for a PS (PS threshold) and/or ALS (upper and lower ALS threshold) event. For the exact interrupt event definition please refer to Tab. 4. This is especially valuable as it allows the SFH 7773 to operate as stand alone device in the *free-running mode,* independent from the main microcontroller. This functionality relieves the microcontroller from active involvement in the PS / ALS monitoring resp. measurement cycle and reduces significantly the I^2C-bus traffic, thus reducing the overall power consumption of the system. Only if the user-defined thresholds are violated, the interrupt signal will inform the microcontroller and the predefined actions can be executed (e.g. after read-out of the interrupt and PS / ALS data registers to get the actual data - if desired).

10 Design-in Guidelines

10.1 Implementation behind Cover Glass

By implementing the SFH 7773 behind a cover glass, two issues need to be taken into account:

- crosstalk
- aperture

The second issue concerning a fully functional design is the necessary aperture to ensure a maximum of performance. This concerns the ALS as well as the PS.

Please refer to Fig. 10 for the radiation characteristics of the IR-LED (emitter). To achieve the maximum switching distance, the recommended minimum aperture (IR-transmissive cover glass) of the IR-LED should be ± 50°. This value has been minimized in order to reduce the cover window opening size required for maximum performance.
Similar considerations are valid for the detector side (PS photodiode + ALS photodiode). Please refer to Fig. 5 for the ALS directivity. An aperture of ± 45° is

Interrupt Event Definition	
proximity sensor	PS data > PS threshold
ambient light sensor	ALS data > ALS upper threshold
	ALS data < ALS lower threshold

Tab. 5: Interrupt event definition.

Cover Transmission (visible light)	**corresponding ALS range outside Cover**	**corr. ALS resolution outside Cover**
100 %	0.3 lx – 6553 lx	0.1 lx
50 %	0.6 lx– 13000 lx	0.2 lx
20 %	1.5 lx– 32500 lx	0.5 lx
10 %	3.0 lx– 65535 lx	1.0 lx

Tab. 6: Impact of cover glass transmission on ALS range and resolution (based on an integration time setting of 100 ms, resulting in a conversion factor of typ. 0.1 lx/count of the sensor).

Cover Transmission (at 850 nm)	**corresponding detection distance (approximation)**
100 % (no glass)	100 %
90 % (clear glass)	90 %
80 %	80 %
70 %	70 %

Tab. 7: Impact of cover glass (IR-) transmission on PS detection range.

recommended for the window opening (IR and visible light transmissive) to get maximum ALS also under tilted situations. Fig. 16 illustrates the above recommendations by utilizing a Ø 1.8 – 2.0 mm aperture (minimum recommended). In case where larger airgaps are used OSRAM recommends apertures of Ø ≥ 2.0 mm. Note that the proximity sensor alone works also with a smaller aperture (the PS detector aperture is the same as the IR-LED (emitter) but a too small aperture might impact the detection distance).
The proposed design values do not count for any manufacturing tolerances concerning the placement of the component vs. cover glass tolerances. Additionally it is worth to mention, that the sensor works also if this geometric guidelines are not followed. However, this might lead - under worst case circumstances - to some performance reductions. It is also important to mention that a reduced IR transmission of the cover glass (at 850 nm) might also reduce the maximum switching distance. To compensate for, it is recommended to either increase the LED current or/and reduce the PS threshold level in the relevant register. As a rule of thumb, a 25 % one way transmission loss at 850 nm reduces the signal at the sensor site by a factor of 0.56 resp. the PS signal by around 13 counts and results in a reduction of the detection range by around a factor of 1.4 (note the pseudo-logarithmic scale of the counts vs. detector irradiance, see also Sec. 5.2). Please refer to Tab. 7 for an overview.

By implementing dark cover glasses in front of the SFH 7773 one has to take into account the spectral transmission characteristics of the glass in order to get the correct readings from the ALS. E.g. a dark cover glass (90 % attenuation) means that the measured ALS count of 100 corresponds now to 1000 lx in front of the cover vs. 100 lx at the sensor (see also Tab. 6). The overall spectral transmission characteristics of the cover glass might also impact the accuracy concerning different light sources (different attenuation of IR vs. visible light). Please contact your local OSRAM technical team for more support on these issues.

For optimized performance OSRAM recommends to avoid placing the sensor close to other components or objects as their reflections might impair the performance of the sensor. It is recommended to have black, low reflective structures next to the sensor.

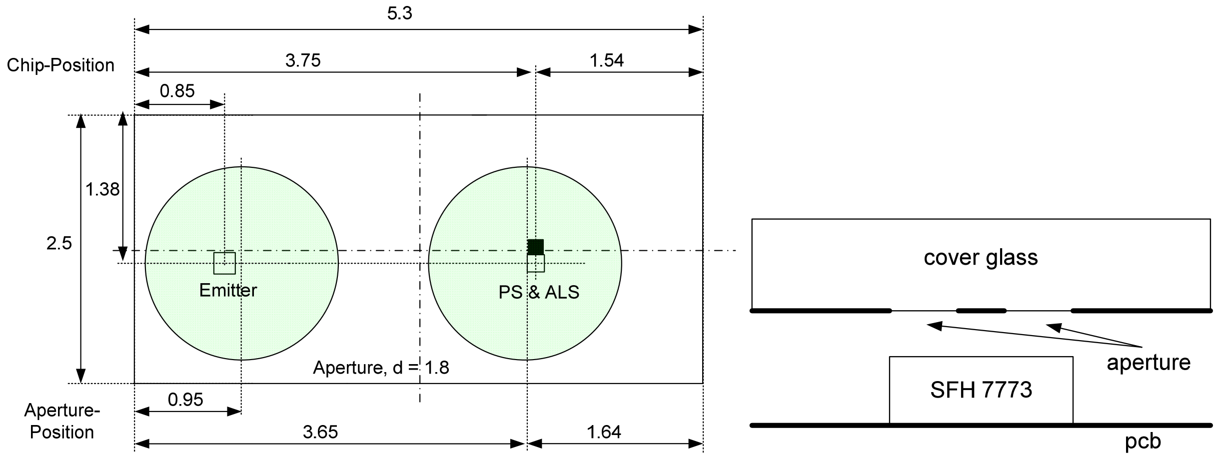


Fig. 16: Aperture design for cover glass. The above values represent an arrangement, without considering mechanical tolerances. Performance evaluation is recommended in any case to verify the viability of the design. Note that the sensor also performs in a less than ideal environment (e.g. smaller apertures). For larger airgaps a larger aperture diameter is recommended. Low reflective structures are recommended in the vicinity of the sensor for optimized performance.

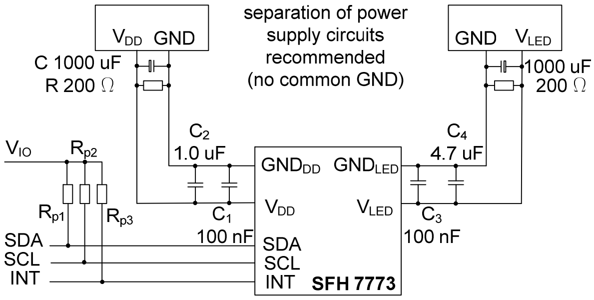


Fig. 17: Suggested setup for evaluation of the SFH7773 in a laboratory environment. R and C improve the dynamics of the power supply. C_1 and C_3 should be placed next to the respective supply pins (same for C_2 and C_4). Special considerations should be paid to separate the supply circuits (V_{DD} and V_{LED}).

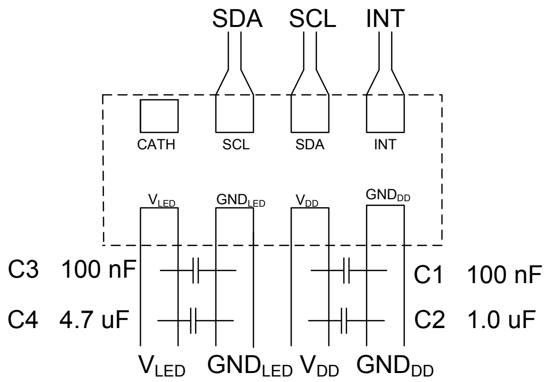


Fig. 18: Layout suggestion for a single sided pcb: The power supply circuits must be decoupled to achieve a low noise operation of the PS with high LED drive current. C_1 and C_3 need to be placed next to the respective pins (as well as C_2 and C_4).

10.2 Power Supply Circuit

This section is especially important for evaluation/operation of the SFH 7773 in a laboratory environment. Especially as regulated laboratory power supplies behave different compared to batteries (like used in e.g. mobile phones). This needs to be considered if the SFH7773 is operated with regulated laboratory power supplies.

In general, regulated voltage supplies should be avoided. Especially as the LED current bursts can influence the overall stability of the supply circuit. This instability can deteriorate the operating characteristics of the proximity sensor. This effect is not observed to occur during normal operation of the sensor with batteries, storage batteries, or stabilized voltage supplies.
The LED is driven with a current between 5 mA to 200 mA in burst mode (667 kHz). Therefore any series resistor between the V_{LED} / GND_{LED} pins and the power supply causes a voltage drop during the IR-LED pulse. In general, any voltage drop within the V_{LED} circuit during the LED burst current must be minimized. A capacitor in the range of few µF as close to the supply pins of the SFH 7773 may help to overcome this issue, as mentioned in Sec. 10.3. The same principle applies for the V_{DD} circuit (ASIC supply).
To support the user the SFH 7773 provides separated GND connections. One for the LED current driver (pin 2, GND_{LED}), one for the supply of the ASIC (pin 4, GND_{DD}). For proper operation this ground lines have to be separated and decoupled, like depicted in Fig. 17 and 18. In general we recommend buffering a laboratory power supply directly with some 1000 µF and use a load resistor in parallel to increase the dynamics of the power supply to best emulate a battery-like environment like in e.g. mobile phone (see Fig. 16).

10.3 Circuit and Layout Considerations

To achieve maximum sensitivity concerning the proximity functionality it is mandatory to have a stable (battery-like) power supply (see also Sec. 10.2).

The recommendation therefore is to connect V_{LED} directly to the battery. This ensures the necessary LED current during the burst operation (up to 200 mA peak, depending on the actual settings of the proximity sensors LED current). It is further recommended to use capacitors as close to the component as possible. This ensures minimum voltage drops at the supply pins of

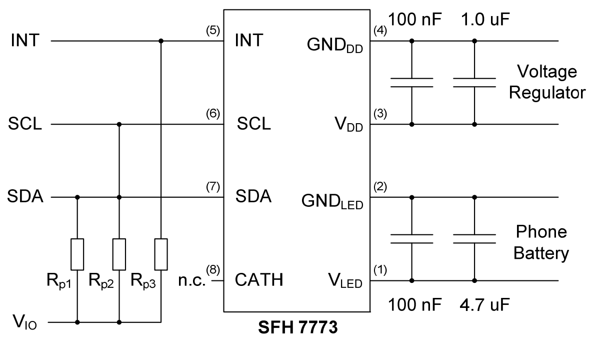
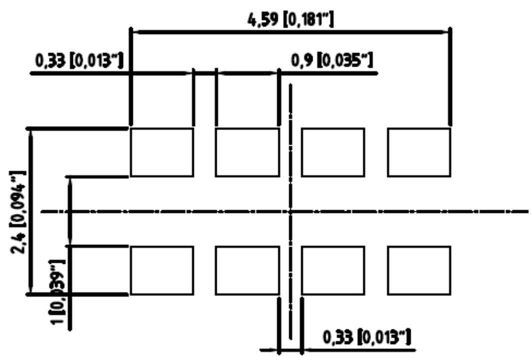


Fig. 19: Recommended implementation into a mobile phone environment.



20: Recommended soldering pad design.

the SFH 7773 and provides the necessary peak burst current. Typ. values are 100 nF || 4.7 µF at the V_{LED} side (for up to 200 mA burst current) and 100 nF || 1.0 µF for the V_{DD} circuit (ASIC supply). The 4.7 µF capacitor can be reduced if the LED burst circuit is reduced to lower levels, e.g. 50 mA.
Fig. 18 illustrates an arrangement for a single sided pcb layout. Using a double sided pcb and placing the capacitors directly beneath the resp. pin is also recommended. The separation/decoupling of the V_{DD} / V_{LED} via separate ground pins provide the necessary stability during the high emitter current bursts (up to 200 mA peak, 667 kHz). Additionally it ensures the stability of the V_{DD} circuit during the LED current bursts. Additionally the capacitors are necessary to isolate the sensor from other possible noise sources on the same power line and guarantee a low noise operation. This is especially important in a laboratory environment, if regulated power supplies are used, which often have poor pulse current capabilities – see recommendation above.

Fig. 19 illustrates a recommendation for implementing the SFH 7773 into a mobile phone environment.

The SCL, SDA and INT lines require pull-up resistors to the logic voltage (V_{IO}). The limits for the logic levels are according to the I^2C-bus specification (1.6 V to 2.0 V) [2]. The recommended value for R_p is 560 Ω (up to e.g. 10 kΩ). Please note the actual value of the pull-up resistor depends - among other issues - on the total load and communication speed of the I^2C-bus.

Fig. 20 presents a reference soldering-pad design. Please refer to the SFH 7773 datasheet for the most up-to-date recommendation.

11. Device Handling and Cleaning

In order to protect the semiconductor chips from environmental influences, e.g. in the soldering environment, a tape based encapsulant is used. Since this tape is very elastic and soft, mechanical stress or damage to the tape should be avoided during processing/assembly. The tape must not be removed under any circumstances.

Excessive force applied to the cover (tape) can lead to a spontaneous failure of the component (damage to the contacts). To prevent damaging or puncturing the tape, the use of all types of sharp objects should be avoided both in the laboratory and factory environments.

Cleaning
In general, OSRAM Opto Semiconductors ***does not recommend a wet cleaning process*** for components like the SFH 7773 as the package is not hermetically sealed.
Due to the open design, all kind of cleaning liquids can infiltrate the package and cause

degradation or a complete failure of the component. It is also recommended to prevent penetration of organic substances from the environment which could interact with the hot surfaces of the operating chips.
Ultrasonic cleaning is generally not recommended for all types of LEDs (see also the application note "Cleaning of LEDs").
As is standard for the electronic industry, OSRAM Opto Semiconductors recommends using low-residue or no-clean solder paste, so that PCB cleaning after soldering is no longer required.
In any case, all materials and methods should be tested beforehand in order to determine whether the component will be damaged in the process.

12. Sample Software Code

Below are simple C-codes which can be used to operate the SFH 7773 in connection with a microcontroller (e.g. PIC18F46J50 from Microchip). The program consists of the commented main micro C-code for the microcontroller, using the two subroutines
`I2C_w_3`: 3 write statements
`I2C_w_2_r_1`: 2 write and 1 read statement.

The main program can be implemented into a repeating loop to get the actual PS resp. ALS data or operate in interrupt mode.

12.1 Operating the ALS

12.1.1 C-code in main program:

```
sfh_address = 0x38;                        // address of SFH 7773
I2C_w_3 (sfh_address*2, 0x80, 0x03);       // initialize ALS of the SFH 7773
I2C_w_2_r_1 (sfh_address*2, 0x8C);         // read low byte of ALS, register 0x8C
lux  =  Content;
I2C_w_2_r_1 (sfh_address*2, 0x8D);         // read high byte of ALS, register 0x8D
lux  =  (lux + Content* 256);              // combining low+high byte to decimal value
```

12.1.2 I2C_w_3 subroutine

```
void I2C_w_3     (unsigned char addw, unsigned char com, unsigned char daw)
{
   unsigned char var;
   OpenI2C (MASTER, SLEW_ON);    // Configures I2C bus module, 100 kHz transfer
   SSP1ADD  = 0x27;              // setting I2C 100 kHz frequency with f osc = 16 MHz
   StartI2C ();                  // Generates I2C bus start condition
   IdleI2C ();                   // Loop till I2C bus is idle
   var = WriteI2C(addw);         // Microchips' Write command to write device address
   if (var ==  0) write_s++;     // var =  0: no bus error
   if (var == -1) write_c++;     // var = -1: slave did not acknowledge write
   if (var == -2) write_ac++;    // var=-2:write collision (bus not ready to tx)
   if (var  <  0) goto stop;     // stop further transmission if error occurred

   var = WriteI2C(com);          // write device register address
   if (var ==  0) write_s++;     // counting of good transmissions
   if (var == -1) write_c++;     // counting of no acknowledge errors
   if (var == -2) write_ac++;    // counting of write collision errors
   if (var  <  0) goto stop;

   var = WriteI2C(daw);          // write register content
   if (var ==  0) write_s++;
   if (var == -1) write_c++;
   if (var == -2) write_ac++;

   stop:
   StopI2C ();                   // generates I2C bus stop condition
   CloseI2C ();                  // master I2C module disabled
}
```

12.1.3 Subroutine I2C_w_2_r_1

```
void I2C_w_2_r_1 (unsigned char addr, unsigned char com)
{
   unsigned char var;
   OpenI2C (MASTER, SLEW_ON);
   SSPADD  = 0x27;
   StartI2C ();
   IdleI2C ();
   var = WriteI2C(addr);
   if (var ==  0) read_s++;
   if (var == -1) read_c++;
   if (var == -2) read_ac++;
   if (var  <  0) goto stop;

   var = WriteI2C(com);
   if (var ==  0) read_s++;
   if (var == -1) read_c++;
   if (var == -2) read_ac++;
   if (var  <  0) goto stop;

   RestartI2C ();                     // generates I2C bus restart condition
   IdleI2C ();
   var = WriteI2C(addr+1);
   if (var ==  0) read_s++;
   if (var == -1) read_c++;
   if (var == -2) read_ac++;
   if (var  <  0) goto stop;
   Content = 0;
   Content = ReadI2C ();
   SSPCON2bits.ACKDT = 1;             // No master Acknowledge to terminate sequence
   SSPCON2bits.ACKEN = 1;             // sending No Acknowledge bit
   PIR1bits.SSPIF = 0;
   while (SSPCON2bits.ACKEN == 1);
   PIR1bits.SSPIF = 0;                // waiting till NA causes interrupt
   stop:
   StopI2C ();
   CloseI2C ();
}
```

12.2 Operating the PS

Below is a small C-code for the main program to operate the proximity sensor of the SFH 7773. The two subroutines, I2C_w_3 and I2C_w2_r1 are the same as above (see Sec. 12.1.2 and 12.1.3).

C-code for main program:

```
sfh_address = 0x38;                     // address of SFH 7773
I2C_w_3 (sfh_address*2, 0x81, 0x03);    // initialize PS of the SFH 7773
I2C_w_3 (sfh_address*2, 0x82, 0x1E);    // set PS LED current to 200 mA
I2C_w_2_r_1 (sfh_address*2, 0x8F);      // read data byte of PS, register 0x8F
PS   =  Content;
```

12.3 Operating the ALS and PS in Interrupt Mode

The small C-code below operates the SFH 7773 in the interrupt mode. The ALS and PS are in free-running mode. The interrupt event can occur through an ALS or PS event. The limits for ALS (`LB_LL, HB_LL, LB_HL, HB_HL`) and PS (`Prox_Limit`) are set within the program. After the interrupt has triggered the microcontroller the relevant sensor is determined and the ALS or PS value is read out.

C-code for main program:

```
// ALS:

I2C_w_3         (0x38*2, 0x80, 0x03);          // ALS free running mode
I2C_w_3         (0x38*2, 0x86, 0x00);          // new data every 100 ms
I2C_w_3         (0x38*2, 0x98, LB_LL);         // setting low byte of low ALS limit
I2C_w_3         (0x38*2, 0x99, HB_LL);         // setting high byte of low ALS limit
I2C_w_3         (0x38*2, 0x96, LB_HL);         // setting low byte of high ALS limit
I2C_w_3         (0x38*2, 0x97, HB_HL);         // setting high byte of high ALS limit

// Prox:

I2C_w_3         (0x38*2, 0x81, 0x03);          // Prox free running mode
I2C_w_3         (0x38*2, 0x82, 0x1E);          // IR LED with 200 mA
I2C_w_3         (0x38*2, 0x85, 0x00);          // new data every 10 ms
I2C_w_3         (0x38*2, 0x93, Prox_Limit);    // setting byte for high prox limit

I2C_w_3         (0x38*2, 0x92, 0x03);          // interrupt triggered by PS and ALS,
latched and ground when active

// Interrupt routine:                          // called when interrupt happened

I2C_w_2_r_1 (0x38*2, 0x8E);
// reading Status Register, Function returns register value as variable Content
if ( (Content & 0x80) == 0x80)
// &=bitwise AND,check whether ALS triggered interrupt
{
       I2C_w_2_r_1 (0x38*2, 0x8C);             // read low byte of ADC, register 0xC
       Content1 = Content;
       I2C_w_2_r_1 (0x38*2, 0x8D);             // read high byte of ADC, register 0xD
       Lux = Content * 256 + Content1;
}

Else                                           // Interrupt must be caused by prox
sensor
{
       I2C_w_2_r_1 (0x38*2, 0x8F);             // read Prox data register 0x8F
       Prox = Content;                         // Value in uW/cm^2 =10power(Content/51)
}

// end of interrupt routine
```

12.4 Implementation into a Mobile Phone Environment

Below are two example flowcharts, describing how the SFH 7773 can be implemented into a microcontroller based mobile phone environment. The interrupt function allows for low-power stand-alone operation of the device.
The first flowchart illustrates a possible operation of the ambient light sensor, the second flowchart relates to the operation of the proximity sensor.

12.4.1 Operation of the ALS

Fig. 21 illustrates a flowchart for a microcontroller based ambient light sensing example. The interrupt (set to active low) alerts the microcontroller only in case the actual ambient light value is outside of the defined ALS window. Using the interrupt functionality and operating the SFH 7773 in the free-running mode helps to minimize traffic on the I^2C-bus as well as to relieve the microcontroller from unnecessary work load. This arrangement helps to save valuable battery power.

By adapting dynamically new thresholds (with hysteresis) relative to the actual ALS value (after an interrupt event took place) it is possible to define very fine steps for adapting the display brightness (quasi-continuous).
By inverting the interrupt polarity (register 0x92) the interrupt alert function can be inverted from outside the ALS window to

inside the ALS window (only in non-latched mode). Like stated above, it is recommended to use a hysteresis by defining the thresholds in order to avoid flickering of the interrupt event.

12.4.2 Operation of the PS

Fig. 22 illustrates the flowchart for a microcontroller based proximity sensing example. Operating the SFH 7773 in the stand alone mode plus using the interrupt functionality helps to save battery power.
The interrupt (set to active low) alerts the microcontroller only in case an object passes a certain distance threshold (towards the sensor, e.g. in a mobile phone). This allows the mobile phone to turn-off the display e.g. during a call to save battery power.
A new threshold (with hysteresis) and the inverting of the interrupt logic of the SFH 7773 - after an event has taken place - allow to adapt the sensor to detect the motion in the opposite direction (only for non-latched interrupt mode). By adapting dynamically new thresholds it is recommended to set a certain hysteresis level to avoid flickering of the interrupt event.

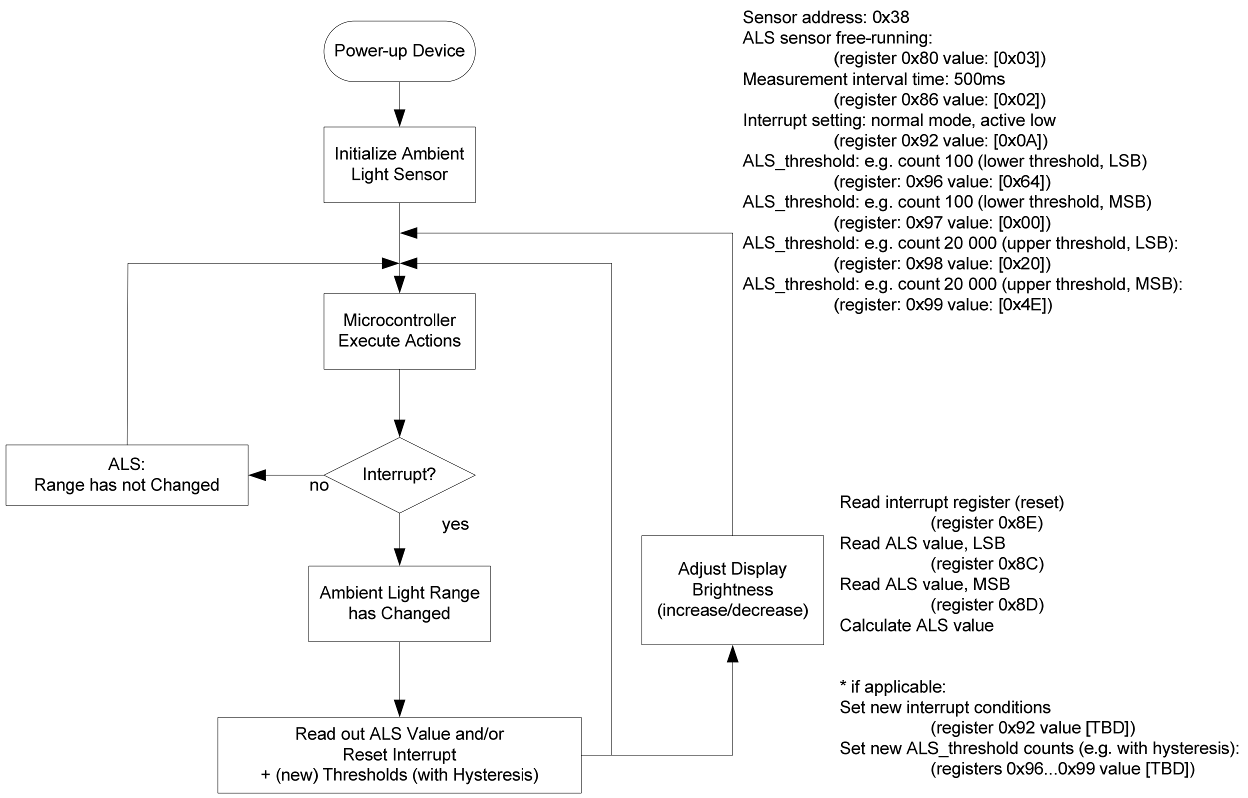


Fig. 21: Flowchart for a microcontroller based ***ambient light sensing example****.*

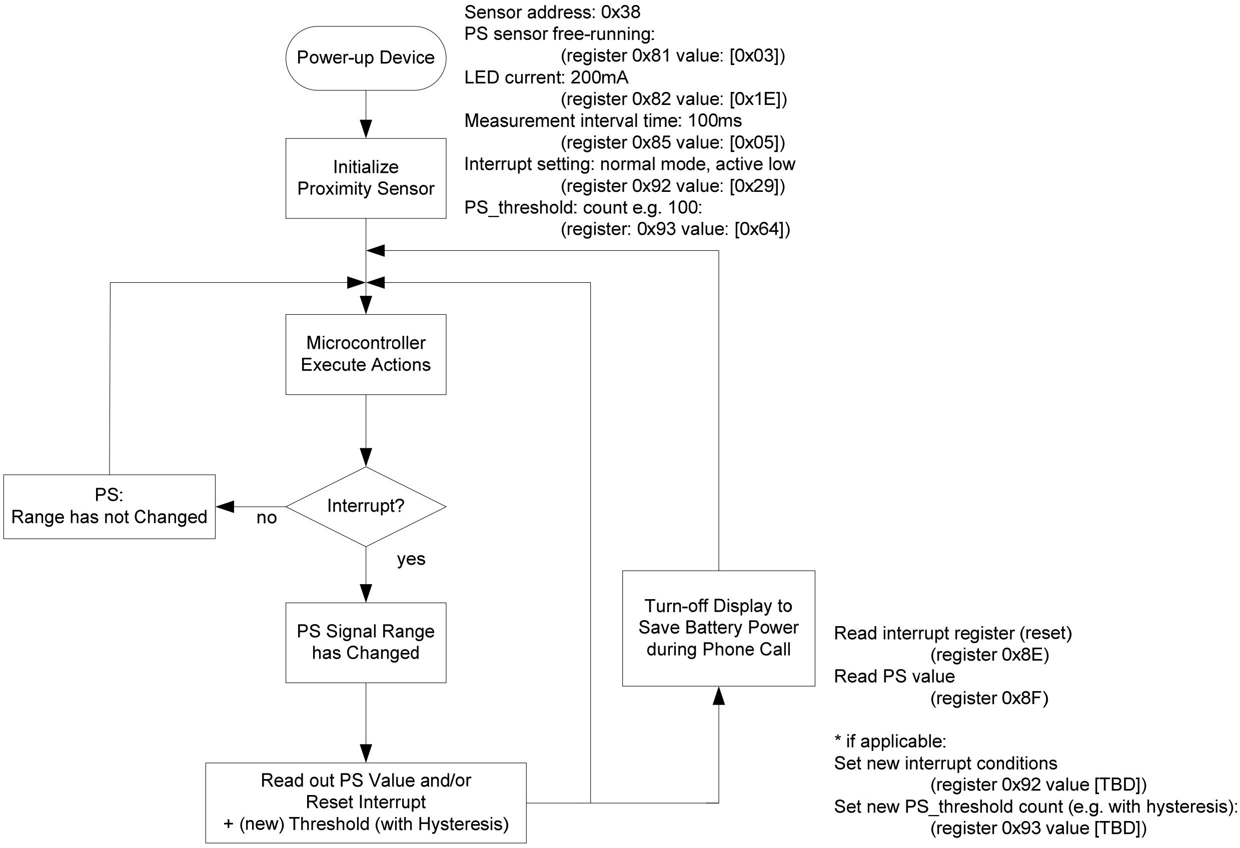


Fig. 22: Flowchart for a microcontroller based ***proximity sensing*** *example.*

13. Literature

[1] OSRAM-OS: http://www.osram-os.com.
[2] “UM10204 I^2C-bus specification and user manual” from NXP Rev. 03 – 19 June 2007

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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.