General Description

The epc600 Camera Spot is a fully assembled and tested TOF Range Finder camera to be used with the epc600/610 Evaluation Kit.

The module includes an epc600 TOF Range Finder chip, an active IR LED illumination for the observation area, a complete lens system and a cable interface to the mainboard. This allows for a flexible and convenient placement in a lab setup. The module has a 1.4° x 1.4° optical aperture angle.

In combination with the epc600/610 Evaluation Kit (which provides all hardware to operate the epc600 Range Finder module), the user has a fully functional TOF evaluation system.

The included application software enables the user to explore the TOF Range Finder technology as well the epc600 Range Finder chip.

Features

- Fully functional TOF Range Finder camera with a 1 pixel epc600 imager chip.
- Comprehensive application software with a graphical user interface to operate the epc600 chip in the camera module.
- Automatic mode to measure distances with adaptive integration times.
- Manual mode to run the camera in an individual set-up or to analyze the raw data.
- Possibility to store and reload operating configurations.
- Functionality for logging measurement data on a PC.

Purpose

- Performance analysis of the epc600 chip in terms of speed, operating range and accuracy.
- Demonstration and evaluation of the hard- and software.
- Development environment for user specific epc600 chip applications.

Overview

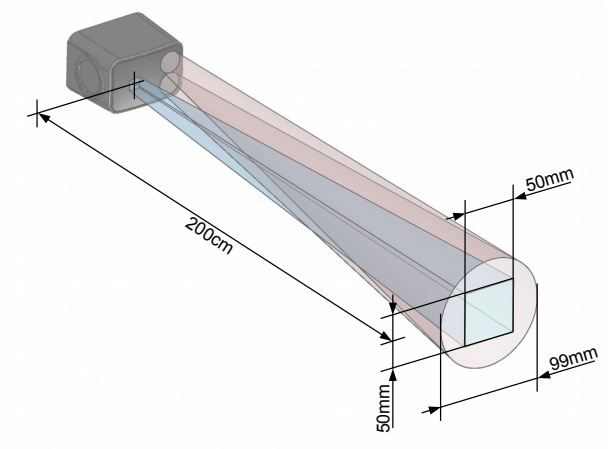

Figure 1: Field of view of the camera

Figure 2: The camera module

Receiver spot: 50 x 50 mm (1.4° x 1.4°)
Emitter spot: 99mm diameter ≙ □ 70 x 70mm

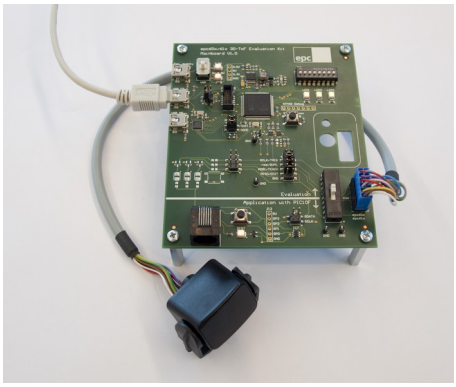

Figure 3: The evaluation system hardware

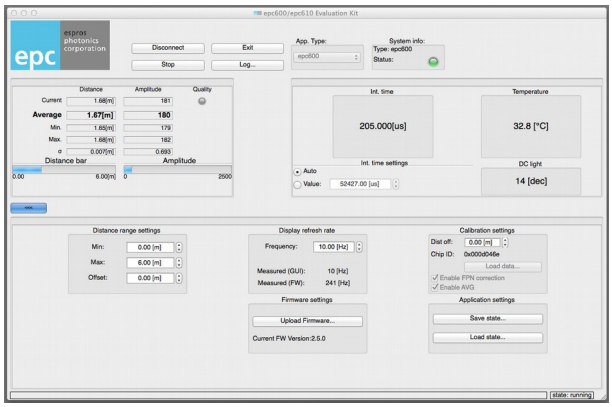

Figure 4: Main dialog of the graphical user interface

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! IMPORTANT INFORMATION !

SAFETY ADVICE

DO NOT LOOK DIRECTLY INTO THE CAMERA UNDER OPERATION !

Depending on the mode of operation, the camera device emits highly concentrated non-visible infrared light. It can be hazardous to the human eye. The use of these devices has to follow the safety precautions given in IEC 60825-1 and IEC62471.

THIS EVALUATION KIT SHOULD ONLY BE INSTALLED AND USED BY AUTHORIZED AND FULLY TRAINED PEOPLE. ALL INSTRUCTIONS IN THIS MANUAL AND IN THE RELATED DOCUMENTS HAVE TO BE FOLLOWED AND FULLY COMPLIED WITH. IN ADDITION, THE INSTALLER AND USER IS REQUIRED TO COMPLY WITH ALL LOCAL LAWS AND REGULATIONS. SHOULD ANY OF THESE INSTRUCTIONS NOT BE CAREFULLY FOLLOWED, SERIOUSLY INJURY MAY OCCUR. THE INSTALLER AND USER IS FULLY RESPONSIBLE FOR THE SAFE USE AND OPERATION OF THE SYSTEM. IT IS THE SOLE RESPONSIBILITY OF THE INSTALLER AND THE USER TO ENSURE THAT THIS PRODUCT IS USED ACCORDING TO ALL APPLICABLE CODES AND STANDARDS IN ORDER TO ENSURE SAFE OPERATION OF THE WHOLE APPLICATION.

ANY ALTERATION TO THE DEVICES BY THE BUYER, INSTALLER OR USER MAY RESULT IN UNSAFE OPERATING CONDITIONS.

ESPROS photonics AG IS NOT RESPONSIBLE FOR ANY LIABILITY OR WARRANTY CLAIM WHICH RESULTS FROM SUCH MANIPULATION.

THIS DEVICES MAY NOT BE USED FOR APPLICATIONS OTHER THAN THE EVALUATION OF THE DESIGNATED DEVICES.

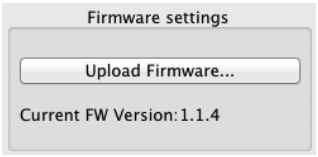
THIS DEVICES MAY NOT BE USED IN SAFETY APPLICATIONS, EXPLOSIVE ATMOSPHERES, OR IN A RADIOACTIVE ENVIRONMENT.

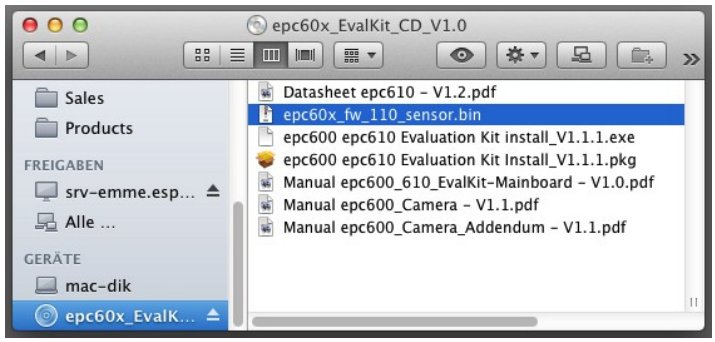
! IMPORTANT INFORMATION !

THIS CAMERA COMES WITH ITS OWN CALIBRATED FIRMWARE.

For proper operation of the Evaluation Kit upload the correct firmware from the CD ROM to the evaluation board.
Do this each time, when you are changing the camera head.

User interface:





Use the dialog “Firmware settings”

Upload the binary file “epc60x_fw_xxx_sensor”

ALSO, MAKE SURE THAT YOU ALWAYS USE THE LATEST SOFTWARE VERSION ON YOUR MAC / PC.
USE THE APPROPRIATE INSTALLER THAT IS ALSO ON THE CD.

Table of Contents

1. General overview of the epc600/610 Evaluation Kit

The chapter gives an overview about the epc600/610 Evaluation Kits, their components and the technical data for this module.

1.1. Ordering information

	Part number	Order information	Description
Kits	P100 110	epc600 Evaluation Kit Spot	Evaluation kit set with an epc600 TOF Range Finder chip – epc600 Camera Spot – epc600/610 Evaluation Kit Mainboard
	P100 227	epc610 Evaluation Kit	Evaluation kit set with an epc610 TOF Imager chip – epc610 Camera Module V1.0 – epc600/610 Evaluation Kit Mainboard

	Part number	Order information	Description
Accessories	P100 113	epc600 Camera Spot	Camera module with an epc600 TOF Range Finder chip with 1.4° x 1.4° optical aperture angle, including cable
	P100 223	epc610 Camera Module V1.0	Camera module with an epc610 TOF Imager chip with 8.7° x 8.7° optical aperture angle, including cable

Table 1: Order information overview

1.2. Scope of delivery

No	Pieces	Designation	Kit	Camera
①	1	epc600 camera with snap-on holder	Yes	Yes
②	1	Cable to connect the camera with the mainboard	Yes	Yes
③	1	epc600/610 Evaluation Kit mainboard	Yes	
④	1	USB type 2 cable to connect the mainboard with a computer	Yes	
⑤	1	CD-ROM with the application software + documentation	Yes	Yes
	1	Manual epc600 Camera; on CD-ROM	Yes	Yes
	1	Manual epc600/610 Evaluation Kit; on CD-ROM	Yes	

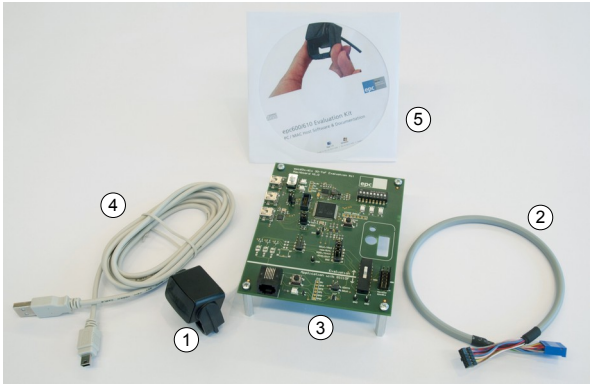


Figure 5: Material of the complete kit

1.3. System requirements for host PC

Description	Personal computer system	
Computer	**IBM PC or compatible**	**Apple (Mac)**
Operating system, minimum	Windows XP or higher	Mac OS X 10.7 (Lion) or higher
Graphics resolution, minimum	1024 x 768 pixel	1024 x 768 pixel
Hard-disk free space	min. 50MByte	min. 50MByte
CD-ROM drive	yes	yes
USB connection	min. USB 2.0 full speed	min. USB 2.0 full speed

Table 2: System requirements

1.4. Technical data epc600 Camera

Description	Data	Remarks
Type	epc600 Camera Spot	
Sensor chip	epc600; 1 pixel	
Supply voltage	+8.0V … +9.0V DC +5.0V ±5%	20mA 200mA
Power consumption	1.2W	
Communication	epc600: 2-wire interface, max. 1Mbit/s	max. cable length: 0.5m
Receiver lens: Focal length	12.6mm	
Receiver lens: Size	16 x16 mm (256 mm^2)	
Operating wavelength (according label)	860nm ±65nm (near infrared)	Caution: This is a IR emitting system !
Optical output power	typ. 50 mW	
Optical modulation frequency	10 MHz, pulsed operation	
Operating range	0 – 600 cm @ remission = 80%	@ varying integration times
Dimensions (length x width x hight)	32 x 22 x 25mm	
Temperature range; Humidity	0° … 45°C; 20% … 80% RH	
CE certificate	The Evaluation Kit is designed as a module level device. Therefore it is not a CE certified device. It is the users responsibility to operate the hardware in compliance with the CE regulations.	
RoHS	Fulfills 2002/95/EC	

Table 3: Technical data epc600 Camera

1.5. Support and technical contact

If you need more information, please contact us at info@espros.ch.

2. Hardware

The purpose of this section is to introduce to the user the epc600 camera module and the functional use of the epc600/610 Evaluation Kit.

2.1. Block diagram

The system consists of 3 main parts: A personal computer, the Evaluation Kit mainboard and a camera module (refer to Figure 6).

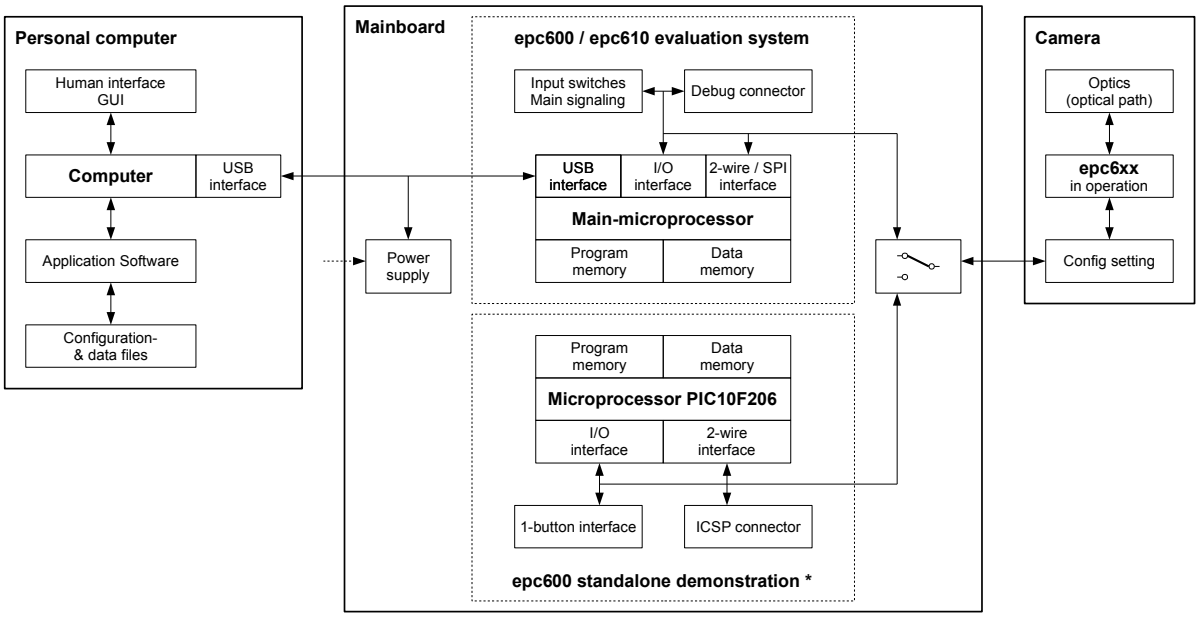


Figure 6: Block diagram (* not implemented)

The Personal computer

- IBM compatible or Apple (Mac).
- Man-machine interface for the operation and visualization of the evaluation system.
- Runs the application software.
- Stores, reads and writes configuration- and data-files for the application.
- Host system for ST ARM 32bit Cortex microprocessor software development.

The mainboard

- Two sections with independent microprocessor systems:
  - The one for the “epc600 / epc610 evaluation system” (Evaluation)
  - The second is a minimal hardware design concept for a Range Finder application with the epc600 (Application with PIC10F).
- A main switch selects which section will be connected to the camera module.
- The mainboard/system is connected to the computer by a USB cable for data communication and power supply.
- The power supply generates all of the necessary supply voltages from the USB connection. An additional external USB power supply can be added if the PC USB interface is not capable of delivering the necessary power (ca. 200mA).
- The “epc600/epc610 evaluation system” section supports and gives access to the full functionality of the epc600 / epc610 devices.
  - Checks for the correct device identification of the camera.
  - Configures and controls the camera.
  - Reads the picture data from the camera and sends it via USB to the computer.
  - Provides configuration DIP switches and signaling LEDs.
  - A “debug connector” allows advanced users to download their own application. For more information, refer to the manual of the corre - sponding processor.
- The “epc600 standalone demonstration” section with a tiny microprocessor PIC10F206 is a fully functional range-finder concept.
  - This part is not yet supported. There is no functional firmware implemented.

The epc600 camera module

- Is a fully functional module with the epc600 TOF Range Finder chip and optics combined.
- Connects to the mainboard for power supply, data communication and configuration reading.

Goals and objectives of this Evaluation Kit:

- Easy-to-use, plug and play demonstrator to show how epc's TOF products work and which possibilities they offer.
- Test kit for engineers, allowing for a first contact with epc's products.
- Reference design kit for design and development engineers.

■ Supports the user during development and testing of his own hard- and software.

Exceptions of this kit:
■ The kit is a demonstrator. It is not designed for verification of datasheet parameters. Such tests need a dedicated test environment.
■ Not designed for use in final applications.

2.2. Schematics

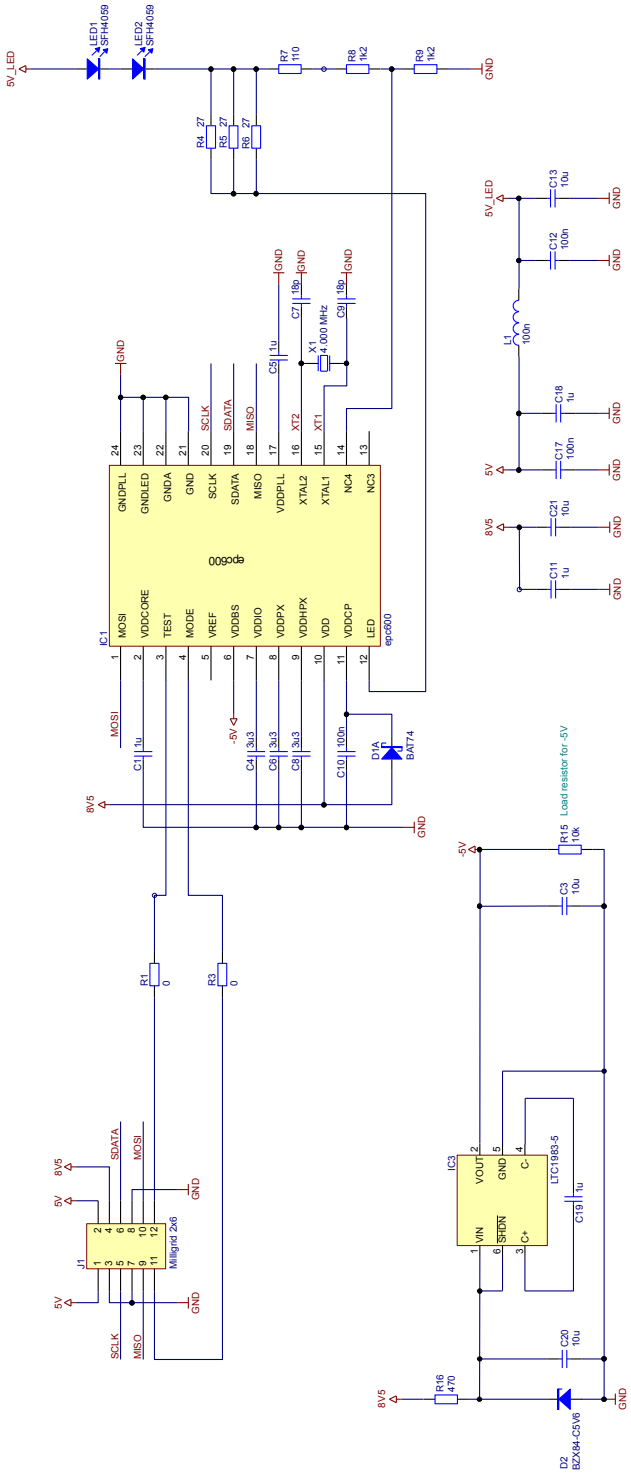


Figure 7: Schematic camera epc600

2.3. Assembly & part list

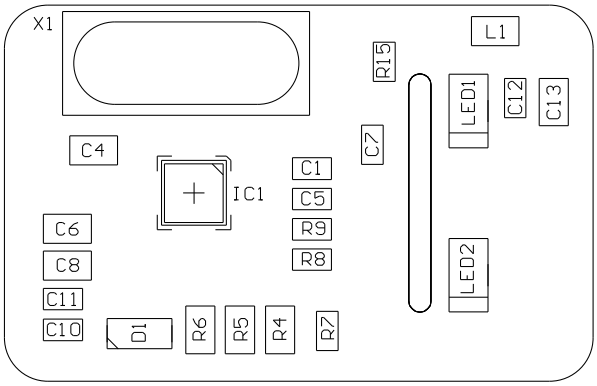


Figure 8: Camera board: Frontside assembly

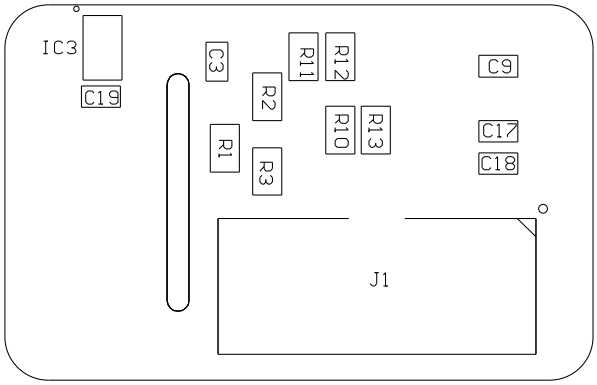


Figure 9: Camera board: Backside assembly

C1, C5, C11, C18, C19	1 µF	Capacitor
C4, C6, C8	3.3 µF	Capacitor
C7, C9	18 pF	Capacitor
C10, C12, C17	100 nF	Capacitor
C3, C13, C20, C21	10 µF	Capacitor
D1	BAT74	Schottky double diode
D2	BZX84-C5V6	Zener diode
IC1	epc600	epc600 sensor chip
IC3	LTC1983-5	Regulated charge pump
J1	Milligrid 2x6	Header, 6-Pin, dual row
L1	100 nH	Inductor
LED1, LED2	SFH4059	Osram IR LED
R1, R3	0 Ohm	Resistor
R4, R5, R6	27 Ohm	Resistor
R7	110 Ohm	Resistor
R8, R9	1.2 kOhm	Resistor
R15	10 kOhm	Resistor
R16	470 Ohm	Resistor
X1	4.0 MHz	Quartz Crystal, SMT

Table 4: Camera board: part list

2.4. Hardware of the camera

The electronics of the camera module contains the epc600 chip, the buffering of the supply voltage, the crystal for the chip clock, two IR emitter LEDs and a connector for the cable to the mainboard. The housing incorporates the emitter and receiver lenses. It minimizes optical crosstalk.

2.4.1. Camera connector J1

Pins 9, 10, 11 and 12 must be terminated, but not necessarily in the camera module. If they are not terminated, the Evaluation Kit reads back the chip type in software and terminates them according to the signals MODE and TEST.

For camera modules supplied by ESPROS photonics, the pin assignment is already done for the correct operation of the module in combination with the mainboard.

For the correct standalone operation of the epc600 camera module, the signals need to be terminated according to the Table 5 and the datasheet epc600.

Pin	Pin assignment
1	+5V
2	+5V
3	GND
4	+8.5V
5	SCLK
6	SDATA
7	GND
8	GND
9	NC1: Do not connect
10	HLLED/NC”: Connect with a 1kOhm resistor to GND
11	GNDM: Connect to GND
12	VDDT: Connect to +5V

Table 5: Pin assignment camera connector J1

3. Evaluation Kit mainboard

For the technical description of the Evaluation Kit mainboard, refer to “Manual – epc600/610 Evaluation Kit – mainboard”.

4. Setup & installation

4.1. Software installation

The enclosed CD contains all necessary application files and drivers to install and run the evaluation system on your computer.

4.1.1. SW installation on PC

System requirements (refer also to Table 2): PC with Windows XP or higher

Before you start the installation process, close all running applications.

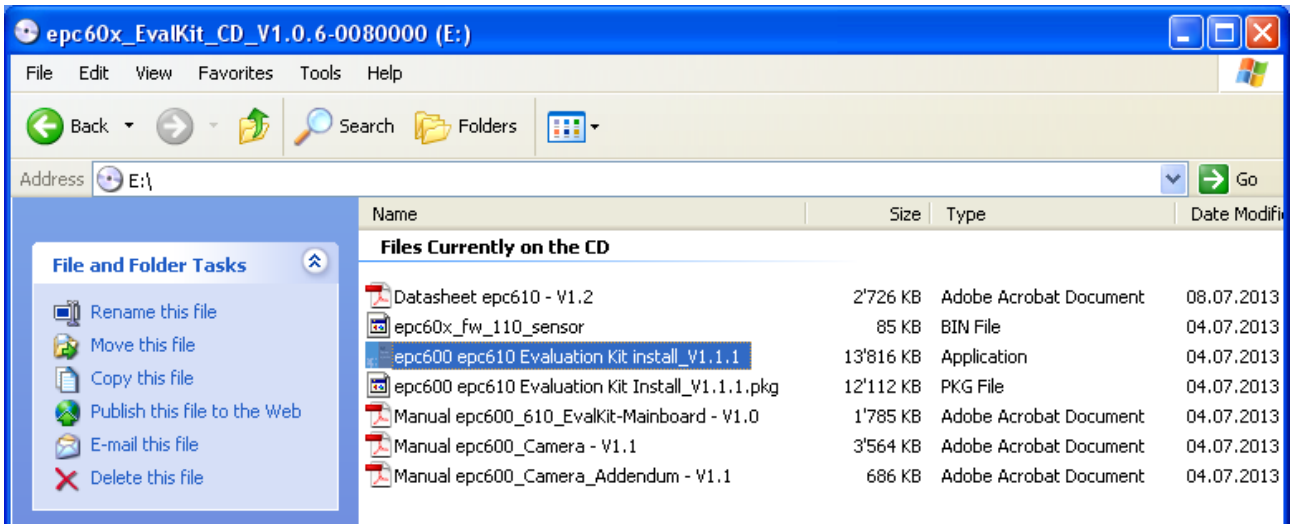


Figure 10: PC installation files

Start the installation by executing the installer “epc60x-evalkit-install.exe”.The installer routine will load the application software as well as the necessary drivers on your system.

After completion of the software installation, connect the evaluation kit through the connector J6 USP FS to your PC with the enclosed USB cable. Make sure that the power supply selection switch on the evaluation kit is switched to “USB” (Figure 11).

The PC will detect the new hardware and start the Windows hardware installation assistant. Choose the default option “Install software automatically” to complete the installation.

Start the application with the link “epc60x Evaluation Kit” that has been added to your program shortcut menu.

Disconnect the USB cable before attaching a camera module and proceed with chapter 4.2. Running the epc600 application.

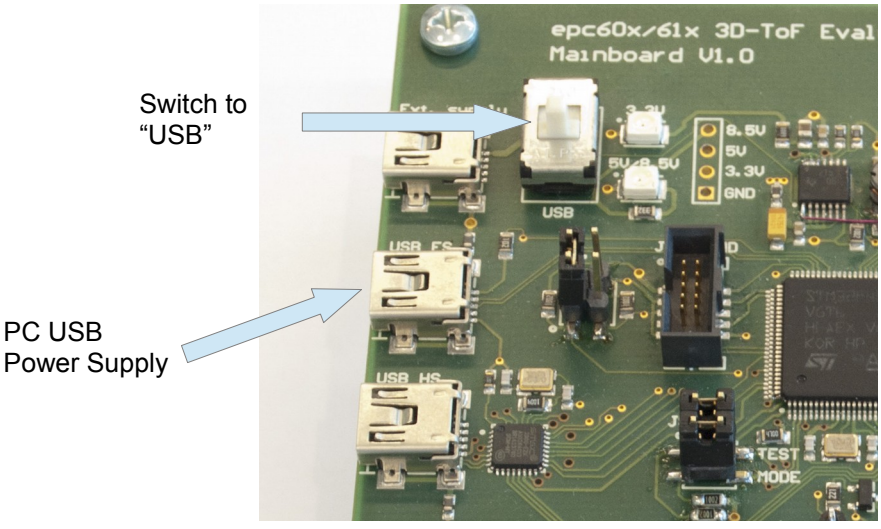


Figure 11: PC USB power supply setting

4.1.2. SW installation on Mac

System requirements (refer also to Table 2): Mac OS X 10.6 or higher

Before you start the installation process, close all running applications.

Copy the installer file “epc600 epc610 Evaluation Kit Install_Vx.x.pkg” from the CD to the desktop. Start the installation by executing the installer “epc600 epc610 Evaluation Kit Install_Vx.x.pkg”. The installer routine will load the application software as well as the necessary drivers on your system. Delete the installer file after successful installation.

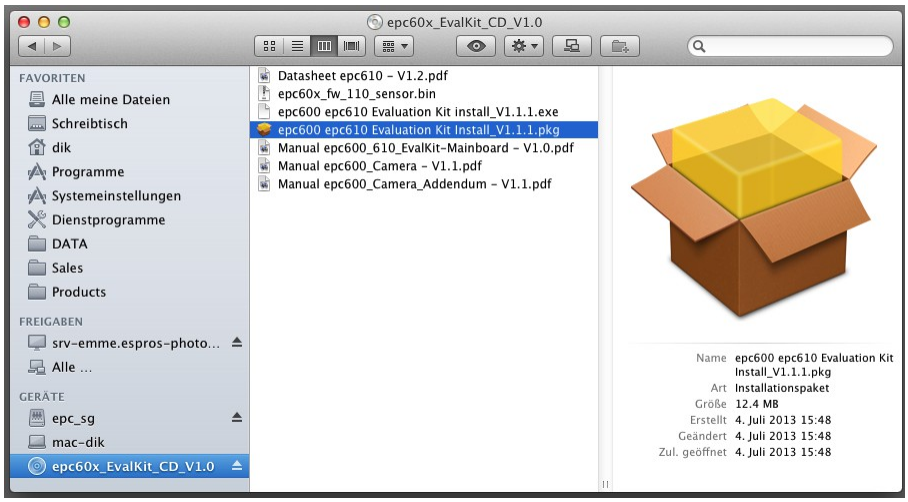


Figure 12: Mac installation files on CD

After completion of the software installation, connect the evaluation kit through the connector J6 USP FS to your PC with the enclosed USB cable. Make sure that the power supply selection switch on the evaluation kit is switched to “USB” (Figure 11).

Start the application with the link “epc60x app” that has been added to your program folder.

Disconnect the USB cable before attaching a camera module and proceed with chapter 4.2. Running the epc600 application.

Notice for Mac users:
The USB Mac driver can hang-up due to insufficient current driving capability. In this case, connect an external supply for powering the Evaluation Board.

4.2. Running the epc600 application

This mode is the actual developer mode which gives access to the full functionality of the epc600 camera module.

It requires a host PC that has the application software installed and running. Check if the application software is installed correctly on the personal computer according to chapter 4.1.: Software installation. The software release must be the one delivered with the camera or higher.

Connect the camera module to the mainboard.

Set the operation switch SW2 to “Evaluation”. (See Figure 13). This will set the evaluation system into the epc600 evaluation mode and allows for the operation through the application software on the computer.

Caution:
The board must be in the unpowered state when the camera is connected to the mainboard and switch SW2 is changed!
Otherwise the board or camera may be damaged.

Connect the camera module to the cable and the other side of the cable to the mainboard.

Remark:

EACH CAMERA COMES WITH ITS OWN CALIBRATED FIRMWARE.

After a change of the camera, the upload of the corresponding firmware is necessary to operate it correctly.
The firmware is on the CD enclosed in the camera package. Refer to chapter 5.1.7. Firmware settings.

Set the operation switch SW2 to “Evaluation”. (See Figure 13). This will set the evaluation system into the epc600 evaluation mode and allows for the operation through the application software on the computer.

Connect with the USB cable the computer to the Evaluation Board. The board is now powered up by USB.

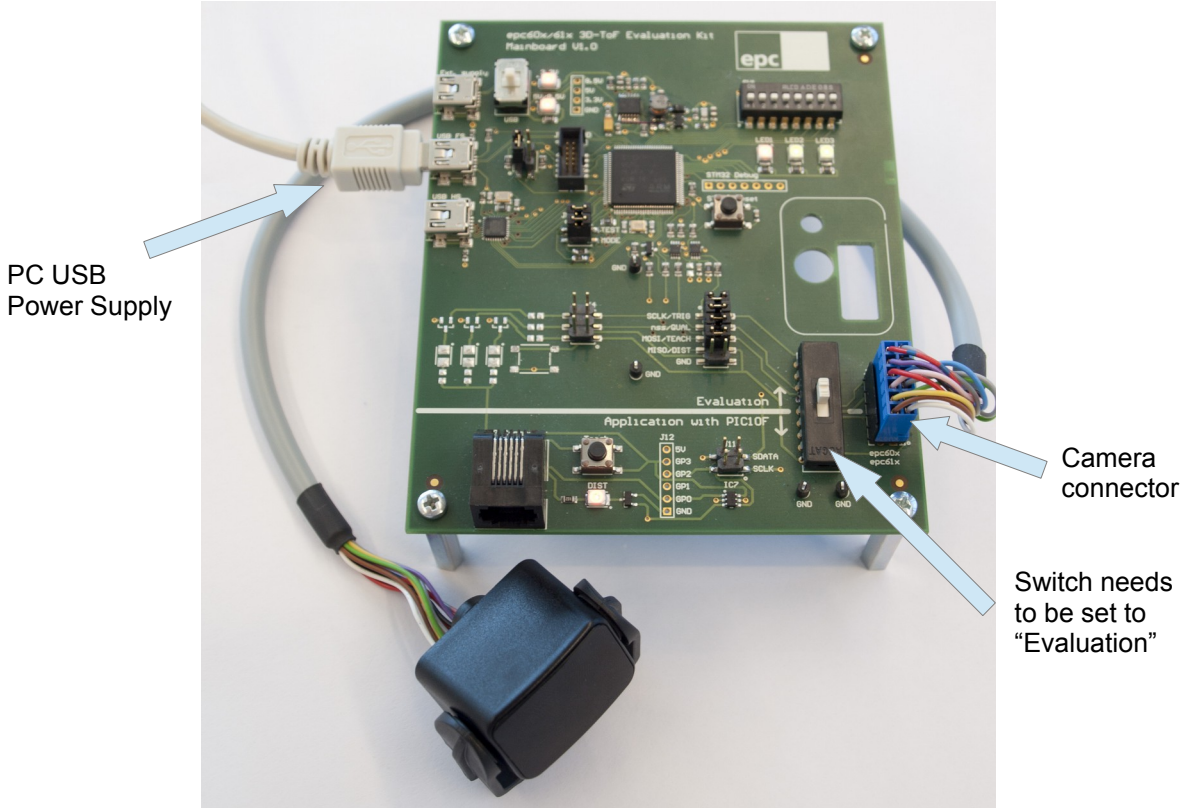


Figure 13: Hooking up USB power and camera module

On power up, the system loads the microprocessor software and checks which type of camera module is connected. The system configures itself automatically according to the connected camera module.

Start the application software on your computer and press the “Connect” button on your main screen to connect the application software to the evaluation system.

Press the button “Start” to start the evaluation software.

Refer to the next chapter “5. Software “epc600 evaluation system” and user interface“ for detailed operating instructions.

5. Software “epc600 evaluation system” and user interface

5.1. Overview

This chapter describes the epc600/610 Evaluation Kit software (SW) and graphical user interface (GUI). The user interface is designed as a dialog based application. The software operates the epc600 camera module, reads the data delivered by the module and allows for data logging.

The one-pixel epc600 sensor with the 2-wire interface works as a **TOF Range Finder**.

5.1.1. User Interface Overview

Figure 14 shows the snapshot of the user interface. All the windows are identical both for Mac and PC. Table 6 provides a brief description of the different user interface elements.

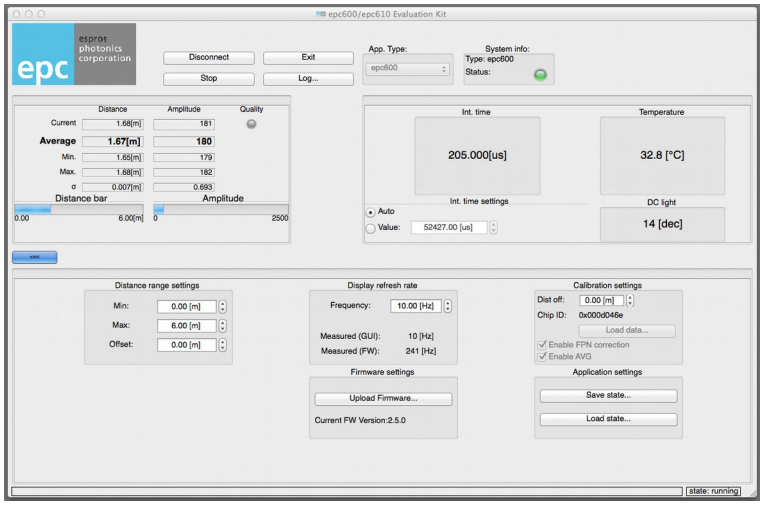


Figure 14: User Interface epc600 application software

Area	Description	
Logo area	epc logo, a double-click opens the “About” dialog”	
Main button group	Buttons for the basic handling of the system:	
Connect / Disconnect	Connects / disconnects the application to / from the Evaluation Kit hardware. Always use this first before you start any other operation.	
Start / Stop	Starts or stops the data acquisition. Use after the Evaluation Kit hardware has been connected.	
Exit	Quits the application.	
Log	Data logging for offline analysis. A dialog window allows the selection of log data and file type.	
App. Type	Shows the type of the connected head.	
System info	This group shows the camera system type and the status of the system with a LED symbol:	
Type	Shows the type of the connected camera system (epc600 or epc610). This information is read from the con - nected camera module.	
Status	Signals the status of the connected camera system with a LED symbol:	
	grey	The system is not connected yet.
	green	The system is connected. No warnings or errors are discovered.
	red	The system has entered an error state. The root-cause of the error is shown in a pop-up box.

Table 6: Functionality of the basic application layout

Area	Description
Distance & Amplitude dialog	Shows the measured distance and amplitude. Real time values as well as statistical figures are displayed.
Integration time dialog	The dialog holds the switch that allows for either the setting of the the integration time manually or to have the internal algorithm automatically set the integration time. The respective value for the integration time is dis - played. This dialog also holds the display fields for the temperature and DC light. This data, like the distance and am - plitude values, is delivered from the TOF chip
Button <<<	With this button, the visibility of extended user interface elements can be toggled:
Distance range settings	Used to set a fixed position offset and measurement range limit.
Display refresh rate	Settings for the refresh rate on the display.
Firmware settings	Upload of new or corresponding firmware versions for the camera to the Evaluation Kit hardware.
Calibration settings	Displays chip ID and additional distance offset.
Application settings	Save and load user interface settings.

Table 6 cont: Functionality of the basic application layout

5.1.2. Basic operation

Before any measurements can be taken, the data link between the camera head and the mainboard needs to be established by pressing the “Connect” button. If the camera head is detected, the status indicator LED in the “System Info” section will be green and the type of camera head is displayed in this section. The actual measurement can now be started with the “Start” button.

The measurement runs continuously and the values will be displayed in real-time. For offline data processing, there is a logging option available. The “Log...” button will open a dialog window that allows setting of specific logging options and to start the logging.

Note:

If the following pop-up window appears after “Connect”:

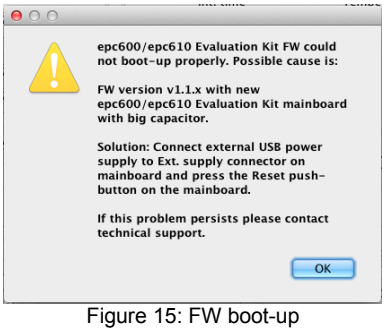


Figure 15: FW boot-up

Reason:
You are using a 1st series camera module with a V1.2 or V2.0 mainboard. The USB power supply is not compatible

Solution:
Use an external 1'000mA USB supply. Connect it to the appropriate plug on the mainboard and switch to „Ext.“ power supply. After pow - er-up press the reset button on the mainboard.

5.1.3. Distance and Amplitude dialog

This dialog shows the main measurement data fields as numeric values as well as range bars in the lower part. The “Current” fields on top will display the values as real time values with a refresh rate that can be set in the user interface area “Display refresh rate”.

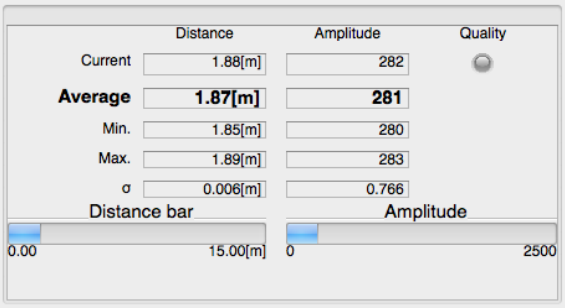


Figure 16: Distance and Amplitude dialog

As additional information to the user, the dialog displays statistical values calculated on the last 100 measurement data points:

- Min: Minimal value within the last 100 data points
- Max: Maximum value within the last 100 data points
- Average: Moving average for the last 100 data points
- σ: One sigma standard deviation for the last 100 data points

The firmware of the camera contains basic calibration and correction algorithms for the distance calculation:
Distance, Reflectivity, Ambient-light and Temperature Compensation as described in the epc600 datasheet. They are calculated by the Arm processor on the Evaluation Kit mainboard.

The measured distances have the following different reliabilities:

- Between 1 and 7 meter: The compensation is optimal.
- From 1 meter to 3.5 meters: The compensation are valuable for a target reflectivity from 90% down to 5%.
- From 3.5 meters to 7 meters: The target reflectivity goes from 90% down to 20%.
- For distances smaller than 1 meter or bigger than 7meters: The measured values are not anymore reliable.

The Quality LED indicator is not in use.

5.1.4. Integration time and temperature dialog

When set to automatic mode, the ec600 camera selects always the most reliable result out of an exposure sequence with the integration times 1.6µs / 12.5µs / 205µs. The integration time corresponding to the selected values is displayed in real time and is continuously adjust - ed to get the optimal measurement result. Refer to the epc600 datasheet for more information on integration time and how to adjust it.

Figure 17: Integration time and Temperature dialog

For some test setups, it may be useful to set the integration time manually. This can easily be done by typing the desired time in the value window and pressing “set”. The integration time will remain at this value until manually changed again.

The temperature and DC light values (ambient-light values) are also continuously read from the epc600 chip and displayed as uncalibrated data. These values are used for compensation of the distance data as explained in chapter 5.1.8: Calibration settings. An actual user appli- cation may require different read rates of these values.

5.1.5. Distance range settings

The settings here affect only the user interface and do not have any influence on the epc600 chip. They are intended to set a fixed offset value and “zoom” in on an operational point. The “zoom” effect will become visible on the range bar of the distance and amplitude dialog.

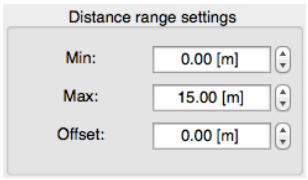


Figure 18: Integration time and temperature dialog

5.1.6. Display refresh rate

Just like the distance rate settings in the chapter before, the display refresh rate setting only affects the user interface on the host computer. However, for informational purposes, the approximative data refresh rate is displayed as well. This provides information on the actual “frame rate” delivered by the chip (FW). Naturally, this value will strongly depend on the integration time.

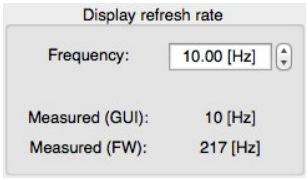


Figure 19: Display refresh rate dialog

5.1.7. Firmware settings

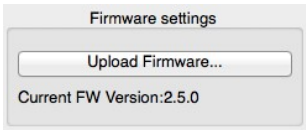


Figure 20: Firmware settings

The Evaluation Kit requires firmware that runs on the ARM controller. This firmware configures the chip, performs the measurements, calculates the result values, interfaces to the PC software and much more. As the development around the epc TOF devices is ongoing, there will be regular updates of this software. By using the “Upload Firmware” button, it is possible to flash such updated versions on the Evaluation Kit.

Remark:
After a change of the camera, the upload of the corresponding firmware is necessary to operate it correctly.
Each camera has its own calibration parameters.
The firmware is on the CD enclosed in the camera package.

5.1.8. Calibration settings

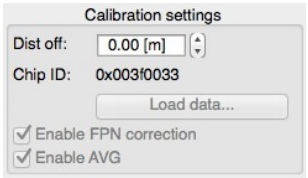


Figure 21: Calibration settings

Similar to 2D imagers, 3D TOF performance can be increased by calibration. While 2D imagers basically only require calibration for fixed pattern noise and temperature, there are several influencing factors on the 3D TOF performance.

These factors are:

- Fixed pattern noise
- Ambient-light (DC light)
- Temperature
- Target reflectivity

The epc TOF devices are designed to suppress ambient-light and to compensate for different target reactivities internally. For many applications, the chip performance will be sufficient in these aspects. However, an additional external calibration will always improve accuracy.

Due to the extremely short timeframes that are relevant for TOF, there is an inherent temperature dependency that leads to a distance drift. Therefore, the epc TOF chips have integrated temperature sensors whose readings can be used to offset this effect. Fixed pattern noise (FPN and AVG) does not apply for the epc600 since there is only one distance value.

In order to deliver optimal performance, each epc600 camera head is calibrated in the factory. These calibration values can be loaded to the Evaluation Kit with the “Load data...” button. Do this every time the camera head is changed. The absolute distance reference can additionally be fine-tuned with the “Dist off” setting (distance offset).

Note:
The specific calibration data file is provided by epc and is specific to the respective chip whose ID is displayed in the Calibration Settings section.

5.1.9. Application settings

This dialogue allows the user, to save and reload user interface configurations. It simplifies the work with predefined user interface settings.

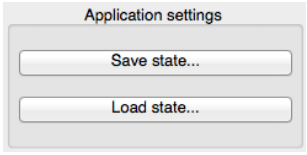


Figure 22: Application settings

5.1.10. Log dialog

This function allows data logging for offline analysis of epc600 chip read-out data as well as corrected data. The data stream can be collected either by number of measurement counts or by a logging time.

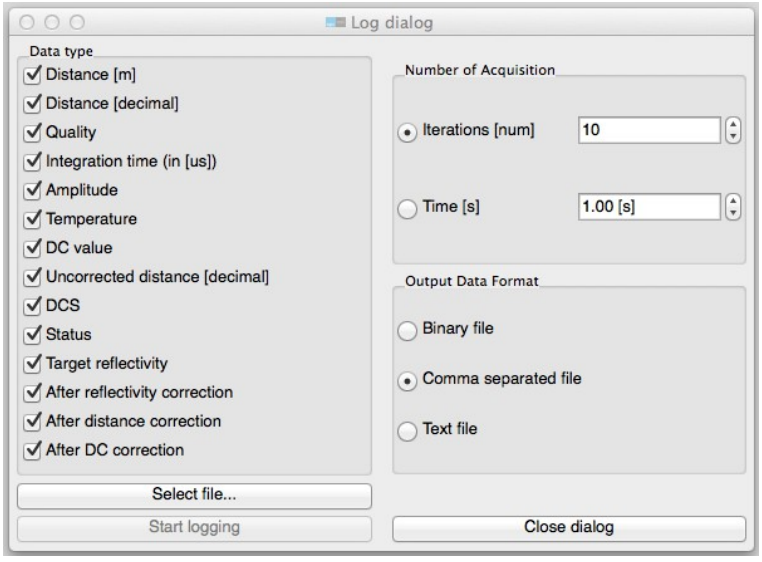


Figure 23: Log dialog

5.2. Additional technical info and definitions

For the detailed technical description and specification of the epc600 chip, refer to the corresponding Datasheet epc600.

Below are some technical considerations to help better understand the working principles and boundary conditions:

Maximum AC input illumination power

This is the amount of the backscattered modulated light, that leads to a saturation of the signal processing path. The camera goes “blind”. This value is also a function of the relative spectral sensitivity (e.g. refer in the datasheet to the table “Sensitivity and ambient-light suppression vs. wavelength”).

Minimum AC input illumination power

This is the minimal amount of the backscattered modulated light to provide just enough signal. Below this level, the distance noise can increase significantly. This value is also a function of the relative spectral sensitivity (e.g. refer in the datasheet to the table “Sensitivity and ambient-light suppression vs. wavelength”).

Integration time

During this time, the sensor is sampling the light power. A longer integration time leads to a higher sensitivity of the camera. This means a weaker illumination can be used. Use this to trade-off between achievable measurement range and illumination power.

Dynamic range at a fixed integration time

Is defined by the span between the maximum to minimum AC input illumination power limits.

Extended dynamic range

By an on-the-fly adaption of the integration time to the illumination conditions of the scenery, the dynamic range of the system can easily expanded.

Unambiguity distance

epc TOF devices are operated with a periodically (e.g sinusoidal) modulated illumination. The unambiguity distance is the distance that corresponds to the traveled distance of light within one modulation period. Light signals inside this time window are can be allocated to a unique distance. Reflected light with a longer travel time will cause false readings (because the sensor cannot distinguish between different modulation periods).

Illumination of the scenery

Is the light actively brought into the observation area by the camera's modulated light signal.

Remission (more commonly known as reflectivity)

The emitted light from the camera is backscattered by the object in the scenery. The surface conditions of this target define how much light will be reflected. This loss of light power is defined by the remission factor (or reflectivity)

Examples: A sheet of white paper has a remission of 90%, whereas a dark carpet reflects only 5%.

Ambient-light suppression

In real world applications, there will always be ambient-light. The epc600 TOF Range Finder is designed to filter out such ambient-light from the received signal (ambient-light suppression). This internal filtering capability works so well that the systems even operates in highly illuminated scenes such as outside applications in bright sunlight. However, there is a limit for this suppression. E.g. a measurement attempted directly towards the sun will fail because of saturation.

The ambient-light suppression also depends on the relative spectral sensitivity (e.g. refer in the datasheet to the table “Sensitivity and ambient-light suppression vs. wavelength”).

Distance offset

There is always a distance offset that is made up by the sum of all delays in the signal chain of the chip. Like any other camera system, TOF systems need be offset-calibrated before they are put into use.

6. Further Application notes

6.1. Illumination

Good illumination is crucial, as is the design of the Rx and Tx lens system. epc provides several application notes on this topic. However, an LED illumination subsystem and the matching Rx and Tx lens systems requires adequate experience.

6.2. Ambient-light & wavelength

Ambient-light is by nature a disturbing factor. There are several options to suppress such interferences in an application. One solution is the use of modulated light (which can easier be separated from typical static (DC) ambient-light). Another widely used approach to increase the ratio of the signal to the ambient-light is to work with specific wavelengths. Sunlight and artificial light sources typically have low infrared (IR) power. This is the reason why epc detectors have high sensitivities in the near infrared range (NIR). Sensor systems based on epc detectors should therefore be designed to work in the NIR Range (e.g. 940nm).

6.3. Noise reduction

The accuracy of the distance readings depends on the signal amplitude in the receiver path. The higher this amplitude, the more accurate the results, the less distance noise occurs. The signal amplitude is equal to the product of the received light energy multiplied by the integration time. The adaptation of the integration time to the highest possible signal values (including a certain safety margin to avoid channel saturation) leads to noise reduced measurement values.

6.4. Temperature compensation

The energy of light emitting devices and the sensitivity of photo-electric sensors both have a certain temperature dependency. If such systems are working under conditions with widely varying temperatures, a compensation of the measurement data as a function of temperature is necessary. The epc600 has internal temperature sensors that can be used for such compensations. For more details, refer to the datasheet of the chip.

6.5. Linearity correction

The actual light modulation signal differs from the theoretical waveform. Therefore, the distance readings typically have some relative errors. The deviations depend on the distortion of the signal waveform by the hardware as well as on the signal amplitude in the receiver path. Such non-linearities can be reduced by using a correction algorithm or look-up table as function of the distance and signal amplitude.

6.6. Special phenomena

Special phenomena can be created by time domain effects, reflections, surface behavior, etc. … Such phenomena mainly result from changing conditions (illumination, reflectivity, fast movements..) during one measurement. Below are some examples.

6.7. Motion blurring (Fast moving objects)

To get correct distance results, an object should not move in any direction faster than the camera needs to catch the 4 corresponding samples for one distance calculation. Faster movement leads to unstable or erroneous readings for a measurement sequence. Figure 24 shows an object crossing though the observation beam. At sample 1, any reflected light is missing due to the fact that the object does not touch the light beam. Sample 2 and 4 see a reduced signal, because not all the light is reflected by the object. In fact, after the distance calculation, the result is not reliable and needs to be scrapped.

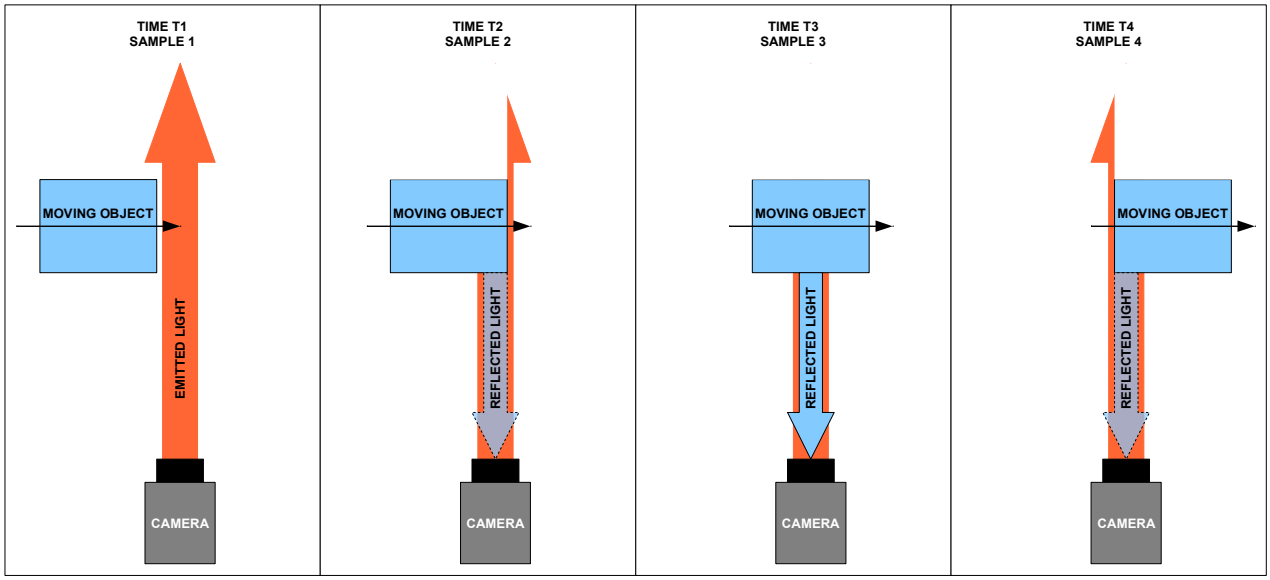


Figure 24: Measurement cycle with moving object

6.8. Transparent objects

Transparent objects may distort the distance reading as they partially separate the illumination. Some of the light is reflected directly and another part may be reflected from objects after passing through the transparent surface. Depending on the ratio of these parts, the distance result may be inaccurate. Keep in mind that visually opaque targets can be transparent for infrared light.

6.9. Changing remission (reflectivity)

The measurement assumes that during a measurement cycle, the object does not change its reflectivity. Physically, this corresponds to 4 correlation samples with equal amplitude. If the remission of the object is changing during the sampling sequence, the amplitudes will mismatch and a distance error may occur.

6.10. Indirect light reflections

The measurement assumes that the emitted light is directly reflected back to the receiver. In real conditions, it may happen that the light that comes back to the sensor returns by multi-point reflections (e.g. by mirroring objects in the background). The camera cannot distinguish between direct or indirect reflected light. Depending on the magnitude of such indirect reflections, such cases may lead to incorrect distance readings.

6.11. Convex surfaces

If light is reflected from convex surfaces (e.g. a round pillar), the reflection magnitude strongly depends on the surface angle. At steeper angles the reflected light is attenuated more .Therefore, such objects look smaller than they actually are.

6.12. Highly reflective background objects

Highly reflective objects in the background of a scene may mask an object in the foreground. While being farther away than the actual object of interest, they may return a higher amplitude signal due to their higher reflectivity. One option to tackle such situations is the reduction of the illumination power.

6.13. Light scattering

This phenomenon happens if light is reflected multiple times between the sensor surface and the receiving lens system. It leads to blurry and diffuse pictures of the object. Therefore, lens systems of industrial sensor systems typically have an anti-reflex coating. It is highly recommended to deploy such anti-reflex coatings for TOF based sensor systems as well.

7. Maintenance and disposal

7.1. Maintenance

The components of the evaluation kit do not need regular maintenance. A functional check is recommended each time the kit is taken into operation:

- Check the mounting position and the detection area of the sensor with respect to the operational conditions. Also check that there is no hazardous situation.
- From time to time, clean the sensor with a soft towel and with a little soapy water to remove dust or dirt.

7.2. Disposal

Disposal should be done using the most up-to-date recycling technologies for electronic components according to the local regulations and laws. The design and manufacture of the kit's components are done in compliance with the RoHS legal regulations. Traces of dangerous materials may be found in the electronic components, but not in harmful quantities.

8. Addendum

8.1. Related documents

- Manual – epc600/610 Evaluation Kit – mainboard, ESPROS photonics corp., 2014
- epc600 datasheet, ESPROS photonics corp., 2014
- STM32F205xx, STM32F207xx, STM32F215xx and STM32F217xx advanced ARM-based 32-bit MCUs, Reference manual, ST Microelectronics corp., 2011
- PIC10F200/202/204/206 datasheet, Microchip, 2007

8.2. Links

www.espros.ch

www.microchip.com

www.microchip.com/icd3

http://infocenter.arm.com

8.3. Licenses

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