



Manual epc635 Evaluation Kit

How to get started

General Description

This document presents an overview about the functionality, operating modes, the most important steps, screens and functions of the epc635 Evaluation Kit.

Features

- Fast intro in the epc635 3D-TOF chip
- Many of the epc635 chip operation modes can be evaluated
- Consists of a DME 635 camera engine, power supply, and tripod
- Wide FOV of H50° x V19°
- Long operating range up to 17m on white targets in the full field of view
- Camera calibration feature
- Log section to capture single images and movie sequences for further processing
- May graphic display modes featuring 3D-TOF in color and point cloud presentation, amplitude, grayscale, and DCS

Applications

- Evaluation and development support



Figure 1: Evaluation Kit epc635

1. Precaution and Safety



Eye safety: 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.



The DME 635 camera module is a bare electronic device without a housing around. Therefore, handle it with the necessary ESD precaution.



Over-voltage: Use only power supplies which corresponds to the datasheet DME 635 to avoid damage of the DME 635 or cause danger for humans.



Cable-tripping: Place the DME 635 with a tripod on a flat solid ground or fix it correctly on a solid support. Place cables carefully. Falling devices can be damaged or harm persons.



This camera comes with its own calibrated firmware. For proper operation of the camera, upload the correct firmware with the evaluation kit to the camera according the instructions given in the quick guide. Do this when you are changing the camera module.



This camera comes with high quality lens. Do not touch, twist or turn it. Otherwise loss of performance occurs.



EMC compatibility: The DME 635 is designed on module level. It is not an EMC certified device. It is users responsibility to operate it in compliance with the EMC regulations.



The DME 635 is designed on module level. It is NOT a CE, UL, CSA certified device. It is the users responsibility to operate it in compliance with the relevant regulations.



The DME 635 and its software may only be used in accordance of the datasheet DME 635



This devices may not be used in safety applications, explosive atmospheres or in radioactive environment.



Limited warranty - Loss of warranty

The DME 635 should only be installed and used by authorized people. All instructions in this datasheet and in the related documents shall 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 or disregarding of given operating instructions.

UPDATES

ESPROS Photonics is constantly striving to provide comprehensive and correct product information. Therefore, please check our website regularly for updated versions of datasheets and documentations: www.espros.com



Download the actual Datasheet epc635: www.espros.com → Downloads → Datasheets → Chips



Download the actual Datasheet DME 635: www.espros.com → Downloads → Datasheets → Camera_and_Modules



Download the actual Manual epc635_Evalkit: www.espros.com → Downloads → Datasheets → Evaluation_Kits



Download the current GUI software (client) and the current BeagleBoneBlack software (server).
Questions: Send an email with your request to your local sales office or to info@espros.com.



Update the DME 635 (BeagleBone board): Go to the folder "ESPROS_TOF-imager_Evaluation_Kit_Software_vX.X.X". Read the Readme-file and follow the instructions accordingly.

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2. epc635 Evaluation Kit

2.1. Scope of delivery



Figure 2: epc635 Evaluation Kit overview

No	Pieces	Designation	Remarks
①	1	Toolbox	
②	1	DME 635-50°/17m	P/N P100 519; with quick release fastener of the tripod
③	1	Power Supply 24V/2.5A	
④	1	Power cord 2 pole EU version and US adapter	Power plug EU Europlug (CEE7/16, 2 pole) Power plug US Type A (NEMA 1-15, 2 pole)
⑤	1	Cable - USB 2.0, A plug - mini-B plug	Length 2m
⑥	1	Plastic bag with Industrial Supply Connector and the toolbox key	The connector can also be inserted in the DME 635
⑦	1	Camera Tripod	
⑧	1	Toolbox belt	
⑨	1	epc635 Quick Guide	also available at www.espros.com/Downloads
	1	DME Cover Plate Set, includes 2 knurled head screw	P/N P100 512, see Figure 16 and Figure 43
		Datasheet DME 635	available at www.espros.com → Downloads
		Datasheet epc635	available at www.espros.com → Downloads
		Application and configuration software, SDK: Use the "ESPROS_TOF-Imager_Evaluation_Kit_Software" for accessing the licensed corresponding tools and software development kit (SDK).	available at www.espros.com → Downloads

Table 1: Bill of material of the delivery

2.2. Ordering information

Part Number	Part Name	Remarks
P100 411	epc635 Evaluation Kit EU & US	Power plug EU Europlug (CEE7/16, 2 pole) & US adapter
P100 512	DME Cover Plate Set	1 set is included in the kit

Table 2: Ordering Information epc635 Evaluation Kit



Figure 3: DME 635 on tripod



Figure 4: epc635 Evaluation Kit



Figure 5: DME 635 tripod mounting



Figure 6: DME 635 with quick release fastener of the tripod

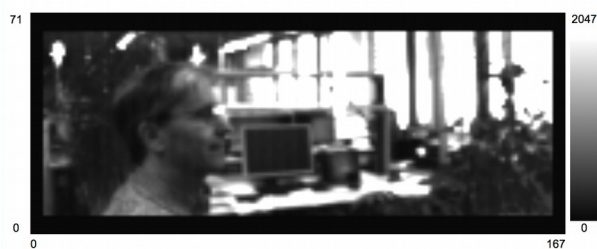


Figure 7: GUI - b&w picture

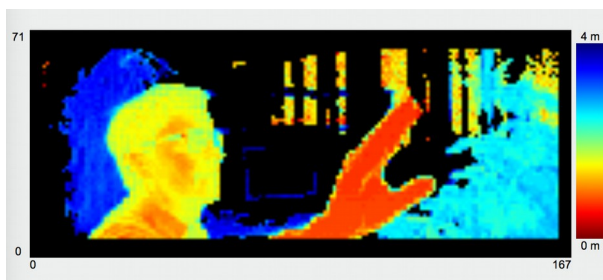


Figure 8: GUI - 3D TOF picture

3. Installation and setup

3.1. Fixation of the DME 635

The DME 635 has various mounting options as shown in Figure 9.

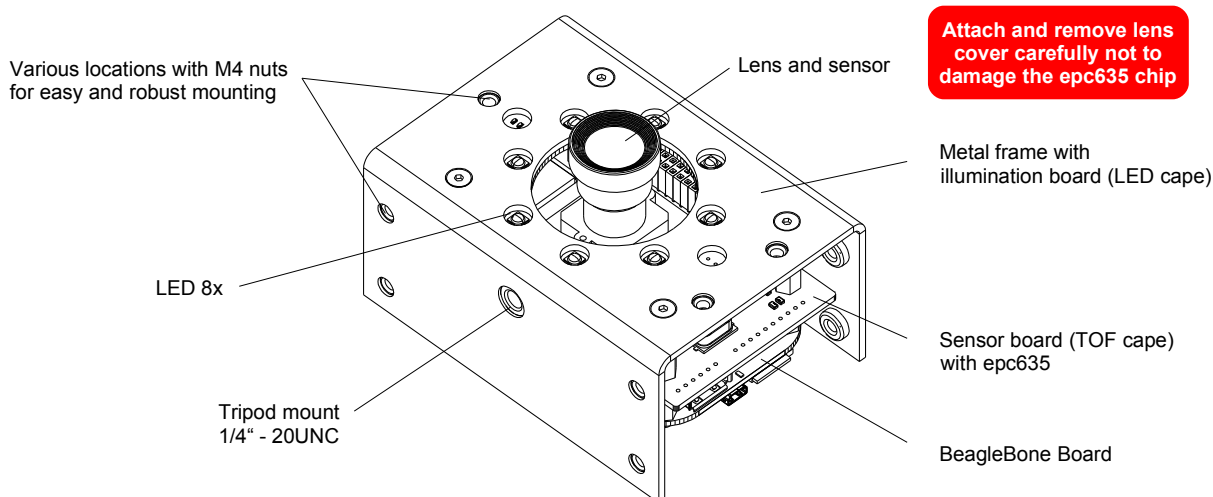


Figure 9: DME 635 overview

3.2. Overview of the DME 635 camera module

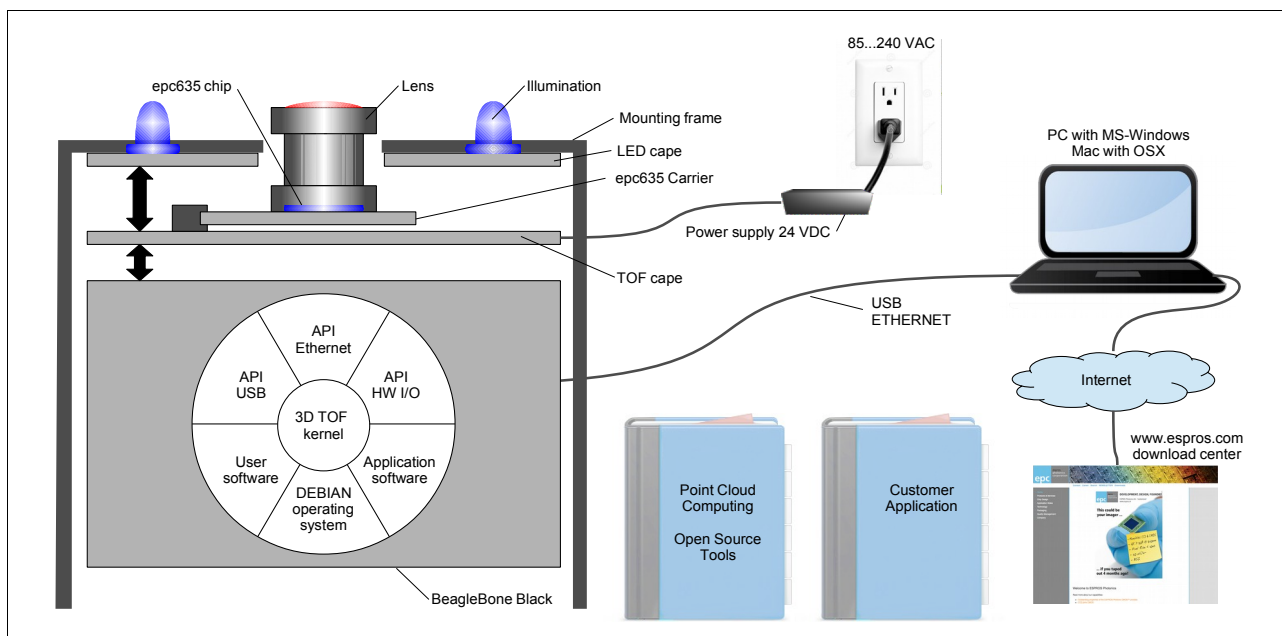


Figure 10: System overview

The epc635 evaluation kit is based on the DME 635 . This is a general purpose camera module based on the epc635 chip:

- The camera is based on a BeagleBone Black (BBB) Linux computer board.
- The TOF cape board communicates with the BBB and carries the epc635 CC Chip Carrier board with the epc635 camera chip and the lens with the lens holder. It carries also the single wire power supply for the hole camera system.
- The camera's active illumination is done by 8 power LEDs on the LED cape which is driven by the TOF cape. The LED cape's metal frame offers two camera mount 1/4" - 20UNC.
- The application software runs on the DEBIAN GNU/Linux operating system. The 3D-TOF kernel manages the camera including correction algorithms. Data for further processing e.g. cloud computing is available on APIs (application programming interface) for USB, Ethernet interfaces or hardware I/O. It opens the world for point cloud computing by using open source tools or by creating own customer applications.

3.3. Software, software development kit (SDK) and application tools

ESPROS Photonics supports the user's development and application by having available various support tools e.g. software development kit (SDK), updates and emulation program downloads for the epc635 chip, application interfaces (API), etc. All they are available by downloading the ESPROS_TOF-Imager_Evaluation_Kit_Software" _vx.x.x. Updates of camera firmware are also included in the package.

After the download, read first the README and CHANGELOG files to get latest operation and application information.

3.4. Exchange of epc635 Card Edge Connector Chip Carrier



Make sure, all assembly procedures are executed on an ESD-compatible workstation.

- Power off the DME 635 and remove cables
- Remove the BeagleBone board
- Remove the TOF cape
- Remove the locking screws from the epc635 CC Chip Carrier
- ⚠ Softly remove the epc635 CC Chip Carrier. The epc635 chip can be destroyed when excessive force is applied.
- Remove lens holder
- Attach the lens holder to the new epc635 CC Chip Carrier
- ⚠ Softly insert the new epc635 CC Chip Carrier
- Insert the locking screws for the epc635 CC Chip Carrier
- Install the TOF cape
- Install the BeagleBone board
- ⚠ First power on the DME 635
- Connect the USB cable
- Download and install on the DME 635 the latest server software according the Readme.txt
- Start the epc635 Evaluation Kit GUI and run a black & white video (start)
- Unlock the fixation of the lens.
- Adjust lens focus
- Lock the fixation of the lens
- Calibrate the DME 635 with this new chip carrier

4. Operation software

The Evaluation Kit epc635 uses software which can be downloaded from the ESPROS Homepage at www.espros.com, click to the link 'Downloads' as shown below:

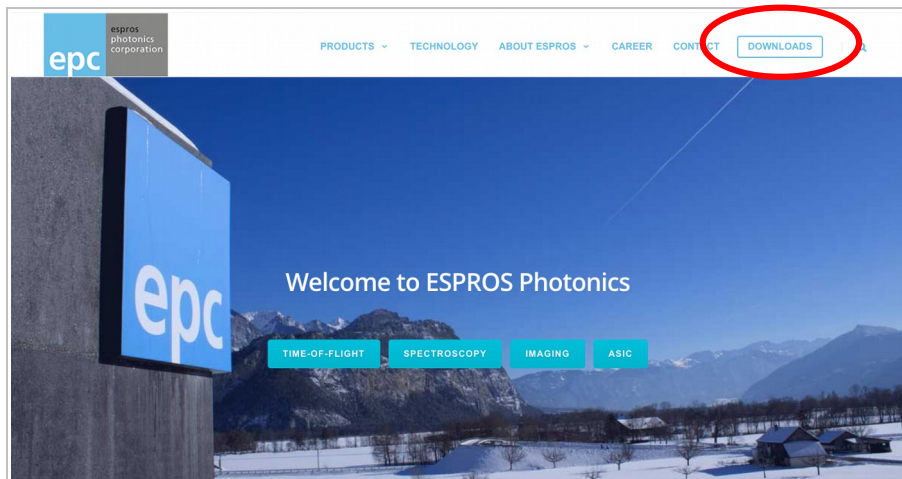


Figure 11: ESPROS homepage with the Download link

You will get a folder structure. Go to the subfolder 03_Evaluation Kits/Evaluationkit_epc635 and download the corresponding file for Windows or Mac of the "ESPROS_TOF-Imager_Evaluation_Kit_Software" _vx.x.x. Unpack the file. You will get a folder structure like shown in Figure 12.

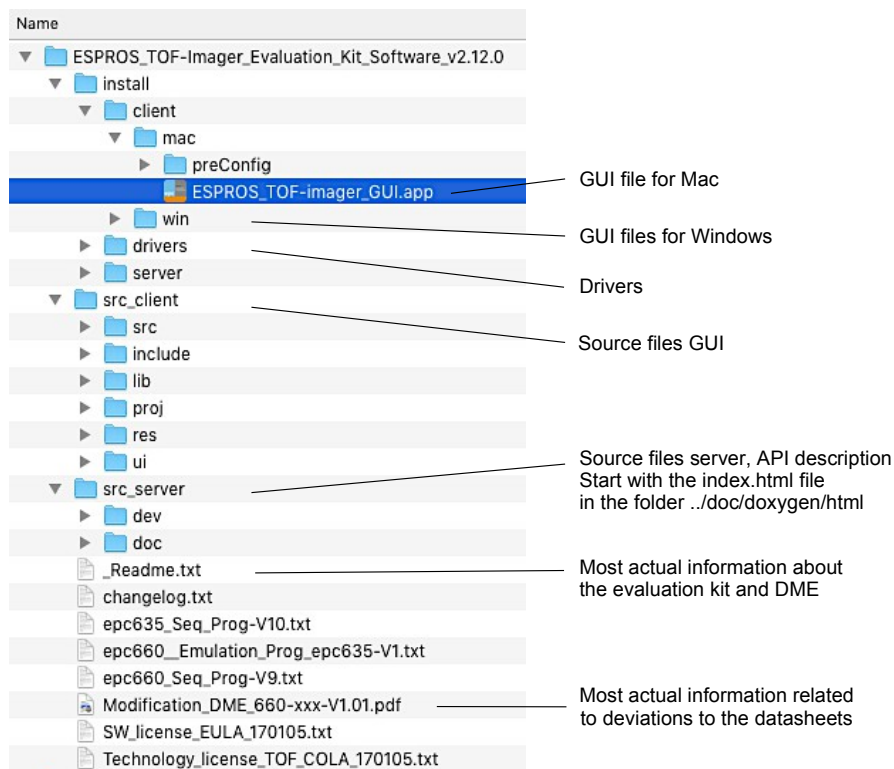


Figure 12: Folder structure after installation

5. GUI Functionality

5.1. Start the GUI software

Note:

First after installation of a new software release, read the files README and CHANGELOG of the download package to get latest evaluation kit information.

After start of the “ESPROS_TOF-imager_GUI” application file, the connect dialog will be displayed.

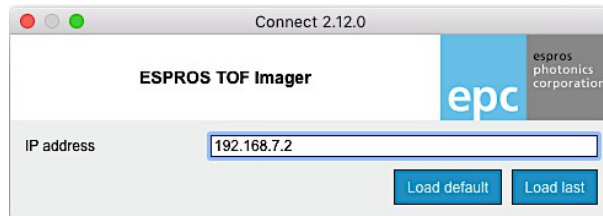


Figure 13: Connect dialog after start up

Followed the selection “Load default”, the dialog of preconfigured, basic operation modes appear.

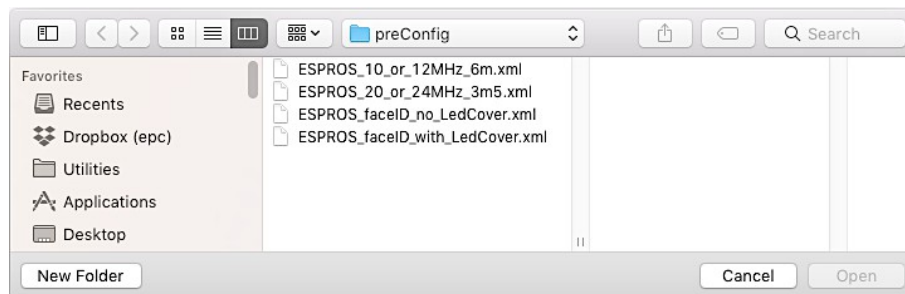


Figure 14: Pre-configurations

Select one of the pre-configurations to start the GUI:

- ESPROS_10_or_12MHz_6m: Basic setup for 6m operating range.
- ESPROS_20_or_24MHz_3m5: Basic setup for 3.5m operating range.
- ESPROS_facelD_no_LedCover: Basic setup for doing Face ID without LED cover.
- ESPROS_facelD_with_LedCover: Basic setup for doing Face ID: This configuration needs a the special LED cover.



Figure 15: Face ID operation e.g. for DME 660



Figure 16: DME with LED cover for face ID

5.2. Overview

The GUI consists of two windows: The control window Figure 17 and the display window Figure 18. The control window is used to set parameters, choose the way of displaying the camera images and to log data. It consists of two sections: Left is the dock with the Apps and right is the control section.

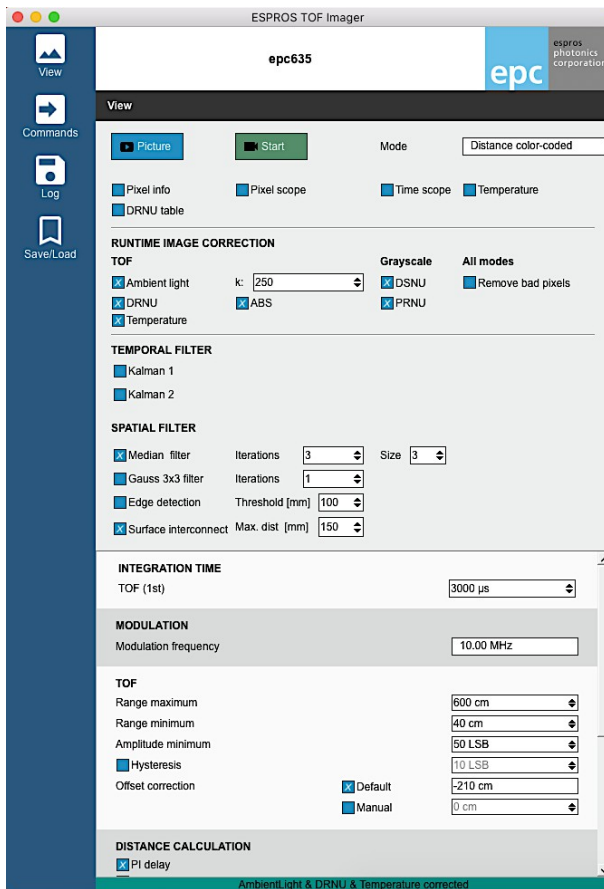


Figure 17: Control window

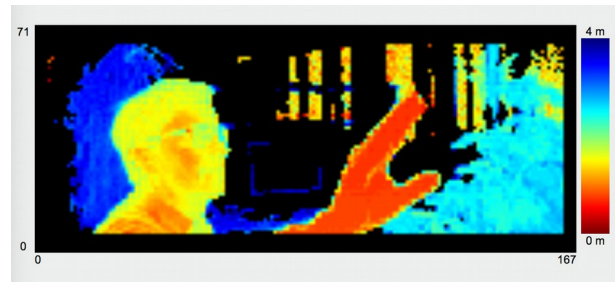


Figure 18: Display window

Most of the functions are self-explaining and are not described herein.

5.3. Operating mode and display setting

The screenshot shows the 'epc635' software interface. At the top, there's a 'View' section with buttons for 'Picture', 'Start', and 'Mode' (set to 'Distance color-coded'). Below this are checkboxes for 'Pixel info', 'Pixel scope', 'Time scope', 'Temperature', and 'DRNU table'. The 'RUNTIME IMAGE CORRECTION' section includes 'TOF' settings like 'Ambient light', 'DRNU', 'Temperature', 'Grayscale', and 'All modes'. The 'TEMPORAL FILTER' section has 'Kalman 1' and 'Kalman 2' options. The 'SPATIAL FILTER' section includes 'Median filter', 'Gauss 3x3 filter', 'Edge detection', and 'Surface interconnect'. The 'INTEGRATION TIME' section shows 'TOF (1st)' set to '3000 µs'. The 'MODULATION' section shows 'Modulation frequency' set to '10.00 MHz'. The 'TOF' section includes 'Range maximum', 'Range minimum', 'Amplitude minimum', 'Hysteresis', and 'Offset correction'. The 'DISTANCE CALCULATION' section has 'PI delay', 'Dual phase mode', and 'Dual integration time mode'. The 'DATA VALIDATION' section includes 'Saturation' and 'ADC overflow'. The 'TRANSFORMATION' section has 'Horizontal flip' and 'Vertical flip'. The 'IMAGE' section includes 'Recursive averaging (weighting factor)'. At the bottom, a status bar indicates 'AmbientLight & DRNU & Temperature corrected'.

Displays connected chip type

Single shot picture or movie
Display mode (grayscale, 3D-TOF, amplitude, DCS, etc.)

Selection for additional information windows e.g Pixel Info: Displays pixel detail data of the pixel pointed by the cursor.

Image and fix pattern noise correction based on calibration. Refer for details to application note AN10 available on www.espros.com, section DOWNLOADS.
ABS: Enables enhanced ambient-light suppression

Smoothing of run-time distance data by temporal filters (Kalman filters). Refer for details to application note AN12 available on www.espros.com, section DOWNLOADS.

Smoothing of run-time distance data by spatial filters. Reduces pixel resolution by increasing picture quality. E.g. the median filter replaces pixel by pixel the value by the median of the selected sliding filter window (size)

Remove erroneous distance data for in-pixel distance transitions e.g. edges
Translation from points into surface in the point cloud function

Integration (or exposure) time for TOF or grayscale imaging

Select unambiguity distance and distance resolution by setting illumination modulation frequency

3D image data representation setup

Data clipping: upper end of color coding

Data clipping: Lower end of color coding

Set data values with too low signal to maximum distance value

Smooths measurement: Set a hysteresis window for distance value changes

Overall shifting of measured distance values

Distance calculation concept

enabled: Result is based on DCS0 ... DCS3, see Figure 22

DCS0/DCS1 resp. DCS2/DCS3 sampling at same int. time, refer to Table 3

DCS0/DCS1 resp. DCS2/DCS3 sampling with different integration times

Mark-up of saturated pixels in the picture

Mark-up of overexposed pixels in the picture

Flipping of displayed image

Smooths measurement: Averaging of distance values over time

Green underlay: Camera is calibrated for the selected parameters

Figure 19: Operating mode and display setting

Notes:

1. DME 635 supports with calibrations default modulation frequency settings for 10MHz, 20MHz (full range, around 31.5cm/calibration step) and 20MHz face ID (up to 1m, round 2cm/calibration step).



Figure 20: Modulation frequency selection

2. Calibrated parameter. Note: DME's without 20 MHz face ID calibration will use instead the regular 20MHz calibration.

5.4. Distance calculation concepts

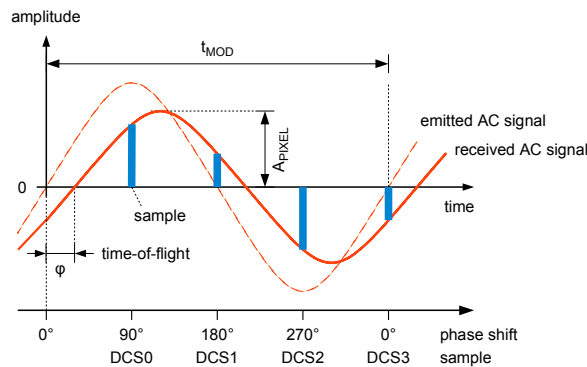


Figure 21: Sampling of the received waveform

There are two check-boxes to choose the way of distance calculation: PI delay and Dual MGX (refer to Figure 19). These functions allow to reduce motion blur and/or accelerate the distance measurement sequence.

	PI Delay	Dual MGX
Enabled	Distance measurement is made by the acquisition of 4 DCS (Differential Correlation Samples). This setting provides the most accurate distance measurement option. Pixel non-linearities are suppressed by differential measurement. Because the distance acquisition is made sequentially by four images, motion blur artifacts occur. This is the default operation mode.	In this mode, in a first acquisition, DCS0 is sampled on the upper row, whereas the DCS1 is sampled into the adjacent lower row. In the second acquisition, DCS2 is sampled on the upper row, whereas the DCS3 is sampled into the adjacent lower row. With these two acquisitions, all 4 DCS are sampled and the distance calculation can take place. Please note that this mode reduces the vertical resolution by 2 (120 rows).
Disabled	Distance measurement is made by the acquisition of 2 DCS. This setting provides a doubled frame rate than with 4 DCS. Also motion blur is reduced. However, pixel non-linearities become visible and therefore, more calibration and compensation is needed.	Full vertical resolution is maintained. This is the default operation mode.

Table 3: PI Delay and Dual MGX mode (motion blur reduction)

Thus, if PI Delay is disabled and Duals MGX is enabled, distance acquisition is made by just on integration. This is the fastest mode which has virtually no motion blur artifact. Figure 22 shows the concepts in a graphical manner.

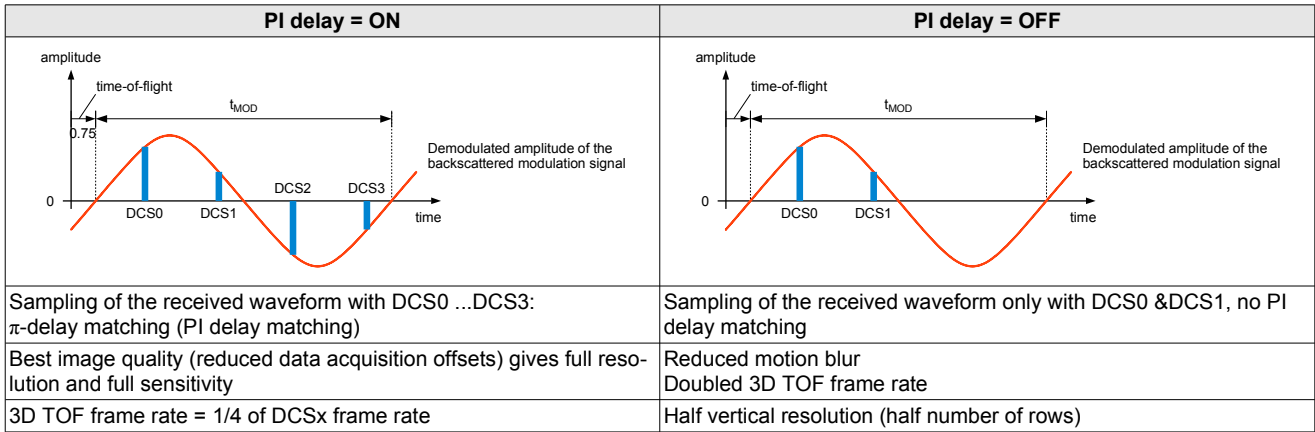


Figure 22: Sampling of the received waveform with or without PI-delay matching

More detailed information regarding the various operating modes can be found in the epc635 datasheet.

5.5. Miscellaneous functions (Examples from DME 660)

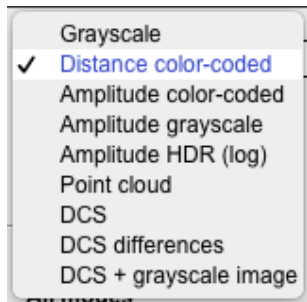


Figure 23: Mode selection overview

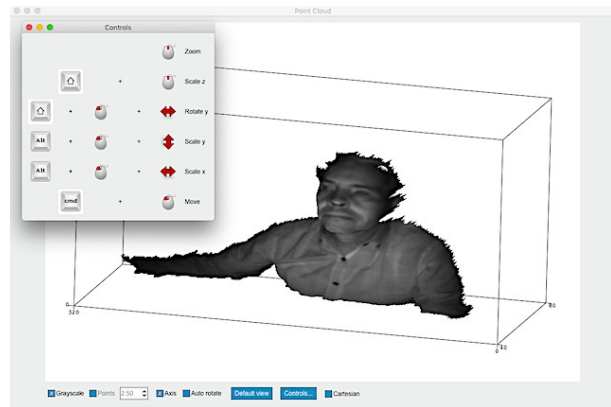


Figure 24: The controls dialog to adjust the point cloud view

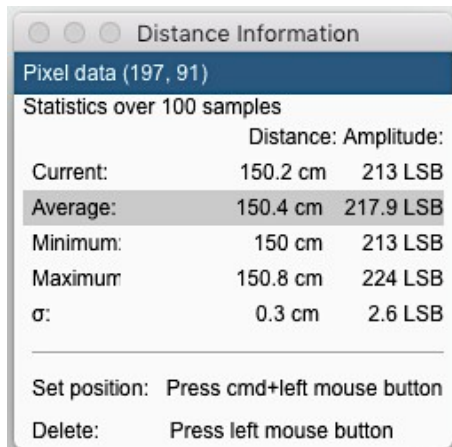


Figure 25: Pixel info

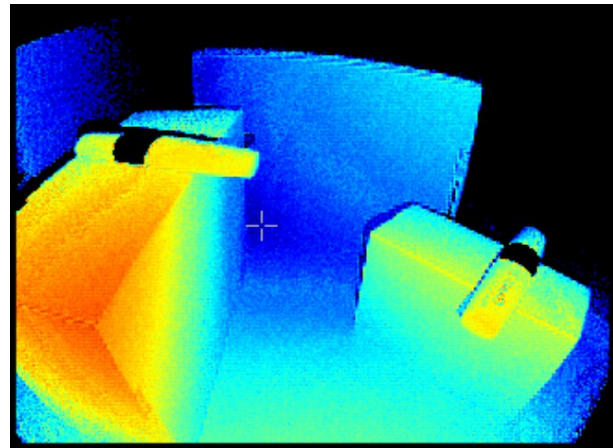


Figure 26: Grey mark-up cross of the pixel info selection

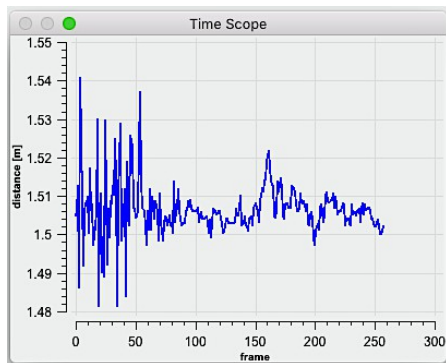


Figure 27: Time sequence data of the pixel info at mark-up

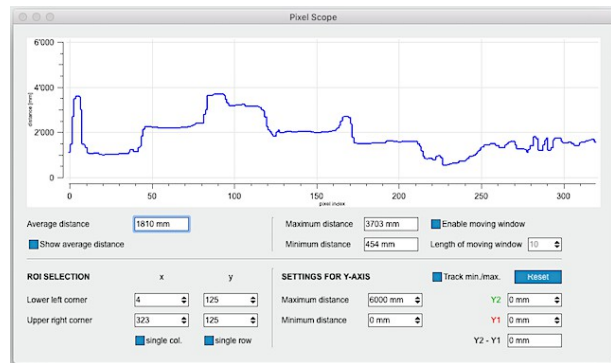


Figure 28: Pixel scope

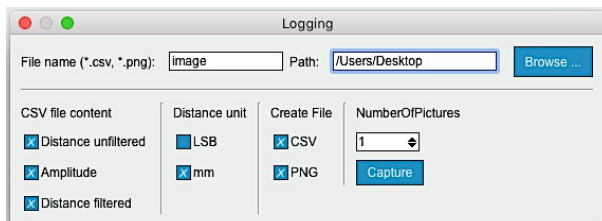


Figure 29: Logging options

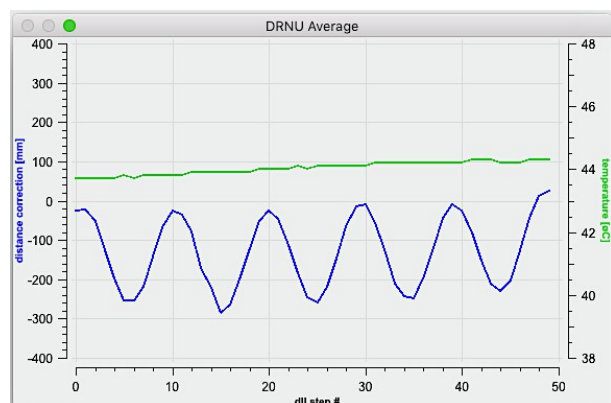


Figure 30: DRNU table for distance corrections

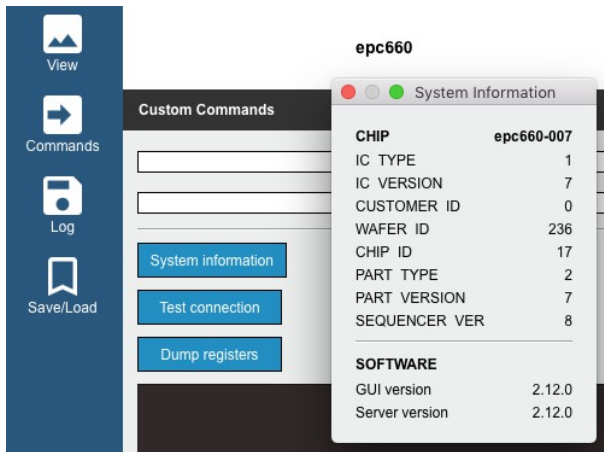


Figure 31: Read system info in the Commands dialog

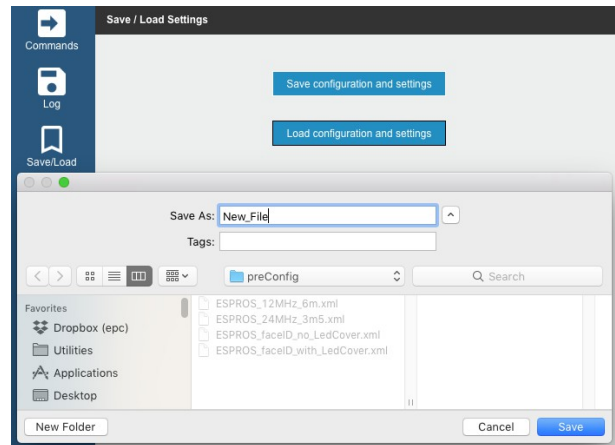


Figure 32: Save and reload system setups in the Save/Load dialog

5.6. Regular greyscale and distance image (Examples from DME 660)

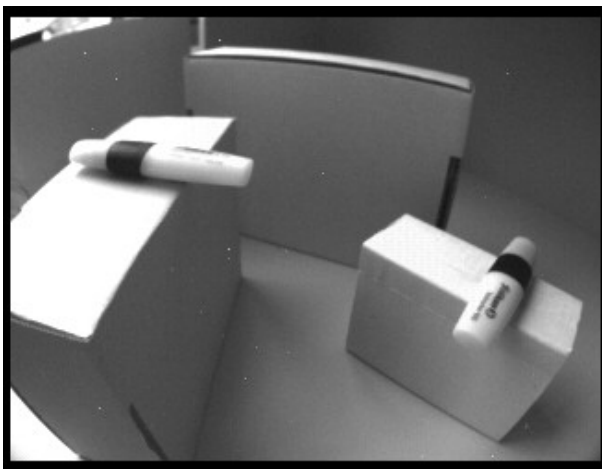


Figure 33: Grayscale picture

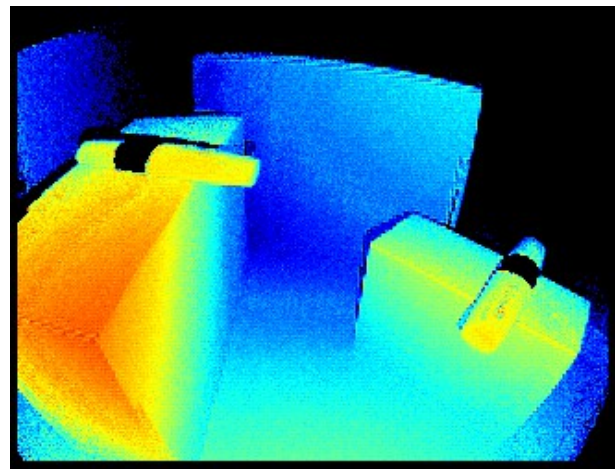


Figure 34: Raw distance picture

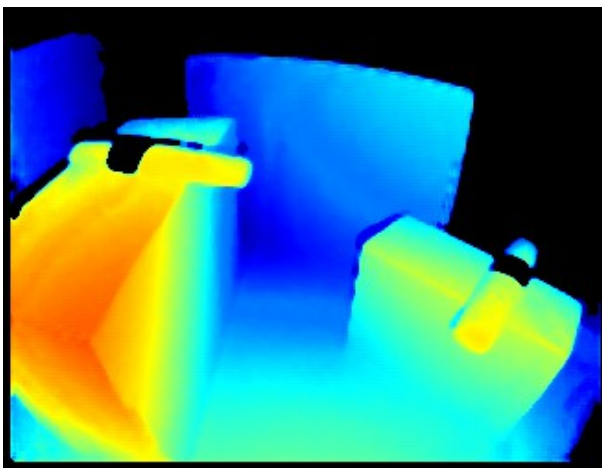


Figure 35: Filtered distance picture

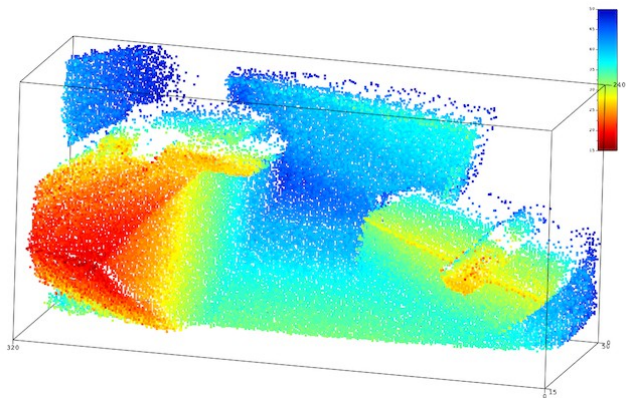


Figure 36: Point cloud

5.7. Self-illuminated grayscale images created by TOF mode (Examples from DME 660)

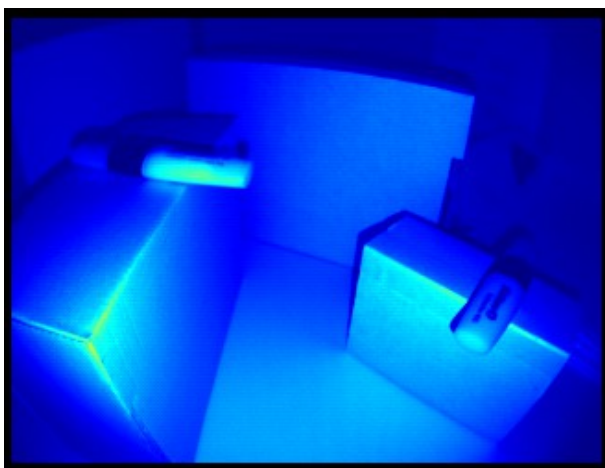


Figure 37: TOF amplitude picture color-coded

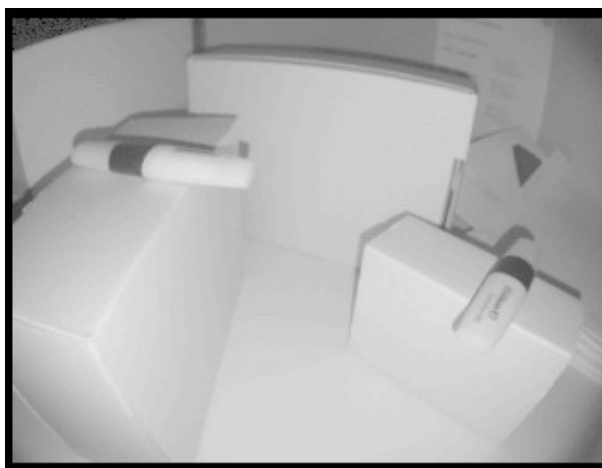


Figure 38: TOF amplitude picture HDR (log)

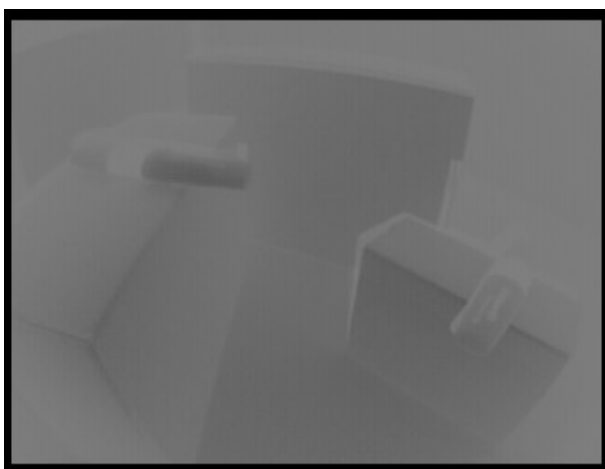


Figure 39: DCS0

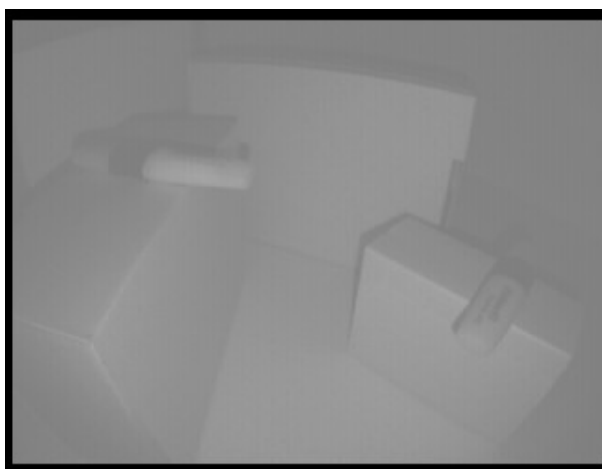


Figure 40: DCS2

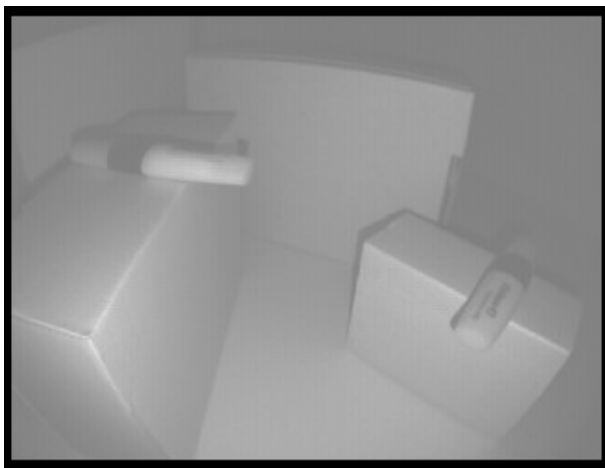


Figure 41: DCS1

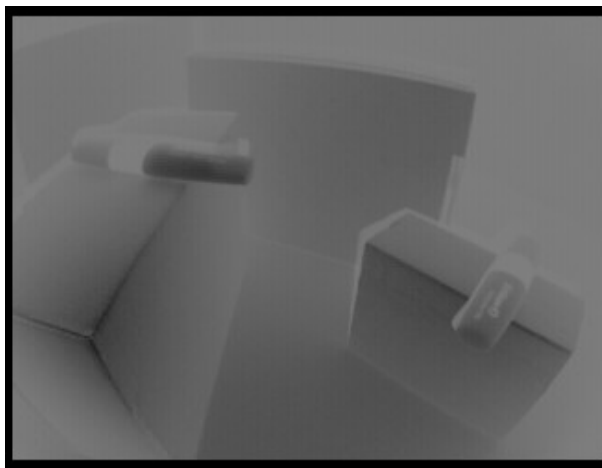
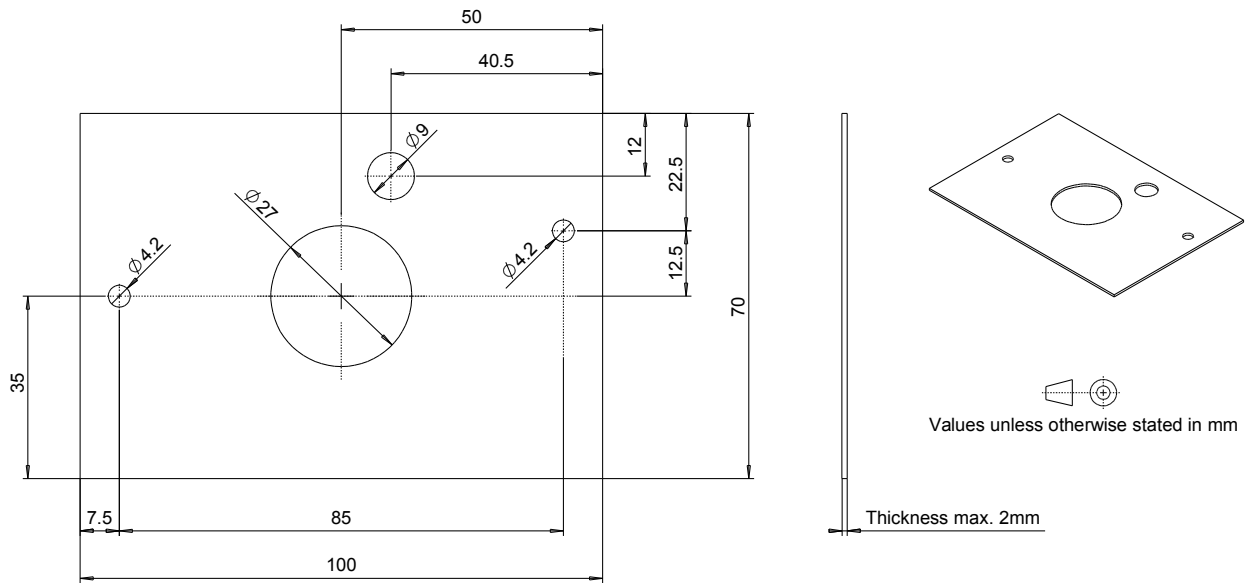


Figure 42: DCS3

5.8. Mechanical dimensions LED cover



5.9. I²C command syntax

The command section / window uses the following syntax for accessing the DME 635 (epc635 chip) by I²C commands:

1. Write to direct address:

Command: w <Direct_address> <Hex value> ---> Response: <01>

Example:

Command: w 92 34 ---> Response: 01

2. Read from direct address:

Command: r <Direct_address> ---> Response: <Hex value>

Example:

Command: r 92 ---> Response: <Hex value>

3. Write to EEPROM (values is active only after power-up or reset)

Command: w 11 <EEPROM_address> <Hex value> ---> Response: <02>

Example:

Command: w 11 92 34 ---> Response: 02

4. Read from EEPROM, data only

Command: w 11 <EEPROM_address> ---> Response: <02>

Command: r 12 ---> Response: <Hex value>

Example:

Command: w 11 92 ---> Response: 01

Command: r 12 ---> Response: <Hex value>

5. Read from EEPROM, EEPROM address and data

Command: w 11 <EEPROM_address> ---> Response: <02>

Command: r11 02 ---> Response: <EEPROM_address> <Hex value>

Example:

Command: w 11 92 ---> Response: 01

Command: r 11 02 ---> Response: 92 <Hex value>

6. Maintenance and disposal

6.1. Maintenance

The components of the device do not need regular maintenance. A functional check is recommended each time the device 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 lens with a soft towel and with a little soapy water to remove dust or dirt.

6.2. 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.

7. Addendum

7.1. Related documents

- Datasheet epc635, ESPROS Photonics Corp.
- Application note AN10_Calibration_and_Compensation, ESPROS Photonics corp.
- Application note AN11_DME_660_Photobiological_Safety_Analysis, ESPROS Photonics corp.
- Application note AN12_TOF_data_improvement_toolbox, ESPROS Photonics corp.
- BeagleBone Hardware Specs and Material, BeagleBone Black wiki
- BeagleBone Black System Reference Manual, BeagleBoard.org
- BeagleBone Black, Document No. 450-5500-001 (Schematics), BeagleBoard.org

7.2. Links

www.espros.com
www.beagleboard.org
www.pointcloud.org - Point Cloud Library (PCL)
www.pdal.io - Point Data Abstraction Library (PDAL)
www.opencv.org - OpenCV (OpenSource Computer Vision)

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