



User Guide

UG000495

TMF882X

EVM User Guide

TMF882X-EVM

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1 Introduction

The Time-of-Flight (hereafter referred to as 'ToF') EVM demonstration kit provides a way to evaluate ToF optical sensor(s) from ams AG. This document is a basic user guide to the setup and operation of the ToF EVM software.

1.1 Kit Content

Below is a checklist of what is included in the ToF EVM kit.

- ToF sensor EVM enclosure and sample glass (some EVMs come without an enclosure)
- USB type A to micro-USB cable(s)
- USB flash drive with EVM GUI software
- EVM documentation (including this guide)

Figure 1:
Kit Content



1.2 Ordering Information

Ordering Code	Description
TMF8821-EVM	TMF8821 EVM
TMF8828-EVM	TMF8828 EVM

As TMF8821 is a superset of the functions of TMF8820, **ams** recommends to use the TMF8821 EVM for evaluating the performance of TMF8820 and TMF8821.

The TMF8828 is a superset of the TMF8821, **ams** recommends to use the TMF8828 EVM for evaluating the performance of TMF8820, TMF8821, and TMF8828.

2 Setting Up the EVM

This section describes the setup steps necessary to start using the EVM software.

2.1 Setting Up the EVM Hardware

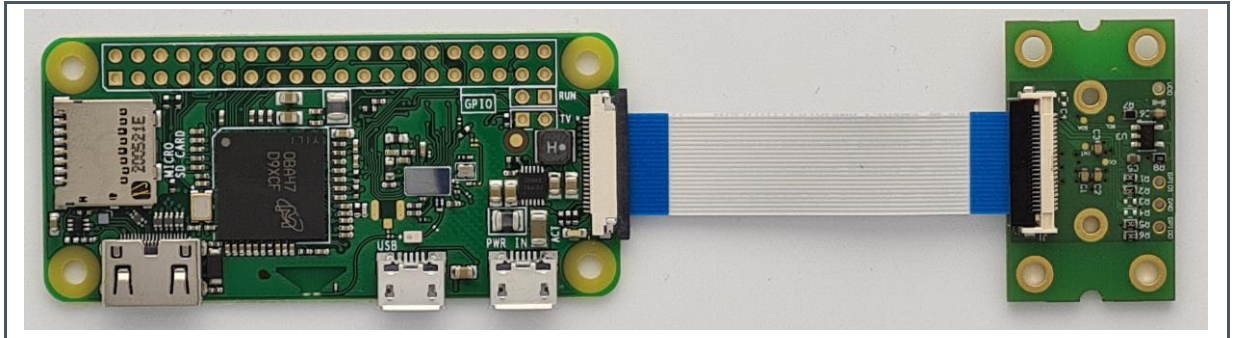
The ToF sensor enclosure is already assembled and ready to plug in to a PC. The EVM with the enclosure exposes only one micro-USB connector:

Figure 2:
EVM with Enclosure



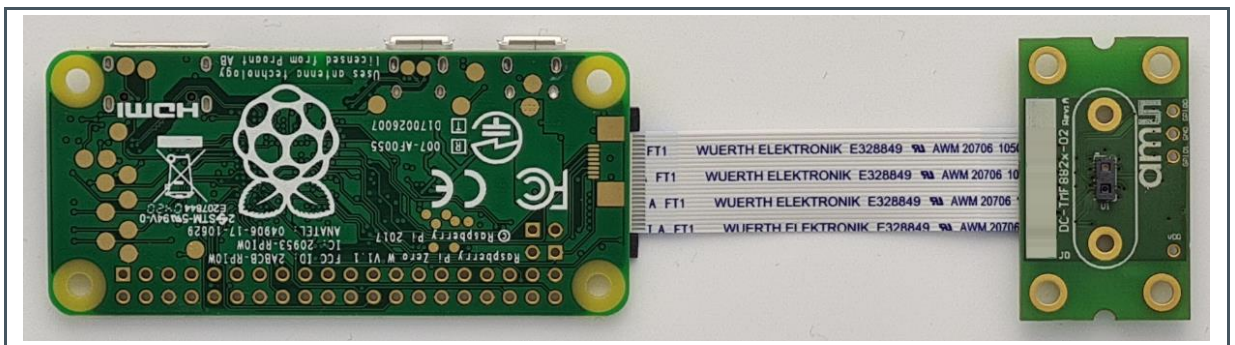
On EVMs without enclosure (or if the enclosure has been removed) plug in the micro-USB connector to the USB connector closer to the center of the Raspberry PI Zero W board (see Figure 3)

Figure 3:
EVM Without Enclosure – Front Side (TMF882X facing to table)



The TMF882X is shown when placing the Raspberry PI Zero W on the backside (see Figure 4)

Figure 4:
EVM Without Enclosure – Back Side (TMF882X facing to ceiling)



2.1.1 Install the EVM USB Windows (one-time only)

When the EVM is plugged into the PC Windows should recognize the EVM as a “Removable Disk”. If your PC does not automatically install the necessary USB driver, the mountable drive contains USB drivers for both Windows and Mac. Install this necessary USB driver:

- ams_raspirndis_setup.exe

This step is only necessary during first-time setup, but will need to be repeated if using the EVM software on a new PC.

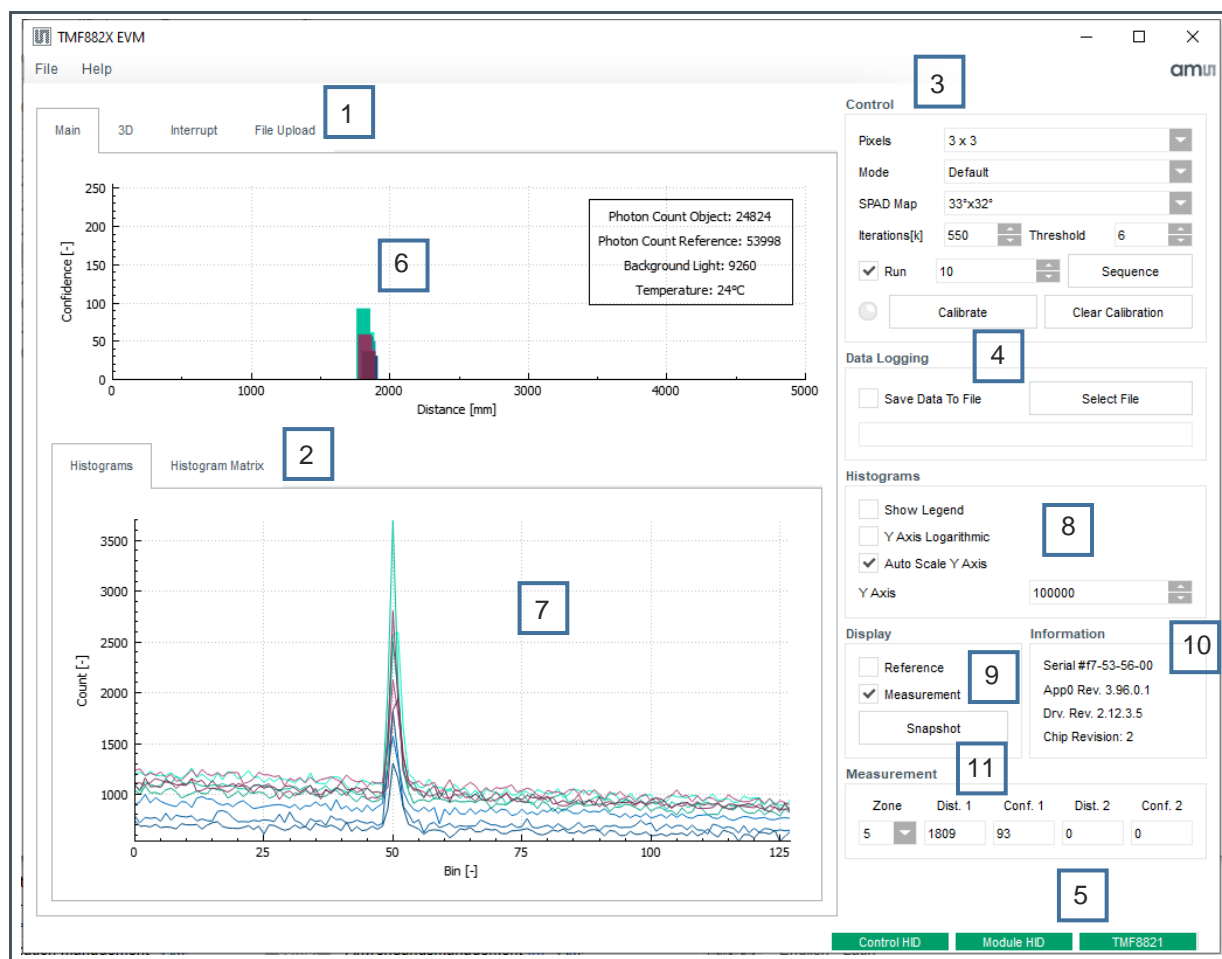
2.1.2 Installing the EVM Graphical User Interface

The ToF EVM GUI software is included on the USB flash drive. Launch the Windows installer and choose the desired installation options. The EVM graphical user interface executable is titled TMF882X_EVM_GUI.exe.

3 Using the EVM Software

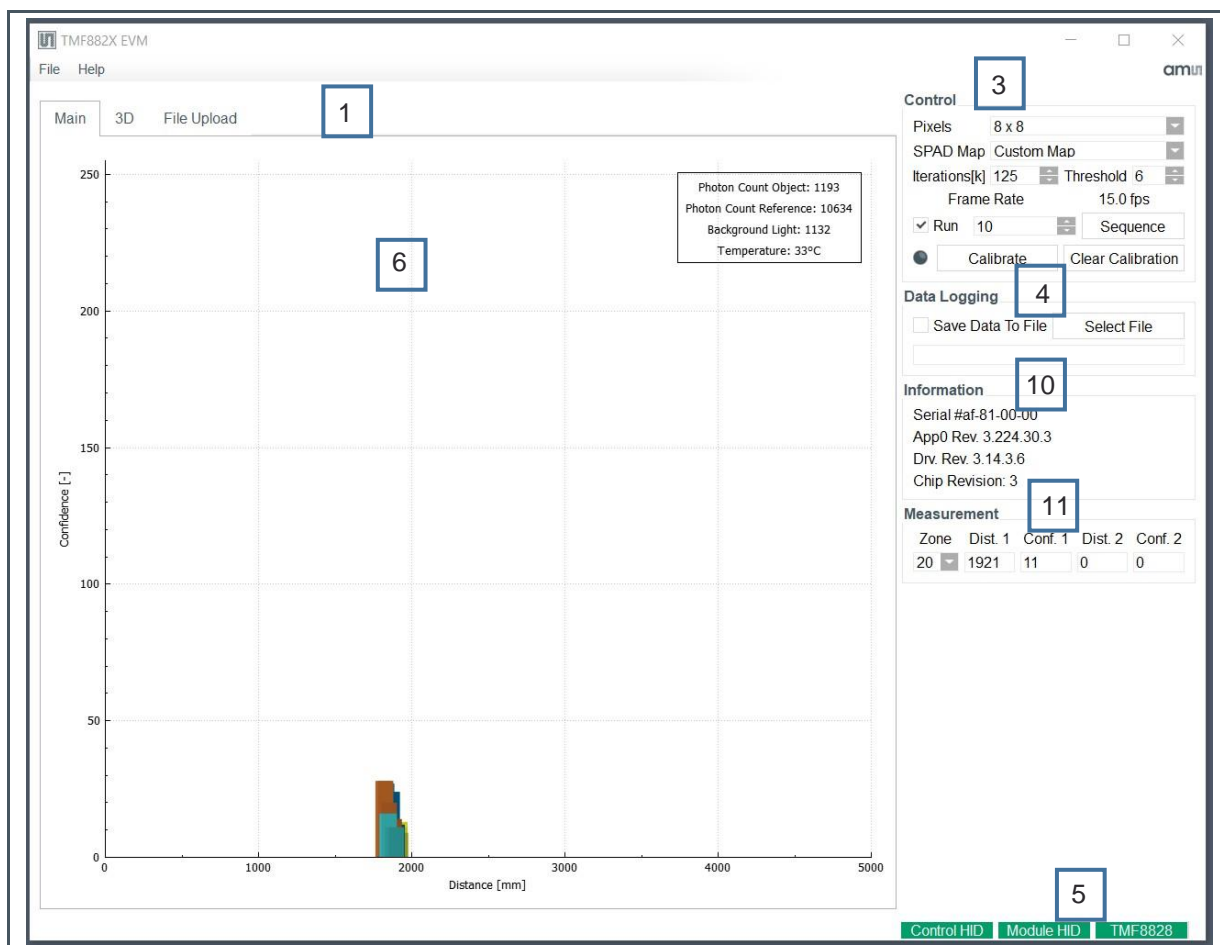
This section describes the operation and capabilities of the EVM Graphical User Interface (EVM GUI).

Figure 5:
EVM GUI Overview in 3x3, 3x6, and 4x4 Pixel Mode



- | | |
|---|---|
| 1 Main Tab Selector (see section 3.1.2) | 6 Distance Bar Chart (see section 3.2.1) |
| 2 Histogram Display Selector (see section 3.1.3) | 7 Histograms Plot (see section 3.2.1) |
| 3 "Control" Box (see section 3.1.4) | 8 "Histograms" Box (see section 3.2.2) |
| 4 "Data Logging" Box (see section 3.1.5) | 9 "Display" Box (see section 3.2.2) |
| 5 Connection Status Indicators (see section 3.1.6) | 10 "Information" Box (see section 3.2.2) |
| | 11 "Measurement" Box (see section 3.2.2) |

Figure 6:
EVM GUI Overview in 8x8 Pixel Mode



- | | |
|---|---|
| 1 Main Tab Selector (see section 3.1.2) | 6 Distance Bar Chart (see section 3.2.1) |
| 3 "Control" Box (see section 3.1.4) | 10 "Information" Box (see section 3.2.2) |
| 4 "Data Logging" Box (see section 3.1.5) | 11 "Measurement" Box (see section 3.2.2) |
| 5 Connection Status Indicators (see section 3.1.6) | |

3.1 Controls for All Tabs

3.1.1 Menu

The global menu contains these entries:

"File" Menu

- "Save Configuration" - save all EVM GUI settings (control values)
- "Load Configuration" - loads all EVM GUI settings (control values)
- "Exit" - leave the EVM GUI

"Help" Menu

- "About Dialog" - shows version information and copyright notices

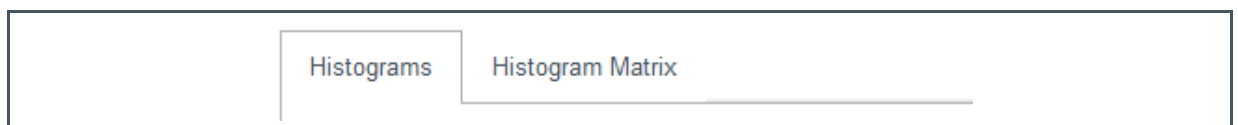
3.1.2 Main Tab Selector [1]

Select your view context here:

- The "Main" tab shows histograms (also in a histogram matrix) and data for the object in the sensor's field of view as a bar chart (distance and confidence)
- The "3D" tab shows a 3D graphical representation the same object data(distance and confidence)
- The "Interrupt" tab is similar to the 3D tab and allows you to set object detection parameters (e.g. relevant object distance)
- You can update the firmware on the EVM module with the "File Upload" tab

3.1.3 Histogram Display Selector [2]

Figure 7:
Histogram Display Selector



You can display histograms either in a combined graph as shown above or separately for each of the channels by selecting "Histogram Matrix".



Information

The 8x8-histogram view is not enabled in the EVM GUI. It automatically hides this element in 8x8 mode.

3.1.4 "Control" Box [3]

Figure 8:
Control Box

The screenshot shows the 'Control' box with the following settings:

- Pixels:** 3 x 3
- Mode:** Default
- SPAD Map:** 33°x32°
- Iterations[k]:** 550
- Threshold:** 6
- Run:** ☒ (checked)
- Run Value:** 10
- Sequence:** Button
- Calibrate:** Button
- Clear Calibration:** Button

"Pixels" Combo Box

The TMF882X detects objects in more than one zone. Select the zone setup here.

Select one of these:

- 3 x 3 - divides the field of view into nine zones, arranged in a 3 by 3 rectangle
- 4 x 4 - divides the field of view into sixteen zones, arranged in a 4 by 4 rectangle
- 3 x 6 - divides the field of view into eighteen zones, arranged in a 3 by 6 rectangle
- 8 x 8 - divides the field of view into 64 zones, arranged in a 8 by 8 rectangle

"SPAD Map" Combo Box

Define the field of view with the entries in this combo box. For a narrow field of view, select e.g. "33°x32°".

For a wide field of view, select e.g. "41°x52°" - 41° horizontal, 52° vertical.

For 8 x 8 zones, the SPAD Map is fixed to a "Custom Map" that cannot be changed.

"Mode" Combo Box

This control is available for 3 x 3, 4 x 4, and 3 x 6 zones. It selects three predefined parameter sets for iterations and threshold:

- Default Mode - 550000 iterations, the TMF882X runs with a measurement frequency of 30 Hz in this mode
- Low Power Mode - 50000 iterations, the TMF882X runs with minimal power consumption in this mode
- High Performance Mode - 4000000 iterations, used for detecting objects with maximum range

In all three modes, the default value for the object detection threshold is 6. This is the minimum confidence required to display an object in the distance bar chart and the 3D graphs.

"Iterations" Spin Box

Select the number of iterations in a single target measurement here. If you increase the number of iterations for a single measurement the overall measurement frequency will decrease.

For 8 x 8 zones, the EVM GUI will display the frame rate depending on the number of iterations. The maximum framerate is 15 samples/second.

"Threshold" Spin Box

Select the minimum confidence threshold for target detection here. If the calculated target detection confidence is below this level, the GUI will not display the corresponding object in the graphs.

"Run" Check Box

Enable this check box to run target measurements continuously.

Sequence Controls

The sequence spin box and the sequence button enable you to run a defined number of target measurements. With the default setting clicking the sequence button will trigger 10 measurements. After that, the EVM GUI will stop requesting new measurement results. This is especially useful for logging an exactly defined number of measurements.

Calibration Controls

The EVM needs to be calibrated for precise measurements. The factory calibration indicator (the dot left of the "Calibrate" button) shows if the EVM was calibrated for the current operation mode (e.g. 3 x 3) and the selected SPAD map.

Without calibration data, the ToF possibly also detects the cross-talk peak caused by the cover glass on the EVM case as valid object.

To initiate a new factory calibration you have to click on the "Calibrate" button. It is recommended to set "High performance mode" before starting the calibration.

To clear the existing calibration data and to set the EVM back to the uncalibrated mode you have to click on the "Clear Calibration" button.

Both calibration and clearing the calibration take approximately 1 - 2 seconds to complete. During this short time, the device is reset and all graphs will stop updating until the reset is complete.

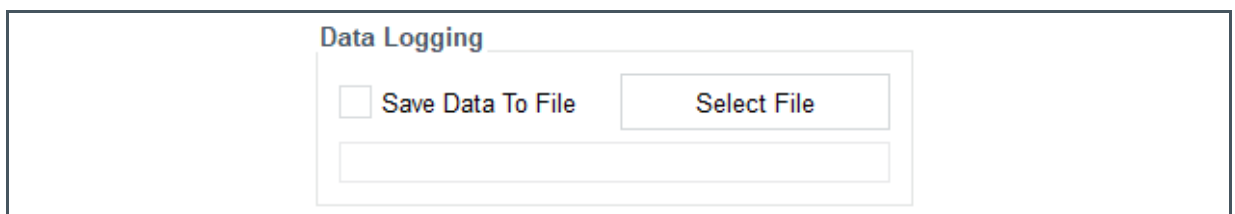


Information

When performing factory calibration no object should be within 400 mm of the ToF sensor's field of view and use low ambient light (avoid high IR content).

3.1.5 "Data Logging" Box [4]

Figure 9:
Data Logging Box



To log measurement data to a file you need to:

- Click on the button "Select File" to select an existing log file or enter the file name for a new file. The EVM GUI then displays the log file name in the text field below.
- Enable the check box "Save Data To File". From now on the EVM GUI logs all measurement results and configuration changes to the selected log file. Please note that logging is only done on enabled objects – for full logging please enable histogram display.
- After all measurements are done you have to disable the check box "Save Data To File". Access to the log file with e.g. MS Excel is now possible.

Please refer to the separate documentation for the EVM GUI log file format for more details.

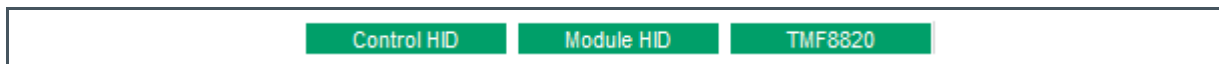


Information

Be careful when logging with multiple data options selected over a long period. With all histograms enabled and continuous logging, the resulting log file can be in the gigabyte range for size in 1 – 2 hours.

3.1.6 Connection Status Indicators [5]

Figure 10:
Connection Status Indicators



These are connection status indicators between the EVM GUI software and the TMF882X EVM software running in the enclosure.

"Control HID" is the connection status with the enclosure software

- A red label indicates there is no working connection with the enclosure software.
- A green label means the connection is working

"Module HID" is the connection status with the TMF882X demo software

- A red label indicates that there is a problem communicating with the TMF882X demo software or an internal software error.
- A green label means the TMF882X software connection is working

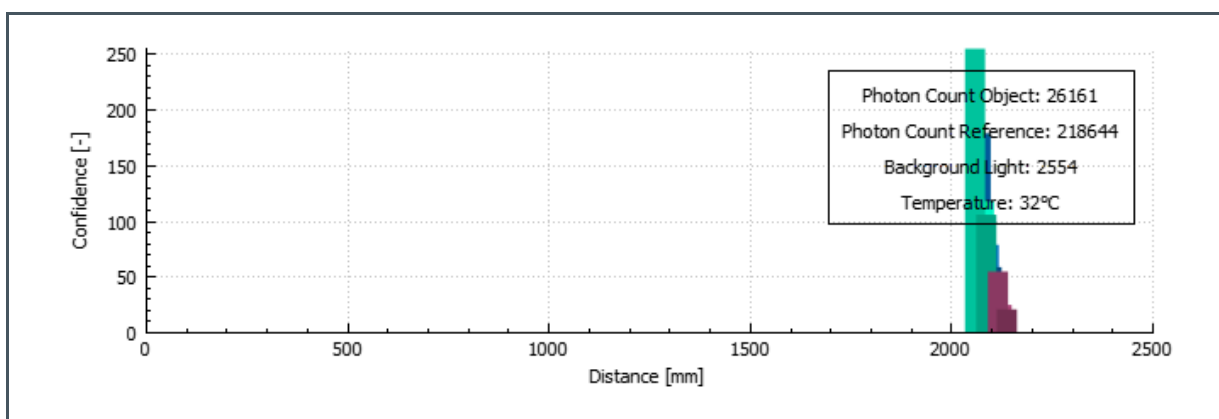
A third indicator displays the type of the ToF sensor the EVM contains. Either "TMF8820", "TMF8821", or "TMF8828".

3.2 EVM GUI "Main" Tab

3.2.1 Main Tab Graphs

Distance Bar Chart [6]

Figure 11:
Distance Bar Chart



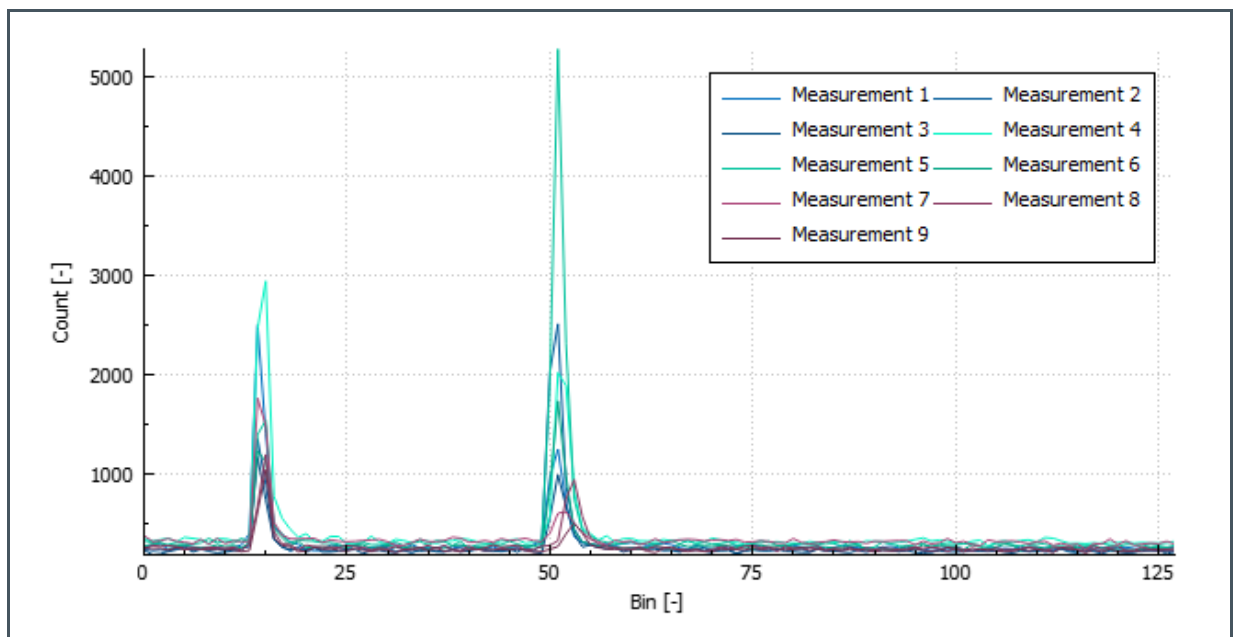
This is a plot of the detected objects' distance vs the confidence value (range 0 – 255) of the current detection (measurement). The X-axis indicates the distance in millimeters and the Y-axis indicates the confidence value. The GUI displays up to 36 bars here (6 x 3 mode, two objects per zone).

The legend of this chart has four entries:

- Photon Count Object - this value increases with the reflectivity of the target object surface
- Photon Count Reference - related to the optical reference channel, not influenced by the target object
- Background Light - related to the (IR only) ambient light, the TMF882X sensor sees
- Temperature - the temperature of the TMF882X sensor (on-chip SPAD sensor array temperature)

Histograms Plot [7]

Figure 12:
Histograms Plot

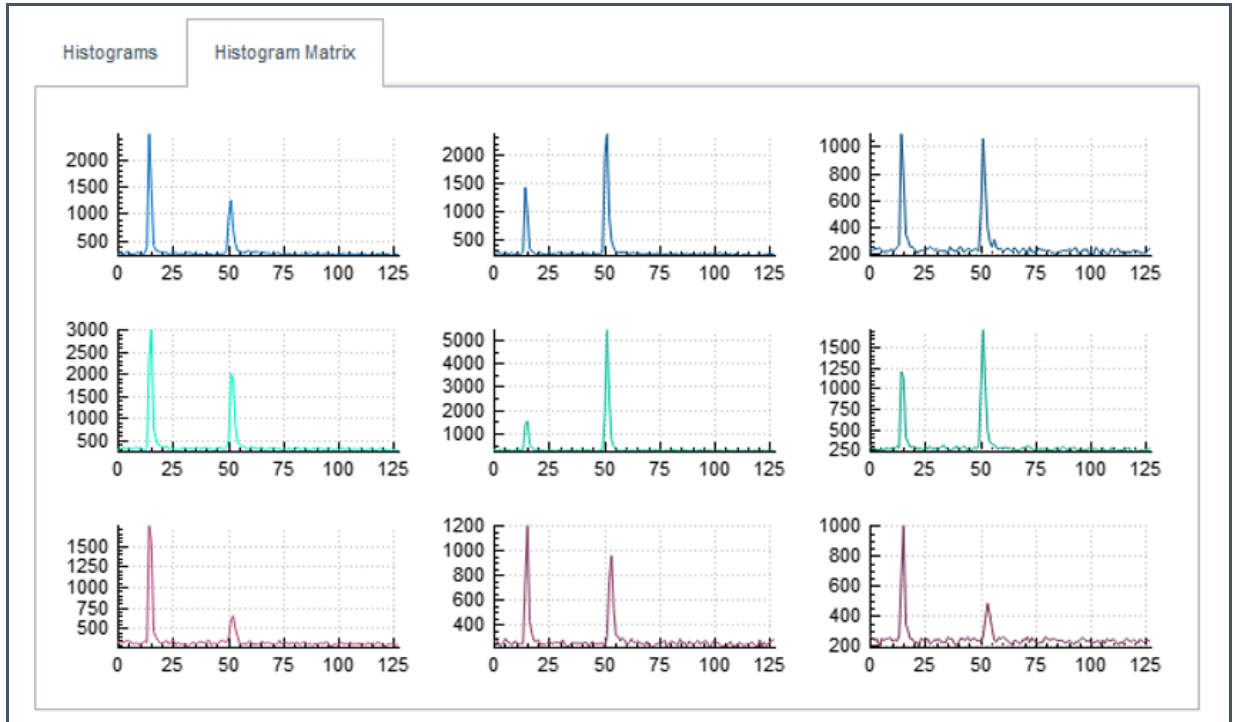


This is a plot of the TDC histogram information based off the selections in the "Display" box and the "Histograms" box.

The X-axis indicates the "time buckets" in 100-picosecond increments, and the Y-axis indicates the number of photonic triggers/hits at the given time interval.

Histogram Matrix

Figure 13:
Histogram Matrix



This is a plot of the TDC histograms for each of the zones (pixels) in the field of view.



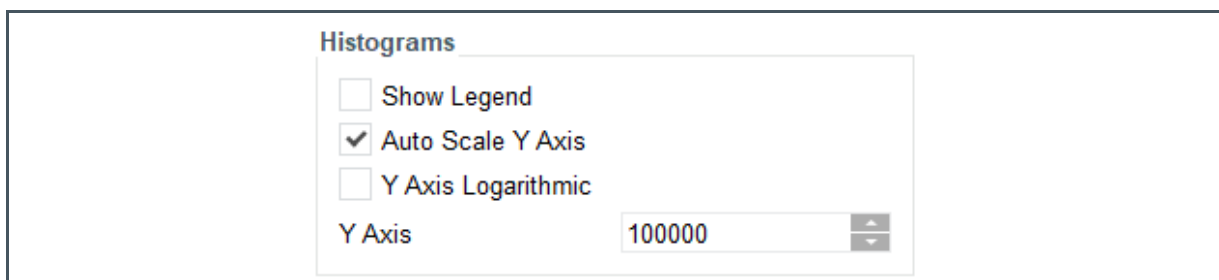
Information

The 8x8-histogram view is not enabled in the EVM GUI. It automatically hides this element in 8x8 mode.

3.2.2 Main Tab Controls

"Histograms" Box [8]

Figure 14:
Histograms Box



Histograms

☐ Show Legend

☒ Auto Scale Y Axis

☐ Y Axis Logarithmic

Y Axis

The controls in this box influence the display of the histograms in the histograms plot and the histogram matrix:

- Switch on the histogram legend with the check box "Show Legend".
- Enable automatic scaling for the Y-axis with the check box "Auto Scale Y axis". If this check box is disabled the histogram plots use the value of the check box "Y Axis" as maximum value.
- As default the histogram graphs are linear in x direction and y direction. You can change the scaling for the Y-axis to logarithmic. This allows to better observe very low values in the first few bins and in the (object and cross-talk) peak tails.

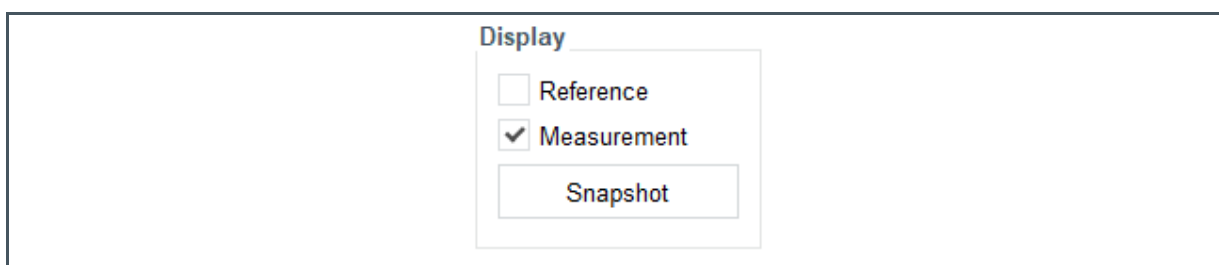


Information

The 8x8-histogram view is not enabled in the EVM GUI. It automatically hides this element in 8x8 mode.

"Display" Box [9]

Figure 15:
Display Box



Display

☐ Reference

☒ Measurement

Select which histograms you are interested in with the controls in this box:

- The "Reference" check box tells the GUI to display the optical reference histograms. The optical path for this histogram is entirely within the sensor package. The target objects in the field of view of the sensor do not influence this histogram.
- The "Measurement" histograms show the reflected light from the objects in the field of view of the sensor.

The Histogram "Snapshot" button allows the user to "freeze frame" the current histogram plot while still plotting the measurement histograms concurrently. This gives you the ability examine two histogram plots (one current, the other one a snapshot) at the same time in the histogram plotting area. Releasing the "Snapshot" button deletes the saved snapshot histograms.



Information

The 8x8-histogram view is not enabled in the EVM GUI. It automatically hides this element in 8x8 mode.

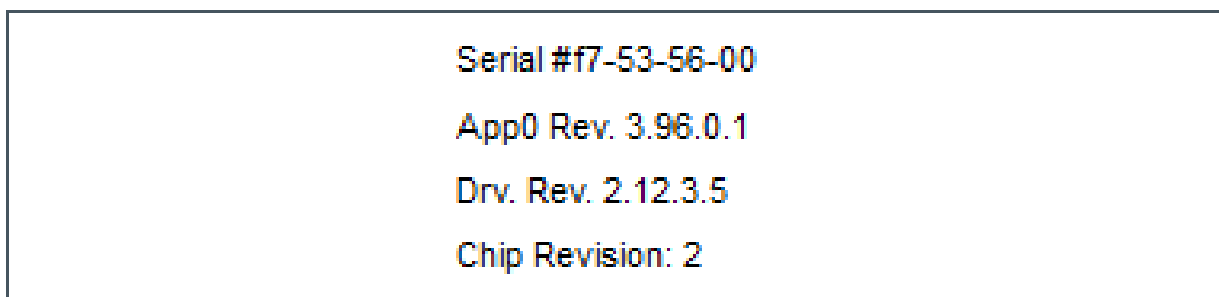


Information

To get fastest ranging time, disable all histogram display check boxes here.

"Information" Box [10]

Figure 16:
Information Box



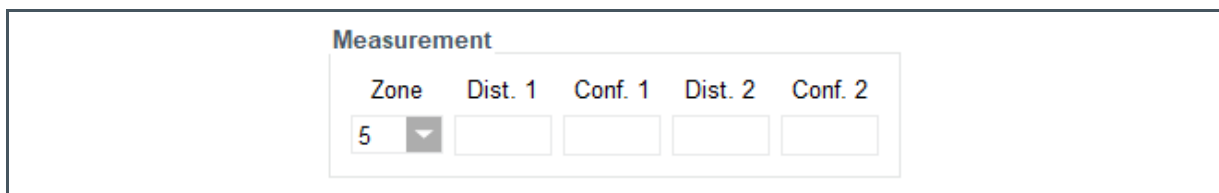
This box contains information about the hardware and software in the EVM enclosure:

- The serial number is the unique hardware ID of the TMF882X sensor
- Below that you can find the revision of the embedded sensor firmware
- The driver revision refers to the software on the controller board (a Raspberry Pi Zero W) in the EVM enclosure

You can find the version of the current EVM GUI in the "About" dialog in the main menu – "Help / About Dialog". The EVM GUI also writes this information into the first lines of each generated log file. Please refer to the separate documentation for the EVM GUI log file format for more details.

"Measurement" Box [11]

Figure 17:
Measurement Box



Zone	Dist. 1	Conf. 1	Dist. 2	Conf. 2
5				

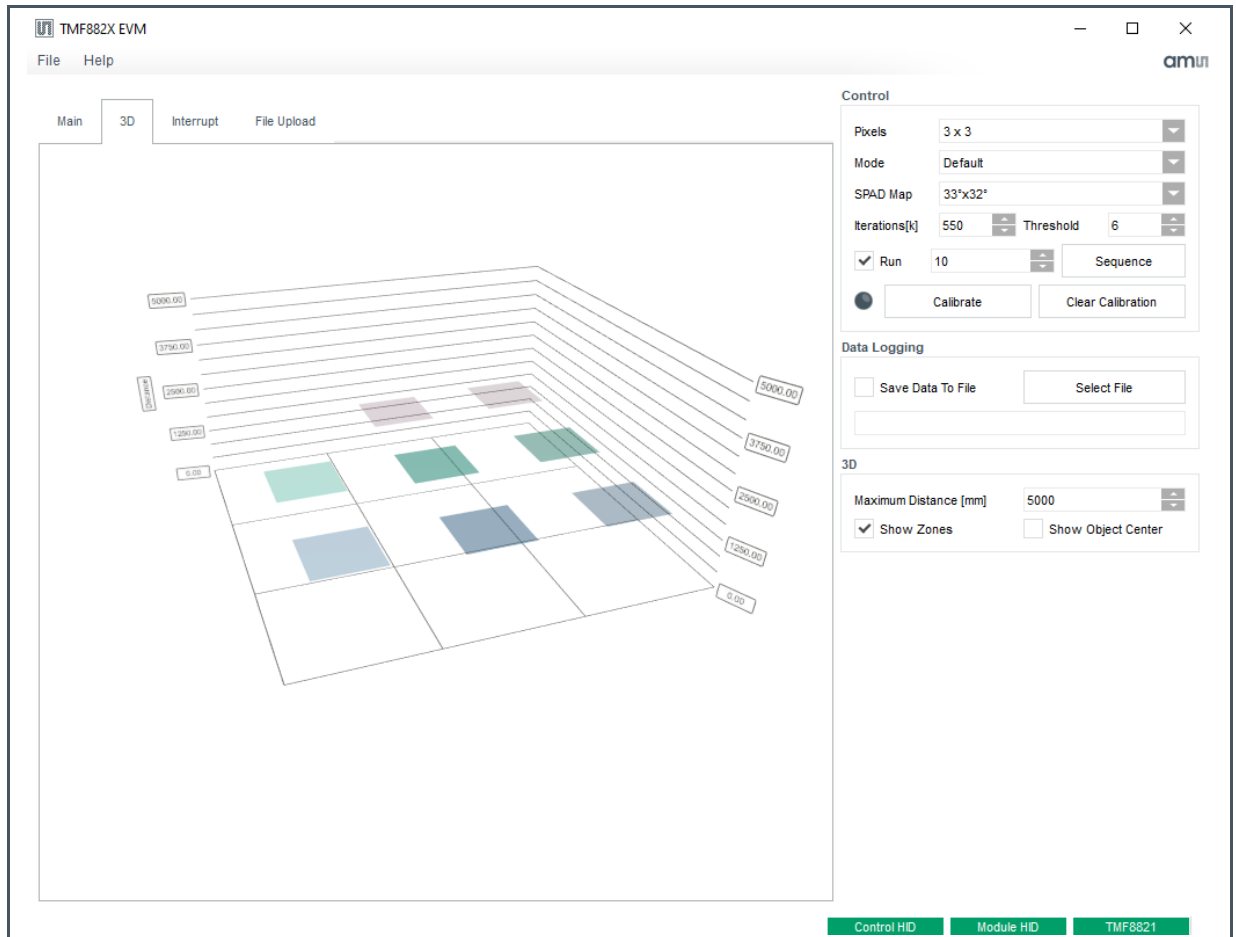
The controls in this box allow you to select one zone in the field of view. For this zone, the GUI displays the current object data values.

- "Zone" - select the zone you are interested in
- "Dist 1." - distance to the first object in the selected zone
- "Conf 1." - confidence for the object detection of the first object in the selected zone
- "Dist 2." and "Conf 2." provide the current data for the second object in the selected zone

The sensor did not detect objects if confidence 1 or 2 is equal zero.

3.3 EVM GUI "3D" Tab

Figure 18:
3D Tab



This graph shows the detected objects in all the zones (pixels) in the field of view of the sensor. As you can see in the screenshot, the sensor detects up to two objects in each zone. Each object is shown as a plate above the base plane. If the calculated detection confidence is high, the object plate is fully colored. If the confidence is low, the plate becomes transparent.

In the example screenshot, the sensor sees a close target (at around 20 cm) in all zones. In addition, it detects the ceiling above the test setup at around 250 cm. The ceiling does not reflect much light. The confidence values for detecting the ceiling are low because of that.

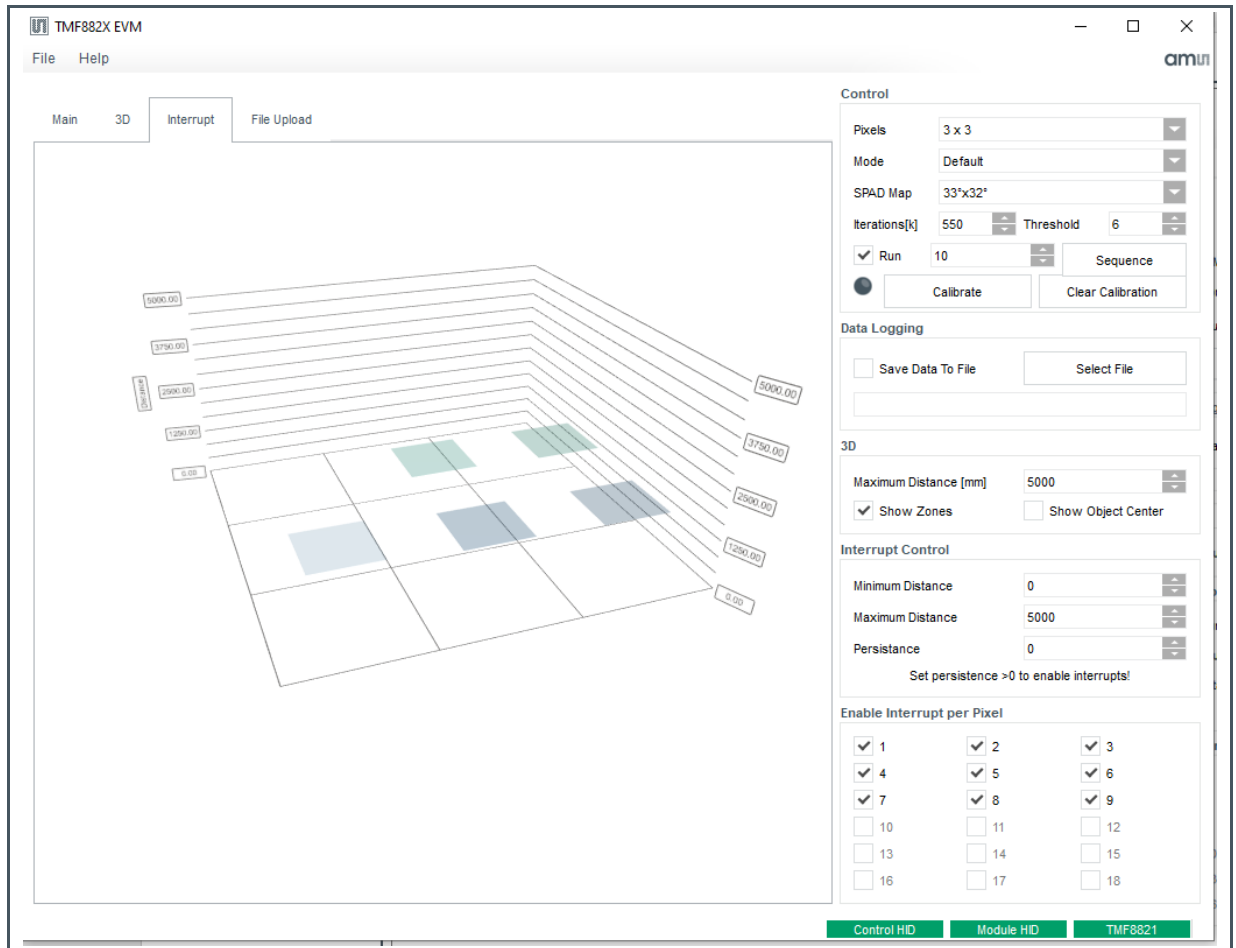
You can freely rotate and zoom this graph with your mouse:

- Click and hold the right mouse button
- Now move the mouse around and observe how the graph is rotated
- Use the mouse scroll wheel to zoom in and out

You can set the maximum distance for this graph with the spin box in the "3D" box.

3.4 EVM GUI "Interrupt" Tab

Figure 19:
Interrupt Tab



This tab looks very much like the "3D" tab. The only difference here are the controls that allow setting parameters for object detection.

- Set the minimum and maximum distance for object detection with the corresponding spin boxes
- Use the "Persistence" control to set the required minimum number of sequential object detections: e.g. only display an object if it is detected six times in a row

You can also define which of the zones in the field of view are relevant for object detection with the "Enable Interrupt per Pixel" check boxes.



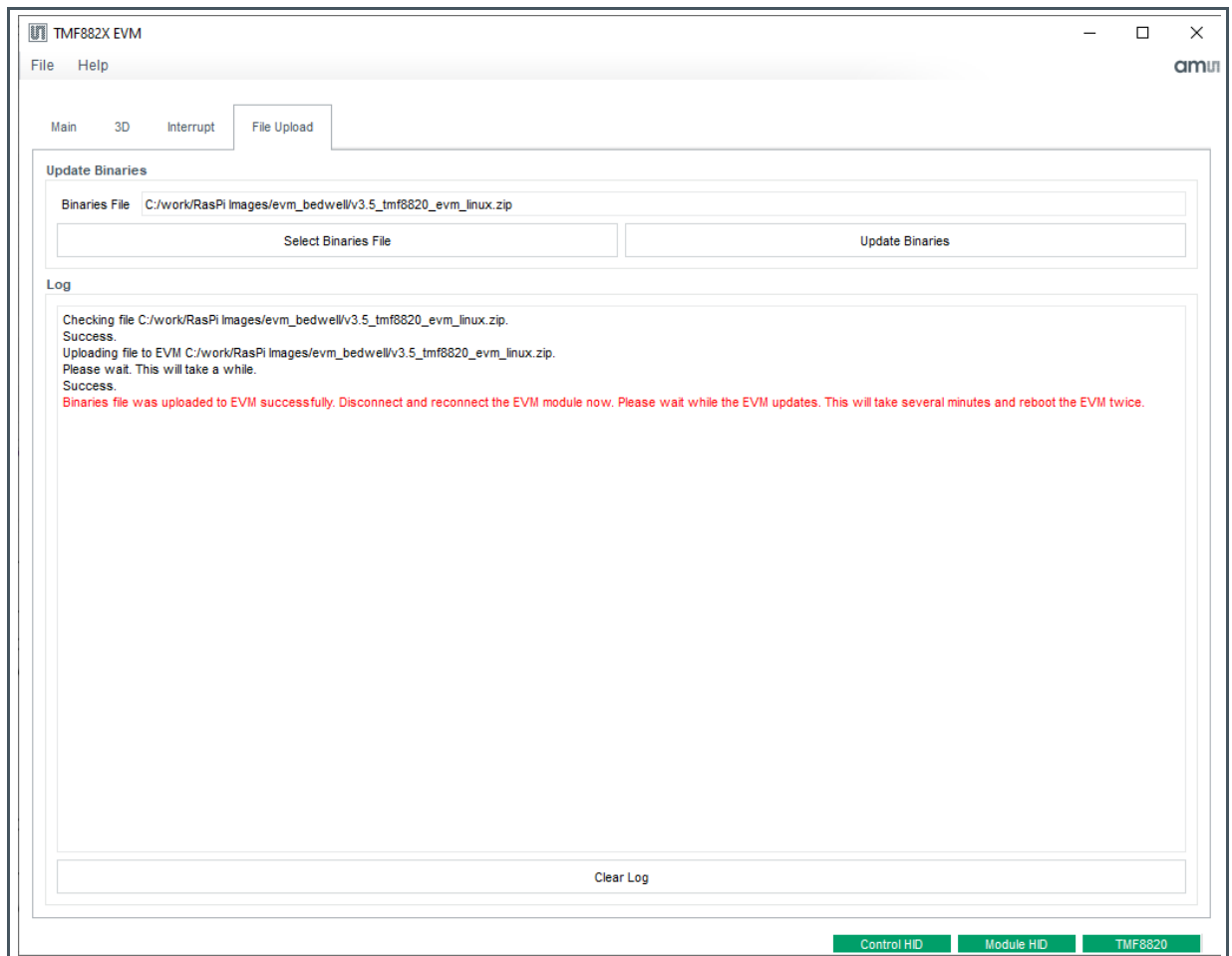
Information

The EVM GUI displays all objects in the field of view if one object in the field of view satisfies the defined requirements. If "Persistence" is set to zero all other parameters are not relevant anymore. The EVM GUI will then display all objects in the field of view.

The GUI has a timeout implemented – if there is no object detection within one second, the GUI automatically clears the graph. Object logging will be stopped too.

3.5 EVM GUI "File Upload" Tab

Figure 20:
File Upload Tab



This tab allows you to update the software running on the controller board in the EVM enclosure (Raspberry Pi Zero W). The binaries file (e.g. v2.9_tmf8820_evm_linux.zip) contains all the necessary files in a single ZIP archive.

How to update:

- Click on “Select Binaries File” and select the binaries archive in the file dialog that opens now.
- Click on “Update Binaries” and wait until the binaries file upload process is complete.
- Disconnect and reconnect the EVM kit.
- Wait several minutes until the update process on the EVM finished updating the binaries on the controller board.
- If the update was not successful after several minutes (all connection indicators have to be green after a successful update) disconnect and reconnect again.

Click on the “Clear Log” button to clear the log file area if necessary.

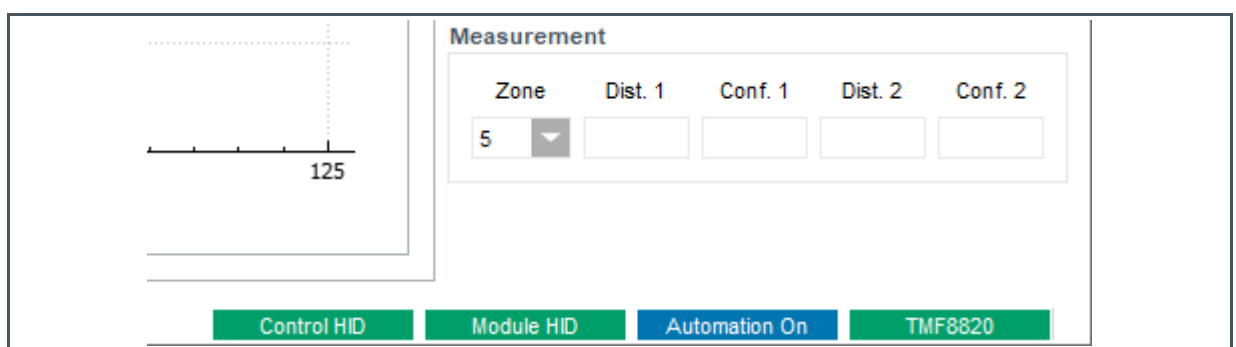
3.6 Automation of Measurements

3.6.1 Overview

The EVM firmware allows control through a separate (e.g. customer) program. The communication link is achieved through TCP/IP using TCP port 39998 on the host where the EVM GUI is running.

- To start the automation mode the automation host needs to open a TCP connection to 127.0.0.1 port 39998. To use 127.0.0.1 (localhost), the automation host must run on the same machine as the EVM GUI. Once connected the GUI shows the following status:

Figure 21:
Status



- After the connection is established, the EVM sends version and calibration information to the automation host. This will look like this:

```
#VER;4c-c0-00-00;2.49.4.2;2.4.23.0;2.6.2.19;8;0
#CAL;1594814890830;0;2;00;0B;03;00;01;FF;26;02;79;56;34;12;53;49;47;F7;6B;A2;
07;00;6B;A2;07;00;6B;A2;07;00;6B;A2;07;00;6B;A2;07;00;6B;A2;07;00;6B;A2;07;00;
6B;A2;07;00;6B;A2;07;00;6B;A2;07;00;77;09;02;00;02;00;00;00;02;00;00;00;02;0
0;00;00;02;00;00;00;02;00;00;00;02;00;00;00;02;00;00;00;02;00;00;00;02;00;00;
00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;
00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;
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00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;
00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;
```

- The EVM GUI also sends header information for easy import of the log output into Microsoft Excel. The header output is too long to include it here into this document.
- To trigger a single measurement the automation host has to send the command string "(m0)" to the EVM GUI.
- The EVM GUI sends all histograms the user selects with the checkboxes in the GUI. The default is the "Measurement" histograms.
- The protocol for the measurement data is described in the document "TMF_8820_EVM_GUI_Logfile_Format.docx".

3.6.2 Automation Interface Reference

These commands are simple strings the remote control programs sends to the GUI via the TCP/IP connection. The GUI sends the command response back to the remote control program over the same connection (socket).

Each command starts with an opening parenthesis "(". The GUI executes the command after the remote control sends a closing parenthesis ")".

The first character in the command (after the opening parenthesis) is the command code. All characters after that are the command parameter (until the closing parenthesis). Command codes are case-insensitive.

e.g.: (l1000) sets the "Iterations [k]" spin box in the GUI to the value 1000.

Set Iterations

Sets the number of ToF measurement iterations ("Iterations [k]" spin box).

Figure 22:
Command Overview

Command Code	Parameter	Example
I	Number of iterations, 0 <= iterations <= 65535	(I1000)

Set Object Detection Threshold

Sets the object detection threshold ("Threshold" spin box).

Figure 23:
Command Overview

Command Code	Parameter	Example
T	Object detection threshold, 0 <= threshold <= 255	(T128)

Run Measurement

Run one GUI measurement and send the results to the remote control program via the TCP/IP connection.

Figure 24:
Command Overview

Command Code	Parameter	Example
M	Ignored	(M0)

Calibration Handling

Control the EVM GUI Calibration Handling.

Figure 25:
Command Overview

Command Code	Parameter	Example
C	0 - Initiate new calibration, 1 - Clear calibration, 2 - Get calibration data The EVM GUI ignores all other parameter values	(C2)

3.6.3 Automation Example Session

To operate the following example, the EVM GUI needs to be started first. Start the Windows shell "cmd" and connect through the Windows program "telnet":

- telnet 127.0.0.1 39998

This causes an immediate response and in the GUI the status 'Automation On' is displayed (removed headers in the output data):

```
sep=;
#VER;ToF Serial Number;App0 Version Number;GUI Version Number;Host Driver Version
Number;Chip ID;Chip Revision
#VER;4c-c0-00-00;2.49.4.2;2.4.23.0;2.6.2.19;8;0
#CAL;1594816397308;0;2;00;0B;03;00;01;FF;26;02;79;56;34;12;53;49;47;F7;6B;A2;07;00
;6B;A2;07;00;6B;A2;07;00;6B;A2;07;00;6B;A2;07;00;6B;A2;07;00;6B;A2;07;00;6B;A2;07;
00;6B;A2;07;00;6B;A2;07;00;77;09;02;00;02;00;00;00;02;00;00;00;02;00;00;00;02;00;0
0;00;02;00;00;00;02;00;00;00;02;00;00;00;02;00;00;00;02;00;00;00;00;00;00;00;00;
00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;
00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;
0;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00;00
;00;00;00;00
```

Send the command (m0) - it executes one measurement and transfers the enabled histograms (removed all but one histogram).

- (m0)

```
#TMP;1594816405200;207;33
#OBJ;1594816405203;207;3;3;1970;19;0;0;1938;42;0;0;1961;16;0;0;1947;49;0;0;1931;11
8;0;0;1944;47;0;0;1946;20;0;0;1929;38;0;0;1948;20;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;
0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0
#LIGHT;1594816405205;207;25079;199532;14146
```

4 Drivers

ams recommends to use one of the available software drivers to operate the TMF882X. The following drivers are available:

- Linux driver – use this for any Linux system (e.g. Android) where the driver is running on the application processor
- MCU driver (sometimes referenced as bare metal driver) – the hardware functions for executing the I²C routines can be easily replaced to simply port this driver to systems without operating systems or systems not running Linux

5 Schematics, Layers and BOM

5.1 Daughter Card

Figure 26:
Daughter Card Picture

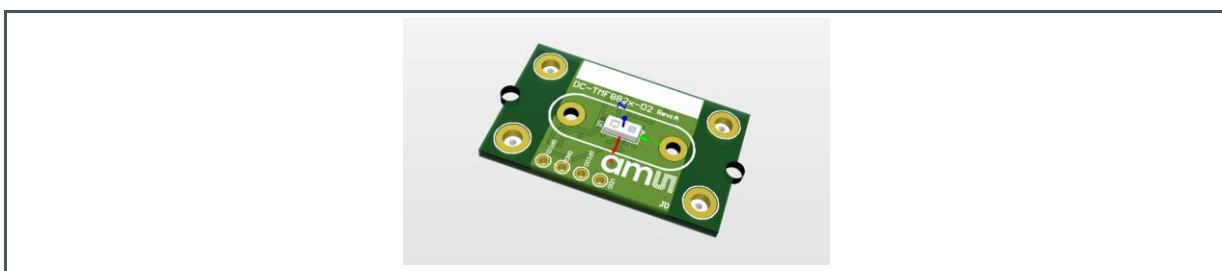


Figure 27:
Daughter Card Schematic

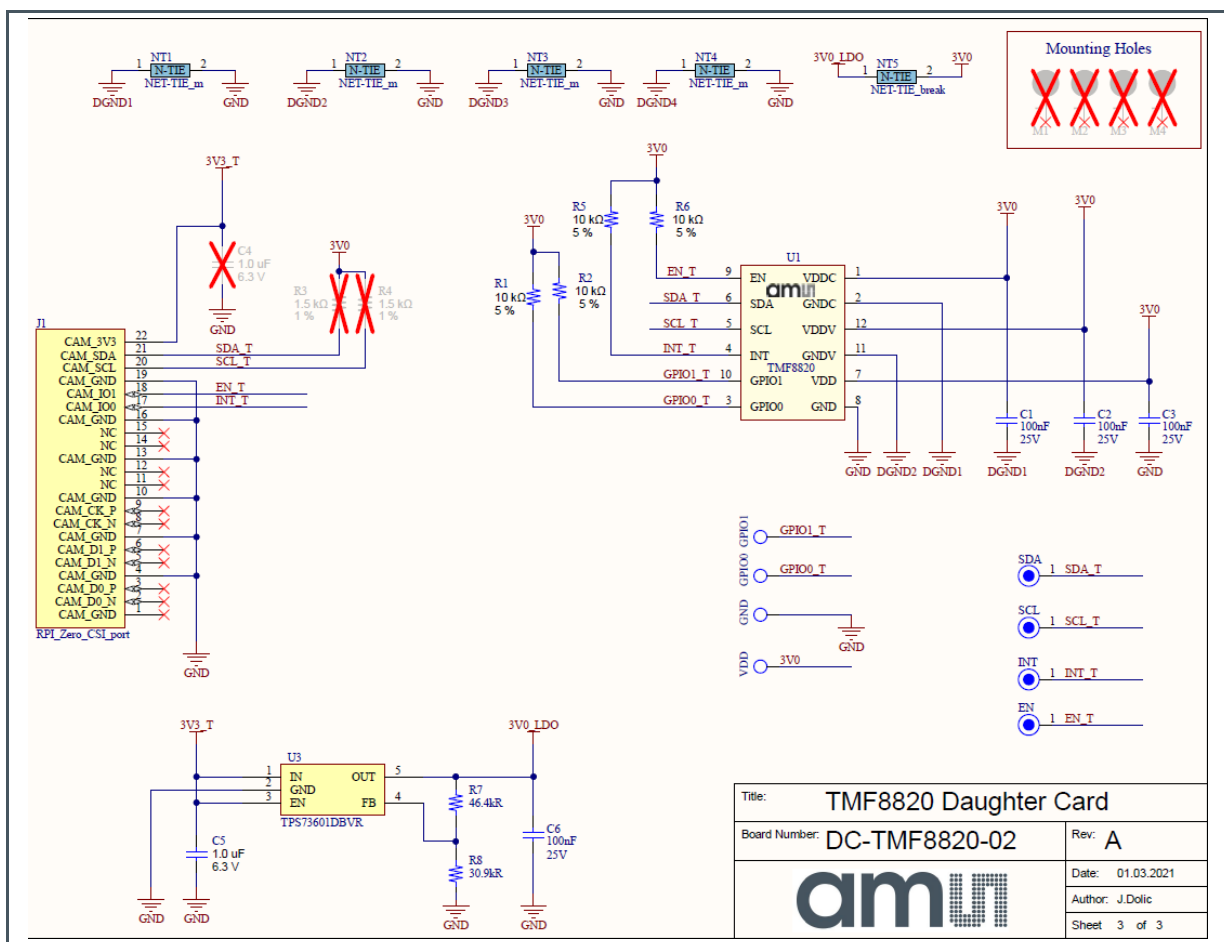
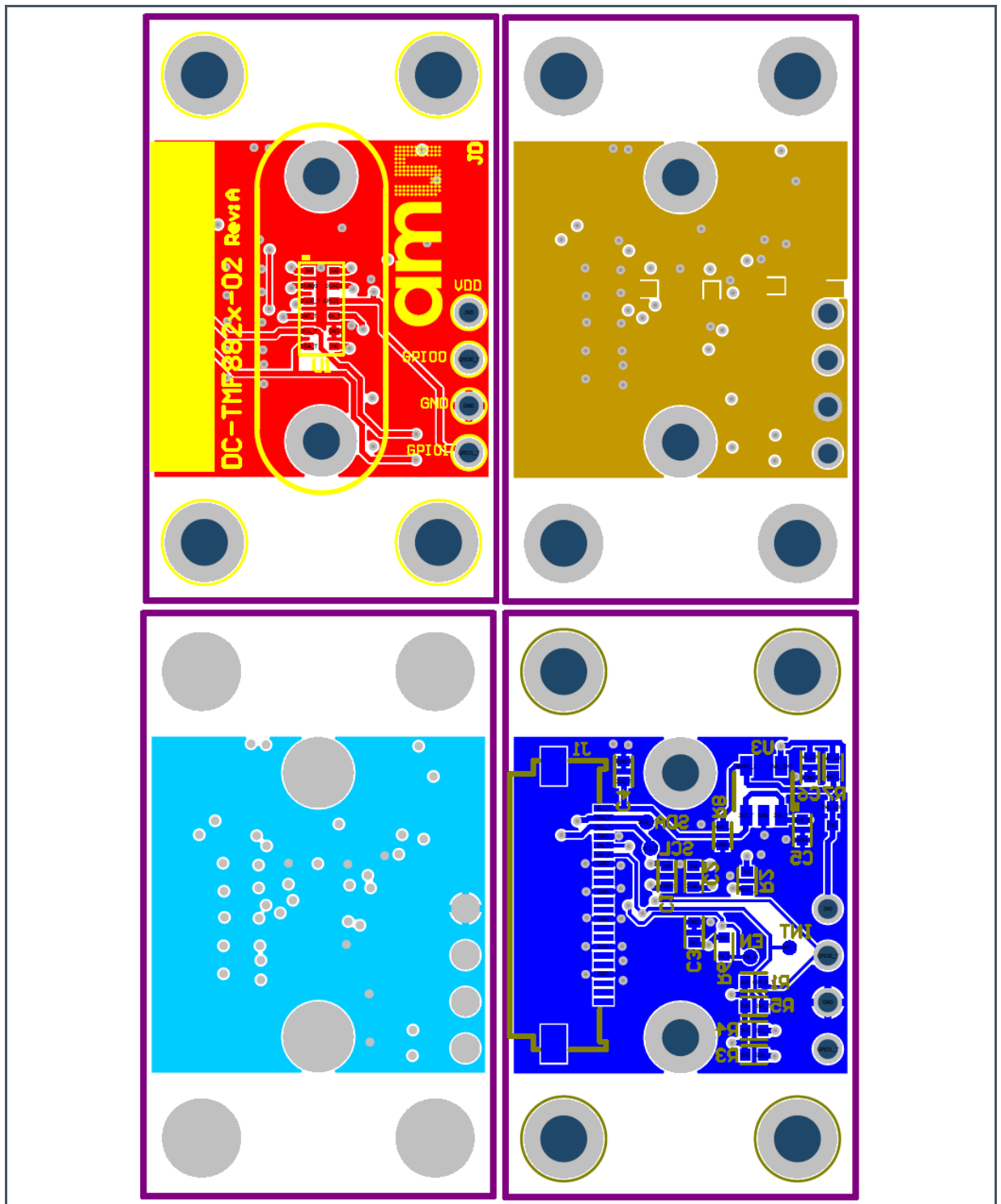


Figure 28:
Daughter Card Layout – Layers 1-4



5.1.1 BOM

Figure 29:
Daughter Card BOM

Index	Designator	Comment	Description	Quantity	Manufacturer	Manufacturer Part Number	Supplier	Supplier Part Number
1, 2, 3, 5	C1, C2, C3, C6	0.1uF,6V3, 0402, 10%	Cap Ceramic 0.1uF 25V X7R 10% SMD 0402 125C Paper T/R, GRM155R71E104KE14D	4	Murata	GRM155R71E104KE14D	Farnell	2666434
4	C5	1.0uF,6V3, 0402, 20%	Cap 1.0uF,6V3, 0402, 20%	1	AVX	04026D105MAT2A	Digi-Key	478-5315-2-ND
6	J1	RPI_Zero_CSI_ port	CONN FFC/FPC BOTTOM 22P .5MM R/A	1	Molex	505110-2291	Digi-Key	WM11288CT-ND
11, 12, 13, 14	R1, R2, R5, R6	10K,0402,5%	Res, 10K, 0402, 5%	4	Vishay Dale	CRCW040210K0JNED	Digi-Key	541-10KJTR-ND
15	R7	46k4,0402,1%	MULTICOMP MCO0625W0402146K4 SMD Current Sense Resistors, MC Series, 46.4 kohm, 62.5 mW, 1%, 50 V, 0402 [1005 Metric]	1	Multicomp	MCO0625W0402146K4	Farnell	2130486
16	R8	30K9,0402,1%	Res, 30K9, 0402, 1%	1	Multicomp	MCMR04X3092FTL	Farnell	2072909
17	U1	TOF	TOF TMF8820	1	ams AG	TMF8820		
18	U3	TP573601DBV R	Adj Low Dropout Regulator	1	TI	TP573601DBVR	DigiKey	296-18255-1-ND

6 Revision Information

Changes from previous version to current revision v4-00	Page
Extended for TFM8828 specific information	All

- Page and figure numbers for the previous version may differ from page and figure numbers in the current revision.
- Correction of typographical errors is not explicitly mentioned.

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