## User Guide

UG000418

# TCS3701

## ALS/Color and Proximity Sensor for Use Behind OLED Displays Evaluation Kit

TCS3701 EVM

v1-00 • 2019-Jan-11

# Content Guide

# 1 Introduction

The TCS3701 evaluation kit comes with everything needed to evaluate the TCS3701 . The device features ambient light and color (RGB) sensing in parallel with proximity detection.

## 1.1 Kit Content

**Figure 1 :**
**Evaluation Kit Contents**

| No. | Item | Description |
|---|---|---|
| 1 | TCS3701 Daughter Card | PCB with TCS3701 sensor installed |
| 2 | EVM Controller Board | Used to communicate USB to I2C |
| 3 | USB Cable (A to Mini B) | Connects EVM controller to PC |
| 4 | Flash Drive | Includes application installer and documents |

## 1.2 Ordering Information

| Ordering Code | Description |
|---|---|
| TCS3701 EVM | TCS3701 ALS/Color and Proximity Sensor for Use Behind OLED Displays Evaluation Kit |

# 2 Getting Started

The software should be installed prior to connecting any hardware to the computer. Follow the instructions found in the Quick Start Guide (QSG). This loads the required driver for the USB interface and also the device's graphical user interface (GUI).

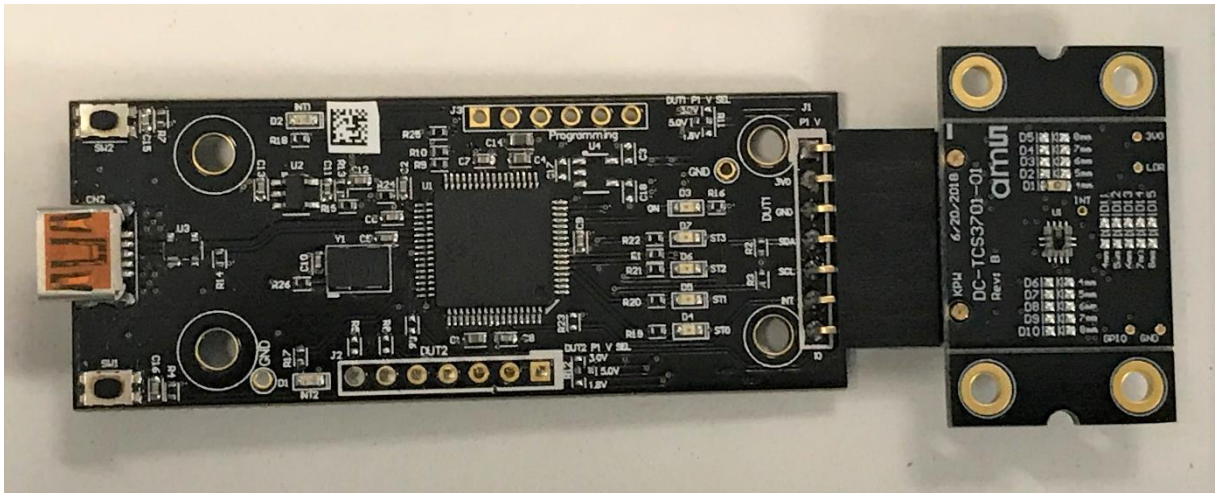
The balance of this document identifies and describes the controls available on the GUI. In combination with the TCS3701 datasheet, the QSG and application notes available on the **ams** website, there should be enough information to allow evaluation of the TCS3701 device.

# 3 Hardware Description

The hardware consists of the EVM Controller, the TCS3701 EVM daughter card, and a USB interface cable. The EVM controller board provides power and I2C communication to the daughter card through a seven pin connector. When the EVM controller is connected to the PC through USB, a green LED on the board flashes once on power up to indicate the system is getting power.

For schematics, layout and BOM information, please see the documents included with the install located in the TCS3701 EVM folder (All Programs -> ams -> TCS3701 EVM  > Documents).

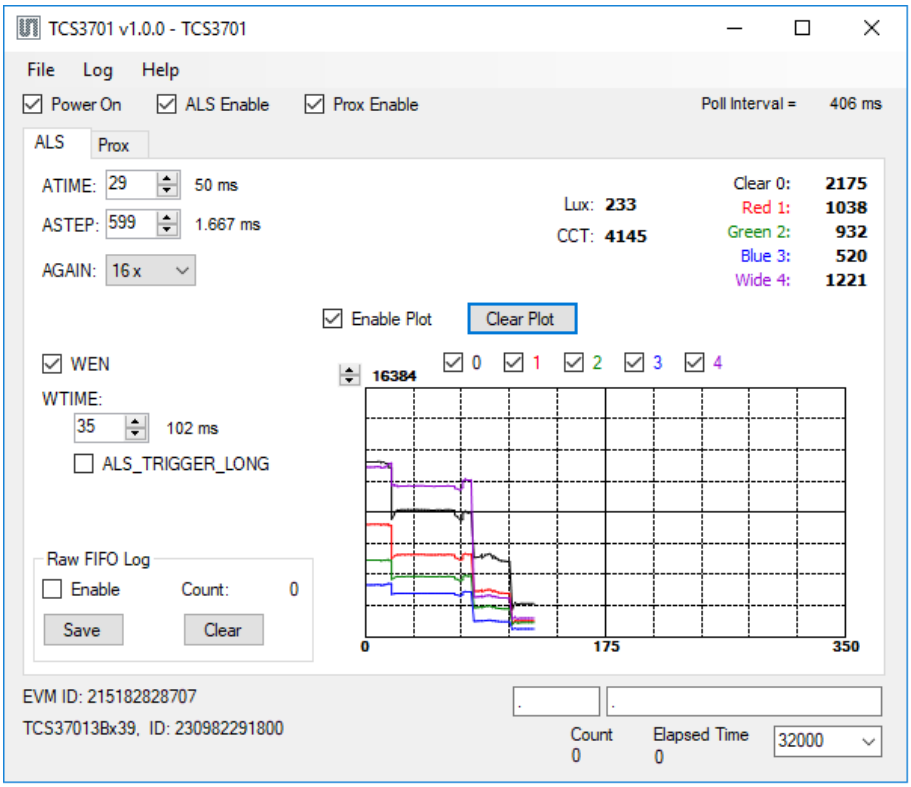
**Figure 2 :**
**Evaluation Kit Hardware**



# 4 Software Description

The main window (Figure 3) contains the system menus, system level controls, device information and logging status. The ALS tab contains controls for the light sensing function. The Prox tab contains settings for the proximity function. The application polls the ALS and proximity raw data continuously and calculates the Lux, CCT, and prox standard deviation values.

**Figure 3 :**
**Graphical User Interface (GUI) Main Window**




## 4.1 Connect Software to Hardware

On startup, the software automatically connects to the hardware. On successful initialization, the software displays a main window, containing controls pertinent to the connected device. If the software detects an error, an error window appears. If “Device not found or is unsupported” appears, verify the correct daughterboard is properly connected to the EVM controller board. If “Cannot connect to EVM board” appears, verify the USB cable is connected. When the EVM controller board is connected to the USB, a green LED on the board flashes once on power up to indicate the USB cable is connected and providing power to the system.

If the EVM board is disconnected from the USB bus while the program is running it displays an error message and then terminates. Reconnect the EVM board and restart the program.

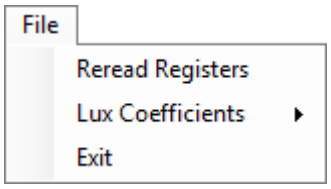
## 4.2 System Menus

At the top of the window there are pull-down menus labeled “File”, “Log”, and “Help”. The File menu provides basic application-level control. The Log menu is used to control the logging function, and the Help menu provides version and copyright information for the application.

### 4.2.1 File Menu

The File menu contains the following functions:

**Figure 4 :**
**File Menu**




The **Reread Registers** function forces the program to re-read all of the control registers from the device and display them on the screen. This does not read the output data, because those registers are continually read while the program is running.

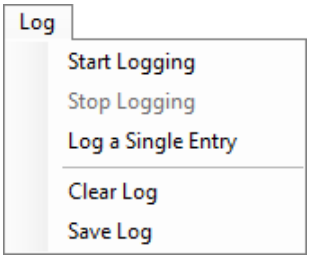
The **Lux Coefficients** menu allows the user to Display, Load or Save the lux coefficients used to calculate lux. See the ALS Lux Coefficients section for more details.

Click on the **Exit** command to close the main window and terminate the application. Any unsaved log data is cleared from memory. The application can also be close by clicking the red “X” in the upper right hand corner.

### 4.2.2 Log Menu

The Log menu is used to control the logging function and to save the log data to a file. Log data is accumulated in memory until it is discarded or written to a data file.

**Figure 5 :**
**Log Menu**




Click **Start Logging** to start the logging function. Each time the program polls the output information from the device, it creates a new log entry showing the raw data values, the values of various control registers, and the values entered by the user into the text fields near the bottom right corner of the window.

Click **Stop Logging** to stop the logging function. Once logging is stopped, the data can be written to a file, or the user can continue collecting additional data by clicking Start Logging again.

The **Log a Single Entry** command causes logging to start, collect one single entry, and immediately stop again. This function is not available when logging is already running.

Click **Clear Log** to discard any data that has already been collected. If there is data in memory, which has not been saved to disk, this function displays a prompt asking to verify it is OK to discard the data. If the log is running when this function is clicked, the log continues running after the existing data is discarded.

Click **Save Log** to save the collected log data to a csv file. This stops the logging function, if it is active, and displays a file dialog box to specify where to store the logged data. The default file name is described in the Log Status and Control Information section, but the file name may be changed if desired.

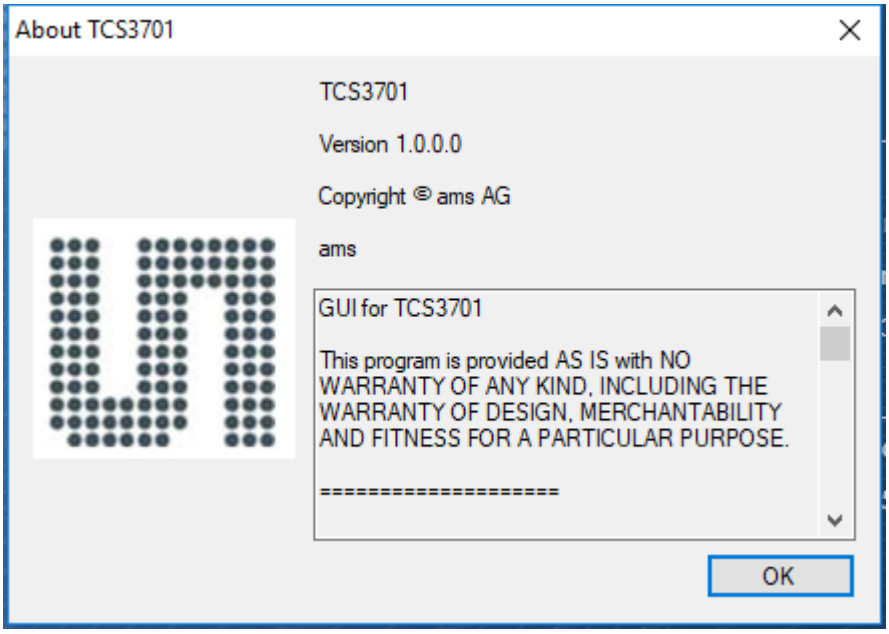
### 4.2.3 Help Menu

The Help menu contains a single function: About.

**Figure 6 :**
**Help Menu**

The About function displays a dialog box (Figure 7) showing the version and copyright information for the application and library. Click the OK button to close this window and continue.

**Figure 7 :**
**About Window**




## 4.3 System Level Controls

Immediately below the top menu bar there are checkboxes used to control the system level functions of the TCS3701 device.

The **Power On** checkbox controls the PON function of the TCS3701 . When this box is checked, the power is on and the device can operate. When this box is unchecked, the power is off and the device does not operate (The control registers can still be written, but the device does not function).

The **ALS Enable** checkbox controls the AEN function of the TCS3701. When this box is checked, the device collects and report ALS data as programmed. When this box is unchecked, the ALS functions do not operate.

The **Prox Enable** checkbox controls the PEN function of the TCS3701. Proximity detection is enabled when this box is checked or disabled when unchecked.

## 4.4 Automatic Polling

The application automatically polls the TCS3701 raw data of ALS and Prox if enabled. The Poll Interval displays the time between reads of the device.

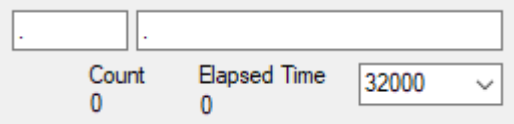
## 4.5 Device ID Information

The lower left corner of the window displays the ID number of the EVM Controller board, identifies the device being used and displays the ID of the device.

## 4.6 Log Status and Control Information

The lower right corner of the window contains status information and controls for the logging function:

**Figure 8 :**
**Logging Status**




This section contains text boxes that are stored in the log file data and used to build the file name for the log file. If the data in these fields are changed, the new values are stored with any new data logged. The default log file name is based on these values at the time the log file is written. If nothing is entered in these boxes they default to a period (“.”).

**Sample default file name:**

TCS3707_1-2-3_Log_HH_MM_SS.csv

From Application

From User Input

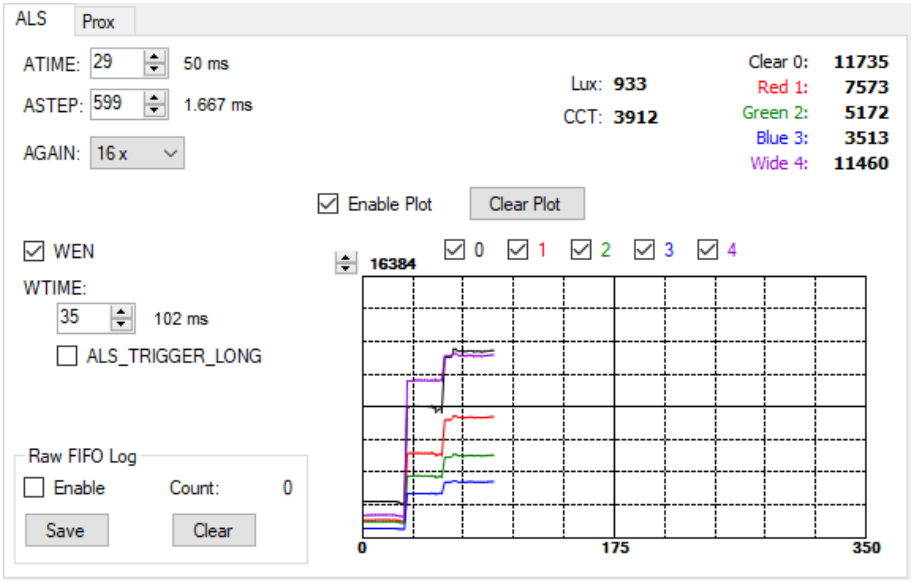
The **Count** value displayed is a count of the number of samples currently in the log buffer.

The **Elapsed Time** value indicates the elapsed time since data logging was started.

## 4.7 “ALS” Tab

The main portion of the screen contains a tab labeled ALS. The controls in this tab are divided into 3 sections, each performing a separate function.

**Figure 9 :**
**ALS Tab**




### 4.7.1 ALS Controls

The left side of the ALS tab contains controls to set various ALS settings.

The **ATIME** control sets the steps of the ALS/color integration from 1 to 256.

The **ASTEP** control sets the integration time per step in increments of 2.78µs.

The **AGAIN** control is a pulldown menu which sets the analog gain of the ALS sensor. The values available are 0.5x, 1x, 2x, 4x, 8x, 16x, 32x, 64x, 128x, 256x, 512x, and 1024x.

The **WEN** checkbox controls the ALS Wait feature. When this box is checked, the values for WTIME and ALS_TRIGGER_LONG are used to determine the time between ALS cycles. When this box is unchecked, there is no wait period between ALS cycles and the values of WTIME and ALS_TRIGGER_LONG are ignored.

The **WTIME** control sets the time to wait between ALS cycles. WTIME can be adjusted in 2.778ms steps.

The **ALS_TRIGGER_LONG** checkbox control sets the WTIME factor. When this box is checked, the wait time between ALS cycles is multiplied by a factor of 16.

The lower left corner of the ALS Tab contains a box titled Raw FIFO Log. Because of the operating speed of the PC and polling rate of the GUI program, the GUI does not display every sample, since the actual TCS3701 is operating faster than the GUI can display and log the data. This is not normally an issue, since the operating environment is not rapidly changing. The Raw FIFO Log is a special function that is designed to capture all of the ALS Data for Channels 0 and 1, without skipping any data.

When this function is enabled, the TCS3701 will store channel 0 and 1 data into its internal FIFO. When the GUI performs its normal data polling it will also extract all of the data in the FIFO and store it in memory. You may then store this data to a special log file.

The Raw FIFO Log controls function as follows:

The **Enable** checkbox will activate the FIFO and collect the data into memory while polling.

The **Count** field displays the number of channel0/1 pairs that have been collected in memory.

The **Save** button will store the accumulated data from memory into a user-specified file. The data in the log file is identified with a time stamp showing when the data was read from the FIFO and a zero-based sequential index number for each time stamp (since there may be several data samples each time the FIFO is emptied.

The FIFO can hold up to 64 channel 0/1 data pairs. If the index numbers for any time stamp increment all the way to 63, then there has likely been FIFO overload which means that data has been lost. This situation should only occur when the ATIME/ASTEP settings are very so small that the TCS3701 is producing several data values per millisecond.

### 4.7.2 ALS Lux Coefficients

The TCS3701 supplies information that is used to calculate Lux (unit of illumination). The Lux equation for the TCS3701 uses a combination of data from the sensor and various coefficients to calculate the Lux value. The software is pre-configured with coefficients for an open-air configuration. When the sensor is placed behind glass, different coefficients should be loaded into the software to update the Lux equation. The coefficients can be loaded or saved to an XML file using the File menu. To ensure the proper XML format first save the current coefficients using File > Lux Coefficients > Save. Once the file is saved locate the XML file created and edit with a text editor such as notepad to change the coefficients. Then go to File > Lux Coefficients > Load and select the XML file that was updated.

The software can also automatically load new coefficients upon starting the GUI. To do this save the XML file as TCS3701_luxeq.xml in the system documents directory (%USERPROFILE%\Documents, also known as My Documents). When GUI is started, you will see a dialog appear with the new coefficients displayed.

If you are experiencing trouble loading new coefficients, this may indicate a problem with the file format. The XML file must contain all the required Lux equation elements to be loaded. The format of the file follows the standard XML format and is as follows:

```
<?xml version="1.0" encoding="utf-8"?>
<!-- Device:TCS3701 Saved:1/9/2019 2:10:00 PM -->
<luxeq>
  <eq_values>
    <coef name="DGF" value="801.65" />
    <coef name="C_Coef" value="0.081" />
    <coef name="R_Coef" value="-0.099" />
    <coef name="G_Coef" value="0.309" />
    <coef name="B_Coef" value="-0.247" />
    <coef name="CT_Coef" value="5089" />
    <coef name="CT_Offset" value="1635" />
  </eq_values>
</luxeq>
```

### 4.7.3 ALS Output Data

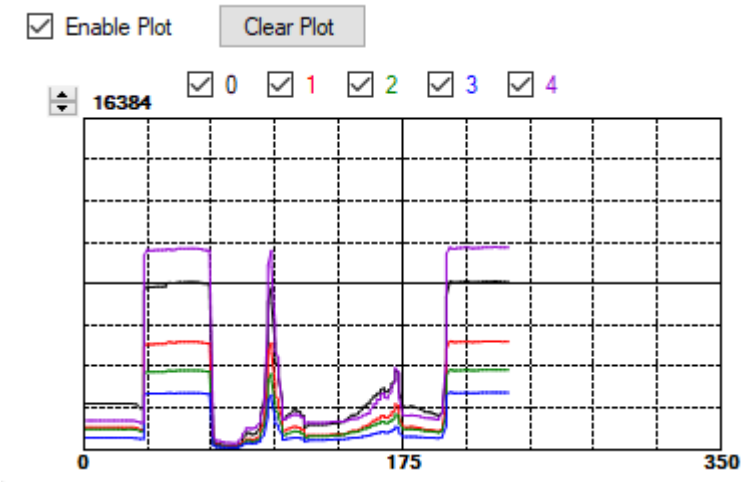
The top right corner of the ALS tab displays the output data. This data is continuously polled. The polling interval is shown above the tab.

- **Clear 0** displays the Clear Channel data count.
- **Red 1** displays the Red Channel data count.
- **Green 2** displays the Green Channel data count or the IR Channel counts if IR Mux is checked.
- **Blue 3** displays the Blue Channel data count.
- **Wide 4** displays the Wideband Channel data count.
- **Lux** displays the calculated lux.
- **CCT** displays the calculated correlated color temperature.

### 4.7.4 ALS Data Plot

The remaining portion of the ALS tab is used to display a running plot of the collected ALS values and calculated Lux. The last 350 values are collected and plotted on the graph. As additional values are added, the old values will be deleted from the left side of the graph. To start the plotting function, check the Enable Plot checkbox and select any of the 0, 1, 2, 3 or 4 checkboxes.

**Figure 10 :**
**ALS Data Plot**



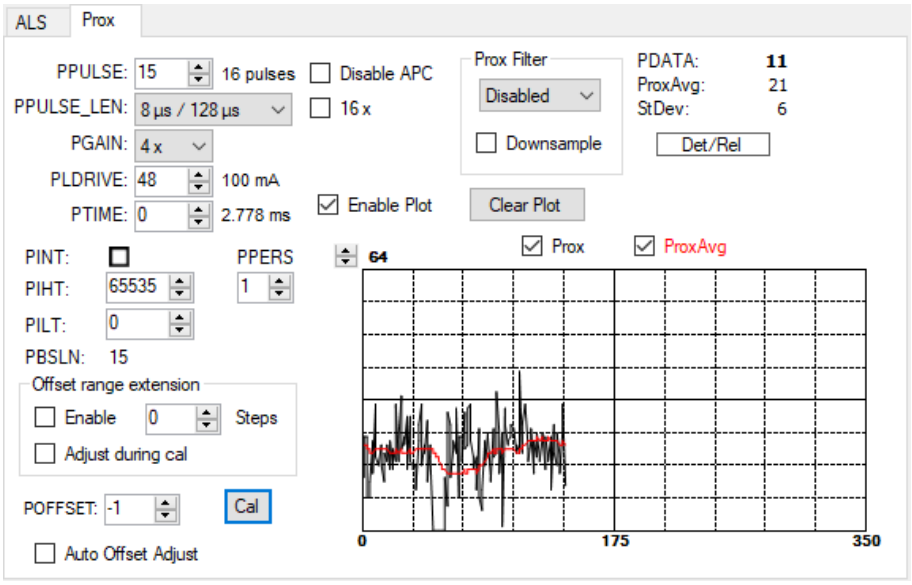

The scale of the Y-axis of the plot can be adjusted by clicking on the small up and down arrows at the top left corner of the plot. The scale can be set to any power of 2 from 64 through 65536.

Click the Clear Plot button to discard the current data and continue plotting the new data. Note if the Clear Plot button is clicked while the plot is disabled, the data is discarded, but the actual plot will not be updated until the plot function is re-enabled.

## 4.8 “Prox” Tab

The main portion of the screen contains a tab labeled Prox. The controls on this tab control the operation of the Proximity function of the TCS3701.

**Figure 11 :**
**Prox Tab**




### 4.8.1 Prox Controls

The left side of the Prox tab contains controls to set various Prox settings.

The **PPULSE** controls the number of pulses used for each prox cycle. The number of pulses is the PPULSE value plus 1 and is displayed immediately to the right of the box.

The **PPULSE_LEN** control sets the width of all IR LED pulses within the proximity cycle. Longer pulses result in increased proximity range and typically result in less electrical noise generated in the analog front end. This drop-down box works in conjunction with the 16x checkbox to select the actual pulse length that is used The values that can be chosen are 4 µs / 64 µs, 8 µs / 128 µs, 16 µs / 256 µs and 32 µs / 512 µs.

When the **16 x** box is checked, the longer pulse length values will be used. When the box is not checked, the system will use the shorter pulse lengths.

The **PGAIN** control is a pulldown menu that lets you select the analog gain of the proximity IR sensor. The values that can be chosen are 1x, 2x, 4x and 8x.

The **PLDRIVE** control sets the drive strength of the IR LED current. The values range 4mA to 258mA.

The **PTIME** control sets proximity sample time to (n + 1) × 2.778 ms, where n is the PTIME value.

The **PINT** control displays if an interrupt is generated. Clicking on this control will clear the interrupt. If the interrupt condition still exists, it will occur again on the next cycle.

The **PIHT** control sets proximity interrupt high threshold value.

The **PIHL** control sets proximity interrupt low threshold value.

The **PPERS** control sets proximity interrupt persistence value. It defines a filter for the number of consecutive occurrences that PDATA must remain outside the threshold range before a PINT interrupt is generated. The frequency of generated interrupts is as follows:

The **PBSLN** control displays a proximity baseline, the minimum PDATA since last calibration.

**Figure 12:**
**PPERS Interrupt Generation**

| Value | Interrupt generated when… |
|---|---|
| 0 | Every proximity cycle |
| 1 | Any proximity value outside of threshold range |
| 2 | 2 consecutive proximity values out of range |
| 3 | 3 consecutive proximity values out of range |
| … | … |
| 15 | 15 consecutive proximity values out of range |

**Information**

The Offset Range Extension feature of the TCS3701 is known to cause the PDATA values to drift over time. Use of this feature IS NOT recommended.

The **Enable** control in the Offset range extension group box enables the coarse offset range when checked.

The **Steps** control in the Offset range extension group box sets the offset range if the Adjust control and Enable control is not set. It read out the offset range here which is set automatically when the Adjust control and Enable control are checked.

The **Adjust during cal** control in the Offset range extension group box enables the coarse offset range calibrated automatically if checked.

The **POFFSET** control shifts PDATA to remove crosstalk from the proximity data. The values range from -255 to 255.

The **Cal** button triggers the sensor's proximity offset calibration sequence. This function automatically selects a POFFSET to remove crosstalk from PDATA.

The **Auto Offset Adjust** control, when checked, will decrease the proximity offset register when proximity ADC measurement is zero. When this box is checked, manual changing of the POFFSET control is disabled and The POFFSET value is read from the device on each update cycle.

The **Disable APC** control disables the automatic pulse control (APC) function. When this function is active, the range of the PDATA value is 0-1023.

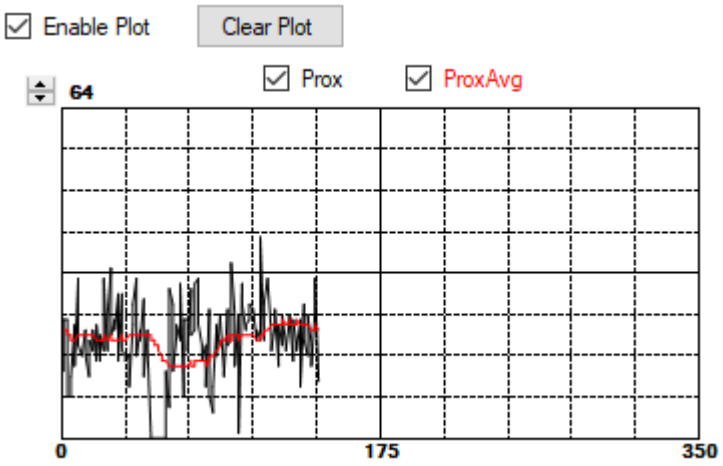
The **Dropdown** control in the Prox Filter group box enables and disables the Proximity Filter. This causes a running average of 1 (Disabled), 2, 4, or 8 samples to be reported in the PDATA register.

When the **Downsample** control in Prox Filter group box is checked, proximity results are checked for interrupts and persistence, and the PDATA register is updated only every Nth time, based on the setting of the dropdown.

### 4.8.2 Prox Data Plot

The remaining portion of the Prox tab is used to display a running plot of the collected PDATA values and/or the calculated average of the most recent 32 PDATA values. The last 350 values are collected and plotted on the graph. As additional values are added, the old values will be deleted from the left side of the graph. To start the plotting function, check the Enable Plot checkbox.

**Figure 13 :**
**Prox Plot Data**




Check the **Prox** or **ProxAvg** boxes to select the value(s) to be displayed.

The scale of the Y-axis of the plot can be adjusted by clicking on the small up and down arrows at the top left corner of the plot. The scale can be set to any power of 2 from 16 to 16384.

Click the Clear Plot button to discard the current data and continue plotting the new data. Note if the Clear Plot button is clicked while the plot is disabled, the data is discarded, but the actual plot will not be updated until the plot function is re-enabled.

# 5 Resources

For additional information regarding the TCS3701, please refer to the datasheet. For information regarding the installation of the TCS3701 EVM host application software please refer to the TCS3701 EVM Quick Start Guide.

Designer's Notebooks dealing with various aspects of optical measurement and optical measurement applications are available.

Additional Resources:

- TCS3701 Datasheet
- TCS3701 EVM Quick Start Guide (QSG)
- TCS3701 EVM User's Guide (this document)
- TCS3701 EVM Schematic Layout
- TCS3701 Optical Design Guide
- TCS3701 Proximity Design Guide

# 6 Revision Information

| Changes from previous version to current revision v1-00 | Page |
|---|---|
| Initial Release | All |
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| | |

- 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.

# 7 Legal Information



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