ISL29501

Evaluation Software User's Manual

UG054
Rev.1.00
Mar. 8, 2017

This document describes the installation, operation, and best practices for using software to control Intersil ISL29501-based evaluation platforms. The goal of the software is to provide an easy to use, flexible interface for setting registers, making measurements, and observing and recording results. In some places the revision number in the illustrations might show a different version of the software but the same concepts apply.

The first step in evaluation is to install the software. Included in the package are the application executable files (TOF.exe and TOFDLL.dll), a configuration file (TOF.ini), an errata document, and the latest copy of this user guide. The package also contains three subdirectories of support files that are imported or exported by the application. These directories are not critical and will be created if not found.

Quick Start

This section gives a user who is familiar with the ISL29501 and eye safety the basic steps to begin making distance measurements. Other users should read this document completely. It is recommended that the user never point the emitter directly toward someone's eye. The emitter has a wavelength of 850nm which is not visible to the human eye.

The following steps show an overview of the process:

1. Extract the files from the archive file to a convenient location on the local disk.
2. Connect the USB cable to the computer and the reference design board.
3. To start the application, double-click TOF.exe.
4. In the application, select File → Load Profile and then select a file to load the safe initial register settings and calibration data.
5. Click Start or Step to begin making distance measurements.

Installation

1. Copy the archive file *GUI_name*.zip to a convenient location on the local disk, where *GUI_name* is the evaluation platform name and the software version.
2. Using WinZip or other file compression software, extract the archive file to a convenient location on the local disk. For full functionality, maintain the relative directory structure.

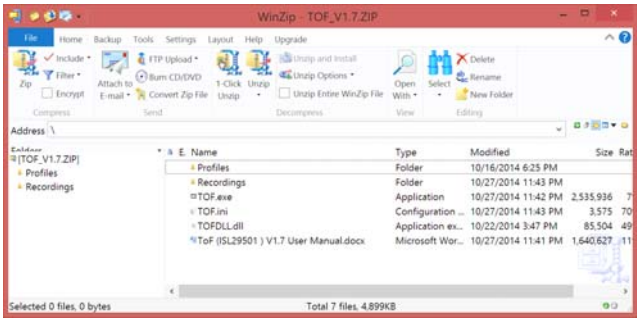


FIGURE 1. FILE COMPRESSION SOFTWARE

Starting the Application

1. Locate the installation directory on the local disk and double-click TOF.exe.
2. The Intersil license agreement shown in Figure 2 will appear. Read the License agreement, because you must accept the agreement by clicking the Accept button to continue. You must scroll to the end of the license before you can accept the agreement.

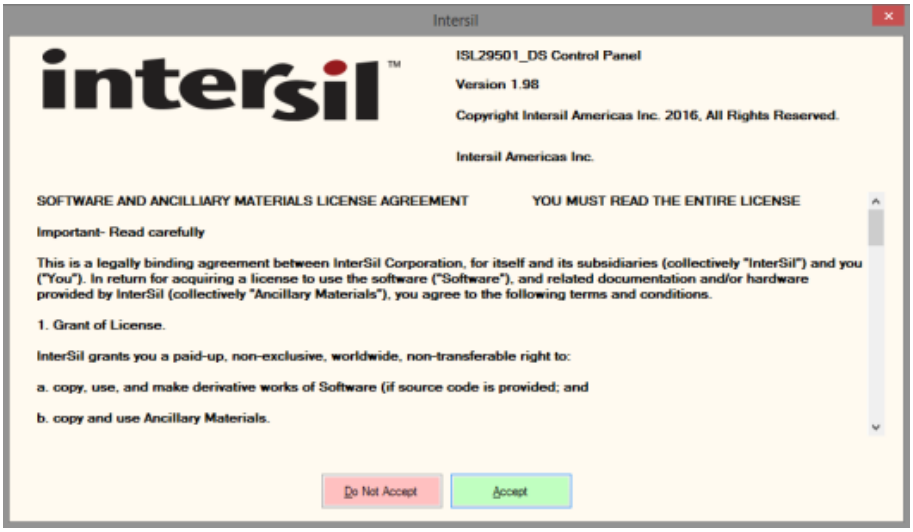


FIGURE 2. INTERSIL LICENSE SCREEN

The Main Application Window

The application will start and scan the USB interfaces for ISL29501 HID devices. If one (or more) is found, the application will automatically connect to the first one it finds. Note that the software does not support hot plugging and unplugging at this time.

Figure 3 shows the main window. The application retains the full functionality of previous versions but the terminology has been changed for consistency.

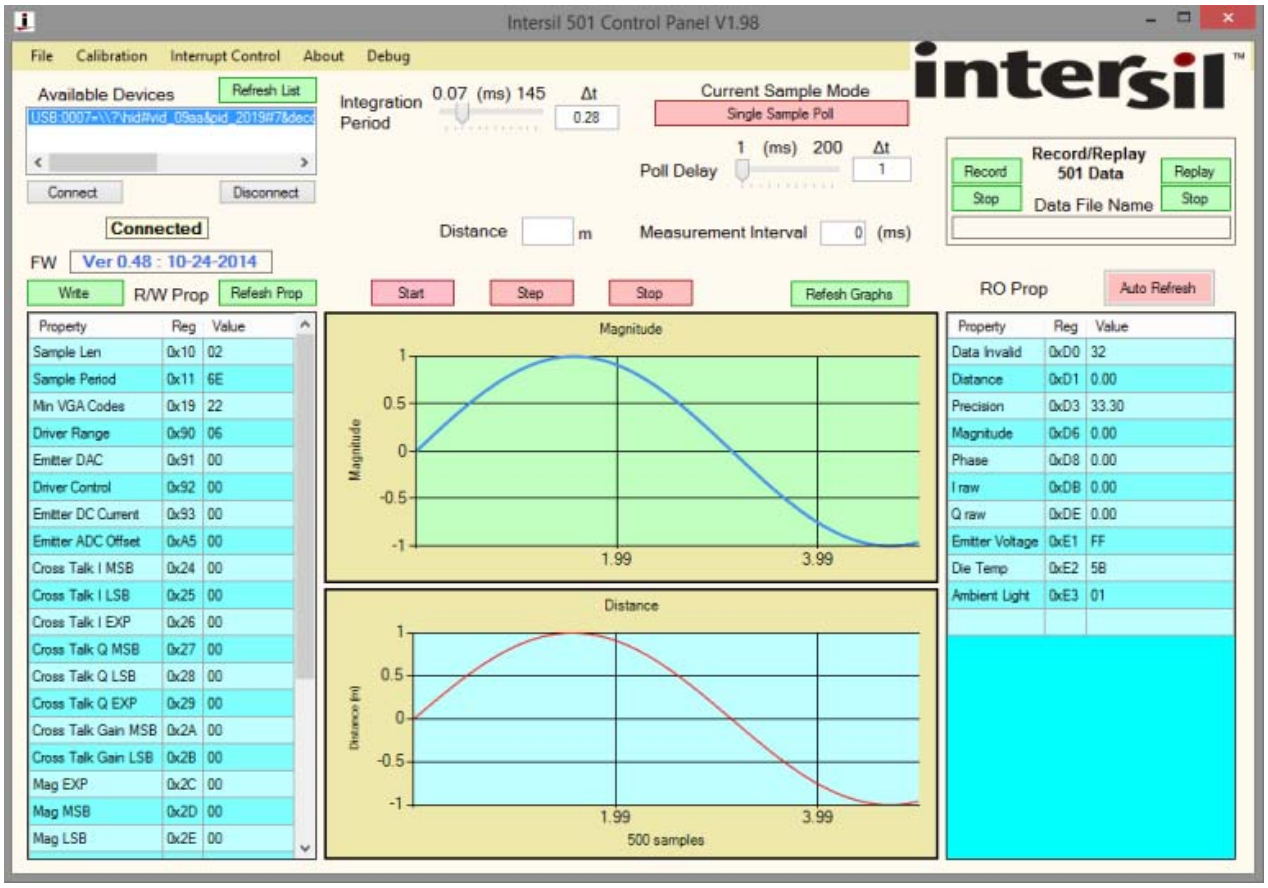


FIGURE 3. MAIN WINDOW

Software Features

Device Selection

When the Time of Flight (TOF) Control Panel application starts, the software will scan the USB interfaces for ISL29501 HID devices. The application will attempt to connect to the first one it finds. The string shows how Windows categorizes USB devices and is probably not useful for the user (A).

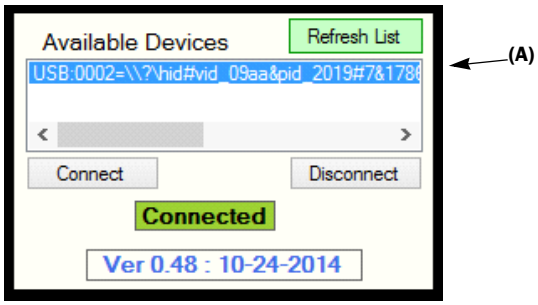


FIGURE 4. AVAILABLE DEVICES

The following commands are available:

- **Refresh List**. Updates the available device list. Use this option if a USB was disconnected and reconnected.
- **Connect**. Connects to the selected device. The device information will be shown, including firmware version and date. This number is useful when communicating with the factory.
- **Disconnect**. Disconnects the current device.

Hot Plugging USB Devices

The software does not support automatic detection of hot plugging or unplugging USB devices. If you disconnect and reconnect the device, you must click Disconnect and then Connect to reestablish the connection.

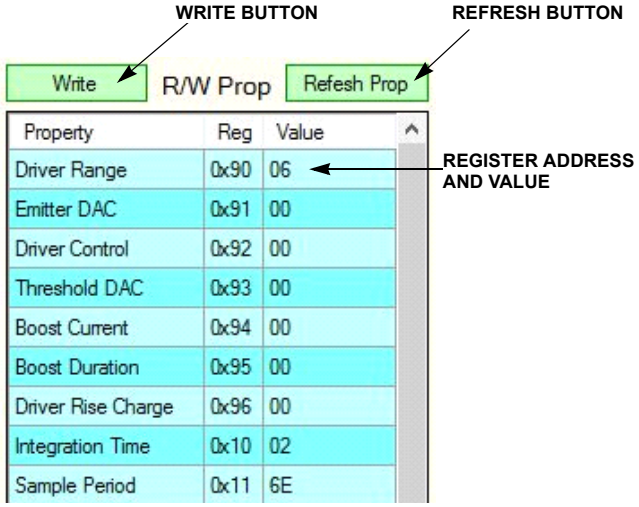
After the device is connected, the application will have control of the board with the registers in their default condition. If the board does not connect, close the application and restart it.

Property lists

The application provides two property lists, one on each side of the application window (see Figure 5). Each row contains a register description, register address, and a register value.

The registers on the left side are read/write (R/W) registers that can be modified. The registers on the right side are read-only (RO) that can be read but not modified.

The user can define which registers are shown in each group by modifying TOF.ini. For more information, see "TOF.ini" on page 10.



Property	Reg	Value
Driver Range	0x90	06
Emitter DAC	0x91	00
Driver Control	0x92	00
Threshold DAC	0x93	00
Boost Current	0x94	00
Boost Duration	0x95	00
Driver Rise Charge	0x96	00
Integration Time	0x10	02
Sample Period	0x11	6E

FIGURE 5A. READ/WRITE REGISTERS

Read Only Prop

Property	Reg	Value
Data Invalid	0xD0	32
Distance MSB	0xD1	36
Distance LSB	0xD2	4C
Precision MSB	0xD3	10
Precision LSB	0xD4	7E
Magnitude Exponent MSB	0xD5	00
Magnitude Significand MSB	0xD6	72
Magnitude Significand LSB	0xD7	B4
Phase Readout MSB	0xD8	36

FIGURE 5B. READ ONLY REGISTERS

FIGURE 5. PROPERTY LISTS

Modifying Register Values

1. Select the row of the desired register and modify the value in the Value column.
2. Click the Write button and the value will be written to the 501's register. The Write button must be clicked for each register modification.

To retrieve a new snapshot of the registers, click the Refresh Prop button. The refresh command updates both the R/W and RO registers.

It is good practice to click Refresh Prop after each write to ensure that each register is written properly.

For eye safety, register 0x91 is programmed to 00h or zero current. To make any distance measurements, this register must be changed to a value between 1 and 255. See the user manual for your reference design for recommended values.

Start, Step, and Stop

The Start, Step, and Stop buttons control the distance measurement process. Measurement results are shown on the Magnitude and Distance graphs in the main window.

FIGURE 6. START, STEP, AND STOP BUTTONS

- **Start**. Press the Start button to begin taking measurements. After a measurement is complete, a restart is issued. The latency between measurements is subject to Windows HID protocols. The resultant graphs will record up to 500 measurements after which the oldest measurement drops off as a new one is added.
- **Stop**. Pauses the continuous measurements.
- **Step**. Makes a single distance measurement, whether the 501 device is in Single Sample or Continuous mode. Single Sample is useful if you want to make a specific number of measurements before changing conditions.

Current Sample Mode

Use the Current Sample Mode button to toggle the 501 device between Single Sample (Single Shot) and Continuous Sampling modes. The currently selected mode is shown on the button. The default and most commonly used mode is Single Sample mode.

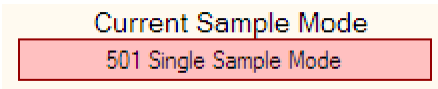


FIGURE 7. CURRENT SAMPLE MODE BUTTON

The controls in "Integration Period and Sample Period" and "Poll Delay" will change depending on the Current Sample mode.

Integration Period and Sample Period

The controls in Figure 8 are defined as follows:

- **Integration Period**. The amount of time during the sample period that the emitter is pulsing. The integration period is when the device makes measurements.
- **Sample Period**. The duration of the entire measurement cycle.

In Continuous mode, the emitter duty cycle = (Integration Period * 0.5)/((Integration Period * 0.5) + Sample Period)

In Single Sample mode, the sample period has no effect, so the option will be unavailable.

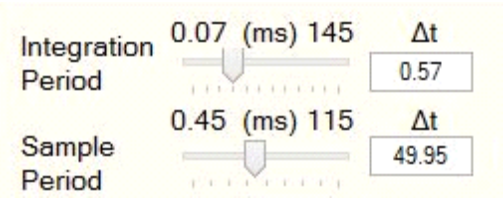


FIGURE 8. INTEGRATION PERIOD AND SAMPLE PERIOD

The IC averages the measurement from each pulse in a burst. Increasing the number of pulses in the integration period increases this averaging but also increases the average power.

Move the sliders to change the integration period and sample period (packet repetition rate) dynamically.

The label above the sliders shows the maximum values for the respective register. The actual time value is in ms and shown under the Δt label. Additional details are available in the ISL29501 datasheet under registers 0x10 and 0x11.

Poll Delay

The Poll Delay adds an additional delay between sample periods. The source of this delay is in the computer.

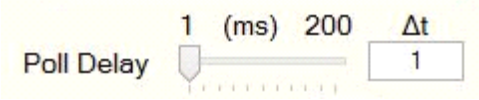


FIGURE 9. POLL DELAY

These values are in ms and the times to be set are shown as Δt. An estimate of overall duty cycle can be calculated using Equation 1:

$$DC = (\text{Integration Period} * 0.5) / ((\text{Integration Period} * 0.5) + \text{Sample Period} + \text{Poll Delay} + \text{Windows Delay}). \quad \text{(EQ. 1)}$$

The Windows delay is ~2ms for Windows 7 and Windows 8.

During Continuous mode, the duty cycle is determined by the Integration Period and the Sample Period so the Poll Delay option will be unavailable.

Refresh Graphs

The Refresh Graphs button clears the Magnitude and Distance graphs so the next measurement will be the first shown (location 500). The refresh clears the display and forces an auto scale on the first measurement. This command is useful if you are running continuously and an adjustment to the setup makes a large change to the magnitude or distance, making the new readings too small to read graphically. Refreshing forces an Autoscale without waiting for 500 samples.

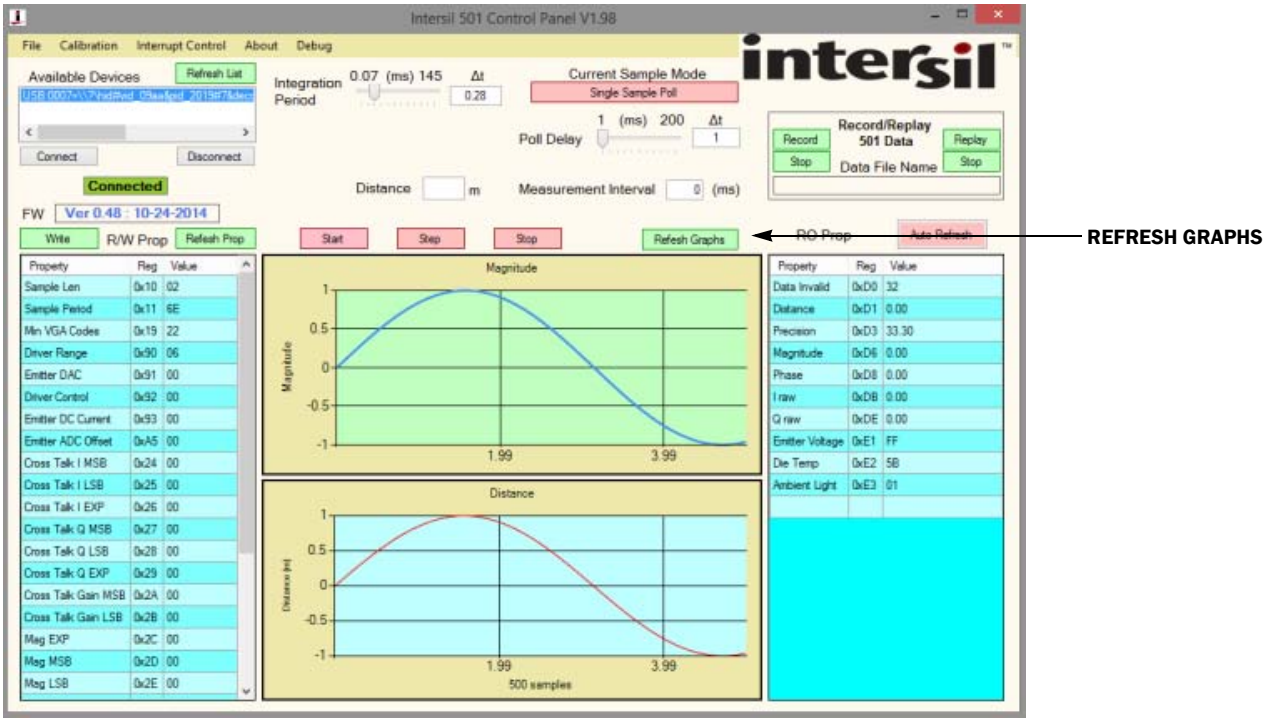


FIGURE 10. MAIN WINDOW

Graphical Displays for Distance and Magnitude

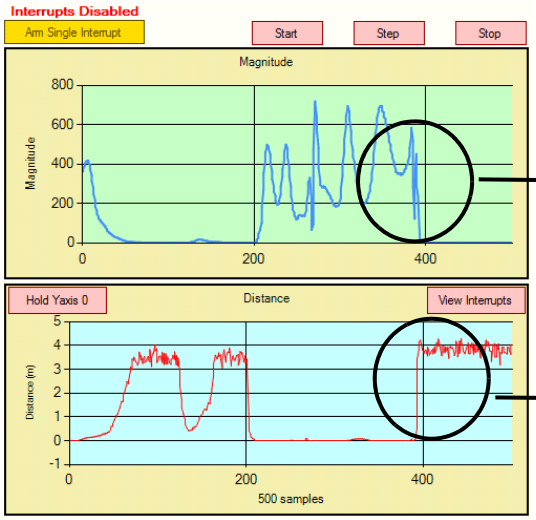


FIGURE 11A. NORMAL DISPLAY

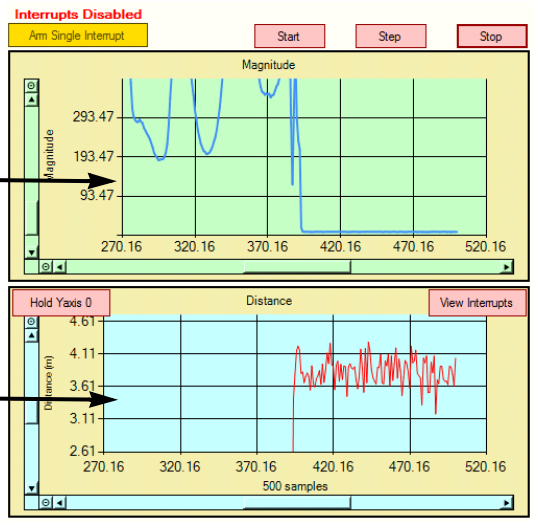


FIGURE 11B. ZOOM

FIGURE 11. GRAPHICAL DISPLAYS

- Distance and magnitude are plotted in real time.
- Integration Period is the time, in milliseconds, that it takes for the application to get a sample from the 501 HID interface. This is purely for user information and is not critical.
- Plotting scales automatically scales the data range changes.
- Distance is shown on a bar chart above the graphs. It shows the distance to the target from 0 to 8 meters in real time.
- Cal Val allows the user to modify the distance offset from relative zero.
  - Distance calibration is normally run to null this offset but this feature allows the user to add an additional offset to compensate for a distance change.
  - The distance shown will be adjusted in real time on each measurement.
- Refresh History resets the plotting scale to its automatic settings and deletes older data in the plot buffer.
- By clicking inside either of the plot areas, the user can zoom into and out of the data. Refresh History reestablishes the normal display scaling.
  - The left mouse button zooms in.
  - The right mouse button zooms out.
- The Hold Yaxis 0 button constrains the y-Axis minimum to 0.

Calibration

For the ISL29501 to measure distance correctly, three calibrations must be done: magnitude calibration, crosstalk (xtalk) calibration, and distance calibration.

Click Calibration to start the calibration wizard. In the wizard there are two property sheets that are shown at the beginning and the end of the calibration process. The Original Values sheet shows the current calibration register values and the New Values sheet shows the proposed new values.

The chip registers will not be written until Accept/Set is clicked. Clicking Cancel/Restore will close the calibration wizard without changing any registers. After start-up, all three calibrations should be run in order unless a profile containing calibration values has been loaded. For more information about profiles, see "Profiles" on page 8. Each of the three calibrations is initiated by clicking the appropriate start button and each spawns a new window.

- Select Calibration to start the calibration wizard.

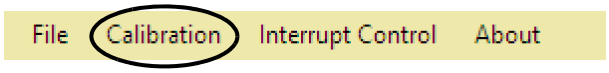
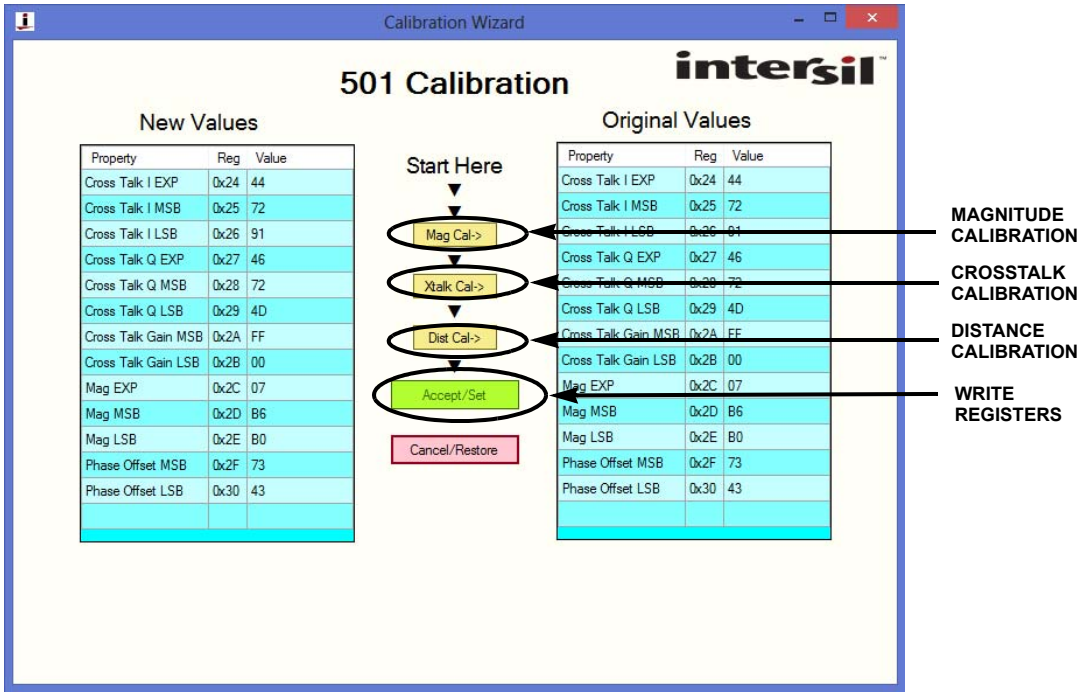


FIGURE 12. CALIBRATION MENU



Property	Reg	Value
Cross Talk I EXP	0x24	44
Cross Talk I MSB	0x25	72
Cross Talk I LSB	0x26	91
Cross Talk Q EXP	0x27	46
Cross Talk Q MSB	0x28	72
Cross Talk Q LSB	0x29	4D
Cross Talk Gain MSB	0x2A	FF
Cross Talk Gain LSB	0x2B	00
Mag EXP	0x2C	07
Mag MSB	0x2D	B6
Mag LSB	0x2E	B0
Phase Offset MSB	0x2F	73
Phase Offset LSB	0x30	43

FIGURE 13. CALIBRATION WIZARD

Click Mag Cal and the window in Figure 14A appears. Magnitude calibration compensates for the emitter current. Click Calibrate and then Done when the calibration finishes. The magnitude calibration process is very quick.

Click Xtalk Cal and the window in Figure 14B appears. Crosstalk calibration compensates for electrical crosstalk observed by the photodiode. The crosstalk will change with the programmed emitter current.
To set up crosstalk calibration, the emitter light must be blocked from reaching the photodiode. This can be done in one of two ways. The first is to point the reference board to infinity. A target that is 3 meters or more away can be considered infinite. The second way, which is more error prone is to cover the emitter to ensure that none of the IR light reaches the photodiode. Click Calibrate and then Done when the calibration finishes. The crosstalk calibration process is slower than magnitude calibration and can take up to 10 seconds. The sample period and poll interval will affect the run time.

Click Distance Cal and the window in Figure 14C appears. Distance calibration creates a coefficient that will be subtracted in each distance measurement.
To set up distance calibration, the evaluation board must be placed a known distance from a target that completely covers the field of view of the emitter diode. The cone of light produced by the emitter and reflected by the target should be unobstructed by any foreign objects. The board must be positioned so that the emitter light does not reflect off a table top, wall, or other object. A good estimation is to keep all objects two times the calibration distance multiplied by the tangent of twice the viewing angle of the emitter. You can picture an imaginary cylinder whose radius you calculated above with the board and the target at the ends. The user should pick a calibration distance between the minimum and maximum expected measurement distance. For the Sand Tiger reference design with a calibration distance of 30cm, the cylinder would have a radius of 6.3cm.
The distance calibration process has an run time similar to crosstalk calibration, up to 10 seconds. The sample period and poll interval will affect the run time.

In each case, a panel appears showing what is expected for setting up the calibration type. Each calibration will zero the previous information set in the 501 registers.

The Done button will turn green to indicate that calibration is complete. Click Done to return to the Calibration Wizard.

In the Calibration Wizard window, click Accept/Set to write the calibration registers, and alternatively click Cancel/Restore to close the wizard without updating the calibration values.

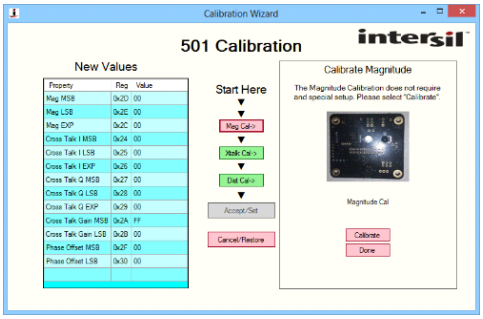


FIGURE 14A. CALIBRATE MAGNITUDE

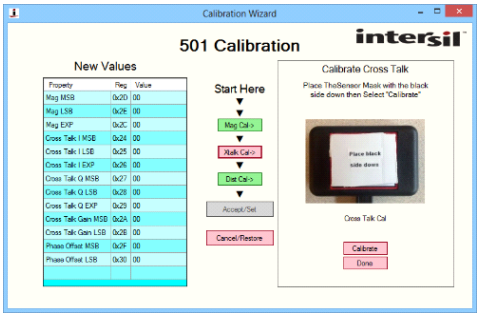


FIGURE 14B. CALIBRATE CROSSTALK

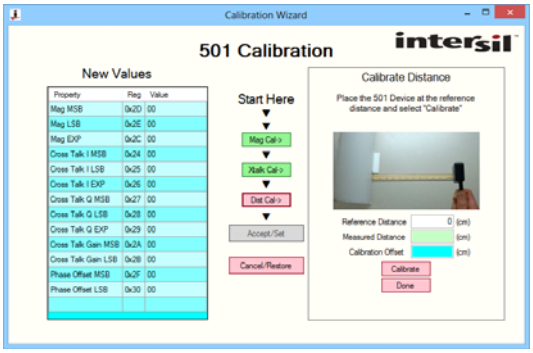


FIGURE 14C. CALIBRATE DISTANCE

FIGURE 14. CALIBRATION WINDOWS

Profiles

Use profiles to save and restore register data to and from the ISL29501 chip. The file is in ASCII text format and can be easily modified in any text editor. Creating a profile is an easy way to save and load configuration data after calibration. Several example profiles are included in the software package so a user can easily learn the Microsoft INI syntax and perform experiments from a known good starting point. It is important to remember that certain settings, such as emitter current or sample length, require a new calibration to achieve the best accuracy.

- Clicking File in the main menu gives two selections: Save Profile and Load Profile.

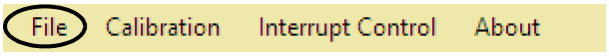


FIGURE 15. FILE MENU

- When loading a profile, a Windows file chooser is called allowing the user to select a file. Profiles are stored in a subdirectory called Profile below the directory where the TOF.exe executable resides. If the directory does not exist, the application will create it.
- When saving a profile, the registers defined in the Profile section of the TOF.ini file are written to the file. For more information about the INI file, see "TOF.ini" on page 10. The user can select all the chip registers or choose any subset.
- If the chosen filename exists, the user is given an option to overwrite the existing file.
- If Load Profile is selected, the 501 registers defined in the selected file will be written to the ISL29501. Registers not defined will remain unchanged.
- The following is a short example of a profile: Reg:DataValue

TABLE 1. PROFILE EXAMPLE

[501 Profile]	[Register:RegValue (in hex)]
Master Control=R0x01:01,RW,Show	
Integration Period =R0x10:02,RW,Show	
Sample Period=R0x11:00,RW,Show	
Sample Range=R0x12:00,RW,Show	
DC Cal=R0x14:02,RW,Show	
ZP Cal=R0x15:02,RW,Show	
Collision=R0x16:02,RW,Show	

The last two arguments shown above do not have any meaning in profiles. They are required for the software to operate properly but their value is not important. It is recommended that the string ",RW,Show" be appended to any new register definitions. The text preceding the "=" is treated as a comment but can be valuable when learning the chip.

Direct Register Manipulation

Use the property lists on the left and right side of the application window to observe and change chip registers. An additional capability is available that allows the user to view all register values and change any that are R/W. The register map is called from the Show Regs option on the About menu. The result is a 256 value array that represents all the chip registers. The left column header holds the upper of the two character register addresses and the top row holds the lower character.

Any number of cells can be selected. Click one cell with the left mouse button, hold the button, and drag to select the desired cells. The user can also hold the Ctrl key to select one cell at a time with the left mouse button. The last method is to select all cells by clicking the upper left cell of the array header. Any R/W cells can be modified. See the register listing in the datasheet to find which registers are writable by the user. Click the Write Selected button to write all selected cells to the chip.

When changing a register value with a write, the number format is decimal. The number returned from a read instruction will appear in hexadecimal format.

It is recommended to read the values after a write to verify that the selected registers contain the intended values. The read might show that the register was not correctly updated by the write. This can happen for two reasons. One reason is that a hex number was typed into a cell. The values must be decimal. Hex values that map into decimal (no A/B/C/D/E/F) will return incorrect values. Hex values that contain (A/B/C/D/E/F) will be rejected and the original value will be returned. Another second reason is that a register is not writable. In that case the previous value will be returned.

- Another handy feature is the ability to save or load all the registers with a single click. These are called register dumps and the application has buttons to save and restore register dumps.

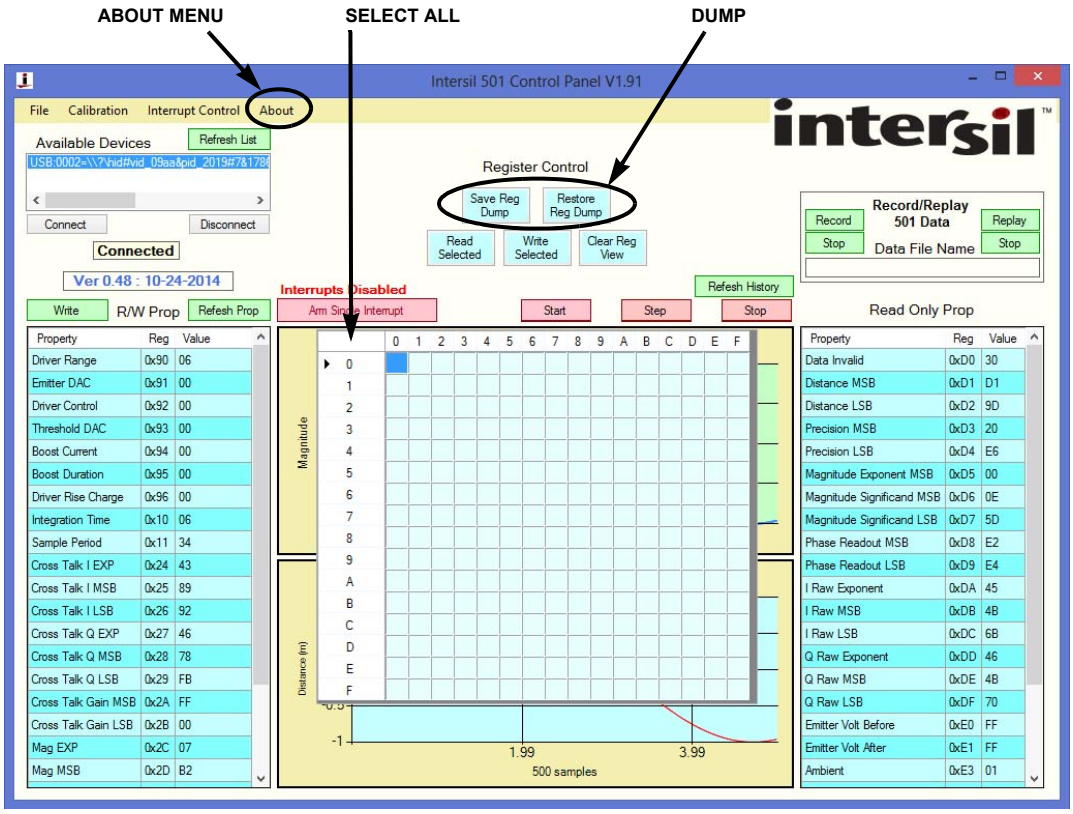


FIGURE 16. MAIN WINDOW

Recording or Logging

This feature allows the user to perform experiments while recording register data to a CSV format file. The data written to the file can be the result of a continuous run (Start and Stop) or Step. We expect that the user will use this feature extensively when doing systematic experiments.

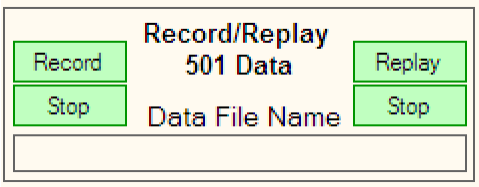


FIGURE 17. RECORD/REPLAY WINDOW

- Click Record to open the specified file in which register values from subsequent distance measurements will be stored in rows. The file is stored in the Recordings directory. Recording will continue until the Stop button is clicked.
- A header row will be created that identifies the 501 registers that have been captured.
- Each row after the header contains the resulting register data in hex format for a single distance measurement. It is important to note that the “0x” prefix to each register value is not included but these are all hex numbers.
- The Replay button allows the user to replay any previously saved recording file.
- Table 2 is an example of the CSV file data showing the header row and data from five distance measurements.
- The recorded file is CSV format and can be directly loaded into Microsoft Excel or any text editor.
- The register set saved during recording is defined in the TOF.ini file. Look for the following key: [Data Capture Registers].

TABLE 2. CSV DATA SAMPLE

Int,0x69,0x6A,0x6B,0xD0,0xD1,0xD2,0xD3,0xD4,0xD5,0xD6,0xD7, 0xD8,0xD9,0xE0,0xE1,0xE2,0xE3,0xE4,0xE5,0xE6,0xE7,0xE8,0xE9, 0xEA,0xEB
00,13,FD,FD,30,1E,20,01,B4,02,C9,AA,31,A6,7F,FF,56,01,FF,FF,FF,00, 3C,00,4C,4C
01,00,00,00,30,1D,10,01,AC,02,CC,F2,30,96,7F,FF,56,01,FF,FF,FF,00, 3C,28,4B,80
01,00,00,00,30,1E,CE,01,BA,02,C6,94,32,54,7F,FF,56,01,FF,FF,FF,00, 3C,04,4B,B4
01,00,00,00,30,1D,20,01,B8,02,C7,60,30,A6,7F,FF,56,01,FF,FF,FF,00, 3C,B0,4B,B0
01,00,00,00,30,1F,B6,01,B0,02,CA,FA,33,3C,7F,FF,56,01,FF,FF,FF,00, 3C,80,4B,C4

Decoding a Recording File

“Recording or Logging” on page 10 shows the CSV file format of a recording. A row consists of about 30 hex numbers that represent the raw register data. In this section, conversion formulas for the 2- or 3-byte register format to decimal floating point values for the more commonly used registers are defined.

To do the conversion, create a new column after the LSB register and paste the following formulas directly into each cell after the header. Some adjustment to the cell number might be required depending on the number of columns inserted. Formulas for common conversions are shown below. Everything to the left of the equal sign is a comment that describes the Excel formula. Distance is the round trip distance so the MSB and LSB are combined and divided by 2. The magnitude is a floating point number in three registers so the MSB and LSB need to be combined, multiplied by the exponent, and divided by 10000 to convert to nanoamps.

- Distance [0xD1 / 0xD2] (mm) = (HEX2DEC(G2)*256+HEX2DEC(H2))/65536*33.1
- Magnitude [0xD5 / 0xD6 / 0xD7] (nA) = ((POWER(2,HEX2DEC(M3))*HEX2DEC(N3)* 256+HEX2DEC(O3)) /100000)

TOF.ini

The TOF.ini file is called when the application executable TOF.exe starts. This file allows the user to customize functions without having to change and compile the application source. There are two types of keywords in this file: Those that define functions that consist of groups of registers and those that define the groups of registers and their values. The three supported functions are as follows:

- [Display List] - The registers that will appear in the main window of the application.
- [Profile Registers] - The registers that appear in a profile when saved.
- [Data Capture Registers] - The registers saved in a recording.

Two of these functions contain groups of register definitions such as [Cal Ref], [Analog Control Registers], and [Sampling]. Each of these contain a list of registers and a number of attributes for each. [Data Capture Registers] has a different format because it lists a range of registers with no additional arguments. The syntax for these is shown in “TOF Configuration File” on page 11 and in the included TOF.ini file. Normally, the included TOF.ini does not need to be modified.

The [Display List] can be used to show mathematical results as well as register values. It might be useful to calculate the actual distance and not just the 2x8 bit register values. Examples are shown in Table 3 on page 12 in the [Data Output] section.

TOF Configuration File

The TOF.ini file consists of several keys ([Key Name]) that have attributes and values.

- Attribute=Value
- Values contain fields separated by commas.

The keys are divided into two different categories:

- Keys that define a sequence of other attributes.
- Keys that define register mappings.

Keys That Define a Sequence of Other Attributes

Some keys contain attributes whose values define a sequence of other attributes, such as Display List and Profile Registers.

- **Display List**. Itemizes the keys that will be evaluated to populate the 501 property displays.
- **Profile Registers**. Itemizes the Register Keys that will be evaluated to generate the list of 501 registers to be saved in a profile. Only register keys whose value contains the field RW will be saved in the profile.

Keys That Define Register Mappings

Some keys contain attributes that define Register mappings. For example, [TOF Control], [Sampling], [Data Output], etc. Attributes of these keys have the following format:

ValueName = EvaluationField, AccessStatus, Visibility, Format
Examples:
Master Control=R0x01,RW,Show
Magnitude Ref=(R0x2D * 256 + R0x2E) * (2.0 ^ R0x2C) / 100000,RW,Show,F2

VALUENAME

The ValueName attribute is used to generate a readable name to be used when showing the attribute.

EVALUATIONFIELD

The EvaluationField attribute consists of terms to be evaluated:

- Register definitions: R0x2D represents a register defining term. This value will be evaluated and used to get or put a value from that register.
- Operators that can be combinations of:
  * multiply
  / divide
  + add
  - subtract
  ^ power
  () nesting - everything within corresponding () is evaluated as a single term.
  Anything else is considered a constant, such as 256 or 2.0
- Terms and operators are separated by one or more spaces and evaluated from left to right without precedence. Nested terms are recursively evaluated to any depth. Each nested term is completely evaluated at its nested level before being applied to the previous result indicated by the operator preceding it.

ACCESSSTATUS

The AccessStatus attribute is RW for Read/Write (for 501 registers) or some other indicator like RO. Anything that is not RW is considered read only.

VISIBILITY

The Visibility attribute determines whether the attribute will be shown (Show) in the property display.

FORMAT

The Format attribute is an optional formatting parameter used to format the result and determine whether to use floating point or integer arithmetic.

The format specifications are those used in the C# ToString() conversion method.

F2 would generate a floating point number with 2-decimal precision, such as 2.32.

X4 would produce four digits of Hex, such as 12AE. The default format is a decimal integer, such as 123456789.

TABLE 3. INI Syntax Example

```
[Display List]
Display=Int Short,Cal Ref,Data Output,Tof Control,Sampling,Algorthm Control

[Profile Registers]
List=Tof Control,Sampling,Algorthm Control,Signal Integrity,Cal Ref,Interrupt Regs,Analog Control Registers

[Data Capture Registers]
List=0xD0:10,0xE0:12

[TOF Control]
Device ID=R0x00,RO,Show
Master Control=R0x01,RW,Show
Status Registers=R0x02,RO,Hide

[Sampling]
Sample Len=R0x10,RW,Show
Sample Period=R0x11,RW,Show
Sample Range=R0x12,RW,Show
Sample Control=R0x13,RO,Show
DC Cal=R0x14,RW,Show
ZP Cal=R0x15,RW,Show
Collision=R0x16,RW,Show

[Data Output]
Data Invalid=R0xD0,RL,Show
Distance=(R0xD1 * 256 + R0xD2) / 65536 * 33.3,RL,Show,F2
Precision=(R0xD3 * 256 + R0xD4) / 65536 * 33.3,RL,Show,F2
Magnitude=(R0xD6 * 256 + R0xD7) * (2.0 ^ R0xD5) / 100000,RL,Show,F2
Phase=(R0xD8 * 256 + R0xD9) / 65536 * 2 * 3.14159,RL,Show,F2
I raw=(R0xDB * 256 + R0xDC) * 2 ^ R0xDA / 100000,RL,Show,F2
Q raw=(R0xDE * 256 + R0xDF) * 2 ^ R0xDD / 100000,RL,Show,F2
EV Before=R0xE0,RL,Show
EV After=R0xE1,RL,Show

[Cal Ref]
Cross Talk I EXP =R0x24,RW,Show
Cross Talk I MSB =R0x25,RW,Show
Cross Talk I LSB =R0x26,RW,Show
Cross Talk Q EXP =R0x27,RW,Show
Cross Talk Q MSB =R0x28,RW,Show
Cross Talk Q LSB =R0x29,RW,Show
Cross Talk Gain MSB=R0x2A,RW,Show
Cross Talk Gain LSB=R0x2B,RW,Show
Mag EXP=R0x2C,RW,Show
Mag MSB=R0x2D,RW,Show
Mag LSB=R0x2E,RW,Show
Phase Offset MSB=R0x2F,RW,Show
Phase Offset LSB=R0x30,RW,Show

[Calibration]
Magnitude Ref=(R0x2D * 256 + R0x2E) * (2.0 ^ R0x2C) / 100000,RW,Show,F2
Cross Talk I=(R0x25 * 256 + R0x26) * (2.0 ^ R0x24) / 100000,RW,Show,F2
Cross Talk Q=(R0x28 * 256 + R0x29) * (2.0 ^ R0x27) / 100000,RW,Show,F2
Cross Talk Gain=R0x2a * 256 + R0x2b,RW,Show,F2
Phase Offset=R0x2f * 256 + R0x30,RW,Show,X4

 [Analog Control Registers]
Driver Range=R0x90,RW,Show
Emitter DAC=R0x91,RW,Show
Driver Control=R0x92,RW,Show
Thresh DAC=R0x93,RW,Show
Front End Ctl=R0x97,RW,Show
Temp Sens ADC Mode=R0xAA,RW,Show
Internal Reset=R0xae,RW,Hide
```

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