TSW12D1620 Evaluation module

User's Guide

Literature Number: SBAU323A
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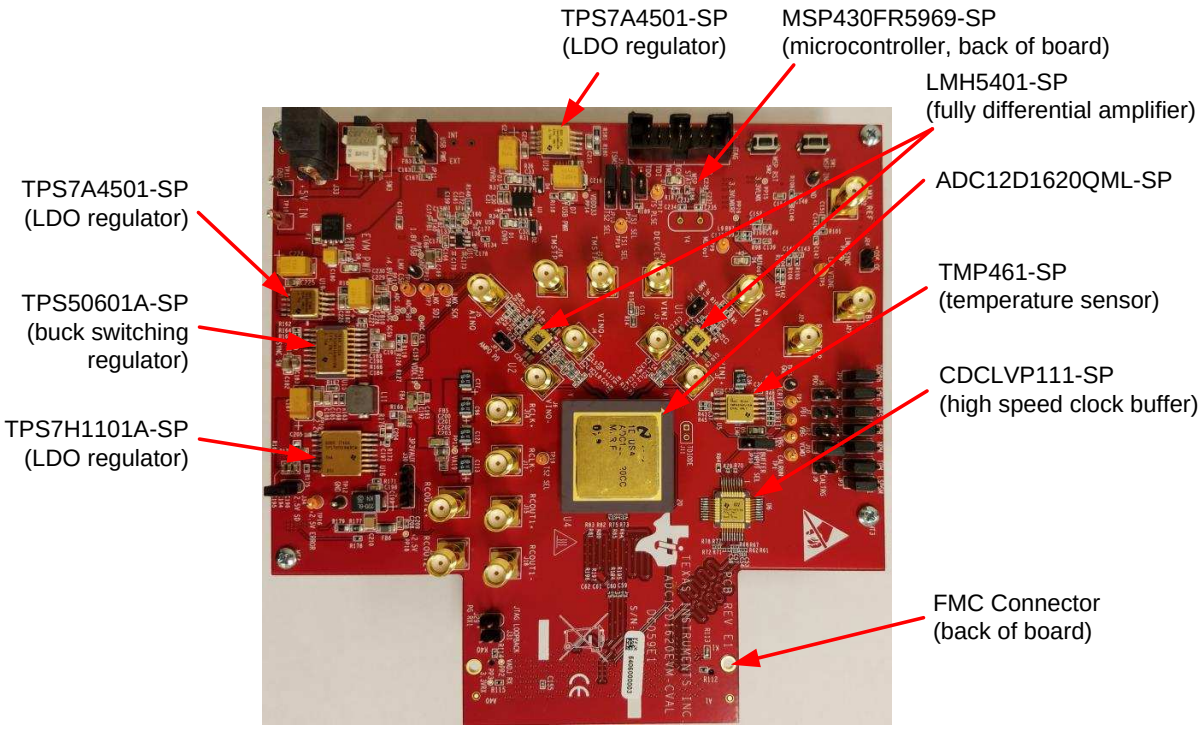

Figure 1. TSW12D1620 Evaluation Module

The TSW12D1620 evaluation module (EVM) is used to evaluate the ADC12D1620QML-SP analog-to-digital converter (ADC) from Texas Instruments. Throughout this document, the terms *evaluation board*, *evaluation module*, and *EVM* are synonymous with the TSW12D1620EVM-CVAL.

The ADC12D1620QML-SP is a dual-channel, 12-bit ADC, capable of operating at sampling rates up to 1.6 Giga-samples per second (GSPS) in dual-channel mode, or 3.2 GSPS in single-channel mode. The TSW12D1620EVM-CVAL device output data are transmitted over a high-speed low-voltage differential signaling (LVDS) interface. This evaluation board also includes the following important features:

- An LMH5401-SP high-performance differential amplifier for the single-ended to differential gain block
- Optional differential input network supporting signals from DC to >3 GHz (requires minor component changes)
- Transformer-coupled clock input network to test the ADC performance with an external low-noise clock source
- High-reliability voltage regulation solution
- A TMP461-SP local and remote diode temperature sensor
- Device register programming through the universal serial bus (USB) connector and an FTDI™ USB-to-serial bus translator

- High-speed LVDS data output via an FMC™ interface connector

The digital data from the TSW12D1620EVM-CVAL board is quickly and easily captured with the TSW14DL3200EVM data capture board and the included FMC-TSW14DL3200EVM adapter.

The TSW14DL3200EVM captures the LVDS data, stores the data in memory, and then uploads the data to a connected PC through a USB interface for analysis. The high-speed data converter pro (HSDC Pro) software on the PC communicates with the hardware and processes the data.

Throughout this document, the TSW12D1620EVM-CVAL is referred to as the *EVM* and the ADC12D1620QML-SP device is referred to as the *ADC* device.

Related Documentation

Technical Reference Documents

- Texas Instruments, *ADC12D1620QML-SP 12-Bit, Single Or Dual, 3200- or 1600-MSPS RF Sampling Analog-to-Digital Converter (ADC)* data sheet
- Texas Instruments, *TSW14DL3200 High-Speed LVDS Data Capture and Pattern Generator User's Guide*
- Texas Instruments, *High Speed Data Converter Pro GUI* user's guide (The HSDC Pro is also available in the software help menu.)
- Texas Instruments, *LMH5401-SP Radiation Hardened 6.5-GHz, Low-Noise, Low-Power, Gain-Configurable Fully Differential Amplifier* data sheet
- Texas Instruments, *TMP461-SP Radiation Hardened Remote and Local Digital Temperature Sensor* data sheet
- FTDI Chip, FTDI USB to Serial Driver Installation Manual

TSW14DL3200EVM Operation

See the TSW14DL3200EVM user's guide for configuration and status information.

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Equipment

This section describes the equipment needed to evaluate the full performance of the ADC device.

1.1 Evaluation Board Feature Identification Summary

Figure 1-1 shows the EVM features.

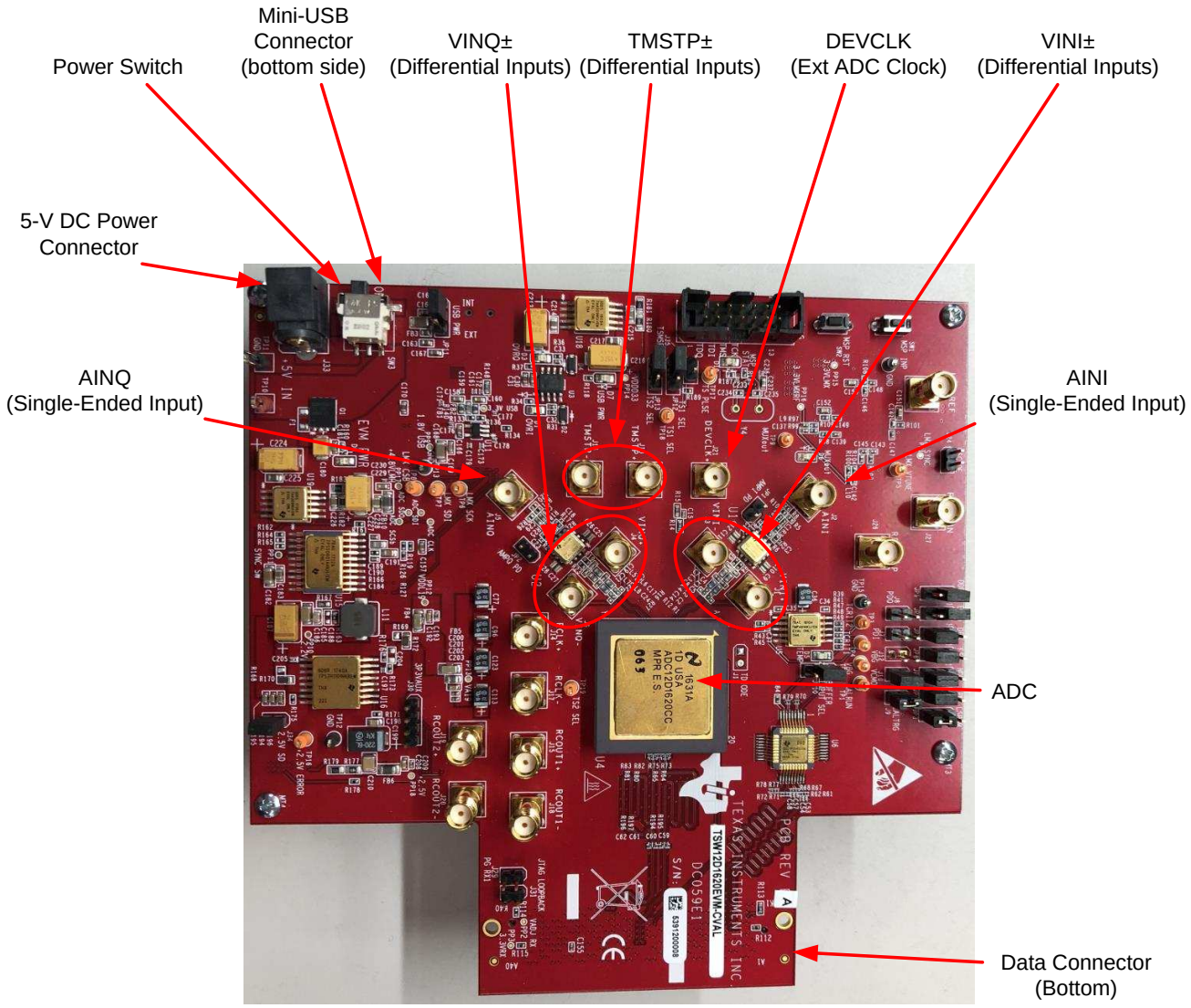

Figure 1-1. EVM Feature Locations

1.2 Required Equipment

The following equipment are included in the EVM evaluation kit:

- Evaluation board (EVM)
- Mini-USB cable
- Power cable
- FMC-TSW14DL3200EVM adapter board

The following equipment is *not* included in the EVM evaluation kit, but is required for evaluation of this product:

- TSW12D1620EVM-CVAL GUI software
- TSW14DL3200EVM data capture board and related items
- HSDC Pro software
- Computer (PC) running the Windows® operating system (XP, 7, 8, or 10)
- One low-noise signal generator for the analog input; TI recommends the following generators:
  - Keysight™ E8663D
  - Rohde & Schwarz® SMA100A or SMA100B
- Band-pass filter for the analog input signal (750 MHz or desired frequency); the following filters are recommended:
  - Band-pass filter (BPF):
    - Greater than or equal to 60-dB harmonic attenuation
    - Less than or equal to 5% bandwidth
    - Greater than 6-dBm power
    - Less than 5-dB insertion loss
  - Trilithic™ 5VH-series tunable BPF
  - K&L Microwave™ BT-series tunable BPF
  - TTE KC6 or KC7-series fixed BPF
- Signal-path cables, SMA, or BNC (or both SMA and BNC)

By default, the TSW12D1620EVM-CVAL uses an external clock source. Future versions of the board may support the LMX2615-SP integrated PLL/VCO onboard clock source. The following equipment is recommended for the external clock source:

- One low-noise signal generator for the ADC DEVCLK input. TI recommends models similar to the analog input source.
- A band-pass filter for the DEVCLK input. TI recommends a filter similar to the analog input path filter.

Setup Procedure

This section describes how to setup the EVM on the bench with the proper equipment to evaluate the full performance of the ADC device. Figure 2-1 shows the EVM test setup.

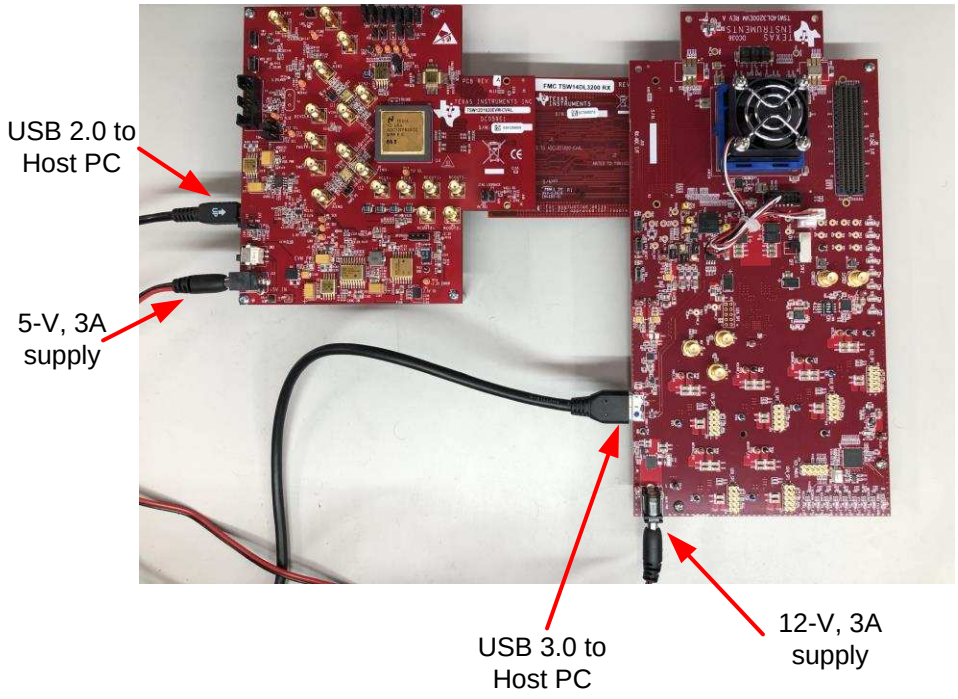

Figure 2-1. EVM Test Setup

NOTE: The HSDC Pro software must be installed before connecting the TSW12D1620EVM-CVAL and TSW14DL3200EVM to the PC for the first time.

2.1 Install the High-Speed Data Converter (HSDC) Pro Software

Download the most recent version of the HSDC Pro software from www.ti.com/tool/dataconverterpro-sw. Follow the installation instructions to install the software.

2.2 Install the TSW12D1620EVM-CVAL GUI Software

1. Download the TSW12D1620EVM-CVAL graphical user interface (GUI) software from the EVM tool folder at www.ti.com/tool/TSW12D1620EVM-CVAL.
2. Extract the files from the compressed zip file.
3. Run the executable file (setup.exe), and follow the instructions.

2.3 Connect the EVM and TSW14DL3200EVM via the FMC-TSW14DL3200EVM Adapter Card

With the power off, connect the TSW12D1620EVM-CVAL to the TSW14DL3200EVM through the FMC-TSW14DL3200EVM adapter card as illustrated in Figure 2-1. Make sure that the standoffs provide the proper height for robust connector connections.

2.4 Connect the Power Supplies to the Boards (Power Off)

1. Confirm that the power switch on the TSW14DL3200EVM is in the off position. Connect the power cable to a 12-V DC (minimum 3 A) power supply. Verify the proper supply polarity by confirming that the outer surface of the barrel connector is GND and the inner portion of the connector is 12 V. Connect the power cable to the EVM power connector.
2. Confirm that the power switch on the TSW12D1620EVM-CVAL is on the off position. Connect the power cable to a 5-V DC (minimum 3 A) power supply for the TSW12D1620EVM-CVAL. **If using an adjustable or lab DC power supply, adjust the voltage setting to 5.3 V.** Verify the proper supply polarity by confirming that the outer surface of the barrel connector is GND and the inner portion of the connector is a positive voltage. Connect the power cable to the EVM power connector.

CAUTION

Make sure that the power connections to the EVMs are the correct polarity. Failure to do so can result in immediate damage.

Make sure that the 12-V power supply is connected to the TSW14DL3200EVM and not the TSW12D1620EVM-CVAL. Providing the TSW12D1620EVM-CVAL with 12 V of power can result in immediate damage.

Leave the TSW12D1620EVM-CVAL and TSW14DL3200EVM power switches in the off position until directed later.

2.5 Connect the Clock Signal Generator to the EVM (RF Output Disabled Until Further Directed)

Connect a signal generator to the DEVCLK input of the EVM through a band-pass filter. This signal generator must be a low-noise signal generator. In addition, TI recommends a Trilithic-tunable band-pass filter to minimize harmonics and noise coming from the generator. Configure the signal generator for the desired clock frequency in the range of 0.2 GHz to 1.6 GHz. For best performance when using an RF signal generator, the power input to the CLK SMA connector must be 9 dBm (2.2 V_{PP} into 50 Ω). The signal generator must increase above 9 dB by an amount equal to any additional attenuation in the clock signal path, such as the insertion loss of the band-pass filter and cables. For example, if the filter insertion loss is 2 dB, the signal generator must be set to 9 dBm + 2 dB = 11 dBm.

2.6 Connect the Signal Generators to the EVM (RF Outputs Disabled Until Further Directed)

Connect a signal generator to the VIN input of the TSW12D1620EVM-CVAL through a band-pass filter and attenuator at the SMA connector. This generator must be a low-noise signal type. TI recommends a Trilithic-tunable band-pass filter to filter the signal from the generator. Configure the signal generator for 147.77 MHz, **–10 dBm.**

2.7 Turn On the TSW14DL3200EVM Power and Connect to the PC

1. Turn on the 12-V power supply connected to the TSW14DL3200EVM.
2. Turn on the power switch on the TSW14DL3200EVM.
3. Connect a mini-USB 3.0 cable from the PC to the TSW14DL3200EVM.
4. If the TSW14DL3200EVM has not previously been connected to the PC, follow the on-screen instructions to automatically install the device drivers. See the TSW14DL3200EVM user's guide for specific instructions.

2.8 Turn On the TSW12D1620EVM-CVAL 5-V Power Supply and Connect to the PC

1. Turn on the 5-V power supply to power up the EVM.
2. Turn on the power switch on the TSW12D1620EVM-CVAL.
3. Connect the EVM to the PC with the mini-USB cable.

2.9 Turn On the Clock Signal Generator RF Output

Turn on the RF signal output of the signal generator connected to the DEVCLK input.

2.10 Turn On the Signal Generator RF Outputs

Turn on the RF signal output of the signal generator connected to VIN.

2.11 Open the TSW12D1620EVM-CVAL GUI and Program the ADC and Clocks

The device configuration GUI is installed separately from the HSDC Pro installation and is a stand-alone GUI.

Figure 2-2 shows the GUI open window to the *EVM* tab. Tabs at the top of the panel organize the configuration into device and EVM features, with user-friendly controls and a low-level tab for directly configuring the registers. The EVM has one configurable device: that along with the TMP461-SP is used for temperature monitoring of the EVM and ADC. The register map for these devices is provided in the device data sheets.

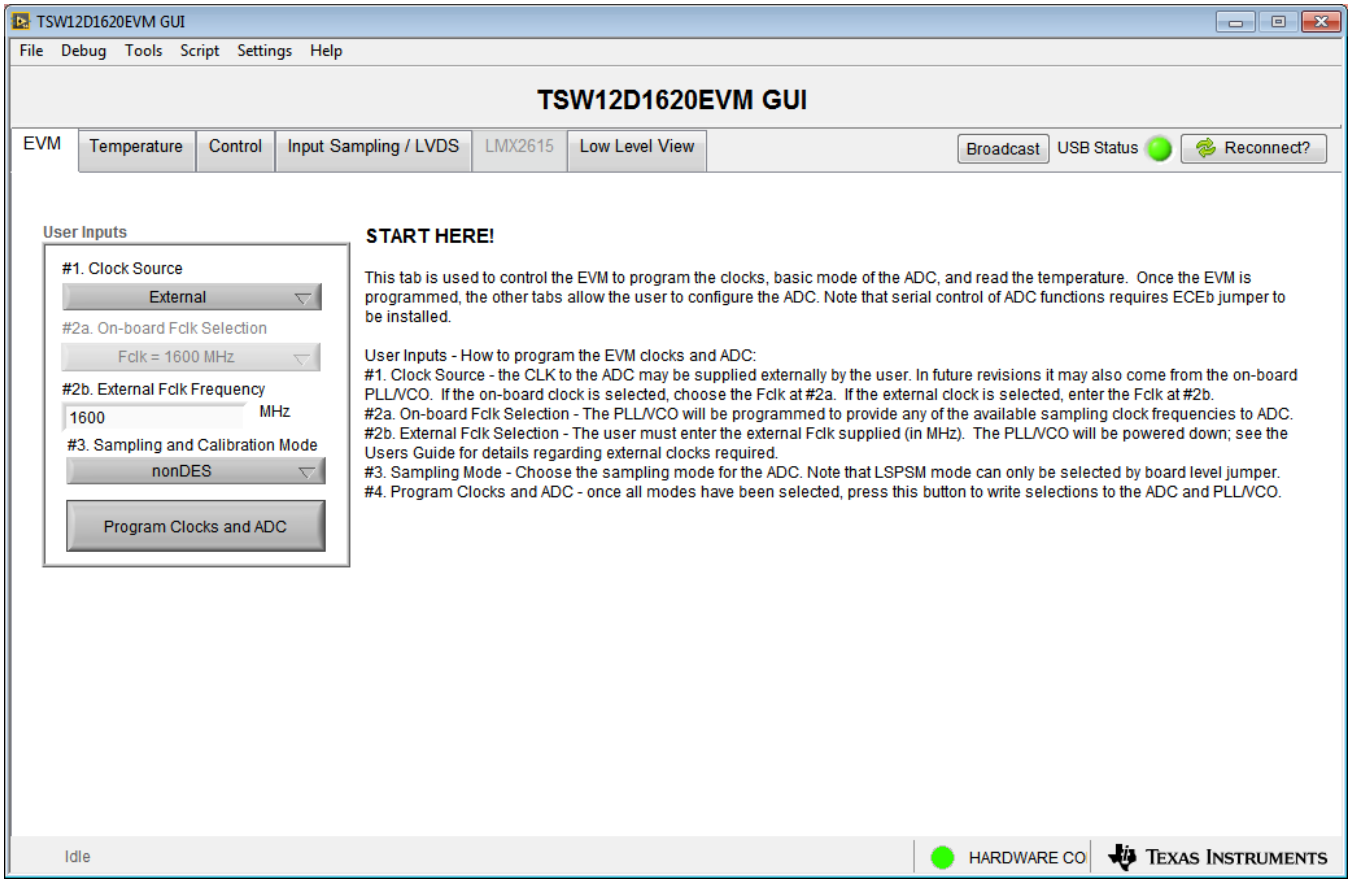

Figure 2-2. Configuration GUI: EVM Tab

1. Open the TSW12D1620EVM-CVAL GUI.
2. Select the external clock as the clock source.
3. Select Fclk = 1600 MHz as the external Fclk selection.
4. Select *nonDES* operating mode.
5. Click *Program Clocks and ADC*. This action overwrites any previous device register settings.

2.12 Calibrate the ADC Device on the EVM

Figure 2-3 shows the GUI open window to the *Control* tab.

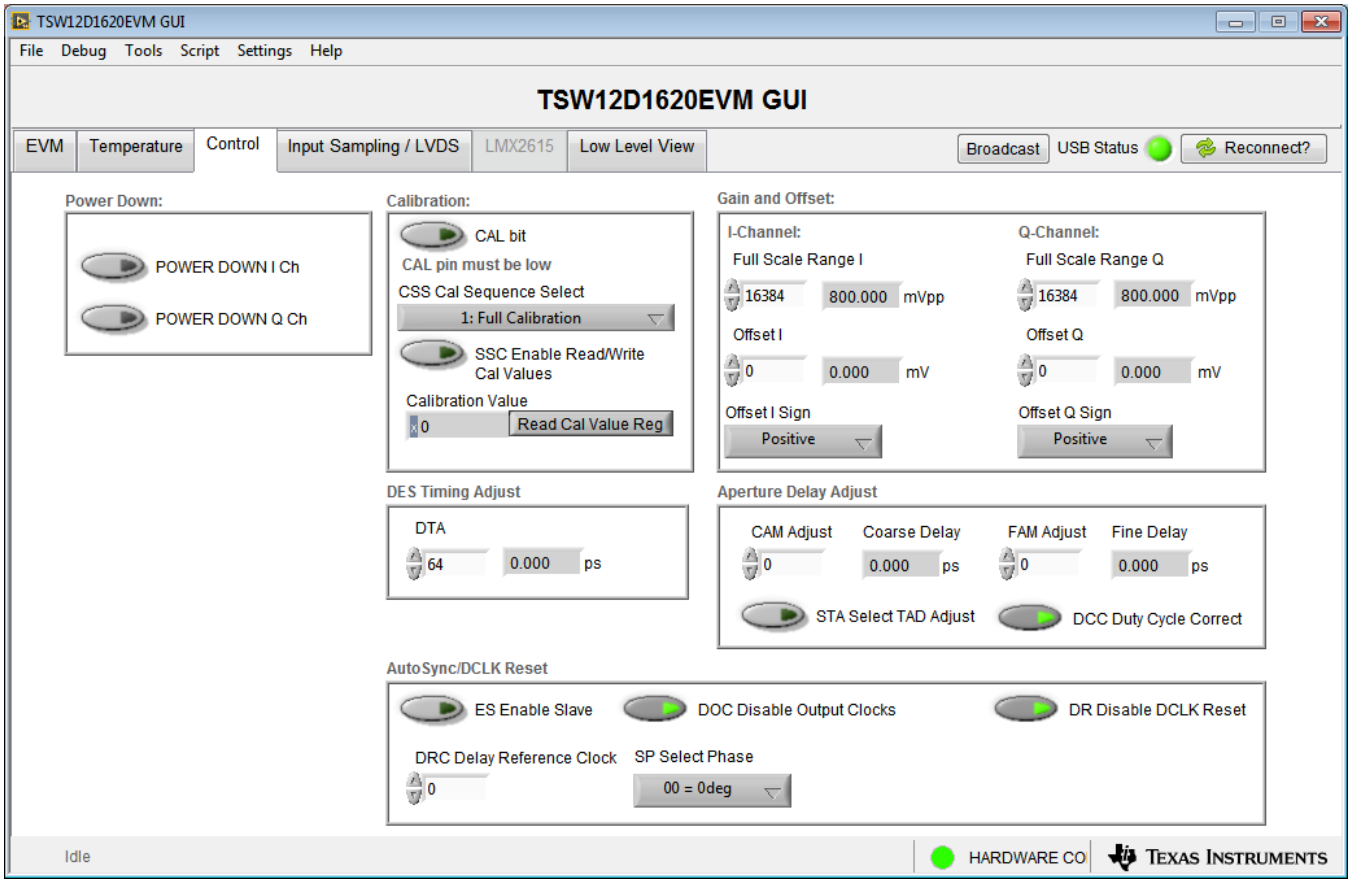

Figure 2-3. Configuration GUI: Control Tab

1. With the EVM GUI open on the PC, navigate to the *Control* tab.
2. To calibrate the ADC, click the *CAL bit* button one time, and then click the button again. This action triggers a new on-command calibration.

NOTE: The *CAL bit* button executes a calibration sequence that is required for full performance. This calibration is performed automatically during the previous step provided in Section 2.11, but must be performed again any time the sampling rate changes, after significant temperature change of the ADC, or after exiting the power-down mode. **See the ADC12D1620QML-SP device data sheet for details regarding the necessary calibration sequence.**

2.13 Open the HSDC Software and Load the FPGA Image to the TSW14DL3200EVM

1. Open the HSDC Pro software.
2. Click *OK* to confirm the serial number of the TSW14DL3200EVM device. If multiple TSWxxxxx boards are connected, select the model and serial number for the one connected to the TSW12D1620EVM-CVAL.
3. Using the green pulldown, select *ADC12D1620_NonLSPSM_Demux_nonDES_DCLK90_DDR*.
4. When prompted, click *Yes* to update the firmware.
5. If the load firmare prompt does not appear, select *Instrument Options>Download Firmware* and choose *TSW14DL3200_FIRMWARE_COMPONENT_MODE_800M.bin*.

NOTE: If the user configures the EVM with options other than the default register values, different instructions may be required for selecting the device in HSDC Pro.

6. Enter the ADC output data rate ($f_{(SAMPLE)}$) as *1600M* or the desired output sample rate. This number must be equal to the actual sampling rate of the device, and must be updated if the sampling rate changes.
7. Proceed to capture data; see Section 2.14.

2.14 Capture Data Using the HSDC Pro Software

Figure 2-4 shows the HSDC Pro GUI. The following steps show how to capture data using the HSDC Pro software:

1. Select the test to perform.
2. Select the data view.
3. Select the channel to view.
4. Click the *Capture* button to capture new data.

Additional tips:

- Use the *Notch Frequency Bins* from the *Test Options* file menu to remove bins around DC (eliminate DC noise and offset) or the fundamental (eliminate phase noise from signal generators).
- Open the *Capture Option* dialog from the *Data Capture Options* file menu to change the capture depth or to enable continuous capture or FFT averaging.
- For analyzing only a portion of the spectrum, use the *Single Tone* test with the *Bandwidth Integration Markers* from the *Test Options* file menu. The *Channel Power* test is also useful.
- For analyzing only a subset of the captured data, set the *Analysis Window (samples)* setting to a value less than the number of total samples captured and move the green or red markers in the small transient data window at the top of the screen to select the data subset of interest.

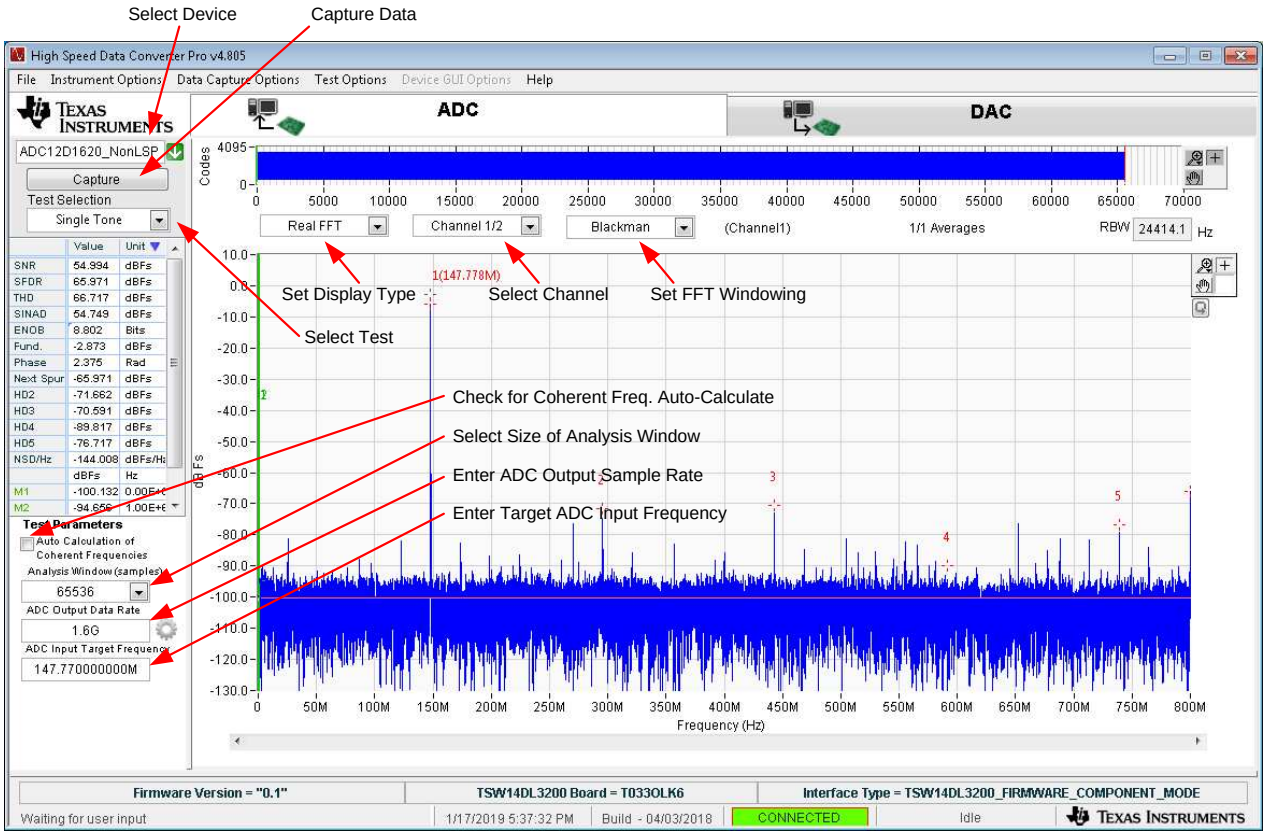

Figure 2-4. HSDC Pro GUI

Device Configuration

The ADC device is programmable through the serial programming interface (SPI) bus accessible through the FTDI USB-to-SPI converter located on the EVM. A GUI is provided to write instructions on the bus and program the registers of the ADC device.

For more information about the registers in the ADC device, see the ADC12D1620QML-SP data sheet.

3.1 Tab Organization

Control of the ADC device features are available in the *EVM*, *Temperature Control*, *Input/Sampling/LVDS*, and *LMX2615 (may be enabled in future versions of the EVM and GUI)* configuration tabs.

3.1.1 EVM (Quick Start) Tab

The *EVM* tab (Figure 3-1) is used to simplify initial configuration of the EVM. When the desired settings are chosen, clicking the **Program Clocks and ADC** button configures the EVM for use.

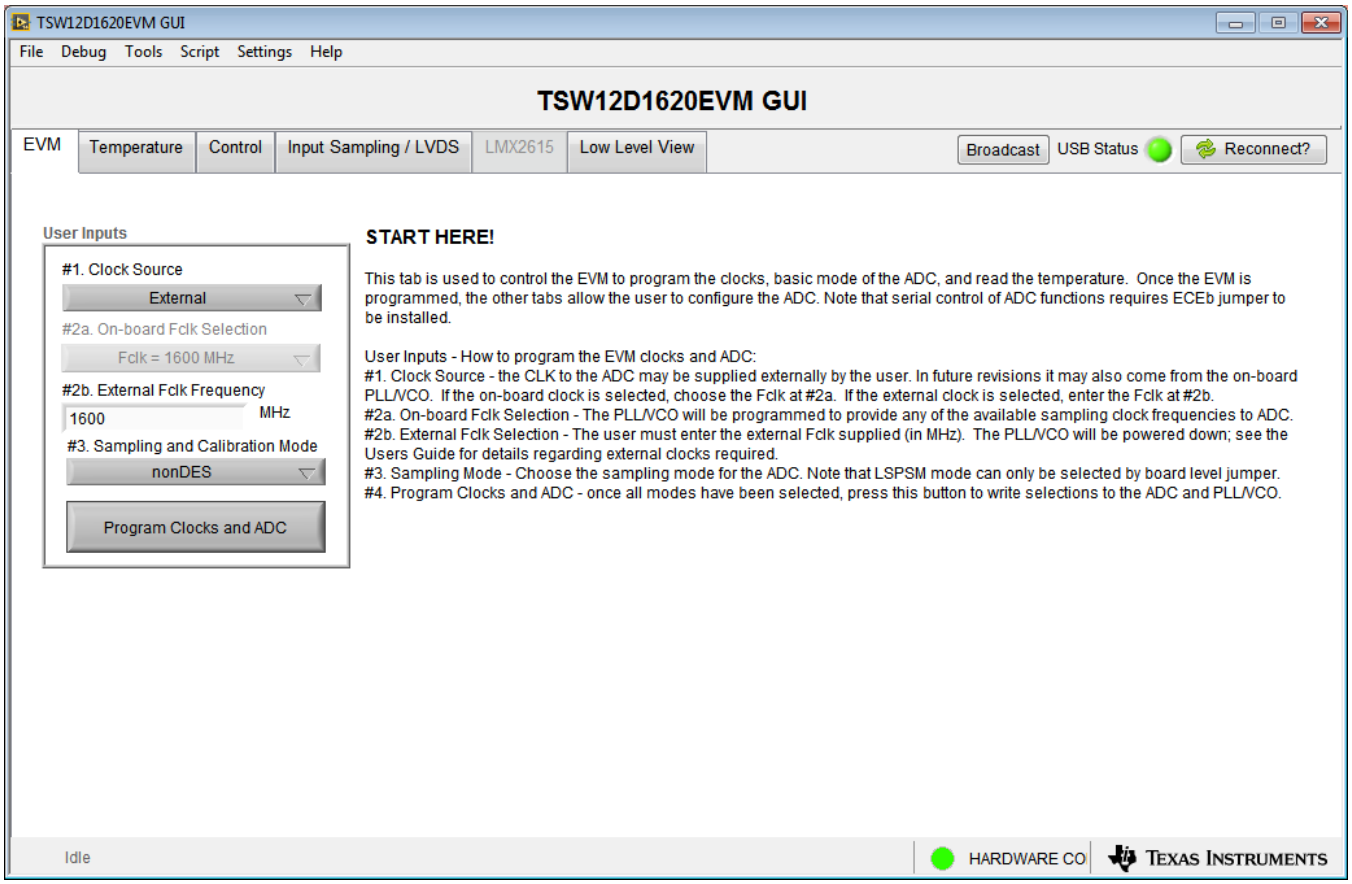

Figure 3-1. Configuration GUI: EVM Tab

Configure the EVM settings as needed using the selection buttons and entry fields, then click the **Program Clocks and ADC** button.

- #1 Select external clocking (future revisions of the EVM may support on-board clock generation, but that option is not currently available)
- #2a For future use: Select the on-board clock frequency to be generated
- #2b Enter the applied external clock frequency
- #3 Set the ADC sampling mode

A history of configuration writes and reads is available by doing the following:

1. Wait until *Idle* is displayed in the lower left corner of the GUI
2. Double click on *Idle* to launch the *Status Log* panel
3. Right-clicking within the *Status Log* panel shows the available commands. A command sequence can be saved for later usage or study by selecting the desired commands, and then right clicking and choosing *Save Selected*. Figure 3-2 shows the status log panel.

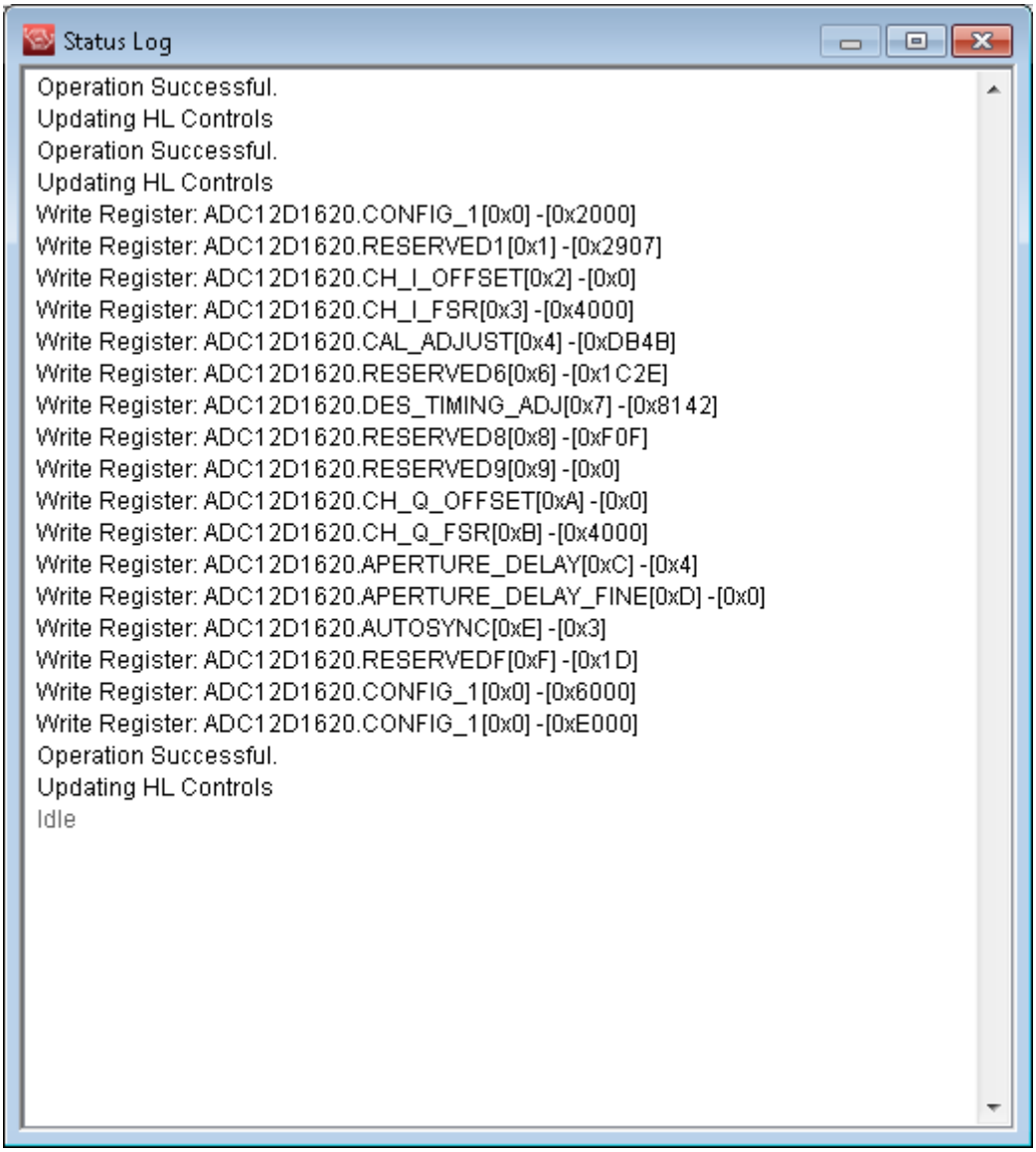

Figure 3-2. Configuration GUI: Status Log Panel

3.1.2 Temperature Tab

The *Temperature* tab (Figure 3-3) enables readout of the different on-board temperature sensors. Depending on the EVM configuration either or both of the TMP461 and MSP430 temperature readout methods is available.

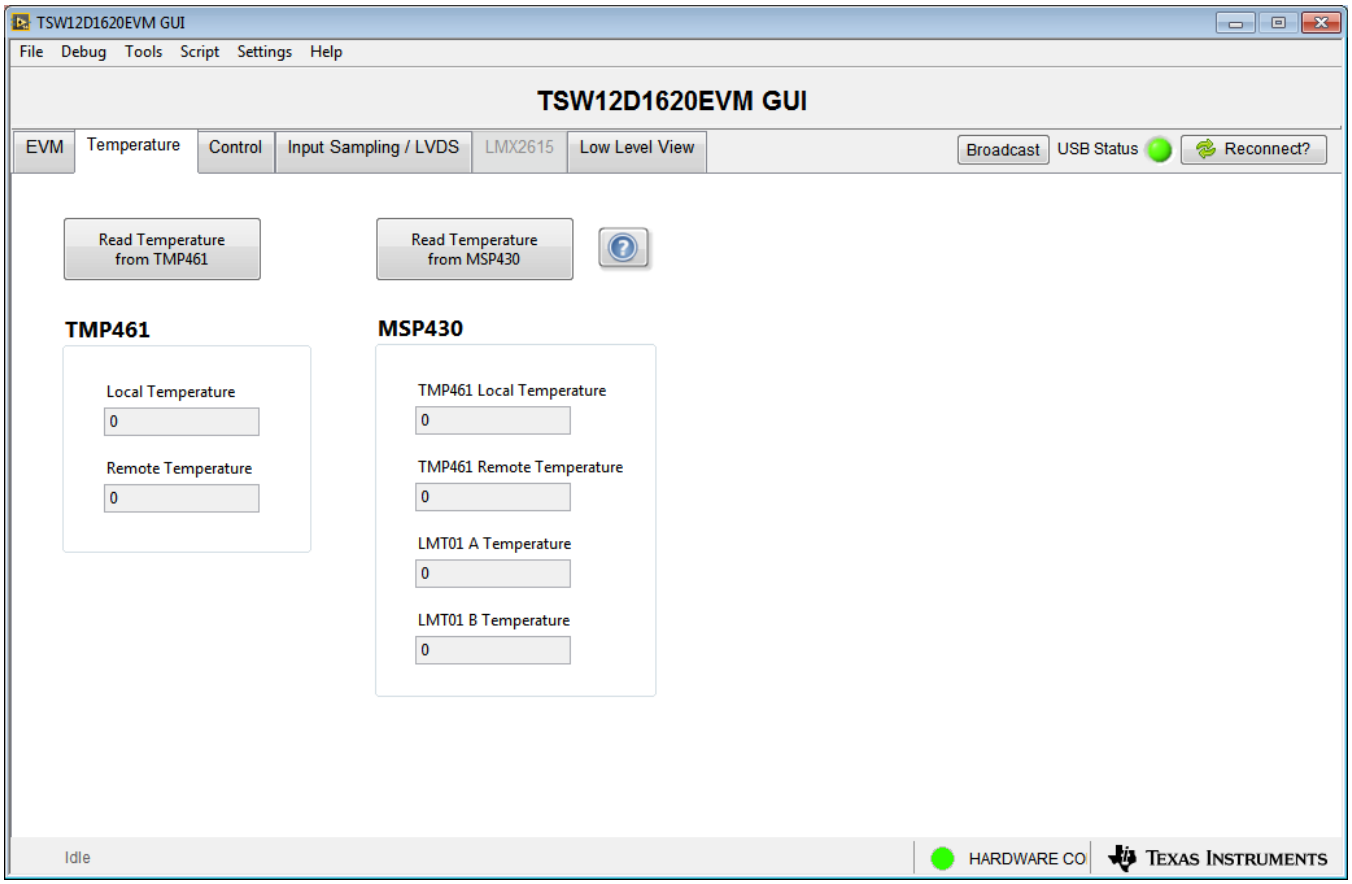

Figure 3-3. Configuration GUI: Temperature Tab

Click on one of the buttons to read temperatures.

- **Read Temperature from TMP461**: This method accesses the TMP461 using the FTDI USB to I^2C interface.
- **Read Temperature from MSP430**: If enabled in hardware or firmware, this method uses the MSP430 to read the TMP461 using I^2C and the LMT01 devices using the pulse count interface.

3.1.3 Control Tab

The *Control* tab (Figure 3-4) adjusts the ADC configuration to use a number of different serial interface registers.

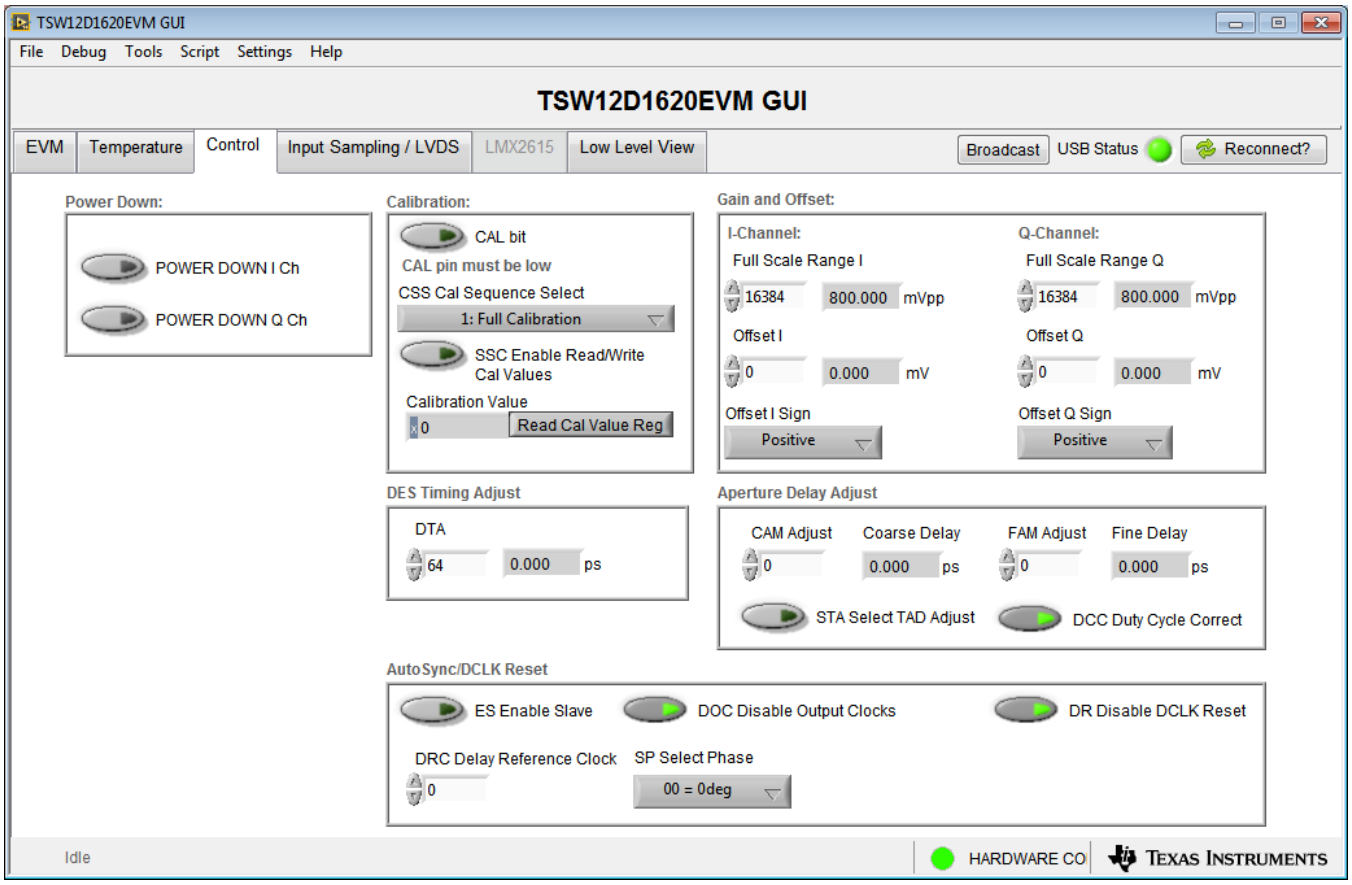

Figure 3-4. Configuration GUI: Control Tab

See the ADC12D1620QML-SP data sheet for information on the specific registers used. The following list summarizes the registers used.

- Power Down: configuration register 1
- Calibration: configuration register 1, calibration adjust
- Gain and Offset: I/Q-channel offset adjust, I/Q-channel full-scale range adjust
- DES Timing Adjust: DES timing adjust
- Aperture Delay Adjust: aperture delay coarse adjust, aperture delay fine adjust
- AutoSync/DCLK Reset: AutoSync

3.1.4 Input Sampling / LVDS Tab

Figure 3-5 shows the *Input Sampling / LVDS* tab.

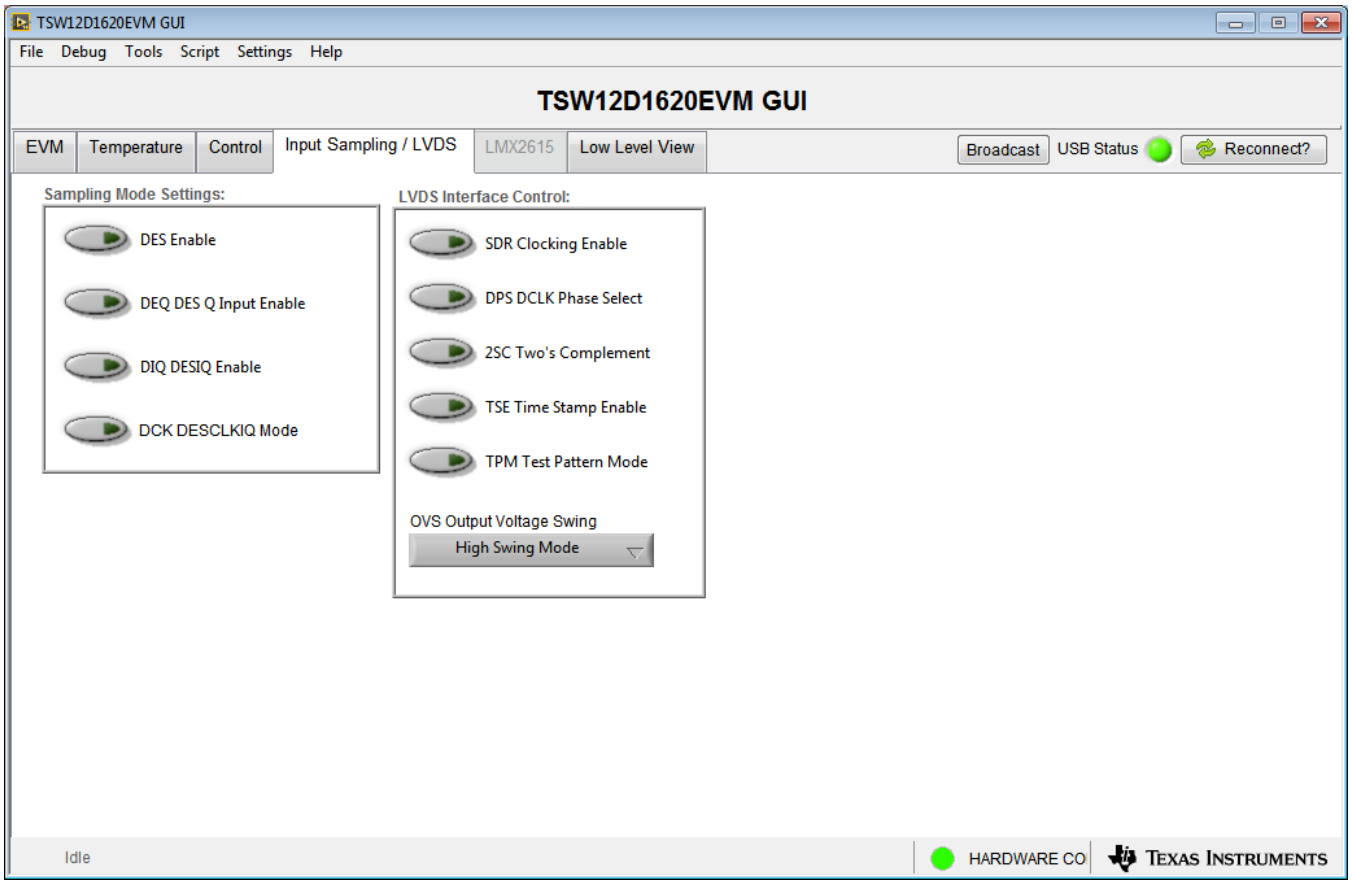

Figure 3-5. Configuration GUI: Input Sampling / LVDS Tab

See the ADC12D1620QML-SP data sheet for information on the specific registers used. The following list summarizes the registers used.

- Sampling Mode Settings: configuration register 1, AutoSync
- LVDS Interface Control: configuration register 1

3.1.5 Low Level View Tab

The *Low Level View* tab (Figure 3-6) allows configuration of the devices at the bit-field level. At any time, the controls in Table 3-1 can be used to configure or read from the device.

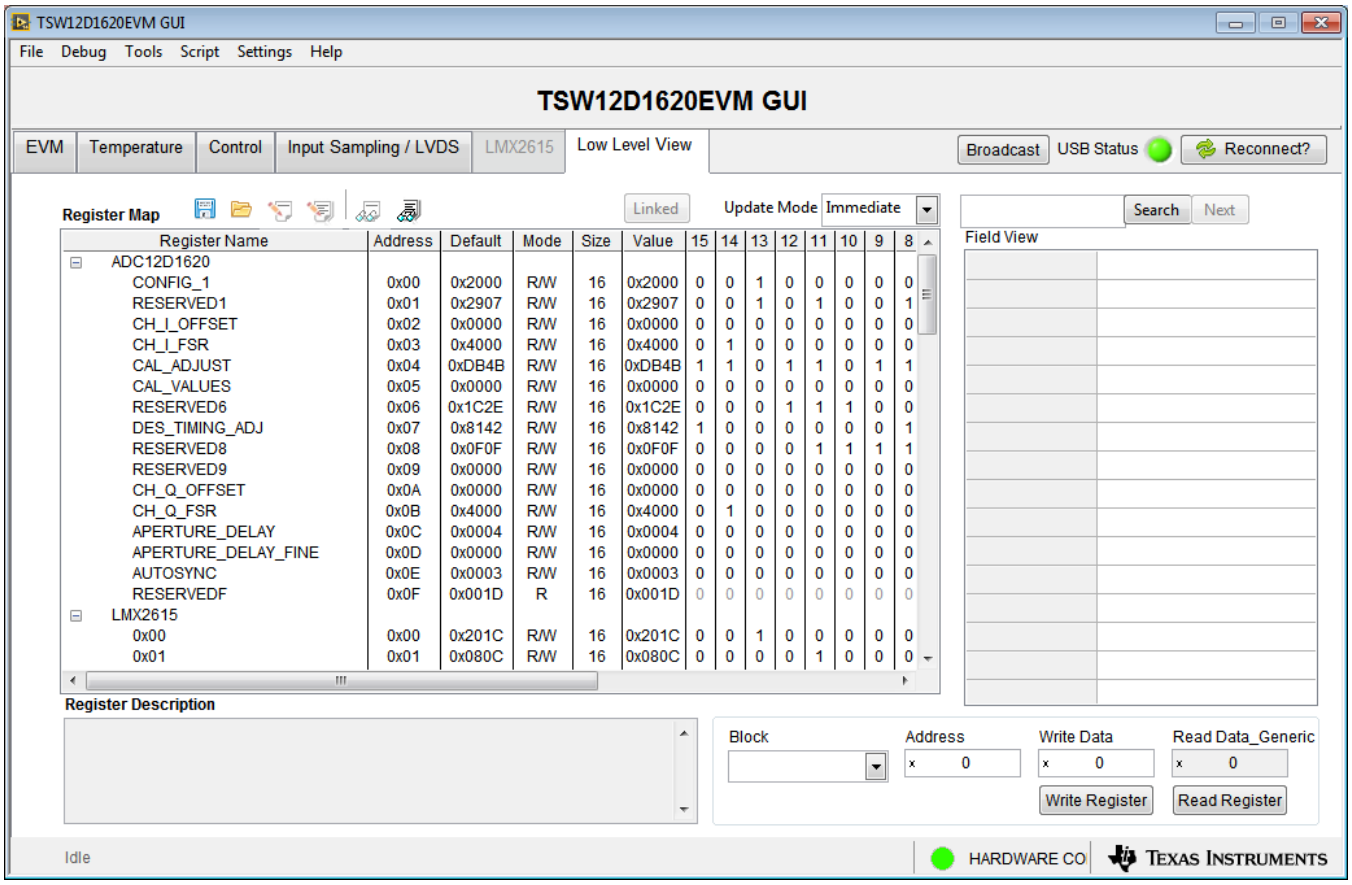

Figure 3-6. Configuration GUI: Low-Level View Tab

Table 3-1. Low-Level Controls

Control	Description
Register map summary	Displays the devices on the EVM, registers for those devices, and the states of the registers. • Clicking on a register field allows individual bit manipulation in the register data cluster. • The value column shows the value of the register at the time the GUI was last updated. • The LR column shows the value of the register at the time the register was last read.
Write register button	Write to the register highlighted in the register map summary with the value in the *Write Data* field.
Write all button	Update all registers shown in the register map summary with the values shown in the *Register Map* summary.
Read register button	Read from the register highlighted in the *Register Map* summary and display the results in the *Read Data* field. This button can be used to synchronize the GUI with the state of the hardware.
Read-all button	Read from all registers in the *Register Map* summary and display the current state of the hardware.
Load Configuration button	Load a configuration file from disk and register address and data values in the file.
Save Configuration button	Save a configuration file to disk that contains the current state of the configuration registers.
Register Data cluster	Manipulate individual accessible bits of the register highlighted in the register map summary.
Individual register cluster with read or write register buttons	Perform a generic read or write command to the device shown in the *Block* drop-down menu using the address and write data information.

Troubleshooting the TSW12D1620EVM-CVAL

Table A-1 lists some troubleshooting procedures.

Table A-1. Troubleshooting

Issue	Troubleshoot
General problems	• Verify the test setup illustrated in Figure 2-1, and repeat the setup procedure as described in this document. • Check the power supply to the EVM and TSW14DL3200EVM. Verify that the power switch is in the on position. • Check the signal and clock connections to the EVM. • Visually check the top and bottom sides of the board to verify that nothing looks discolored or damaged. • Make sure the board-to-board FMC connection is secure. • After changing the ADC configuration, click *Instrument Options → Download Firmware* and download *TSW14DL3200_FIRMWARE_COMPONENT_MODE_800M.bin*. • Power cycle the external power supply to the EVM, and reprogram the LMK and ADC devices.
TSW14DL3200EVM LEDs are not correct	• Verify the installed jumpers on the TSW14DL3200EVM. • Verify that the clock going to the CLK input is connected and the appropriate LEDs are blinking. • Verify that the ADC device internal registers are configured properly. • If the LEDs are not blinking, reprogram the ADC EVM devices. • Click *Instrument Options → Download Firmware* and download *TSW14DL3200_FIRMWARE_COMPONENT_MODE_800M.bin*.
Configuration GUI is not working properly	• Verify that the USB cable is plugged into the EVM and the PC. • Check the computer device manager and verify that a *USB serial device* is recognized when the EVM is connected to the PC. • Verify that the green *USB Status* LED light in the top right corner of the GUI is lit. If not lit, click the **Reconnect FTDI** button. • Close and start the configuration GUI.
Configuration GUI is not able to connect to the EVM	• Use the free FT_PROG software from FTDI chip and verify that the onboard FTDI chip is programmed with the product description *TSW12D1620EVM*.
HSDC Pro software is not capturing good data or analysis results are incorrect	• Verify that the TSW14DL3200EVM is properly connected to the PC with a mini USB 3.0 cable and that the board serial number is properly identified by the HSDC software. • Check that the proper ADC device mode is selected. The mode must match in HSDC Pro and the ADC GUI. • Check that the analysis parameters are properly configured.
HSDC Pro software gives a time-out error when capturing data	• Verify that the ADC sampling rate is correctly set in the HSDC software. • Select *Instrument Options → Download Firmware* and download *TSW14DL3200_FIRMWARE_COMPONENT_MODE_800M.bin*. Try to capture again.
Suboptimal measured performance	• Click the **Cal Triggered/Running** button two times to calibrate the ADC in the current operating conditions. The button is located on the *Control* tab of the configuration GUI. • Check that the spectral analysis parameters are properly configured. • Verify that band-pass filters are used in the clock and input signal paths and that low-noise signal sources are used.

Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Original (January 2019) to A Revision	Page
• Changed *TSW12D1620 Evaluation Module* figure to show MSP430FR5969-SP placement	4

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