TSW12J54EVM User's Guide

The TSW12J54EVM is an evaluation module (EVM) that demonstrates a Wideband Receiver Reference Design. It provides a wide bandwidth high performance AC- or DC-coupled capture platform with up to 2 GHz of continuous capture bandwidth. Built-in DDC functions enable tuning, down-conversion and bandwidth reduction of captured signals for flexible RF-sampling application development. Wide-bandwidth and DC-coupled input capability also support high frequency time domain applications.

The board includes the LMH5401 8-GHz, DC-coupled, fully-differential amplifier and ADC12J4000 for analog-to-digital (ADC) conversion at up to 4 Giga-samples/second, outputting data over the high-speed serial JESD204B interface. Also included on board are a TRF3765 clock synthesizer, LMK04828 JESD204 clock generator and a high efficiency switching plus linear regulator solution to power all devices from the 5-V DC input.

Contents

List of Figures

List of Tables

1 Features

This evaluation board includes the following important features:

- ADC12J4000 12-bit, 4 GSPS, ADC with flexible internal DDC and JESD204B data interface
- LMH5401 DC-coupled, fully-differential amplifier front end
- 4.8-GHz, low-phase noise, TRF3765 clock synthesizer generates the ADC sampling clock
- The LMK04828 system clock generator generates SYSREF and FPGA reference clocks for the high-speed serial interface
- 2-GHz Butterworth low pass filter design
- Complete TI power solution
- LM95233 temperature sensor monitors, ADC12J4000 device, and ambient/board temperatures
- High-speed serial data output over a high pin count FMC interface connector
- Device register programming through USB connector and FTDI USB-to-SPI bus translator

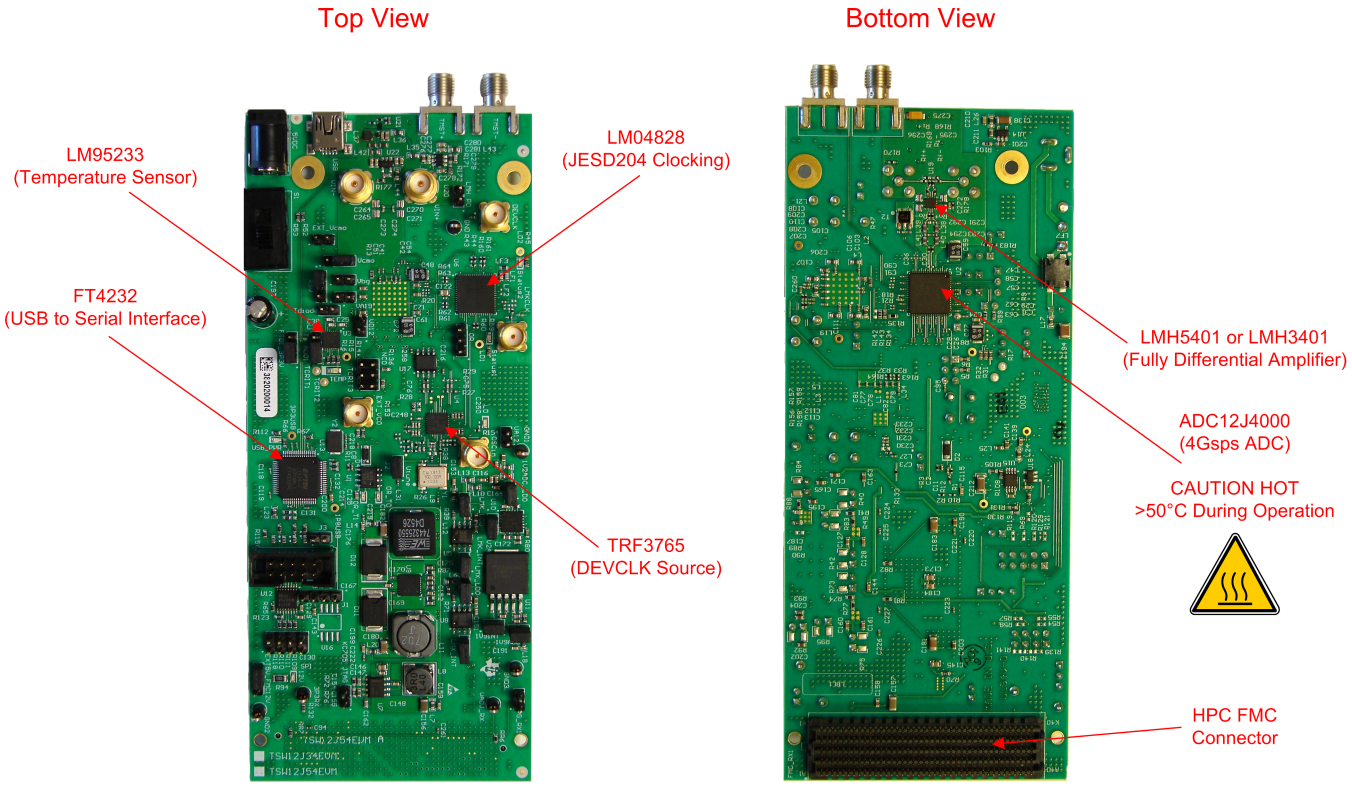

Figure 1. EVM Orientation

The digital data from the TSW12J54EVM board is quickly and easily captured with the TSW14J56EVM data capture board. The TSW14J56EVM captures the high-speed serial data, decodes the data, stores the data in memory, and then uploads it 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.

With proper hardware selection in the HSDC Pro software, the TSW14J56 device is automatically configured to support a wide range of operating speeds of the TSW12J54EVM, but the device may not cover the full operating range of the ADC device. Serial data rates (and corresponding sampling rates) of 10 Gb/s (4 GSPS) down to 1 Gb/s (1 GSPS) are supported.

In the following sections of this document, the TSW12J54EVM evaluation board is referred to as the *EVM*, the LMH5401 device is referred to as the *Amplifier* and the ADC12J4000 device is referred to as the *ADC*.

2 Equipment

This section describes how to setup the EVM on the bench with the proper equipment to evaluate the full performance of the ADC device.

2.1 Evaluation Board Feature Identification Summary

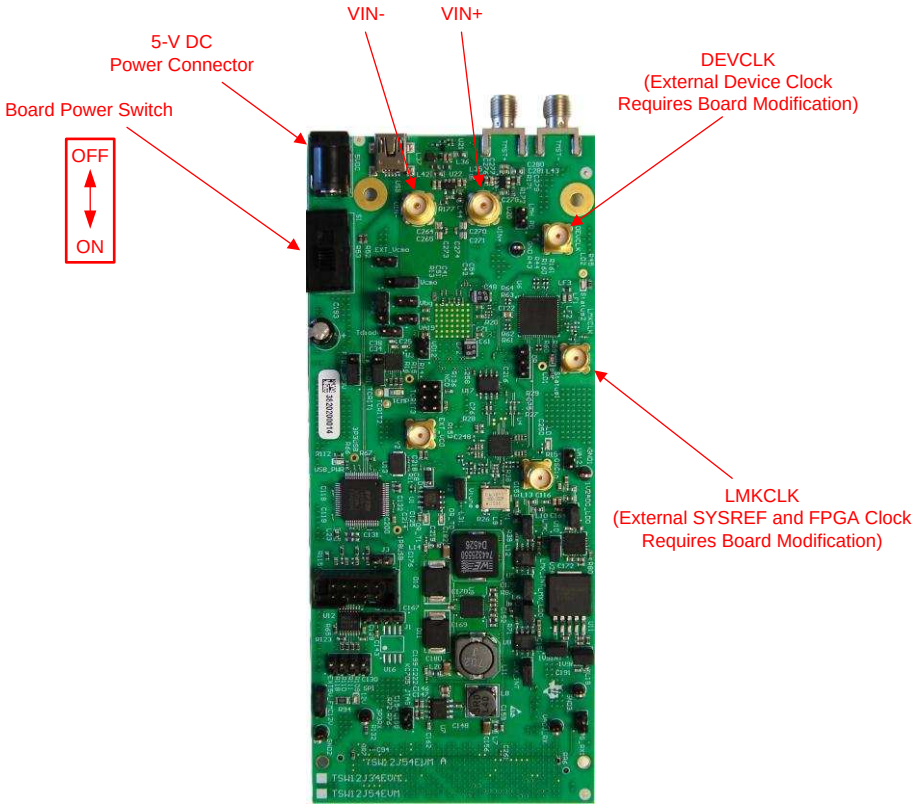

Figure 2. EVM Feature Locations

2.2 Required Equipment

The following equipment and documents are included in the EVM evaluation kit:

- Evaluation board (EVM)
- Mini-USB cable
- DC-Power Cable

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

- Low-noise 5-V DC power supply (minimum 3-A current capability)
- TSW14J56EVM data capture board plus power cable and mini-USB cable
- High-Speed Data Converter Pro software
- PC computer running Microsoft® Windows® XP, Windows 7, or Windows 8
- One low-noise signal generator for analog input. TI recommends the following generators:
  - Keysight E8663D
  - Rohde & Schwarz™ SMA100A
- Bandpass filter for analog input signal (500 MHz, or desired frequency). The following filters are recommended:
  - Bandpass filter, greater than or equal to 60-dB harmonic attenuation, less than or equal to 5% bandwidth, greater than 18-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 - SMA connector type

By default, the TSW12J54EVM has an onboard clocking solution. A few small board modifications enable external clocking. If external clocking is used, the following equipment is recommended:

- Two low-noise signal generators. TI recommends similar models to the analog input source.
- A bandpass filter for the DEVCLK input. TI recommends a filter similar to the analog-input path filter.

NOTE: The clock source used to drive the LMK04828 (labeled LMKCLK) must be half of the frequency used to drive the ADC12J4000 sampling clock (labeled DEVCLK). The clock generators must be frequency locked using a common 10-MHz reference.

3 Setup Procedure

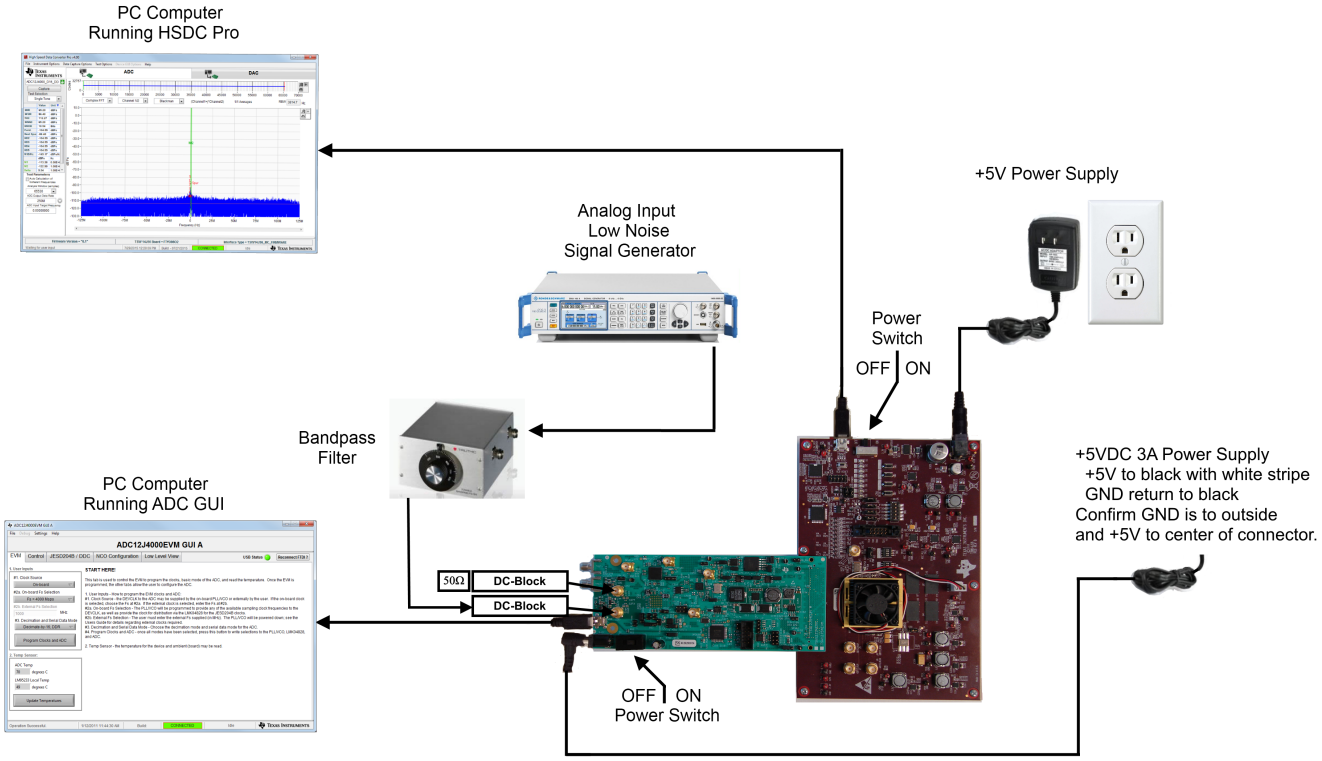

Figure 3. EVM Test Setup

NOTE: The HSDC Pro software must be installed before connecting the TSW14J56EVM to the PC for the first time.

3.1 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.

3.2 Install the ADC12J4000EVM GUI Software

1. Download the configuration GUI software from the EVM tool folder at http://www.ti.com/tool/TSW12J54EVM.
2. Extract files from the .zip file.
3. Run the setup.exe executable file and follow the instructions.

3.3 Connect the EVM and TSW14J56EVM

With the power off, connect the TSW12J54EVM to the TSW14J56EVM through the FMC connector as shown in Figure 3. Ensure that the standoffs provide the proper height for robust connector connections.

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

1. Confirm that the power switch on the TSW14J56EVM is in the off position. Connect the 5-V power supply adapter to the TSW14J56EVM.
2. Confirm that the 5-V DC (minimum 3-A capability) lab power supply for the TSW12J54EVM is turned off. Connect the leads of the cable to the power supply as follows: The black with white stripe wire to the +5-V terminal and the black wire to the ground return terminal. Double check that the ground wire

is connected to the outside of the barrel connector, and the +5-V wire is to the inside/center of the connector. Insert the cable barrel connector to the +5-V power connector on the TSW12J54EVM.

CAUTION

ENSURE THE 5-V POWER CONNECTIONS TO THE TSW12J54EVM ARE THE CORRECT POLARITY. FAILURE TO DO SO MAY RESULT IN IMMEDIATE DAMAGE!

Do not turn on the power to any board. Powering up the boards in the incorrect order could potentially cause damage to one of the boards.

3.5 Connect the Signal Generators to the EVM (*RF Outputs Disabled Until Directed)

1. Connect a signal generator to the VIN– input of the TSW12J54EVM through a bandpass filter and DC-Block at the SMA connector. This must be a low-noise signal generator. TI recommends a Trilithic-tunable bandpass filter to filter the signal from the generator. Configure the signal generator for 497.97 MHz, –6 dBm.
2. Connect a DC-Block to the VIN+ input of the TSW12J54EVM and connect a 50-Ω SMA termination to the DC-Block.
   If external clocking is used (optional):
3. Connect a signal generator to the DEVCLK input of the EVM through a bandpass filter. This signal generator must be a low-noise signal generator. TI recommends a Trilithic-tunable bandpass filter to filter the signal coming from the generator. Configure the signal generator for 4 GHz. For best performance when using an RF signal generator, the power input to the CLK SMA connector must be 11 dBm (2.2 Vpp into 50 Ω) must be at least 4 dBm to function. Therefore, the signal generator must increase above 11 dB by an amount equal to any additional attenuation in the clock signal path, such as the insertion loss of the bandpass filter. For example, if the filter insertion loss is 2 dB, the signal generator must be set to 11 dBm + 2 dB = 13 dBm.
4. Connect a signal generator to the LMKCLK input of the EVM through a bandpass filter. Configure the signal generator to 2 GHz.

NOTE:

1. LMKCLK must be set to half the frequency of the DEVCLK.
2. Ensure that the DEVCLK and LMKCLK sources are frequency locked using a common 10-MHz reference to ensure functionality. Frequency-locking the input signal generator to the other generators can also be done if coherent sampling is desired.
3. Do not turn on the RF output of any signal generator at this time.

3.6 Turn On the TSW14J56EVM Power and Connect to the PC

1. Turn on the power switch of the TSW14J56EVM.
2. Connect a mini-USB cable from the PC to the TSW14J56EVM.
3. If this is the first time connecting the TSW14J56EVM to the PC, then follow the on-screen instructions to automatically install the device drivers. See the TSW14J56EVM user's guide (SLWU086) for specific instructions.

3.7 Turn On the TSW12J54EVM Power Supplies and Connect to the PC

1. Turn on the 5-V power supply and slide the EVM power switch to the on position (away from the power connector). Several LEDs on the board should illuminate.
2. Connect the EVM to the PC with the mini-USB cable.

3.8 Turn On the Signal Generator RF Outputs

Turn on the RF signal output of the signal generator connected to VIN. If external clocking is used, turn on the RF signal outputs connected to DEVCLK and LMKCLK.

3.9 Open the ADC12J4000EVM 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.

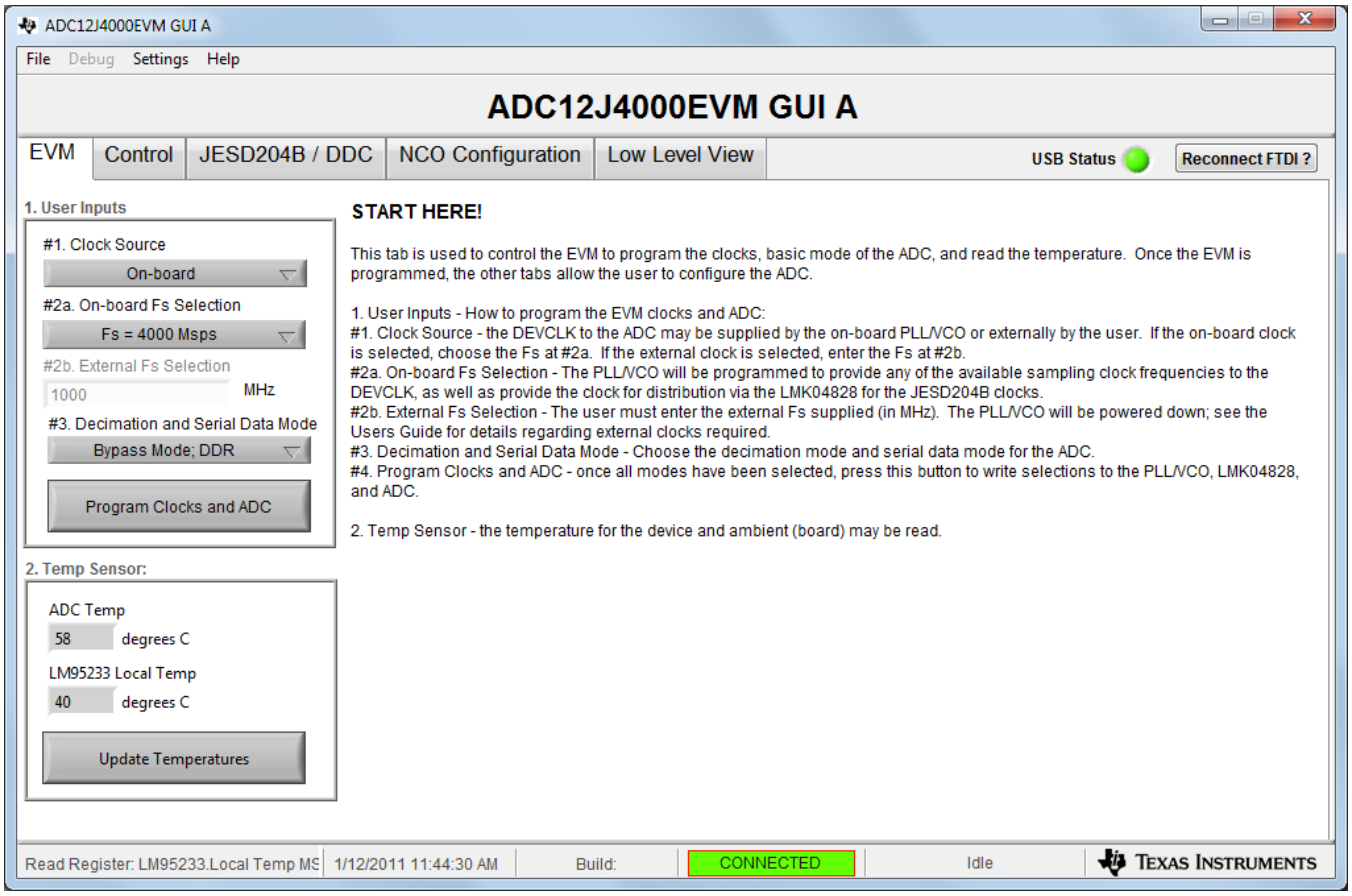

Figure 4. Configuration GUI EVM Tab

Figure 4 and Figure 6 show the GUI open to the *EVM* tab and *Control* tab respectively. 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 three configurable devices, namely the ADC12J4000, LMK04828, and TRF3765. The register map for each device is provided in the device data sheet (SLAS989, SNAS605, and SNAS601, respectively).

1. Open the ADC12J4000EVM GUI
2. Select the onboard clock as the clock source
3. Select Fs = 4000 MSPS as the onboard Fs selection
4. Raw output data versus decimation:
   (a) If raw output data is desired, select Bypass Mode; DDR for the decimation and serial data mode.
   (b) If decimation is desired, select one of the decimate options. Decimate-by-16; DDR for example.
5. Click *Program Clocks and ADC* (Note: This action will overwrite any previous device register settings.)

3.10 Configure NCO Tab (if Decimation is Selected)

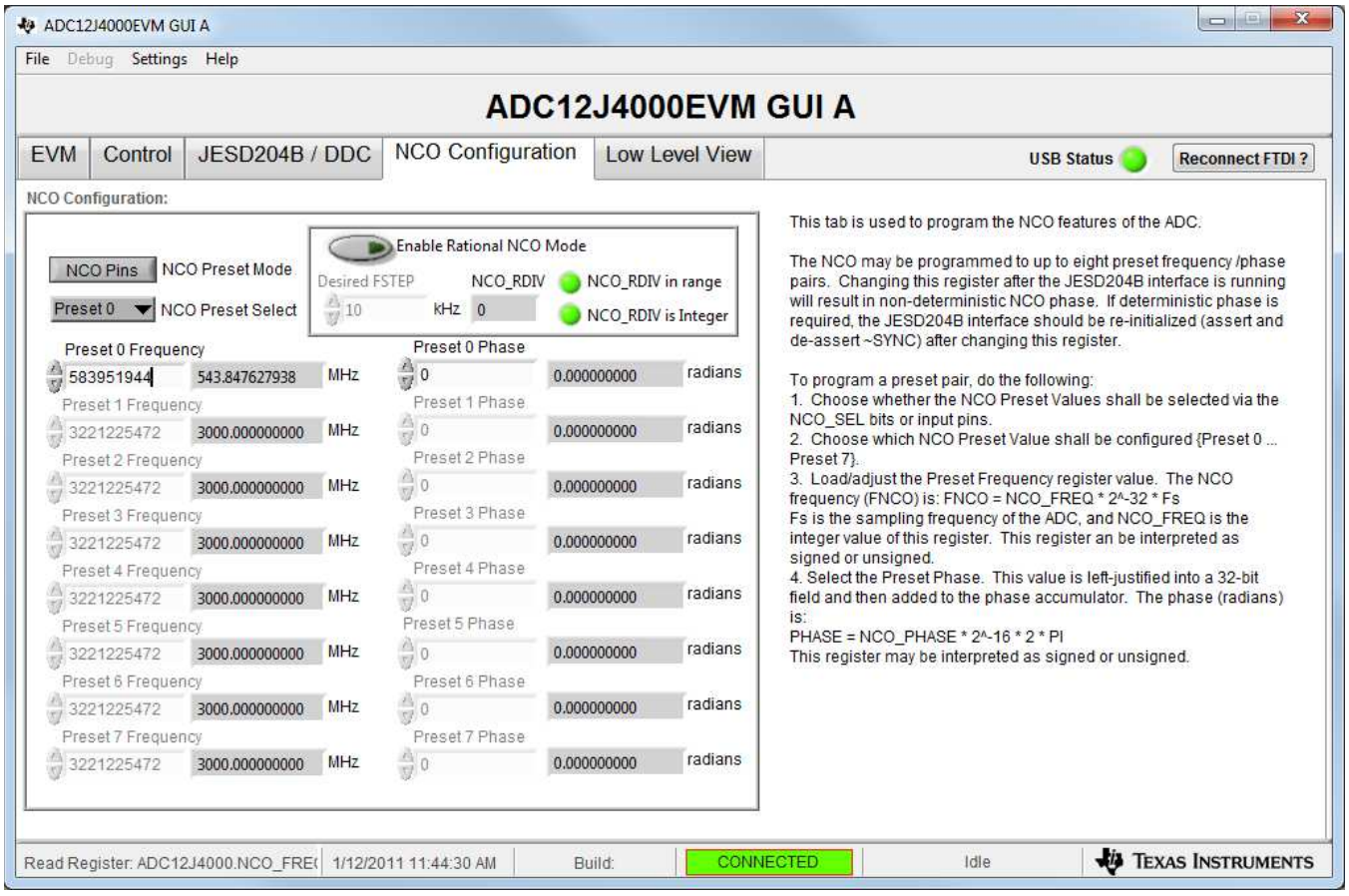

Figure 5. Configure NCO Tab

1. Select *Register Bits* as NCO Configuration
2. Select *Preset 0* for NCO Preset Select
3. Change *Preset 0* Frequency to 583951944, which corresponds to an NCO frequency of 543.847627938 MHz.

3.11 Calibrate the ADC Device on the EVM

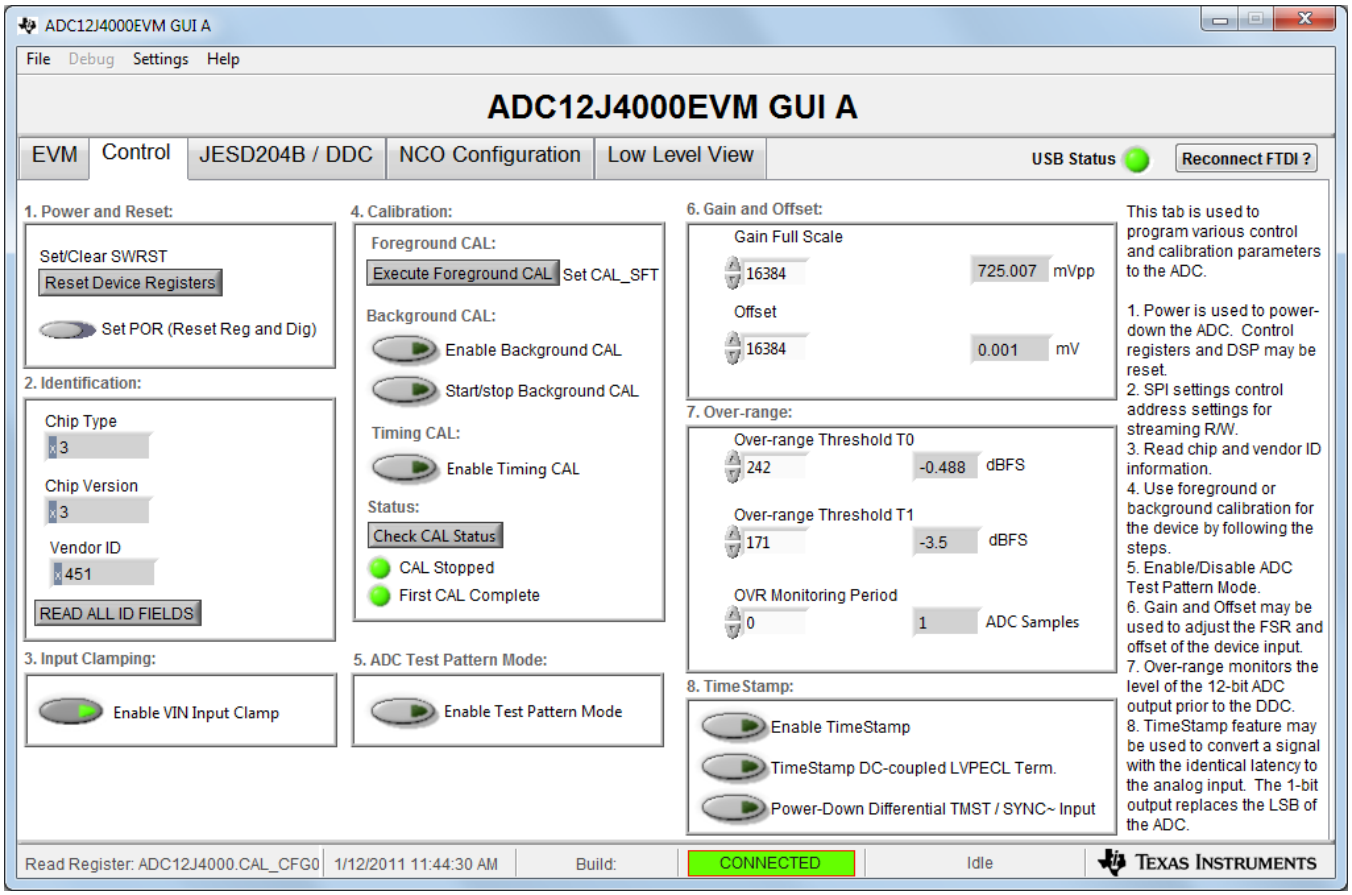

Figure 6. Configuration GUI ADC Control

1. With the EVM GUI open on the PC, navigate to the *Control* tab.
2. Click *Execute Foreground CAL* to calibrate the ADC.

NOTE: This calibrate button executes a calibration sequence that is required for full performance. This calibration is performed automatically during the Section 3.9 step 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 ADC12J4000 device data sheet, SLAS989, for details regarding the necessary calibration sequence.

3. If Background Calibration Mode is desired, first click the "Enable Background CAL" button to enable the mode and then click the "Start/Stop Background CAL" button. Then click the Execute Foreground CAL button once to properly initiate the calibration process.
4. To stop Background Calibration Mode, first click the "Start/Stop Background CAL" button, then click the "Enable Background CAL" button. Then click the Execute Foreground CAL button once to properly calibration the device in Foreground Mode.

3.12 Open the HSDC Software and Load the FPGA Image to the TSW14J56EVM

1. Open the HSDC Pro software.
2. Click *OK* to confirm the serial number of the TSW14J56EVM device.
3. Select the *ADC12J4000_BYPASS* device from the ADC select drop-down in the top left corner.
4. When prompted, click *Yes* to update the firmware.

NOTE: There are 3 new device files labeled ADC12J4000A_D10_DDR, ADC12J4000A_D20_DDR.ini, and ADC12J4000A_D20_SDR.ini. These should be used with the TSW12J54EVM. The original files without the A suffix are still available for compatibility with the earlier revision ADC EVMs.

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. See Appendix B for more details.

5. Enter the ADC Output Data Rate ($f_{(SAMPLE)}$) as 4000M 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.

3.13 Verify the TSW14J56EVM Switch Settings and Status LEDs

1. Observe the switches and jumpers on the TSW14J56EVM and verify that they are in the correct position. See the TSW14J56EVM user guide (SLWU086) for more information regarding the proper (default) switch and jumper settings.
2. Verify the status of the D1 to D8 LEDs on the TSW14J56EVM. See the TSW14J56EVM user guide (SLWU086) for more information regarding the status LEDs.

3.14 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 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 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 7. High Speed Data Converter Pro (HSDC) GUI

When using decimation and NCO features, the Additional Device Parameters window can be used to enter the following details:

1. ADC Sampling Rate
2. ADC Input Signal Frequency
3. NCO Frequency
4. Decimation Factor

The HSDC Pro GUI will calculate the ADC Output Data Rate based on these inputs. The Fundamental and Harmonic frequency locations will also be calculated and identified in the FFT display.

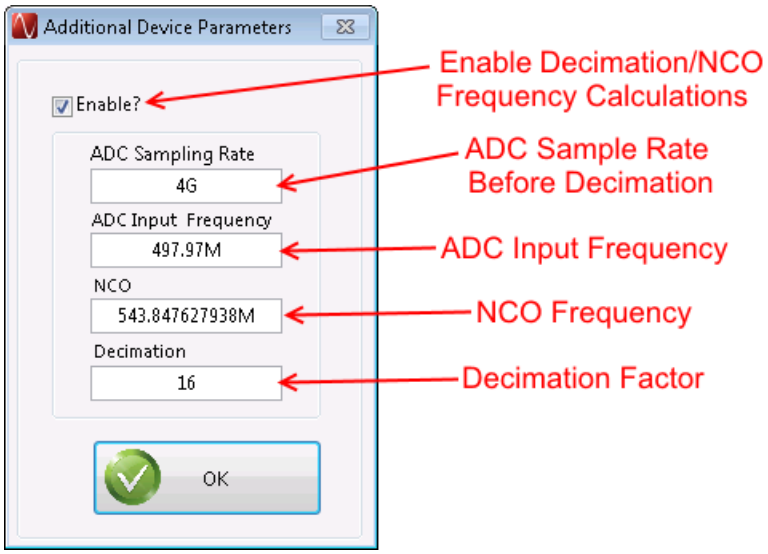

Figure 8. Additional Device Parameters Tab

3.15 Re-Verify TSW14J56EVM Status LEDs

Verify the status of the D1 to D8 LEDs on the TSW14J56EVM. See the TSW14J56EVM user guide (SLWU086) for more information regarding the status LEDs.

4 EVM and Device Configuration

The Amplifier section of the EVM can be used in AC-coupled and DC-coupled configurations, and with single-ended or differential inputs. The default configuration is for single ended AC-coupled input. Other cases are described in and .

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

For more information about the features and configuration registers in the ADC device, see the ADC12J4000 data sheet (SLAS989).

4.1 DC-Coupled Single Ended Input Signal

The input signal can also be DC-coupled to the analog inputs of the TSW12J54EVM, but some special considerations and preparation are required. The termination impedance of the VIN– and VIN+ inputs must always match, both at DC and at higher frequencies. The default configuration uses DC-Block devices to ensure the DC termination of VIN– and VIN+ match. If the DC-blocks are eliminated, DC impedance of the signal source becomes much more important.

Most bandpass or even low-pass filters will not be 50 ohms at DC, making it difficult to provide matched input terminations. One configuration that ensures the DC terminations match is to apply a 50-ohm termination directly to the VIN+ input, and use a Bias-T to drive the VIN– input. A 50-ohm termination will be applied to the DC port of the Bias-T. The output of the bandpass filter can be applied to the RF port of the Bias-T.

If the DC-impedance of the source is controlled at 50 ohms, then it can be used to directly drive the VIN– input.

4.2 Differential Input Signal

The TSW12J54EVM can also be driven with a differential signal source using either AC-coupled or DC-coupled connection. For DC-coupled differential connections, the same termination impedance issues discussed in apply.

4.3 Supported JESD204B Device Features

The ADC device supports some configuration of the JESD204B interface. Due to limitations in the TSW14J56EVM firmware, all JESD204B link features of the ADC device are not supported. Table 1 lists the supported and non-supported features.

Table 1. Supported and Non-Supported Features of the JESD204B Device

JESD204B Feature	Supported BY ADC Device	Supported BY TSW14J56EVM
Number of lanes per channel (L)	L = 1, 2, 3, 4, 5, 8 (1)	L = 1,2,4,8 supported L = 3 and 5 not currently supported
Number of frames per multi-frame (K)	K_{min} = 2–12 (1) K_{max} = 32	Most values of K supported, constrained by requirement that K × F = 4^n
Scrambling	Supported	Supported
Test patterns	PBRS7, PBRS11, PBRS15, Ramp, D21.5, K28.5, Repeat ILA, Modified RPAT, Long/Short Transport, Serial Out 0, Serial Out 1, Bypass Lane ID, ADC Test Pattern (1)	ILA, Ramp, Long/Short Transport and ADC Test Pattern are supported. Other patterns not supported at this time.
Speed	Lane rates from 1 to 10 Gbps (1)	Lane rates from 2 to 10 Gbps currently supported. $f_{(SAMPLE)}$ parameter must be properly set in HSDC Pro GUI.

(1) Dependent on bypass or decimation mode and output rate selection. Always disable the JESD204 block before enabling any of the JESD204B settings. Once the settings are changed, re-enable the JESD204 block.

4.4 Tab Organization

Control of the ADC device features are available in the EVM, JESD204B/DDC, NCO Configuration, and Low-Level View tabs.

4.5 Low-Level Control

The Low-Level tab, listed in Figure 9, allows configuration of the devices at the bit-field level. At any time, the following controls can be used to configure or read from the device.

Table 2. 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 Can be used to re-synchronize the GUI with the state of the hardware
Read register button	Read from the register highlighted in the register map summary and display the results in the Read Data field
Read-all button	Read from all register in the register map summary and display current state of hardware
Load configuration button	Load a configuration file from disk and register address/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 box using the address and write data information

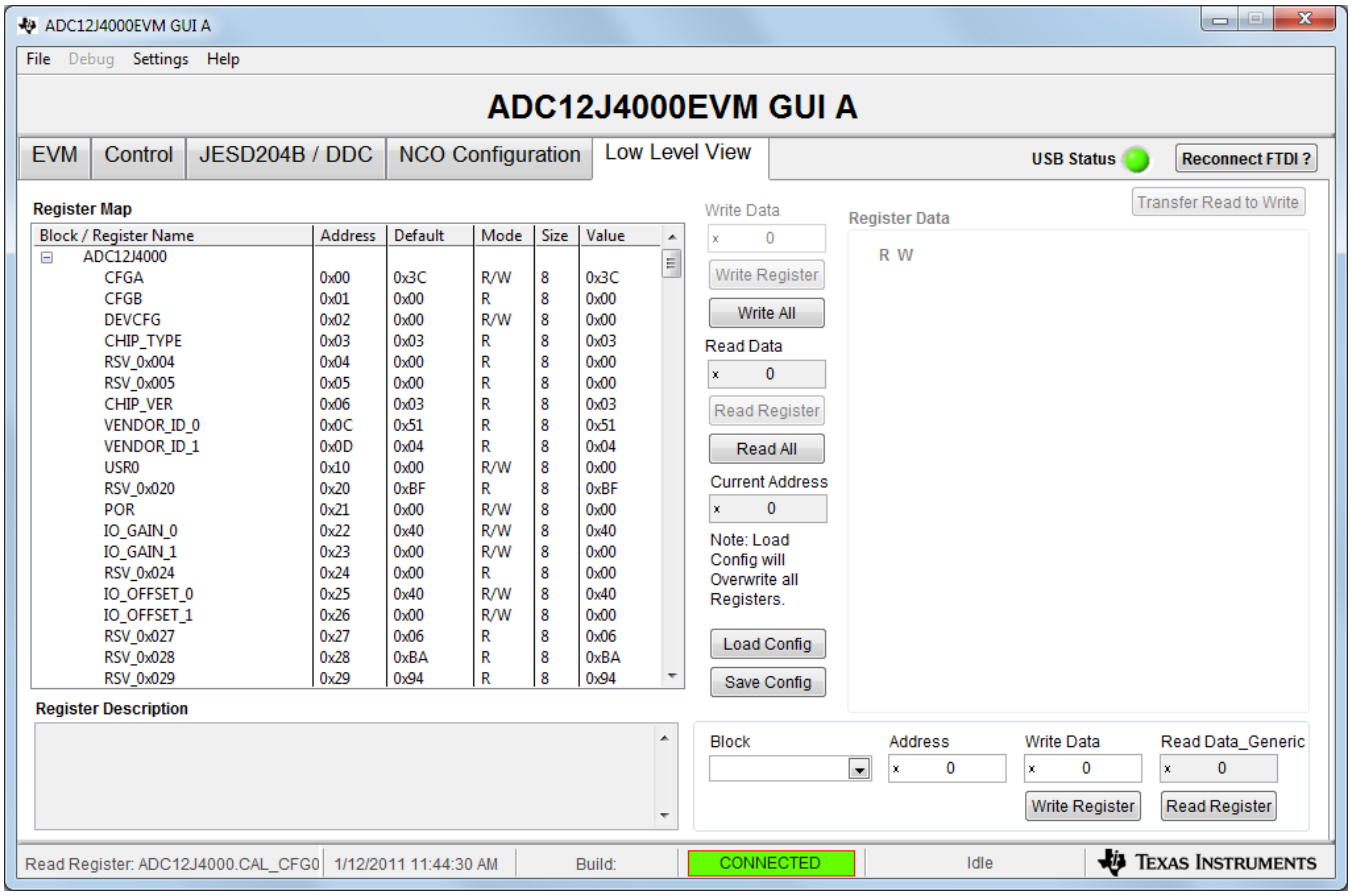

Figure 9. Low-Level Register Control Tab

5 Evaluation Troubleshooting

Table 3. Troubleshooting

Issue	Troubleshoot
General problems	• Verify the test setup shown in Figure 3, and repeat the setup procedure as described in this document. • Check power supply to EVM and TSW14J56EVM. Verify that the power switches are in the on position. • Check signal and clock connections to EVM. • Visually check the top and bottom sides of the board to verify that nothing looks discolored or damaged. • Ensure the board-to-board FMC connection is secure. • Try pressing the CPU_RESET button on the TSW14J56EVM. Also try clicking *Instrument Options → Reset Board* after changing the ADC configuration. • Try power-cycling the external power supply to the EVM, and reprogram the LMK and ADC devices.
TSW14J56 LEDs are not correct	• Verify the settings of the configuration switches on the TSW14J56EVM. • 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 LEDs are not blinking, reprogram the ADC EVM devices. • Try pressing the CPU_RESET button on the TSW14J56EVM. • Try capturing data in HSDC Pro to force an LED status update.
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 it is not lit, click the *Reconnect FTDI* button. • Try restarting 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 on-board FTDI chip is programmed with the product description *ADC12J4000_A0*.
HSDC Pro software is not capturing good data or analysis results are incorrect.	• Verify that the TSW14J56EVM is properly connected to the PC with a mini-USB 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 should 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	• Try to reprogram the LMK device and reset the JESD204 link. • Verify that the ADC sampling rate is correctly set in the HSDC software.
Sub-optimal measured performance	• Try clicking *Execute Foreground CAL* on the *Control* tab of the configuration GUI to recalibrate the ADC. • Check that the spectral analysis parameters are properly configured. • Verify that bandpass filters are used in the clock and input signal paths and that low-noise signal sources are used.

References

A.1 Technical Reference Documents

- ADC12J4000 data sheet (SLAS989)
- LMH5401 data sheet (SBOS710)
- LMH3401 data sheet (SBOS695)
- TSW14J56EVM user's guide (SLWU086)
- User's guide for the High Speed Data Converter Pro Software, also available in the help menu of the software (SLWU087)
- LMK04828 data sheet (SNAS605)
- TRF3765 data sheet (SLWS230)
- FTDI USB to Serial Driver Installation Manual, www.ftdichip.com/Support/Documents/InstallGuides.htm

A.2 TSW14J56EVM Operation

Refer to the TSW14J56EVM user guide (SLWU086) for configuration and status information.

HSDC Pro Settings for Optional ADC Device Configuration

B.1 Changing the Number of Frames per Multi-Frame (K)

Changing the number of frames per multi-frame output by the JESD204 transmitter (ADC device) is configured using the K parameter on the JESD204B tab in the Configuration GUI. This parameter must be matched by the receiving device, and the SYSREF frequency must also be programmed to a compatible frequency.

B.2 Customizing the EVM for Optional Clocking Support

By default, the TRF3765 is configured to generate the device clock with an onboard crystal oscillator and the LMK04828 is used as a clock distribution and provides the system reference clock for the FPGA. The EVM can be configured to use external clocks with the following steps (see Figure 10):

1. Modify the Hardware:
   (a) Remove C32 and C33, populate C30 and C36
   (b) Remove C112 and C113, populate C114 and C123
2. Connect the Signal Generators:
   (a) Connect the 10-MHz reference from Sig Gen 1 to Sig Gen 2.
   (b) Configure Sig Gen 2 to use the 10-MHz reference input from Sig Gen 1.
   (c) Sig Gen 1 connects to DEVCLK. Set to the generator frequency to the desired F_{DEVCLK}.
   (d) Sig Gen 2 connects to LMKCLK. Set the generator frequency as follows:
   $F_{LMKCLK} = F_{DEVCLK} / 2$
3. Program the GUI:
   (a) In the EVM tab, set the Clock Source to *External*.
   (b) Enter the Sampling Frequency (F_{DEVCLK}) in step 2(b).

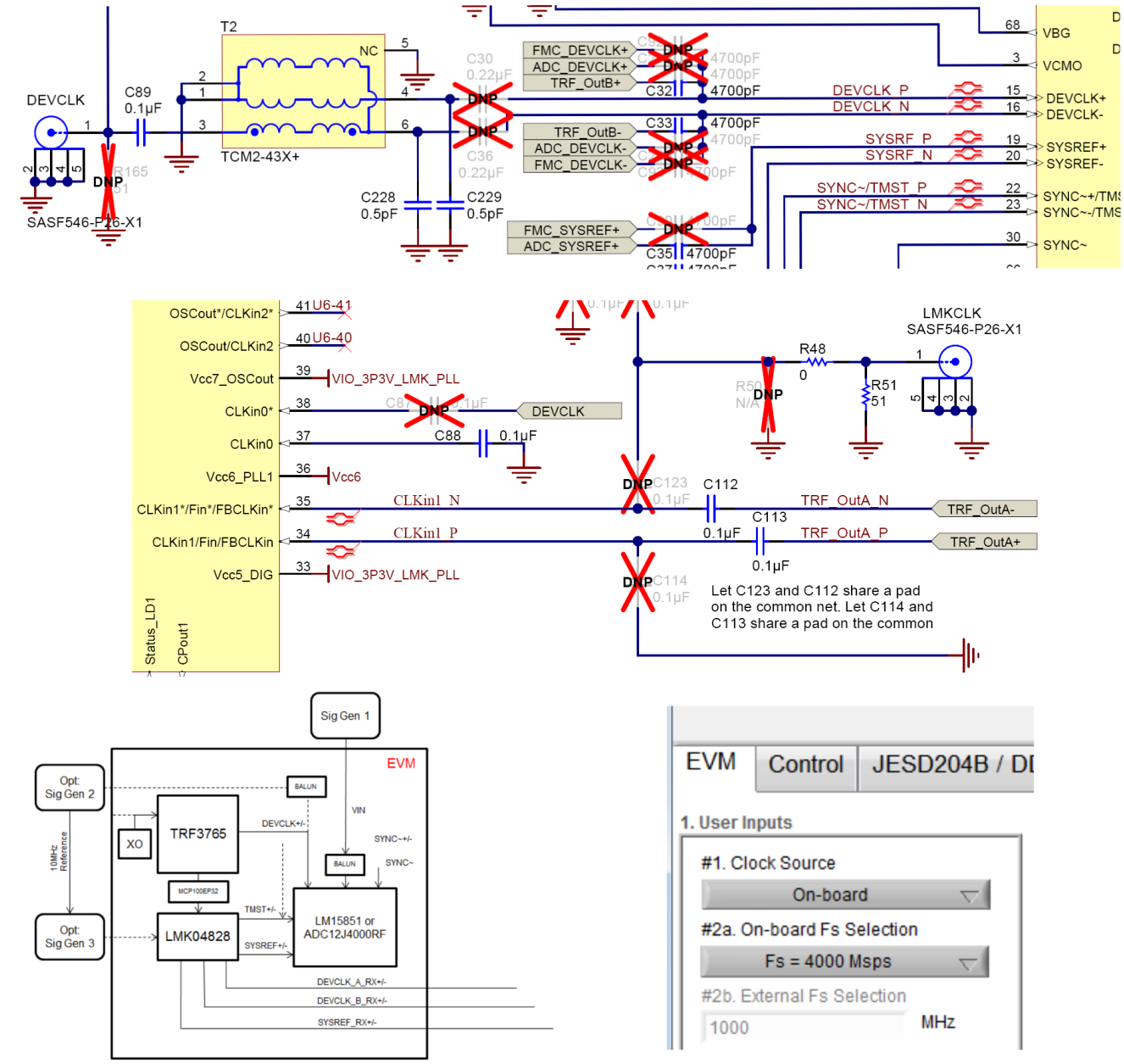

Figure 10. Configuration for Optional Clocking Support

The TRF3765 and LMK04828 may be reconfigured to exercise more features, but this EVM is not intended to be a full evaluation platform for these devices. For a full evaluation platform see the LMK04828 tool folder: www.ti.com/tool/lmk04828bevm and the TRF3765 tool folder: http://www.ti.com/tool/trf3765evm.

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2 *Limited Warranty and Related Remedies/Disclaimers*:

   2.1 These terms and conditions do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.

   2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for any defects that are caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI. Moreover, TI shall not be liable for any defects that result from User's design, specifications or instructions for such EVMs. Testing and other quality control techniques are used to the extent TI deems necessary or as mandated by government requirements. TI does not test all parameters of each EVM.

   2.3 If any EVM fails to conform to the warranty set forth above, TI's sole liability shall be at its option to repair or replace such EVM, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

3 *Regulatory Notices:*

   3.1 *United States*

      3.1.1 *Notice applicable to EVMs not FCC-Approved:*

      This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.

      3.1.2 *For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant:*

      CAUTION

      This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

      Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

      FCC Interference Statement for Class A EVM devices

      NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FCC Interference Statement for Class B EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- *Reorient or relocate the receiving antenna.*
- *Increase the separation between the equipment and receiver.*
- *Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.*
- *Consult the dealer or an experienced radio/TV technician for help.*

3.2 *Canada*

3.2.1 *For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210*

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concernant les EVMs avec appareils radio:

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Concerning EVMs Including Detachable Antennas:

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur

3.3 *Japan*

3.3.1 *Notice for EVMs delivered in Japan:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。
http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page

3.3.2 *Notice for Users of EVMs Considered "Radio Frequency Products" in Japan:* EVMs entering Japan may not be certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required by Radio Law of Japan to follow the instructions below with respect to EVMs:

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

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1. 電波法施行規則第6条第1項第1号に基づく平成18年3月28日総務省告示第173号で定められた電波暗室等の試験設備でご使用いただく。
2. 実験局の免許を取得後ご使用いただく。
3. 技術基準適合証明を取得後ご使用いただく。

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西新宿三井ビル

3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page

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4 *EVM Use Restrictions and Warnings:*

4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.

4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.

4.3 *Safety-Related Warnings and Restrictions:*

4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.

4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.

4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.

5. *Accuracy of Information:* To the extent TI provides information on the availability and function of EVMs, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.

6. *Disclaimers:*

   6.1 EXCEPT AS SET FORTH ABOVE, EVMS AND ANY WRITTEN DESIGN MATERIALS PROVIDED WITH THE EVM (AND THE DESIGN OF THE EVM ITSELF) ARE PROVIDED "AS IS" AND "WITH ALL FAULTS." TI DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING SUCH ITEMS, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF ANY THIRD PARTY PATENTS, COPYRIGHTS, TRADE SECRETS OR OTHER INTELLECTUAL PROPERTY RIGHTS.

   6.2 EXCEPT FOR THE LIMITED RIGHT TO USE THE EVM SET FORTH HEREIN, NOTHING IN THESE TERMS AND CONDITIONS SHALL BE CONSTRUED AS GRANTING OR CONFERRING ANY RIGHTS BY LICENSE, PATENT, OR ANY OTHER INDUSTRIAL OR INTELLECTUAL PROPERTY RIGHT OF TI, ITS SUPPLIERS/LICENSORS OR ANY OTHER THIRD PARTY, TO USE THE EVM IN ANY FINISHED END-USER OR READY-TO-USE FINAL PRODUCT, OR FOR ANY INVENTION, DISCOVERY OR IMPROVEMENT MADE, CONCEIVED OR ACQUIRED PRIOR TO OR AFTER DELIVERY OF THE EVM.

7. *USER'S INDEMNITY OBLIGATIONS AND REPRESENTATIONS.* USER WILL DEFEND, INDEMNIFY AND HOLD TI, ITS LICENSORS AND THEIR REPRESENTATIVES HARMLESS FROM AND AGAINST ANY AND ALL CLAIMS, DAMAGES, LOSSES, EXPENSES, COSTS AND LIABILITIES (COLLECTIVELY, "CLAIMS") ARISING OUT OF OR IN CONNECTION WITH ANY HANDLING OR USE OF THE EVM THAT IS NOT IN ACCORDANCE WITH THESE TERMS AND CONDITIONS. THIS OBLIGATION SHALL APPLY WHETHER CLAIMS ARISE UNDER STATUTE, REGULATION, OR THE LAW OF TORT, CONTRACT OR ANY OTHER LEGAL THEORY, AND EVEN IF THE EVM FAILS TO PERFORM AS DESCRIBED OR EXPECTED.

8. *Limitations on Damages and Liability:*

   8.1 *General Limitations*. IN NO EVENT SHALL TI BE LIABLE FOR ANY SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL, OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF THESE TERMS ANDCONDITIONS OR THE USE OF THE EVMS PROVIDED HEREUNDER, REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. EXCLUDED DAMAGES INCLUDE, BUT ARE NOT LIMITED TO, COST OF REMOVAL OR REINSTALLATION, ANCILLARY COSTS TO THE PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES, RETESTING, OUTSIDE COMPUTER TIME, LABOR COSTS, LOSS OF GOODWILL, LOSS OF PROFITS, LOSS OF SAVINGS, LOSS OF USE, LOSS OF DATA, OR BUSINESS INTERRUPTION. NO CLAIM, SUIT OR ACTION SHALL BE BROUGHT AGAINST TI MORE THAN ONE YEAR AFTER THE RELATED CAUSE OF ACTION HAS OCCURRED.

   8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY WARRANTY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS AND CONDITIONS, OR ANY USE OF ANY TI EVM PROVIDED HEREUNDER, EXCEED THE TOTAL AMOUNT PAID TO TI FOR THE PARTICULAR UNITS SOLD UNDER THESE TERMS AND CONDITIONS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM AGAINST THE PARTICULAR UNITS SOLD TO USER UNDER THESE TERMS AND CONDITIONS SHALL NOT ENLARGE OR EXTEND THIS LIMIT.

9. *Return Policy.* Except as otherwise provided, TI does not offer any refunds, returns, or exchanges. Furthermore, no return of EVM(s) will be accepted if the package has been opened and no return of the EVM(s) will be accepted if they are damaged or otherwise not in a resalable condition. If User feels it has been incorrectly charged for the EVM(s) it ordered or that delivery violates the applicable order, User should contact TI. All refunds will be made in full within thirty (30) working days from the return of the components(s), excluding any postage or packaging costs.

10. *Governing Law:* These terms and conditions shall be governed by and interpreted in accordance with the laws of the State of Texas, without reference to conflict-of-laws principles. User agrees that non-exclusive jurisdiction for any dispute arising out of or relating to these terms and conditions lies within courts located in the State of Texas and consents to venue in Dallas County, Texas. Notwithstanding the foregoing, any judgment may be enforced in any United States or foreign court, and TI may seek injunctive relief in any United States or foreign court.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265

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In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI’s goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or “enhanced plastic” are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have ***not*** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

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