EVM User's Guide: AFE7952EVM
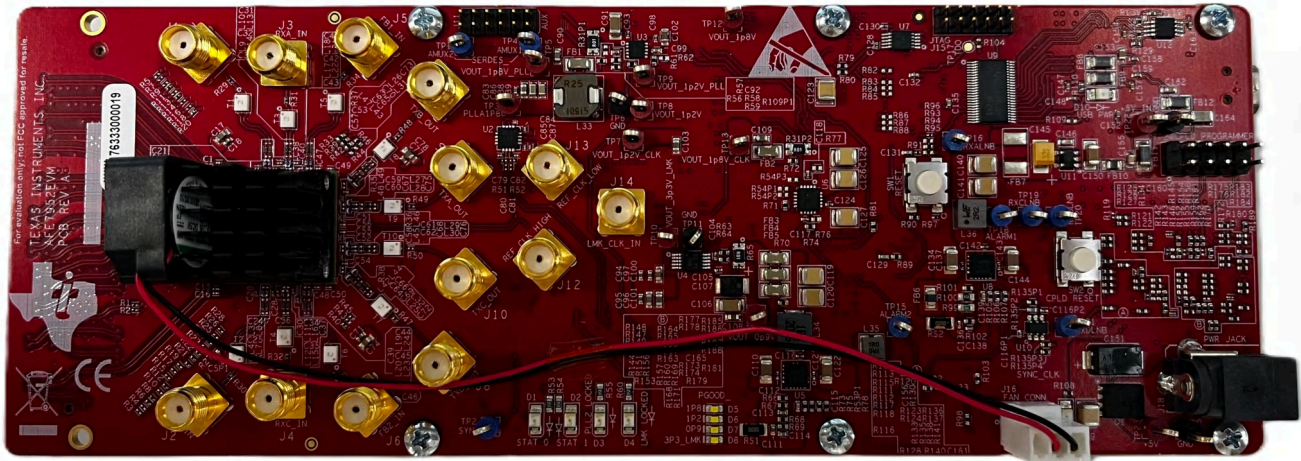# AFE7952 Evaluation Module

TEXAS INSTRUMENTS

Description

The AFE7952 evaluation modules (EVMs) are evaluation boards used to evaluate the AFE7952 integrated RF sampling transceiver from Texas Instruments. The EVM includes the LMK04828 clock generator to provide reference clocks and SYSREF to the analog front end (AFE) and capture card (field-programmable gate array, FPGA). The EVM works off a single 5.5V input and includes complete power management circuitry. External clocking options include support for feeding the reference clock for the on-chip PLL. The design interfaces with the TI pattern and capture card (TSW14J58), as well as many FPGA development kits.

Features

- Onboard FPGA mezzanine card (FMC) connector
- Includes complete power management circuitry
- Onboard clock generator to provide reference clocks and SYSREF
- Internal PLL/VCO to generate DAC/ADC clocks
- Optional external CLK at DAC or ADC rate
- SerDes data interface:
  - JESD204B and JESD204C compliant
  - 8 SerDes transceivers up to 29.5Gbps
  - 8b/10b and 64b/66b encoding
  - 12-bit, 16-bit, 24-bit, and 32-bit resolution
  - Subclass 1 multidevice synchronization

AFE7952EVM Top View

1 Evaluation Module Overview

1.1 Introduction

The AFE7952 devices support up to four-transmit, four-receive, and two feedback channels (4T4R2F) and integrates phase-locked loop (PLL) and voltage-controlled oscillator (VCO) for generating data converter clocks. The AFE7952 device integrates eight JESD204B- and JESD204C-compatible serializer and deserializer (SerDes) transceivers capable of running up to 29.5Gbps to transmit and receive digital data through the onboard FPGA mezzanine card (FMC) connector.

This document is the user's guide for the evaluation board (EVMs) meant for evaluating the AFE7952 integrated RF sampling transceiver from Texas Instruments. This user's guide describes the basic steps and functions that are required for the proper operation and quick setup of the EVM. The AFE7952EVM includes a clocking and power solution and runs off a single 5.5V supply. As AFE7952EVM Top View shows, the RF inputs and outputs using subminiature version A (SMA) connectors are on the top side of the EVM. A reference clock (for example, 10MHz) to lock the onboard voltage-controlled crystal oscillator (VCXO) with the LMK04828, PLL-1 can be provided to the connector named LMK CLKIN (SMA J19).

Note

Many typical lab equipments have a 10MHz oscillator output to synchronize multiple lab systems. The onboard LMK04828 can accept the 10MHz from external lab equipment to establish synchronization and coherency of the data capture and generation to the AFE7952 EVM.

SMA J12 (REF_CLK_HIGH) or SMA J13 (REF_CLK_LOW) can be used to feed an external reference clock to lock the PLLs in the AFE7952. The USB connector and the 5.5V connector are on the right side of the board.

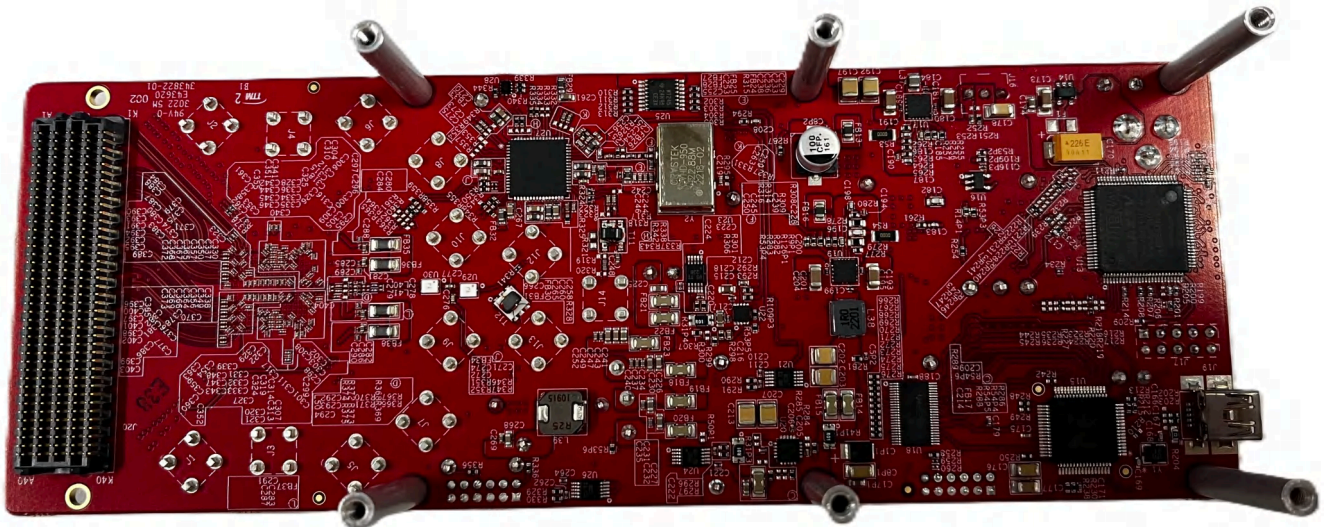Figure 1-1 shows the bottom view of the AFE7952EVM.

Figure 1-1. AFE7952EVM Bottom View

The capture card used with the AFE7952 EVM is the TSW14J58. TSW14J58 supports a SerDes speed of up to 29.5Gbps. Refer to Figure 1-2 for typical the connections between the TSW14J58 EVM and the AFE7952 EVM.
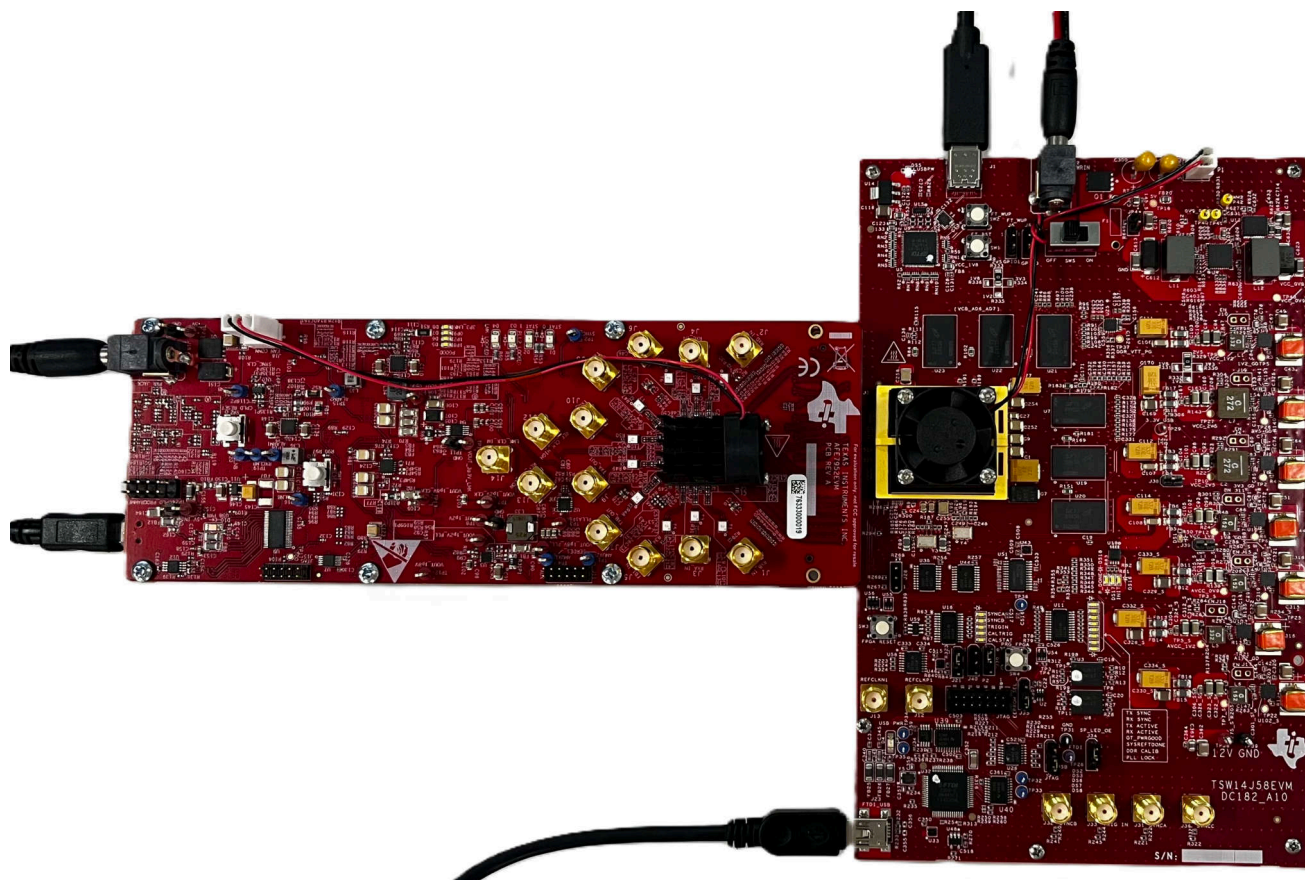
Figure 1-2. AFE7952EVM and TSW14J58EVM Rev. A10

1.2 Kit Contents

Table 1-1 lists the components of the EVM kit. Contact the Texas Instruments Product Information Center if any components are missing. TI highly recommends that users check ti.com to verify that the latest versions of the related software is in use.

Table 1-1. Kit Contents

Item	Quantity
AFE7952 EVM	1
Mini USB cable	1
Power cable	1

1.3 Specifications

Click here for the device specifications.

1.4 Device Information

The AFE7952 is a high performance, wide bandwidth multi-channel transceiver, that integrates four RF sampling transmitter chains, four RF sampling receiver chains, and two RF sampling digitizing auxiliary chains (feedback paths). The high dynamic range of the transmitter and receiver chains allows the device to generate and receive 3G, 4G, and 5G signals from wireless base stations, while the wide bandwidth capability of the is designed for multi-band 4G and 5G base stations.

Each receiver chain includes a 25dB range digital step attenuator (DSA), followed by a 3GSPS analog-to-digital converter (ADC). Each receiver channel has an analog peak power detector and various digital power detectors to assist an external or internal autonomous automatic gain controller, and RF overload detectors for device reliability protection. The single or dual digital down converters (DDC) provide up to 600MHz of combined signal

BW in dual DDC mode or 1200MHz BW in single DDC mode. In TDD mode, the receiver channel can be configured to dynamically switch between the traffic receiver (TDD RX) and wideband feedback receiver (TDD FB), with the capability of reusing the same analog input for both purposes.

Each transmitter chain includes a single or dual digital up-converters (DUCs) supporting up to 2400MHz for 2TX or 1200MHz BW for 4TX combined signal bandwidth. The output of the DUCs drives a 12GSPS DAC (digital-to-analog converter) with a mixed mode output option to enhance second or third Nyquist operations. The DAC output includes a variable gain amplifier (TX DSA) with a 40dB range and 1dB analog and 0.125dB digital steps.

The feedback path includes an 25dB range DSA driving a 3GSPS RF sampling ADC, followed by a DDC with up to 1200MHz bandwidth.

2 Hardware

Two bench power supplies are required to power the AFE7952EVM and the TSW14J58 EVM. A PC to program the EVM and capture card is required. See Section 2.1 for more information. All lab equipment requirements (such as signal generator, signal analyzer, and so forth) are left to the users' discretion.

Note

Typically, the bench power supply with rating of 5.5V and current limit of 5A is used to power the AFE7952 EVM. The nominal EVM power supply voltage is 5V. The additional 0.5V overhead is added to compensate for the power cable loss as the AFE7952 EVM and the configuration of TSW14J58 in full operating mode to accommodate the voltage drop associated with power cable loss.

2.1 Recommended Test Environment

- Power supply at 5.5V, 5A maximum for the AFE7952 EVM.
- Power supply at 5.5V, 5A maximum for the TSW14J58 EVM.
- A Windows PC that supports USB 3.0 for fast file transfer from ADC capture and DAC pattern loading.
- High-quality RF signal generator that supports RF frequency of interest for evaluation. The example set-up uses Keysight™ PSG series of signal generator.
- High-quality RF spectrum analyzer that supports RF frequency of interest for evaluation. The example set-up uses a Rohde & Schwarz™ FSQ-26 series of spectrum analyzer.

2.2 Required Hardware

- AFE7952 EVM
- TSW14J58 EVM
- 1 × USB 3.0 Micro-B cable (up to TSW14J58 REV A8) / USB Type-C® 3.0 cable (TSW14J58 REV A9+)
- 2 × USB Mini-B cable
- 2 power supply cables

2.3 Hardware Setup

2.3.1 AFE7952 EVM and TSW14J58 EVM Connections

1. Connect the FMC connector U31 of AFE7952 EVM to FMC connector J3 of TSW14J58 EVM.
2. With the power supply in powered down mode, connect a 5.5V, 5A maximum power supply to J2 *+5V IN* connector of the TSW14J58EVM.
3. Connect USB 3.0 cable from the PC to J1 connector of the TSW14J58 EVM.
4. Connect USB Mini-B cable from the PC to FTDI_USB connector of the TSW14J58 EVM.
5. With the power supply in powered down mode, connect the 5.5V, 5A maximum power supply to J18 connector of the AFE7952 EVM.
6. Connect USB Mini-B cable from the PC to J19 connector of the AFE7952 EVM.
7. Optionally: Connect 10MHz of lab equipment reference to J14, LMK_CLK_IN connector.
8. Optionally: Choose the FPGA bitfile version by changing J35 jumper position.

   a. Default: For bitfile version 204B, check that the physical position of jumper J35 is covering pins 2 and 3 (the two pins positioned furthest from the FPGA fan).
   b. For bitfile version 204C, check that the physical position of jumper J35 is covering pins 1 and 2 (the two pins positioned nearest to the FPGA fan).
   c. The configuration steps in this guide assume the ser is using bitfile version 204B.

Refer to Figure 1-2 for typical connection between the TSW14J58 EVM and the AFE7952 EVM. It is recommended to connect the USBs directly to the PC, rather than a USB hub, and disconnect unnecessary USB devices from the PC. Other USB devices can potentially interfere with the PC's ability to recognize the EVM USB handles.

After completing these steps, turn on the power supplies.

2.3.2 Power Supply Setup

1. Check that the D9 (PWR) LED is lit up. The power supply draws approximately 550mA to 650mA.
2. Check that the D10 (USB_PWR) LED is lit up. The LED light strength depends on the USB cable length. If the LED is not lit up, use a shorter USB cable. TI tested three-foot USB cables in this setup.
3. The power supply sequencer on the AFE7952 EVM has power status for each rail. If the power good (PGOOD) is in logic HI, the corresponding power supply rail is powered correctly. The respective LEDs light up. Check the following LEDs to verify that there is light.
    *   D5 (1P8) LED
    *   D6 (1P2) LED
    *   D7 (0p9) LED
    *   D8 (3p3_LMK) LED

3 Software

3.1 Required Software

The software used to configure the AFE7952EVM is named *Latte*. The latest version of Latte is available for download from TI's Secure Resources website. The installer file is named *TI-AFE79xx-Latte_V2p5.exe.*

3.1.1 Software Installation Sequence

1. Install *TI-AFE79xx-Latte_V2p5.exe*, or latest version. Once the software is installed, launch the software from the AFE79xx Startup window from the Start Menu, or by clicking on the AFE79xx icon in Desktop. Initializing the software takes up to 2 minutes.
2. Note the directory where the Latte software is installed.

Note

The Default Latte Software Directory is in:

C:\Users\"User ID"\Documents\Texas Instruments\Latte

Replace the "User ID" with the proper Windows login ID.

3.2 Latte Overview

After fully initializing the software, launch the Latte GUI from the desktop shortcut or by selecting *All Programs* then selecting *Texas Instruments*.
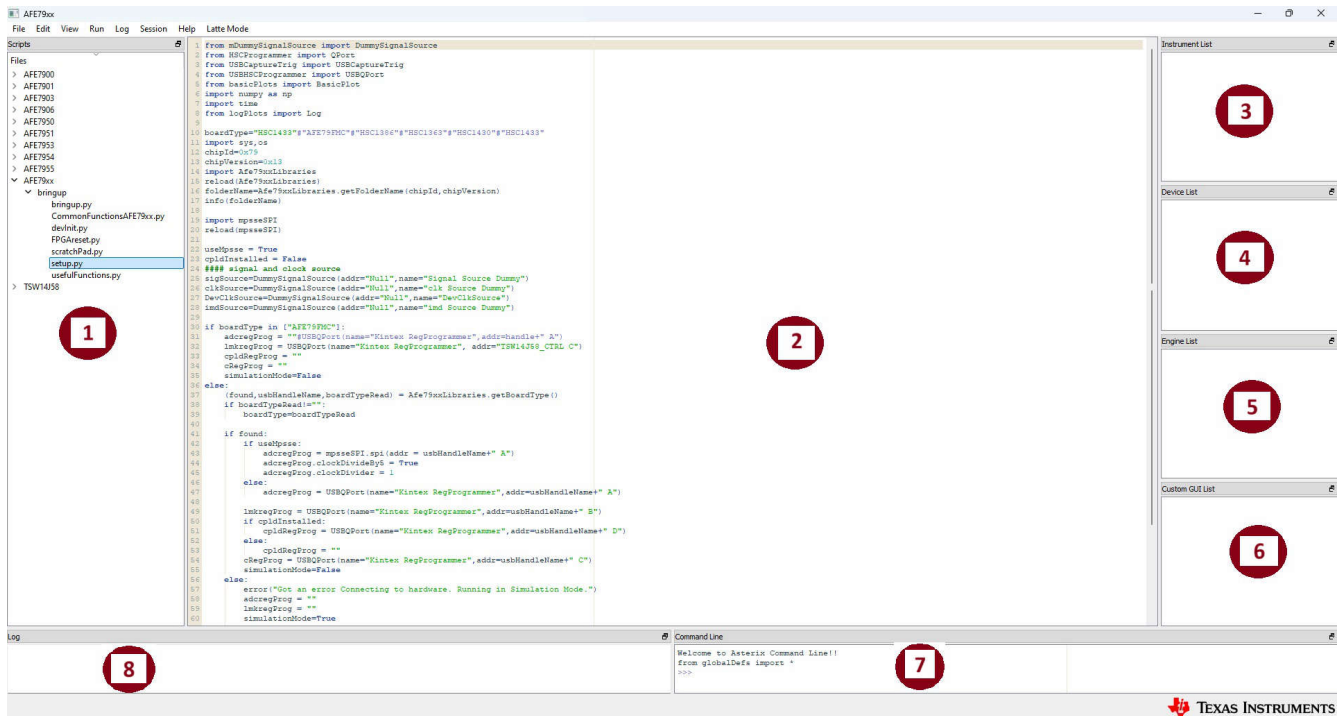

Figure 3-1. Latte GUI Overview

3.2.1 Latte User Interface

The Latte UI is split into eight windows (labeled 1 to 8) with the following functions:

- **Window 1:**

   This window (also called *Scripts*) shows the list of python scripts available that generate the register commands to configure the AFE7952EVM. The script files shown are located in

the ..\Documents\TexasInstruments\AFE79xxLatte\projects\AFE79xx\bringup folder. Modify and create new scripts as necessary, which appear in the Window 1 sub-window when Latte restarts.

- **Window 2:**

  This window (also called *Editor*) shows the code in the script currently selected and can be used to modify and save the code as necessary.

- **Window 3 to 6:**

  These windows update as the scripts run to configure the AFE7952EVM and mostly are informational.

- **Window 7:**

  This window (also called *Command Line*) is used to enter and run individual commands. Examples of such commands include changing the TX, RX, and FBRX DSA, NCOs, and so forth.

- **Window 8:**

  This window (also called *Log*) displays messages during execution of scripts to display the current status. This window is also used for troubleshooting.

3.2.2 Useful Latte Short-Cuts

Run Script file: Run a script file by first selecting the file in the Scripts window and then by pressing F5 (or selecting *Run* and then *Buffer* in the menu bar).

Run part of script: Run part of a script file by selecting the lines in the Editor window and then by pressing F7 (or selecting *Run* and then *Run Selection* in the menu bar).

Stop Execution: Stop the current execution by pressing F10 (or selecting *Run* and then *Stop* in the menu bar).

Clear Session: The current session can be cleared to reset the Latte UI to its initial state by pressing Ctrl-T (or selecting *Session* and then *Clear Session* in the menu bar). This process is equivalent to a restart and can be used to restart a session without closing the GUI.

4 Implementation Results

4.1 AFE7952EVM Configuration

This section guides you through the sequence of steps to bring-up the AFE7952EVM. The automatic setup process is broken down in this section for users to understand the process and make modifications accordingly.

4.1.1 Connect Latte to Board

This step establishes a connection between the PC running Latte and the AFE7952EVM.

1. In the scripts window, select the *AFE79xx* drop-down, then the *bringup* drop-down. Select *setup.py*. On line 13, verify that the chip version is 0x13. Press F5 to run the program.
2. Check the Log window to verify that there are no errors. Check that the following line is displayed twice: *Kintex RegProgrammer - USB Instrument created*.
3. Missing or obsolete drivers for the FT4232H chip in the AFE7952EVM is a common error source. In Latte, use the *View* tab then *USB Handles* to check USB handle connections to Latte. There are four connections for the TSW14J58 and four connections to the EVM. Alternatively, use the device manager to verify a connection between the PC and the EVM by checking the USB instantiations.
4. Update your PC with the appropriate driver, if necessary.

Figure 4-1. Latte Log After Successful setup.py

4.1.2 Compile Libraries

In this step, the library of scripts packaged with the Latte UI is compiled and takes approximately 30 seconds to run.

1. In the scripts window, select *devInit.py*.
2. Press F5 to run the program.
3. Check the Log window for status and errors.

Figure 4-2. Latte Log After Successful devInit.py

4.1.3 Program AFE7952 EVM

In this step, the LMK04828 and AFE7952 on the AFE7952EVM are programmed.

1. Select the script named *bringup.py* and press F5. No errors are expected, ignore any warnings regarding SPI control, relinquish, or reset property. This step takes a few minutes.
2. Check the Log window to monitor any errors. This step completes the AFE7952EVM configuration. Current consumption into the AFE7952EVM is approximately 3A.

3. A mismatch FPGA bitfile version error indicates that the firmware does not match the configuration file. For bitfile version 204b, check that the physical position of jumper J35 is covering pins 2 and 3 (the two pins positioned furthest from the FPGA fan).

4. An LOS error indicates that the SerDes RX is electrically idle and the TX output is not normal. Resolve this error by resending the data (the DAC pattern) and reconfiguring the AFE7952EVM by rerunning *bringup.py*.

5. GPIO warnings or sysref errors usually indicate supply voltage or current limitations. Verify the power supply to the AFE7952EVM and verify that a 5.5V supply voltage and a 5A current limit is used. Restart the Latte UI and rerun the scripts.

```
Log
AFE AGC configured.
AFE GPIO configured.
Sysref Read as expected
###########Device DAC JESD-RX 0 Link Status##########
CS State TX0: 0b10101010 . It is expected to be 0b10101010
FS State TX0: 0b01010101 . It is expected to be 0b01010101
Could get the link up for device RX: 0
#################################
###########Device DAC JESD-RX 1 Link Status##########
CS State TX0: 0b10101010 . It is expected to be 0b10101010
FS State TX0: 0b01010101 . It is expected to be 0b01010101
Could get the link up for device RX: 1
#################################
AFE Configuration Complete
#Done executing ,, AFE79xx/bringup/bringup.py
#End Time 2025-04-03 16:05:57.313000
#Execution Time = 104.355000019 s
#=============== ERRORS:0, WARNINGS:1 =================#
```

Figure 4-3. Latte Log After Successful bringup.py

4.1.4 TXDAC Evaluation

1. Connect the signal analyzer to J9 (TXA), J7 (TXB), J10 (TXC), or J8 (TXD) to monitor the TXDAC output.
2. Highlight portion of applicable code and select F7 to run. See Figure 4-4 for a typical performance measurement.

```
### TX Tone Out

## Send 10 MHz Tone to TX AB
amplA = -10 #band 0 amp in dBfs
freqA = 10 #band 0 freq in MHz
amplB = -10 #band 1 amp
freqB = 10 #band 1 freq
AFE.selectCH(2,0)
AFE.FPGA.sendSingleTone(0,freqA,amplA,freqB,amplB)

## Send 10 MHz Tone to TX CD
amplA = -10 #band 0 amp
freqA = 10 #band 0 freq
amplB = -10 #band 1 amp
freqB = 10 #band 1 freq
AFE.selectCH(2,2)
AFE.FPGA.sendSingleTone(0,freqA,amplA,freqB,amplB)
```
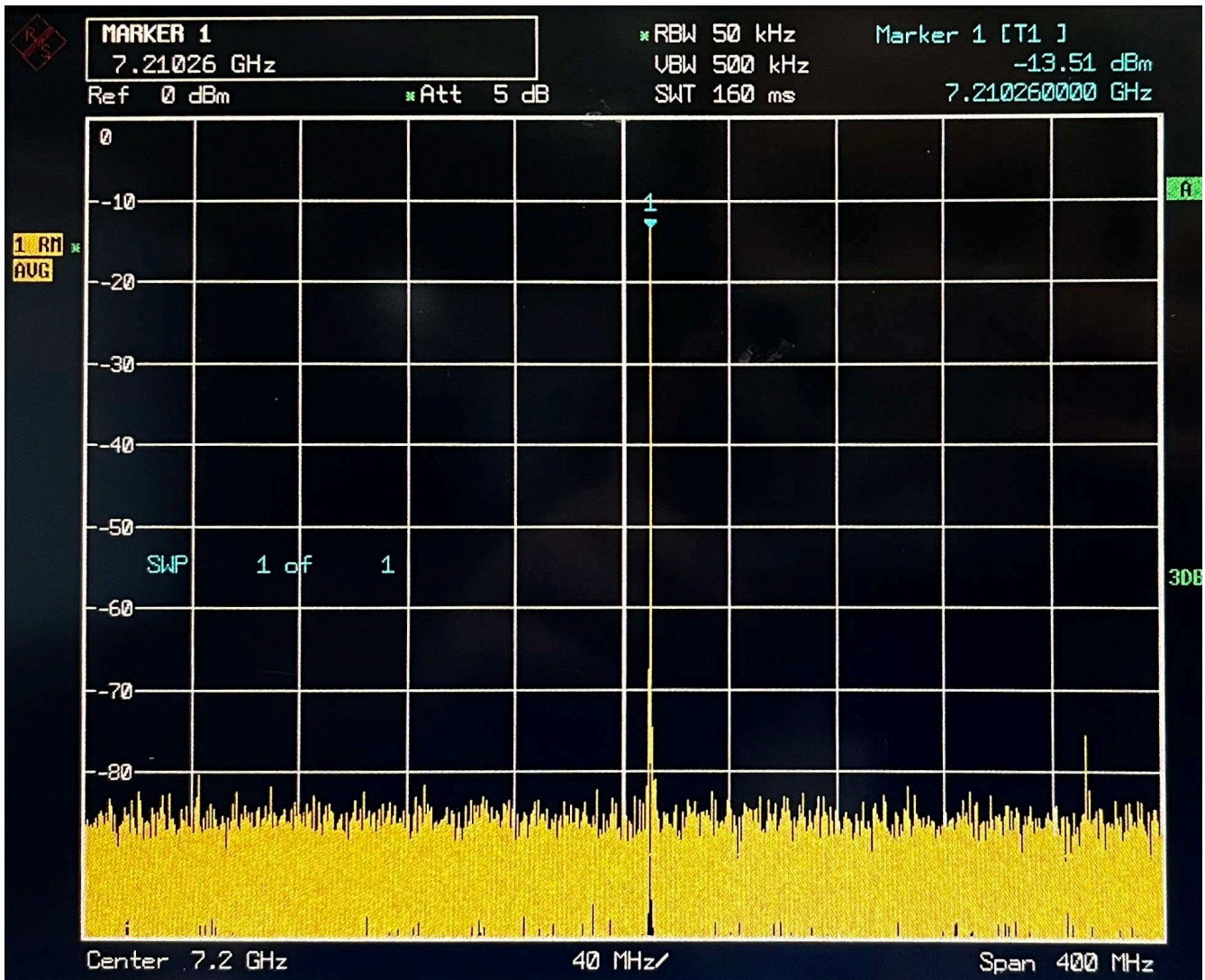
Figure 4-4. Typical TXDAC 10MHz Single Tone Performance at 7.2GHz NCO with -10dBFS Amplitude

4.1.5 RXADC and FBADC Evaluation

1. Connect the signal generator to J3 (RXA), J1 (RXB), J4 (RXC), or J2 (RXD) to supply the RXADC input at the defined NCO + 15MHz. Connect the signal generator to J5 (FBAB) or J6 (FBCD) to supply the FBADC input at the defined NCO + 15MHz.
2. Highlight portion of applicable code below and select F7 to run. In Latte Window 6, select CGui_CGui_Custom_Gui to view the capture.
3. In the capture window, select the *Finite Samples* capture type. View the capture in the *Complex* tab.

```
### RX/FB Tone In
AFE.selectCh(0,0,0) # select RX A, band 0
AFE.selectCh(0,0,1) # select RX A, band 1
AFE.selectCh(0,1,0) # select RX B, band 0
AFE.selectCh(0,1,1) # select RX B, band 1
AFE.selectCh(0,2,0) # select RX C, band 0
AFE.selectCh(0,2,1) # select RX C, band 1
AFE.selectCh(0,3,0) # select RX D, band 0
AFE.selectCh(0,3,1) # select RX D, band 1

AFE.selectCh(1,0) #select FBAB
AFE.selectCh(1,1) #select FBCD
```
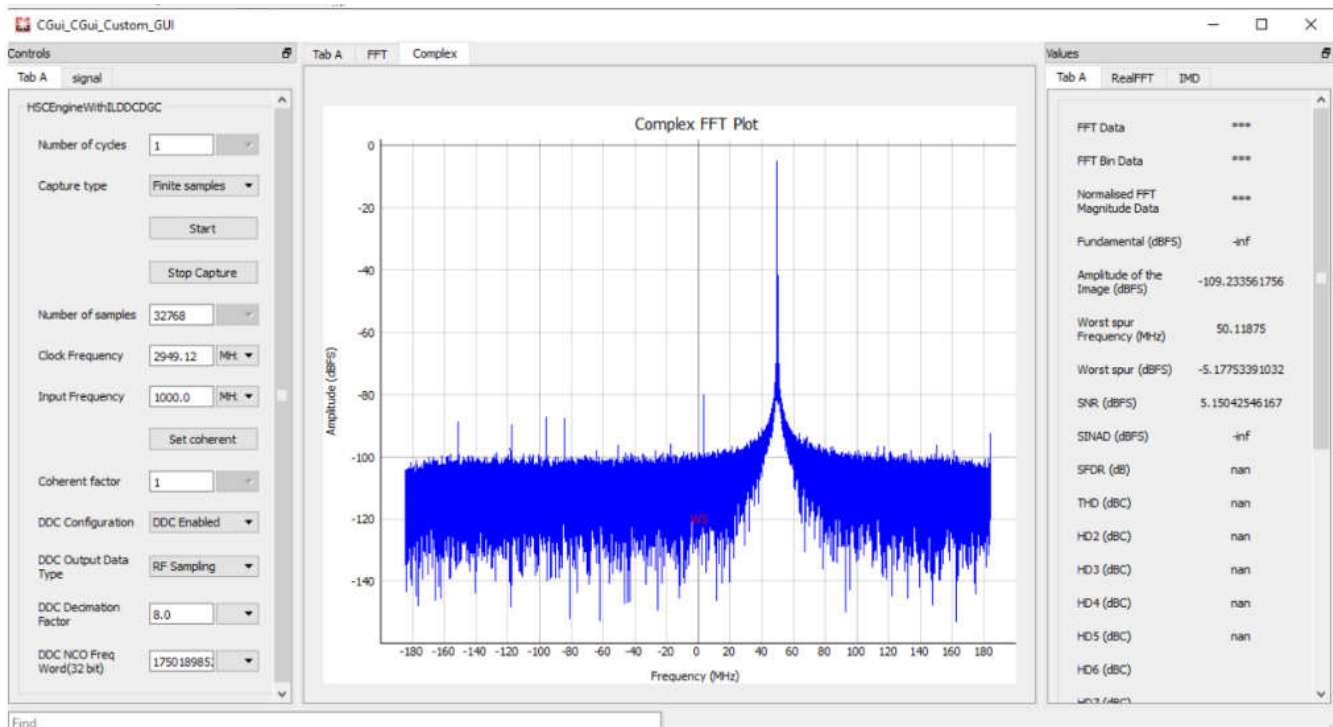
Figure 4-5. Typical RXADC 15MHz Single Tone Performance at 7.2GHz NCO

4.2 AFE7952EVM Configuration Modifications

The provided scripts configure the AFE7952 with the default settings declared in Latte scripts. Change the settings by modifying a set of parameters.

This section includes the sequence of steps to modify the bring-up for the AFE7952EVM through the python scripts. The example used in this section is the default AFE7952EVM. Table 4-1 shows the default mode configuration overview.

Table 4-1. AFE7952 EVM Default Configuration Overview

Mode	Default Programming
TX (transmitter)	4 TXDACs are enabled, DSA = 0, LMFSHd_2TX = 44210, 24 × interpolation, 491.52MSPS data rate
RX (receiver)	4 RXADCs are enabled, DSA = 0, LMFSHd_2RX = 24410, 12 × decimation, 245.76MSPS data rate
FBRX (feedback receiver)	2 FBADCs are enabled, DSA = 0, LMFSHd_1FB = 22210, 6 × decimation, 491.52MSPS data rate
SerDes	8 lanes running at 9830.4Mbps
Data Converter Clock Rates	F_{RXADC} = 2949.12MSPS, F_{FBADC} = 2949.12MSPS, F_{TXDAC} = 11796.4MSPS
Status	RX AGC is disabled, RX, TX DSA step impairments are uncorrected, DAC is in interleaved mode

4.2.1 Data Converter Clocks Settings

This parameter is used to configure the data converter clocks and clock distribution path.

```
#Configures the reference input frequency to the on-chip PLL of the AFE7952.
sysParams.FRef    = 491.52
#Configures the RXADC converter sample rate.
sysParams.FadcRx   = 2949.12
#Configures the FBADC converter sample rate.
sysParams.FadcF   = 2949.12
#Configures the TXDAC converter sample rate.
sysParams.Fdac    = 2949.12*4
#Sets the clock source for the RXADC converters. The source is now from the on-chip PLL.
```

```
sysParams.externalClockRx = False
#Sets the clock source for the TXDAC converters. The source is now from the on-chip PLL.
sysParams.externalClockTx = False
```

4.2.2 Data Rate and JESD Parameters

Data rates in the signal chain are often connected with the JESD mode (LMFS, SerDes rate), and a list of compatible modes are provided in the device data sheet. Use the following parameters in the *bringup.py* script to modify the configuration. Rerun the script after assigning new values to the following parameters.

```
## In below parameters, each element sets the particular LMFS-Hd for the particular channels.
# JESD and Serdes Parameters
sysParams.LMFSHdRx              = ["12410","12410","12410","12410"]
sysParams.LMFSHdFb             = ["24410","24410"]
sysParams.LMFSHdTx             = ["44210","44210","44210","44210"]
# Decimation and interpolation parameters for the data converter signal chains.
sysParams.ddcFactorRx          = [8,8,8,8]
sysParams.ddcFactorFb          = [8,8]
sysParams.ducFactorTx          = [16,16,16,16]
```

4.2.3 Steps to Modify NCO

1. The default AFE7952 EVM has the following RF frequency matching network:
    a. RXA, RXB, FBAB, TXA, and TXB = 7200MHz
    b. RXC, RXD, FBCD, TXC, and TXD = 7200MHz

2. The following script is an example script to change the NCO to match the default RF frequency matching network:

```
## Update RX NCO
afeInst = 0 #AFE Instance of AFE79_INST_TYPE type. If using the EVM this should be 0.
rxChSel = 0 #Value to select the RX chain.Value 0 for RXA to 3 for RXD.
bandNo = 0 #Band number. 0-band0, 1-band1.
ncoNo = 0 #NCO number. 0-NCO0, 1-NCO1.
ncoFreq = 7200#NCO frequency to set the NCO to in MHz.

if sysParams.ncoFreqMode == '1KHz':
    mixer = ncoFreq*1e3 #Should pass value in KHz in 1KHz ncoFreqMode and the frequency word
value in FCW mode.

elif sysParams.ncoFreqMode == 'FCW':
    mixer = int(round(2**32*ncoFreq/sysParams.FadcRx)) #Should pass value in KHz in 1KHz
ncoFreqMode and the frequency word value in FCW mode.

CAFE.updateRxNco(afeInst,rxChSel,mixer,bandNo,ncoNo)
engine.DDCNCOFreqWord=((ncoFreq)%sysParams.FadcRx)/(sysParams.FadcRx)*2**32 #Updating NCO word
in capture window

## Update TX NCO
afeInst = 0 #AFE Instance of AFE79_INST_TYPE type. If using the EVM   this should be 0.
txChSel = 0 #Value to select the TX chain. Value 0 for TXA to 3 for TXD.
ncoNo = 0 #NCO number. 0-NCO0, 1-NCO1.
band0NCO0 = 7200000 #NCO frequency to set the band 0 NCO0 to in KHz.
band1NCO0 = 7200000 #NCO frequency to set the band 1 NCO0 to in KHz.
band0NCO1 = 7200000 #NCO frequency to set the band 0 NCO1 to in KHz.
band1NCO1 = 7200000 #NCO frequency to set the band 1 NCO1 to in KHz.
CAFE.updateTxNcoDb(afeInst,txChSel,ncoNo,band0NCO0,band1NCO0,band0NCO1,band1NCO1)
```

5 Hardware Design Files

5.1 Schematics

Click here for the device schematics.

5.2 PCB Layouts

Click here for the PCB layouts.

5.3 Bill of Materials (BOM)

Click here for the bill of materials.

6 Additional Information

6.1 Status Check and Troubleshooting Guidelines

This section provides a general guideline on the status indicators of the AFE7952 EVM and also the respective troubleshooting guidelines.

6.1.1 AFE7952 EVM Status Indicators

At this point, the green LED D3 is illuminated. D3 indicates that PLL loop 2 of the LMK04828 is locked. Optionally, the LED D4 indicates that PLL loop 1 of the LMK04828 is locked. If there are external equipment providing a 10MHz reference to the LMK04828 for lab equipment synchronization, then this LED D4 must illuminate. The EVM is still functional without PLL loop 1 running, but PLL loop 2 is necessary for a successful bring-up.

- If PLL loop 1 is not running, check the 10MHz reference. The 10MHz reference is necessary to achieve signal coherency with the signal generators and spectrum analyzer.
- If PLL loop 2 is not locked, contact TI applications for additional support.

6.1.2 TSW14J58 EVM

TSW14J58EVM: On the LED strip, TX_Sync and RX_Sync is not illuminated. TX_Active and RX_Active is illuminated. Illumination specifications are necessary requirements for the JESD204B transceiver mode to work. TX_Active flashing indicating the TXDAC JESD204B link is established, while RX_Active flashing indicating the RXADC or FBADC JESD204B link is established.

AFE7952EVM: Enable data transmission on the DAC and data capture on the ADC. Adjust the RXNCO, FBNCO, and TXNCO at this point.

Adjust the RXDSA, FBDSA, and TXDSA at this point.

```
## Set RX DSA
afeInst = 0 #AFE Instance of AFE79_INST_TYPE type. If using the EVM this should be 0.
rxChSel = 0 #Value to select the RX chain.Value 0 for RXA to 3 for RXD.
dsaSetting = 20 #Analog DSA Index. Attenuation applied is   dsaSetting*0.5dB
CAFE.setRxDsa(afeInst,rxChSel,dsaSetting)

## Set TX DSA
afeInst = 0 #AFE Instance of AFE79_INST_TYPE type. If using the EVM this should be 0.
txChSel = 0 #Value to select the TX chain.Value 0 for TXA to 3 for TXD.
dsaSetting = 20 #Analog DSA Index. Attenuation applied is dsaSetting*1dB
CAFE.setTxDsa(afeInst,txChSel,dsaSetting)
```

6.2 Trademarks

Keysight™ is a trademark of Keysight Technologies, Inc..
Rohde & Schwarz™ is a trademark of Rohde & Schwarz GmbH & Co. KG.
USB Type-C® is a registered trademark of USB Implementers Forum.
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7 Revision History

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

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2. *Limited Warranty and Related Remedies/Disclaimers*:

    2.1 These terms 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 a nonconforming EVM if (a) the nonconformity was 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, (b) the nonconformity resulted from User's design, specifications or instructions for such EVMs or improper system design, or (c) User has not paid on time. Testing and other quality control techniques are used to the extent TI deems necessary. TI does not test all parameters of each EVM. User's claims against TI under this Section 2 are void if User fails to notify TI of any apparent defects in the EVMs within ten (10) business days after delivery, or of any hidden defects with ten (10) business days after the defect has been detected.

    2.3 TI's sole liability shall be at its option to repair or replace EVMs that fail to conform to the warranty set forth above, 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.

WARNING

Evaluation Kits 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 shall operate the Evaluation Kit within TI's recommended guidelines and any applicable legal or environmental requirements as well as reasonable and customary safeguards. Failure to set up and/or operate the Evaluation Kit within TI's recommended guidelines may result in personal injury or death or property damage. Proper set up entails following TI's instructions for electrical ratings of interface circuits such as input, output and electrical loads.

NOTE:
EXPOSURE TO ELECTROSTATIC DISCHARGE (ESD) MAY CAUSE DEGREDATION OR FAILURE OF THE EVALUATION KIT; TI RECOMMENDS STORAGE OF THE EVALUATION KIT IN A PROTECTIVE ESD BAG.

3   *Regulatory Notices:*

3.1   *United States*

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

FCC NOTICE: 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 or RSS-247*

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSSs. 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。

https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-delivered-in-japan.html

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 to follow the instructions set forth by Radio Law of Japan, which includes, but is not limited to, the instructions below with respect to EVMs (which for the avoidance of doubt are stated strictly for convenience and should be verified by User):

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.

【無線電波を送信する製品の開発キットをお使いになる際の注意事項】 開発キットの中には技術基準適合証明を受けて

いないものがあります。 技術適合証明を受けていないもののご使用に際しては、電波法遵守のため、以下のいずれかの

措置を取っていただく必要がありますのでご注意ください。

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。

なお、本製品は、上記の「ご使用にあたっての注意」を譲渡先、移転先に通知しない限り、譲渡、移転できないものとします。

上記を遵守頂けない場合は、電波法の罰則が適用される可能性があることをご留意ください。 日本テキサス・イ

ンスツルメンツ株式会社

東京都新宿区西新宿６丁目２４番１号

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

電力線搬送波通信についての開発キットをお使いになる際の注意事項については、次のところをご覧ください。https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-for-power-line-communication.html

3.4 *European Union*

3.4.1 *For EVMs subject to EU Directive 2014/30/EU (Electromagnetic Compatibility Directive)*:

This is a class A product intended for use in environments other than domestic environments that are connected to a low-voltage power-supply network that supplies buildings used for domestic purposes. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

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 MATERIALS PROVIDED WITH THE EVM (INCLUDING, BUT NOT LIMITED TO, REFERENCE DESIGNS 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 EPIDEMIC FAILURE WARRANTY OR 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 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, REGARDLESS OF WHEN MADE, CONCEIVED OR ACQUIRED.

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. 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 OR THE USE OF THE EVMS , 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 TWELVE (12) MONTHS AFTER THE EVENT THAT GAVE RISE TO THE CAUSE OF ACTION HAS OCCURRED.

    8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY USE OF AN EVM PROVIDED HEREUNDER, INCLUDING FROM ANY WARRANTY, INDEMITY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS, , EXCEED THE TOTAL AMOUNT PAID TO TI BY USER FOR THE PARTICULAR EVM(S) AT ISSUE DURING THE PRIOR TWELVE (12) MONTHS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM 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.

IMPORTANT NOTICE AND DISCLAIMER