User's Guide
SLAU706A–January 2017–Revised September 2017

TSW40RF8x Evaluation Module

This user's guide describes the characteristics, operation, and use of the TSW40RF80 and TSW40RF82 Evaluation Module (EVM). A complete schematic diagram, printed-circuit board layouts, and bill of materials are included in this document.

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Trademarks

1 Introduction

1.1 Overview

The TSW40RF8x EVM is a 2T2R RF sampling solution. The board includes the dual 9-GSPS DAC (DAC38RF8x) and a dual, 14-bit, 3-GSPS ADC (ADC32RF45). The TSW40RF80 uses the DAC38RF80 device with integrated balun and the TSW40RF82 uses the DAC38RF82 device with differential output. The board includes the required clocking solution needed for sampling the data converters.

1.2 EVM Block Diagram

Figure 1 shows the configuration of the EVM.

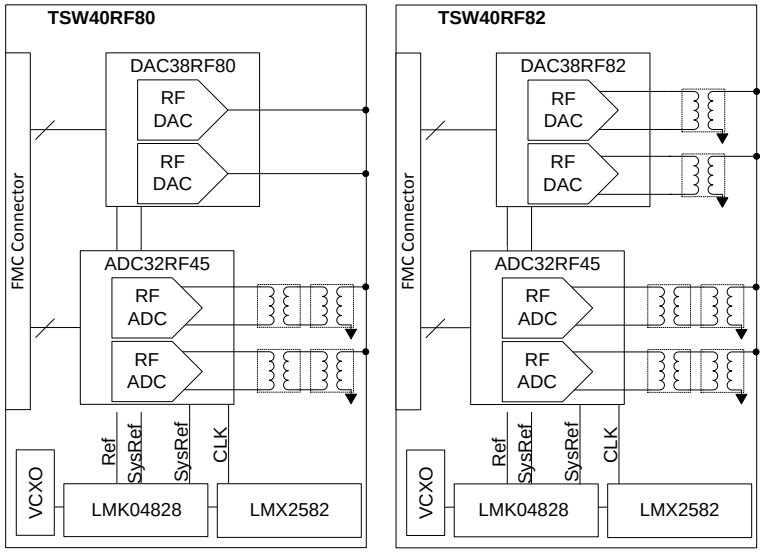


Figure 1. EVM Block Diagram

2 Software Control

2.1 Installation Instructions

Use the following instructions to install the software:

- Open the folder named: TSW40RF8x GUI Installer
- Run *Setup.exe*
- Follow the on-screen instructions

3 Basic Set-Up

3.1 Test Block Diagram

Figure 2 shows the test set-up for general testing of the TSW40RF8x EVM.

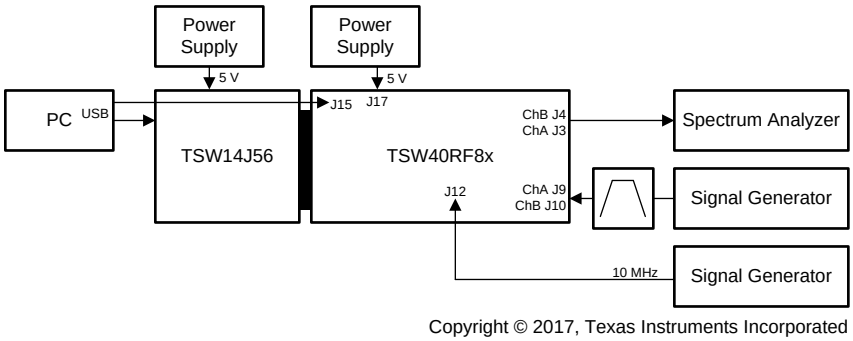


Figure 2. Test Set-Up Block Diagram

3.2 Test Set-Up

The following steps describe the test set-up procedures:

1. Connect the TSW40RF8x EVM to the TSW14J56 EVM
2. Connect a 5-V supply to the power supply jack

NOTE: Set the current limit to 4.0 A. A 5-V supply with 4-A current capability is required.

3. Connect a 10-MHz signal to J12 at 10 dBm
4. Connect the USB cable to the programming computer
5. Connect an RF cable from J3 to the *Spectrum Analyzer*. Compensate for the cable loss in the *Reference Level Offset* parameter of the instrument.
6. *Spectrum Analyzer* set up:

- Set center frequency to: 1960 MHz
- Set frequency span to: 50 MHz
- Ref Level: approximately 0 dBm
- Set Reference Level Offset: RF output cable loss
- RBW: 300 kHz
- VBW: 3 kHz
- Attn: 10 dB

7. Connect the signal generator through BPF and into J9 for the RX

- Set the frequency to: 1960 MHz
- Set amplitude to: 10 dB

4 Quick Start Procedure

4.1 Initial Configuration and DAC Output

Use the following for initial configuration and DAC output:

- Engage the 5-V supply; the initial current should be 1.6 ±0.2 A
- Launch the TSW40RF8x EVM GUI:
  - Go to **Start** → **Texas Instruments** → **TSW40RF8x GUI**

    NOTE: USB connection is possible only when the power is engaged to the board.
  - If needed, press the **Connect FTDI?** button to establish the USB connection; pressing this button multiple times may be necessary to get it to engage
- Select the *DAC38RF8x* tab → *Quick Start* tab
- Press the **LOAD DEFAULT** button

  NOTE: This loads the file:
  2T2R_RevC_ConstInput_12xDec_18xInt_2949p12M_4915p2Gb.cfg

  This also loads the proper registers but does not back-fill the values to the *ADC* tab front panel. To complete this task go to *Low Level* tab and press the *Read All* icon.

  Read All does not back-fill the DAC NCO frequency value. If desired, manually go to the *DAC38RF8x* tab → *DAC38RF8x* tab → *Digital(DAC A/B)* to change *NCO Frequency(MHz)* to: 1960.

  Read All does not load the actual ADC NCO frequency (the NCO value is loaded). To see the frequency go to ADC32RFxx tab → ADC32RFxx tab → DDC Configuration tab. Place cursor in the numerical value and hit a space then enter; the NCO frequency is then calculated.

  This file engages the DAC constant input feature to easily see an output tone without pattern generation; this must be disengaged when sending a digital pattern to the DAC.
- Press the **PLL AUTO TUNE** button
- Verify:
  - LED D4 and D5 illuminate
  - 5-V supply current increases to 3.6 ±0.4 A
- Verify tone output on the spectrum analyzer exists at 1960 MHz at:
  - TSW40RF80: –2 ±2 dBm
  - TSW40RF82: 0 ±2 dBm

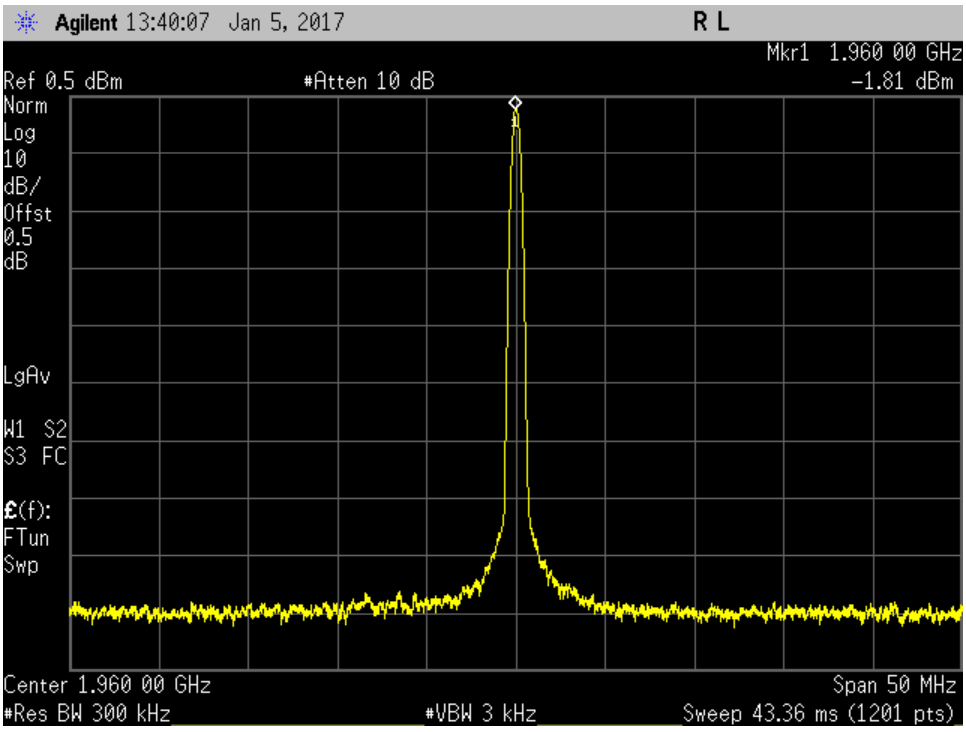


Figure 3. DAC Output Spectrum

4.2 ADC Output

Use the following to set ADC Output:

- Launch *High-Speed Data Converter Pro* (HSDC Pro) version 4.2, or later
- Load the ini file: ADC32RF80_LMF_8821.ini
  - Confirm *yes* to load firmware
- Change to *Complex FFT*
- Change to *Channel 1/8*
- Toggle the ADC Output Setup icon
  - Click *Enable?* and *Remember for this session*
  - Change the ADC Sampling rate to: 2949.12M
  - Change the ADC Input Frequency to: 1960M
  - Change NCO to: –1890M
  - Change Decimation to: 12
  - Press the **OK** button
- Press the **Capture** button
- Verify that LED D4 on TSW14J56 is blinking
- Verify tone capture in HSDC Pro similar to Figure 4

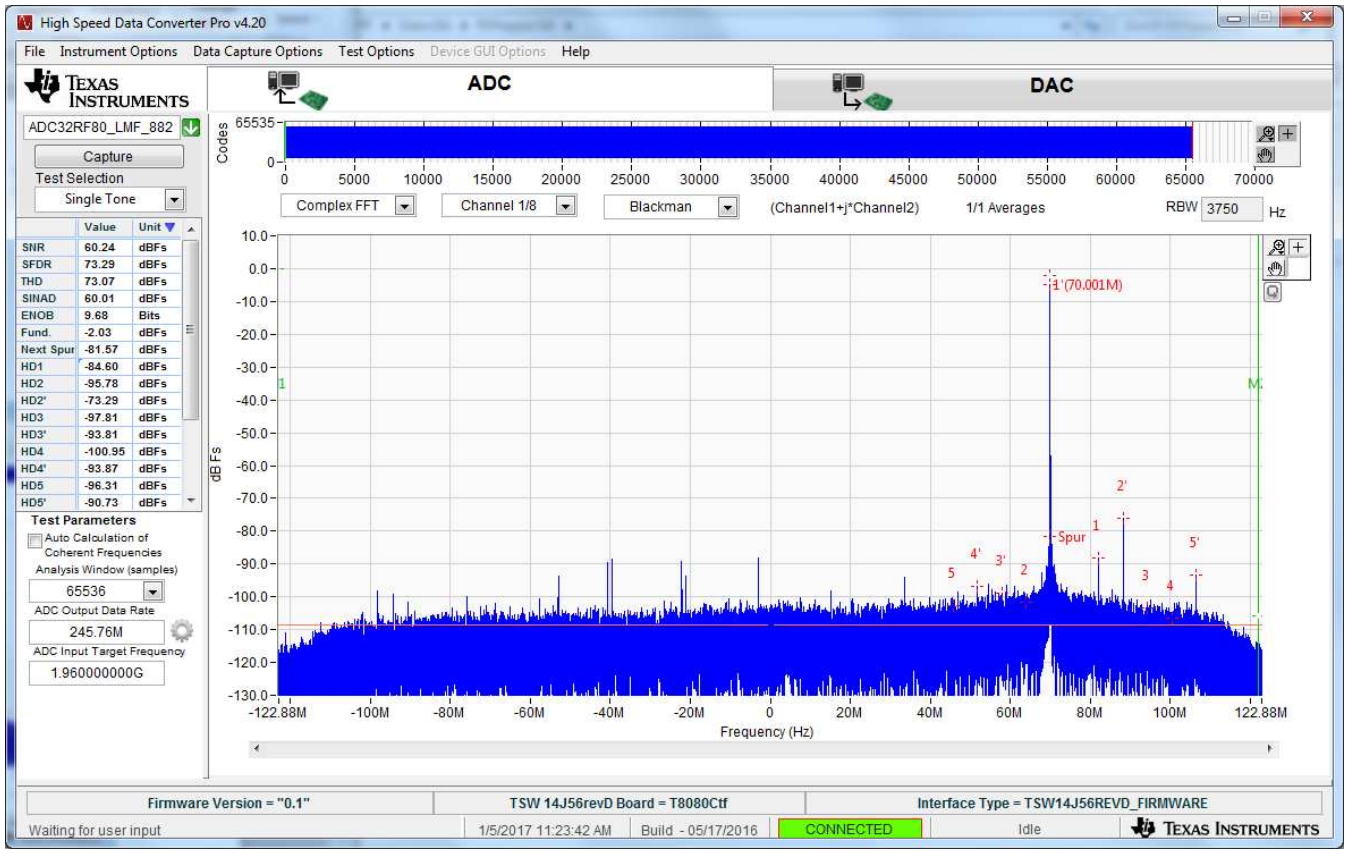


Figure 4. Captured Output Tone

5 Optional Modes and Information

5.1 Software Manipulation

This section includes directions for software manipulation:

5.1.1 Enter ADC NCO Adjustment

- Select the *ADC32RFxx* tab → *ADC32RFxx* tab → *DDC Configuration* tab
- Adjust NCO frequency values as desired, and press enter; this will calculate the closest NCO numerical value
- Place the cursor in the NCO numerical value, press the *space* bar then press the *Enter* key; this will calculate the **exact** NCO frequency value.

5.1.2 DAC NCO Adjustment

- Select the *DAC38RF8x* tab → *DAC38RF8x* tab → *Digital(DACA/B)* tab
- Change the desired NCO value at: *NCO → NCO Frequency(MHz)* (for example, 1960)
- Select *Update NCO*

5.2 DAC Pattern Generation

DAC pattern generation is set up with the following:

- Select the *DAC38RF8x* tab → *DAC38RF8x* tab → *Digital(DACA/B)* tab
  - Un-select *Constant input*
- Select the *DAC* tab on the HSDC Pro Software
- Load: DAC38RF8x_LMF_841_RevD.ini
- Change *Data Rate (SPS)* to: 491.52M
- Change the *DAC Option* to: 2's Compliment
- Modify *I/Q Multitone Generator*
  - Set Tone BW to: 1
  - Set # to: 1
  - Set Tone Center to: 0
  - Set the *Tone Selection* to: Complex
  - Press the **Create Tones** button
- Press the **Send** button; click **OK** if a window pops up
- Verify:
  - LED D2 on the TSW14J56 flashes
  - The tone output located at NCO frequency value (for example, 1960 MHz)
    - The **Reset DAC JESD Core & SYSREF TRIGGER** button in the *DAC38RF8x* tab → *Quick Start* tab may need to be pressed

5.3 HSDC Pro ini Files

HSDC Pro ini files are discussed in this section:

5.3.1 Transceiver Mode

- Transceiver mode allows TX and RX to operate simultaneously
- Transceiver mode is enabled when Transceiver Mode = 1 in the ini file for both DAC and ADC ini files
- Transceiver mode is limited to SerDes speeds of 5 Gbps or less

5.3.2 ini File Modification

- DAC ini files are the same as used by the DAC38RF8x EVM; modify parameter Transceiver Mode = 1 for transceiver mode, if desired.
- ADC ini files are the same as used by ADC32RFxx EVM; modify parameter Transceiver Mode = 1 for transceiver mode, if desired.

5.4 ADC Clocking Options

Use the following steps for ADC clocking options:

1. Default clock mode: JP3, JP7, JP8 = [111]
   - LMX2582 is the clock source for the ADC
2. LMK Clock: JP3, JP7, JP8 = [131]
   - Add jumper at JP5 to disable the LMX device
   - LMX04028 serves as ADC clock source
3. DAC Output Clock: JP3, JP7, JP8 = [311]
   - Divided down RF DAC output clock used as ADC input clock
   - Add jumper at JP5 to disable the LMX device
   - Modify DAC clock output
     – Select *DAC38RF8x* tab → *DAC38RF8x* tab → *Clocking* tab
     – Verify the *CLKTX* divider is set to: /3
     – Set *Peak to Peak Swing* to maximum: 1.4V
     – Un-select the *Sleep* check box
4. External clock: JP3, JP7, JP8 = [113]
   - Feed external clock at J8
   - Add jumper at JP5 to disable the LMX device

5.5 DAC External Clocking Options

The DAC clock may be injected from an outside source.

NOTE: The DAC SysRef is still generated from the LMK so it must be set up properly for the desired clock frequency.

- Inject external DAC clock at J1; set amplitude to 10 dBm, or greater.
- Modify the GUI on *DAC38RF8x* tab → *DAC38RF8x* tab → *Clocking*
  – Check *External Clock Select* to engage *Single-Ended* clock input
  – Un-check *DAC PLL Settings* → *PLL Enable*

5.6 Alternative Configuration File Options

Table 1 and Table 2 describe the available pre-created configuration file options. Check the TSW40RF8xEVM product page for updated configuration files if desired.

Table 1. Configuration File Name

File #	File Name
1	2T2R_RevC_ConstInput_12xDec_18xInt_2949p12M_4915p2Gb.cfg
2	2T2R_RevC_ConstInput_8xDec_12xInt_2949p12M_7372p8Gb.cfg
3	2T2R_RevC_ConstInput_12xDec_24xInt_2949p12M_5898p2_2IQ_4915p2Gb.cfg
4	2T2R_RevC_ADC-BypassLMFS82820_18xInt_2949p12.cfg
5	2T2R_RevC_ADC-Bypass-82820_DAC-Int18x-8847p36M_TxClkOut-Div3.cfg
6	2T2R_RevC_ConstInput_12xDec_18xInt_2949p12M_4915p2Gb_TXClkOut-Div3.cfg
7	2T2R_RevC_ConstInput_12xDec_12xInt_2949p12M_5898p2_4915p2Gb.cfg
8	2T2R_RevC_ConstInput_6xDec_18xInt_2949p12M_4915p2Gb_2ndNyquist.cfg
9	2T2R_RevC_ConstInput_6xDec_12xInt_2949p12M_5898p2_4915p2Gb.cfg
10	2T2R_RevC_ConstInput_4xDec_12xInt_2949p12M_7372p8G.cfg

Table 2. Configuration File Description

File #	TCVR Mode	DAC Clock [MHz]	I/Q Paths	Int	NCO [MHz]	Const Input	Mode	ADC Clock [MHz]	ADC Clock Source	Dec	NCO [MHz]
1	Yes	8847.36	1	18	1960	Yes	DDC	2949.12	LMX	12	1890
2	No	8847.36	1	12	1960	Yes	DDC	2949.12	LMX	8	1890
3	Yes	5898.24	2	24	1960	Yes	DDC	2949.12	LMX	12	1890
4	No	8847.36	1	18	1960	Yes	Bypass	2949.12	LMX	-	-
5	No	8847.36	1	18	1960	Yes	Bypass	2949.12	DAC	-	-
6	Yes	8847.36	1	18	1960	Yes	DDC	2949.12	DAC	12	1890
7	Yes	5898.24	1	12	1960	Yes	DDC	2949.12	LMX	12	1890
8	Yes	8847.36	1	18	1960	Yes	DDC	2949.12	LMX	6	1890
9	Yes	5898.24	1	12	1960	Yes	DDC	2949.12	LMX	6	1890
10	No	8847.36	1	12	1960	Yes	DDC	2949.12	LMX	4	1890

5.7 Manual Software Adjustment

In general, the GUI software operates similar to the individual GUIs of the DAC38RF8x EVM and the ADC32RFxx EVM. It is possible to operate in a manual mode following the procedure of the RF DAC and RF ADC respectively; however, there are a few minor differences.

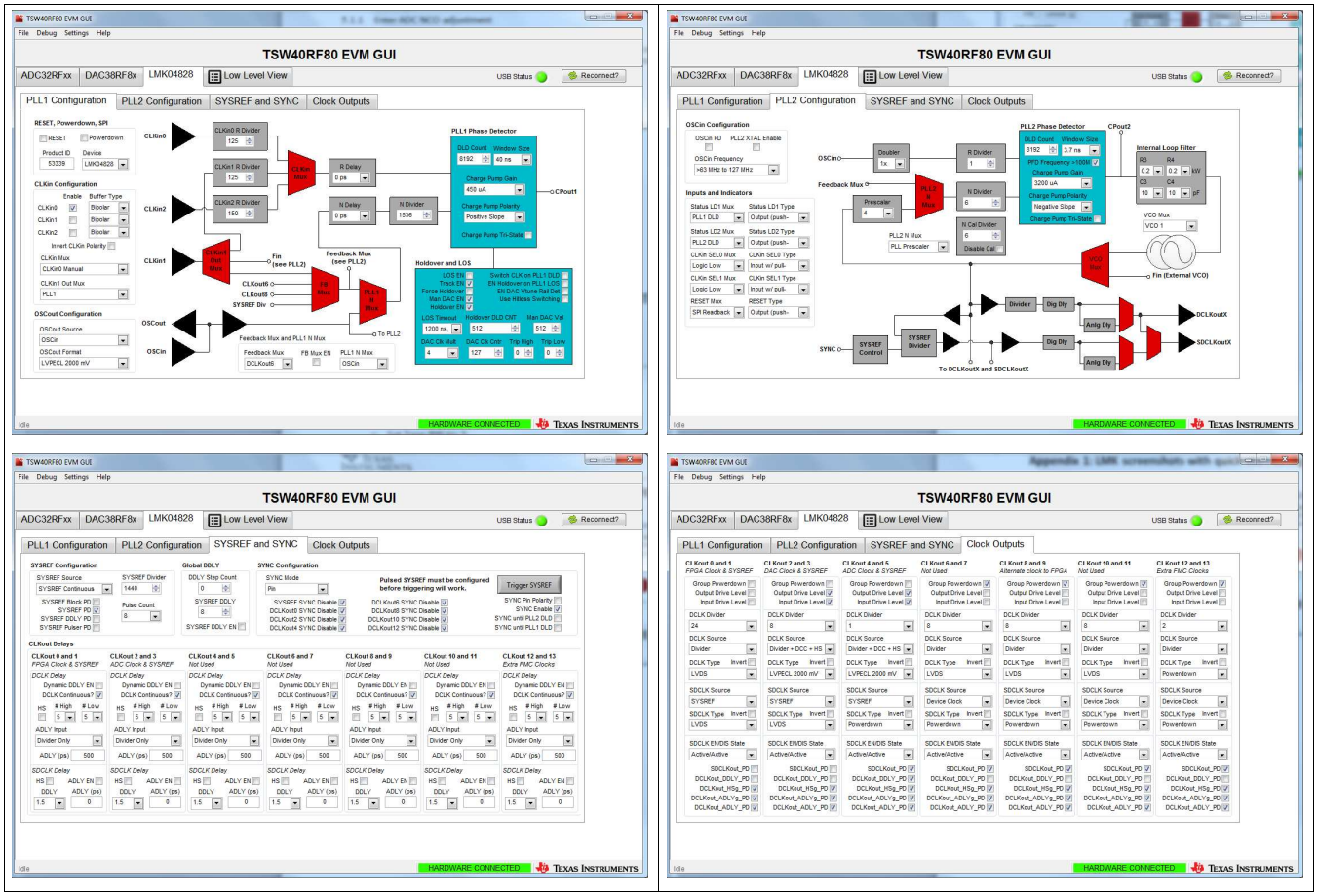
5.7.1 RF DAC Set-Up Conditions

The DAC PLL reference frequency is derived from the LMK VCO divided down outputs. This is the only way to provide this reference; there is no option for external PLL reference.

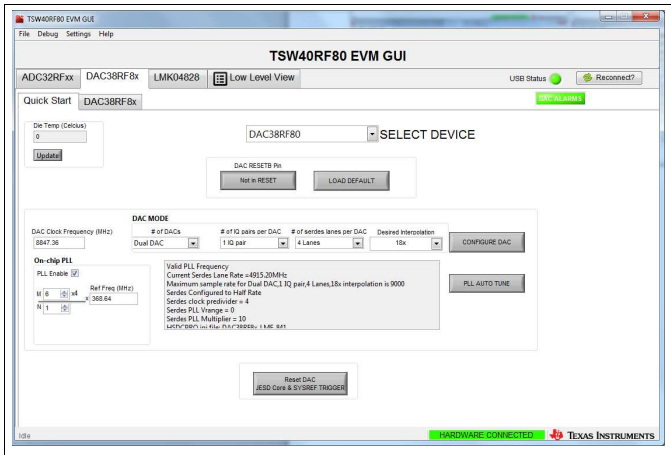
5.7.2 RF ADC Set-Up Conditions

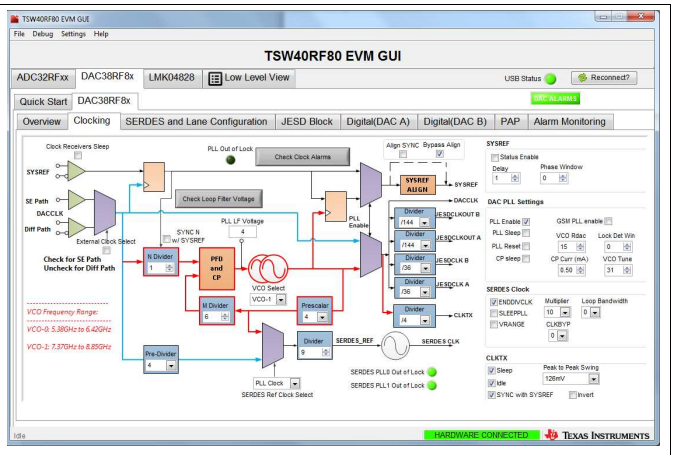
- ADC SysRef is generated through the LMK device so its VCO must be set to the desired clocking frequency.
- Clock divider for the FPGA is calculated based on SerDes rate of the DAC.

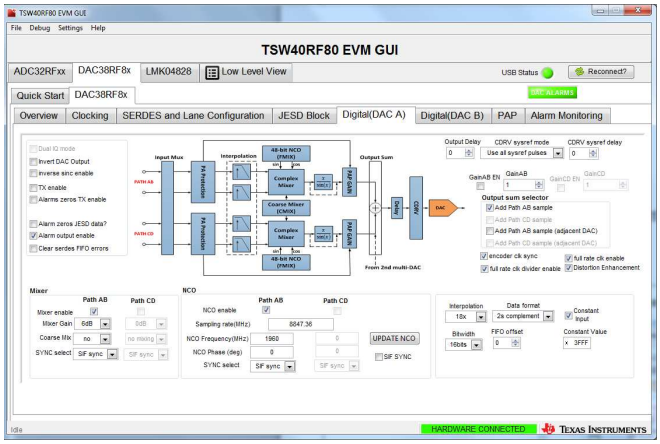
LMK Screen Shots With Quick-Start Configuration

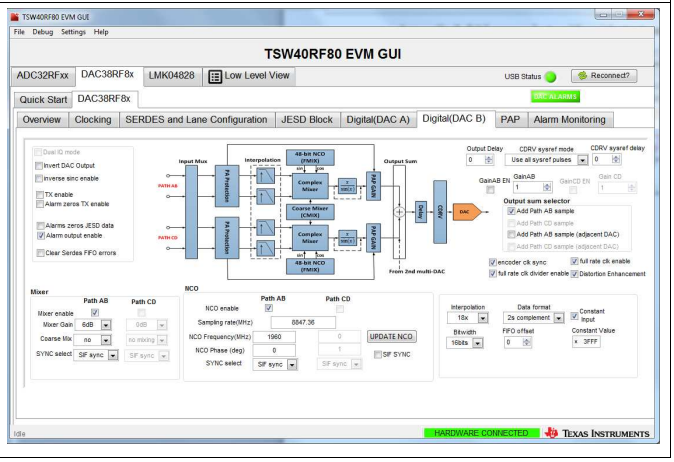


DAC Screen Shots With Quick-Start Configuration

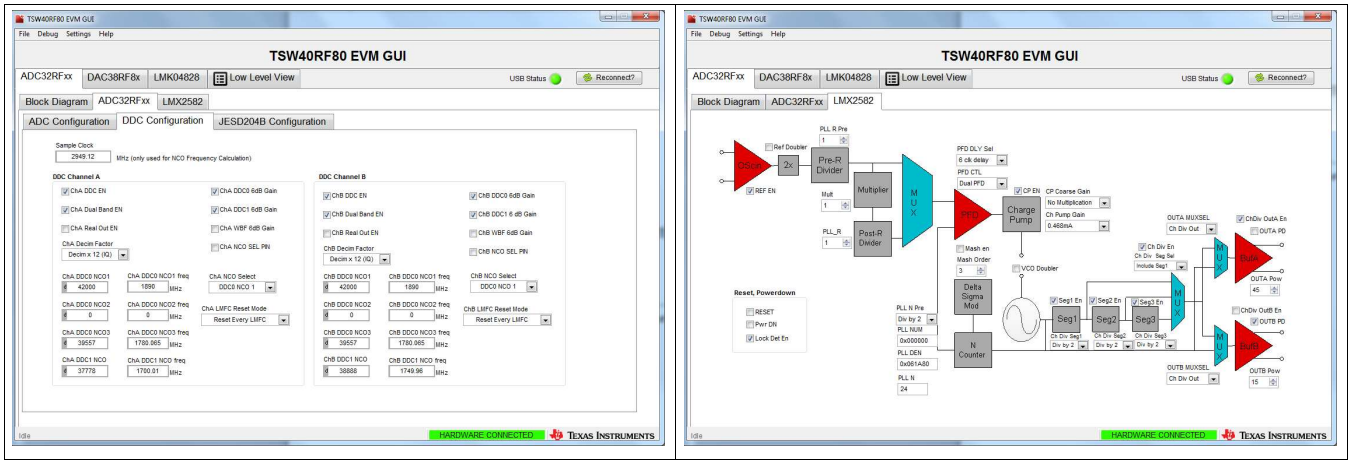




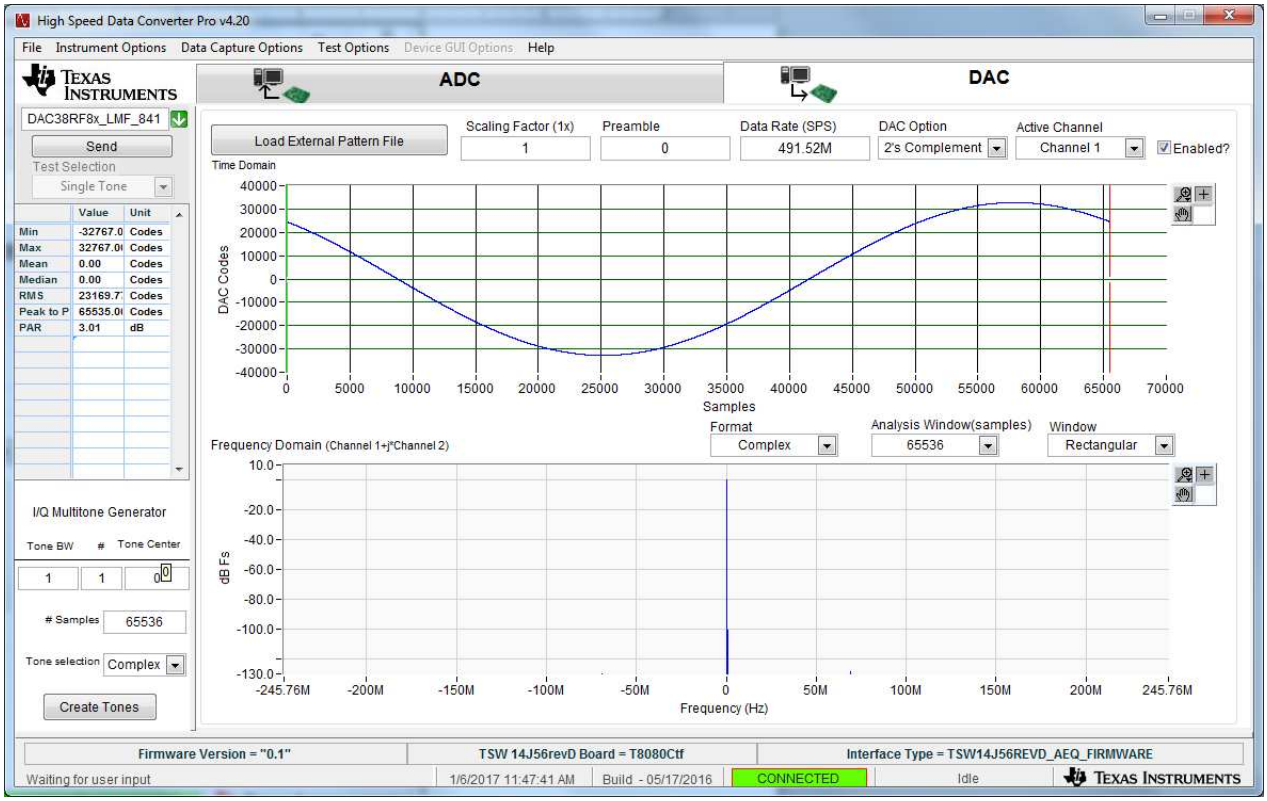


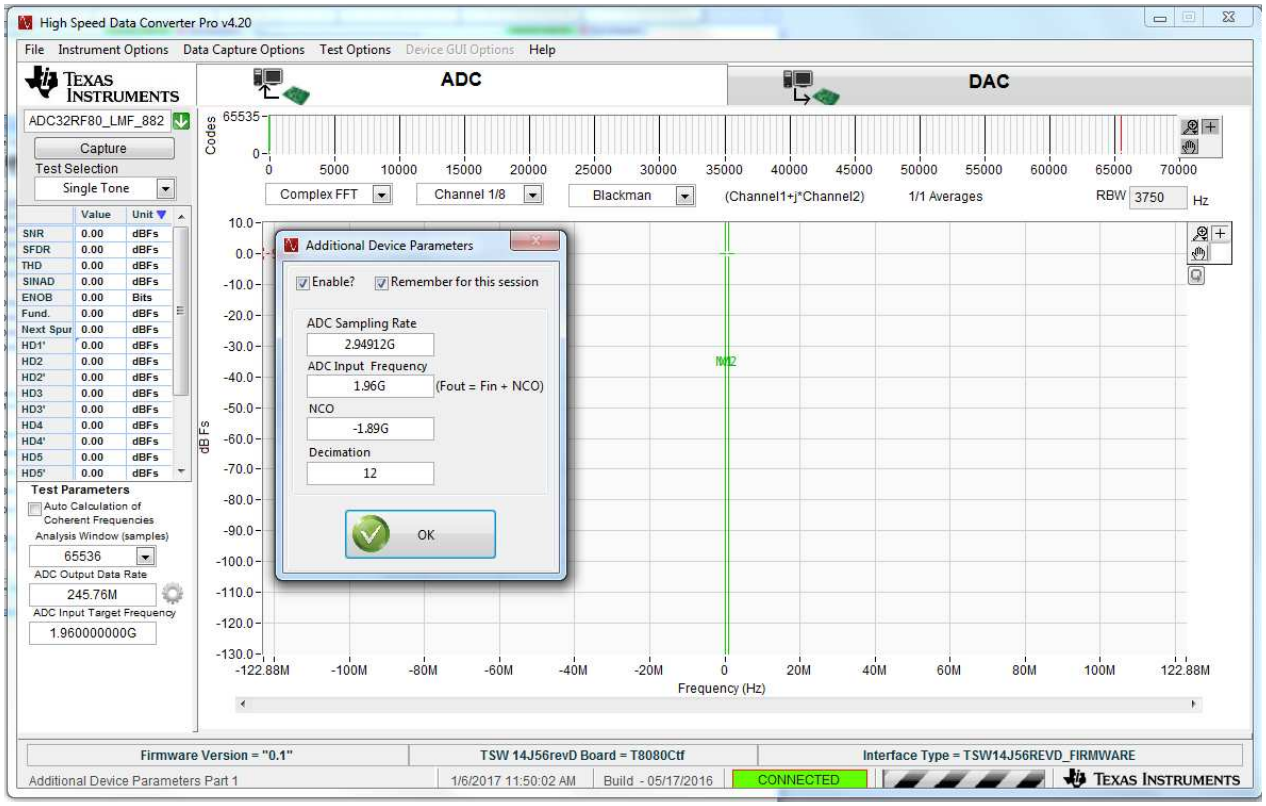


ADC Screen Shots With Quick-Start Configuration



HSDC Pro Screen Shots With Quick-Start Configuration





Revision History

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

Changes from Original (January 2017) to A Revision	Page
• Added support for the TSW40RF82 EVM throughout the document.	1

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      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。
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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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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。http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page

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.

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