ADC117x Evaluation Module

This user's guide describes the function and use of the ADC117x evaluation module (EVM). Included in this document are a quick-start guide, jumper and connector descriptions, software description, and alternate hardware configurations.

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1 Overview

The ADC117xEVM is designed to evaluate the ADC1173, ADC1175, and ADC1175-50. The EVM provides simple and minimal external components to reduce system cost and power consumption.

The following features apply to this EVM:

- 8-bit, low-cost, low-power, high-speed CMOS interface ADC117x data converter
- Onboard oscillator or external source for sampling clock
- User-programmable, low-dropout (LDO) voltage regulator
- Level-shifting data buffer for ADC CMOS output

The ADC117xEVM is designed to work seamlessly with the TSW1400EVM, TI's CMOS and LVDS pattern generator and data-capture board.

1.1 Required Hardware

The following equipment is **included** in the EVM kit:

- ADC117xEVM
- Standard banana jack power supply cables

The following list of equipment are items that are **not included** in the EVM kit, but are items required for optimal evaluation of this product:

- *TSW1400EVM Data Capture Board*, 5-VDC cable connector, and mini-USB cable
- Personal computer running Microsoft® Windows® XP or later.
- One low-noise signal generator. Recommendations:
  - RF generator, > +17 dBm, < −40 dBc harmonics, < 500 fsec jitter 20 kHz–20 MHz, 1-MHz to 2-GHz frequency range
  - Examples: HP HP8644B, Rohde & Schwarz SMA100A
- DC power supply. Recommendations:
  - Power supply, 0–6 VDC, > 3 A
  - Examples: Agilent E363A or equivalent
- Band-pass filter for desired analog input. Recommendations:
  - Filter, ≥ 60-dB harmonic attenuation, ≤ 5% bandwidth, > +18-dBm power, < 5-dB insertion loss
  - Examples: Trilithic 5VH-series Tunable BPF, K&L BT-series Tunable BPF, TTE KC6 or KC7-series Fixed BPF
- Signal path cables, SMA or BNC with BNC-to-SMA adapters

1.2 Required Software

The following software is required to operate the TSW1400EVM and is available online. See Section 6 for links.

- *High-Speed Data Converter Pro* (HSDC Pro)

1.3 EVM Features and Jumpers

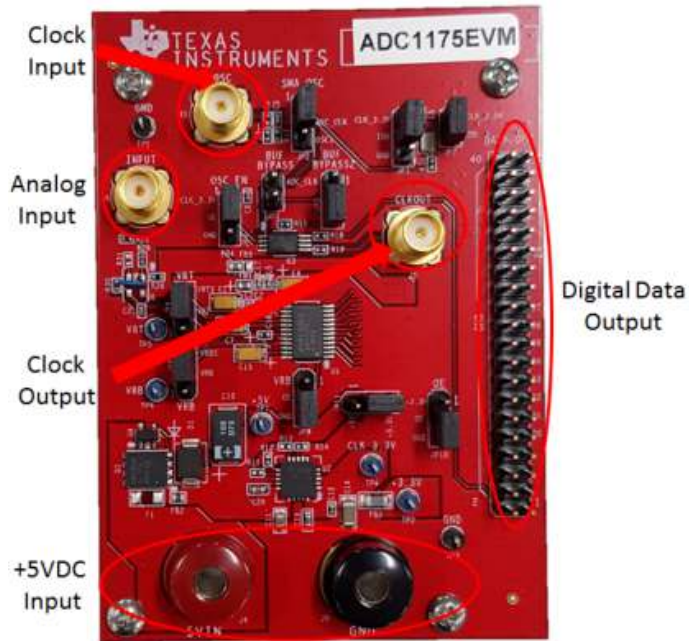Figure 1 shows the EVM features and Figure 2 shows the EVM jumper locations.
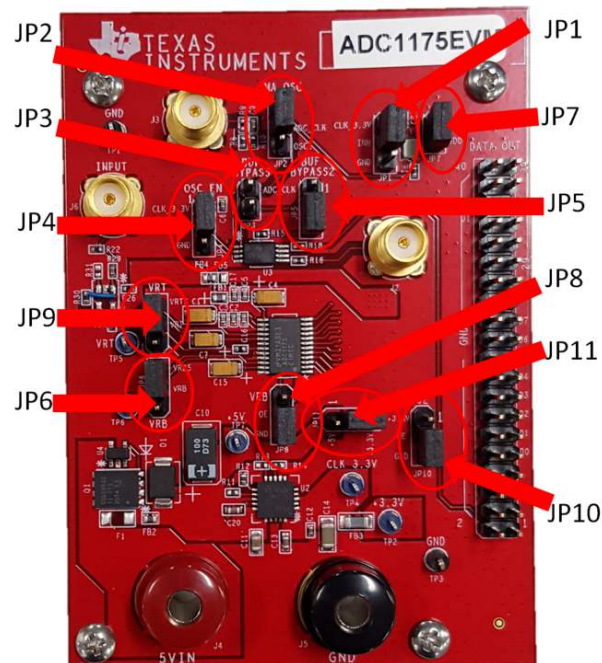

Figure 1. EVM Feature Identification

Figure 2. EVM Jumper Identification

2   Quick-Start Guide

This section details the EVM test procedure to obtain a valid data capture from the ADC117xEVM using the TSW1400EVM capture card and HSDC Pro. This should be the starting point for all evaluations.

2.1   Software Installation

HSDC Pro must be installed before beginning the evaluation. See Section 1.2 for a list of the required software. Section 6 contains links to find the software on the TI website.

1. Download HSDC Pro from the TI website. The References section of this document contains the link to find the software on the TI website.
2. Extract the files from the zip file.
3. Run *setup.exe* and follow the installation prompts.

2.2   Hardware Setup Procedure

Figure 3 shows a typical test setup using the ADC117xEVM and the TSW1400EVM. This is the test setup used for the quick-start procedure. The rest of the section describes the hardware setup steps for each variant of the ADC117xEVM.
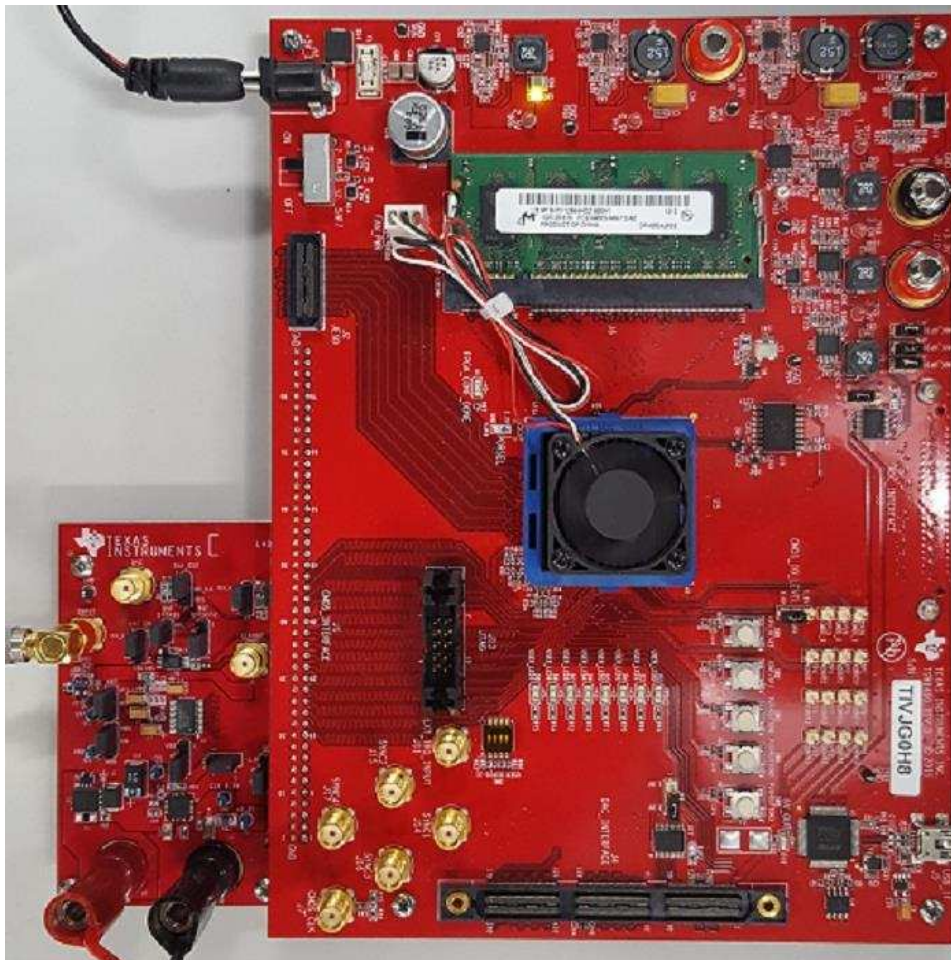

Figure 3. Typical Test Setup Using ADC117xEVM and TSW1400EVM

2.2.1 TSW1400EVM Setup

Set up the TSW1400EVM using the following steps:

1. Connect the ADC117xEVM to the TSW1400EVM connecting pin 1 of the CMOS_INTERFACE (J1) to pin 1 of ADC117xEVM output data (J1).
2. Connect the power cable to connector J12 (5 V IN) to the TSW1400EVM.
3. Connect the mini-USB cable to the USB connector (J5).
4. Turn on the power supply. Flip the power switch (SW7) to the ON position.

This setup procedure is performed for each variant of the ADC117xEVM.

2.2.2 ADC1173EVM Setup

Set up the ADC1173EVM using the following steps:

1. Connect the banana jack power-supply cables to the EVM. Connect the red wire to +5 VDC of a power supply, rated for at least 3 A, and to J4.Connect the black wire to J5 and to GND of the power supply.
2. Turn on the power supply.
3. Ensure JP2 is shunted to the 1-2 position to provide a 15-MHz clock signal to the ADC and CMOS interface. To use an external clock source, provide an external 15-MHz, 1-dBm, clock signal to J3. Shunt jumper JP2 to the 2-3 position.
4. Set the analog input signal generator to 4.44 MHz, +7 dBm.
5. Place a 4-MHz band-pass filter at the output of the analog input signal generator to reduce noise and harmonics.
6. Connect the output of the band-pass filter to the analog input at J6.

2.2.2.1 ADC1173EVM Evaluation

Use the following steps for ADC1173EVM evaluation:

1. Launch HSDC Pro by going to *Start Menu → All Programs → Texas Instruments → High Speed Data Converter Pro.*
2. A prompt appears showing the TSW1400EVM as a connection. Click *OK.*
3. A dialog box informs you that there is no firmware loaded, click on the *Select ADC* box and choose *ADC1173_cmos.* Select *Yes* when prompted to update the firmware.
4. Once the firmware has been loaded, enter "15M" in the *ADC Output Data Rate* field, and push enter on the keyboard.
5. Click the *Capture* button. The results of the captured data should look like that of Figure 4, and the performance should be similar to that of Table 1.

> **NOTE:** After performing the capture, ensure that the amplitude of the analog input signal is –1 dBFS or lower.
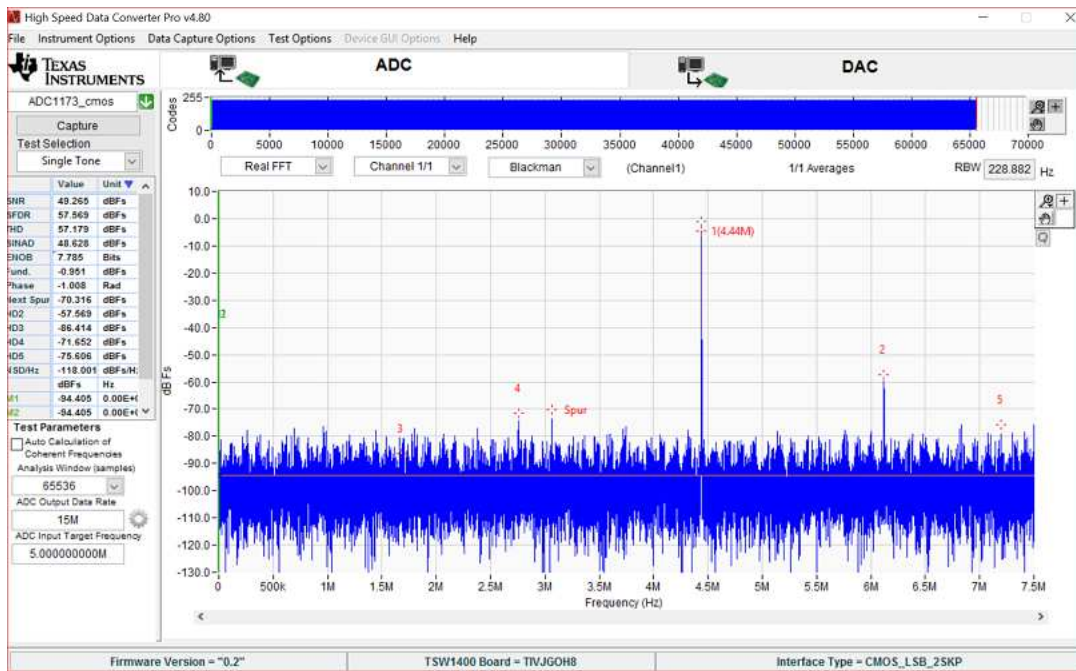
Figure 4. ADC1173 Data Capture Using the HSDC Pro GUI

Table 1. Quick-Start Measurements for ADC1173

Result	Measured Value	Units
SNR	48	dBFS
SFDR	55	dBFS

2.2.3 ADC1175EVM Setup

See Section 2.2 if the TSW1400EVM is not set up.

Set up the ADC1175EVM using the following steps:

1. Connect the banana jack power-supply cables to the EVM. Connect the red wire to +5 VDC of a power supply, rated for at least 3 A, and to J4.Connect the black wire to J5 and to GND of the power supply.
2. Turn on the power supply.
3. Ensure JP2 is shunted to the 1-2 position to provide a 20-MHz clock signal to the ADC and CMOS interface. To use an external clock source, provide an external 20-MHz, 1-dBm, clock signal to J3. Shunt jumper JP2 to the 2-3 position.
4. Set the analog input signal generator to 4.9 MHz, +10 dBm.
5. Place a 5-MHz band-pass filter at the output of the analog input signal generator to reduce noise and harmonics.
6. Connect the output of the band-pass filter to the analog input at J6.

2.2.3.1 ADC1175EVM Evaluation

Use the following steps for ADC1175EVM evaluation:

1. Launch HSDC Pro by going to *Start Menu → All Programs → Texas Instruments → High Speed Data Converter Pro.*
2. A prompt appears showing the TSW1400EVM as a connection. Click *OK*.
3. A dialog box informs you that there is no firmware loaded, click on the *Select ADC* box and choose

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ADC1175_cmos. Select *Yes* when prompted to update the firmware.

4. Once the firmware has been loaded, enter "20M" in the *ADC Output Data Rate* field, and push enter on the keyboard.
5. Click the *Capture* button. The results of the captured data should look like that of Figure 5, and the performance should be similar to that of Table 2.

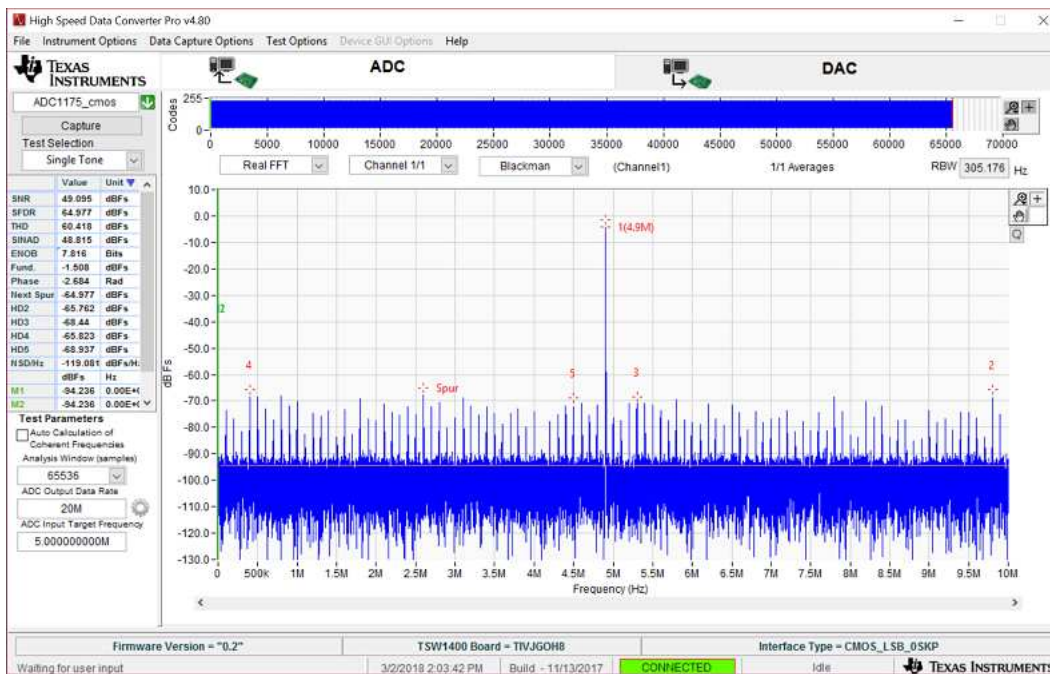NOTE: After performing the capture, ensure that the amplitude of the analog input signal is –1 dBFS or lower.

Figure 5. ADC1175 Data Capture Using the HSDC Pro GUI

Table 2. Quick-Start Measurements for ADC1175

Result	Measured Value	Units
SNR	46	dBFS
SFDR	53	dBFS

2.2.4   ADC1175-50EVM Setup

See Section 2.2 if the TSW1400EVM is not set up.

Set up the ADC1175-50EVM using the following steps:

1. Connect the banana jack power-supply cables to the EVM. Connect the red wire to +5 VDC of a power supply, rated for at least 3 A, and to J4.Connect the black wire to J5 and to GND of the power supply.
2. Turn on the power supply.
3. Ensure JP2 is shunted to the 1-2 position to provide a 20-MHz clock signal to the ADC and CMOS interface. To use an external clock source, provide an external 20-MHz, 1-dBm, clock signal to J3. Shunt jumper JP2 to the 2-3 position.
4. Set the analog input signal generator to 5 MHz, +10 dBm.
5. Place a 5-MHz band-pass filter at the output of the analog input signal generator to reduce noise and harmonics.

6. Connect the output of the band-pass filter to the analog input at J6.

2.2.4.1 ADC1175-50EVM Evaluation

Use the following steps for ADC1175-50EVM evaluation:

1. Launch HSDC Pro by going to *Start Menu → All Programs → Texas Instruments → High Speed Data Converter Pro.*

2. A prompt appears showing the TSW1400EVM as a connection. Click *OK.*

3. A dialog box informs you that there is no firmware loaded, click on the *Select ADC* box and choose *ADC1175-50_cmos*. Select *Yes* when prompted to update the firmware.

4. Once the firmware has been loaded, enter "50M" in the *ADC Output Data Rate* field, and push enter on the keyboard.

5. Click the *Capture* button. The results of the captured data should look like that of Figure 6, and the performance should be similar to that of Table 3.

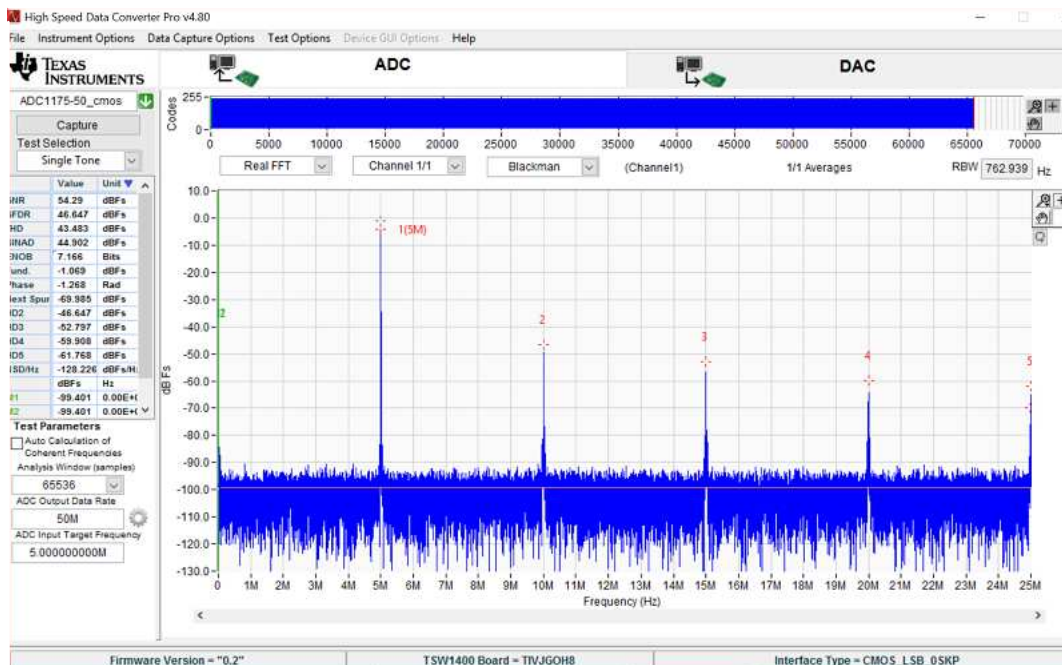> **NOTE:** After performing the capture, ensure that the amplitude of the analog input signal is –1 dBFS or lower.

Figure 6. ADC1175-50 Data Capture Using the HSDC Pro GUI

Table 3. Quick-Start Measurements for ADC1175-50

Result	Measured Value	Units
SNR	44	dBFS
SFDR	51	dBFS

3   Evaluation Optimization

3.1   Clocking Optimization

The sampling clock provided to the ADC needs to have very low phase noise to achieve optimal results. The default EVM configuration uses a crystal oscillator to generate the sampling clock. Another option to improve the clock noise performance is bypassing the onboard clock in favor of an external clock. The clock must have very low noise and must use an external narrow pass-band filter to achieve optimal noise performance.

3.2   Coherent Input Source

A *Rectangular* window function can be applied to the captured data when the sample rate and the input frequency are set precisely to capture an integer number of cycles of the input frequency (sometimes called coherent frequency). This may yield better SNR results. The clock and analog inputs must be frequency locked (such as through 10-MHz references) in order to achieve coherency.

3.3   HSDC Pro Settings

HSDC Pro has some settings that can help improve the performance measurements. These are highlighted in Table 4.

Table 4. HSDC Pro Settings for Optimizing Results

HSDC Pro Feature	Description
Analysis Window (Samples)	Selects the number of samples to include in the selected test analysis. Collect more data to improve frequency resolution of Fast-Fourier Transform (FFT) analysis. If more than 65,536 samples are required, increase the setting in the Data Capture Options to match this value.
Data Windowing Function	Select the desired windowing function applied to the data for FFT analysis. Select Blackman when sampling a non-coherent input signal or Rectangle when sampling a coherent input signal.
Test Options → Notch Frequency Bins	Select bins to be removed from the spectrum and back-filled with the average noise level. May also customize which Harmonics and Spurs are considered in SNR and THD calculations and select the method for calculating spur power.
Test Options → Bandwidth Integration Markers	Enable markers to narrow the Single-Tone FFT test analysis to a specific bandwidth.
Data Capture Options → Capture Options	Configure the number of contiguous samples per capture (capture depth). May also enable Continuous Capture and FFT Averaging

4   Alternate Hardware Configurations

This section describes alternate hardware configurations in order to achieve better results or to more closely mimic the user's system configuration.

4.1   Clocking Options

The default clocking mode uses an onboard oscillator, and clock splitter, to generate the ADC sampling clock and FPGA clocks.

4.1.1   External Clock

To use an external source to provide the clock signal, shunt JP2 (2-3) and remove the jumper on JP7. Connect the external clock source to J3.

4.1.2   Clock Splitter Bypass

The clock splitter, U3, receives the clock signal, from the either the onboard oscillator or external source, and then distributes the clock to the ADC and the FPGA. If desired, the clock splitter signal to the ADC can be bypassed by shunting JP3 (1-2) and JP5 (1-3).

4.2 Voltage Reference Options

The default reference voltage is set by tying both VRT and VRTS (the upper reference voltage limit), and VRB and VRBS (the lower reference voltage limit), to ground via JP6 (shunt 2-3) and JP9 (shunt 2-3). This configuration provides ADC reference voltages of 1.56 V to 0.36 V for the ADC1173EVM and 2.6 V to 0.6 V for the ADC1175EVM and ADC1175-50EVM.

> **NOTE:** The analog input op amp (OPA830) has been set to provide a known DC offset (0.96 V for the ADC1173EVM and 1.6 V for the ADC1175EVM and ADC1175-50EVM). Modifying the reference voltages will require modifying the DC offset to ensure that the analog input signal is within the bounds of the references.

4.2.1 External Voltage Reference

An external voltage reference can be used to supply the reference voltage to the ADC. For this option, jumper VRT (JP9) and VRB (JP6) must be pulled out and left OPEN. If the desired voltage references are 1.5 V and 0.5 V, apply the top voltage reference (1.5 V) at the test point VRTP (TP5) and bottom reference (0.5 V) at VRBP (TP6). Change jumpers JP9 and JP8 to shunt 1-2.

5 Jumper Settings

Table 5 details the EVM jumper settings.

Table 5. EVM Jumper Settings

Jumper	Default Position	Description
JP1	1-2	Enable onboard clock source
JP2	1-2	Select internal clock source
JP3	Not Populated	Use clock splitter output for ADC clock
JP4	1-2	Enable clock splitter
JP5	2-3	Use clock splitter output for ADC clock
JP6	2-3	Set VRB for ADC
JP7	1-2	VDD for onboard clock source
JP8	2-3	Enable ADC
JP9	2-3	Set VRT for ADC
JP10	2-3	Enable output data buffer
JP11	2-3	Input data voltage level. Shunt 1-2 for ADC1175-50EVM

6 References

- Texas Instruments, *ADC1173 8-Bit, 3-Volt, 15MSPS, 33mW A/D Converter Data Sheet*
- Texas Instruments, *ADC1175 8-Bit, 20MHz, 60mW A/D Converter*
- Texas Instruments, *ADC1175-50 8-Bit, 50 MSPS, 125 mW A/D Converter*
- Texas Instruments, *TSW140x High Speed Data Capture/Pattern Generator User's Guide*
- Texas Instruments, *High Speed Data Converter Pro GUI Installer*
- Texas Instruments, *TSW140x High Speed Data Capture/Pattern Generator Card User's Guide*

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1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, and/or documentation which may be provided together or separately (collectively, an "EVM" or "EVMs") to the User ("User") in accordance with the terms set forth herein. User's acceptance of the EVM is expressly subject to the following terms.

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   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.

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。 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 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.

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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, INDEMNITY 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.