User's Guide
SNAU212–June 2017

ADC1xD1x00CVAL Board User's Guide

The ADC1xD1x00QML products are low-power, high-performance 10b and 12b ADCs with sampling rates up to 1.6 GSPS as a dual-channel ADC or 3.2 GSPS in a single-channel interleaved mode. These products come in a hermetic 376 column ceramic grid array package (376 CCGA) for harsh environments, such as down hole or space.

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1 Overview

The ADC1xD1x00 Evaluation Board (ADC1xD1x00CVAL) provides flexible ADC I/O connections for laboratory performance evaluation. As configured, the board is equipped with support shrouds for 100 pin Samtec connectors for interface to a logic analyzer, but capable of being configured for other types of logic analyzer connectors.

Because the 10- and 12-bit Gig ADCs are pin-compatible with one another, this board can be used with the following parts:

- ADC10D1000QML
- ADC12D1600QML
- ADC12D1620QML

Refer to the individual product data sheets for information on the absolute maximum ratings and recommend operating conditions.

NOTE: The top surface of the ADC (U1) can reach temperatures above 55°C during normal operation. Use caution and avoid touching the top surface of the ADC when it is operating.

CAUTION

Caution Hot surface.
Contact may cause burns.
Do not touch.

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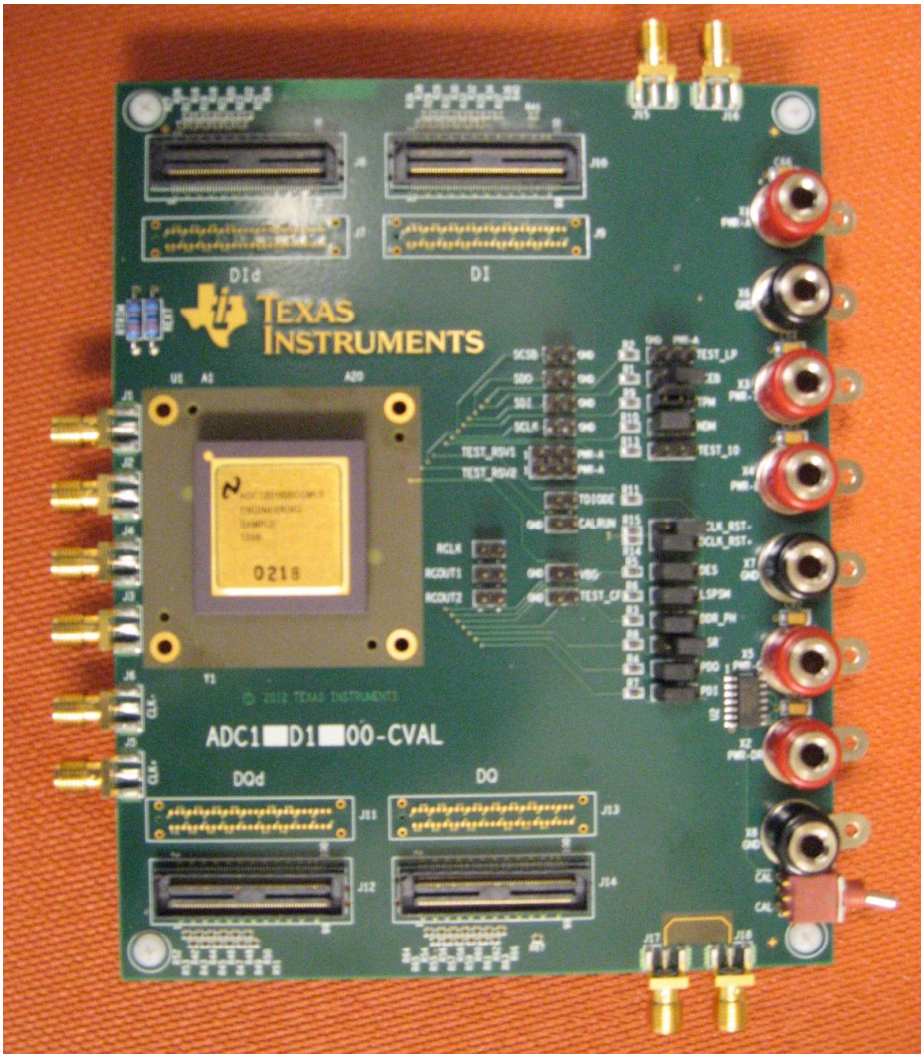

Figure 1. ADC1xD1x00CVAL Board

2 Lab Equipment

2.1 Required Lab Equipment

The following lab equipment is required to use the ADC1xD1x00 EVAL board:

- Bench supply to drive 1.9 V at 3 A
- 1 signal generator + bandpass filter + balun to drive sampling clock. Suggested equipment:
  - SMA100A with B22 enhanced low phase-noise option
  - Trilithic 5VF tunable filter
- 1 signal generator to drive the analog input
- High-speed Logic Analyzer to capture the data. Suggested equipment:
  - Keysight 16702B Logic Analysis System
  - Keysight 16760A Timing and State Module
  - Keysight E5379A Differential Probe Adapter
  - Keysight E5386A Half-channel Probe Adapter (for data rates greater than 800MSPS)

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Three key requirements for the sampling clock signal generator are low distortion, broad band noise, and phase noise. Even the highest quality signal generator will also produce harmonics, which the ADC performance is very sensitive to. Therefore, a bandpass filter, which can be tuned to the desired sampling clock frequency, will improve the performance of the system. In addition to this, the bandpass filter will reduce broadband noise and increase the system performance.

The logic analyzer should be able to capture differential LVDS signals at high speed, as determined by the sampling clock speed and ADC Demux Mode. In general, the Output Data Rate per Bank can be determined as follows:

Table 1. Output Data Rate Per Bank by Mode

MODE	OUTPUT DATA RATE PER BANK [MSPS]
DES 1:1 Non-Demux	Fs/2
DES 1:2 Demux	Fs/4
Non-DES 1:1 Non-Demux	Fs
Non-DES 1:2 Demux	Fs/2

For example, the ADC12D16x0 will generate data at the following rates:

Table 2. ADC12D16x0 Output Data Rate Example

MODE	FCLK [MHz]	FS [MSPS]	OUTPUT DATA RATE PER BANK [MSPS]
DES 1:1 Non-Demux	1600	3200	1600
DES 1:2 Demux	1600	3200	800
Non-DES 1:1 Non-Demux	1600	1600	1600
Non-DES 1:2 Demux	1600	1600	800

The EVAL board is designed to be used with the Samtec ASP-65067-01 for the logic analyzer probe connection to the Keysight E5379A Differential Probe Adapter. There is also a footprint for the Keysight E5405A Pro Series Soft Touch Connectorless Probe, but this option is not recommended, as the signal integrity is better through the Samtec connector.

2.2 Optional Lab Equipment

If the EVAL board is being used in Extended Control Mode (ECM), then it is also necessary to have a system which can write to the SPI. One option is the Aardvark I2C/SPI Host Adapter and accessories.

- Aardvark I2C/SPI Host Adapter
  http://www.totalphase.com/products/aardvark_i2cspi/
- Level Shifter Board
  http://www.totalphase.com/products/level_shifter/
- 10-pin Split Cable
  http://www.totalphase.com/products/split_cable/

3 Driving the Clock and Inputs

3.1 Driving the Sampling Clock

The CLK± SMA inputs are connected directly to the ADC; they must be driven AC-coupled and differentially. Therefore, a set of DC blocks is required at the input. To convert a single-ended signal to differential, a National Anaren balun board (400 MHz to 3 GHz) may conveniently be used.

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3.2 Driving the Analog Inputs

The analog inputs may be driven AC-coupled and must be driven differentially. Depending upon the application, an amplifier or balun board may be used to achieve single-ended to differential conversion.

4 Jumper Settings

Most of the jumper pins on the EVAL board are also available for customer use, and are more clearly explained in the datasheet; some exceptions are the TEST pins as described below. These pins are related to internal test functions and are not available.

The ADC may be used in either Extended Control Mode (ECM) or Non-ECM, also known as *pin-control mode*; this is set by the ECEb pin. In ECM, the ADC modes and settings are written through the Serial Port Interface. Some control pins remain active in ECM.

Table 3. Control Pins and Function

PIN (BOARD)	PIN (DATASHEET)	I/O	FUNCTION
TEST_LP	N/A	N/A	Internal test function; do not connect
ECEB	ECEb	Input	ECM and Non-ECM: Extended Control Mode Enable bar select
TPN	TPM	Input	Non-ECM only: Test Pattern Mode select
NDM	NDM	Input	ECM and Non-ECM: Non-Demux Mode select
TEST_IO	N/A	N/A	Internal test function; do not connect
POR_EN	N/A	N/A	Internal test function; do not connect
DCLK_RST+/-	DCLK_RST+/-	Input	Differential DCLK Reset DES DES Input Non-ECM only: DES Mode select
LSPSM	LSPSM	Input	Low sampling power saving mode
DDR_PH	DDRPh	Input	Non-ECM only: DDR Phase select
FSR	FSR	Input	Non-ECM only: Full-Scale Range select
PDQ	PDQ	Input	ECM and Non-ECM: Power-Down Q-channel
PDI	PDI	Input	ECM and Non-ECM: Power-Down I-channel
SCSB	SCSb	Input	SPI: Serial Chip Select bar
SDO	SDO	Output	SPI: Serial Data Out
SDI	SDI	Input	SPI: Serial Data In
SCLK	SCLK	Input	SPI: Serial Clock
TEST_RSV1	N/A	N/A	Internal test function; do not connect
TEST_RSV2	N/A	N/A	Internal test function; do not connect
TDIODE	TDIODE+/-	Output	Temperature Sensor Diode terminals
CALRUN	CalRun	Output	Calibration Running indication
VBG	VBG	I/O	Bandgap Voltage Output / LVDS Common-mode Voltage select
TEST_CF	N/A	N/A	Internal test function; do not connect
RCLK	RCLK+/-	Input	AutoSync: Reference Clock Input
RCOUT1	RCOut1+/-	Output	AutoSync: Reference Clock Differential Output 1
RCOUT2	RCOut2+/-	Output	AutoSync: Reference Clock Differential Output 2

In Non-ECM, the following control pins are available.

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Table 4. Non-ECM Pin Control Settings

PIN (BOARD)	LOW	HIGH	FLOATING
ECEB	ECM	Non-ECM	Not valid
TPN	Non-TPM	TPM	Not valid
NDM	1:2 Demux	1:1 NDM	Not valid
DES	Non-DES	DES	Not valid
LSPSM	Normal	Low sampling power saving	Not valid
DDR_PH	0˚ Mode	90˚ Mode	Not valid
FSR	See data sheet for details		Not valid
PDQ	Q-channel active	Power-Down Q-channel	Not valid
PDI	I-channel active	Power-Down I-channel	Not valid
VBG	N/A	Higher LVDS common-mode voltage	Lower LVDS common-mode voltage

5 Board Power Up

Refer to the individual product data sheets for information about the absolute maximum ratings and recommend operating conditions.

5.1 Power Supply

For flexibility, each of the different ADC power supply pins has been brought out to a red PWR terminal. TI recommends powering all supply pins from a single power-supply source. The supply voltage to any of the PWR terminals must not exceed that applied to X-1 PWR (VA). The supply voltage is a nominal 1.9 V and should not exceed 2 V.

5.2 Power-Up Sequence

The ADC should be powered up in Non-ECM, by putting the ECEB pin high. The ADC does not have a Power-on-Reset. If the part is started in extended control mode (ECM), by having the ECEB pin low, the registers will come up in an unknown random state, and the part will be in an unknown operating condition. If ECM mode is desired, the board can be placed in ECM by moving the ECEB pin low after power up with the ECEB pin high.

After the board has stabilized, the ADC should be calibrated by flipping the red CAL switch from low (CALb) to high (CAL). If the switch remains high, the part cannot be recalibrated in ECM. To enable the part to be recalibrated, in either ECM or with the switch, the CAL switch must be low (CALb). Recalibrate the part when there has been a major change in operating conditions, such as change in Fclk, or temperature.

5.3 VBG Pin

Some versions of this universal board allow for the option to put the VBG pin low. This not a supported state, and the VBG pin should not be taken low.

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5.4 Samtec Connector

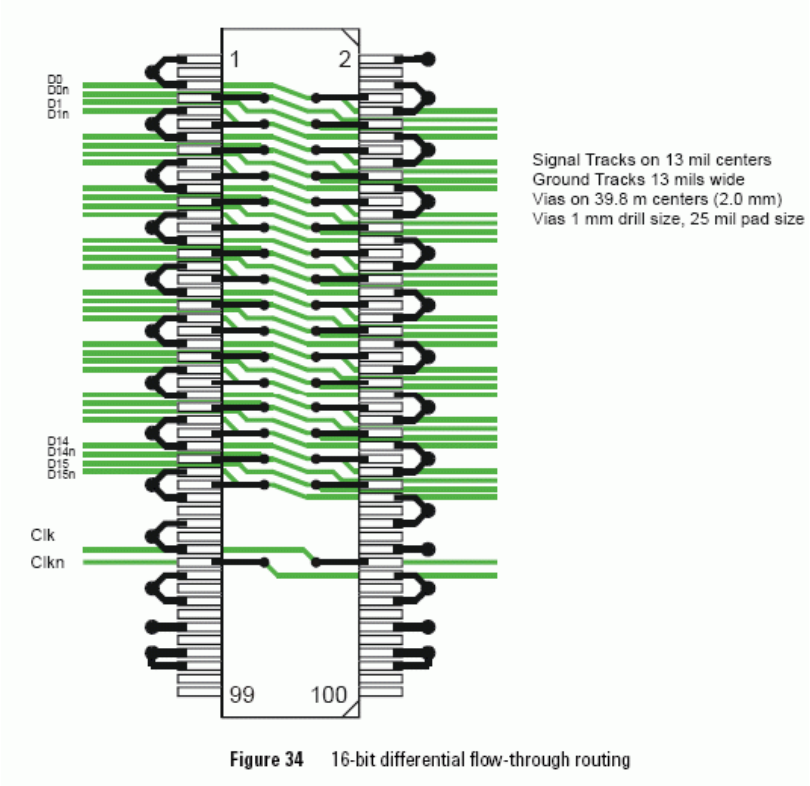

Figure 2. Flow-Through Routing for the Samtec Connector

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5.4.1 Footprint Dimensions

Footprint dimensions

Use the following 100-pin Samtec connector footprint and support shroud mounting hole dimensions to design your target system board.

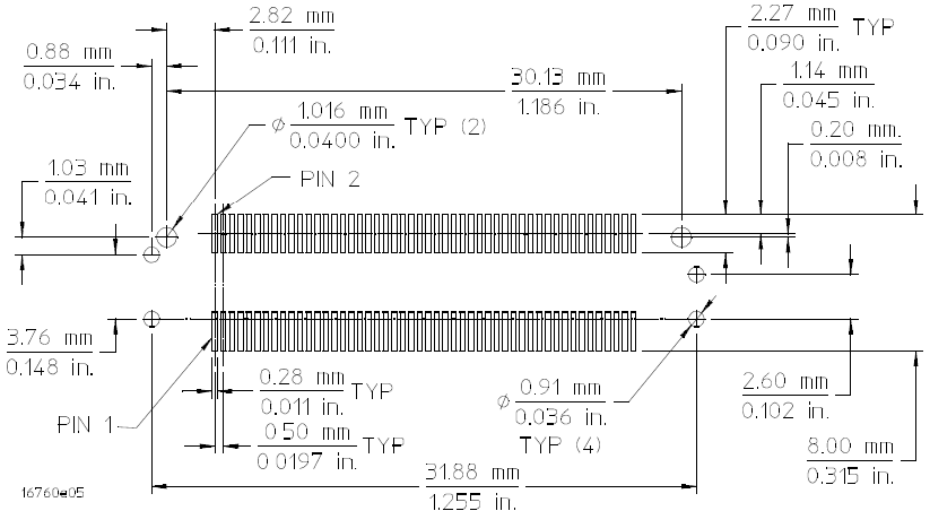

Figure 8 100-pin Samtec connector footprint and support shroud mounting hole dimensions

Figure 3. Samtec Connector Footprint

Ordering Probing Connectors and Shrouds

Connectors and shrouds may be ordered in kits or ordered separately. Select a support shroud appropriate for the thickness of your PC board. The following table lists the Agilent part numbers for each.

CAUTION The support shrouds marked with an asterisk in the following table are made of conductive metal. Care should be taken to avoid shorting adjacent boards or components with the shrouds. For this reason it may be advisable not to connect the shrouds to ground.

For Probe Model #	Agilent Part Number	Consists of	For Target PC Board Thickness
E5378A & E5379A	16760-68702	5 Mating Connectors & 5 Support Shrouds*	up to 1.57 mm (0.062 in.)
	16760-68703		up to 3.05 mm (0.120 in.)

Figure 4. Samtec Connector Ordering Information

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6 Using the AARDVARK

The Aardvark I2C/SPI Host Adapter is a fast and powerful I2C bus and SPI bus host adapter through USB (see Figure 5). It allows a developer to interface a Linux or Windows PC to a downstream embedded system environment and transfer serial messages using the I2C and SPI protocols.

Part Number: TP240141

RoHS Compliant: Yes

Figure 5. Aardvark I2C/SPI Host Adapter

For more information, visit the manufacturer website at:
http://www.totalphase.com/products/aardvark_i2cspi/

Level translation is required due to the different signaling levels (3.3 V for the Aardvark vs. 1.9 V for the ADC). A level shifter can be obtained from Total Phase or can be built as shown Figure 6.

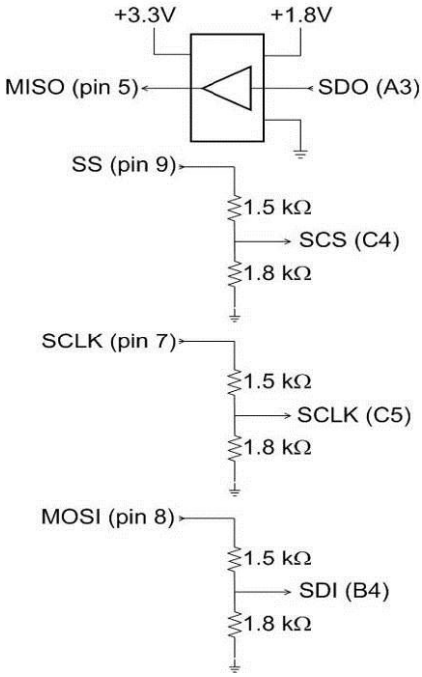

Figure 6. Level Translator for Aardvark to ADC

1. Download the Aardvark control GUI software
   (a) Go to: http://www.totalphase.com/products/aardvark_i2cspi/ and select the Downloads tab.
   (b) Download and install the Control Center Software.
2. Configure and connect the hardware
   (a) Put the ADC into Extended Control Mode (ECM) by setting the ECEB jumper to GND.

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(b) The I2C/SPI Level Shifter board should have jumpers at TPWR, MASTER, and 1.8 V. (The Gig ADC runs at 1.9 V, but 1.8 V is appropriately close.)

(c) Connect a USB cable from the PC to the Aardvark

(d) Connect the Aardvark cable to the I2C/SPI Level Shifter board, ADAPTER input

(e) Connect the additionally supplied ribbon cable from the I2C/SPI Level Shifter board, TARGET1 port to the ribbon cable with split outputs

(f) Connect the split output wires to the ADC EVAL board

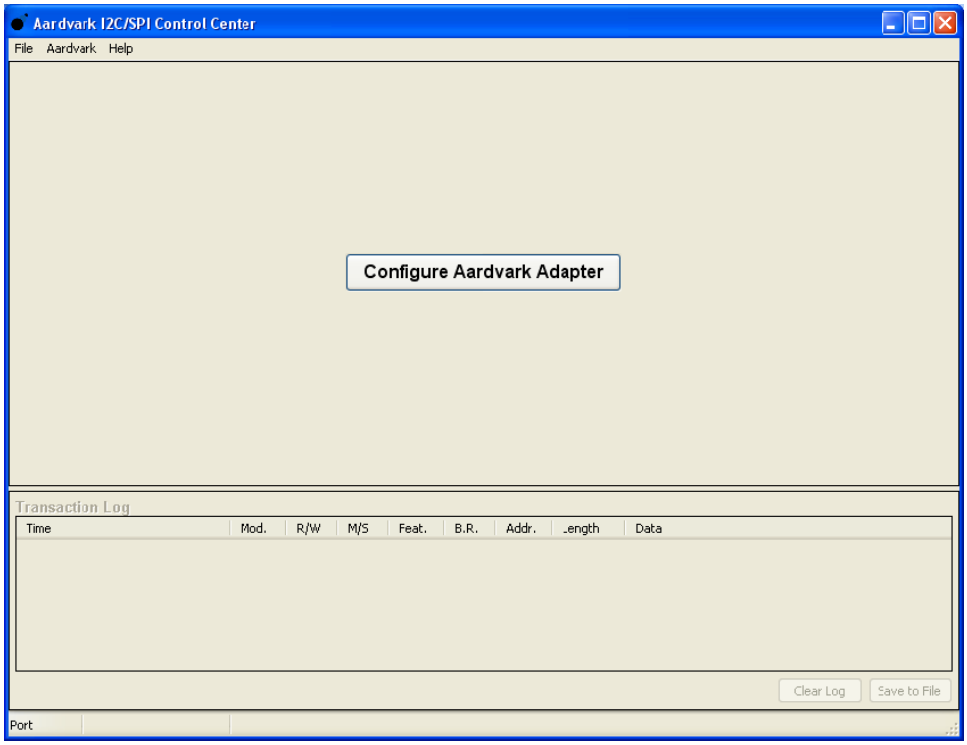
(i) SS (white) = SCSb

(ii) MOSI (grey) = SDI

(iii) SCLK (purple) = SCLK iv. GND (black) = GND

3. Configure the Aardvark software

(a) Select Configure Aardvark Adapter



(b) Select anywhere on the row of the available port, select the SPI – GPIO radio button and hit OK

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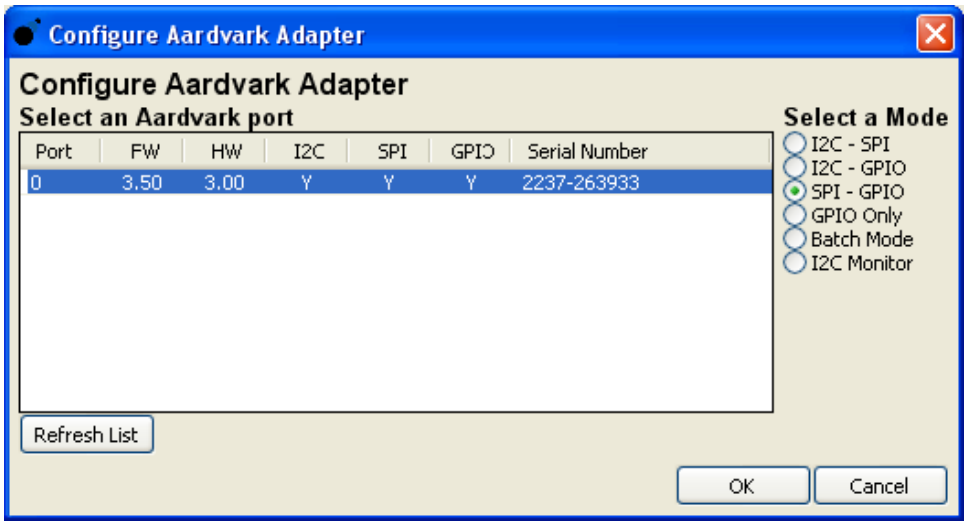
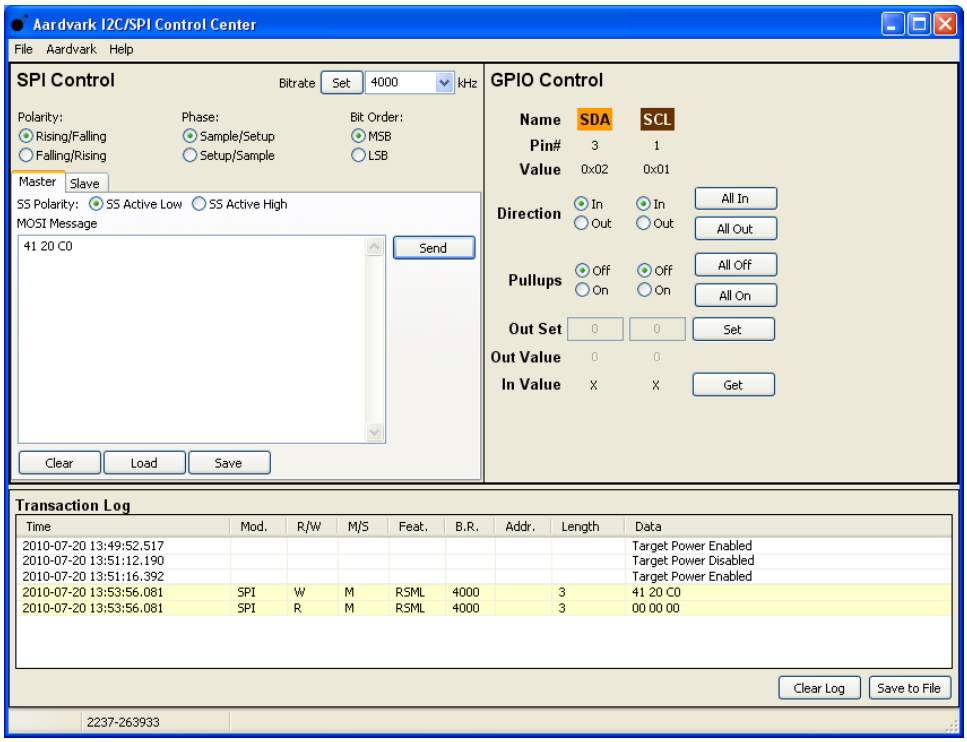


(c) In the Aardvark I2C/SPI Control Center software, select Aardvark → Target Power. On the I2C/SPI Level Shifter board, both LEDs for TARGET (orange) and POWER (green) should light up.

4. Using the software

(a) Type the command (hex) in the MOSI Message window and hit the Send button. For example, putting the ADC into DESQ Mode:



5. Tips and tricks

(a) During the entire time the ADC is being used in SPI Mode (also known as Extended Control Mode), the jumper on the EVAL board for ECEB stays connected to GND. Moving the ECEB jumper from GND to VA back to GND again is a short-cut to reset the SPI registers back to their default values

(b) The Calibration pin is OR'd with the Calibration bit in the SPI internally to the ADC, that is, the pin remains active when the ADC is in ECM. To calibrate the ADC, it is more convenient to use the Calibration pin (move the jumper from GND to VA and back to GND) than to write the SPI twice.

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7 Importing Data into WaveVision5

The data from the Logic Analyzer has the following (or similar) format:

Listing(Listing<1>) – 28 October 2010 (21:54)

State Number Decimal	DId Hex	DI Hex	DQ Hex	DQd Hex	ORI Binary	ORQ Binary
0	2B	24	80	80	0	1
1	D3	DC	80	80	0	1
2	2E	22	80	80	0	1
3	D1	DE	80	80	0	1
4	30	20	80	80	0	1
5	CE	E0	80	80	0	1
6	33	1E	80	80	0	1
7	CC	E3	80	80	0	1
8	35	1C	80	80	0	1
9	C9	E4	80	80	0	1
10	38	1A	80	80	0	1

Figure 7. Logic Analyzer Data Listing View

When the data is imported into WaveVision, it is necessary to make selections about how the data was taken so that it can be correctly reconstructed. Some of these selections are: Demux / Non-Demux Mode, DES / Non-DES Mode, Hexadecimal / Binary / Decimal, Sampling Rate, and Number of Bits. For example, this data was taken on the I-channel in Demux, Non-DES Mode in the Hexadecimal format.

For Non-DES Mode, the data is ordered {DId, DI} or {DQd, DQ}. For DES Mode, the data is ordered {DQd, DId, DQ, DI}.

1. To import data, select Channels → Import WaveVision 4 data or a single/double column ASCII data file

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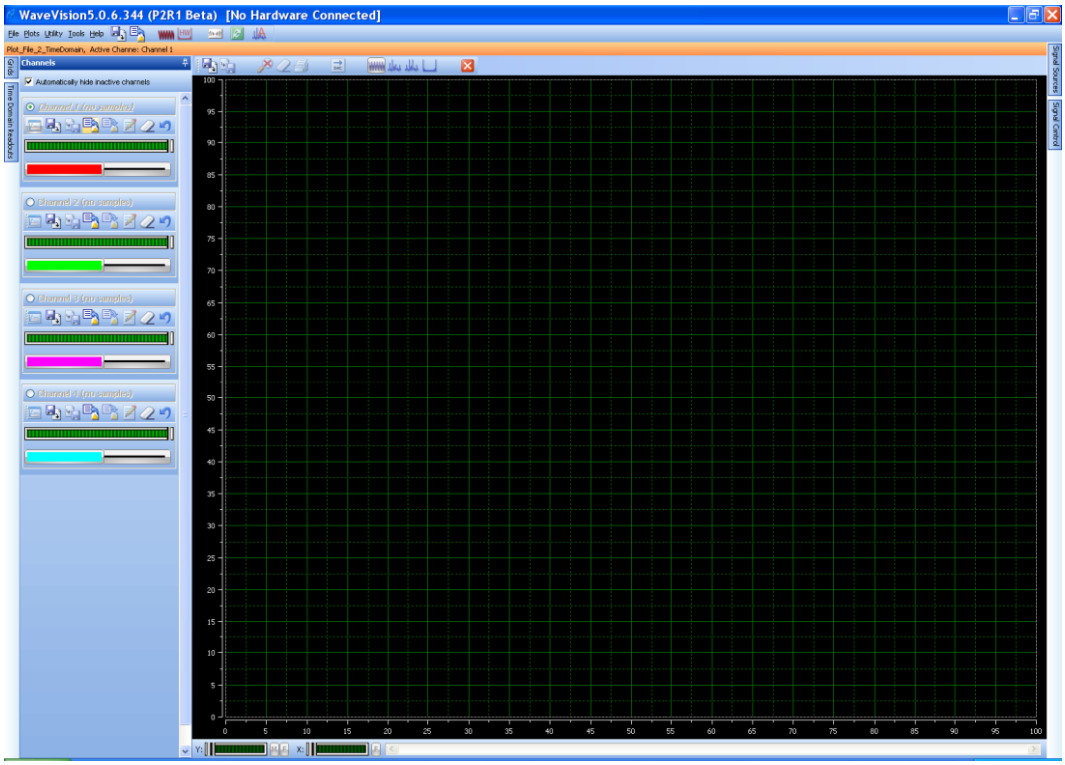
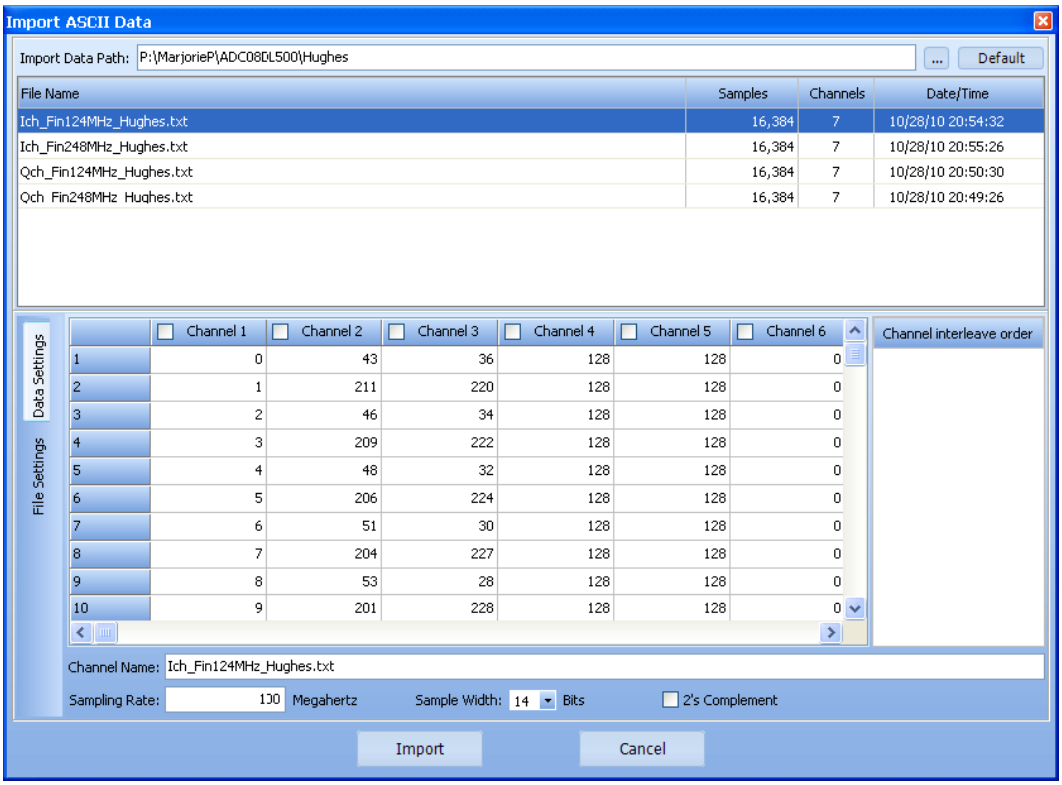


2. Select the Import Data Path. Note that this can take a few moments if there are many or large data files in the directory.



3. Select the Sampling Rate, Sample Width, channels with data (Channel 2, 3 in this example), and the Channel interleave order.

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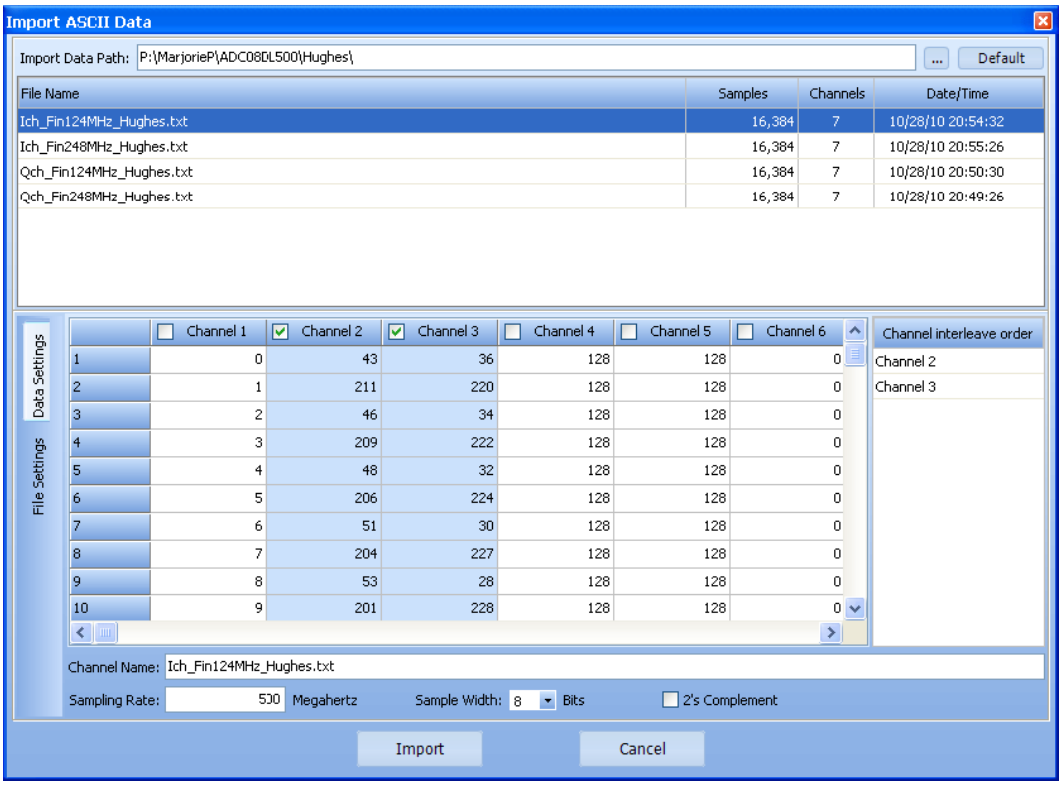
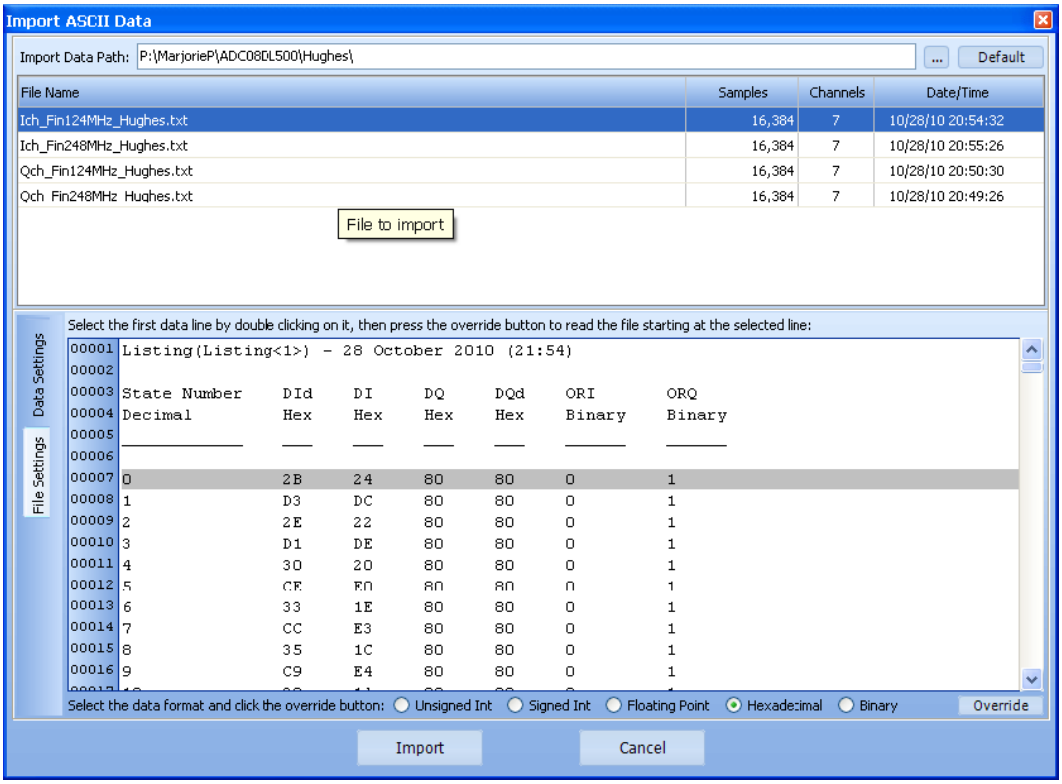


4. To verify the channel headings or override the automatically selected data format, select the File Settings tab and make the adjustments.



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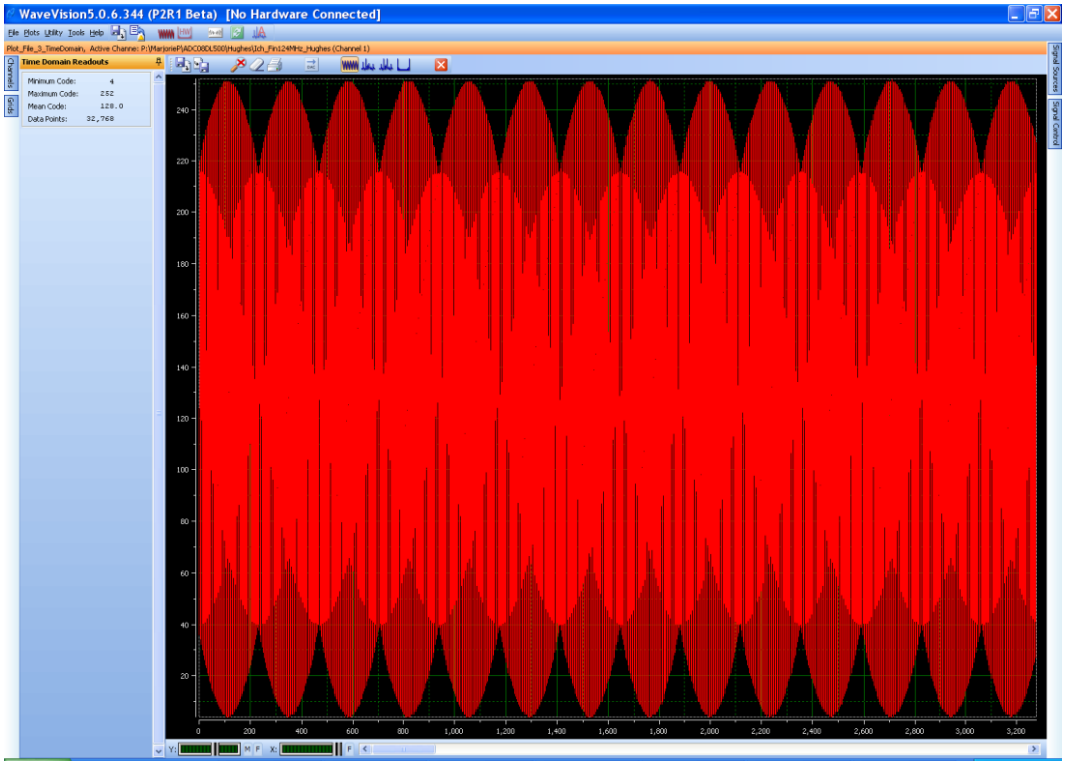
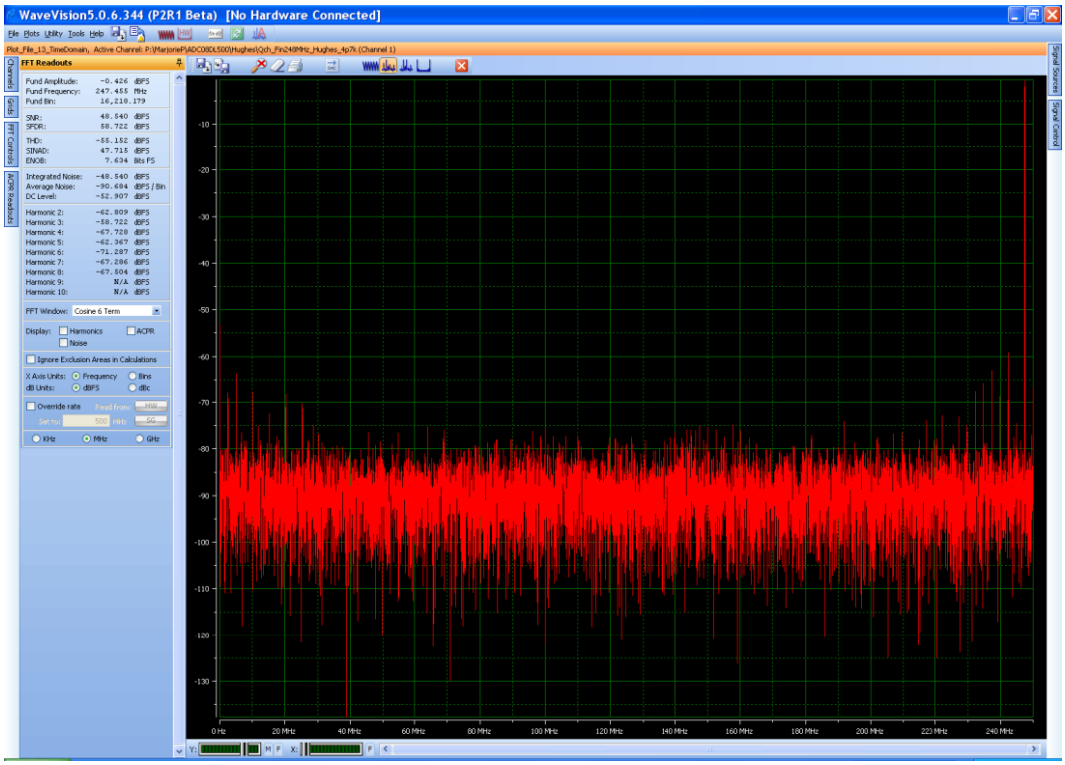
5. The data will be imported into the Time Domain view:



6. The Frequency Domain (FFT) as well as Dynamic Performance metrics may also be selected:



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

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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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