DAC90x Evaluation Module

This user's guide describes the function and use of the DAC90x evaluation module (EVM). Included in this document are a quick-start guide, instructions for optimizing evaluation results, jumper and connector descriptions, software description, and alternate hardware configurations.

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Trademarks

1 Overview

The DAC90xEVM is an evaluation module (EVM) designed to evaluate the DAC90x. The EVM provides simple and minimal external components to minimize system cost and power consumption. The DAC90xEVM is designed to work seamlessly with the TSW1400EVM, data capture and pattern generator module. The TSW1400EVM is programed through TI's High-Speed Data Converter Pro Graphic User Interface (HSDC Pro GUI) software tool for high-speed data converter evaluation.

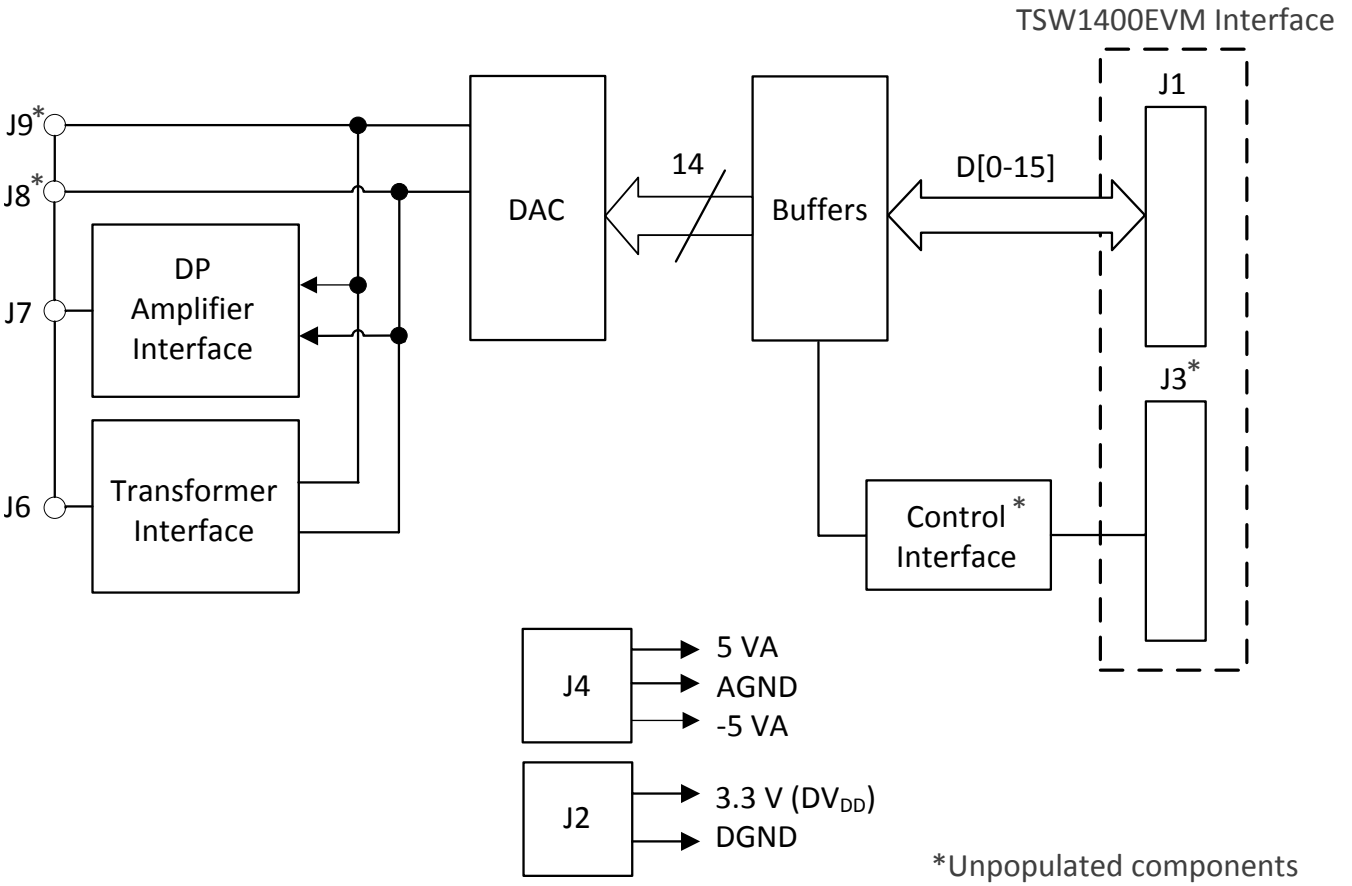

Figure 1. DAC90xEVM Block Diagram

1.1 Required Hardware

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

- DAC90xEVM

The following list of equipment are items that are **not included** in the EVM evaluation kit but are items required for evaluation of this product in order to achieve the best performance:

- *TSW1400EVM Data Capture Board*, +5 V DC cable connector and mini-USB cable
- Computer running Microsoft® Windows® 8, Windows 7, or Windows XP
- One dual-channel pulse generator.
  - Examples: Keysight 81160A, 81134A, 8133a, or similar.
- Triple-output DC power supply. Recommendations:
  - DC Power Supply, **Output 1:** 30 W, 6 V, 5 A. **Output 2:** 25 W, 25 V, 1 A, **Output 3:** 25 W, –25 V, 1 A.
  - Examples: Keysight E3631A or equivalent

- Signal path cables, SMA or BNC with BNC-to-SMA adapters
- One of the following (depending on the requirements of the user)
  - Spectrum Analyzer. Example: Agilent E4440A
  - Oscilloscope: Example: Agilent DSO3052T

1.2 Required Software

The following software is required to operate the TSW1400EVM and is available online. See References, Section 1.4 for links.

- High-Speed Data Converter Pro software version 4.7

1.3 Evaluation Board Feature Identification Summary

The EVM features are labeled in Figure 2.

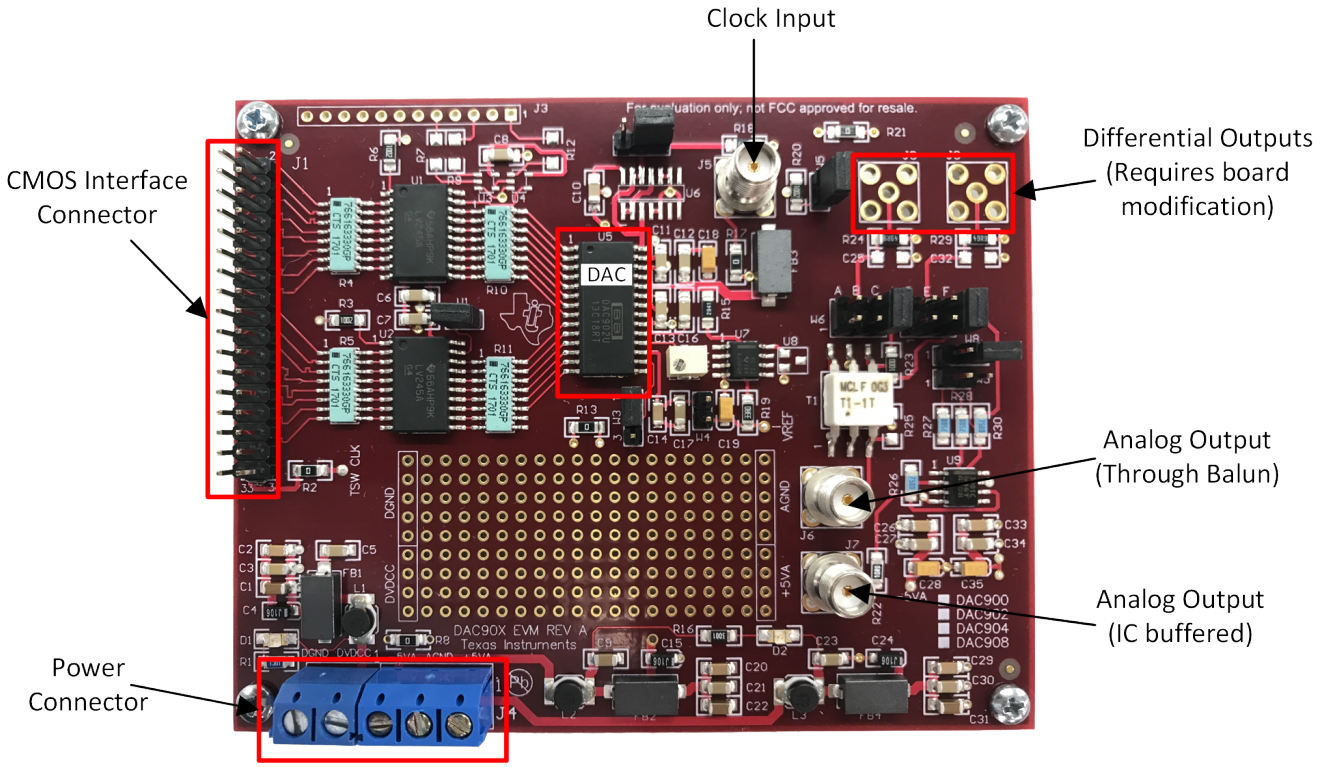

Figure 2. EVM Feature Locations

1.4 References

- DAC90x data sheet (SBAS093), available at www.ti.com/product/DAC900
- TSW1400EVM User's Guide (SLWU079), available at www.ti.com/tool/TSW1400EVM
- High-Speed Data Converter Pro software (SLWC107) and User's Guide (SLWU087), available at www.ti.com/tool/dataconverterpro-sw

NOTE: Schematics, layout, and BOM are available on each EVM tool page on www.ti.com:

- DAC900EVM
- DAC902EVM
- DAC904EVM
- DAC908EVM

2 Quick-Start Guide

This section guides the user through the EVM test procedure to obtain a valid data capture from the DAC90xEVM using the TSW1400EVM capture card. This should be the starting point for all evaluations.

2.1 Software Installation

The proper software must be installed before beginning evaluation. See Section 1.2 for a list of the required software. The References section of this document contains links to find the software on the TI website.

Important: The software must be installed before connecting the DAC90xEVM and TSW1400EVM to the computer for the first time.

2.1.1 High-Speed Data Converter Pro GUI Installation

The *High-Speed Data Converter Pro* (HSDC Pro) is used to control the TSW1400EVM and analyze the captured data. See *High Speed Data Converter Pro GUI* for more information.

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

A typical test setup using the DAC90xEVM and TSW1400EVM is shown in Figure 3. This is the test setup used for the quick-start procedure. The rest of this section describes the hardware setup steps.

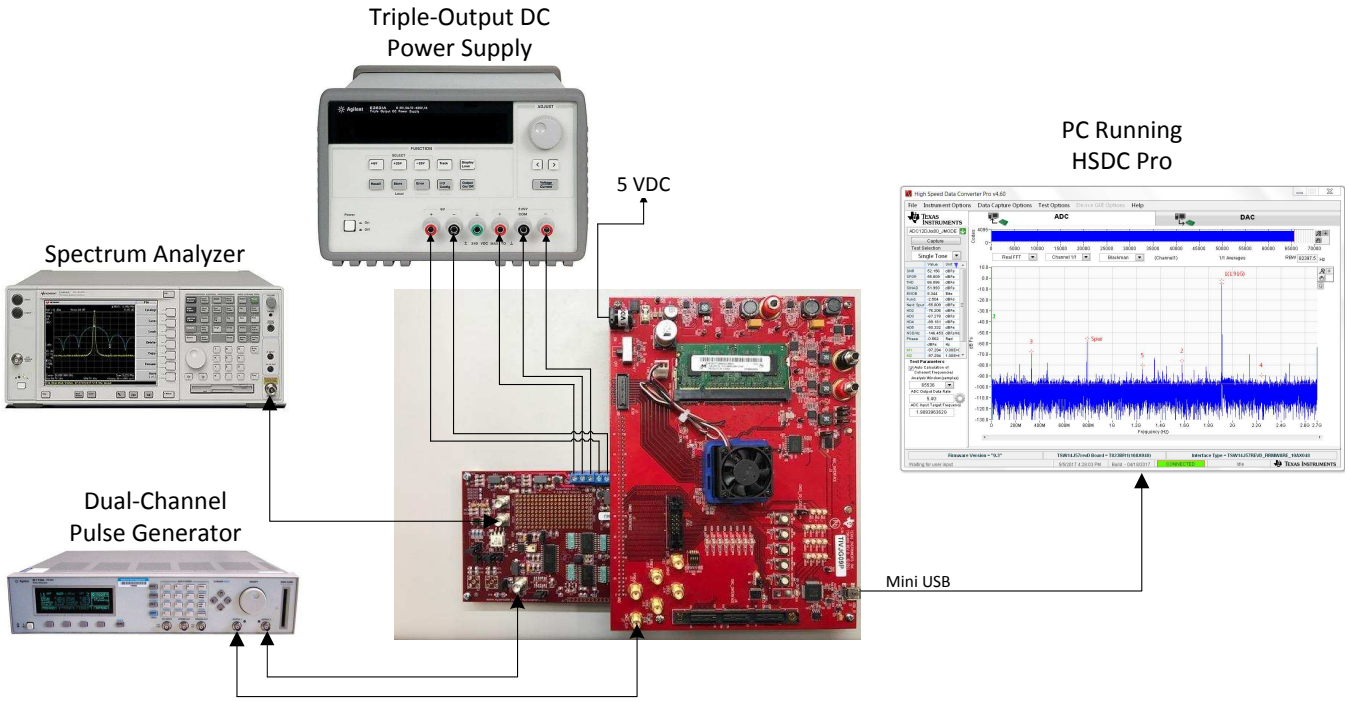

Figure 3. Quick-Start Test Setup

2.2.1 TSW1400EVM Setup

Set up the TSW1400EVM with the following steps:

1. Connect the DAC90xEVM to the TSW1400EVM by connecting pin 1 of the CMOS_INTERFACE (J1) to pin 1 of the DAC90xEVM 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. The board should draw around 0.5 A after power up. This will increase to around 1.7 A when loaded with firmware.

2.2.2 DAC90xEVM Setup

Continue the hardware setup of the DAC90xEVM using the following:

1. Connect the power supply cables to the EVM. refer to Figure 2 and Table 6 for proper connections.

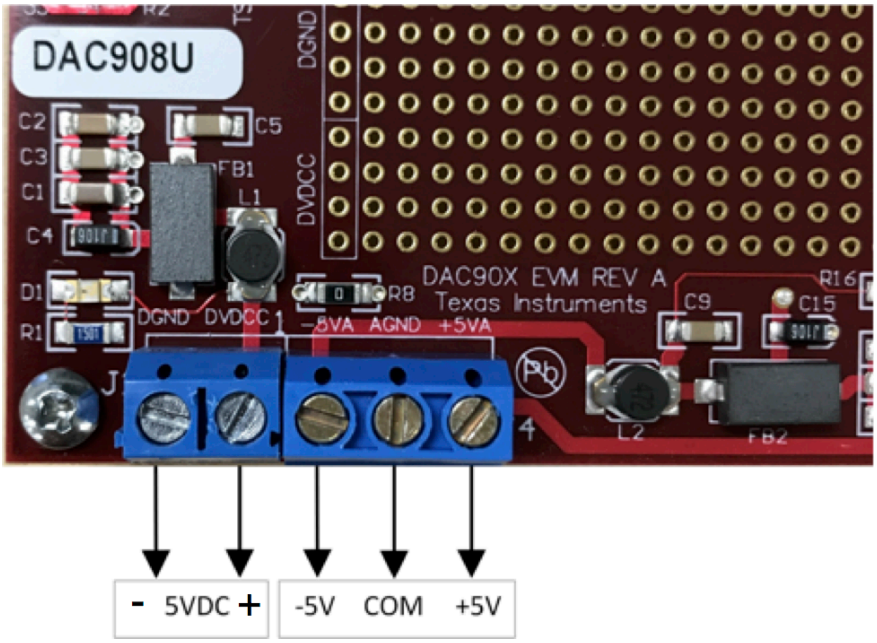

Figure 4. Power Supply Connections

2. Connect the SMA connector from the pulse generator to the EXT Clock input (J5).
3. Turn on the power supply.
4. Connect an SMA cable from the output of the DAC90xEVM (J6) to the input of the spectrum analyzer.

2.3 Software Setup Procedure

The software can be opened and configured once the hardware is properly setup.

2.3.1 HSDC Pro GUI Configuration

1. Open High Speed Data Converter Pro by going to *Start Menu* → *All Programs* → *Texas Instruments* → *High Speed Data Converter Pro*. The GUI main page looks as shown in Figure 5.

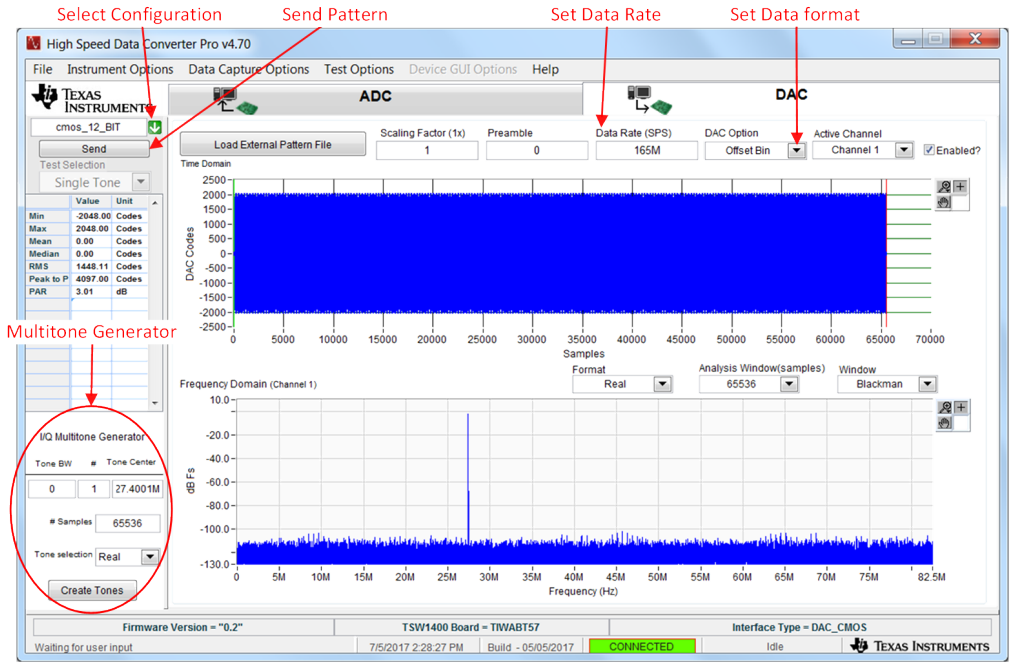

Figure 5. HSDC Pro GUI Main Panel

2. When prompted to select the capture board, select the TSW1400. If multiple TSW1400EVMs are connected, choose the serial number that corresponds to the serial number on the TSW1400EVM connected to the DAC90x and click *OK*. This popup can be accessed through the *Instrument Options* menu.
3. If no firmware is currently loaded, there is a message indicating this. Click *OK*.
4. Verify the *DAC* tab at the top of the GUI is selected.
5. Use the *Select DAC* drop-down menu at the top left corner to select the correct configuration file for the DAC90x variant being used, see Table 1.

Table 1. Configuration Files

DAC90xEVM Variant	Configuration File
DAC900	CMOS_10_Bit
DAC902	CMOS_12_Bit
DAC904	CMOS_14_Bit
DAC908	CMOS_8_Bit

6. When prompted to update the firmware for the DAC, click *Yes* and wait for the firmware to download to the TSW1400. This takes approximately 10 seconds.
7. Enter “150M” into the *"Data Rate (SPS)*" field at the upper portion of the DAC tab, and ensure that "offset Bin" is selected for "DAC Option".
8. In the lower left corner of the HSDC Pro window, enter the following parameters into the *I/Q Multitone generator*:
   - ToneBW = 0
   - # = 1
   - Tone Center = 27.4
9. Click the *Create Tones* button
10. The result should be now visible on the oscilloscope or spectrum analyzer. If performance is not meeting data sheet specifications, it may be necessary to provide a delay on the clock signal to the DAC in order to meet setup and hold time requirements. If no output is seen, then see *Quick Start Troubleshooting*.

2.4 Quick-Start Troubleshooting

Use Table 2 to assist with problems that may have occurred during the quick-start procedure.

Table 2. Troubleshooting Tips

Issue	Troubleshooting Tips
General problems	Verify the test setup shown in Section 2 and repeat the setup procedure as described in this document.
	Check power supplies to the EVMs. Verify that the power switches are in the ON position and supplies are drawing the appropriate current.
	Check signal and clock connections to the EVM.
	Check that all boards are properly connected together.
	Try power-cycling the external power supply to the EVMs.
TSW1400 LEDs are not correct: D2 – D9 *OFF*	Verify the settings of the configuration switches on the TSW1400EVM.
	Verify that the EVM configuration GUI is communicating with the USB and that the configuration procedure has been followed.
	Try capturing data in HSDC Pro to force an LED status update.
HSDC Pro software is not capturing good data or analysis results are incorrect.	Verify that the TSW1400EVM is properly connected to the PC with a mini-USB cable and that the board serial number is properly identified by the HSDC Pro software.
	Check that the proper DAC device is selected, and the proper configuration file is being used.
	Check that the analysis parameters are properly configured.
HSDC Pro software gives a time-out error when capturing data	Restart HSDC Pro and reload the firmware.
	Verify that the data rate is correct in the HSDC Pro software.
Sub-optimal measured performance	Adjust the delay time of DAC clock.
	Measure test points to verify operating voltage ranges.
	Verify jumper configurations are in default locations.
	Verify that filters are used in the clock and input signal paths and that low-noise signal sources are used.

3 Alternate Hardware Configurations

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

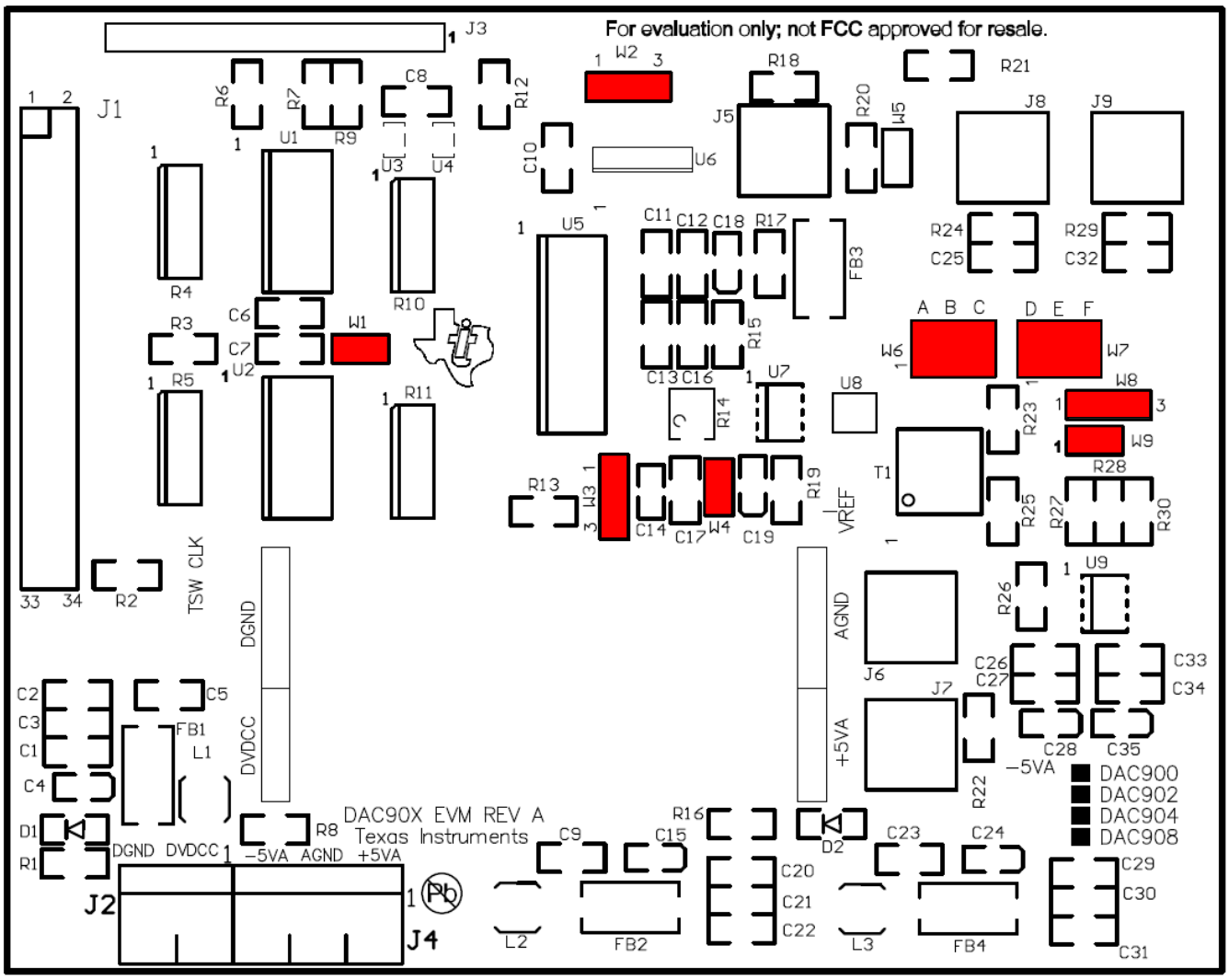

Figure 6. Reconfiguration Hardware Location

3.1 Control Modes

The $\overline{\text{INT}}$/EXT, REF_{in} and FSA pins of the DAC904, DAC902, DAC900, and DAC908 control various DAC features and functions. This section describes the function of these pins.

3.1.1 FSA Input Pin

For an output current of 20 mA, the potentiometer R14 value is typically set to 2 kΩ. Owing to the fact that the maximum full-scale current is 20 mA when IOUT1 and IOUT2 are terminated into 50-Ω load resistors, the voltage at J8 and J9 is 1 V.

3.1.2 $\overline{\text{INT}}$/EXT Pin

The internal 1.2-V Vref is selected when the $\overline{\text{INT}}$/EXT pin is grounded (W3 pins 2 and 3 shorted). When the $\overline{\text{INT}}$/EXT pin is tied to 5 V (W3 pins 2 and 3 shorted) and the W4 jumper is in place, the external 1.2-V Vref is selected.

3.1.3 REF_{in} Pin

An external reference voltage is provided via the REF_{in} input pin. U7 or U8 is used to generate the external reference voltage. Jumper W4 is for selecting the external reference voltage.

3.2 External Clock Generation

When connected to an AVDD supply of 5 V and DVDD supply of 5 V, the maximum operating speed of the DAC90x is 200 MHz. When the DVDD supply is 3.3 V, the maximum clock speed is 165 MHz. The clock signal comes from either the DSP CLKOUT signal or from an external source via J5. The DAC90xEVM requires an external clock source when used with the TSW1400EVM.

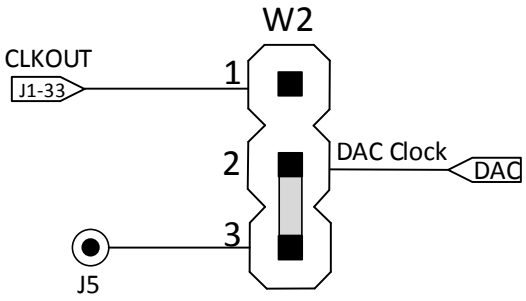

Figure 7. External Clock Signal

3.3 Analog Output Circuits

The analog signal output of the DAC90x can be configured to drive a resistive load, a transformer, an operational amplifier, or other output configuration, as long as the limitations set by the output voltage compliance and full-scale range are not exceeded.

3.3.1 Transformer-Coupled Output

The optimum dynamic performance of the DAC90x is achieved with the outputs used differentially. The DAC90xEVM is configured to operate with transformer output coupling by default. The 1:1 RF transformer is used for impedance matching, dc isolation, and interfacing between the differential outputs of the DAC and an external single-ended device. The resistors R23, R24, and R29 are used to form a network that reflects 50 Ω across the primary circuit (J6).

A spectrum analyzer with 50-Ω input impedance is normally used to measure the performance of the DAC. A 50-Ω coaxial cable is used to connect J6 output to the 50-Ω input of the spectrum analyzer. The spectrum analyzer impedance is in parallel to the transformer 50-Ω reflected impedance across J6. Therefore, the voltage at the input of the spectrum analyzer is ½ J6. If a larger voltage is required, use a 1:2 step up voltage ratio transformer to produce twice the voltage at J6. In addition set R23 to 200 Ω and remove R24 and R29. R14 may require some adjustments.

3.3.2 Direct Output

Direct output configuration allows the user to connect the outputs of the DAC90x directly to external circuitry. This configuration requires that J8 and J9 be installed by the user. A 1-V output will appear at J8 and J9 when IOUT1 and IOUT2 are terminated into 50-Ω external resistor loads (output taken from J8 and J9 and W6 and W7 open).

3.3.3 Operational Amplifier Output

In addition to the transformer-coupled output configuration, the DAC90xEVM offers three more configurations which use the THS3001 operational amplifier. The THS3001 can be configured as a difference amplifier, an inverting amplifier, and a non-inverting amplifier.

3.3.3.1 Difference Amplifier Configuration

The THS3001 operates as a differential amplifier when: W9 is left opened, W8 pins 1 and 2 are connected together, W6 position A is connected to IOUT1, and W7 position D is connected to IOUT2.

3.3.3.2 Inverting Amplifier Configuration

The THS3001 operates as an inverting amplifier under the following conditions: W9 is connected, R27 is set to 0 Ω, W8 pins 1 and 2 are connected together, and the input is from either W6 position B or W7 position D. If the input is via W6 position B, the output at J7 is –1.2 V. If the input is via W7 position D, the output will be –1.2 V.

3.3.3.3 Non-Inverting Amplifier Configuration

The THS3001 operates as a non-inverting amplifier when: W9 is opened, W8 pins 2 and 3 are connected together, and the input is from either W6 position A or W7 position E. If the input is via W6 position A, the output voltage is 2 V. If the input is taken via W7 position E, the output voltage at J7 is 2 V.

Jumper and Connector Descriptions

A.1 Jumper Descriptions

The EVM jumpers are shown in Table 3 as well as the default settings for the jumpers. Use this table to reset the EVM in the default configuration, in case of issues.

Table 3. Jumper Descriptions and Default Settings

Jumper	Description	Default Setting
W1	$\overline{OE}$ input for the SN74LVT245B buffers	Shunt pins 1-2
W2	Selects CLKOUT signal from the DSP or clock input from signal gen.	Shunt pins 2-3
W3	Selects external or internal Vref.	Shunt pins 1-2
W4	Supplies external Vref to the DAC	Open
W5	No function	N/A
W6	Selects IOUT1 or IOUT2 output from DAC to amplifier or transformer	Position C
W7	Selects IOUT1 or IOUT2 output from DAC to amplifier or transformer	Position F
W8	Configures the op amp for either differential input, noninverting or inverting mode	Shunt pins 2-3
W9	Configures the op amp for inverting, noninverting or differential mode	Open

A.1.1 Connector Descriptions

The EVM connectors and their function are described in Table 4.

Table 4. Connector Descriptions

Reference Designator	Function
J1	Data bits 0 through 13 and CLKOUT input
J2, J4	Supplies power to the EVM
J3	Input control signals used to create EVM chip select
J5	Input for a clock signal source
J6, J7, J8, J9	DAC output signal

A.1.2 CMOS Data Connector Pinout

The J1 parallel data connector pins and functions are listed in Table 5.

Table 5. J1 Parallel Data Connector

Pin Number	Function	Pin Number	Function
1	DSP_15 (MSB)	2	Ground (digital)
3	DSP_14	4	Ground (digital)
5	DSP_13	6	Ground (digital)
7	DSP_12	8	Ground (digital)
9	DSP_11	10	Ground (digital)
11	DSP_10	12	Ground (digital)
13	DSP_09	14	Ground (digital)
15	DSP_08	16	Ground (digital)
17	DSP_07	18	Ground (digital)
19	DSP_06	20	Ground (digital)
21	DSP_05	22	Ground (digital)
23	DSP_04	24	Ground (digital)
25	DSP_03	26	Ground (digital)
27	DSP_02	28	Ground (digital)
29	DSP_01	30	Ground (digital)
31	DSP_00 (LSB)	32	Ground (digital)
33	CLKOUT	34	Ground (digital)

A.1.3 Power Connectors

The J4 and J2 power connector pins and their functions are listed in Table 6.

Table 6. J4 and J2 Power Connectors

Pin Number	Function
J2–1	Digital power 3 V–5 V
J2–2	DGND
J4–1	Analog power +5 V
J4–2	AGND
J4–3	Analog power –5 V

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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

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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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3.3.3 *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.

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