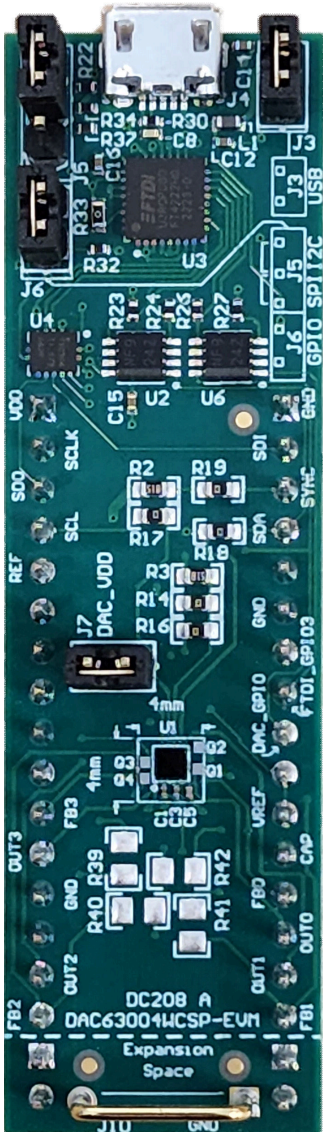
User's Guide

DAC63004WCSP-EVM User's Guide

ABSTRACT



This user's guide describes the characteristics, operation, and use of the DAC63004WCSP-EVM evaluation module (EVM). This EVM is designed to evaluate the performance of the DAC63004W and DAC53004W commercial, buffered voltage output DACs in a variety of configurations. The DAC63204W, DAC53204W, and DAC63202W are also supported by this EVM. Throughout this document, all these devices are referred to as the DACx3004W, and the terms evaluation board, evaluation module, and EVM are synonymous with the DAC63004WCSP-EVM. This document includes a schematic, printed-circuit board (PCB) layouts, and a complete bill of materials.

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Trademarks

1 Overview

The DAC63004WCSP-EVM is an easy-to-use platform to evaluate the functionality and performance of the DAC63004W and DAC53004W commercial devices. The DAC63004WCSP-EVM has optional, nonpopulated components that can be used to evaluate the DACx3004W with external FemtoFET™ MOSFETs for high current source applications in a small, 4-mm × 4-mm solution size.

The 12-bit DAC63004W and 10-bit DAC53004W are a pin-compatible family of ultra-low power, quad-channel, buffered, voltage-output and current-output smart digital-to-analog converters (DACs). The DAC outputs are capable of both voltage and current output. The DACx3004W support Hi-Z power-down mode and Hi-Z output during power-off conditions. The DAC outputs provide a force-sense option for use as a programmable comparator and current sink. The multifunction GPIO, function generation, and nonvolatile memory (NVM) enable these smart DACs for use in applications and design reuse without the need for runtime software. These devices also automatically detect I^2C, SPI, and PMBus interfaces, and contain an internal reference.

1.1 Kit Contents

Table 1-1 details the contents of the EVM kit. Contact the nearest TI Product Information Center if any component is missing. Make sure to verify the latest versions of the related software at the Texas Instruments website, www.ti.com. Table 1-2 lists the optional components not included with the kit. These optional components are available for purchase from the Texas Instruments website at www.ti.com.

Table 1-1. Contents of DAC63004WCSP-EVM Kit

Item	Quantity
DAC63004WCSP-EVM evaluation board PCB	1
USB micro-B plug to USB-A plug cable	1

Table 1-2. Optional Components Not Included With Kit

Item	Quantity
BOOSTXL-DAC-PORT digital-to-analog converter (DAC) BoosterPack™ plug-in module	1
TM4C1294 Connected LaunchPad™ Evaluation Kit (EK-TM4C1294XL) (In this document, the LaunchPad Evaluation Kit is referred to as TI launchpad)	1

1.2 Related Documentation from Texas Instruments

The following document provides information regarding Texas Instruments integrated circuits used in the assembly of the DAC63004WCSP-EVM. This user's guide is available from the TI web site under literature number SLAU879. Any letter appended to the literature number corresponds to the document revision that is current at the time of the writing of this document. Newer revisions may be available from the TI web site at www.ti.com, or call the Texas Instruments Literature Response Center at (800) 477-8924 or the Product Information Center at (972) 644-5580. When ordering, identify the document by both title and literature number.

Table 1-3. Related Documentation

Document	Literature Number
DAC63004W product page	SLASF72
DAC53004W product page	

2 System Setup

2.1 Software Setup

This section provides the procedure for EVM software installation.

2.1.1 Operating Systems

The EVM software is compatible with the Windows™ 10 operating system.

2.1.2 Software Installation

Before software installation, make sure that the DAC63004WCSP-EVM is not connected to the computer.

The software can be downloaded from the device product folders. After the software is downloaded, navigate to the download folder, and run the DAC63004WCSP-EVM software installer executable.

When the DAC63004WCSP-EVM software is launched, an installation dialog window opens and prompts the user to select an installation directory. Figure 2-1 shows that the software path defaults to *C:\Program Files (x86)\Texas Instruments\DAC63004WCSP-EVM*.

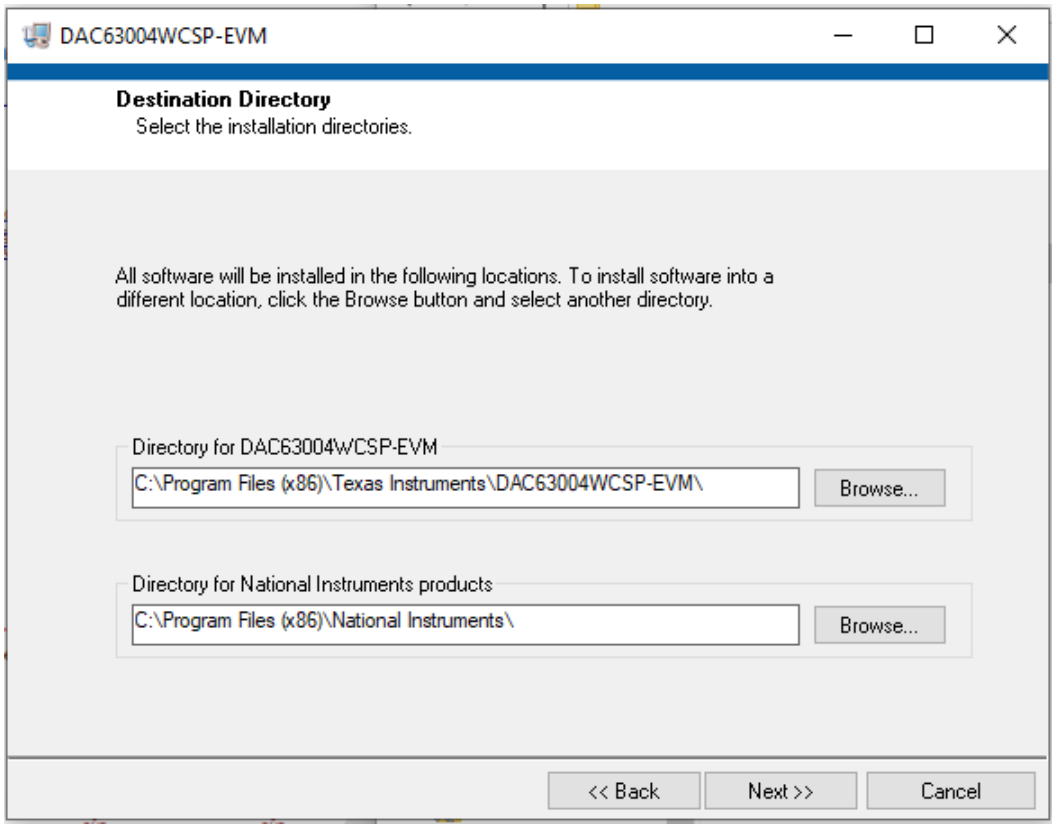

Figure 2-1. Software Installation Path

The software installation also installs the FTDI USB drivers, and automatically copies the required LabVIEW™ software files and drivers to the computer. The FTDI USB drivers install in a second executable. Figure 2-2 shows the window that is automatically launched after the DAC63004WCSP-EVM software installation is complete.

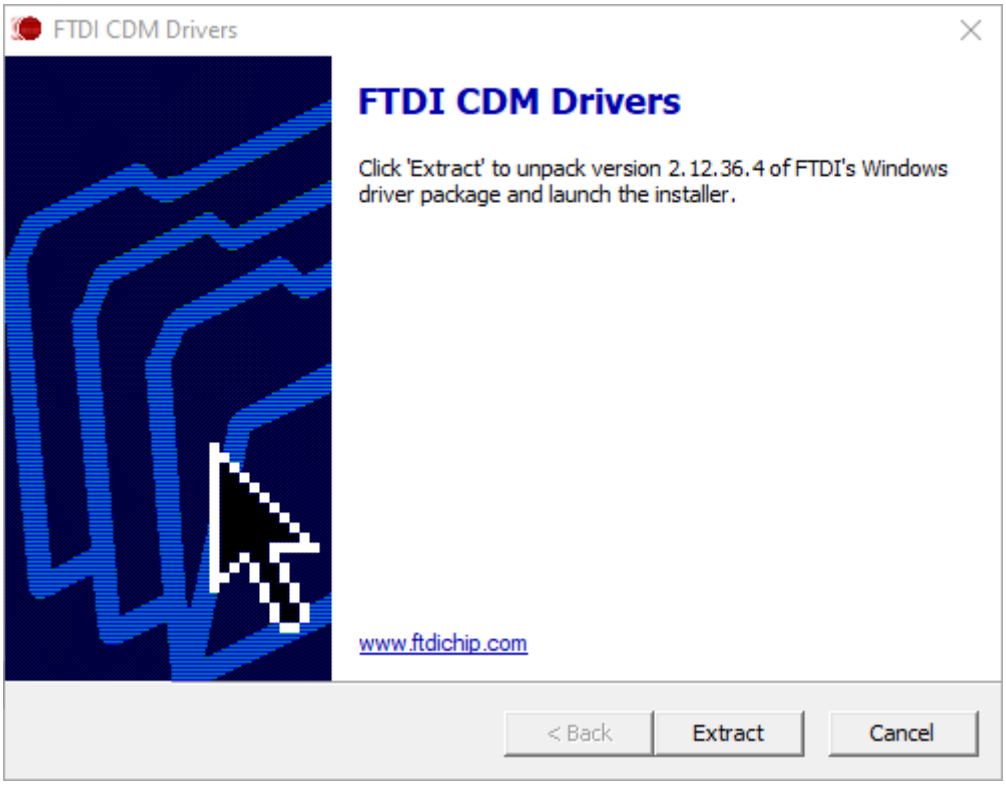

Figure 2-2. FTDI USB Drivers

2.2 Hardware Setup

This section describes the overall system setup for the EVM. A computer runs the software that provides an interface to the DAC63004WCSP-EVM through the onboard controller.

The USB connection generates 5 V of power for use as the DAC supply voltage (VDD). The onboard controller generates 3.3 V of power for the input/output (IO) signals generated by the controller. These IO signals are level translated to the VDD voltage of the DAC. Figure 2-3 displays the system hardware setup.

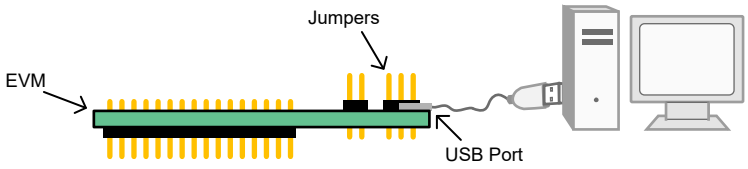

Figure 2-3. Hardware Setup

2.2.1 Electrostatic Discharge Caution

CAUTION

Many of the components on the DAC63004WCSP-EVM are susceptible to damage by electrostatic discharge (ESD). Observe proper ESD handling precautions when unpacking and handling the EVM, including the use of a grounded wrist strap at an approved ESD workstation.

2.2.2 Power Configurations and Jumper Settings

The DAC63004WCSP-EVM provides electrical connections to the device supply pins. Table 2-1 shows the connections.

Table 2-1. DAC63004WCSP-EVM Power Supply Inputs

DAC63004WCSP-EVM Connector	Supply Name	Voltage Range
J2.1	VDD	1.8 V to 5.5 V (5 V available from the USB); remove J3 if applying an external VDD to the DAC.
J1.1	GND	0 V

The jumper settings on the DAC63004WCSP-EVM are crucial to the proper operation of the EVM. Table 2-2 provides the details of the configurable jumper settings on the EVM.

Table 2-2. DAC63004WCSP-EVM Jumper Settings

Jumper	Default Position	Available Option	Description
J3	Closed: 5-V USB supply connected to EVM VDD supply	Open: 5-V USB supply disconnected from EVM VDD supply	External or onboard VDD selection
J5	2-3: I^2C enabled	1-2: SPI enabled	I^2C or SPI selection
J6	Closed: GPIOs enabled	Open: GPIOs disabled	Controller GPIO enable
J7	Closed: EVM VDD supply connected to DAC VDD	Open: EVM VDD supply disconnected from DAC VDD	Supply selection for theDACx3004W

If an external supply is applied to the DAC VDD pin, remove jumper J3 to disconnect the 5-V USB supply from the DAC VDD pin.

J7 can be used to measure the supply current for the DACx3004W. Place jumper J7 to connect the EVM supply to the DACx3004W. Remove jumper J7 and place a current meter between the J7 header pins to measure the current consumed by the ultra-low power DACx3004W.

GPIO2 from the onboard controller is connected to the DAC GPIO pin of the DACx3004W. This input can be controlled through the graphical user interface (GUI) using the controls for GPIO2. If DAC GPIO is configured as an output, remove J6 to disable the GPIOs from the onboard controller.

GPIO3 from the onboard controller is broken out to J1, pin 8 and is controlled through the GUI using the controls for GPIO3.

To enable the GPIO pins, close jumper J6. To disable the GPIO pins, remove jumper J6.

2.2.3 Connecting the Hardware

After the power and jumper configurations are set up as per Section 2.2.2, connect the USB cable from the DAC63004WCSP-EVM USB port to the computer.

3 Detailed Description

3.1 Hardware Description

The following sections provide detailed information on the EVM hardware and jumper configuration settings.

3.1.1 Theory of Operation

Figure 3-1 shows a simplified schematic of the DAC63004WCSP-EVM board. There are two 16-pin connectors that provide access to all of the DAC pins. The GPIO, I^{2}C, and SPI signals from the onboard controller are connected to the DAC through three level translators. Each level translator can be independently disabled to disconnect the onboard controller GPIO, I^{2}C, and SPI signals from the DAC signals while the DAC is running in stand-alone mode.

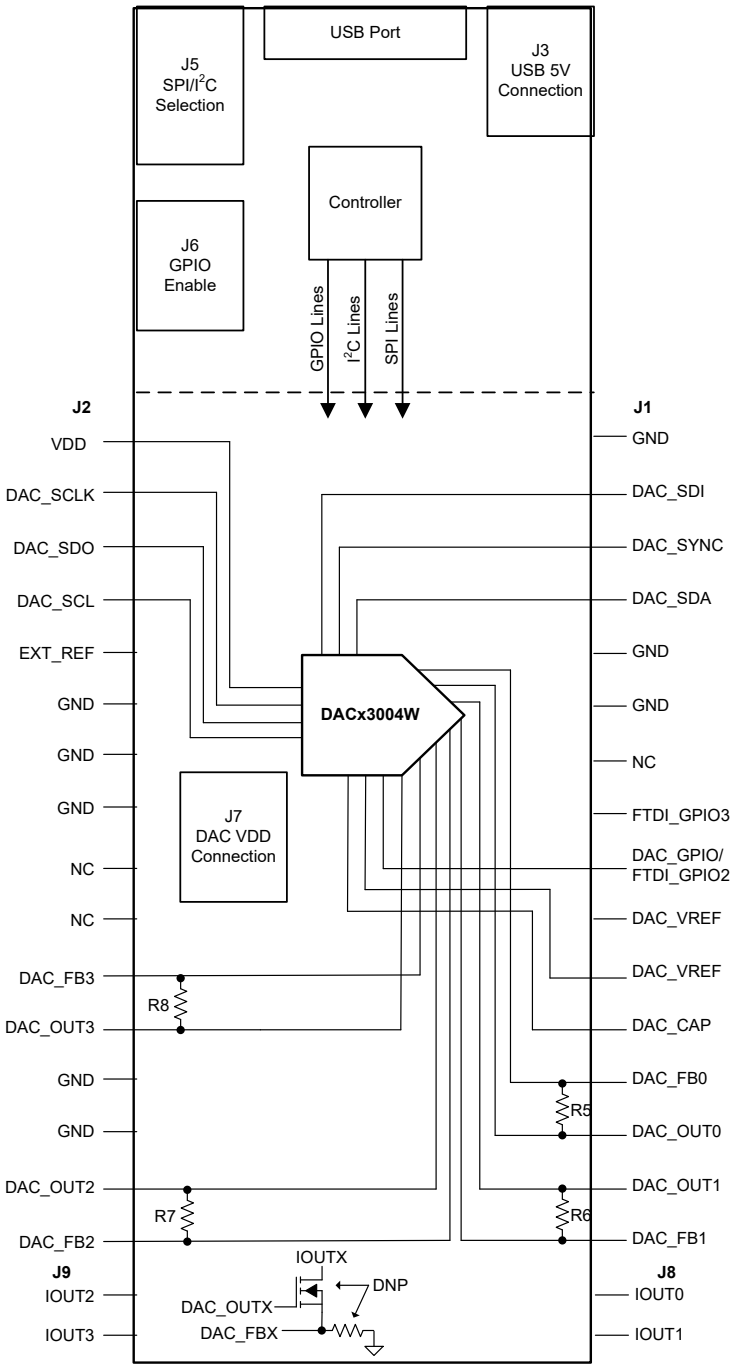

Figure 3-1. DAC63004WCSP-EVM Hardware Simplified Schematic

3.1.1.1 Signal Definitions

The DAC63004WCSP-EVM provides access to all DAC pins through connection J1 and J2. Table 3-1 and Table 3-2 list the J1 and J2 pin definitions. J8 and J9 provide access to the current outputs when the optional components are populated. Table 3-3 and Table 3-4 list the J8 and J9 pin definitions.

Table 3-1. DAC63004WCSP-EVM J1 Pin Definitions

Pin#	Signal	Description
1	GND	Ground
2	DAC_SDI	SPI SDI signal for DAC
3	DAC_SYNC	SPI SYNC signal for DAC
4	DAC_SDA	I^2C SDA
5	GND	Ground
6	GND	Ground
7	NC	Not connected
8	FTDI_GPIO3	GPIO3 output of the onboard controller
9	DAC_GPIO	GPIO Input for DACx3004W
10	DAC_VREF	DAC_VREF
11	DAC_VREF	VREF input to the DAC
12	DAC_CAP	LDO bypass capacitor
13	DAC_FB0	Feedback pin for DAC VOUT0
14	DAC_OUT0	Output pin for DAC VOUT0
15	DAC_OUT1	Output pin for DAC VOUT1
16	DAC_FB1	Feedback pin for DAC VOUT1

Table 3-2. DAC63004WCSP-EVM J2 Pin Definitions

Pin#	Signal	Description
1	DAC_VDD	VDD power supply for DAC
2	DAC_SCLK	SPI SCLK
3	DAC_SDO	SPI SDO
4	DAC_SCL	I^2C SCL
5	EXT_REF	External reference input for DAC
6	GND	Ground
7	GND	Ground
8	GND	Ground
9	NC	Not connected
10	NC	Not connected
11	DAC_FB3	Feedback pin for DAC VOUT3
12	DAC_OUT3	Output pin for DAC VOUT3
13	GND	Ground
14	GND	Ground
15	DAC_OUT2	Output pin for DAC VOUT2
16	DAC_FB2	Feedback pin for DAC VOUT2

Table 3-3. DAC63004WCSP-EVM J8 Pin Definitions

Pin#	Signal	Description
1	IOUT0	Current output connection for Q1
2	IOUT1	Current output connection for Q2

Table 3-4. DAC63004WCSP-EVM J9 Pin Definitions

Pin#	Signal	Description
1	IOUT2	Current output connection for Q3
2	IOUT3	Current output connection for Q4

3.1.1.2 Optional Current Source Circuitry

The DAC63004WCSP-EVM has optional, nonpopulated components that can be used to evaluate the DACx3004W with external FemtoFET MOSFETs for high current source applications in a small, 4 mm × 4 mm area.

Figure 3-2 shows the block diagram for the optional circuit. The DACx3004W is a four channel device, so there are up to four high current outputs available with the optional circuitry. 3-Ω R_{SET} resistors are used in this example. This circuit can achieve a current of 200 mA when the DAC outputs are set to 0.6 V. The R_{SET} resistors used in this example are size 0603 with a power rating of 0.33 W. Larger resistors can be used to achieve a higher power rating which allows for a higher current output.

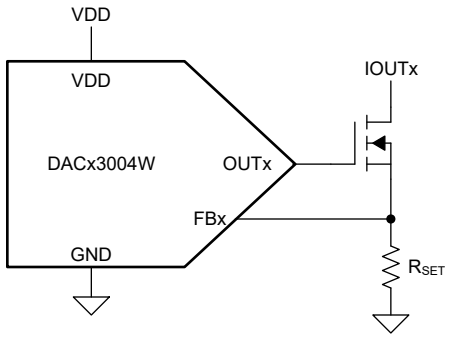

Figure 3-2. DAC63004WCSP-EVM High Current Output Stage Block Diagram

Figure 3-3 is a snip of the 4-mm × 4-mm high current output stage layout. The layout consists of the DACx3004W, four FemtoFET MOSFETs, and four size-0603 resistors. The DAC63004WCSP-EVM has footprints for 0805 resistors that are not a part of the example layout so that larger resistors can also be evaluated with the DAC63004WCSP-EVM.

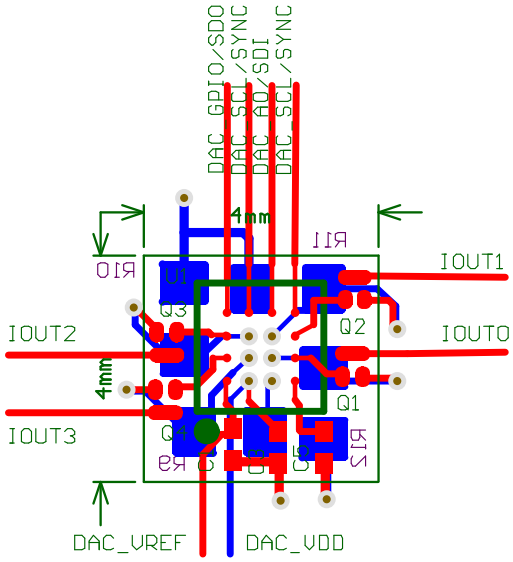

Figure 3-3. DAC63004WCSP-EVM Optional Current Source Circuit Layout

Remove R5, R6, R7, and R8 on the DAC63004WCSP-EVM to disconnect the DAC_OUTx and DAC_FBx pins before populating the optional components for the high current output stage.

3.2 Software Description

This section describes the features of the DAC63004WCSP-EVM software, and discusses how to use these features. The software provides basic control of all the DACx3004W registers and functions.

3.2.1 Starting the Software

To launch the software, navigate to the Texas Instruments folder in the *Start* menu, and select the *DAC63004WCSP-EVM* icon.

Figure 3-4 shows that if the onboard controller is connected correctly, the status bar at the bottom of the screen displays *CONNECTED.* If the controller is not properly connected or not connected at all, the status displays *DEMO*. If the GUI is not displaying the *CONNECTED* status while the EVM is connected, unplug and reconnect the EVM, and then relaunch the GUI software. If the display continues to display DEMO, uncheck the *Demo Mode* checkbox (see Figure 3-6, upper-right corner).

Figure 3-4. DAC63004WCSP-EVM GUI Connection Detection

Figure 3-5 shows the *Interface Settings* window. When the GUI starts, the Interface Settings window pops up. This window contains drop-down menus that select protocol (SPI or I^2C) and, if I^2C protocol is selected, the I^2C device address.The menu does not pop up if the GUI starts in Demo mode. In this case, uncheck the *Demo Mode* checkbox. If the interface must be updated again, toggle the *Demo Mode* checkbox for the menu to reappear.

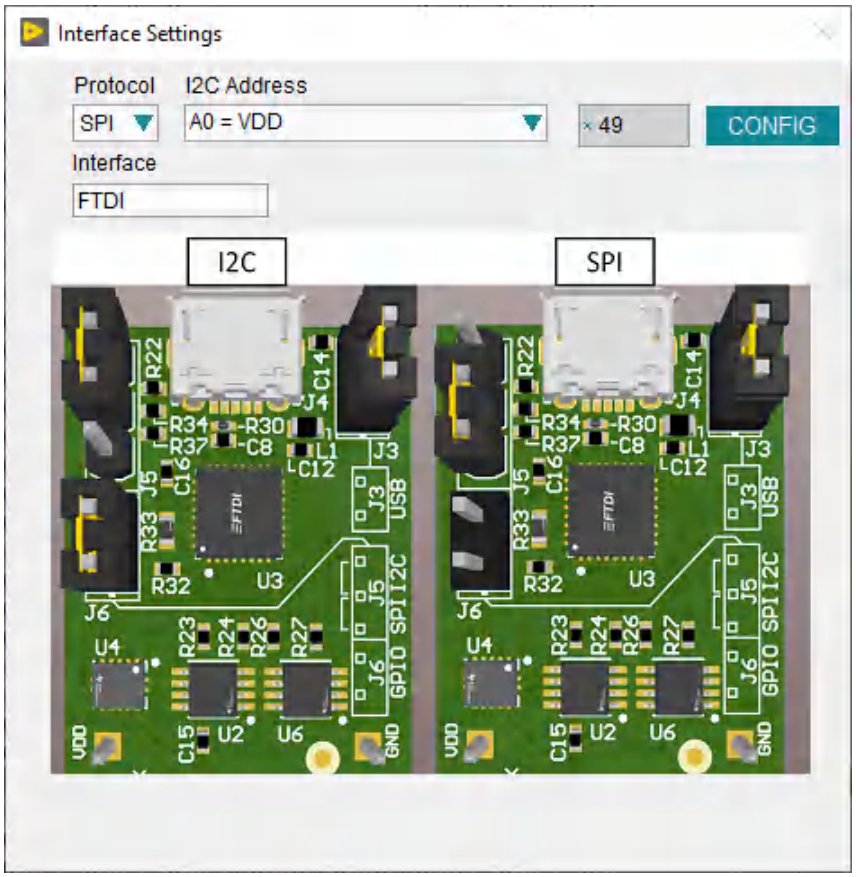

Figure 3-5. Interface Settings

The SDO pin on the DACx3004W is connected to the GPIO2 output from the onboard controller. Before configuring the SDO pin as an output to enable readback, remove J6 to disable the GPIO outputs from the onboard controller or remove R13 on the DAC63004WCSP-EVM to disconnect the GPIO2 pin from the SDO pin.

3.2.2 Software Features

The DAC63004WCSP-EVM GUI incorporates interactive functions that help configure an individual DACx3004W device using I^2C or SPI communication. These functions are built into several GUI pages, as shown in the following subsections. The menu bar on the far left of the GUI allows the user to switch between pages. The menu bar displays the *High Level Configuration* page with *Basic DAC*, *Margining*, and *Function Generation* subpages*, and the Low Level Configuration* page.

Before using the GUI, see the respective device data sheet for detailed DACx3004W programming instructions.

3.2.2.1 High Level Configuration Page

Figure 3-6 shows the *High Level Configuration* page that provides an interface to quickly configure the parameters and relevant register settings for the respective DACx3004W device. The *High Level Configuration* page consists of the *Basic DAC*, *Margining*, and *Function Generation* subpages.

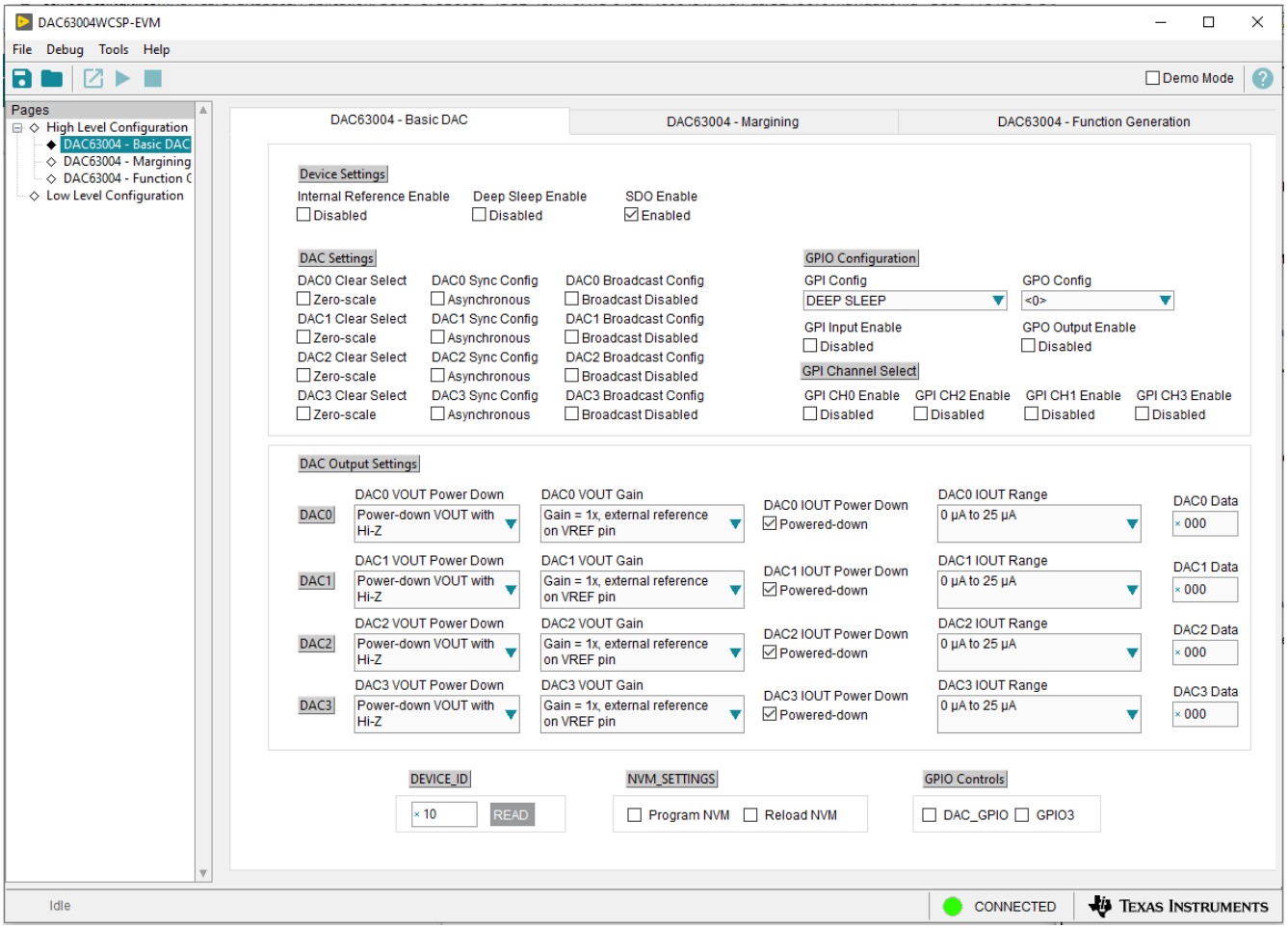

Figure 3-6. High Level Configuration Page

3.2.2.1.1 Basic DAC Subpage

Figure 3-7 shows the *Basic DAC* subpage that provides an interface to quickly power up, select the reference and output span, and program the output voltage or current for the respective DACx3004W device. When VDD is applied, the DACx3004W device starts up in Hi-Z power-down mode by default. The *Basic DAC* subpage also provides controls to configure the GPIO pin on the respective DACx3004W device, and control the two GPIO outputs of the DAC63004WCSP-EVM onboard controller. The register settings can be programmed or retrieved using the *Program NVM* or *Reload NVM* checkboxes, respectively.

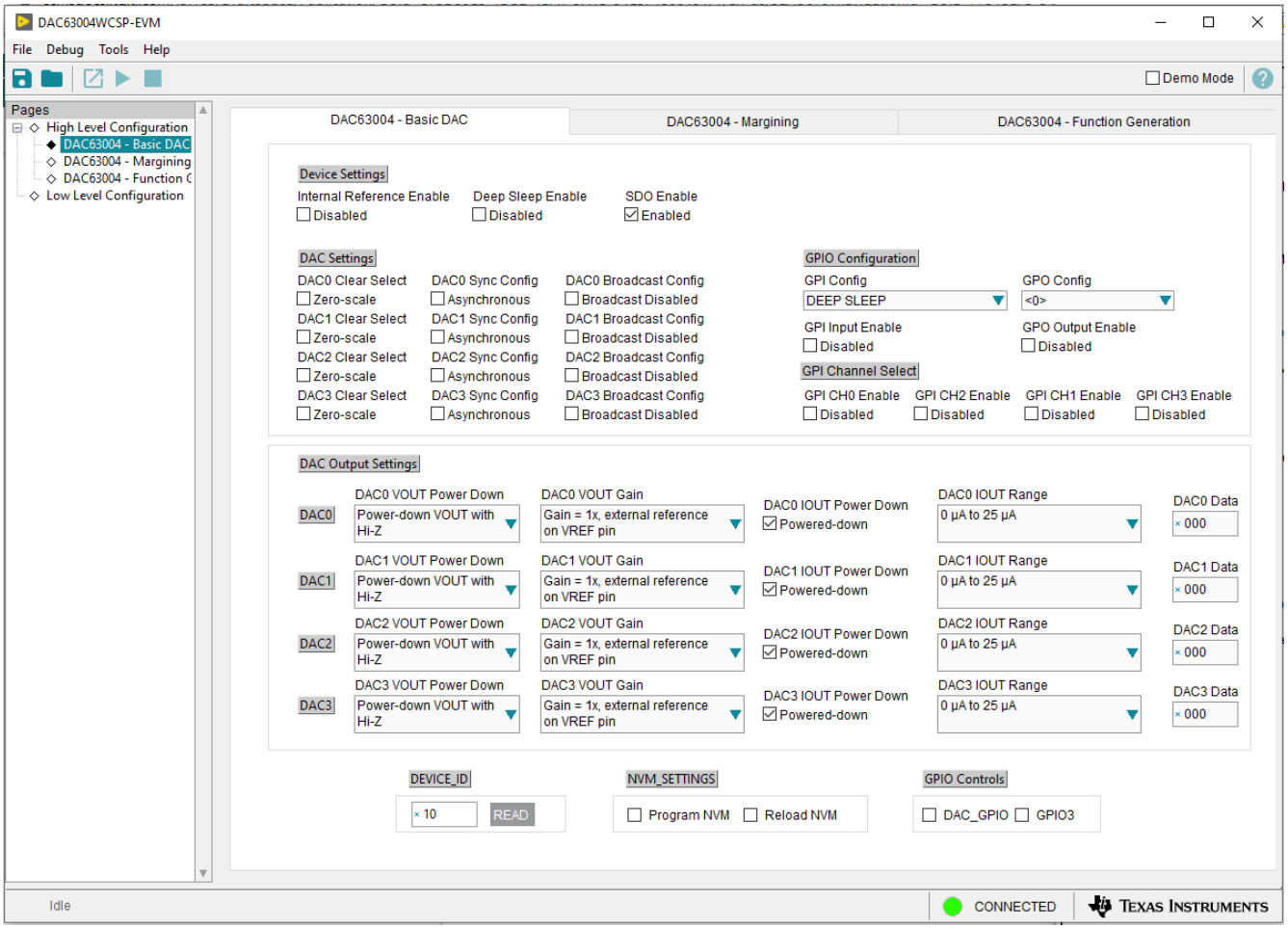

Figure 3-7. Basic DAC Subpage

3.2.2.1.2 Margining Subpage

Figure 3-8 shows the *Margining* subpage. This subpage provides the settings for the margin-low, margin-high, and nominal DAC outputs. Self-resetting triggers are used to trigger the margin-high and margin-low voltage levels for each DAC channel. The *Code Step* and *Slew Rate* drop-down menu settings are also provided on this page to control the slew of each margin high or low trigger (*Trigger MHx*). The register settings are programmed or retrieved using the *Program NVM* or *Reload NVM* checkboxes, respectively.

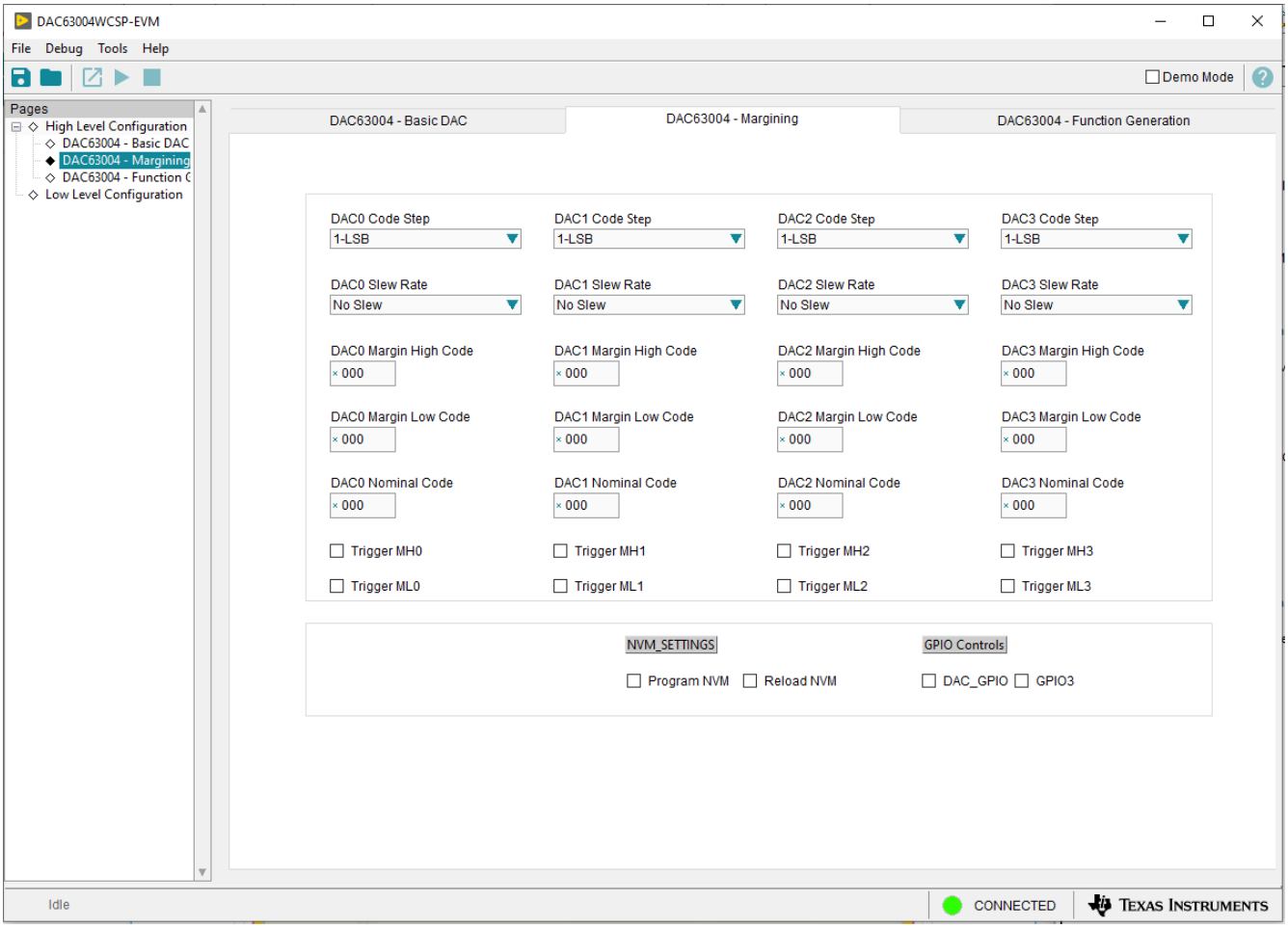

Figure 3-8. Margining Subpage

3.2.2.1.3 Functions Generation Subpage

Figure 3-9 shows the *Function Generation* subpage. This subpage provides control of the relevant register settings for function generation This subpage provides the ramp programming done through the *Code Step* and *Slew Rate* drop-down menu settings. The DAC waveform drop-down menu selects the waveform to be generated: triangular, saw-tooth, inverse saw-tooth, square, or sine. The *Margin High Code* and *Margin Low Code* settings define the upper and lower bounds of the waveform, respectively. The *Start Function Gen* checkboxes start or stop the defined function generation for each channel. The register settings can be programmed or retrieved using the *Program NVM* or *Reload NVM* checkboxes, respectively.

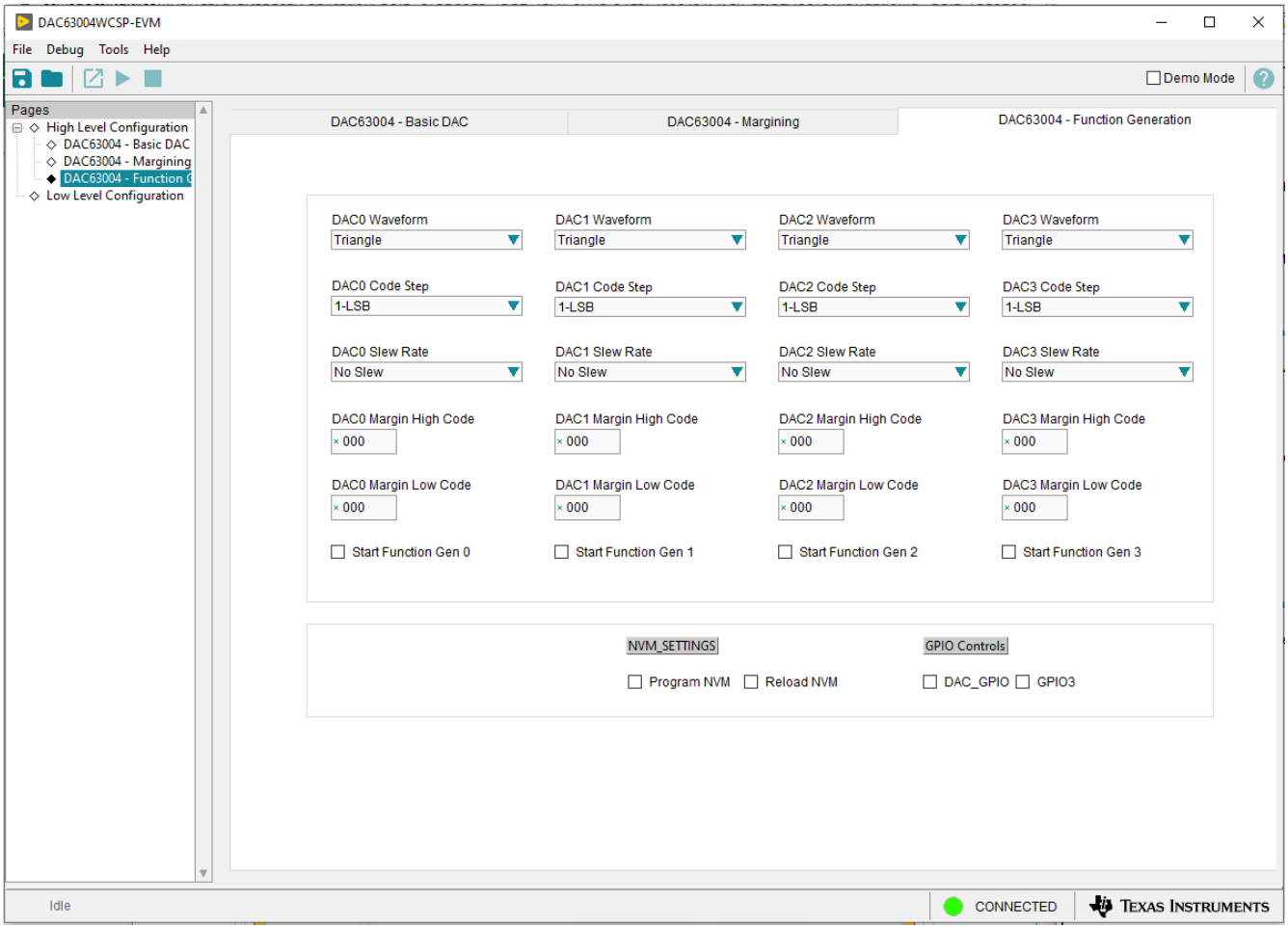

Figure 3-9. Function Generation Subpage

3.2.2.2 Low Level Configuration Page

Figure 3-10 shows the *Low Level Configuration* page. This subpage allows access to low-level communication directly with the respective DACx3004W device registers. Select a register on the *Register Map* list to show a description of the values in that register, as well as information on the register address, default value, size, and current value. Data are written to the registers by entering a value in the value column of the GUI.

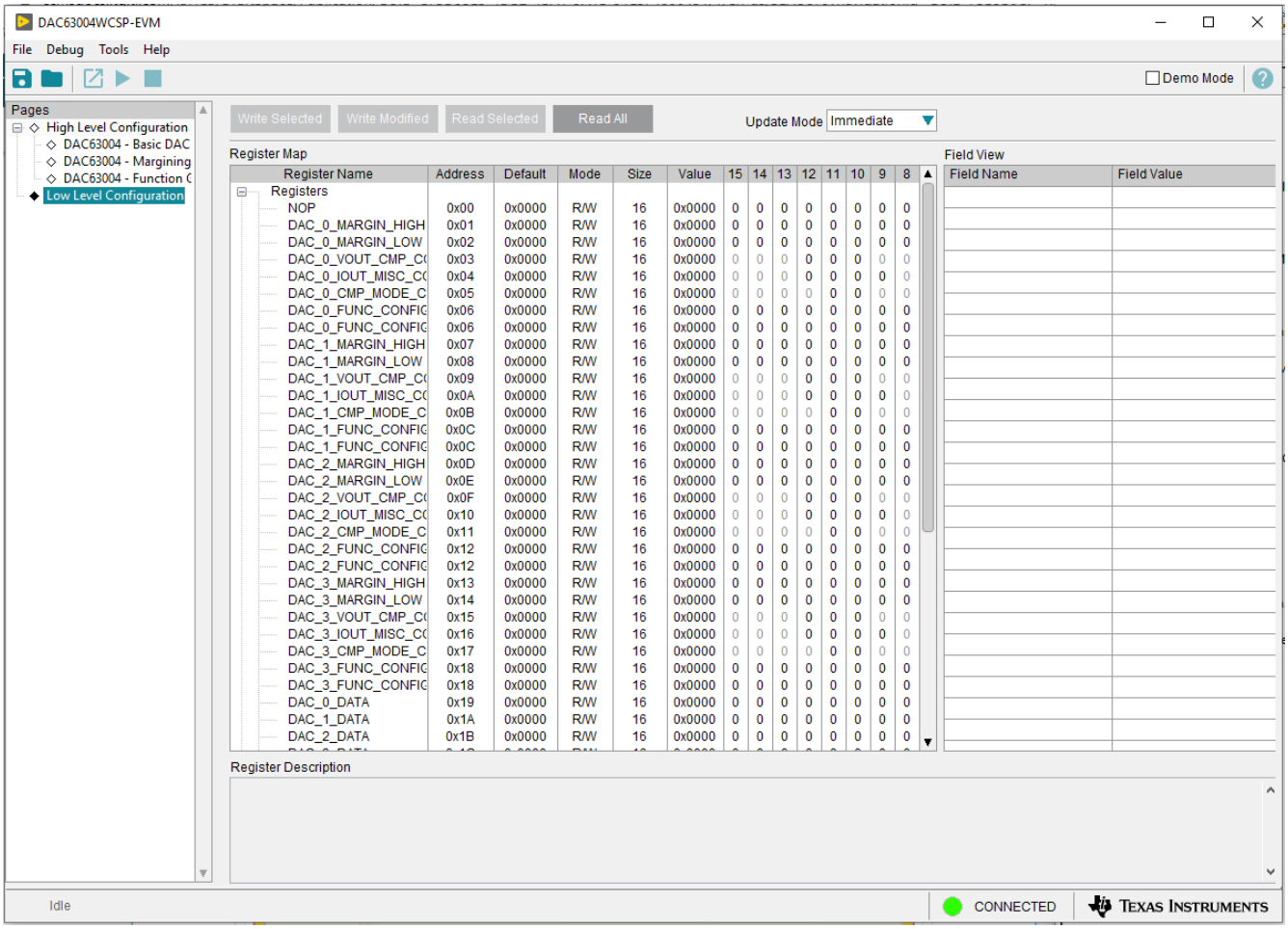

Figure 3-10. Low Level Configuration Page

To store the values of the register map locally, select *Save Configuration* under the *File* menu option. The stored configuration files can be recalled and loaded by selecting *Open Configuration*.

Figure 3-11 shows the four configuration buttons provided on the *Low Level Configuration* page that allow the user to read from and write to the device registers:

- **Write Selected**
- **Write Modified**
- **Read Selected**
- **Read All**

The **Write Modified** button is enabled only in *Deferred Update Mode*. *Deferred Update Mode* initiates a write operation only when the **Write Selected** or **Write Modified** buttons are pressed. By default, *Immediate Update Mode* is selected for the *Low Level Configuration* page write operations.

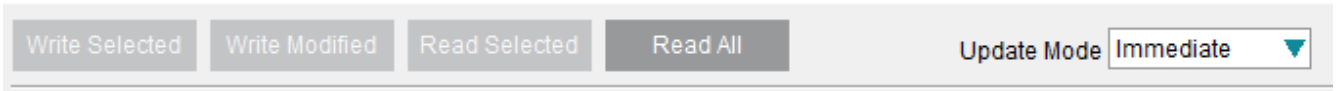

Figure 3-11. Low Level Configuration Page Options

4 Schematic, PCB Layout, and Bill of Materials

This section contains the schematics, printed circuit board (PCB) layout diagrams, and a complete bill of materials for the DAC63004WCSP-EVM. The optional components are shown as do not populate (DNP) on the schematic, and have quantities of zero in the BOM.

4.1 Schematics

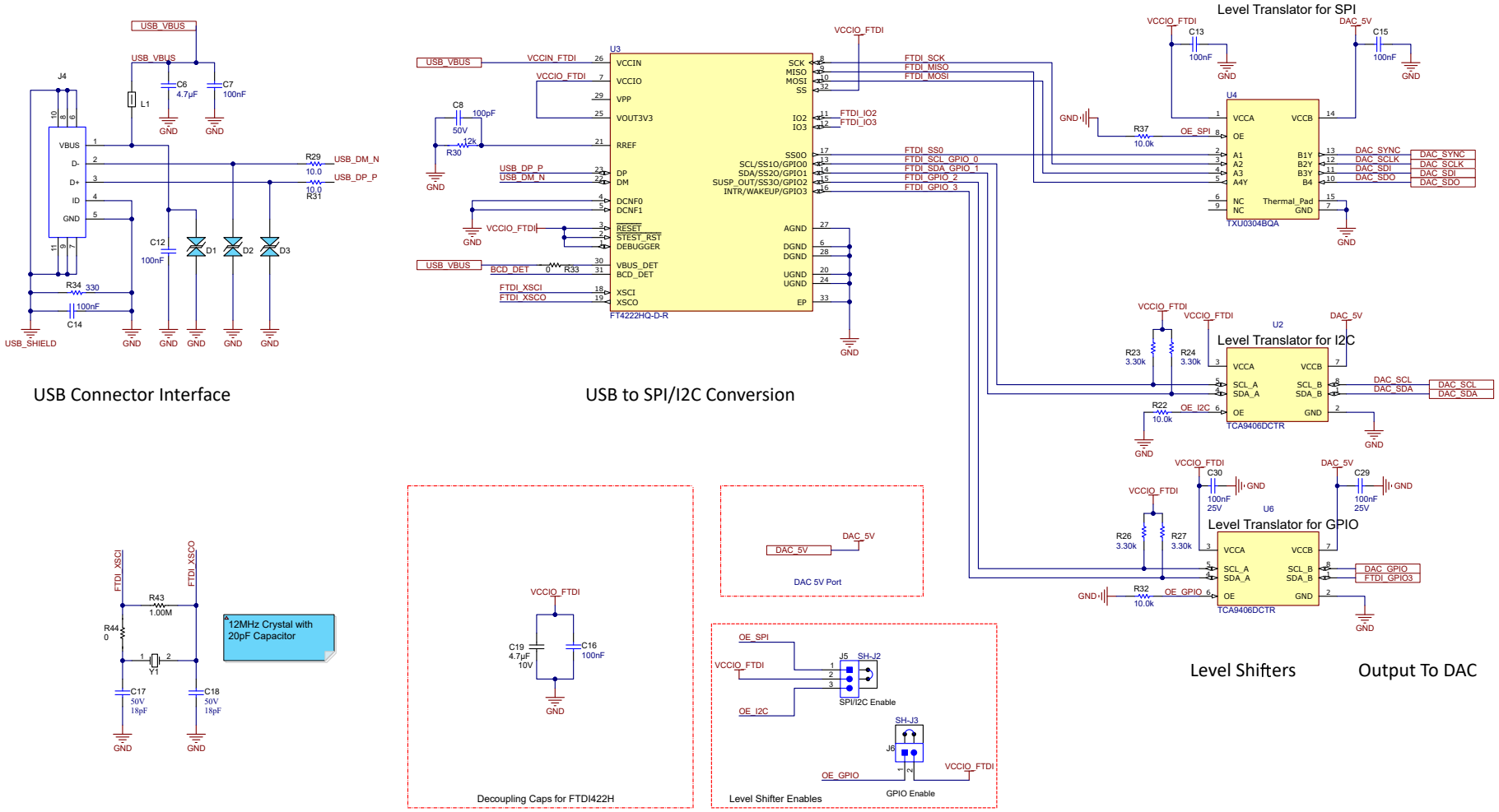

Figure 4-1. DAC63004WCSP-EVM Schematic Page 1

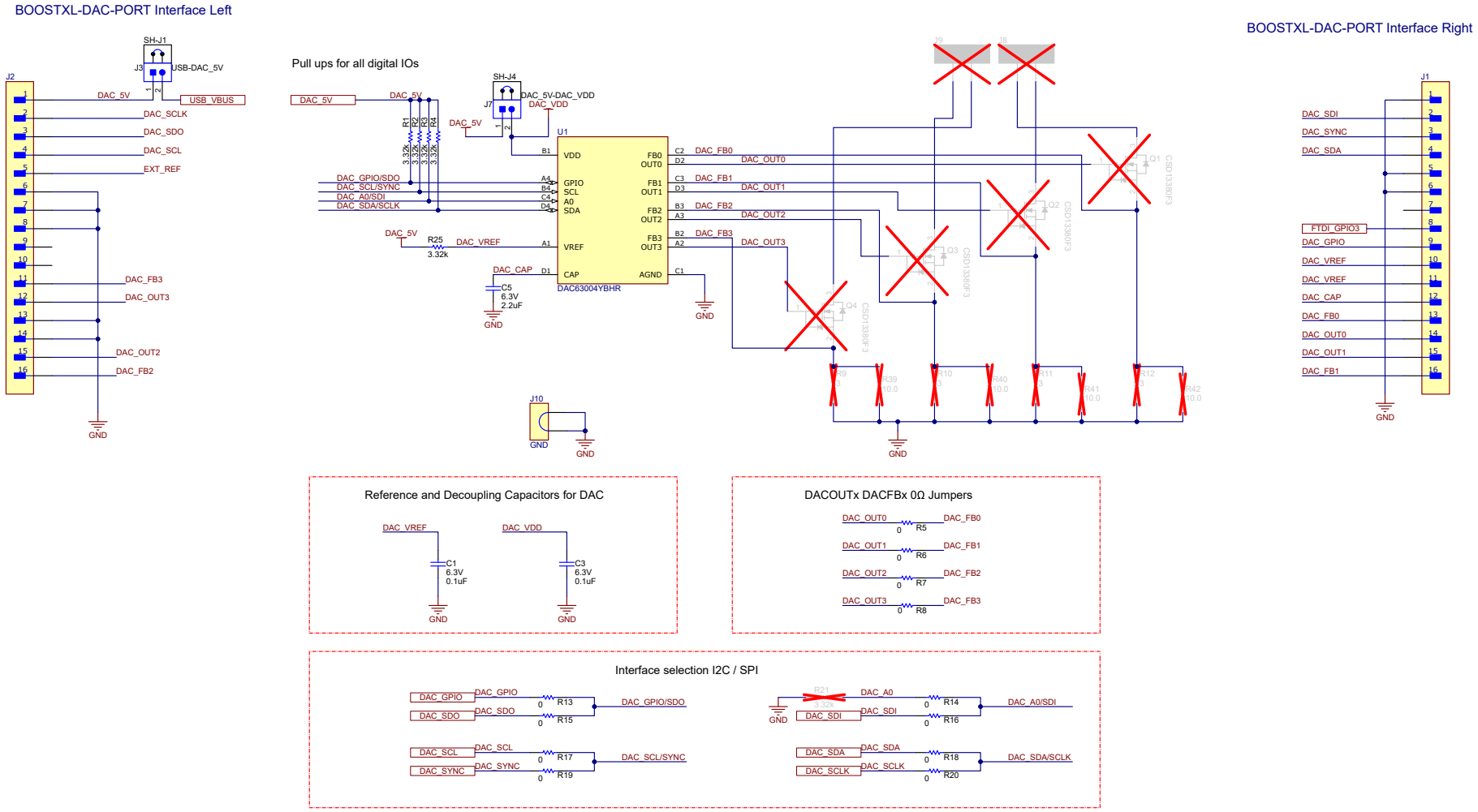

Figure 4-2. DAC63004WCSP-EVM Schematic Page 2

4.2 PCB Layout

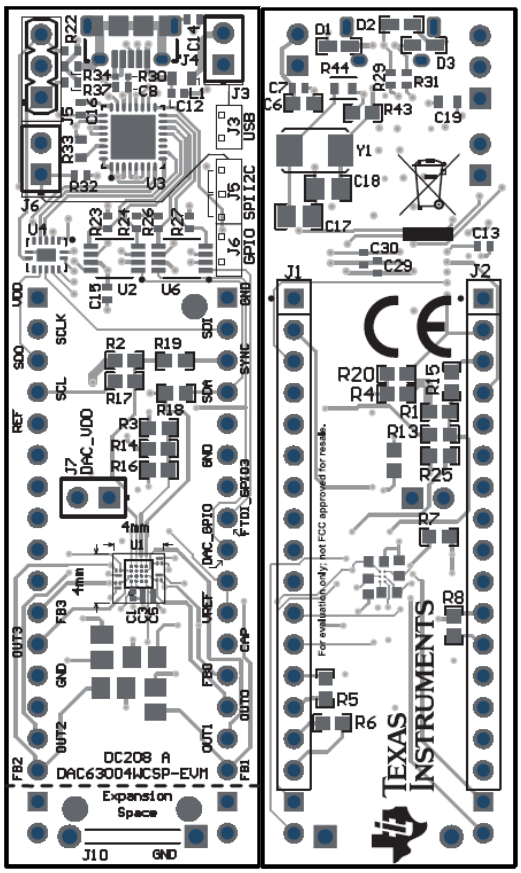

Figure 4-3. DAC63004WCSP-EVM PCB Components Layout

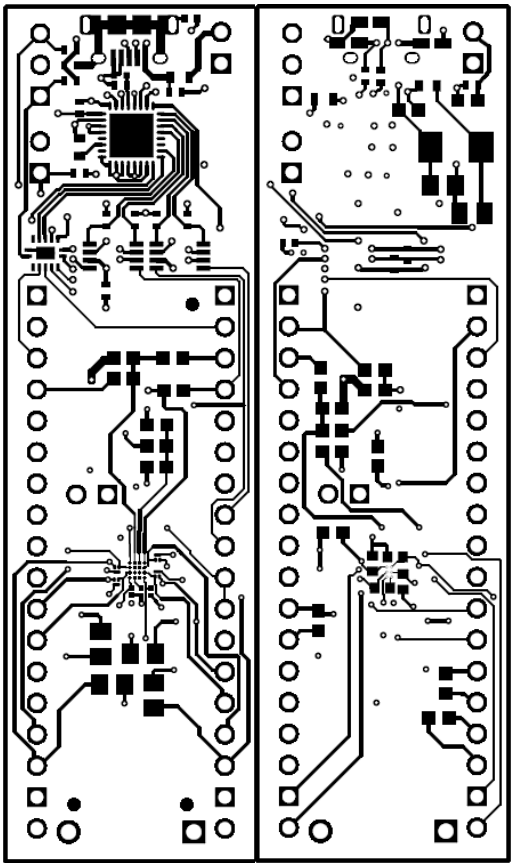

Figure 4-4. DAC63004WCSP-EVM PCB Layers

4.3 Bill of Materials

Table 4-1. DAC63004WCSP-EVM Bill of Materials

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
!PCB	1		Printed Circuit Board		DC159	Any
C1, C3	2	0.1 µF	CAP, CERM, 0.1 uF, 6.3 V, +/- 10%, X5R, 0201	0201	GRM033R60J104KE19D	MuRata
C5	1	2.2 µF	CAP, CERM, 2.2 uF, 6.3 V, +/- 20%, X5R, 0201	0201	CL03A225MQ3CRNC	Samsung Electro-Mechanics
C6, C19	2	4.7 µF	CAP, CERM, 4.7 uF, 10 V, +/- 20%, X7R, 0603	0603	GRM188Z71A475ME15D	MuRata
C7, C12, C13, C14, C15, C16, C29, C30	8	0.1 µF	CAP, CERM, 0.1 µF, 25 V,+/- 10%, X7R, 0402	0402	CC0402KRX7R8BB104	Yageo
C8	1	100 pF	CAP, CERM, 100 pF, 50 V, +/- 10%, X7R, 0402	0402	885012205055	Wurth Elektronik
C17, C18	2	18 pF	CAP, CERM, 18 pF, 50 V, +/- 5%, C0G/NP0, 0805	0805	08055A180JAT2A	AVX
J1, J2	2		Header, 2.54mm, 16x1, TH	Header, 2.54mm, 16x1, TH	PEC16SABN	Sullins Connector Solutions
J3, J6, J7	2		Header, 2.54mm, 1x2, Tin, Black, TH	Header, 2.54mm, 2x1, TH	PEC01DAAN	Sullins Connector Solutions
J4	1		Receptacle, USB 2.0, Micro-USB Type B, R/A, SMT	USB-micro B USB 2.0, 0.65mm, 5 Pos, R/A, SMT	10118194-0001LF	FCI
J5	1		Header, 2.54mm, 3x1, Tin, TH	Header, 2.54mm, 3x1, TH	68001-403HLF	FCI
J8, J9	0		Header, 2.54mm, 2x1, Tin, TH	Header, 2.54mm, 2x1, TH	PEC02SABN	Sullins Connector Solutions
J10	1		Gold Jumper	Bar	D3082-05	Harwin
L1	1	600 Ω	Ferrite Bead, 600 Ω @ 100 MHz, 1 A, 0603	0603	782633601	Wurth Elektronik
Q1, Q2, Q3, Q4	0	12 V	MOSFET, N-CH, 12 V, 3.6 A, YJM0003A (PICOSTAR-3)	YJM0003A	CSD13380F3	Texas Instruments
R1, R2, R3, R4, R25	5	3.32 kΩ	RES, 3.32 k, 1%, 0.1 W, 0603	0603	RC0603FR-073K32L	Yageo America
R5, R6, R7, R8, R13, R14, R15, R16, R17, R18, R19, R20	12	0 Ω	RES, 0, 5%, 0.1 W, 0603	0603	RC0603JR-070RL	Yageo America
R9, R10, R11, R12	0	3 Ω	RES Thick Film, 3 Ω, 1%, 0.33 W, 100 ppm/°C, 0603	0603	CRCW06033R00FKEAHP	Vishay
R21	0	3.32 kΩ	RES, 3.32 k, 1%, 0.1 W, 0603	0603	RC0603FR-073K32L	Yageo America
R22, R32, R37	3	10.0 kΩ	RES, 10.0 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	RMCF0402FT10K0	Stackpole Electronics Inc
R23, R24, R26, R27	4	3.30 kΩ	RES, 3.30 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	RK73H1ETTP3301F	KOA Speer

Table 4-1. DAC63004WCSP-EVM Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
R29, R31	2	10 Ω	RES, 10.0, 1%, 0.063 W, 0402	0402	RK73H1ETTP10R0F	KOA Speer
R30	1	12 kΩ	12 kOhms ±1% 0.1W, 1/10W Chip Resistor 0402 (1005 Metric) Automotive AEC-Q200 Thick Film	0402	ERJ-2RKF1202X	Panasonic ECG
R33, R44	2	0 Ω	0 Ohms Jumper 0.1W, 1/10W Chip Resistor 0603 (1608 Metric) Automotive AEC-Q200 Thick Film	0603	ERJ-3GEY0R00V	Panasonic
R34	1	330 Ω	RES, 330, 1%, 0.1 W, AEC-Q200 Grade 0, 0402	0402	ERJ-2RKF3300X	Panasonic
R39, R40, R41, R42	0	10 Ω	RES, 10.0, 1%, .5 W, AEC-Q200 Grade 0, 0805	0805	ERJ-P6WF10R0V	Panasonic
R43	1	1 MΩ	RES, 1.00 M, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06031M00FKEA	Vishay-Dale
SH-J1, SH-J2, SH-J3, SH-J4	4	1x2	Shunt, 100mil, Gold plated, Black	Shunt	SNT-100-BK-G	Samtec
U1	1		DAC63004YBHR	DSBGA16	DAC63004YBHR	Texas Instruments
U2, U6	2		Voltage Level Translator Bidirectional 1 Circuit 2 Channel 24Mbps SM8	SSOP8	TCA9406DCTR	Texas Instruments
U3	1		USB2.0 to QuadSPI/I2C Bridge IC, VQFN-32	VQFN-32	FT4222HQ-D-R	FTDI
U4	1		4-Bit Fixed Direction Voltage-Level Translator with Schmitt- Trigger Inputs, and Tri-State Outputs, WQFN14	WQFN14	TXU0304BQA	Texas Instruments
Y1	1		Crystal, 12 MHz, 18 pF, SMD	ABM3	ABM3-12.000MHZ-B2-T	Abracon Corporation

STANDARD TERMS FOR EVALUATION MODULES

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.

   1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI semiconductors products. EVMs have no direct function and are not finished products. EVMs shall not be directly or indirectly assembled as a part or subassembly in any finished product. For clarification, any software or software tools provided with the EVM (“Software”) shall not be subject to the terms and conditions set forth herein but rather shall be subject to the applicable terms that accompany such Software

   1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.

2 *Limited Warranty and Related Remedies/Disclaimers*:

   2.1 These terms do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.

   2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for a nonconforming EVM if (a) the nonconformity was caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI, (b) the nonconformity resulted from User's design, specifications or instructions for such EVMs or improper system design, or (c) User has not paid on time. Testing and other quality control techniques are used to the extent TI deems necessary. TI does not test all parameters of each EVM. User's claims against TI under this Section 2 are void if User fails to notify TI of any apparent defects in the EVMs within ten (10) business days after delivery, or of any hidden defects with ten (10) business days after the defect has been detected.

   2.3 TI's sole liability shall be at its option to repair or replace EVMs that fail to conform to the warranty set forth above, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

WARNING

Evaluation Kits are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems.

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

NOTE:

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

3 *Regulatory Notices:*

3.1 *United States*

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

FCC NOTICE: This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.

3.1.2 *For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant:*

CAUTION

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

FCC Interference Statement for Class A EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FCC Interference Statement for Class B EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- *Reorient or relocate the receiving antenna.*
- *Increase the separation between the equipment and receiver.*
- *Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.*
- *Consult the dealer or an experienced radio/TV technician for help.*

3.2 *Canada*

3.2.1 *For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210 or RSS-247*

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSSs. Operation is subject to the following two conditions:

(1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concernant les EVMs avec appareils radio:

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Concerning EVMs Including Detachable Antennas:

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur

3.3 *Japan*

3.3.1 *Notice for EVMs delivered in Japan:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。
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 *European Union*

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

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

4 *EVM Use Restrictions and Warnings:*

4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.

4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.

4.3 *Safety-Related Warnings and Restrictions:*

4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.

4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.

4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.

5. *Accuracy of Information:* To the extent TI provides information on the availability and function of EVMs, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.

6. *Disclaimers:*

6.1 EXCEPT AS SET FORTH ABOVE, EVMS AND ANY MATERIALS PROVIDED WITH THE EVM (INCLUDING, BUT NOT LIMITED TO, REFERENCE DESIGNS AND THE DESIGN OF THE EVM ITSELF) ARE PROVIDED "AS IS" AND "WITH ALL FAULTS." TI DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING SUCH ITEMS, INCLUDING BUT NOT LIMITED TO ANY EPIDEMIC FAILURE WARRANTY OR IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF ANY THIRD PARTY PATENTS, COPYRIGHTS, TRADE SECRETS OR OTHER INTELLECTUAL PROPERTY RIGHTS.

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   8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY USE OF AN EVM PROVIDED HEREUNDER, INCLUDING FROM ANY WARRANTY, INDEMITY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS, , EXCEED THE TOTAL AMOUNT PAID TO TI BY USER FOR THE PARTICULAR EVM(S) AT ISSUE DURING THE PRIOR TWELVE (12) MONTHS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM SHALL NOT ENLARGE OR EXTEND THIS LIMIT.

9. *Return Policy.* Except as otherwise provided, TI does not offer any refunds, returns, or exchanges. Furthermore, no return of EVM(s) will be accepted if the package has been opened and no return of the EVM(s) will be accepted if they are damaged or otherwise not in a resalable condition. If User feels it has been incorrectly charged for the EVM(s) it ordered or that delivery violates the applicable order, User should contact TI. All refunds will be made in full within thirty (30) working days from the return of the components(s), excluding any postage or packaging costs.

10. *Governing Law:* These terms and conditions shall be governed by and interpreted in accordance with the laws of the State of Texas, without reference to conflict-of-laws principles. User agrees that non-exclusive jurisdiction for any dispute arising out of or relating to these terms and conditions lies within courts located in the State of Texas and consents to venue in Dallas County, Texas. Notwithstanding the foregoing, any judgment may be enforced in any United States or foreign court, and TI may seek injunctive relief in any United States or foreign court.

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