

EVM User's Guide: DAC81404EVM

DAC81404 Evaluation Module



Description

The 16-bit, 4-channel DAC81404 and 12-bit, 4-channel DAC61404 are a pin-compatible family of quad-channel, buffered, high-voltage-output digital-to-analog converters (DACs) with an integrated 2.5V internal reference. These devices are specified monotonic and provide exceptional linearity of less than 1LSB.

Get Started

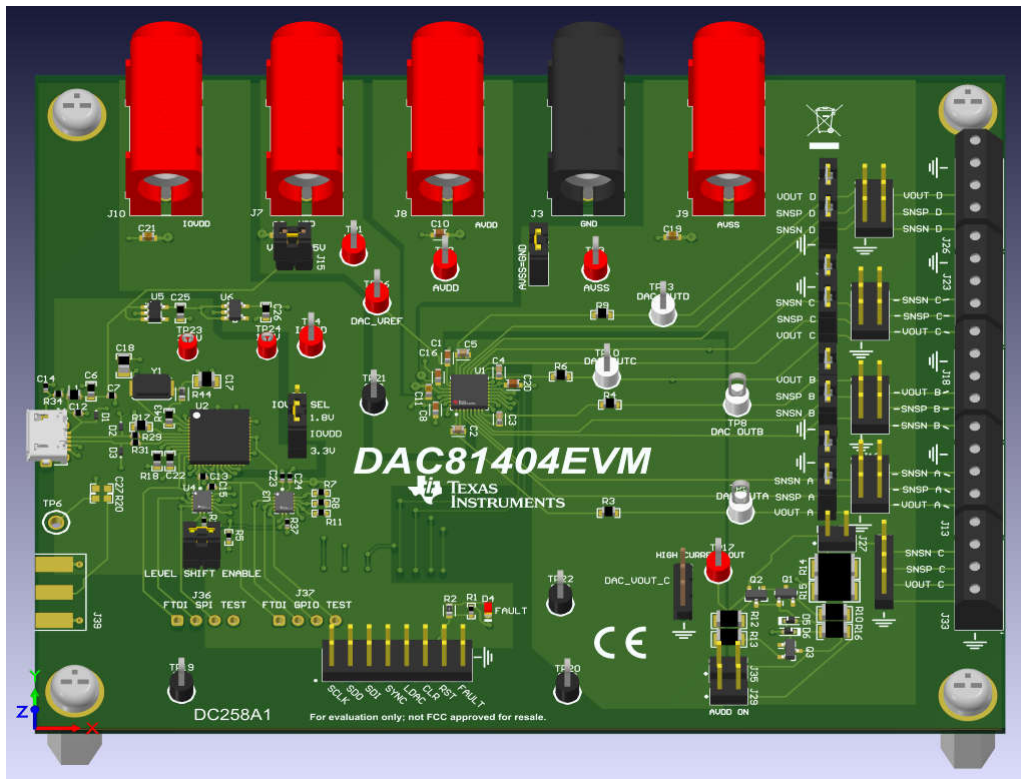
1. Order the EVM from the product folder ([DAC81404EVM](#))
2. Configure EVM jumpers
3. Install DAC814xxEVM GUI from ti.com ([DAC81404EVM tool folder](#))
4. Connect USB and external power supplies
5. Launch DAC814xxEVM GUI

Features

- Configurable circuit to evaluate DAC
- Onboard VDD and IOVDD (1.8V or 3.3V) support
- Trigger output is available for synchronous measurement
- FT4232 used to easily write to DAC using DAC814xxEVM GUI
- External SPI connections available

Applications

- [Semiconductor test](#)
- [Lab and field instrumentation](#)
- [Analog output module](#)
- [Data acquisition](#)
- LCD test
- [Servo drive control module](#)



1 Evaluation Module Overview

1.1 Introduction

This user's guide describes the characteristics, operation, and recommended use cases of the DAC81404EVM. This document provides examples and instructions on how to use the DAC81404EVM board and included software. Throughout this document, the terms evaluation board, evaluation module, and EVM are synonymous with the DAC81404EVM. This document also includes a schematic, reference printed circuit board (PCB) layouts, and a complete bill of materials (BOM).

1.2 Kit Contents

Table 1-1 details the contents of the EVM kit. Contact the TI Product Information Center at (972) 644-5580 if any component is missing. Download the latest versions of the related software on the TI website, www.ti.com.

Table 1-1. DAC81404EVM Kit Contents

| Item | Quantity |
|-----------------------------|----------|
| DAC81404EVM | 1 |
| USB-A to Micro-USB Cable | 1 |

1.3 Specification

Figure 1-1 shows the block diagram of the DAC81404EVM board. By default, the DAC81404EVM connects to a local machine USB port through a USB-A to micro-USB cable.

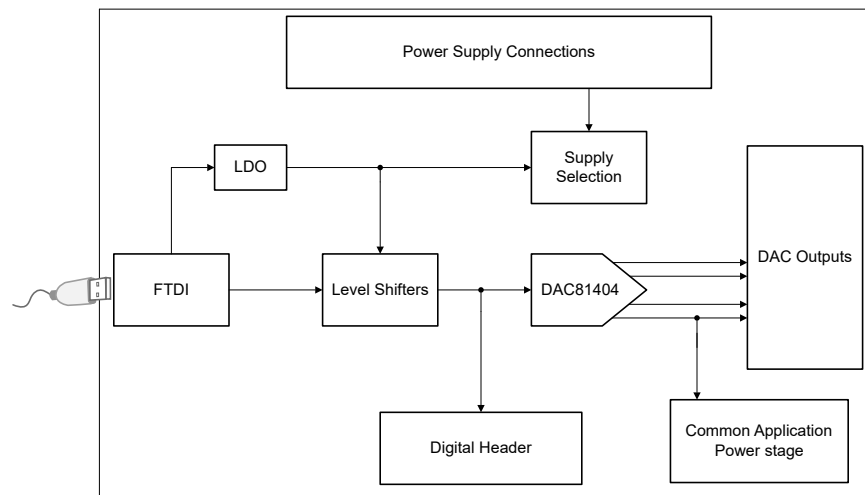


Figure 1-1. DAC81404EVM Functional Block Diagram

The USB provides the 5V default VDD supply to the DAC81404. Voltage regulators generate 3.3V and 1.8V from USB 5V supply. These 3.3V and 1.8V supplies are used to power the FTDI controller, level shifter, and IOVDD of DAC81404. IOVDD can be 3.3V or 1.8V depending on the jumper J5 setting. DVDD and IOVDD device supply inputs for the DAC81404 can be externally supplied through banana jacks. The AVDD and AVSS need external supply connections as well.

1.4 Device Information

The DACx1404 devices offer bipolar output voltages of $\pm 20V$, $\pm 10V$, $\pm 5V$, and full-scale unipolar output voltages of 40V, 10V and 5V. The DAC output range is programmable.

2 Hardware

2.1 Power Requirements

The USB connection at J15 provides 5V to the EVM. This connection is necessary if using the DAC814xxEVM GUI, as the communication is done through the USB port and the FT4232 is powered by one of the LDOs on the board. Onboard supply for IOVDD is available (LDO generated 1.8V or 3.3V through J21). DVDD and IOVDD power supply of DAC81404 can be provided externally through J7 and J10 respectively. AVDD and AVSS power supply of DAC81404 need to be connected externally through J8 and J9 respectively. AVSS can be connected to GND through J22.

- AVDD : 0 to 41.5V (default + 15V)
- AVSS : 0 to -21.5 V (default - 15V)
- DVDD : 4.5V to 5.5V (default + 5V)
- IOVDD : 1.7V to 5.5V (default + 3.3V)
- (AVDD - AVSS) must not be greater than 43V

Table 3-1 summarizes the external power connections.

Table 2-1. DAC81404EVM Power Supply Inputs

| Terminal | Name | Function |
|----------|-------|---|
| J8 | AVDD | Positive supply voltage for the DAC81404 output buffers. |
| J9 | AVSS | Negative supply voltage for DAC81404 output buffers. |
| J7 | DVDD | Digital and analog supply voltage for the DAC81404. |
| J10 | IOVDD | IO supply voltage for setting the digital I/O operating voltage for the DAC81404. |
| J3 | GND | Ground connection. |

2.2 Jumper Information

The jumpers must be connected properly to operate the DAC81404EVM for the intended operation. Table 3-2 provides the details of the configurable jumper settings on the EVM.

Table 2-2. DAC81404EVM Jumper Summary

| Header | Name | Function |
|-------------------|--------------------|--|
| J15 | VDD = USB5V | Short 1-2 – VDD = 5V supplied through USB power (default) Open – VDD supplied through J7 |
| J22 | AVSS = GND | Short 1-2 – AVSS is grounded (default) Open – AVSS is supplied by J9 |
| J21 | IOVDD SEL | Short 1-2 – IOVDD = 3.3V supplied through LDO output (default) Short 2-3 – IOVDD = 1.8V supplied through LDO output Open – IOVDD is supplied through J10 |
| J1, J16, J19, J24 | DAC_ANALOG_X | Short 1-2 – Sense pin for the positive voltage output load is shorted to the DAC output (default) Short 3-4 – Sense pin for the negative voltage output load is shorted to the ground (default) |
| J5 | LEVEL SHIFT ENABLE | Short 1-2 - Enable voltage level shifters (default) Open -Disable voltage level shifters |

2.3 Setup

After the power and jumper configurations are set up per [Figure 3-1](#) or [Figure 3-2](#), and the DAC814xxEVM GUI is fully installed, connect the USB cable from the DAC81404EVM USB port to the local machine.

Once all the connection is done, power up the DAC81404EVM hardware as described in [Section 2.1](#).

For basic DAC81404 device check, use one of the following sequences in the DAC814xxEVM GUI:

- **From *DAC81404 Register* page**
 - Write 0x0A04 to the SPI_CONFIG (0x03) register to power up the device
 - Write 0x0000 to the GEN_CONFIG (0x04) register to power up the internal reference
 - Write 0x0000 to the DAC_PWDWN (0x09) register to power up the DAC outputs
 - Write 0x7FFF to the DACA (0x10) register to configure the DAC_OUT to 2.5V on DAC_OUTA (TP5)
- **From *DAC81404 High Level* page**
 - Device Power Down: select *Active mode* to power up the device
 - Reference Power-Down: select *Activate internal ref* to power up the internal reference
 - DACA Channel Power-Down: select *Activate channel* to power up the DAC output
 - DACA_DATA: write 0x7FFF to get 2.5V on DAC_OUT (TP5)

The default voltage range for the DAC81404 is 0V to 5V. Configure the voltage range by modifying the *DACx Voltage Range* control on DAC814xxEVM GUI High Level page, or by writing to the "DACx_RANGE" register in the Low Level page as shown in [Section 3.2](#).

2.4 Test Points

Table 2-3. DAC81404EVM Test Points

| Test Point | Net | Description |
|------------------------|------------------|---------------------------------------|
| TP1 | VDD | DAC81404 VDD |
| TP2 | AVDD | DAC81404 AVDD |
| TP3 | AVSS | DAC81404 AVSS |
| TP4 | IOVDD | DAC81404 IOVDD |
| TP5 | DAC_OUTA | DAC81404 output A |
| TP8 | DAC_OUTB | DAC81404 output B |
| TP10 | DAC_OUTC | DAC81404 output C |
| TP13 | DAC_OUTC | DAC81404 output D |
| TP19, TP20, TP21, TP22 | GND | Ground connections |
| TP17 | HIGH CURRENT OUT | Output of a high current stage |
| TP23 | 3.3V | 3.3V LDO output |
| TP24 | 1.8V | 1.8V LDO output |
| TP6 | TRIG | Trigger for FTDI |
| TP26 | DAC_VREF | Reference voltage signal for DAC81404 |

2.5 High-Current Optional Stage

This output stage is designed to output high current (100mA) for applications such as motor control. The design uses a class AB amplifier output with a diode-and-resistor-based constant current biasing.

Figure 2-1 shows the schematic of the stage.

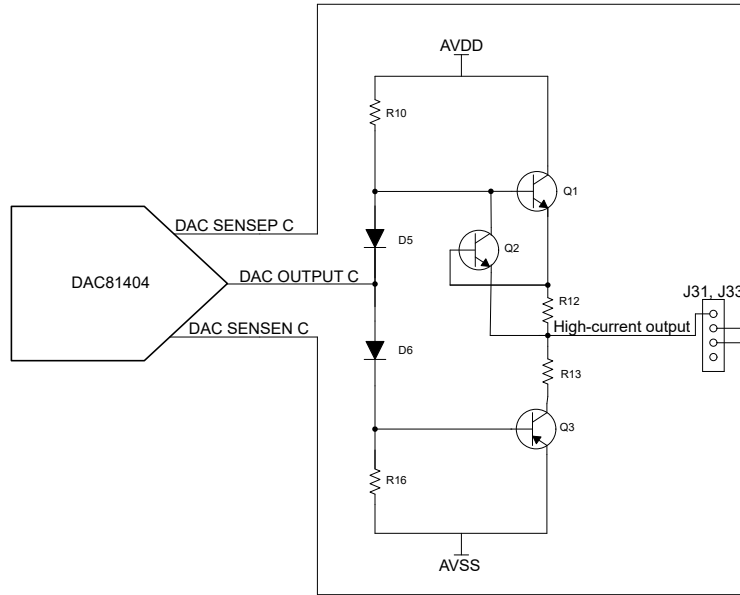


Figure 2-1. DAC81404EVM High-current Output Stage Diagram

The power is disconnected to the high-current output stage by default. Refer to Table 2-4 for power connection information.

Table 2-4. DAC81404EVM High-Current Stage Headers

| Header | Name | Function |
|--------|-------------|--|
| J29 | AVDD ON | Short 1-2 – Connect AVDD to the high-current output stage. Open – AVDD is disconnected from the high-current output stage (default). |
| J32 | DAC VOUT ON | Short 1-2 – Connect output of channel C of the DAC to the high-current output stage. Short 2-3 – Connect the high-current output stage input to the ground. Open – high-current output stage input is floating (default). |
| J35 | AVSS ON | Short 1-2 – Connect AVSS to the system. Open – AVSS is disconnected from the high-current output stage (default). |
| J27 | LOAD | Short 1-2 – Connect high current output of the system to the on-board resistive load. Open – The high current output stage is disconnected from the on-board resistive load (default). |

3 Software

3.1 GUI Installation

This section provides the procedure for EVM software installation.

The EVM software is compatible with the Windows® 10 operating system. Before installing the software, make sure that the DAC80404EVM is not connected to the local machine.

Download the latest version of the EVM graphical user interface (GUI) installer from the *Order and start development* subsection of the [DAC81404EVM tool folder](#) on TI.com. Run the GUI installer to install the DAC81404EVM GUI software on your local machine.

When the DAC804xxEVM GUI is launched, an installation dialog window opens and prompts the user to select an installation directory. If left unchanged, then [Figure 3-1](#) shows that the software location defaults to `C:\Program Files (x86)\Texas Instruments\DAC814xxEVM`.

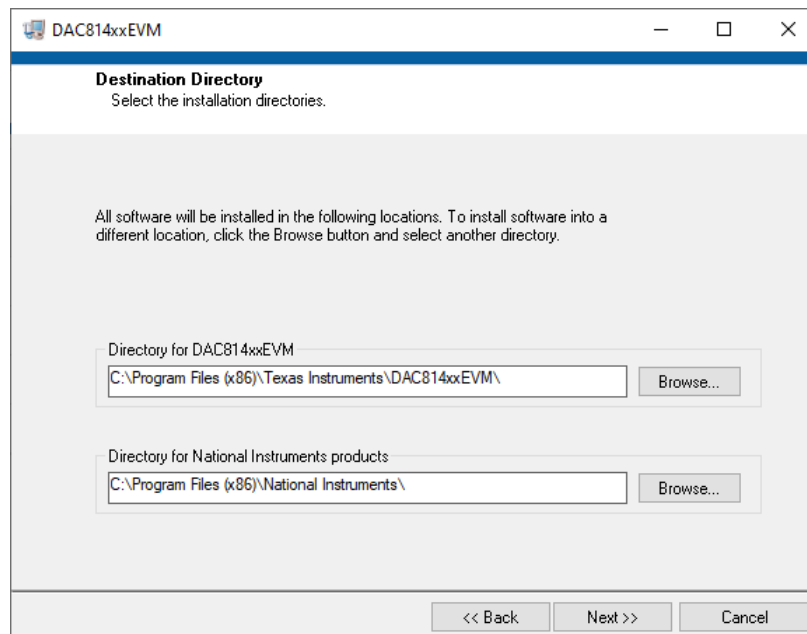


Figure 3-1. Software Installation Path

The EVM software also installs the Future Technology Devices International Limited (FTDI) USB drivers using a separate executable file. Figure 3-2 shows the FTDI USB drivers installation window that is automatically launched after the DAC814xxEVM software installation is complete.

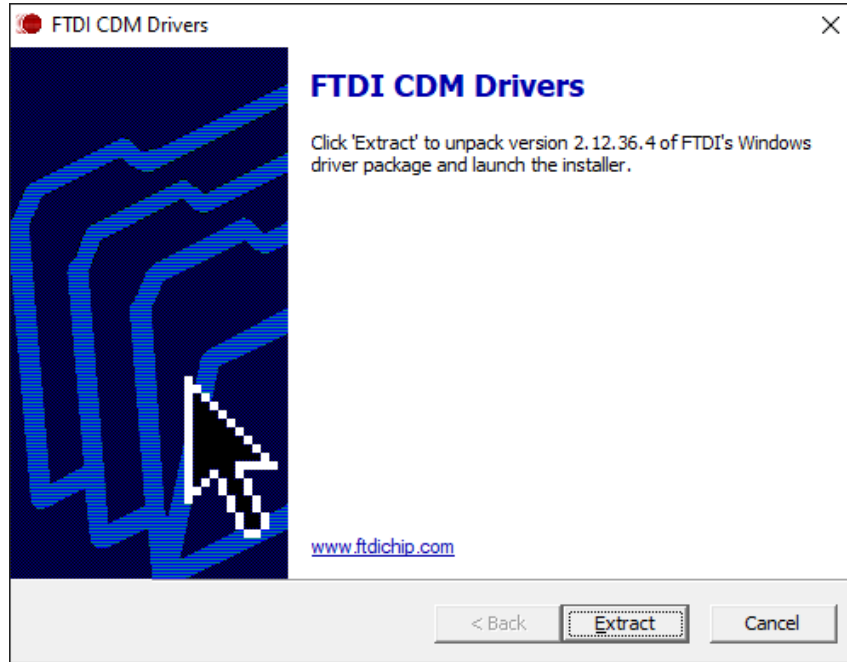


Figure 3-2. FTDI USB Drivers

3.2 Software Development

To launch the software, locate the *DAC814xxEVM* icon in the *Start Menu*, and select the *DAC814xxEVM* icon as shown in Figure 3-3.

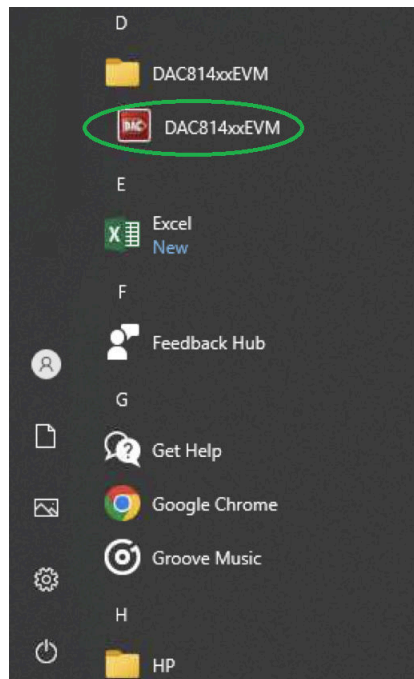


Figure 3-3. DAC814xxEVM Software Installation in Start Menu

Upon launching the software, a drop-down menu pops up. Select an appropriate device. For the scope of this EVM, select DAC81404 option.

Figure 3-4 shows that if the onboard FTDI controller is connected correctly, then the status bar at the bottom of the screen displays *CONNECTED*. If the controller is not properly connected or not connected at all, then the status displays *DEMO*. If the graphical user interface (GUI) does not display the *CONNECTED* status while the EVM is connected, then unplug and reconnect the EVM and relaunch the GUI software.

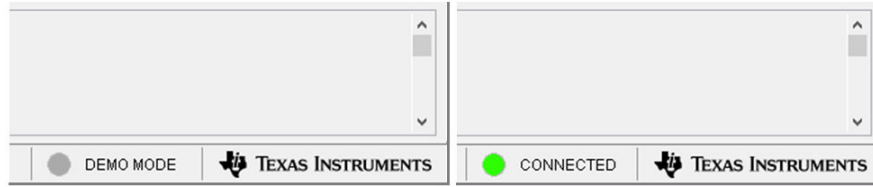


Figure 3-4. DAC814xxEVM GUI Connection Detection

DAC81404 High Level page provides quick access to basic DAC81404 functionality as shown in Figure 3-5.

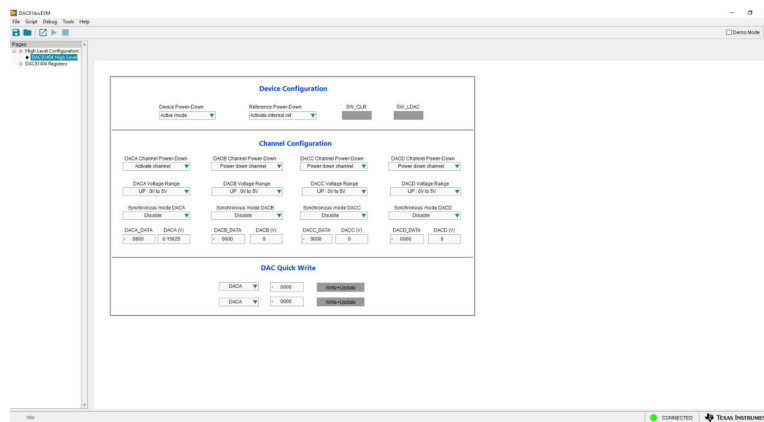


Figure 3-5. DAC81404EVM High Level Page

The *DAC81404 Registers* page allows the user to access low-level communication directly with the DAC81404 registers as shown in Figure 3-6. Selecting a register on the Register Map list shows a description of the values in that register, as well as information on the register address, default value, size, and current value. Values are read from and written to the registers by writing to the Value or bit field of the GUI.

The *Register Map* page also provides the FTDI GPIO controls for DAC81404EVM. For example, OPE_EN, TRIG and FAULT pins, under the FTDI section.

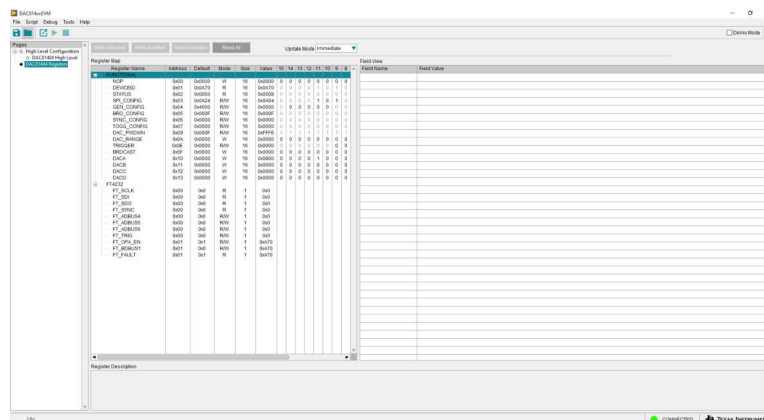


Figure 3-6. DAC81404EVM Registers Page

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* as shown in [Figure 3-7](#).

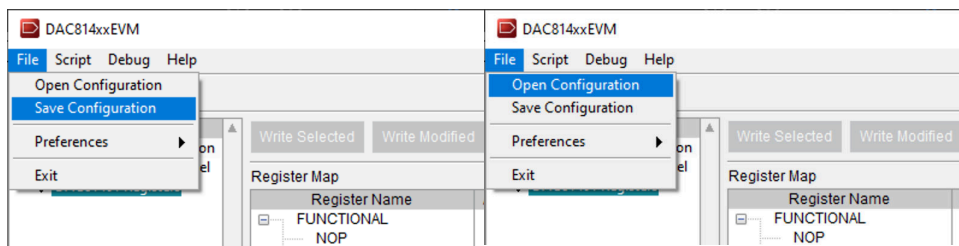
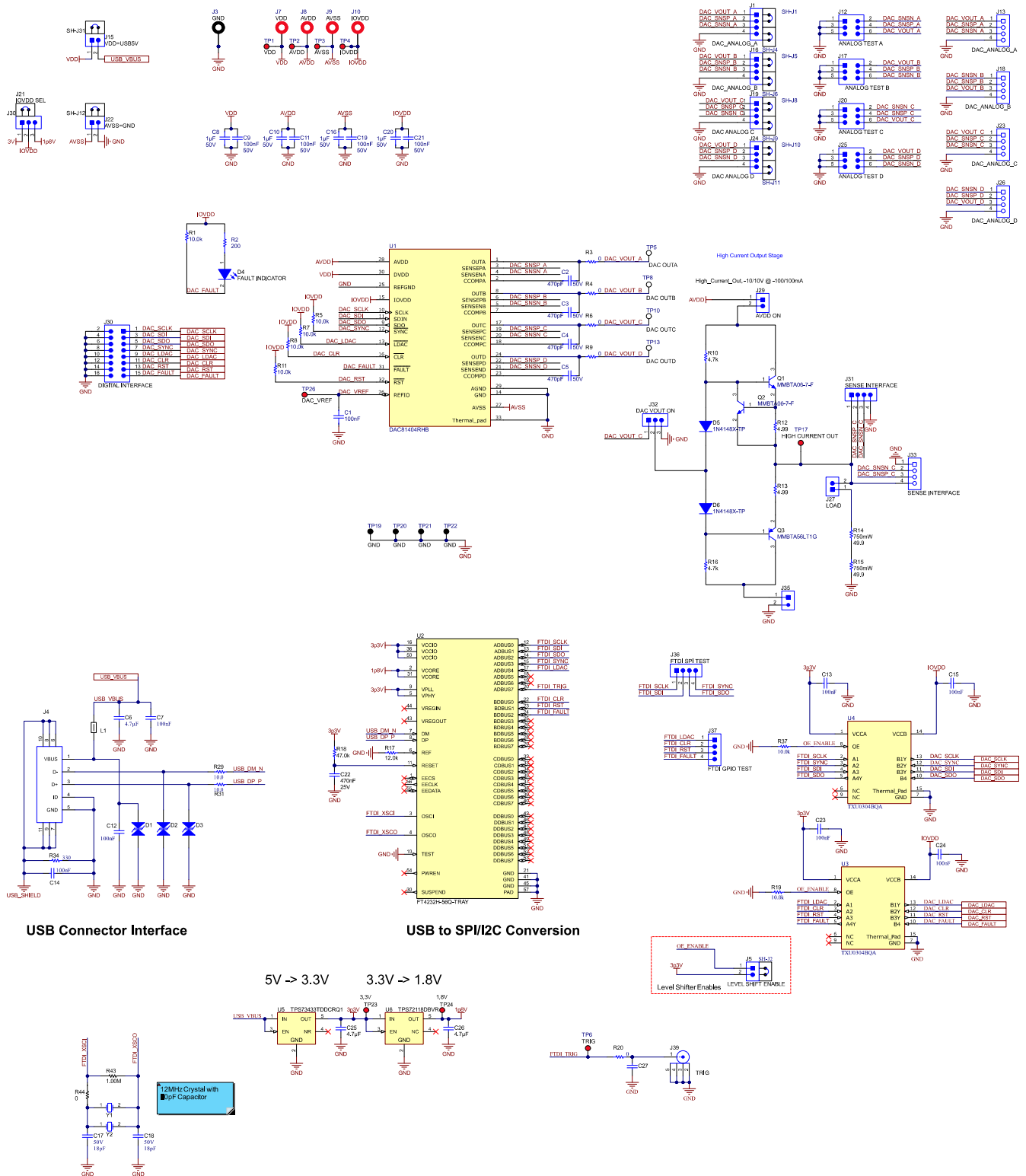


Figure 3-7. DAC81404EVM Save/Open Configuration

4 Hardware Design Files

4.1 Schematics



4.2 PCB Layouts

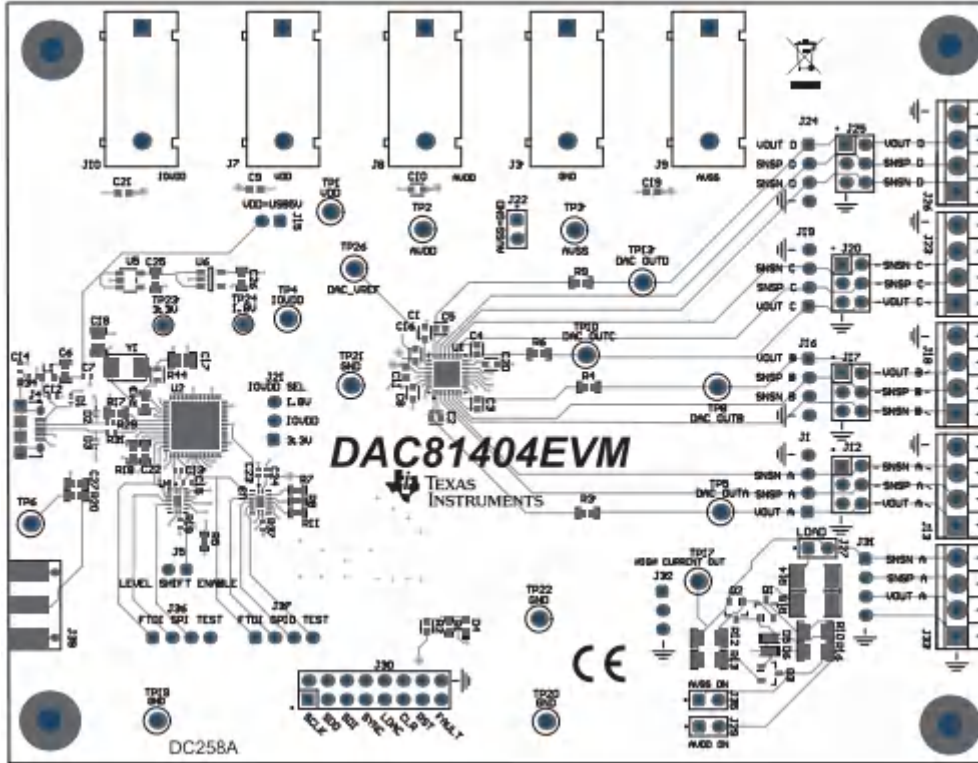


Figure 4-1. DAC81404EVM (Top View)

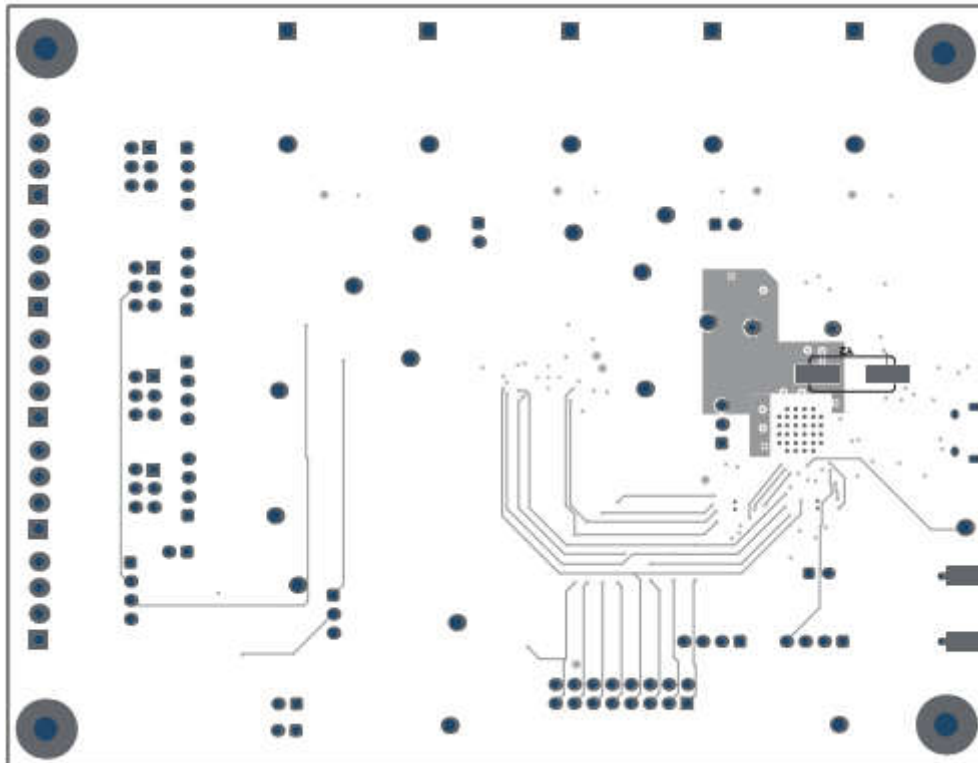


Figure 4-2. DAC81404EVM (Bottom View)

4.3 Bill of Materials (BOM)

Table 4-1. Bill of Materials

| Designator | Qty | Value | Description | Package Reference | Part Number | Manufacturer |
|----------------------------------|-----|-----------|---|--|--------------------|-----------------------------|
| C1 | 1 | 100nF | 0.1µF ±10% 25V Ceramic Capacitor X7R 0603 (1608 Metric) | 0603 | GMC10X7R104K25NT | CAL-CHIP ELECTRONICS |
| C2, C3, C4, C5 | 4 | 470pF | Cap Ceramic 470pF 50V C0G 1% SMD 0603 125°C Paper T/R | 0603 | C0603X471F5GACTU | KEMET |
| C6 | 1 | 4.7uF | CAP, CERM, 4.7uF, 10V, +/- 20%, X7R, 0603 | 0603 | GRM188Z71A475ME15D | MuRata |
| C7, C12, C13, C14, C15, C23, C24 | 7 | 0.1uF | CAP, CERM, 0.1µF, 25V,+/- 10%, X7R, 0402 | 0402 | CC0402KRX7R8BB104 | Yageo |
| C8, C10, C16, C20 | 4 | 1µF | 1µF ±10% 50V Ceramic Capacitor X7R 0603 (1608 Metric) | 0603 | GMC10X7R105K50NT | Cal-Chip Electronics |
| C9, C11, C19, C21 | 4 | | CAP CER 0.1UF 50V X7R 0603 | 0603 | CL10B104KB8NNNC | Samsung |
| C17, C18 | 2 | 18pF | CAP, CERM, 18pF, 50V, +/- 5%, C0G/NP0, 0805 | 0805 | CC0805JRNP09BN180 | Yageo America |
| C22 | 1 | 0.47uF | CAP, CERM, 0.47uF, 25V, +/- 10%, X7R, 0603 | 0603 | GRM188R71E474KA12D | MuRata |
| C25, C26 | 2 | 4.7uF | CAP, CERM, 4.7uF, 16V,+/- 10%, X7R, 0603 | 0603 | GRM188Z71C475KE21D | MuRata |
| D1, D2, D3 | 3 | | 1-Channel ESD Protection Diode for USB Type-C and Thunderbolt 3, DPY0002A (X1SON-2) | DPY0002A | TPD1E01B04DPYR | Texas Instruments |
| D4 | 1 | Super Red | LED, Super Red, SMD | LED, 1.6x.6x.8mm | SML-LX0603SRW-TR | Lumex |
| D5, D6 | 2 | 75V | Diode, Switching, 75V, 0.3A, SOD-523 | SOD-523 | 1N4148X-TP | Micro Commercial Components |
| H1, H2, H3, H4 | 4 | | Machine Screw, Round, #4-40 x 1/4, Nylon, Phillips panhead | Screw | NY PMS 440 0025 PH | B&F Fastener Supply |
| H5, H6, H7, H8 | 4 | | Standoff, Hex, 0.5"L #4-40 Nylon | Standoff | 1902C | Keystone |
| J1, J16, J19, J24, J31 | 5 | | Header, 100mil, 4x1, Gold, TH | 4x1 Header | TSW-104-07-G-S | Samtec |
| J3 | 1 | | Standard Banana Jack, insulated, 10A, black | 571-0100 | 571-0100 | DEM Manufacturing |
| 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, 2x1, Tin, TH | Header, 2.54mm, 2x1, TH | TSW-102-23-T-S | Samtec |
| J7, J8, J9, J10 | 4 | | Standard Banana Jack, insulated, 10A, red | 571-0500 | 571-0500 | DEM Manufacturing |
| J12, J17, J20, J25 | 4 | | Header, 100mil, 3x2, Gold, TH | 3x2 Header | TSW-103-07-G-D | Samtec |
| J13, J18, J23, J26, J33 | 5 | | Terminal Block, 3.5mm Pitch, 4x1, TH | 14x8.2x6.5mm | ED555/4DS | On-Shore Technology |
| J15 | 1 | | Header, 2.54mm, 2x1, Gold, TH | Header, 2.54mm, 2x1, TH | 61300211121 | Wurth Elektronik |

Table 4-1. Bill of Materials (continued)

| Designator | Qty | Value | Description | Package Reference | Part Number | Manufacturer |
|--|-----|---------|---|-------------------------|------------------|---------------------------|
| J21 | 1 | | Header, 100mil, 3x1, Gold, TH | 3x1 Header | TSW-103-07-G-S | Samtec |
| J22, J27, J29, J35 | 4 | | Header, 100mil, 2x1, Gold, TH | 2x1 Header | TSW-102-07-G-S | Samtec |
| J30 | 1 | | Header, 100mil, 8x2, Gold, TH | 8x2 Header | TSW-108-07-G-D | Samtec |
| J32 | 1 | | Header, 2.54mm, 3x1, Gold, TH | Header, 2.54mm, 3x1, TH | 61300311121 | Würth Elektronik |
| L1 | 1 | 600 ohm | Ferrite Bead, 600 ohm at 100MHz, 1A, 0603 | 0603 | 782633601 | Würth Elektronik |
| Q1, Q2 | 2 | 80V | Transistor, NPN, 80V, 0.5A, SOT-23 | SOT-23 | MMBTA06-7-F | Diodes Inc. |
| Q3 | 1 | 80V | Transistor, PNP, 80V, 0.5A, SOT-23 | SOT-23 | MMBTA56LT1G | ON Semiconductor |
| R1, R5, R7, R8, R11 | 5 | 10.0k | RES, 10.0 k, 1%, 0.1 W, 0402 | 0402 | ERJ-2RKF1002X | Panasonic |
| R2 | 1 | 200 | 200 Ohms ±0.1% 0.5W, 1/2W Chip Resistor 0603 (1608 Metric) Thin Film | 0603 | RA73F1J200RBD | TE Connectivity |
| R3, R4, R6, R9 | 4 | 0 | RES, 0, 5%, 0.1 W, 0603 | 0603 | RC0603JR-070RL | Yageo America |
| R10, R16 | 2 | 4.7k | RES, 4.7 k, 5%, 0.25 W, AEC-Q200 Grade 0, 1206 | 1206 | CRCW12064K70JNEA | Vishay-Dale |
| R12, R13 | 2 | 4.99 | RES, 4.99, 1%, 0.25 W, 1206 | 1206 | RC1206FR-074R99L | Yageo America |
| R14, R15 | 2 | 49.9 | RES, 49.9, 1%, 0.75 W, AEC-Q200 Grade 0, 2010 | 2010 | CRCW201049R9FKF | Vishay-Dale |
| R17 | 1 | 12.0k | RES, 12.0 k, 1%, 0.1 W, 0603 | 0603 | RC0603FR-0712KL | Yageo |
| R18 | 1 | 47.0k | RES, 47.0 k, 1%, 0.1 W, 0603 | 0603 | RC0603FR-0747KL | Yageo |
| R19, R37 | 2 | 10.0k | RES, 10.0 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402 | 0402 | RMCF0402FT10K0 | Stackpole Electronics Inc |
| R29, R31 | 2 | 10 | RES, 10.0, 1%, 0.063 W, 0402 | 0402 | RK73H1ETTP10R0F | KOA Speer |
| R34 | 1 | 330 | RES, 330, 1%, 0.1 W, AEC-Q200 Grade 0, 0402 | 0402 | ERJ-2RKF3300X | Panasonic |
| R43 | 1 | 1.00Meg | RES, 1.00M, 1%, 0.1W, AEC-Q200 Grade 0, 0603 | 0603 | CRCW06031M00FKEA | Vishay-Dale |
| R44 | 1 | | 0 Ohms Jumper 0.1W, 1/10W Chip Resistor 0603 (1608 Metric) Automotive AEC-Q200 Thick Film | 0603 | ERJ-3GEY0R00V | Panasonic |
| SH-J1, SH-J4, SH-J5, SH-J6, SH-J8, SH-J9, SH-J10, SH-J11 | 8 | | Shunt, 2.54mm, Gold, Black | Shunt, 2.54mm, Black | 60900213421 | Würth Elektronik |

Table 4-1. Bill of Materials (continued)

| Designator | Qty | Value | Description | Package Reference | Part Number | Manufacturer |
|--------------------------------|-----|-------|--|-------------------------------|-----------------------|----------------------|
| SH-J2, SH-J12, SH-J30, SH-J31 | 4 | 1x2 | Shunt, 100mil, Gold plated, Black | Shunt | SNT-100-BK-G | Samtec |
| TP1, TP2, TP3, TP4, TP17, TP26 | 6 | | Test Point, Multipurpose, Red, TH | Red Multipurpose Test point | 5010 | Keystone Electronics |
| TP5, TP8, TP10, TP13 | 4 | | Test Point, Multipurpose, White, TH | White Multipurpose Test point | 5012 | Keystone Electronics |
| TP19, TP20, TP21, TP22 | 4 | | Test Point, Multipurpose, Black, TH | Black Multipurpose Test point | 5011 | Keystone Electronics |
| TP23, TP24 | 2 | | Test Point, Miniature, Red, TH | Red Miniature Test point | 5000 | Keystone |
| U1 | 1 | | Quad, 16-Bit, High-Voltage-Output DACs With Internal Reference | VQFN32 | DAC81404RHB | Texas Instruments |
| U2 | 1 | | Future Technology Devices International Ltd FT4232H Quad High Speed USB to Multipurpose UART/MPSSE IC, VQFN-56 | VQFN-56 | FT4232H-56Q-TRAY | FTDI |
| U3, U4 | 2 | | 4-Bit Fixed Direction Voltage-Level Translator with Schmitt- Trigger Inputs, and Tri-State Outputs, WQFN14 | WQFN14 | TXU0304BQA | Texas Instruments |
| U5 | 1 | | Single Output High PSRR LDO, 250mA, Fixed 3.3V Output, 2.7V to 6.5V Input, with Low IQ, 5-pin SOT (DDC), -40 to 105 degC, Green (RoHS & no Sb/Br) | DDC0005A | TPS73433TDDCRQ1 | Texas Instruments |
| U6 | 1 | | Single Output Low Input Voltage Requirement LDO, 150mA, Fixed 1.8V Output, 1.8V to 5.5V Input, with Low IQ, 5-pin SOT-23 (DBV), -40 to 125 degC, Green (RoHS & no Sb/Br) | DBV0005A | TPS72118DBVR | Texas Instruments |
| Y1 | 1 | | Crystal, 12MHz, 18pF, SMD | ABM3 | ABM3-12.000MHZ-B2-T | Abracon Corporation |
| C27 | 0 | 4.7uF | CAP, CERM, 4.7uF, 16V,+/- 10%, X7R, 0603 | 0603 | GRM188Z71C475KE21D | MuRata |
| J36, J37 | 0 | | Header, 100mil, 4x1, Gold, TH | 4x1 Header | TSW-104-07-G-S | Samtec |
| J39 | 0 | | Connector, End launch SMA, 50 ohm, SMT | End Launch SMA | 142-0701-801 | Cinch Connectivity |
| R20 | 0 | 0 | RES, 0, 5%, 0.1 W, 0603 | 0603 | RC0603JR-070RL | Yageo America |
| TP6 | 0 | | Test Point, Multipurpose, Red, TH | Red Multipurpose Test point | 5010 | Keystone Electronics |
| Y2 | 0 | | Crystal, 12MHz, 30ppm, 18pF, SMD | 11.4x4.7mm | ABLS2-12.000MHZ-D4Y-T | Abracon Corporation |

5 Additional Information

5.1 Trademarks

Windows® is a registered trademark of Microsoft.
All trademarks are the property of their respective owners.

6 Related Documentation

The documents in [Table 6-1](#) provide information regarding Texas Instruments integrated circuits used in the assembly of the DAC81404EVM. This user's guide is available from the TI web site under literature number SLAU912. 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 are 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 6-1. Related Device Documentation

| Document | Literature Number |
|---|-------------------------|
| DAC81404 product data sheet | SLAU912 |

7 Revision History

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

| Changes from Revision * (January 2024) to Revision A (October 2024) | Page |
|--|-------------|
| • Updated schematics..... | 10 |

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 DEGRADATION 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/lstds/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。

<https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-delivered-in-japan.html>

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.

【無線電波を送信する製品の開発キットをお使いになる際の注意事項】 開発キットの中には技術基準適合証明を受けていないものがあります。技術適合証明を受けていないものご使用に際しては、電波法遵守のため、以下のいずれかの措置を取っていただく必要がありますのでご注意ください。

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。
3. 技術基準適合証明を取得後ご使用いただく。

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西新宿三井ビル

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

電力線搬送波通信についての開発キットをお使いになる際の注意事項については、次のところをご覧ください。 <https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-for-power-line-communication.html>

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.

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4. *EVM Use Restrictions and Warnings:*
 - 4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.
 - 4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.
 - 4.3 *Safety-Related Warnings and Restrictions:*
 - 4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.
 - 4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.
 - 4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.
 5. *Accuracy of Information:* To the extent TI provides information on the availability and function of EVMs, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.
 6. *Disclaimers:*
 - 6.1 EXCEPT AS SET FORTH ABOVE, EVMS AND ANY MATERIALS PROVIDED WITH THE EVM (INCLUDING, BUT NOT LIMITED TO, REFERENCE DESIGNS AND THE DESIGN OF THE EVM ITSELF) ARE PROVIDED "AS IS" AND "WITH ALL FAULTS." TI DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING SUCH ITEMS, INCLUDING BUT NOT LIMITED TO ANY EPIDEMIC FAILURE WARRANTY OR IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF ANY THIRD PARTY PATENTS, COPYRIGHTS, TRADE SECRETS OR OTHER INTELLECTUAL PROPERTY RIGHTS.
 - 6.2 EXCEPT FOR THE LIMITED RIGHT TO USE THE EVM SET FORTH HEREIN, NOTHING IN THESE TERMS SHALL BE CONSTRUED AS GRANTING OR CONFERRING ANY RIGHTS BY LICENSE, PATENT, OR ANY OTHER INDUSTRIAL OR INTELLECTUAL PROPERTY RIGHT OF TI, ITS SUPPLIERS/LICENSORS OR ANY OTHER THIRD PARTY, TO USE THE EVM IN ANY FINISHED END-USER OR READY-TO-USE FINAL PRODUCT, OR FOR ANY INVENTION, DISCOVERY OR IMPROVEMENT, REGARDLESS OF WHEN MADE, CONCEIVED OR ACQUIRED.
 7. *USER'S INDEMNITY OBLIGATIONS AND REPRESENTATIONS.* USER WILL DEFEND, INDEMNIFY AND HOLD TI, ITS LICENSORS AND THEIR REPRESENTATIVES HARMLESS FROM AND AGAINST ANY AND ALL CLAIMS, DAMAGES, LOSSES, EXPENSES, COSTS AND LIABILITIES (COLLECTIVELY, "CLAIMS") ARISING OUT OF OR IN CONNECTION WITH ANY HANDLING OR USE OF THE EVM THAT IS NOT IN ACCORDANCE WITH THESE TERMS. THIS OBLIGATION SHALL APPLY WHETHER CLAIMS ARISE UNDER STATUTE, REGULATION, OR THE LAW OF TORT, CONTRACT OR ANY OTHER LEGAL THEORY, AND EVEN IF THE EVM FAILS TO PERFORM AS DESCRIBED OR EXPECTED.

8. *Limitations on Damages and Liability:*

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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, INDEMNITY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS, , EXCEED THE TOTAL AMOUNT PAID TO TI BY USER FOR THE PARTICULAR EVM(S) AT ISSUE DURING THE PRIOR TWELVE (12) MONTHS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM SHALL NOT ENLARGE OR EXTEND THIS LIMIT.

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

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

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