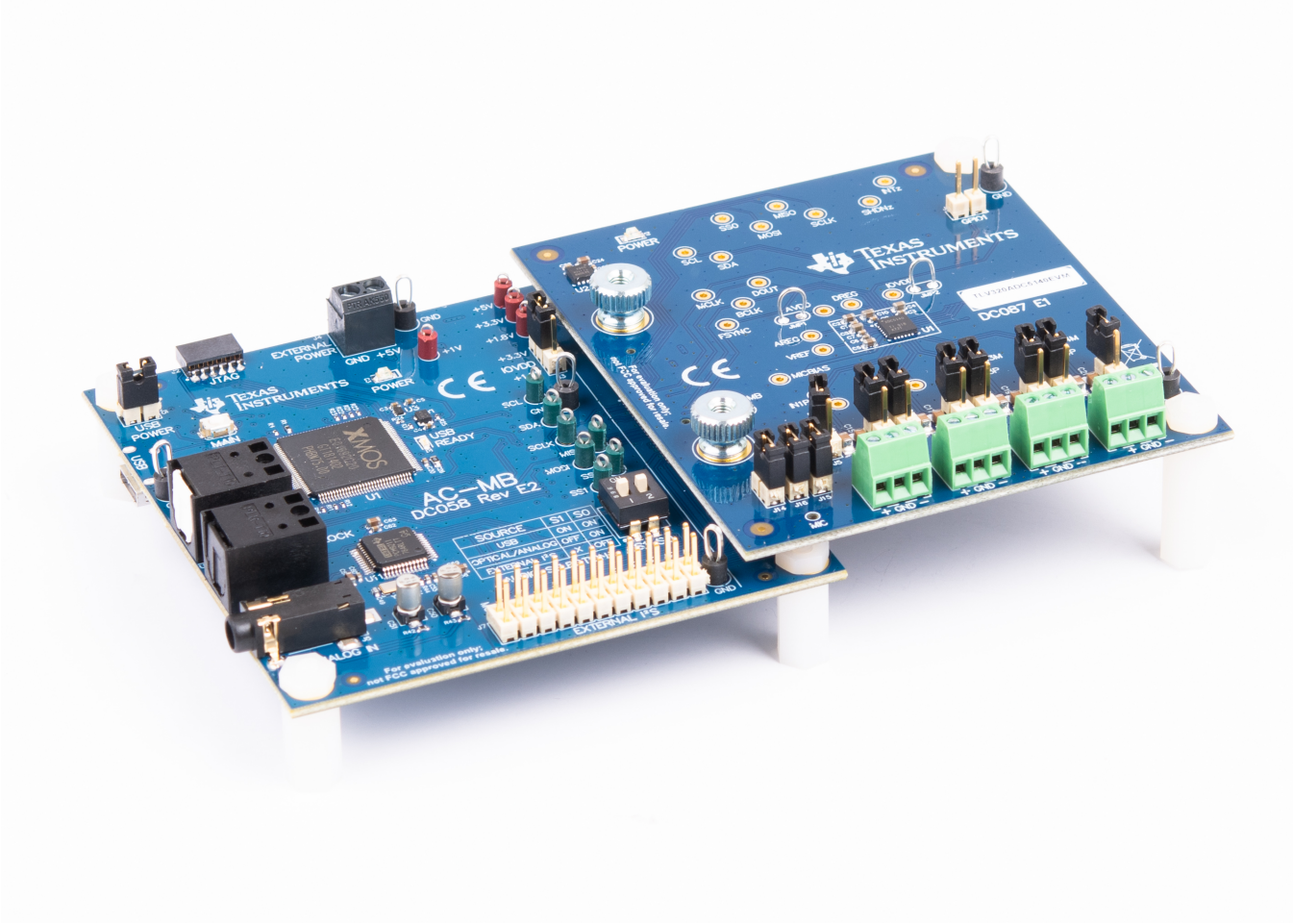
User's Guide

SBAU335–May 2019

# ADCx140EVM-PDK

This user's guide describes the function and use of the ADCx140EVM-PDK. This document includes the hardware configuration instructions, a quick-start guide, jumper and connector descriptions, software description, schematics, and printed circuit board (PCB) layout that demonstrate TI's recommended practices for these devices.



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## Trademarks

PurePath is a trademark of Texas Instruments.
Audio Toolbox is a trademark of MathWorks.
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# 1 Introduction

The ADCx140EVM-PDK is an evaluation module (EVM) designed to demonstrate the performance and functionality of the TLV320ADCx140 family of devices. This family includes the devices shown in Table 1 with differences in performance and function noted.

**Table 1. TLV320ADCx140 Family**

| Device | SNR Without DRE (dB) | SNR With DRE (dB) |
|---|---|---|
| TLV320ADC3140 | 106 | N/A |
| TLV320ADC5140 | 108 | 120 |
| TLV320ADC6140 | 112 | 123 |

# 2 Hardware Overview

The evaluation kit consists of the TLV320ADCx140EVB daughterboard and the AC-MB motherboard. The motherboard is used to provide power, control, and digital audio signals to the evaluation module. The daughterboard contains the TLV320ADCx140 device and its input connections. A detailed functional overview of the TLV320ADCx140EVB system is described in Section 5.

## *2.1 AC-MB Settings*

### 2.1.1 Audio Serial Interface Settings

The AC-MB provides the digital audio digital signals to the evaluation module from the universal serial bus (USB), optical, stereo jack, and external audio serial interface (ASI) header. Figure 1 shows a block diagram of the ASI routing on the AC-MB.

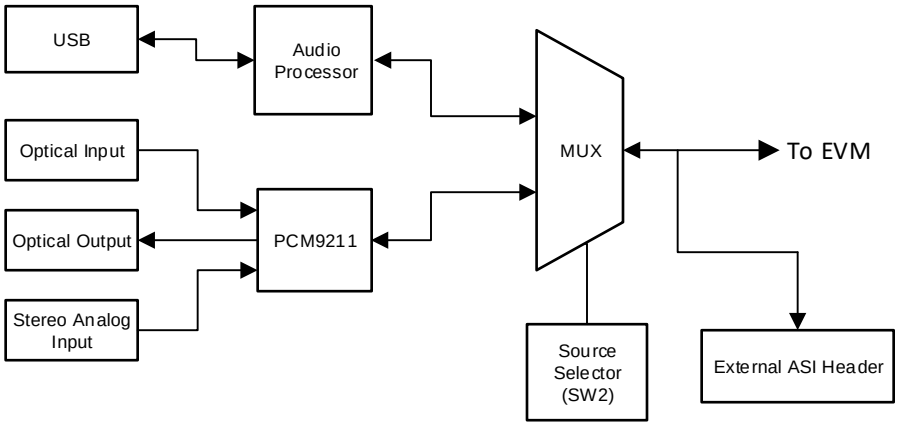


**Figure 1. AC-MB Audio Serial Interface Routing**

Switch SW2 on the AC-MB selects the audio serial bus that interfaces with the TLV320ADC5140EVB. Next to switch SW2, the AC-MB has a quick reference table to identify the audio serial interface source options and switch settings. The AC-MB acts as the master for the audio serial interface, with three different modes of operation (see Figure 2): USB, optical or analog, or external ASI.

#### 2.1.1.1 USB

The serial interface clocks and data are provided from the USB interface. The sampling rate and format are determined by the USB audio class driver on the operating system. The default settings for the USB audio interface are 32-bit frame size, 48-kHz sampling rate, BCLK and FSYNC ratio is 256, and the format is time-division multiplexing (TDM).

The AC-MB is detected by the OS as an audio device with the name *TI USB Audio UAC2.0*. Figure 2 shows the AC-MB audio setting for the USB mode of operation.

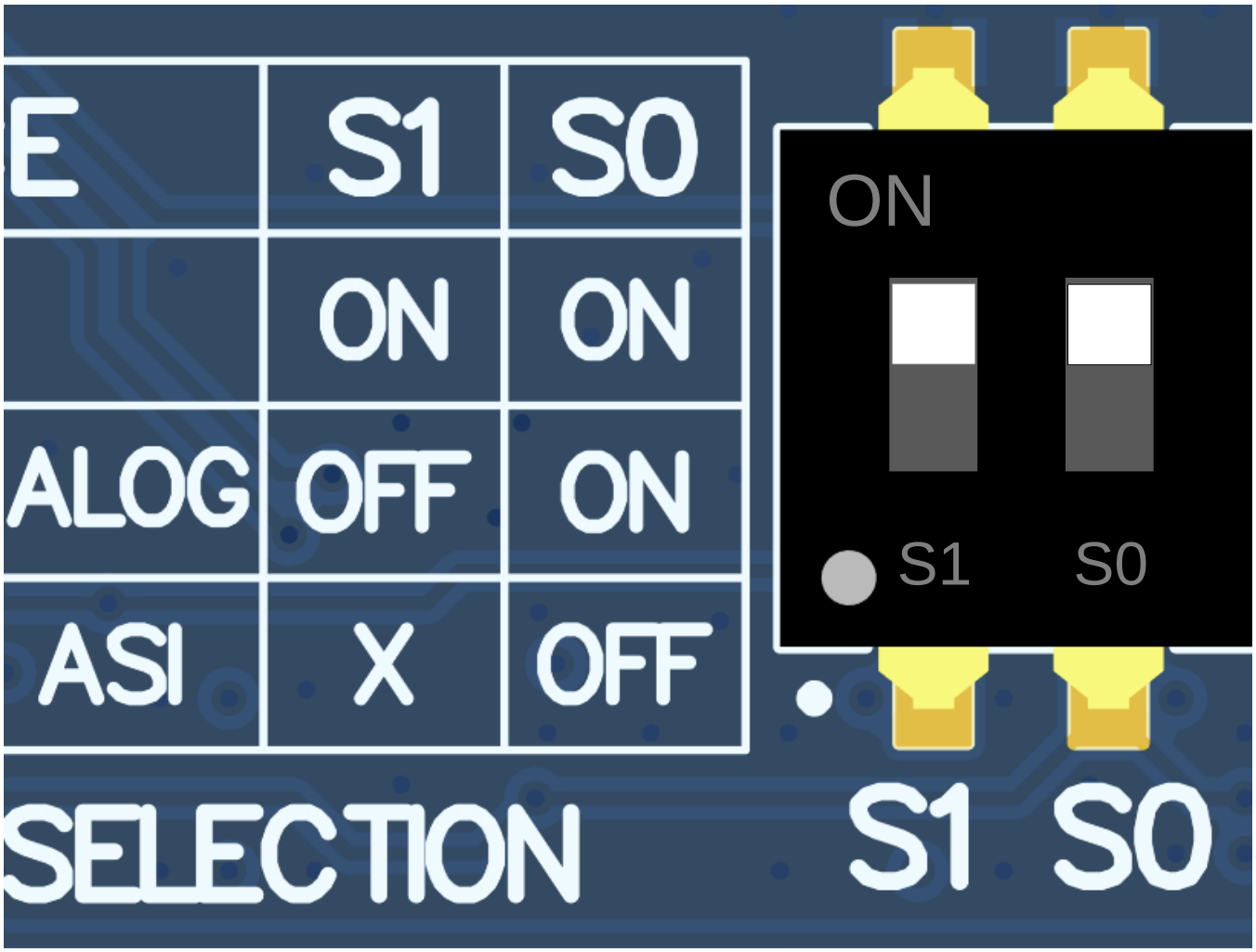


**Figure 2. AC-MB USB Audio Setting**

#### 2.1.1.2 Optical or Auxilary Analog Audio Input

Serial interface signals are provided from the PCM9211 digital transceiver, which is capable of sending digital data to the EVB from an analog input or optical input. Meanwhile, the data from the EVB can be streamed through the optical output. Figure 3 shows the AC-MB audio setting for the optical and analog mode of operation.

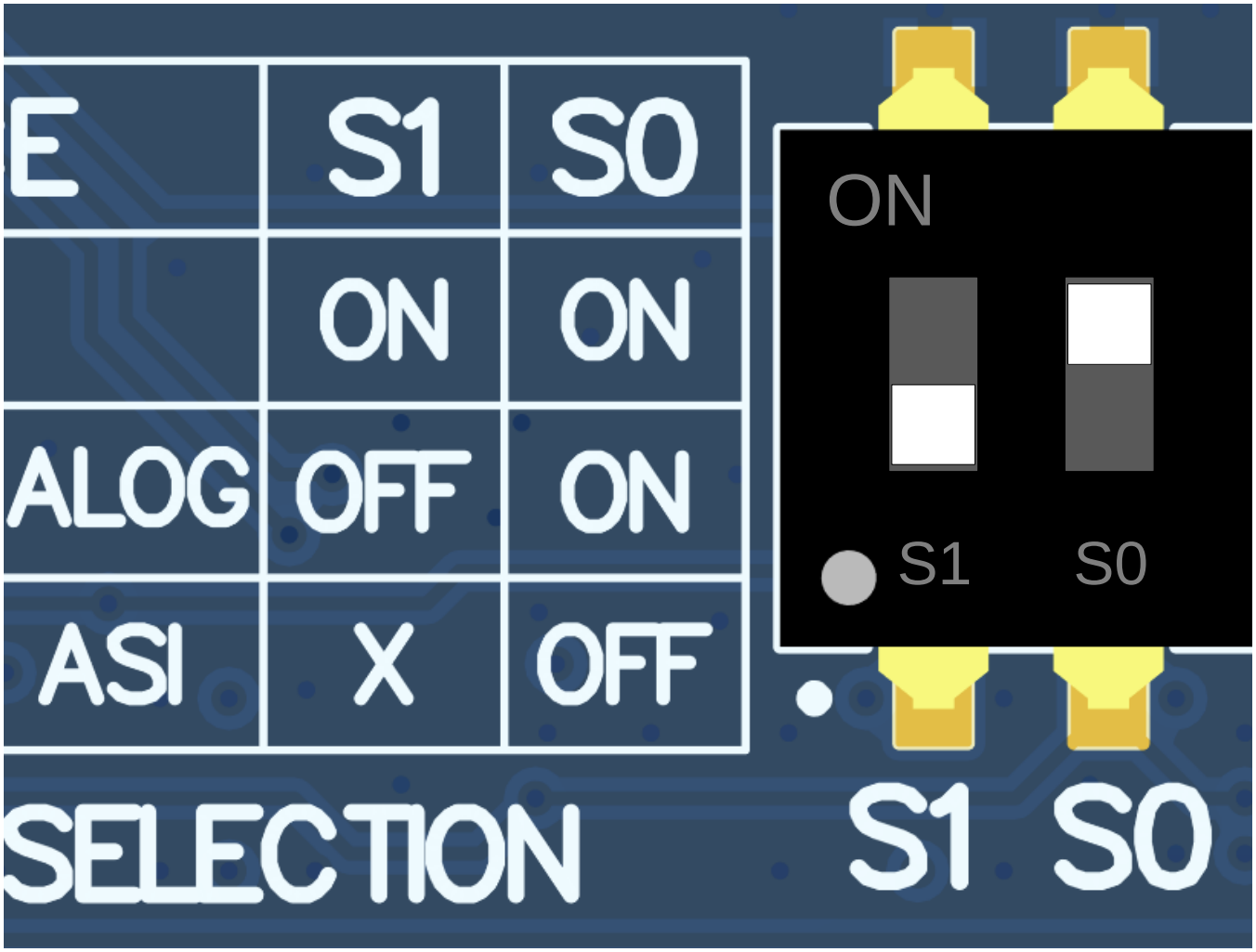


**Figure 3. AC-MB Optical or Auxiliary Analog Audio Setting**

The optical output of the AC-MB streams the data captured on the EVM with the format determined by the input source used. When there is an optical input connected, the LOCK LED must be ON, and the PCM9211 streams the audio serial interface clocks with the format determined by the optical input frame. The digital data from the optical input is streamed to the evaluation module. If the optical input is not connected, the PCM9211 captures the input signal provided through the analog input, and streams the signal to the evaluation module. This feature can be useful when a digital input DAC is connected to the AC-MB, providing an analog input for quick evaluation. In Auxiliary Analog Audio mode the audio serial interface format is fixed to a 24-bit, 48-kHz, $I^2S$ mode.

#### 2.1.1.3 External

In this mode, the audio serial interface clocks for the evaluation board are provided through connector J7 from an external source. This architecture allows the use of an external system to communicate with the evaluation board, such as a different host processor or test equipment (for instance, Audio Precision PSIA). The clocks generated from the USB interface and PCM9211 are isolated with this setting. Figure 4 shows the AC-MB audio setting for the external mode of operation.

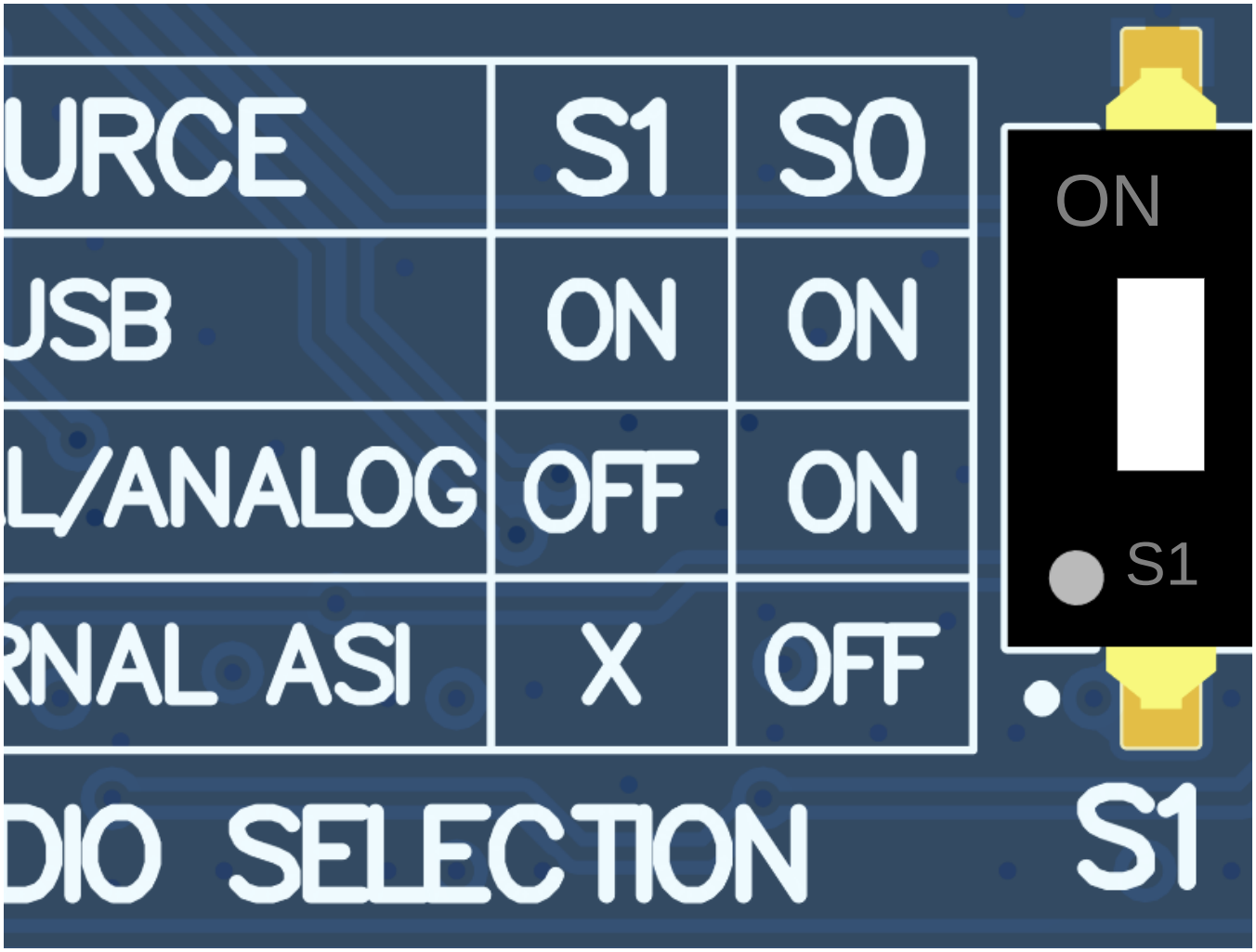


**Figure 4. AC-MB External Audio Setting**

Figure 5 shows how to connect the external audio interface, with the bottom row for the signal and the top row for ground.

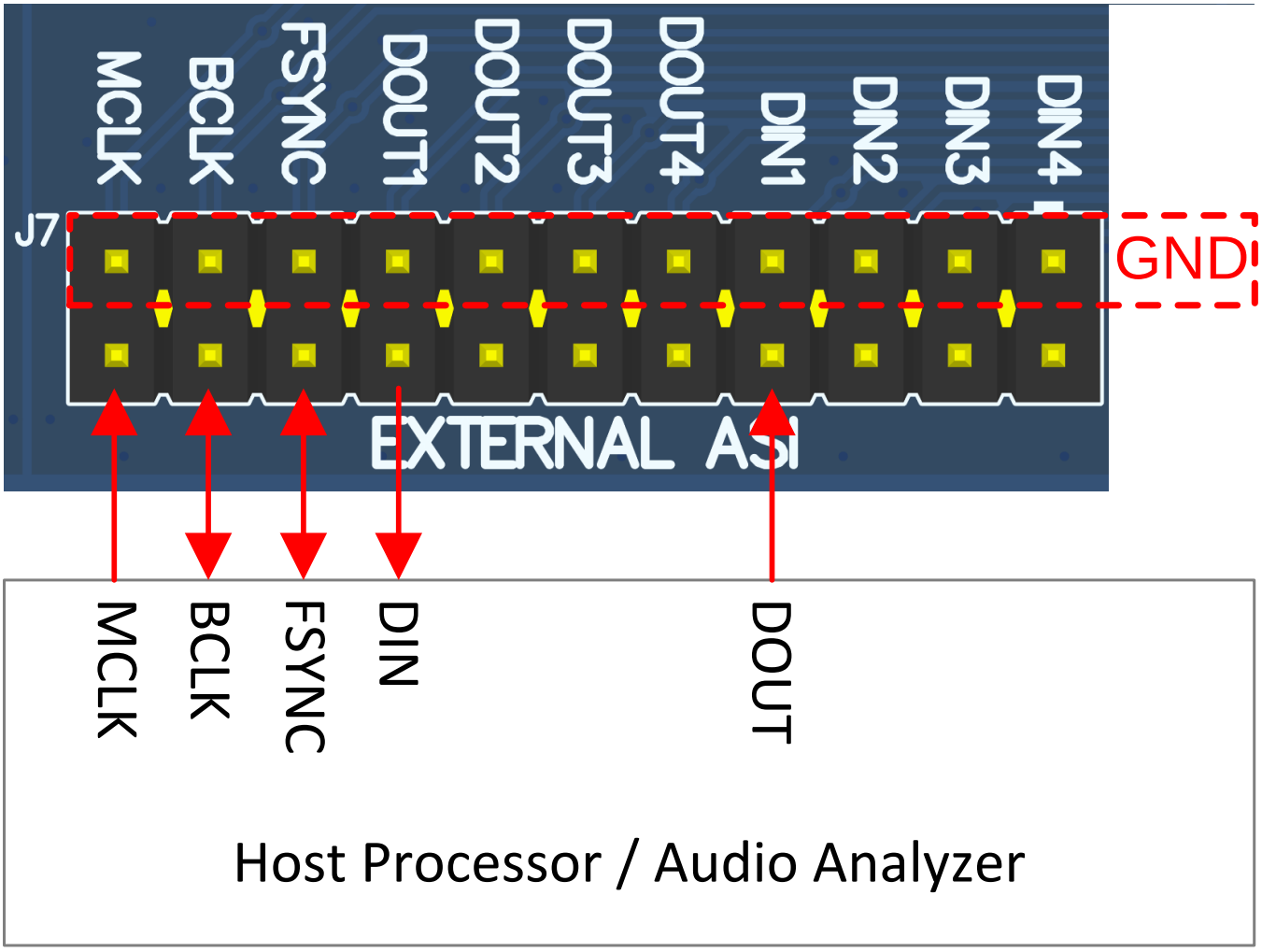


**Figure 5. AC-MB Connection with External Audio Serial Interface**

### 2.1.2 AC-MB Power Supply

The complete EVM system is powered from a single 5-V power supply. However, the motherboard has different low-dropout regulators (LDOs) integrated that provide the required power supplies to the different blocks of the board. Figure 6 shows a block diagram depicting the power structure of the AC-MB.

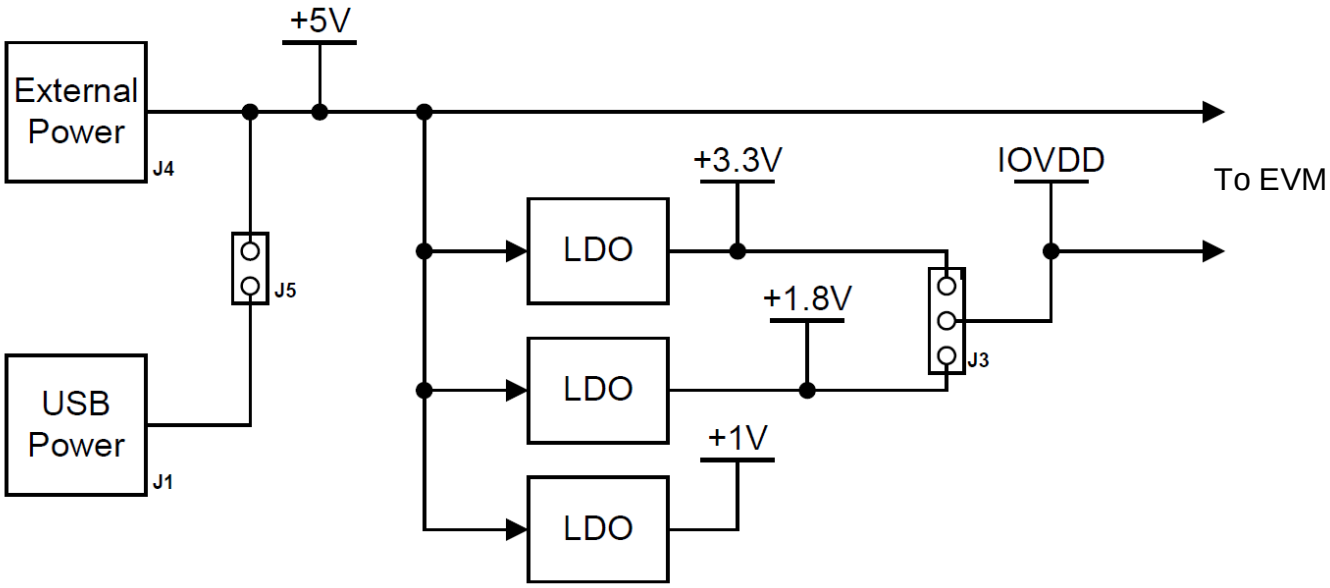


**Figure 6. Power-Supply Distribution of the AC-MB**

The AC-MB can be powered from the host computer by using the USB 5-V power supply (VBUS) by shorting header J5, USB POWER. Additionally, the AC-MB can be powered from an external power supply connected to terminal J4, EXTERNAL POWER. Header J5 must be open for external supply operation. The IOVDD voltage for the digital signals that is provided to the evaluation module is generated on the motherboard from the main power supply (USB or external). The voltage levels available are 1.8 V and 3.3 V, and can be selected via the J3 header IOVDD. For 1.8-V operation, short pins 2 and 3 of header J3; for 3.3-V operation, short pins 1 and 2. When the motherboard is fully powered and the power supplies from the onboard LDOs are correct, the green POWER LED (D3) turns ON. The USB READY LED indicates that a successful USB communication is established between the AC-MB and the host computer.

## 2.2 ADCx140EVM-PDK Hardware Settings

The TLV320ADCx140 evaluation module has several input configuration options and offers extensive flexibility to allow the user to evaluate the device across multiple operation modes. The different operation modes are highlighted in this section. The INxP and INxM pins of the TLV320ADCx140 can optionally connect to an onboard microphone for quick evaluation, and can be optionally configured to bypass the input decoupling capacitors for evaluating the functionality of the digital microphones or GPIOs. Figure 7 shows the architecture of the inputs to the evaluation module.

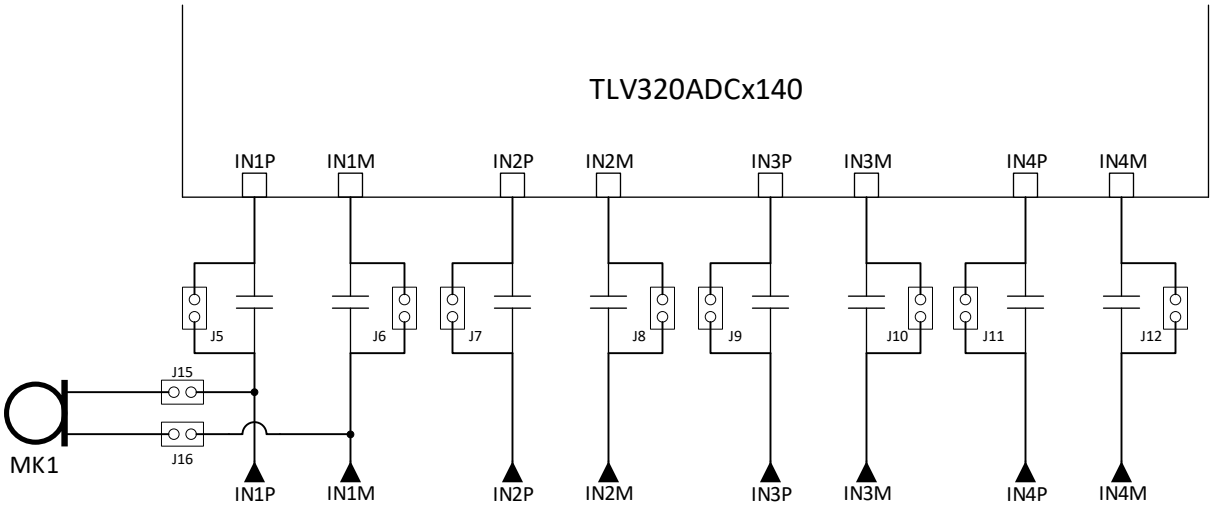


**Figure 7. TLV320ADCx140EVB Input Architecture**

### 2.2.1 Line Inputs

For the line input configuration (shown in Figure 8), the TLV320ADCx140 captures the audio signal provided through terminals J2 (IN1), J3 (IN2), J4 (IN3), and J5 (IN4). The input accepted in this mode is a differential, 2-VRMS, full-scale audio signal. If a single-ended source is used, the 1-VRMS signal is supported.

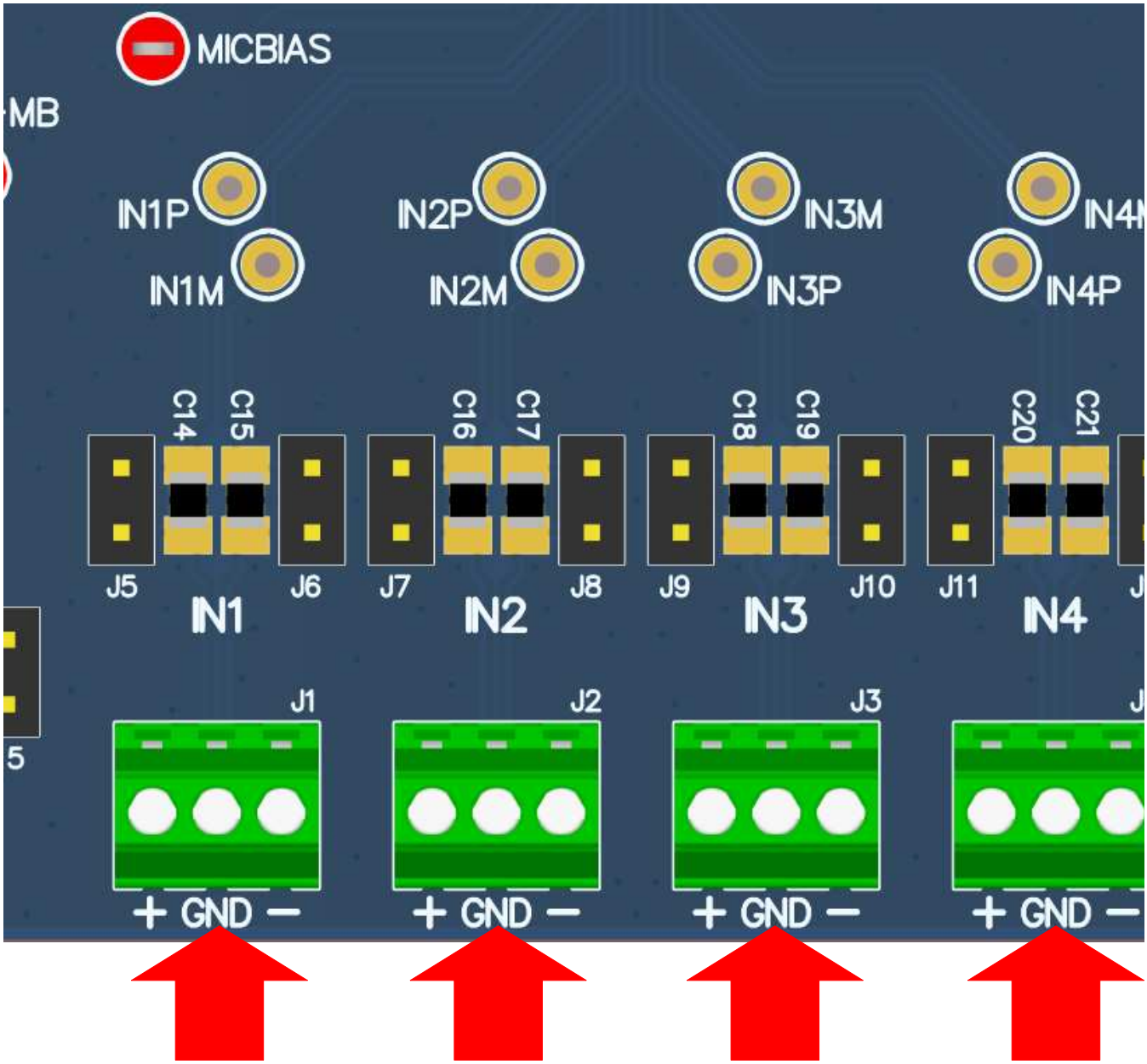


**Figure 8. TLV320ADCx140EVB Connection for Line Input Application**

### 2.2.2 Onboard Microphone Input

For the onboard microphone input configuration (shown in Figure 9), the TLV320ADCx140 records the audio captured from the microphones located on the bottom edge of the board. MICBIAS is used to power the onboard microphone, so header J14 must be shorted. There must not be any connections to J1 during onboard microphone use to preserve the performance of the microphone.

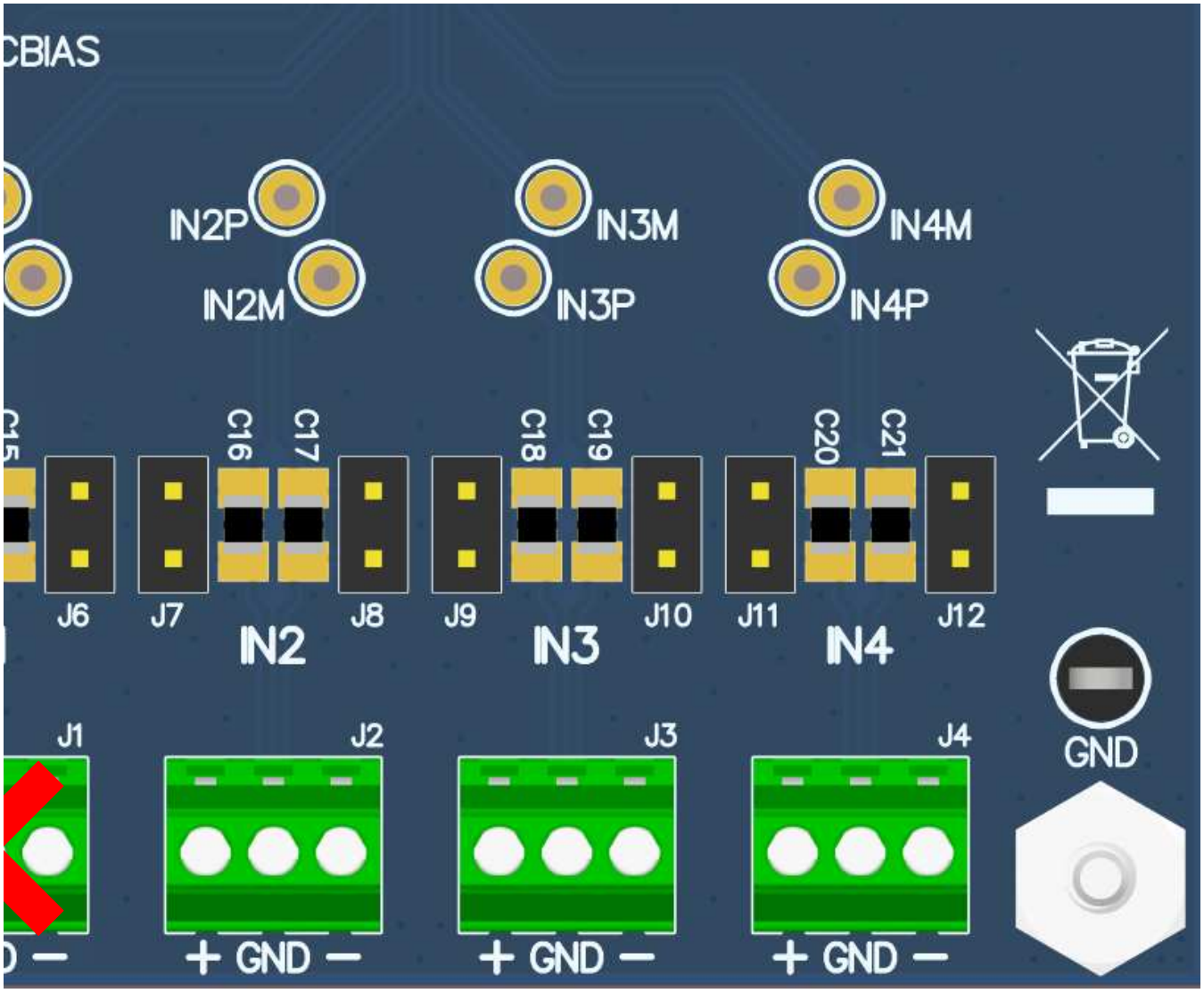


**Figure 9. TLV320ADCx140EVB Connection for the Onboard Microphone Test**

# 3 Software Overview

Texas Instrument's PurePath™ Console 3 (PPC3) graphical development suite is a program that serves as a platform for many of TI's audio products. PPC3 is designed to simplify the evaluation, configuration, and debug process associated with the development of audio products.

## *3.1 PurePath Console 3 Installation*

The ADCx140EVM-PDK GUI is an application that installs into the PPC3 framework. PPC3 must be installed prior to downloading the ADCX140EVM-PDK GUI. To download the PPC3, visit www.ti.com/tool/PUREPATHCONSOLE and request access. If the PPC3 is already installed, proceed to Section 3.2. Figure 10 shows the setup directory for the PPC3 installation.

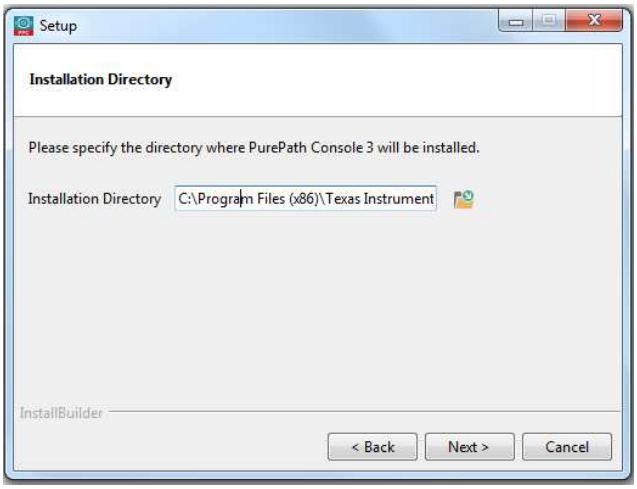


**Figure 10. PurePath Console 3 Installation**

Open the PPC3 installer and follow the instructions in the setup wizard.

## 3.2 ADCx140EVM GUI Installation

### 3.2.1 Software Setup

Open the PPC3 application in the directory chosen for the GUI installation in Section 3.1. Figure 11 shows the resulting app center window. Click on the TLV320ADCx140 app tile.

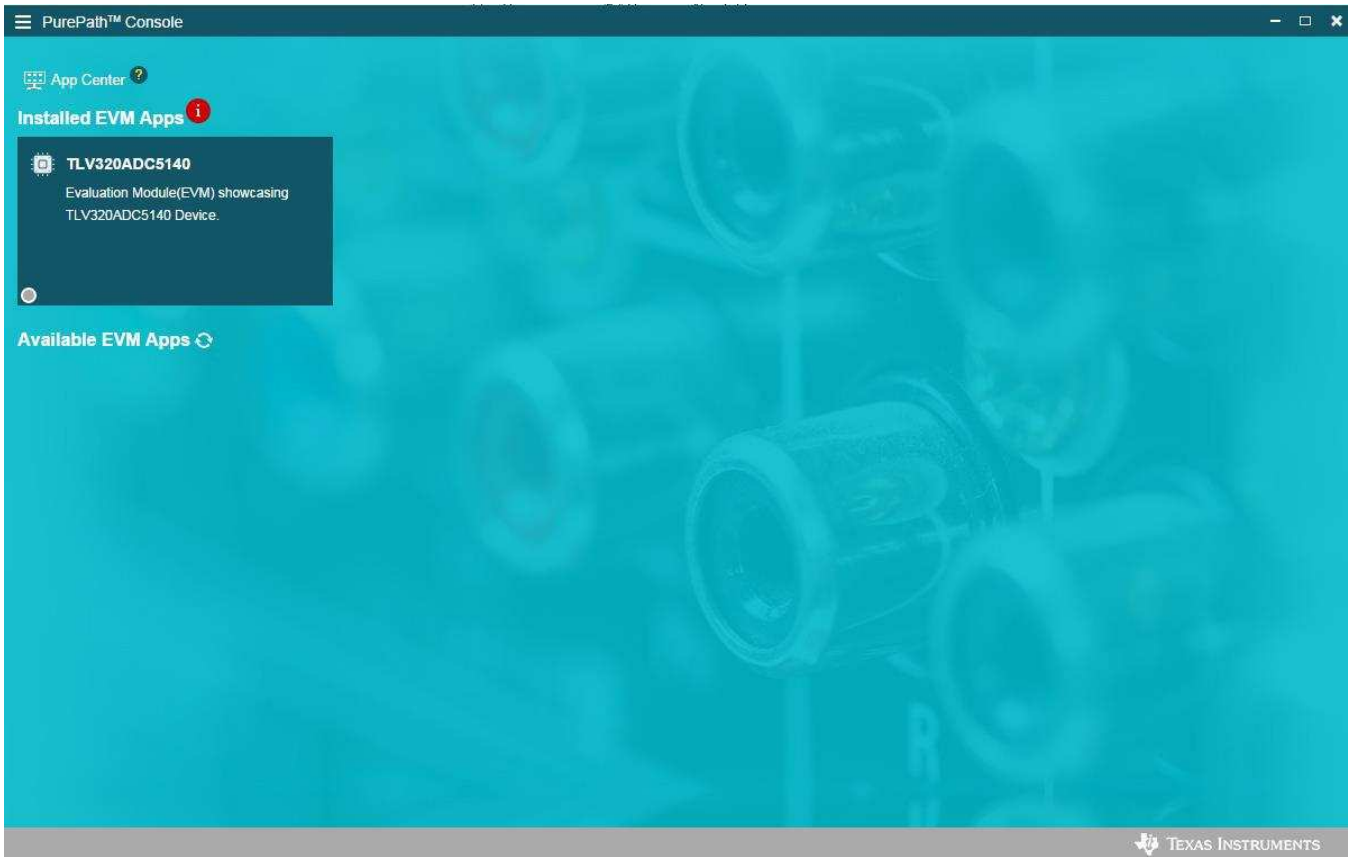


**Figure 11. PurePath Console 3 App Center**

The TLV320ADCx140 GUI is designed to work with up to four devices at any time. As shown in Figure 12, choose the 1 device radial button and click *New*.

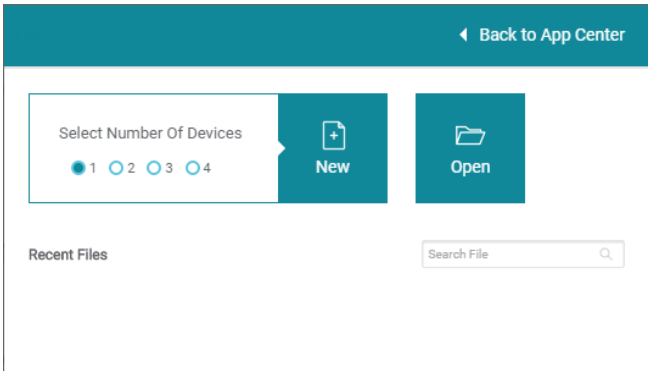


**Figure 12. Initial GUI Configuration**

As shown in Figure 13, the GUI opens to the *Audio Config* tab.

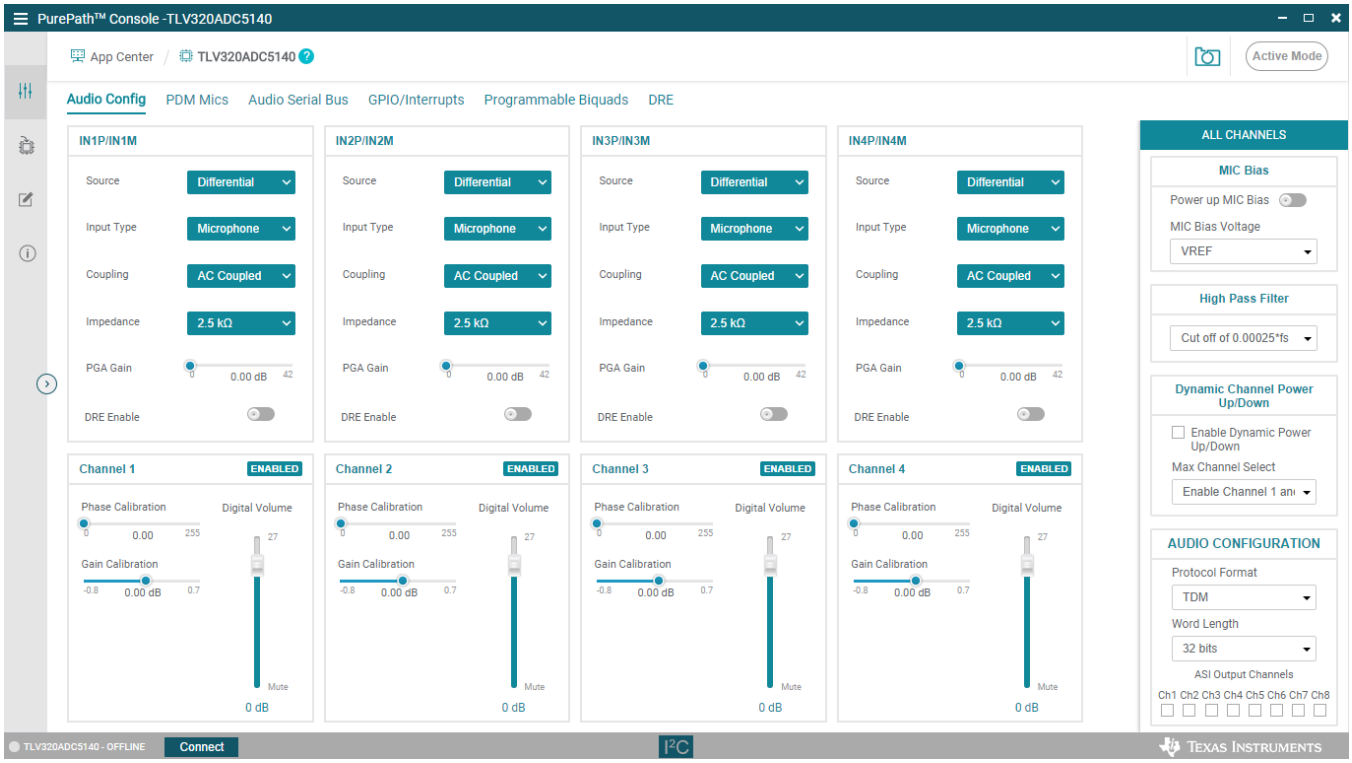


**Figure 13. Audio Config Tab**

Before changing any parameters, check the lower left corner of the PPC3 window, as shown in Figure 14, to verify that the EVM is connected. If no EVM is detected, the text will read *ADCx140 offline*. If the EVM is detected, a *Connect* button appears. Clicking this button connects the hardware.

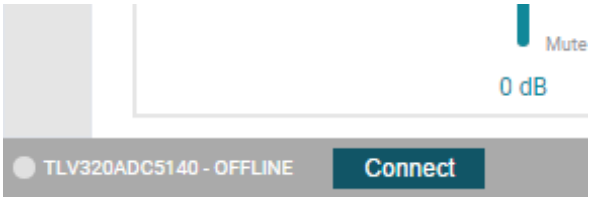


**Figure 14. Hardware Connect**

When the hardware is connected, the *Connect* button changes to read *Disconnect*, and the device is ready to be configured.

# 4 Quick Start

Configure the AC-MB for the USB audio (TDM) and the TLV320ADCx140EVB for the onboard microphone input.

All configurations for this example are done on the audio configuration tab. In the *Audio Configuration* block in the lower right portion of the audio configuration tab (as shown in Figure 15), select a word length of 16 bits, and enable the ASI output channel 1.

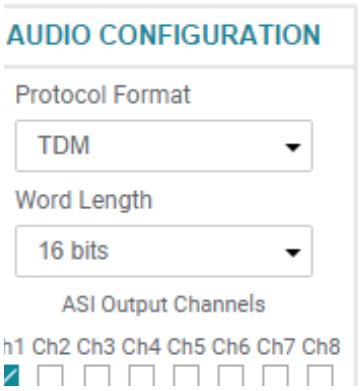


**Figure 15. Audio Configuration**

As shown in Figure 16, select *AVDD* for the MIC bias voltage and power-up the MIC bias.

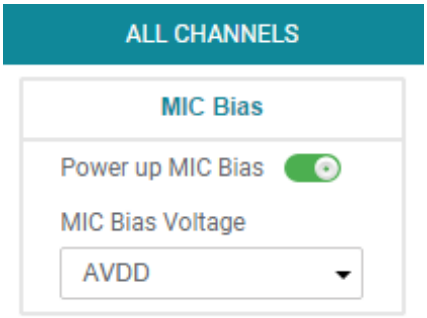


**Figure 16. MIC Bias Configuration**

The default state for the TLV320ADCx140 is standby mode and, with the exception of the channel digital volume, all device configurations must be done in standby mode. The TLV320ADCx140 does not provide a digital audio output in standby mode. Figure 17 shows how to change the mode from standby to active.

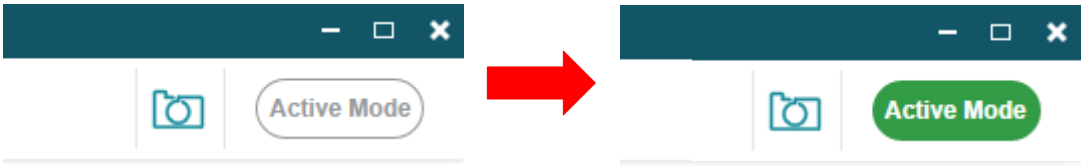


**Figure 17. Standby to Active Mode**

When active mode is enabled, any controls not configurable in active mode are grayed out. These controls can be changed again when the device is brought out of active mode. Figure 18 shows which controls are disabled.

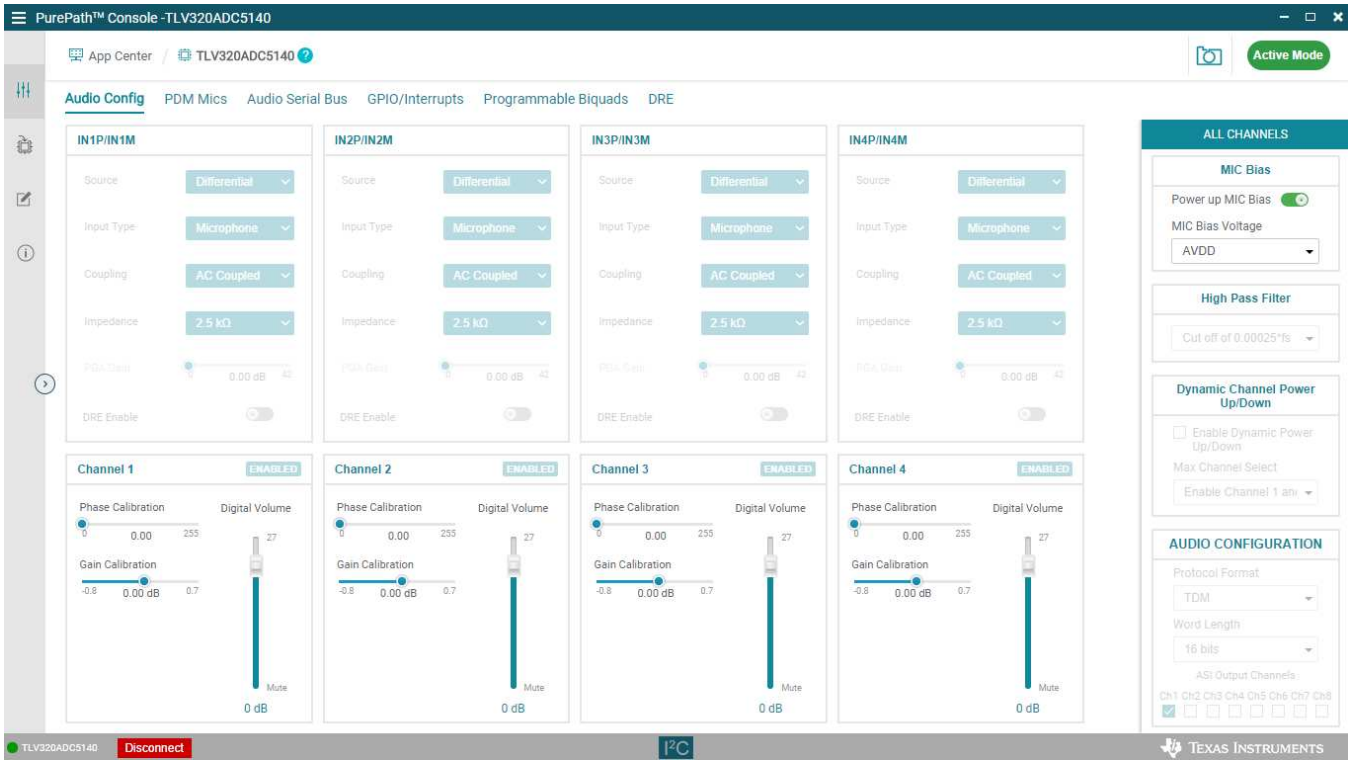


**Figure 18. Disabled Controls in Active Mode**

Audio can now be captured on your PC using the audio program of your choice.

## 4.1 Configuring the Audio Serial Bus for the I²S Output

The TLV320ADCx140 features a highly flexible audio serial bus that can be configured to implement a wide range of data formats. The default format is TDM, however the GUI can be used to change the data format to I²S. This section describes how to configure the TLV320ADCx140EVM for a 2-channel I²S output to a USB audio at 16 bits and 48 kHz. Configure the AC-MB for USB audio as described in Section 4. As shown in Figure 19, select the audio serial bus tab.

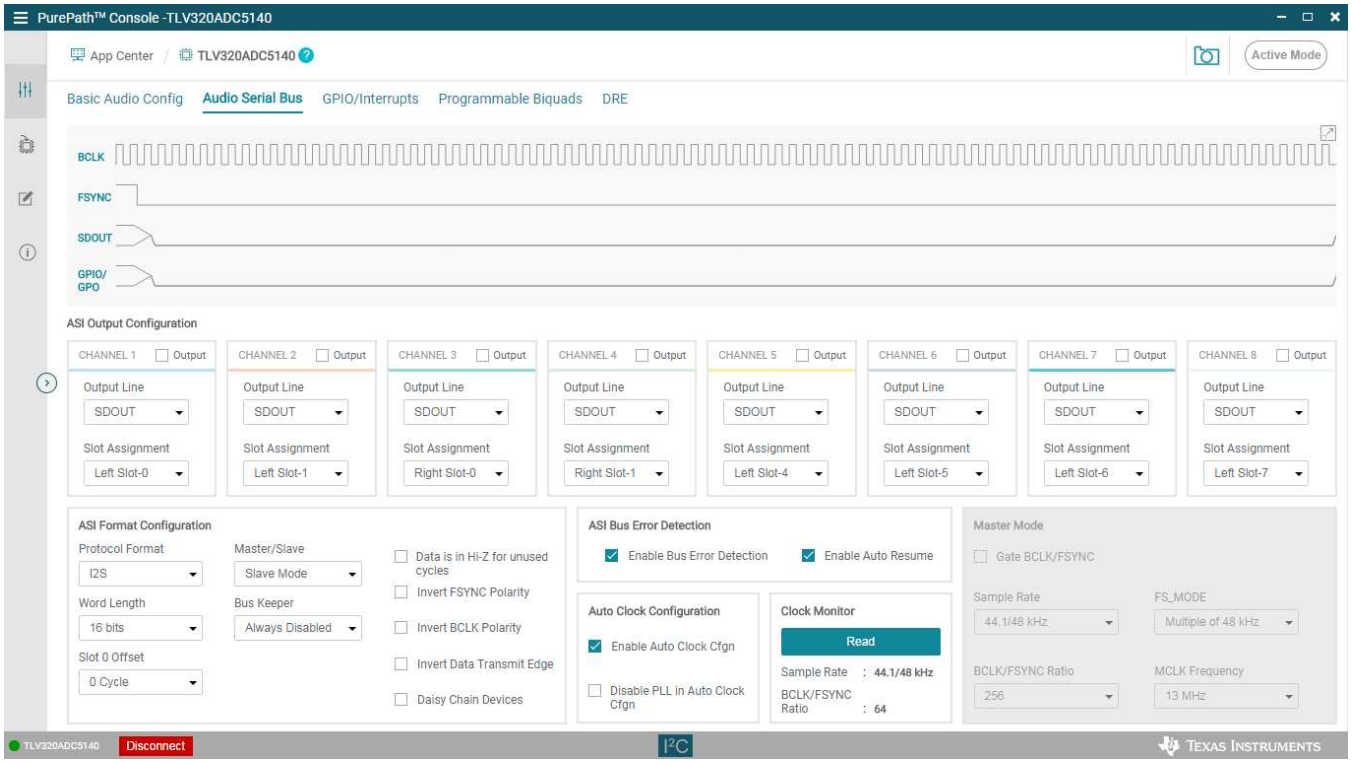


**Figure 19. Audio Serial Bus Tab**

In the ASI format configuration pane (shown in Figure 20), change the protocol format to I²S, and the word length to 16 bits.

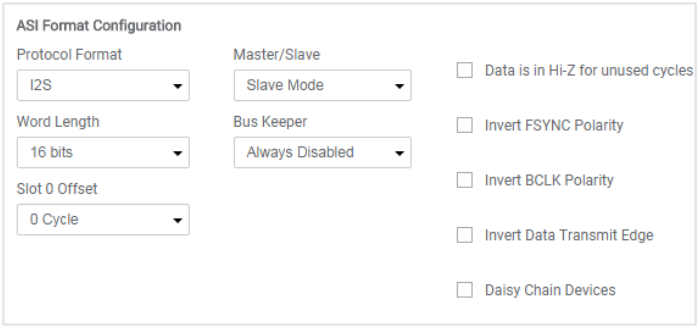


**Figure 20. ASI Format Configuration**

When the protocol format is changed to I²S in the GUI, the USB audio processor on the AC-MB also changes the audio format to I²S. The GUI reads the ASI status register (page 0 register 0x15), providing the detected sampling rate and BCLK and FSYNC ratio. The ASI status register can also be read manually in the audio serial bus tab by clicking the *Read* button, as shown in Figure 21, in the clock monitor pane.

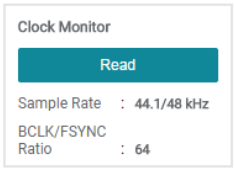


**Figure 21. Clock Monitor Pane**

The default slot assignment for channel 1 is left slot 0 and the default slot assignment for channel 2 is left slot 1. As shown in Figure 22, change the channel 2 slot assignment to right slot 0. The diagram at the top of the window updates to display the data format and slots selected.


**Figure 22. Channel Output Configuration and Diagram**

The AC-MB USB audio currently supports only two channels per data line when in I²S mode and the BCLK and FSYNC ratio is fixed at 64. The EVM is now ready for use with the audio recording program of your choice.

### 4.2 Saving a Configuration

To save a configuration, as shown in Figure 23, click the upper left corner of the PPC3 window and select *Save*. The configuration is saved as a .ppc3 file. To load a saved configuration, click the upper left corner of the PPC3 window and select *Open*. Navigate to the location of the saved .ppc3 file, and click *Open*.

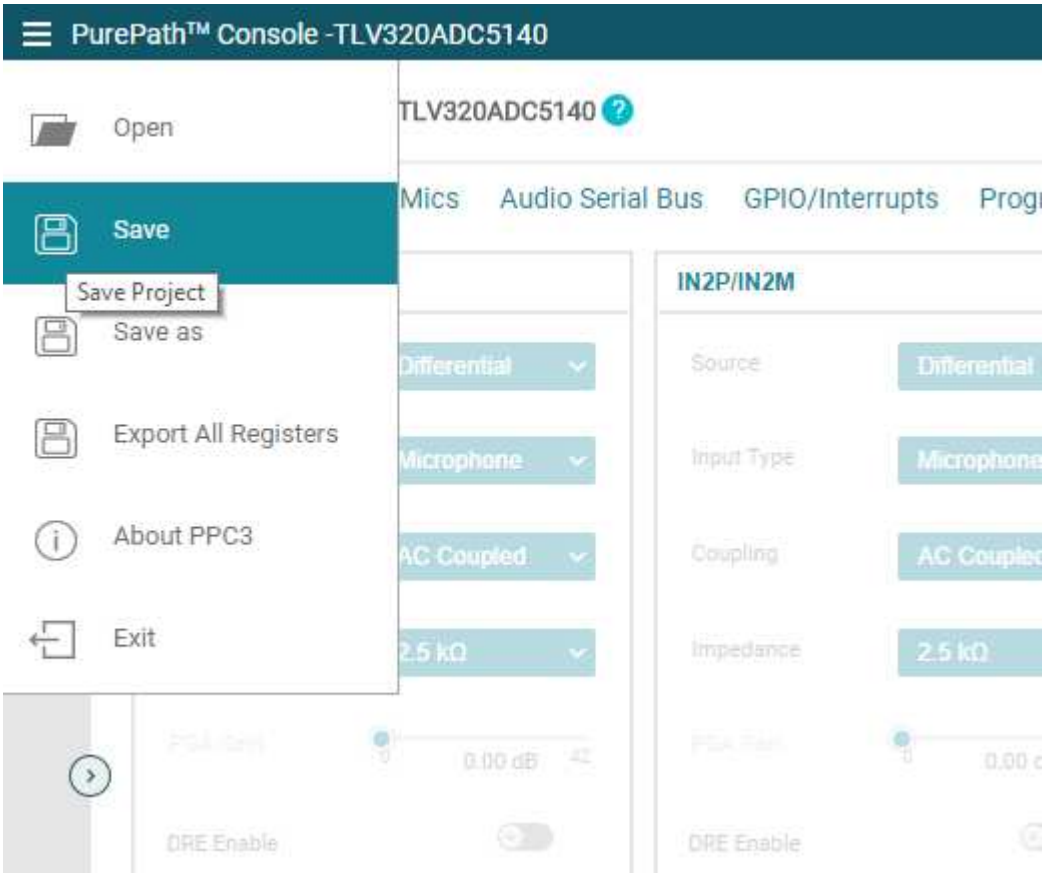


**Figure 23. Saving a Configuration in PPC3**

# 5 System Overview

Figure 24 shows an overview of the system.

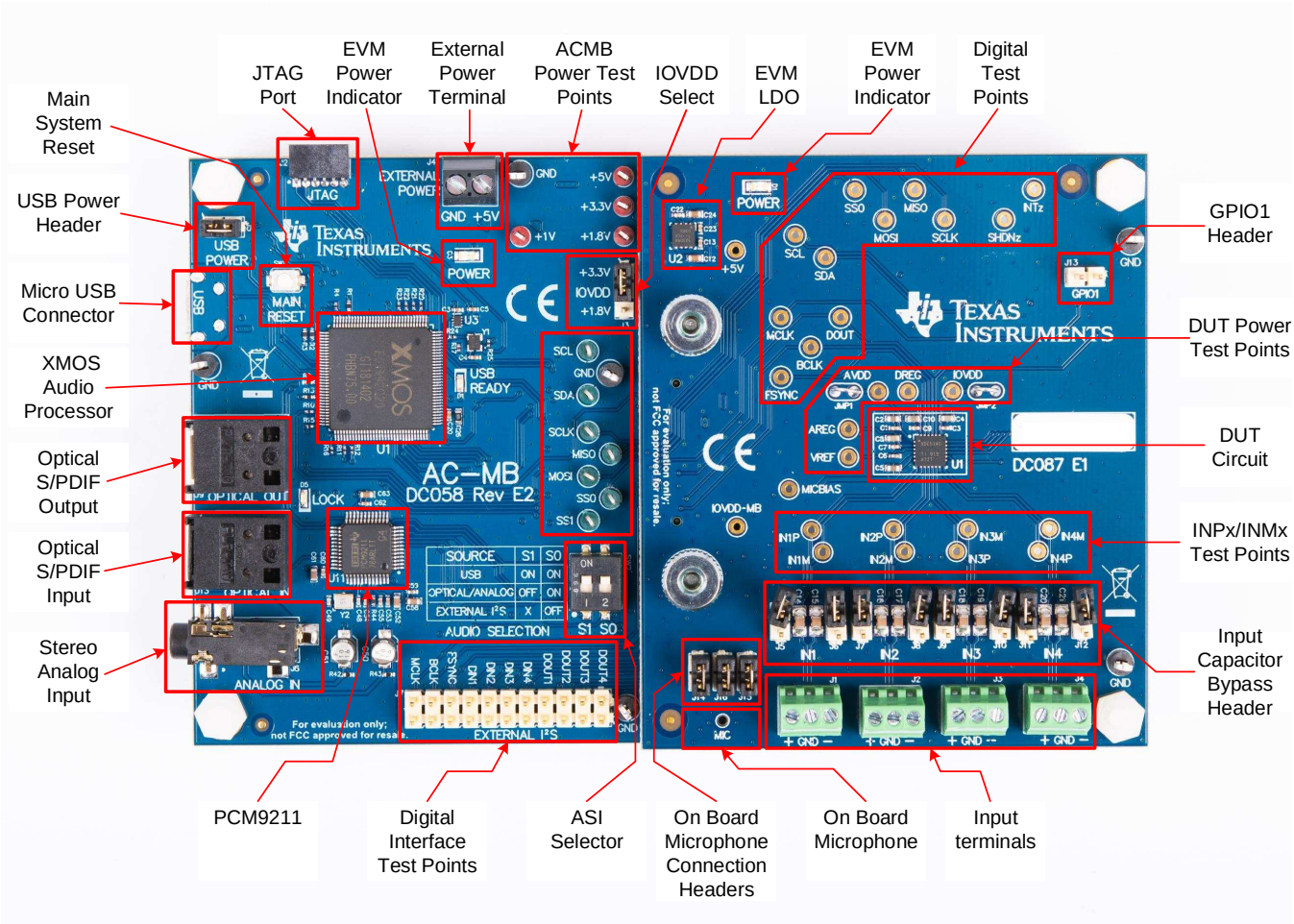


**Figure 24. System Overview**

# 6 Schematic and Bill of Materials

## 6.1 ADCx140EVM-PDK Schematic and Bill of Materials

This section provides the schematics and bill of materials (BOM) for the ADCx140EVM-PDK.

### 6.1.1 ADCx140EVM-PDK Schematic

Figure 25 shows the schematics for the ADCx140EVM-PDK.

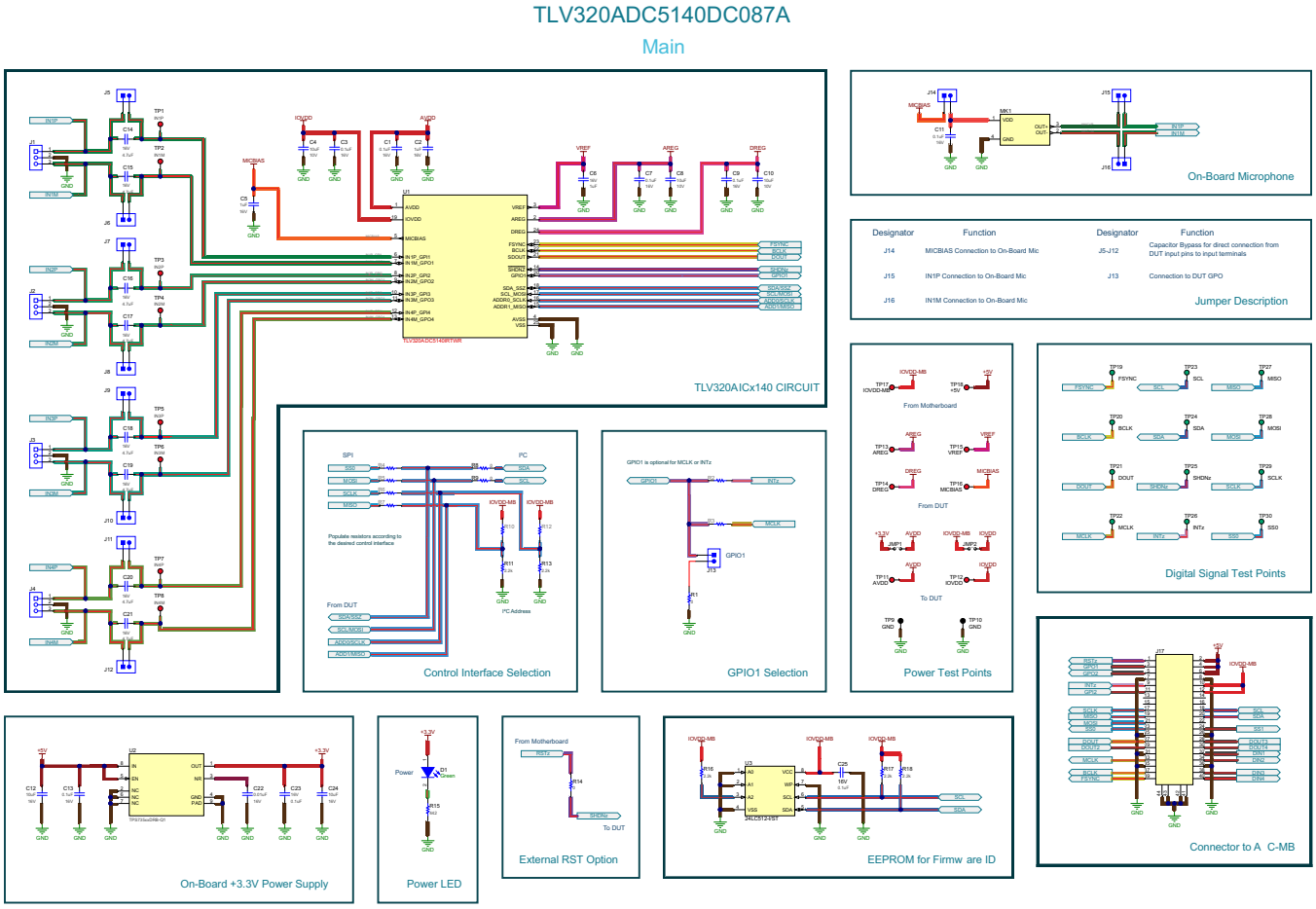


**Figure 25. ADCx140EVM-PDK Schematics**

### 6.1.2 ADCx140EVM-PDK Bill of Materials

Table 2 lists the BOM for the ADCx140EVM-PDK.

**Table 2. ADCx140EVM-PDK Bill of Materials**

| Designator | Qty | Value | Description | Package Reference | Part Number | Manufacturer |
|---|---|---|---|---|---|---|
| C1, C3, C7, C9, C11, C13, C23, C25 | 8 | 0.1uF | CAP, CERM, 0.1 uF, 16 V, +/- 10%, X7R, 0402 | 0402 | 885012205037 | Wurth Elektronik |
| C2 | 1 | 1uF | CAP, CERM, 1 uF, 16 V, +/- 10%, X7R, 0603 | 0603 | 885012206052 | Wurth Elektronik |
| C4, C8, C10 | 3 | 10uF | CAP, CERM, 10 uF, 10 V, +/- 20%, X5R, 0603 | 0603 | C1608X5R1A106M080AC | TDK |
| C5 | 1 | 1uF | CAP, CERM, 1 uF, 16 V, +/- 10%, X7R, 0603 | 0603 | EMK107B7105KA-T | Taiyo Yuden |
| C6 | 1 | 1uF | CAP, CERM, 1 uF, 16 V, +/- 10%, X5R, 0402 | 0402 | EMK105BJ105KVHF | Taiyo Yuden |
| C12, C24 | 2 | 10uF | CAP, CERM, 10 uF, 16 V, +/- 20%, X5R, 0603 | 0603 | EMK107BBJ106MA-T | Taiyo Yuden |
| C14, C15, C16, C17, C18, C19, C20, C21 | 8 | 4.7uF | CAP, CERM, 4.7 uF, 16 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0805 | 0805 | GCM21BR71C475KA73L | MuRata |
| C22 | 1 | 0.01uF | CAP, CERM, 0.01 uF, 16 V, +/- 10%, X7R, 0402 | 0402 | 520L103KT16T | AT Ceramics |
| D1 | 1 | Green | LED, Green, SMD | LED_0805 | LTST-C170KGKT | Lite-On |
| H1, H3 | 2 | | Small nylon hex nut, 0.10 thick with a 0.250 outside diameter and a 4-40 threading | Hex Nut,4-40 Thread, 250" Head Dia | 9605 | Keystone |
| H2, H4 | 2 | | HEX STANDOFF 4-40 NYLON 3/4" | HEX STANDOFF 4-40 NYLON 3/4" | 4804 | Keystone |
| J1, J2, J3, J4 | 4 | | CONN TERM BLOCK 2.54MM 3POS PCB | HDR3 | OSTVN03A150 | On Shore Technology |
| J5, J6, J7, J8, J9, J10, J11, J12, J13, J14, J15, J16 | 12 | | Header, 100mil, 2x1, Gold | 2x1 Header | TSW-102-07-G-S | Samtec |
| J17 | 1 | | Connector, Header, High Speed, 20 pairs, SMT | QTE-020-01-X-D-A | QTE-020-01-L-D-A | Samtec |
| JMP1, JMP2 | 2 | | Jumper Wire, 100mil spacing, | Wire Jumper | 923345-01-C | 3M |
| LBL1 | 1 | | Thermal Transfer Printable Labels, 0.650" W x 0.200" H | PCB Label 0.650 x 0.200 inch | THT-14-423-10 | Brady |
| MK1 | 1 | | Ultra-Low Noise Microphone with Differential Output, LGA-4 | 4x3mm, LGA | ICS-40720 | InvenSense |
| R1, R8, R9, R14 | 4 | 0 | RES, 0, 1%, 0.1 W, AEC-Q200 Grade 0, 0603 | 0603 | RMCF0603ZT0R00 | Stackpole Electronics Inc |
| R11, R13 | 2 | 2.2k | RES, 2.2 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603 | 0603 | ERJ-3GEYJ222V | Panasonic |
| R15 | 1 | 442 | RES, 442, 1%, 0.1 W, AEC-Q200 Grade 0, 0603 | 0603 | CRCW0603442RFKEA | Vishay-Dale |
| R16, R17, R18 | 3 | 2.2k | RES, 2.2 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402 | 0402 | CRCW04022K20JNED | Vishay-Dale |
| SH1, SH2, SH3, SH4, SH5, SH6, SH7, SH8, SH9, SH10, SH11 | 11 | 1x2 | Shunt, 100mil, Gold plated, Black | Shunt | SNT-100-BK-G | Samtec |
| TP9, TP10 | 2 | | Test Point, Multipurpose, Black, TH | Black Multipurpose Testpoint | 5011 | Keystone |
| U1 | 1 | | Quad Channel, 384-kHz, Audio Analog-to-Digital Converter, RTW0024H (WQFN-24) | RTW0024H | TLV320ADC5140IRTWR | Texas Instruments |
| U2 | 1 | | 500-mA, Low Quiescent Current, Low-Noise, High PSRR, Low-Dropout Linear Regulator for Automotive | DRB0008B | TPS73533QDRBRQ1 | Texas Instruments |
| U3 | 1 | | EEPROM, 512KBIT, 400KHZ, 8TSSOP | TSSOP-8 | 24LC512-I/ST | Microchip |
| R2, R3, R4, R5, R6, R7 | 0 | 0 | RES, 0, 1%, 0.1 W, AEC-Q200 Grade 0, 0603 | 0603 | RMCF0603ZT0R00 | Stackpole Electronics Inc |
| R10, R12 | 0 | 2.2k | RES, 2.2 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603 | 0603 | ERJ-3GEYJ222V | Panasonic |

**Table 2. ADCx140EVM-PDK Bill of Materials (continued)**

| Designator | Qty | Value | Description | Package Reference | Part Number | Manufacturer |
|---|---|---|---|---|---|---|
| TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP8, TP11, TP12, TP13, TP14, TP15, TP16, TP17, TP18 | 0 | | Test Point, Miniature, Red, TH | Red Miniature Testpoint | 5000 | Keystone |
| TP19, TP20, TP21, TP22, TP23, TP24, TP25, TP26, TP27, TP28, TP29, TP30 | 0 | | Test Point, Miniature, Green, TH | Green Miniature Testpoint | 5116 | Keystone |

## 6.2 AC-MB Schematic and Bill of Materials

This section provides the schematics and BOM for the AC-MB.

### 6.2.1 AC-MB Schematic

Figure 26 shows the schematics for the ADCx140EVM-PDK.

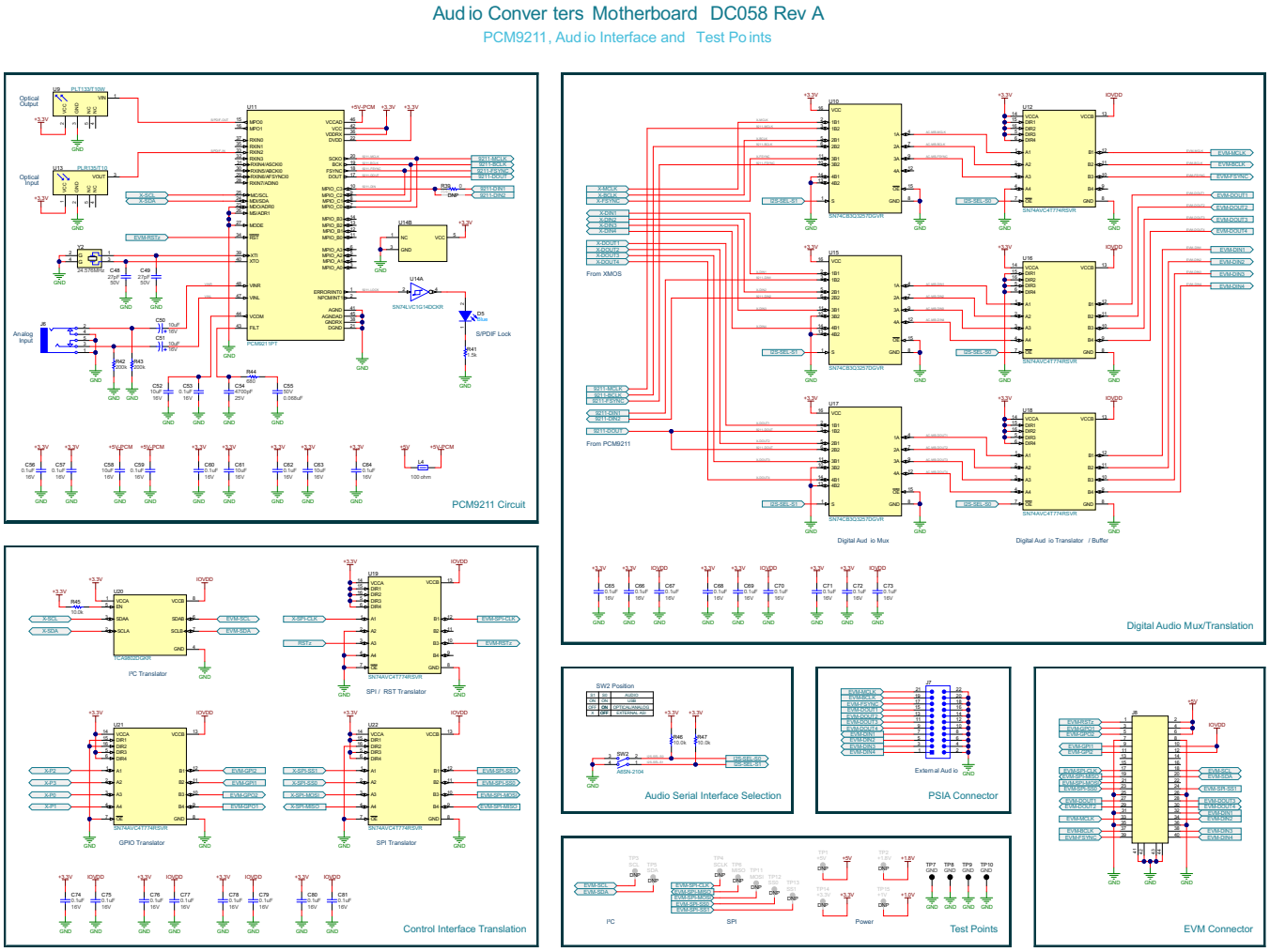


**Figure 26. AC-MB Schematics**

### 6.2.2 AC-MB Bill of Materials

Table 3 lists the BOM for the AC-MB.

**Table 3. AC-MB Bill of Materials**

| Designator | Quantity | Value | Description | PackageReference | PartNumber | Manufacturer |
|---|---|---|---|---|---|---|
| !PCB1 | 1 | | Printed Circuit Board | | DC058 | Any |
| C1 | 1 | 2.2uF | CAP, CERM, 2.2 uF, 16 V, +/- 10%, X7R, 0603 | 0603 | EMK107BB7225KA-T | Taiyo Yuden |
| C2, C3, C4, C5, C6, C7, C8, C9, C10, C11, C12, C13, C14, C15, C16, C17, C18, C19, C20, C21, C22, C23, C24, C25, C26, C27, C28, C29, C30, C31, C32, C33, C34, C38, C42, C43, C44, C45, C46, C53, C56, C57, C59, C60, C62, C64, C65, C66, C67, C68, C69, C70, C71, C72, C73, C74, C75, C76, C77, C78, C79, C80, C81, C82 | 64 | 0.1uF | CAP, CERM, 0.1 uF, 16 V, +/- 10%, X7R, 0402 | 0402 | 885012205037 | Wurth Elektronik |
| C35 | 1 | 470pF | CAP, CERM, 470 pF, 50 V, +/- 5%, C0G/NP0, 0603 | 0603 | 06035A471JAT2A | AVX |
| C36, C37 | 2 | 22uF | CAP, CERM, 22 uF, 10 V, +/- 10%, X7R, 1206 | 1206 | LMK316AB7226KL-TR | Taiyo Yuden |
| C39, C40, C41 | 3 | 1uF | CAP, CERM, 1 µF, 16 V,+/- 10%, X7R, AEC-Q200 Grade 1, 0603 | 0603 | CGA3E1X7R1C105K080AC | TDK |
| C47 | 1 | 1500pF | CAP, CERM, 1500 pF, 16 V, +/- 10%, X7R, 0603 | 0603 | CGA1A2X7R1C152K030BA | TDK |
| C48, C49 | 2 | 27pF | CAP, CERM, 27 pF, 50 V, +/- 5%, C0G/NP0, 0402 | 0402 | GJM1555C1H270JB01 | MuRata |
| C50, C51 | 2 | 10uF | CAP, AL, 10 uF, 16 V, +/- 20%, SMD | D3xL5.4mm | UWX1C100MCL2GB | Nichicon |
| C52, C58, C61, C63 | 4 | 10uF | CAP, CERM, 10 uF, 16 V, +/- 20%, X5R, 0603 | 0603 | EMK107BBJ106MA-T | Taiyo Yuden |
| C54 | 1 | 4700pF | CAP, CERM, 4700 pF, 16 V, +/- 10%, X7R, 0402 | 0402 | 885012205029 | Wurth Elektronik |
| C55 | 1 | 0.068uF | CAP, CERM, 0.068 uF, 50 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0402 | 0402 | CGA2B3X7R1H683K050BB | TDK |
| D1, D5 | 2 | Blue | LED, Blue, SMD | LED_0603 | 150060BS75000 | Wurth Elektronik |
| D2, D4 | 2 | 20V | Diode, Schottky, 20 V, 1 A, SOD-123FL | SOD-123FL | MBR120LSFT1G | ON Semiconductor |
| D3 | 1 | Green | LED, Green, SMD | LED_0805 | LTST-C170KGKT | Lite-On |
| H1, H2, H3, H4 | 4 | | Small nylon hex nut, 0.10 thick with a 0.250 outside diameter and a 4-40 threading | Hex Nut,4-40 Thread, 250" Head Dia | 9605 | Keystone |
| H5, H6 | 2 | | Thumb Nut, M3 x 0.5 Thread, 8mm Head Dia | | 96115A420 | McMaster Carr |
| H7, H8, H9, H10 | 4 | | Standoff, Hex, Male/Female, 4-40, Nylon, 1/2" | Standoff, Hex, Male/Female, 4-40, Nylon, 1/2" | 4802 | Keystone |

**Table 3. AC-MB Bill of Materials (continued)**

| | | | | | | |
|---|---|---|---|---|---|---|
| H11, H12 | 2 | | Standoff, Male/Male Thread, 5.15 mm, M3 x 0.5 | Standoff | SO-0515-02-02-01 | Samtec |
| J1 | 1 | | Connector, Receptacle, Micro-USB Type AB, R/A, Bottom Mount SMT | Connector, USB Micro AB | DX4R205JJAR1800 | JAE Electronics |
| J2 | 1 | | Receptacle, 50mil, 6x1, Gold, R/A, TH | 6x1 Receptacle | LPPB061NGCN-RC | Sullins Connector Solutions |
| J3 | 1 | | Header, 100mil, 3x1, Gold, TH | 3x1 Header | TSW-103-07-G-S | Samtec |
| J4 | 1 | | Terminal Block, 3.5mm Pitch, 2x1, TH | 7.0x8.2x6.5mm | ED555/2DS | On-Shore Technology |
| J5 | 1 | | Header, 2.54 mm, 2x1, Tin, TH | Header, 2.54 mm, 2x1, TH | TSW-102-07-T-S | Samtec |
| J6 | 1 | | Audio Jack, 3.5mm, Stereo, R/A, SMT | Phone Jack, 6x5x17mm | 35RASMT4BHNTRX | Switchcraft |
| J7 | 1 | | Header, 2.54 mm, 11x2, Gold, TH | Header, 11x2, 2.54mm, TH | TSW-111-07-G-D | Samtec |
| J8 | 1 | | Connector, SMT, Receptacle, High Speed, 20 pairs | QSE-020-01-X-D-A | QSE-020-01-L-D-A | Samtec |
| L1, L3 | 2 | 600 ohm | Ferrite Bead, 600 ohm @ 100 MHz, 2 A, 0805 | 0805 | MPZ2012S601AT000 | TDK |
| L2 | 1 | 470nH | Inductor, Shielded, Ferrite, 470 nH, 2.35 A, 0.0528 ohm, AEC-Q200 Grade 1, SMD | 2.0x1.6x1.0mm | SRN2010TA-R47Y | Bourns |
| L4 | 1 | 100 ohm | Ferrite Bead, 100 ohm @ 100 MHz, 1 A, 0603 | 0603 | MPZ1608D101BTD25 | TDK |
| R1 | 1 | 1.0k | RES, 1.0 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402 | 0402 | CRCW04021K00JNED | Vishay-Dale |
| R2, R3 | 2 | 2.2k | RES, 2.2 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402 | 0402 | CRCW04022K20JNED | Vishay-Dale |
| R4, R10, R11, R12, R15, R16, R18, R19, R20, R21, R22, R23, R24 | 13 | 33.2 | RES, 33.2, 1%, 0.05 W, 0201 | 0201 | RC0201FR-0733R2L | Yageo America |
| R5 | 1 | 47.0 k | RES, 47.0 k, 1%, 0.0625 W, 0402 | 0402 | RC0402FR-0747KL | Yageo America |
| R6 | 1 | 10.0 k | RES, 10.0 k, 1%, 0.1 W, 0402 | 0402 | ERJ-2RKF1002X | Panasonic |
| R7, R8 | 2 | 47k | RES, 47 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402 | 0402 | CRCW040247K0JNED | Vishay-Dale |
| R9 | 1 | 43.2 | RES, 43.2, 1%, 0.063 W, AEC-Q200 Grade 0, 0402 | 0402 | CRCW040243R2FKED | Vishay-Dale |
| R13 | 1 | 10k | RES, 10 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402 | 0402 | CRCW040210K0JNED | Vishay-Dale |
| R14, R41 | 2 | 1.5k | RES, 1.5 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603 | 0603 | CRCW06031K50JNEA | Vishay-Dale |
| R17 | 1 | 0 | RES, 0, 5%, 0.05 W, AEC-Q200 Grade 1, 0201 | 0201 | ERJ-1GE0R00C | Panasonic |
| R25, R27, R28, R29, R34, R35, R37, R45, R46, R47 | 10 | 10.0 k | RES, 10.0 k, 1%, 0.05 W, 0201 | 0201 | CRCW020110K0FKED | Vishay-Dale |
| R26 | 1 | 4.7 | RES, 4.7, 5%, 0.1 W, AEC-Q200 Grade 0, 0603 | 0603 | CRCW06034R70JNEA | Vishay-Dale |
| R30 | 1 | 25.5 k | RES, 25.5 k, 1%, 0.05 W, 0201 | 0201 | RC0201FR-0725K5L | Yageo America |
| R31 | 1 | 51.0 k | RES, 51.0 k, 1%, 0.05 W, 0201 | 0201 | RC0201FR-0751KL | Yageo America |

**Table 3. AC-MB Bill of Materials (continued)**

| | | | | | | |
|---|---|---|---|---|---|---|
| R32 | 1 | 40.2 k | RES, 40.2 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402 | 0402 | CRCW040240K2FKED | Vishay-Dale |
| R33 | 1 | 1.00 Meg | RES, 1.00 M, 1%, 0.125 W, AEC-Q200 Grade 0, 0805 | 0805 | CRCW08051M00FKEA | Vishay-Dale |
| R36 | 1 | 162k | RES, 162 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402 | 0402 | CRCW0402162KFKED | Vishay-Dale |
| R38 | 1 | 442 | RES, 442, 1%, 0.1 W, AEC-Q200 Grade 0, 0603 | 0603 | CRCW0603442RFKEA | Vishay-Dale |
| R39 | 1 | 0 | RES, 0, 1%, 0.1 W, AEC-Q200 Grade 0, 0603 | 0603 | RMCF0603ZT0R00 | Stackpole Electronics Inc |
| R42, R43 | 2 | 200k | RES, 200 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402 | 0402 | CRCW0402200KJNED | Vishay-Dale |
| R44 | 1 | 680 | RES, 680, 5%, 0.063 W, AEC-Q200 Grade 0, 0402 | 0402 | CRCW0402680RJNED | Vishay-Dale |
| SH1, SH2 | 2 | 1x2 | Shunt, 100mil, Gold plated, Black | Shunt | SNT-100-BK-G | Samtec |
| SW1 | 1 | | Switch, Tactile, SPST-NO, 0.05A, 12V, SMT | Switch, 4.4x2x2.9 mm | TL1015AF160QG | E-Switch |
| SW2 | 1 | | Switch, Slide, 2 SPST, Off-On, 0.025 A, 24 VDC, SMT | 7x7.5mm | A6SN-2104 | Omron Electronic Components |
| TP7, TP8, TP9, TP10 | 4 | | Test Point, Multipurpose, Black, TH | Black Multipurpose Testpoint | 5011 | Keystone |
| U1 | 1 | | IC MCU 512KB RAM, 128TQFP | TQFP-128 | XEF216-512-TQ128-C20 | XMOS semiconductor |
| U2 | 1 | | Programmable 1-PLL VCXO Clock Synthesizer with 2.5-V or 3.3-V LVCMOS Outputs, PW0014A (TSSOP-14) | PW0014A | CDCE913PWR | Texas Instruments |
| U3 | 1 | | Dual-Bit Dual-Supply Bus Transceiver, DQE0008A, LARGE T&R | DQE0008A | SN74AVC2T244DQER | Texas Instruments |
| U4, U7 | 2 | | Enhanced Product Dual Buffer/Driver with Open-Drain Output, DCK0006A (SOT-SC70-6) | DSF0006A | SN74LVC2G07DSFR | Texas Instruments |
| U5 | 1 | | Single-Channel Ultra-Small Adjustable Supervisory Circuit With Active-High Open-Drain Output, DRY0006A (USON-6) | DRY0006A | TPS3897ADRYR | Texas Instruments |
| U6 | 1 | | Automotive Catalog, Dual, 200mA, Low-IQ Low-Dropout Regulator for Portable Devices, DSE0006A (WSON-6) | DSE0006A | TLV7103318QDSERQ1 | Texas Instruments |
| U8 | 1 | | Low-Quiescent-Current 1% Accurate Supervisor With Programmable Delay, DSE0006A (WSON-6) | DSE0006A | TPS389018DSER | Texas Instruments |
| U9 | 1 | | Photolink- Fiber Optic Transmitter, TH | 13.5x10x9.7mm | PLT133/T10W | Everlight |
| U10, U15, U17 | 3 | | 4-Bit One-of-2 FET Multiplexer/Demultiplexer 2.5-V/3.3-V Low-Voltage, High-Bandwidth Bus Switch, DGV0016A (TVSOP-16) | DGV0016A | SN74CB3Q3257DGVR | Texas Instruments |
| U11 | 1 | | 216 kHz Digital Audio Interface Transceiver (DIX) with Stereo ADC and Routing, PCM, S / PDIF, ADC, 4.5 - 5.5V for Analog, 2.9 - 3.6V for DIX, -40 to 85 degC, 48-Pin LQFP (PT), Green (RoHS & no Sb/Br) | PT0048A | PCM9211PT | Texas Instruments |
| U12, U16, U18, U19, U21, U22 | 6 | | 4-Bit Dual-Supply Bus Transceiver With Configurable Voltage-Level Shifting and 3-State Outputs, RSV0016A (UQFN-16) | RSV0016A | SN74AVC4T774RSVR | Texas Instruments |
| U13 | 1 | | Photolink- Fiber Optic Receiver, TH | 13.5x10x9.7mm | PLR135/T10 | Everlight |

**Table 3. AC-MB Bill of Materials (continued)**

| | | | | | | |
|---|---|---|---|---|---|---|
| U14 | 1 | | Single Schmitt-Trigger Inverter, DCK0005A (SOT-SC70-5) | DCK0005A | SN74LVC1G14DCKR | Texas Instruments |
| U20 | 1 | | Level-Translating I2C Bus Buffer/Repeater, DGK0008A (VSSOP-8) | DGK0008A | TCA9802DGKR | Texas Instruments |
| U23 | 1 | | Low-Capacitance + / - 15 kV ESD-Protection Array for High-Speed Data Interfaces, 2 Channels, -40 to +85 degC, 5-pin SOT (DRL), Green (RoHS & no Sb/Br) | DRL0005A | TPD2E001DRLR | Texas Instruments |
| VR1 | 1 | | 3-A Step-Down Converter with DCS-Control and Hiccup Short Circuit Protection in 2x2 HotRod Package, RLT0007A (VSON-HR-7) | RLT0007A | TPS62085RLTR | Texas Instruments |
| Y1 | 1 | | OSC, 24 MHz, 2.25 - 3.63 V, SMD | 2x1.6mm | ASTMLPA-24.000MHZ-EJ-E-T | Abracon Corporation |
| Y2 | 1 | | Crystal, 24.576 MHz, 10pF, SMD | 2.5x0.5x2.0mm | ABM10-24.576MHZ-E20-T | Abracon Corporation |
| FID1, FID2, FID3, FID4, FID5, FID6 | 0 | | Fiducial mark. There is nothing to buy or mount. | N/A | N/A | N/A |
| R40 | 0 | 0 | RES, 0, 1%, 0.1 W, AEC-Q200 Grade 0, 0603 | 0603 | RMCF0603ZT0R00 | Stackpole Electronics Inc |
| TP1, TP2, TP14, TP15 | 0 | | Test Point, Miniature, Red, TH | Red Miniature Testpoint | 5000 | Keystone |
| TP3, TP4, TP5, TP6, TP11, TP12, TP13 | 0 | | Test Point, Miniature, Green, TH | Green Miniature Testpoint | 5116 | Keystone |

# 7 Matlab Audio Capture Example

The driver for the AC-MB may be controlled with Matlab, allowing for some automated testing. The following code demonstrates capturing audio from the AC-MB with Matlab. This example requires the Audio Toolbox™.

```
        if ismac                % macOS driver
        deviceReader = audioDeviceReader( 'Device', 'TI USB Audio 2.0',…
                                    'SampleRate', 48000, …
                                    'NumChannels', 8 ,…
                                   'BitDepth', '32-bit float',…
                                   'OutputDataType','double');
     elseif ispc            % windows driver
        devoiceReader = audioDeviceReader( 'Driver','ASIO', 'Device', 'Texas Instruments USB
Audio ...',…
                                    'SampleRate', 48000, …
                                    'NumChannels', 8 ,…
                                    'BitDepth', '32-bit float',…
                                    'OutputDataType','double’);
    end
    setup(deviceReader);                            % Setup the device reader

    % Play out a file through PC and capture in the EVM
    info = audioinfo( infile_name );                        % Read audiophile infile_name
    fileReader = dsp.AudioFileReader( infile_name );        % Create fileReader object
    fileInfo   = audioinfo(infile_name);                    % Copy info from infile_name
    fileWriter = dsp.AudioFileWriter( outfile_name, 'SampleRate', deviceReader.SampleRate,
'DataType', 'int32’);    % Create fileWriter object

    audioOut = audioDeviceWriter('SampleRate', fileInfo.SampleRate);    % Setup audio playback
    setup( audioOut, zeros(deviceReader.SamplesPerFrame, fileInfo.NumChannels) );

    while ~isDone(fileReader)                           % For each block played out, record the
block from EVM
        audioToPlay = fileReader();                     % Read a chunk of audio from
infile_name
        audioOut(audioToPlay);                         % Play a chance of audio
        [audioRead, numOverrun] = deviceReader();       % Grab a chunk of audio from EVM
        fileWriter(audioRead);                         % Write the chunk of audio from EVM to a
file
    end

    release(audioOut);                                 % Close all objects
    release(fileReader);
    release(fileWriter);
    release(deviceReader);
```

## 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.

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   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.

【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。

なお、本製品は、上記の「ご使用にあたっての注意」を譲渡先、移転先に通知しない限り、譲渡、移転できないものとします。
上記を遵守頂けない場合は、電波法の罰則が適用される可能性があることをご留意ください。 日本テキサス・インスツルメンツ株式会社
東京都新宿区西新宿 6 丁目 2 4 番 1 号
西新宿三井ビル

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
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。http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page

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.

6.2 EXCEPT FOR THE LIMITED RIGHT TO USE THE EVM SET FORTH HEREIN, NOTHING IN THESE TERMS SHALL BE CONSTRUED AS GRANTING OR CONFERRING ANY RIGHTS BY LICENSE, PATENT, OR ANY OTHER INDUSTRIAL OR INTELLECTUAL PROPERTY RIGHT OF TI, ITS SUPPLIERS/LICENSORS OR ANY OTHER THIRD PARTY, TO USE THE EVM IN ANY FINISHED END-USER OR READY-TO-USE FINAL PRODUCT, OR FOR ANY INVENTION, DISCOVERY OR IMPROVEMENT, REGARDLESS OF WHEN MADE, CONCEIVED OR ACQUIRED.

7. *USER'S INDEMNITY OBLIGATIONS AND REPRESENTATIONS.* USER WILL DEFEND, INDEMNIFY AND HOLD TI, ITS LICENSORS AND THEIR REPRESENTATIVES HARMLESS FROM AND AGAINST ANY AND ALL CLAIMS, DAMAGES, LOSSES, EXPENSES, COSTS AND LIABILITIES (COLLECTIVELY, "CLAIMS") ARISING OUT OF OR IN CONNECTION WITH ANY HANDLING OR USE OF THE EVM THAT IS NOT IN ACCORDANCE WITH THESE TERMS. THIS OBLIGATION SHALL APPLY WHETHER CLAIMS ARISE UNDER STATUTE, REGULATION, OR THE LAW OF TORT, CONTRACT OR ANY OTHER LEGAL THEORY, AND EVEN IF THE EVM FAILS TO PERFORM AS DESCRIBED OR EXPECTED.

8. *Limitations on Damages and Liability:*

   8.1 *General Limitations*. IN NO EVENT SHALL TI BE LIABLE FOR ANY SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL, OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF THESE TERMS OR THE USE OF THE EVMS , REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. EXCLUDED DAMAGES INCLUDE, BUT ARE NOT LIMITED TO, COST OF REMOVAL OR REINSTALLATION, ANCILLARY COSTS TO THE PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES, RETESTING, OUTSIDE COMPUTER TIME, LABOR COSTS, LOSS OF GOODWILL, LOSS OF PROFITS, LOSS OF SAVINGS, LOSS OF USE, LOSS OF DATA, OR BUSINESS INTERRUPTION. NO CLAIM, SUIT OR ACTION SHALL BE BROUGHT AGAINST TI MORE THAN TWELVE (12) MONTHS AFTER THE EVENT THAT GAVE RISE TO THE CAUSE OF ACTION HAS OCCURRED.

   8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY USE OF AN EVM PROVIDED HEREUNDER, INCLUDING FROM ANY WARRANTY, 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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