

User's Guide

ADCx120Q1EVM-PDK, PCMD3140Q1EVM-PDK Evaluation Module



ABSTRACT

This user's guide describes the function and use of the ADCx120Q1EVM-PDK and PCMD3140Q1EVM-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.

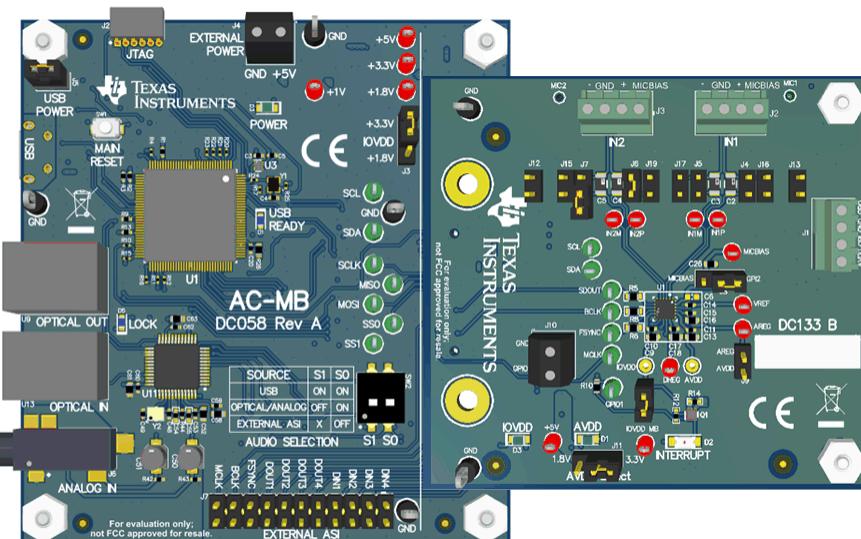


Table of Contents

1 Introduction.....	3
2 Hardware Overview.....	3
2.1 AC-MB Settings.....	3
2.2 ADCx120Q1EVM-PDK Hardware Settings.....	6
3 Software Overview.....	12
3.1 PurePath Console 3 Installation.....	12
3.2 ADCx120Q1EVM GUI Installation.....	13
4 GPIO1 Settings.....	15
5 Master Mode Operation.....	16
6 Quick Start.....	16
6.1 Configuring the Audio Serial Bus for the I ² S Output.....	18
6.2 Saving a Configuration.....	19
7 Schematic and Bill of Materials.....	20
7.1 ADCx120Q1EVM-PDK Schematic and Bill of Materials.....	20
7.2 AC-MB Schematic and Bill of Materials.....	24
7.3 Matlab Audio Capture Example.....	29

List of Figures

Figure 2-1. AC-MB Audio Serial Interface Routing.....	3
Figure 2-2. AC-MB USB Audio Setting.....	4
Figure 2-3. AC-MB Optical or Auxiliary Analog Audio Setting.....	4

Figure 2-4. AC-MB External Audio Setting.....	4
Figure 2-5. AC-MB Connection with External Audio Serial Interface.....	5
Figure 2-6. Power-Supply Distribution of the AC-MB.....	5
Figure 2-7. PCMX120-Q1EVB Input Architecture.....	6
Figure 2-8. PCMX120-Q1EVB Connection for Line Input Application.....	7
Figure 2-9. Onboard Mic Jumpers.....	9
Figure 2-10. External Mics: 2x Analog Microphones.....	10
Figure 2-11. External Mics: 4x Digital Microphones.....	11
Figure 2-12. External Mics: 2x Analog and 2x Digital Microphones.....	11
Figure 3-1. PurePath Console 3 Installation.....	12
Figure 3-2. PurePath Console 3 App Center.....	13
Figure 3-3. Initial GUI Configuration.....	13
Figure 3-4. Audio Config Tab.....	14
Figure 3-5. Hardware Connect.....	14
Figure 4-1. GPIO1 Function and Output Drive Settings.....	15
Figure 4-2. GPIO1 Schematic.....	15
Figure 6-1. Loading Presets.....	16
Figure 6-2. Onboard Mic Preset.....	16
Figure 6-3. MIC Bias Configuration.....	17
Figure 6-4. Standby to Active Mode.....	17
Figure 6-5. Disabled Controls in Active Mode.....	17
Figure 6-6. Audio Serial Bus Tab.....	18
Figure 6-7. ASI Format Configuration.....	18
Figure 6-8. Clock Monitor Pane.....	18
Figure 6-9. Channel Output Configuration and Diagram.....	19
Figure 6-10. Saving a Configuration in PPC3.....	19
Figure 7-1. ADCx120Q1EVM-PDK Schematics.....	20
Figure 7-2. AC-MB Schematics.....	24

List of Tables

Table 1-1. PCMX120-Q1 Family.....	3
Table 2-1. Onboard Mic Jumper Configuration.....	8
Table 7-1. ADCx120EVM-PDK Bill of Materials.....	21
Table 7-2. AC-MB Bill of Materials.....	25

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1 Introduction

The ADCx120Q1EVM-PDK is an evaluation module (EVM) designed to demonstrate the performance and functionality of the PCMx120-Q1 family of devices. This family includes the devices shown in [Table 1-1](#) with differences in performance and function noted. The family also includes the PCMD3140-Q1, which is the digital mic only version of the device.

Table 1-1. PCMx120-Q1 Family

Device	SNR Without DRE (dB)	SNR With DRE (dB)
PCM3120-Q1	106	N/A
PCM5120-Q1	108	120
PCM6120-Q1	112	123
PCMD3140-Q1	127 (5th-order PDM)	N/A

2 Hardware Overview

The evaluation kit consists of the PCMx120-Q1EVB 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 PCMx120-Q1 device and its input connections.

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 2-1](#) shows a block diagram of the ASI routing on the AC-MB.

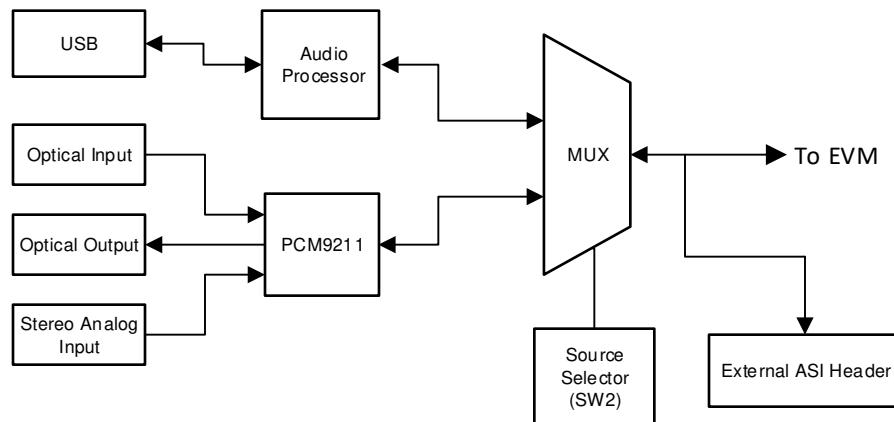


Figure 2-1. AC-MB Audio Serial Interface Routing

Switch SW2 on the AC-MB selects the audio serial bus that interfaces with the PCMx120 -Q1 EVB. 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: 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 2-2](#) illustrates the AC-MB audio setting for the USB mode of operation.



Figure 2-2. AC-MB USB Audio Setting

2.1.1.2 Optical or Auxiliary 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 2-3](#) shows the AC-MB audio setting for the optical and analog mode of operation.



Figure 2-3. 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, I²S 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 2-4](#) shows the AC-MB audio setting for the external mode of operation.



Figure 2-4. AC-MB External Audio Setting

Figure 2-4 shows how to connect the external audio interface, with the top row for the signal and the bottom row for ground.

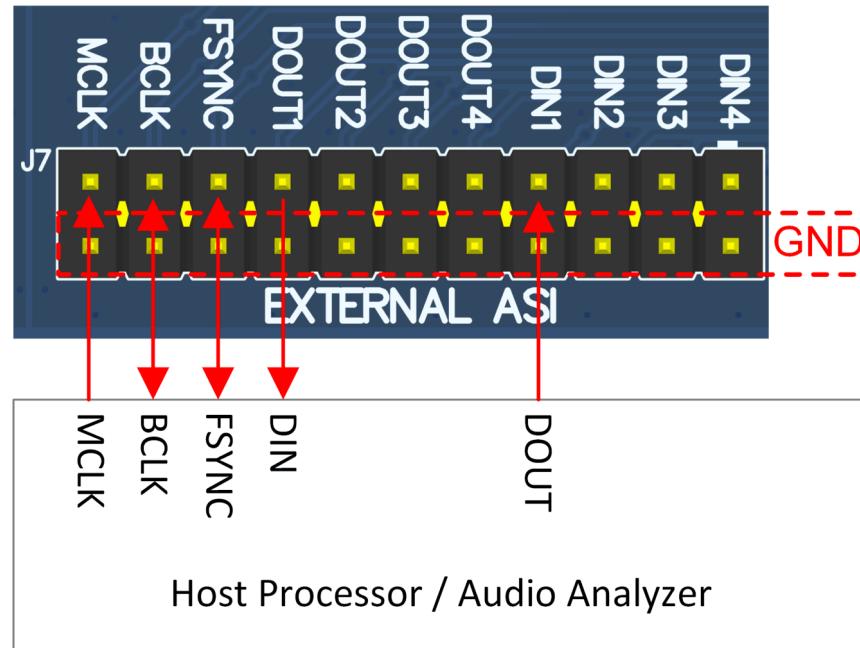


Figure 2-4. External ASI Connection

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 2-6 shows a block diagram depicting the power structure of the AC-MB.

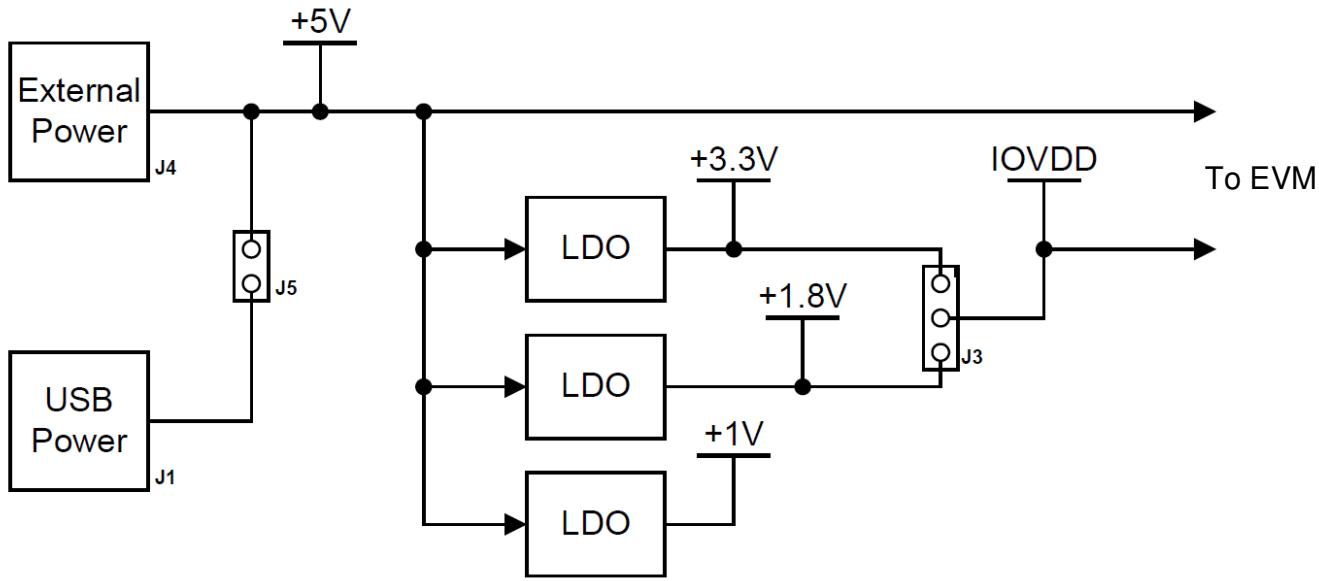


Figure 2-6. Power-Supply Distribution of the AC-MB

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 ADCx120Q1EVM-PDK Hardware Settings

The PCMx120-Q1 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 PCMx120-Q1 can optionally connect to onboard microphones for quick evaluation, and can be optionally configured to bypass the input decoupling capacitors for evaluating the functionality of digital microphones, GPIOs, or in DC coupled applications. [Figure 2-7](#) shows a diagram of the EVM input architecture.

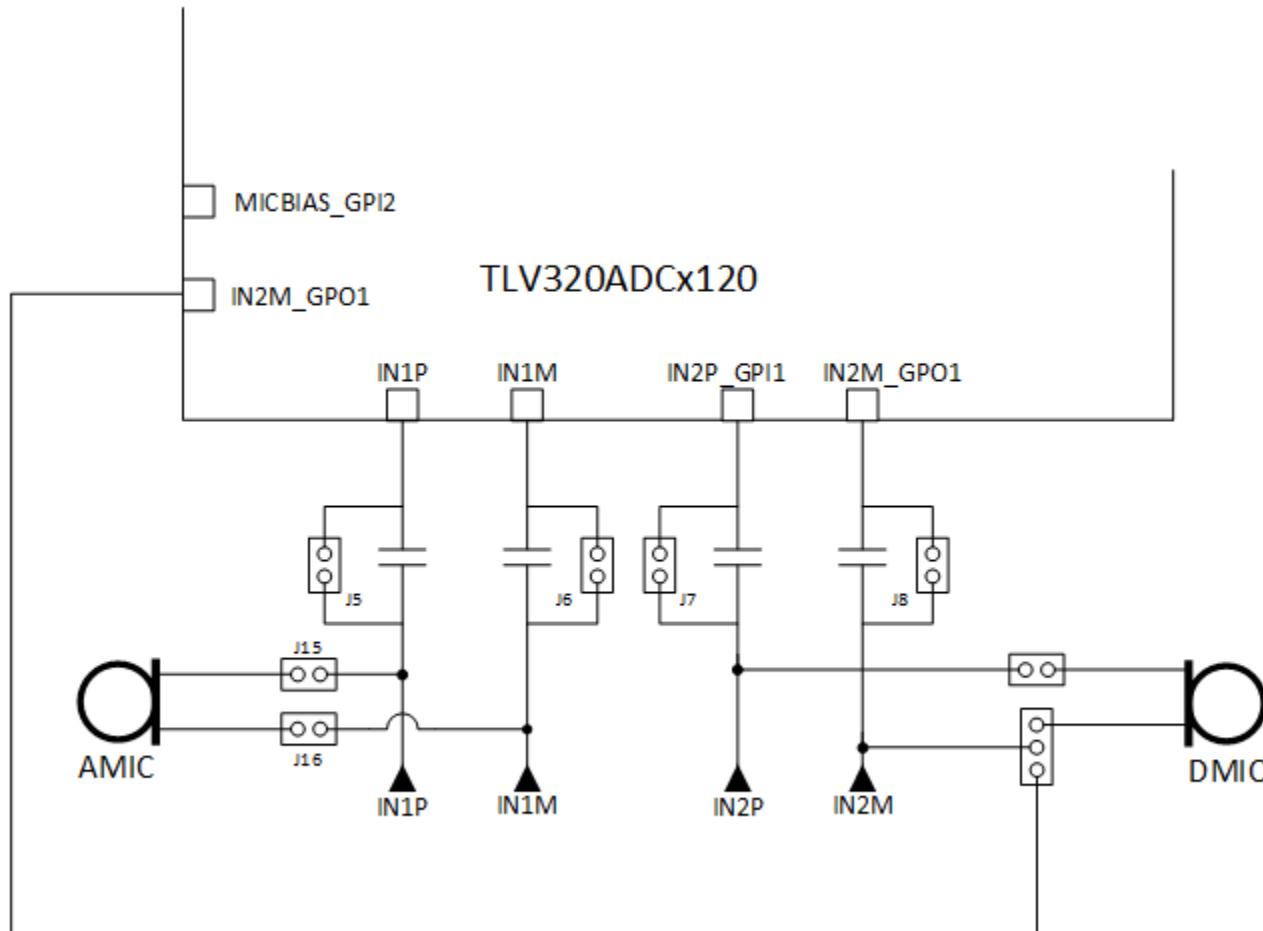


Figure 2-7. PCMx120-Q1EVB Input Architecture

2.2.1 Line Inputs

For the line input configuration (shown in [Figure 2-8](#)), the PCMX120-Q1 captures the audio signal provided through terminals J2 (IN1) and J3 (IN2). The input accepted in this mode is a differential, 2-VRMS, full-scale audio signal. If a single-ended source is used, then 1-VRMS signal is supported

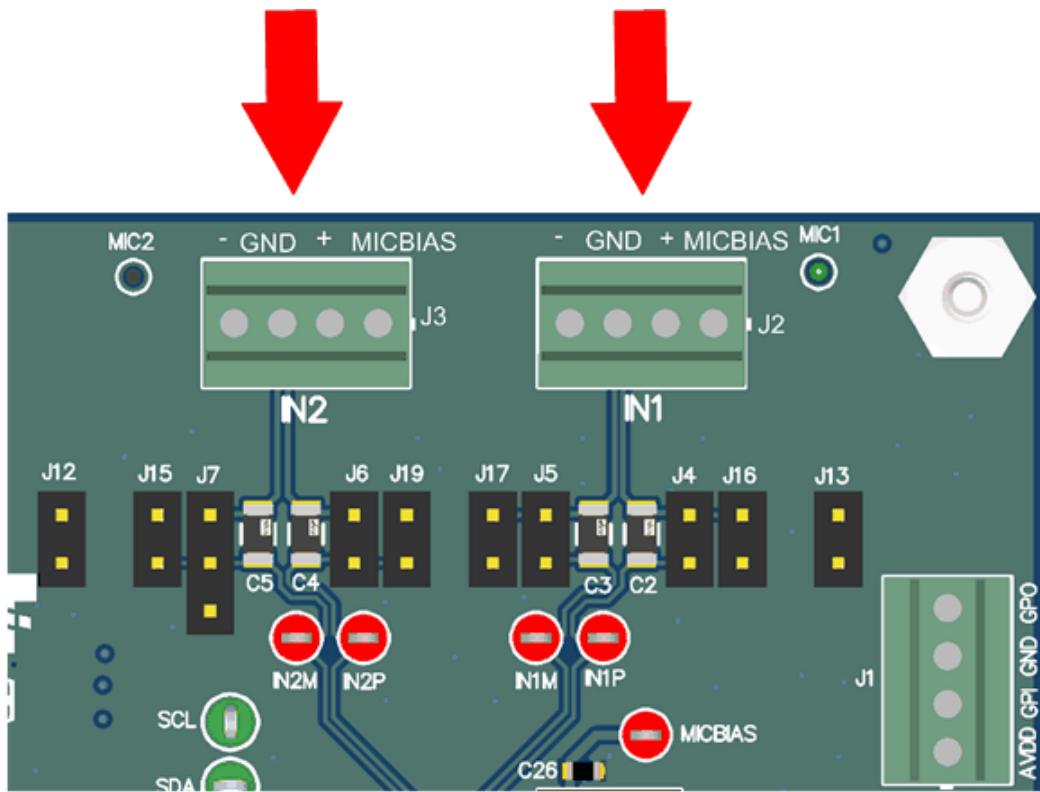


Figure 2-8. PCMx120-Q1EVB Connection for Line Input Application

2.2.2 Onboard Microphone Configuration

The ADCx120Q1EVM-PDK comes equipped with 2 onboard microphones: 1x ICS-40740 analog microphone and 1x T5818 digital microphone. The ICS-40740 can be connected to IN1 and the T5818 can be connected to IN2 with onboard shunts using the jumper settings shown in [Table 2-1](#) and [Figure 2-9](#). MICBIAS is used to power the ICS-40740, so header J8 must be set to MICBIAS. There must not be any connections to J2 or J3 during onboard microphone use to preserve the performance of the microphones. The PCMD3140Q1EVM-PDK only includes the T5818 digital microphone, but the same script in [Table 2-1](#) and [Figure 2-9](#) can be used for configuring the microphone.

Table 2-1. Onboard Mic Jumper Configuration

Jumper	Setting
J13	Short
J16	Short
J17	Short
J12	Short
J15	Short
J19	Short
J4	Open
J5	Open
J6	Open
J7	Open
J8	Pins 1-2; MICBIAS
J9	Open (if 3.3V AVDD is used) Short (if 1.8V AVDD is used)
J10	Open
J11	Pins 1-2: AVDD = 3.3V Pines 2-3: AVDD = 1/8V
J14	Short

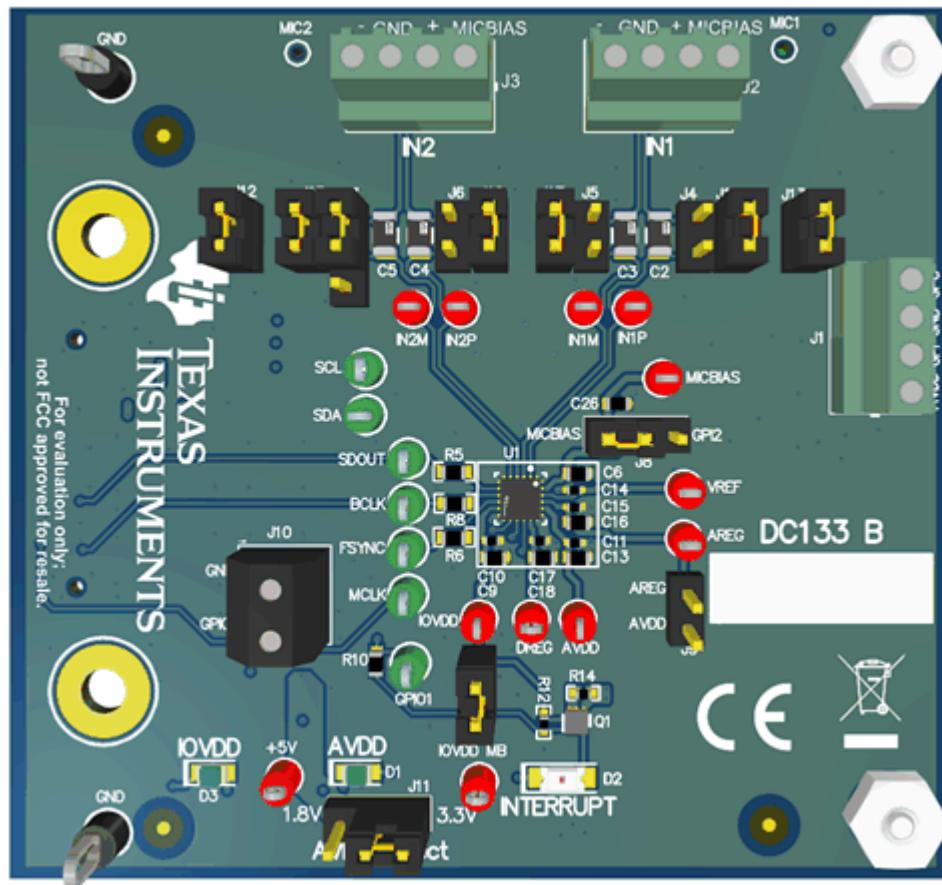


Figure 2-9. Onboard Mic Jumpers

To configure the ADC for both onboard microphones, use the *Onboard Microphones* preset in the PPC3 GUI, or copy and paste the following script in I2C master app:

```
#####On-Board MIC Config#####
w 9c 02 81 #Wake up device and enable AREG
w 9c 01 01 #Software Reset
d 100 #Wait 100ms
w 9c 00 00 #Set page 0
w 9c 02 81 #Wake up device and enable AREG
d 10 #wait 10 ms
w 9c 0d 01 #Set Ch-3 data to ASI left slot 1
w 9c 22 41 #Set IN2M_GPO1 to PDCMLK output (Default 3.072MHz)
w 9c 2b 50 #Set IN2P_GPI1 to PDMDIN2 for channel 3 and 4
w 9c 73 A0 #Enable input Ch-1 and Ch-3
w 9c 74 A0 # Enable ASI Output Ch-1 and Ch-3 slots
w 9c 75 E0 # Power-up ADC, MICBIAS and PLL
```

2.2.3 External Microphone Configurations

The PCMx120-Q1 family of devices support both analog and digital PDM inputs with up to 2 channels of analog input or 4 channels of digital PDM input. It is also possible to use various combinations of analog and digital inputs with up to 2 analog inputs and 2 digital inputs operating simultaneously.

Single-ended or differential analog inputs can be applied on the following pin pairs: IN1P, IN1M, IN2P_GPI1, IN2M_GPO1.

Digital PDM inputs can be applied to the following pins: IN2P_GPI1, MICBIAS_GPI2, GPIO1. A PDM clock can also be output on pins: IN2M_GPO1, GPIO1.

On the EVM access to these pins is provided on terminals J1, J2, J3, and J10. [Figure 2-10](#), [Figure 2-11](#), and [Figure 2-12](#) illustrate the recommended pin connections for common use-cases.

Note, the GPIO1 pin is referenced to the IOVDD domain while IN2P_GPI1, MICBIAS_GPI2, and IN2M_GPO1 are all referenced to AVDD. Thus, if using 2 analog mics in addition to digital mics it is recommended that AVDD and IOVDD be set to the same voltage or a level translator be placed between GPIO1 and the digital microphone. If only 1 analog mic is used then it is recommended to use IN1P and IN1M for the analog mic. If digital mics are used, it is recommended to use IN2M_GPO1 to generate the PDMCLK signal.

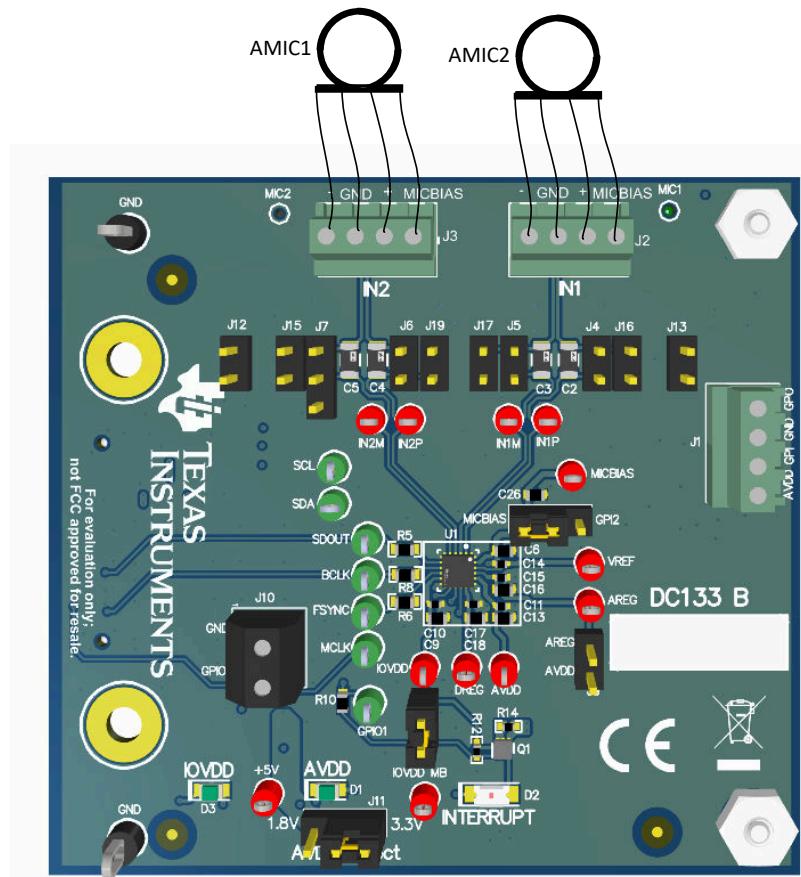


Figure 2-10. External Mics: 2x Analog Microphones

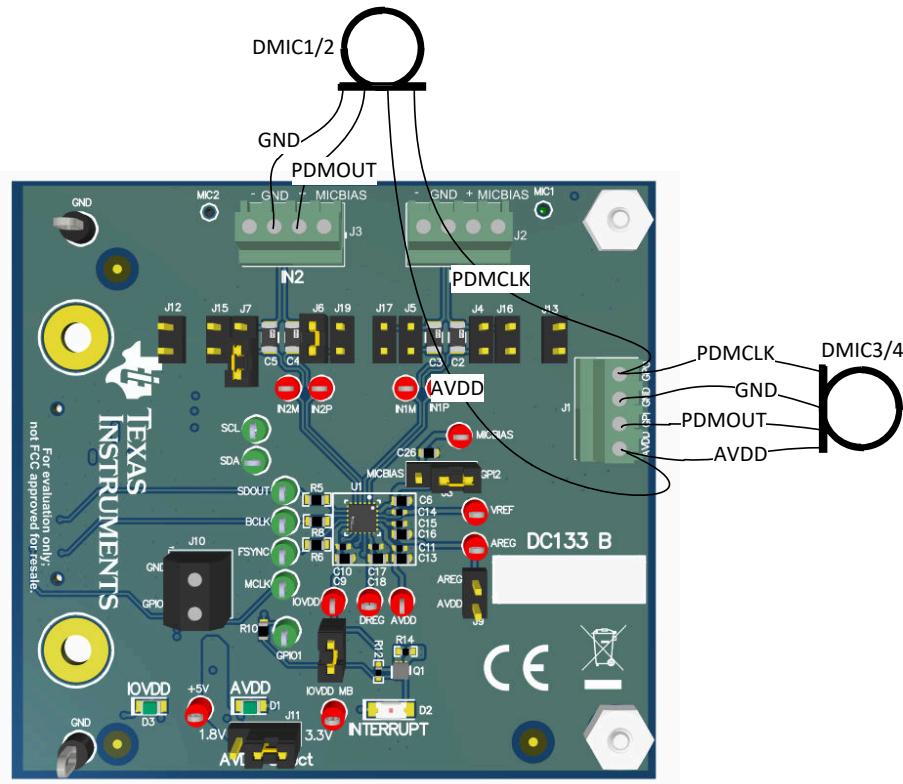
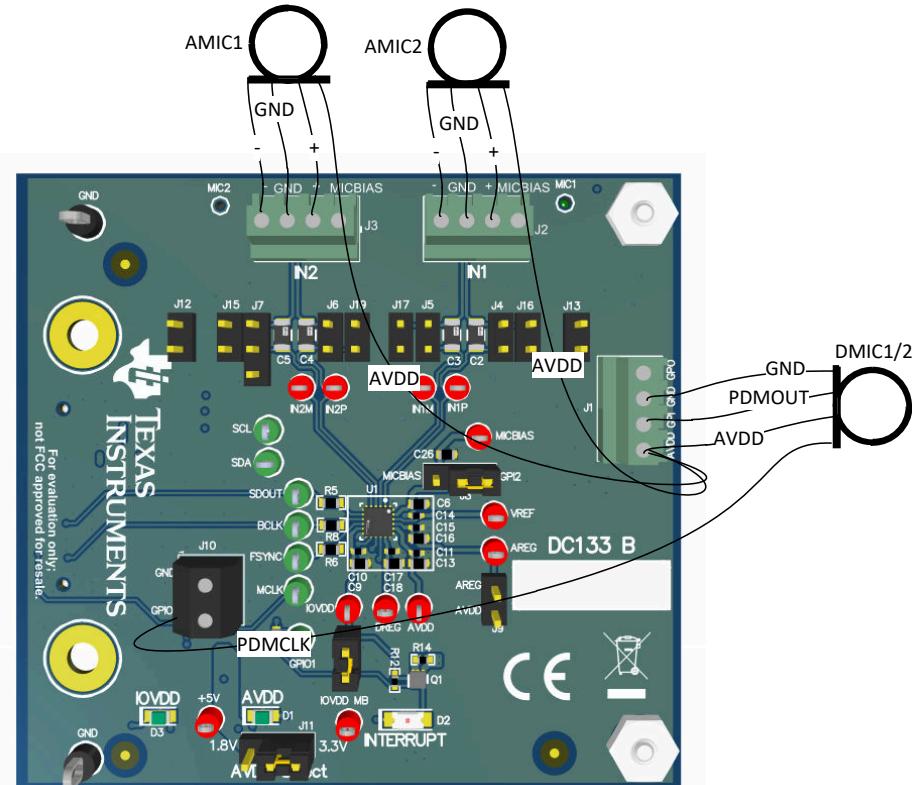


Figure 2-11. External Mics: 4x Digital Microphones



*Requires AVDD = IOVDD

Figure 2-12. External Mics: 2x Analog and 2x Digital Microphones

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 ADCx120Q1EVM-PDK GUI is an application that installs into the PPC3 framework. PPC3 must be installed prior to downloading the ADCx120Q1EVM-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 3-1 shows the setup directory for the PPC3 installation.

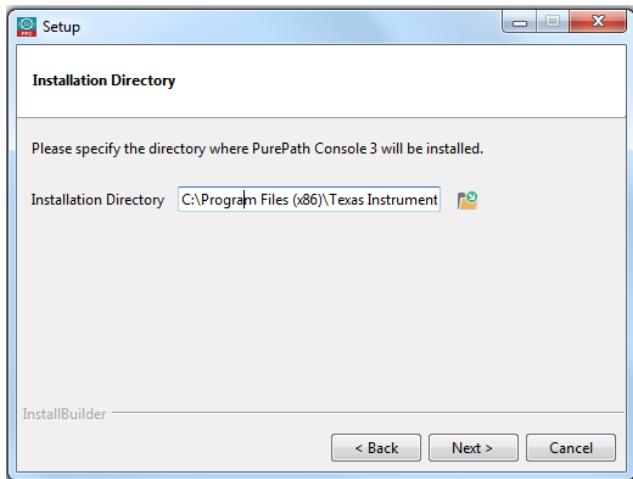


Figure 3-1. PurePath Console 3 Installation

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

3.2 ADCx120Q1EVM GUI Installation

3.2.1 Software Setup

Open the PPC3 application in the directory chosen for the GUI installation in [Section 3.1](#). [Figure 3-2](#) shows the resulting app center window. Click on the PCMx120-Q1 app tile.

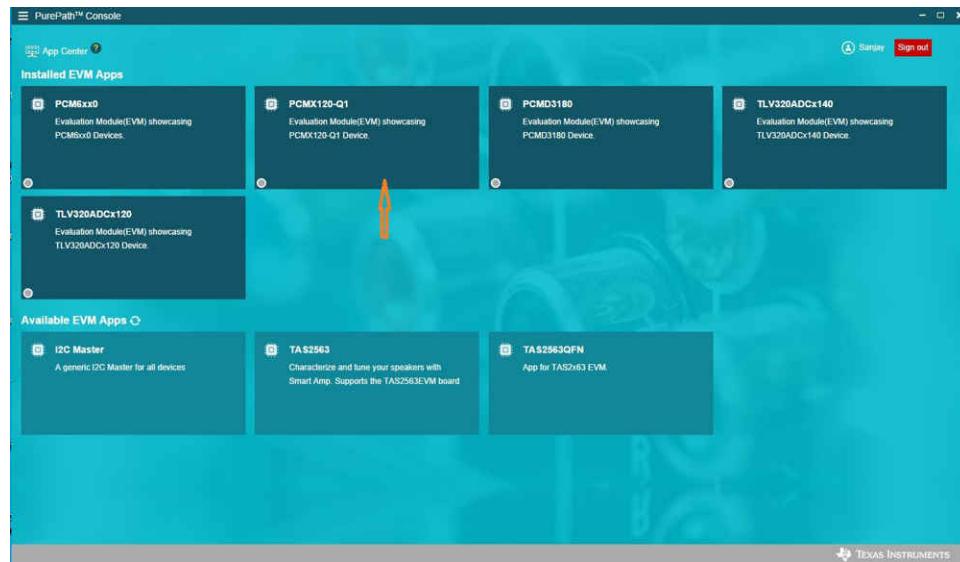


Figure 3-2. PurePath Console 3 App Center

The PCMx120-Q1 GUI is designed to work with up to four devices at any time. As shown in [Figure 3-3](#), choose the 1 device radial button and click **New**.

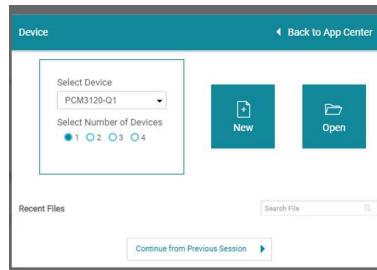


Figure 3-3. Initial GUI Configuration

As shown in [Figure 3-4](#), the GUI opens to the *Audio Config* tab.

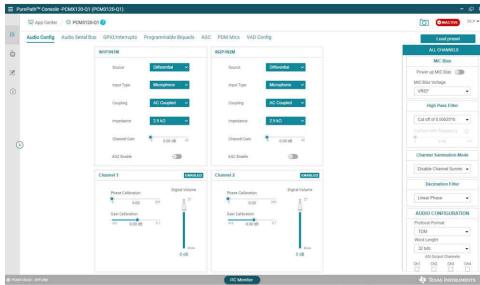


Figure 3-4. Audio Config Tab

Before changing any parameters, check the lower left corner of the PPC3 window, as shown in [Figure 3-5](#), to verify that the EVM is connected. If no EVM is detected, the text will read *PCMx120-Q1 offline*. If the EVM is detected, a *Connect* button appears. Clicking this button connects the hardware.



Figure 3-5. Hardware Connect

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

4 GPIO1 Settings

The GPIO1 pin can be configured for a variety of different functions. [Figure 4-1](#) shows the possible settings. By default, the EVM is configured with GPIO1 connected to an interrupt LED to match the default GPIO1 configuration of the PCMX120-Q1 device. This setting causes the INTERRUPT LED on the board to light whenever an IRQ occurs, such as when the VAD is configured to generate an interrupt on voice detection. If GPIO1 is to be used a function other than interrupt, modifications may be required to the 0-Ω resistors installed. [Figure 4-2](#) shows a schematic for the GPIO1 pin layout.

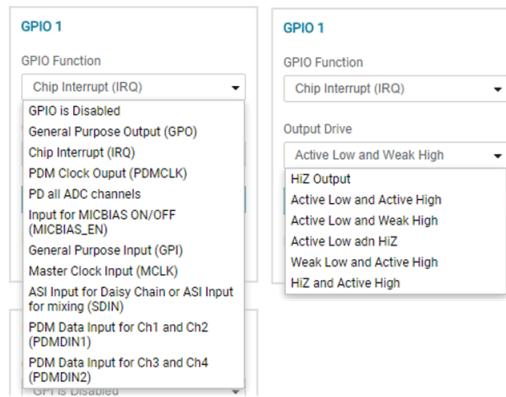


Figure 4-1. GPIO1 Function and Output Drive Settings

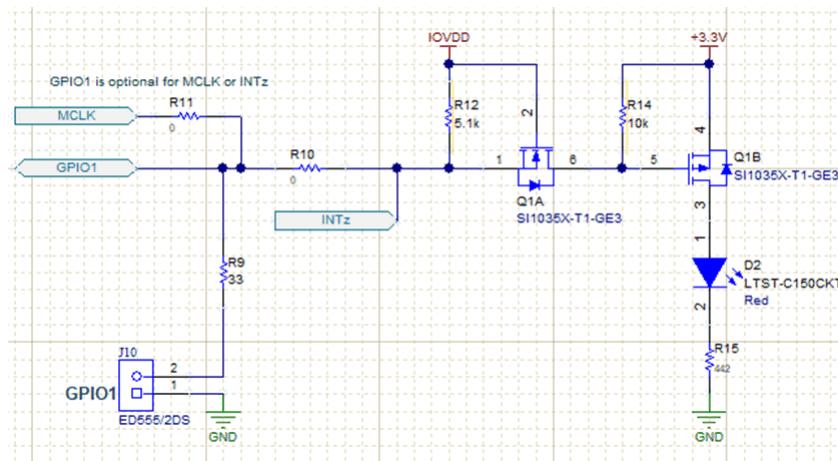


Figure 4-2. GPIO1 Schematic

5 Master Mode Operation

To operate ADCx120Q1EVM-PDK in master mode, S1 and S0 on the AC-MB must first be set to "External ASI" as illustrated in [Figure 2-4](#).

The device does not have a dedicated MCLK pin, the master clock can be applied at GPIO1, IN2P_GPI1, or MICBIAS_GPI2. Since GPI1 and GPI2 are multipurpose pins shared with analog inputs and MICBIAS, using them as the MCLK input limits the devices functionality. It is recommended to use the GPIO1 pin for MCLK.

To use GPIO1 as MCLK the MCLK signal must either be applied at the J10 terminal, or at the "External ASI" header on the AC-MB board with the other clocks. To use the "External ASI" header, it is necessary to install a 0-Ohm resistor at R11 on the EVM, which is depopulated by default.

6 Quick Start

Configure the AC-MB for the USB audio (TDM) and the PCMX120-Q1EVB for the onboard microphone inputs.

The GUI comes with preset files to that can be used for easy initial setup. Select the *Load preset* option in the top corner of the GUI and load the *On Board Microphone* setting, as shown in [Figure 6-1](#) and [Figure 6-2](#). Be sure to populate the jumpers described in the settings as described in [Table 2-1](#).

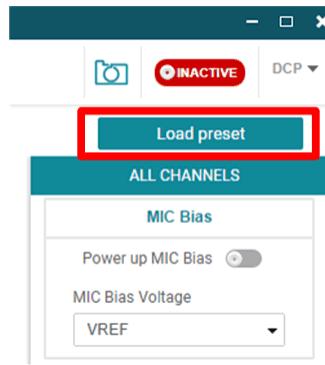


Figure 6-1. Loading Presets

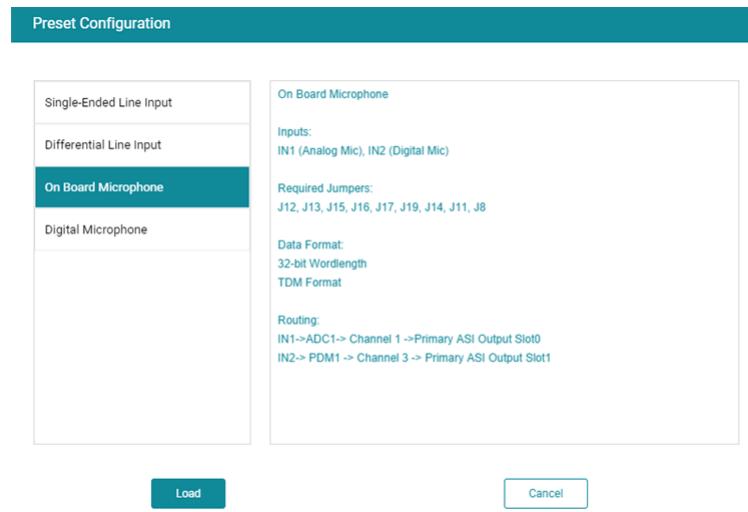


Figure 6-2. Onboard Mic Preset

As shown in [Figure 6-3](#), make sure AVDD is selected for the MIC bias voltage and powered up.

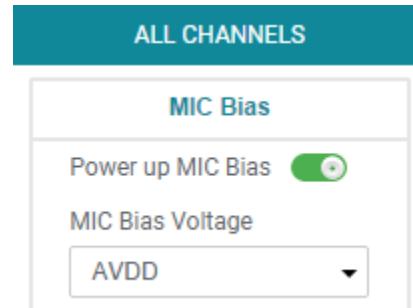


Figure 6-3. MIC Bias Configuration

The default state for the PCMx120-Q1 is standby mode and, with the exception of the channel digital volume, all device configurations must be done in standby mode. The PCMx120-Q1 does not provide a digital audio output in standby mode. [Figure 6-4](#) shows how to change the mode from standby to active.

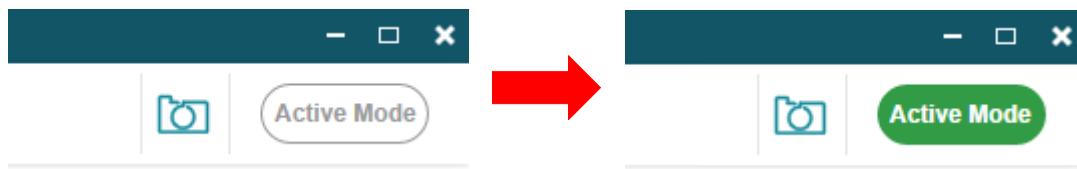


Figure 6-4. Standby to Active Mode

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 6-5](#) shows which controls are disabled.

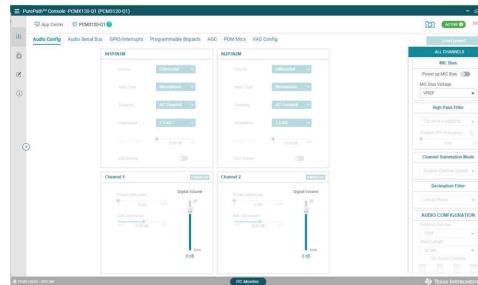


Figure 6-5. Disabled Controls in Active Mode

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

6.1 Configuring the Audio Serial Bus for the I²S Output

The PCMx120-Q1 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 PCMx120-Q1 EVM 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 6](#). As shown in [Figure 6-6](#), select the audio serial bus tab.

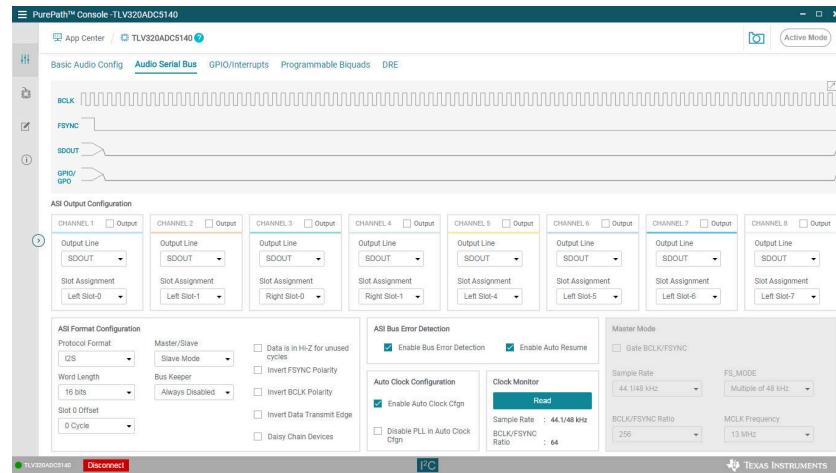


Figure 6-6. Audio Serial Bus Tab

In the ASI format configuration pane (shown in [Figure 6-7](#)), change the protocol format to I²S, and the word length to 16 bits.

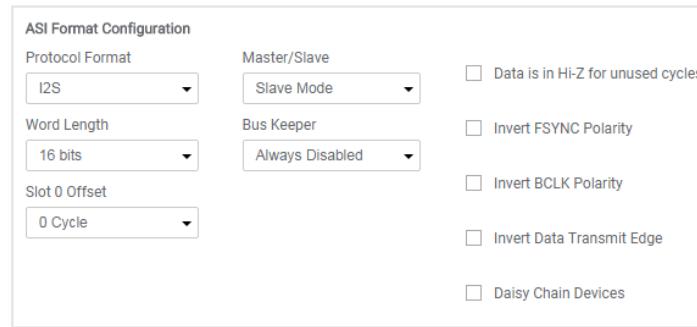


Figure 6-7. ASI Format Configuration

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 6-8](#), in the clock monitor pane.



Figure 6-8. 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 6-9](#), 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.

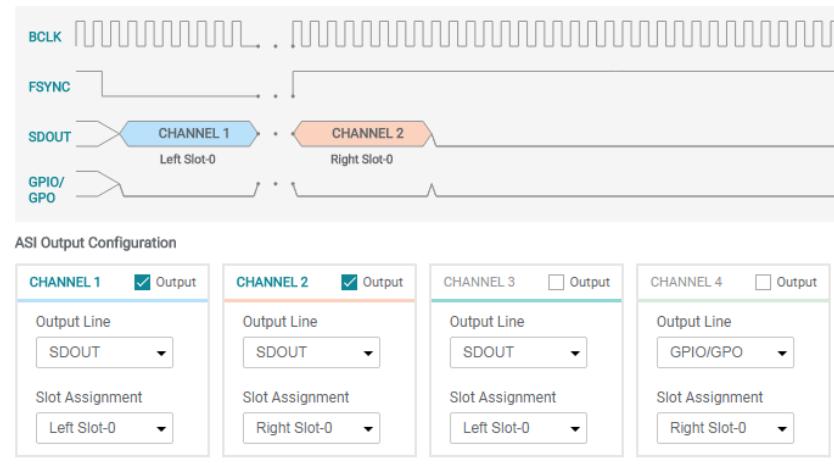


Figure 6-9. Channel Output Configuration and Diagram

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.

6.2 Saving a Configuration

To save a configuration, as shown in [Figure 6-10](#), 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*.

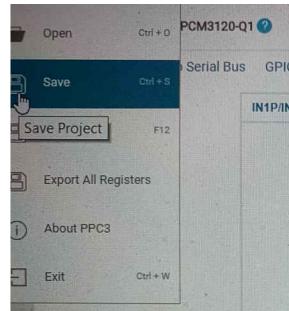


Figure 6-10. Saving a Configuration in PPC3

7 Schematic and Bill of Materials

7.1 ADCx120Q1EVM-PDK Schematic and Bill of Materials

This section provides the schematics and bill of materials (BOM) for the ADCx120Q1EVM-PDK.

7.1.1 ADCx120Q1EVM-PDK Schematic

Figure 7-1 shows the schematics for the ADCx120Q1EVM-PDK.

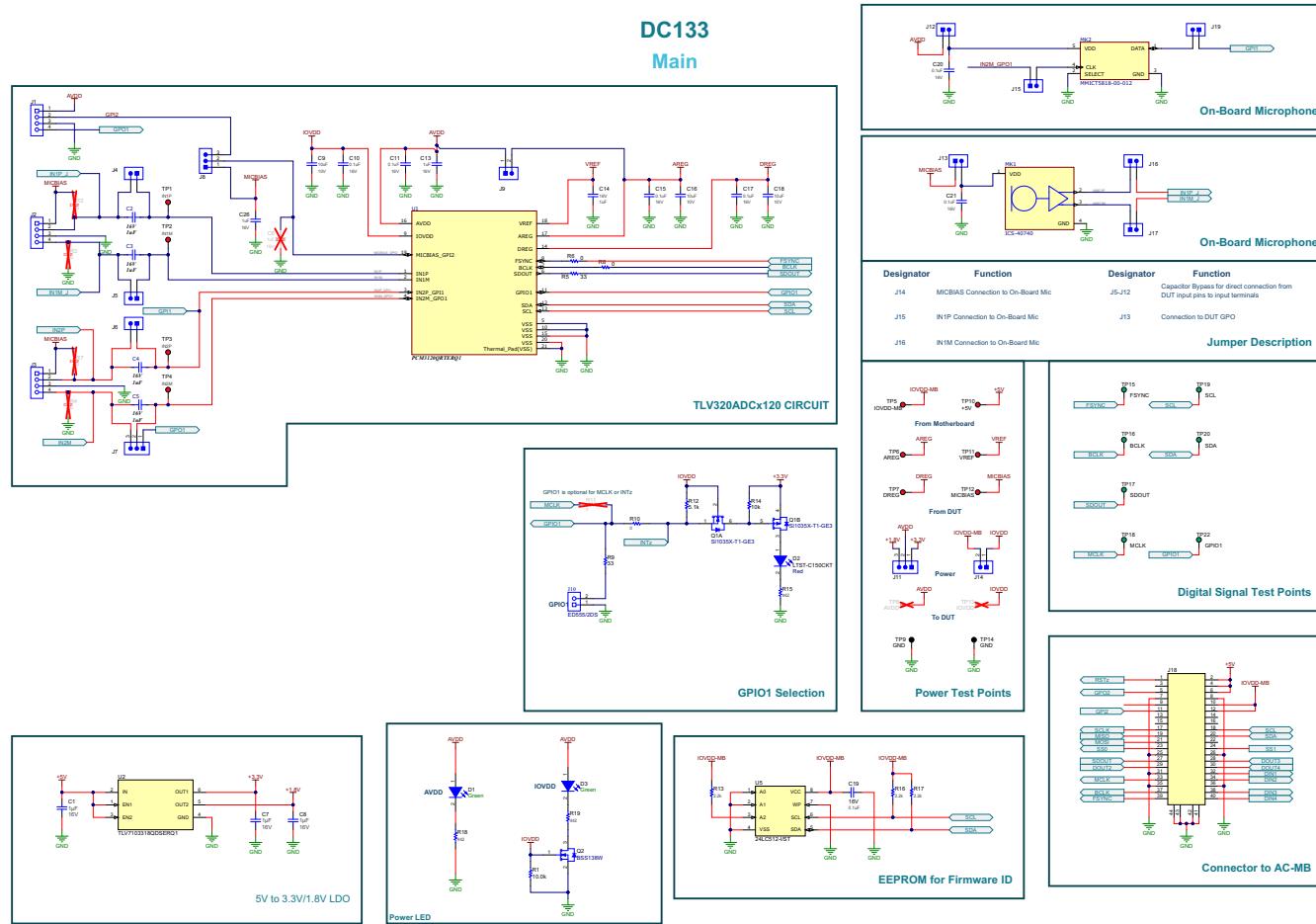


Figure 7-1. ADCx120Q1EVM-PDK Schematics

7.1.2 ADCx120Q1EVM-PDK Bill of Materials

Table 7-1 lists the BOM for the ADCx120Q1EVM-PDK.

Table 7-1. ADCx120EVM-PDK Bill of Materials

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
C1, C7, C8	3	1uF	CAP, CERM, 1 μ F, 16 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	0603	CGA3E1X7R1C10 5K080AC	TDK
C2, C3, C4, C5	4		1 μ F Film Capacitor 12V 10V Acrylic, Metallized 1206 (3216 Metric)	1206	FCA1206A105M-H3	Cornell Dubilier Electronics
C9, C16, C18	3	10uF	CAP, CERM, 10 μ F, 10 V, +/- 20%, X5R, 0603	0603	C1608X5R1A106 M080AC	TDK
C10, C11, C15, C17, C19, C20, C21	7	0.1uF	CAP, CERM, 0.1 μ F, 16 V, +/- 10%, X7R, 0402	0402	885012205037	Wurth Elektronik
C13	1	1uF	CAP, CERM, 1 μ F, 16 V, +/- 10%, X7R, 0603	0603	885012206052	Wurth Elektronik
C14	1	1uF	CAP, CERM, 1 μ F, 16 V, +/- 10%, X5R, 0402	0402	EMK105BJ105KV HF	Taiyo Yuden
C26	1	1uF	CAP, CERM, 1 μ F, 16 V, +/- 10%, X7R, 0603	0603	EMK107B7105KA -T	Taiyo Yuden
D1, D3	2	Green	LED, Green, SMD	LED_0805	LTST-C170KGKT	Lite-On
D2	1	Red	LED, Red, SMD	1206	LTST-C150CKT	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	3		Terminal Block, 2.54mm, 4x1, Brass, TH	Terminal Block, 2.54mm, 4-pole, TH	OSTVN04A150	On-Shore Technology
J4, J5, J6, J9, J12, J13, J14, J15, J16, J17, J19	11		Header, 100mil, 2x1, Gold, TH	2x1 Header	TSW-102-07-G-S	Samtec
J7, J8, J11	3		Header, 100mil, 3x1, Gold, TH	3x1 Header	TSW-103-07-G-S	Samtec
J10	1		Terminal Block, 3.5mm Pitch, 2x1, TH	7.0x8.2x6.5mm	ED555/2DS	On-Shore Technology

Table 7-1. ADCx120EVM-PDK Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
J18	1		Connector, Header, High Speed, 20 pairs, SMT	QTE-020-01-X-D-A	QTE-020-01-L-D-A	Samtec
MK1	1		77Hz ~ 20kHz Analog Microphone MEMS (Silicon) 1.5V ~ 3.63V Omnidirectional (-37.5dB ±1dB @ 94dB SPL) Solder Pads	LGA4	ICS-40740	TDK
MK2	1		Bottom Port PDM Digital Output Multi-Mode Microphone	SMT_3MM50_2MM65	MMICT5818-00-012	TDK
Q1	1	20V	MOSFET, 2-CH, N/P-CH, 20 V, 0.18 A, SOT-563	SOT-563	SI1035X-T1-GE3	Vishay-Siliconix
Q2	1	50V	MOSFET, N-CH, 50 V, 0.21 A, SOT-323	SOT-323	BSS138W	Fairchild Semiconductor
R1	1	10.0k	RES, 10.0 k, 1%, 0.1 W, 0603	0603	CRCW060310K0FKEA	Vishay-Dale
R5, R9	2	33	RES, 33, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060333R0JNEA	Vishay-Dale
R6, R8	2	0	RES, 0, 5%, 0.1 W, 0603	0603	CRCW06030000Z0EA	Vishay-Dale
R10, R11	2	0	RES, 0, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	RMCF0603ZT0R00	Stackpole Electronics Inc
R12	1	5.1k	RES, 5.1 k, 5%, 0.063 W, 0402	0402	CRCW04025K10JNED	Vishay-Dale
R13, R16, R17	3	2.2k	RES, 2.2 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW04022K20JNED	Vishay-Dale
R14	1	10k	RES, 10 k, 5%, 0.063 W, 0402	0402	CRCW040210K0JNED	Vishay-Dale
R15, R18, R19	3	442	RES, 442, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW0603442RFKEA	Vishay-Dale
SH1, SH2, SH3, SH4, SH5, SH6, SH7, SH8, SH9, SH10, SH11, SH12, SH13	13	1x2	Shunt, 100mil, Gold plated, Black	Shunt	SNT-100-BK-G	Samtec

Table 7-1. ADCx120EVM-PDK Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP10, TP11, TP12	10		Test Point, Miniature, Red, TH	Red Miniature Testpoint	5000	Keystone
TP9, TP14	2		Test Point, Multipurpose, Black, TH	Black Multipurpose Testpoint	5011	Keystone
TP15, TP16, TP17, TP18, TP19, TP20, TP22	7		Test Point, Miniature, Green, TH	Green Miniature Testpoint	5116	Keystone
U1	1		2-Channel, 768- kHz, Burr-Brown Audio ADC	WQFN20	TLV320ADC6120I RTER	Texas Instruments
U2	1		Automotive Catalog, Dual, 200mA, Low- IQ Low-Dropout Regulator for Portable Devices, DSE0006A (WSON-6)	DSE0006A	TLV7103318QDS ERQ1	Texas Instruments
U5	1		EEPROM, 512KBIT, 400KHZ, 8TSSOP	TSSOP-8	24LC512-I/ST	Microchip
C6	0	1uF	CAP, CERM, 1 uF, 16 V, +/- 10%, X7R, 0603	0603	EMK107B7105KA -T	Taiyo Yuden
FID1, FID2, FID3, FID4, FID5, FID6	0		Fiducial mark. There is nothing to buy or mount.	N/A	N/A	N/A
R2, R3, R4, R7	0	0	RES, 0, 5%, 0.1 W, 0603	0603	CRCW06030000Z 0EA	Vishay-Dale
TP8, TP13	0		Test Point, Miniature, Red, TH	Red Miniature Testpoint	5000	Keystone

Please Note: Reference designator U1 has the below part numbers for different EVM's

EVM	U1
ADC3120Q1EVM-PDK	PCM3120-Q1
ADC5120Q1EVM-PDK	PCM5120-Q1
ADC3120Q1EVM-PDK	PCM6120-Q1

7.2 AC-MB Schematic and Bill of Materials

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

7.2.1 AC-MB Schematic

Figure 7-2 shows the schematics

Audio Converters Motherboard DC058 Rev A
 PCM9211, Audio Interface and Test Points

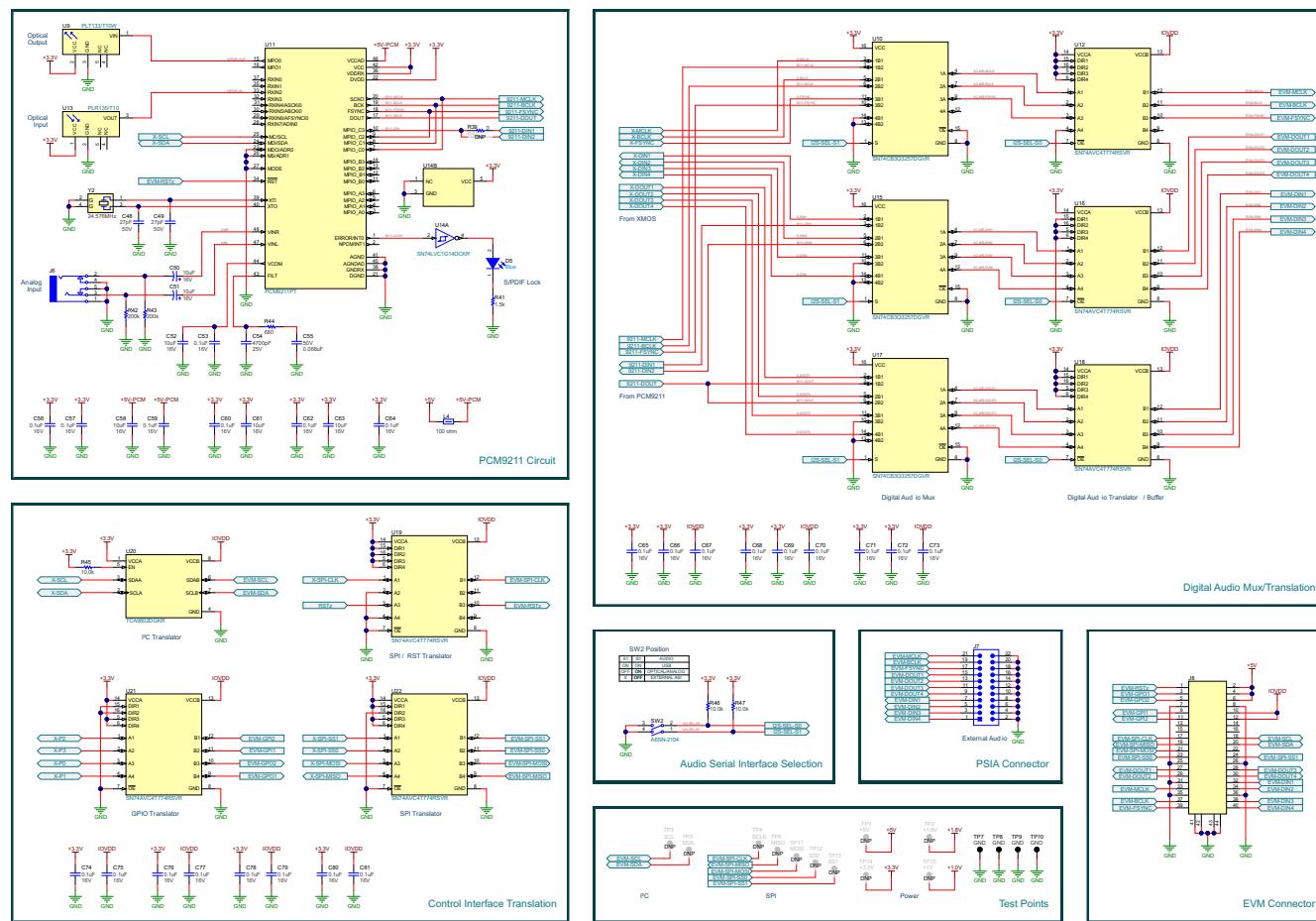


Figure 7-2. AC-MB Schematics

7.2.2 AC-MB Bill of Materials

Table 7-2 lists the BOM for the AC-MB.

Table 7-2. AC-MB Bill of Materials

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
C1	1	2.2uF	CAP, CERM, 2.2 uF, 16 V, +/- 10%, X7R, 0603	0603	EMK107BB7225K	Taiyo Yuden A-T
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	LMK316AB7226K	Taiyo Yuden L-TR
C39, C40, C41	3	1uF	CAP, CERM, 1 μ F, 16 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	0603	CGA3E1X7R1C10	TDK
C47	1	1500pF	CAP, CERM, 1500 pF, 16 V, +/- 10%, X7R, 0603	0603	CGA1A2X7R1C15	TDK
C48, C49	2	27pF	CAP, CERM, 27 pF, 50 V, +/- 5%, C0G/ NP0, 0402	0402	GJM1555C1H270	MuRata
C50, C51	2	10uF	CAP, AL, 10 uF, 16 V, +/- 20%, SMD	D3xL5.4mm	UWX1C100MCL2	Nichicon
C52, C58, C61, C63	4	10uF	CAP, CERM, 10 uF, 16 V, +/- 20%, X5R, 0603	0603	EMK107BBJ106M	Taiyo Yuden A-T
C54	1	4700pF	CAP, CERM, 4700 pF, 16 V, +/- 10%, X7R, 0402	0402	885012205029	Wurth Elektronik
C55	1	0.068 μ F	CAP, CERM, 0.068 μ F, 50 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0402	0402	CGA2B3X7R1H68	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
H11, H12	2		Standoff, Male/Male Thread, 5.15 mm, M3 x 0.5	Standoff	SO-0515-02-02-01	Samtec

Table 7-2. AC-MB Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
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	35RASMT4BHNT RX	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	MPZ2012S601AT 000	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	MPZ1608D101BT D25	TDK
R1	1	1.0k	RES, 1.0 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW04021K00J NED	Vishay-Dale
R2, R3	2	2.2k	RES, 2.2 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW04022K20J NED	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-0733R 2L	Yageo America
R5	1	47.0k	RES, 47.0 k, 1%, 0.0625 W, 0402	0402	RC0402FR-0747K L	Yageo America
R6	1	10.0k	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	CRCW040247K0J NED	Vishay-Dale
R9	1	43.2	RES, 43.2, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW040243R2F KED	Vishay-Dale
R13	1	10k	RES, 10 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW040210K0J NED	Vishay-Dale
R14, R41	2	1.5k	RES, 1.5 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06031K50J NEA	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	10.0k	RES, 10.0 k, 1%, 0.05 W, 0201	0201	CRCW020110K0F KED	Vishay-Dale
R26	1	4.7	RES, 4.7, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06034R70J NEA	Vishay-Dale
R30	1	25.5k	RES, 25.5 k, 1%, 0.05 W, 0201	0201	RC0201FR-0725K 5L	Yageo America
R31	1	51.0k	RES, 51.0 k, 1%, 0.05 W, 0201	0201	RC0201FR-0751K L	Yageo America
R32	1	40.2k	RES, 40.2 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW040240K2F KED	Vishay-Dale

Table 7-2. AC-MB Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
R33	1	1.00M eg	RES, 1.00 M, 1%, 0.125 W, AEC-Q200 Grade 0, 0805	0805	CRCW08051M00 FKEA	Vishay-Dale
R36	1	162k	RES, 162 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW0402162KF KED	Vishay-Dale
R38	1	442	RES, 442, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW0603442RF KEA	Vishay-Dale
R39	1	0	RES, 0, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	RMCF0603ZT0R0 0	Stackpole Electronics Inc
R42, R43	2	200k	RES, 200 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW0402200KJ NED	Vishay-Dale
R44	1	680	RES, 680, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW0402680RJ NED	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	SN74AVC2T244D QER	Texas Instruments
U4, U7	2		Enhanced Product Dual Buffer/Driver with Open-Drain Output, DCK0006A (SOT-SC70-6)	DSF0006A	SN74LVC2G07DS FR	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	TLV7103318QDS ERQ1	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 (TSSOP-16)	DGV0016A	SN74CB3Q3257D GVR	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	SN74AVC4T774R SVR	Texas Instruments
U13	1		Photolink- Fiber Optic Receiver, TH	13.5x10x9.7mm	PLR135/T10	Everlight
U14	1		Single Schmitt-Trigger Inverter, DCK0005A (SOT-SC70-5)	DCK0005A	SN74LVC1G14DC KR	Texas Instruments

Table 7-2. AC-MB Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
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-24.000 MHZ-EJ-E-T	Abracan Corporation
Y2	1		Crystal, 24.576 MHz, 10pF, SMD	2.5x0.5x2.0mm	ABM10-24.576MH Z-E20-T	Abracan 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

7.3 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
deviceReader = 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);

```

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3.1 United States

3.1.1 Notice applicable to EVMs not FCC-Approved:

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

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

CAUTION

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

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

FCC Interference Statement for Class A EVM devices

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

FCC Interference Statement for Class B EVM devices

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

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

3.2 Canada

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

Concerning EVMs Including Radio Transmitters:

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

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

Concernant les EVMs avec appareils radio:

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

Concerning EVMs Including Detachable Antennas:

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

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotope 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/lsts/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.

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1. 電波法施行規則第6条第1項第1号に基づく平成18年3月28日総務省告示第173号で定められた電波暗室等の試験設備でご使用いただく。
2. 実験局の免許を取得後ご使用いただく。
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/lsts/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.

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/LICENSENSORS 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, 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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