

# TI Designs: TIDA-01454

## PCM1864 based Circular Microphone Board Reference Design

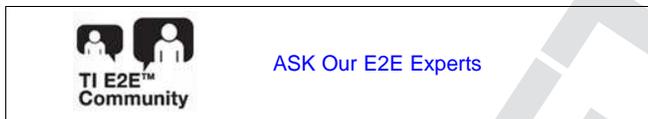


### 1 Description

The PCM1864 Circular Microphone Board (CMB) is a low-cost, easy-to-use reference design for applications that require clear spoken audio, such as voice triggering and speech recognition. This TID uses microphone array to capture voice signal and converts it to digital stream that can be used by DSP system to extract clear audio from noisy environments.

### 2 Resources

|  |                |
|--|----------------|
| <a href="#">TIDA-01454</a>                 | Design Folder  |
| <a href="#">PCM1864</a>                    | Product Folder |
| <a href="#">TIDEP-0077</a>                 | Product Folder |
| <a href="#">TMS320C5517</a>                | Product Folder |
| <a href="#">Chip Support Library (CSL)</a> | Tools Folder   |
| <a href="#">TELECOM Lib</a>                | Tools Folder   |

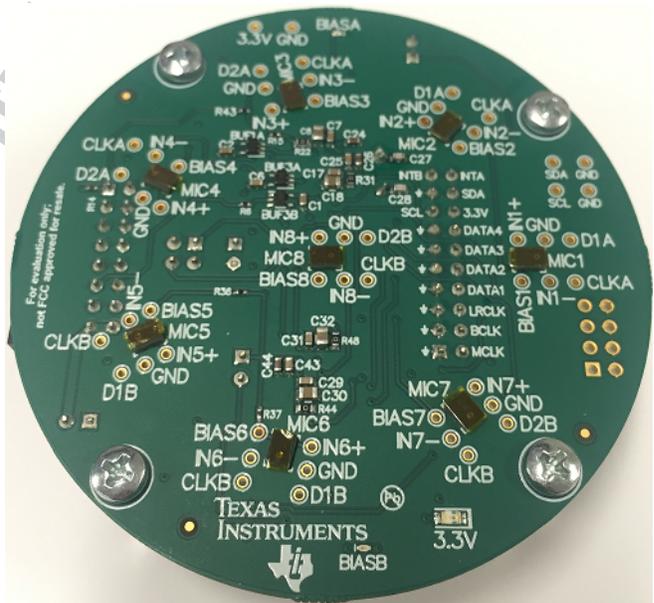
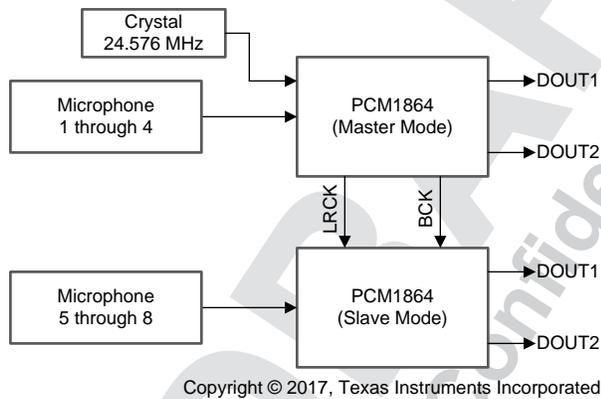


### 3 Features

- Uses Two PCM1864 (4-ch Audio ADC) to Interface With Eight Microphone Arrays to Extract Clear Speaker Voice from Noisy Environments
- Energy-Sense Notification for Signal Presence and Loss – Can be a Central Part of a Low-Power, High-Performance Audio Solution
- Offers Complete System Reference Design Using Microphone Array, Texas Instruments™ Provided Software, and Evaluation Module

### Applications

- Interface-to-Cloud-Based Voice Recognition for Voice-Activated Digital Assistant Applications
- Interface-to-Cloud-Based Voice Recognition for Smart Home Applications
- Local (Limited Dictionary) Voice Recognition for Voice-Based Appliances Control
- Voice and Speech Applications (Such as Video Conferencing)



An IMPORTANT NOTICE at the end of this TI reference design addresses authorized use, intellectual property matters and other important disclaimers and information.

#### 4 System Description

This TI Design uses TI hardware and sophisticated field-proven software algorithms to obtain clear speech and audio from noisy environments. This Circular Microphone Board provides the streaming of multiple data inputs to the processor, which implements a beamforming algorithm to form a virtual directional microphone that points at the direction of the speaker or the desired audio source and then amplifies the speech signal from the desired direction, which attenuates all signals from all other directions.

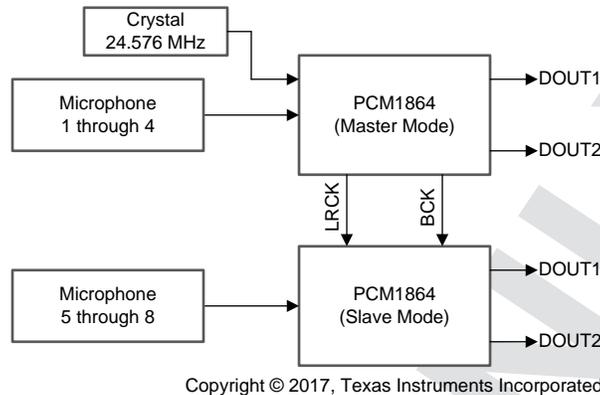
The PCM1864 device is a highly flexible audio front end that supports input levels from small-mV microphone inputs to 2.1-VRMS line inputs without external resistor dividers. Without requiring a 5-V supply or an external programmable-gain amplifier, smaller, smarter products are feasible at reduced cost.

**DRAFT ONLY**  
TI Confidential – NDA Restrictions

## 5 System Overview

### 5.1 Block Diagram

Figure 1 shows the TIDA01454 block diagram.



**Figure 1. TIDA-01454 Block Diagram**

### 5.2 Highlighted Products

#### 5.2.1 PCM1864

The PCM1864 device is a highly integrated, high performance audio analog-to-digital converter (ADC) with four mono ADC channels and 103-dB SNR. It is a software controlled device with integrated PLL that provides audio master clocks for the entire system. PCM186x supports EnergySense, which allows easy-to-implement power-down and wake-up scenarios to meet the European Ecodesign Directive.

See the [PCM1864](#) product folder for a full description of this device.

#### 5.2.2 TMDSEVM5517

The TMDSEVM5517 Evaluation Module is an evaluation module that is based on the C5517 processor. For a full description of the TMDSEVM5517, see the tools folder.

#### 5.2.3 Chip Support Library (CSL) – C55xx\_csl

The CSL library contains utilities and drivers that are used to configure control and use all the peripherals and IP that are part of the C5517 chip, as well as the TMDSEVM5517 peripherals.

A free download of the CSL is available at [TMS320C55x Chip Support Libraries \(CSL\) – Standard and Low-Power](#). Use version 3.7 or higher of C55\_csl.

#### 5.2.4 TI Audio Libraries

The TI Audio Libraries (TELECOMLIB) consist of two optimized libraries that are used in this reference design: the Acoustic Echo Cancellation/Removal (AEC-AER) library and the Voice Library (VOLIB). In addition, the Processor SDK includes a set of optimized libraries that can be used, such as DSPLIB that contains many signal processing optimized algorithms. AEC-AER and VOLIB can be downloaded the [Telecom and Media Libraries](#)LECOM tools folder. The user must install the audio libraries in the same directory as the C55xx\_csl was installed.

## 6 Getting Started Hardware and Software

### 6.1 Hardware and Software Setup

#### 6.1.1 Circular Microphone Board as Standalone Unit

See [Table 1](#) and [Table 2](#) to configure and test the Circular Microphone Board to interface as a standalone unit.

**Table 1. Circular Microphone Board Jumper Settings**

| Pin |              | Parameter |
|-----|--------------|-----------|
| J3  |              | ON        |
| J8  | Pins 1 and 2 | ON        |
|     | Pins 3 and 4 | OFF       |
| J10 |              | ON        |
| J11 |              | ON        |

**Table 2. Host Processor Interface With CMB**

| Host Processor | CMB Pin       |
|----------------|---------------|
| HOST_DOUT1     | CMB_DSP_DATA1 |
| HOST_DOUT2     | CMB_DSP_DATA2 |
| HOST_DOUT3     | CMB_DSP_DATA3 |
| HOST_DOUT4     | CMB_DSP_DATA4 |
| HOST_SDA       | CMB_DSP_SDA   |
| HOST_SCL       | CMB_DSP_SCL   |
| HOST_GND       | CMB_DSP_GND   |

After the hardware setup is complete, each PCM1864 device must be configured as listed in the following code snippet to set up the operation mode, sampling frequency, PLL clock reference, and more by using the I<sup>2</sup>C interface.

Device U1 can be configured by using device address 0x94 to run in master mode with the following register writes.

```

0x94 0x00 0x00    // Change to Page 0
0x94 0x01 0x40    // PGA CH1_L to 32dB
0x94 0x02 0x40    // PGA CH1_R to 32dB
0x94 0x03 0x40    // PGA CH2_L to 32dB
0x94 0x04 0x40    // PGA CH2_R to 32dB
0x94 0x05 0x86    // Enable SMOOTH PGA Change; Independent Link PGA;
0x94 0x06 0x41    // Polarity: Normal, Channel: VINL1[SE]
0x94 0x07 0x41    // Polarity: Normal, Channel: VINR1[SE]
0x94 0x08 0x44    // Polarity: Normal, Channel: VINL3[SE]
0x94 0x09 0x44    // Polarity: Normal, Channel: VINR3[SE]
0x94 0x0A 0x00    // Secondary ADC Input: No Selection
0x94 0x0B 0x44    // RX WLEN: 24bit; TX WLEN: 24 bit; FMT: I2S format
0x94 0x10 0x03    // GPIO0_FUNC - SCK Out; GPIO0_POL - Normal
0x94 0x11 0x50    // GPIO3_FUNC - DOUT2; GPIO3_POL - Normal
0x94 0x12 0x04    // GPIO0_DIR - GPIO0 - Output
0x94 0x13 0x40    // GPIO3_DIR - GPIO3 - Output
0x94 0x20 0x11    // MST_MODE: Master; CLKDET_EN: Disable
    
```

Device U2 can be configured by using device address 0x96 to run in slave mode with the following register writes.

```

0x96 0x00 0x00      // Change to Page 0
0x96 0x01 0x40      // PGA CH1_L to 32dB
0x96 0x02 0x40      // PGA CH1_R to 32dB
0x96 0x03 0x40      // PGA CH2_L to 32dB
0x96 0x04 0x40      // PGA CH2_R to 32dB
0x96 0x05 0x86      // Enable SMOOTH PGA Change; Independent Link PGA;
0x96 0x06 0x41      // Polarity: Normal, Channel: VINL1[SE]
0x96 0x07 0x41      // Polarity: Normal, Channel: VINR1[SE]
0x96 0x08 0x44      // Polarity: Normal, Channel: VINL3[SE]
0x96 0x09 0x44      // Polarity: Normal, Channel: VINR3[SE]
0x96 0x0A 0x00      // Secondary ADC Input: No Selection
0x96 0x0B 0x44      // RX WLEN: 24bit; TX WLEN: 24 bit; FMT: I2S format
0x96 0x10 0x00      // GPIO0_FUNC - GPIO0; GPIO0_POL - Normal
0x96 0x11 0x50      // GPIO3_FUNC - DOUT2; GPIO3_POL - Normal
0x96 0x12 0x00      // GPIO0_DIR - GPIO0 - Input
0x96 0x13 0x40      // GPIO3_DIR - GPIO3 - Output
0x96 0x20 0x01      // MST_MODE: Slave; CLKDET_EN: Enable

```

### 6.1.2 Circular Microphone Board With TMDSEVM5517 Evaluation Module

To configure and test the Circular Microphone Board by interfacing with the TMDSEVM5517 unit, see [Audio Pre-Processing Reference Design for Voice-Based Applications](#).

## 7 Testing and Results

Testing the Circular Microphone Board to validate the device configuration and proper microphone bias can be achieved by:

- Ensuring the BIASA and BIASB LEDs are ON once the devices are configured
- Evaluating the digital data stream from both PCM1864 devices

Figure 2 shows the FFT plot for the DOUT data streaming using the an AP2722 device when playing a 1-kHz monotone.

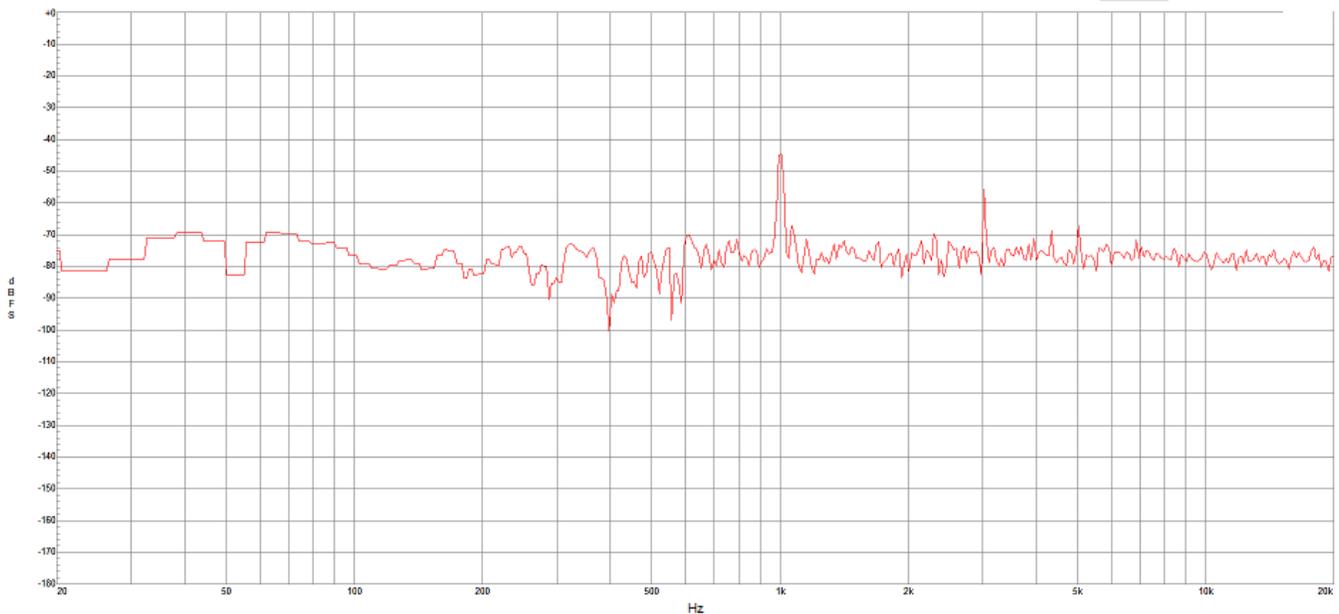


Figure 2. FFT Plot

DRAFT

TI Confidential - NI

Figure 3 shows the LRCK and I2S data stream on DOUT1 and DOUT2 on both devices in time domain.

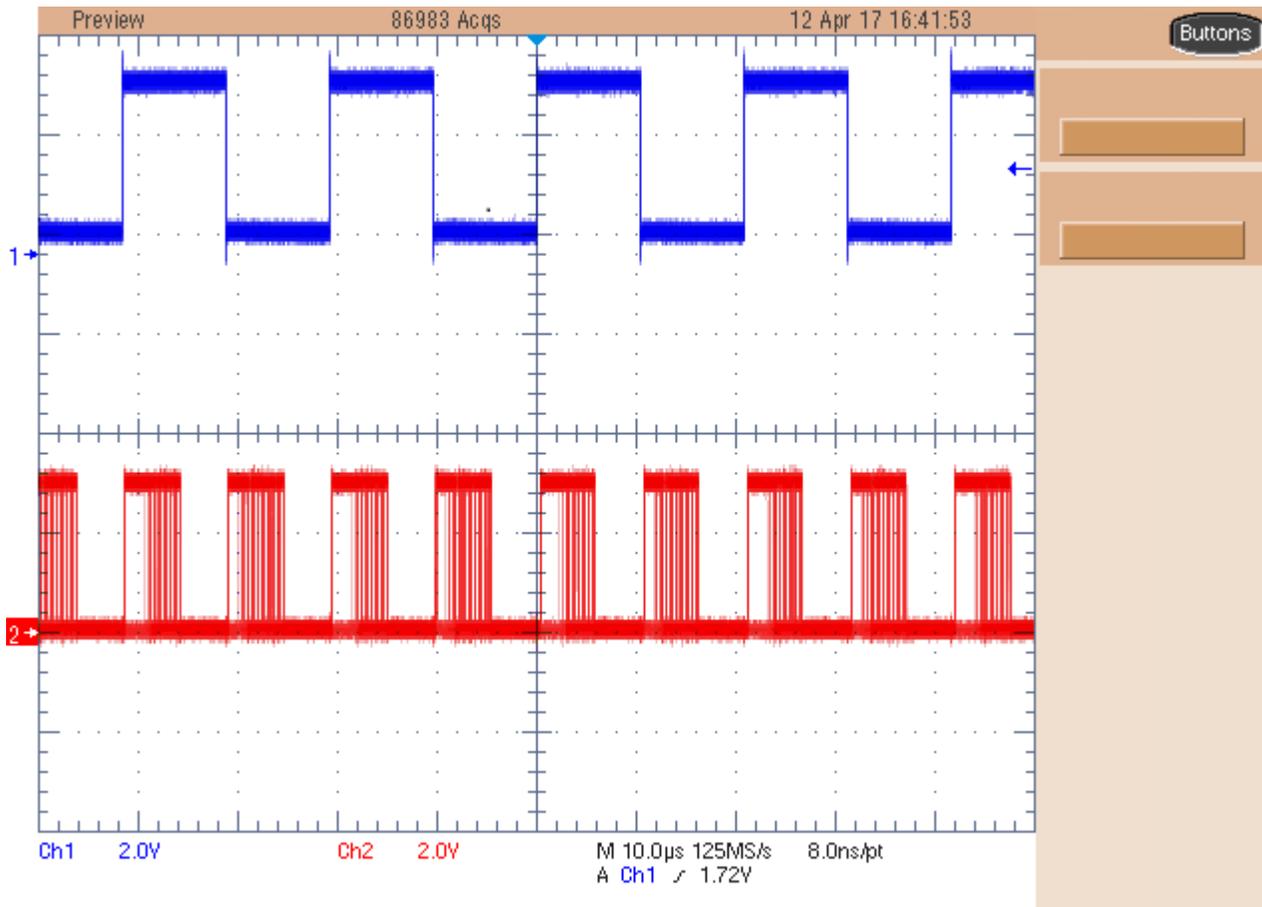


Figure 3. I2S Plot

## 8 Design Files

### 8.1 Schematics

To download the schematics, see the design files at [TIDA-01454](#).

### 8.2 Bill of Materials

To download the bill of materials (BOM), see the design files at [TIDA-01454](#).

### 8.3 PCB Layout Recommendations

#### 8.3.1 Layout Prints

To download the layer plots, see the design files at [TIDA-01454](#).

### 8.4 Altium Project

To download the Altium project files, see the design files at [TIDA-01454](#).

### 8.5 Gerber Files

To download the Gerber files, see the design files at [TIDA-01454](#).

### 8.6 Assembly Drawings

To download the assembly drawings, see the design files at [TIDA-01454](#).

## 9 Software Files

To download the software files, see the design files at [TIDA-01454](#).

## 10 Trademarks

Texas Instruments is a trademark of Texas Instruments.  
All other trademarks are the property of their respective owners.

## IMPORTANT NOTICE FOR TI DESIGN INFORMATION AND RESOURCES

Texas Instruments Incorporated ("TI") technical, application or other design advice, services or information, including, but not limited to, reference designs and materials relating to evaluation modules, (collectively, "TI Resources") are intended to assist designers who are developing applications that incorporate TI products; by downloading, accessing or using any particular TI Resource in any way, you (individually or, if you are acting on behalf of a company, your company) agree to use it solely for this purpose and subject to the terms of this Notice.

TI's provision of TI Resources does not expand or otherwise alter TI's applicable published warranties or warranty disclaimers for TI products, and no additional obligations or liabilities arise from TI providing such TI Resources. TI reserves the right to make corrections, enhancements, improvements and other changes to its TI Resources.

You understand and agree that you remain responsible for using your independent analysis, evaluation and judgment in designing your applications and that you have full and exclusive responsibility to assure the safety of your applications and compliance of your applications (and of all TI products used in or for your applications) with all applicable regulations, laws and other applicable requirements. You represent that, with respect to your applications, you have all the necessary expertise to create and implement safeguards that (1) anticipate dangerous consequences of failures, (2) monitor failures and their consequences, and (3) lessen the likelihood of failures that might cause harm and take appropriate actions. You agree that prior to using or distributing any applications that include TI products, you will thoroughly test such applications and the functionality of such TI products as used in such applications. TI has not conducted any testing other than that specifically described in the published documentation for a particular TI Resource.

You are authorized to use, copy and modify any individual TI Resource only in connection with the development of applications that include the TI product(s) identified in such TI Resource. NO OTHER LICENSE, EXPRESS OR IMPLIED, BY ESTOPPEL OR OTHERWISE TO ANY OTHER TI INTELLECTUAL PROPERTY RIGHT, AND NO LICENSE TO ANY TECHNOLOGY OR INTELLECTUAL PROPERTY RIGHT OF TI OR ANY THIRD PARTY IS GRANTED HEREIN, including but not limited to any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information regarding or referencing third-party products or services does not constitute a license to use such products or services, or a warranty or endorsement thereof. Use of TI Resources may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

TI RESOURCES ARE PROVIDED "AS IS" AND WITH ALL FAULTS. TI DISCLAIMS ALL OTHER WARRANTIES OR REPRESENTATIONS, EXPRESS OR IMPLIED, REGARDING TI RESOURCES OR USE THEREOF, INCLUDING BUT NOT LIMITED TO ACCURACY OR COMPLETENESS, TITLE, ANY EPIDEMIC FAILURE WARRANTY AND ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, AND NON-INFRINGEMENT OF ANY THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

TI SHALL NOT BE LIABLE FOR AND SHALL NOT DEFEND OR INDEMNIFY YOU AGAINST ANY CLAIM, INCLUDING BUT NOT LIMITED TO ANY INFRINGEMENT CLAIM THAT RELATES TO OR IS BASED ON ANY COMBINATION OF PRODUCTS EVEN IF DESCRIBED IN TI RESOURCES OR OTHERWISE. IN NO EVENT SHALL TI BE LIABLE FOR ANY ACTUAL, DIRECT, SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF TI RESOURCES OR USE THEREOF, AND REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

You agree to fully indemnify TI and its representatives against any damages, costs, losses, and/or liabilities arising out of your non-compliance with the terms and provisions of this Notice.

This Notice applies to TI Resources. Additional terms apply to the use and purchase of certain types of materials, TI products and services. These include; without limitation, TI's standard terms for semiconductor products (<http://www.ti.com/sc/docs/stdterms.htm>), [evaluation modules](#), and [samples](http://www.ti.com/sc/docs/sampterm.htm) (<http://www.ti.com/sc/docs/sampterm.htm>).

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
Copyright © 2017, Texas Instruments Incorporated