ANALOG DEVICES

High Performance Digital MEMS Microphone's Simple Interface to SigmaDSP Audio Processor with I²S Output

CIRCUIT FUNCTION AND BENEFITS

The circuit, shown in Figure 1, allows up to two digital micro-electromechanical systems (MEMS) microphones to be interfaced to an audio processor on a single data line. The ADMP441 consists of a MEMS microphone element and an application specific integrated circuit (ASIC) with I²S output. This circuit allows stereo microphones to be used in an audio system without the need for a codec between the MEMS microphones and the processor. The ADMP MEMS microphones have a high signal-to-noise ratio (SNR) and a flat wideband frequency response, making them an excellent choice for high performance, low power applications.

Up to two ADMP441 MEMS microphones can be input to a single data line on the ADAU1446 SigmaDSP® audio processor. The ADAU1446 can be set up with up to nine serial data inputs, so up to eighteen ADMP441 devices can input to a single audio processor.

CIRCUIT DESCRIPTION

Table 1. Devices Connected/Referenced

Product	Description
ADAU1446	SigmaDSP® digital audio processor with flexible audio routing matrix
ADMP441	Digital MEMS microphone

The ADMP441 digital MEMS microphones are connected to the SDATA_IN pins of the ADAU1446. The only necessary passive components in this circuit are a single 0.1 μF bypass capacitor, for each ADMP441, and a large pull-down resistor (100 kΩ) on the SD line to discharge the bypass capacitor while the ADMP441 output drivers are tristated. Place the bypass capacitors as close to the VDD pin (Pin 7) of the ADMP441 as possible.
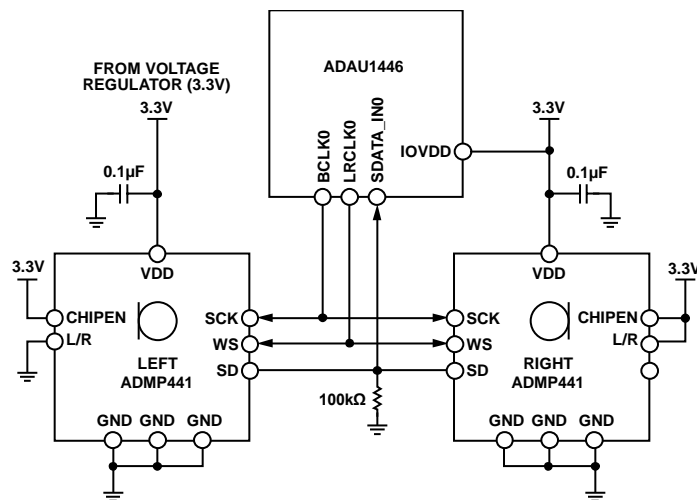
Figure 1. Digital MEMS Microphone Connection to SigmaDSP Audio Processor (Simplified Schematic: Power Supply Decoupling and All Connections Not Shown)
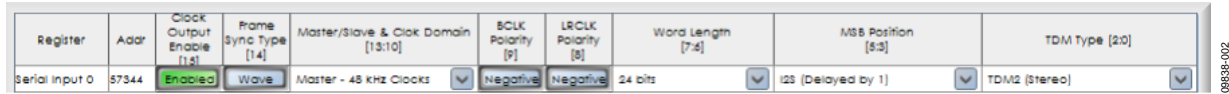
Figure 2. SigmaStudio Serial Input Port Configuration for ADMP441 Microphone Input to ADAU1446

The VDD pin of the MEMS microphones is supplied from the same source as the 3.3 V IOVDD pin of the ADAU1446. Even though the ADMP441 can operate with VDD between 1.8 V and 3.3 V, IOVDD on the ADAU1446 must be 3.3 V.

There are three signals that need to be connected between the ADMP441 and the ADAU1446 for the I²S data stream to function: the frame clock signal, the bit clock signal, and the data signal. Table 2 shows the connections when using the ADAU1446 Serial Data Input Port 0 (SDATA_IN0).

Table 2. Hardware Signal Connections

Signal	ADMP441	ADAU1446
Frame Clock	WS (Pin 3)	LRCLK0 (Pin 15)
Bit Clock	SCK (Pin 1)	BCLK0 (Pin 12)
Serial Data	SD (Pin 2)	SDATA_IN0 (Pin 11)

Set the The L/R pin on the two ADMP441 devices to opposite settings—one pulled to the VDD pin, and the other to GND. When pulled to GND, the microphone outputs its data on the left channel of the I²S stream. When pulled to the VDD pin, it outputs its data on the right channel.

The ADMP441 is enabled by pulling the CHIPEN pin high. The CHIPEN pin can either be tied directly to the VDD pin of the microphones, which keeps it always enabled while it is powered, or it can be connected to a general-purpose input/output pin (GPIO) on the ADAU1446, allowing the SigmaDSP to enable and disable the microphone.

The ADMP441 has a sensitivity of −26 dBFS. In most applications, the microphone output needs to have some gain added in the ADAU1446 signal flow. The SigmaDSP core can add up to 24 dB of gain to the input signal before a full-scale signal at 120 dB sound pressure level (SPL) is clipped. If gain is added to the signal in the SigmaDSP, then the output of the processor must still be limited to 0 dBFS.

Register Settings

Register 0xE000 must be set in the ADAU1446 to enable its serial input port for I²S input. When this register is set to 0xA40x00 (should there be a space in the middle?), Serial Input Port 0 is configured for:

- Enabling the clock outputs.
- 50% duty cycle clock.
- 48 kHz clock master.
- Data changes on the falling edge of BCLK, clocked on the BCLK rising edge.
- LRCLK polarity set for left channel low, right channel high.
- 24-bit, I²S data format.

A screenshot of the SigmaStudio register controls for the serial input port is shown in Figure 2.

The register settings described here are for using Serial Input Port 0 with Clock Input 0, but they can be applied to any of the nine serial input ports. Serial Input 1 to Serial Input 8 are controlled with Register 0xE001 to Register 0xE008. If any of these serial input ports are connected to additional ADMP441 MEMS microphones, set the corresponding registers in the same way as Serial Input Port 0.

In the SigmaStudio schematic, the data from Serial Input Port 0 is on Pin 0 and Pin 1 of the input cell. The left channel is on Pin 0 and the right channel is on Pin 1. Figure 3 shows a simple SigmaStudio schematic with two audio channels going through a volume control to the outputs.
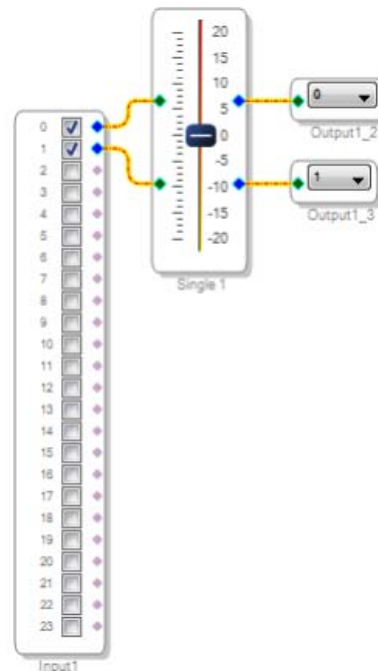

Figure 3. SigmaStudio Schematic with Stereo Input on Serial Input Port 0

COMMON VARIATIONS

Audio Processors

This circuit can also be set up with an ADAU1442 or an ADAU1445, instead of the ADAU1446. The difference between these processors is that the ADAU1446 does not have any asynchronous sample rate converters (ASRCs), and the ADAU1442 and ADAU1445 have different numbers of ASRC channels. These other processors with ASRCs can be used if microphones run at different sampling rates, or if multiple I²S master devices need to be connected to the processor. The ADAU1442, the ADAU1445, and the ADAU1446 are all pin-compatible.

MEMS Microphones

A mono MEMS microphone circuit using a single ADMP441 can be set up by removing one of the ADMP441 MEMS microphones. The other connections remain the same in this mono configuration. Additional ADMP441 MEMS microphones can be connected to the ADAU1446 serial input ports in the same way as the first stereo pair.

LEARN MORE

The ADMP MEMS microphone products mentioned in this Application Note are manufactured by InvenSense, 1745 Technology Dr., San Jose, California 95110.

Elko, Gary W. and Kieran P. Harney. "A History of Consumer Microphones: The Electret Condenser Microphone Meets Micro-Electro-Mechanical-Systems," *Acoustics Today*, 2009.

Lewis, Jerad. AN-1112 Application Note. *Microphone Specifications Explained.* Analog Devices, Inc., 2013.

Nielsen, Jannik Hammel, and Claus Fürst. *Toward More Compact Digital Microphones*, Analog Dialogue Volume 41, September 2007, Analog Devices, Inc.

Data Sheets and Evaluation Boards

ADAU1446 Data Sheet

ADAU1446 Evaluation Board

ADAU1442 Data Sheet

ADAU1445 Data Sheet

REVISION HISTORY

www.analog.com