

High-Performance Digital MEMS Microphone Simple Interface to SigmaDSP Audio Codec

CIRCUIT FUNCTION AND BENEFITS

The circuit shown in Figure 1 allows up to two MEMS digital microphones to be interfaced to an audio processor on a single data line. The INMP441 consists of a MEMS microphone element and an ASIC with I²S output. This allows stereo microphones to be used in an audio system without the need for a codec between the microphones and the processor. InvenSense 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.

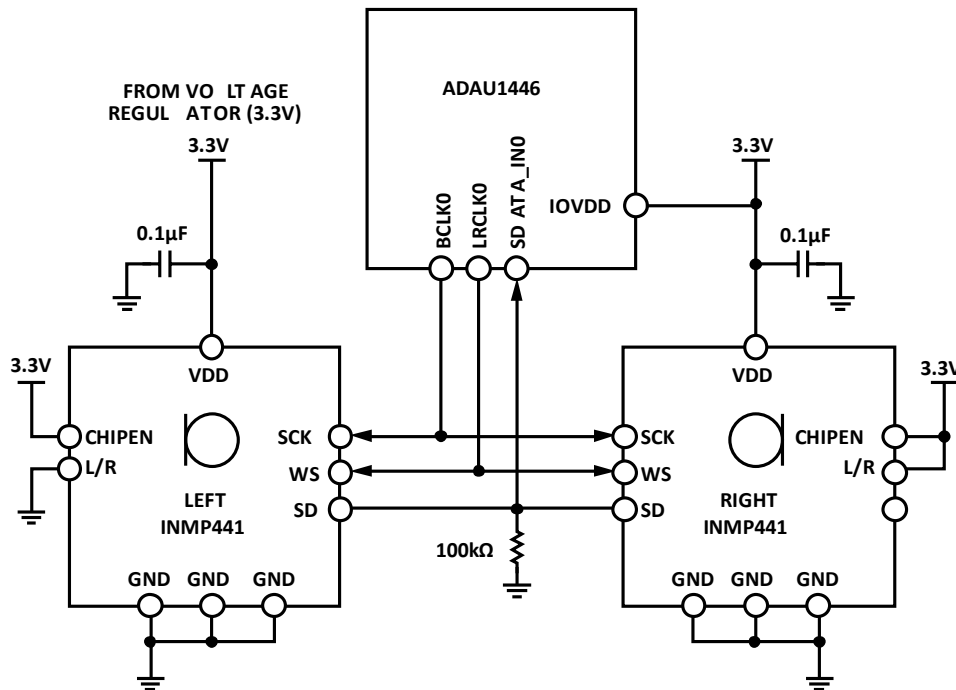


Figure 1. Microphone Connection to SigmaDSP Audio Processor
 (Simplified Schematic: Power Supply Decoupling and All Connections Not Shown)

Up to two INMP441 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 18 INMP441s can input to a single audio processor.

CIRCUIT DESCRIPTION

The INMP441 microphones are connected to the ADAU1446's SDATA_IN pins. The only necessary passive components in this circuit are a single 0.1 µF bypass capacitor for each INMP441 and a large pull-down resistor (100 kΩ) on the SD line to discharge it while the INMP441's output drivers are tri-stated. The bypass capacitors should be placed as close to the INMP441 VDD pin (Pin 7) as possible.

The microphone's VDD should be supplied from the same source as the ADAU1446's 3.3 V IOVDD. Even though the INMP441 can operate with VDD between 1.5 V and 3.6 V, IOVDD on the ADAU1446 must be 3.3 V.

There are three signals that need to be connected between the INMP441 and ADAU1446 for the I²S data stream: frame clock, bit clock, and data. Table 1 shows the connections when using the ADAU1446's serial data input port 0.

Table 1. Hardware Signal Connections

Signal	INMP441	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)

The L/R pin on the two INMP441s should be set to opposite settings—one pulled to VDD, and the other to ground. When pulled to GND, the microphone will output its data on the left channel of the I²S stream, and when pulled to VDD it will output its data on the right channel.

The INMP441 is enabled by pulling the CHIPEN pin high. This pin can either be tied directly to the microphone’s VDD, which will keep it always enabled while it is powered, or it could be connected to a GPIO on the ADAU1446, allowing the SigmaDSP to enable and disable the microphone.

The INMP441 has a sensitivity of –26 dBFS. In most applications, the microphone output needs to have some gain added in the ADAU1446’s 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 SPL is clipped. If gain is added to the signal in the SigmaDSP, then the processor’s output must still be limited to 0 dB FS.

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 0xA4 0x00, Serial Input Port 0 will be 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 screen shot of the SigmaStudio register controls for the serial input port is shown in Figure 3.

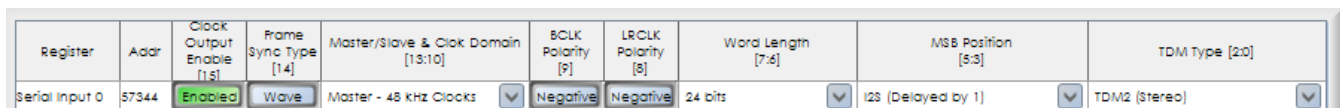


Figure 2. SigmaStudio Serial Input Port Configuration for INMP441 Microphone Input to ADAU1446

The registers settings described here are for using serial input port 0 with clock input 0, but they could be applied to any of the nine serial input ports. Serial inputs 1-8 are controlled with registers 0xE001 to 0xE008. If any of these serial input ports are connected to additional INMP441 microphones, the corresponding registers should be set in the same way as serial input port 0 described above. In the SigmaStudio schematic, the data from serial input port 0 is on pins 0 and 1 of the Input cell. The left channel is on pin 0 and the right channel on pin 1. Figure 3 shows a simple SigmaStudio schematic with two audio channels going through a volume control to the outputs.

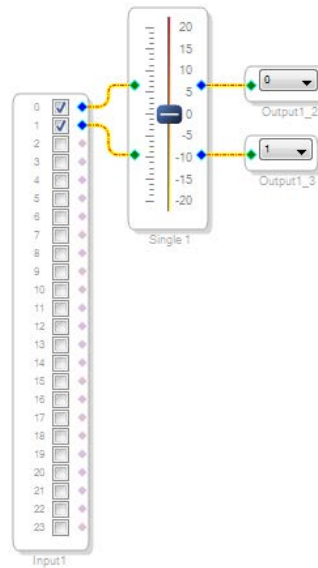


Figure 3. SigmaStudio Schematic with Stereo Input on Serial Input Port 0

CIRCUIT EVALUATION AND TEST

Evaluation boards for the INMP441 and ADAU1446 are available and can be easily connected using headers on the boards.

Equipment Needed

The SigmaStudio GUI software requires a PC meeting the following: Windows 7, Vista, Windows XP Professional or Home Edition with SP2, 128 MB of RAM (256 MB recommended),

50 MB of available hard disk space, 1024 × 768 screen resolution, USB 1.1/2.0 data port.

In addition, the ADAU1446 Evaluation Board (EVAL-ADAU1446EBZ) and the INMP441 Evaluation Board (EV_INMP441-FX) are needed.

Getting Started

The EV_INMP441-FX has eight output wires including VDD, ground, data, and clocks. The VDD wire should be connected to IOVDD on the EV_ADAU1446EBZ. The INMP441 board's serial data port signals (SD, WS, and SCK) can be connected to the appropriate serial data inputs on header J21.

Complete documentation for the EVAL-ADAU1446EBZ evaluation board can be found in User Guide UG-032.

Functional Block Diagram

The documentation for the ADAU1446 evaluation board describes the system setup and gives a complete schematic of the board. The only external connections required are the USB connection to the PC and to the audio outputs of the ADAU1446.

Setup and Test

See the EVAL-ADAU1446EBZ board documentation for additional details regarding circuit description, jumper settings, setup, and testing.

COMMON VARIATIONS

Audio Processors

This circuit can also be set up with an ADAU1442 or ADAU1445 instead of an 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 could be used if microphones are to be run at different sampling rates or if multiple I²S master devices need to be connected to the processor. The ADAU1442, ADAU1445, and ADAU1446 are all pin-compatible.

Microphones

A mono microphone circuit using a single INMP441 can be set up by simply removing one of the INMP441 microphones. The other connections remain the same in this mono configuration.

Additional INMP441 microphones can be connected to the ADAU1446's serial input ports in the same way as the first stereo pair.

REVISION HISTORY

REVISION DATE	REVISION	DESCRIPTION
02/22/2014	1.0	Initial Release

Compliance Declaration Disclaimer:

InvenSense believes this compliance information to be correct but cannot guarantee accuracy or completeness. Conformity documents for the above component constitutes are on file. InvenSense subcontracts manufacturing and the information contained herein is based on data received from vendors and suppliers, which has not been validated by InvenSense.

Environmental Declaration Disclaimer:

InvenSense believes this environmental information to be correct but cannot guarantee accuracy or completeness. Conformity documents for the above component constitutes are on file. InvenSense subcontracts manufacturing and the information contained herein is based on data received from vendors and suppliers, which has not been validated by InvenSense.

This information furnished by InvenSense is believed to be accurate and reliable. However, no responsibility is assumed by InvenSense for its use, or for any infringements of patents or other rights of third parties that may result from its use. Specifications are subject to change without notice. InvenSense reserves the right to make changes to this product, including its circuits and software, in order to improve its design and/or performance, without prior notice. InvenSense makes no warranties, neither expressed nor implied, regarding the information and specifications contained in this document. InvenSense assumes no responsibility for any claims or damages arising from information contained in this document, or from the use of products and services detailed therein. This includes, but is not limited to, claims or damages based on the infringement of patents, copyrights, mask work and/or other intellectual property rights.

Certain intellectual property owned by InvenSense and described in this document is patent protected. No license is granted by implication or otherwise under any patent or patent rights of InvenSense. This publication supersedes and replaces all information previously supplied. Trademarks that are registered trademarks are the property of their respective companies. InvenSense sensors should not be used or sold in the development, storage, production or utilization of any conventional or mass-destructive weapons or for any other weapons or life threatening applications, as well as in any other life critical applications such as medical equipment, transportation, aerospace and nuclear instruments, undersea equipment, power plant equipment, disaster prevention and crime prevention equipment.

©2014 InvenSense, Inc. All rights reserved. InvenSense, MotionTracking, MotionProcessing, MotionProcessor, MotionFusion, MotionApps, DMP, AAR, and the InvenSense logo are trademarks of InvenSense, Inc. Other company and product names may be trademarks of the respective companies with which they are associated.

