Products covered:

EVMA2BMIC, consisting of

- AB0001 A²B to I²S module
- AB0200 8 channel PDM Mic module
- AB0100 PDM to I²S module
# TABLE OF CONTENTS

1. Introduction .................................................................................................................................... 3
   1.1 Software support ..................................................................................................................... 4
2. Getting started with the EVM .......................................................................................................... 4
   2.1 Connection steps ..................................................................................................................... 5
   2.2 Pushbutton switch ................................................................................................................... 7
   2.3 User LED .................................................................................................................................. 8
   2.4 Default I^C addresses ............................................................................................................... 8
3. EVM design information .................................................................................................................. 8
   3.1 Power input ............................................................................................................................. 9
4. Connector information .................................................................................................................... 9
   4.1 A2B moduleConnector .......................................................................................................... 10
      4.1.1 IOVdd jumper .............................................................................................................. 11
   4.2 J6 external control connector ................................................................................................ 11
   4.3 Mic to PDM board connector ................................................................................................. 12
5. Mechanical information ................................................................................................................ 13
   5.1 Microphone board ................................................................................................................. 14
   5.2 PDM/I^S board mechanical design ......................................................................................... 15
6. Configuration example with Sigma Studio .................................................................................... 16
   6.1 Accessing the LED and switches from Sigma Studio .............................................................. 16
      6.1.1 The hard way ................................................................................................................. 16
      6.1.2 The easy way .................................................................................................................. 17
   6.2 Configure the ADAU7118 ....................................................................................................... 18
   6.3 Turn on the RGB LEDs ........................................................................................................... 19
   6.4 Stream example .................................................................................................................... 20
      6.4.1 Example data ................................................................................................................. 22
The Clockworks 8 channel microphone array is a three board stack intended to allow developers to quickly integrate Analog Device’s A\(^2\)B capability into a prototyping environment for speech and audio processing systems.

The microphone board is separate to allow different microphone configurations to be evaluated. The standard EVM kit uses 8 microphones equally spaced. Most applications will require a different microphone configuration; with dozens of possibilities it’s not possible to design and stock all variants. Customers can either design their own add-on microphone boards or have Clockworks create them under a quick-turn fixed cost basis.

Figure 1 A\(^2\)B microphone EVM board stack: A\(^2\)B module, PDM to I\(^2\)S module, 8 mic array module.

In Figure 1 the board stack is, by convention, shown upside down. The microphone pickups are created by holes in the PCB on the microphone board. Since that would normally be the top then all components are mounted on the bottom side of the boards.\(^1\) In Figure 2 the board is shown oriented how it would normally be used.

The supplied microphone board uses Infineon IM68D130 microphones, which provide a wide frequency response (28 Hz to 20 kHz \(+/-\ 3\)dB) and handle up to 128 dBSPL.

The microphone board also has eight RGB LEDs to allow development of visual feedback while prototyping the application. They are controlled by a TI LP5024 controller which has a number of features to simplify control of RGB LEDs.

\(^1\) The design database treats the component side as the top side.
The PDM to I2S adapter uses ADI’s ADAU7118 device. This provides flexibility for mapping a microphone to a specific channel in the TDM output that goes to the A2B module.

Figure 2 Example of RGB LEDs enabled

1.1 SOFTWARE SUPPORT

All A2B software is supplied by ADI directly. Normally this software package includes both an add on for Sigma Studio that allows an A2B network to be described graphically, and a library with a standard API that can be used by the (host) processor that is connected to the A2B master (first) device. The documents included with the API software, typically (for Windows) found after installation in C:\Analog Devices\ADI_A2B_Software-Rel1#.#.\Docs, contain the information for setting up the software environment.

Details of the A2B device’s registers are found in “AD2420(W)/6(W)/7(W)/8(W)/9(W) Automotive Audio Bus A2B Transceiver Technical Reference” document 82-100138-01, Rev 1.1 or as updated to the latest version. That document along with understanding how to use SigmaStudio is needed to understand how to create A2B system configurations.

Functionally the Clockworks 8 channel mic just looks like a slave node on the A2B network.

2 GETTING STARTED WITH THE EVM

The modules are ESD sensitive and must be handled following good ESD practices with a proper and safe grounding of the work area and anyone handling the boards.

---

2 The ADAU7118 has one data line output so it’s operated in TDM8 mode. With the clock in 256 Fs mode this is 12.28 MHz for a microphone sample rate of 48 kHz.
The EVM kit ships with a 9V DC power supply that has universal input. The North America version uses the two blade plug, whereas the international version of the kit has multiple adapters that mate with the supply.

If using the international version of the kit please attach the correct AC mains adapter to the supply.

The AC adapter supplies 500 mA at 9 VDC (center positive) via standard 2.1 mm barrel connector. Alternately the board can be powered from a bench supply providing 5 – 9V DC by connecting wires to the Phoenix block connector.

See Figure 2 and Figure 3 for the location on the hardware for the items discussed in the next section.

### 2.1 CONNECTION STEPS

The EVM is shipped with an A²B module installed. The A²B module is configured for IOVdd of 1.8V.

- Set SW1 (power) to the off position (slide button at board edge).
- Attach the 9VDC supply to input jack J1 and plug the supply in to the AC mains.
  - DO NOT CONNECT A 12V SUPPLY – YOU WILL RELEASE THE SPECIAL SMOKE!
- Connect an A²B cable to the module jack (“From Master”) to the A²B master or A²B slave located electrically closer to the A²B master.

![Figure 3 External connectors on adapter board](image)
At this point the EVM can be powered up by switching SW1 to the "ON" position. The 3.3V and 5V power indicator LEDs on the EVM and on the A2B module should be light.

At this point the board can be discovered on the A2B network. An example SigmaStudio diagram[^3] is included in the design package. If using an ADI WDZ board as the master it can be open and run

[^3]: Currently SigmaStudio 4.5. The A2B extensions for SigmaStudio must have been previously installed.
directly. If using a different ADI board as the master you will need to create a new, equivalent diagram with the correct host schematic connections.

Open SigmaStudio and open the file a2bmic_test_2.dsproj (or if not using WDZ as host, use this as a guide to create a schematic with your host connection). Hit the link, compile, download button, all of the blocks will turn green to indicate a successful A²B network configuration. If an error occurs the most likely cause is power is not switched on or a cable is unplugged.

![A²B 8 channel microphone array User Guide](image)

Figure 6 Example schematic in SigmaStudio

### 2.2 PUSHBUTTON SWITCH

The adapter includes a pushbutton switches that connect to the A²B module. Specific software must be used to define interactions with the switch. A small capacitor is used to aid in the debounce of the switch but software should verify a clean switch closure and release.

The switch is connected to the IRQ pin, which can also be used as GPIO 0 on the AD2428 device.

![2.2 PUSHBUTTON SWITCH](image)

Figure 7 User switch location on PDM to I²S board
2.3 USER LED

There is one user controlled LED on the PDM to I²S board. It’s connected to the IO7 pin of the A²B module/AD2428.

![Figure 8 User LED](image1)

2.4 DEFAULT I²C ADDRESSES

The ADAU7118 PDM to I²S chip (on PDM to I²S board) is set for address 0x28 (0x14 7-bit). R7 and R8 control the part’s address, only one may be installed (R7 to pull up, R8 to pull down).

![Figure 9 ADAU7118 base address jumper](image2)

For Rev 2 hardware or later: The24FC256 (32Kx8) EEPROM (on PDM to I²S board) is set to its default (lowest) address with the address bits grounded⁴, which corresponds to 0xA0 (0x60 -bit). There are three pads with a shorting trace that can be modified should another address be needed.

The LPC5024 LED controller (on microphone board) is at address 0x50 (0x28 7-bit). There are two jumper sets (R20-R23) that can be used to modify the base address.

![Figure 10 LPC5024 base address jumpers](image3)

3 EVM DESIGN INFORMATION

---

⁴ please note Rev 1 hardware does not have an EEPROM
When the EVM is purchased a design package is provided by email or an emailed link to download the information from.

The package includes the following information:

- PDF of schematics to the mic board and the PDM to I²S boards. Part information is embedded in the PDF, click on a part symbol to see detailed information on the part.
- 3D PDF of the boards. Note that Acrobat Reader security will ask if you trust the document. You must click yes. You then may need to click in the blank field to make it display. Some versions of Reader have a bug and will not display unless the document is saved locally. You can enable display of various board features and components using the standard 3D Acrobat features.
- STEP models of the boards
- Zip with Gerbers and Altium source files to the mic board and the PDM to I²S board.
- BOMs as an Excel spreadsheet

3.1 POWER INPUT

The EVM design include a diode on the DC input to prevent damage from a reverse connected input supply. This diode also reduces the input voltage by about 0.7V; on the board/schematic this is rounded off to call the supply an “8V” supply; the actual voltage is about 8.3V.

The AD2428 maximum supply voltage is 9V and this small extra drop prevents operating the AD2428 on the module near its limit. The module design includes a Schottky diode as suggested by ADI's design guide for a local powered A²B module, meaning there is another 0.4V or so drop on the A²B module and this the actual voltage to the AD2428 on the module is about 8V.

The only possible impact from the lower supply voltage is if A²B phantom power feature is used to power multiple downstream slave nodes; each node has a 0.4V drop. For more details please see the full AD2428 datasheet for a discussion on phantom power of slave nodes.

The EVM does not use the IOVDD module output. The A²B module must be jumpered for 1.8V IO when used with the EVM.
4.1 A2B MODULE CONNECTOR

This connector is located on the PDM to I$\text{S}$ PCB. For detailed information on the A$^2$B module mounting please see the User Manual for the A$^2$B module/EVM kit.

![A2B module connector location on PDM to I$\text{S}$ board](image)

Figure 11 A$^2$B module connector location on PDM to I$\text{S}$ board

Pinout – A Connector, J1 on PCB label.

<table>
<thead>
<tr>
<th>Pin</th>
<th>Name</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>IOVDD</td>
<td>Jumper selects between AD2428 internal regulator voltages, default is 3.3V (vs. 1.8V)</td>
</tr>
<tr>
<td>2</td>
<td>GND</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>ADR2</td>
<td>AD2428 ADR2/IO2 line with 10K pulldown</td>
</tr>
<tr>
<td>4</td>
<td>ADR1</td>
<td>AD2428 ADR1/IO1 line with 10K pulldown</td>
</tr>
<tr>
<td>5</td>
<td>IRQ</td>
<td>AD2428 IRQ/IO0 line</td>
</tr>
<tr>
<td>6</td>
<td>GND</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>SDA</td>
<td>I2C data</td>
</tr>
<tr>
<td>8</td>
<td>SCL</td>
<td>I2C clock</td>
</tr>
<tr>
<td>9</td>
<td>GND</td>
<td></td>
</tr>
<tr>
<td>10,11</td>
<td>Vxx</td>
<td>Power 5-8V suggested range, 4V min, 9V max.</td>
</tr>
<tr>
<td>12</td>
<td>GND</td>
<td></td>
</tr>
</tbody>
</table>
Pinout – B Connector, J2 on PCB label.

<table>
<thead>
<tr>
<th>Pin</th>
<th>Name</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>GND</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>BCLK</td>
<td>AD2428 bit clock (output from module as a slave)</td>
</tr>
<tr>
<td>3</td>
<td>GND</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>SYNC</td>
<td>AD2428 frame sync (output from module as a slave)</td>
</tr>
<tr>
<td>5</td>
<td>GND</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>DTX0</td>
<td>AD2428 DTX0 with 10K pulldown (output)</td>
</tr>
<tr>
<td>7</td>
<td>DTX1</td>
<td>AD2428 DTX1 with 10K pulldown (output)</td>
</tr>
<tr>
<td>8</td>
<td>GND</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>DRX0</td>
<td>AD2428 DRX0</td>
</tr>
<tr>
<td>10</td>
<td>DRX1</td>
<td>AD2428 DRX1</td>
</tr>
<tr>
<td>11</td>
<td>GND</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>IO7</td>
<td>AD2428 IO7/PDMCLK pin</td>
</tr>
</tbody>
</table>

### 4.1.1 IOVDD JUMPER

![Image of IOVDD jumper]

**Figure 12 Rev 2: IOVdd jumper resistors.** 3.3V is the factory default for modules purchased independently of the microphone kit. Your module should NOT look like this.

The 1V9 label actually should read 1V8. Oopsies.

### 4.2 J6 EXTERNAL CONTROL CONNECTOR

This connector is located on both the adapter board and the microphone board and provides access to the (1.8V) I²C signals. It is not normally used and is not installed/provided.
This 6 pin connector can be populated with a TE MTA-100 series part, 640456-6. It follows the same pinout as used on other Clockworks products. SDA and SCL lines on this board are pulled up to 1.8V and should not be connected to `I²C` devices that pullup to 3.3V. Pin assignments are as follows:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>GND</td>
</tr>
<tr>
<td>2</td>
<td>SDA (1.8V)</td>
</tr>
<tr>
<td>3</td>
<td>GND</td>
</tr>
<tr>
<td>4</td>
<td>SCL (1.8V)</td>
</tr>
<tr>
<td>5</td>
<td>NC</td>
</tr>
<tr>
<td>6</td>
<td>RESETn</td>
</tr>
</tbody>
</table>

The RESETn line is not used by the hardware. Pin 5 is normally used for 3.3V but is not connected on this connector.

If using the `I²C` bus keep in mind that the AD2428 device on the A²B module is normally the `I²C` master.

4.3 MIC TO PDM BOARD CONNECTOR

A 16 pin dual row .1" (2.54 mm) socket and header are used to interconnect the microphone board to the PDM/I²S board. The header (male) side is on the microphone board. All signals are 1.8V levels.

3.3V power is supplied via this connector, the microphone board should implement local 1.8 LDO regulators (low noise) for powering the microphones. 5V is supplied for the purpose of running the RGB LEDs. A separate ground is maintained for the LEDs as they are PWM modulated and could potentially...
lead to local ground noise. The LED ground and system ground must be connected to provide a reference for the I²C bus. That connection takes place on the PDM/I²S board. Solid ground planes are used to further reduce ground noise, as well as decoupling caps to filter power noise and minimize ground loop area for HF noise.

<table>
<thead>
<tr>
<th>Pin</th>
<th>Name</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3V3</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>GND</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>SDA</td>
<td>I²C data (2.2k pullup on mic board)</td>
</tr>
<tr>
<td>4</td>
<td>PDM_CLK</td>
<td>PDM Clock from ADAU7118. 64 Fs; 3.072MHz</td>
</tr>
<tr>
<td>5</td>
<td>SCL</td>
<td>I²C clock (2.2k pullup on mic board)</td>
</tr>
<tr>
<td>6</td>
<td>GND</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>ID2</td>
<td>Mic ID 2, routed to IO1 on AD2428</td>
</tr>
<tr>
<td>8</td>
<td>PDM_0</td>
<td>Chan 0, 1 of PDM data</td>
</tr>
<tr>
<td>9</td>
<td>ID1</td>
<td>Mic ID 1, routed to DTX1 (IO4) on AD2428</td>
</tr>
<tr>
<td>10</td>
<td>PDM_1</td>
<td>Chan 2, 3 of PDM data</td>
</tr>
<tr>
<td>11</td>
<td>ID0</td>
<td>Mic ID0, routed to DTX0 (IO3) on AD2428</td>
</tr>
<tr>
<td>12</td>
<td>GND</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>L_GND</td>
<td>Ground for LEDs</td>
</tr>
<tr>
<td>14</td>
<td>PDM_2</td>
<td>Chan 4, 5 of PDM data</td>
</tr>
<tr>
<td>15</td>
<td>5V0</td>
<td>LED 5V supply</td>
</tr>
<tr>
<td>16</td>
<td>PDM_0</td>
<td>Chan 6, 7 of PDM data</td>
</tr>
</tbody>
</table>

5 MECHANICAL INFORMATION

Both PCBs are 100mm in diameter. All mounting holes are 3.5mm for use with M3 bolts and standoffs. All mounting holes are grounded and the general suggestion is to use metallic (conductive) standoffs,
though in actual use some systems may perform better with non-conductive standoffs and rely just on the ground connections made through the connectors.

5.1 MICROPHONE BOARD

Figure 13 shows the locations of the holes and components on the microphone board and should be used as the template for a custom board. The (0,0) coordinate is the lower left side of a 100x100mm square that can contain the 100 mm round PCB.

The microphone holes are located on a circle 90mm in size, i.e. 5mm from the edge of the PCB. It’s assumed that a custom mic board would place the mic in a different arrangement and therefor the mic hole locations are just intended to help with use of the microphone board in the kit.
5.2 PDM/I²S BOARD MECHANICAL DESIGN

This board is 100mm in diameter and provides the mating connector to the 16 pin header on the microphone board and the four mounting holes. It also provides the connectors and four mounting holes for the Clockworks A²B module. There are an additional four holes that can be used to mount the PDM board to a chassis.
6 CONFIGURATION EXAMPLE WITH SIGMA STUDIO

This section outlines the steps for using the Clockworks EVM with the Analog Devices A²B add-on for Sigma Studio.

For more details about the PDM to I²S conversion options please see the ADAU7118 datasheet. For more details about programming the RGB LEDs please see the LP5024 datasheet.

6.1 ACCESSING THE LED AND SWITCHES FROM SIGMA STUDIO

GPIO can be accessed from the AD2428 block in Sigma Studio by right clicking on the block associated with the EVM board. There are two ways to do this, one at a low level of direct register access, like what a program would do, and the other via the more convenient “General View,” though that second method only helps for output, i.e. turning the LED on and off.

6.1.1 THE HARD WAY

Select Register View and the IO tab. For details of the registers and their bit maps please see the AD242x Programmers Reference Manual.
Figure 17 IO tab in SigmaStudio

Top operate the LED first write 0x10 to the GPIOEN register (0x4D). Then place 0x80 in the GPIODATSET or GPIODATCLR register and write that to turn the LED on and off. The LED is connected (through the EVM to A2B module connector) to IO7 pin of the AD2428.

To read the switch for write 0x41 to GPIOIN register (0x4E). SW2 is connected to to IRQ/IOo (bit map 0x01). Select GPIOIN and hit the Read button to see the switch values.

6.1.2 THE EASY WAY

This will allow turning the EVM’s LED on and off, which might be useful to confirm the node you’ve selected is the one you think it is. On the General View tba select the Pin Config dialog and set GPIO7 to be an output. High turns the LED on, Low shuts it off.
6.2 CONFIGURE THE ADAU7118

There are a number of configuration options in the ADAU7118. In the software directory along with the example Sigma Studio schematic are some .xml files that can be loaded to the board. The Sigma Studio manual explains how to create these xml files by capturing I2C read/write sequences.

A2B connectivity to the ADAU7118 can be checked by reading address 0x01 and 0x02, which will return 71 and 18, i.e. the part number.

adau7118_defaults.xml sets the following:

- chip address 0x4 – data 0x1F (enable PDM clk0 and all 4 inputs)
- chip address 0x5 – data 0x00 (use PDM CLK 0 for all channels)
- chip address 0x7 – data 0x01 (TDM mode)
A²B 8 channel microphone array User Guide

It may be desirable to set the high pass filter (address 0x06) to on to avoid DC offsets from showing up in the output. See the ADAU7118 manual for details on enabling this feature.

To select and execute an xml file right click on the RGB LEDs in the Sigma Studio schematic and select Peripheral Properties. Then select the XML file and hit the Program button.

Figure 19 ADAU7118 typical default settings

6.3 TURN ON THE RGB LEDS

The download includes two example files for loading sequences in to the RGB LED controller:

mic_green_leds.xml
mic_all_leds.xml

The first one just sets all of the RGB LEDs to the green LEDs only. The second example executes a sequence using the delay capability of Sigma Studio.

To select and execute an xml file right click on the RGB LEDs in the Sigma Studio schematic and select Peripheral Properties.
If running the basic setup there are two outputs available from the master board. The A²B Stream controls in Sigma Studio can be used to easily manipulate the dataflow. For example all 8 channels can be bundled like this:

![A²B 8 channel microphone array User Guide](image1)

**Figure 20 RGB LED programming example**

### 6.4 STREAM EXAMPLE

If running the basic setup there are two outputs available from the master board. The A²B Stream controls in Sigma Studio can be used to easily manipulate the dataflow. For example all 8 channels can be bundled like this:

![A²B 8 channel microphone array User Guide](image2)

and then routed to the master node:
The ADAU1452 device runs a default pass through program. Modify that to select the channel(s) of interest and where you want them output. In this example based on the ADI default pass through program 2 channels have been routed to the ToS output (labeled as SpdifOut1 and SpdifOut 2 in the diagram) so the microphone output can be captured digitally for analysis by external equipment.
6.4.1 EXAMPLE DATA

Using the device programming from the previous section, the following FFT plot was obtained in a quiet room with the mic board sandwiched between acoustic foam, which would reduce signals above a few hundred hertz but not much related to hum from motors, etc.
Figure 21 Background noise spectrum of mic in quiet room (16K pt FFT, 16 averages)
Microphone is 3.3V, DC
preferred. 3.3V isn't
powered by Arduino,
2x on boardVIN

No audio or
mic board.

Irregular audio
levels. 3.3V
preferred.

Plugs
Unplugs

Plugs
Unplugs

Irregular audio
levels. 3.3V
preferred.