

A²B 8 CHANNEL MICROPHONE ARRAY USER MANUAL



Rev 1.2

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CLOCKWORKS
Signal Processing

<http://clk.works/>

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Products covered:

EVMA2BMIC, consisting of

- AB0001 A²B to I²S module
- AB0200 8 channel PDM Mic module (rev 1)
- AB0100 PDM to I²S module (rev 2)

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1 INTRODUCTION

The Clockworks 8 channel microphone array is a three board stack intended to allow developers to quickly integrate Analog Device's A²B capability in to 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.

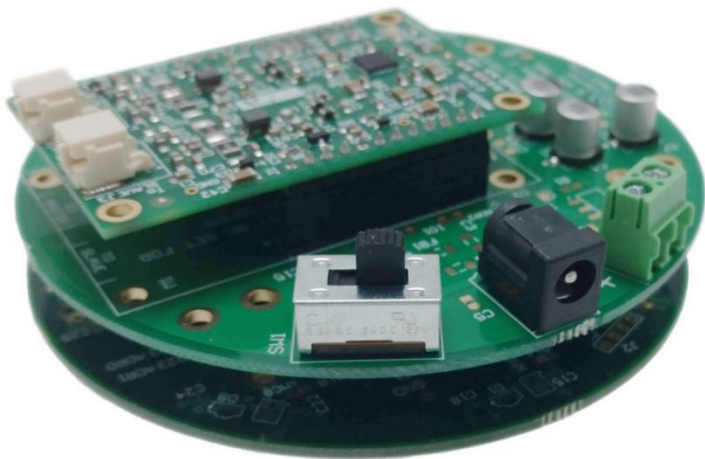


Figure 1 A²B microphone EVM board stack: A²B module, PDM to I²S module, 8 mic array module.

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 +/- 3dB) and handle up to 128 dB SPL.

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 module².



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.

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The EVM kit ships with a 9V DC power supply that has universal input. The North America version uses the two blade plug, where as 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 2.1mm barrel connector. Alternately the board can be power 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 IO_{Vdd} of 1.8V

- Set SW₁ (power) to the off position (slide button at board edge).
- Attach the 9 VDC supply to input jack J1 and plug the supply in to the AC mains.
 - o **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.

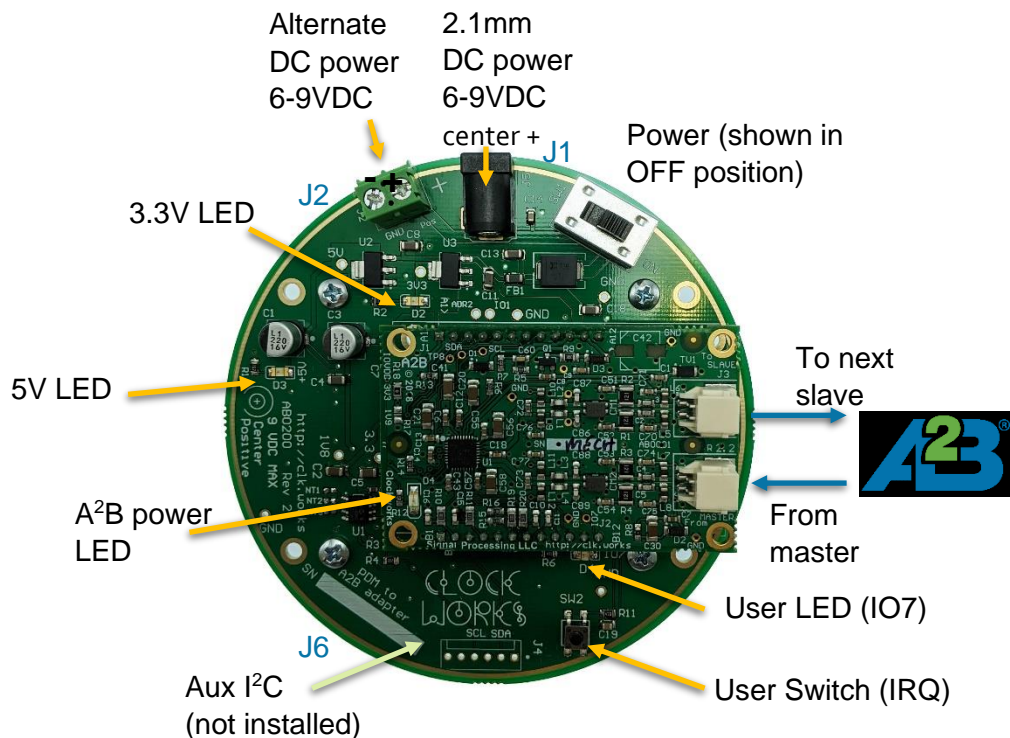


Figure 3 External connectors on adapter board

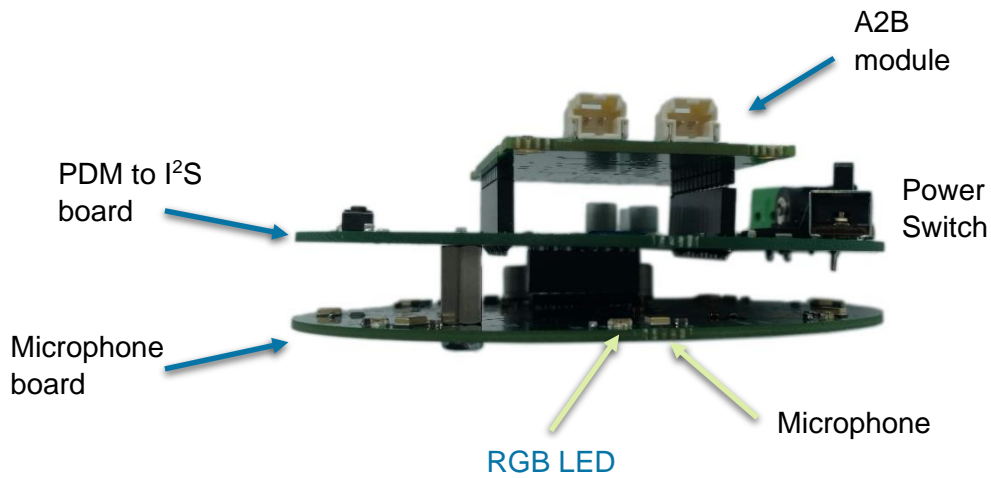


Figure 4 EVM Components (most standoffs removed)

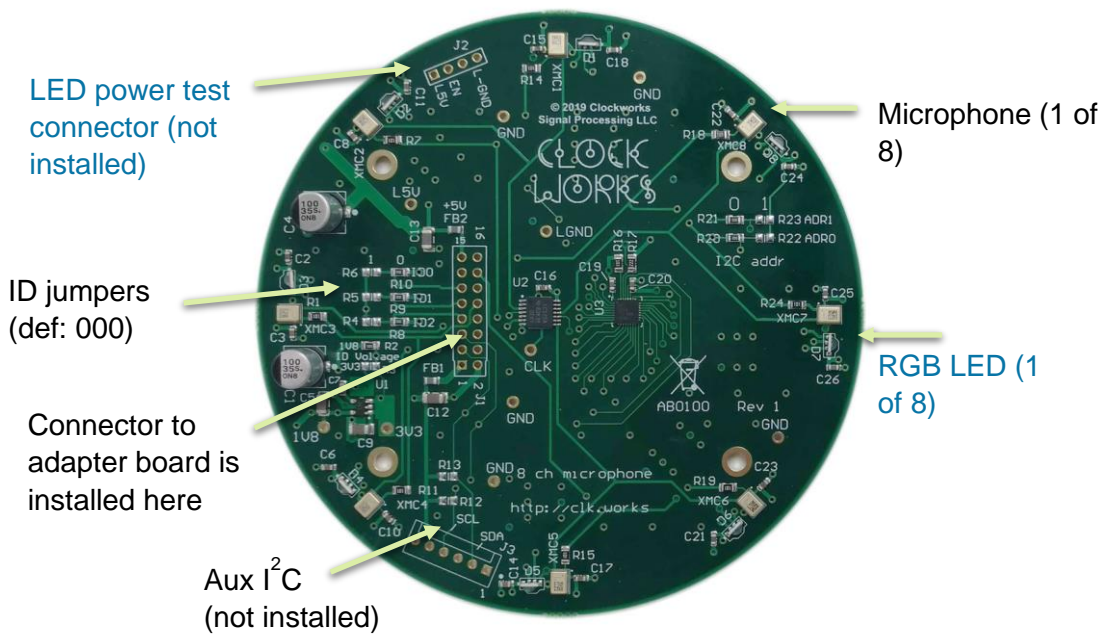


Figure 5 Microphone board connectors and components

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.

The board can be discovered on the A²B network. An example SigmaStudio diagram³ is included in the design package. If using an ADI WZ board as the master it can be open and run directly. If using a

³ Currently SigmaStudio 4.5. The A²B extensions for SigmaStudio must have been previously installed.

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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 `newWDZ_a2bmic.dspproj` (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.

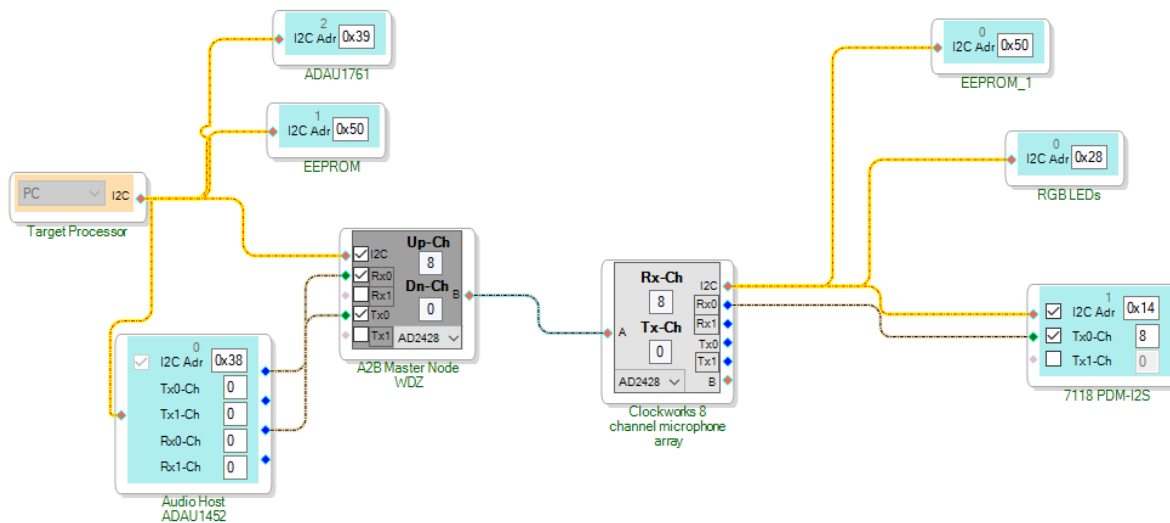


Figure 6 Example schematic in SigmaStudio

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.



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

2.4 DEFAULT I²C ADDRESSES

The ADAU7118 PDM to I²S chip (on PDM to I²S board) is set for address 0x14 (0x28 8-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

For Rev 2 hardware or later: The 24FC256 (32Kx8) EEPROM (on PDM to I²S board) is set to its default (lowest) address with the address bits grounded⁴, which corresponds to 0x50 (0xA0 7-bit). There are three pads with a shorting trace that can be modified should another address be needed. Refer to the schematic and EEPROM datasheet for details.

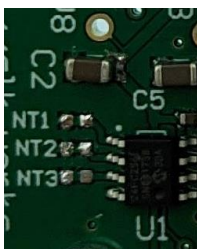


Figure 10 EEPROM address jumper/trace

The LPC5024 LED controller (on microphone board) is at address 0x28 (0x50 8-bit). There are two jumper sets (R20-R23) that can be used to modify the base address.

⁴ please note Rev 1 hardware does not have an EEPROM



Figure 11 LPC5024 base address jumpers

3 EVM DESIGN INFORMATION

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 IOV_{DD} module output. **The A²B module must be jumpered for 1.8V IO when used with the EVM.**

4 CONNECTOR INFORMATION

4.1 A²B MODULE CONNECTOR

This connector is located on the PDM to I²S PCB. For detailed information on the A²B module mounting please see the User Manual for the A²B module/EVM kit.



Figure 12 A²B module connector location on PDM to I²S board

Pinout – A Connector, J₁ on PCB label.

Pin	Name	Notes
1	IOVDD	Jumper selects between AD2428 internal regulator voltages, default is 3.3V (vs. 1.8V)
2	GND	
3	ADR2	AD2428 ADR2/IO2 line with 10K pulldown
4	ADR1	AD2428 ADR1/IO1 line with 10K pulldown
5	IRQ	AD2428 IRQ/IO0 line
6	GND	
7	SDA	I2C data
8	SCL	I2C clock
9	GND	
10,11	Vxx	Power 5-8V suggested range, 4V min, 9V max.
12	GND	

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Pinout – B Connector, J2 on PCB label.

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

4.1.1 IOVDD JUMPER



Figure 13 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 to be consistent with what ADA calls the voltage, even though it measure closer to 1.9V in real life. Oopsies.



Figure 14 Correct jumper location for 1.8V IO

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.



Figure 15 External/Aux control connector

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:

1	GND
2	SDA (1.8V)
3	GND
4	SCL (1.8V)
5	NC
6	RESETn

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.

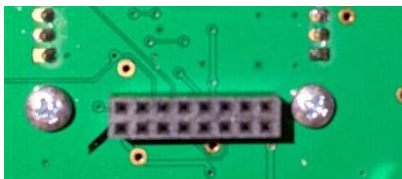


Figure 16 16 pin connector on PDM/I²S board

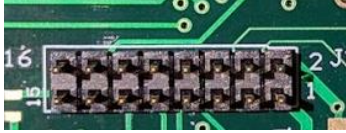


Figure 17 16 pin connector on microphone board

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.

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

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 18 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 therefore the mic hole locations are just intended to help with use of the microphone board in the kit.

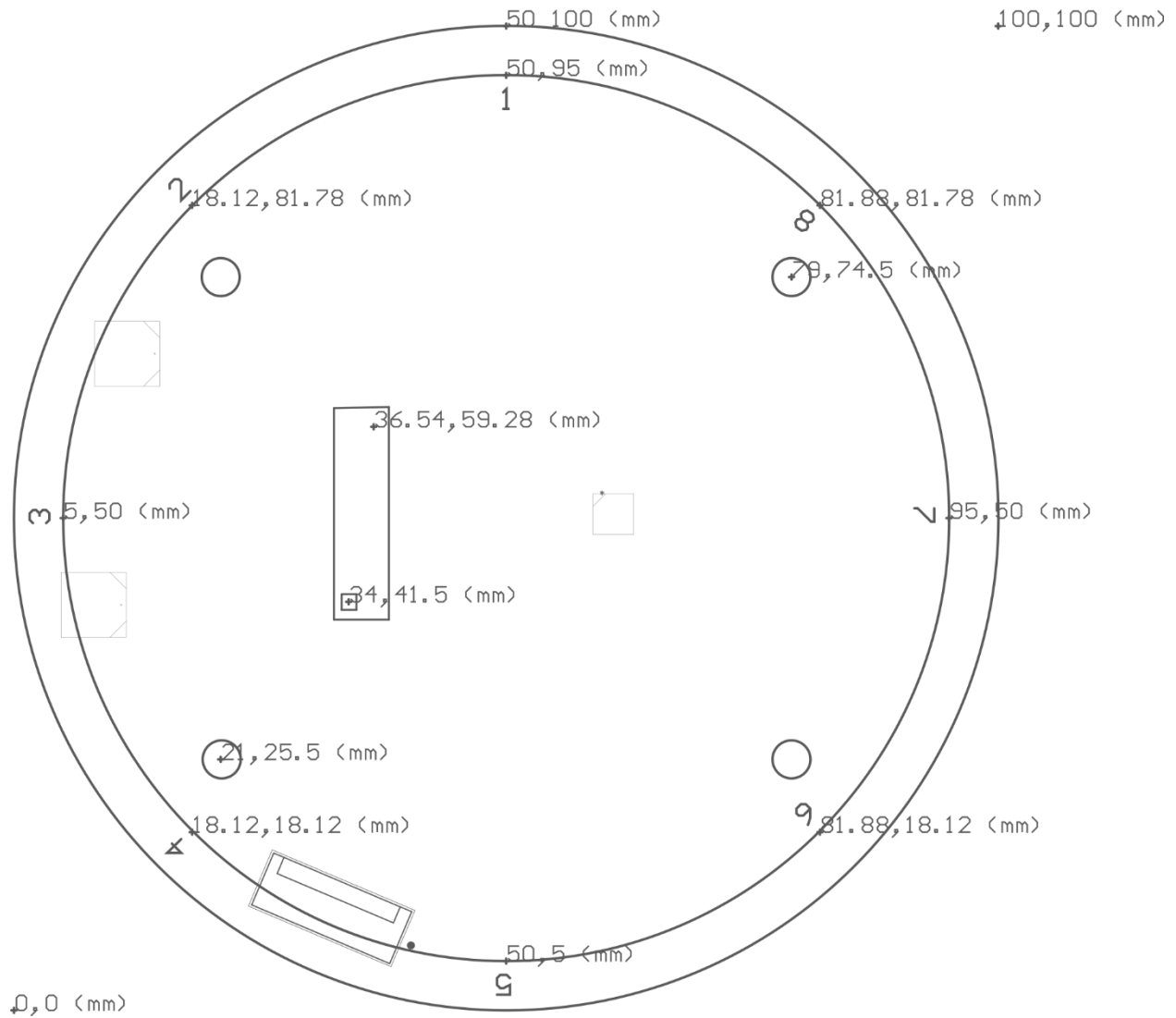


Figure 18 microphone module hole locations

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.

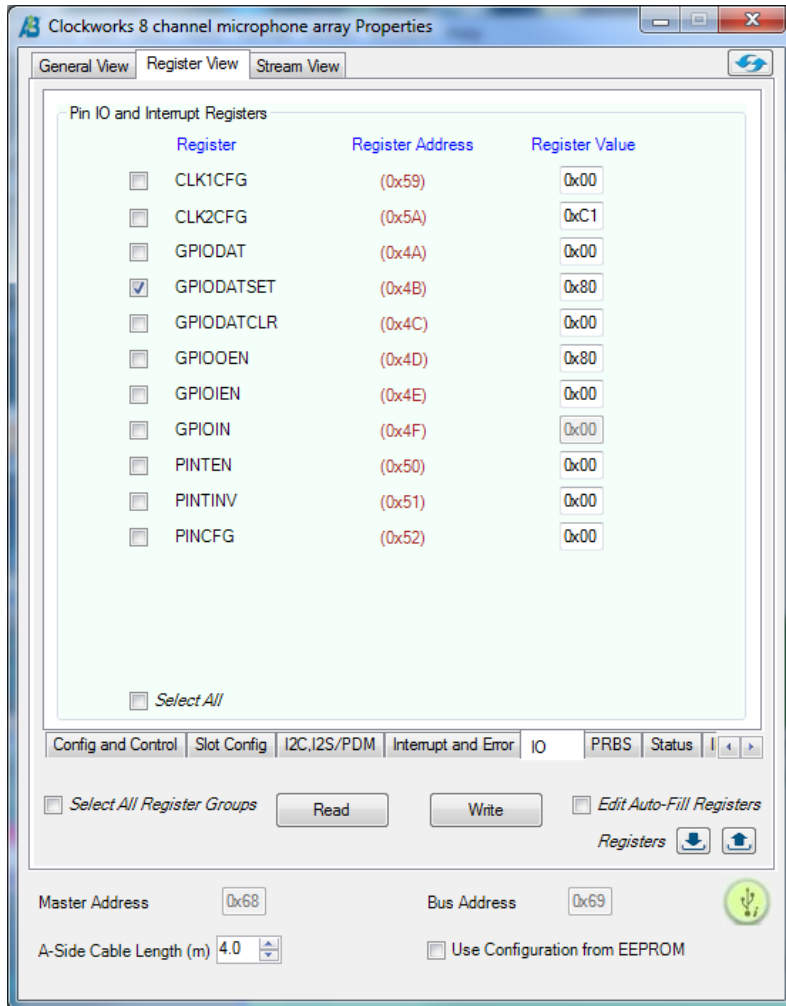


Figure 19 IO tab in SigmaStudio

To 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 GPIOIEN register (0x4E). SW2 is connected to IRQ/IO0 (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 tab select the Pin Config dialog and set GPIO7 to be an output. High turns the LED on, Low shuts it off.

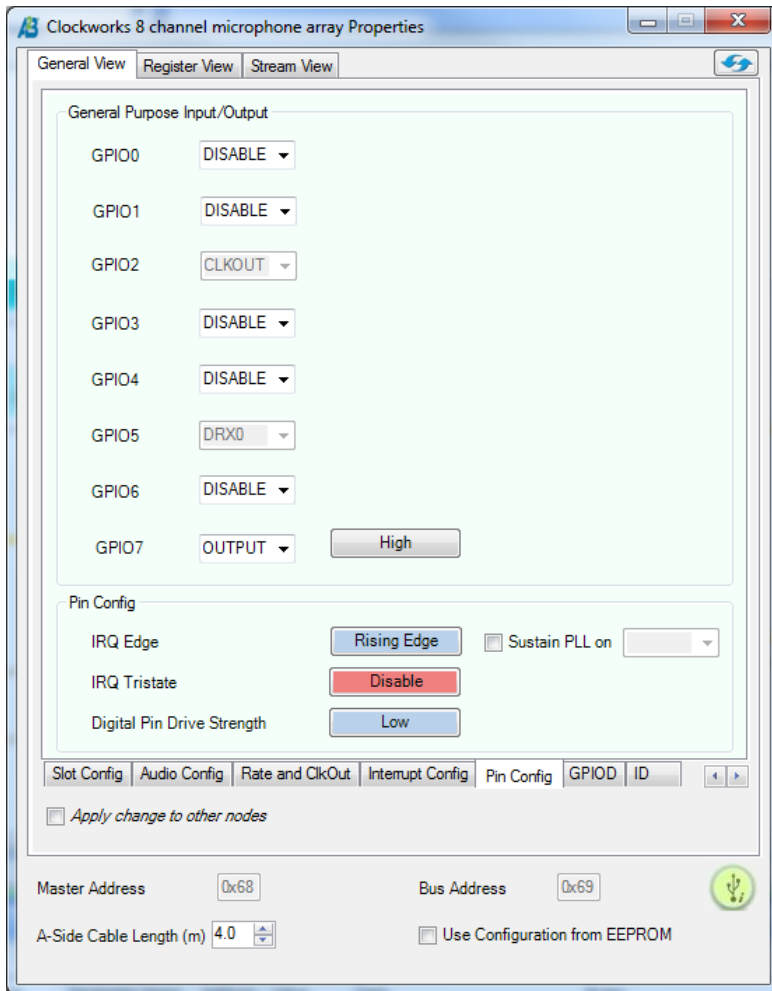


Figure 20 EVM User LED (GPIO 7) control

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 clko and all 4 inputs)

chip address 0x5 – data 0x00 (use PDM CLK o for all channels)

chip address 0x7 – data 0x01 (TDM mode)

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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.

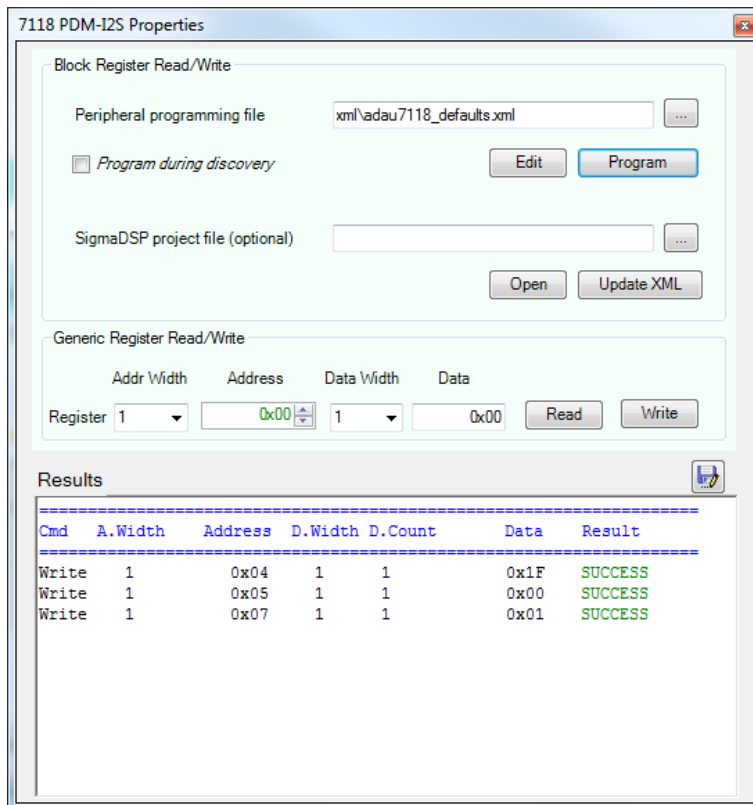


Figure 21 ADAU7118 typical default settings

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.

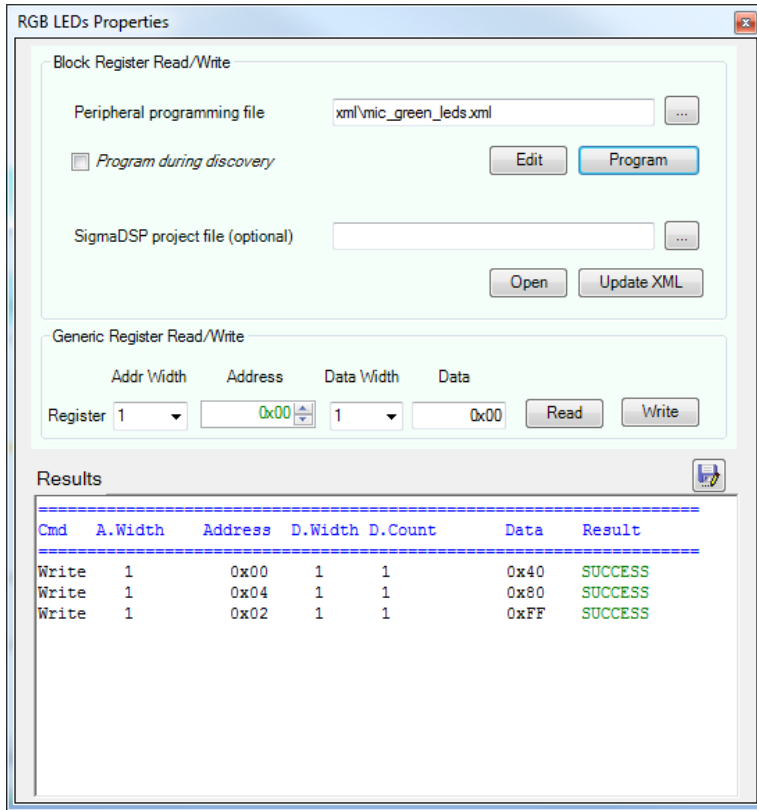
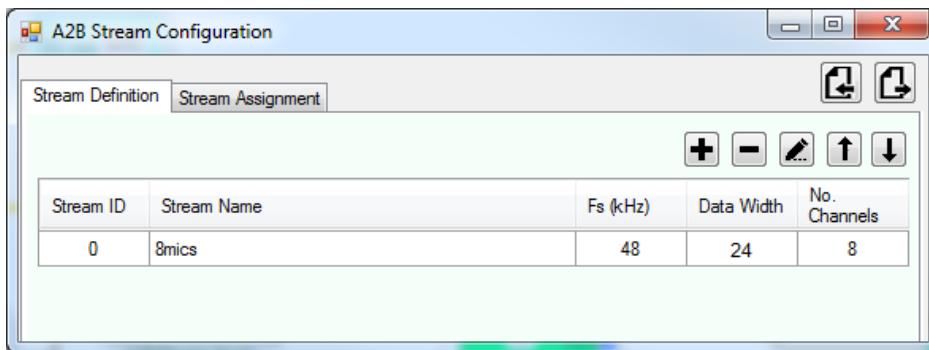


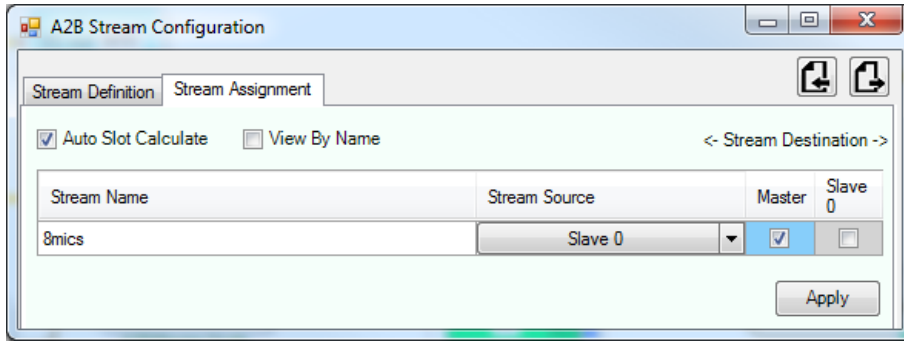
Figure 22 RGB LED programming example

6.4 STREAM EXAMPLE

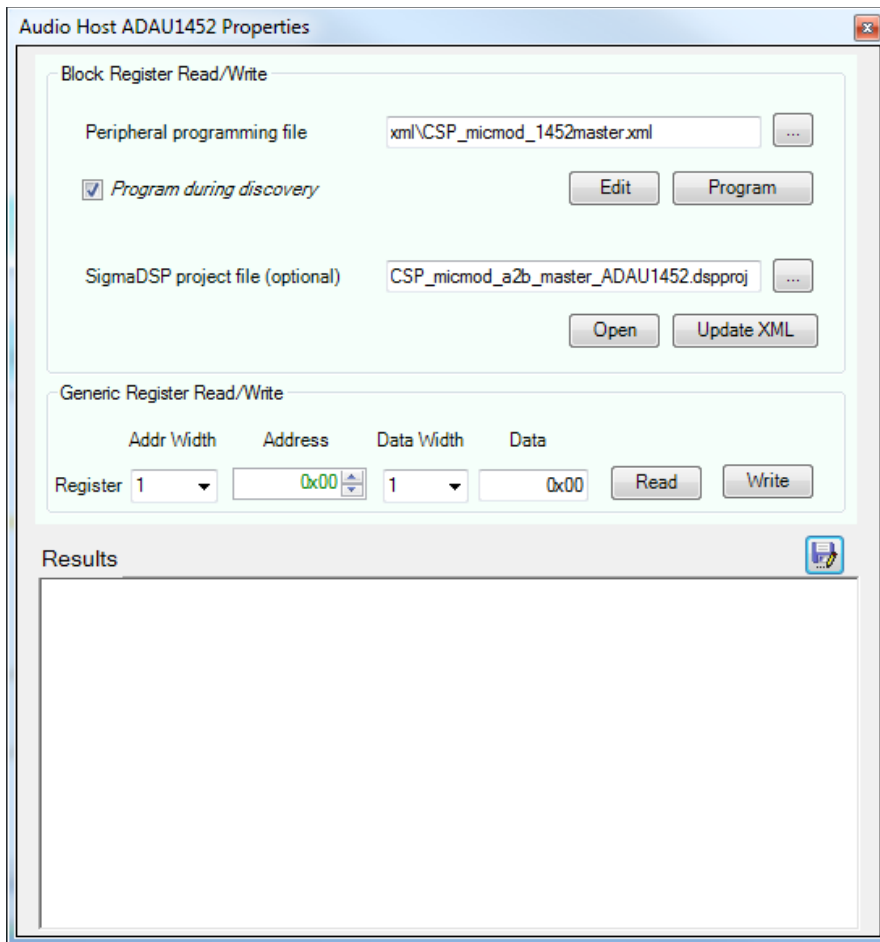
If running the basic setup there are two outputs available from the master board. The A²B Stream controls in Sigma Studio can be used to easily manipulate the dataflow. For example all 8 channels can be bundled like this

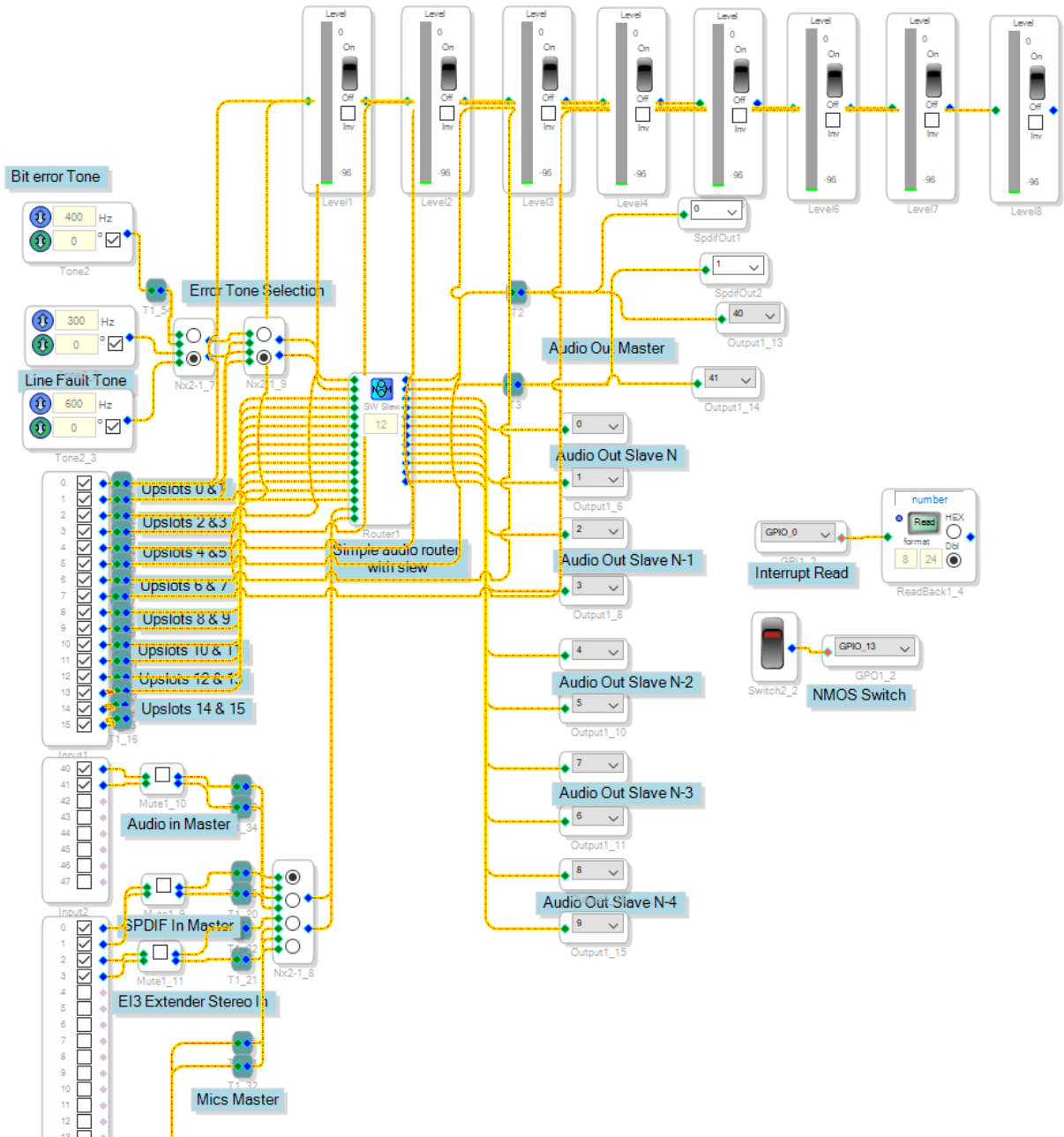


and then routed to the master node:



The ADAU1452 device runs a default pass through program which is copied from the one provided with the WDZ board. 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 SpdifOu1 and SpdifOut 2 in the diagram) so the microphone output can be captured digitally for analysis by external equipment.





To make changes to the ADAU1452 settings via this diagram you must first select the *link, compile, connect* button in Sigma Studio. 8 level meters are available and can be activated to monitor the 8 microphones. For more information about changing the diagram and saving a new XML please see the A²B Sigma Studio User Guide. Changes you make to the SigmaStudio file are not reflected in the XML file until you explicitly create a new XML file.

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.

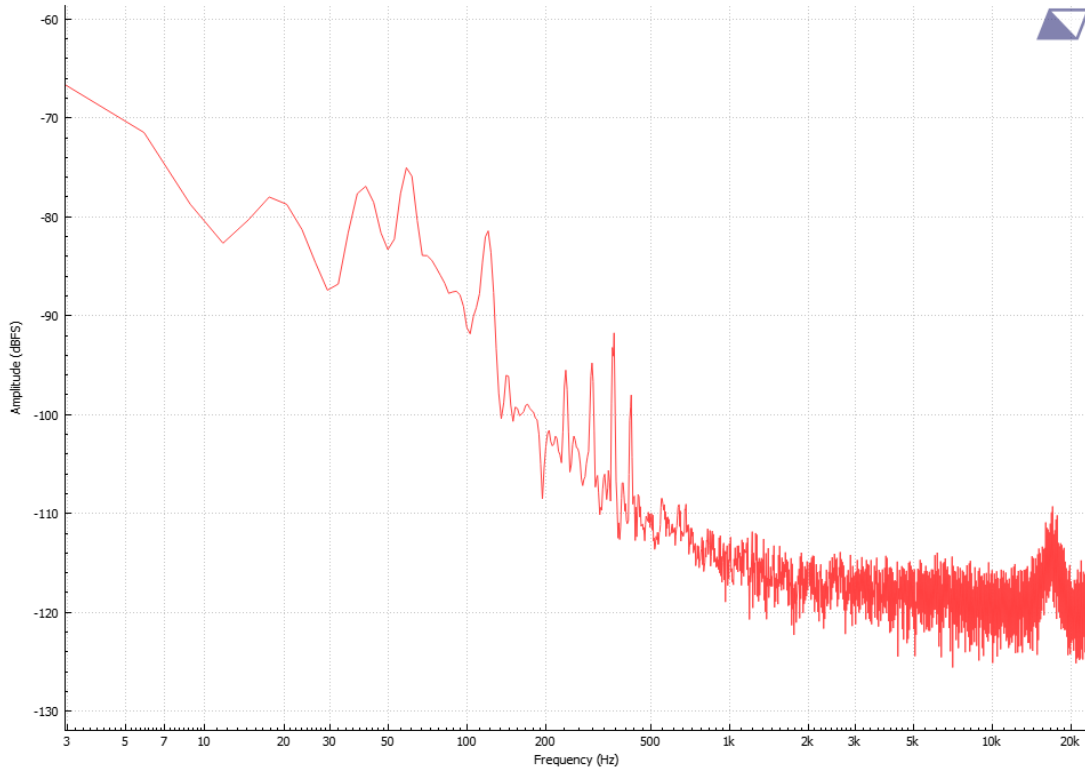


Figure 23 Background noise spectrum of mic in quiet room (16K pt FFT, 16 averages)