



TESTING A²B AUDIO DEVICES USING APx AND AN ADI BUS ANALYZER

by Ben Kilada and Eric Schultheis

The Automotive Audio Bus® (A²B®)* is a technology developed and patented by Analog Devices, Inc. (ADI), and adopted by a number of key automotive manufacturers. A²B provides the ability to transport up to 32 channels of 24-bit, 48 kHz sample rate audio up to 15 meters between network nodes with deterministic, sub 50 μ s latency. Audio, clock, control data and power are all carried on a single run of unshielded, low-cost twisted-pair wire. The twisted-pair wiring reduces infotainment wiring harness weight by as much as 75%, lowering manufacturing costs and improving fuel efficiency. Applications for A²B technology include multichannel audio for entertainment, hands-free voice communication, acoustic noise control (ANC) and in-vehicle communication systems.

All A²B implementations are based on Analog Devices A²B chips.

This technote describes the A²B audio testing solution Audio Precision has developed in cooperation with Analog Devices. Using an Audio Precision analyzer and the Analog Devices A²B Bus Analyzer, you can configure an A²B network for testing an automotive head unit, power amplifier nodes, powered speaker nodes, MEMS microphone nodes and other A²B audio implementations, including evaluation boards from Analog Devices. In this Technote, we'll use an ADI evaluation board to represent two automotive audio applications. We'll look at:

- Sending A²B audio to an audio amplifier and measuring the acoustic output of a connected loud-speaker; and

- Outputting an acoustic signal to be picked up by MEMS mics embedded in an A²B node, while measuring the acquired audio.

Required Components

The following components are needed to perform the measurements described in this Technote:

- An Audio Precision APx audio analyzer with a S/PDIF Toslink interface (via a DIO or ADIO module).
- An Analog Devices A²B Bus Analyzer.
- A²B cabling (twisted pair with connectors). Note that connectors may vary among automobile manufacturers and evaluation boards.
- An A²B node with an analog output.
- An A²B node with on-board microphones or microphone inputs.
- A measurement microphone.
- A microphone power supply.
- A Windows personal computer (PC) with at least two USB ports and the following software installed:
 - APx500 measurement software
 - The ADI A²B Bus Analyzer Application

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The ADI A²B Bus Analyzer

The **ADI A²B Bus Analyzer** is a development tool from Analog Devices that supports the design and debug of AD242x/3x based A²B networks. It can be configured to act as an active node emulation tool and/or as a passive bus monitor.



Figure 1. ADI A²B Bus Analyzer, showing ports for bus monitoring, power and audio connections on the left-side panel.

When the **Standalone** switch is set to Off, the A²B analyzer can connect to a PC using a dedicated USB connection. Network configuration is downloaded to the analyzer using the ADI A²B Bus Analyzer Application running on the PC.



Figure 2. Connections for node simulation, on the right-side panel.

Audio Interfaces

The Bus Analyzer provides four interfaces for streaming audio to or from an A²B network:

- S/PDIF, via Toslink (2 channels)
- ASIO (up to 16 channels)
- 3.5mm Line I/O (2 channels)
- File output

While streaming up to 16 audio channels is possible via ASIO, due to the lack of a dedicated ASIO driver we advise using S/PDIF until a first-party driver is available from ADI. A S/PDIF Toslink interface can be added to an Audio Precision analyzer via a **Digital Input/Output module (DIO)** or **Advanced Digital Input/Output module (ADIO)**.

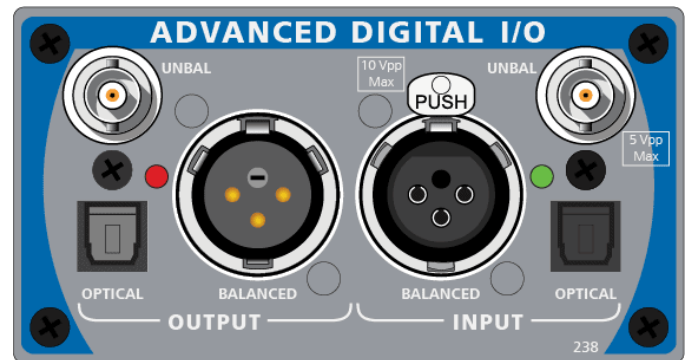


Figure 3. Advanced Digital Input/Output module (ADIO).

If an A²B node has an I²S interface, it may also be possible to stream audio directly to and from the node (or another node on the same network) via an Audio Precision analyzer equipped with a Digital Serial Input/Output (DSIO) module. This configuration negates the need for an A²B analyzer and supports up to 16 channels.

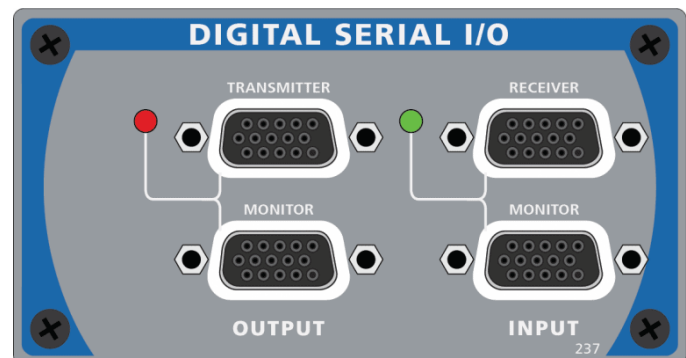


Figure 4. DSIO, Digital Serial Input/Output module.

In this technote, we will be using S/PDIF.

The A²B Network

An **A²B network** is a daisy chain consisting of one master node and at least one slave node. The network interconnection is carried on inexpensive, lightweight unshielded twisted-pair cables.

Clocking, control signals, audio, and power are all carried on the same pair of wires. Control and audio information are bidirectional, so that a slave and master can correspond, and audio can flow to a node or from a node.



Figure 5. A²B unshielded twisted-pair cable with connector. Note that connector types may vary with OEMs and eval board versions.

Audio data is streamed using time-division multiplexing (TDM), so that multiple channels can be carried independently, and each node can tap off (or insert) only the signals appropriate to that node. Standard A²B networked power is sufficient for small circuits at some nodes; high-current devices such as large power amplifiers will require a high-power bus (AD243x transceivers only) or dedicated power connection.

Network Configuration

The first task in testing an A²B network is to configure the A²B Analyzer. Audio streams, TDM configuration, peripheral configuration and node configuration must be defined in SigmaStudio+ then linked, compiled, and downloaded to the A²B analyzer. In SigmaStudio+, linking, compiling, and downloading to a connected A²B analyzer via the A²B Bus Analyzer Application can be accomplished with a single click (Figure 6).

Graphical programming of A²B networks in SigmaStudio+ is enabled via an A²B plugin available on the Analog Devices website.

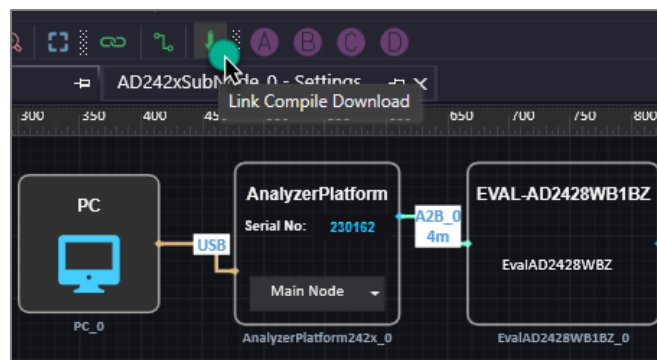


Figure 6. Link, Compile, and Download of a simple network in SigmaStudio+.

Networks can also be manually uploaded into the A²B Bus Analyzer Application via .dat network configuration files. This technote comes with a couple example network configuration files to support the described test scenarios.

This technote does not cover how to design networks in SigmaStudio+. For information on network design, refer to the SigmaStudio+ documentation or contact ADI Support.

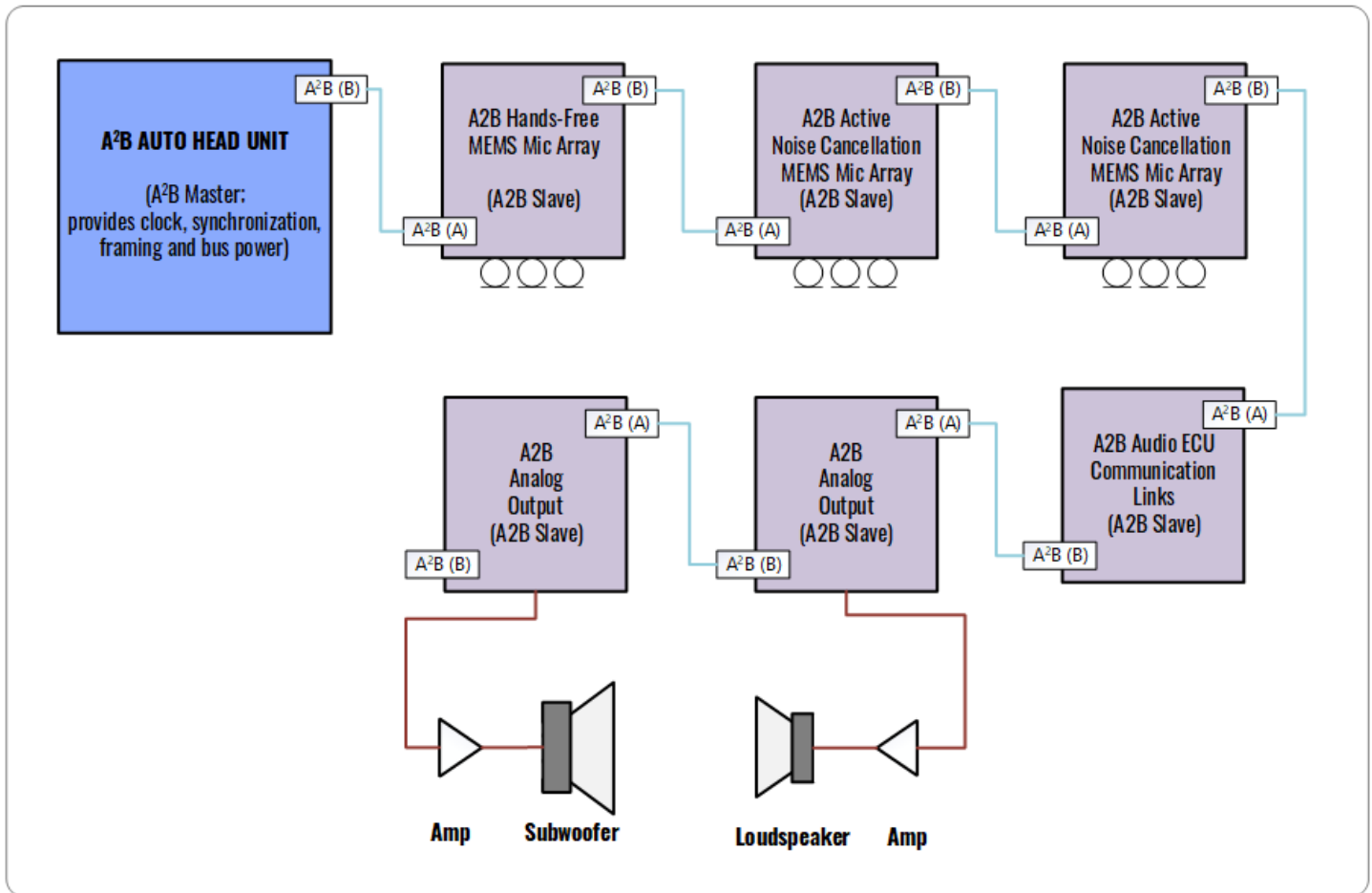


Figure 7. An Example A²B Network.

Test Setup 1: A²B to Audio Power Amplifier/Loudspeaker

In this first example, we are sending A²B audio via the ADI A²B Analyzer to an AD2428WB1BZ evaluation board that is playing the role of an audio output node such as an automotive amplifier. Although an APx585 analyzer is pictured in the diagram below, any APx analyzer with a DIO or ADIO module can be used.

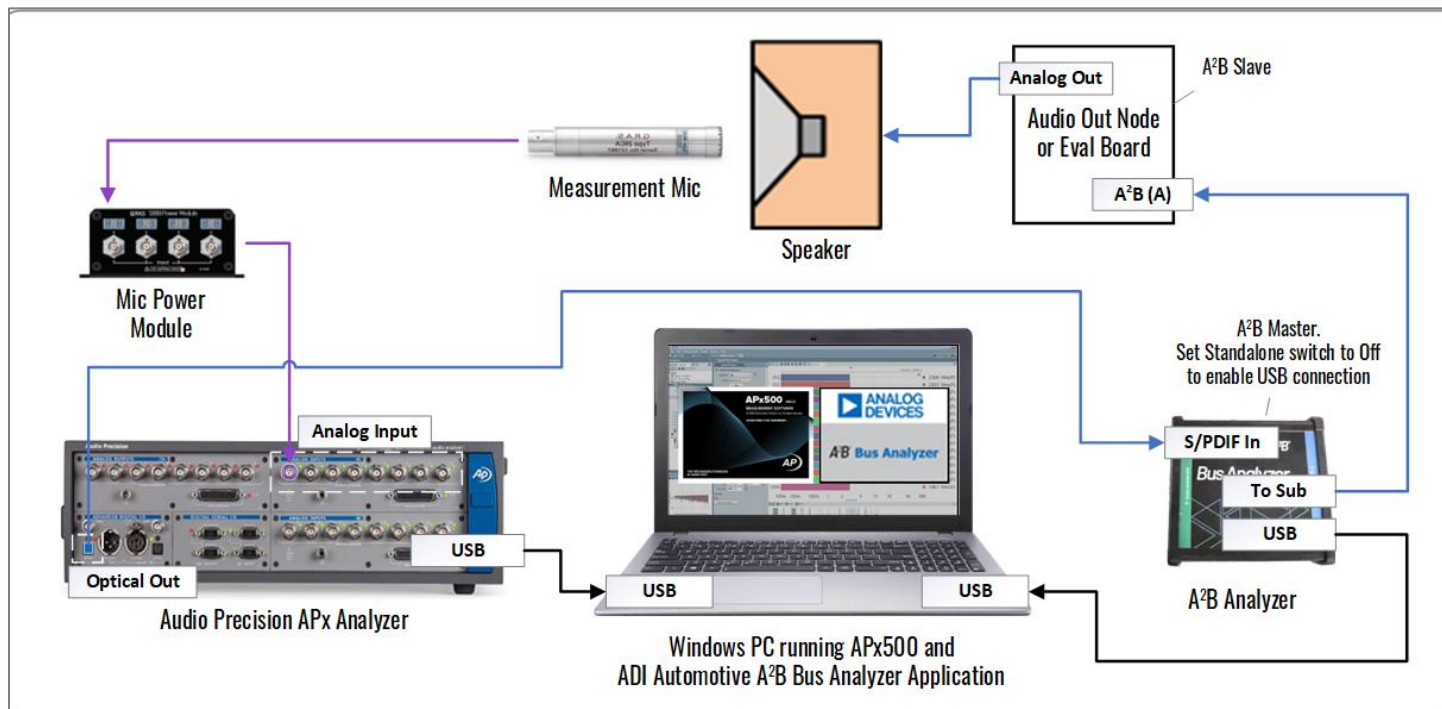


Figure 8. Test Setup 1, showing the PC, audio analyzer, A²B analyzer and evaluation board.

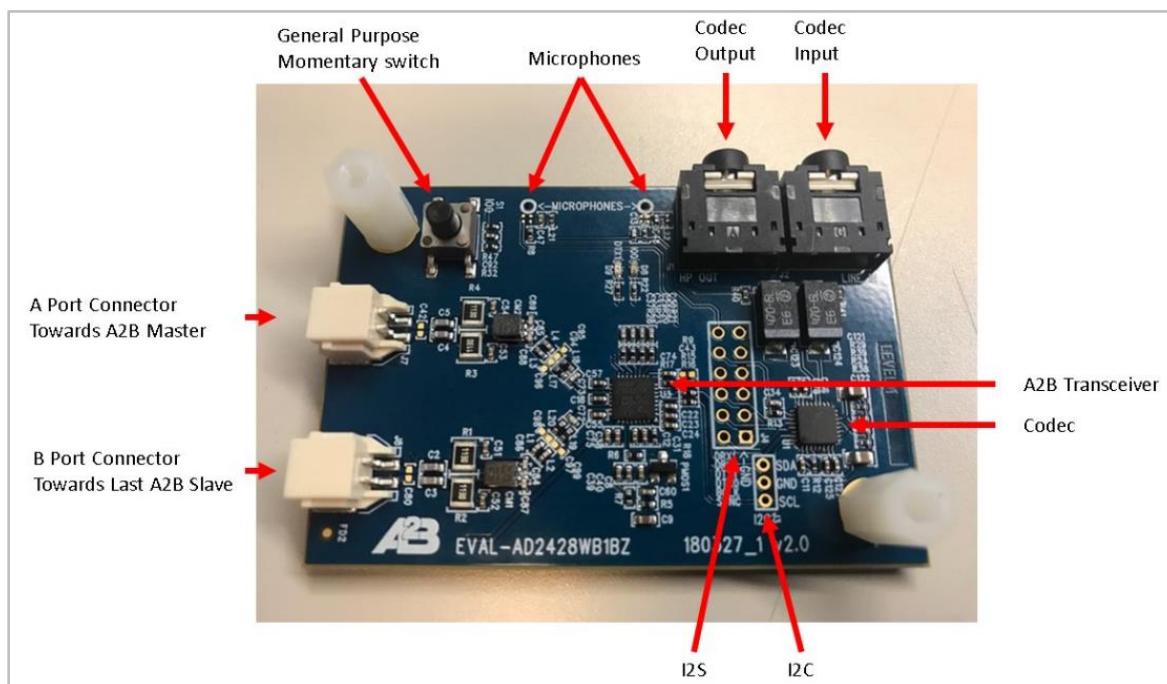


Figure 9. The AD2428WB1BZ evaluation board

Connecting to the Bus Analyzer

First, install the ADI A²B Bus Analyzer Application on the same personal computer that has APx500 installed. Connect the APx analyzer via USB and the ADI Analyzer via a second USB cable. Be sure to use the USB port on the Node Emulator side of the A²B analyzer, setting the Standalone switch to Off. Connect power to the Bus Analyzer and launch the ADI A²B Bus Analyzer Application.

If the application cannot find the A²B analyzer, the device selection menu will read Select device... (Figure 10).

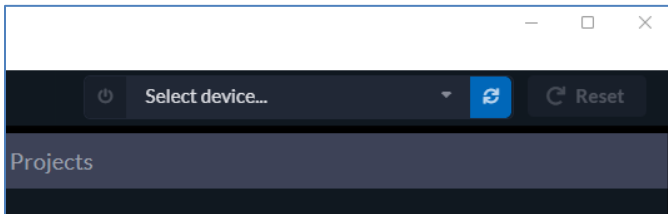


Figure 10. No analyzers detected.

If the A²B Analyzer is detected, the device with its serial number is shown.

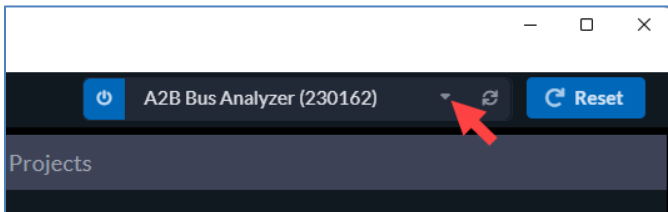


Figure 11. A²B Bus Analyzer detected.

Click the blue Power symbol to the left of the device drop-down to connect to the A²B Analyzer. If successful, the button becomes green (Figure 13).

Using the Node Emulator ports, connect the STD PWR or HIGH PWR “Towards Sub” port to the “A” port on your A²B node. In our case, we connected the STD PWR “Towards Sub” port to the A port of our eval board (see Figure 9).

Discovery

Use the File menu to load the example A²B project file “AmplifierSpeakerTest.a2bproj”. From the left-hand column, select Std-Power Emulator. From Device settings, browse for your Network Config File or use the example file “AmplifierSpeakerTest.dat”, then click the green Play symbol to start Discovery. (Figure 12).

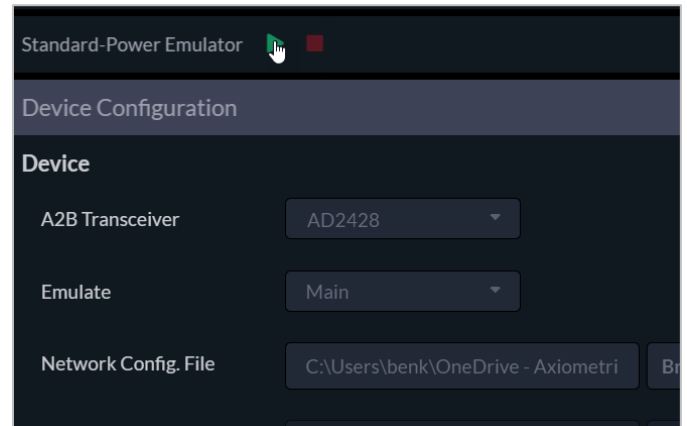


Figure 12. Enabling the Emulator

If discovery is successful, a green banner will appear (Figure 13).

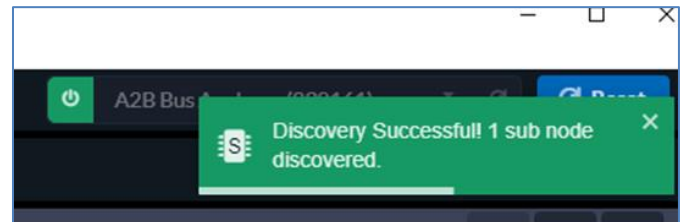


Figure 13. Banner indicating successful discovery.

If discovery fails with an error about reverse connection, double check that you have correctly connected to the A port on your node.

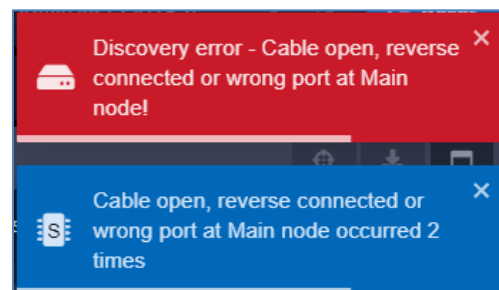


Figure 14. Discovery error

Note: The A²B Bus Analyzer application may throw a “cable shorted” error if a bus-powered node and A²B analyzer share the same ground. While we have not seen this with a SPDIF connection, this error occurred when the serial interface of an APx analyzer was connected to the I2S interface of a node during discovery. Connecting the Digital Serial interface to the node after discovery resolved the error. See ADI help documentation or contact ADI support for more information.

Peripheral Configuration

To use the AD2428WB1BZ evaluation board as an audio output node, the headphone output on the ADAU1761 peripheral (a sub-component of the eval board) must be programmatically enabled. In the Bus Analyzer application, navigate to the Device tab, then under Registers select I2C Peripherals (Figure 15). Set the Input File to the example configuration file “di_a2b_sub_ADAU1761.xml”, then click Run File Commands to program the device.

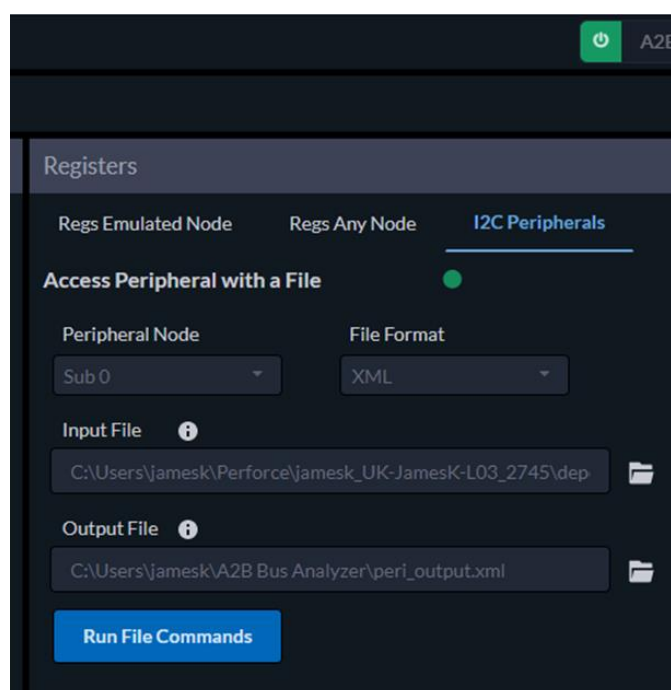


Figure 15. Settings for I2C Peripherals.

Audio Stream Routing

Select the Audio tab from the left-hand column. There should be two streams shown under Source Audio. Under the Controls column, click the left-facing arrow next to each stream and select “SPDIF” from the list that appears.

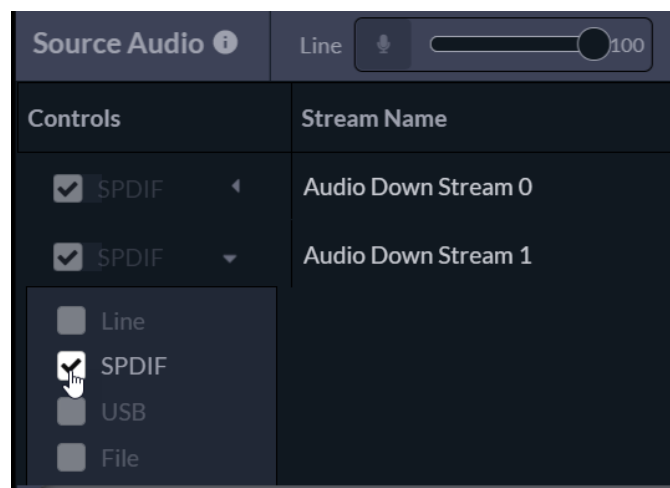


Figure 16. Stream routing controls.

The A²B network is now configured to receive two channels of audio from the A²B Analyzer’s S/PDIF input, route the audio to the evaluation board over A²B, then output from the eval board’s 3.5mm analog output (“Codec Output” in Figure 9).

Configuring APx500

With the APx analyzer connected to the PC and powered on, launch APx500. Select either Bench Mode or Sequence Mode from the drop-down menu in the upper right corner of the application (Bench Mode is optional on some analyzers).

In Signal Path Setup **Output Configuration**, select the S/PDIF Toslink interface by choosing Digital Optical.

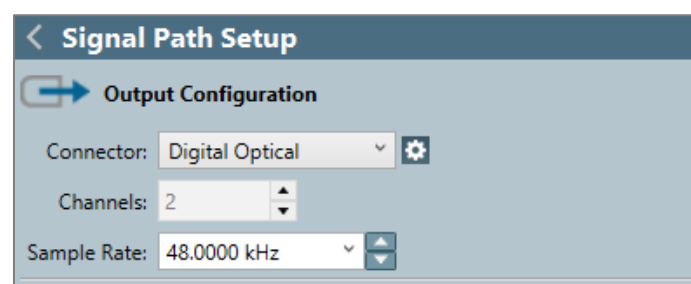


Figure 17. Output Configuration settings.

In **Input Configuration**, choose Analog Unbalanced. Alternatively, if using an APx517 audio analyzer, select Mic input, and if using an APx analyzer with an APx1701 interface, select Transducer Interface. Finally, set the **Measure** type to Acoustic and enter the sensitivity of the measurement microphone(s) in the **Sensitivity** field(s) of the input channels grid.

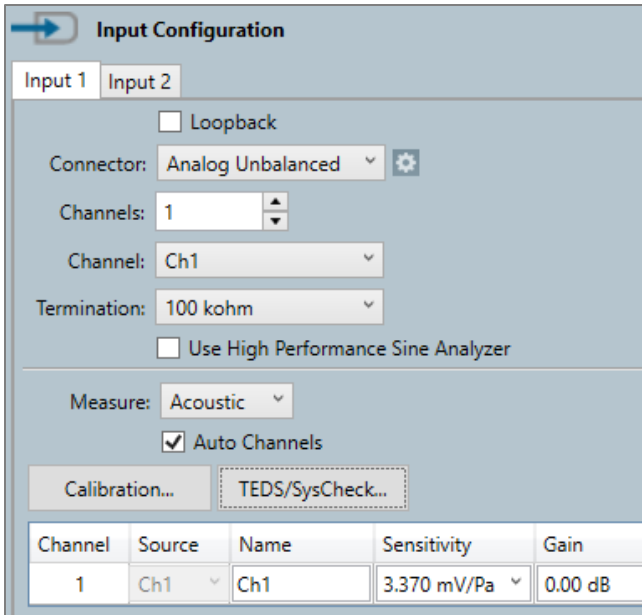


Figure 18. Input Configuration settings.

Verify Connections

In our setup (Figure 8), we connect a cable from the analog output of the eval board (playing the role of the automotive amplifier) to a loudspeaker. A GRAS measurement microphone captures the acoustic output of the loudspeaker and connects to the first Analog Unbalanced input of the APx analyzer through a GRAS 12BA Mic Power Module.

If using Sequence Mode, expand the Signal Path Setup **Verify Connections** panel, adjust generator levels as necessary and turn the generator on. If using Bench Mode, configure generator settings from the **Generator** panel. If setup is successful, you will hear a 1 kHz sinewave playing from the loudspeaker and see a sinewave in the input Signal Monitors (Figure 19). Turn on the input Signal Monitors if disabled.

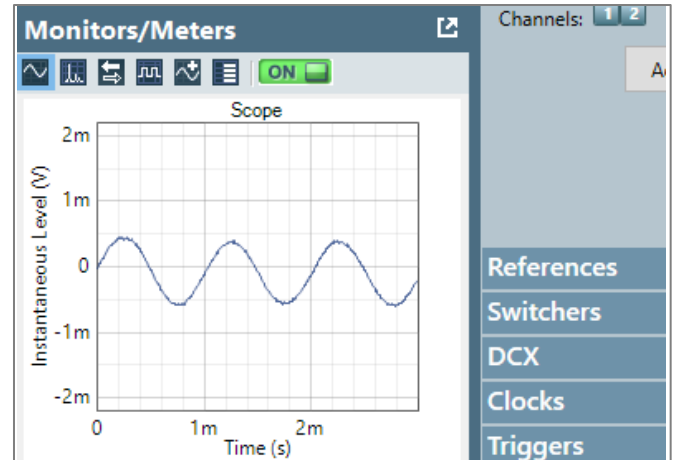


Figure 19. The Scope time-domain signal monitor with signal monitors set to ON.

The A²B Bus Analyzer Application will also show stream levels at the S/PDIF input of the A²B Analyzer (Figure 20). Note that due to a difference in units (dB RMS vs dBFS), indicated stream levels may not match what is typed into the generator level field in APx500 software.

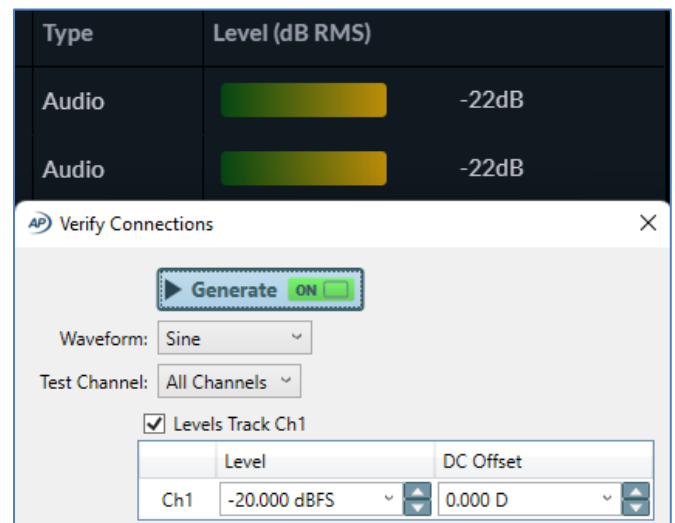


Figure 20. Level meters in A²B Bus Analyzer application showing received audio levels at S/PDIF input on A²B Bus Analyzer.

At this point, you can measure level, frequency response, distortion, crosstalk, delay, rub and buzz, and any other types of audio measurement provided in the APx500 software. For loudspeaker measurements, Acoustic Response is a great place to start. For amplifier test, start with Continuous Sweep.

APx Analyzers



Figure 21. AP586 audio analyzer, with 8 analog outputs and 16 analog inputs, an Advanced Digital IO Module (ADIO) with S/PDIF connections, and an additional Digital Serial module with chip-level I/O (not required).

While the AD2428WB1BZ evaluation board supports 2 analog output channels, a real A²B node may have 4, or 8 or even 16 analog output channels. The Audio Precision APx Series APx526, 585 or 586 analyzers can support these higher channel counts, with up to 16 analog input channels and 8 analog output channels. APx analyzers can also be outfitted with a wide range of digital interfaces, including AES and S/PDIF digital I/O, chip-level protocols such as I²S and TDM, PDM, as well as HDMI and Bluetooth interfaces.

Figure 22 shows an APx500 display showing simultaneous THD+N measurements on 16 input channels. By using our signal [Switchers](#), up to 192 inputs can be measured in a single sequence using multiple Signal Paths in the APx500 software.

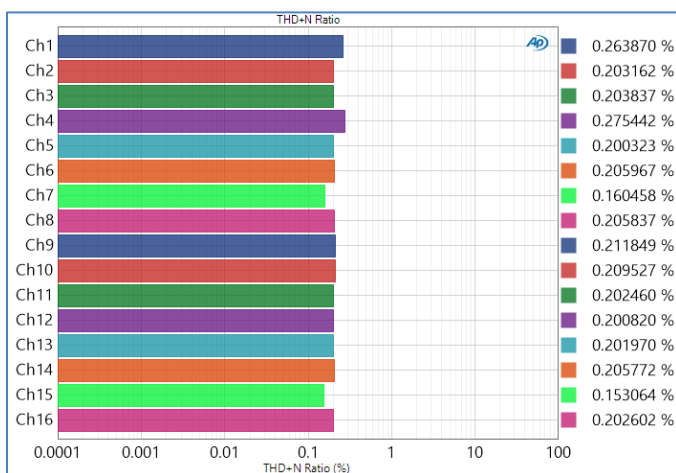


Figure 22. 16 channel THD+N measurement display in APx500.

APx500 can be downloaded for evaluation in Demo Mode from the Audio Precision website at ap.com. Embedded help in the application and the APx500 User's Manual PDF will answer questions about using the APx platform. Also on the website, a broad selection of "Quick Tip" videos provide

brief looks at many aspects of the APx measurements and user interface choices.

Acoustic Test Equipment

GRAS Acoustics sells a variety of measurement microphones, test fixtures, mic power supplies and acoustic calibrators useful for both in-cabin and general-purpose acoustic measurement.

The GRAS [46BL-1 1/4" CCP Pressure Standard Microphone Set, High Sensitivity](#) fulfills the Audio Engineering Society's (AES) recommendations for infotainment system evaluation. The microphone set can be attached to the [GRAS RA0399 holder](#), designed for holding 1/4" measurement microphones in 6 predefined positions, simulating the head positions of a person in a car. The RA0399 array together with the GRAS 46BL-1 fulfills all test demands from the 2023 AES white paper on In-car Acoustic Measurements.



Figure 23. GRAS 46BL-1 microphone set.

The GRAS 12Bx series of power supplies can be used with APx500 software to automatically extract TEDS (Transducer Electronic Data Sheet) data from connected microphones, including microphone sensitivity.



Figure 24. GRAS 12BA/BE/BB (CCP) power supplies (top row) alongside GRAS 12BC/BF/BD (LEMO) power supplies.

The [GRAS 42AG](#) is a sound calibrator that can be used for quick verification of the microphone and microphone signal chain.



Figure 25. 42AG Multifunction Sound Calibrator.

For more information on acoustic test equipment from GRAS, visit grasacoustics.com

Test Setup 2: Acoustic Audio to A²B

In this second example, we are sending analog audio (acoustically) to an ADI evaluation board that is playing the role of a node with microphone input channels. In a real use case, the APx would be connected to a loudspeaker, or perhaps a Head and Torso Simulator (HATS) for characterizing hands-free performance. One or more microphones would acquire the acoustic signal and pass it up the A²B network. The ADI Analyzer would bring it to the APx for analysis via S/PDIF.

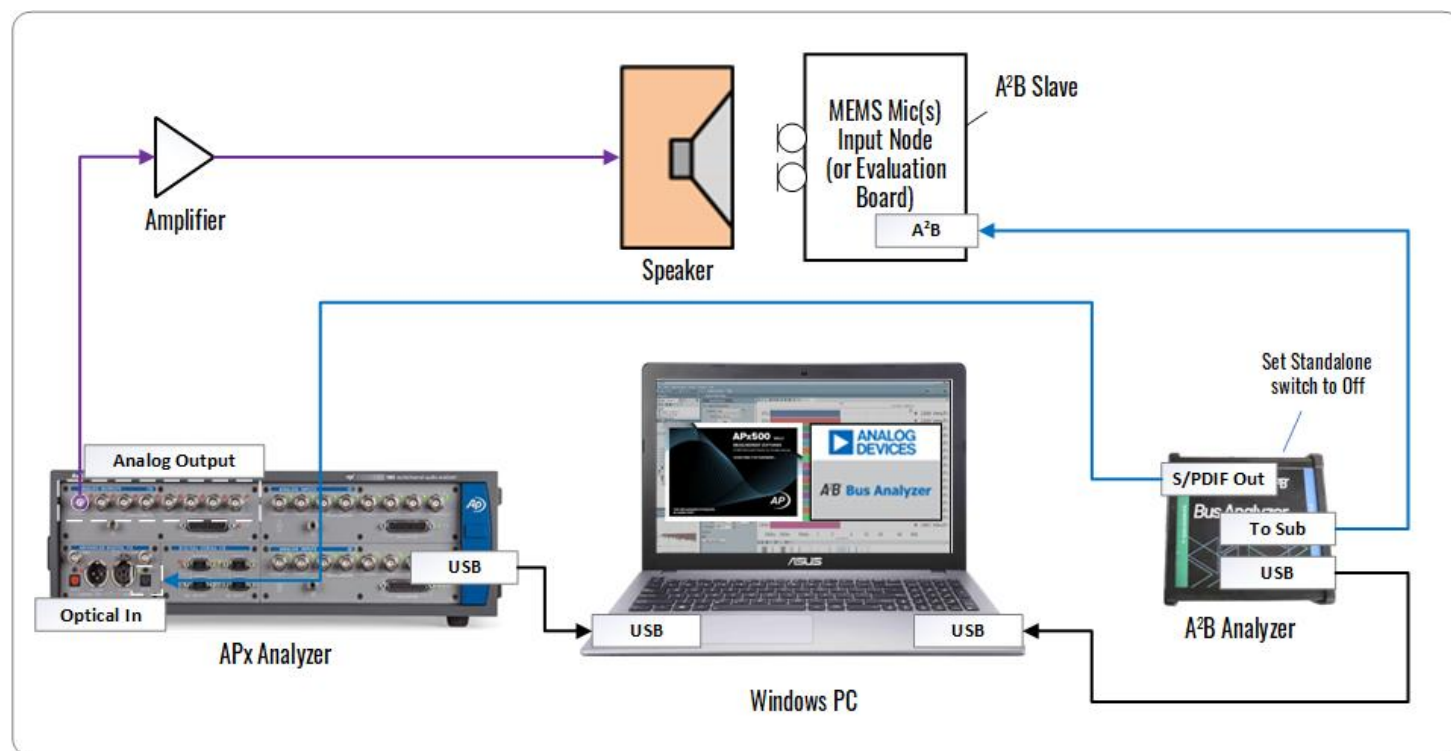


Figure 26. Test Setup 2 showing the PC, audio analyzer, A²B analyzer and evaluation board.

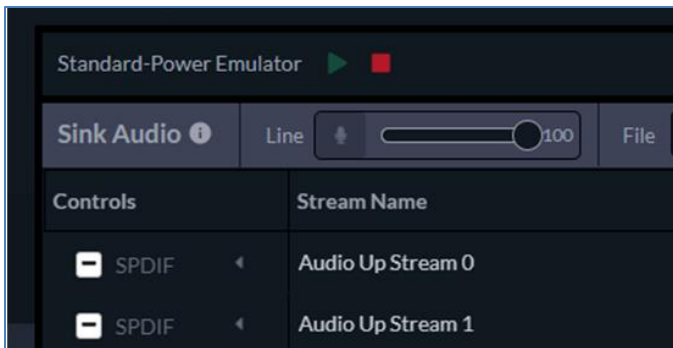
Discovery

The initial steps of configuring the A²B Bus Analyzer Application are the same as the steps detailed in Test Setup 1, beginning on page 6. As before, connect the A²B Analyzer “Towards Sub” port to your device (in our case, the same AD2428WB1BZ evaluation board), using the Node Emulator side of the analyzer.

In the Bus Analyzer app, load the A²B project file “MEMSTest.a2bproj”. From the left-hand column, select the Device tab, then browse for the example network configuration file “MEMSTest.dat”. Click the green Play symbol to initiate discovery.

Audio Stream Routing

Select the Audio tab from the left-hand column. There should be two streams shown under Sink Audio. Under the Controls column, select “SPDIF” for both streams.



The A²B network is now configured to transmit the signal from the two MEMS microphones on the evaluation board to the S/PDIF output on the A²B analyzer.

Configuring APx500

Launch APx500. In Signal Path Setup **Output Configuration**, choose the analyzer Output Connector that connects to the loudspeaker. In our configuration, we are connecting Analog Unbalanced channel one directly to an active loudspeaker. If using an APx1701 Transducer Interface to drive a passive speaker, select Transducer Interface as the output. If using an APx517, select Power Amp.

In **Input Configuration**, choose **Digital Optical**.

Our evaluation board has two MEMS microphones which can be measured simultaneously over S/PDIF. A direct I²S connection to the node via a Digital Serial interface module may be necessary if simultaneous measurement of more than 2 microphones (up to 16) is required.

In the Signal Path Setup Verify Connections panel or the Bench Mode Generator panel, turn the generator on. If setup is successful, you will hear a 1 kHz sinewave playing from the loudspeaker and see a sinewave in the input Signal Monitors.

As discussed on page 9, you can now run any audio measurement provided in the APx500 software.

Software and Device Info

The table below contains information about the software used in the creation of this technote and associated materials.

APx500 Software:	9.0
A ² B Analyzer Firmware:	3.4.19
A ² B Bus Analyzer App:	3.4.61
SigmaStudio+:	2.1.0
SigmaStudio+ A ² B Plugin:	1.3.2
Operating System:	Windows 11

References

Audio Precision:
<https://www.ap.com>

GRAS Acoustics:
<https://grasacoustics.com>

ADI A²B Analyzer information and documentation:
<https://www.analog.com/en/design-center/evaluation-hardware-and-software/evaluation-boards-kits/a2b-bus-analyzer.html>

ADI AD2428WB1BZ evaluation board:
<https://www.analog.com/en/resources/evaluation-hardware-and-software/evaluation-boards-kits/eval-ad2428wb1bz.html>

ADI SigmaStudio+:
<https://www.analog.com/en/resources/evaluation-hardware-and-software/software/sigmastudio-plus.html>

ADI A²B Plugin for SigmaStudio+:
<https://www.analog.com/en/resources/evaluation-hardware-and-software/software/a2b-software.html#software-overview>

A²B information:
<https://www.analog.com/en/applications/technology/a2b-audio-bus.html>