Low-Cost, Low Latency Spatial Audio Rendering with A2B Distribution and Signal Processing

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ABSTRACT

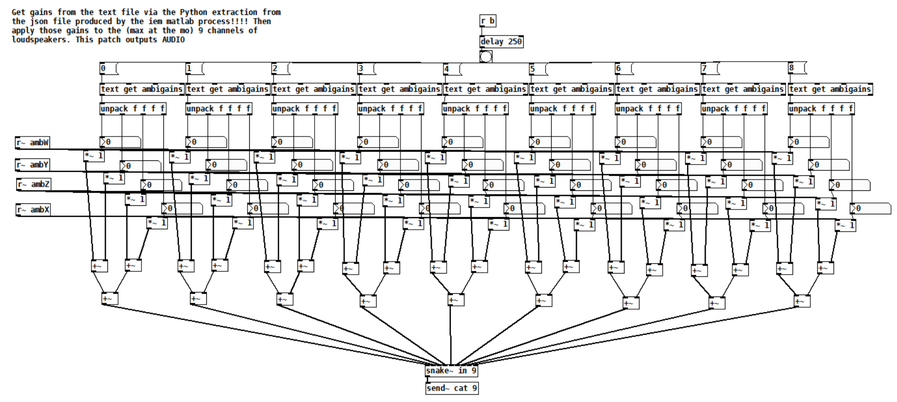
This project demonstrates the creation of a multi-channel spatial audio rendering system using open-source software, cheap non-proprietary hardware and custom-built 3D loudspeakers. The fluid control and choice of rendering algorithms allows users to create and experience spatial audio without the logistical or financial challenges of accessing purpose-built spaces.

The outcome of this work is the provision of a real-time spatial audio processing system that:

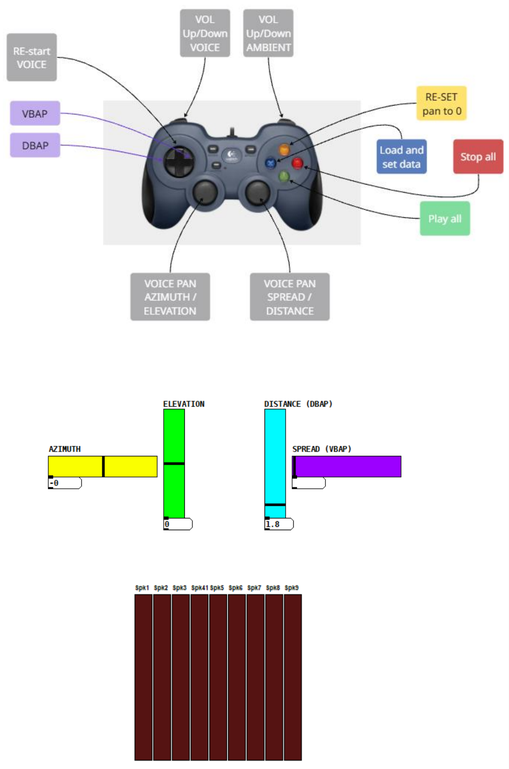
- ✓ Utilises low-cost hardware
- ✓ Can ingest multi-channel audio from analogue and digital audio sources such as USB, Dante / AES67 or even AVB/Milan devices
- ✓ Distributes audio signals and power over distance to distributed end-points using A²B™ communications bus[1] on a single, twisted pair cable
- ✓ Implements low-cost class-D amplifiers with digital (I²S / TDM) inputs
- ✓ Plays back on custom designed, 3D printed loudspeaker enclosures

RENDERING & OBJECT CONTROL IN PURE DATA

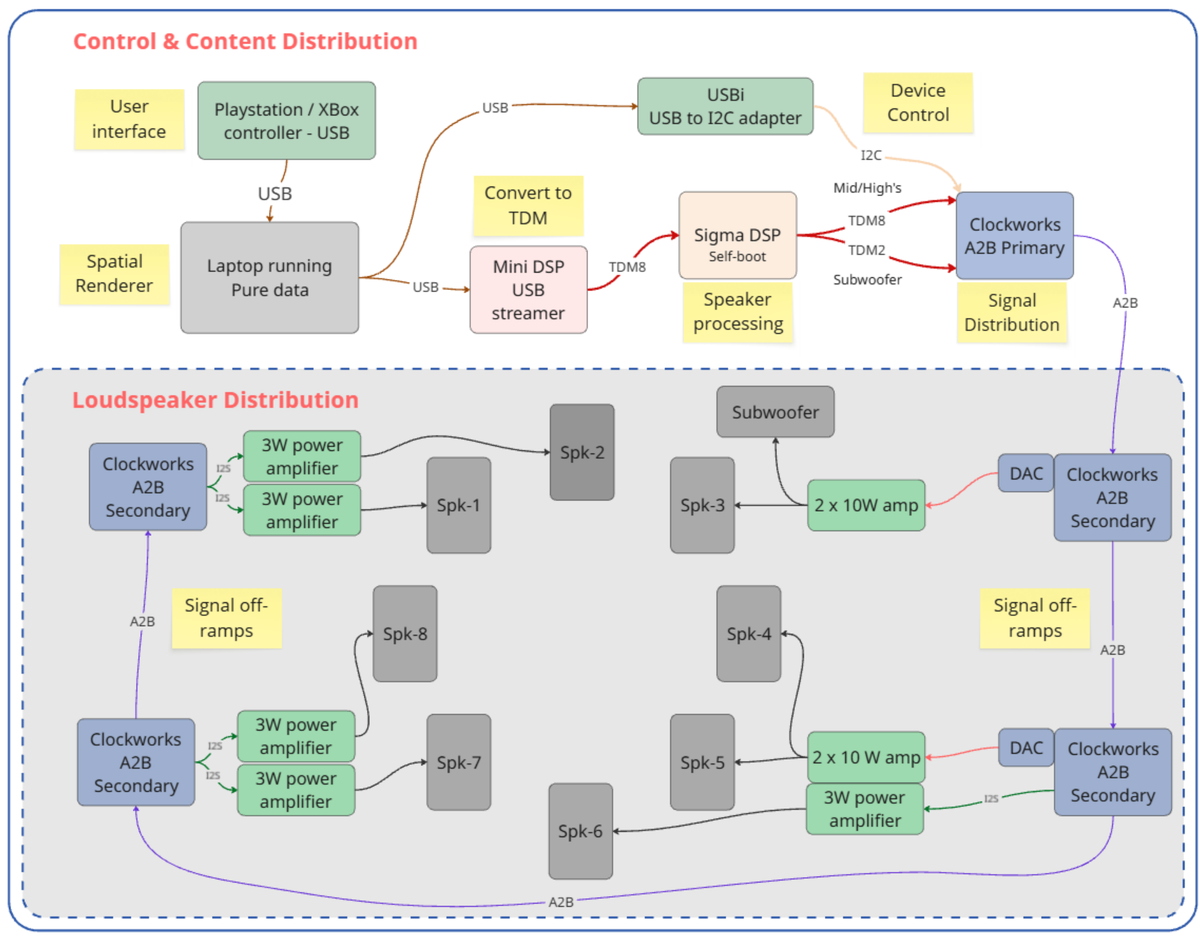
- Provides real time panning in 3D space with a familiar controller.
- Implements DBAP and VBAP algorithms.
- Uses AllRAD for decoding 1st order ambisonics files to the arbitrary loudspeaker arrangement



USER INTERFACE

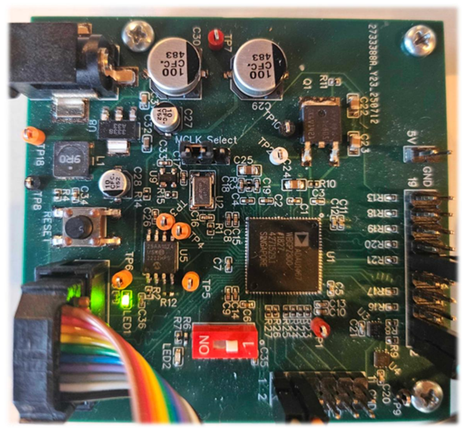


SYSTEM TOPOLOGY



LOUDSPEAKER PROCESSING

We have developed and built a low-cost DSP board (Analog Devices ADAU1467 with self-boot facility) to process loudspeaker signals. This board could contain calibration information for a spatial system, or even provide an OSC-controllable gain matrix for panning (rather than achieve that externally)



SIGNAL DISTRIBUTION VIA A2B

A²B™ (Automotive Audio Bus) was developed by Analogue Devices as a signal pair cable digital audio signal transport system for I2S, TDM, PDM and I2C control. The daisy-chain topology, bus power and low (deterministic) latency makes it ideal for small spatial system implementation.

More information at https://www.analog.com/en/solutions/a2b-audio-bus.html

This system utilises the A2B transceiver and EVM board developed by Clockworks Signal Processing. More information at https://clk.works/products/a2b-products/

Assistance for this project was provided by Brewster LaMacchia at Clockworks

LOUDSPEAKERS

Tiny loudspeakers for portability were designed using spreadsheets, drawn in Rhino (Grasshopper) and 3D printed. We use a 2” Tectonic driver. Form factor suitable for desk-mounting and avoiding nasty internal reflections.

Mid-high speakers - bandwidth to about 200 Hz.

Combined semi-subwoofer from 200 Hz down to 70 Hz.

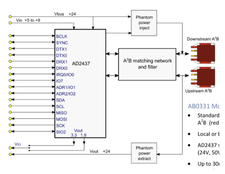
Simple, cheap, light, portable and decent sounding.

Home-made and go-anywhere!

DISCUSSION & FUTURE WORK

- ✓ Get off your headphones and into the real world of spatial audio!
- ✓ We have implemented a system that can be used with commercial spatial audio rendering software via USB-I2S interface and distribution / power of the A2B bus.
- ✓ Create your own entire system using bespoke rendering algorithms and this cheap, effective signal distribution and powering system.
- ✓ Do it yourself – you don’t have to rely on the A$60k (+) boxes which put these systems out of reach for most people.
- ✓ Use commercial loudspeakers by implementing DAC outputs as endpoints
- ✓ Use the bi-directional features of A2B to transport inputs to your DAW.
- ✓ Get away from networked audio!
- ✓ Get dedicated DSP for your loudspeaker system that’s part of the deployment system

OTHER STUFF



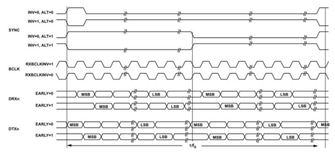


Figure 5-17: Driving Edge = Sampling Edge (I²S Controller)

The *I²C Interface* figure shows the I²C interfaces in a typical A²B system.

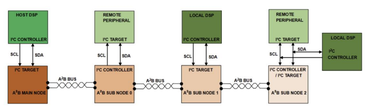
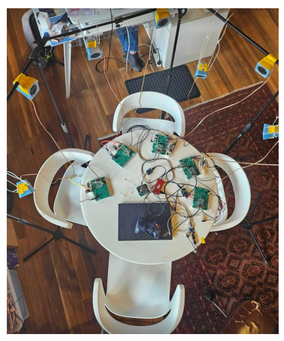


Figure 5-1: I²C Interface



Acknowledgements

Thanks to the excellent ongoing support provided by Clockworks and Analog Devices

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