



Precision Audio Field Control

PROGRAM OBJECTIVE

A client required a concert venue loudspeaker set in which each seat had an ideal listening experience.

The goal:

- Uniform frequency response across the entire seating area
- No preferred listening position; every seat required controlled performance
- High output capability without distortion
- Physically constrained installation footprint

THE TECHNICAL CONSTRAINT

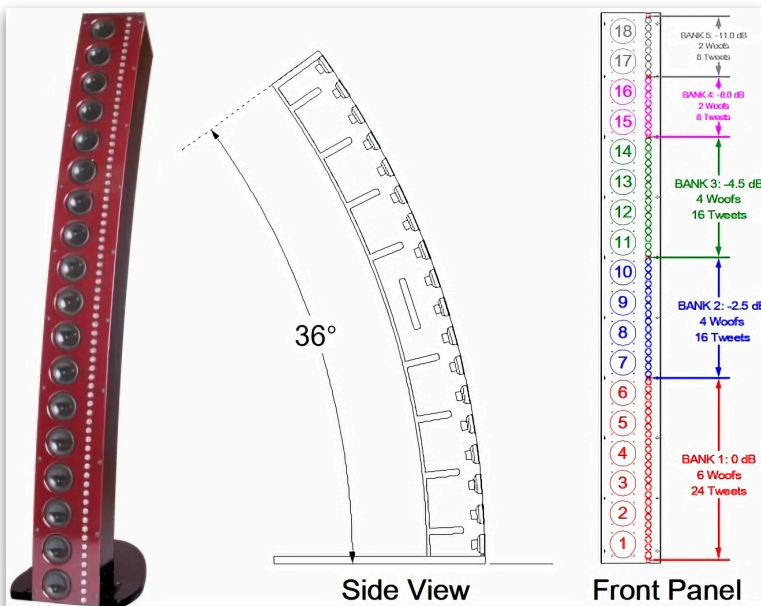
Achieving uniform response across a spatial volume requires:

- Controlled vertical dispersion
- Deterministic amplitude shading
- Precise time-of-arrival alignment
- Phase coherence across the aperture

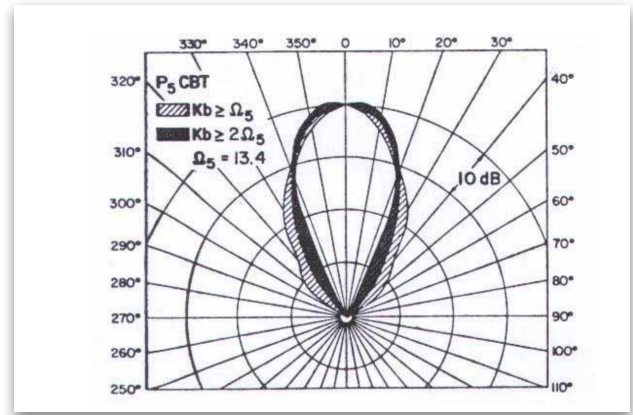
Constant Beamwidth Transducer (CBT) array geometry

CBT theory requires:

- Non-linear amplitude distribution across the array
- Element-specific delay
- Phase correction per transducer



Constant Beamwidth Transducer design selection (Keele, AES 2000)



Beam pattern simulation — Legendre-function amplitude shading across the aperture. (Keele, AES 2000)

WHY CBT

CBT theory, originally developed at the U.S. Naval Research Laboratory for sonar aperture control, uses Legendre-function shading to produce a frequency-independent beam pattern with extremely low sidelobes. The beam pattern is essentially constant above a cutoff frequency and the spatial distribution is independent of distance from the source.

For a discrete transducer array, this means:

- Every element in the array must receive a unique amplitude coefficient derived from the Legendre shading function
- Delay and phase correction must be applied individually per element; the array is curved, so path lengths differ
- All of this must be deterministic and repeatable, not approximated

THE CONSTRAINT AT SCALE

With dozens of transducers in a vertical array, each requiring independent amplitude, delay, and phase correction, the system demanded per-element signal processing. A centralized DSP approach was evaluated and rejected because it introduced a computational bottleneck, created a single point of failure, and increased routing complexity.

Implementation: Distributed DSP at the Transducer Level

WHY WE SELECTED DISTRIBUTED PROCESSING

A decentralized DSP feeding all transducers would:

- Eliminate a computational bottleneck in a central DSP hub
- Decrease routing complexity vs central node
- Significantly increase system flexibility
- Decrease sensitivity to transmission path variation

SYSTEM HARDWARE

- Each node used a TAS5825M DSP amplifier
- We used USB C PD to deliver 240W to each loudspeaker tower
- Partnered with Scanspeak, SB Acoustics, and Kartesian for custom drivers to fit the center-to-center transducer requirements
- All nodes received a shared, relocked and buffered I2S digital backbone
- Each node executed its own processing locally from an I2C config file generated from Texas Instruments Purepath Console software

THE IMPLEMENTATION ARCHITECTURE

Each transducer was paired with its own DSP-enabled amplifier.

- Independent IIR filtering (biquad coefficients via the Texas Instruments export-controlled PurePath Console)
- Amplitude shading
- Precision time delay
- Phase correction

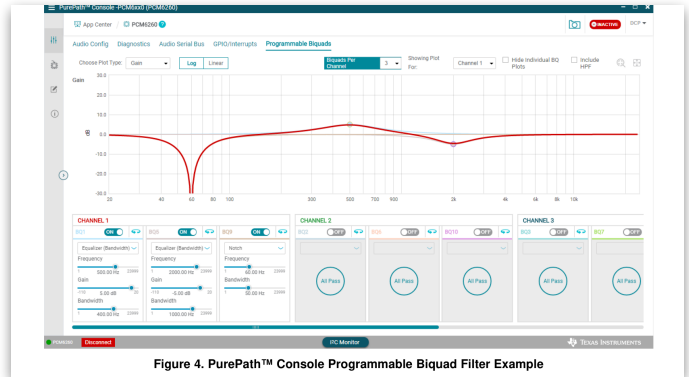
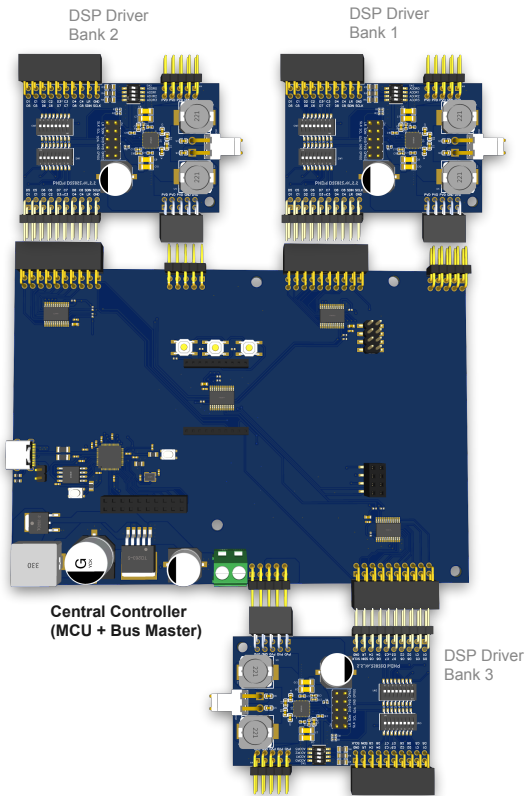


Figure 4. PurePath™ Console Programmable Biquad Filter Example

Per-node IIR coefficient synthesis via PurePath™ Console



Completed Unit Delivered to Customer