

Class-D Audio with Post-Filter Feedback Using MPS Axign Technology

February 2024

Start Time: February 21, 2024 | 8:00 AM PST | 11:00 AM EST | 5:00 PM CET | 12:00 PM CST | 7:00 PM EAT



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Introduction

- Axign is a fabless semiconductor company based in the Netherlands
 - Founded in 2014
- Two locations in NL:
 - Enschede (HQ)
 - Nijmegen
- Long relationship between Axign and MPS due to complementary IP
- Axign acquired by MPS at the beginning of 2024
- Presenter:
 - Olaf van der Meer
 - Business Development Mgr.
 - Background in Axign's Applications & Customer Support Team

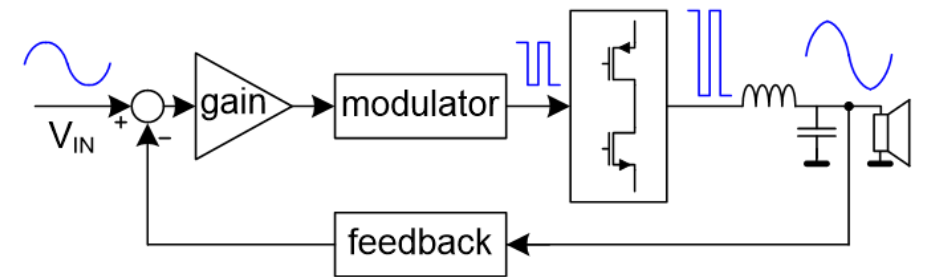
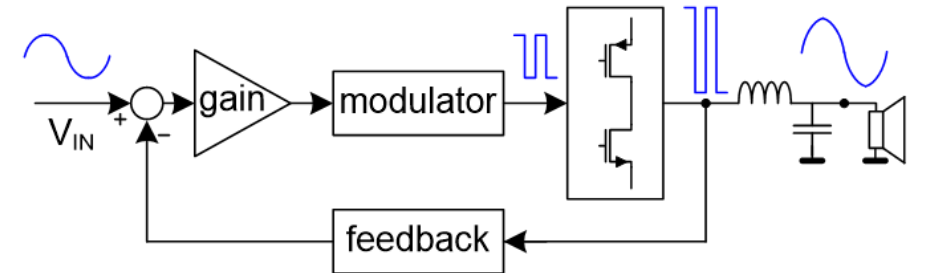
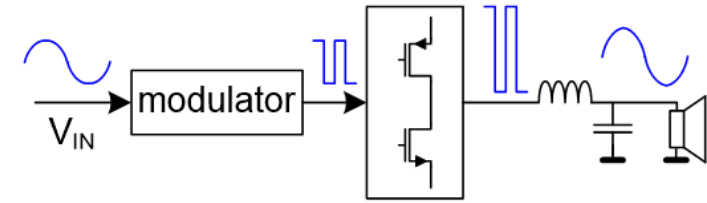


"Axign is excited to announce that we are now a part of Monolithic Power Systems. Our unique audio technology and expertise, coupled with MPS' manufacturing, product breadth, and system-level expertise will enable us to offer industry-leading audio solutions without compromise."



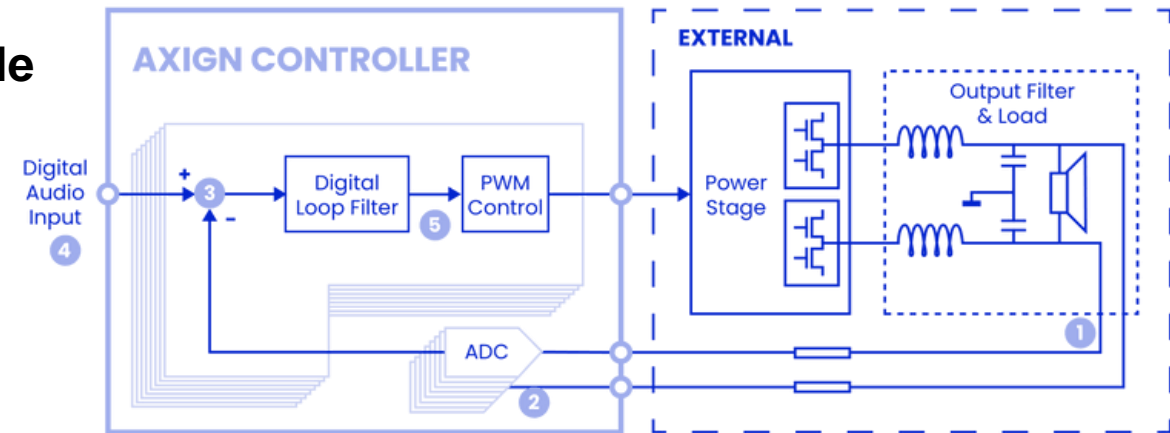
Post-Filter Feedback in Class-D Audio

- What is class-D audio?
 - Switching audio amplifier
 - Modulator creates PWM/PDM
- What is post-filter feedback (PFF) in Class-D audio?
 - PFF implies taking the feedback point after the output filter
- Feedback suppresses noise and distortion in the forward path
 - Errors in the modulator
 - Errors in the power stage
 - PFF corrects errors in the output filter as well
- THD+N in the feedback path cannot be corrected
 - High-quality feedback is key



Fully Digital Feedback Loop Design

- In the analog domain, parameter spread will present a limitation
 - High-order feedback loop designs will have smaller margins of stability
- Digital feedback loops are **consistent** and **programmable**
 - Digital coefficients are loaded on start-up
- Programmable feedback loops can be fine-tuned to:
 - Performance requirements
 - Lowest power dissipation
- Ultimately, quality of a feedback system is limited by the quality of the feedback path
 - High-resolution analog-to-digital converter (ADC) is required
 - Patented ADC technology is cornerstone of Axign technology solutions



Fully Digital Feedback Loop - Products

- 2-CH and 4-CH controllers for post-filter feedback available now
- Power-stages and DC-DC available from MPS
- AX5688 and AX5689 are power-stage agnostic
- More MPS Axign products are in development

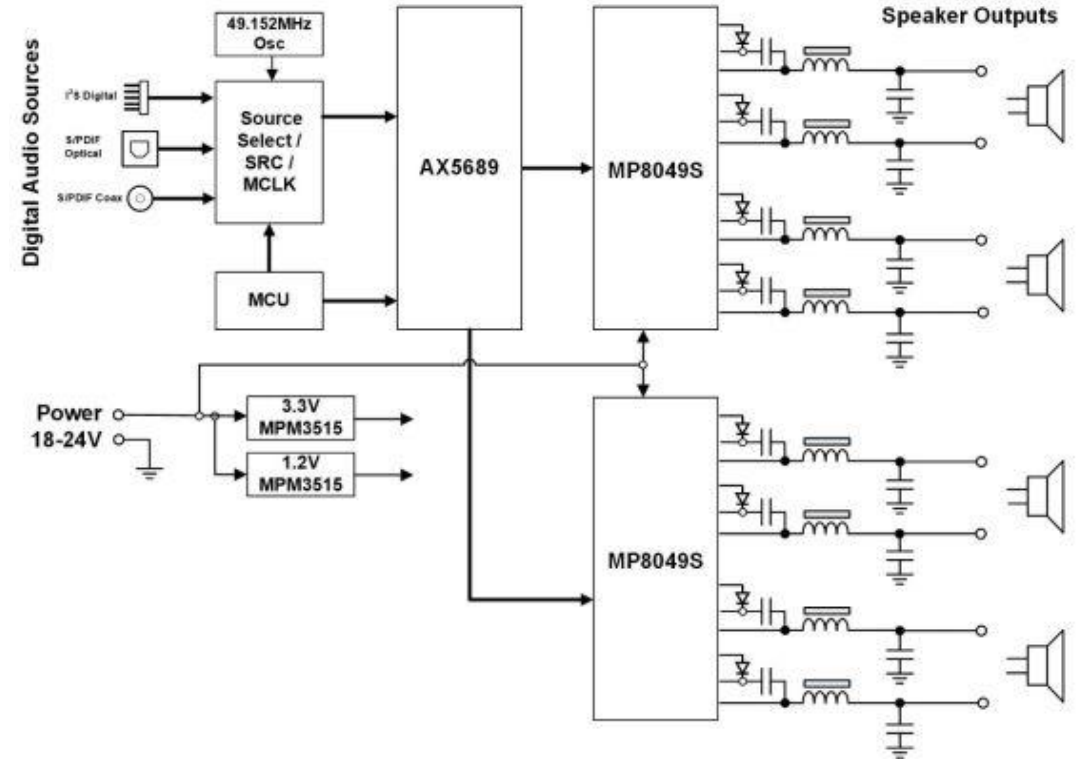
AX5688

Digital Audio Converter and Amplifier Controller (2-ch BTL / 1-ch PBTL)



AX5689

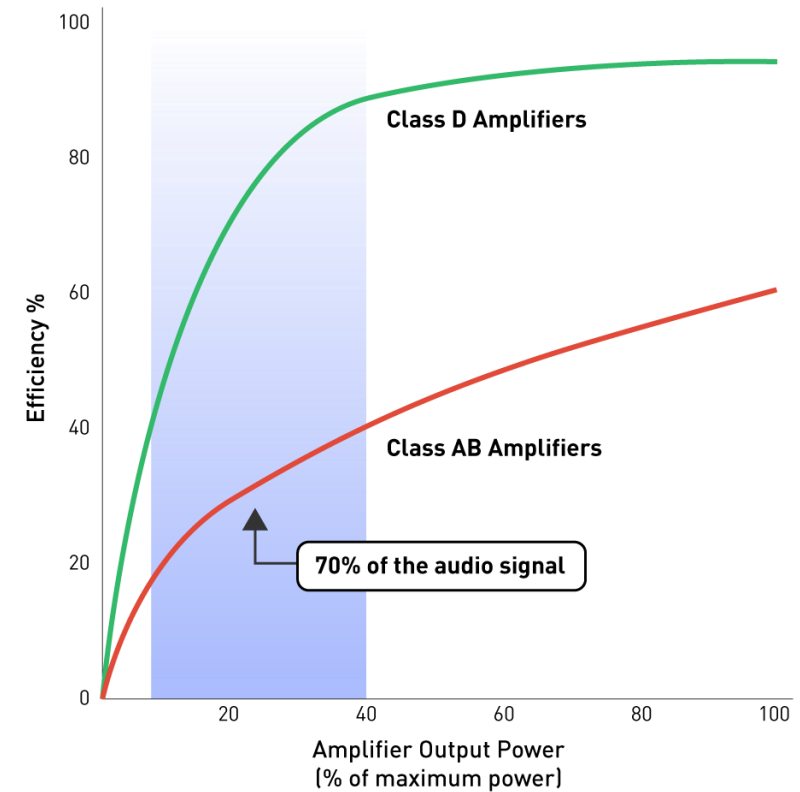
Digital Audio Converter and Amplifier Controller (4-ch BTL / 2-ch PBTL)



High-Efficiency Audio Amplification

High-Efficiency Audio Amplification

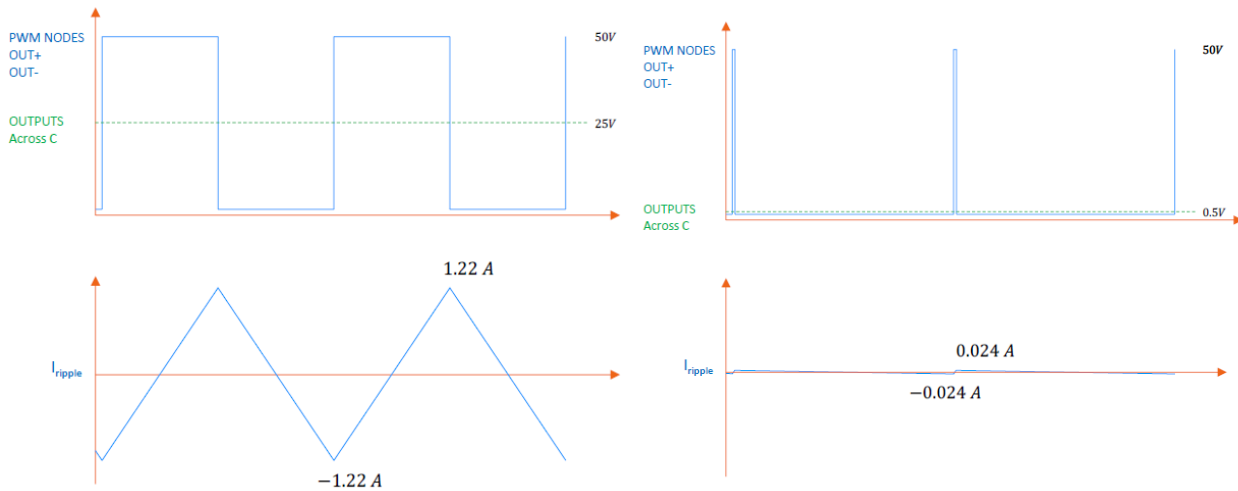
- Class-D is traditionally popular due to its high efficiency
- Typical audio content contains very low average power
- Losses at normal listening levels are largely determined by:
 - Switching losses
 - Ripple losses



- Switching losses largely occur due to the (parasitic) capacitance charging and depleting
- Ripple currents run through the power stage and output filter inductors
 - Maximum ripple at low outputs in traditional Class-D amplifiers
- This means wasting the most energy while at realistic listening levels!

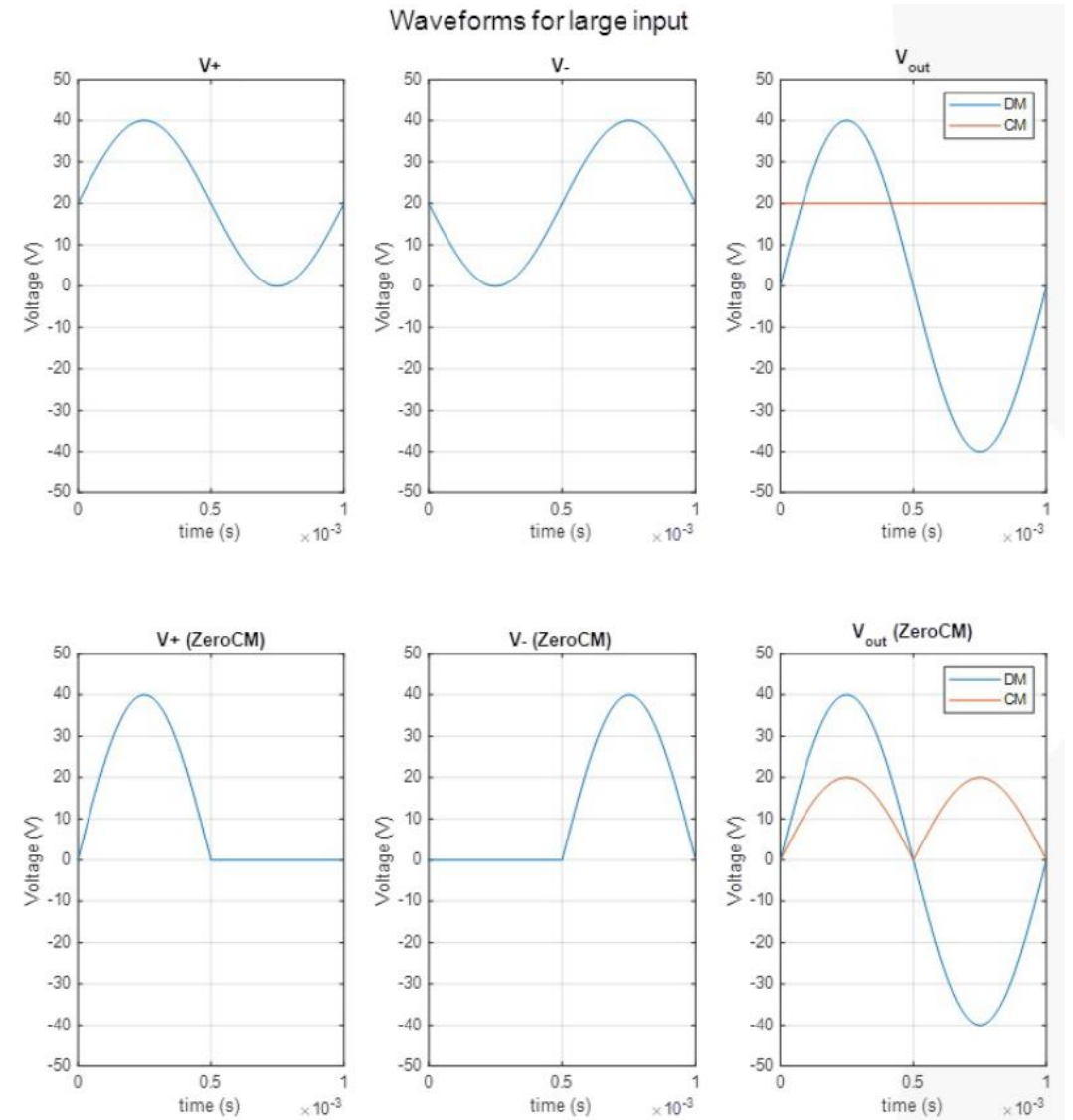
High-Efficiency Audio Amplification

- Fix both switching losses and ripple losses with one solution:
 - **Zero common-mode (ZCM) switching**
- Only one side switches, reducing switching losses drastically
- Eliminates ripple currents for very small signals



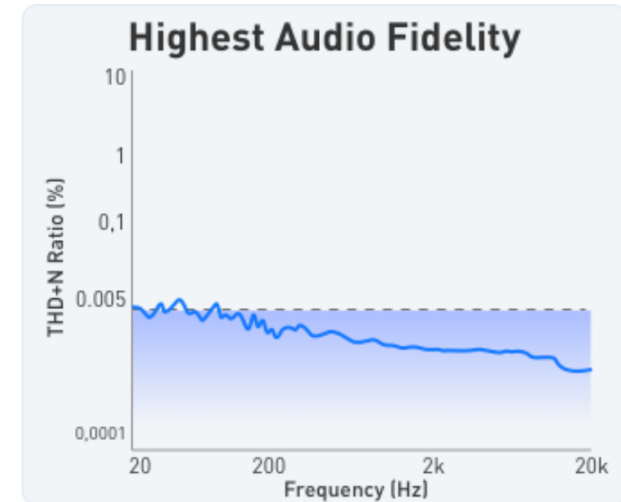
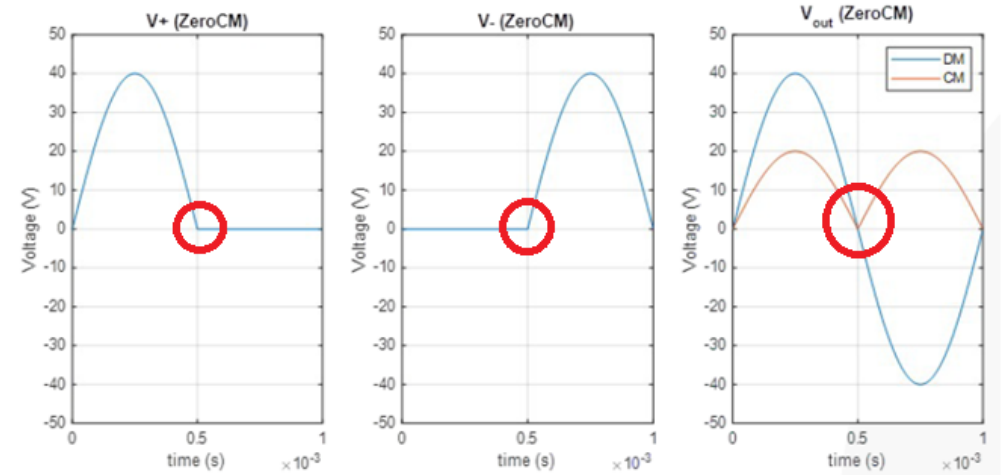
BD Modulation

ZCM Modulation



High-Efficiency Audio Amplification

- Traditionally causes significant (crossover) distortion
- Distortion in the audio band is eliminated by high loop gain
- THD+N well below 0.005% is possible
 - Frequency independent
 - Load independent

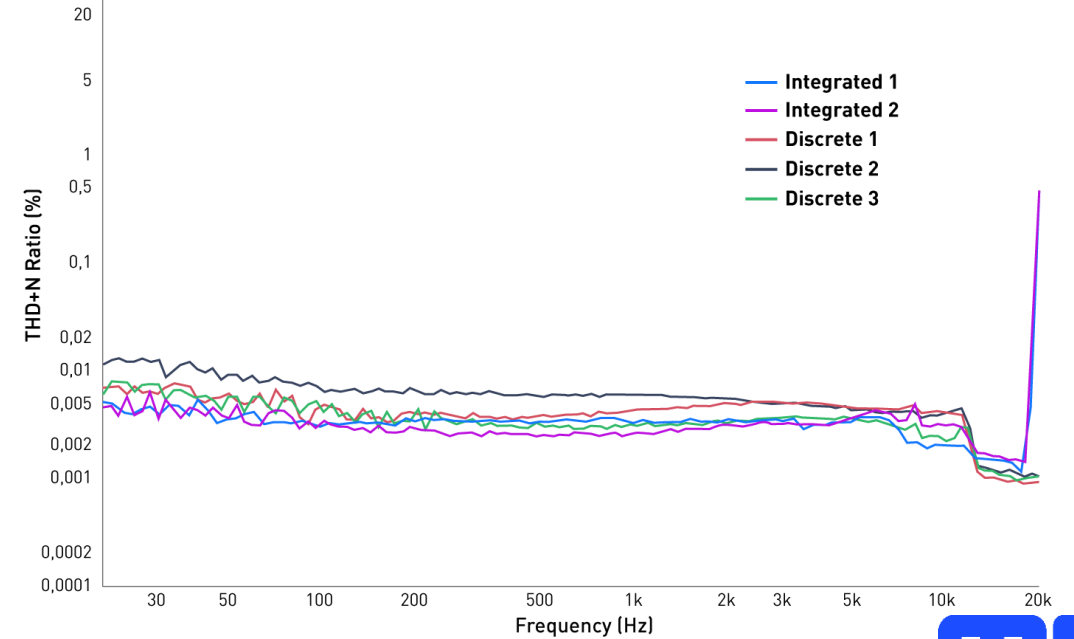
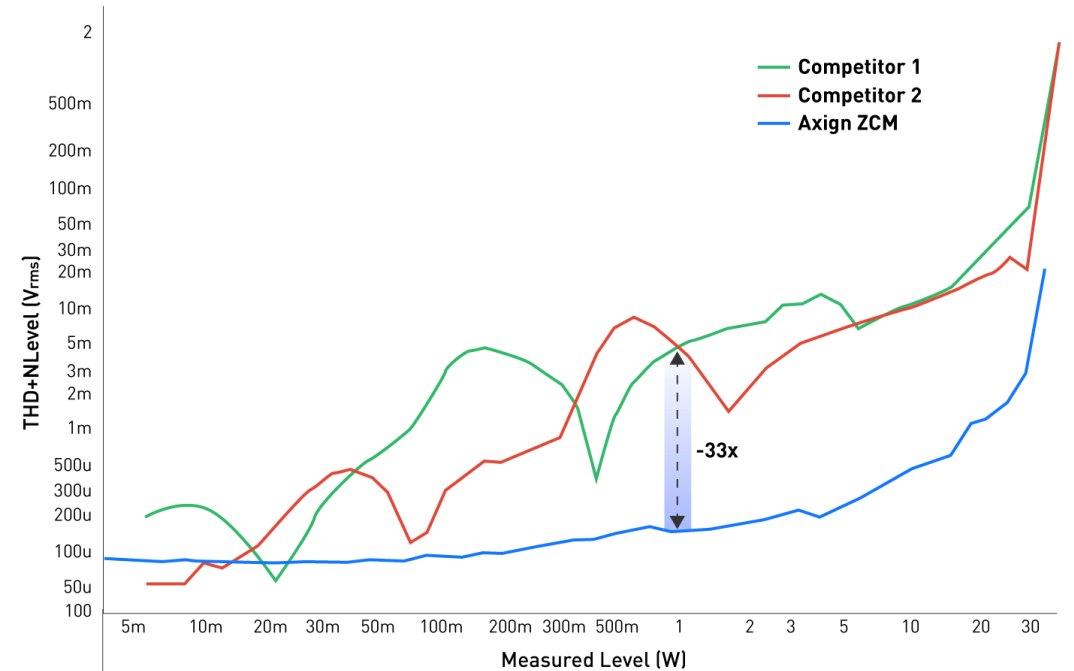


Combining extremely low losses with high audio quality, no compromise

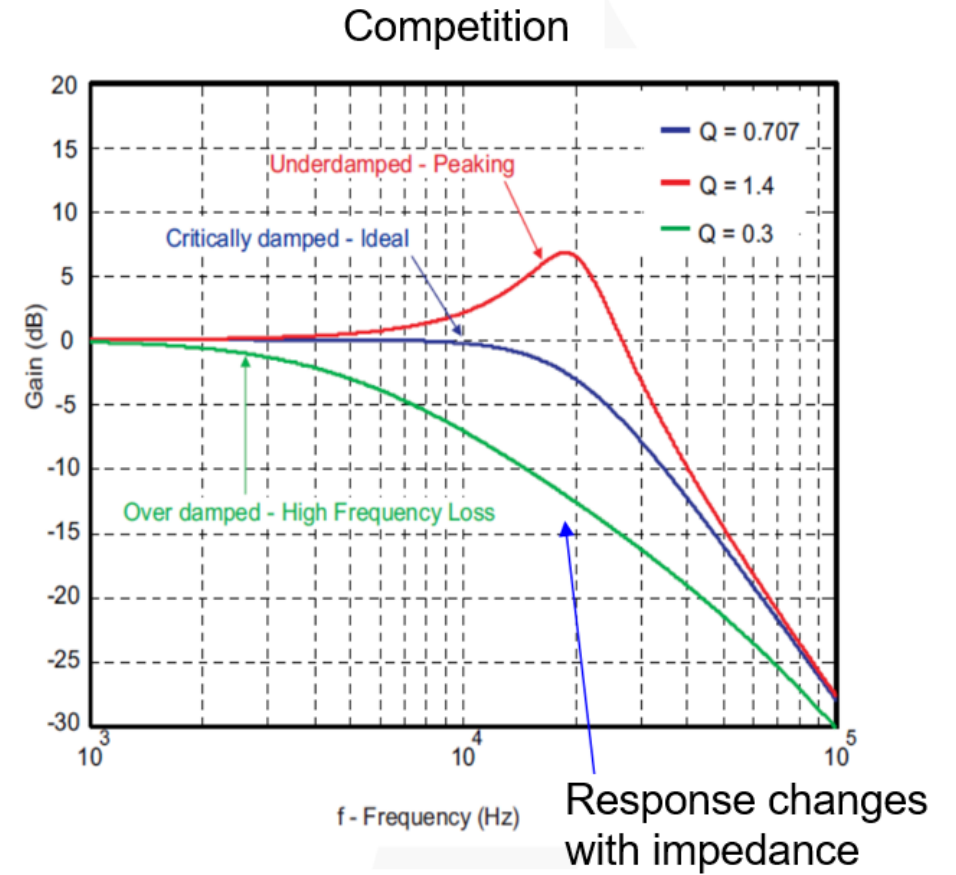
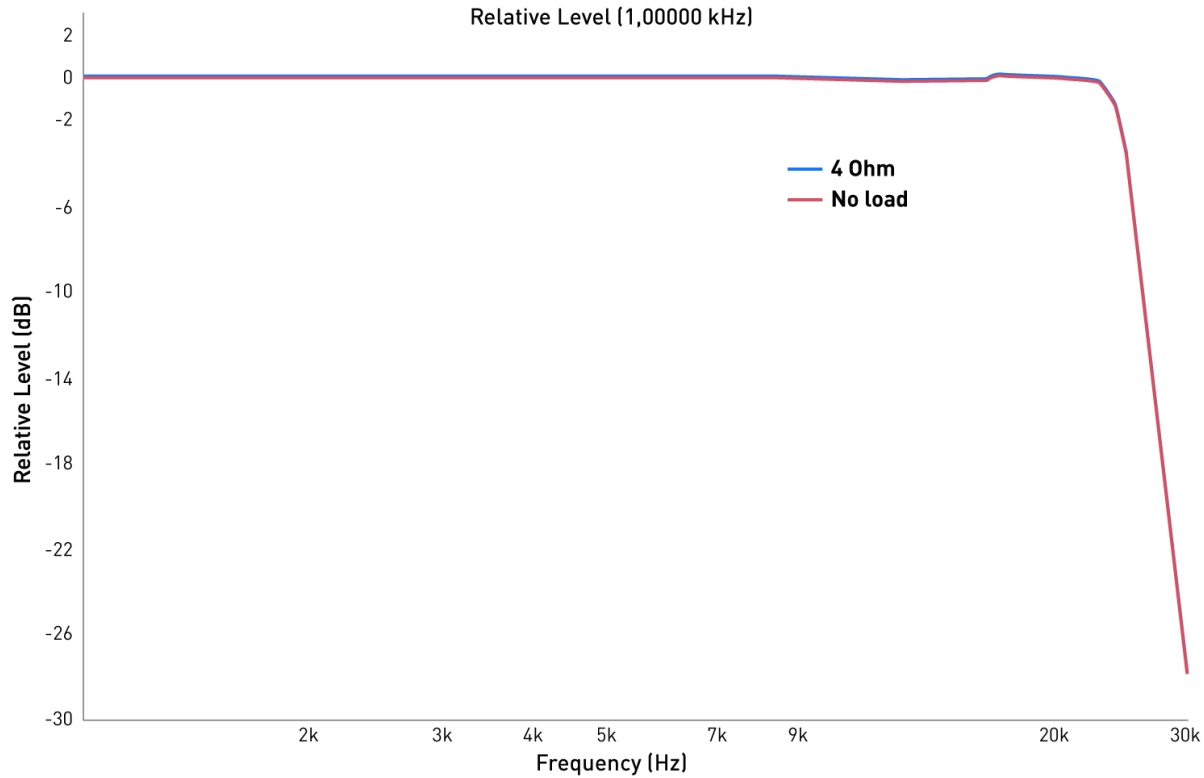
Audio Quality

Audio Quality

- What determines high audio quality?
- Distortion
 - The “oof” feeling at high volumes
 - The human ear is incredibly sensitive to distortion
 - Distortion commonly caused by output inductors
- MPS Axign’s feedback loop has tight control at all output levels
- Low total harmonic distortion (THD) throughout the audio band
 - With a large variety of power stages



Audio Quality

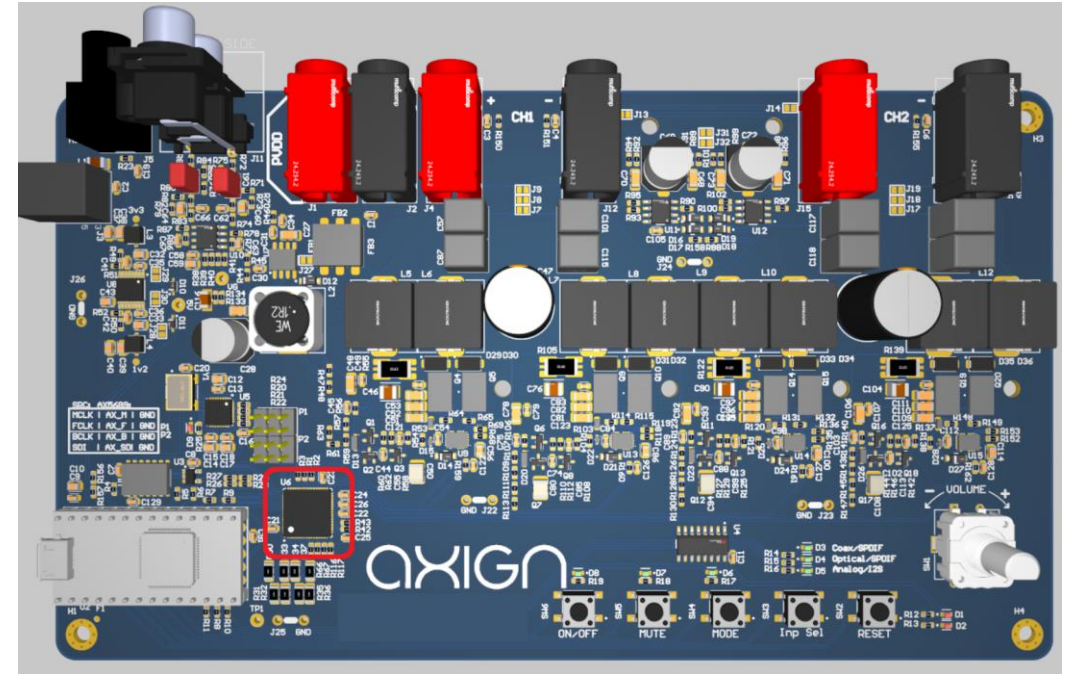


- MPS Axign technology creates extremely flat frequency response with minimal phase shift in the audio band
- Independent on speaker load!
- No smearing of the sound, instruments are distinct and precise

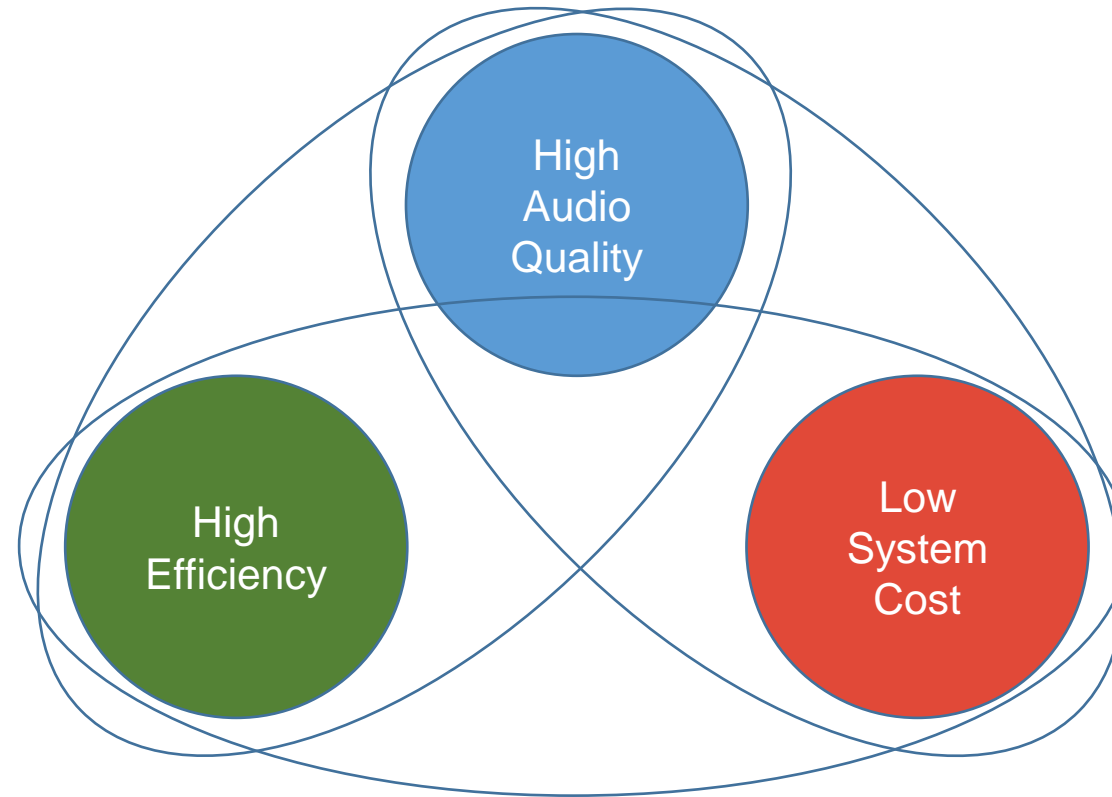
Cost-Effective Solutions

Cost-Effective Solutions

- Heatsinkless
 - Proven in practice
- Remove fans from enclosure
- No constraint on inductor performance
 - Design freedom
 - Lower-cost inductors possible
- Power stage agnostic
 - Cheap parts can be used (including motor drivers)
 - High dead time or low-performance power stages are no issue due to feedback
- Lower power supply requirements
 - Extremely high PSRR due to feedback

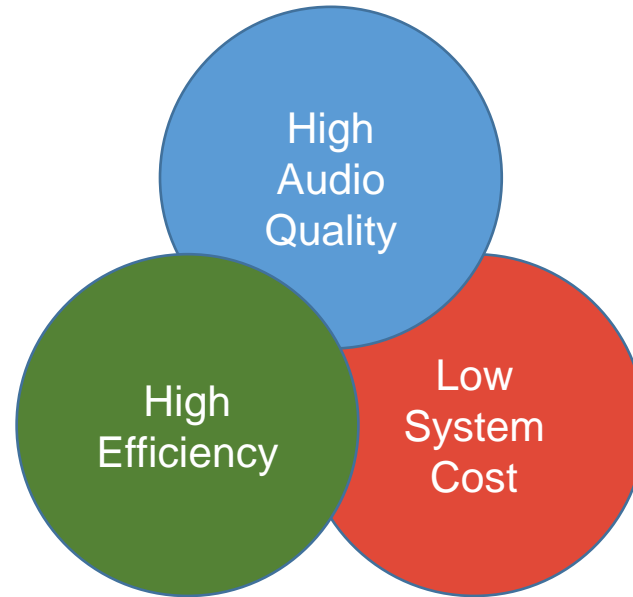


Design Objectives



With traditional amplifier solutions,
audio designers are forced to choose two...

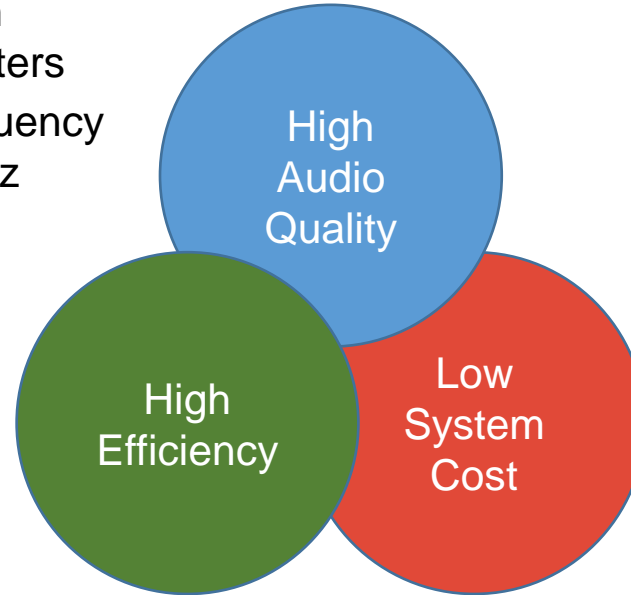
Design Objectives



...but with post-filter feedback,
audio designers can achieve all three!

Design Objectives

- High Audio Quality
 - Compensates for distortion introduced by the output filters
 - Load-independent flat frequency response from DC to 40kHz
 - THD+N < 0.005%



- Low System Cost
 - Eliminate heatsink
 - Low-cost, nonlinear inductors
 - Easy choice for power stage and power supply

- High Efficiency
 - Zero common-mode (ZCM) operation minimizes losses for realistic audio levels

Summary

- Fully digital feedback loops have distinct advantages over analog feedback loops
 - Configurable
 - No component spread
- MPS Axign technology is built on (patented) ADC and mixed-signal expertise
 - Enables the best audio feedback loops
- Zero common-mode (ZCM) switching drastically reduces power losses
 - Ripple currents are drastically reduced for realistic listening levels
 - Switching losses reduced, only one side switches at a time
- Noise and Distortion in the audio band are suppressed by high-order feedback loop
- Extremely flat and load-independent frequency response due to post-filter feedback (PFF)
- Highest audio quality, lowest power losses, cost-effective solution
 - No compromise!

Next Webinar

MPS Axign Class-D Technology Deep Dive

Webinar: MPS Axign Class-D
Technology Deep Dive

Tuesday, March 5th

MPS



Please join us for our upcoming webinar: MPS Axign Class-D Technology Deep Dive. Post-filter feedback in our solution is enabled by the low-latency analog-to-digital converter (ADC) and our high-speed digital signal processing capabilities. This deep dive will walk you through the signal path of a generic MPS Axign-enabled Class-D amplifier solution, starting at the input signal and how it traverses to the speaker terminals via our digital IP.

The following topics will be covered in this webinar:

- Low-Latency ADC Design
- Configurable Digital Filter
- Pulse-Width Modulation (PWM)

We will be presenting the same content 2 times. Please select the day and time that works best for your location.

Session 1: March 5, 2024 | 1:00 AM PST | 4:00 AM EST | 10:00 AM CET | 5:00 PM CST | 12:00 PM EAT

Session 2: March 5, 2024 | 8:00 AM PST | 11:00 AM EST | 5:00 PM CET | 12:00 PM CST | 7:00 PM EAT

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Q&A