Application Note

Getting Started with AVB

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Abstract

Audio video bridging (AVB) technology can be used with Ethernet to enable communication and synchronized playback of audio data. Additionally, TI PHYs offer features to reduce system complexity when implementing AVB.

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1 Introduction

Audio video bridging (AVB) is a technology used to transmit synchronized audio or video data through an Ethernet network, as defined in IEEE 1722. While it has broad applications, this application note focuses on the use of AVB in automotive applications, where it is primarily used for synchronized audio.

The need for network-based synchronized audio is driven by the transition from domain controller architectures to zonal controller architectures. In a zonal architecture, zones are typically connected through Ethernet. Amplifiers can be located in each of the zones, creating a distributed amplifier architecture. This enables several benefits:

- **Cable harness cost reduction:** Traditional point-to-point wiring harnesses are heavy and expensive; by routing audio and control signals over a centralized Ethernet backbone, significant cost and weight savings are achieved.
- **Multi-purpose communication bus:** A single Ethernet bus can carry audio streams, control data, sensor information, and diagnostics simultaneously, reducing system complexity.
- **Distributed amplification:** Rather than a centralized head unit driving all speakers, small amplifiers placed near each speaker zone receive synchronized audio over Ethernet, enabling more flexible and scalable audio architectures.

1.1 Architecture Comparison

1.1.1 Domain Architecture

In a domain architecture, audio processing and amplification is typically centralized within the vehicle. An impact of this is that amplified audio signals must be transmitted throughout the vehicle to the speakers. This increases cable harness cost and weight.

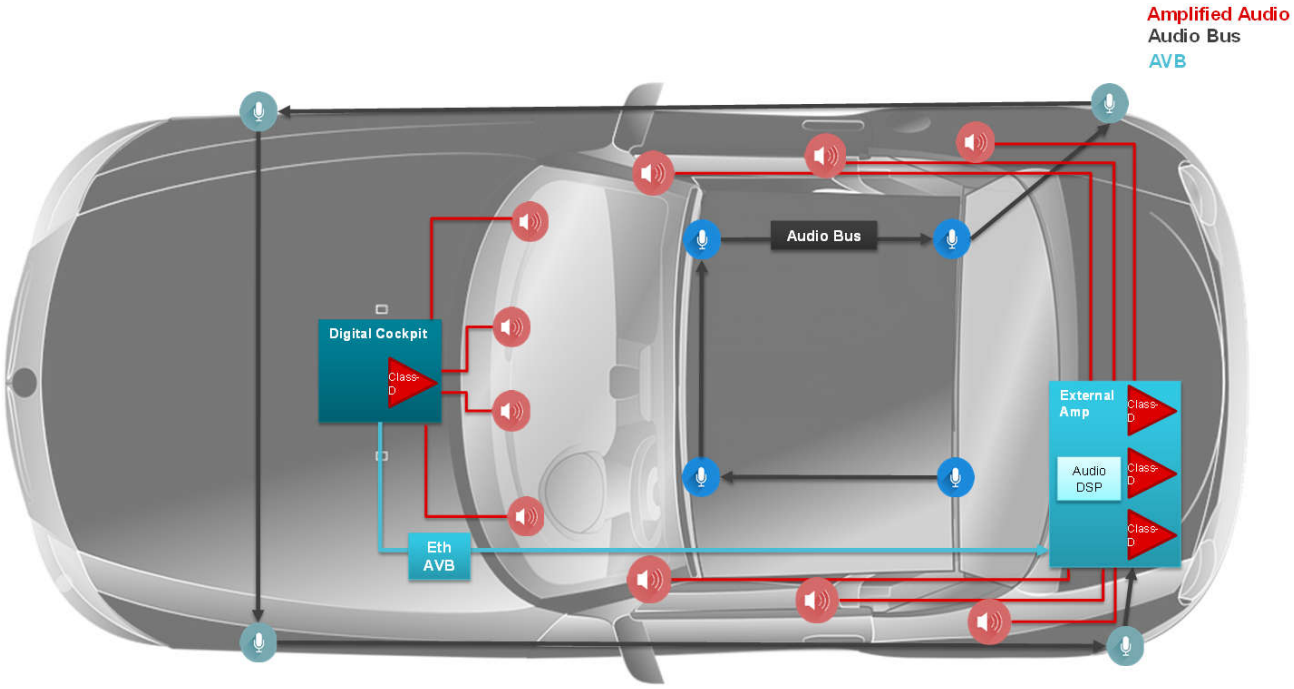


Figure 1-1. Domain Architecture

1.1.2 Zonal Architecture

A zonal architecture decentralizes the audio decoding and amplification to zonal ECUs throughout the vehicle. Audio data can be transmitted between zones using communication (Ethernet) that is shared with other functions. Because ECUs are located closer to speaker positions, this helps reduce the cost and weight of speaker cable harness.

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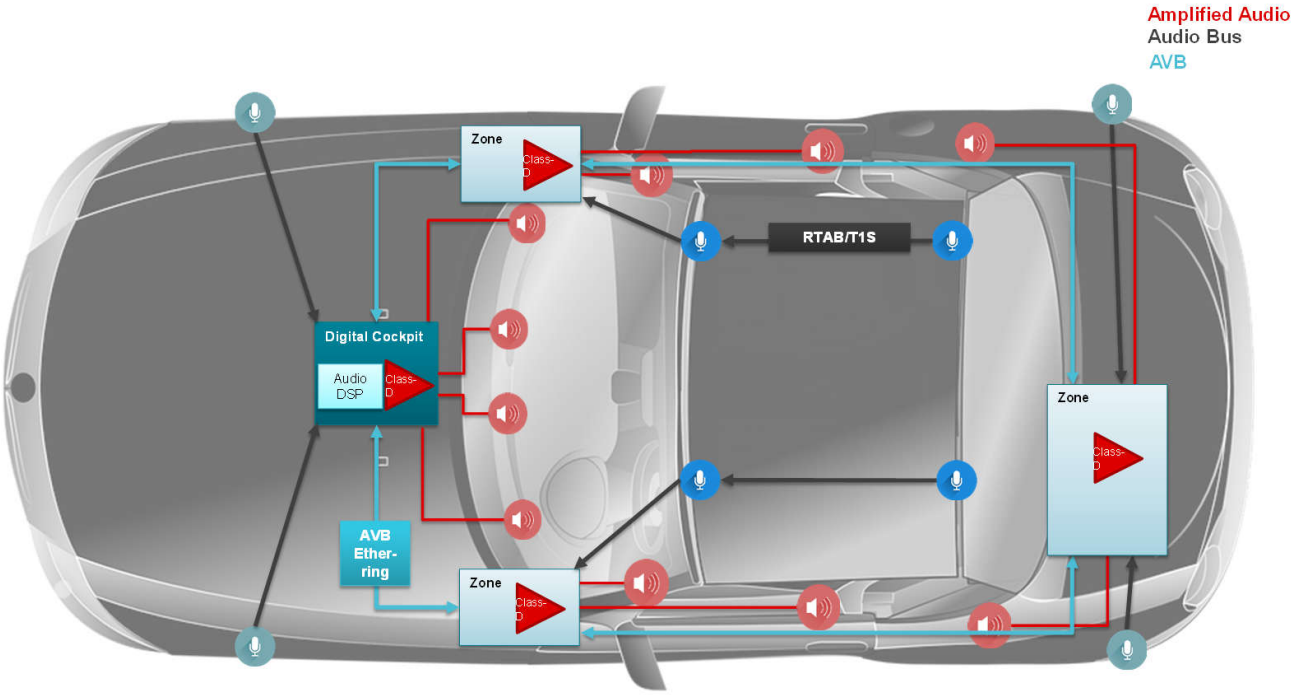


Figure 1-2. Zonal Architecture

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2 AVB Topology

2.1 Role of TSN

Time-sensitive networking (TSN) is the foundation that enables AVB, based on the IEEE 802.1AS specification. TSN enables synchronization of "wall clocks" on each node across a network. This is critical, as CRF and AVB packets leverage time stamps to enable synchronized clocks and data across the network. These timestamps inform listeners when they must present the data associated with the timestamp, often referred to as presentation time. Since each listener's clock has been synchronized through TSN, this enables listeners to present audio data at the same time, enabling synchronized audio.

Using TI PHYs with IEEE802.1AS support, time synchronization accuracy on the order of tens of nanoseconds can be achieved. In comparison, MAC level time synchronization is commonly on the order of microseconds.

2.2 Role of Talker

The talker is the source of audio content on the AVB network. It encapsulates audio data into IEEE 1722 (AVBTP) packets and transmits them onto the network. There are two key types of talker streams in automotive AVB:

- **Clock Reference Format (CRF) Talker:** Generates and transmits CRF packets containing timestamps spaced according to the period of the audio sample rate. For example, if audio is sampled at 48KHz, timestamps within a CRF packet would be spaced by:

  $$\frac{1}{48\text{KHz}}s \quad (1)$$

  These timestamps are also padded with the maximum network transit time so that listeners receive the timestamps before the time encoded by the timestamp has passed.
- **Audio Talker:** Encapsulates audio samples in IEEE 1722 packets and attaches a presentation time to each packet. This presentation time specifies the exact moment at which the audio must be played at all listener endpoints, providing synchronous playback across the network.

2.3 Role of Listener

Listeners are the receiving endpoints (for example, zone amplifiers). Each listener performs two functions:

- **CRF Decoding and Clock Alignment:** The listener decodes incoming CRF packets and uses the embedded timestamps to align its local media clock (FSYNC) and bit clock (SCLK) to the network-wide clock reference. This is the mechanism by which all amplifiers in the vehicle play audio in synchrony.
- **Audio Decoding and Presentation:** The listener decodes incoming IEEE 1722 audio packets and holds the audio data in a buffer until the specified presentation time, at which point the audio is released to the digital amplifier for playback.

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3 AVTP Audio Format

The audio video transport protocol (AVTP), defined in IEEE 1722, specifies the Layer 2 encapsulation format used to transport time-sensitive audio streams across an AVB network. AVTP Audio Format (AAF) packets carry raw audio samples along with the metadata needed for synchronized playback.

In addition to audio data, a key part of the AAF packet is the presentation time. This informs the listener when to play the audio packet.

<table>
<tr><td colspan="4">Ethernet Header
Destination MAC, Source MAC, Ethertype</td></tr>
<tr><td colspan="4">AVTP Common Stream Data Header
Stream ID, Timestamp</td></tr>
<tr><td colspan="4">AAF Header
Audio data format, audio data length</td></tr>
<tr><td colspan="4">AAF Data</td></tr>
<tr><td>Audio Sample 1</td><td>Audio Sample 2</td><td>Audio Sample 3</td><td>Audio Sample 4</td></tr>
<tr><td>Audio Sample 5</td><td colspan="2">...</td><td>Audio Sample N</td></tr>
</table>

Figure 3-1. AAF Packet Structure

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4 Clock Reference Format

CRF packets carry only clock timestamp information, allowing listeners to recover and regenerate the talker's media clock locally without requiring locked network latency. A typical CRF packet carries multiple clock edge timestamps, which enables clock synchronization for listeners

<table>
<tr><td colspan="4">Ethernet Header

Destination MAC, Source MAC, Ethertype</td></tr>
<tr><td colspan="4">AVTP Common Stream Data Header

Stream ID</td></tr>
<tr><td colspan="4">CRF Header

CRF type, clock frequency, number of timestamps</td></tr>
<tr><td colspan="4">CRF Timestamps</td></tr>
<tr><td>Timestamp 1</td><td>Timestamp 2</td><td>Timestamp 3</td><td>Timestamp 4</td></tr>
<tr><td>Timestamp 5</td><td colspan="2">...</td><td>Timestamp N</td></tr>
</table>

Figure 4-1. CRF Packet Structure

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5 Advantage of TI PHYs for AVB Applications

5.1 BOM Reduction

In a typical system, an external clock generator is required in order to supply I2S/TDM audio clocks. TI's AVB PHYs reduce the system BOM by supplying the audio clocks necessary for communicating I2S/TDM data, removing the need for an external clock generator.

5.2 Reduced Software Complexity

In a typical system, the MAC has to decode CRF packets and facilitate a feedback loop with the clock generator in order to synchronize the audio clocks with the timestamps in the CRF packets. TI's AVB PHYs handle this synchronization by decoding the CRF packets and adjusting its own audio clocks. This reduces software requirement on the MAC.

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6 Summary

As vehicles transition from domain based architectures to zonal architectures, AVB technology can be used to enable synchronized audio throughout vehicles. This comes with the benefit of reducing cost and weight of audio cable harnesses. Using TI PHYs for audio clock generation can additionally simplify design complexity and reduce cost by removing the need for an external clock generator.

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7 References

- Texas Instruments, DP83TC818-Q1 Design Resources site
- Texas Instruments, DP83TG721-Q1 Design Resources site
- IEEE, IEEE Std 1722-2025

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