Design Guide: TIDA-020033

Automotive Class-H Audio and Tracking Power Supply Reference Design

Description

This reference design demonstrates a Class-H audio and tracking power supply audio subsystem. The TAS6584-Q1 audio amplifier tracks the envelope of the digital audio input and adjusts the LM5123-Q1 boost output voltage to meet the power efficiency requirements without the need for an external microcontroller. This design leads to improved efficiency, thermal performance, and a smaller total footprint. In addition, this reference design allows for a Class-H implementation to be plug-and-play with minimal software changes to the rest of the automotive audio architecture.

Resources

TIDA-020033	Design Folder
TAS6584-Q1	Product Folder
LM5123-Q1	Product Folder

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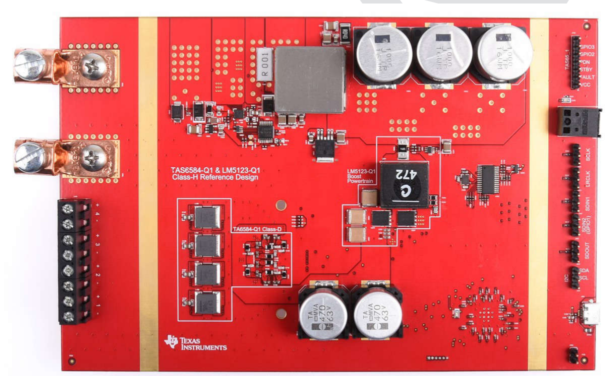
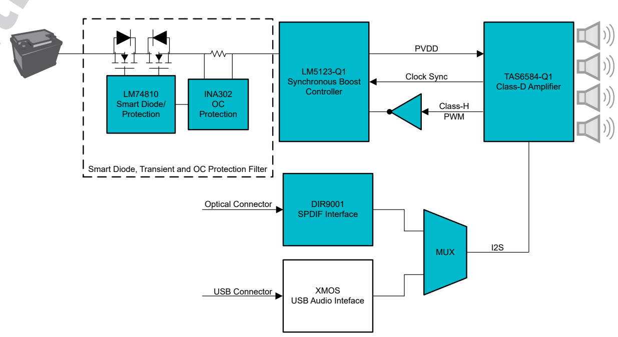
Features

- TAS6584-Q1 is the first 45-V automotive Class-D audio amplifier with integrated current sense and integrated Class-H control in the industry. The device delivers maximum output power and high-fidelity audio
- LM5123-Q1 is a 2.2-MHz wide-V_{IN} low-I_Q synchronous boost controller with a TRACK pin for simplified tracking power-supply design
- Self-contained Class-H control allows for simplified implementation in external amplifier applications and minimizes the need for additional digital power controller or software
- Includes an input protection circuit to protect against external transients, reverse battery conditions, and system overcurrent events

Applications

- Automotive external amplifier





1 System Description

In a traditional high-power audio amplifier system, a boost converter provides a constant voltage to achieve the maximum possible power to be delivered to the speaker load. The dynamic nature of music typically only needs this maximum voltage for short moments, and only when the listener sets the system to full volume. This means the power supply of the amplifier far exceeds typical requirements and there are significant power losses in the boost converter and amplifier system. The total system must be designed for this maximum power use-case but suffers in thermal performance and system efficiency to meet those requirements. This leads to larger heat sinks, inductors, MOSFETs, and copper area on the system to handle the increased thermal load.

These types of system challenges can be solved with a Class-H tracking power supply system. The audio signal sent to the system is analyzed to determine the required power supply voltage at a given moment in the audio stream and the boost converter is adjusted appropriately. The entire system operates to directly match the needs of the audio signal at all times instead of only maintaining the voltage required at the maximum power use-case. Power losses in the system are reduced and power efficiency and thermals improve significantly.

The TIDA-020033 showcases the integrated Class-H features of the TAS6584-Q1. Utilizing the integrated DSP, the TAS6584-Q1 can track the envelope of the incoming audio stream and send a signal to the LM5123-Q1 boost converter to adjust the power supply voltage. This function is self-contained within these two devices. No additional monitoring of the audio signal or external control of the boost converter from a microcontroller is necessary.

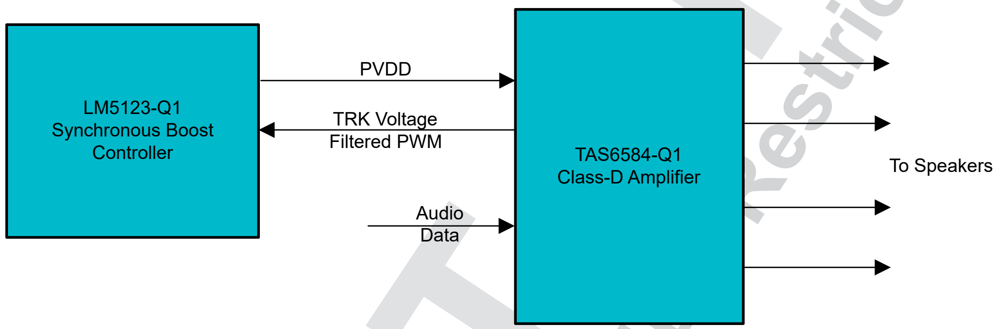


Figure 1-1. Simplified Class-H System With TAS6584-Q1 and LM5123-Q1

This self-contained system provides design flexibility to an automotive audio system designer. External amplifiers can operate as more of a "plug-and-play" system rather than one that needs monitoring and control from a remote module (like a head unit or radio tuner) to calculate the audio envelope and control the power supply. Different automotive fleet variants with different audio system requirements will not need significant changes to the delivery of the audio data to the external amp or new software variants for different Class-H envelope tracking needs.

The implementation of Class-H power control in TIDA-020033 also provides several other key benefits at the system level, such as:

- Smaller LM5123-Q1 power supply inductor due to lower average input currents
- Smaller heat sink for the TAS6584-Q1 Class-D amplifier due to lower die temperatures
- Less copper thermal relief area on the PCB due to lower junction temperatures in the system
- Improved EMI performance due to lower switch-node currents leading to lower electromagnetic energy

2 System Overview

For extensive details on the reference design, including Schematics, BOM, Altium Files, Test Data, and more, request access to the *Secure resources* folder.

2.1 Block Diagram

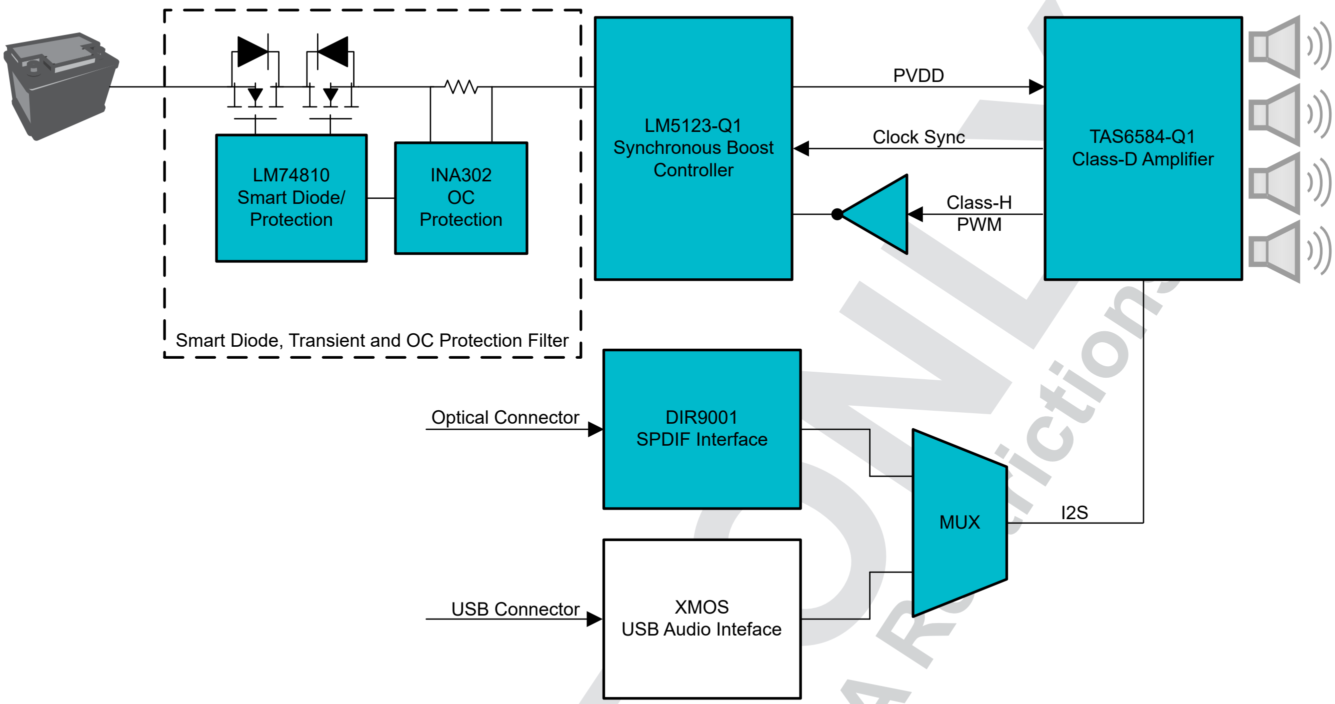


Figure 2-1. TIDA-020033 Block Diagram

2.2 Design Considerations

For extensive details on the design, device implementation, and test results, request details from the *Secure resources* folder.

2.3 Highlighted Products

2.3.1 TAS6584-Q1

The TAS6584-Q1 device is a four-channel digital input Class-D audio amplifier, specifically designed for use in the automotive industry. The device is designed for higher voltage operation up to 45 V as well as high-output current demands. The ultra-efficient Class-D technology allows for reduced power consumption, reduced PCB area, and less heat in the electrical system. The device realizes a high-fidelity audio sound system design with smaller size, lower weight and advanced functionality. The TAS6584-Q1 has an integrated DSP that enables the Class-H functionality in this system.

2.3.2 LM5123-Q1

The LM5123-Q1 device is a wide input range synchronous boost controller that employs peak current-mode control. The device features a low shutdown I_Q and a low I_Q sleep mode, which minimizes battery drain at no and light load condition. The device also supports an ultra-low I_Q deep-sleep mode with bypass operation, which eliminates the need for an external bypass switch when the supply voltage is greater than the boost output regulation target. The output voltage can be dynamically programmed by using the tracking function.

3 Hardware, Software, Testing Requirements, and Test Results

For extensive details on the design, device implementation, and test results, request access to the *Secure resources* folder.

3.1 Hardware Requirements

3.2 Test Results

Section 3.2.1 and Section 3.2.2 Below are some demonstrative examples of the performance of the TIDA-020033 and the expected efficiency improvements of a Class-H audio system. For more details, request access to the *Secure resources* folder.

3.2.1 Class-H Tracking Waveform Example

Figure 3-1 and Figure 3-2 show examples of the output of the LM5123-Q1 with and without the envelope tracking software running in the TAS6584-Q1. When disabled, the output of the boost is set to a constant 42 V to allow for a maximum output power of about 120 W into an 8-Ω load. When enabled, the output voltage will follow the envelope of the audio waveform and can vary anywhere from 15 V to 42 V.

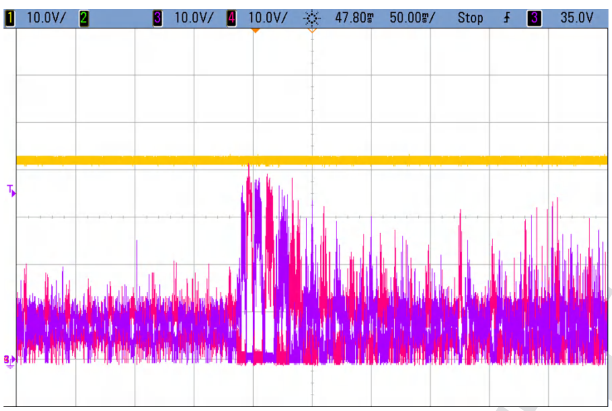


Figure 3-1. Audio Output and Boost Voltage Without Class-H Operation

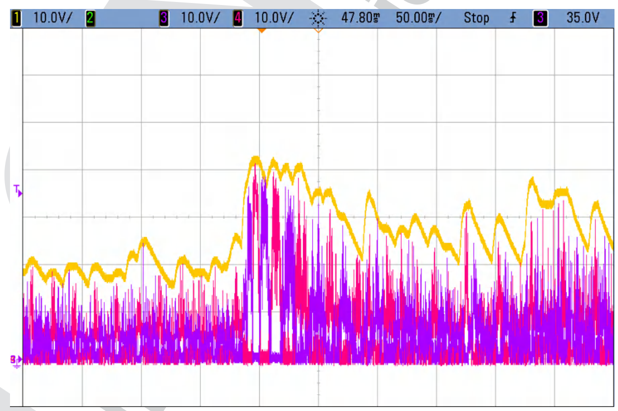


Figure 3-2. Audio Output and Boost Voltage With Class-H Operation

3.2.2 Thermal Performance

Figure 3-3 through Figure 3-6 are thermal images that demonstrate the improvement in efficiency of the system when running the system with Class-H. This was tested with a simple 1-kHz sine wave that would vary between full power for 100 ms and one-eighth of full power for 900 ms repeatedly. The system was allowed to reach a stable temperature before capturing with a thermal camera. When examining the system thermally, there are key areas that show significant improvement:

1. The low-side MOSFET of the boost
2. The boost inductor
3. Output filter inductors of the Class-D amplifier

Class-H operation allows these key areas to operate with lower average currents at lower voltages, significantly reducing thermal losses.

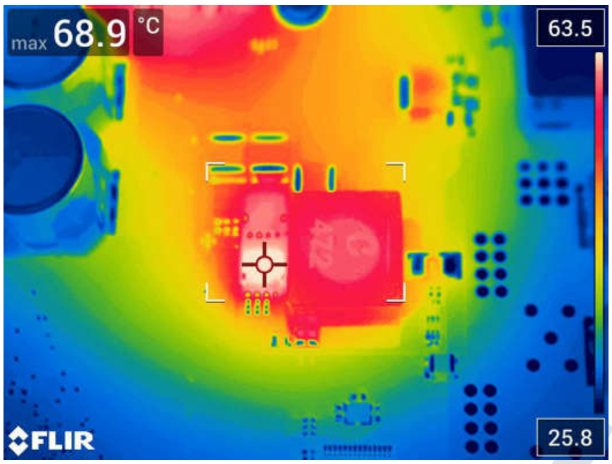


Figure 3-3. Thermal Image of Boost Powertrain With Class-H Disabled

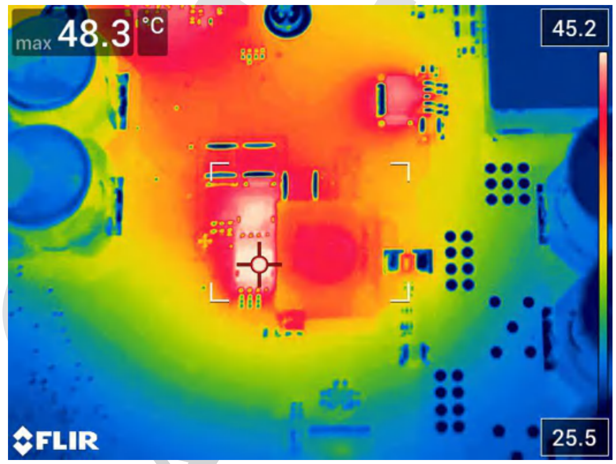


Figure 3-4. Thermal Image of Boost Powertrain With Class-H Enabled

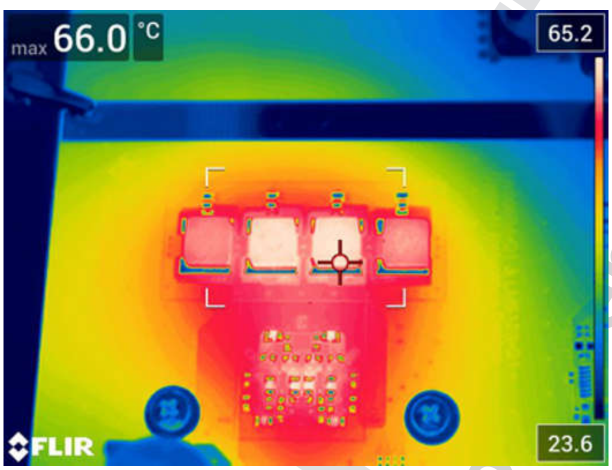


Figure 3-5. Thermal Image of Amplifier Output Inductors With Class-H Disabled

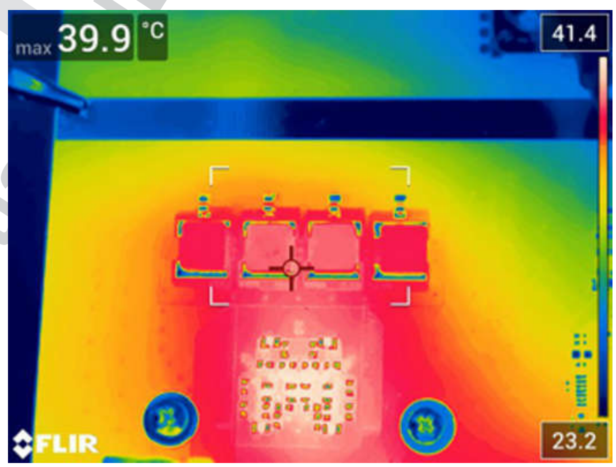


Figure 3-6. Thermal Image of Amplifier Output Inductors With Class-H Enabled

4 Design and Documentation Support

4.1 Design Files

For extensive details on the design, request access to the *Secure resources* folder.

4.2 Support Resources

TI E2E™ support forums are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

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5 About the Author

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6 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision * (January 2022) to Revision A (November 2024)	Page
• Updated *Secure resources* links in Section 2, Section 2.2, Section 3, and Section 3.2	1

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