Application Note

Using TI Audio Amplifiers in Automotive Seat Shaker Applications

Jeff McPherson

ABSTRACT

This paper explores the application of TI audio amplifiers in automotive seat shaker systems, which provide feedback through seat vibrations for safety alerts, audio enhancement, and comfort features in premium vehicles. The document examines Linear Resonant Actuators (LRAs), Eccentric Rotating Mass (ERM) motors, and Solenoids, and demonstrates how these three primary vibration technologies align well with traditional audio speaker requirements. By leveraging Class-D audio amplifiers, automotive designers can efficiently drive both conventional speakers and vibration elements using a unified audio infrastructure. The paper provides selection criteria for appropriate TI amplifiers based on channel count, power requirements, and additional features, highlighting some automotive-qualified devices that can be used for these emerging seat shaker applications.

Copyright © 2026 Texas Instruments Incorporated

1 Introduction

High-end vehicles seek to enhance the experience of the driver as well as provide additional feedback and assistance. One of the ways this feedback is given is through shakers that vibrate the driver's seat. These vibrations can be used as safety warnings for back-up collisions and lane assist, or quality of life features such as audio bass enhancement. In the most premium vehicles this technology can be used as a lower back massager. The same technology can also be translated to driving simulators and amusement attractions.

While seat vibration can be achieved with typical motor drivers, audio amplifiers are an attractive design for system designers since amplifiers pair well with existing audio infrastructure in the system. A well-chosen multichannel Class-D amplifier can deliver the necessary power to the vibration elements while also driving traditional audio speakers. The frequencies chosen for vibration effects are also commonly found in the audio bandwidth (20Hz – 20kHz) which make audio amps a great fit for this application.

2 Types of Vibrating Loads

Vibration elements are typically one of three types: Linear Resonant Actuators (LRA), Eccentric Rotating Mass (ERMs) Motors, or Solenoids.

2.1 Linear Resonant Actuators (LRAs)

LRAs are most similar to traditional speaker coil designs. Voltage applied to an electromagnet oscillates a mass fixed to a spring according to the AC signal applied. The voltage required is typically low (2Vrms) and the force applied by the moving mass is linear only, providing a well-defined directional force. However, the force has a significant improvement around the resonant frequency of the LRA, which limits the frequency range that can be used to deliver a meaningful force. The resonant frequencies of LRAs are typically between 100Hz – 300Hz LRAs similarity to speakers and use of AC signals makes them an easy fit for audio amplifiers.

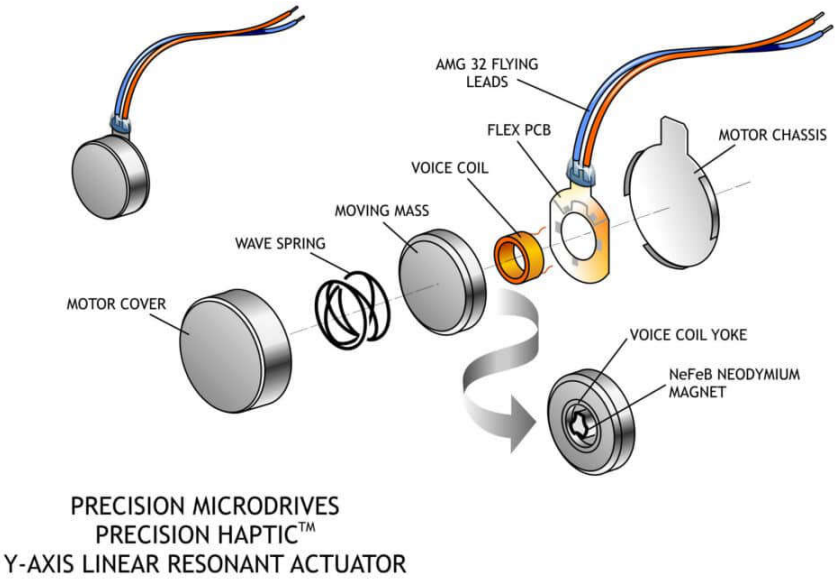

Figure 2-1. LRA Architecture Courtesy of Precision Motordrives™

Copyright © 2026 Texas Instruments Incorporated

2.2 Eccentric Rotating Mass (ERMs)

ERMs are operated similar to Brushed DC Motors, using a DC voltage to rotate an unbalanced mass. The force created is not directional, and the mass is slow to startup and slowdown. As a result, the sensation created is not as sharp or defined as an LRA. However, ERM's do not have the same resonance restriction as an LRA and can oscillate at higher frequencies to increase the force created. Despite audio being a normally AC-only application, TI Audio Amps can support driving DC signals on their output by disabling the high pass filter.

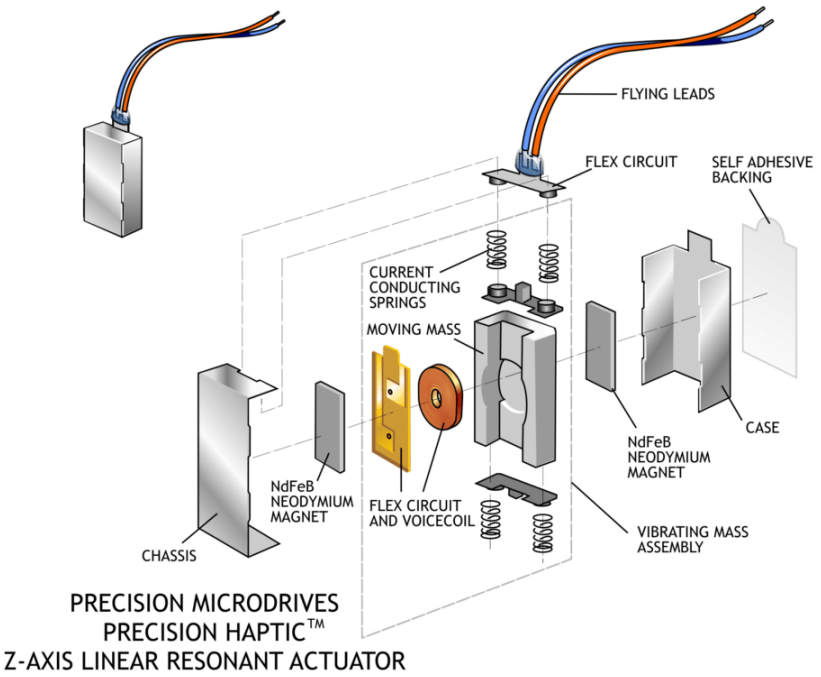

Figure 2-2. ERM Architecture Courtesy of Precision Motordrives™

Copyright © 2026 Texas Instruments Incorporated

2.3 Solenoids

Solenoids have a wide variety of types to create forces: push/pull, latching/bistable, and proportional. Each type uses either DC or AC signals to create the force, both of which are supported by audio amplifiers. Details on each type can be found *here.* Regardless of the solenoid used, the H-Bridge used in a Class-D amp can also act as a driver for these solenoids.

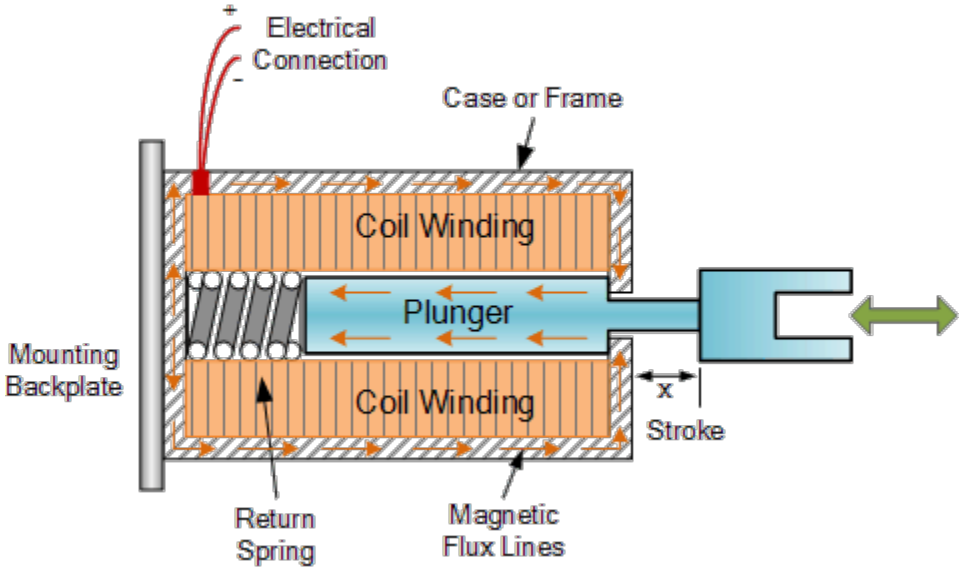

Figure 2-3. Solenoid Architecture Courtesy of Aspencore, Inc.©

Copyright © 2026 Texas Instruments Incorporated

3 Selecting a TI Audio Amplifier

LRAs, ERMs, and Solenoids typically have DC impedances that fall into the same range as audio speaker impedances: 4Ω - 16Ω. This makes it simple for nearly any Class-D audio amp to drive these loads. To help narrow down which device to select, there are other parameters to consider. Criteria can include but is not limited to the following:

- Number of channels
- Output power per channel
- Supply voltage
- Audio input source (analog or digital)
- Dynamic processing (Equalizer, Compression, and so on.)
- Load Diagnostics

TAS6424E-Q1 is a device that succeeds in this kind of application due to its ability to drive the required actuators as well as the speakers in the vehicle. The common design makes it easy to drive speaker loads and use extra channels to drive the actuators as well: all from the same digital audio bus.

See Table 3-1 for a short selection-guide on hero devices for this application.

Table 3-1. Automotive Amp Hero Devices

Device	Channel Count	Output Power per Channel; THD < 10% @ 4 ohm	Supply Voltage	Notable Features
TAS6424E-Q1	4	75W	4.5V – 26.4V	2MHz switching, load diagnostics, 40V load dump
TAS6754-Q1	4	30W	4.5V – 19V	1L modulation, current sense, real-time load diagnostics, 40V load dump
TAS6684-Q1	4	54W	4.5V – 45V	Up to 13A / channel, current sense and real-time load diagnostics, 50V load dump
TAS6422-Q1	2	75W	4.5V – 26.4V	2MHz switching, load diagnostics, 40V load dump
TAS6511-Q1	1	30W	4.5V – 19V	1L modulation, current sense, real-time load diagnostics, 40V load dump

Copyright © 2026 Texas Instruments Incorporated

4 Summary

LRAs, ERMs, and solenoids share many electrical and mechanical properties to traditional speakers, meaning that vibrating load applications, such as those found in automotive seats, can be solved with TI automotive amplifiers. The TI Audio portfolio covers the various needs around channel count, output power, and other quality of life features that enable customers to use vibrating loads alongside audio systems.

Copyright © 2026 Texas Instruments Incorporated

5 References

- Texas Instruments, *Haptics: Solutions for ERM and LRA Actuators*, brochure.

  Precision Microdrives, *Vibration Motors - ERMs and LRAs - Precision Microdrives*, webpage.

  Piezo.com, *Haptic Actuators: Comparing Piezo to ERM and LRA*, blog.

  Custom Coils, *Solenoids: Working Principle, Types, & Applications*, webpage.

  Electronics Tutorials, *Solenoids: Working Principle, Types, & Applications*, webpage.

  Texas Instruments, *TAS6424E-Q1 45-W, 2-MHz Digital Input 4-Channel Automotive Class-D Audio Amplifier with Load Dump Protection and I2C Diagnostics datasheet (Rev. A)*, datasheet.

  Texas Instruments, *TAS6754-Q1 1L Modulation, 2MHz Digital Input 4-Channel Automotive Class-D Audio Amplifier with Current Sense and Real-time Load Diagnostics datasheet (Rev. A)*, datasheet.

  Texas Instruments,*TAS6684-Q1 - 45V, 13A Digital Input 4-Channel Automotive Class-D Audio Amplifier with Current Sense and Real-time Load Diagnostics datasheet (Rev. A)*, datasheet.

  Texas Instruments, *TAS6422-Q1 75-W, 2-MHz Digital Input 2-Channel Automotive Class-D Audio Amplifier*, datasheet

  Texas Instruments, *TAS6511-Q1 - 50W, 2MHz Digital Input 1-Channel Automotive Heatsink-Free Class-D Audio Amplifier with Current Sense and Real-time Load Diagnostics* datasheet

Copyright © 2026 Texas Instruments Incorporated

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATASHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES “AS IS” AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you fully indemnify TI and its representatives against any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI’s products are provided subject to TI’s Terms of Sale, TI’s General Quality Guidelines, or other applicable terms available either on ti.com or provided in conjunction with such TI products. TI’s provision of these resources does not expand or otherwise alter TI’s applicable warranties or warranty disclaimers for TI products. Unless TI explicitly designates a product as custom or customer-specified, TI products are standard, catalog, general purpose devices.

TI objects to and rejects any additional or different terms you may propose.

Copyright © 2026, Texas Instruments Incorporated

Last updated 10/2025