

# Developments in Audio Technology and How They Affect Automotive Audio Systems

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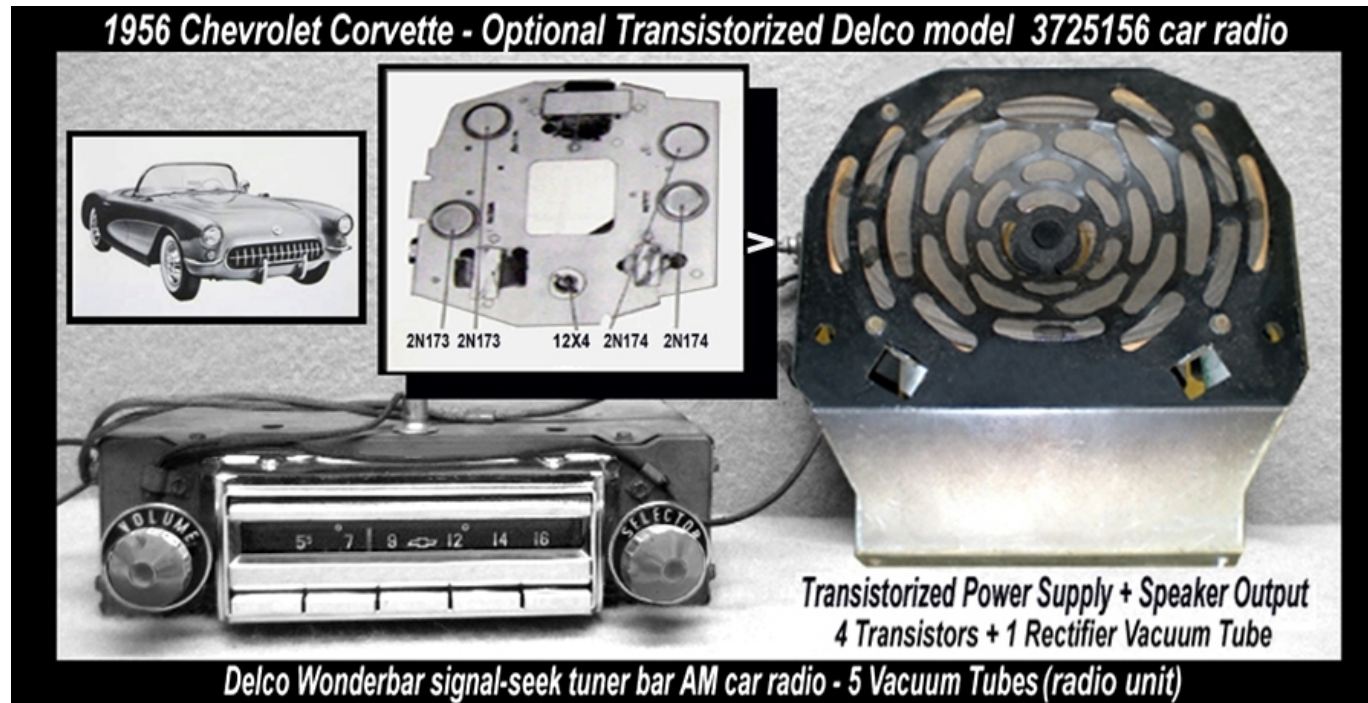
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# History of Car Audio Systems

- 1956 Premium radio
  - AM/FM tuner, One speaker, ~2W output power



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# History of Car Audio Systems

- 1990 typical radios
  - AM/FM tuner, Cassette, 4 speakers, ~15-20W output power per speaker



<http://www.ebay.com/itm/89-90-91-92-Pontiac-Firebird-Trans-Am-Formula-GTA-Delco-GM-AM-FM-Cassette-Radio-/272206951218>

# History of Car Audio Systems

- 1990 Premium radios

- AM/FM tuner, Cassette and/or CD, 8 speakers, ~25W output power per speaker



<http://thelincolnmarkviiclub.org/phpBB3/viewtopic.php?f=24&t=4310>

<http://www.allpar.com/stereo/Infinity-II/>



# History of Car Audio Systems

- Today's Premium Sound Systems

- AM/FM tuner, HD or DAB, 19+ speakers, ~25W output power most speakers, 100W+ some speakers

**VIGOROUS SOUND WITH HARMAN KARDON**  
Harman Kardon High Efficiency Audio System

Jeep harman/kardon  
by HARMAN

- ✓ Superior sound quality, high Sound Pressure Level (SPL) output, with minimum energy consumption
- ✓ Powerful 35 Volt Tracking Power Supply (TPS) and 11-Channel Class-D amplifier
- ✓ High performance DSP functions & legendary Logic 7® Surround Sound with 19 speakers in a 7.3 speaker playback architecture
- ✓ Innovative GreenEdge™ technology for less electricity consumption while delivering an increased sound performance
- ✓ Superior spectral balance and dynamic response

19 High Performance, High Efficiency GreenEdge™ Loudspeakers

[http://www.wk2jeeps.com/wk2\\_srt8\\_harman.htm](http://www.wk2jeeps.com/wk2_srt8_harman.htm)

# History of Car Audio Systems

- Features come & go

Turntable <i>Really!</i>	8-track	Cassette	Auxiliary jack
DVD	USB	Bluetooth	AM-stereo
FM HD radio	DAB	Satellite radio	Touchscreen

- The constant development has been More Power
  - More speakers
  - More power per speaker
  - Very pronounced in premium systems

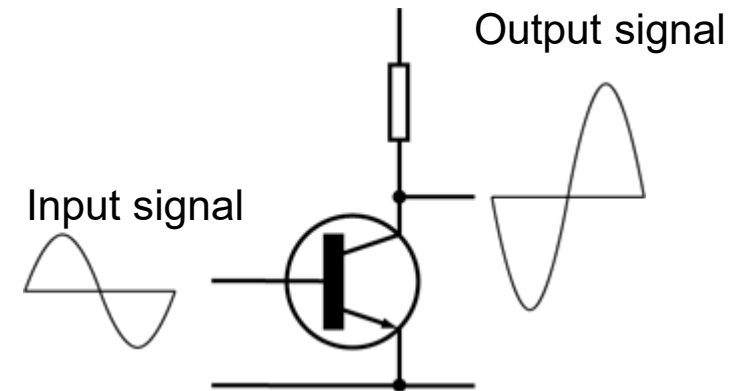
# Evolution of Automotive Audio Amplifiers



# Evolution of Automotive Audio Amplifiers

- Very high audio quality
- No crossover distortion
- Simple design
- Still has a cult following for premium home systems
- Limited output power due to high heat generated in transistor
- Highest efficiency possible is 25%
  - Much lower in typical conditions

## Amplifier Topology - ClassA



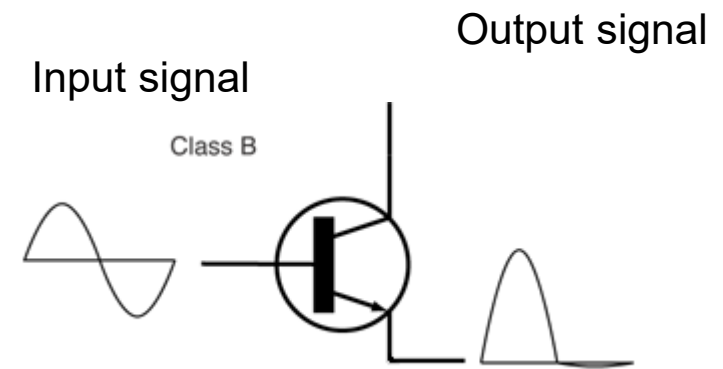
By GRAHAMUK with modification of Yves-Laurent Allaert - en:Image:Electronic\_Amplifier\_Class\_A.png, CC BY-SA 3.0, <https://commons.wikimedia.org/w/index.php?curid=1103693>



# Evolution of Automotive Audio Amplifiers

- Simple design
- Used for beeps in early IBM Personal computers
- Very poor audio quality. Unusable except for sound effects
- Highest efficiency possible is ~75%

## Amplifier Topology - Class B

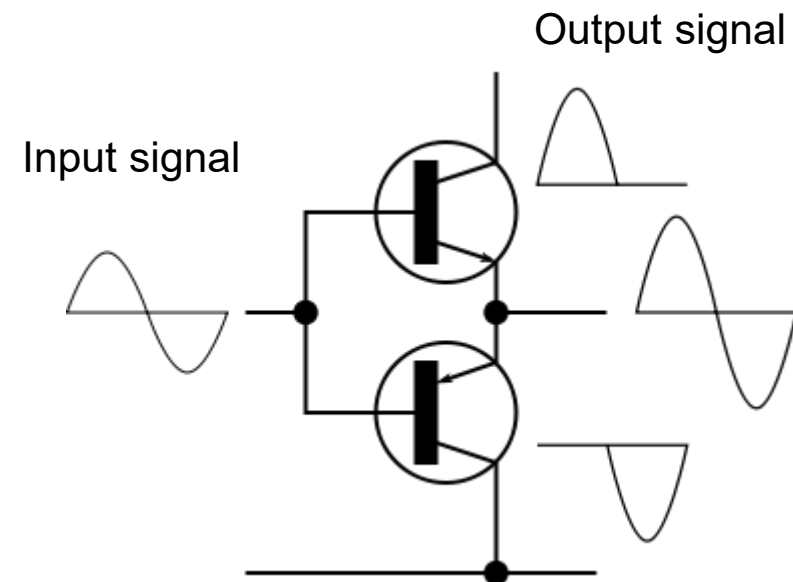


By Nitram cero at English Wikipedia - Transferred from en.wikipedia to Commons by Logan using CommonsHelper., CC BY-SA 3.0, <https://commons.wikimedia.org/w/index.php?curid=14602402>

# Evolution of Automotive Audio Amplifiers

- Can be very good audio quality
- Must design carefully to avoid crossover distortion
- Very commonly used in automotive
- Depending on conditions, limited to 50W-75W/speaker because of thermal issues
- Highest efficiency possible is ~50%
  - lower in typical conditions

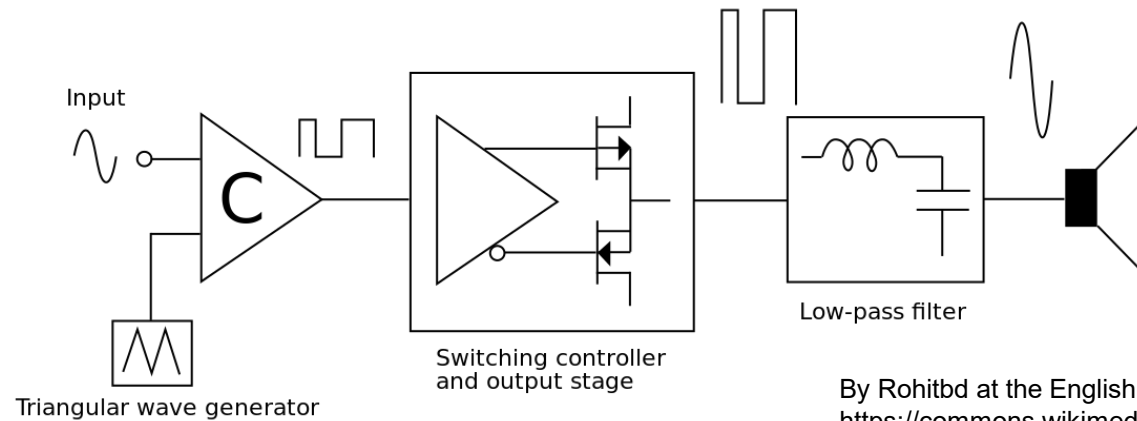
## Amplifier Topology - ClassAB



By Lakkasuo - File:Electronic Amplifier Push-pull.png, GFDL, <https://commons.wikimedia.org/w/index.php?curid=11447880>

# Evolution of Automotive Audio Amplifiers

## Amplifier Topology – ClassD



By Rohitbd at the English language Wikipedia, CC BY-SA 3.0,  
<https://commons.wikimedia.org/w/index.php?curid=3219218>

- Used in automotive for 75W+ output to speakers, sometimes recently for less power
- More expensive System - Bill of Materials is higher
- Can theoretically be 100% efficient – in practice ~90% efficiency at higher power levels
- Complex tradeoffs between audio quality, radiated emissions and efficiency, both in silicon and PCB design

# Ramifications of the Power Trends



# Ramifications – Rough Calculations

- Consider 2019 Premium Sound Systems
  - Up to 32 speakers – an example split
    - 28 speakers at 25W
    - 4 speakers at 150W
  - $28 \times 25W + 4 \times 150W$  – up to 1300W power delivered
- Gross overestimation of “typical” usage, but  $\frac{1}{4}$  of this is 325W output power – feasible for very loud listening
- Typical alternator might deliver 50A at idle; assuming 13V, that’s 650W

# Ramifications – Rough Calculations

- How power is required to deliver 325W?
  - Efficiency = Useful Power Out/Power In
  - Remember, 325W is only  $\frac{1}{4}$  peak power
- Crude calculation in the coming slides, but be aware:
  - ClassA is nonsense – we can't get 25W to a speaker
  - ClassAB by itself is unworkable; we can't get 150W to a speaker
  - (maybe with liquid cooling?)

# Ramifications – Rough Calculations

- Power to deliver 325W?
- ClassA – up to 25% efficient at high power
  - $0.25 = 325W / \text{Power In} \rightarrow 1300W$  from alternator
  - Typical alternator (650W) cannot run the sound system at idle
  - High capacity (heavy, expensive) alternator required to run sound system plus headlights, dashboard lights, electronics, etc
  - Requires higher RPM at idle with the sound system on, burning fuel

# Ramifications – Rough Calculations

- Power to deliver 325W?
- ClassAB – up to 50% efficient at high power
  - $0.5 = 325W / \text{Power In} \rightarrow 650W$  from alternator
  - Typical alternator can run only(!) the sound system at idle
  - High capacity alternator required to run sound system plus headlights, dashboard lights, electronics, motors
  - Possibly requires higher RPM idle with the sound system on, burning fuel



# Ramifications – Rough Calculations

- Power to deliver 325W?
- Combination: ClassAB for 28x25W and ClassD for 4x150W
  - AB – 700W/4, 50% efficiency, 350W
  - D – 600W/4, 90% efficiency, 167W
  - 500W+ Significant alternator load
  - Typical alternator can probably not run sound system and vehicle electronics/motors at idle
  - Might require higher idle RPM to operate sound system
- Today's most cost effective solution looking only at the price of the sound system

# Ramifications – Rough Calculations

- Power to deliver 325W?
- ClassD – up to 90% efficient at high power
  - $0.9 = 325W / \text{Power In} \rightarrow 350W$  from alternator
  - Significant, but modest alternator load
  - Typical alternator can probably run sound system and all vehicle electronics/motors at idle

# Final Ramifications

- A full ClassD audio system will cost more than a ClassAB or Combination system
- However, since it allows the vehicle to use a smaller alternator it could give system savings
- It's difficult for audio teams to translate this to dollars – need cooperation with the vehicle level power management teams
  - Less size/weight in the heatsinks and alternator
  - Less alternator drag on engine
  - Better driving performance/fuel efficiency/emissions

# Conclusions



# Conclusions

- In the past engineering effort has gone to make better sounding systems. Efficiency was only considered as it caused thermal problems.
  - Better Sounding largely meant More Power & More Speakers.
- Premium systems today contribute to alternator current budget, often requiring more expensive, heavier alternators.
- OEMs (and Tier1s) are early in their understanding the true advantages of efficiency.
  - OEM audio teams consider the size & weight of the audio system, but usually not power consumption as it relates to the rest of the vehicle.
  - Not (yet!) working closely with Power Management or Fuel Economy teams
- Savings are available as they consider how the audio system impacts the entire vehicle



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