

HIFICRITIC

.....*the audio journal*

Are Class 'D' Amplifiers High Fidelity?

A brief analysis of the technical and sound quality performance of some famous Class D amplifiers

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Introduction

- A brief review of the case for Class D
- Do we need it for high quality audio?

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- A Practical Perspective

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Class 'D' Technology

- Generally 'Class D' does not mean that we have that dream of an all-digital amplifier.
- An all-digital amplifier without feedback is non linear, of high order.
- Now include feedback correction and it is then topologically equivalent to an 'analogue' Class D design but with a DAC input stage.
- Most 'digitals' are in fact analogue input Class 'D' designs.
- They have feedback type error correction.
- They convert the linear input signal into full level variations in pulse width, at high output current.
- A filter at the output removes some of the many wide band switching signals which result.

Class 'D' Technology

- A conventional linear, power transformer power supply may be used
- To make the products small and light most Class D amplifiers use high frequency switch mode feedback power supplies

Claims

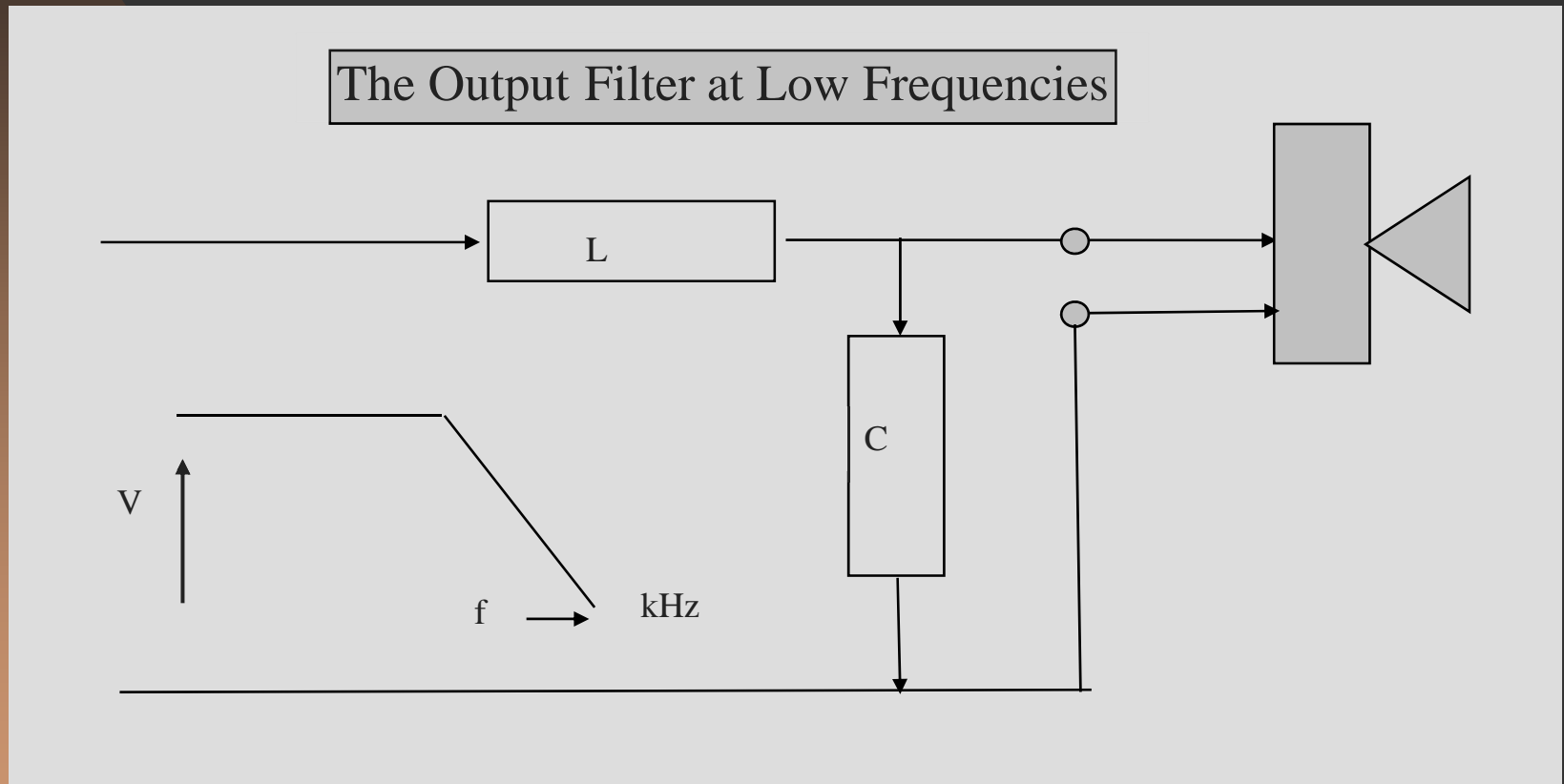
- Each Class D manufacturer claims to have the answer to the best sound
- They preach the advantages, small and light, small heat sinks and high efficiency (theoretical)
- They boast an ecological superiority over conventional designs

Some Strange Aspects

- The output filter problem
- The conditional stability factor
- Floating outputs may have a high DC potential
- Compressor and limiter circuits

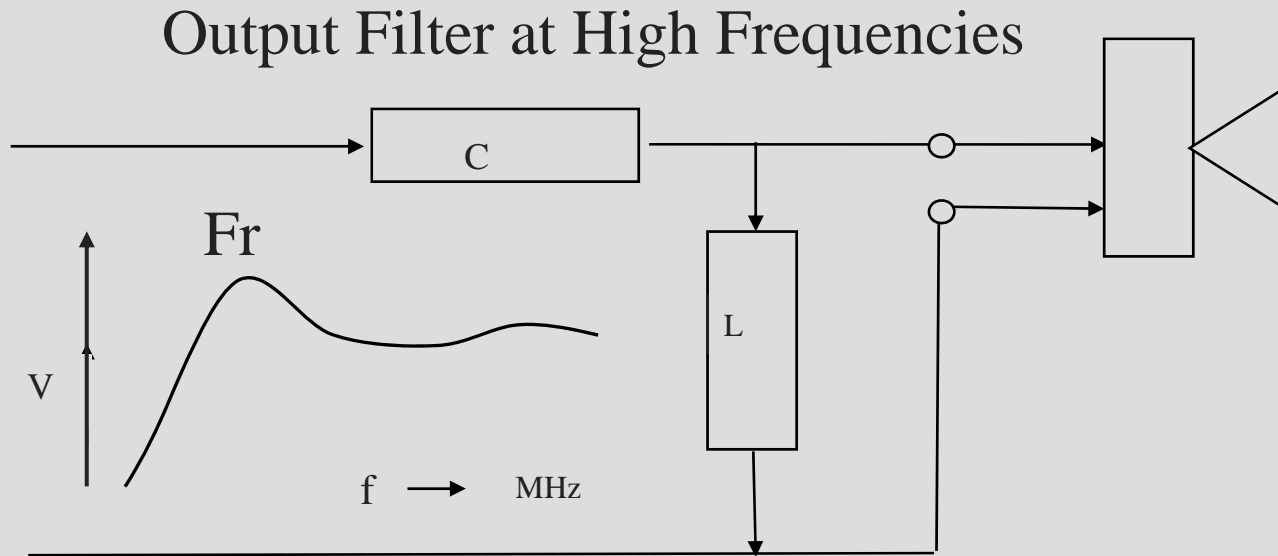
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Some Strange Aspects



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Some Strange Aspects



Some Strange Aspects

- The conditional stability factor: high order feedback correction is a delicate balance requiring defined termination.
- several designs e.g. NuForce are unstable, oscillate at high frequencies without a load connection. They can then burn out

Some Strange Aspects

Floating amplifier outputs
often with a high DC potential:

- Several designs employ half rail power supplies despite a bridge type output circuit.
- This means that a high DC potential e.g. 63V is present on the loudspeaker output terminals and on the speaker cables too.

Some Strange Aspects

Compressors and Limiters: when the output stage clips or saturates in this class of amplifier there is almost no useful information fed back to the control system and the amplifier may become unstable, usually in bursts with high distortion.

- To prevent this poor behaviour a compressor circuit is often present in the signal path to soft limit the drive to avoid full clipping. Threshold effects may impair clarity and result in quality changes with input signal dynamics.
- The output stages are fragile and may easily overheat. Sophisticated current limiting with a frequency and time dependant envelope is used to protect the devices. Thus sound quality near full power may be variable and load dependant.

Sound Quality Results

- The listener should not be seduced by the often high powers and sound levels which these amplifiers are often capable
- The listening tests are very difficult
- A new language is required to describe the unfamiliar sonic errors which these designs introduce

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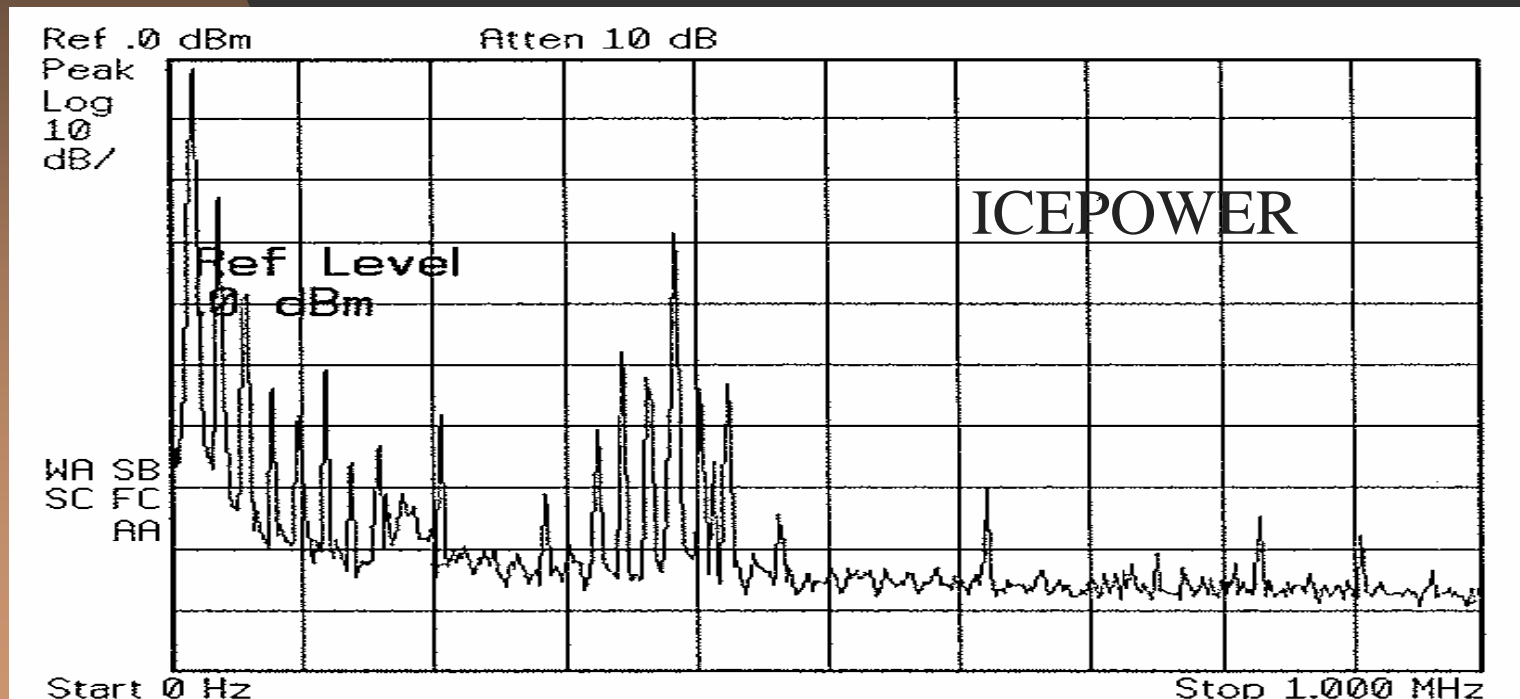
Sound Quality Results

- Below average treble
- Average bass quality
- High damping factor is misleading
- Lightweight mid range timbre
- False sense of 'presence'
- Poor rhythm, weakened sense of drive, of propulsive momentum
- Cross modulation between music strands
- Lack of stable focus and inconsistent image transparency
- Listener fatigue

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Laboratory Test Results

- These Amplifiers are difficult to measure because of high frequency noise levels, and this is a big clue as to why they present such a complex evaluation problem (see ICEPOWER result below)
- Radio frequency noise may be extended to 500MHz, with up to 2V frequently measured at around 50kHz, this fed directly to the speaker cable and loudspeakers



Why do we think that digital amplifiers do not work ?

Briefly summarising the test findings, the designers of 'switching amplifiers', 'Class D', seem to be perfectly happy to ignore several decades of conventional audio engineering wisdom.

These wisdoms have helped shape many great sounding linear analogue products.

The 19 Bad Behaviours (1)

- They conduct broad-band radio frequency noise into the power supply outlets
- Conduct broad-band radio frequency noise into the input signal line and ground connections.
- Drive broad-band radio frequency noise into the speaker cables and loudspeaker.
- Define output using a passive filter, with an output impedance which varies with frequency and is dependant on speaker loading.
- Allow the amplifier to be marginally or completely unstable for either open circuit or high impedance loading

The 19 Bad Behaviours (2)

- Employ soft compressor type clipping circuits prior to full power clipping to prevent feedback saturation.
- Employ high order negative feedback to improve in-band distortion figures and low frequency output impedance.
- Specify numerically high damping factor at low frequencies and claim that this guarantees fine bass.

The 19 Bad Behaviours (3)

- Use steep low pass input filters to limit the upper high frequency range, partially negating the move to a wider reproduction bandwidth e.g. with source material such as SACD. The resulting filter phase shifts may also be audible in the working band.
- Have input circuits which are highly sensitive to stray high frequency input signals, including upper band noise shaper signals, and related DAC artifacts. Here the result is poorer treble sound quality and measurable distortion.

The 19 Bad Behaviours (4)

- Use circuit designs with poor high frequency resolution. This results in high levels of intermodulation products for high frequency signals.
- Suffer from 'Sampler' type, noise-shaped noise floors. The latter vary dynamically with the signal level, and frequency, and the complexity of the input signals.

The 19 Bad Behaviours (5)

- Have thermal dissipation limitations due to the small power module size which means that thermally associated dynamic variations are present in the performance with time and temperature.
- To protect the fragile output stages all kinds of pre-clip and aggressive fold back protection regimes are included, which are frequency dependant and are also associated with duty cycle. Unexpected sound quality variations may result when operated at higher powers and with more difficult loads.

The 19 Bad Behaviours (6)

- Operate at an equivalent sample rate which is insufficient for good resolution above 7kHz. DSD, 1 bit pulse-width modulation operates at 2.4MHz, nearly ten times the 0.3MHz rate typically used in 'Class D' amplifiers.
- Some have constant DC voltages (up to 70V) at the output terminals relative to local ground and hence also the loudspeaker connections and cable.
- Use a high feedback, switch mode power supply which has to react dynamically to the power draw variations of the power amplifier with the music programme. Some Class D amplifiers are designed for the input signal frequency and level to modulate the output switching frequency, encouraging a form of cross modulation

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- For a linear amplifier designer the presence of even one or two of the above nineteen integers would generally be regarded as potentially prejudicial to sound quality.
- Considering this, the odds seem to be stacked against the switching amplifier for genuine high quality audio applications.
- Perhaps instead of criticising, we should instead be applauding the Class 'D' amplifier designers for what they have achieved, despite their huge problems.

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What this means:

- I consider that elements of the audio industry have exaggerated the need for High Fidelity enthusiasts to adopt 'Class D' amplification.
- The claimed efficiency advantage is largely valueless except to save for heat sinks for very large sub woofer amplifiers.
- High frequency and radio frequency noise is a vital issue and has not been sufficiently addressed with Class D designs. Class D amplifiers conduct and radiate substantial wide frequency range noise, both correlated and de-correlated.
- We know that high frequency noise degrades both the sound quality of the connected audio system and the amplifier itself.

The Mysteries of Human Perception

- Audiophiles and audio critics do not always hear the same things in the same way
- Musical performance and 'entertaining the listener' is more important than merely reproducing the notes.
- 'Switching' amplifiers change the sound in many subtle and varied ways: do not make the mistake of hearing a 'different' sound for a 'better' sound.
- 'Switching' amplifiers are audio system dependant: They interact with the load impedance, and with the bandwidth of the source. They react poorly to high frequency input noise fed to their input.

The Mysteries of Human Perception

- 'Class D' amplifiers can be inconsistent in their sound quality during auditioning
- Listeners are confused by these variations
- 'Class D' amplifiers have the ability to modulate one part of the sound spectrum power with another which results in dynamic variations in clarity and focus.

A Practical Perspective

- Audio critics need to maintain a healthy scepticism concerning equipment performance claims of all kinds which are based on marketing and promotion.
- Human perception is notoriously difficult to quantify, especially when sound quality differences are fairly small. Carefully controlled tests are essential to overcome errors due to expectation, suggestion and prejudice.

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The Future of Class D

- Amplifier technologists who are not experienced in High Fidelity should not take high sound quality for granted.
- The kind of high frequency noise levels which are not a problem for an automobile system or a portable radio are unlikely to be good enough for high quality audio.
- Far from being simple and cost effective, Class D is a finely tuned and complex technology requiring immense care in its execution
- Both the amplifier and the power supply deserve devoted attention, especially if the supply is also switch mode.
- Despite 30 years of development for Class D technology, at this stage HIFICRITIC does not think that it has truly attained High Fidelity standards.

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■ Thank you for coming !

- This PowerPoint will available on our site.
- If you want to know more about 'Class D' sound please visit www.HIFICRITIC.com

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