

Design Brief - UFPD 2 Amplification Technology

5 May 2018

A bit of background

The term "Class D" is sometimes misunderstood as meaning a "digital" amplifier. While some Class D amps may indeed be controlled by digital circuits or include digital signal processing devices, Primare's UFPD modules operate entirely in the analogue domain. Basically, the UFPD amplifier module takes an analogue input sine wave and converts it into a high-frequency pulse-width modulated square wave for amplification. This square wave is then filtered, resulting in an amplified analogue sine wave at the output.

The main reason that Class D was invented was for efficiency, and many of the performance benefits derived from class D amplification are the result of the significantly greater ability of the circuit to deliver more of the power fed into it as musical signal output: Class A = 20% efficient; Class B = 50% efficient; Class AB = 75% efficient; Class D = 90–95% efficient. Some manufacturers of Class D based amplification do not embrace the full potential this can provide, but our amplifiers do so in combining state of the art efficiency together with state of the art audio performance. This efficiency not only radically reduces amplifier size, but also heat and the need for massive heat sinks. This allows for compact heat sinks that can be located directly within the heart of the amplifier module for a more compact, short and simple circuit path where the final output stage is connected directly to the speaker binding posts.

We first used an existing class D amplifier module in two compact integrated systems we were designing. One was CD based, while the other featured a DVD drive. Along with their respective drives, both included DAC, tuner, preamplifier, and amplifier sections. With space at a premium and heat a real consideration, as we wanted these products to be compact enough to fit in as many living environments as possible, we naturally considered class D as an obvious solution to best work within the design constraints. The results were better than we could have imagined, having assumed a compromise would be the natural outcome of using class D as a result of misconceptions the technology still suffers from in some circles.

The key thing to remember is that we have experience producing not only solid-state class A and A/B amplifiers, but tube amplifiers as well, as a result of our time manufacturing for the great Danish Copland brand. It is, in fact, that experience that allowed us to recognize the advantages of well-implemented Class D.

Our experience led to:

- 1) Our appreciation of the overwhelming advantages that class D technology could provide and the resulting performance potential
- 2) Our belief that we could unlock that full performance potential of Class D through careful and artful application of specific design improvements

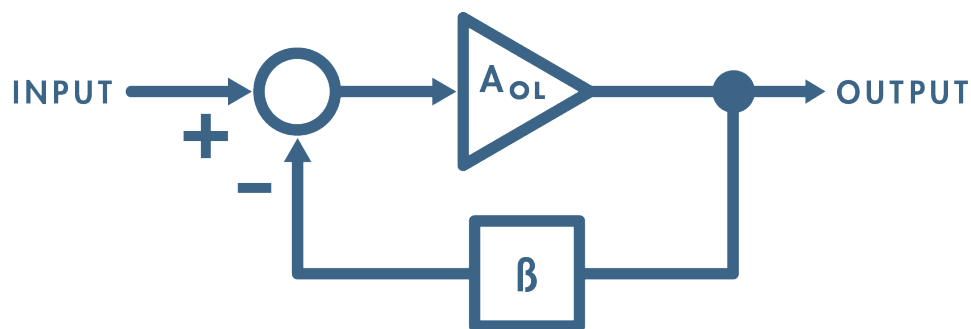
The result was UFPD and now UFPD 2, incorporating all that we have learned designing and producing Class D amplifiers for over ten years.



The amplification section

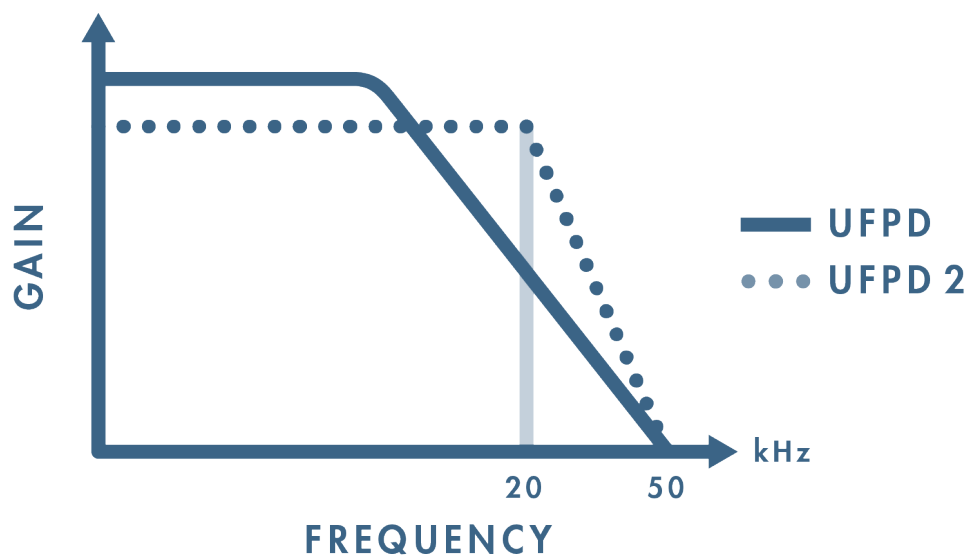
A major source of distortion in class D designs is the demodulation filter on the output that becomes unstable with variations in loudspeaker impedance unless it's controlled by sufficient feedback. The failure to provide enough feedback to cope with dynamic changes in loudspeaker impedance across the audio band results in rising THD with frequency. While sounding very dynamic and vivid initially, it can become tiring and uncontrolled in the long term, especially when driving complex loads.

UFPD provides a consistent 26dB feedback loop gain across the entire audio range and is stable way beyond the audio band. Rather than have the amplifier and then the filter as discrete stages, the UFPD design integrates the two, making control with feedback much more immediate and accurate.



The UFPD amplifier actively adapts the loop gain to keep the total loop stable during start up, clipping and current limit. It senses the changes to the filter output and compensates by applying the precise amount of feedback. This adaptive control allows for several more dBs of constant loop gain across the audio band and maintains performance irrespective of load (impedance) variations.

As a result, UFPD treats all signals equally, regardless of frequency or slew rate, and has the ability to suppress the filter resonance entirely. Consequently THD is kept very low at all frequencies. With a very wide 'load independent' frequency response UFPD is able to drive any speaker while maintaining control and accuracy.



In UFPD 2, a new output circuit has been developed to keep the gain constant in the audio band by using a custom-made 2nd order filter output coil, which means that while gain is somewhat lower at low frequencies than with UFPD, it is much higher at high frequencies. The result is absolute linear amplification, with lower noise and improved tonal balance, providing absolute “black” backgrounds from which music has a more holographic, three-dimensional, and life-like character.

We have further optimized the performance of our innovative design with the precise selection of circuit component values and quality, verifying the design with extensive measurement and listening. We put very high value in keeping the signal path extremely short by using as few components as possible. For example our amplifiers use only one OPAMP in the correction path while some other designs use up to 5 or 6 OPAMPs to get spectacular THD numbers at low frequencies.

The power supply section

We believe that the power supply, including strategically placed discrete supplies within the larger circuit, is the foundation of any great design. In UFPD 2, the APFC (Active Power Factor Control) technology in the power supply controls the current from the mains voltage so that it is a pure sine wave with the same frequency and phase as the mains voltage. This means that even if 1000W is taken from the mains, other equipment in the room will not be affected. Its presence becomes virtually invisible to the mains voltage. The isolating stage of the converter works in a ZVS mode and as a result, the switch flanks contain a lower quantity of harmonics, providing lower EMI and a clean environment for the entire system to work in.

The Active Power-Factor Correction (APFC) converter comprises dual PFC converters 180 degrees out of phase from each other, thereby avoiding input current harmonics and minimizing interference with other devices being powered from the same source. This reduces the total current ripple and improves EMC (Electromotive Compatibility), while current ripple at the output of the PFC converter is also reduced, which decreases stress within the circuit for prolonged life. Additionally, the supply operates in what is called “transition mode”, minimizing switching losses and improving overall efficiency.

For UFPD 2 the UFPD power supply has been improved for greater efficiency, by nearly 5% for 115Vac input. The UFPD power supply had an efficiency of 88.2% at 115Vac and 91.1% at 230Vac, while the new UFPD 2 power supply has an efficiency of 93.1% at 115Vac and 93.6% at 230Vac. This means if you use 550 watts in the older supply the new supply will need only 500w from the mains.

Summary

The combined result is an amplifier with the lowest distortion and noise floor Primare has ever built. However, we understand that there may be some, dare we say, who may prefer the distortions and noise of a more traditional amplifier design, much in the same way some might continue to prefer the pleasing sound or noise of an internal combustion sports car engine compared to the superior performance and low noise of a high performance all electric vehicle. For more of our thoughts on comparing UFPD to electric cars to better understand Class D performance benefits, see [Performance Benefits of UFPD Amplification](#).

