Design Brief - UFPD 2 Amplification Technology

20 September 2017

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. 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

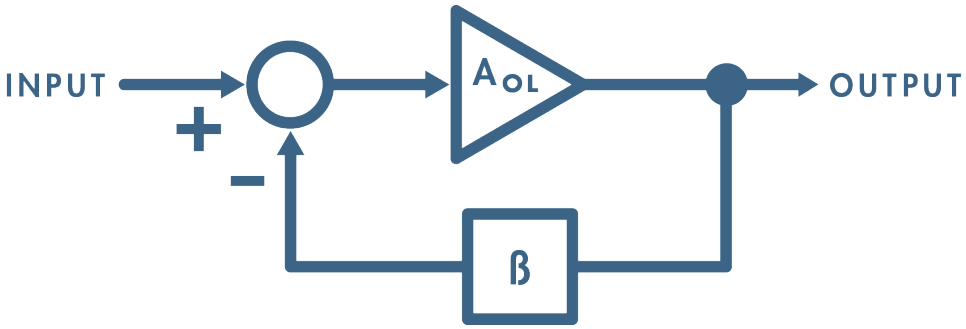
The result was UFPD and now UPFD 2, incorporating all that we have learned designing and producing Class D amplifiers for over ten years.

The amplification section

As mentioned, 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.

Primare builds upon this basic efficiency advantage in the UFPD circuit design by treating all signals equally, regardless of frequency or slew rate. This results in the ability to suppress filter resonance entirely. Consequently, THD is kept very low at all frequencies. With a very wide "load independent" frequency response, UFPD amplifiers are able to drive virtually any speaker with control and accuracy.

Rather than have the amplifier and 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 feedback loop gain to keep the total loop stable during startup, 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 dB of constant loop gain across the audio band and maintains performance irrespective of load (impedance) variations.



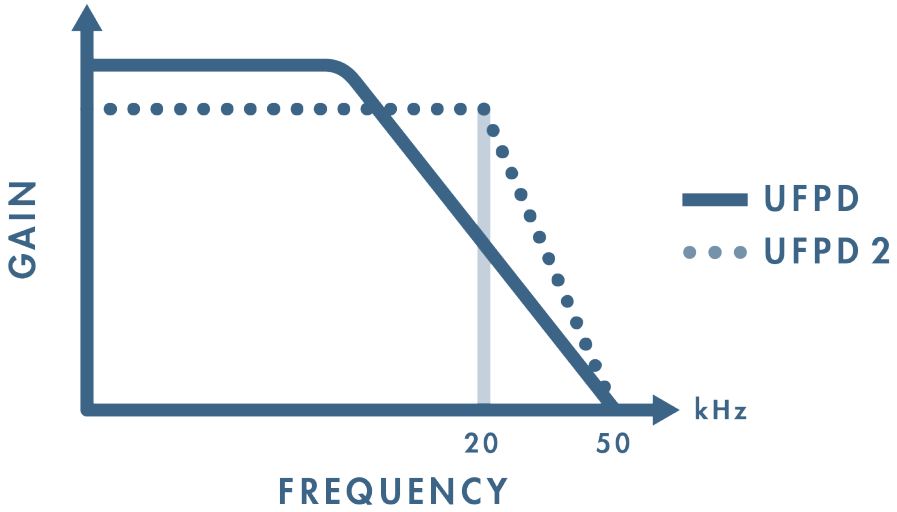
In this way, Primare's UFPD treats all signals equally regardless of frequency or slew rate and has the ability to suppress the filter resonance entirely. Consequently THD is kept very low at all frequencies. With a very wide 'load independent' frequency response UFPD is able to drive any speaker while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

We put very high value in keeping the signal path extremely short by using as few components as possible. Our amplifiers use only one OPAMP in the correction path while some of the competitors can use up to 5 or 6 OPAMPs to get spectacular THD numbers at low frequencies. Our amplifiers are designed in a much more clever way and instead of focusing on low THD at low frequencies, where it is easily obtained, we focus on minimizing THD in the entire audio band. Another difference is the large bandwidth and low phase shift, which we achieve by careful loop design.

Both UFPD and UFPD 2 use a self-oscillating Class D amplifier as a core, which oscillates on the residual after the output filter. This gives it very low output impedance and phase shift compared to a traditional Class D amplifier. The bandwidth of this Class D amplifier is huge, but can exhibit less than ideal linearity. We correct for this by adding an additional loop, including an error amplifier, with bandwidth restricted to the audio band.

In UFPD 2 a new error amplifier circuit has been developed that does not affect the gain versus frequency curve and thereby the bandwidth does not have to be limited. This gives very low phase shift in the audio band and a larger closed loop bandwidth. Also, it uses a custom-made output coil in the 2nd order filter error amplifier with the same loop gain resulting in feedback control across the entire audio band. It has been optimized to keep the loop gain constant in the audio band, which means it is actually lower at low frequencies than with UFPD but much higher at high frequencies. The result is more linear

amplification, with lower noise with UFPD 2, providing absolute “black” backgrounds from which music has a more holographic, three-dimensional, life-like character.



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 conjunction with UFPD and UFPD 2, we use APFC (Active Power Factor Control) technology in the power supply, which 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.

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 UPFD 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.

The Active Power-Factor Correction (AFPC) converter comprises dual PFC converters 180 degrees out of phase from each other. AFPC is used to avoid input current harmonics, thereby 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.

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 UFDP Amplification.