Fail Safe Power Supply
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Over-current protection is strongly recommended, especially with high current A class amplifiers where it can protect the amplifier from excessive damage should a fault develop. Fuses are just not fast enough! The circuit is also useful when first setting up a new amplifier. A class designs draw heavy currents and some circuits can be rather sensitive to output bias settings. It is all too easy to 'go the wrong way' with a trim pot.

The PSU is a power mosfet capacitance multiplier circuit which uses fast, sensitive gate triacs to cut the gate voltage when the current drawn by the amplifier reaches a preset value. The supply has a soft start characteristic which reduces turn-on thump should your amplifier not have a speaker protection circuit. The basic version may be used as a direct replacement for many of the Pass Zen/Aleph designs. A dual, balanced version has been successfully used with LTPZen and is used to eliminate the loudspeaker decoupling capacitors.

The Basic Circuit

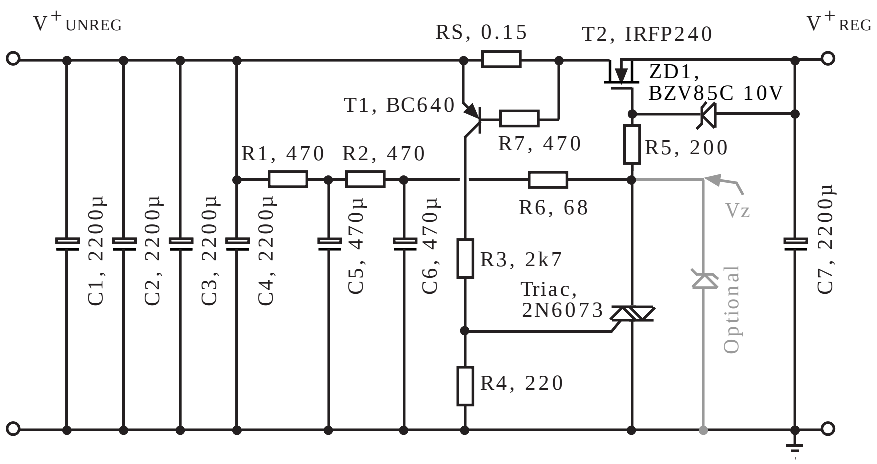

Figure 1. Basic Fail-Safe PSU

Capacitors C1 to C4 provide the initial smoothing. A bank of capacitors has been used because it cheaper and more compact than a single high value capacitor. R1 and C5 along with R2 and C6 form a 2nd order low pass mains ripple filter which feeds the gate of source follower, T2. The low pass filter provides the soft start characteristic shown in Figure 2. As a precaution against parasitic oscillation a 200 ohm resistor, R5 has been included in the gate feed. Capacitor C7 is an output reservoir which helps to supply peak transient currents. Without this, the current trip might be over-sensitive.

The trip circuit is about as simple as it can get. Transistor T1 starts to conduct when the voltage dropped across the current sense resistor, Rs reaches ~ 0.6V. The collector current triggers the gate of the triac which in turn, pulls the gate of T2 down to ground and the output voltage collapses. The output will stay low whilst the capacitor bank is charged. The PSU is simply reset by powering down, waiting a moment for the input capacitors to discharge and powering back up again.

The trip current ~ 0.6/Rs and is preset by choosing the right value of Rs. For a trip current of 4A, a resistance of 0.15 Ohms would be required. LTPZen uses a two 3W 0.22 ohm wire-wound resistors in parallel for a trip current of 5.5A. 2N6073 is a sensitive gate device which triggers with a gate current of about 5mA. For a single rail positive supply, a sensitive gate thyristor could be used instead.

The choice of mosfets is not critical. IRFP244 is robust and offers high transconductance and hence low output resistance. Logic level mosfets can be used if you need to lower the dropout voltage.

Zener Diode D1 reduces the risk of gate oxide rupture when the triac fires. If you prefer a regulated supply, insert a zener diode or zener diode chain where shown.

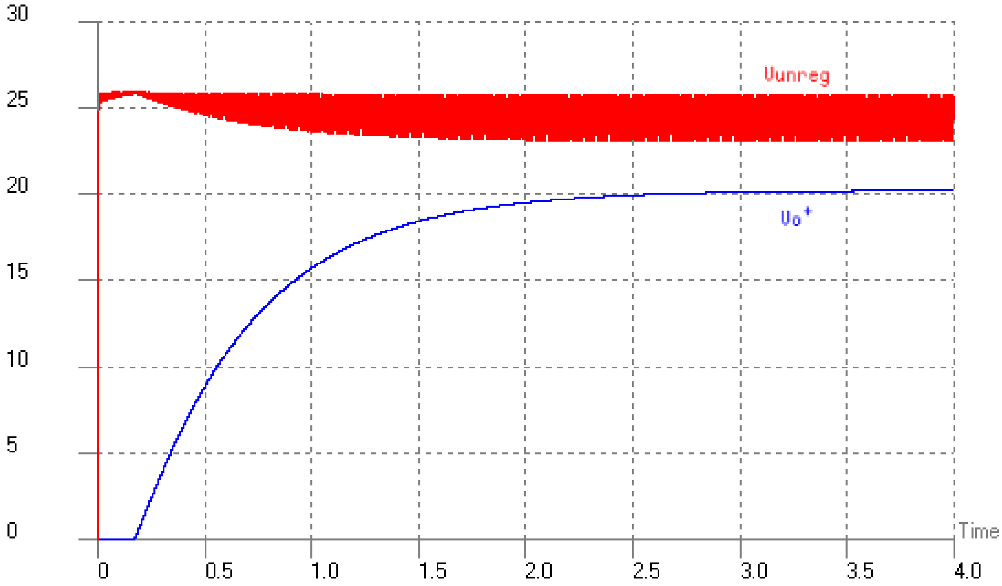

Figure 2. Soft-start Characteristic

Power Supply with secondary, higher voltage rail

Occasionally it is useful to have an additional supply rail running at slightly higher voltage. The LED based constant current source in the output stage of LTPZen for example can benefit from being fed by a low current, higher voltage supply. The simplest way of achieving this is to use an emitter follower in parallel with the source follower. The output voltage of the secondary supply will be raised by Vgs-Vbe or about 3.5 volts. The secondary supply should only be used for light, preferably constant current loads. Transistor T3 has a relatively high HFE so secondary loading through T2 will not feed through to the gate of T2 and affect the main supply. The over current protection circuit also trips the secondary supply. The output characteristic is shown in Figure 3.

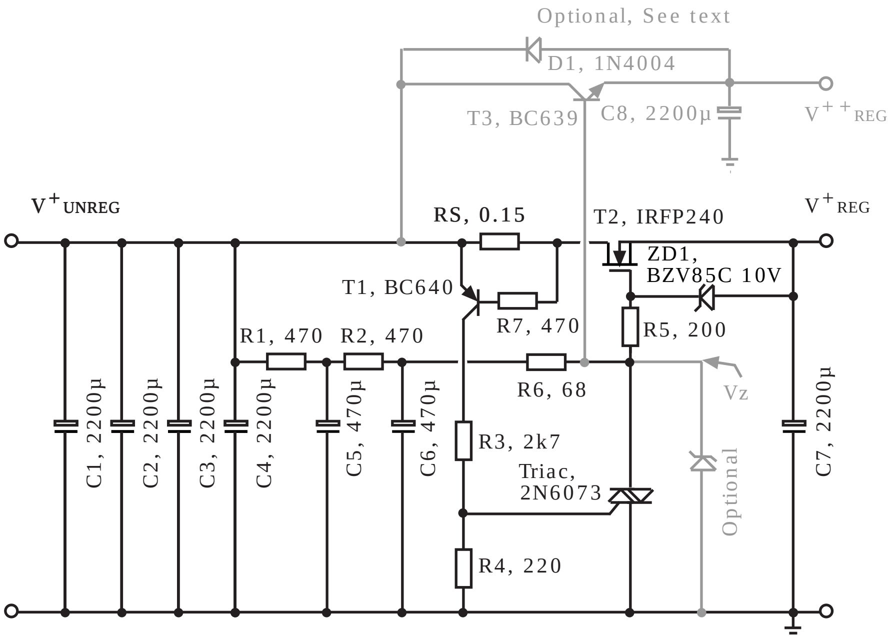

Figure 3. PSU with Optional Higher Voltage Rail

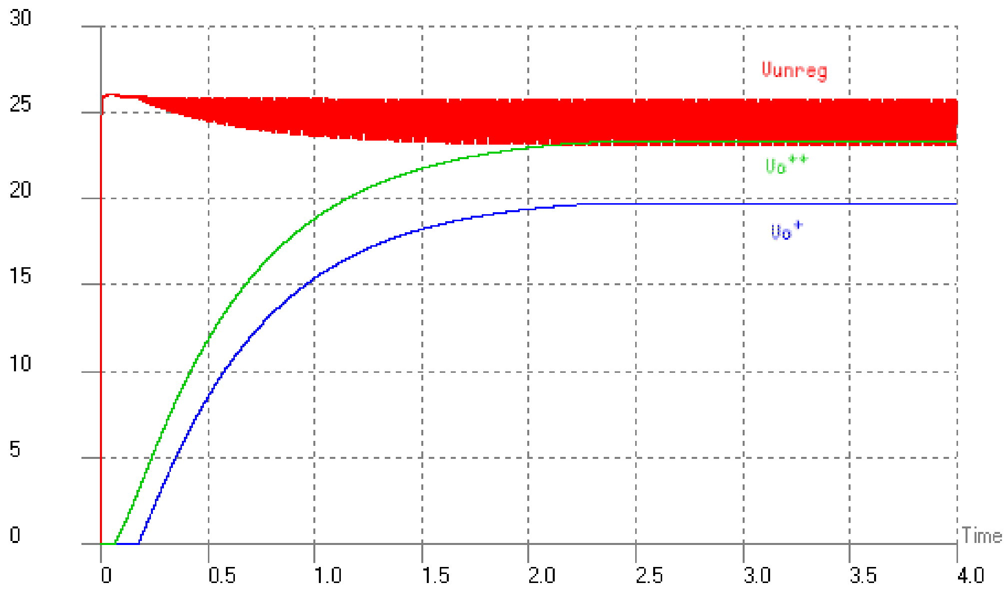

Figure 4. Output Characteristic of PSU with Secondary Rail

Dual Power Supply

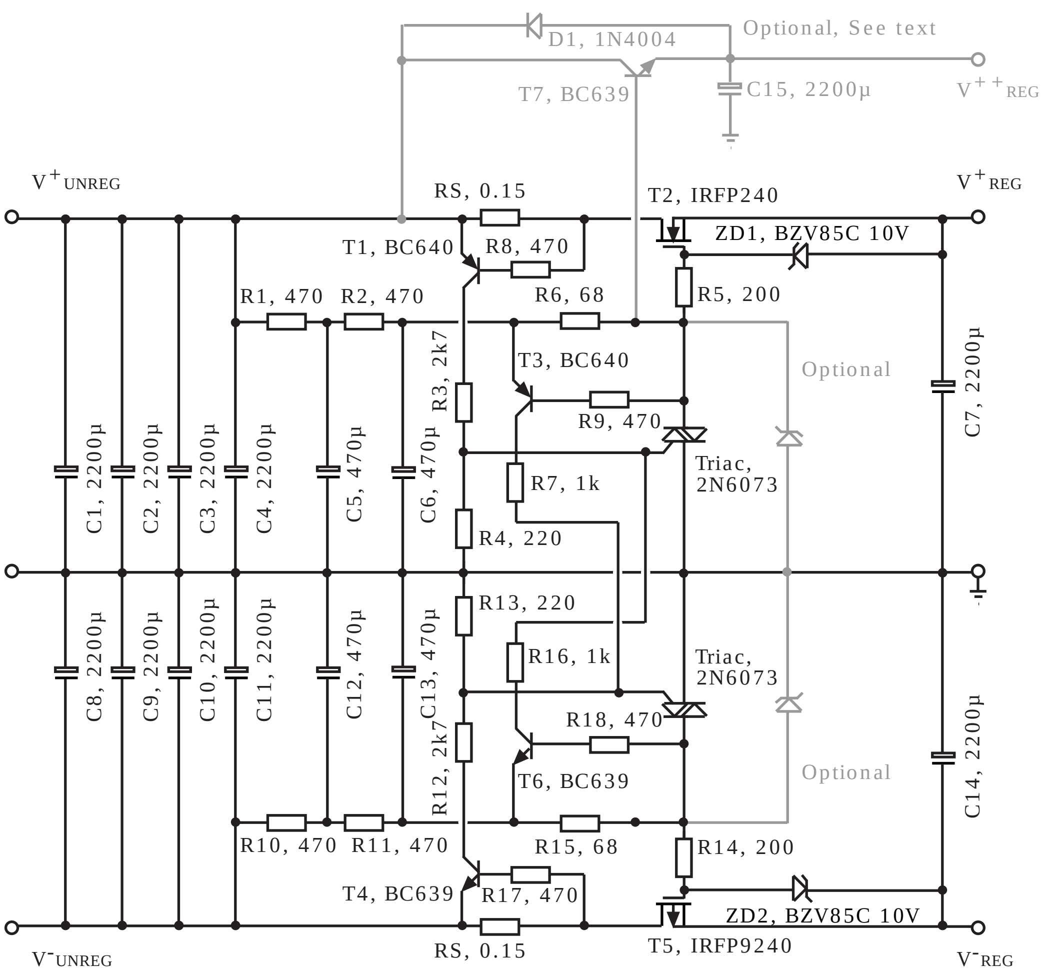

Figure 5. Fail-safe Dual PSU

In it's most basic form, a fail-safe balanced supply can be made by mirroring the single rail design. The version shown in Figure 5. is a little more complex with the additional of transistors, T3 and T6, and resistors, R7, R9, R16 and R18. This arrangement ensures that both positive and negative rails trip in the event of excessive current in either half of the supply. Figure 6 shows the trip characteristic.

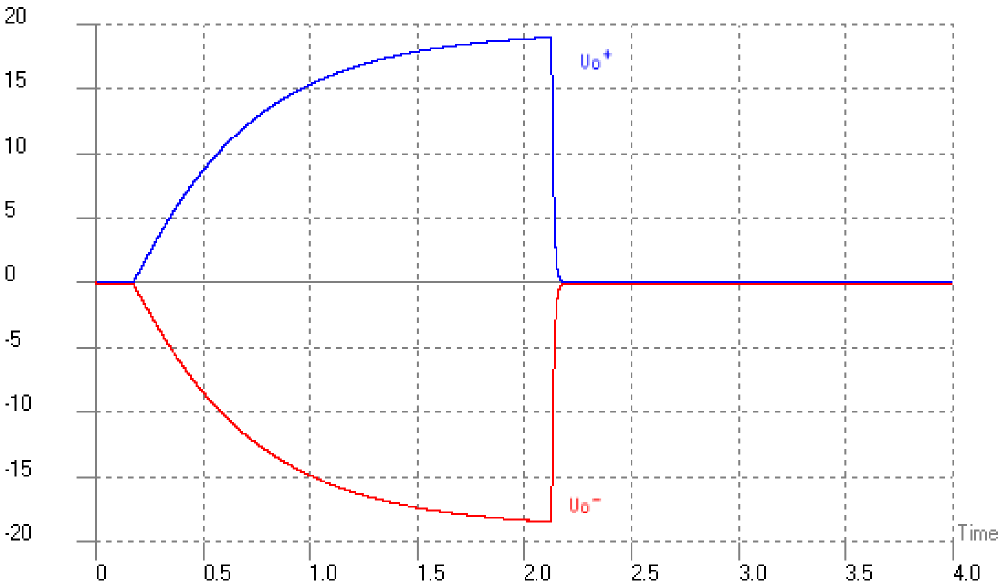

Figure 6. Dual PSU Trip Characteristic

Performance

Once the load current reaches the preset trip level, the output voltage takes about 10mS to collapse. The gate voltage collapses very quickly, but it can take several milliseconds for the load to drain the output reservoir capacitor(s). If a faster response is required, their capacitance will need to be reduced.

Figure 7. shows the output ripple into a 3 Amp load. The peak to peak ripple voltage is 2.2mV. The unregulated ripple voltage on the input reservoir was measured at 2.67 V peak to peak which represents a ripple rejection of -62dB.Thi is equivalent to a passive filter capacitor of about 12 Farads.

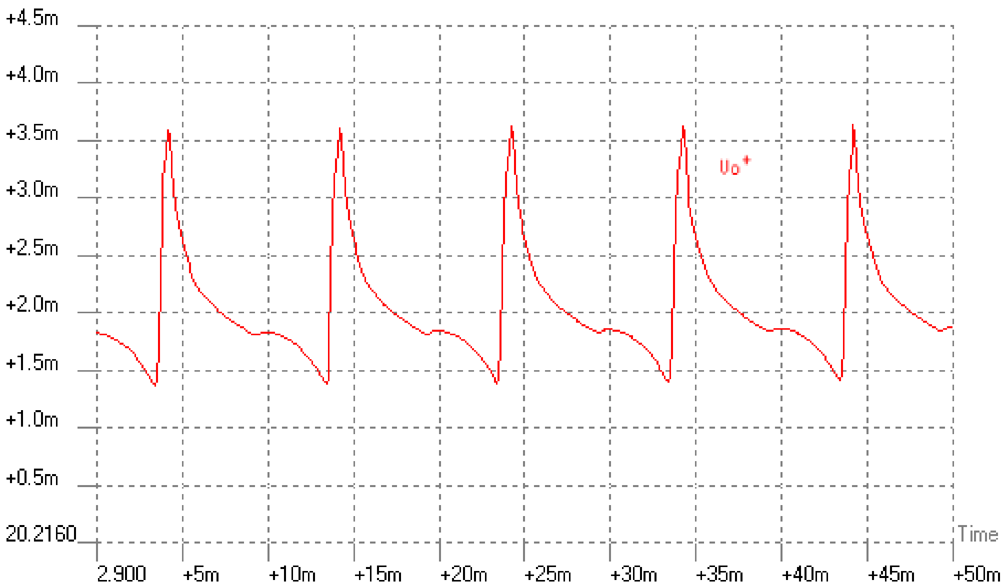

Figure 7. Output Ripple

The circuit has no negative feedback and will have an output impedance equal to the inverse transconductance ~50 mOhms which is not particularly low. Because of this series resistance, a component of the audio signal will be super-imposed on the output of the Power Supply. At full power, the supply voltage modulation will be around 100mV. With A class amps, the AC load current varies linearly with the audio signal.and the full wave audio signal super-imposed on the PSU output has no effect on amplifier distortion.

With other configurations, class AB, and class B, the supply voltage modulation is likely to include a partial or half wave audio signal component. Any amplifier with a Power Supply Rejection Ratio, or PSRR better than -60dB should be compatible. Circuits with differential input stages, and symmetrical designs should have reasonable PSSR figures.

Acknowledgements

I would like to thank several members of the DIY Audio Forum for their comments. Thanks in particular to Patrick, aka EUVL and Vaughan, aka Sherelec. Referring to Figure 1, contributions include the repositioning of bleed resistor R6 from the triac "anode" lead, M_{T2} to the position currently indicated in the schematic. This change improves the trip response of the circuit. The current limiting resistor R7 in the base lead of T1 and ZD1, the protection diode for the gate of the output transistor were also suggested.