Project: C-0060-502-R02

Single Ended Class A Audio Amplifier

Design: Nico Ras

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Introduction:

This design started off on the 04/05/2007 as a very simple single ended class A amplifier using an op-amp as the voltage amplifier, an LM 337 as constant current source and IRFP 640 as the output stage.

It has since evolved into what we have now, still a simple amplifier that is simple to construct and a pleasure to listen to. With a bit of care and purchasing adequately rated components, it would easily rank amongst the so-called high-end amplifiers available today.

In order to keep costs down and heat dissipation to a manageable level it was decided not to limit the power to around 35 watts rms. This does not mean that the amplifier does not need adequate heat sinks, on the contrary, being a single ended design this amplifier will dissipate around 170 watts of heat per channel and would need very large heat sinks or fan cooling.

Being the designer, I do not want to elaborate on what it sounds like but rest assured, I have designed and build several hundreds of high-end amplifiers and would only comment that its sound quality rates amongst the best I have heard.

Performance Specifications:

Output power:	>27Watt rms into 8 Ω
THD:	< 0.1% at 27 watts
Type:	Single ended class A
Input Sensitivity:	0.707 V for full output
Gain:	26 dB
Bandwidth:	-3dB 1 Hz to 1Mhz
Slew Rate:	28V/uS
P – P Output:	42V for 0.707V input into 8 Ω

Circuit Description:

The circuit is straightforward. The input is by means of Q1 and Q2 a PNP differential pair. The resistors R8 and R14 are degeneration resistors and helps with balancing the input pair if there is a gain mismatch. Capacitor C3 ensures that the emitters are at equal signal potential.

The collector loads are by means of a current mirror consisting of Q3 and Q4 in stead of resistors because there is a significant reduction in distortion using current mirrors.

The emitters are connected to a constant current source that is a simple 5V1 zener voltage stabiliser ZD1 bypassed by a 470 µF capacitor and resistor R9 setting the current to 1.4 ma

The voltage amplifier consists of Q5 setting the bias voltage on the gate of the output MOSFET Q10. Instead of utilising a current source I used a bootstrap consisting of R6, R7 and C4.

The constant current source is made of Q14 and Q6 regulates it gate voltage relative to the voltage drop across R20. The bias is derived from R5 connected to the zero volt or ground rail.

Q14 is set to source about 2.8 amps and to achieve the 42-Volt output swing Q10 it will have to pass at least 5.8 amps, hence the reason for choosing rather hefty MOSFETS.

It is not necessary to adjust the off-set voltage because the differential amp holds the output off-set to less than 30 mV, but by careful matching of the differential pair as I have done in the prototype off-set voltages of 200 µV is achievable.

Power requirements

This is the one of the most important aspects of building a high-end amplifier. To reduce costs in the prototype I used two separate transformers to get the ±24V required for the amplifier. Both transformers are rated 24V rms since this is where the power supply voltage will be not at the potential normally calculated as 1.414 x transformer voltage, which essentially is the open circuit voltage of the transformer. The transformer feeding the negative supply is rated at about 3.5 amps (85VA) while the transformer used for the positive supply is rated at about 6 amps (150VA).

In order to reduce the ripple to a minimum I used a total of 47 000 µF capacitance on each rail. It is recommended to use many 4700 µF capacitors in parallel rather than single capacitors as the ripple current specification add together. The capacitors used should be rated for switch-mode power supplies with very low ESR.

Of course you can use a regulated power supply for the amplifier or a capacitance multiplier as that described in Project15 on http://sound.westhost.com both these will improve the sound quality but will add significant cost. Also remember that there is a

voltage drop across the regulator and you have to increase the transformer voltage if you want the benefit of using a regulated power supply.

Heat sink

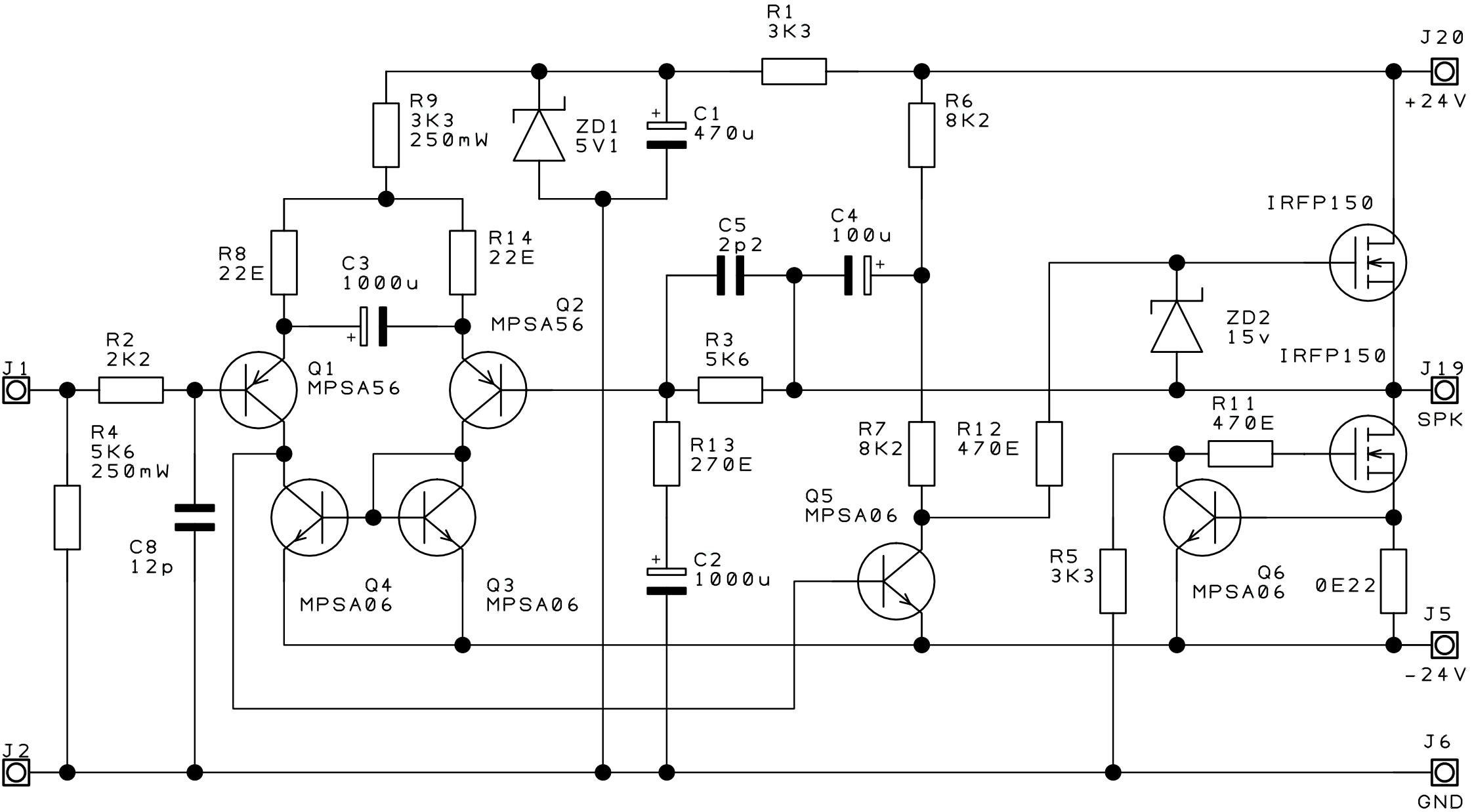
This is probably the most important aspect of the amplifier and I must warn you that it runs hot. 340 watts of heat is a lot of heat to get rid of and adequate heat sinks is not essential in is imperative. In the prototype I used heat sinks from power inverters that is rated 0.12°C/W and this is still a hefty 40°C above ambient. If you consider room temperature at an average of 25°C then the heat sink will be at 65°C and could burn you.

Fan cooling is of course an option and you will be surprised at how much more effective heat sinks become even with a very moderate airflow. If you don't want the fan to run continually there are many thermal switches available that you can use to switch the fan on and off. Keep in mind that the fan switching can cause clicks and pops to be transferred to your speakers so take care to use snubbers across the switch contacts.

Conclusion

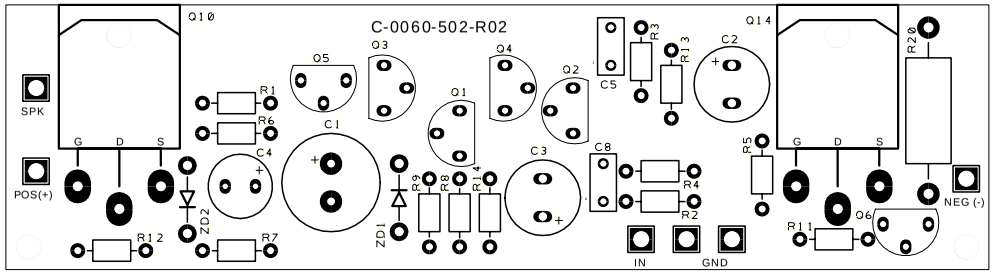
Although this is a very simple amplifier to build electronically, much care is needed when designing your power supply and heat sink as either not properly designed can lead to either disaster or you will be very unhappy with the sound. A single ended class A design that makes use of a current source is very unforgiving when it runs out of steam (over driven) and will sound absolutely awful! Make sure that your transformers are up to the job, it is better to have more VA available than to little and I cannot over stress the heat sink. Although the MOSFET will function happily at 100°C it becomes a hazard to people especially if there are small children around that does not realise that your amp is as hot as a pot of boiling water.

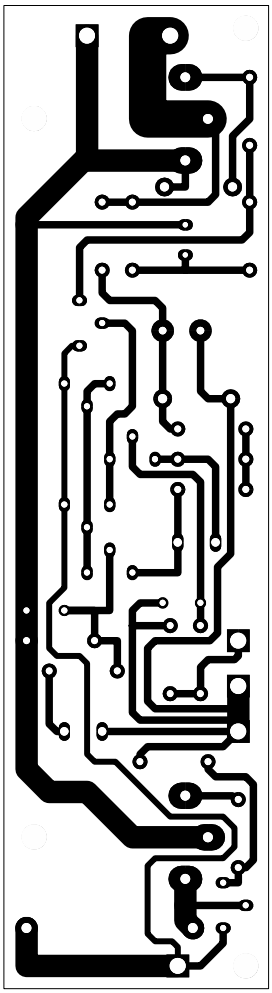
While using the IRFP150 which has ample drive capability the amplifier can withstand certain short circuits but I would advise to use in line fuses to your speakers. People all to often think that fuses are to protect the electronics, that is not so. Fuses are there to protect you against a potential fire hazard.


R1
3K3
J20
+24V
R9
3K3
250mW
ZD1
5V1
C1
470u
R6
8K2
IRFP150
R8
22E
C3
1000u
R14
22E
C5
2p2
C4
100u
Q2
MPSA56
ZD2
15v
IRFP150
J1
R2
2K2
Q1
MPSA56
R3
5K6
J19
SPK
R11
470E
R4
5K6
250mW
R13
270E
R7
8K2
R12
470E
Q5
MPSA06
C8
12p
C2
1000u
R5
3K3
Q6
MPSA06
0E22
Q4
MPSA06
Q3
MPSA06
J5
-24V
J2
J6
GND

C-0060-502-R02.lsp

Ref	Qty	Name	Description	Package
R20	1	0E22	Resistor	5 Watt
C2 C3	2	1000u	Capacitor Elec Radial	16V
C4	1	100u	Capacitor Elec Radial	35V
C8	1	12p	Capacitor Cerm 50V	5.0 mm
R8 R14	2	22E	Resistor	250mW
R13	1	270E	Resistor	250mW
R2	1	2K2	Resistor	250mW
C5	1	2p2	Capacitor Cerm 50V	5.0 mm
R1 R5 R9	3	3K3	Resistor	250mW
R11 R12	2	470E	Resistor	250mW
C1	1	470u	Capacitor Electr Radial	63V
R3 R4	2	5K6	Resistor	250mW
R6 R7	2	8K2	Resistor	250mW
Q10 Q14	2	IRFP150	MOSFET	TO-3P
Q3 Q4 Q5 Q6	4	MPSA06/BC550C	Transistor	TO-92
Q1 Q2	2	MPSA56/BC556C	Transistor	TO-92
ZD2	1	ZD 15v0 500mw	Zener	Radial
ZD1	1	ZD 5v1 500 mW	Zener	Radial


C-0060-502-R02
Q10
Q14
SPK
POS(+)
NEG (-)
G
D
S
R1
R6
R12
R7
C4
ZD2
C1
Q5
Q3
Q4
Q2
Q1
C3
ZD1
R8
R14
C8
C5
R3
R13
C2
R5
R4
R2
R20
R11
Q6
IN
GND

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