# *Radical Audio Synthesis*

# Model 10A

The Radical Audio Synthesis Model 10A is an extremely simple single ended 10-watt class-A amplifier. This amplifier uses three transistors and two MOSFET type IRF150 although many other may be substituted provided that you take care not to exceed the device thermal specifications.

The front end consists of a PNP differential amplifier using MPSA56 transistors. However low noise BC556 or its derivatives will work as well. VR2 is a 10 turn pre-set potentiometer of 100Ω used to adjust the offset voltage as well as being degeneration resistors for the differential pair. Although matching transistors are said to improve the sound quality and balance in an amplifier, I find this practice totally unnecessary and measurable differences are virtually non-existent.

The differential amplifier is followed by the voltage amplifier consisting of a NPN transistor of the type MPSA06, but BC557 and its derivatives will work equally well or even better.

Instead of the commonly used constant current generator the collector of the Q3 is loaded by a bootstrap consisting of C1, R8 and R9. I have had very good results with this simple configuration and found it offers several advantages over the current source.

Q5 is the constant current source that loads the output stage and what makes this amp single ended. The constant current source can be adjusted by the 10-turn 1KΩ potentiometer VR1. VR1 forms a potential divider with R11 and R12. The maximum current allowable is fixed by the value R12 that offers some measure of safety should you accidentally adjust VR1 to maximum value.

The current source is proportional to the gate voltage on Q5 and adjusting VR1 by increasing the gate voltage would in turn increase the current supplied by the source.

The current requirement set for your amplifier is very important and you need to decide what output power you need the amplifier to be. I would suggest that beginners not fully aware of the thermal consequences of class-A amplifier should kick-of with a low power setting until familiar with just how hot this little beast can get.

Single ended class-A amplifiers are the most inefficient of all amplifiers and generate easily three to four times more heat than audio output it produces.

Let us assume for this exercise that 5-watts into an 8 Ω loudspeaker would be sufficient. The current needed from the current source during the negative half cycle of the signal would be $P=I^2R$, where P is the output power into the speaker, I the current and R the nominal speaker impedance. From the equation it can be seen that a constant current of around 800mA is needed.

However, it is wise to allow an additional 10% margin since speakers are not purely resistive and impedance can vary quite substantially under dynamic conditions, thus 880mA would be the figure to aim for.

Now calculate the supply voltage for the amplifier keeping in mind that this is a split supply and the positive supply has to be the same as the negative supply. Using the value of I calculate the supply voltage from P=VxI which is 9 Volts rms.

Your transformer should thus be a dual winding that would provide 9 – 0 – 9 VAC. All that remains now is to calculate the VA rating of the transformer.

If you look carefully at the circuit, you will notice that in the idle state, when no signal is present, both Q5 and Q4 conduct 880mA. When a signal is applied that swings fully to the positive rail, it is obvious that Q4 would have to conduct twice the current that it would in the idle state, thus 1.760 amp.

In order to make sure that your power supply is beefy enough to handle this current it must be able to supply 1.8 amp rms. Thus the transformer rating has to be 1.8 amp x 18 volts = 32 VA. This requirement is for one channel and for a stereo amplifier the requirement doubles to 64 VA.

The power supply for this amplifier is simple and consists only of a rectifier bridge and two large reservoir capacitors, one for each rail. The capacitors must be large in order to supply the peak current while the supply voltage decays between cycles. Typically 10 000 $\mu$F would be fine for this amplifier but larger values will improve bass performance.

When powering up your amplifier and you measure the rail voltages of the power supply, you will immediately notice that the usual calculation of 1.414 x transformer voltage is not valid. This is because your amplifier is drawing current continuously and the rail voltage would be close to the transformer ac voltage, probably only about 10 volts.

Choosing the heat sink is the next problem to solve and a simple rule of thumb would be to calculate the power dissipated by Q4 and Q5, this is roughly (1.8 + 0.88 amp) x 9 volt = 24 watt.

Now decide what the maximum ambient temperature is where you will use this amplifier, let us assume that it could get to 50$^0$C. Your amplifier should not run much higher that 20 – 25$^0$C above ambient. Thus the maximum allowable temperature of the heat sink should never exceed 75$^0$C. Be careful this is hot and could burn you.

Should you choose a heat sink of 1K/w for your little 5-watt single ended amplifier, the temperature would be 24 degrees and the maximum temperature of the heat sink at 50$^0$C ambient will be around 74$^0$C. This is okay, but choose a better heat sink if you can afford it.

Of course forced air-cooling is far more efficient that normal circulation and even a very small fan could improve matters quite substantially.

Q4 and Q5 have to be isolated from the heat sink and mica or silicone washers are required for this purpose. Although they say you do not need silicone grease when using silicone washers, I use it because its purpose is to create a better contact area between the device and heat sink.

Only after your transistors are mounted securely on the heat sink and you have checked the wiring, should you turn the power on. Never power the amp without a heat sink, the transistors no matter how many watts they are rated at will be destroyed instantly.

Wiring an amp is probably the area where even an experienced DIY fanatic can go horribly wrong and find that their amps hum and buzz and it is impossible to find the problem. The rules are actually very simple, treat each amplifier as a stand-alone unit so that they do not share any length of wire.

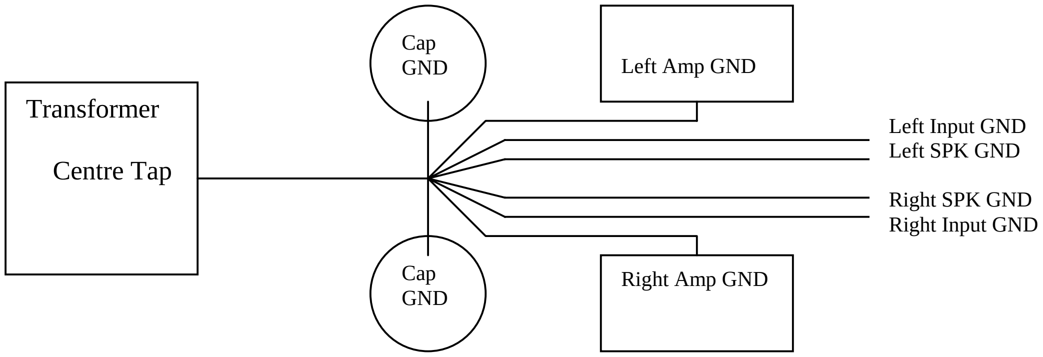
When you wire your power supply ensure that the ground connection between all the capacitors are separate and connect to only one single point, the same point should connect to each speaker negative terminal, each input terminal and each amplifier ground. There must be no shared wires, e.g. going from ground point to one input and then to the other. Each wire must be dedicated to each ground terminal.

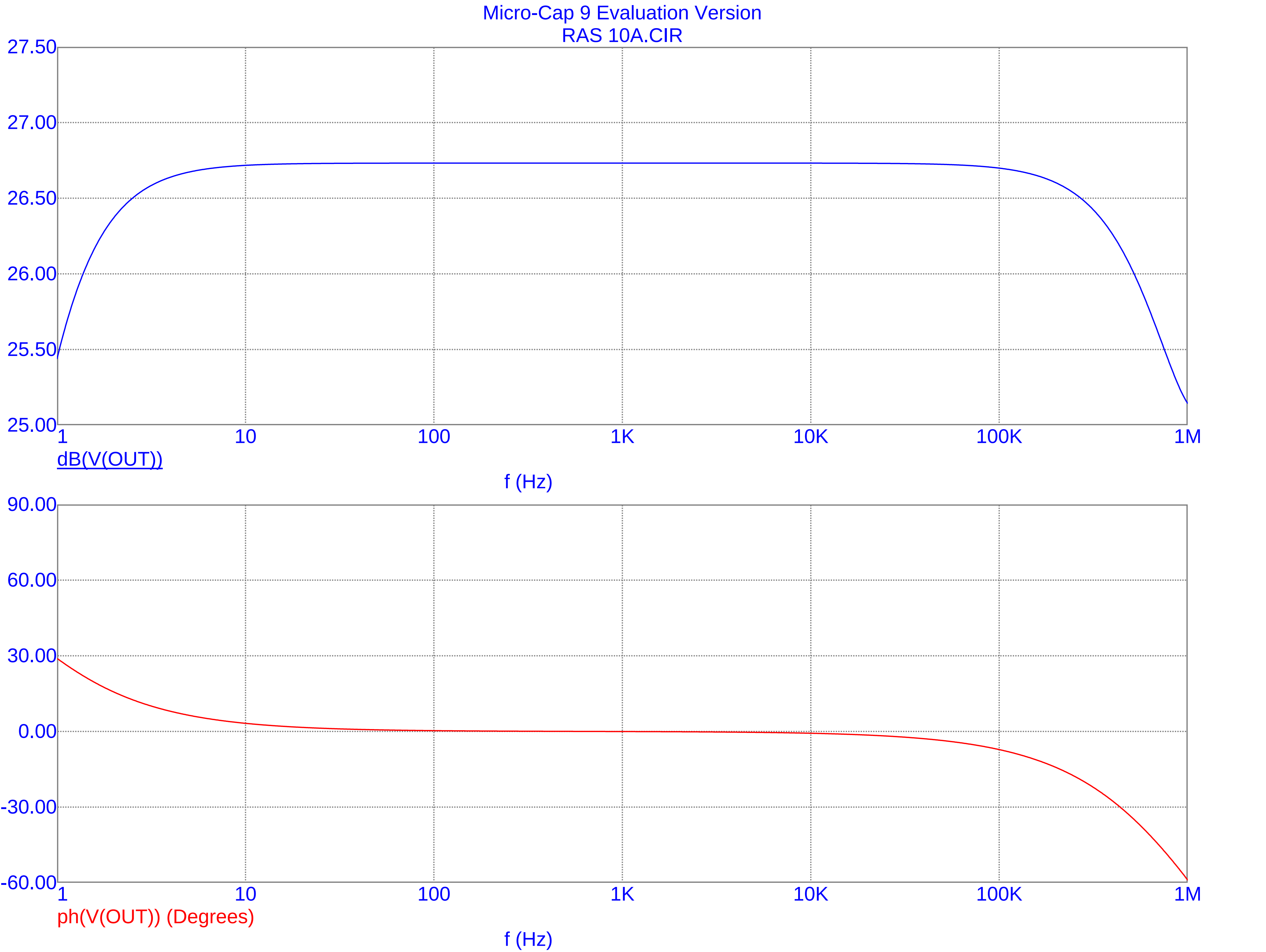
Also do not run the screen from the input of the amplifier to the input terminal ground, this is not ground when it reaches the terminal, believe me, even if your multi-meter says zero Ohms it is not for ac signals!

If you decide to add a volume control do not be fooled by connecting the grounds on your volume control together, they are not the same and should be treated as two separate controls, each volume control ground terminal must be connected to the single central ground connection.

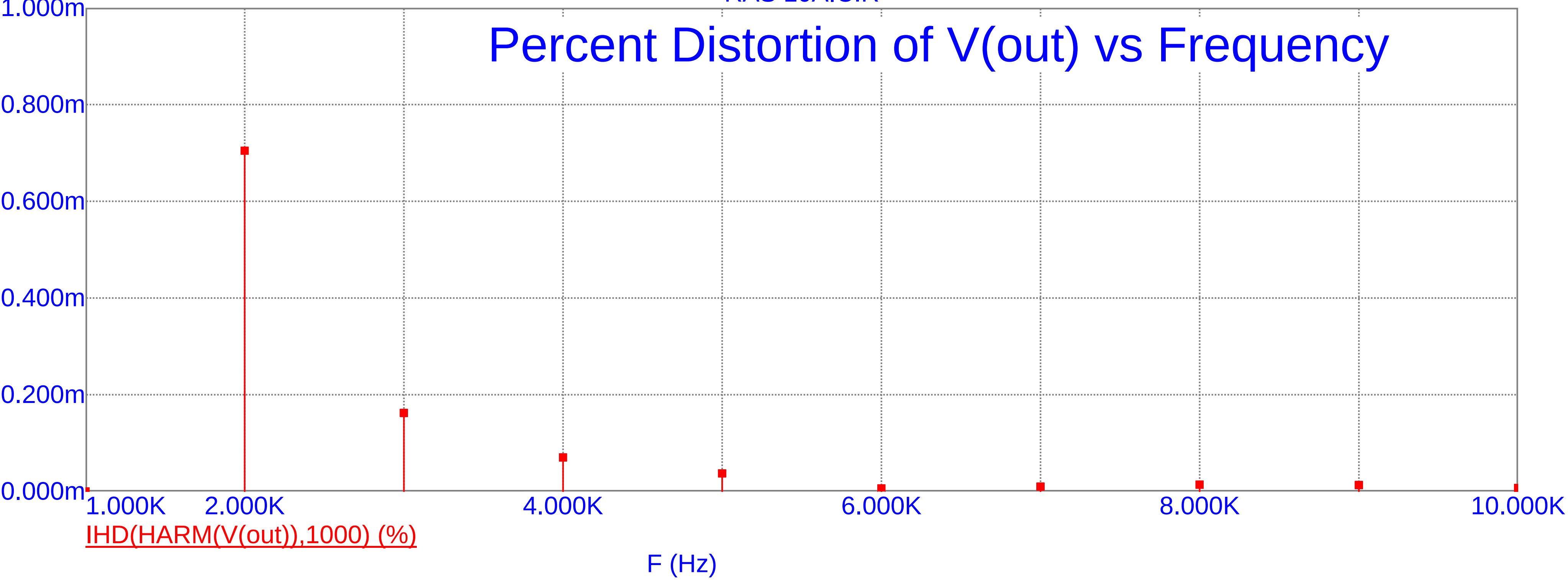
Anyway, if you followed the simple rules carefully, you will end up with an amplifier like mine that has absolutely no hum, buzz or noise. Even if the wiring looks like a birds nest and untidy, don't worry, it works.

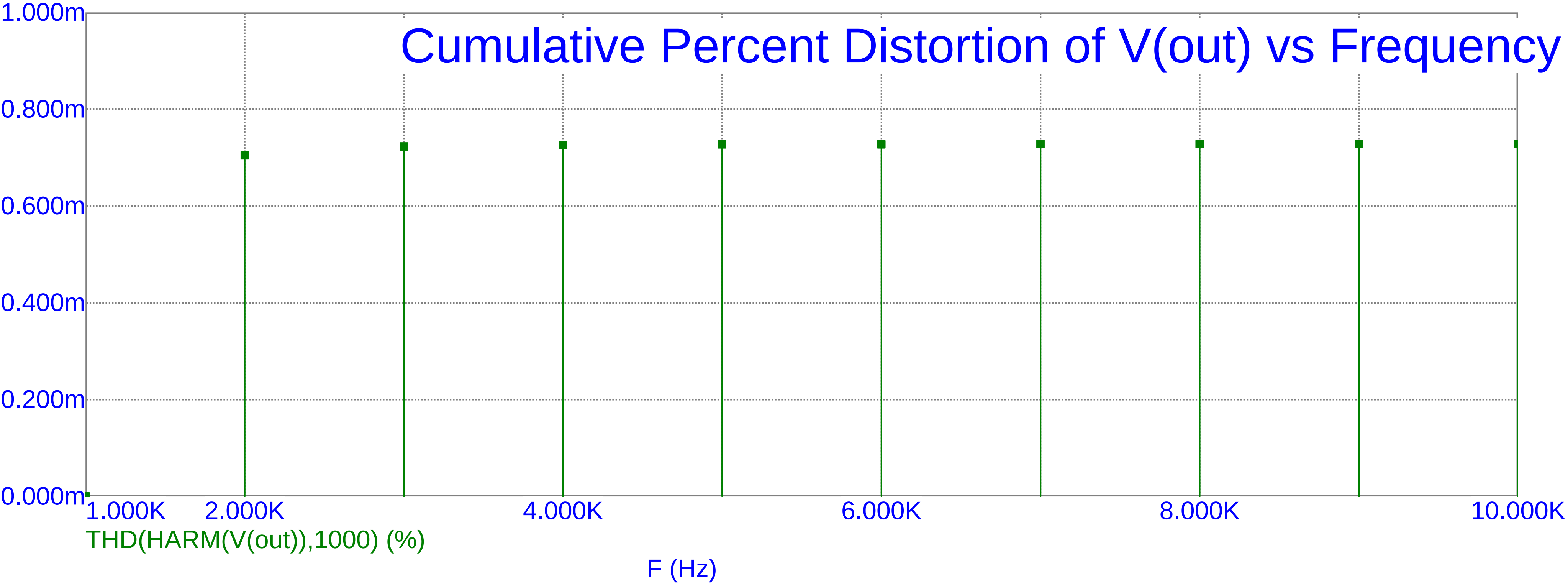
Below is an example of the ground wiring layout I would suggest.

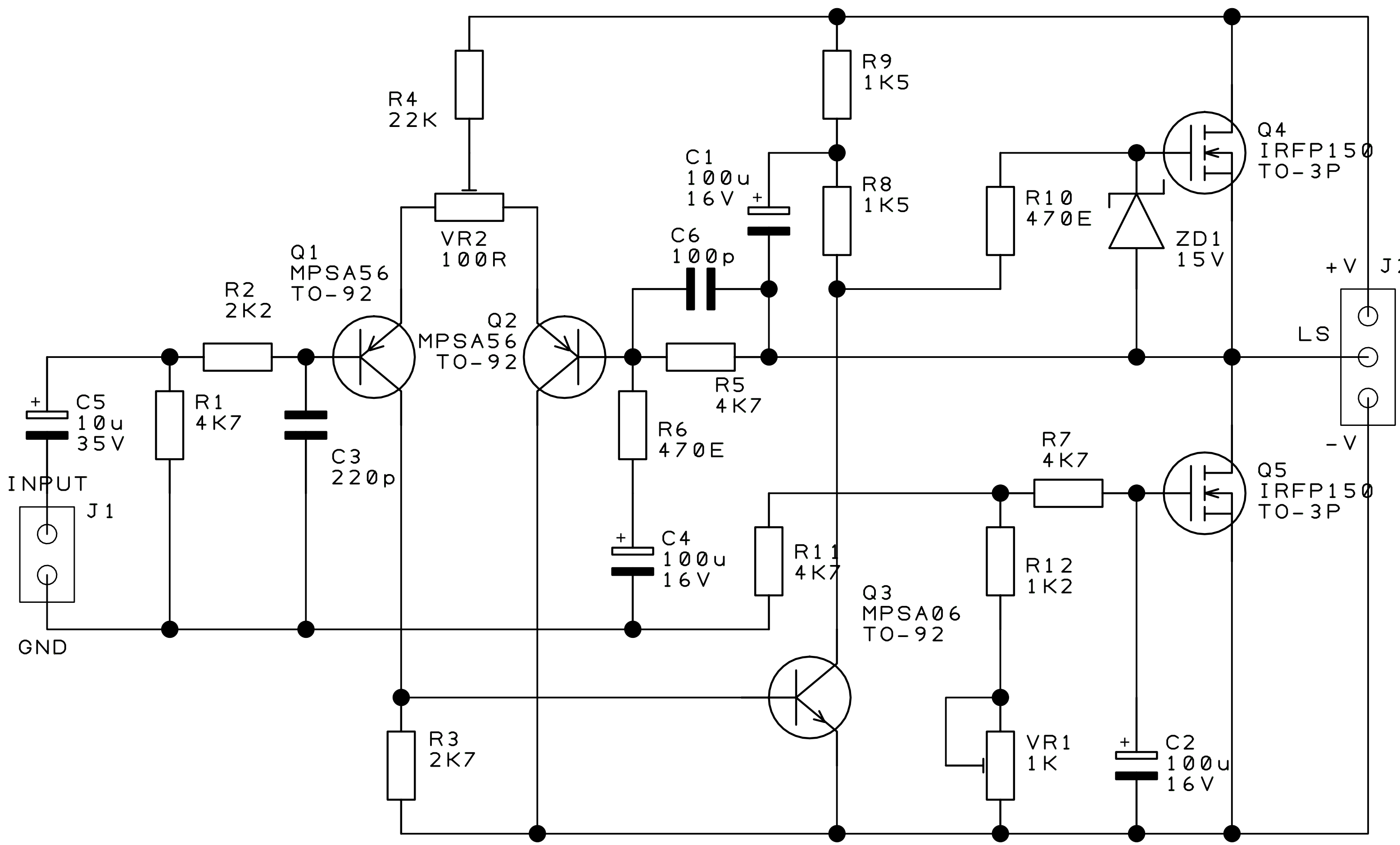



Micro-Cap 9 Evaluation Version
RAS 10A.CIR
27.50
27.00
26.50
26.00
25.50
25.00
1
10
100
1K
10K
100K
1M
dB(V(OUT))
f (Hz)
90.00
60.00
30.00
0.00
-30.00
-60.00
1
10
100
1K
10K
100K
1M
ph(V(OUT)) (Degrees)
f (Hz)

Micro-Cap 9 Evaluation Version
RAS 10A.CIR

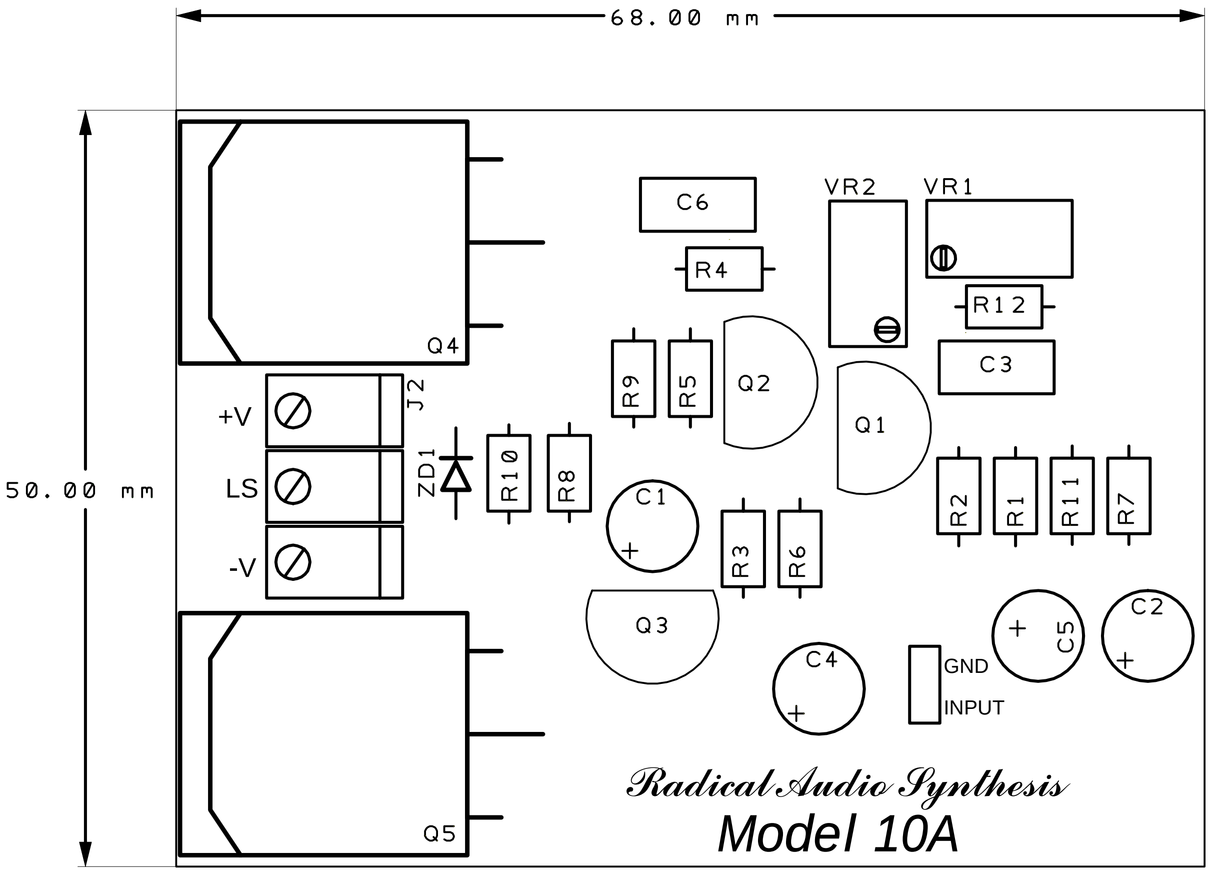



R4
22K
VR2
100R
R9
1K5
C1
100u
16V
R8
1K5
R10
470E
Q4
IRFP150
TO-3P
ZD1
15V
+V
J2
LS
-V
Q1
MPSA56
TO-92
R2
2K2
Q2
MPSA56
TO-92
C6
100p
R5
4K7
C5
10u
35V
R1
4K7
C3
220p
R6
470E
INPUT
J1
GND
C4
100u
16V
R11
4K7
R7
4K7
Q5
IRFP150
TO-3P
R12
1K2
Q3
MPSA06
TO-92
R3
2K7
VR1
1K
C2
100u
16V

SIMPLE CLASS A R05.lsp

| Ref | Qty | Name | Description | Package |
|---|---|---|---|---|
| C6 | 1 | 100p | | 5_0 mm |
| C1<br>C2<br>C4 | 3 | 100u | Capacitor Elec Radial | 16V |
| C5 | 1 | 10u | Capacitor Elec Radial | 35V |
| R12 | 1 | 1K2 | Resistor | 250mW |
| R8<br>R9 | 2 | 1K5 | Resistor | 250mW |
| VR1<br>VR2 | 2 | 1K0 T- POT | | G |
| J1 | 1 | 2 Way Pin | | DSC |
| C3 | 1 | 220p | Capacitor Cerm 50V | 5_0 mm |
| R4 | 1 | 22K | Resistor | 250mW |
| R2 | 1 | 2K2 | Resistor | 250mW |
| R3 | 1 | 2K7 | Resistor | 250mW |
| R6<br>R10 | 2 | 470E | Resistor | 250mW |
| R1<br>R5<br>R7<br>R11 | 4 | 4K7 | Resistor | 250mW |
| J2 | 1 | 8191-3 | | DSC |
| Q4<br>Q5 | 2 | IRFP150 | | TO-3P |
| Q3 | 1 | MPSA06 | | TO-92 |
| Q1<br>Q2 | 2 | MPSA56 | | TO-92 |
| ZD1 | 1 | ZD 15v0 500mw | | Radial |


68.00 mm
50.00 mm
Q4
Q5
C6
R4
VR2
VR1
R12
C3
Q2
Q1
R9
R5
J2
+V
LS
-V
ZD1
R10
R8
C1
R3
R6
R2
R1
R11
R7
Q3
C4
C5
C2
GND
INPUT
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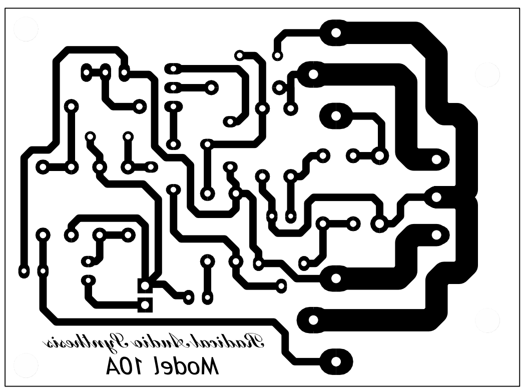
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