

Repairing the Hafler 9503/9505 Amplifiers

A friend of mine brought over a Hafler 9505 amplifier that made a thump when turning off. I removed the top cover and ran the unit for less than an hour and discovered some very hot transistors. My electronic thermometer indicated some of them were near 100 degrees C. Not a good situation to say the least, so I started to investigate.

After locating and studying the schematic, I learned the transistors are used in a complimentary PNP and NPN configuration to drive the output stage. All eight transistors are in TO-92 packages, which can dissipate a maximum of 625 milliwatts if kept at 25 degrees C. Above this temperature, the rating decreases significantly and these transistors were well above 25 degrees C. By reading the voltage drop across R44 and R48, I was able to determine they were both passing well over 40 ma and Q15 was consuming approximately 500 mw and Q16 nearly 600 mw. After an exhaustive effort to find the cause of the excessive current flow through the driver stage, I came to the conclusion that the biasing circuit as designed and implemented was over driving them into failure. I replaced several of the transistors and built a nice heatsink for each set out of circuit board material. This helped to cool them down but the dissipation was still too high. The current through the driver transistors is controlled by diode D5, which conducts current that would otherwise be going into the emitters of transistors Q12 and Q13. However, D5 is not conducting enough current to keep the driver stage out of trouble. The maximum voltage across D5 cannot exceed 1.2 volts and any attempt to do so will pump more current into Q12 and Q13 and on to the driver transistors. There is no bias adjustment for the driver stage so I installed a resistor and potentiometer across D5 to siphon off some of the current to reduce the amount going through the driver transistors. A test with a sin wave showed that at the absolute maximum input drive level of 6 volts peak to peak, the current flow through the driver transistors only varied by a few milliamps. After letting the amplifier warmup for a few hours, I set the bias current to 16 milliamps by using a digital voltmeter to read the voltage drop across R44 and setting it to .8-volt DC. There appeared to be very little current creep after running the amplifier for several more hours and the transistors are only warm. This means

the bias level is such that the transistors won't wonder into a thermo runaway condition and the driver stage will not fall out of class A operation.

The change in the bias of the driver stage affected the current through the output transistors as expected. P2 controls the current and should be set to 400 milliamps as explained in the owner's manual. The output transistors operate in Class B as a push pull amplifier. It is important that current through all 8 transistors never drops to zero in order to prevent crossover distortion. Another test showed that at full output power the current only nears zero if the bias current is set at or below 250 milliamps. Since the owner of this amplifier will not be using it anywhere near its limits, the bias was set at 350 milliamps. This will provide plenty of current at crossover and has the added benefit of cooler transistors and heatsink. I consider the overheating transistor problem solved, but if my friend encounters a problem, I can always increase the bias level if needed.

The source of the turn on and turn off thumping problem turned out to be far more difficult to locate. The use of an oscilloscope showed a 50-volt spike at the amplifier's output right after turn-off. The source of the spike appeared to be everywhere and nowhere specific. All DC measurements were normal. The amplifier's output is feedback to both sides of a current mirror consisting of Q8, Q11 and U9. This made it difficult to pin down the exact source. The first area I looked at was of course the turn-on turn-off control circuit which is part of the power supply and consist of 3 transistors, Q201, Q202, Q203, a few diodes, capacitors, and resistors. This circuit controls Q10, a transistor biased to sink around 11 ma. It delays the turn on of the current source at power up and shuts it down very quickly at power off. This circuit was found to be operating correctly. By using a multi-channel oscilloscope, it was found that Q12 was still conducting for a short period of time after the current source had been shut off. It was this current that generated the pulse that was applied to the base of the P channel MOSFETs. The replacement of Q12 ended the thumping problem but during the process of finding Q12, it was discovered that several of the P-channel MOSFETs were leaking. Probably damaged by the erroneous spike. It is easy to tell if there are leaky transistors in the output stage. The transistors are all enhancement mode MOSFETS and

should have near infinite drain to source resistance when not driven. The voltage across the large 20,000 ufd capacitors should remain for several days after power is shut off, if not, one or more of the transistors are most likely leaking.

Conclusion:

What fixed this amplifier is the replacement of a SMT NPN transistor and the change of bias for the input and driver stages. I ended up replacing all the MMBT5088 transistors with 50C02CH-TL-E NPN transistors made by ON Semiconductors. The MMBT5088 transistors are only rated at 30 volts from collector to emitter, these amplifiers use plus and minus 24 volts. Over time they become leaky and don't turn off like they should. After replacing them, the thumping during turn on and turn off was gone. To cool down the 4 driver transistors I added a 1k pot and a 330-ohm resistor across D5 and adjusted it for .8 volts across R44 and R48. This resulted in a bias current of about 16 ma going through Q14, Q15, Q16 and Q17. Even at full power, the current through the driver transistors only changed by a few milliamps. Now the transistors won't cook and fail. I also changed R12 and R10 in the input stage to reduce the idle current though transistors Q4, Q5 and Q6, Q7 to 100 to 120 ma. The bias changes I made should not affect the performance of the amplifier unless it is driven hard. I changed all the electrolytic capacitors but not the 20,000 ufd ones. I also changed all the MOSFETs in the output stage only because the thumping damaged the P channel MOSFETs. This can easily be checked by measuring the voltage across the 20,000 ufd caps. With the amplifier turned off, the caps should take a day or so to discharge, if they discharge over night or in a few hours, a transistor is leaking, or of course the associated cap may be bad. Do the same modifications described here to the other channel as well. Good Luck

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