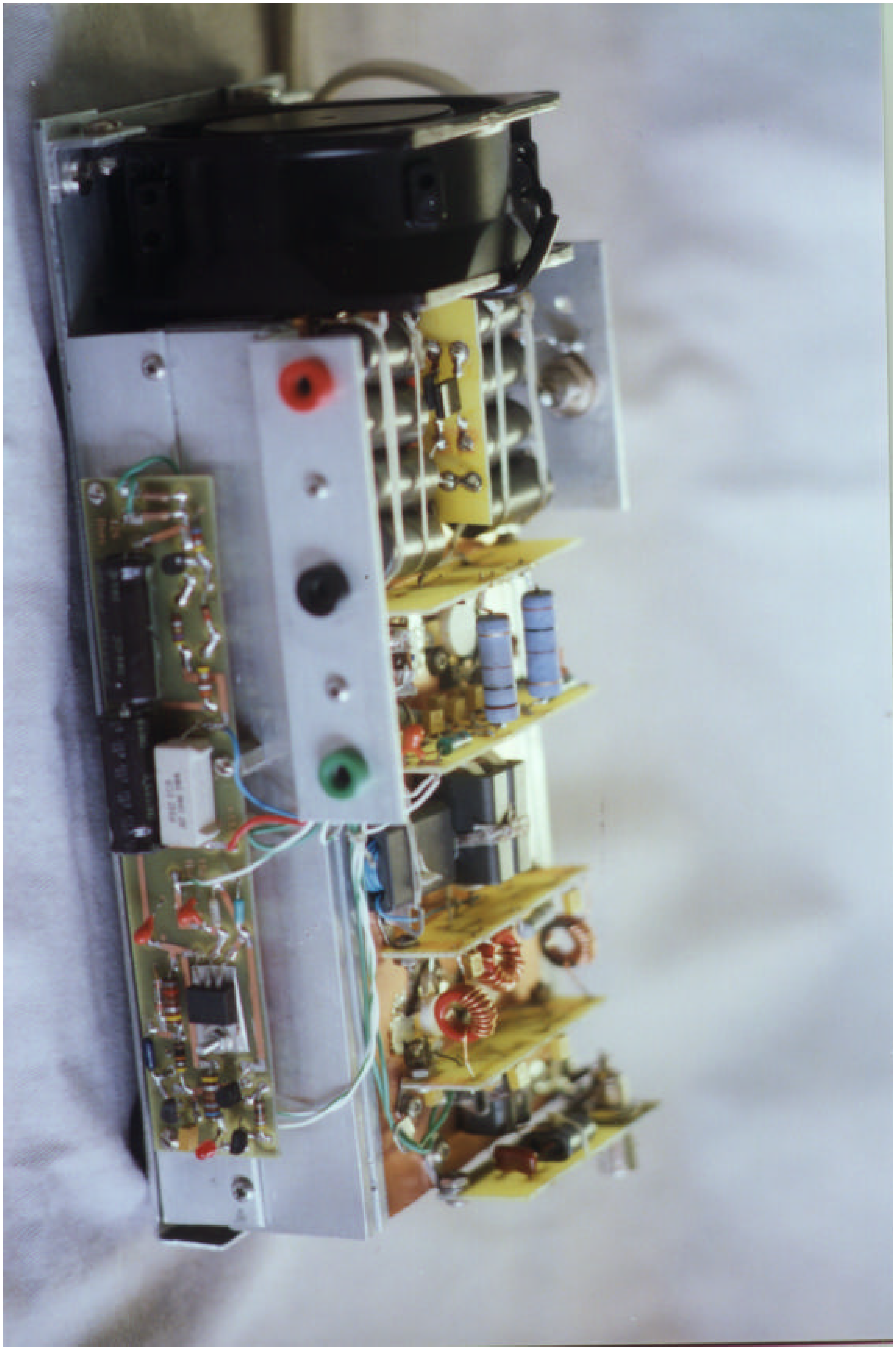
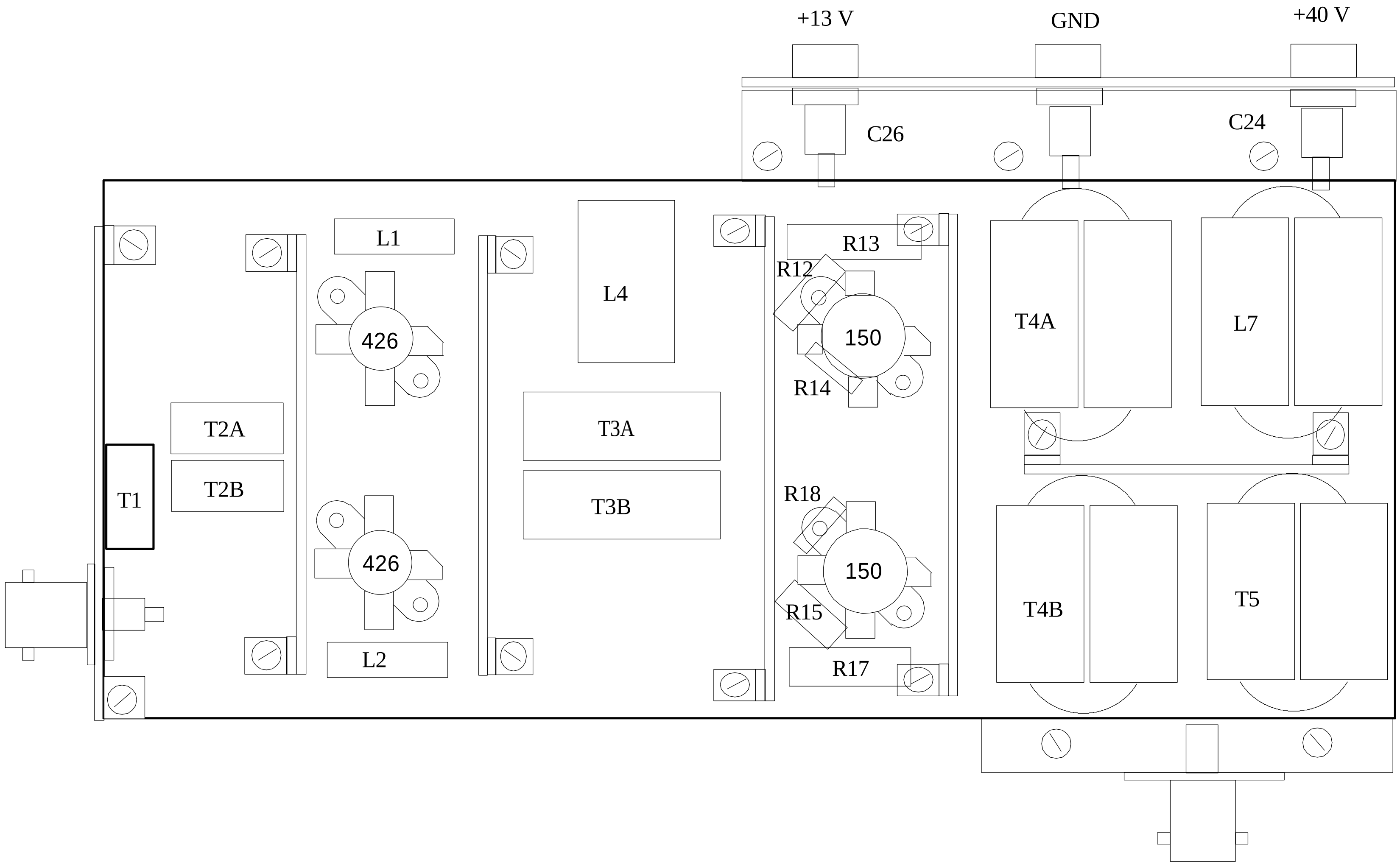
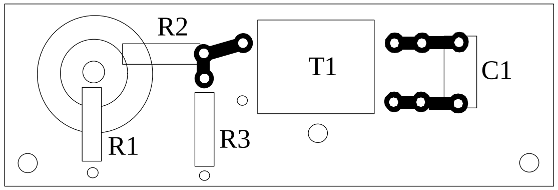
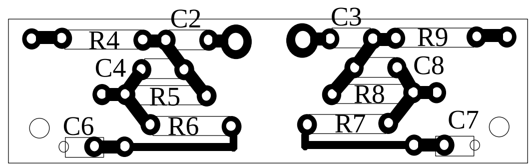




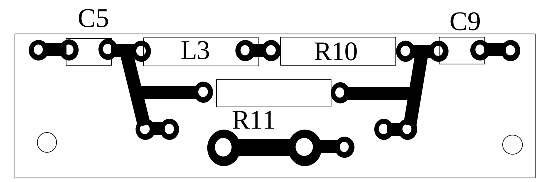
+13 V
GND
+40 V
C26
C24
L1
L4
R13
R12
426
150
R14
T4A
L7
T2A
T3A
T1
T2B
T3B
R18
426
150
T4B
T5
R15
L2
R17



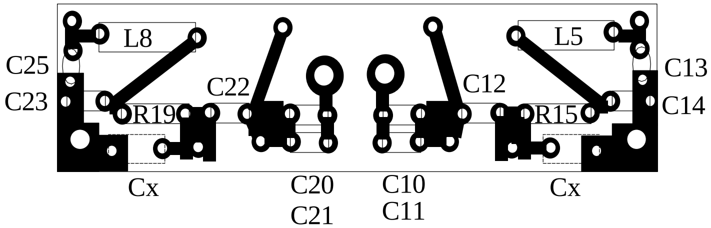
INPUT BOARD



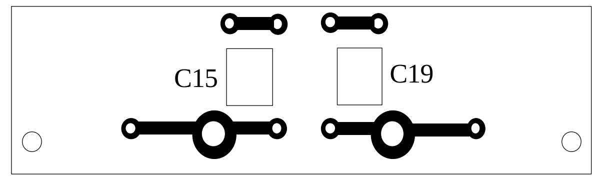
FIRST STAGE INPUT



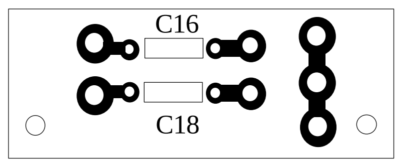
FIRST STAGE OUTPUT



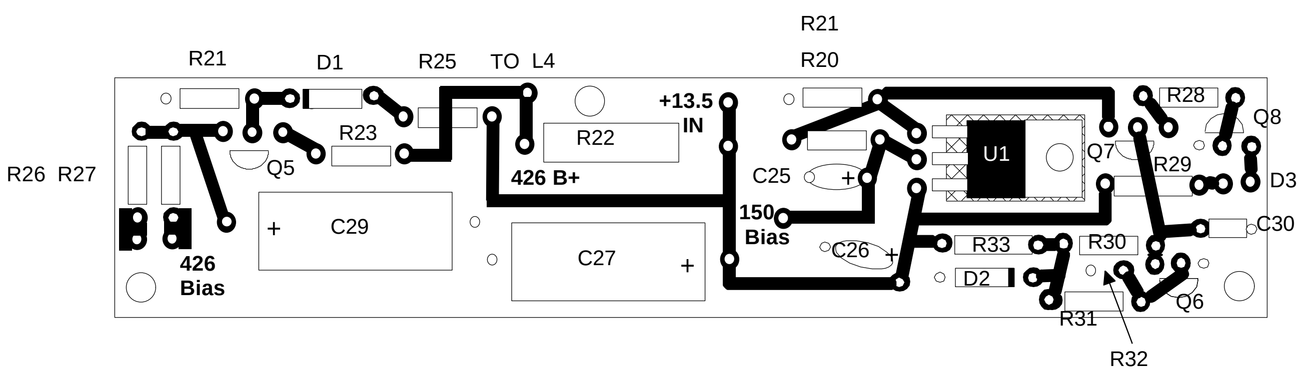
SECOND STAGE INPUT

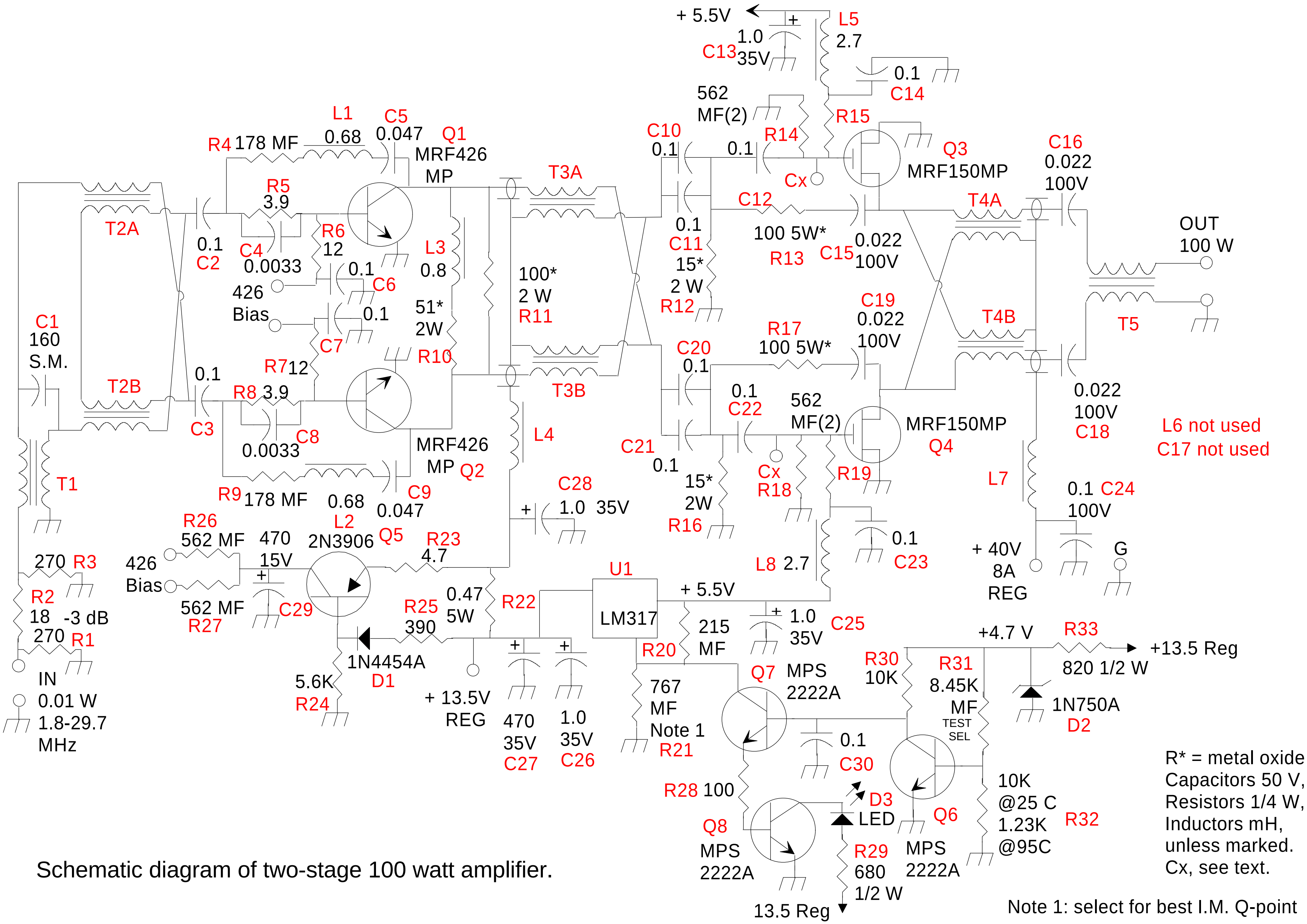


SECOND STAGE OUTPUT



COAX OUTPUT





Schematic diagram of two-stage 100 watt amplifier.

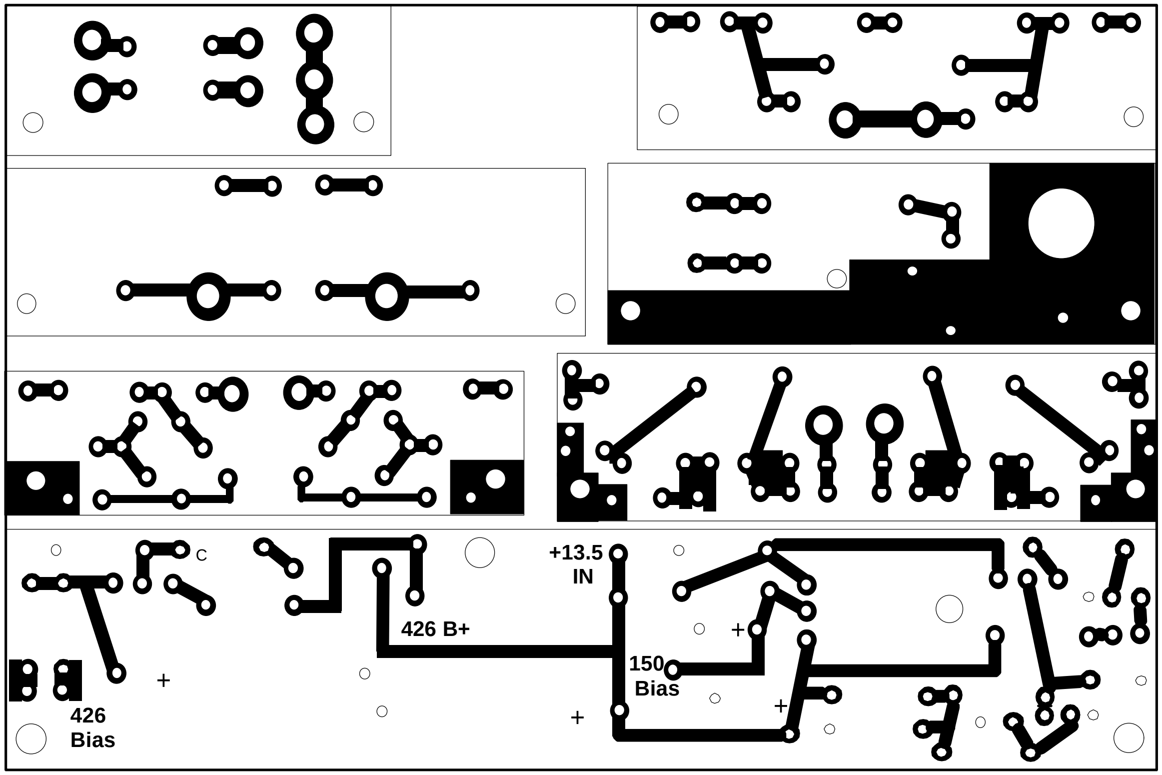


Figure 8. Four inch by 6 inch pc board that provides the seven individual boards.

MRF150 Temperature Analysis. Determine junction temp and maximum allowable dissipation, based on measured case temp. Pdiss =110 watts per FET. Final estimated case temp is between 85 and 95 deg C.

$q\_jc := 0.6$ Deg C per watt (spec)

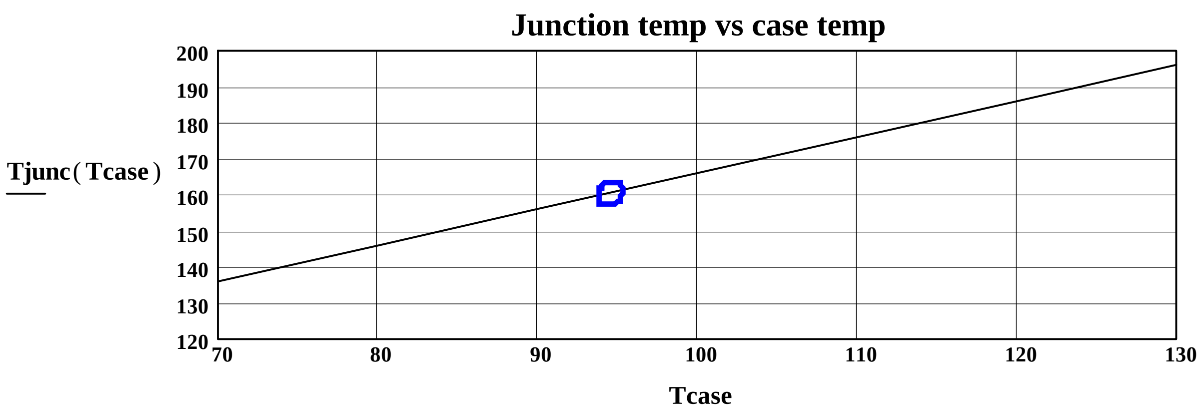
$Pmax := 300$ Watts (spec)

$TJmax := 200$ Deg C (spec)

$Tcase := 70, 80 .. 130$ Deg C parameter

$PDC := 110$ Watts dissipation per FET

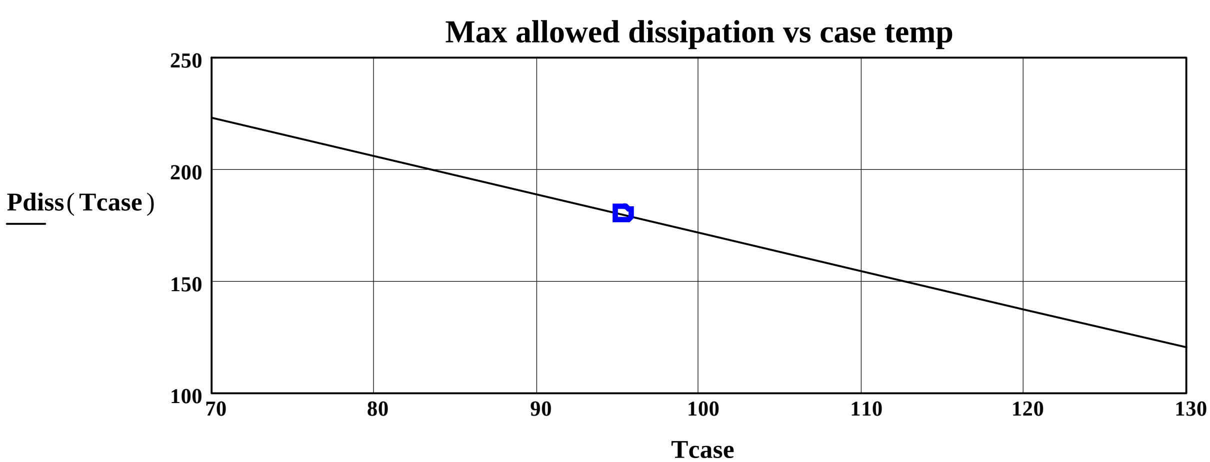
$Tjunc(Tcase) := Tcase + q\_jc \cdot PDC$ Junction temp vs case temp



Derate dissipation for case temperature

$Derate := 1.71$ Watts per deg C above 25

$Pdiss(Tcase) := Pmax - Derate \cdot (Tcase - 25)$ Allowed dissipation vs case temp



Parts list

C1	160 PF S.M.
C2,3,6,7,10,11,12,14, 20,21,22,23,30	0.1UF 50 V CK05
C4,8	0.0033UF 50 V CK05
C5,9	0.047UF 50 V CK05
C13,25,26,28	1.0UF 35 V tantalum
C15,16,18,19	0.022UF 100 V CK05
C17	56 PF S.M.
C24	0.1UF 100 V CK05
C27	470UF 35 V aluminum
C29	470UF 15 V aluminum
D1	1N4454A or equiv.
D2	1N750A
D3	LED RS 276-307
L1,2	0.68UH T50-2 core 10T #26 180°
L3	0.8UH T50-2 core 12T #26 270°
L4	BN-43-3312 4-1/2T #22 hookup wire
L5,8	2.7UH molded
L6	0.22UH T50-2 core 5T #26 180°
L7	2 FB-43-5621 cores 1-1/2 T #12 stranded
Q1,2	MRF426 matched pair
Q3,4	MRF150 matched pair
Q5	2N3906 PNP
Q6,7,8	MPS2222A
R1,3	270 Ω, 1/4 W 5%
R2	18 Ω, 1/4 W 5%
R4,9	178 Ω MF 1% 1/8 W
R5,8	3.9 Ω 1/4 W 5%

R6,7	12 Ω 1/4 W 5%
R10	51 Ω 2 W metal oxide
R11	100 Ω 2 W metal oxide
R12,16	51 Ω 2 W metal oxide
R13,17	100 Ω 5 W metal oxide
R14,15,18,19,26,27	562 Ω 1/8 W MF 1%
R20	215 Ω 1/8 W MF 1%
R21	767 Ω 1/8 W MF 1% Test selected
R22	0.47 Ω 5W wire wound
R23	4.7 Ω 1/4 W 5%
R24	5.6K Ω 1/4 W 5%
R25	390 Ω 1/4 W 5%
R28	100 Ω ¼ W
R29	680 Ω ½ W
R30	10K Ω ¼ W
R31	8.45K Ω MF (test select)
R32	10K Ω @25°C RS 271-110
T1	BN-43-202 2-1/2 T #32 bi-filar
T2A,B	BN-43-202 2-1/2 T #32 bi-filar
T3A,B	BN-43-3312 2-1/2 T 25 Ω miniature coax*
T4A,B	2 FB-43-5621 1-1/2 T 25 Ω miniature coax*
T5	2 FB-43-5621 2-1/2 T 50 Ω miniature coax
U1	LM317 adj.regulator

* Microdot D260-4118-0000 available from Communication Concepts, Inc.

All cores available from Amidon.

Closely matched pair transistors from RF Parts.

Temperature Limiting the 100 W MOSFET Amplifier

The amplifier described in Nov/Dec QEX uses some fairly expensive MRF150 transistors. As a followup to the project I decided that it would be prudent to add a circuit that will protect them from excessive junction temperature, in case the fan fails or the dissipation increases too much for some reason.

A "Precision Thermistor", Radio Shack 271-110, is rated at 10 K Ω ± 1% at 25 °C. I measured its resistance in boiling water to verify at 100 °C the calibration chart that comes with the thermistor. At 90 to 95 °C its resistance is about 1230 Ω. I attached the thermistor to the ceramic button of one of the FETs, using a small drop of epoxy to hold it in place as shown in Fig A. The ceramic button is the hottest and the fastest responding location so I decided to control it, rather than flange or heat sink. This helps to assure early detection of a FET temperature problem. The MRF150 has a junction-to-case thermal resistance θ_{JC} of 0.6 °C per watt. Assuming that the "case" is the ceramic button, at a temperature of 95 °C and a worst-case dissipation of 110 W per FET the junction temperature reaches 160 °C, which is 40 °C below the 200 °C Max allowed. The Max allowed dissipation per FET is 300 W, derated to 180 W at a 95 °C case temperature, which provides a 70 W safety margin at that temperature.

Fig B shows the circuit that controls temperature. The 4.7 V zener, the 8.45 K Ω 1% metal film resistor and the thermistor are a voltage divider. When the thermistor resistance falls to 1230 Ω the V_{BE} of Q1 falls slightly below 0.6 V, Q1 comes out of saturation and Q2 quickly goes into saturation. The condition for this is the voltage divider equation:

$$0.6 = 4.7 \cdot \frac{R_{TH}}{R_{TH} + R_B}$$

From this a value of R_B, in my case 8450 Ω (a standard value), is correct for an R_{TH} of 1230 Ω. This causes the FET gate bias to fall quickly to a low value which shuts off the

FETs. They remain off until the case temperaure falls below 95 °C. While the FETs are off, Q3 lights the red LED, which can be mounted on the front panel of the equipment. The thermistor is across V_{BE} of Q1, which is 0.6 V or less, and this minimizes thermistor self-heating. I modified the regulator board to add the circuitry, and the modified board set is available from FAR Circuits (see Note 11 of the article).

In normal SSB/CW/Data operation at 100 W PEP output on all bands the protection circuit is idle, as intended. It is also idle at 100 W continuous key-down, except on 160 meters, where it toggles for short periods. On that band the efficiency is a little less because of transformer T4, which is marginal for that band because of the type 43 ferrite , and a 1 dB reduction of output eliminated the toggling. If the fan quits or any other mishap occurs the circuit takes over and keeps the case temperature at a safe 95 °C, but if the red LED is on frequently, take prompt action. As mentioned in the article, the fan as shown in Fig 1 or on the front cover is more than adequate at the 100 W power output level, except as noted here. I do urge that the fan be mounted in a way that maximizes the air flow through the fins and that a high quality heat sink be used.

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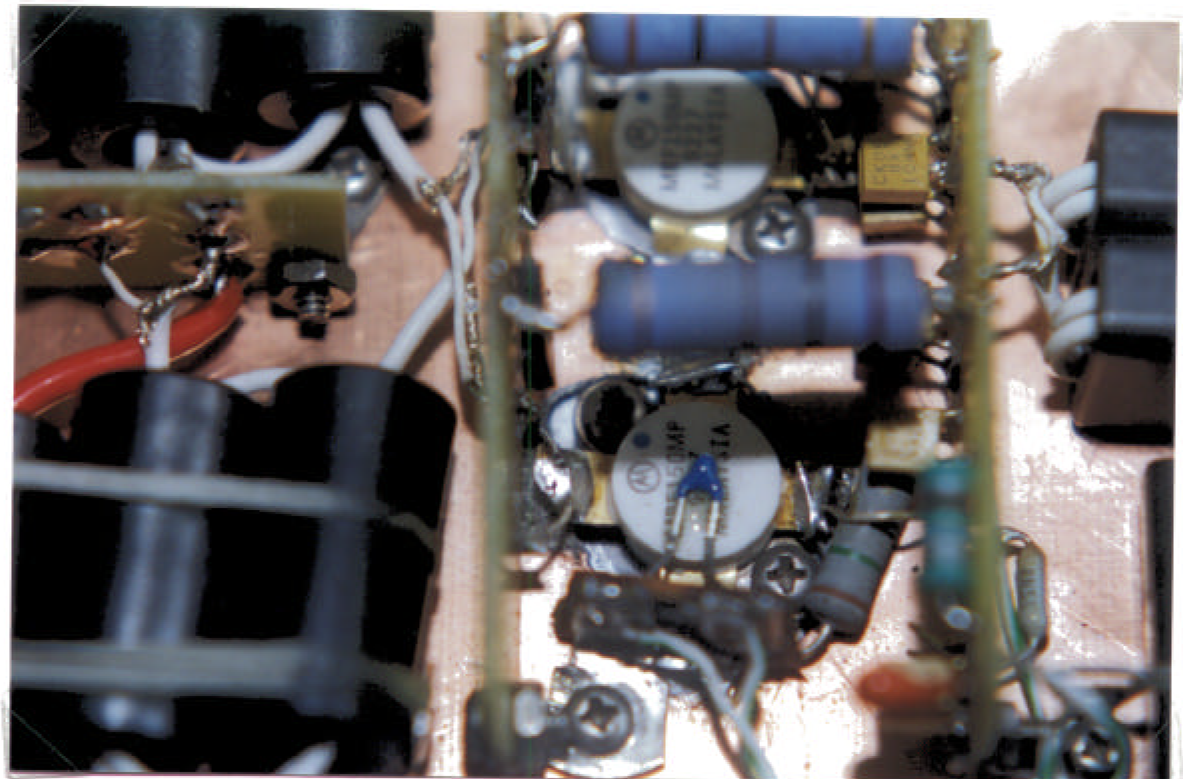

Fig A. Mountins the thermistor

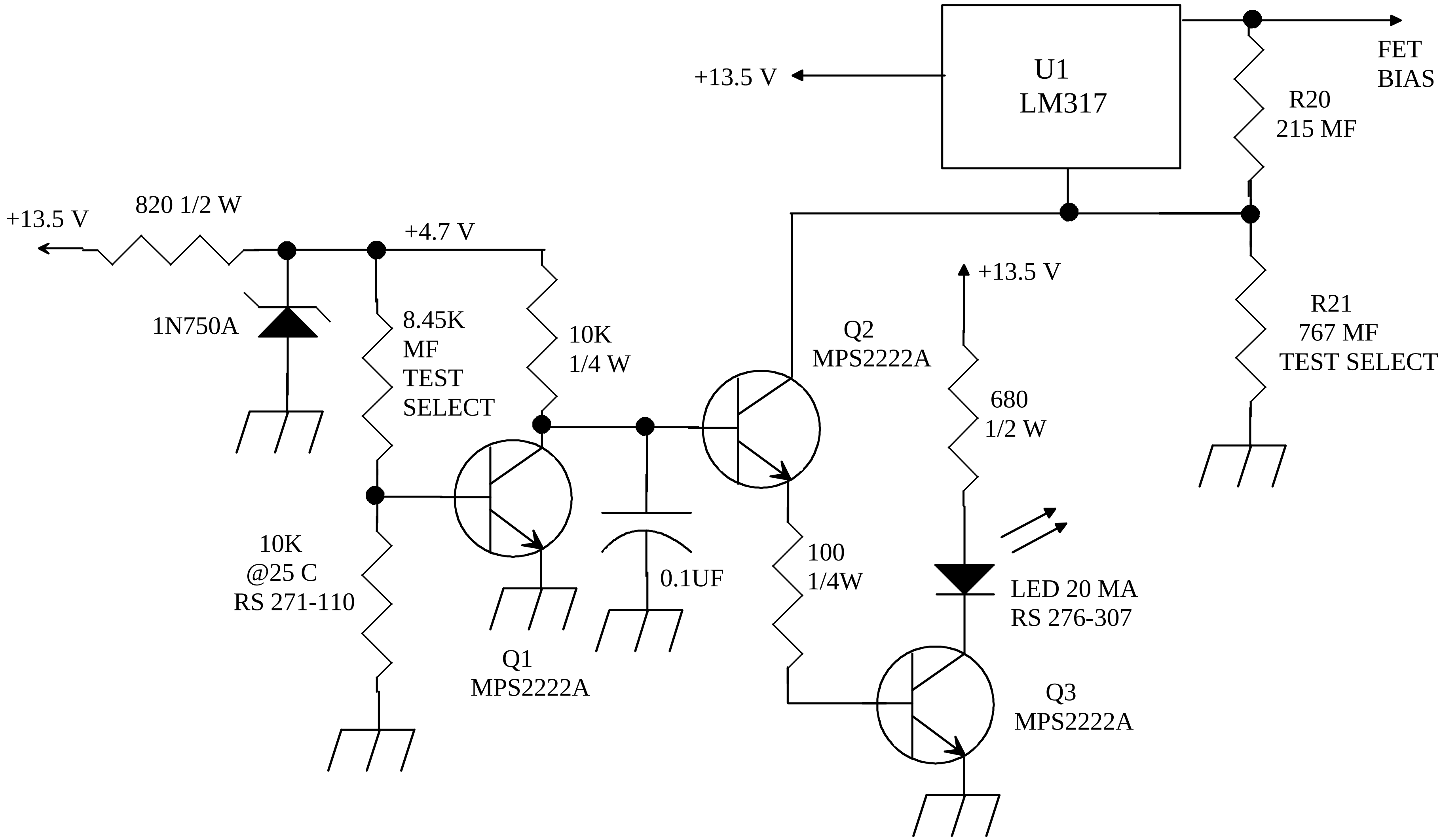

FIG B. FET TEMP CONTROL CIRCUIT