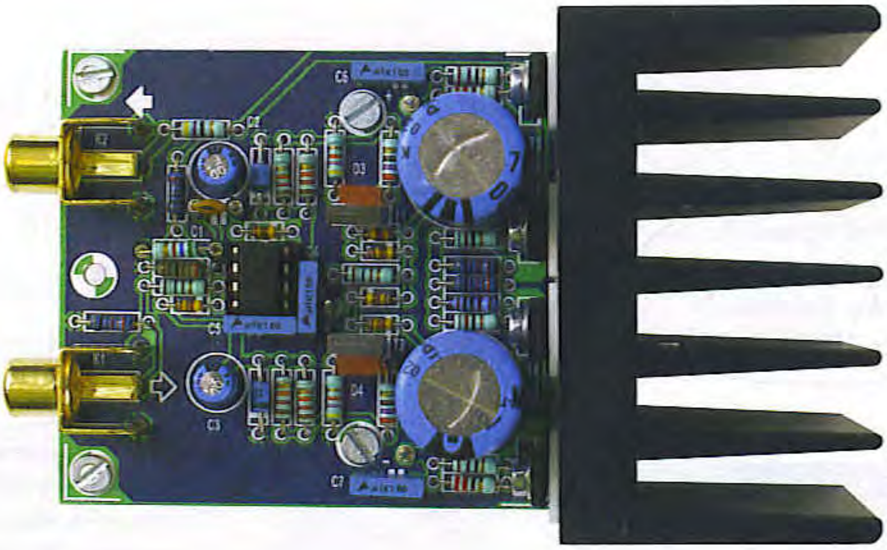
001

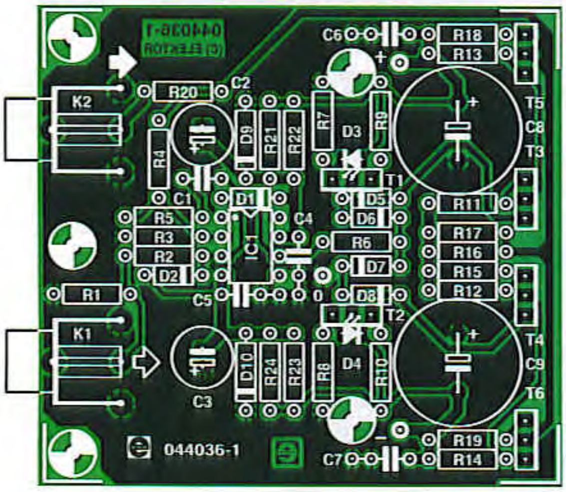
High Voltage Amplifier

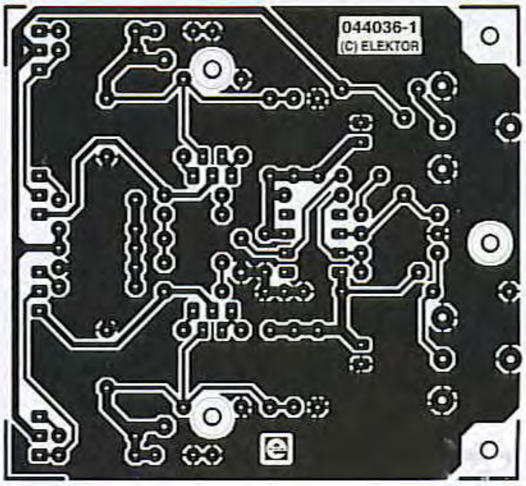
Audio analysers, such as the Audio Precision series have signal generators that for certain test purposes do not have a sufficiently high output voltage. That is why we have designed this 'booster' amplifier stage. It provides the same amount of voltage as a 300-W amplifier into 8 Ω. Applications for this amplifier include the testing of measuring filters or an automatic range-switching circuit.



The amplifier can, with a ±75 V power supply, generate 50 V_{RMS}, with an input signal of 5 V_{RMS} from the signal generator. In other words, the voltage gain is set to 10 times. In many cases the full bandwidth of the generator is not available at maximum output voltage. For this reason the amplifier gain is a little more than what is actually required for this application.

The graph shows the distortion (THD+N) as a function of output voltage. It is obvious that at 1 kHz (curve A), from about 10 V with 10 kΩ load, the limit of the Audio Precision has been reached. The steps in the curve are caused by range switching in the analyser. At less then 10 V, the measurement is mostly noise.





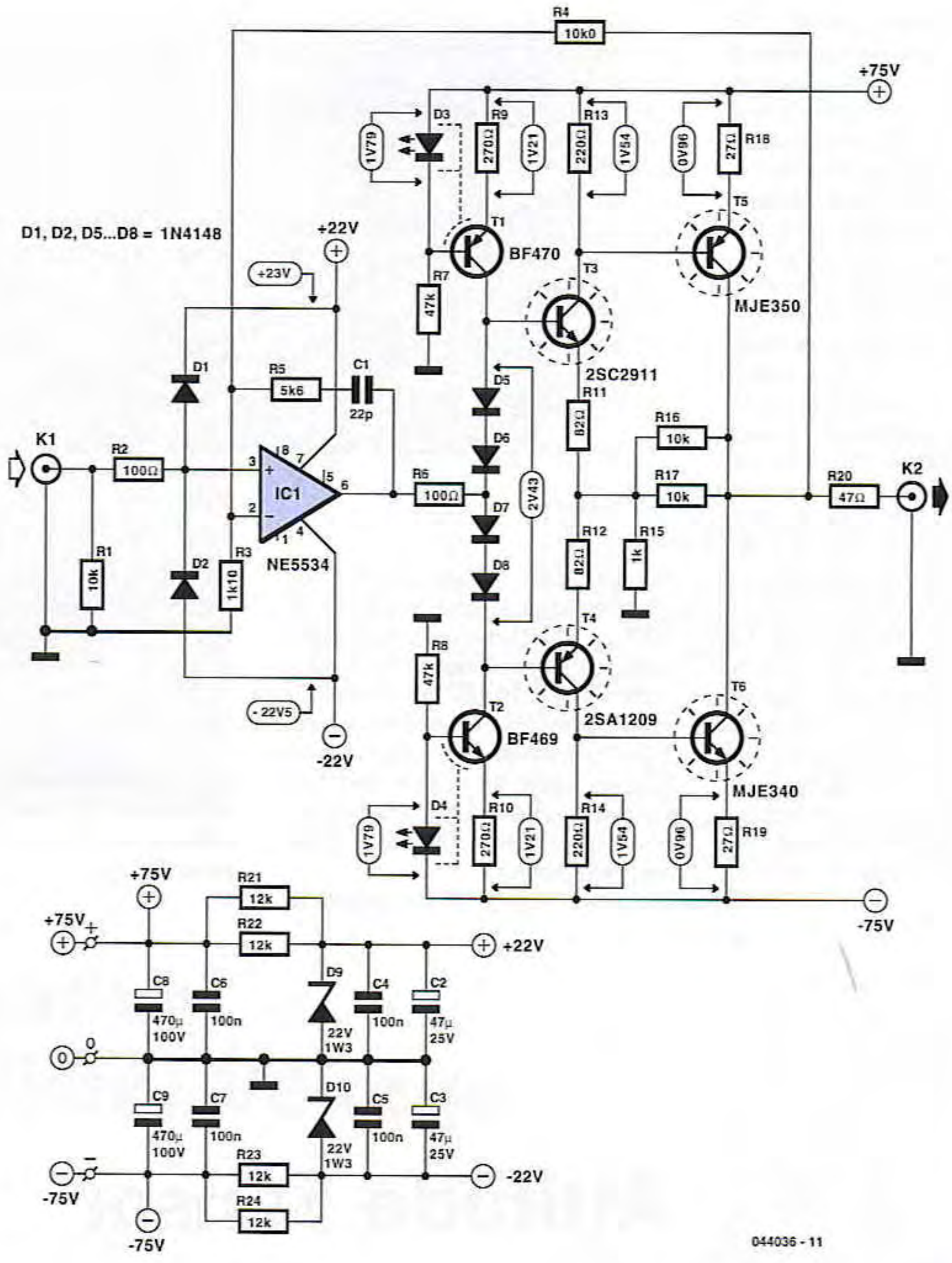
COMPONENTS LIST

Resistors:
R1,R16,R17 = 10kΩ
R2,R6 = 100Ω
R3 = 1kΩ10
R4 = 10kΩ0
R5 = 5kΩ6
R7,R8 = 47kΩ
R9,R10 = 270Ω
R11,R12 = 82Ω
R13,R14 = 220Ω
R15 = 1kΩ
R18,R19 = 27Ω
R20 = 47Ω
R21-R24 = 12kΩ

Capacitors:
C1 = 22pF
C2,C3 = 47µF 25V radial
C4-C7 = 100nF (C6/C7: 100V!)
C8,C9 = 470µF 100V radial

Semiconductors:
D1,D2,D5-D8 = 1N4148
D3,D4 = rectangular LED, red
D9,D10 = zener diode 22V 1.3W
T1 = BF470
T2 = BF469
T3 = 2SC2911
T4 = 2SA1209
T5 = MJE350
T6 = MJE340
IC1 = NE5534

Miscellaneous:
K1,K2 = cinch socket, PCB mount, T-709G from Monacor/Monarch
Heatsink, 2.5 K/W (e.g. Fischer type SK100, 50mm height)
PCB, order code 044036-1 from The PCBShop



From 20 kHz (curve B) the distortion increases slowly, but with only 0.008% at 50 V remains small even at nearly full output! Both curves were measured with a bandwidth of 80 kHz.

The amplifier is built around the old faithful NE5534 and a discrete buffer stage. The buffer stage has been designed as a symmetrical compound stage, which maximises the output voltage. The advantage of the compound stage is that it is possible to have voltage gain. This possibility has been taken advantage of, because the NE5534 can operate from a maximum of only ±22 V (and that is pushing it!). We make the assumption that the opamp can supply 15 V_{peak} without distortion. There is, therefore, 4.7-times gain required in the compound-stage. This is set with the local negative feedback R15, R16 and R17. The values are as small as possible to enable the use of normal resistors. At first glance, the gain should in theory be 6 times, but the stages T3 and T4 influence the local feedback. When driven with DC, the dissipation in R16 (R17) will be a maximum of about 0.3 W.

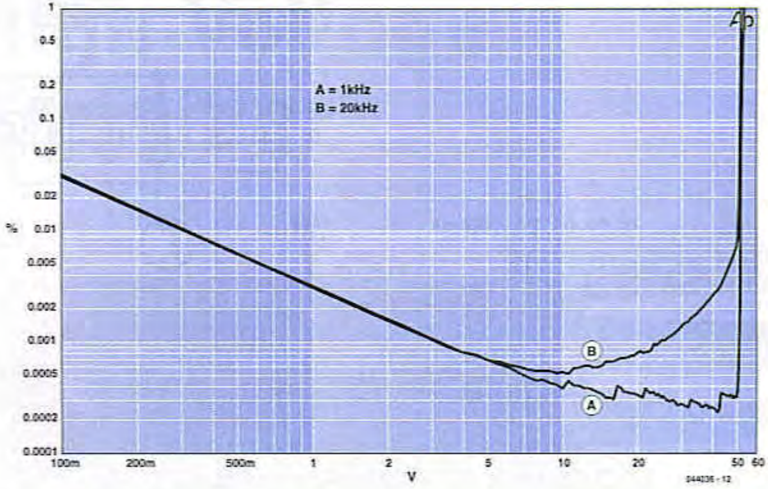
For T5 and T6, the MJE340 and MJE350 were selected. This pair has been practically unrivalled for many years. At a collector/emitter voltage of 150 V, the MJE350 can carry a collector current of 40 mA. The output stage is, with an idle current of 35 mA through T5 and T6, well into class-A operation. Local and total feedback requires a maximum of 20 mA. Despite this 'no load' the output transistors are well within their safe operation area. The minimum load is a few kΩ.

The amplifier is not short-circuit proof. If necessary, R20 can be increased to 1 kΩ or a current limit circuit can be added. However, this is likely to reduce the quality of the amplifier.

The drivers T3 and T4 are a couple of new transistors from Sanyo. These have a considerably better linearity (h_{FE}) and have a lower capacitance than the MJEs. The maximum collector/emitter voltage is 160 V. At this value (DC), up to 7 mA may be processed (or 20 mA for 1 s). The actual operating voltage for these will in practice be about 100 V. With a current setting of 7 mA, these transistors are operating well inside their safe operating area. These are details that have to be taken into account because of the high power supply voltage.

T3 and T4 are, with the aid of four 1N4148 diodes, biased at a fixed current, so it is not necessary to adjust the quiescent current. The current through these diodes is set with two symmetrical current sources to a value of about 4.5 mA (T1 and T2). BF-series devices were selected for this application because they have even lower capacitance. Should the availability of the BF469 and BF470 prove to be a problem then it is possible to substitute the same devices as used for T3 and T4, i.e. 2SC2911 (NPN) and 2SA1209 (PNP) respectively.

This stage is driven from the middle of D5 through D8, so that the opamp only needs to deliver the amount of current to compensate for the difference in current between T3 and T4. R6 protects the output of IC1 from any possible capacitive feedback from the output stage. The overall feedback loop is set with R4 and R3. This has been quite accurately adjusted for a gain of 10 times (A = 1 + R4/R3), so the actual value is 10.09 times. R5 and C1 are the compensation network for the entire amplifier by providing the opamp with local feedback. Note that if you change the gain of the amplifier, the compensation network has to change as well. An NE5534 has internal compensation when the gain is 3 or greater. So the ratio between R5 and R3 must be greater than 2.



The bandwidth of the amplifier at 11 MHz is quite good (measured at 40 V_{rms}). R2, D1 and D2 provide input protection. R1 determines the input resistance, which is 10 kΩ. The value of R1 may be increased, but the result will be a higher output offset. The bias current of IC1 can easily be 0.5 µA and that explains the offset of 50 mV at the output. For most applications this value will not cause any problems.

The power supply for the opamp is derived from the ±75-V power supply using two zener diodes. This is designed with two parallel resistors so that it is not necessary to use special power resistors. C6 through C9 decouple the output stage and C2 through C5 decouple the opamp. The total current draw of the prototype, after it had warmed up, was about 57 mA. The 'High voltage supply' elsewhere in this issue can be used as the power supply.

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