A general purpose audio amplifier module

One of the handiest 'tools' for the electronics experimenter is a genuine general purpose audio amp. This module will work from a wide range of supply voltages, has good sensitivity, is robust and reliable — easy to build too!

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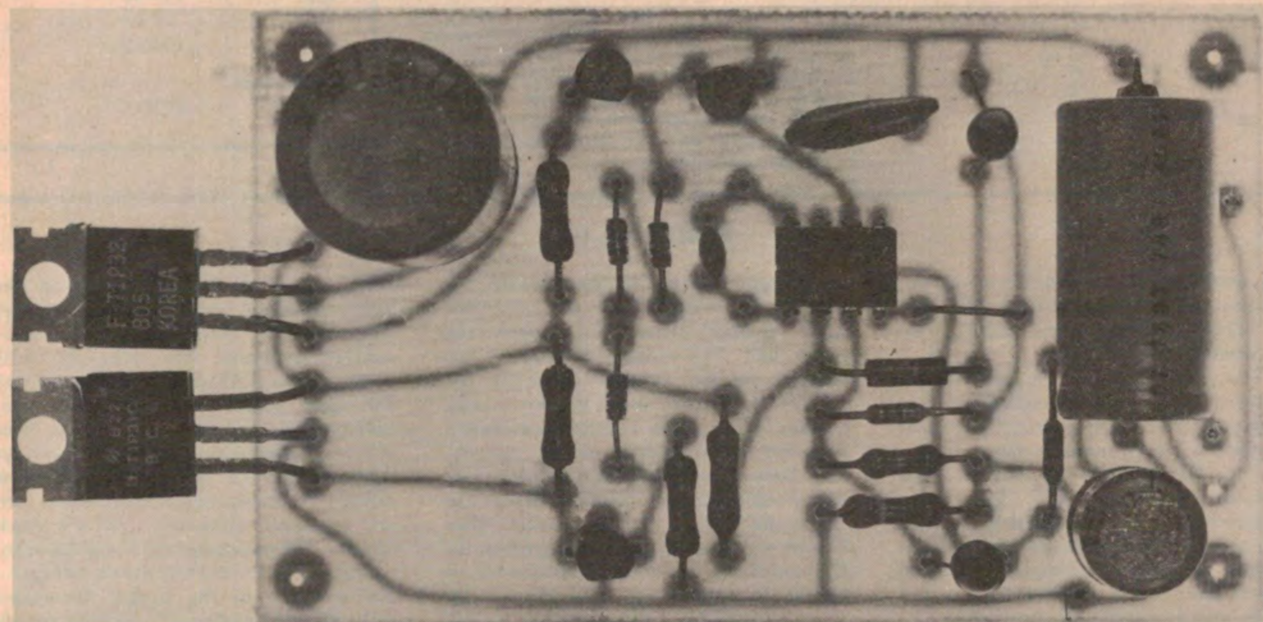

WHEN DESIGNING and building electronic projects, one of the most often needed circuits is a simple, low cost audio amplifier stage capable of driving a 4 or 8 ohm loudspeaker. This amp module is capable of driving a 4 ohm load with over 20 watts. This is more power than is necessary in many applications but it is a simple matter to decrease the maximum output power by simply decreasing the supply voltage. The table gives the relationship between output power and supply voltage. At lower power levels the amp module will not require any form of heatsinking. Some experimentation will be necessary to determine the amount of heatsinking that should be used at higher power levels.

The circuit gives maximum power out with an input level of about 300 mV which should be easily obtained by the stage used to drive the amp module. This figure can be changed slightly by varying the amount of negative feedback. Resistor R6 is the negative feedback resistor and, together with R5, determines the overall gain of the circuit.

Specifically, the gain of the circuit is given by R6/R5. In the circuit shown this becomes

$$\frac{120k}{2k2} = 54.55.$$

The output voltage will be this figure, multiplied by the input signal voltage. So, for an input voltage level of 100 mV RMS the output level will be 100 mV x 54.55 = 5.45 volts RMS, which is equivalent to 3.7 watts into an 8 ohm load. If you have only 50 mV available, for example, and wish this signal level to drive the amp to 3.7 watts, it would be necessary to halve the amount of negative feedback, thereby doubling the gain of the amplifier. The negative feedback resistor would have to be doubled in value to 240k. In practice, ▶

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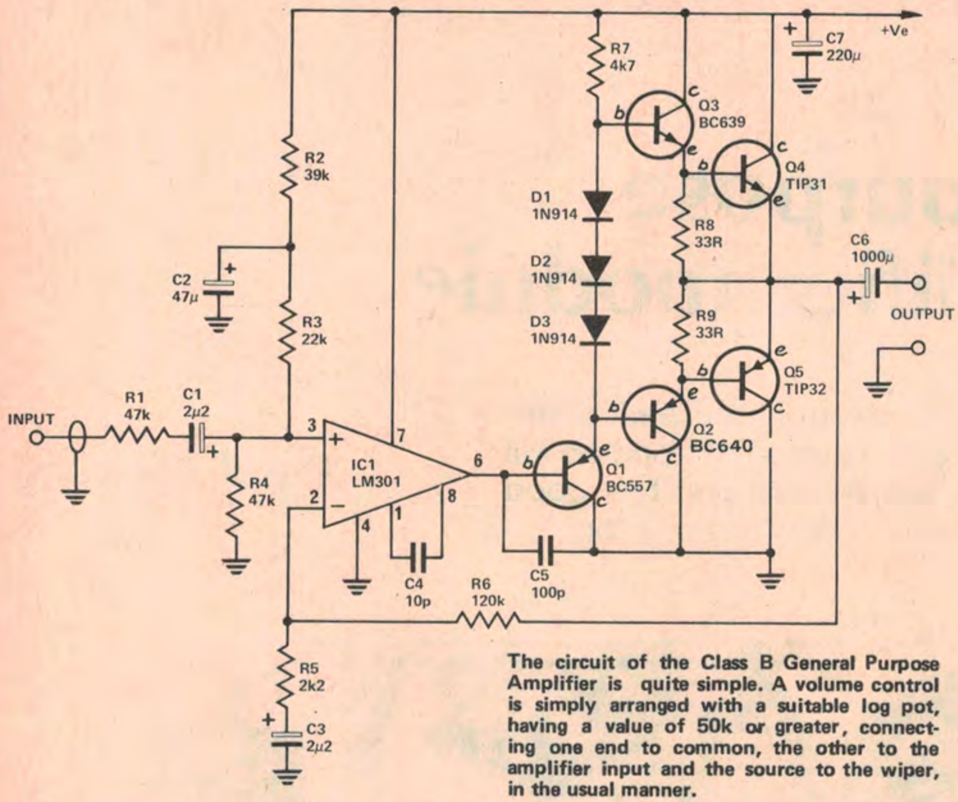


The circuit of the Class B General Purpose Amplifier is quite simple. A volume control is simply arranged with a suitable log pot, having a value of 50k or greater, connecting one end to common, the other to the amplifier input and the source to the wiper, in the usual manner.

PARTS LIST - ETI 453

Resistors all ½W, 5%

R1	47k
R2	39k
R3	22k
R4	47k
R5	2k2
R6	120k
R7	4k7
R8, R9	33R

Capacitors

C1	2μ2 35V tantalum
C2	47μ 25V electrolytic
C3	2μ2 35V tantalum
C4	10p disc ceramic
C5	100p disc ceramic
C6	1000μ 25V electrolytic
C7	220μ 25V electrolytic

Semiconductors

D1–D3	IN914 signal diode or similar
Q1	BC557
Q2	BC640
Q3	BC639
Q4	TIP 31
Q5	TIP 32
IC1	LM301

Miscellaneous

ETI 453	pc board

HOW IT WORKS

The amplifier can be considered in two sections, the voltage amplifier built around the LM301 op-amp and the current amplifying output stage.

The LM301 is an IC operational amplifier that is used to amplify the input signal up to the voltage levels needed by the output stages. Input to the op-amp is via the 47k resistor R1 and the 2u2 tantalum capacitor, C1. The input impedance at the non-inverting input of the op-amp is determined by resistors R4 and R3. R4 is connected directly to ground and the 47u electrolytic capacitor C2 represents a short circuit to ground for any ac signals flowing through resistor R3. As far as ac signals are concerned, R3 and R4 represent parallel resistance to ground. As a result, the impedance at this point is around 15k. R1 serves to increase the input impedance to approx 60k: R1 in combination with C1 also determines the lower frequency 3 dB bandwidth point of the circuit, setting it to around 10Hz.

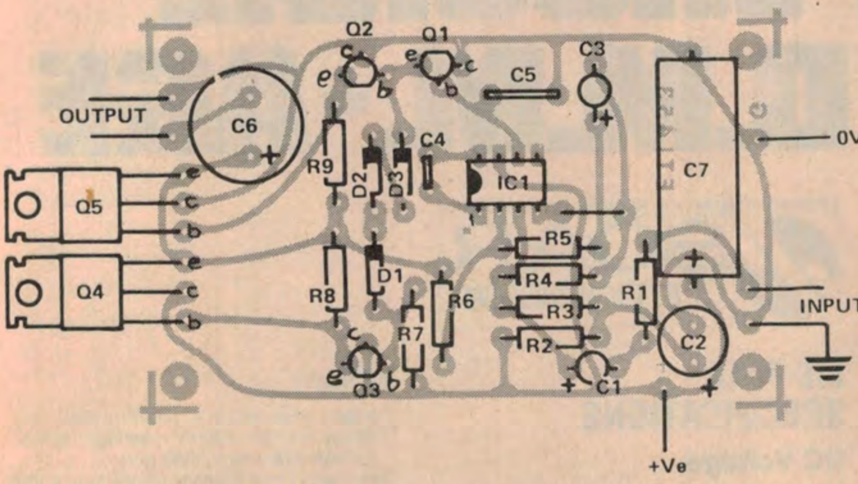
The LM301 is normally used with a split supply i.e: positive and negative supply rails. Since the objective of this design was to construct a general purpose amplifier module and its supply would, in many instances, be taken from an existing power supply, the circuit was designed to operate from a single supply. For this reason, the op-amp must be biased up to around half supply. This is accomplished by the resistors R2, R3 and R4. R2 and R3 form the upper half of a potential divider, R4 forming the lower half. The resistors chosen set the voltage on the positive input of the LM301 to about 0.44 of the supply voltage. Since these resistors are biasing the non-inverting input of the op-amp, any noise present on the positive supply rail would be communicated directly to the input of the amplifier through these biasing resistors. To prevent this, capacitor C2 was placed so as to represent a short circuit to noise voltages on the supply. This is much more effective than simply filtering the power supply (which must be done as well). In this configuration, the capacitor is fed from the 39k resistor R2, instead of directly from the positive supply as would be the case if C2 was used as a simple supply decoupling capacitor.

At audio frequencies, C2 will represent an impedance very much lower than 39k, effectively shorting out noise currents through R2. This would not be the case if R2 were not present, as the impedance of the supply would be a fraction of the impedance of the capacitor.

The amplified signal from pin 6 (output) of the LM301 is fed to Q1, which acts as the first current amplifier stage. This provides a reasonably low output impedance necessary to drive the remaining output stages. Diodes D1. D2 and D3 maintain about 1.8 volts between the bases of Q2 and Q3. These two transistors will drop 0.6 volts across the base – emitter junctions. This leaves 0.6 volts across the two 33 ohm resistors, R8 and R9. Each resistor will drop 0.3 volts, holding this voltage across the base emitter junctions of the output transistors. Since these devices, like the driver transistors, require 0.6 volts to turn on, they will remain off until the signal supplies the necessary additional 0.3 volts.

Capacitor C6 isolates the dc voltage on the emitters of the output transistors from the loudspeaker. C7 provides supply decoupling. If the amp module is used to deliver 10 watts or more, additional supply decoupling will probably be necessary.

Negative feedback is supplied by the potential divider formed from resistors R6 and R5. The capacitor C3 represents a short circuit to ground for ac signals in the audio range. Audio frequencies will therefore see R5 and R6 as a potential divider. The overall gain of the circuit will be determined by the value of R6/R5. (In this case, equal to 54.55). As the frequency decreases the impedance of C3 will increase, decreasing the gain of the circuit by increasing the amount of negative feedback. At very low frequencies, the gain of the circuit is reduced virtually to unity. This ensures that the voltage on the emitters of the output devices is stable.



Overlay showing placement of components.

The pc board pattern is on page 113.

a 220k resistor would be used. Note also that in order to obtain 3.75 watts it would be necessary to provide a supply rail of around 24 volts.

Since the project was to be a general purpose amp, it was essential that the design be robust and reliable. Class B was chosen for this reason as it has no bias current in the output stage and requires no set up procedure. The output devices are actually off, being switched on by the signal itself.

Construction

Start by soldering the resistors and capacitors into their positions on the printed circuit board. The electrolytic and tantalum capacitors must be placed on the board with the correct orientation. These are capacitors C1, C2, C3, C6 and C7. The printed circuit board overlay shows the correct orientation for these components on the board.

Solder the transistors and diodes in place, being careful that the transistors are inserted in the correct locations. Every transistor used in this project is different and as such, they are not interchangeable. Finally, solder the IC and wire link into position. Orient the IC so that the 'notch' points towards the output transistors.

Connection to the input of the power amp is best made with shielded cable to decrease the possibility of hum being induced into the amplifier. ●

TABLE 1

SUPPLY VOLTAGE	POWER INTO 8 OHMS	POWER INTO 4 OHMS
9	0.13 W	0.25 W
12	0.5 W	1 W
18	1.7 W	3.52 W
22	3.13 W	6.25 W
26	4.5 W	9 W
30	8 W	16 W
35	10.13 W	20.25 W

These are measured power output figures for different supply voltages. Powers quoted are at the onset of clipping.