10-Band Graphic Equaliser

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Until now, many articles on power amplifiers, tone controls, preamplifiers, etc have appeared in EFY. These articles can help one make a stereo system on one's own. Sometimes, when one is fond of changing the tonal quality of the programme, or when one is in the habit of making duplicate cassettes from original sound tracks, an equaliser—properly known as a Graphic Equaliser—seems indispensable. Moreover, graphic equalisers offer greater control over the quality of music than a simple tone control system with just bass and treble controls.

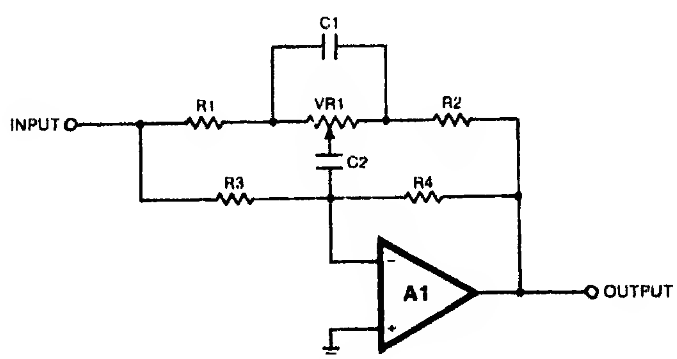
There are many types of equalisers—ranging from 10-band equalisers to something like a 30-band graphic equaliser. However, for all practical purposes, a 10-band graphic equaliser—also known as First Octave Equaliser—is more than sufficient for a good home system. This article deals with the construction of a high quality, low distortion 10-band graphic equaliser. The specifications are given in Table 1.

This first octave graphic equaliser has ten controls for ten different frequencies, which have a definite relationship with each other. The relationship can be noticed easily by observing the numerical values of the frequencies for which the controls are provided, viz, 32 Hz, 64 Hz, 125 Hz, 250 Hz, etc. Except for the relation between 64 Hz and 125 Hz, the ratio between any two adjacent frequencies is 1:2. The frequencies could have been 32 Hz, 64 Hz, 128 Hz, 256 Hz, etc, but this would also make the values look odd. For example, 1 kHz 'sounds' better than 1.024 kHz, although the latter is what one will get actually if one goes on doubling the values of frequencies from 32 Hz.

The basic circuit

The basic building block of this equaliser is very much different from the usual ones that we often see in articles in EFY. Fig. 1 shows a 'normal' equaliser portion while Fig. 2(a) shows the type that is used in our equaliser. One can easily find out the main difference. While the portion of a 'normal' equaliser in Fig. 1 uses capacitors to fix the frequency, a tuned circuit is used in Fig. 2(a).

The disadvantages of the circuit shown in Fig. 1 are that



$$\text{BOOST} = \frac{\text{RESISTANCE OF VR1+R2}}{\text{R1}}$$

$$\text{CUT} = \frac{\text{R2}}{\text{RESISTANCE OF VR1+R1}}$$

$$C2 = \frac{C1}{10}$$

R4 AND R3 ARE USUALLY AROUND 1M

Fig. 1: Schematic showing a part of a normal equaliser.

TABLE I

Number of bands	: 10 (32 Hz, 64 Hz, 125 Hz, 250 Hz, 500 Hz, 1 kHz, 2 kHz, 4 kHz, 8 kHz, 16 kHz)
Boost/cut on each band	: ±15dB
THD% (At V_{OUT}=1V)	: < 0.05%
S/N Ratio	: >80dB
Input impedance (Z_{IN})	: 100k
Output impedance (Z_{OUT})	: <150 ohms
Input voltage for V_{OUT}=1V	: 180mV
Max. input voltage	: 10V
Max. input voltage for undistorted sound	: 2.5V

inductors alone will occupy the entire cabinet. Anyway, this is not what we want. To overcome the problem, simulated inductors are used.

For those who are not familiar with simulated inductors, some details about designing a simulated inductor are given in Fig. 3(a). Here, C1 is the series tuning capacitor while all the other components make up the simulated inductor. Full details to explain the working of the simulated inductor are not given here due to limitations of space. However, the formulae in Fig. 3(a) should help readers design one by themselves. Fig. 3(b) shows an equaliser section using this simulated inductor.

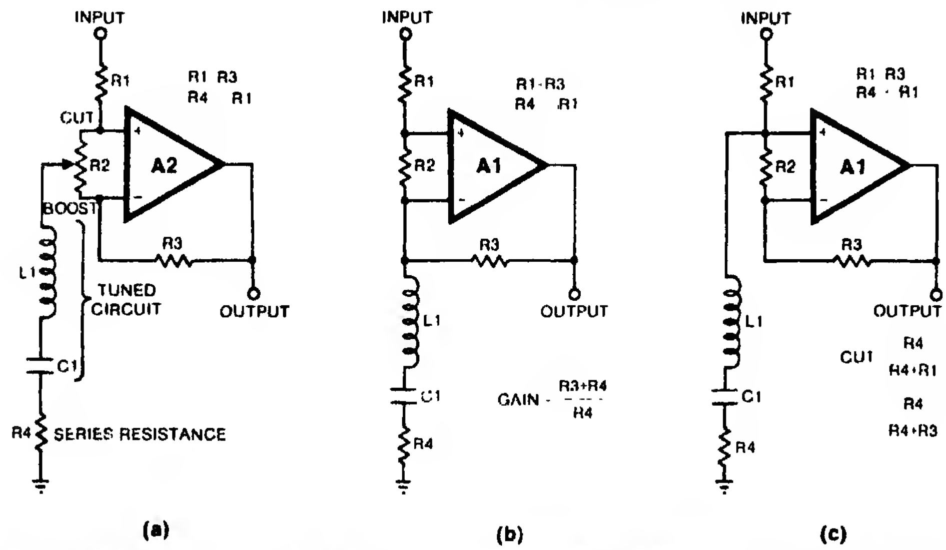


Fig. 2: Equaliser section using tuned circuit:(a) in 'flat' condition, (b) in 'boost' condition, (c) in 'cut' condition.

the roll-off is not sharp (or steep), and the amount of cut or boost that is obtainable in a 10-band equaliser of this type is low. When a 10-band equaliser of the type shown in Fig. 1 is made, the gain or cut must be limited in such a way that boosting a frequency does not interfere with the next frequency or the one preceding it. If the circuit shown in Fig. 2(a) is used, the 'Q' and gain can be easily varied to an extent that even 30-band equalisers are possible.

Fig. 2(b) shows the equaliser section in full boost condition. If the resistance of the tuned circuit is considered very small, then the only resistive element is R4. The gain is now conveniently given by the relationship (R3+R4)/R4. By making R4 low, and the value of R3 high, high gain can be obtained. If 'Q' of the inductor is made high, then the effect of one control on its adjacent bands will be very very small.

Fig. 2(c) shows the same equaliser section under full cut condition. Now the input voltage is divided between R1 and R4. Since R4 is very small, a part of the input signal appears across R4. The op-amp A1 will not produce any gain now and acts as a buffer. The loss in voltage or the cut can now be given by R4/(R3+R4).

For low frequencies such as 32 Hz and 64 Hz, the size of inductor L1 will become very big—not only in value but also physically. So when a 10-band stereo equaliser is made, the

The circuit

The complete 10-band equaliser circuit using twelve op-amps (three TL084s) is given in Fig. 4. Op-amp A1 is an input amplifier with a gain of 5.5. The output of this op-amp is connected to the group of potentiometers that are used to boost or cut specified frequencies. Capacitor C2 serves to filter very high frequencies to some extent. The op-amps A2 to A11 make up the simulated inductors. Op-amp A12 is the active part that actually boosts or cuts any band of frequencies. This A12 can be considered as the op-amp A1 in Fig. 3(b).

The power supply section is not at all complicated and therefore needs no explanation. The supply to each IC (TL084) is connected through two 10-ohm resistors and is decoupled with 0.1μF capacitors.

The potentiometers can be of any type, sliding or rotory. But the controls should be logarithmic ones; their resistance should change slowly at both ends and quickly in the middle. This type of control is necessary because as the value of the resistance between the wiper and any one end of the control approaches 470 ohm, the control becomes very sensitive. To overcome this problem, logarithmic controls of the above-mentioned type must be used.

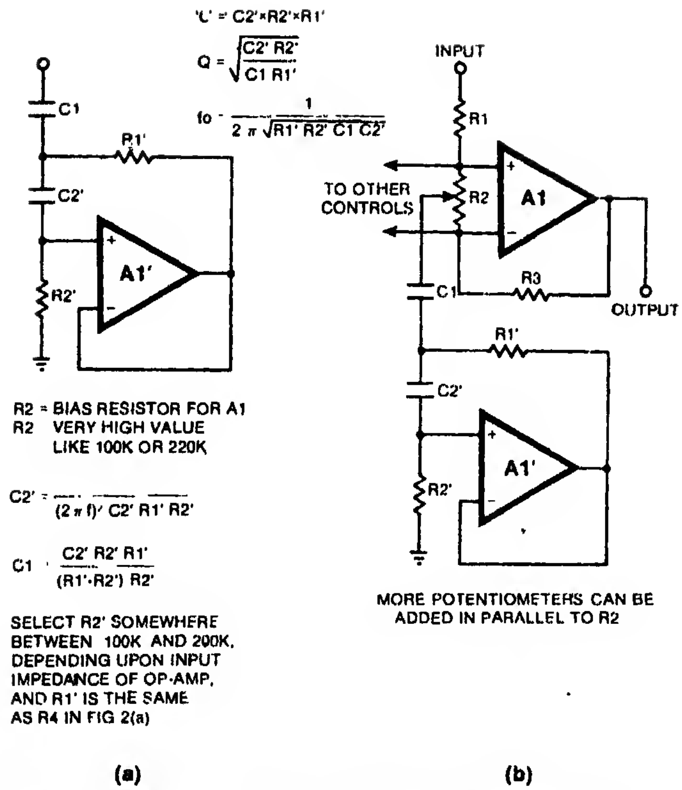


Fig. 3: Simulated inductor: (a) basic design consideration; (b) incorporation in equaliser.

Construction

The construction should not be difficult if a PCB is used. A possible actual-size PCB pattern for a mono equaliser is shown in Fig. 5. Two of these boards are required to make a stereo version. The component layout is given in Fig. 6. The power supply circuit diagram to obtain a regulated ±15V dual power supply is shown in Fig. 7. PCB pattern for the power supply is shown in Fig. 8, and its component layout in Fig. 9.

As far as possible use polycarbonate (metallised) or polyester capacitors. The only problem components are the 4.7μF, 2.2μF, 1.2μF and the 0.56μF capacitors. If you are unable to get a 0.56μF polyester or polycarbonate capacitor, use a ceramic capacitor. In this case it is better to try with two or three capacitors until you get the best possible effect from the equaliser.

For 4.7μF, 2.2μF etc, two tantalum capacitors can be used in back-to-back configuration. If nothing is available, use a high voltage (around 100V) 4.7μF electrolytic capacitor. But before soldering it compare it with some other capacitor of known value and verify that the capacitor is really 4.7μF in value.

In component layout (Fig. 6) all the values of capacitors are given for each frequency band as per Table II. Table III will help you identify which capacitors are used for which frequencies. You can also do this by looking at the marking near the control to which the capacitors are connected in case of any doubt.

Another point about the values of capacitors: Capacitors with values like 100 pF and 680 pF can be of ceramic disc type.

The 1.2μF capacitor can be difficult to obtain. In that case two capacitors of 1μF and 0.2μF are connected in parallel and solder them to the board.

As far as possible, standard values have been chosen. Wherever you are unable to get the specified value, use a very high voltage electrolytic capacitor whose capacitance is known to be the value specified. If you have a capacitance meter of any kind, it can help you to get the correct capacitor.

The sliding controls can be fixed on a plain laminate and then fixed on to the panel of the cabinet from inside. This will prevent all the fixing screws from being seen outside. While earthing the shield of the shielded wire used for connecting the input socket (if used) to the board, earth the shield near the socket, and on the PCB.

In the power supply board try to use polyester capacitors for the two 0.22μF capacitors. Use 0.1μF disc capacitors for those which are used to decouple the supply after the 10-ohm resistors.

Checking and fault finding

First of all, before switching on, check whether you have connected the positive and negative supplies on to the PCB

TABLE II

Freq.	*Values of* C4	C5	C6	C7
32 Hz	4.7 μF	0.56 μF	0.1 μF	—
64 Hz	2.2 μF	0.47 μF	0.05 μF	—
125 Hz	1.2 μF	0.15 μF	0.022 μF	2.7 kpF
250 Hz	0.68 μF	—	0.012 μF	—
500 Hz	0.33 μF	—	6.2 kpF	—
1 kHz	0.15 μF	0.02 μF	2.7 kpF	470 pF
2 kHz	0.082 μF	2 kpF	1.5 kpF	—
4 kHz	27 kpF	15 kpF	680 pF	100 pF
8 kHz	0.02 μF	—	390 pF	—
16 kHz	0.01 μF	—	200 pF	—

TABLE III

IC Pin No.	*Components [capacitors] connected to*	*for frequency*
IC1		
5, 6, 7	C4, C5, C6	32 Hz
8, 9, 10	C4, C5, C6	64 Hz
12, 13, 14	C4, C5, C6, C7	125 Hz
IC2		
1, 2, 3	C4, C6	250 Hz
5, 6, 7	C4, C6	500 Hz
8, 9, 10	C4, C5, C6, C7	1 kHz
12, 13, 14	C4, C5, C6	2 kHz
IC3		
1, 2, 3	C4, C5, C6, C7	4 kHz
5, 6, 7	C4, C6	8 kHz
8, 9, 10	C4, C6	16 kHz

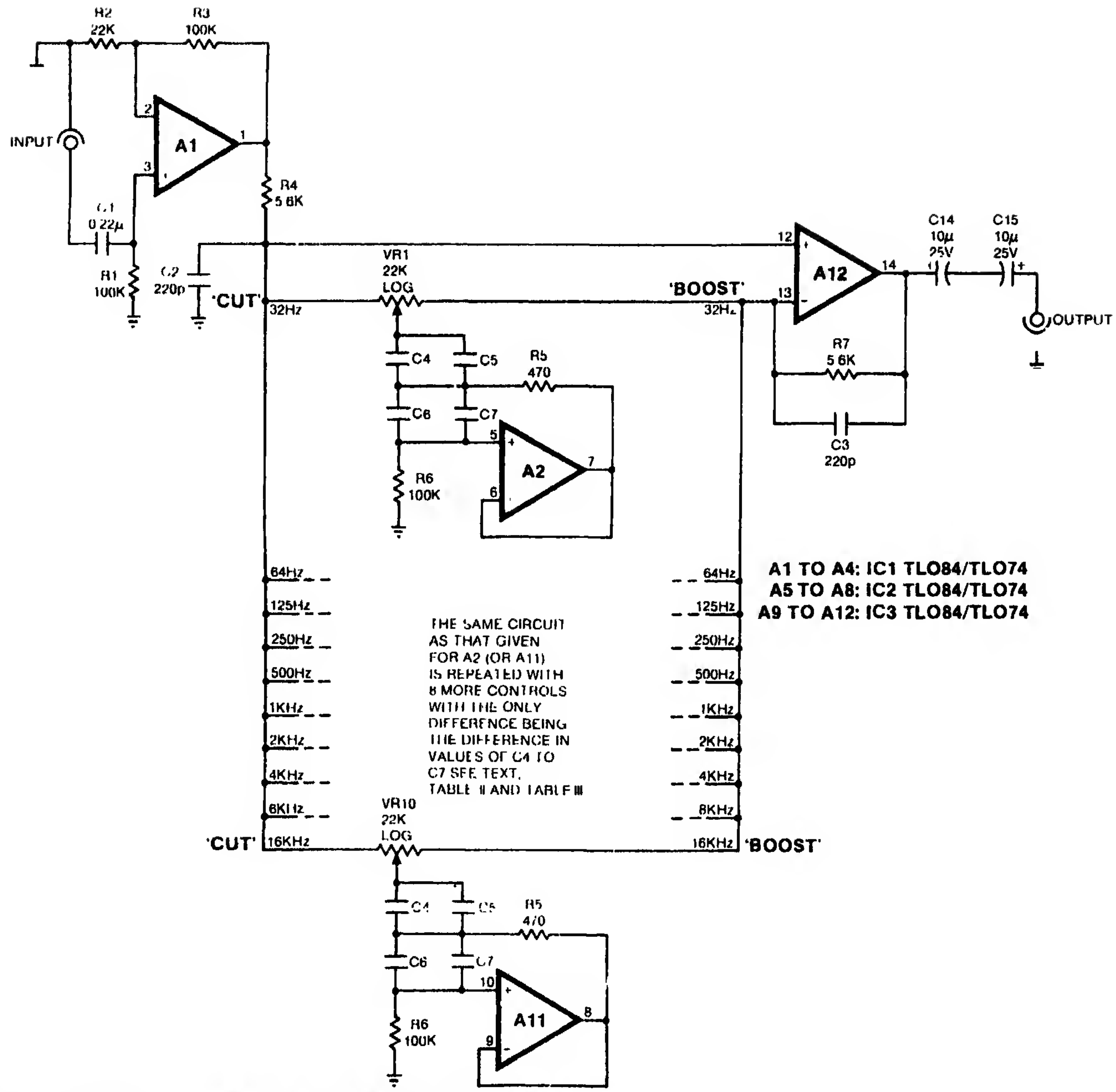


Fig. 4: Circuit diagram of a first octave, 10-band graphic equaliser.

PARTS LIST

Semiconductors:
IC1-IC3 — TL084/TL074 Bi-FET quad op-amp
IC4 — LM7815, 15V positive voltage regulator
IC5 — LM7915, 15V negative voltage regulator
D1-D4 — 1N4002, 1-amp rectifier diode

Resistors [all 1/4 watt, ±5% carbon]:
R1, R3 — 100-kilohm
R2 — 22-kilohm
R4, R7 — 5.6-kilohm
R5 — 470-ohm (10 pcs)
R6 — 100-kilohm (10 pcs)
R8-R13 — 10-ohm
VR1-VR10 — 22-kilohm log. potentiometer

Capacitors:
C1, C18-C21 — 0.22μF polyester
C2, C3 — 220pF styroflex
C4-C7 — See Table II
C8-C13 — 0.1μF disc
C14, C15, C22, C23 — 10μF, 25V electrolytic
C16, C17 — 2200μF, 35V electrolytic

Miscellaneous:
X1 — 18V-0-18V, 250 mA secondary transformer
S1 — DPDT toggle switch
— PCB, enclosure, 3-core shielded wire, plastic spacers, screws, nuts, mains lead, aluminium knobs, flexible wires etc.

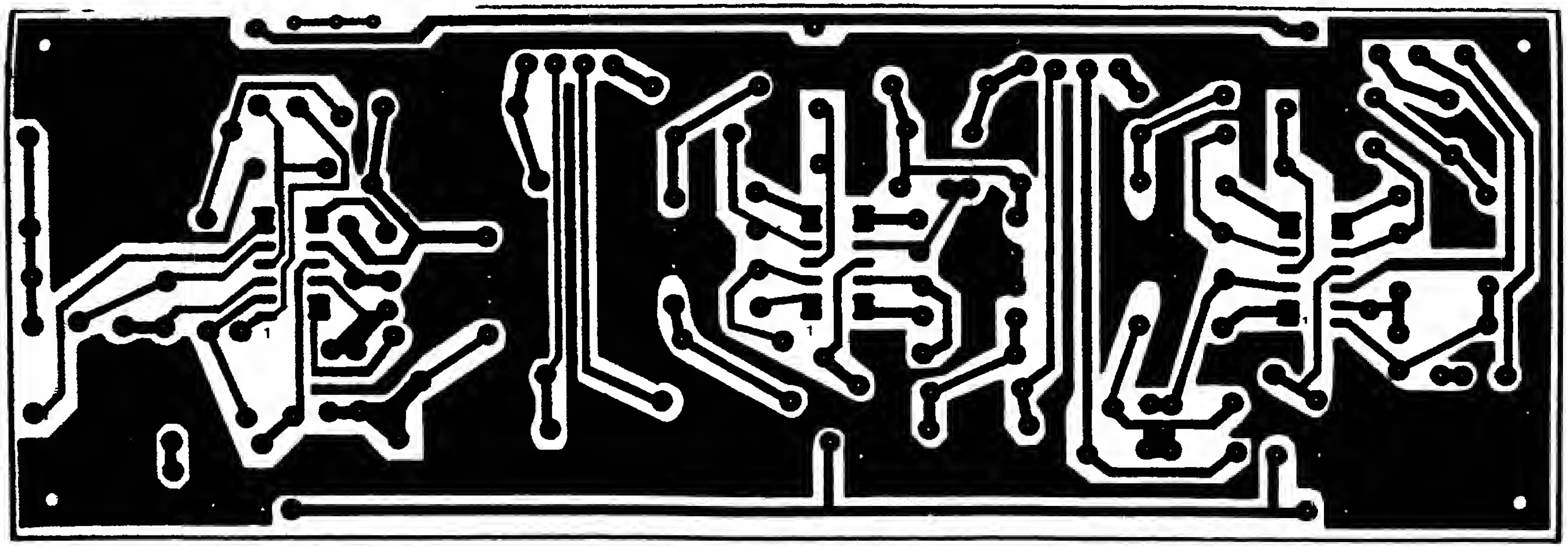


Fig. 5: Actual size PCB layout for the main circuit

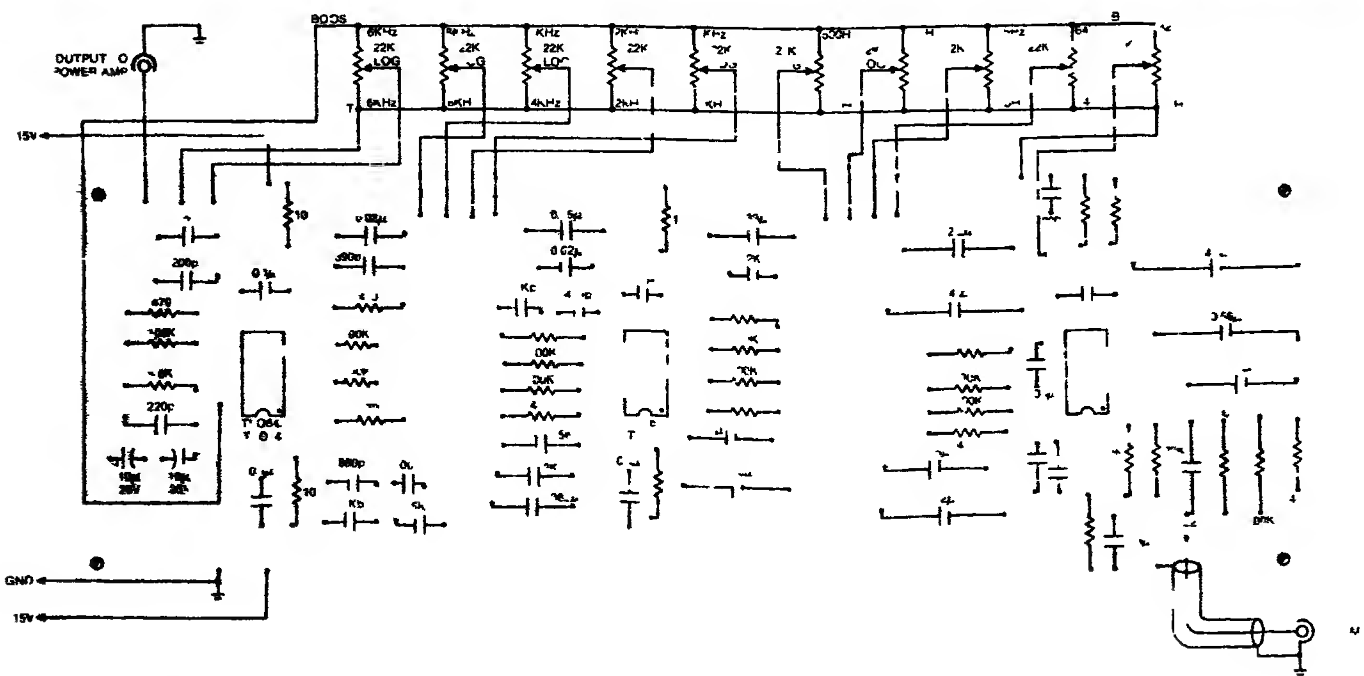


 Fig. 6: Component layout for the main circuit

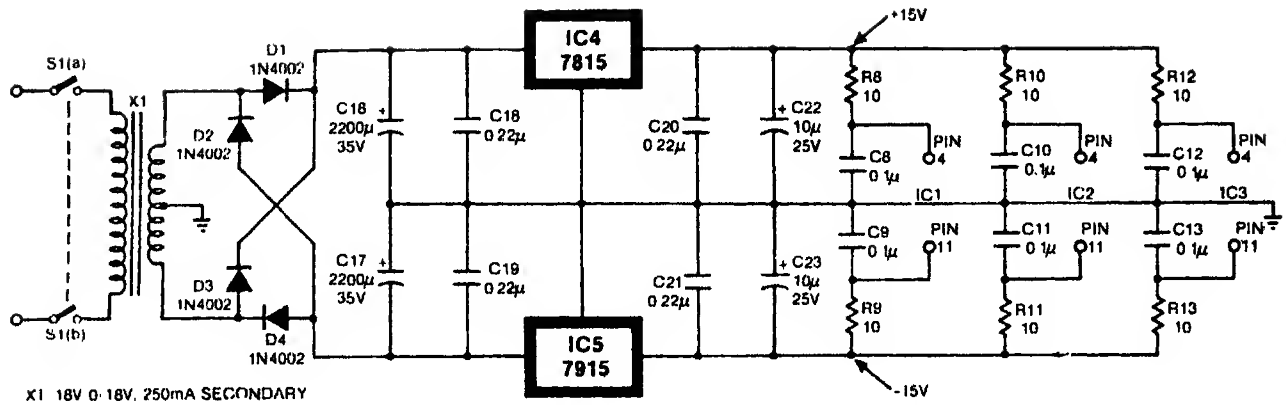


Fig. 7: Circuit diagram of power supply.

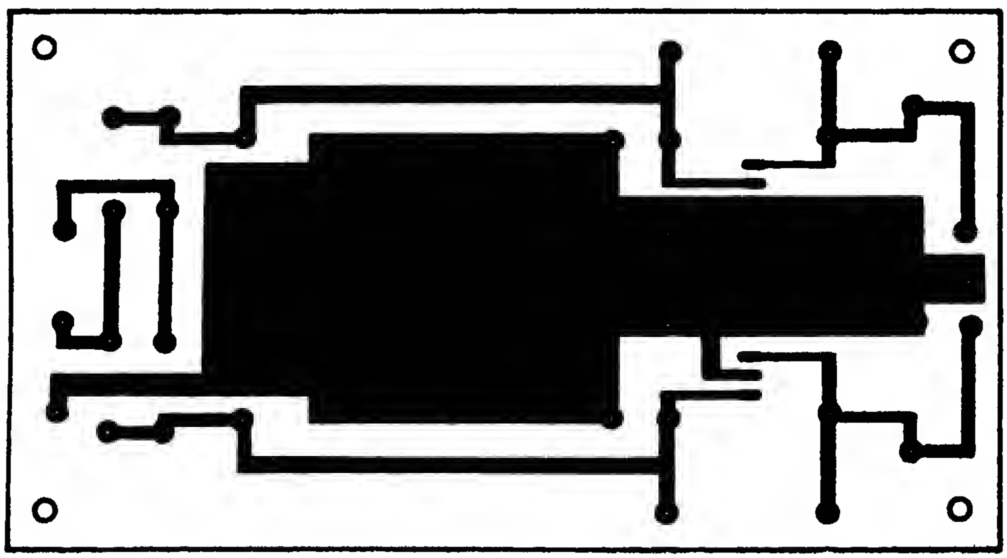


Fig. 8: Actual size PCB layout for power supply.

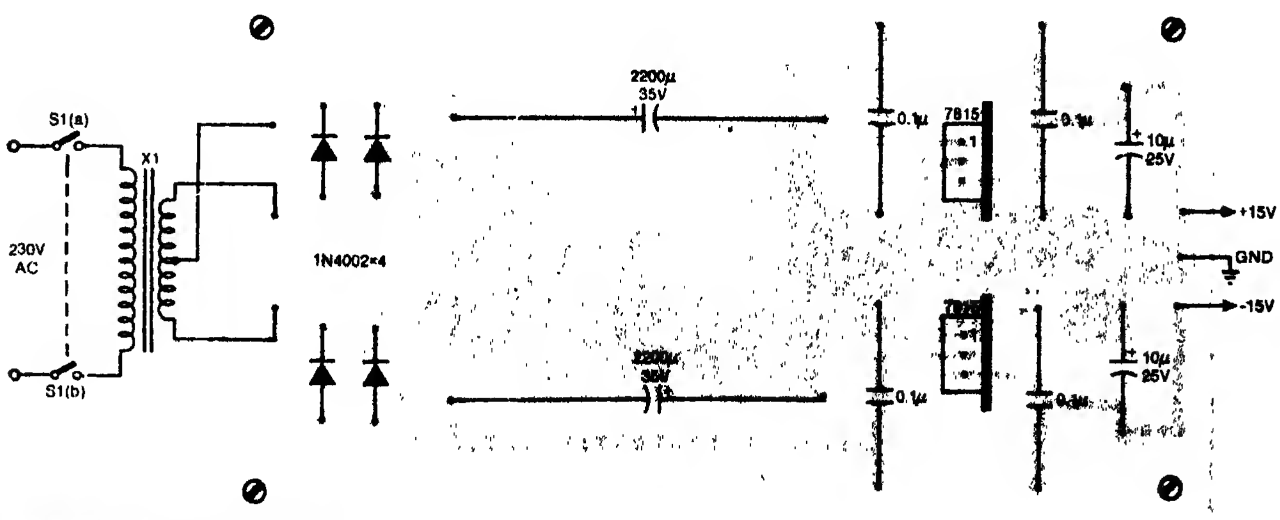


Fig. 9: Components layout for the PCB.

correctly. Then check whether you have connected the common point of all the controls, on the 'cut' side to the non-inverting input of A12 (see Fig. 6). This connection is very important.

Do not solder any controls first. Connect just the common point as mentioned above. Do not insert IC2. Switch on the power supply and check whether any of the ICs are heating up. They should just be warm.

Now connect the output to an amplifier. (If you have a volume control keep it at a low level.) Connect some source to the input of this equaliser. You should be able to hear the sound after the power amplifier.

Check the AC voltages, with an AC millivoltmeter, at pins 3 and 1 of IC1 with respect to ground. The voltage at pin 1 should be approximately five times the voltage at pin 3. If this is so, connect all the controls and then switch on again and connect a source. All the controls should work perfectly.

If any control is ineffective, look for bad soldering of the capacitors. Of course, IC2 must be inserted after all the controls are connected.

These are some simple tests you should perform before you fix up everything into a good stereo system. □