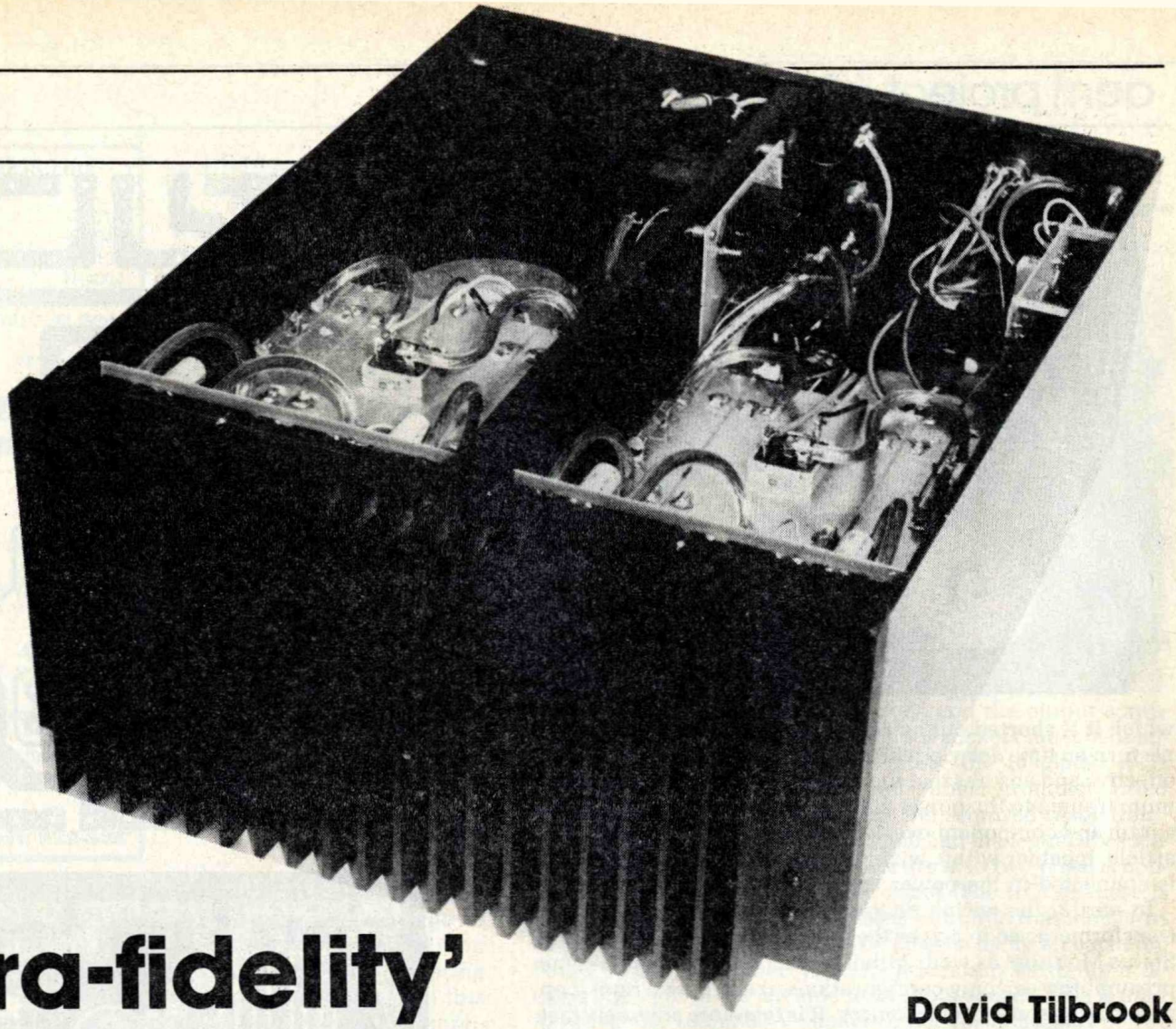


An 'ultra-fidelity' power amplifier

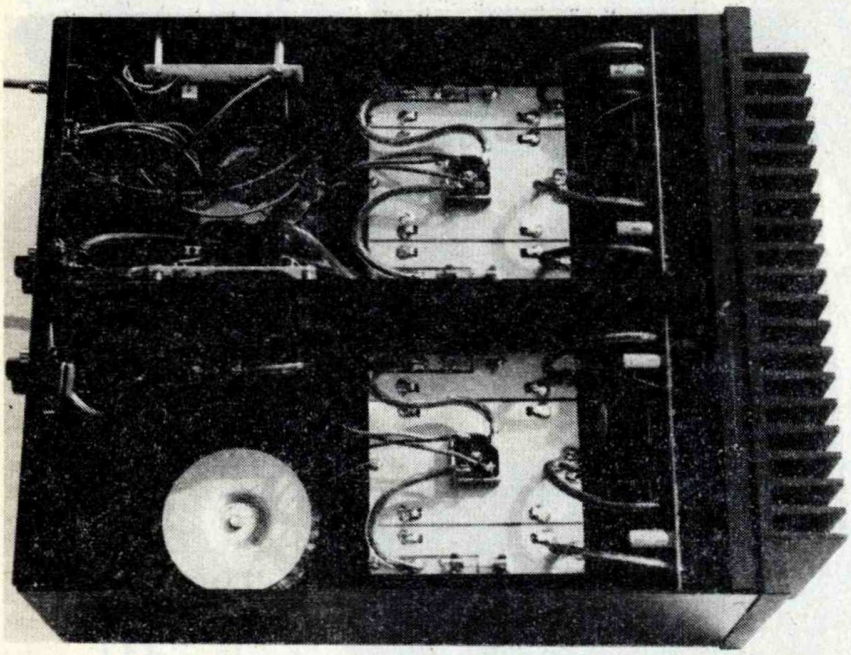
David Tilbrook

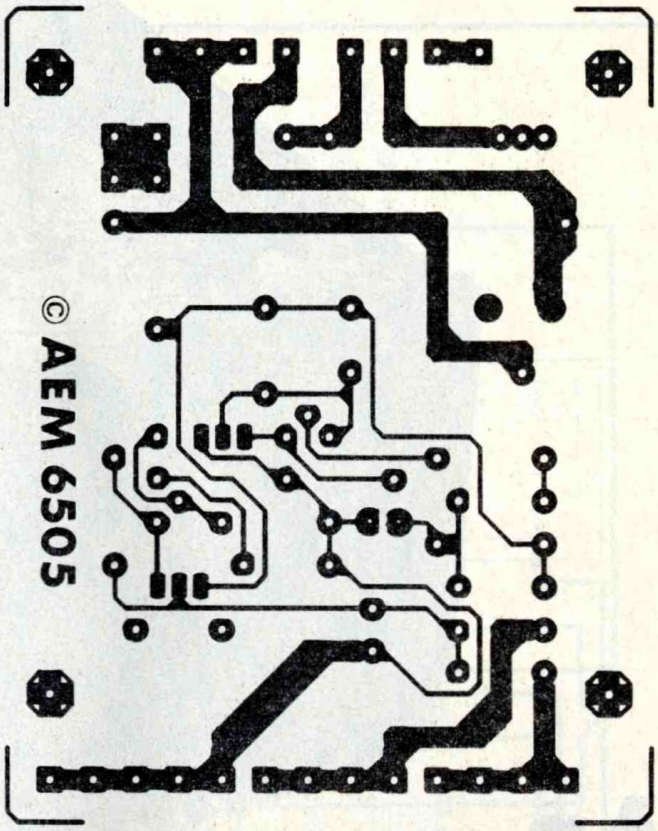
In Part 3 of this series I described the recommended power supply for incorporation with the AEM6000 power amplifier modules. In this article the surge current limiter and the remainder of the construction is described including the 240 Vac mains wiring.

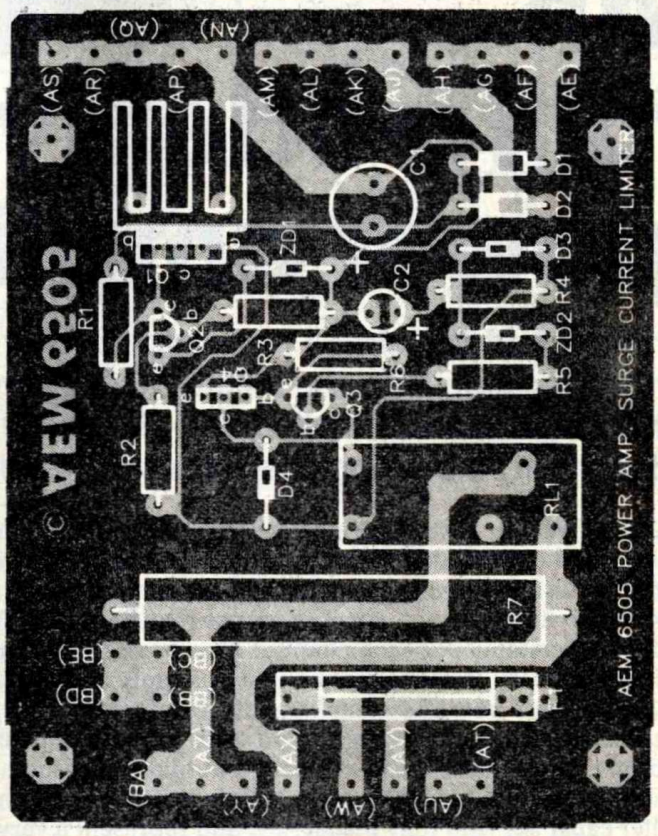
AS SHOWN in part 3, the power supply recommended for use with the AEM6000 power amp modules employs separate 300 VA toroidal power transformers for each channel, connected to high current capacity bridge rectifiers and 40 000 uF of capacitance for each channel. This provides each module with a very low-impedance power supply and helps ensure the best possible sound quality from the power amp modules. One problem associated with the low-impedance supply, however, is the in-rush current that can result at the moment of switch-on. When the supply is first turned on, the filter capacitors are fully discharged and represent a very low impedance (in fact nearly a short circuit) to the output of the power transformers. The resulting current is determined by impedances associated with the rest of the power supply wiring.

It is very important when using power MOSFETs in the output stage of a power amplifier such as this to ensure a very low impedance from each power amp module to the main power supply filter capacitors, and from the 0 V point at the capacitors back to the amp modules. If this current path has significant impedance, both the distortion and stability performance of the power amplifier can be severely affected. For this reason it is recommended that this wiring be done with a very low impedance cable such as Monster Cable (Monster Cable is a registered trade mark of Monster Cable Inc. It is distributed here by Convoy International and available through many hi-fi outlets and selected electronics retailers). Similarly, to ensure a very low impedance in this wiring it is necessary to remove power supply rail fuses from their usual location between the filter capacitors and the power module and to incorporate them instead between the ouput of the bridge rectifier and the filter capacitors. This still provides good fuse protection for the + ve and -ve supply rails in the event of a major power amp failure, but has the disadvantage that the fuses are exposed to the main turn-on in-rush current. Even if the appropriated slow-blow fuses are used in this application, the shock at each turn-on will significantly reduce the fuses' lifetimes.

In order to decrease the current in-rush at the moment of turn-on, a surge current limiter has been incorporated with the mains wiring. This places a resistor in series with the 240 Vac mains wiring leading to the primaries of the three toroidal power transformers. This resistor remains in series for a short time only, around 100 or 200 milliseconds, after ▶







which it is shorted out by relay contacts controlled by simple turn-on time delay circuitry. This simple technique is very effective and ensures that the power amp turns on with minimum trauma to the power supply components. A circuit diagram and component overlay have been included with this article, together with a wiring diagram which shows how it is connected to the power transformers.

In part 3, the wiring diagram shows the 80 VA toroidal transformer used to power the preamplifier connected to the Status Monitors as well. Although this is allowable on some preamplifier earthing configurations, it can create hum loop problems in some circumstances. It is therefore advisable that the Status Monitors and the surge current limiter be powered from a separate transformer secondary to that used for the preamp. This can easily be obtained by winding an additional 15-0-15 volt secondary winding on the 80 VA toroidal transformer.

Use two windings of 0.5 mm enamelled copper wire, each with 150 turns around the 80 VA transformer. The easiest way to do this is to wind the two 15 V windings simultaneously by winding with two lengths of wire. Start by winding two enamelled wires of different colour together onto a former with a small enough diameter to fit through the hole in the centre of the transformer. Make each winding by passing the former through the hole so that each pass completes one turn. When 150 turns have been wound, join the top of one of the windings to the bottom of the other. This task is greatly simplified if the two different coloured emanel wires have beem used.

It is very important to ensure that the correct wires have been joined together. If the start of a winding is joined to the finish of the same winding, this represents a short across the transformer and will cause it to draw excessive current and overheat.

Construction

The construction details for the Power Amp modules and Status Monitors have already been described. Start by constructing the power amp modules and status monitors as described in these earlier articles.

The construction of the AEM6505 surge current limiter can be tackled first. It should present few difficulties. This pc board is also used to carry the 240 V wiring to the transformers to minimise the number of external terminal strips required. Since the board has 240 Vac on it, it should be constructed based on the pc board pattern published with this article and only fibreglass board should be used. Assembly of the '6505 is relatively straightforward and only a few special precautions are necessary. Start by soldering the small passive components onto the pc board first and then move onto the semiconductors. The voltage regulator TIP31A transistor is mounted on a small pc-mounting heatsink. Mount the transistor to the heatsink first and, after positioning the transistor's leads through the pc board, solder the heatsink mounting pins before soldering the leads to the transistor itself.

AEM6505 PARTS LIST

Semiconductors

Q1 ..... TIP31A
Q2, Q3 ..... BC548
Q4 ..... BD139
D1, D2 ..... 1N4004
D3, D4 ..... 1N914
ZD1, ZD2 .... 5V1/1 W zener

Resistors All 1/4W, 5% unless noted

R1 ..... 10k
R2 ..... 1k
R3 ..... 820R
R4 ..... 22k
R5, R6 ..... 10K
R7 ..... 10R

Capacitors

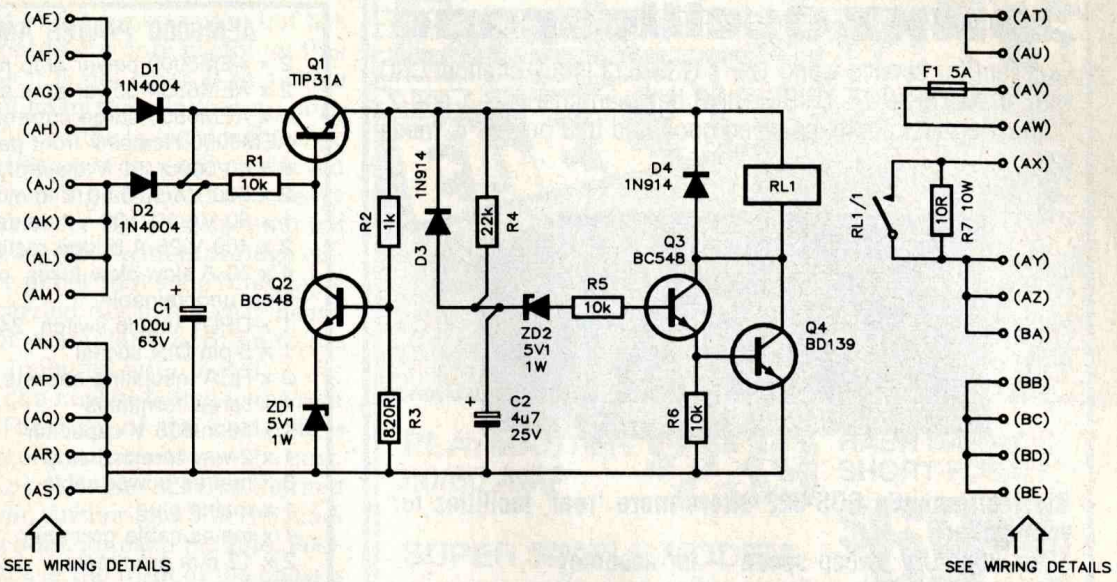
C1 .... 100μ/63 V RB electro.
C2 ..... 4μ7/25 V RB electro.

Miscellaneous

RL1 ..... SPDT 5 A contacts, 12 V coil
F1 ... 5 A 3AG slow-blow fuse

AEM6505 pc board; heatsink, pc-mount type DSE H3490 or similar.

Expected cost: $22-$28



The final step of particular importance in the construction of the surge current limiter is the mounting of the large 10 W wirewound current limiting resistor. If a fault condition arises in the '6505 which prohibits the relay from operating correctly then the power dissipation produced within this resistor will become extremely high when the power amplifier is driven to even modest output levels. It is therefore essential that this resistor is mounted well off the pc board so that the board will not be affected by the heat and consequently destroyed. The best type of power resistor to use for this application is one which is thermally protected. These are fitted with a length of spring steel used to form a switch contact which has been soldered closed with special, very low temperature solder. This contact is in series with the resistor so that if it becomes excessively hot, the solder melts allowing the contact to spring open, disconnecting the resistor from the circuit. Unfortunately, these resistors do not seem to be commonly stocked by electronics retailers in Australia and may be difficult to obtain.

With all of the boards assembled, the remainer of the construction can be completed. The prototype power amplifier was constructed in a custom-made steel chassis with a gravity diecast front panel heatsink of aluminium. The chassis was supplied with a steel centre panel which serves to isolate the two channels and also provides a convienient mounting panel for the two AEM6504 Status Monitors. Drilling details for the panels have been included with this article.

Commence by winding the extra secondary around the 80 VA toroidal transformer as discussed above. Mount the transformers to the chassis using the special mounting kits provided with them. One of the rubber discs is placed between the chassis and the toroidal transformer. The other is placed between the top of the transformer and the circular steel mounting panel. Pass the mounting bolt through the chassis so that the nut is on the top of the transformer inside the chassis. Before tightening the mounting nuts, rotate the transformer so that the leads are positioned closest to the electrolytic capacitors. Mount the smaller 80 VA transformer to the rear panel of the chassis in a similar way.

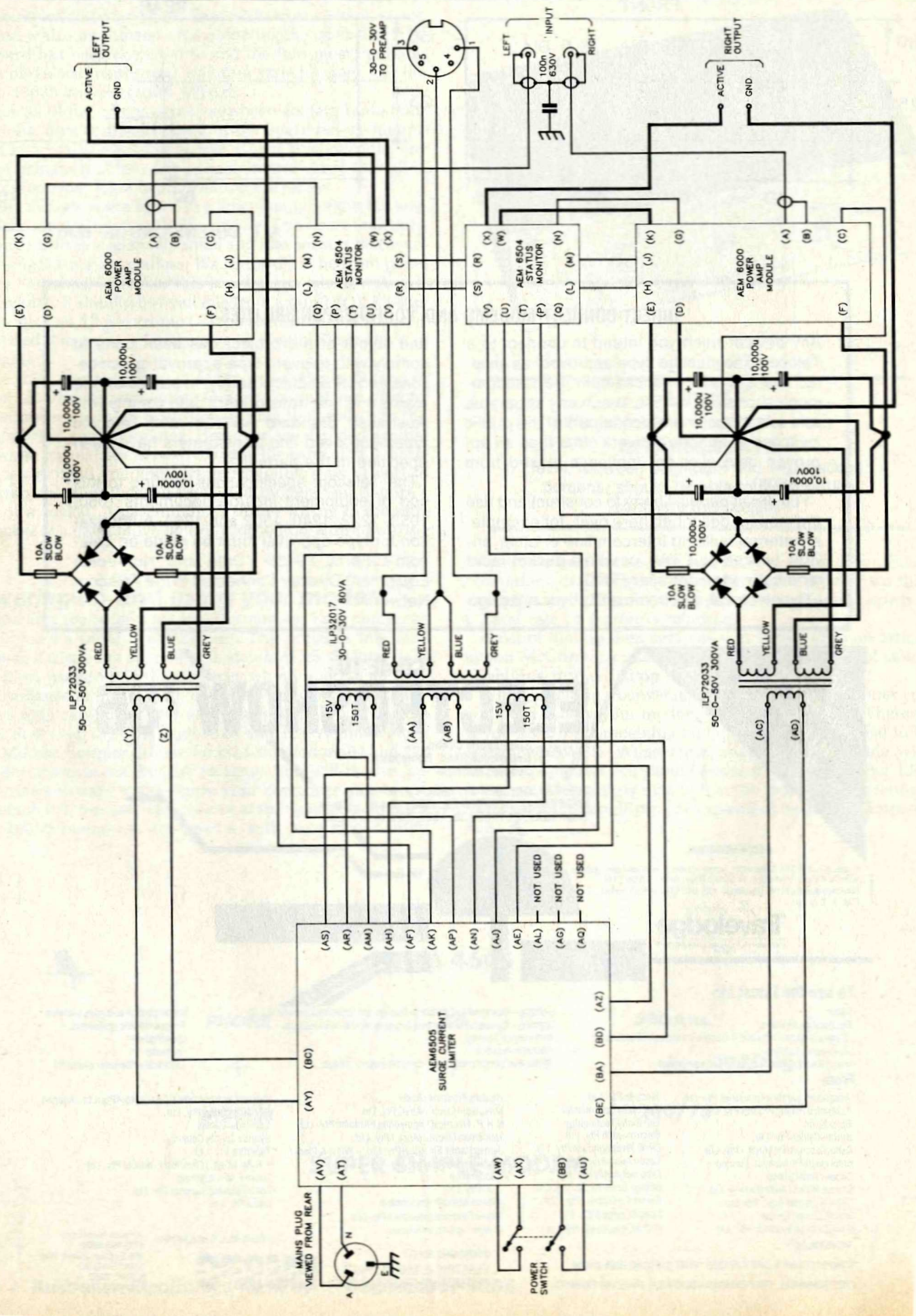
Mount the two input RCA sockets and the output screw terminals to the rear panel. The input sockets must be insulated from the chassis, so use either the insulated RCA chassis-mount sockets or use 8 mm rubber grommets fitted to the mounting holes to provide the required insulation.

Next mount the 240 V mains switch and the 5-pin DIN socket to the rear of the chassis. There are also two chassis connections to be made to the rear panel. The first of these is located adjacent to the 240 V mains switch so that the mains cable earth can be secured to the chassis using an earth lug bolted to the rear panel. The second chassis earth lug is located adjacent to the left side RCA input socket. This is used to solder the 100n/630 V capacitor between chassis and the input shield. This capacitor ensures that the chassis acts as an effective shield for the power amp for RF, while providing sufficient impedance at 50 Hz to eliminate the potential hum loop that can result if the chassis is connected directly to the signal earth within the power amp.

After positioning the surge current limiter roughly in place the 240 V wiring can be carried out. Use a locking type 240 V mains cable grommet and mount the cable to the rear panel after first preparing the ends of the cable. The mains cable active and neutral wires are soldered directly to the '6505 pc board. The earth lead should be soldered to the chassis lug bolted to the rear panel. The four wires leading to the power switch all solder directly to the '6505 pc board as do the primaries of the three power transformers. The right channel power transformer and the 80 VA preamp transformer can solder directly to the pc board. The leads to the left channel power transformer must be extended by soldering lengths of cable and then passed through the bottom hole in the rear of the centre panel. This hole should be fitted with a grommet to ensure that the metal cannot cut through the plastic insulation surrounding the wires. In the prototype power amp the leads to the left channel power traqnsformer were extended by taking them to a two-way screw terminal block which had been mounted to the rear panel of the power amp. A small piece of surplus pc board was fitted between the metal rear and the terminal strip to help ensure sufficient isolation of the 240 V mains wiring from the chassis; 240 V rated cable was then taken from this terminal block to the '6505 pc board.

Finally, ensure that all 240 V wiring is adequately insulated to prevent the possibility of accidental contact. When doing this however, be careful not to allow flammable materials such as PVC insulation tape to come into contact with the ▶

aem project 6000



AEM6000 POWER AMP PARTS LIST

2 x AEM6000 power amp modules
2 x AEM6504 power amp status monitors
1 x AEM6505 surge current limiter
AEM6000 Heatsink front panel and chassis
8 x 10 000u/100 V electrolytics
2 x 300 VA/50-0-50 V toroidal power transformers
1 x 80 VA/30-0-30 V toroidal power transformer
2 x 400 V/25 A bridge rectifiers
4 x 10 A slow-blow fuses, or 10 A quick-blow types if slow-blow unobtainable.
1 x DPDT toggle switch, 240 V/5 A
1 x 5-pin DIN socket
2 x RCA insulating sockets.
4 x screw terminals
1 x 100n/630 V capacitor
1 x 2-way terminal strip
3 x metres power cable
1 x mains plug
1 x mains cable grommet
2 x 12 mm grommets
2 x 8 mm grommets
8 x 6 mm spacers
4 x 25 mm spacers
4 x red LEDs
4 x LED mounting grommets
4 x metres Monster Cable, or similar 6BA and 4BA nuts and bolts
2 x solder lugs
2 x metres shielded cable
Assorted hookup wire

10 W current limiting resistor on the '6505 pc board because, as mentioned earlier, this resistor can become excessively hot under some fault conditions.

Before mounting the '6505 pc board to the side panel, complete the low-voltage ac wiring from the output of the 80 VA, transformer. The main 30-0-30 V secondary is wired directly to the DIN socket on the rear of the chassis. The extra 15-0-15 V winding connects to the '6505 pc board from where it is distributed to the two '6504 pc boards. The remaining wiring to the '6505 runs to the two '6504 power amp Status Monitors. Place each of the '6504 pc boards roughly in position on either side of the rear section of the centre panel. Measure lengths of hookup cable by running these around the chassis first and then solder them to the '6504 pc boards. The wiring to the left channal Status Monitor passes through the bottom hole at the rear of the centre panel. When all of the wiring has been soldered to the '6504 pc boards they can be mounted to the centre panel using 6 mm spacers and four 25 mm bolts which pass through both '6504 pc boards.

Finally, the wiring from the '6504 pc boards can be soldered to the '6505, which can then be bolted into its position on the right side wall of the chassis. In our prototype, 25 mm spacers were used to ensure good clearance between the side wall and the 240 V wiring on the rear of the '6505 pc board.

With the two AEM6504 Status Monitors mounted onto the centre panel and the '6505 mounted in its position, the main electrolytic filter capacitors, bridge rectifier and high current power supply wiring can be done. Start by bolting the capacitors to the chassis. Orient the capacitors so that their positive terminals are closest to the right side wall of the chassis (as viewed from the front). This minimises the power supply wiring to the power amp modules since their positive rail connection points are also closest to this side of the chassis.

In the prototype, the wiring between the filter capacitors and the fuses, and then to the bridge rectifiers, was achieved through the use of simple pc boards which were soldered directly to the tops of the filter capacitors. This has the ad-

vantage of simplifying this part of the construction but has the disadvantage that the pc boards are only useful on this particular type of capacitor. As it is not clear at this stage which electrolytics will be supplied by the retailers supporting this project we have not included the layout for these pc boards with the article. The wiring can be easily achieved without the use of pc boards by using conventional heavy duty tinned copper wire. In this case, use chassis-mounted 3AG fuse holders and bolt these, together with the bridge rectifier, to either side of the centre panel above the filter capacitors. The wiring should be carried out using very heavy duty cables (Monster Cable, for example) according to the power supply wiring diagram included with part 3.

The two power amp modules can now be bolted to the rear of the front panel heatsink. The rear of the heatsink is machined flat so that good thermal contact between the power amp brackets and the heatsink is achieved. Use thermal paste to improve the contact even further and bolt the module in place using six mounting bolts for each module. Position the heatsink roughly in place at the front of the chassis and wire the shielded cables between the inputs of the modules and the input RCA sockets on the rear of the chassis. Pass the cables between the centre panel and the '6504 pc boards since this helps to keep the input cables away from the power transformers. Wire the input earth between the modules and the 0 V point on the electrolytic capacitors, then wire the leads from the '6504 boards to the four LEDs which mount through the front panel. Make sure that these connections are well insulated from each other and from the front panel. Mount the LEDs to the front panel by passing them through the rear of the front panel. In the prototype unit we used conventional LED mounting grommets which were first glued to the front panel.

Once the LEDs are mounted and the input and output earths have been connected, the front panel assembly can be bolted into place on the front of the chassis.

The remaining wiring between the power supply and the power modules can now be completed, together with the wiring from the power amp module output to the Status Monitor relay and then to the output terminals. The earth for the output terminals is connected directly to the 0 V point on the power supply filter capacitors.

Finally, solder a length of insulated hookup wire between the two RCA input earths on the rear panel. This wire passes through the top hole in the centre panel which should be fitted with a grommet.

Powering up

Before applying power, check all of the 240 V wiring. Check that the earth pin of the mains plug is connected to the chassis using a multimeter. Check all of the power supply wiring, being sure to check that the correct transformer leads are connected to the correct points on the power supply. If all is well, insert fuses into the fuse holders and switch on. Do not connect speaker leads at this stage. Instead, measure the output offset voltage on the output terminals at the rear of the chassis. If necessary, the output offset of each module can be adjusted using a small screwdriver, being careful not to short the preset to any other components on the power amp pc board. Preferably, a plastic 'trimming tool' should be used for this purpose.

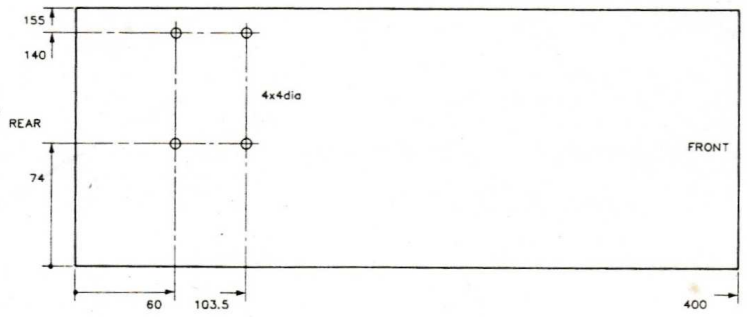
Once this has been done, the speakers can be connected. The AEM6000 is a very quiet power amp, so very little noise should be heard in the speakers with the preamp disconnected. To avoid possible damage to the loudspeakers, turn the power amp off before connecting the preamp and be sure that the volume control on the preamp is turned fully down. Remember that the power amp will supply 240 W to each ▶

loudspeaker, if required, and this is more than enough to guarantee destruction of most loudspeakers if the power amp is used incorrectly.

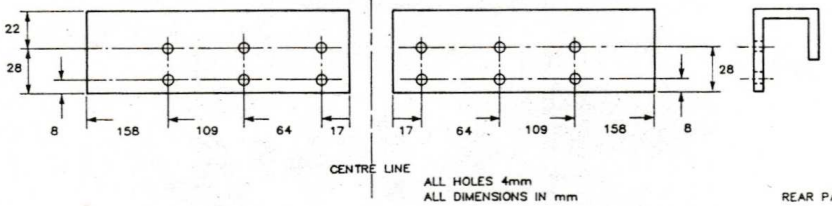
Good listening!

RH SIDE PANEL VIEWED FROM THE INSIDE

ALL DIMENSIONS IN mm



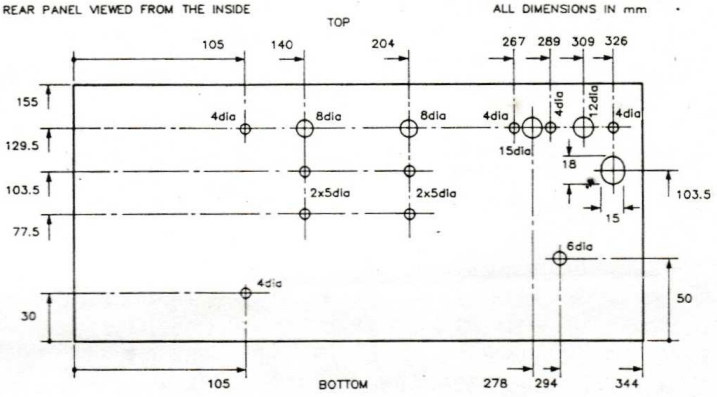
POWER MODULE HEATSINK BRACKET TO FRONT PANEL HEATSINK MOUNTING – BRACKET DRILLING



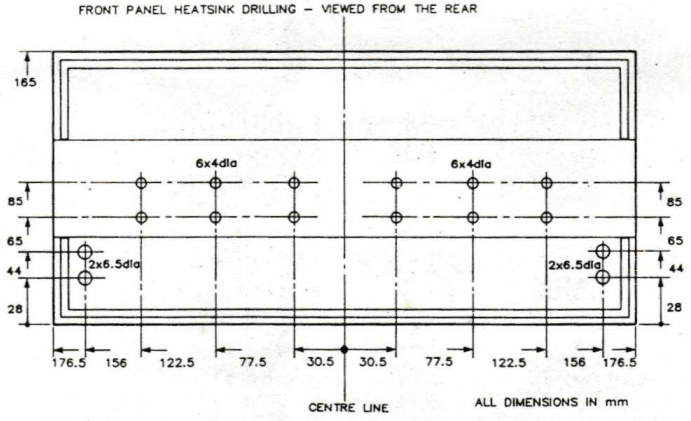
ALL HOLES 4mm
ALL DIMENSIONS IN mm

REAR PANEL VIEWED FROM THE INSIDE

ALL DIMENSIONS IN mm

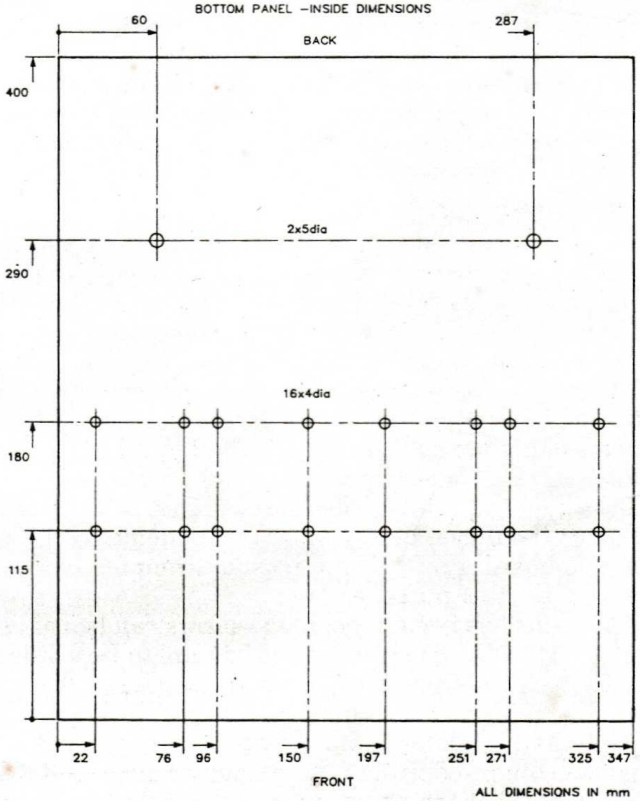


FRONT PANEL HEATSINK DRILLING – VIEWED FROM THE REAR



ALL DIMENSIONS IN mm

BOTTOM PANEL –INSIDE DIMENSIONS



ALL DIMENSIONS IN mm

CENTRE PANEL

ALL DIMENSIONS IN mm