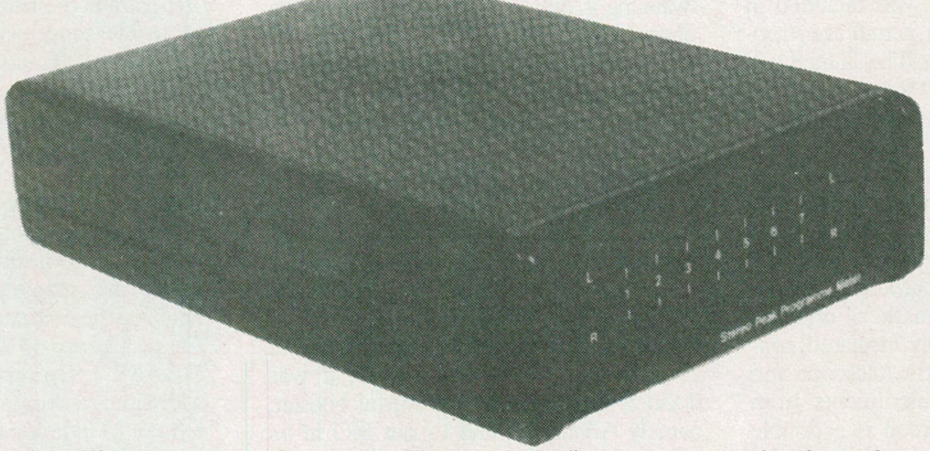
Peak Program Meter

Long a European standard, the PPM offers advantages over the VU

IAN COUGHLAN



There are two major differences between the typical peak program meter and the VU meters that are more familiar to most people. The PPM has very different ballistics—it attacks quickly and decays slowly so that peak signal levels are clearly displayed. In addition the PPM's scale is roughly linear, whereas the scale of a VU is anything but.

A Different VU

Let's look at the VU meter in more detail. The audio signal is rectified and integrated to produce a reading corresponding to the average signal level (the PPM shows the peak level). At the left end of the scale is -20, and at the right end is +3VU. About two-thirds of the way along is 0VU, which by convention corresponds to +4dBm in professional equipment (0dBm in domestic units).

Put a sine wave into the VU meter at a level of +4dBm and it will read 0VU. Simple. Put a typical audio signal in at an average level of +4dBm and it will still read 0VU, although the needle will jump around a bit in response to the signal.

A typical audio signal however, contains peaks that will be more than +4dBm. Since a VU meter integrates, these peaks will not produce a proportionate increase in the meter reading and the audio system can be driven into overload even though the meter says everything is fine.

This may be relatively unimportant—analog tape recorders, for example, exhibit a soft overload characteristic and the distortion is not too objectionable. Other media are not always so forgiving. Digital recording systems, radio transmitters and audio amplifiers have very sharply defined upper limits. Drive them even a little above their limits and they simply will not go. The signal will clip and the resulting distortion is very nasty indeed.

Obviously the best signal-to-noise ratio from an audio path is obtained by running as close to the upper limit as you can, short of overload. If all you've got is a VU meter, the peaks are not going to register, so you'll have to allow a considerable amount of headroom above the average signal level for these peaks and that's going to compromise the performance at the bottom end.

Enter the PPM

The fast response of the PPM means that the magnitude of peaks within the signal can be monitored with precision and if you know where your system's upper limit is (it's easy to find, just increase the signal until the output clips), adjust the level so that the peaks are just below the limit. You may want to allow headroom for extra large peaks, but with prerecorded or broadcast material the recording engineers will have squashed those out long before they get to you.

Not just any old meter can be used for a PPM. Only specialized (and expensive) movements have the necessary ballistics, most ordinary movements being far too slow. The PPM to be described in this article uses LEDs in place of a meter movement and they're as fast as anyone could want. Cheap, too—the cost of producing this stereo PPM with built-in power supply is less than the price of one PPM meter with drive card. True, it doesn't have the ultimate accuracy of such a meter, but in side by side comparisons monitoring typical program material, no visual differences could be observed.

The PPM scale is quite distinctive. Unlike the VU meter which tends to squeeze the area of interest into the top half of the scale, the PPM stretches this area out so that it spans the full width of the scale.

The PPM1 on the left corresponds to -12dBm, PPM7 on the right is +12dBm. In the center of the scale is PPM4, which is 0dBm. The scale marking are equally spaced, each 4dBm from its neighbours.

PPM	Volts RMS	Volts Peak	dBm
1	0.195	0.275	−12
2	0.308	0.436	−8
3	0.489	0.69	−4
4	0.775	1.095	0
5	1.228	1.736	+4
6	1.946	2.752	+8
7	3.084	4.36	+12

Note:
0dBm is referred to 1mW in 600R, accepted as 0.775V RMS.

Table 1 PPM display levels.

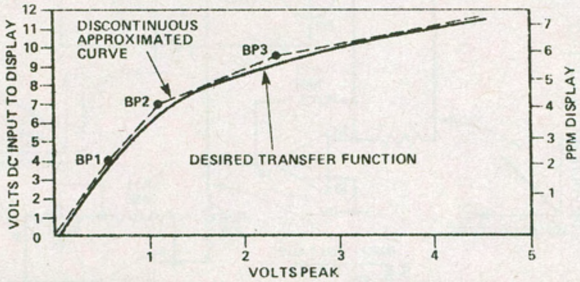


Fig.1 Transfer functions for the peak program meter.

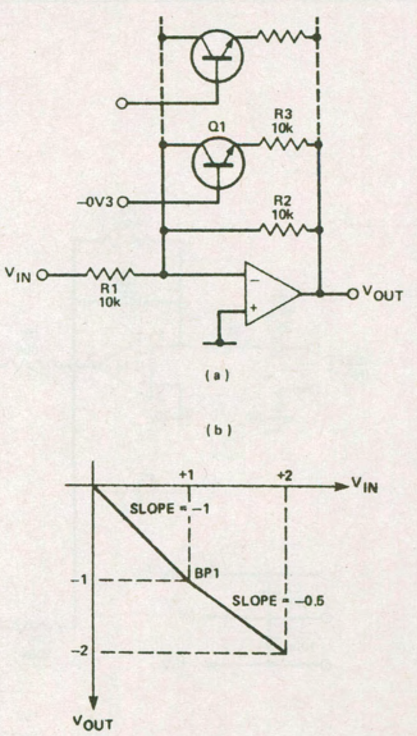


Fig.2 Setting transfer function breakpoints.

Table 1 shows the PPM numbers with their corresponding dBm levels and voltage levels (RMS and peak). To achieve this linear scale a nonlinear amplifier is needed. Fig.1 shows the desired transfer function of this amplifier. The function is realized in this design by a technique known as discontinuous approximation. The output of the nonlinear amplifier does not change in a smooth, continuous manner; instead the transfer function consists of a series of straight lines, designed to approximate to the desired curve as shown by the dotted curve. The slope of the amplifier is made to change at each breakpoint and the more breakpoints and slopes there are the more accurate will be the approximation.

This design uses three breakpoints and four slopes, which is quite adequate for the application. Fig.2 illustrates the technique.

For all the input voltages up to +1V, the gain of the amplifier will be -1 since Q1 will be nonconducting (its base is held at -0.3V). As the output falls below -1V, Q1 will begin to conduct, providing an extra feedback path around the amplifier. The feedback resistance is now effectively R3 in parallel with R2, so that the gain becomes -0.5. Further breakpoints can be added as shown.

How It Works

The circuit diagrams of the two boards are shown in Figs. 3 and 4. Apart from the power supply, the PPM consists of identical circuits, so for reasons of clarity only one half will be described.

IC1a is an inverting amplifier with a gain of about 20dB when SW1 is in the -20dBm position and unity gain when in the 0dBm position. In this way the PPM can be used on professional equipment with signal levels of 0dBm and also on domestic equipment which has a much lower signal level. Note that the input impedance will be 9.1k in the -20dBm position and 100k in the 0dBm position.

IC2a and b are configured as a full wave rectifier. IC2a will ignore the positive half cycle of the signal waveform, but will invert the negative half cycle. IC2b will do the reverse. The resulting signal on D2's cathode will be positive going and is used to charge C3 via R8. The voltage on this capacitor is equal to the peak input signal level. The charging time constant is determined by R8 and C3, the discharge time constant is determined by R4 in series with R8 and C3. This is what gives the PPM its fast attack/slow decay characteristic. IC2c buffers the voltage on C3. IC2d is the nonlinear amplifier and its operation is described elsewhere in the article. RV3 sets breakpoint 1 (BP1), RV2 sets BP2 and RV1 sets BP3. Before BP1 is reached, the gain of the stage is R13/R9. Above BP1, R12 is in parallel with R13 and the gain falls accordingly. Above BP2 but below BP3, R11, R12 and R13 are all in parallel. Above BP3, R10, R11,R12 and R13 are in parallel. Thus as the input rises, the of the stage drops to a lower value at each breakpoint.

Construction

The front and rear panels should be cut and drilled as shown in Fig.5. Drilling the holes in the front panel will not be as easy as it looks. The trick is to drill the four large holes first and fix stripboard to the panel with the holes aligned with the positions of the LED holes. Now drill pilot holes in the panel, 1mm in diameter, using the strip as a jig. Remove the stripboard and drill the holes out to 2mm. But be warned—don't rush ahead. Practise on a piece of scrap material first.

Fix the phono sockets, slide switch, and power inlet to the rear panel. Also, fit a solder tag to the rear panel for the ground connection: mains voltages are present within the unit and it's up to you to see that it is safe to use.

Solder R55 and R56 to the slide switch, SW1. Put all the LEDs into a piece of stripboard (observing polarity) but

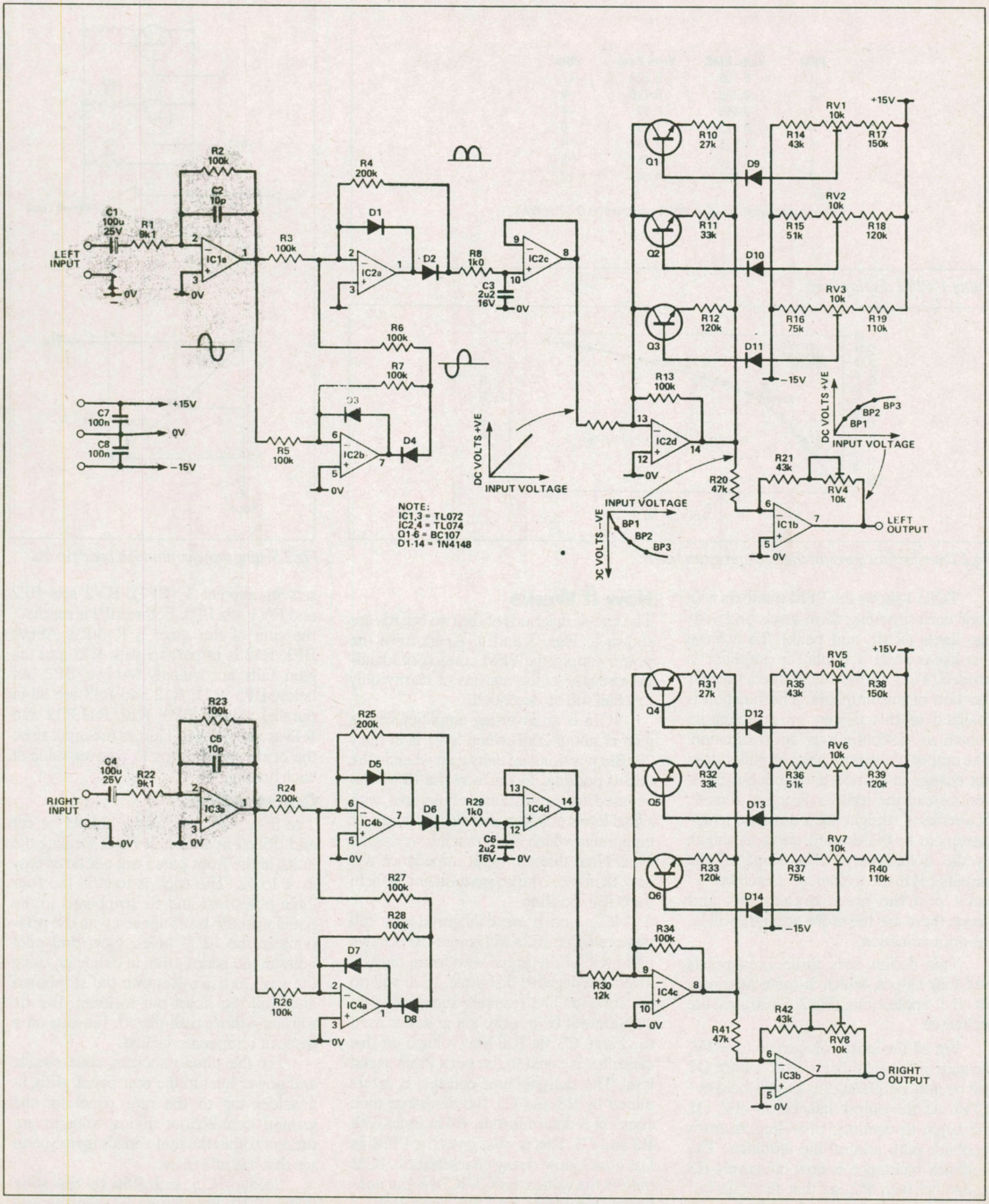


Fig.3 Circuit diagram of the small board.

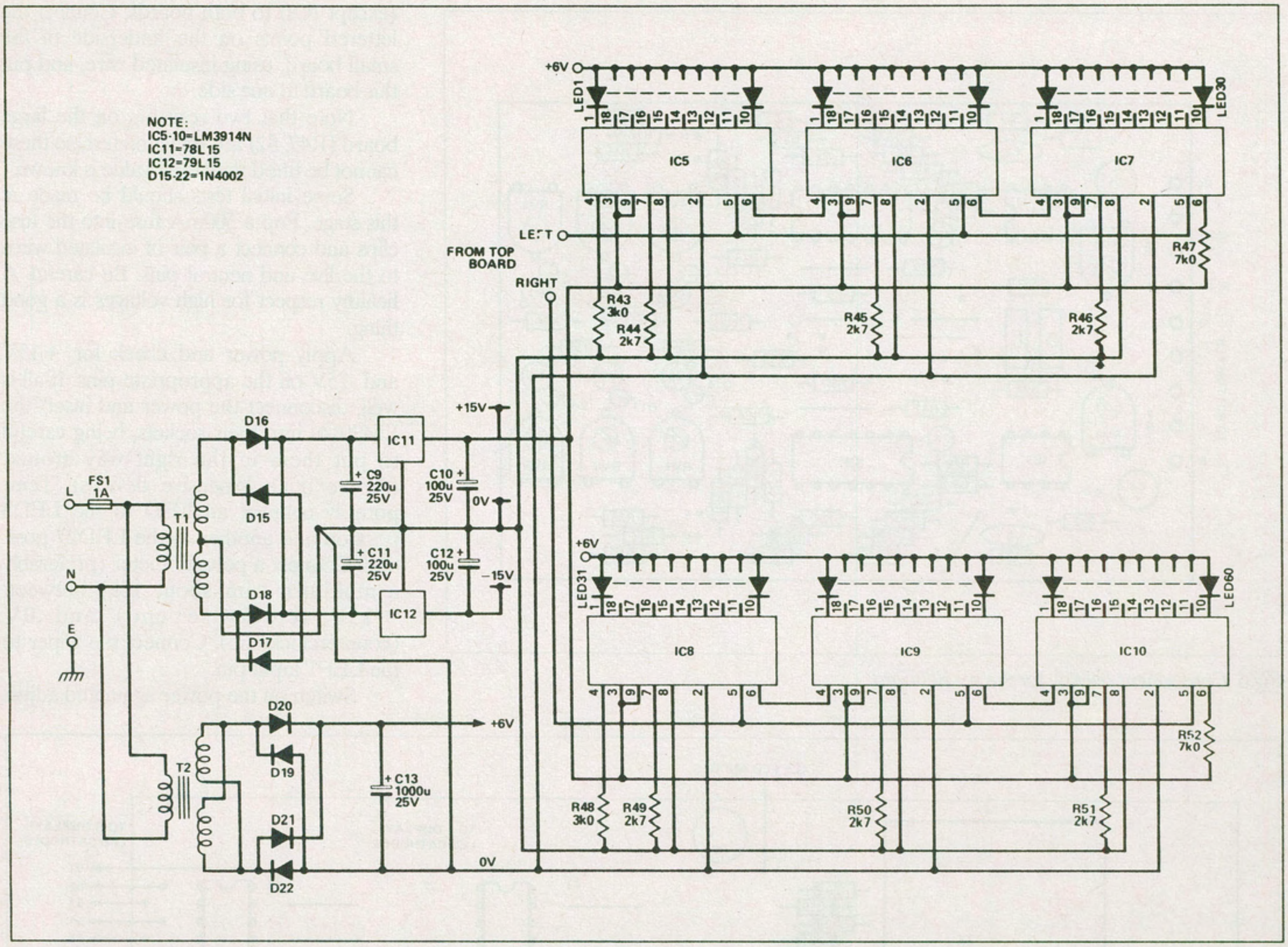


Fig.4 Circuit diagram of main board.

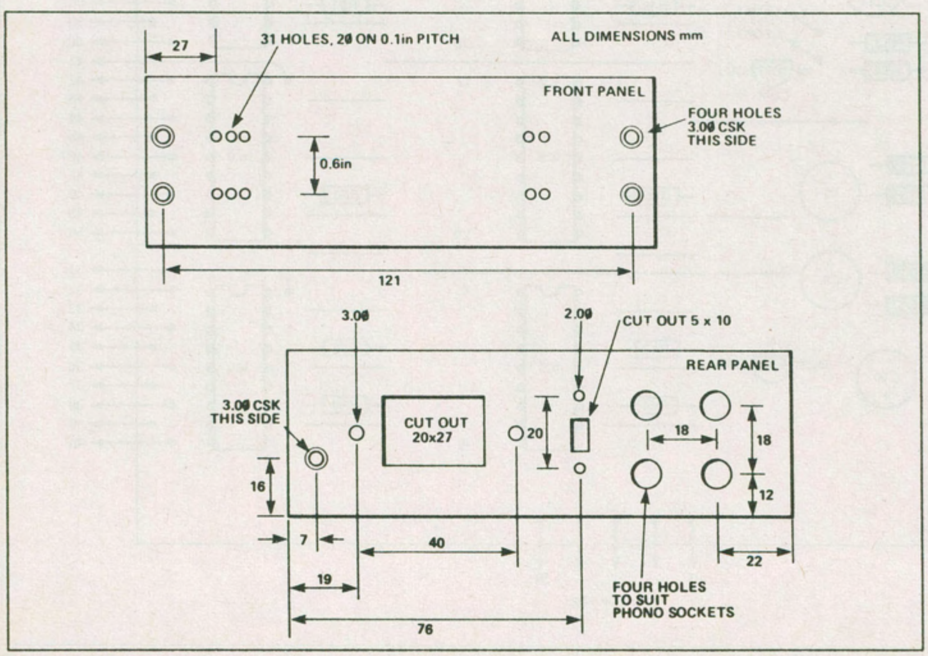


Fig.5 Front and rear panel drilling.

don't solder them yet. Guide the LEDs through the holes in the front panel, and fix the stripboard to the panel using countersunk screws from the front and 6.35mm (1/4 in) spacers. Fix a solder tag to one of the screws – this is the ground connection for the front panel.

Now is a good time to check that all LEDs work using a power supply of about 12V and a series resistor of 4k7. If all is well, slide a piece of thin card down between the two rows of LEDs, to prevent light from one row spilling into the next. Put the front and rear panels to one side.

Check both PCBs for short circuits before you start on them. The overlays are shown in Figs.6 and 7. Insert the through pins from the copper side of the large board and from the component side of the small board. This will keep all the wiring between the boards, resulting in a neater overall appearance.

Fit and solder links, resistors, capacitors, DIP sockets, trim pots, fuse clips, transformers and semiconductors

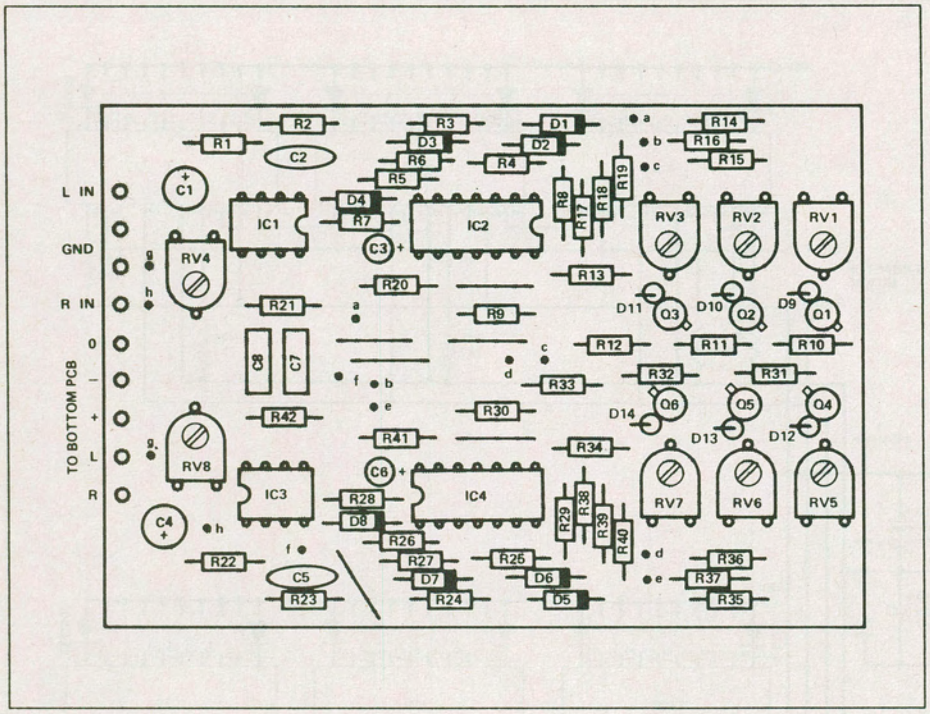


Fig.6 Component overlay for the small board.

(except ICs) to both boards. Connect the lettered points on the underside of the small board, using insulated wire, and put this board to one side.

Note that two resistors on the large board (R47, 52) are select on test, so these cannot be fitted until their value is known.

Some initial tests should be made at this stage. Pop a 500mA fuse into the fuse clips and connect a pair of insulated wires to the live and neutral pins. Be careful. A healthy respect for high voltages is a good thing.

Apply power and check for +15V and -15V on the appropriate pins. If all is well, disconnect the power and insert the LM3914s into their sockets, being careful to put them in the right way around (they're quite expensive devices). Temporarily connect an LED to the LED3 position and another to the LED27 position. Connect a potentiometer (preferably a multiturn trim about 10k) between +15V (clockwise end) and 0V (counterclockwise). Connect the wiper to the LEFT input pin.

Switch on the power again and adjust

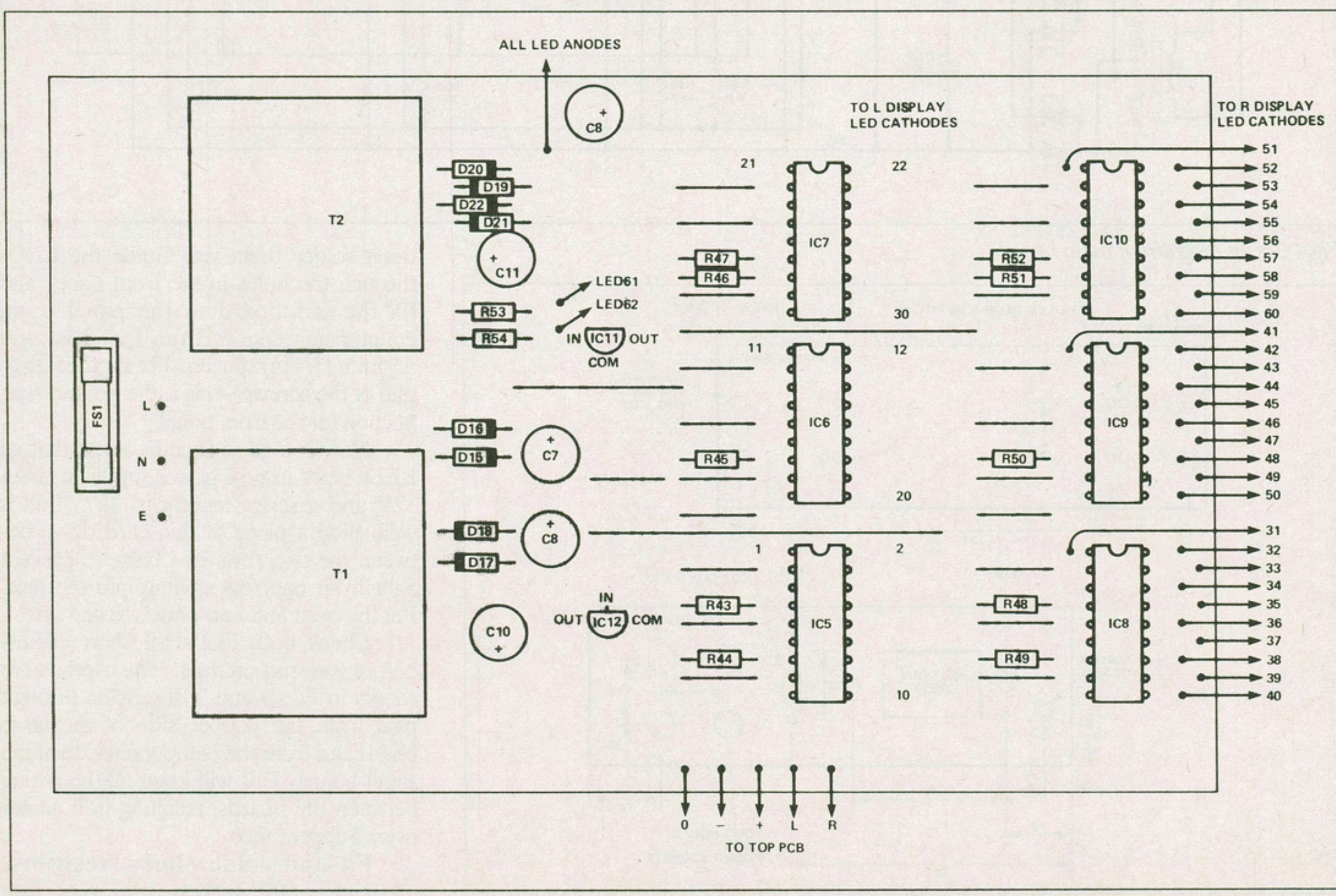


Fig.7 Component overlay for the main board.

the potentiometer for +11.25V on its wiper. R47 must now be selected so that LED27 is only just on. Another preset (20k) will make this easier. When the value is known, solder R47 into place. It may be necessary to fit two or more resistors in series or parallel. Now check that LED3 is on above a voltage of +1.25V on the wiper of the multiturn preset.

The above procedure must now be repeated for the RIGHT channel, so move the LEDs over to LED33 and LED57 and move the wiper of the multiturn preset to another input. Once you're happy with both channels, disconnect the power and remove all the other temporary connections.

Wire in the cathodes of the LEDs. The left hand LED of each channel (LED 61, 62) are lit at power-on and connect to the center of the main board. The display for the left channel then runs from LED30 to LED1 and for the right channel from LED60 to LED31. Fix the two boards together with 1in spacers. Fit the ICs to the small board. Cut a piece of card and fit it to isolate the input sockets from the mains end of the PCB. Drop the two PCBs into the box and fix the assembly into place. Fit the front and rear panels and wire them to the large PCB as shown in Fig.8. Remember to fit an insulating boot to the power connector and to connect the ground wires.

Calibration

Calibrating the PMM is very straightforward. You'll need an audio oscillator, capable of producing to +12dBm (3.08V RMS). The procedure is identical for both channels, so do the left channel as described here and then the right channel, with appropriate changes to component references.

Set the slide switch on the rear panel to the 0dBm position. Apply a sine wave at a level of -8dBm (304.4mV RMS) to the left input, and adjust RV4 until the meter reads PPM2. Increase the signal level to 0dBm (775mV RMS) and adjust RV3 for PPM4. Increase the signal level to +4dBm (1.228V RMS) and adjust RV2 for PPM5. Increase the signal level again to +12dBm (3.08V RMS) and adjust RV1 for PPM7. Check the PPM points against the signal levels shown in Table 1 and if necessary repeat the above procedure. When you're happy with the left channel, move onto the right.

Calibration is now complete. Fix the lid in place and the PPM is ready for use. In use, the PPM simply connects into the audio circuit you want to monitor. ■

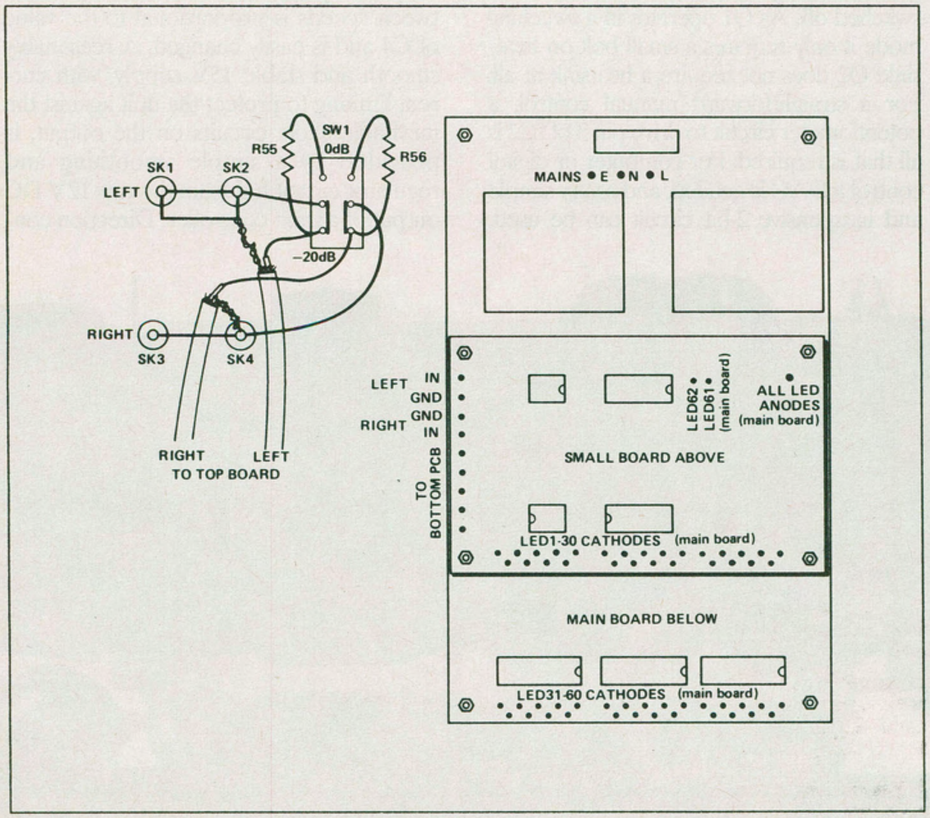


Fig.8 Constructional diagram.

PARTS LIST

Resistors

(all 1/4w 5% unless specified)

R1,22	9k1
R2,5,6,7,13,23,26,27,28,34	100k
R3,4,24,25	200k
R28,29	1k0
R9,30	12k
R10,31	27k
R11,32	33k
R12,18,33,39	120k
R14,21,35,42	43k
R15,51	51k
R16,37	75k
R17,38	150k
R19,40	110k
R20,41	47k
R43,48	3k0 2%
R44,45,46,49	91k
R50,51	2k7
R47,52	7k0 (Nominal:see text)
R53,54	3k9
55,56	91k
RV1-8	10k trim pot

Capacitors

C1,4,10	
12,13..	100u 25V electrolytic radial
C2,5	10 polystyrene
C3,6	2.2u 16V tantalum bead
C7,	100n ceramic
C9,11.	220u 25V electrolytic radial
C10....	100u 25V electrolytic radial

Semiconductors

IC1,3	TLO72
IC2,4	TLO74
IC5-10	LM3914N
IC11	78L15
IC12	79L15
Q1-6	2N3904
D1-14	1N4148
D15-2	1N4002 or equiv.
LED1-62	red LED

Miscellaneous

FS1	1A fuse
SK1-4	Phono sockets
SW1 ..	DPDT submin. slide switch
T1	30V center tap
T2	12V center tap

Case, fuse clips, IC sockets, solder tags, stripboard, cardboard, pins, insulating sleeving, wire, nuts and bolts. If PCB transformers are not available, standard transformers may be used, mounted on or off the PCB with nuts and bolts.