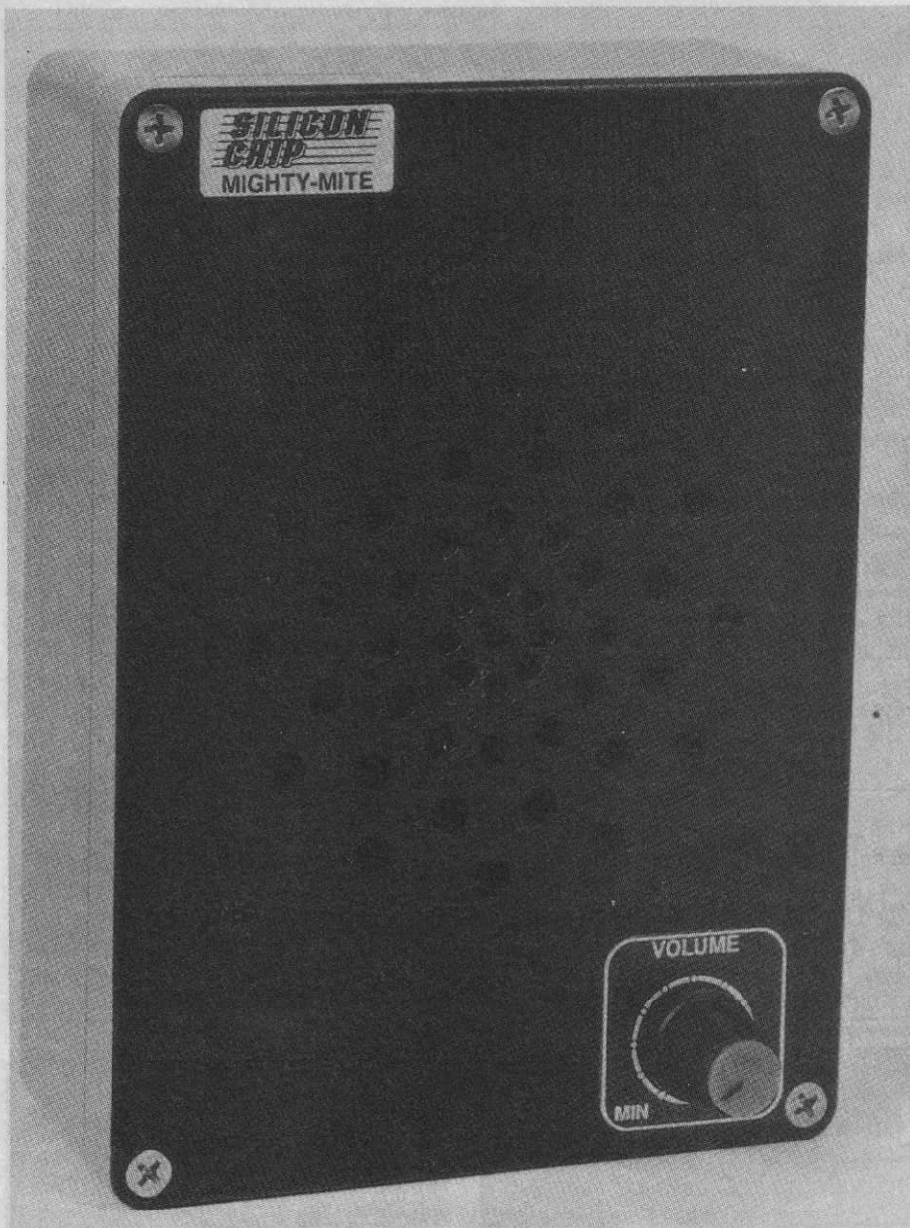


Build the *Mighty-Mite* Powered Loudspeaker



Revitalise the sound card in your computer with the **Mighty-Mite Powered Loudspeaker**. It uses a miniature surface-mount IC amplifier which only requires a 5V supply to deliver a 1W output.

By JOHN CLARKE

Sound cards for computers and multimedia are all the go at present. But without suitable loudspeakers, much of the impact of the sound can be lost. By building the Mighty-Mite Powered Loudspeaker, you can obtain sound quality that's far superior to that available from low-cost multimedia loudspeaker systems.

The system to be described is based on an LM4860M integrated circuit (IC) audio amplifier and this drives a 100mm dual-cone loudspeaker. Both the amplifier circuitry and the loudspeaker are housed in a compact sealed plastic case. The only front panel control is for volume while at the rear are the signal input and DC supply sockets.

The amplifier circuit is powered from a 5V rail and this can come from

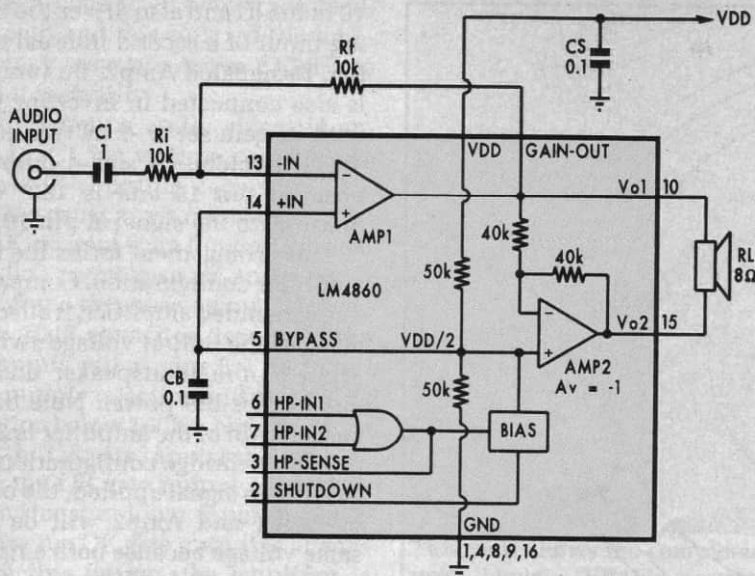
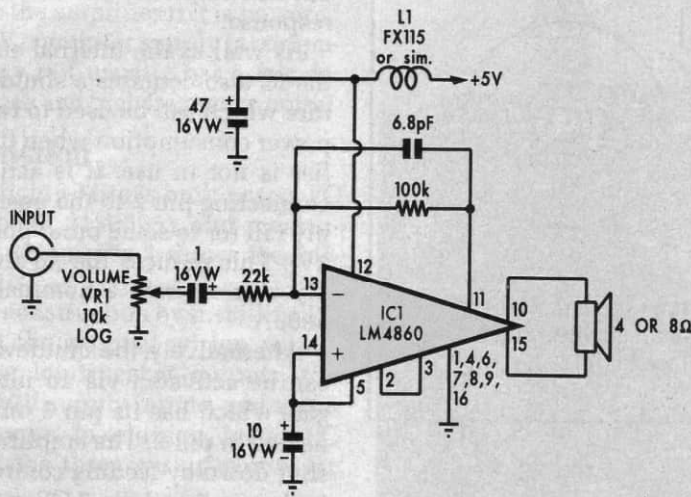


Fig. 1: the internal arrangement of the LM4860M audio amplifier IC. Amp1 is the main amplifier & is connected in inverting mode. Its output appears at pin 10 & also drives inverting amplifier stage Amp2 to derive an out-of-phase output at pin 15.



MIGHTY-MITE

Fig. 2: this diagram shows the complete circuit details for the Mighty-Mite Powered Loudspeaker. It operates with a gain of nine & this provides an input sensitivity of about 320mV for 1W output into 8-ohms.

the computer itself – either from the games port or from the sound card input/output port (see Fig.4). Alternatively, the circuit may be powered from a 9-12VAC plugpack via an optional 5V regulator circuit which is also described here.

Of course, the Mighty-Mite is not just suitable for multimedia applications. It can be used anywhere a powered loudspeaker system is required; eg, as part of a low-cost audio system or in a workshop. If you do use them with a computer system though, be sure to heed the accompanying warn-

ing panel. Unlike most multimedia loudspeakers, these units are not magnetically shielded, so don't place them too close to the monitor.

The audio amplifier IC

One of our first tasks in designing this system was to choose a suitable audio amplifier IC. There are many such units available, most capable of providing excellent results. We finally settled on the LM4860M because of its excellent specifications (considering its small surface-mount package), its 1W (RMS) power output and its

PARTS LIST

- 1 PC board, code 01305951, 33 x 25mm
- 1 sealed ABS box, 171 x 121 x 55mm (Jaycar HB-6128 or equivalent)
- 1 dual-cone 100mm loudspeaker, 4Ω or 8Ω (DSE Cat. A9651 or equivalent)
- 1 10kΩ 16mm log pot (VR1)
- 1 FX115 ferrite bead or equivalent (L1)
- 3 self-adhesive labels
- 1 16mm dia. knob
- 1 DC panel socket
- 1 chassis mount RCA panel socket
- 2 25mm long x 3mm dia. screws & nuts
- 2 9mm tapped spacers
- 2 6mm long x 3mm screws
- 4 black countersunk 4mm diameter screws & nuts (to attach loudspeaker)
- 9 PC stakes
- 1 25mm length of 0.8mm tinned copper wire

Semiconductors

- 1 LM4860M surface mount 1W audio amplifier (IC1)

Capacitors

- 1 47μF 16VW PC electrolytic
- 1 10μF 16VW PC electrolytic
- 1 1μF 16VW PC electrolytic
- 1 6.8pF ceramic

Resistors (0.25W, 1%)

- 1 100kΩ
- 1 22kΩ

Optional 5V Regulator

- 1 PC board, code 01305952, 59 x 35mm
- 1 heatsink, 26 x 29 x 13mm
- 1 7805T 3-terminal regulator (REG1)
- 1 B104 bridge rectifier (BR1)
- 1 470μF 25VW PC electrolytic capacitor
- 1 10μF 16VW PC electrolytic capacitor
- 4 PC stakes
- 1 6mm long x 3mm dia. screw & nut

ability to operate from a 5V supply.

At first glance, it might seem impossible to obtain a 1W output into 8-ohms from such a low supply rail.

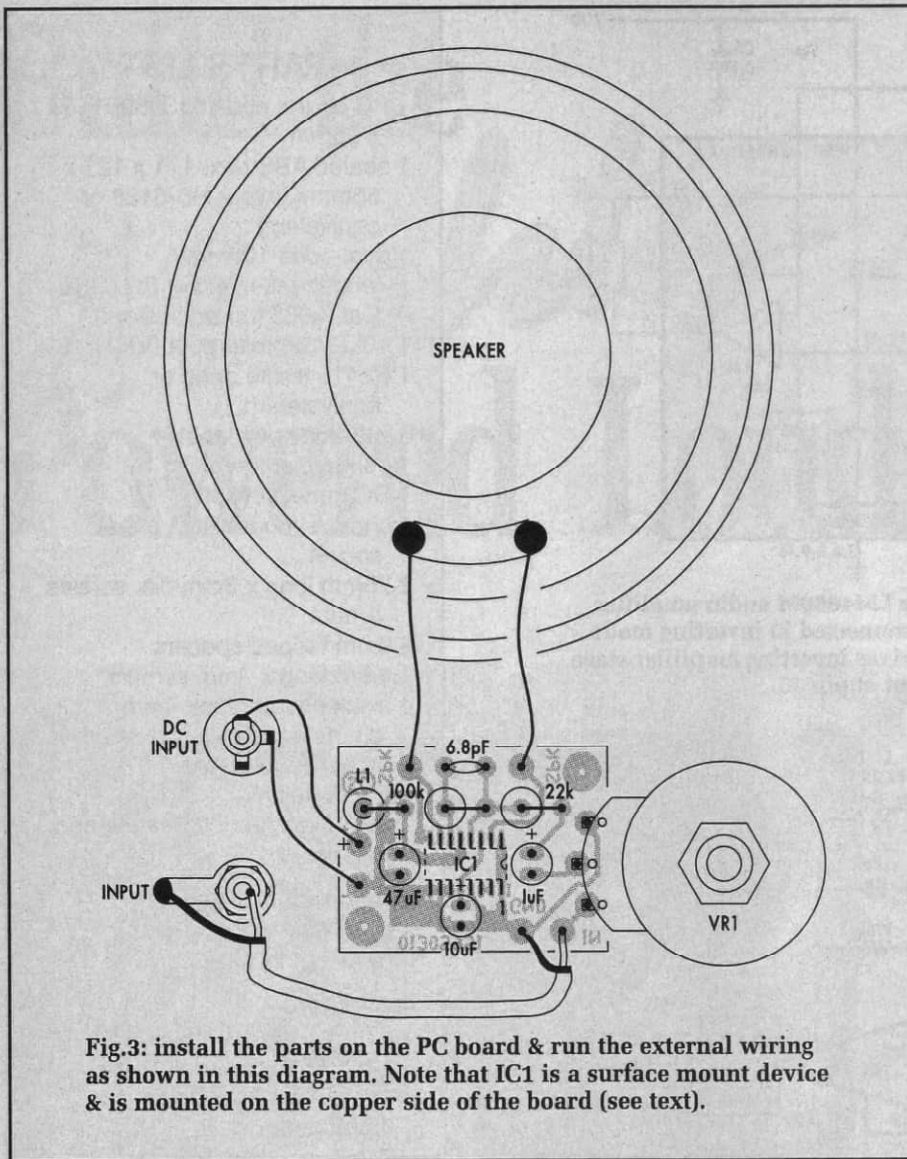


Fig. 3: install the parts on the PC board & run the external wiring as shown in this diagram. Note that IC1 is a surface mount device & is mounted on the copper side of the board (see text).

This is because, to obtain 1W, the amplifier would have to deliver 2.83V RMS or 4V peak into the load. In other words, it would have to deliver 8V peak-to-peak, which is greater than the supply voltage.

However, the LM3860M is a bridge amplifier which drives both terminals of the loudspeaker. Thus, when one terminal of the loudspeaker is driven high, the other terminal is driven low with the opposite phase. As a result, the effective power output from a bridge amplifier is four times that available from a standard amplifier ($P = V^2/R$).

Fig. 1 shows the internal arrangement of the LM4860M and the typical external connections. Amp1 is the main amplifier and this is connected in inverting mode. Its gain is set by the ratio of the feedback resistor (R_f)

to the input resistor (R_i), and in this case is set to -1. The non-inverting input is set to half-supply by two internal 50k Ω voltage divider resistors and is decoupled using capacitor C_B . The output of Amp1 appears at pin

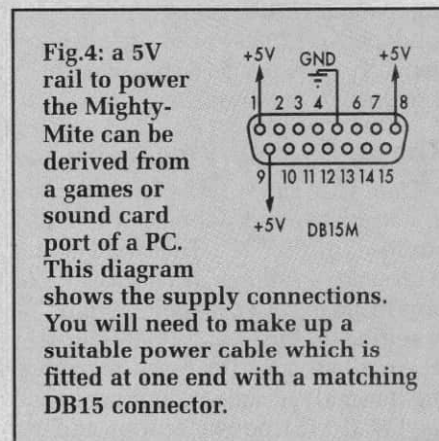


Fig. 4: a 5V rail to power the Mighty-Mite can be derived from a games or sound card port of a PC. This diagram shows the supply connections. You will need to make up a suitable power cable which is fitted at one end with a matching DB15 connector.

10 of the IC and also drives the inverting input of a second internal amplifier. Designated Amp2, this amplifier is also connected in inverting mode, with its gain set to -1 by two internal 40k Ω resistors. Its signal output appears at pin 15 and is 180° out of phase with the signal at pin 10.

This arrangement forms the bridge amplifier configuration. Compared to a single-ended amplifier, it effectively doubles the output voltage swing applied to the loudspeaker and thus quadruples the power. Note that the overall gain of the amplifier is $2R_f/R_i$, due to the bridge configuration.

With no signal applied, the outputs of Amp1 and Amp2 will be at the same voltage because both amplifiers are biased at half supply. Consequently, there is no need for an output coupling capacitor to prevent DC from flowing in the voice coil. This not only reduces the component count but also improves the low frequency response.

As well as the internal amplifiers, the IC also contains a shutdown feature which can be used to reduce the power consumption when the amplifier is not in use. It is activated by connecting pin 2 to the positive supply rail (or to some other point above 3V). This reduces the no-signal supply current from a nominal 7mA to 500 μ A.

Alternatively, the shutdown feature can be activated via an internal OR gate which has its pin 3 output connected to pin 2. The amplifier is then shut down by feeding control signals to the pin 6 and pin 7 OR gate inputs. When either or both of these inputs are at a logic high, the amplifier is disabled.

These control inputs are typically used to shut down the amplifier in situations where a set of headphones is plugged into a preceding stage. In this case, the control input is derived by switching in a suitable voltage via an internal switch in the headphone socket.

Circuit details

Refer now to Fig. 2 for the final circuit details of the Mighty-Mite Powered Loudspeaker. In this circuit, the gain has been set to nine by the 100k Ω feedback and 22k Ω input resistors. This provides an input sensitivity of about 320mV for 1W output into eight ohms. In addition, a 6.8pF capacitor

has been connected across the feedback path and this rolls off the high-frequency response above 230kHz to prevent instability.

The incoming audio signal is applied to IC1 via volume control VR1 and a 1 μ F coupling capacitor. This coupling capacitor is necessary to prevent DC current from flowing through the 22k Ω input resistor and VR1. It rolls off the response below 7Hz.

The 10 μ F capacitor decouples the half-supply rail at pins 5 & 14 to improve supply rejection and reduce the distortion below 100Hz. Note that pins 6 & 7 (the OR gate inputs) are tied low, while the OR gate output at pin 3 is tied to the shutdown input at pin 2. Because the OR gate output is always low in this design, the amplifier is permanently enabled.

Finally, the power supply to IC1 is isolated using a ferrite bead and decoupled by a 47 μ F capacitor. This measure helps to reduce noise injection into the amplifier if it is powered from a 5V computer supply (a computer supply rail usually has a fair degree of hash and high frequency noise).

Construction

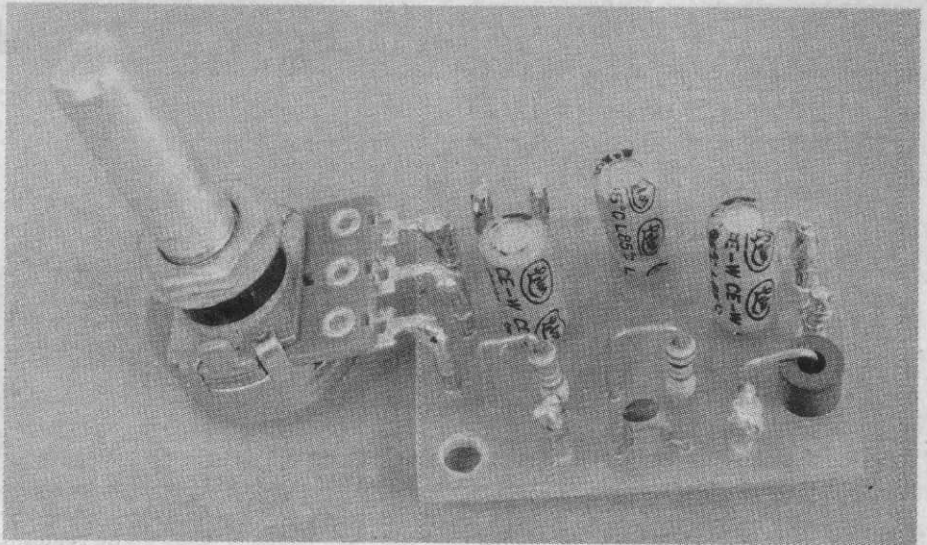
The Mighty-Mite is built onto a PC board coded 01305951 and measuring 33 x 25mm. Fig.3 shows the wiring details.

Begin construction by installing PC stakes at the external wiring points; ie, at the loudspeaker outputs, the +5V and 0V supply inputs, and at the signal inputs. In addition, install PC stakes at the three wiring points for VR1.

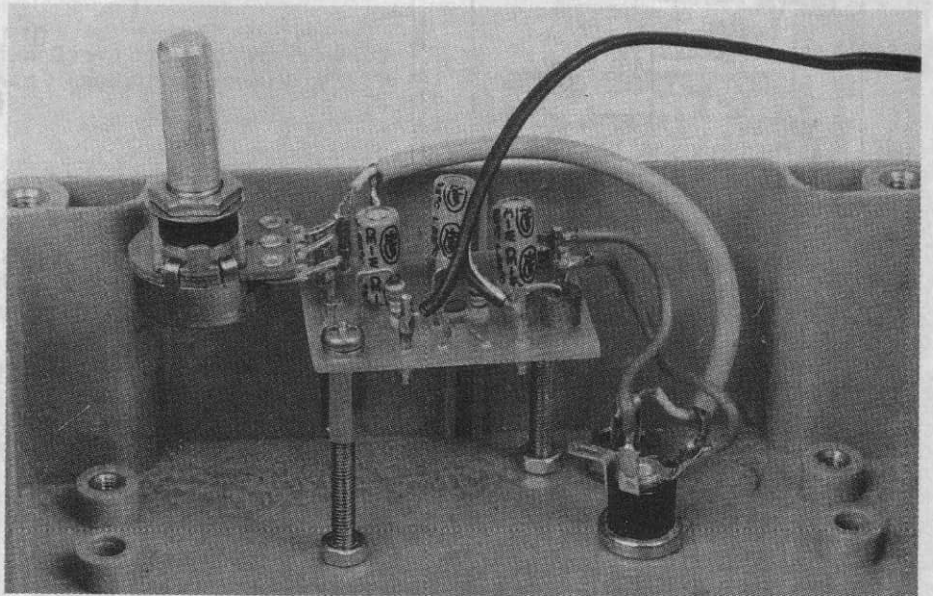
Once the PC stakes are in, IC1 can be installed. Because this is a surface-mount component, it is mounted on the copper side of the board.

Before soldering IC1, the copper lands should be pretinned using a fine-tipped soldering iron. This done, place the IC on the board with the notch in its plastic body towards the 1 μ F capacitor position, then carefully tack solder a couple of pins to the pretinned lands by heating them gently with the iron. The pins can then all be carefully soldered.

Be sure to use only small amounts of solder during this job, to prevent unwanted shorts between adjacent pins of the IC. In fact, it is a good idea to carefully inspect the completed job under a magnifying glass to ensure that all is correct.



This view shows the completed amplifier module. Note that the volume control potentiometer (VR1) is mounted by soldering its terminals to three PC stakes at one end of the board.



This close-up view shows the mounting details for the amplifier board. It sits 27mm above the floor of the case on two 9mm-long spacers which are screwed onto 25mm long x 3mm dia. mounting screws.

Performance of Prototype

Output power	1.3W into 4 Ω at onset of clipping; 1W into 8 Ω at onset of clipping
Distortion	<1% see graphs
Signal-to-noise ratio	76dB with respect to 1W with 1k Ω input resistor & 20Hz to 20kHz bandwidth; 91dB A weighted
Frequency response	-2dB at 10Hz & 100kHz
Sensitivity for 1W out	320mV RMS
Supply voltage	2.7-5.5V
Quiescent current	<15mA; typically 7mA
Output offset voltage	<50mV

Building The Optional 5V Regulator Board

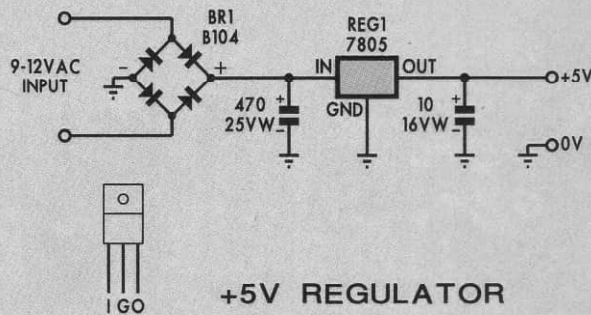
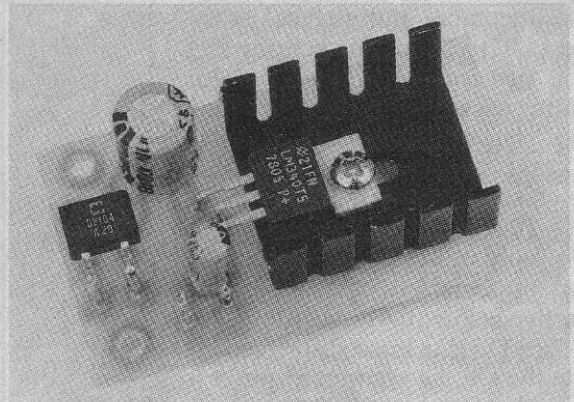


Fig.5: you will need this simple regulator circuit if you intend powering the unit from an AC or DC plugpack supply.



The regulator board only takes a few minutes to assemble. Make sure that all parts are correctly oriented & use PC stakes at external wiring points.

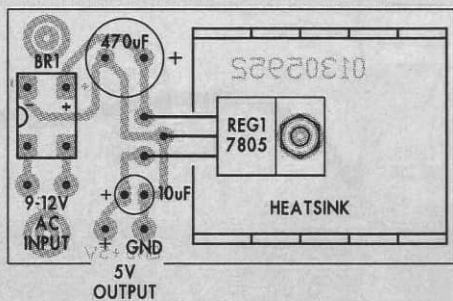


Fig.6(a): here's how to install the parts on the regulator board. Note that REG1 is bolted to a small U-shaped heatsink.

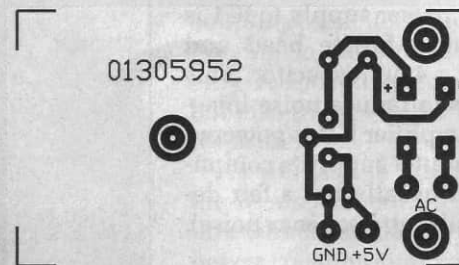


Fig.6(b): this is the full-size etching pattern for the regulator PC board. Check the board carefully before installing any parts.

If you wish to power the unit from a 9-12VAC (or 9-12V DC) plugpack, then you will need to add the 5V regulator circuit shown in Fig.5. As shown, the output from the plugpack is fed to a bridge rectifier (BR1) and this in turn drives 3-terminal regulator REG1 to derive a regulated 5V rail. The 470µF and 10µF electrolytic capacitors provide filtering for the IN and OUT terminals of

the regulator respectively.

A PC board (code 01305952) has been designed to accommodate the regulator components – see Fig.6(a). Install the parts on this board exactly as shown and note that REG1 is bolted to a small finned heatsink to ensure adequate heat dissipation. Apply a thin smear of heatsink compound to the metal tab of the regulator before bolting it down.

In no circumstances should you power the amplifier from a voltage greater than 5.5V. The audio amplifier chip could fail if you do.

The 5V regulator board can either be mounted inside the case of the Mighty-Mite, or mounted in a separate case and used externally. Take care to ensure that the supply connections to the amplifier board are correct.



The LM4860 IC (IC1) is mounted on the copper side of the PC board as shown here. Use a fine-tipped soldering iron for this job & make sure that the device is correctly oriented.

The remaining components mount on the top of the PC board. Take care with the electrolytic capacitors - they must be oriented with the correct polarity, as shown on Fig.3. The resistors mount end on, while L1 simply consists a short length of tinned copper wire fed through the ferrite bead.

Finally, the board assembly can be completed by soldering VR1's terminals to the top of the PC stakes.

The completed amplifier, along with the loudspeaker, is housed in a sealed ABS box measuring 171 x 121 x 55mm.

This box is fitted with three adhesive labels – two on the front panel and one on the rear. Fit these labels to the locations shown in the photographs, then drill mounting holes in the rear panel for the DC power socket and the RCA input socket.

Similarly, on the front panel, drill a hole for the volume control shaft. Note that it's best to start with a small pilot hole and then carefully enlarge the hole to the correct size using a tapered reamer. Once this has been done, mark out and drill the loudspeaker mount-

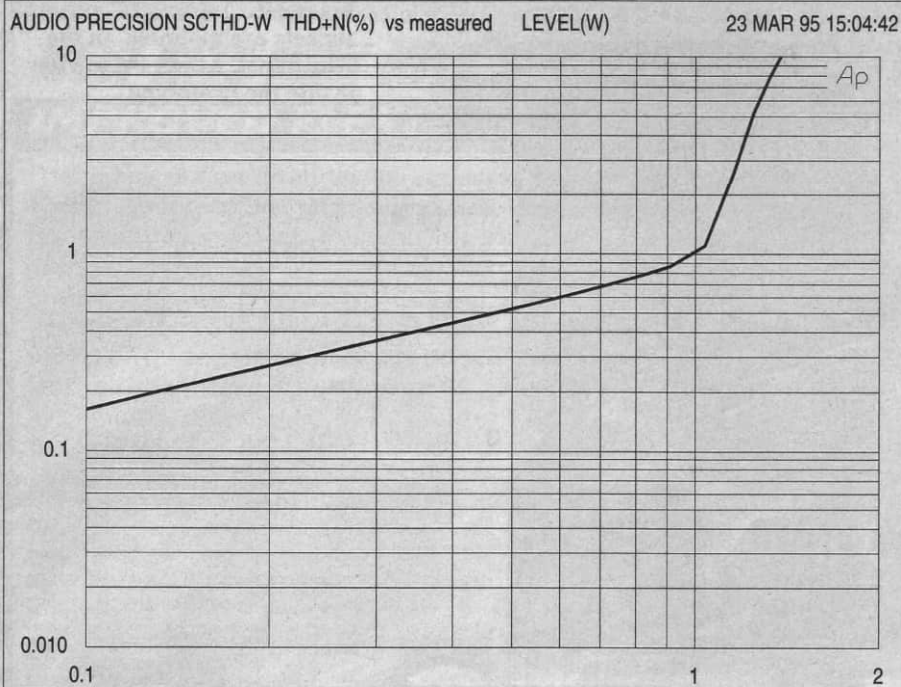


Fig.7: this graph shows the distortion as a function of output power into an 8-ohm load. Note that the distortion is less than 1% for output powers up to 1W & rises steeply beyond this level of output.

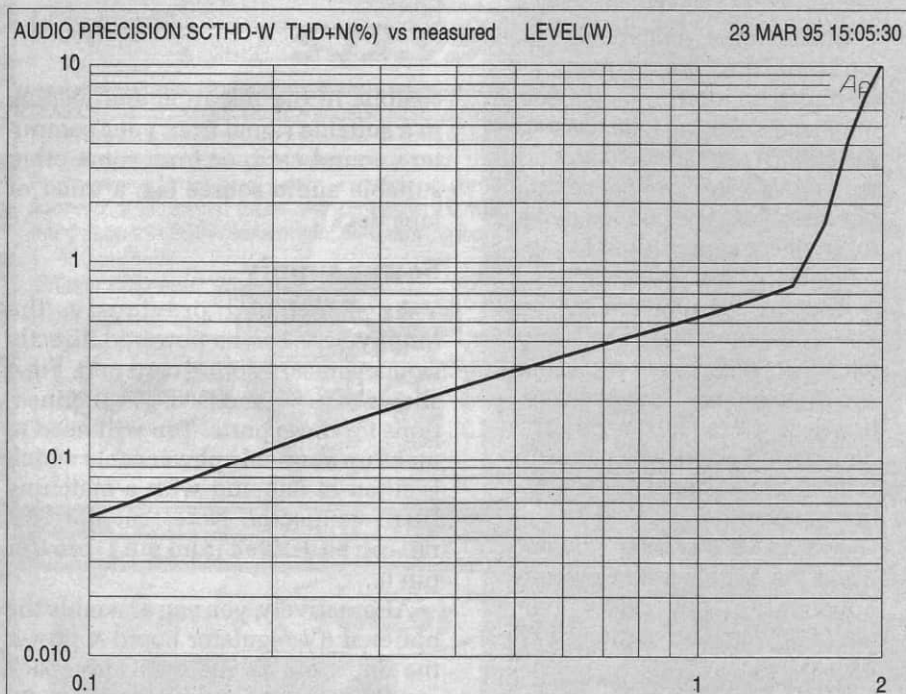


Fig.8: distortion vs. output power into a 4-ohm load. The distortion is less than for 8-ohm loads, while slightly more output power (1.3W) can also be obtained.

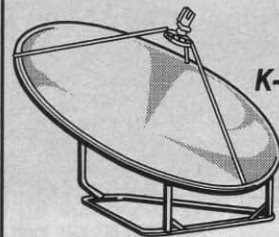
ing holes plus a circular pattern of holes in front of the cone position to let the sound escape.

Next, carefully measure out, mark and drill the mounting holes for the PC board in the base of the case. The PC board assembly is then installed in the case as shown in one of the photos.

To do this, first fit two 25mm long x 3mm dia. screws to the mounting holes and secure them with nuts. A 9mm spacer is then fitted to each screw. Screw these spacers down until their top surfaces are 27mm above the base of the case, then fit the PC board and secure it to the spacers with 6mm long screws.

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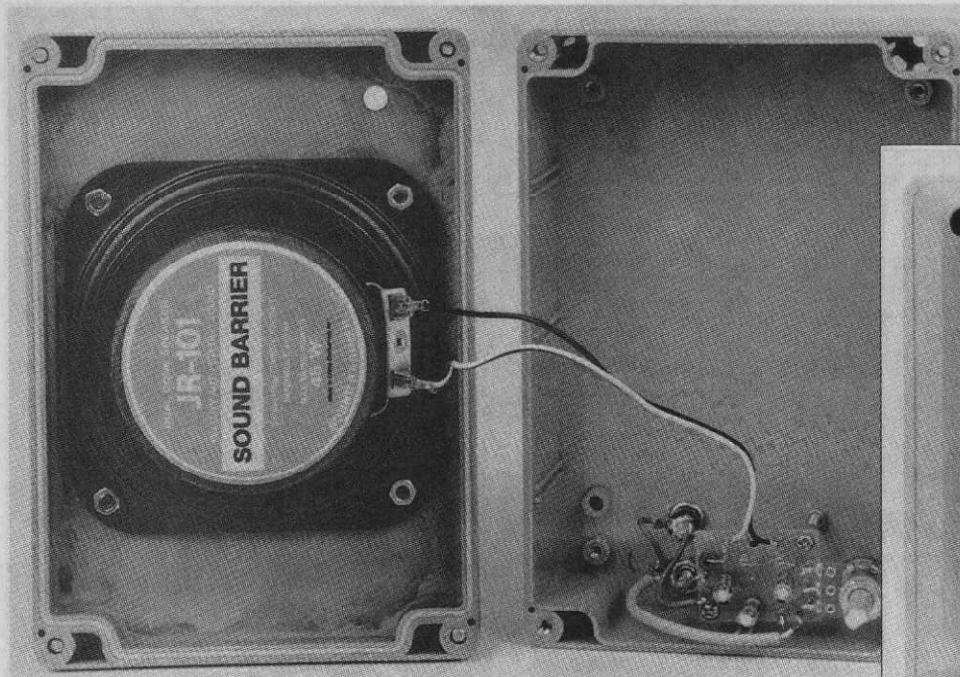
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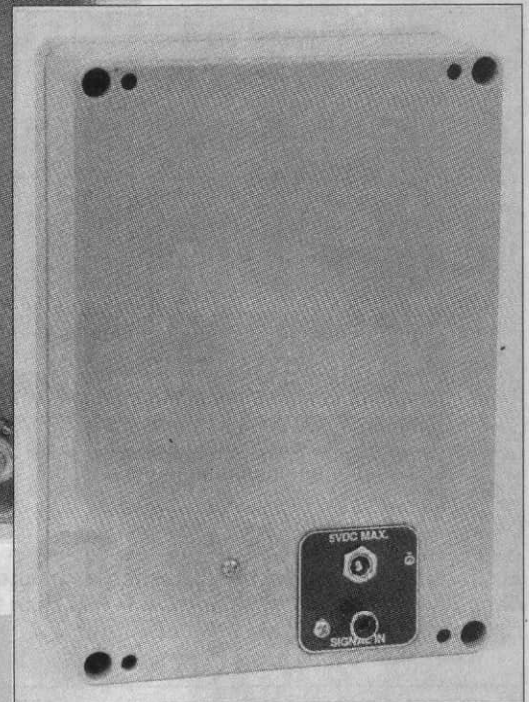
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Below: the input & DC power sockets are mounted on the rear panel. At left is the view inside the prototype.



All that remains now is to run the small amount of internal wiring – see Fig.3. This consists of: (1) connecting the supply leads from the DC socket to the PC board; (2) running a short length of shielded cable from the RCA socket to the input terminals; and (3) running a length of figure-8 cable from the board to the loudspeaker terminals.

Testing

To test the unit, first connect a 5V DC supply to the DC socket, taking care to ensure that the polarity is correct. This done, switch on and check that the wire link through the ferrite bead is at +5V with respect to ground. If this is correct, check that the accessible lead of the 22kΩ resistor is at 2.5V (ie, half supply). The two loudspeaker terminals should also each be at 2.5V, give or take 50mV.

If all checks out, then you are ready to try the Mighty-Mite out. This simply involves completing the case as-

Warning

Unlike most multimedia loudspeakers, the Mighty-Mite design does not include magnetic shielding. As a result, the strong magnetic field around the loudspeaker can cause colour distortion if placed too close to a monitor screen, due to magnetisation of the shadow mask.

Usually, this problem will be cured by the internal degaussing circuitry of the monitor each time it is switched on. Severe cases, however, will require the use of a degaussing wand, which means a trip a professional service organisation.

To avoid this problem, do not place the Mighty-Mite Powered Loudspeaker any closer than about 300mm from a monitor or TV set.

sembly, fitting the knob and feeding in a suitable signal from your computer's sound card, or from some other suitable audio source (eg, a tuner or tape deck).

Power supply

As mentioned previously, the Mighty-Mite can be powered directly from a games or sound card port. Fig.4 shows the +5V and GND (0V) connections for these ports. You will need to make up a suitable power cable which is fitted at one end with a matching DB15 connector. Note that the +5V rail can be derived from pin 1, pin 8 or pin 9.

Alternatively, you can assemble the optional 5V regulator board & power the unit from an AC or DC plugpack supply. **SC**

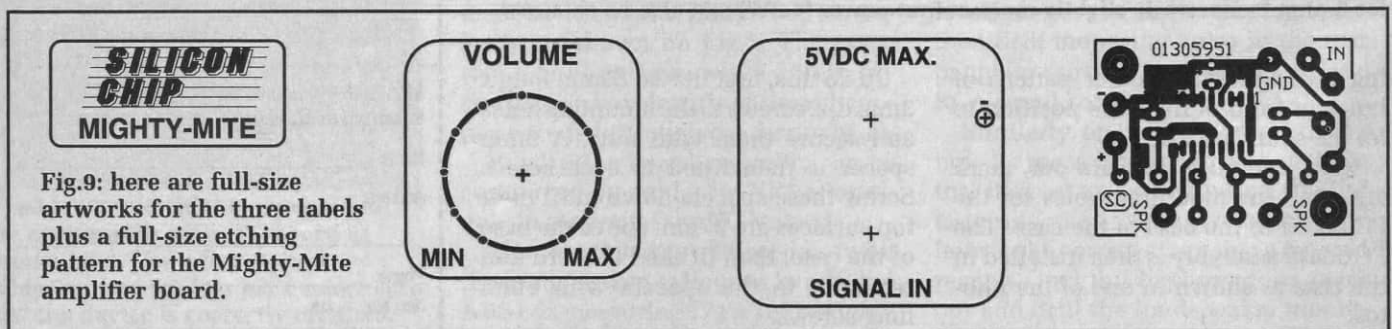


Fig.9: here are full-size artworks for the three labels plus a full-size etching pattern for the Mighty-Mite amplifier board.