by Gavin Cheeseman

Low Power AUDIO AMPLIFIER

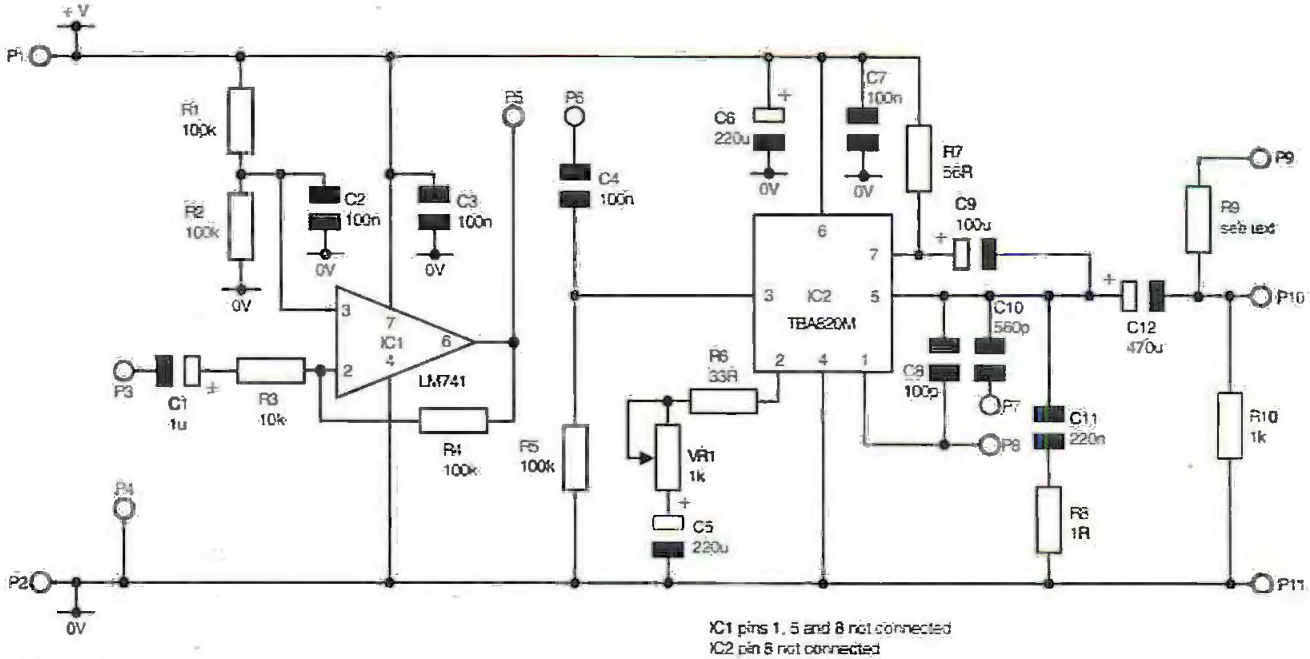

Figure 1. Circuit diagram

In this article we look at a low power audio amplifier with a host of different uses. The circuit is easy to construct and uses readily available components. It is ideal as a headphone amplifier, for applications such as intercoms and door phones and as an add-on to existing projects such as simple radio receivers.

Circuit Description

As may be seen from Figure 1, the circuit is based around the TBA820M power amplifier (IC2). For many applications, the device provides sufficient gain without the need for any additional stages. However a preamplifier stage is included to provide an additional boost when the input signal is insufficient to drive the amplifier directly.

The preamp stage is based around operational amplifier IC1. The IC is configured as a standard inverting amplifier with a voltage gain of 10. The potential divider formed by resistors R1 and R2 is used to provide a half supply reference to the non-inverting input (pin 3) of the op-amp. Capacitor C2 helps to ensure that the reference voltage is relatively free of high frequency noise. Input signals applied on terminal P3 are AC coupled to the preamplifier stage via C1. The voltage gain is set by the values of R3 and R4 and C3 provides high frequency supply decoupling. The amplified signal is made available on terminal P5. It should be noted that the output of this stage is directly coupled and therefore has a DC offset of approximately half the supply voltage. This does not present a problem when driving an input that is capacitively coupled but in any other situation a suitable coupling capacitor should be added.

Input signals are applied to the power amplifier on terminal P6 either from the preamplifier (P5) or directly from an external source depending on the signal level. The signal is AC coupled to the input of IC2 by C4. The power supply is de-coupled by C6 and C7. Variable resistor VR1 allows the gain of the stage to be adjusted with R6 limiting the maximum gain. Capacitors C8 and C10 are used for frequency compensation. Connecting terminal P7 to P8 connects C10 in parallel with C8 reducing the high frequency response of the circuit. This may be used to reduce noise in applications where the full audio bandwidth is not required. The presence of unwanted high frequencies at the output is minimised by C11 and R8. These components are required for the stable operation of the circuit and should not be omitted. Output signals are coupled to P10 via C12 with P9 providing a current limited output that may be used when driving headphones etc. The value of R9 depends on the specific application but might typically be 120 ohms for headphones. In most cases the output at P10 will be connected to an 8 ohm loudspeaker. However, in the absence of an external load, R10 provides a charge path for C12.

Construction

The amplifier can be constructed using almost any standard type of circuit board. Matrix board or strip board is fine. If the preamplifier section is not required, the relevant components can be omitted so as to save cost and space. These are R1-R4, C1-C3,

IC1, P3 and P5. Without the preamplifier, the circuit will also operate over a wider range of supply voltages and is therefore ideal for low voltage battery powered operation.

Try to keep interconnections between components as short as possible. It is usually easiest to start by fitting the small components such as resistors first leaving larger parts until last. The use of DIL sockets for the IC's is recommended. IC pin-outs are shown in Figure 2. Although the devices are not particularly fragile, the IC's should not be fitted until all soldering is complete. This minimises the chance of inadvertent damage resulting from overheating with a soldering iron.

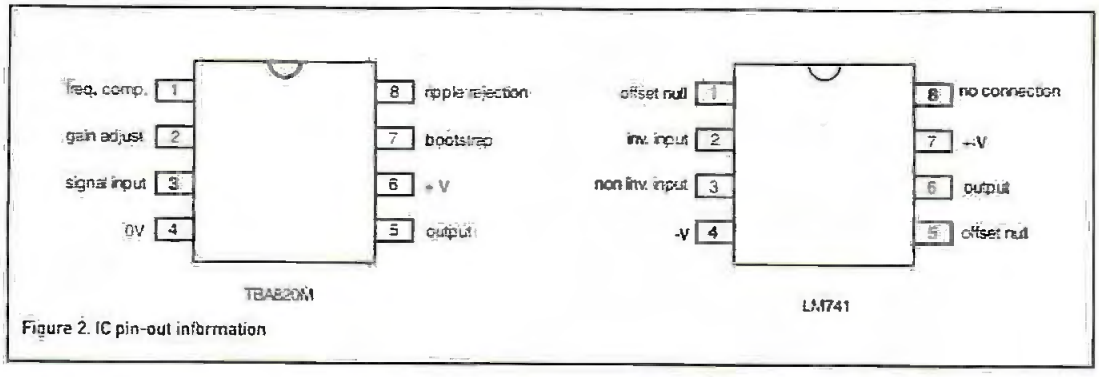

Figure 2. IC pin-out information

Electrolytic capacitors must be fitted observing the correct polarity so as to avoid the possibility of component damage or explosion. The negative lead of the capacitor (normally the shortest of the two) is usually indicated by a minus symbol (-) on the component case. Always double check the supplier/manufacturer's data if unsure.

When all of the components have been soldered onto the circuit board, take a second look at the soldering to make sure that there are no unwanted short circuits or dry joints. Also check that all of the components are correctly connected and of the right value. It is easier to correct these problems before applying power, as even a simple mistake can seriously damage the components.

Power Supply

The circuit is designed to operate with a 12V 500mA DC power supply (the voltage may be reduced if the preamplifier section is omitted). When the circuit is not powered from a battery, a regulated power supply should be used. In either case the supply should have a current capability of at least 500mA. Unless the power supply current is limited to less than 1A, do not forget to fit a fuse in series with the positive power supply lead. It is surprising just how much current even small batteries can deliver under short circuit conditions.

Without the preamplifier section the circuit will operate with power supply voltages as low as 3VDC but it should be remembered that at this voltage, the output power will be considerably reduced.

Basic Test Procedure

Figure 3 shows the necessary connection information for the amplifier. A suitable signal source is required. A sine wave signal generator covering the range 20Hz to 20kHz is ideal but if this is not available a simple oscillator such as that shown in Figure 4 may be used. This circuit outputs an impure signal which is not ideal but does allow the basic functionality of the amplifier to be tested.

When operating the amplifier outside an enclosure it is sensible to wear eye protection. Under certain fault conditions (e.g. when the device is incorrectly connected or the circuit is suffering from instability), the temperature of small amplifier IC's can increase rapidly. This condition can be destructive and may occasionally result in parts of the IC being expelled. Over many years of use, I have never experienced this sort of problem with the TBA820M but caution is always advisable, particularly when powering a new circuit for the first time.

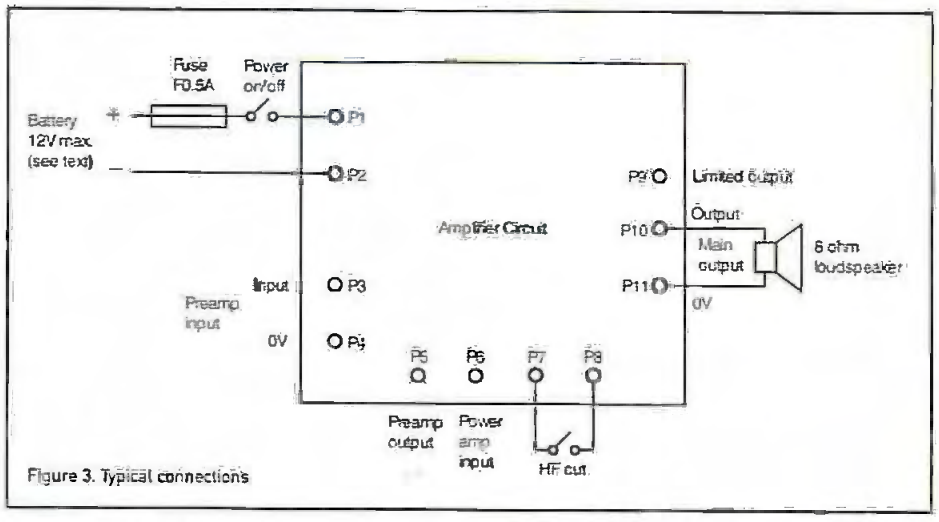

Figure 3. Typical connections

Before applying power to the circuit, set VR1 to maximum resistance (minimum gain). Connect the power supply to the circuit. Terminal P1 is connected to +V (battery positive) and P2 is connected to 0V (battery negative). If available, a multimeter set to read current should be connected in series with the positive power supply lead. This enables the current consumption of the circuit to be monitored and can give an early indication when a fault condition is present.

Switch on the amplifier. There may be an initial click after which the circuit should remain silent except for a quiet hiss from the loudspeaker. The current consumption of the circuit should be just a few mA. A high power supply current at this stage suggests there may be a problem. If this happens, switch off immediately and check for short circuits.

If all is well, a suitable test signal may be applied to the amplifier input. The input signal is connected between terminal P6 (input) and P4 (0V). If a signal generator is used, set the frequency to 1kHz (sine wave). Before connecting the signal source, make sure that the signal level is set to zero (minimum). Slowly increase the signal level until a tone can be heard from the loudspeaker. Try adjusting VR1 on the amplifier board. As the resistance of VR1 is reduced the gain of the amplifier should increase, resulting in a louder output from the loudspeaker. Depending on the level of the input signal, a point may be reached where the amplifier runs into distortion (clipping). This is usually fairly easy to detect particularly when the input signal is a pure sine wave, as the sound of the tone becomes much harsher. At this point the amplifier is being overdriven and either the level of the input signal or the amplifier gain (VR1) should be reduced. It is sensible to avoid running the amplifier at maximum power continuously. If an oscilloscope is available, the output signal at P10 may be monitored and the point at which clipping occurs can be clearly seen.

Next check the preamplifier stage (IC1). With no input signal, the standing voltage at the output of IC1 (terminal P5) should be approximately half of the supply voltage. So with a 12V supply, P5 should sit at around 6V. The easiest way to test the preamplifier stage is with a signal source and an oscilloscope. Apply a 100mV peak to peak 1kHz sine wave to the input of IC1 between P3 (input) and P4 (0V). Monitor the output on P5. The output amplitude should be approximately 1V peak to peak.

If an oscilloscope is not available a rough indication that IC1 is working correctly can be obtained by connecting together terminals P5 and P6 so that the output of the preamplifier is driving the input of the power amplifier. VR1 should be set for minimum gain. Connect a signal source (level set to minimum) to the input of the preamplifier on P3 (0V connection to P4). Slowly increase the signal level until a signal is clearly audible in the amplifier loudspeaker. Now, remove the link between P5 and P6, disconnect the signal generator from P3 and connect it to P6. The sound level from the loudspeaker should be less without the additional gain of IC1. Please note: the amplifier is easily overdriven when the preamplifier is being used.

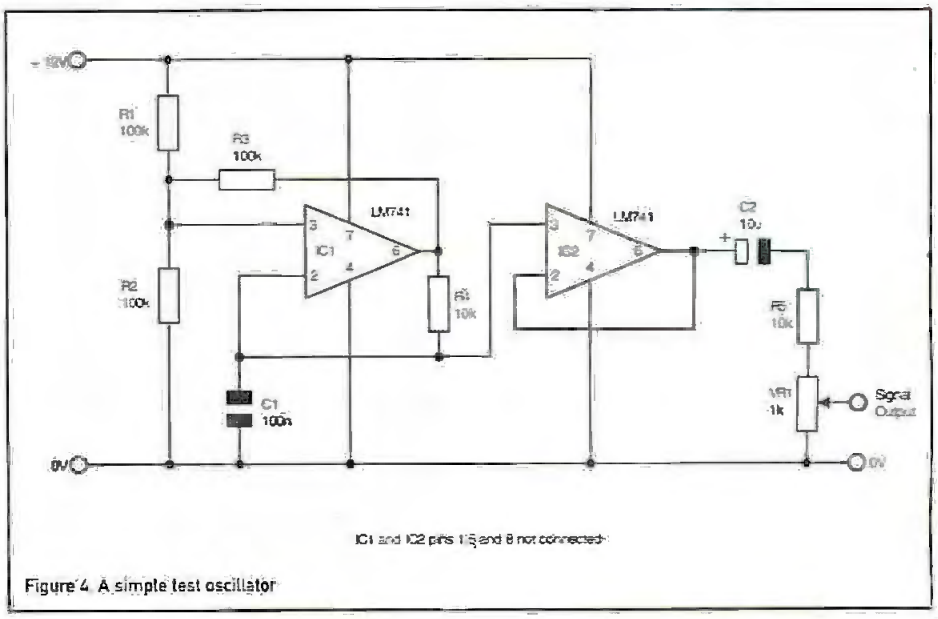

Figure 4. A simple test oscillator

Housing the amplifier

The type of housing used for the amplifier will depend on the final application. If the amplifier is being used as a permanent add-on to another circuit, it will usually share the same enclosure. The circuit does not take up much board space and in many cases should be relatively easy to accommodate. Alternatively, to make a stand alone unit, the amplifier can be housed in its own case with a battery supply or power socket and sockets for inputs and outputs. If the loudspeaker is housed in the box a switched socket may be used at the output so that the internal speaker is disconnected when the external speaker connector is plugged into the socket. Air should be allowed to flow freely around the components so as to maintain efficient cooling.

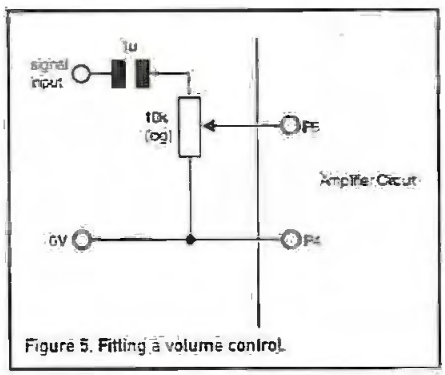

Figure 5. Fitting a volume control

Fitting a volume control

A volume control may be fitted to the input of the circuit if required as shown in Figure 5. A standard log potentiometer is used and may be mounted on the same circuit board as the amplifier or wired externally. The leads to the potentiometer should be kept as short as possible to minimise unwanted noise pickup.

Minimising external pick-up

External noise pickup can be a problem with any high gain amplifier. The problem becomes more pronounced when connecting leads are long. Common examples are mains derived hum and RF pickup.

Mains derived noise manifests itself as a continuous buzzing sound from the loudspeaker. The best cure for this is to use screened leads at the input. Hum can also relate to earth loops where earth returns are taken back to various points in the circuit. Star earthing all 0V connections to the same low impedance point usually results in an improvement.

RF pickup can be an absolute menace when an amplifier is being used with long connecting leads, for example as part of an intercom or door phone system. Short wave radio stations are often the cause. The signals are picked up by input, output and power leads, which may form a resonant length at a frequency where strong signals are present. Signals are rectified by the semiconductor junctions in the IC's which form a crude AM detector. Often, the interfering stations are clearly audible from the loudspeaker. This problem is not always easy to cure. It depends on the source and amplitude of the interfering signal. Possible cures include changing the length of the leads, fitting ferrite rings or beads to the leads close to the amplifier and fitting small value capacitors (a few pF) across the input leads. Reducing the gain of the amplifier may also result in a cure.

Parts List

Resistors (minimum 0.5W metal film)		
R1, 2, 4, 5	100k	4
R3	10k	1
R6	33R	1
R7	56R	1
R8	1R	1
R9	see text	1
R10	1k	1
VR1	1k variable trimmer	1
Capacitors (minimum voltage rating 16V)		
C1	1uF radial electrolytic	1
C2, 3, 7	100nF ceramic disc	3
C4	100nF polyester layer	1
C5, 6	220uF radial electrolytic	2
C8	100pF polystyrene	1
C9	100uF radial electrolytic	1
C10	560pF polystyrene	1
C11	220nF polyester layer	1
C12	470uF radial electrolytic	1
Semiconductors		
IC1	LM741	1
IC2	TBA820M	1
Miscellaneous Items		
Circuit board (eg strip-board)		
8 pin DIL sockets		2
P1 - P11, PCB pins		11
8 ohm loudspeaker (2W*)		1
Fuse F500mA		1
SPST toggle switch		2

* Loudspeaker power rating may be reduced at lower supply voltages in line with amplifier output power.

Parts are widely available from component suppliers such as Farnell Components and Maplin Electronics.