GUITAR Practice Amplifier

by Gavin Cheeseman

THIS SIMPLE GUITAR AMPLIFIER PROVIDES A HEADPHONE OUTPUT AND IS IDEAL FOR USE IN THE HOME ENVIRONMENT WHERE IT ALLOWS THE GUITARIST TO PRACTICE WITHOUT BLOWING THE ROOF OFF!

The design operates from a 9V battery and features a 'fuzz' effect and basic tone controls. The circuit uses easily available components and may be constructed in just a few hours.

How does it work?

Figure 1 shows the circuit diagram of the amplifier. It effectively consists of a preamplifier stage (IC1) followed by a small power amplifier based around the LM386 IC (IC2). Power is switched to the circuit by toggle switch S1. Diode D1 provides protection if the power supply is accidentally connected with the incorrect polarity. Capacitor C4 provides high frequency supply decoupling close to IC1. The input signal (from the guitar pickup) is connected between terminals P3 (signal) and P4 (ground). The input signal is applied to the non-inverting input of operational amplifier IC1 via coupling capacitor C1. Resistors R1 to R3 bias the op-amp input to approximately half of the supply voltage with C2 providing decoupling. The maximum gain of the preamplifier stage is determined by the values of resistors R4 and R5 together with variable resistor VR1. When the preamplifier output signal is at a relatively low level, diodes D2 to D5 do not conduct and the output waveform is simply an amplified version of that at the input. Adjusting the setting of VR1 affects the gain of the preamplifier. A higher resistance setting results in increased gain. When the output signal level exceeds the point where the diodes start to conduct, the gain is reduced with the result that the output signal is effectively clipped. This part of the circuit is used to create a fuzz effect.

Switch S2 is used to select one of two different fuzz effect settings. With S2 closed, diodes D4 and D5 are bypassed and the positive and negative halves of the waveform clip at approximately the same level. With S2 open, D4 and D5 are connected in series with D3 resulting in unsymmetrical clipping. Because of the difference in harmonic content this creates a different sound at the output.

Output signals from IC1 are coupled to power amplifier IC2 via C5. Variable resistor VR2 controls the input level to the power amplifier and is used as the master volume control. Series resistor R6 helps to ensure that the amplifier is not overdriven. The power amplifier stage also incorporates basic tone controls VR3 and VR4. Tone control is achieved by adjusting the frequency response of the amplifier using resistors and capacitors connected in parallel with the IC's internal feedback components. Capacitors C6 and C7 provide supply decoupling close to IC2.

The output of IC2 is AC coupled by C12 to output terminal P6. A limited output via R10 is available at P5.

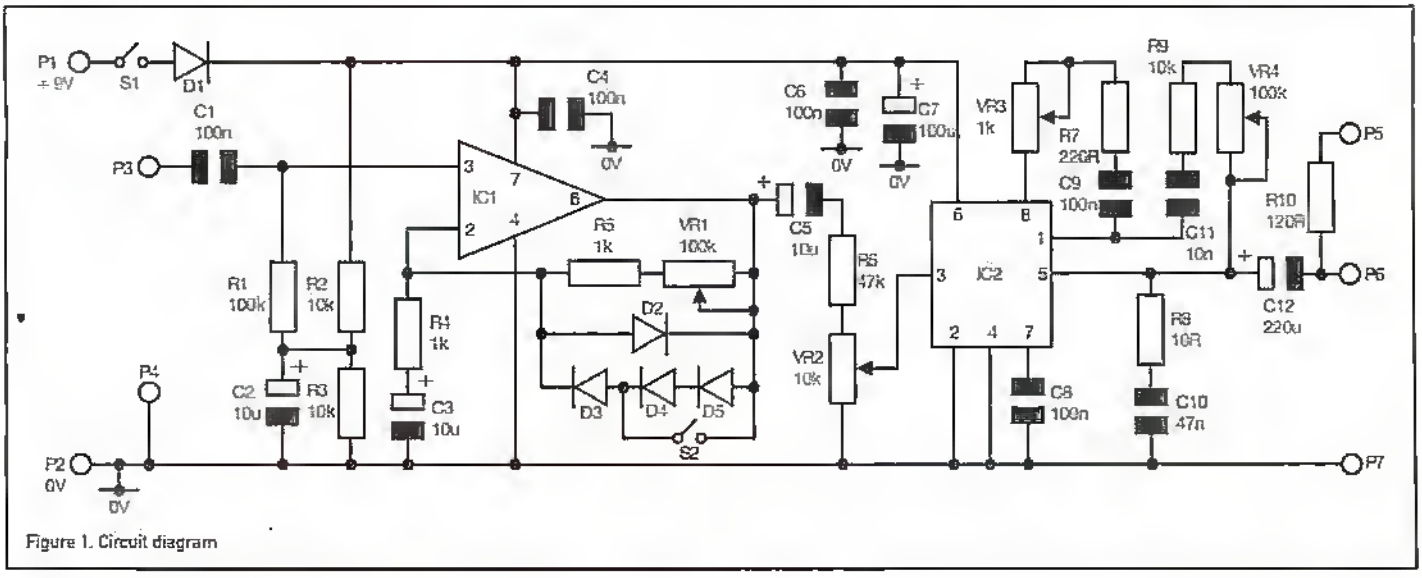


Figure 1. Circuit diagram

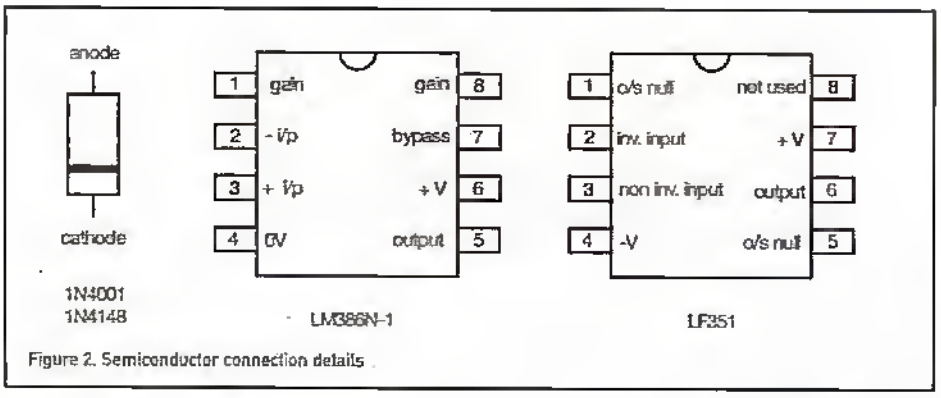


Figure 2. Semiconductor connection details

Building the Amplifier

The amplifier can be built using standard construction media such as matrix board, strip board or PCB. As with most high gain circuits, some attention should be paid to component layout if noise pickup and instability are to be avoided. Interconnections between components should be kept as short as possible with input and output wiring kept separate. Input leads should be screened to reduce the chance of coupling the output signal back to the input and to avoid excessive levels of mains derived hum. It is sensible to run separate power leads to the preamplifier and power amplifier stages. The positioning of decoupling capacitors is critical. C4 should be connected as close as possible to IC1 whereas C6 and C7 are best positioned near IC2. Connections to panel mounted controls such as the potentiometers (variable resistors) should be short and if the components are mounted off board may require screened lead.

As always, it is essential to pay attention to component polarities. Figure 2 shows pinout details for the semiconductors. The polarity of electrolytic capacitors is usually indicated on the component body. Normally, the negative lead is marked by a minus (-) symbol nearby on the case. The negative lead is also usually the shortest. Conventions may vary so please check if unsure. Similarly, make sure that the battery clip is connected the right way round. The positive lead is connected to terminal P1 (+9V) and the negative lead to P2 (0V).

Housing

The circuit may be housed in a small plastic case or any other suitable housing. Adequate room must be allowed for the potentiometers, switches and battery. Always take care that none of the components short out when the case is fitted together. Allow sufficient space around the components for efficient cooling. In normal use, with adequate ventilation, the components do not operate at an excessively high temperature. However, the power amplifier section may run at an elevated temperature when driven hard. Remember to allow for access so that the battery may be easily replaced when required.

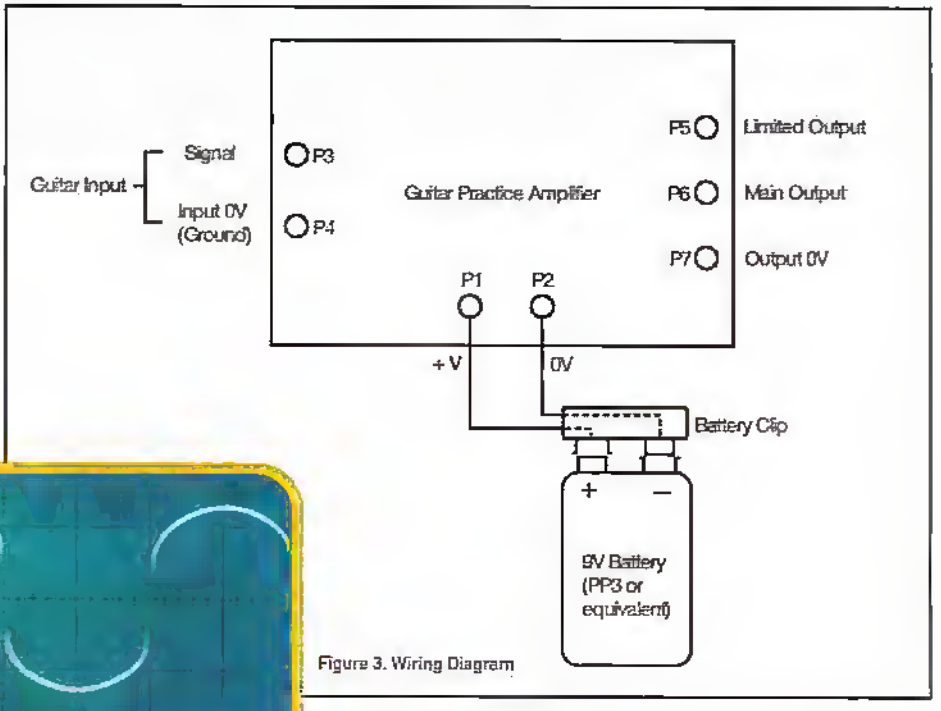


Figure 3. Wiring Diagram


A practical example of diode clipping

Testing the Amplifier

No special tools or equipment are required to test the amplifier but if a sine wave signal generator and an oscilloscope are available, these will allow the correct operation of the circuit to be verified before connecting a guitar. If available, it is also useful to connect a multimeter in series with the positive power supply rail in order to monitor the supply current when the circuit is first tested.

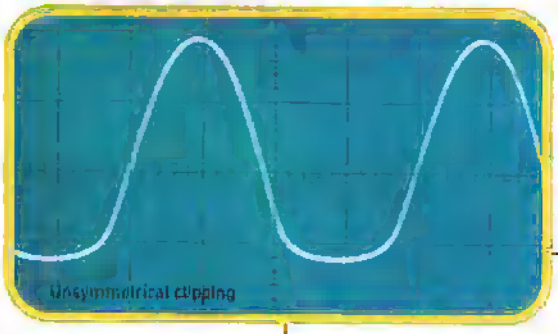
To ensure personal safety, it is recommended that the circuit board is temporarily installed in its housing during testing as components can occasionally explode if they are incorrectly connected or under certain fault conditions. However, do not permanently install the circuit board until testing is complete as it may be necessary to gain access to the circuit if a fault or error becomes apparent.

Check that S1 is set to the 'off' position. Connect a suitable 9V battery (PP3 or equivalent) to the circuit as shown in the wiring diagram (Figure 3). Set VR1 to minimum resistance. Set VR2 to the minimum volume setting and VR3 and VR4 to the centre position. Close switch S2.

Connect a sine wave generator set to 1kHz or other suitable audio signal source between P3 (input) and P4 (0V). The level of the signal source must be adjustable from zero up to a few tens of mV and to start with should be set to minimum. Some method is required to monitor the output of the amplifier. A pair of headphones is fine. To prevent possible damage to the headphones and your hearing when first testing the unit, it is recommended that the headphones are connected in series between terminals P5 (limited output) and P7 (0V). An oscilloscope may also be used to monitor the output.

Switch on the amplifier (close S1). After an initial click the output should remain silent. Advance the setting of VR2 about a quarter of its travel and slowly increase the input signal level. The signal should be clearly audible at the output. At low level, the output should faithfully reproduce the input signal without introducing a significant degree of distortion. If a sine wave is applied to the input, the output should also be sinusoidal. Adjust the setting of VR1 so as to increase the gain of the preamplifier stage. As long as the input signal level is sufficient, a point should be reached where the preamplifier stage starts to clip. The effect of diode clipping is illustrated in Figure 4. This creates an audibly

harsher sound at the output. When monitored using an oscilloscope, the clipping effect should be clearly recognisable (see Photo 1). Opening S2 should result in a slightly different waveform and increased output level. Careful observation will show that the negative half of the waveform clips at a lower level than the positive half. Photo 2 shows the sort of waveform produced.



The effect of tone controls VR3 and VR4 may not be immediately obvious when driving the amplifier with a single frequency test signal and this feature is best tested with a guitar connected to the input. Alternatively the frequency response may be checked by sweeping the frequency of the test signal over the audio frequency range whilst observing the level of the output signal compared to the input signal. For this test, the input signal level and the setting of VR1 should be adjusted so that clipping does not occur.

When testing the amplifier for the first time, it is important to watch out for signs of high frequency instability. If this problem is going to occur, it is more likely to be present when VR1 and VR2 are set for maximum gain and when the tone controls are adjusted to provide treble boost. Instability may be present continuously or just on the peaks of the output waveform. The problem is best detected using an oscilloscope as the effect is not always audible. If an oscilloscope is not available, pointers to look out for that may indicate the presence of high frequency oscillation include a whistling sound from the headphones and a sudden rise in supply current level if the gain of the amplifier is increased when there is no input signal. If instability is found to be present, switch off the amplifier and double check the component values and wiring layout.

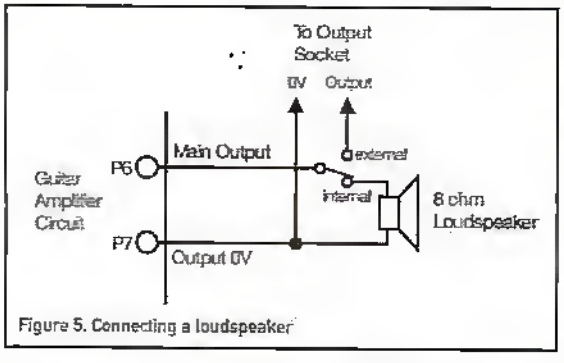


Figure 5. Connecting a loudspeaker

Using the Guitar Practice Amplifier

The amplifier offers a simple way to practice at home with a minimum of annoyance to other occupants and is therefore primarily designed to be used with headphones. The input is relatively high impedance (about 100k) and will accept the output from most types of transducer. However, always check that the guitar is compatible with this type of input before connection.

In addition to use with headphones, the main output at P6 will drive an 8 ohm loudspeaker if required. The loudspeaker could be enclosed in the case but if the enclosure is relatively small there will tend to be a lack of bass response. Therefore, it is probably better to fit a suitable connector so that an external speaker cabinet may be connected. A switch may be fitted to select either the internal loudspeaker or the external output. The available power is limited, so don't expect too much volume.

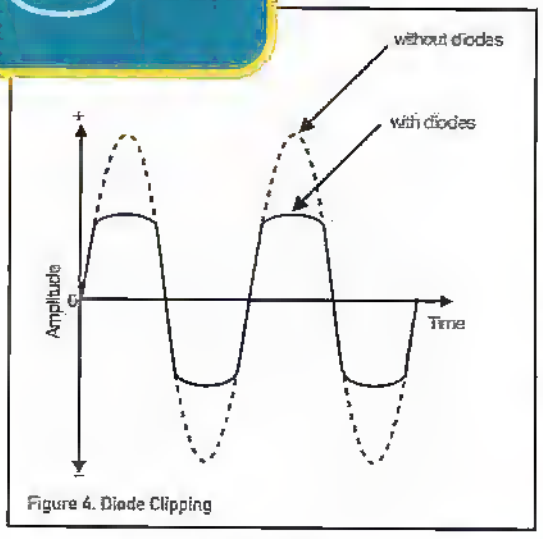


Figure 4. Diode Clipping

Care should be taken never to short the main output to P7 (or any other part of the circuit) as this may result in irreparable damage. The drive current at P5 is limited by R10 and therefore this output may be used to drive low impedance headphones. The main output at P6 has no additional limiting resistor and therefore caution is required if the output is used to drive headphones. In either case, the output ground connection is made to P7 (0V).

In order to obtain the best sound it is usually necessary to play around with the volume and tone control settings. To use the amplifier without the fuzz effect, set VR1 to minimum gain position. Then adjust VR2 to a suitable volume level. When the fuzz effect is required, carefully increase the setting of VR1 until the desired level of distortion is obtained. It is sensible to reduce the amplifier volume before adjusting VR1. Try both settings of S2 and adjust tone controls VR3 and VR4 to see which sound is preferred.

Experimenting with the Tone Controls

Some readers may like to experiment with the response of the tone controls but some caution is required as too much gain at high frequencies can result in instability. Changing the values of capacitors C9 and C11 will alter the frequency response of the circuit. Similarly if the tone control components (R7, R9, VR3, VR4, C9, C11) are omitted, the response will be flat over much of the audio frequency range tailing off only at low and high frequencies. In this case the voltage gain of the amplifier is determined by the internal feedback components of IC2. So as to maintain stability, where R9 is fitted, the value should not be less than 10k.

Battery Life

Battery life is dependant on how the amplifier is used. If the unit is used to drive a loudspeaker at full volume, it will drain the battery more quickly than when it is used at comparatively low volume levels to drive headphones. For best performance always use a long life alkaline battery.

Parts List

Resistors (minimum 0.5W metal film)		
R1	100k	1
R2, 3, 9	10k	3
R4, 5	1k	1
R6	47k	1
R7	220R	1
R8	10R	1
R10	120R	1
VR1, 4	100k variable pot lin.	2
VR2	10k variable pot log.	1
VR3	1k variable pot lin.	1
Capacitors (voltage rating 16V or greater)		
C1, 4, 6, 8, 9	100nF Ceramic	5
C2, 3, 5	10uF Electrolytic	3
C7	100uF Electrolytic	1
C10	47nF Ceramic	1
C11	10nF Ceramic	1
C12	220uF Ceramic	1
Semiconductors		
IC1	LF351	1
IC2	LM386N-1	1
D1	1N4001	1
D2-5	1N4148	1
Miscellaneous Items		
S1, 2	SPST toggle switch	1
P1-P7	PCB terminal pins	7