ELECTRONIC VIBRATO UNIT

by G. WAREHAM

SOME PEOPLE find the vibrato or tremolo stop (so frequently used in cinema organs) sufficiently pleasing to want to add it to their sound systems. This article shows how it can be done simply and easily by using modern silicon transistors. No bulky coils or transformers are needed and the power supply can be obtained from the main amplifier. Apart from the power supply, only two connections are needed to insert the vibrato unit into the sound system.

A vibrato circuit is just a device for modulating the amplitude of the audio signals. It is often achieved by inserting into the a.f. amplifier an extra stage of amplification, but in this case a stage whose gain is varied periodically is used to produce the desired effect. Unfortunately, it is hazardous to add an extra stage to a multi-stage amplifier. Doing so carries a risk of unexpected low frequency instability in the form of "motor-boating". The constructor then finds he has two vibrato effects, one of which can be controlled at will and another which cannot be controlled.

The device to be described here adds no extra stage. Instead, it is placed across the path of the audio signals, and modulates them by periodically short-circuiting them. It is called a shunt modulator.

BASIC PRINCIPLE

The principle of operation is shown in Fig. 1a. If switch S is closed, the audio signal is all dissipated in R1, and nothing appears at the output. Periodically opening and closing of the switch at a suitable low frequency (say 10c/s) would produce a vibrato effect. Musicians tend to use the term "vibrato" for deep modulation at low frequencies, and "tremolo" for the fluttering effect produced by shallower modulation at a higher frequency. The unit described here produces both effects.

Of course, the circuit in Fig. 1a is impractical on its own. Real vibrato units use, instead of a mechanical switch, a non-linear impedance controlled by a low-frequency oscillation. Ordinary semiconductor diodes are suitable, and can be connected as shown in Fig. 1b. Here R1 is in practice the source impedance of the a.f. signals, and R2 is the input impedance of the next stage of the main a.f. amplifier.

We have as yet no means of "fading in" the vibrato effect, and Fig. 1c shows how a potentiometer VR1 can be added to make this possible. (It should be a "log. law" component as used for a volume control.)

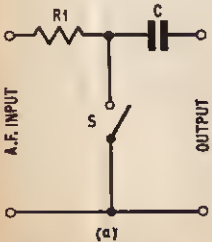


Fig. 1a. Principle of the shunt modulator

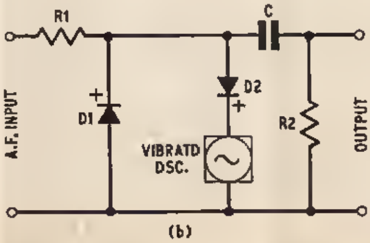


Fig. 1b. Practical modulator using diodes instead of a mechanical switch

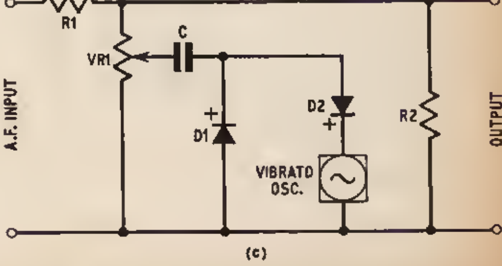


Fig. 1c. Modulator with a fader control

INSERTION LOSS

Connecting a shunt modulator inevitably attenuates the a.f. signals, and if one is not careful the amount of attenuation can be excessive. It is necessary to select certain component values to suit the particular equipment to which the vibrato unit is to be added. This is quite straightforward. The equivalent circuit of the modulator is given in Fig. 2. Here r_d is the effective resistance of the two diodes in parallel, and the other resistances are the same as before.

Ideally, r_d varies between zero and infinity, to produce the required modulation. In practice, it varies between a few hundred ohms and a few hundred-thousand ohms, the exact figures depending on the type of diode used.

The circuit behaves as a potential divider or inverted-L attenuator even when r_d is infinitive, and thus produces the "insertion loss" of the device. Thus if the value of R3 is small compared with that of R1 the loss is large, and vice versa. The insertion loss could be eliminated by making R1 zero, but this would prevent total modulation; R1 is usually there already, and outside the control of the constructor.

A little thought shows that, for small loss, the value of R1 should not be larger than that of R2 and R3 in parallel. A good rule is to make R1 equal to R2 and R3 in parallel. (The insertion loss is then 6dB.) A typical case is shown in Fig. 3, where the vibrato modulator is connected across the grid circuit of one of the amplifier stages. Here the source resistance is virtually equal to the anode load R_L of the preceding stage, and the load R2 is virtually the same as the grid leak resistor (Rg) of the next stage. In this case, VR1 can have a value somewhere between that of R1 and R2. The precise value is not critical, but it should not be too large compared with R1, or the vibrato fade-in control will be too " fierce ", that is, the vibrato will come in suddenly when VR1 is turned up almost to maximum. In valve amplifiers a typical value for VR1 would be about 250 kilohms; in transistor amplifiers it would be about 5 kilohms.

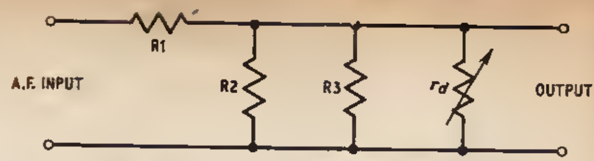


Fig. 2. Equivalent circuit of the shunt modulator

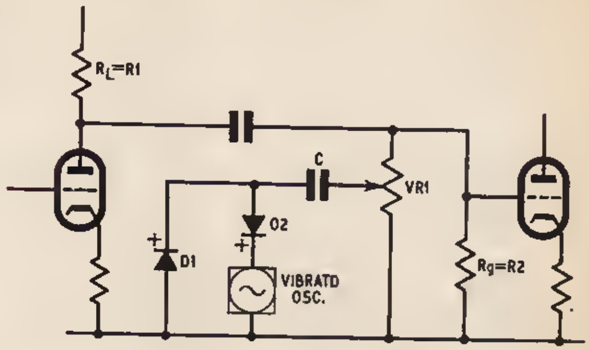
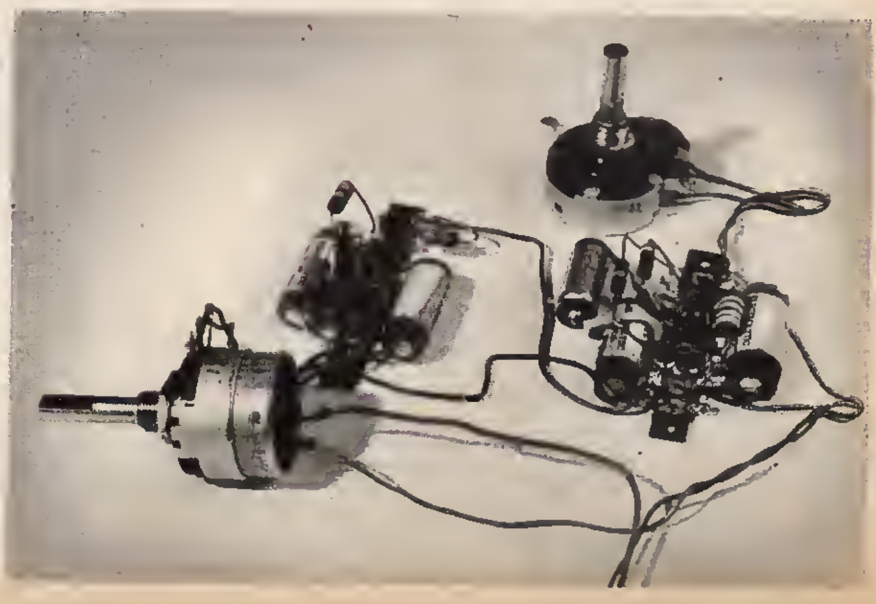


Fig. 3. One method of connecting the modulator between two stages of an existing valve amplifier

BREAKTHROUGH

One more component must be selected by the user. This is the capacitor C shown in Fig. 1c and Fig. 3. If it is too small, modulation depth is reduced. If it is too large, unwanted ticking noises will be produced on the loudspeaker. These are simply the audible effects of the vibrato oscillator output, some of which appears at the junction of the two diodes and then gets into the amplifier via C. To reduce this effect, the value of C is chosen so that its impedance is no smaller than R_1 at the lowest frequency of interest. If it is equal to R_1, then $C = 1/(2\pi f R_1)$. In valve amplifiers C is usually in the range $0{\cdot}01\mu$F to $0{\cdot}1\mu$F; in transistor amplifiers it would be between about $0{\cdot}1\mu$F to 1μF.

Photograph of the assembled tag strips ready for mounting in the amplifier cabinet or chassis



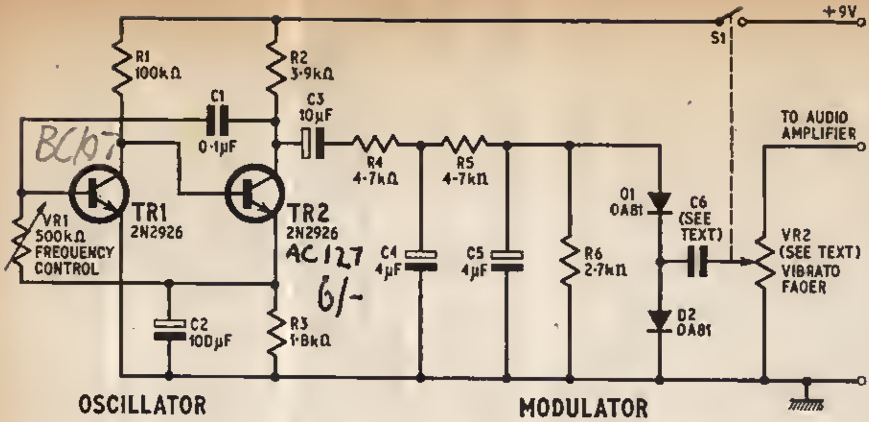


Fig. 4. Complete circuit of the vibrato unit for construction. The values of C6 and VR2 depend on the impedance of the amplifier to which it is connected (see text). VR1 is ganged to S1 so that the unit can be switched on and off

Choice of *C* is invariably a compromise, but by good luck it is made easier by a peculiarity of human hearing. Vibrato effects can be produced without modulating the entire a.f. band down to the lowest frequency. Modulating the harmonics is enough to create the effect. Thus *C* can be smaller than at first seems necessary, and breakthrough of the fundamental vibrato frequency is correspondingly reduced.

Vibrato harmonics are attenuated less by C, and they must be reduced by making sure that the vibrato waveform applied to the diodes contains no high harmonics. Perfectionists may say that the vibrato oscillator should generate a pure sine wave. This is difficult to achieve, especially if the vibrato frequency is variable, and even a pure sine wave gets distorted by the diodes, and harmonics are thereby created. The ideal design would ensure that the vibrato wave form which appears at the junction of the diodes was a sine-squared pulse.

In practice, there is always some breakthrough, but good results can be obtained without too much difficulty, partly by selecting C and partly by ensuring that the audio input signals to the vibrato modulator are between approximately 100mV to 1 volt.

This is typical of the level of signals at the input to a modern power amplifier. Thus a possible position for the vibrato unit is between the pre-amplifier and the power amplifier. If the pre-amplifier has a low impedance output, e.g. a cathode follower, it will probably be necessary to use an actual physical resistor for R1—a few thousand ohms. The modulator may also be connected across the audio path at some intermediate stage, say between first and second stages of a pre-amplifier (see Fig. 3). The vibrato circuit should not be connected so that it comes inside a negative feedback loop, or the negative feedback will act against the modulation.

COMPLETE CIRCUIT

Now let us look at the complete circuit (Fig. 4). Two *npn* silicon planar transistors type 2N2926 are used in a relaxation oscillator type of circuit. The frequency (5–30c/s approx.) is controlled by C1 and VR1. An inverse-log. potentiometer is best, but if this is not available use an ordinary log.-law volume control, connected so that the resistance increases when the knob is turned clockwise. The frequency then decreases with clockwise movement.

Before being applied to the diodes, the oscillator output is filtered by R4, C4, R5, and C5, removing some of the harmonic content.

COMPONENTS . . .

Resistors

R1 100kΩ R4 4·7kΩ
R2 3·9kΩ R5 4·7kΩ
R3 1·8kΩ R6 2·7kΩ
All resistors 10% ¼ watt carbon.

Potentiometers

VR1 500kΩ inverse log. or log. carbon
VR2 250kΩ or 5kΩ log. carbon (see text) with S1 ganged switch (Radiospares)

Capacitors

C1	0·1μF	paper	150V
C2	100μF	elect.	12V
C3	10μF	elect.	12V
C4	4μF	elect.	12V
C5	4μF	elect.	12V
C6	(see text)	paper	150V

Transistors

TR1 2N2926, TR2 2N2926 (Obtainable from Amatronix Ltd., 396 Selsdon Road, Croydon, Surrey)

Diodes

D1 OA81, D2 OA81 (Mullard)

H.T. Dropper for 9V supply

Either

Resistors

R7 To be calculated (see Fig. 6a)
R8 2·7kΩ
Both 10% 1 watt carbon

Capacitor

C7 1,000μF elect. 12V

Or

Resistor

R7 (see Fig. 6b) 10% 1W carbon

Diode

D3 OAZ212 (9 volts) (Mullard)

Miscellaneous

Two 8 way tag strips; P.V.C. wire; Screened wire

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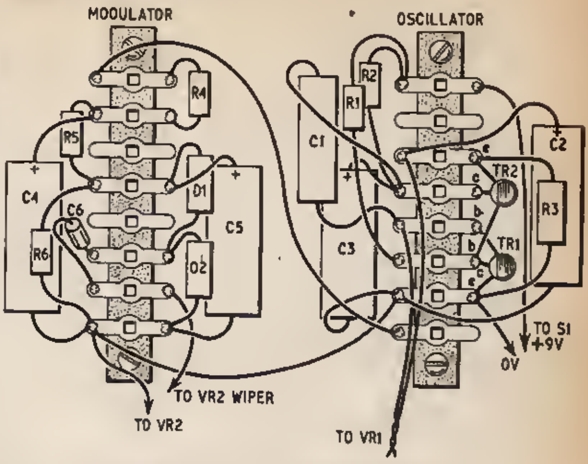

Fig. 5. Wiring of the modulator and oscillator

TWO TAG STRIPS

The complete vibrato unit can be made up in any one of a variety of methods. The prototype, shown in the photograph, was made on two separate tag strips.

Fig. 5 shows the layout and wiring of the components on the tag strips. Little description is necessary since the illustrations give all the required details.

When the final unit has been completed and the wiring has been checked, the terminals across VR2 can be connected to the guitar amplifier across the grid resistor as shown in Fig. 3. Since this part of the amplifier circuit has a high impedance, the connecting wire from the vibrato unit should be as short as possible and screened, with the screen connected to chassis.

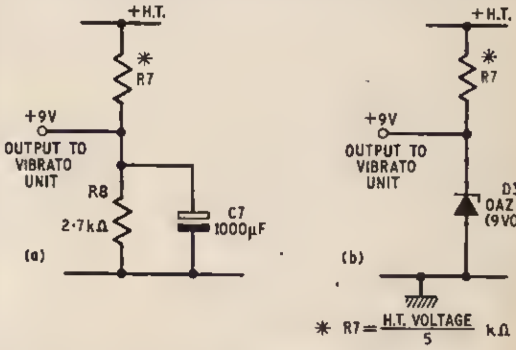

Fig. 6a. Method of obtaining a 9 volt supply for the vibrato unit using a resistive potential divider
Fig. 6b. Another method of obtaining 9 volts. R8 and C7 are replaced by a 9 volt Zener diode

POWER SUPPLIES

Most amplifier h.t. supplies will provide an extra 5mA without trouble, and this is ample. Two ways of connecting the power supplies are shown in Fig. 6. Of these, the method (b), shown in Fig. 6b, using a Zener diode, is the best and occupies less space. Alternatively, a 6·3 volt l.t. supply may be rectified and smoothed, or the unit may be battery operated.

This unit should not be used on a.c./d.c. equipment.★