Easy Sine Generator

A low cost, versatile auido signal generating with up to six volts of ouput.

By Mark Stuart

This simple low cost audio generator is extremely useful to have around. The output is a sine wave of up to six volts peak to peak and the frequency can be varied from 33Hz up to 33kHz. Two output sockets give variable outputs of 0-60mV, and 0-6 volts. A third socket gives a constant six volts output which can drive loads as low as eight ohms directly at up to 0.5 watts. This high power output level is ideal for checking loudspeakers and associated wiring. The compact construction makes the unit perfect for the tool box or pocket.

The Circuit

The circuit diagram of the oscillator is shown in **Fig.1.** A single audio amplifier IC, the LM386N-1, does everything. The frequency of oscillation is set by the dual variable control VR2a and VR2b, in conjunction with whichever pair of capacitors is selected by S1b and S1c. Capacitors C1 and C4 give the low frequency range of 33Hz to 330Hz, C2 and C5 give 330Hz to 3.3kHz, C2 and C5 give 330Hz to 3.3kHz, and C3 and C6 give 3.3kHz to 33kHz.

The components together form a frequency selective network known as a Wein Bridge. At the frequency of oscillation the circuit has its maximum voltage loss of one third, but most important, it also has a phase shift of zero. This means that the output signal is fed back to the input in-phase, creating the oscillation. Above or below this frequency the loss is less. Unlike the sort of tuned circuits used in radio receivers which can have very sharp peaks, this circuit has only a gentle hump in its frequency response. Its big advantage is that it does not use inductors (which would be very large for low frequencies) and that the frequency can be varied by changing just two resistor values. Feedback via this network is passed from the output of IC1 (pin five) to its non-inverting input (pin three) via R2 and R3. If the amplifier gain is exactly three, the losses of the feedback network are made up and the whole circuit will oscillate as required.

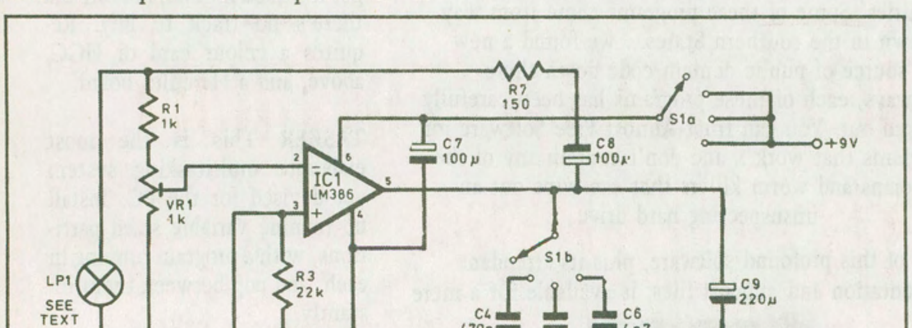

Fig. 1. The complete circuit diagram of the signal generator. See the text for further information on the stabilizing lamp and the potentiometers.

The problem in a practical circuit is that a gain of exactly three is impossible to achieve. If the gain is only slightly less than three the circuit will never oscillate, and if the gain is slightly more than three the oscillations will go on increasing the level until the amplifier is driven into clipping and the output is no longer a sine wave.

What is needed is a means of measuring the output level and increasing or decreasing the gain as the output voltage falls or rises. Many elaborate circuits have been designed to do this, some of which are very sophisticated and are used in top class audio measuring instruments. One of the most common methods is to use a pair of diodes or Zener diodes in the feedback network to introduce a controlled form of clipping and to set the gain to slightly over three. This method introduces a small amount of distortion but is adequate for some applications.

The Thermistor

An alternative is to use a thermistor which is driven by some of the output signal and as a result increases in temperature and changes resistance. This change in resistance is arranged to affect the feedback signal so that if the output rises and the thermistor gets hotter the gain is automatically reduced and vice-versa. In this way the gain is constantly controlled and sets itself to exactly three. Low distortion and simple circuitry are the merits of this method, the only drawback being the cost and availability of the thermistor. As this has to be heated by a very small signal it has to be physically small and contained inside an evacuated glass envelope. In this circuit the thermistor method has not been used but instead a small cheap filament lamp is employed.

Lamp Characteristics

It is generally known that the resistance of a filament lamp changes as it heats and cools. What is probably less well known is exactly how much. To get some idea of the figures involved a small bulb of 12 volts 60mA rating was tested. The voltage across it was varied and the current measured at different voltages from 25 millivolts upwards. The resulting curve is plotted in **Fig. 2.** A normal resistor would produce a straight line as shown by the dotted line for a 200 ohm resistor. The shape of the curve shows that initially the current increases rapidly for only a small increase in voltage but gradually increases less and less as the voltage gets higher.

At very low current and voltage (1mA, 25mV) the slope of the curve shows the resistance to be around 25 ohms. At higher currents the effective resistance rises, becoming 335 ohms at 12 volts. This has very interesting implications from the point of view of switch-on surges. In this case a 60mA bulb will actually look like a 25 ohm resistor at switch-on and will draw a current of 500mA. If the power supply can only provide 250mA, then a voltage dip will occur which could result in numerous undesirable circuit effects. If is assumed that all bulbs behave similarly it indicates that a car headlight bulb rated at 48 watts or four amps will draw an initial surge current at switch-on of around 35A. The headlamp switch must therefore be able to handle regular 60A current surges.

Getting back to the original purpose of all this, it is clear that the bulb filament can be used in the same way as a thermistor to control the gain of the oscillator circuit. The bulb resistance increases as the power in it increases and this must be arranged so that it causes a decrease of circuit gain.

Second Feedback Loop

The arrangement shown in Fig. 1 achieves the necessary control by introducing a second feedback loop around IC1. This loop is from the output to the inverting input, and so it is negative feedback. The output signal is coupled via C8 and R7 to the lamp LP1. The voltage across the lamp is tapped off via R1 and VR1 and fed to pin two of IC1. Operation is as follows: Initially when the circuit is switched on, LP1 is cold and so has a very low resistance. Any feedback via R7 is therefore shunted away and has little effect. Without negative feedback the circuit has high gain and so oscillation commences and builds up.

As LP1 is heated by the increasing output signal, its resistance increases and so the voltage across it also increases. This causes more negative

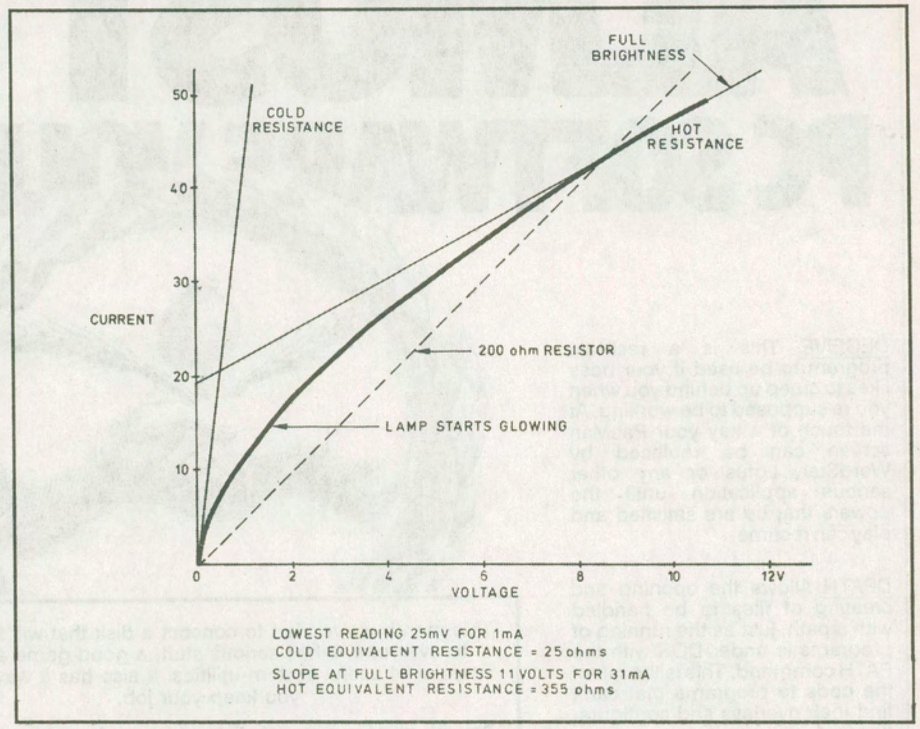

Fig. 2. Lamp resistance variation with current.

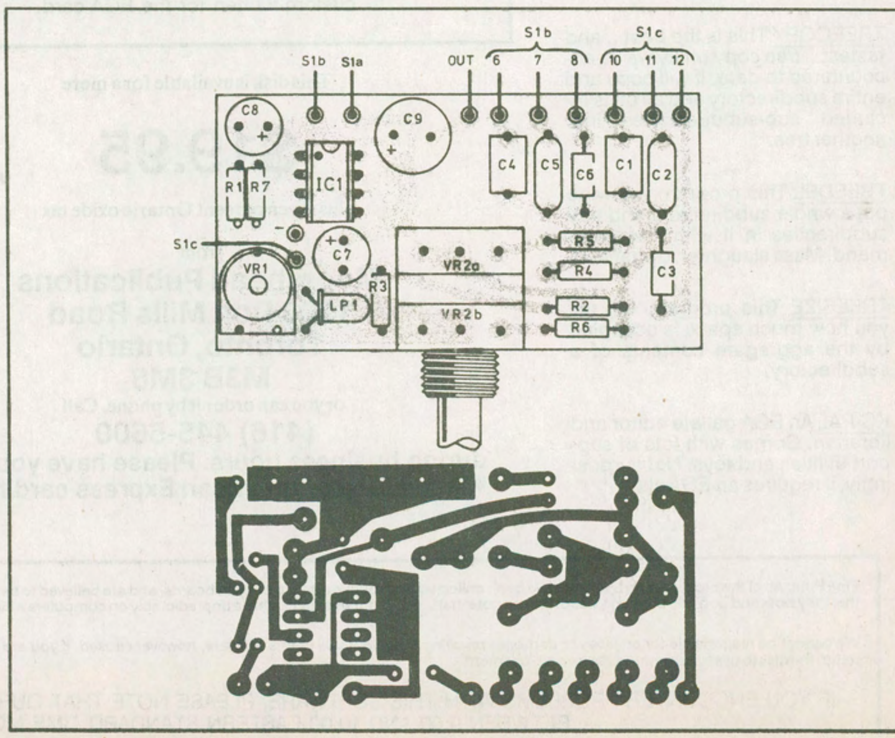

Fig. 3. The printed circuit layout and wiring details.

feedback to be applied to the circuit which reduces its gain. This stabilizes the oscillations at a level which can then be preset by means of VR1. The result is a good stable sine wave output of 6V peak to peak.

Although the final circuit is very simple, the actual design of the negative feedback stabilization loop is quite difficult. The thermal inertia of the lamp puts a delay into the circuit which can cause the stabilization to overshoot. This means that the output level can have a tendency to bounce up and down as the frequency is varied. Careful design is necessary to reduce this effect to a minimum.

Outputs

Three outputs are available from the circuit. One is straight from the IC output via C9, and is capable of driving a speaker at up to 0.5 watts. The second output is variable by means of VR3 from zero to six volts. R8 protects this output from short circuits. The third output is divided by 100 by R9 and R10 and so is suitable for use with sensitive input circuits.

Power

The circuit can be powered either by 9 or 12 volts. A 9V alkaline battery will give adequate power for intermittent use. An 9V or 12V AC-to-DC mains adaptor should be used if the unit is in use for longer periods, for example during bench testing. A section of S1 (S1a) is used as the on-off switch.

Pots

The main frequency control pot VR2 should be a 10k reverse-log taper. This allows the frequency dial markings to be spread out evenly around the dial; a linear pot will make the markings jam up together at one end. If you can't find a reverse-log pot, and they're very hard to find, you can (a) put up with the condensed range of a linear pot, or (b) use a standard dual log pot and mark the dial backwards (in other words, the frequency decreases with clockwise rotation.

Output pot VR3 should be a log pot to prevent its range being squeezed into one end, but you can get away with a 1k linear. It's not all that critical.

Construction

The whole circuit is built on a small printed circuit board which is shown in Fig. 3, the copper track pattern is also

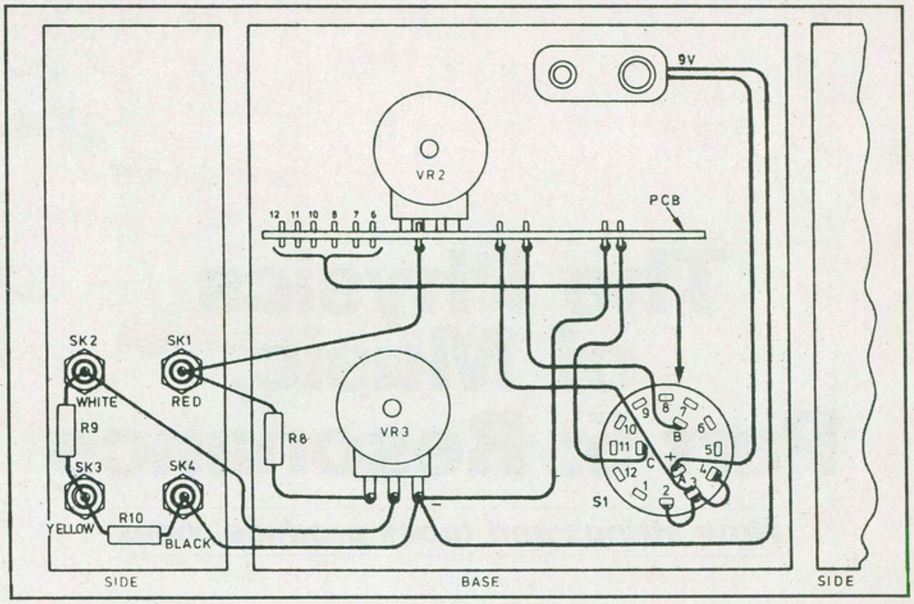

Fig. 4. Interwiring details.

shown. Assemble the board as shown taking care to get C7, C8 and C9 the right way around. A socket should be used for IC1 . The board should be fitted with flexible wire leads for the connections to VR3 and S1. These leads are best fitted directly to the board by stripping approximately 6mm of insulation and passing the bar ends through from the component side and soldering on the track side.

Refer to the wiring diagram of **Fig. 5** for all of the necessary off-board connections. Switch S1 has all of its tags numbered or lettered for ease of identification. If different switches are used it may be necessary to make changes to this. The lamp LP1 should be secured to the board with a small blob of adhesive. It is important that the correct lamp is used for the stabilization circuit. Because of variations in lamp construction, it's wise to buy several and select the one that gives the most stable signal.

Setting Up

The circuit only requires adjustment of VR1 to be up and ready to use. Fortunately this adjustment is quite simple. Ensure that a fresh battery is fitted, select the lowest frequency range and set the dial to give approximately 50Hz. Connect a multimeter set to AC volts between OV and "Output 1". Adjust VR1 to give a reading of 2.1 volts, and that's it. The calibration of VR2 can be done by borrowing a frequency meter or oscilloscope, or in a slightly more primitive way by comparison with musical instruments (A above middle C is 440Hz).

Parts List

Resistors

R1,5,6	1k
R2	47k
R3	22k
R4	68k
R7	150
R8	8R2
R9	10k
R10	100

Potentiometers

VR1	1k trim pot
VR2	10k dual log (see text)
VR3	1k log (see text)

Capacitors

C1,4	470n
C2,5	47n
C3,6	4n7
C7,8	100u, 16V
C9	220u, 16V

Semiconductors

IC1 LM386N-1 power op amp

Miscellaneous

LP1 12V, 60mA miniature wire-ended lamp, S1 3-pole 4-way rotary switch, SK1 to SK4 panel sockets or binding posts to suit, 2 suitable knobs, optional 8-pin IC socket, 9V battery clip, metal case, wire, solder, etc.