For servicing audio gear & broadcast receivers

A modulated signal injector

This compact piece of test equipment should appeal alike to the beginner, the serious amateur and the professional serviceman. It is easy and economical to build and is small enough to be carried in the pocket and may be used as a source of signals for audio equipment, broadcast receivers and well into the television bands.

by IAN POGSON

Signal injectors have been around for a long time now. We have described a number of them in the past, the last two being presented in February 1964 and more recently, in June 1973. However, some of our younger readers may not have come across this type of instrument before. It may be considered as a very rough type of "signal generator". In its simplest form, it consists of a low frequency audio oscillator designed to produce a waveform as rich in harmonics as possible. As such, it produces a large number of frequencies which are multiples of the fundamental and these appear at the output of the unit.

A signal injector therefore becomes a source of signals across a wide frequency band and which may be used for testing such things as audio amplifiers, broadcast radio receivers, etc.

By limiting the concept to a single audio oscillator, the band of frequencies will also be limited. By adding an extra and similar type of oscillator, this time with its fundamental frequency in the lower RF range, it follows that its harmonics will extend further into the high frequencies and even into the VHF range. The audio frequency oscillator can be made to "modulate" the RF oscillator and we then have an even more useful and versatile instrument. This is the principle on which our new signal injector is designed.

Because many integrated circuit chips are readily available at low cost and include a number of separate circuits which may be combined or used separately, the extended concept of the signal injector becomes very easy to implement.

A diecast metal case was used to house the prototype. The probe was made from a stout piece of tinned-copper wire soldered to the centre lug of a jack plug.

In this particular case, we have made use of the IC type 4069, or 74C04, described as a "hex inverter". With six separate inverters available, we are able to use three of them for an audio oscillator and the other three for an RF oscillator. By adding just a few components around this chip, we are able to produce a versatile signal injector at a very modest cost.

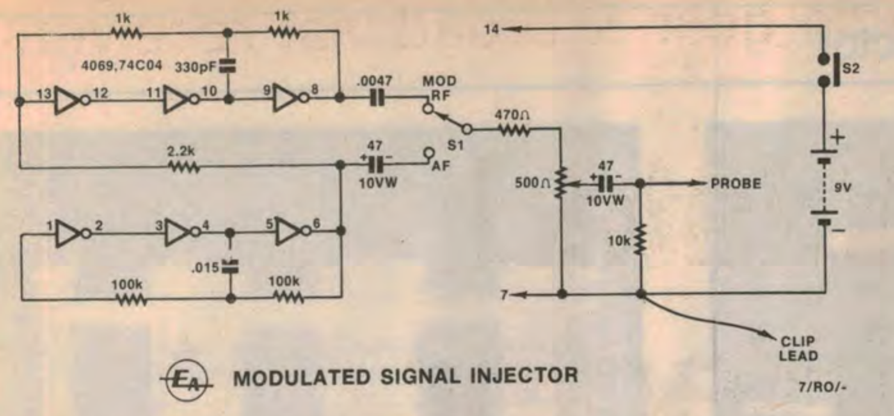
With the component values given, the frequency of the audio oscillator is about 300Hz and the RF oscillator comes out to about 700kHz. This means that the signal injector may be used, not only for audio and broadcast radio tests, but it may also be used for high frequency receivers and even for making some checks on television receivers.

To be a little more specific, perhaps the most basic use for the signal injector is to make stage-by-stage checks on a faulty audio amplifier, similar to the old "finger-on-the-grid" technique used when valves held sway. With many valve amplifiers still in use, the technique still applies, with its extension to what may now be called "finger-on-the-base" method.

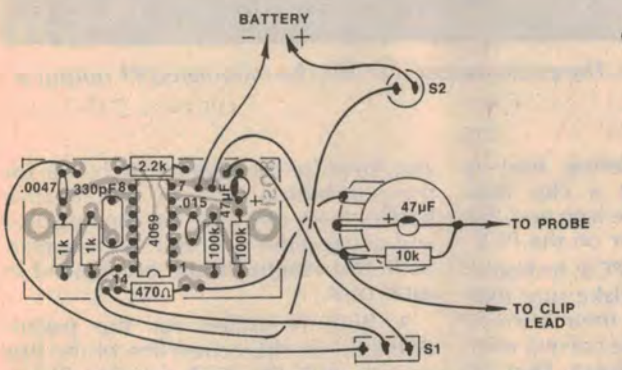
Only a short step away is the application to ordinary broadcast receivers, whether valve or transistor equipped. It is just a matter of probing along, stage-by-stage with the injector, until the faulty stage is isolated.

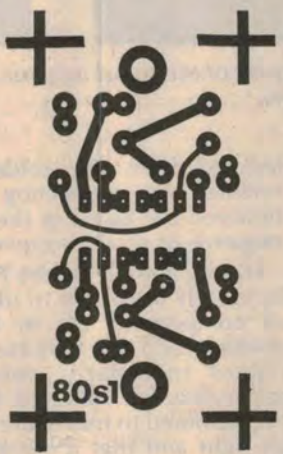
These tests are possible by using the audio oscillator section. By using the added modulated RF oscillator, we can extend the tests to receivers covering the HF range and well beyond.

Because of the heavy modulation of the RF oscillator by the audio oscillator, a series of "bursts" of RF is produced. This feature and the almost square



Two CMOS oscillators form the basis of the circuit. The audio oscillator has a frequency of about 300Hz; the RF oscillator a frequency of 700-800kHz.





The wiring diagram for the Modulated Signal Injector. At right is an actual size artwork of the PC board.

PARTS LIST

1 Diecast metal box, Eddystone 89mm x 30mm x 35mm
1 Printed circuit board, 48mm x 25mm code 80s1
1 Potentiometer, 500 ohm linear carbon
1 Knob
1 Miniature toggle switch, SPDT
1 Miniature pushbutton switch
1 Battery, 9V No. 216
1 Lead for battery
1 Jack socket, 3.5mm
1 Jack plug, 3.5mm
1 IC, 4069/74C04 14-pin DIL
1 IC socket, 14-pin DIL
1 330pF polystyrene capacitor
1 .0047uF greencap (metallised polyester) capacitor
1 .015uF greencap capacitor
2 47uF/10VW tantalum capacitors

RESISTORS:
1 x 470 ohm
2 x 1k
1 x 2.2k
1 x 10k
2 x 100k

MISCELLANEOUS:
Screws, nuts, solder, hookup wire, 16-gauge tinned copper wire for probe.

NOTE: Ratings are those used on the prototype. Components with higher ratings may generally be used providing they are physically compatible.

waves produced by the RF oscillator make it very useful for testing the signal circuits of television receivers. By applying the probe at appropriate spots along the signal line, a definite pattern of bars is produced on the screen. It should be noted, however, that the upper RF range is limited and we found that the prototype was good up to 100MHz as previously mentioned and so only the first few TV channels may be checked.

A switch has been provided to take the output from the audio oscillator only, to cope with audio amplifiers and broadcast frequencies, or the modulated RF output may be selected when tests are to be made on HF and television receivers.

To increase the versatility of the signal injector even further, we have provided means of controlling the level of the output to the probe. This feature could be used to ascertain whether or not any gain is available over any particular stage. The gain control is a simple potentiometer in the output circuit and it is very effective on the audio output but there is a reasonable amount of leakage at RF by virtue of the "hop-on" effect of the potentiometer. This means that when applied to some aerial inputs, the amount of signal is still quite high but in practice this is not a significant restriction.

Although there is not much to it, let us have a look at the circuit of our signal injector. The heart of the circuit is the hex inverter chip. Three of the inverters are connected in series (input to output) to form an audio oscillator when two resistors and a capacitor are added. As mentioned earlier, the two 100k resistors and the .015uF capacitor set the frequency of oscillation to about 300Hz. The other three inverters are similarly connected and this time, there are two 1k resistors and a 330pF capacitor, giving a frequency of 700 to 800kHz.

The output of the audio oscillator is connected to the input of the RF oscillator, via a 2.2k resistor, for the modulation process. The output of the audio oscillator is taken off also via a 47uF tantalum capacitor, to one pole of the output selector switch. Similarly, the output of the RF oscillator is taken via a .0047uF capacitor to the output switch.

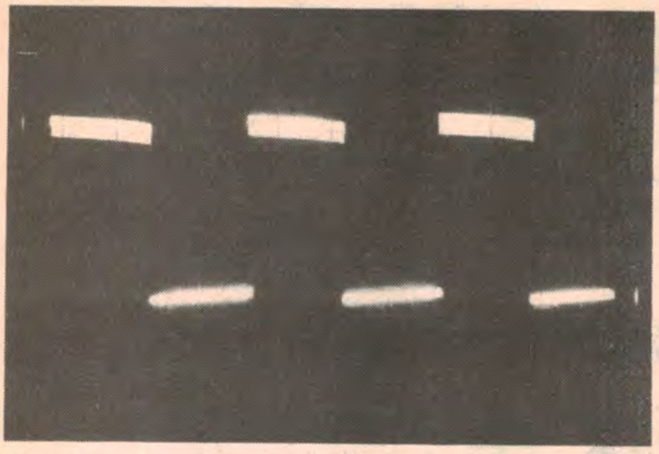
The output of the switch is fed via a 470 ohm resistor to a 500 ohm carbon track potentiometer, the rotor of which is coupled via a 47uF tantalum capacitor and a 10k resistor, to the probe. The 470 ohm resistor in series with the potentiometer is to prevent the oscillators from being excessively loaded.

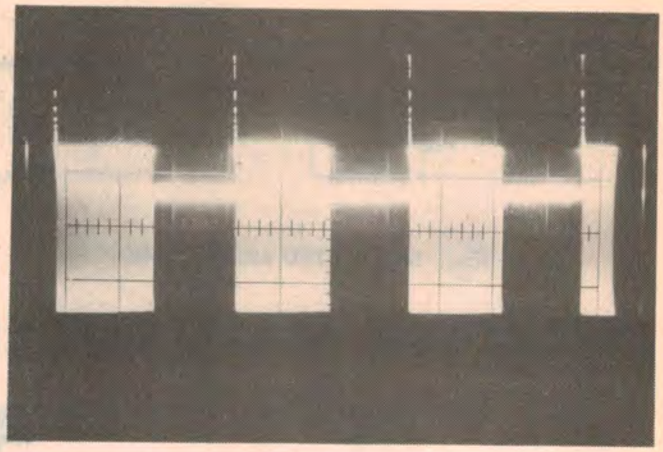
A small 9V battery is used as the source of supply for the IC. This is applied via a momentary pushbutton, which ensures that the battery will not be left on unintentionally.

It will be noticed that we have provided two large-value capacitors in the output circuit, each in such a way that they will be charged by any voltage applied to the input side. This was done so that the square wave of the audio oscillator would be passed on to the circuit being checked with a minimum of distortion. However, this feature may not be required and there may be some cases where it may be desired to test circuits with voltages in excess of the ratings of these two components. In such an event, the capacitors could be reduced to .01uF polycarbonates rated at 400V. The 10k resistor could also be omitted.

To give some idea of the waveforms to be expected from the signal injector, we took pictures from the CRO screen and these are reproduced here. The photographic process has resulted in some changes to the detailed appearance of the waveforms. One obvious point is that some of the lines have been somewhat increased in width. This applies particularly to the square wave picture and to the "DC" level of the modulated RF waveform.

Modulated signal injector





These two photos show the output waveforms of the signal injector. The audio output is at left, the modulated RF output at right. CRO settings: 0.5V/div and 1ms/div.

Also, the RF component assumes a solid block, rather than each cycle being visible. Finally, the vertical components of the square wave were so thin that they have been lost completely. However, these points do not detract from the overall impression.

CONSTRUCTION

Because the signal injector has only a few component parts, construction is not difficult. However, it demands a certain amount of care, particularly when it comes to fitting the components into the small diecast box.

Before attempting to fit any components into the box, the printed circuit board should be assembled. It is quite small and should present no problems. In keeping with normal procedure, the smallest items, such as resistors and capacitors should be soldered in first, followed by larger items. Although it is not essential, I favour the use of sockets for ICs, particularly for CMOS devices.

Readers who elect to solder the IC in directly are reminded that it is important to make sure that any possible leakage from the soldering iron is nullified by connecting a clip lead between the barrel of the iron and the negative or earthy copper on the PCB.

Having completed the PCB, it should be closely inspected to make sure that all components are in their correct positions and that they are correct with regard to polarity, where that is applicable. All soldered joints should be examined to make sure that they are all right and that there are no solder bridges.

Reference to the picture will help in the assembly. Two screws are needed to fix the PCB. Two holes should be drilled on the correct centres and such that the PCB just clears the corner buttress of the box. Also, the board should only just clear the bottom of the box. This will ensure that the top edge of the PCB will not foul the lid of the box. The PCB is stood off the side of the box by using two half nuts between the box and the board, making three nuts in all for each screw.

Before finally screwing the PCB into place, seven leads should be soldered to it, for external destinations. These are: three for the toggle switch, one for the pushbutton, one for the negative battery lead, one each for the negative and active sides of the potentiometer. Sufficient length should be allowed in each case.

A hole is drilled for the potentiometer, on the centre line of the box and so that the body of the potentiometer just clears the end of the box. The spindle will be cut to suit the knob used. Before tightening the nut, orientate the potentiometer so that the lugs are nearer to the pushbutton side, with the earthy lug about on the centre line.

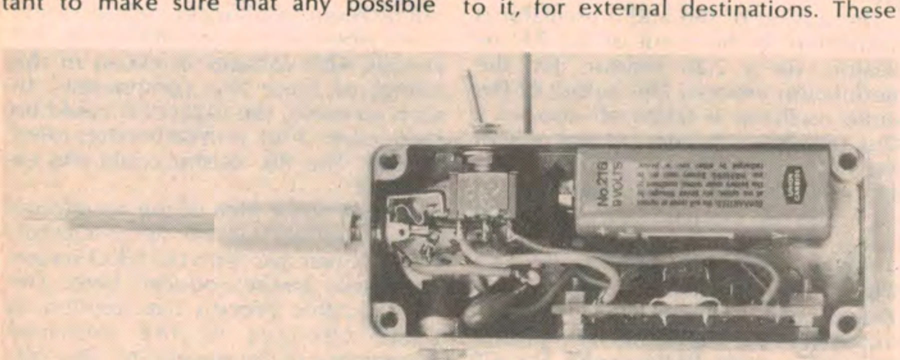
A hole is drilled to take the pushbutton, so that its body just clears the potentiometer and the buttress of the box.

Next, a hole is drilled in the end of the box to take the jack socket for the probe. The socket should be placed so that it just clears the potentiometer and the lugs on the pushbutton. You may find that the position for the socket is off centre, as it was on the prototype.

Now drop the battery in place temporarily, so that it butts against the buttress on the box. It may be necessary to dress some of the leads from the PCB, to allow space for the battery. The toggle switch is mounted on the side of the box, between the battery and the jack socket. The switch should be placed so that it clears the potentiometer, with a gap between the switch and the jack of between one and two millimetres. Care should also be taken to make sure that the lugs of the toggle switch and the pushbutton do not interfere. The pushbutton lugs may be bent if necessary.

Drill another hole, just large enough to clear a piece of hookup wire, on the toggle switch side and opposite the earthy lug on the potentiometer. The earth clip lead passes through this hole.

Most of the wiring from the PCB to



View inside the completed prototype. Assemble the various components into the case as described in the text and take care to avoid inadvertent "shorts".

the other components will be left to the builder but a few comments may be helpful. A convenient common earth point is the lug on the potentiometer. A wire is run from here to the earth lug on the jack socket, to earth the box. Also, the 10k resistor is earthed at the potentiometer lug. The other end is connected to the 47uF tantalum capacitor "in mid air", with the other end of the capacitor going to the rotor lug on the potentiometer.

The probe is made up by a piece of 16-gauge tinned-copper wire, about 55mm long and soldered to the centre lug of the jack plug. A piece of spaghetti tubing, about 45mm long, is slipped over the tinned-copper wire and it is then crimped onto what is normally the earth lug of the plug. The outer case is screwed back into place and the probe is then plugged in.

This almost completes the assembly work. If a socket is used, the IC should be plugged into its socket, taking care that no pins are bent over in the process. It is sometimes necessary to bend the pins inwards slightly, to make them enter the socket. This done, the battery plug is connected to the battery

We estimate that the current cost of parts for this project is approximately

$12.00

This includes sales tax.

and the unit is ready for checks to see that it is in working order.

The signal injector is very easy to use and a little practice is all that is necessary to make best use of the device. The normal procedure is to start testing at the high level, working backwards towards the lower level stages. By adopting this method, the offending stage can usually be isolated. If you wish to check whether or not a particular stage is giving any gain, the signal should first be injected at the output of the stage and noting the amount of output. The injector is then moved to the input of the stage and an increase in output should be noted.

When making tests with the signal injector, the level control can often be useful when coping with different signal level requirements. Also, the output may be switched between the audio and the modulated RF sources, depending on the nature of the checks being made. Experimentation during the initial stages could be helpful in getting the best out of the instrument.