UHF TV-modulator

Circuits which produce an amplitude modulated VHF or UHF signal from a video input signal have many applications. They allow direct connection to the TV aerial input of such devices as TV games, video biofeedback circuits and test pattern generators, to name but a few. Unfortunately, the performance of most simple modulators leaves much to be desired. However, the circuit described in this article, though extremely simple (one transistor!), offers extremely good performance.

We use the term 'modulator' as a conveniently short way to describe a circuit comprising an r.f. oscillator and an amplitude modulator (figure 1). In many simple modulator circuits the oscillator and modulator are but a single transistor, the video signal being injected direct into the base of the oscillator transistor to vary the amplitude of oscillation. The disadvantage of this method is that the frequency stability of the oscillator suffers, and phase or frequency modulation can also be introduced, which is apparent as poor picture definition. Ideally, the oscillator output amplitude should remain constant, and modulation should be performed by feeding the signal through a separate modulator circuit.

Many simple TV modulators have an oscillator frequency whose fundamental lies in the VHF band, since these are the highest frequencies that can be obtained using conventional construction techniques (wound coils). For reception in the UHF band on which modern TV's operate, one has to rely on the large harmonic content of the oscillator, which is not an entirely satisfactory solution.

A modulator whose fundamental lies in the UHF band has significant advantages over a VHF modulator:

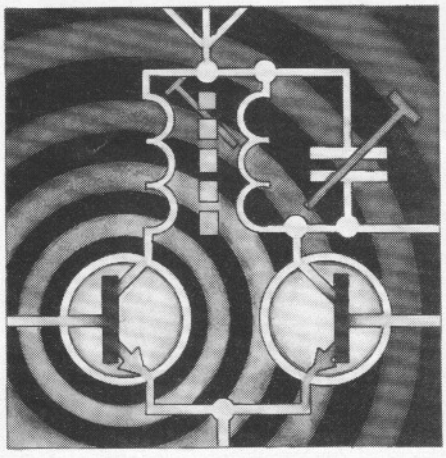
- when used with equipment containing logic circuits (pattern generators for example) a UHF modulator is much less prone to spurious interference.
- the circuit can be simply constructed using striplines etched on a p.c. board instead of conventional wound inductors.
- a large number of channels are available in the UHF band, so that even with fairly generous component tolerances the oscillator frequency will still lie in the correct band.

The spectrum of a normal amplitude modulated signal consists of the carrier signal and two sidebands, one above and one below the carrier frequency, each occupying a bandwidth equal to the bandwidth of the modulating signal. Thus a signal amplitude modulated with video information having a 5.5MHz bandwidth (standard I), would occupy a channel width of 11MHz.

However, each of the sidebands contains all the information present in the modulating signal, so one of the sidebands is redundant. To allow the maximum number of channels to be packed into the UHF band, the channel width is limited to 8 MHz, and in broadcast TV transmitters this is achieved by the use of a sideband filter, which partially suppresses the lower sideband to produce the type of spectrum illustrated in figure 2.

The lower sideband is not totally suppressed, nor is the carrier suppressed as in a true SSB transmission, since this would require a complex SSB demodulator in the TV receiver, whereas partial sideband suppression and retention of the carrier allows a simple envelope demodulator to be employed.

However, since the modulator described in this article is not intended for broadcast purposes, but merely as an interface between video signals and the TV set, suppression of the unwanted sideband is not necessary. Perfectly satisfactory results will be obtained by tuning the TV set to the 'correct' sideband.



The circuit

Figure 3 shows the complete circuit of the UHF modulator, which consists of two sections. The UHF oscillator section is constructed around T1 and stripline inductors L1 and L3. The oscillator frequency may be tuned over the range of approximately 430 MHz to 600 MHz by means of C6.

Stripline L2 is inductively coupled to L1 and thus picks up part of the UHF signal from the oscillator. Trimmer C7 allows L2 to be tuned to the same frequency as the oscillator.

Diode D1 functions as a current controlled resistor; in the absence of a video input signal its dynamic forward resisttance is high. If a positive voltage is applied to the video input then the current through the diode will increase and its dynamic resistance will fall, thus damping the resonant circuit L2/C7 and attenuating the signal developed across L2. With potentiometer P1 set to maximum the modulator will saturate at an input voltage of approximately 2

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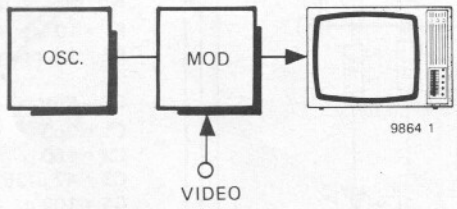

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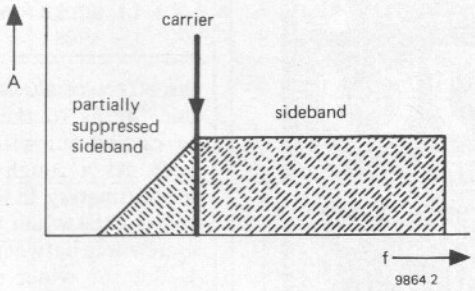

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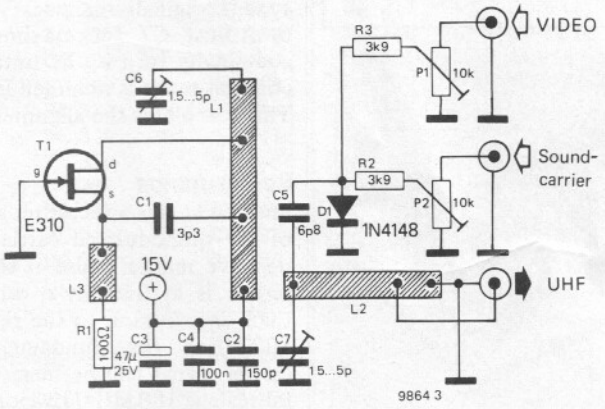

volts, and if the video input level is higher than this P1 must be used to reduce it accordingly.

If a sound-carrier is available (i.e. modulated 5.5MHz or 6MHz carrier), the correct modulation depth on the main carrier can be set by means of P2. The output signal is taken from a tap about three-quarters of way down L2.

Since the capacitance of diode D1 is voltage dependent, and because the oscillator load varies due to modulation, a small amount of spurious frequency modulation will occur. However, this amounts to a frequency deviation of no more than 40kHz/V. This may seem quite a large amount when compared with the deviation of normal VHF FM transmissions, but compared to the TV channel width of 8MHz it is quite negligible, and is certainly much less then the spurious FM produced by directly modulated oscillators. An A-B comprison will demonstrate this without any shadow of doubt.

Figure 1. In a good modulator system the oscillator and modulator should be separate circuits. Circuits where the oscillator is modulated directly, produce unacceptable spurious frequency modulation.

Figure 2. In a broadcast TV transmission a sideband filter partially suppresses the lower sideband to minimise channel width. However, for normal applications, where the modulator output is being fed direct to a single TV set, this is not necessary.

Figure 3. Complete circuit of the UHF modulator. L1, L2 and L3 are striplines etched on a printed circuit board.

Construction

To achieve good oscillator stability and suppression of harmonics, the stripline must have a high Q-factor, and for this reason the circuit is etched on special low-loss UHF copper laminate board. Home production of the p.c. board is therefore not recommended.

A layout for the printed circuit board is given in figure 5, and it should be noted that the components are mounted on the same side of the board as the copper track pattern as shown in photo 2. It is absolutely essential that all component leads should be as short possible, since the inductance of even a few millimetres of wire can be significant at UHF.

It should be noted that one important detail could not be made clear on the component layout. The right-hand end of stripline L2 must be connected to supply common, as shown in figure 3. This is achieved by inserting a piece of wire in the hole underneath the coaxial socket,and soldering it to both sides of the p.c. board (see figure 6). It is strongly recommended to do this *before* mounting the socket!

A 75 Ω BNC or TV coaxial socket can be used as the output connector, and should be mounted directly on the board in the position shown. The completed modulator board should then be mounted in a small metal box, and a ground connection between the circuit and the box must be made only at the output socket.

Power Supply

Almost any stable 15 V supply is suitable for the modulator, and a suggested circuit is given in figure 4. This is a modified version of the power supply for the 'local radio' described in Elektor 22 (February 1977), and a printed circuit board EPS 9499-2 is available.

Alignment

1. The TV set should first be tuned to an unoccupied channel at the low end of the UHF band (between channels 21 and 30). The television aerial is then unplugged and the modulator is connected. At this stage there should be no video input to the modulator.
2. Adjust C6 until the carrier wave is picked up, when the screen will darken.
3. Using C6 tune up and down the band to check that it is in fact the carrier that is being up and not some spurious response due to overload of TV tuner. The carrier signal should be much stronger than any spurious signals. Since

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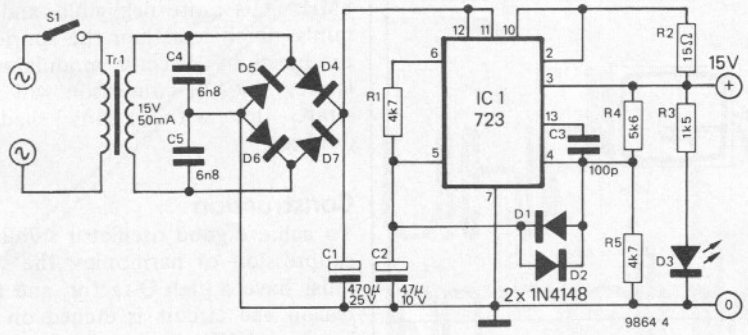

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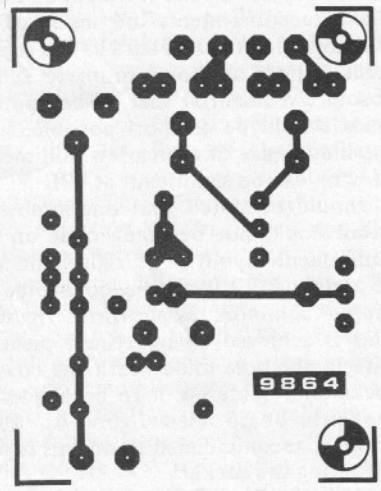

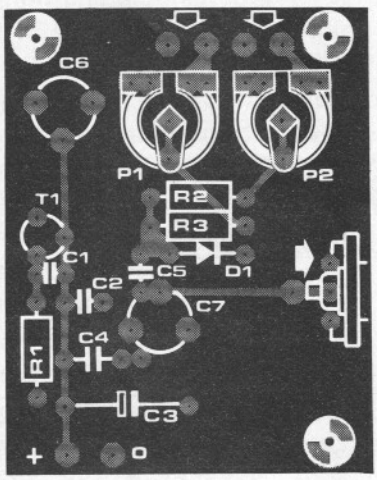

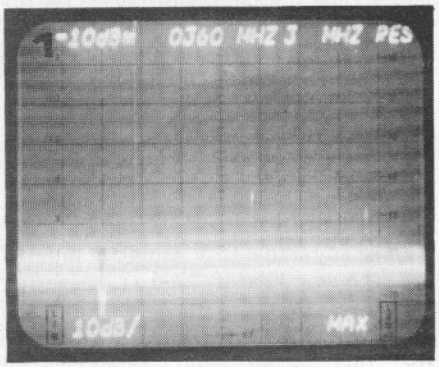

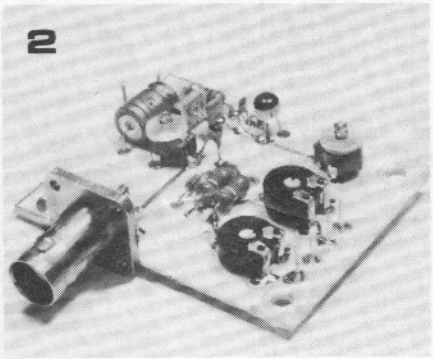

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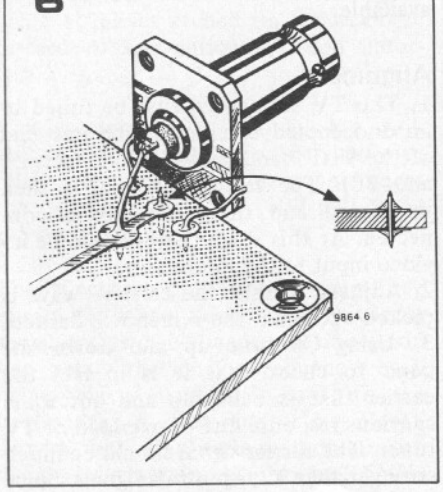

Figure 4. Suggested power supply circuit for the modulator. This can be mounted on the p.c. board EPS 9499-2.

Figure 5. Printed circuit board and component layout for the UHF TV modulator (EPS 9864).

Figure 6. Note the (arrowed) connection between the 'cold' end of L2 and supply common.

Photo 1. This spectrum analyser trace illustrates the purity of the UHF oscillator signal.

Photo 2. The completed modulator board.

Parts list to figure 3

Resistors:
R1 = 100 Ω
R2, R3 = 3k9
P1 = 10 k preset
P2 = 1 k preset

Capacitors:
C1 = 3p3
C2 = 150 p
C3 = 47 µ/25 V
C4 = 100 n
C5 = 6p8
C6, C7 = trimmer 1.5 - 5 p

Semiconductors:
T1 = FET E 310
D1 = 1N4148

Miscellaneous:
L1, L2, L3 = striplines on p.c. board.

the effect of C6 is quite coarse the final fine tuning to the carrier signal should be carried out with the TV tuning controls. As a rough guide C6 should be approximately in its mid-position (vanes half-closed) when the oscillator is tuned somewhere between channels 21 and 30.
4. Set the wiper of P1 to its mid-position and feed in a video signal of a few volts peak-to-peak. Adjust the TV tuning controls until a sharply defined picture is obtained, although at this stage it may not sync properly.
5. Turn down P1 until the picture is barely visible, or until it goes out of sync if originally in sync.
6. Adjust C7 for maximum contrast, and finally turn up P1 until the desired contrast range is obtained in the picture. This completes the alignment.

Performance

Photo 1 shows a spectrum analyser trace of the unmodulated carrier signal. The negative marker pulse at the left of the screen is at 360 MHz, whilst just less than one division to the right (at about 500 MHz) the fundamental of the carrier signal can be seen. The horizontal scale is 180 MHz/division.
The vertical scale is 10 dB/division, with the top of the screen being at −10 dBm with respect to 0 dBm = 100 mV. The top of the screen thus represents an amplitude of 70 mV. The second and third harmonics are extremely attenuated, about 53 dB below 0 dBm in the case of the second harmonic and 56 dB down in the case of the third harmonic. These figures represent absolute signal levels of around 225 µV for the second harmonic, and 160 µV for the third harmonic.
The amplitude of the fundamental is certainly not small; as can be seen from the photograph it extends off the top of the trace beyond the −10 dBm (70 mV) level.
Editorial note: FCC regulations prohibit the use of home-built TV modulators in the U.S.A.