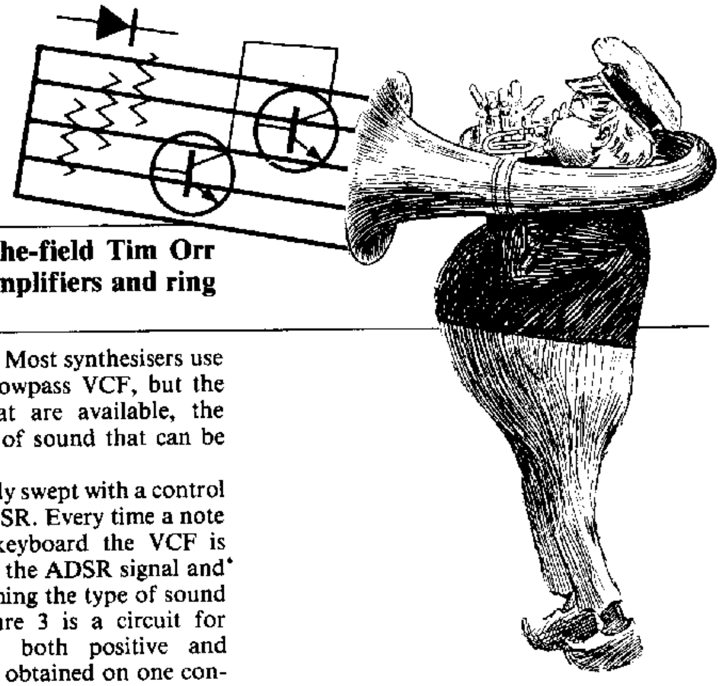
Electromusic Techniques Part 2



The second in this design series by leading-expert-in-the-field Tim Orr features voltage controlled filters, voltage controlled amplifiers and ring modulators.

THE FIRST group of circuits we consider this month are voltage-controlled filters. Figure 1 shows the circuit for a state variable filter with four frequency responses; lowpass, highpass, bandpass and notch. All four responses can be controlled by varying the gain of the two integrators. The Q factor of the filter can also be voltage controlled. If the Q is set to maximum, by turning off the feedback CA3080, then the circuit will become a sine wave oscillator (because the damping has been reduced to zero). Prior to this, very high Q factors can be obtained, of the order of 400. The frequency responses are shown in Fig. 2. Most synthesisers use a −24 dB/octave lowpass VCF, but the more responses that are available, the wider is the choice of sound that can be preduced.

VCFs are usually swept with a control voltage from an ADSR. Every time a note is played on the keyboard the VCF is swept, the shape of the ADSR signal and its polarity determining the type of sound that is heard. Figure 3 is a circuit for sweeping a VCF. both positive and negative sweeps are obtained on one control pot. Figure 4 shows a VCF chip, the SSM 2040 which was covered in the November, 1982 issue of ETI.

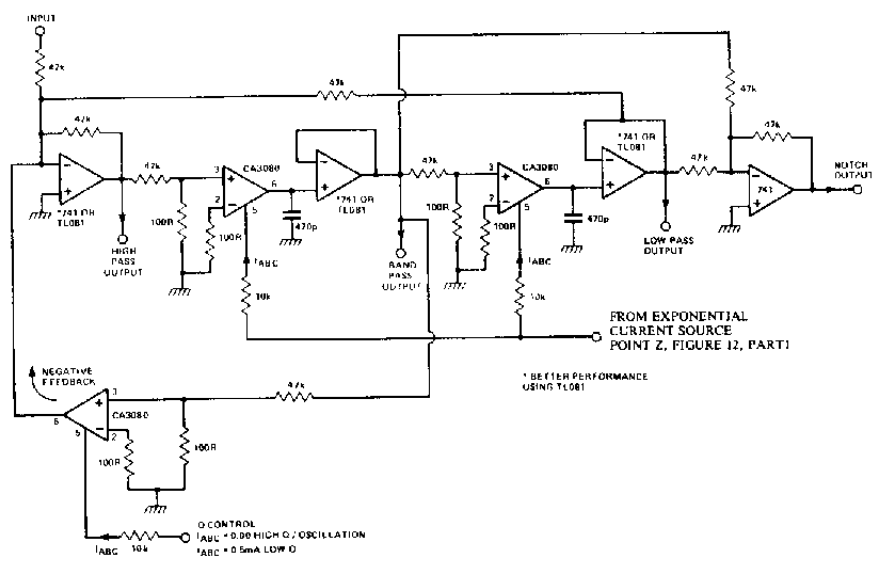


Fig. 1 State variable VCF.

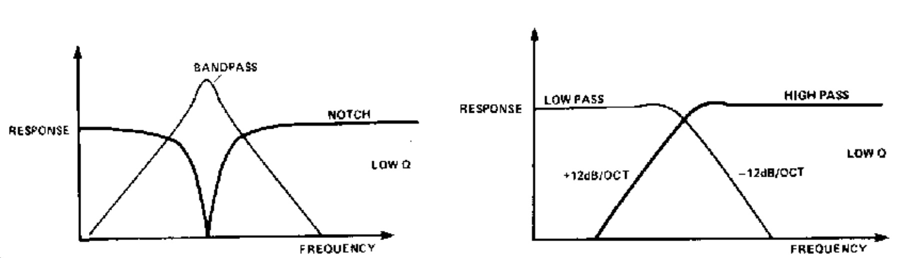


Fig. 2 State variable filter responses.

Another CA3080 VCF is shown in Fig. 5. Note that the accuracy of the exponentiator need not be as good as that needed for a VCO (unless you are going to make the VCF oscillate and track a VCO). A somewhat different VCF is shown in Figs. 6 and 7. The bi-quadratic filter has a Q factor that is proportional to the cut-off frequency. So, as this frequency is increased, the Q factor will increase. This gives a constant ringing time which is independent of frequency. All the previous VCFs have a constant Q operation.

VCA And Ring Modulators

Voltage controlled amplifiers are one of the easier synthesiser building blocks to make, as long as you don't want low noise and low distortion operation. Figure 8 shows a standard linear VCA. The audio input is attenuated to about 40 mVpp and then fed into the CA3080, the gain of which is controlled by the I_{ABC} current. If the audio input is removed, control breakthrough will probably be seen at the output. Most of this is caused by the input offset voltage of the CA3080 being multiplied by the I_{ABC} control current. The offset can be nulled out by adding a small DC voltage to the non-inverting terminal, which should eliminate most of the control breakthrough. Any residual breakthrough is due to current mirror mismatches in the CA3080 and is unavoidable. Distortion may also be rather high, perhaps in the region of

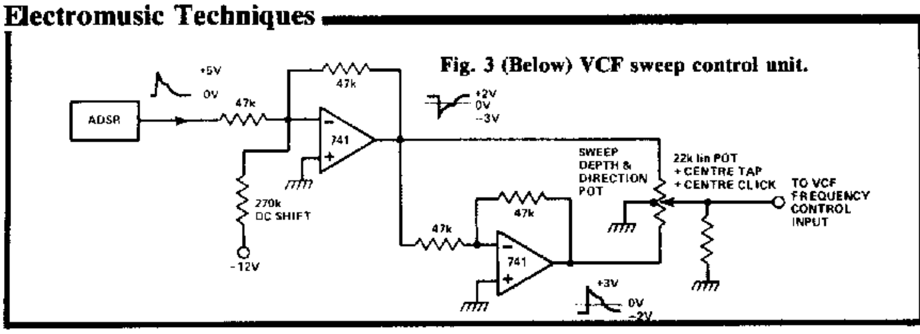


Fig. 3 (Below) VCF sweep control unit.

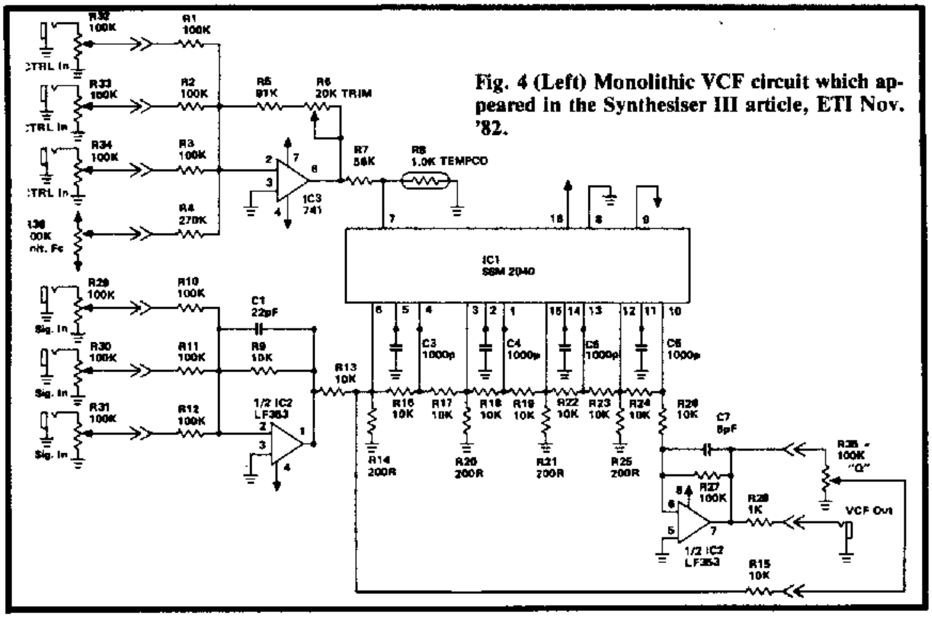


Fig. 4 (Left) Monolithic VCF circuit which appeared in the Synthesiser III article, ETI Nov. '82.

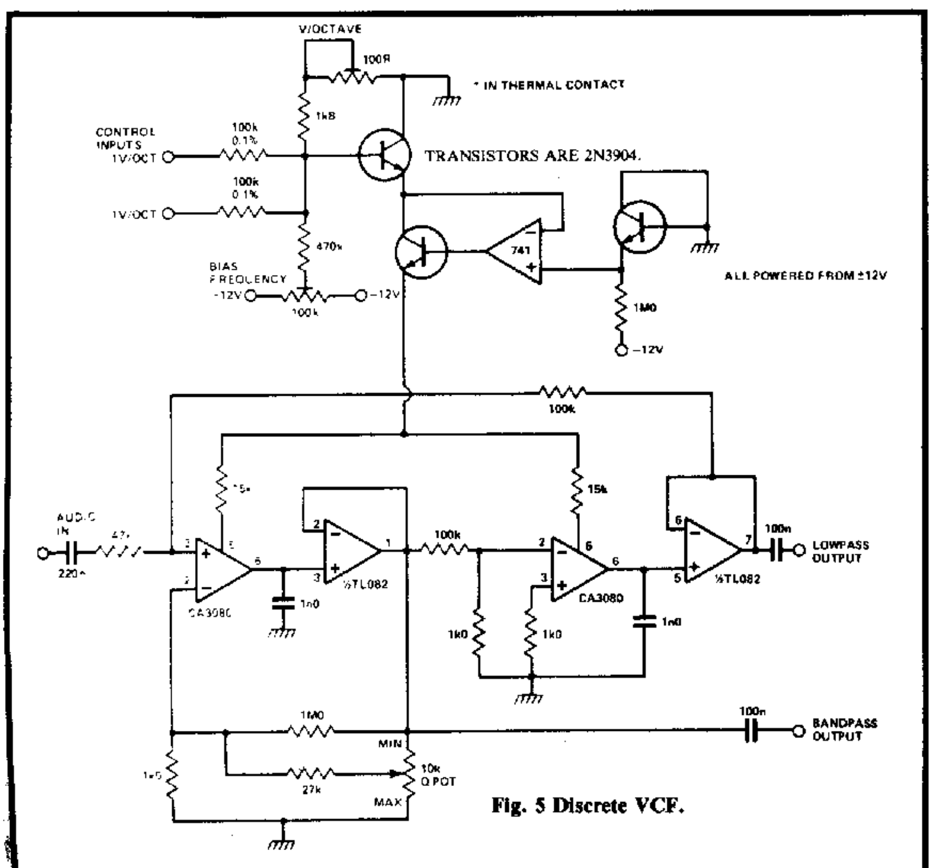


Fig. 5 Discrete VCF.

0.5%, but this is not generally considered to be a problem in synthesiser circuits. Lowering the input signal level will reduce the distortion at the expense of an increase in the noise level.

A better VCA is shown in Figure 9. This is the 1537A monolithic VCA, and can be configured for either stereo or mono. A complete article covering applications of this chip appeared in the June, '81 issue of ETI. A third VCA is shown in Fig. 10, this one being constructed from a CA3046 transistor array. It uses two of the transistors as a predistortion circuit so that a higher operating signal level can be used for the same level of distortion. In fact, the predistortion principle is used in several multiplier chips, including the LM13600 which is used in the next circuit, (Fig. 11). The two LM13600 circuits are used as low distortion VCAs. A predistortion diode bias current is inserted into the IC at pins 2 and 15. The gain of each VCA is controlled by the I_{ABC} current (pins 1 and 16), this current being derived from a pair of complementary control voltages. As the gain of the channel increases the other decreases. Some interesting effects can be obtained with this circuit; for example a note can pan from left to right every time it is played.

The VCAs mentioned so far have all been two quadrant multipliers. The operation of a four quadrant multiplier (sometimes called a balanced modulator or ring modulator) is very different (Fig. 12). When two sine waves are multiplied together the result is a signal composed of sum and difference tones. For example, if the two input sine waves have frequencies of 100 Hz and 1 kHz, then the output will be composed of two tones, one at 1100 Hz (sum) and one at 900 Hz (difference). If the same sine wave is applied to both inputs, then the sum tone is twice the original frequency, and the difference tone is a DC voltage. Ring modulators are used to produce discordant sounds and special effects.

Figure 13 is a simple ring modulator circuit. The performance suffers a bit from poor X and Y feedthrough, which can be minimized by adjustment of the two presets. A better modulator is shown in Fig. 14; this circuit employs a balanced modulator chip made by National Semiconductor and others. The feedthrough adjustments are very sensitive and so it is necessary to run the circuit from a stable pair of supply rails. Adjustment of the presets is as follows. Insert a carrier signal (1 kHz at 2 Vpp), look at the output and adjust the carrier fundamental and then the carrier second harmonic presets for minimum feedthrough. Repeat this for the signal path. Feedthrough should be the order of 60 dB down on the maximum output level.

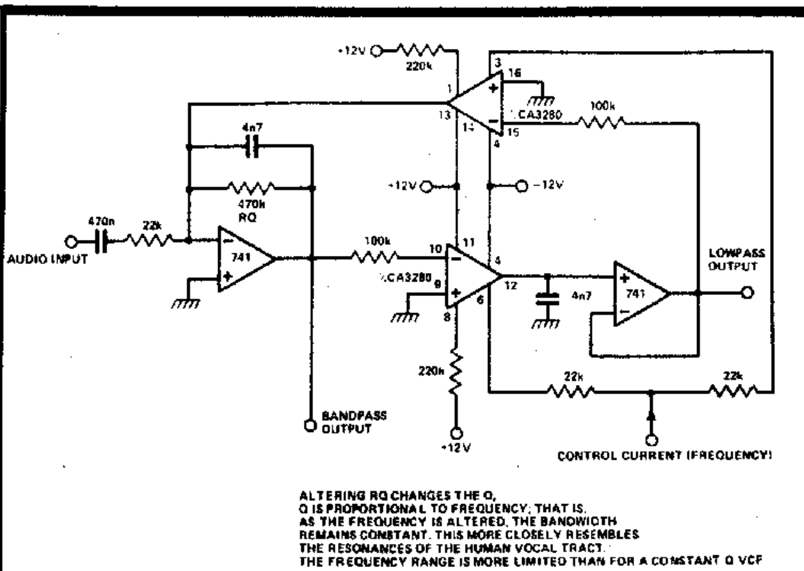


Fig. 6 (Above) Biquadratic VCF.

Fig. 7 Biquadratic lowpass response.

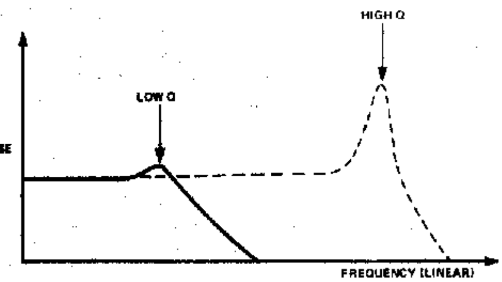
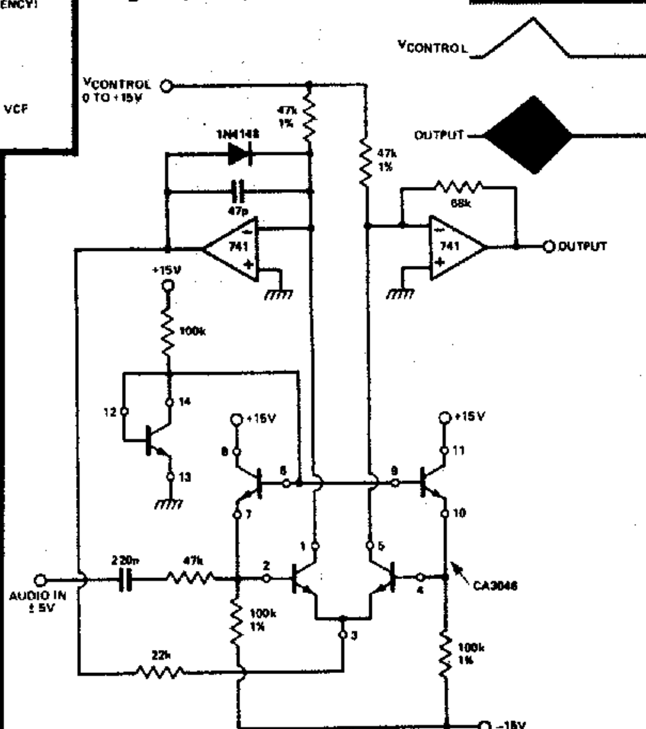


Fig. 10 (Below) Discrete VCA.



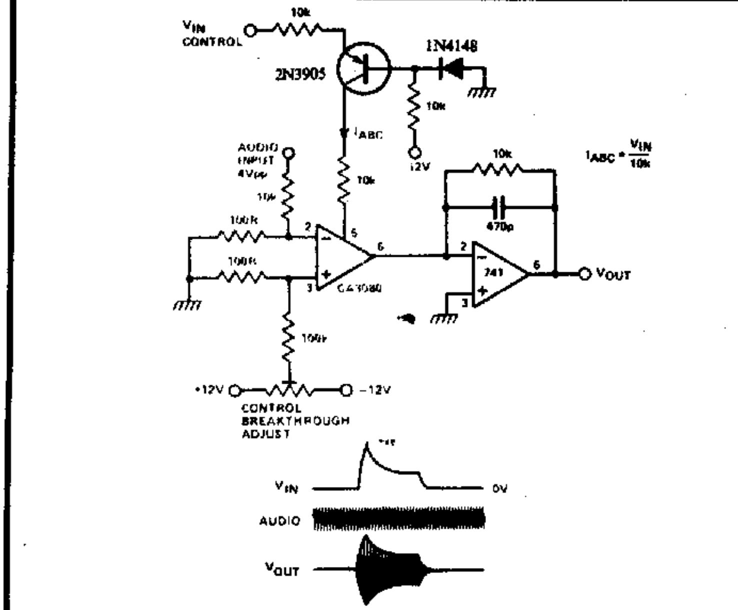
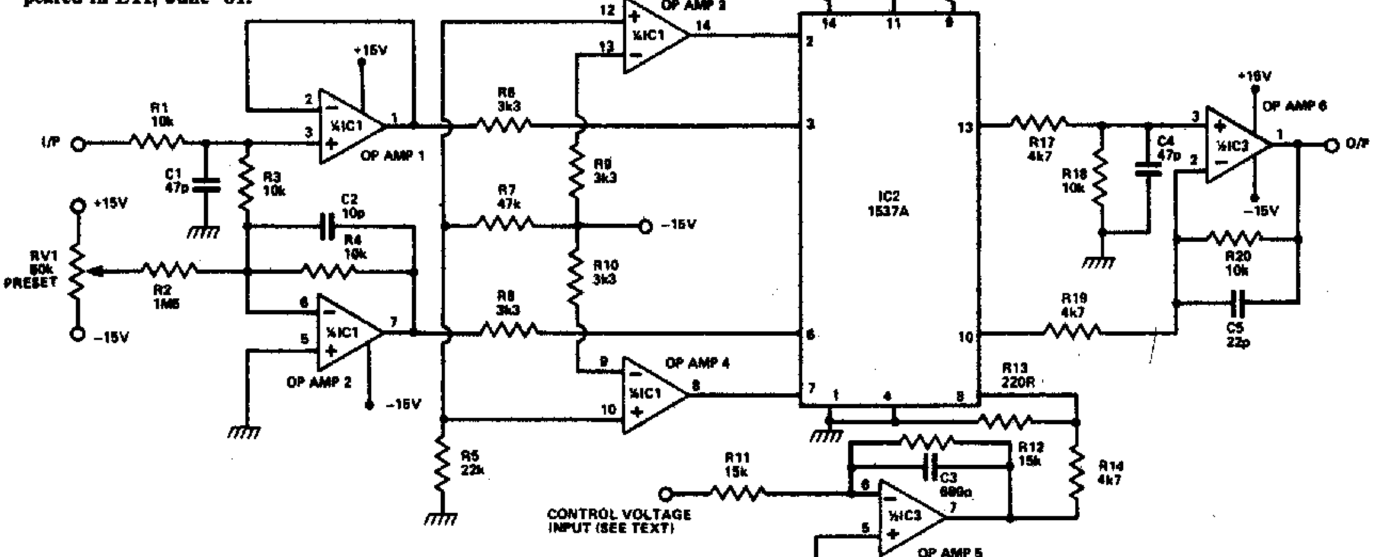


Fig. 8 (Above) Simple VCA.

Fig. 9 (Left) Monolithic VCA circuit which appeared in ETI, June '81.



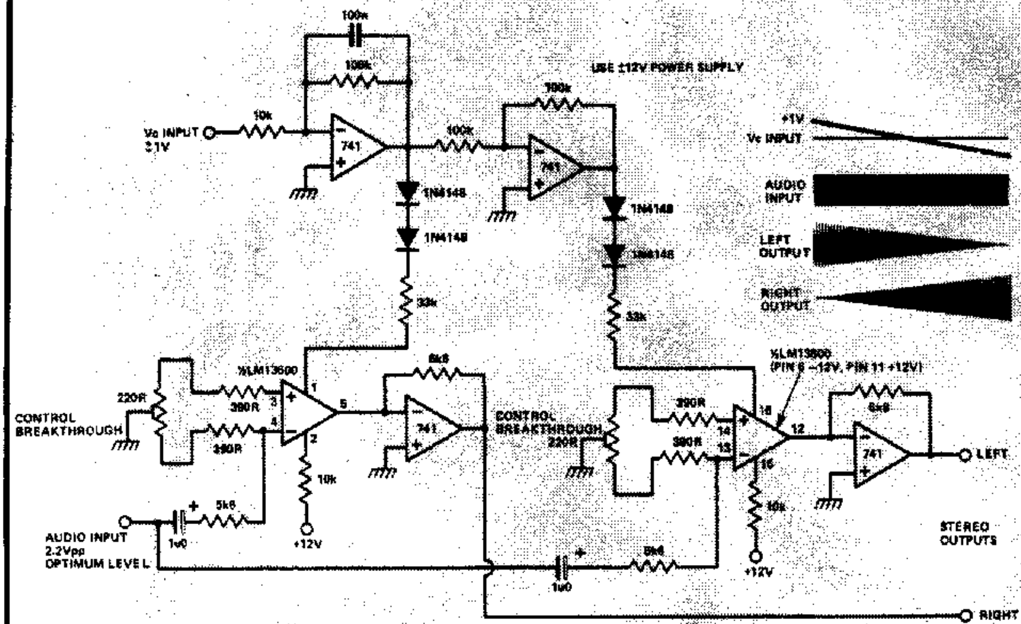


Fig. 11 (Above) Voltage controlled panning.

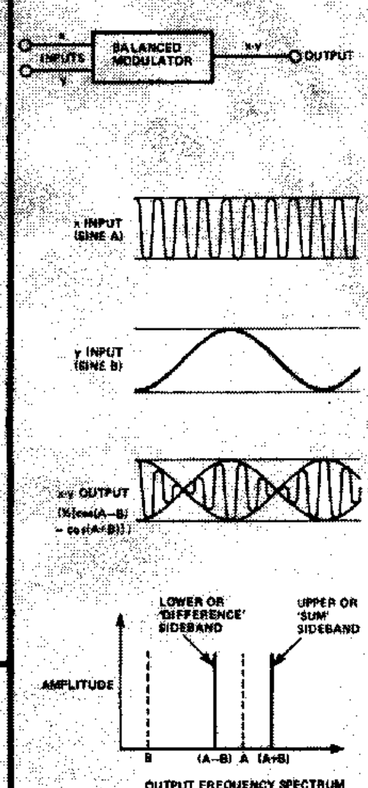


Fig. 12 (Above) Ring modulation.

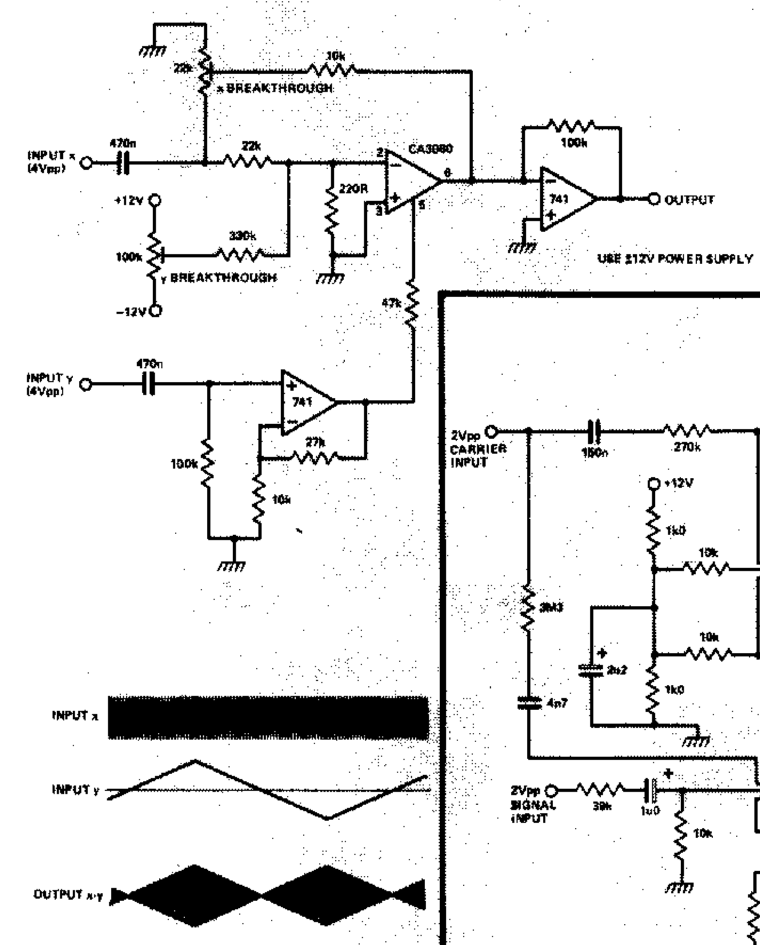


Fig. 13 (Left) Four quadrant multiplier (ring modulator).

Fig. 14 (Below) Another ring modulator circuit.