F. For intermediate time envelopes (those you need most of the time), the pitch shift is not negligable. It is likely to be most annoying on decay. This is most likely because the maximum shift is related to the most feedback, the top of the envelope. On attack, the envelope, being exponential, is moving very slowly in the top region. On decay, the envelope moves very rapidly away from the top region (concave exponential).

G. While psychoacoustical effects are important in hearing (or not) a significant pitch shift, the pitch shift itself is not psychoacoustical. This can be verified in two ways. First, a scope manually synchronized to the output frequency will jump forward on attack (lower freq.) and backward on decay (higher frequency). Secondly, instead of applying the envelope to change from triangle to cusp through the self-modulation loop, we have tried a switch between an already modulated VCO (cusp) and a second triangle from an independent oscillator. There is no pitch shift in this case.

H. It is possible to add the AC coupling not as shown in the figure above, but rather in the line at the point marked "a" in the figure. This is probably the most logical place since it also takes out any VCA offsets. It will also help with external modulation oscillator imbalances. The only problem with putting the capacitor here is that it has to charge when power is first applied, and until it does, the coupling acts like DC, and the pitch will shift downward, probably to zero, before returning to the proper position about 20 seconds later (for C = 0.82 mfd in this case and installed at "a" with the capacitor at the top of the density pot shorted out). This happens only once when power is applied, but if you have seen it - that's why.

From these results, we could draw the following conclusions. First, if you have built this oscillator, you might want to try changing the AC coupling capacitor from its original position to point "a", but this will not solve the pitch shift associated with dynamic depth self-modulation (a very high-order sharp cutoff high-pass might do this, but it is too much trouble). You can continue to use self-modulation as a static "spectral density" control, and you can continue to use external modulation without a pitch shift. Self-modulation, dynamic depth, should be considered a special effect only. If you haven't built this, you might want to consider leaving out the VCA part (as suggested in the original EN#75 writeup) and just keeping the self-modulation as a spectral density control. Keep in mind that there is nothing "wrong" with the design - just with one of the ways we suggested using it.

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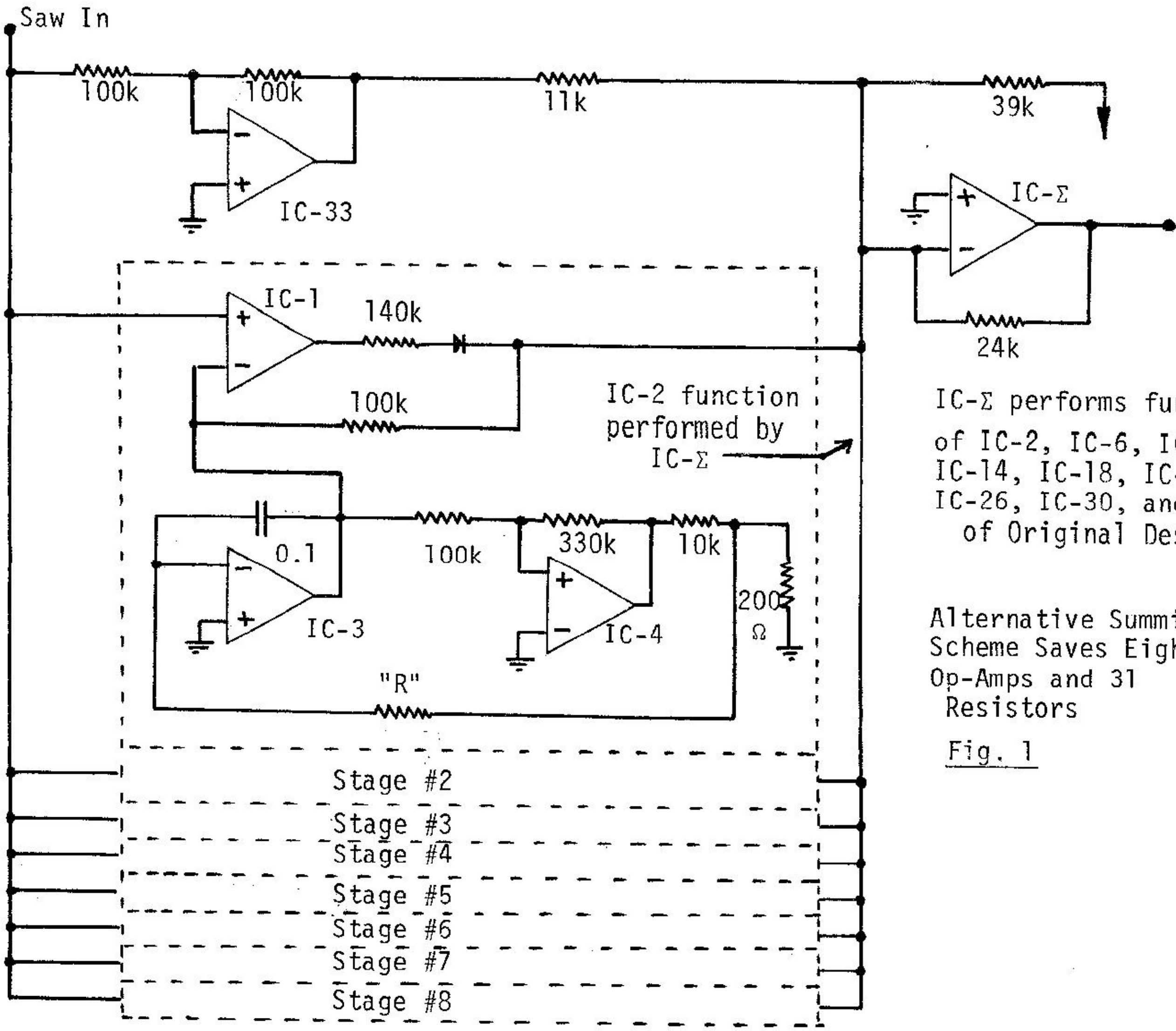
Multi-Phased Waveform Animator With Reduced Parts Count And Two Extensions:

-by Lester Ludwig

An observation shows there exist some unneeded summing in the original Multi-Phase Waveform Animator (EN #87) design. The summing in each stage (at the equivalent to IC2) can be performed directly at IC-Σ, and in this the eight additions of the inverted saw and dc terms (together with the "original direct through") need only be done once (with the appropriate coefficients). These points lead naturally to the circuit of Figure 1, saving 8 op amps and 31 resistors (reducing the cost and complexity by 25%). At first glance it may also appear that IC-33 is also unnecessary since the signal might be introduced with proper sign at the non-inverting input of IC-Σ. This will not work as constant impedance to ground is required of the inverting input (to obtain constant gain for this signal) and the impedance is constantly step-wise changing as the 8 diodes forward or reverse bias.

There is a good reason for still using the original design however, as buffered versions of the eight phase-shifted saws are available for further processing. In particular, the circuit of Fig. 2, a simplified level-shifted adapatation of the Eμ scheme presented in the same issue ("Minimum Parts Count Synthesizer," EN#87) provides concise saw-to-triangle conversion that could be used at each stage. Mixing these with a triangle output from the source VCO, one obtains the multiphase process for triangles



IC-Σ performs functions of IC-2, IC-6, IC-10, IC-14, IC-18, IC-22, IC-26, IC-30, and IC-34 of Original Design

Alternative Summing Scheme Saves Eight Op-Amps and 31 Resistors

Fig. 1

(see Figure 3), offering an animated sound with much lower harmonic content. Note this sound is distinct from low harmonic content sounds that result from lowpass filtering of the original MPWA sawtooth output (most likely this is true because triangles contain only odd harmonics while saws contain all harmonics). A devoted VCO is a good idea here (say a SSM2030 or CES3340 level shifted give a ±5V saw out) as the triangle converters require a well-defined sawtooth amplitude into the circuit. Trimming of the 140K value is required to null out the glitch in the sawtooth before the triangle converters are adjusted for proper shape. (I found most to trim up to about 130K to null the glitch). Summing of the phase-shifted

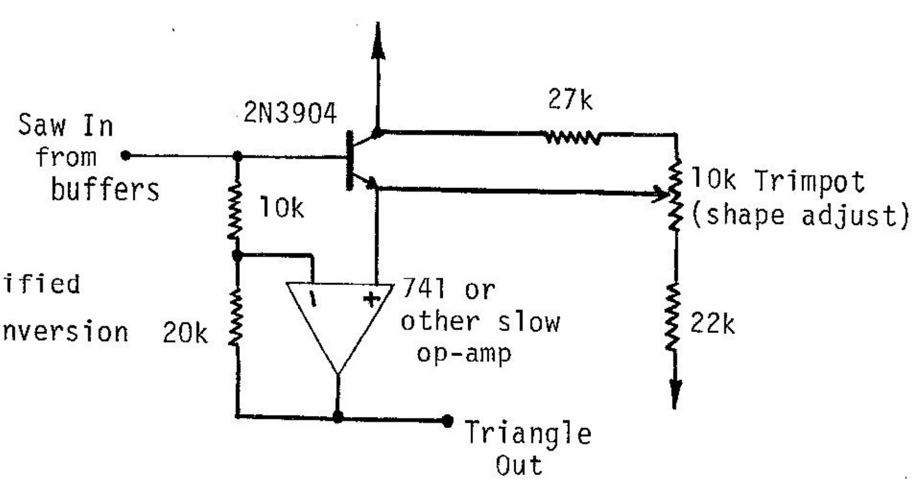


Fig. 2 Simplified Triangle Conversion

triangle waves is done by reproducing the summing structure around IC-34 of the original EN#87 design (see Fig. 3 below). Useful distinct sounds also result if triangle or sine waves are substituted for the sawtooth at the animator input (abuses #1 and #2 in Fig. 3). A devoted VCO setup should inculde a selector switch for this function. Either or both outputs of the animator can be used in Fig. 3.

Three desires to put forth on any of these designs are, 1) it would be nice to have some control over the degree of animation, 2) something might be done to obtain the same effect produced with lower frequencies at higher frequencies, and 3) though if you listen really hard you can hear the very slow shift (produced from the "R" = 16.17M stage) at times it seems questionable whether it is worth the hardware used to produce it. An answer is made to all of these via a brilliant suggestion by my perceptive wife, Myra: Devote this slowest stage to a variable speed control. Upon replacing the 16.17M resistor with the circuit of Figure 4

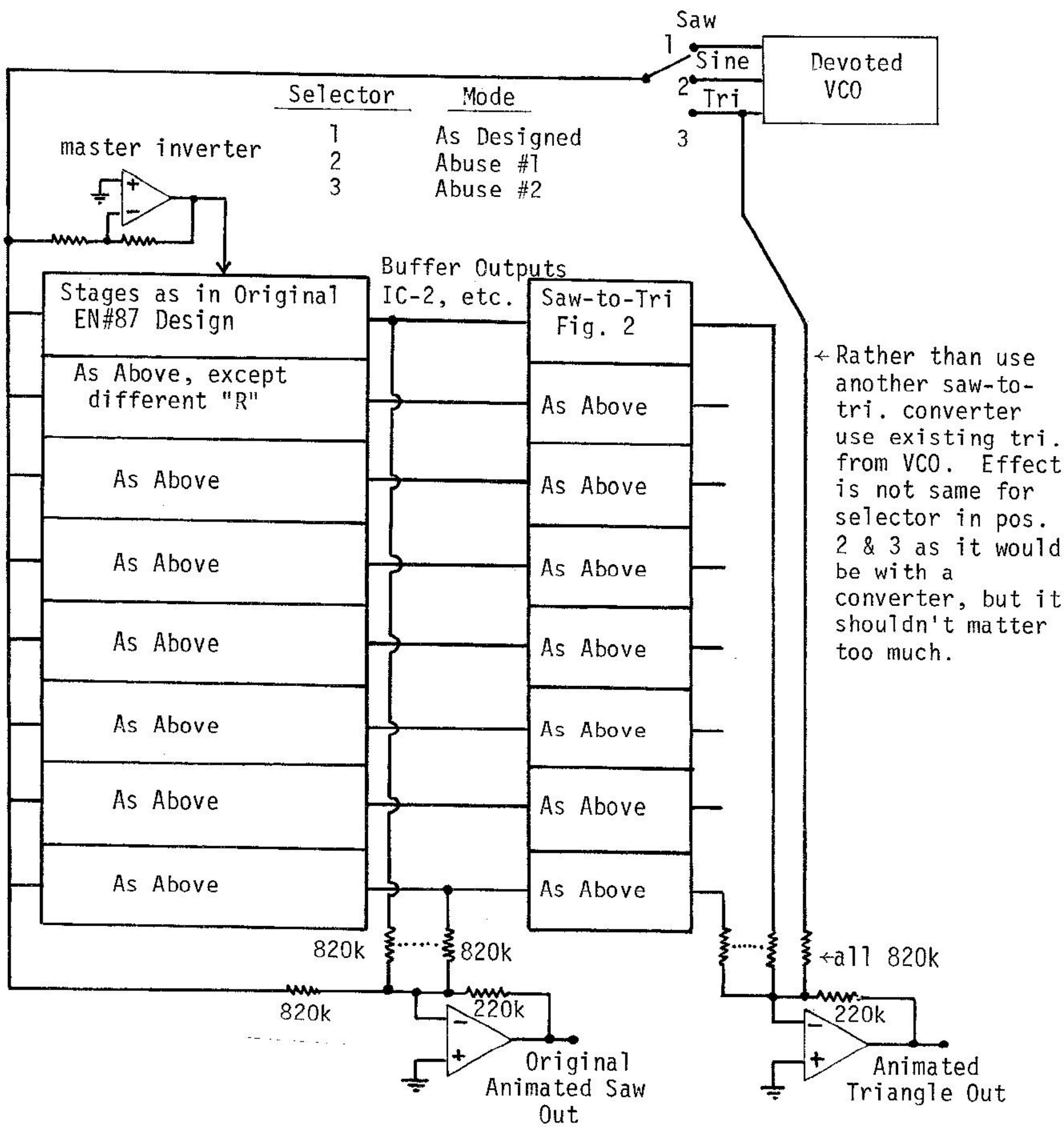


Fig. 3 Modifications of Original Design to Obtain Animated Triangle as Well as Saw

(I used a 1M log pot and 47K resistor), the perhaps otherwise dubious stage now offers an excellent appeal to the previous remarks 1 and 2. For some reason varying the speed of this single stage provides a good control over the overall animation effect (perhaps something like a weighting argument - i.e., the location of the center-of-mass of the animation speeds moves as the control is adjusted). With a high animation setting the high-frequency effect is similar to the low frequency effect at a lower animation setting. This suggests a meaningful voltage control port for the MPWA (as well as the answer to 3 above). Though I have yet to introduced such voltage control, the obvious thing to do is to replace the integrator in the 16.17M stage VCO with an OTA integrator. (Note that such depth controls may be added to any of the MPWA designs mentioned).

The MPWA is about the best new effect to come along recently. Everyone who is building should try one, and with the reduced-part version first discussed the encounter should be less frightening... I guarantee the result to be well worth 28 op-amps. Note this is $10 for semiconductors, about the same price as a filter chip.

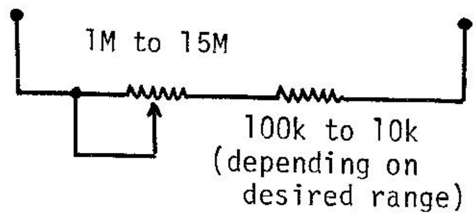


Fig. 4 Animation Depth Control

Replace the "R" resistor with this circuit

Editor's Note: One additional extension of the original animation scheme is under investigation and will be reported soon.

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A New Look At Pulse Width Modulation - Part 1: -by Bernie Hutchins

INTRODUCTION: Pulse Width Modulation (PWM) is generally available on most VCO designs. This is mainly due to the ease of implementation and the usefulness of the sounds obtained with PWM. Dispite the popularity of the effect, detailed information on PWM is not generally available, and the consequences of arbitrary variations among various implementations is little understood. In this part, we will be looking at the "quasi-static" case of PWM, based on Fourier series calculations and other simple procedures. In part 2, we will describe some calculation methods for PWM spectra, and also look at other interesting results.

THE "QUASI-STATIC" APPROXIMATION:

By "Quasi-Static" (QS) we mean that we are assuming that the instantaneous spectrum of the PWM waveform is the same as though the pulse width were fixed at the instantaneous width. Thus we treat a changing pulse width at each instance as though it were not changing. By way of analogy, we might examine the forces a car puts on a road as though the car were standing still. Naturally we expect that this QS approximation for the car is better when the car is moving very slowly (say one M.P.H.) than it is when the car is moving very rapidly.

We expect that if we actually vary the pulse-width rapidly, that the spectrum will show energy shifting from static harmonics to sidebands, in the manner of other modulation processes. In the QS approximation, we will ignore the sidebands as being of insignificant amplitude, and of insufficient separation from the static harmonic components, to be important. This QS case can be expected to apply, for example, when we vary the initial pulse-width control at a normal rate by hand, or when the pulse width is controlled by an envelope during a single extended musical note. A typical QS PWM situation is illustrated in Fig. 1. In one case, the user may adjust the initial pulse-width control slowly until he achieves a harmonic density and distribution that