ELECTRONOTES
1 PHEASANT LANE
ITHACA, NY 14850
(607)-273-8030

APPLICATION NOTE NO. 73
February 4, 1978

MULTI-PHASE SCANNING WITH SAWTOOTH WAVEFORMS

by Lester Ludwig & B. Hutchins

The circuitry described here is basically for the purpose of time shifting a sawtooth waveform. It can thus be thought of as a phase shifter for sawtooth waveforms. There are a number of applications that we have in mind for this, but we will be directing our design toward one where the sawtooth waves are controlling some other circuit that must be sequenced in a certain manner that requires several sawtooth phases.

A circuit that can be used to provide a voltage-controlled phase shift of a sawtooth waveform is shown in Fig. 1.

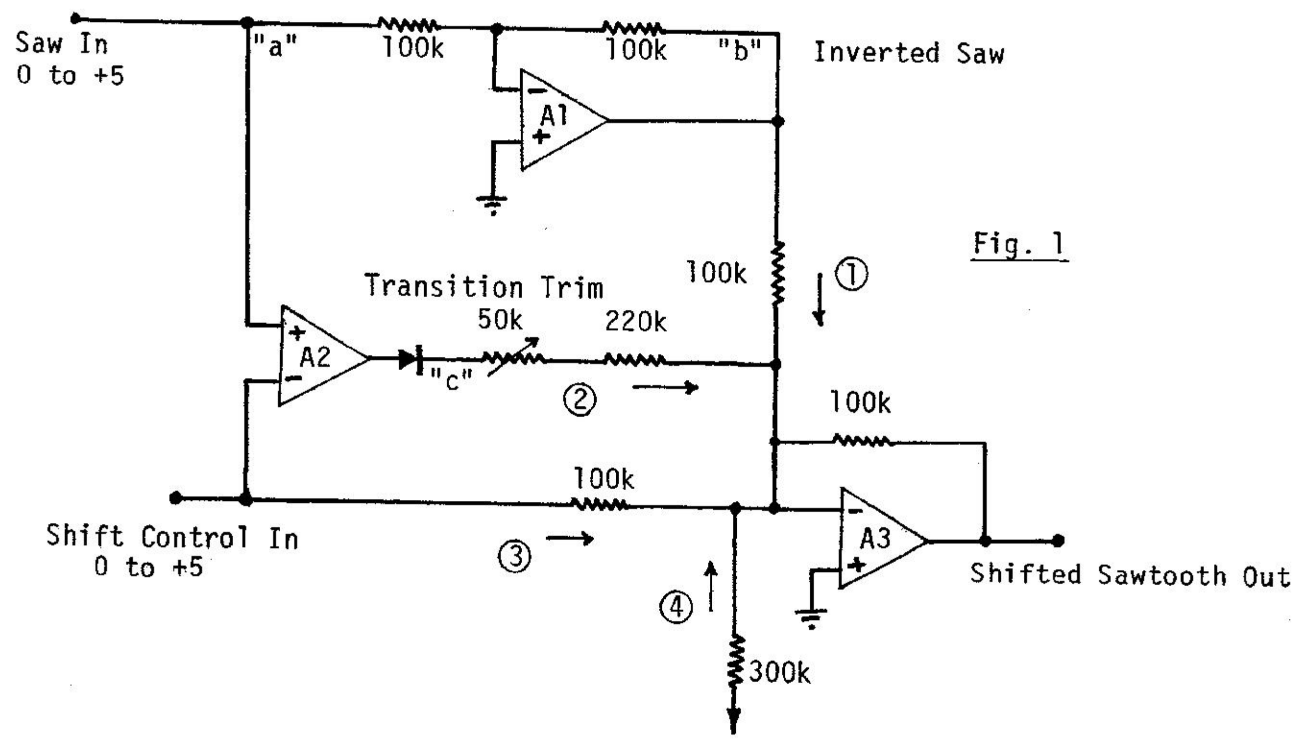

Fig. 1

In Fig. 1, op-amp A1 serves the simple function of inverting the input sawtooth. If there are many shifts to be accomplished, A1 can be used to drive all the sections, and only the A2 and A3 part of the circuit needs to be repeated. A2 is just an op-amp used as a comparator, and A3 is the usual type of op-amp inverting summer. Keep in mind that A3 is inverting in what follows. First, there are two negative voltage contributions ① and ④ in Fig. 1, which result in a positive output of A3. These contributions are ① the inverted sawtooth and ④ a constant -5 volts, so the output of A3 with only these two contributions would be a sawtooth varying from +5 to +10. This sawtooth is then brought down by contribution ③ which subtracts the shift control voltage from the output of A3. Finally, there is a contribution ② which (allowing for the diode drop and the fact that A2 does not reach its full supply voltage, but rather something like 13.7 on a 15 volt supply) subtracts 5 volts from the output of A3 whenever the comparator is high, which occurs when the sawtooth at the input goes above the level of the shift control voltage. Thus 5 volts is subtracted from a portion of the sawtooth, and this accounts for the change of phase as will be clear from Fig. 2.

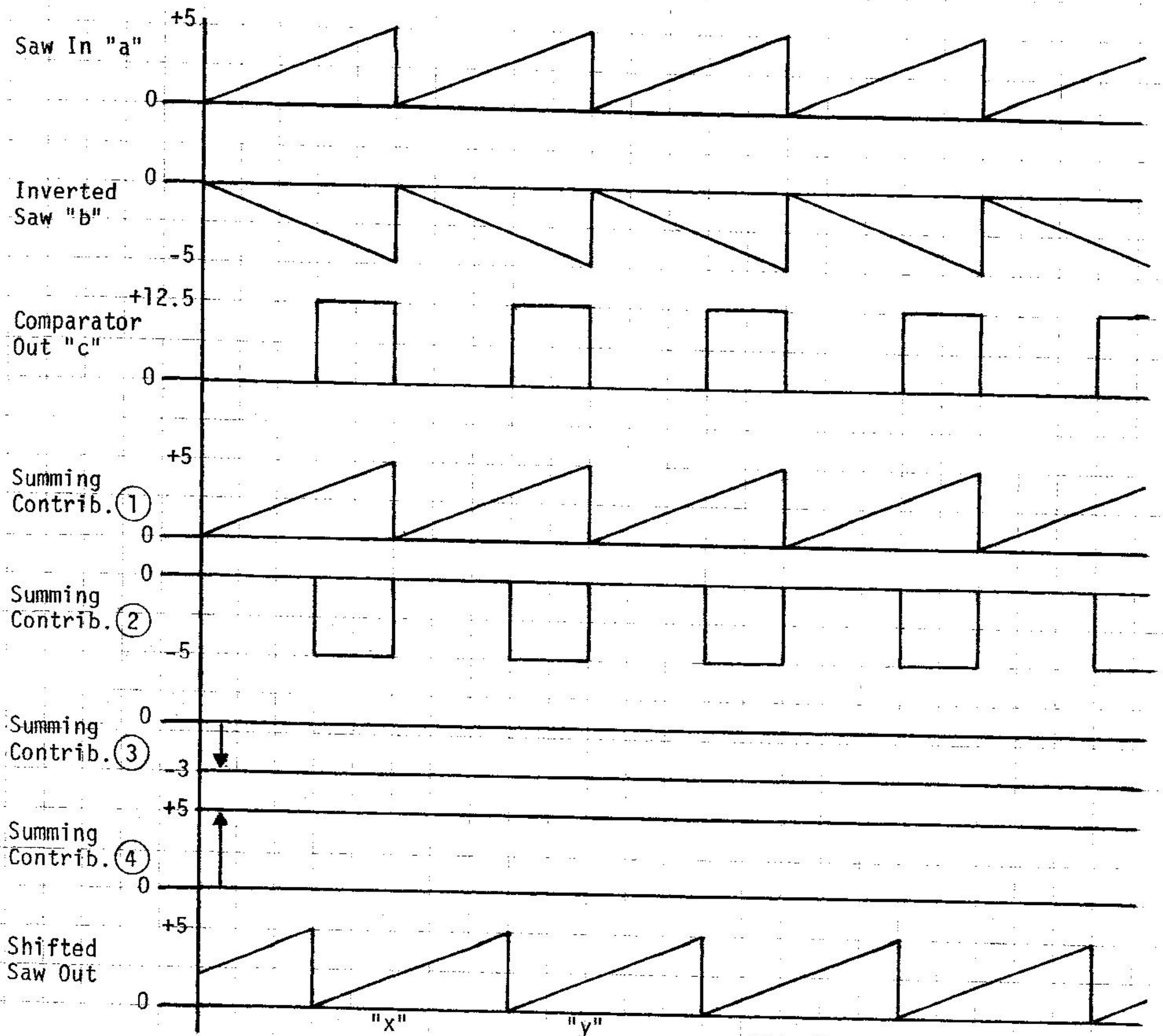

Fig. 2

A study of Fig. 2 will show that the waveforms and summing contributions from Fig. 1 do in fact add up to the shifted sawtooth shown. Note that the unshifted sawtooth results from a shift control voltage of zero or of +5, and the sawtooth shifts a full 360° for voltages between 0 and +5. The voltage "c" is something like 12.5 volts, but depends on the individual op-amp and diode, so the trimmer is used to trim out small discontinuities on the shifted saw out at points in the ramp such as those marked with "x" and "y".

APPLICATIONS:

The sawtooth shifter can be used to provide a voltage-controlled shift of a sawtooth wave, and is thus useful for adjusting the phase of function generators and voltage-controlled oscillators that provide waveforms based on a sawtooth wave. In some scanning applications, a single sawtooth sweep will work, but the sweep rate and corresponding acquisition time is limited by the speed of the device being swept. If we use n such devices and sawtooth sweep ramps shifted 360°/n apart, any region to be swept will be reached in 1/n of the original time, and acquisition time is speeded up by this sort of parallel processing. Note that in such an application, the shift control voltage can be provided simply by applying a resistor of 200k or greater between the +15 volt supply and the shift control in terminal in Fig. 1. For example, a 500k resistor would give a 2.5v control voltage and a 180° phase shift.