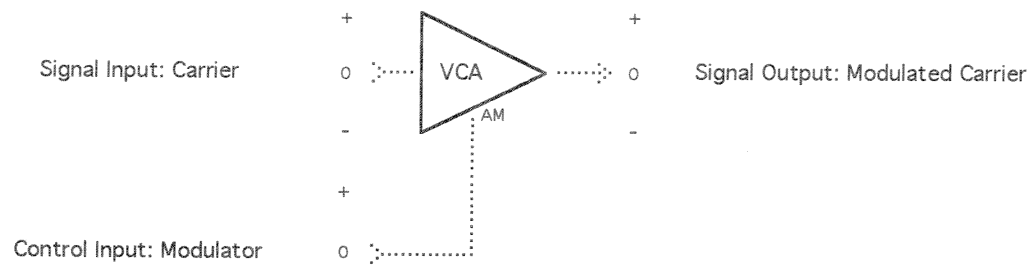
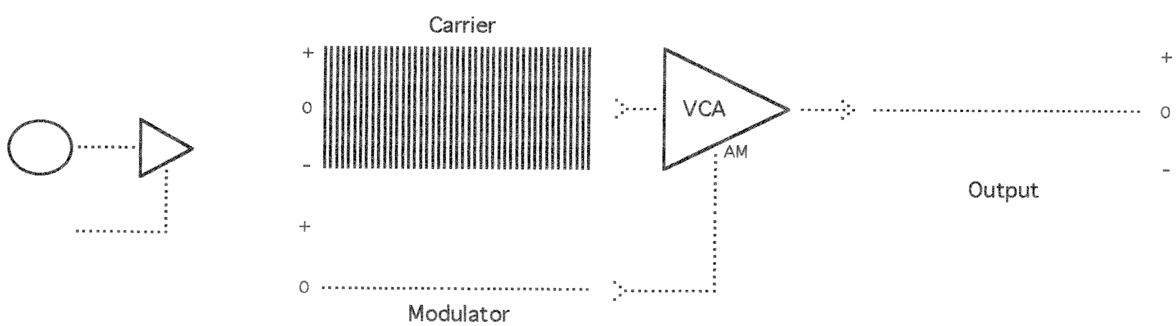
VCA: Voltage Controlled Amplifier

A VCA (Voltage Controlled Amplifier) is a *processor* that alters the *amplitude* of a signal proportional to control signal(s) routed to its AM (Amplitude Modulation) Control Input. Designs called TVA (Time Varying Amplifier), DCA (Digitally Controlled Amplifier), and *two quadrant multiplier* function similarly. The term "VCA" is used in this discussion.

The classic VCA is an analog device that can accept a bipolar signal at its *carrier,* or "signal" input, and a unipolar positive signal at its *modulator,* or "control" input. The resulting "signal" output, or *modulated carrier* is the *instantaneous product* of the two input signals; it is literally a *multiplication* of the respective amplitudes of *carrier* and *modulator* at each instant in time .

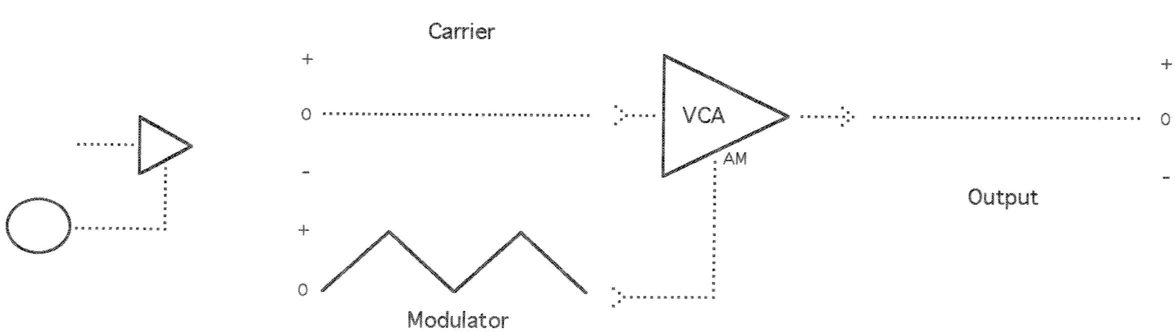


The VCA is an *amplifier.* This amp is designed so that when it is *biased* to zero (0) gain, no signal will pass through it. A carrier signal will pass through the VCA only if: (1) a positive (+) bias is provided; or (2) a positive signal is present at the *modulator* Input. The VCA is a *multiplier.* If bias = 0, when either the *carrier* or *modulator* signal has a instantaneous value of zero (0), even momentarily, there will be *no VCA* output at that instant. When no *modulator* signal is connected, there would be *no output* in a Voltage Controlled Amplifier (VCA) that is biased to zero (0) gain:



The user may change the internal *bias* signal to a *positive* value using a front panel control at any time. In this case the VCA is said to be "biased open," and when a *carrier* is present at the VCA Signal Input, it will pass through to its Signal Output. A *modulator* isn't required for VCA output.

When no *carrier* signal is connected, there is *no output* in a VCA, even if the VCA is biased to *full scale* positive (maximum gain). So, the *modulator* signal *as such* never appears at the VCA Signal Output, regardless of bias setting, or whether signal(s) are present at one or *both* Inputs:



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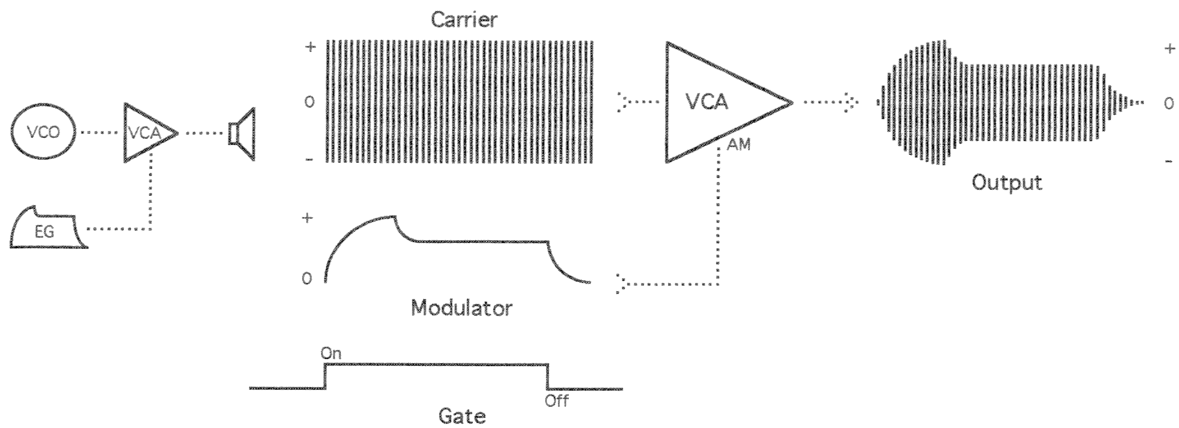
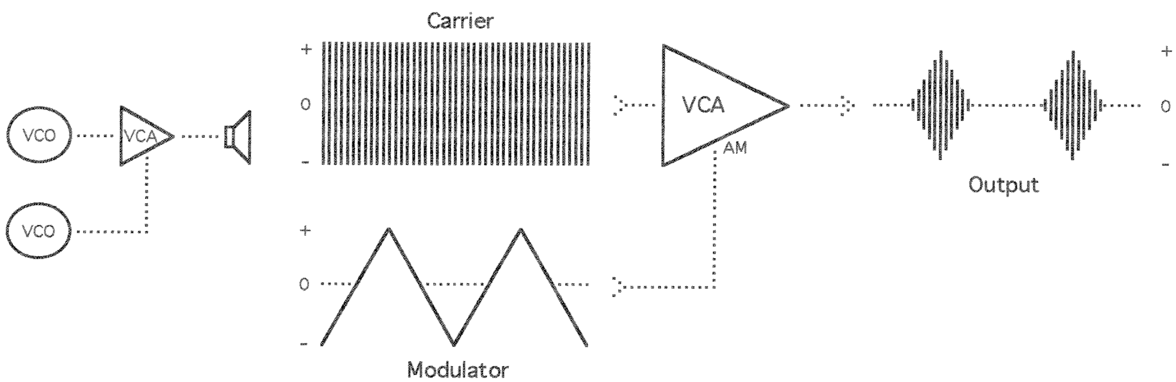
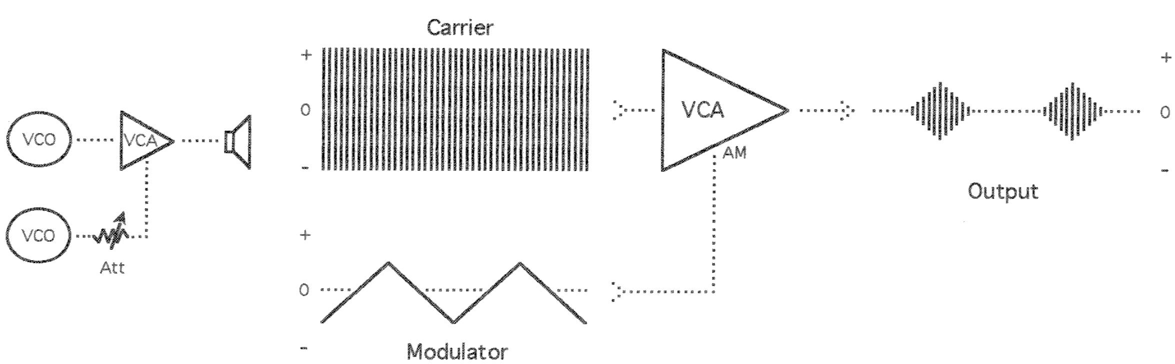
A combination of periodic and/or aperiodic signals may be selected as *carrier* and/or *modulator* as VCA Inputs. A typical configuration, *with zero VCA bias*: an audio frequency, periodic *carrier* signal, e.g. VCO output; and a subaudio, unipolar positive, aperiodic *modulator* signal, e.g. ADSR Envelope Generator (EG) output. When VCA Signal Output is monitored, then *articulated sound* will be heard (only) when the ADSR Envelope Generator's signal is enabled by a "gate" signal:



Tremolo is a slow, smooth, *repeating* change of loudness, requiring a *periodic* modulator signal. To use a VCA to impart tremolo to a *pitched* sound, *both* VCA input signals must be periodic :



The *carrier* VCO shown above is an "audio" device, *regardless* of its frequency, solely due to its *connection* to an audio *input* (through the VCA to the monitor). The *modulator* VCO is a "control" device because it is connected to a (VCA) *control input. When* tuned to a subaudio frequency, e.g. 5 Hz, this "control" VCO can cause tremolo. This particular *modulator's* polarity is *bipolar,* and when the VCA is biased to zero (0), output will occur only when the modulator signal is positive, i.e. every "half wave." It isn't smooth tremolo. *Attenuate* the modulator (see below) and listen:



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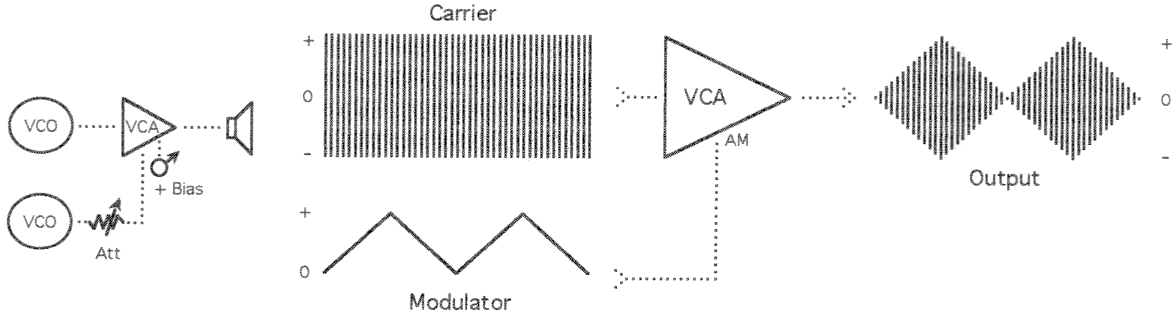
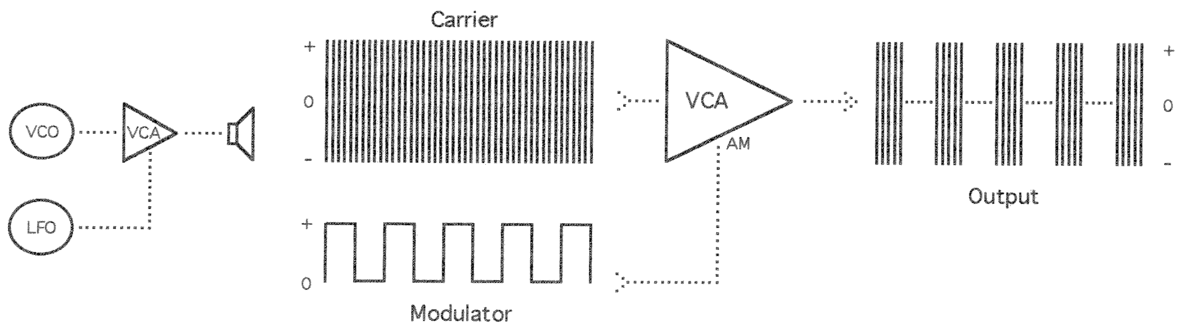
Attenuating the *modulator* signal does not change its polarity, only its *amplitude.* VCA output is subsequently reduced, but the *modulator* remains bipolar, and this continues to make "half wave" modulation. But, if we now add a *positive bias* of sufficient size to the bipolar *modulator* signal, the *sum* of these signals will then be a unipolar positive signal, and smooth tremolo can result:



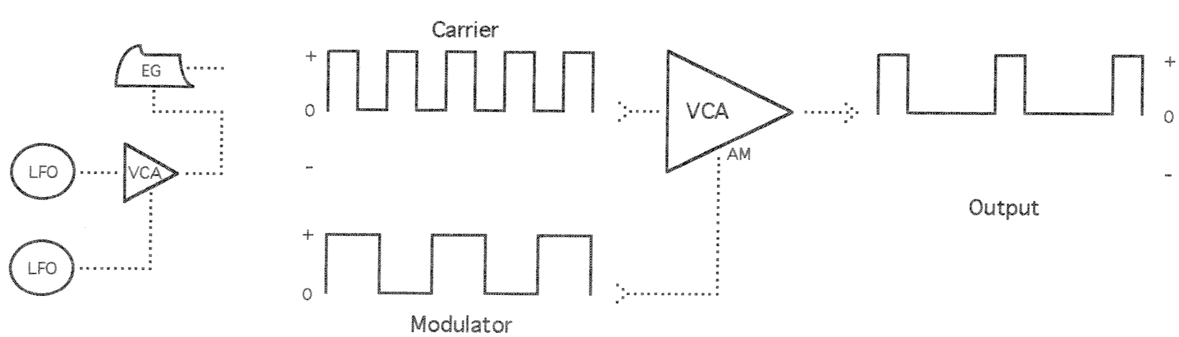
Some waveforms produced by the typical LFO (Low Frequency Oscillator) *are* unipolar positive. Attenuation or (+) bias may not be required when such a waveform is used as the *modulator.* As the diagram below indicates, the *modulated* carrier reflects the subaudio LFO *waveshape* aurally:



Using an LFO as a *modulator* in lieu of a VCO typically reduces patch flexibility. A VCO modulator could be controlled dynamically by another signal; the VCO can provide modulations with *dynamic rate.* LFO frequency is typically *biased* to a *static* frequency within LFO frequency span. And, the typical LFO *frequency span* (e.g. from a fraction of a Hertz to 50 Hz) is less than that of the VCO.

There is no justification for calling the VCA an "audio" device, though it is often used to process an audio signal (see examples shown previously). The Output Signal of a VCA may be connected to one or several of a *variety* of inputs, including audio, control, timing, and logic signal inputs. The signal processed by the VCA takes on the *function* of the input *type* to which it is connected.

The diagram below illustrates this principle. LFO signals function as both *carrier* and *modulator.* VCA Signal Output is connected to the *timing,* or *Gate* Input of the Envelope Generator. The VCA output will occur only when both carrier *and* modulator signals have positive values. Since both input signals have binary levels, the VCA effectively functions like a logical "AND" circuit that will "gate" the EG based on coincidence of logical "yes," or "on" conditions of *both* input signals.



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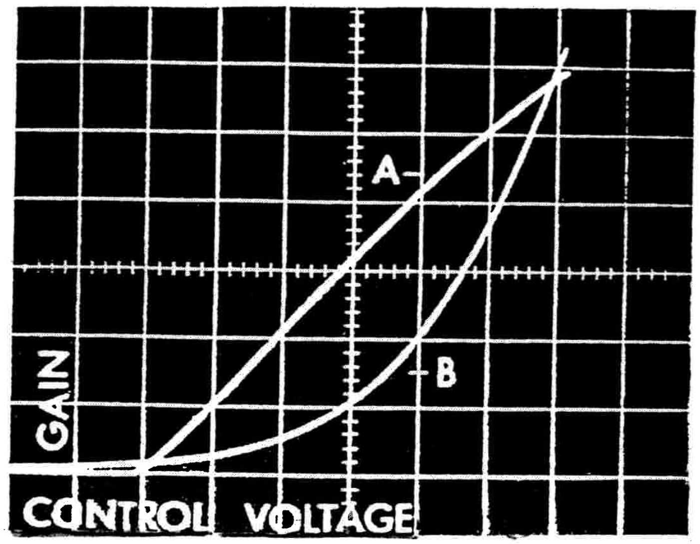
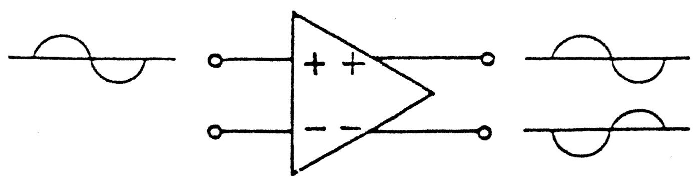
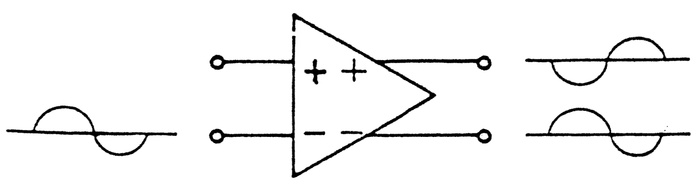
VCA Control Input Response



A = Linear Response: Gain vs Control Voltage
B = Exponential Response: Gain vs Control Voltage





VCA Differential Signal Inputs/Outputs

VCF Signal Input Frequency Response
AC = Capacitor Coupled (Rejects DC)
DC = Direct Coupled (Accepts DC)