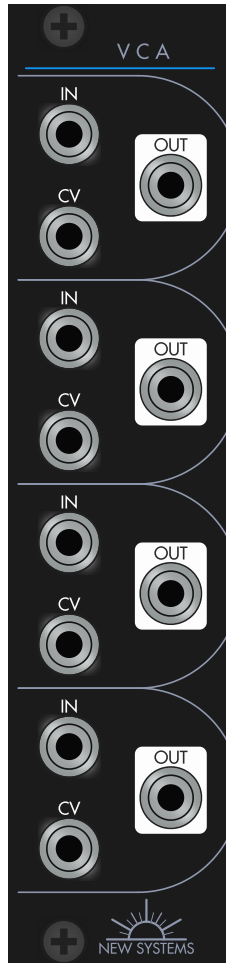


# VCA



Phaseless Multiplication

Manual Revision 1.0.1

## SPECIFICATIONS

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<b>Size</b>	6HP
<b>Depth</b>	22mm
<b>Power Consumption</b>	+12V 25mA -12V 25mA
<b>THD+N at 1kHz</b>	0.2% (max), ~0.05% (typical)
<b>Output Swing</b>	-10V+10V peak
<b>Input Range</b>	-10V+10V peak
<b>CV Unity</b>	5V
<b>Input Impedance</b>	85k $\Omega$
<b>Output Impedance</b>	150 $\Omega$
<b>Output Drive</b>	2k $\Omega$ (min), 20k $\Omega$ + (ideal)

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## INSTALLATION

Before installing the module, make sure the power is off. Attach the power cable to the module and to the bus. Double check the alignment of the red stripe (or the brown wire for a multicolor cable) with the markings on the module and the bus. The red stripe should correspond with -12V, as is standard in Eurorack. Check the documentation of your bus and power solution if you are unsure. Screw the module to the rails of the case using the provided screws. (M2.5 and M3 size screws are provided.)

New Systems Instruments modules all have keyed headers and properly wired cables. But please remember to double check the other side of the cable for proper installation with the bus. Additionally, if using a different power cable, note that not every company wires modular power cables such that the red stripe will align properly with a keyed header. While our modules are reverse polarity protected as much as is practical, it is still possible that you could damage the module, your power supply, or another module by installing the power cable improperly.

Lastly, please fully screw down the module before powering on your case. The electronics are potentially sensitive to shorts, and if the module is not properly attached to a case, there is a risk of contact with conductive or flammable matter.

## BASIS

This VCA implements a *phaseless multiplication*. It can be characterized by the following function:

$$f(x, a) = \begin{cases} x \times a & a \geq 0 \\ 0 & a < 0 \end{cases}$$

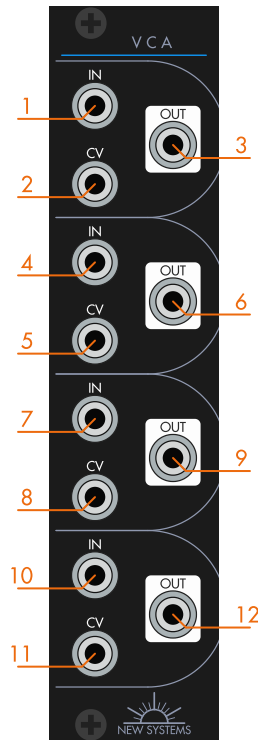
## EXPLANATION

Multiplication is a symmetric, binary function that affects two aspects of a signal: amplitude and phase. Often it is desired only to control amplitude, without also controlling phase. This is accomplished by a phaseless multiplication, more commonly known as “two-quadrant” multiplication (from electrical engineering). This function is no longer symmetric, but instead accepts an input signal  $x$ , and a controlling signal,  $a$ , which it treats differently. While the input signal is unconstrained, the control signal alters the amplitude of the input signal without being able to change its phase. Any control value below zero will simply set the output to zero.

Like any stateless function, phaseless multiplication can be characterized by a set of curves mapping  $x$  to an output value for each value of  $a$ . The accuracy of these curves, how closely they implement the desired multiplication function, can be assessed by two different metrics. On the one hand, there is the accuracy of the map between the input and output: for any given value of  $a$ , the linearity of the mapping between  $x$  and the output. This is generally measured as THD + noise, which is the relative level of every aspect of the signal that differs from pure transparency. (Or sometimes by THD alone, this unwanted difference in so far as it correlates with the input signal). On the other hand, there is the accuracy of the mapping between various values of  $a$  and the resulting amplitudes of the output. This does not have a traditional way of being measured, but it is potentially of equal or greater importance in synthesis.

This VCA is extremely accurate, both in terms of THD + noise, and in terms of the linearity of the mapping between  $a$  and the output amplitude.

## INTERFACE



1. First VCA: Input,  $x$ .
2. First VCA: Control,  $a$ .
3. First VCA: Output,  $f(x, a)$ .
4. Second VCA: Input,  $x$ .
5. Second VCA: Control,  $a$ .
6. Second VCA: Output,  $f(x, a)$ .
7. Third VCA: Input,  $x$ .
8. Third VCA: Control,  $a$ .
9. Fourth VCA: Output,  $f(x, a)$ .
10. Fourth VCA: Input,  $x$ .
11. Fourth VCA: Control,  $a$ .
12. Fourth VCA: Output,  $f(x, a)$ .

## USING THE VCA

To use the VCA, take a signal path from one module to another, and plug the VCA in the middle of that path. Then apply some kind of control signal to the CV input. The level of the control signal will control the level of the VCA's output.

This VCA is not designed for any one function over another. It should accept a wide range of frequencies and levels in each of its inputs and behave appropriately. Unity is set at +5V, which matches general practice in Eurorack as closely as possible. Note, however, that some envelopes are 0–+8V. This should work fine, too—the signal will be amplified—but do be aware that any amplification necessarily decreases the headroom available, both within the VCA and in subsequent modules.