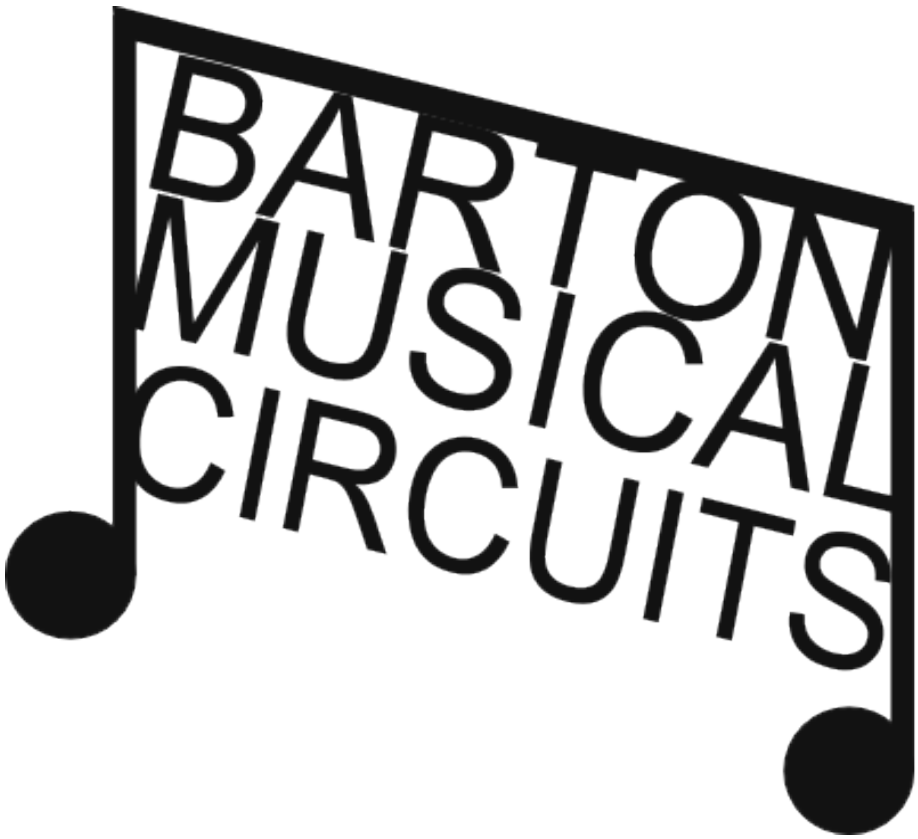


BMC 093. Diode Shaper VCA
Build Documentation.

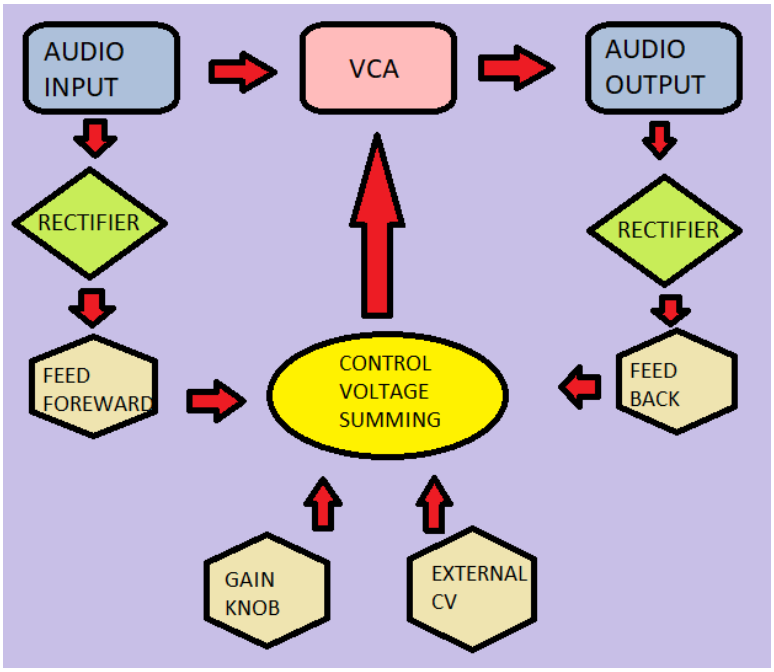
Current PCB Revision: 1
Last updated – November 29, 2022

I. Using The Module.

This module is a VCA that uses rectified feedback/feedforward to provide waveshaping. Both the feedback/forward knobs can provide positive or negative feedback and the external CV control is an attenuverter. It also includes switchable Zener diode limiters to soften the output when large amounts of positive feedback are used.

The module is DC coupled, so it can be used with LFOs, Envelopes and CV sources as well waveforms. The DC coupling also allows for DC offset to be applied to the input which increases harmonic possibilities.

To the right is a diagram showing how signal flows in the module.



CONTROLS

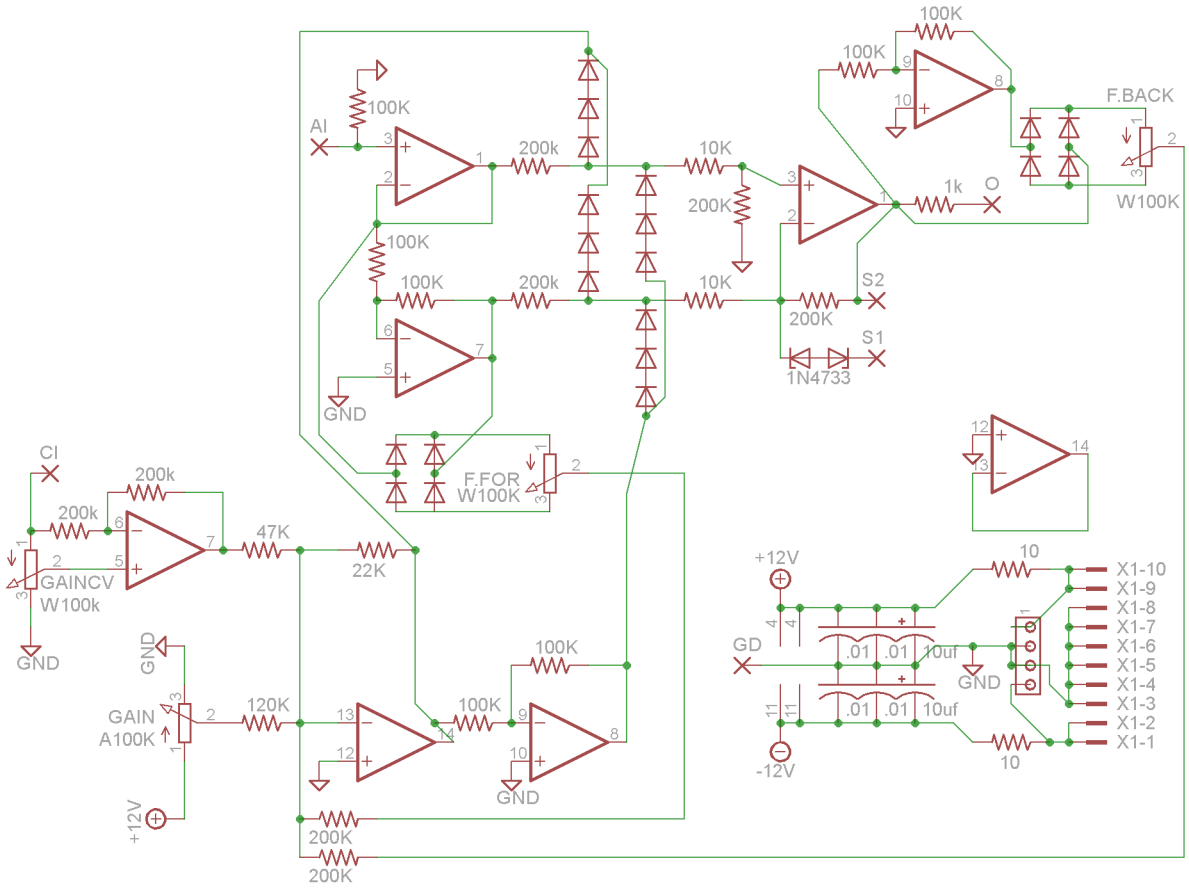
1. Gain Knob – This sets a baseline of gain for the module.
2. CV Knob – This controls the amount and polarity of external control voltage modulating the gain. Pointed straight up, no CV is added. As you turn it to the left, negative signal is applied and to the right positive.
3. Feed forward Knob – This controls the amount and polarity of rectified input signal is used to modulate the gain. Pointed straight up, no signal is added. As you turn it to the left, negative signal is applied and to the right positive.
4. Feed back Knob - This controls the amount and polarity of rectified output signal is used to modulate the gain. Pointed straight up, no signal is added. As you turn it to the left, negative signal is applied and to the right positive.
5. Zener Toggle – This enables Zener diode limiting, this limits the output of the module to +/-5V. This will change the sound of the module, but make it easier not to overload equipment that's sensitive to large voltage swings.

INPUTS/OUTPUTS

1. Audio Input – The main signal input of the module. This is DC coupled, so any signal can be input and works fine when used as a normal VCA. The wave shaping functions will have very little effect on square/pulse waves, it's most useful with triangle, sine waves or waveforms that have been filtered by a low pass filter.
2. CV Input – Input a signal to modulate the gain of the VCA.
3. Output – The signal output.

MP3 DEMOS

Demo 1. Zener clippers off, triangle wave in and an envelope generator is introduced halfway through. Just adjusting knobs and trying to get different sounds.
Demo 2. Same as demo 1 but with Zener clippers on.



II. Schematic.

Above is the schematic for this module. In the top center of the diagram is the wirepad “AI” (Audio Input) which is the main input. It connects to an op-amp buffer and to a 100K resistor providing ground reference. The output of the buffer goes to another op-amp wired as an inverter. The outputs of these two op-amps are then sent to two different sets of diodes doing different things.

Below the first two op-amps we see 4 diodes arranged as a full wave rectifier. The outputs of the rectifier are sent to the outside lugs of a potentiometer. This makes it so when the pot has equal resistance to both sides, the positive and negative signals will cancel each other out at the wiper. The wiper of the pot goes to the CV summer below.

Next, the first two op-amps outputs go through 200K resistors to 6 diodes in series each. The cathode of the first diode and anode of the last diode are connected to the outputs of the CV summers. These diodes act as voltage controlled resistors, as the difference in voltage between the first cathode and the last anode becomes smaller, the resistance lessens. Together with the 200K resistor in series these form a voltage controlled attenuator, which when amplified becomes a voltage controlled amplifier.

After the attenuation, the two signals are routed to a differential amplifier. In addition to making the signal louder, the differential amplifier will also negate any CV feed through going into the signal. The 10K and 200K resistors set the gain of this amplifier and the zener diodes are in its feedback path in series with a toggle to switch them in and out of the circuit. A 1K resistor connects the output to this differential amp.

The output signal is also fed into an op-amp wired as an inverter. The output and it’s inverse are then sent to another full wave rectifier for feedback, working like the diodes/potentiomter for feed forward.

On the left is the control voltage input (wirepad "CI" for "Control Input"). It connects to an op-amp and potentiometer wired in the attenuverting arrangement. (Read the schematic section of this doc for more info on attenuverters) It's output is then summed with the output of the gain knob and the feedback/feedforward pots by an inverting amplifier. The inverting amplifier has a 22K resistor in it's feedback path to attenuate all the input signals. The output of this amplifier connects to the first cathodes of the diode series. This voltage is then inverted and sent to the last anodes of the diode series.

On the right we see an unused opamp wired to use no current, and then the power connections. The PCB has footprints for MOTM and Eurorack style power connectors in parallel. The voltage rails are filtered by passive 10 ohm/10uf low pass filters, and .01uf capacitors are placed next to the power pins of all ICs to provide extra high frequency filtering.

III. Construction

A. Parts List

Semiconductors

Value	Quantity	Notes
TL074	2	14 pin DIP – TL064 will also work
1N4148	20	
1N4733	2	Or other Zener rated for voltage around 5V

Resistors

Value	Quantity	Notes
10 ohm	2	5mm lead spacing. Use 3.5mm body length or stand up
1K ohm	1	
10K ohm	2	
22K ohm	1	
47K ohm	1	
100K ohm	7	
120K ohm	1	
200K ohm	8	
A100K Potentiometer	1	PC Mounted 16mm/17mm. Like this.
W100K Potentiometer	3	B100K will also work if W100K is hard to find. Using a pot with a center detent makes the module easier to use overall. Using a value other than 100K for the feedback/forward will affect the performance.

Capacitors

Value	Quantity	Notes
.01uf	4	Small ceramic disc. Value not critical
10uf	2	Electrolytic

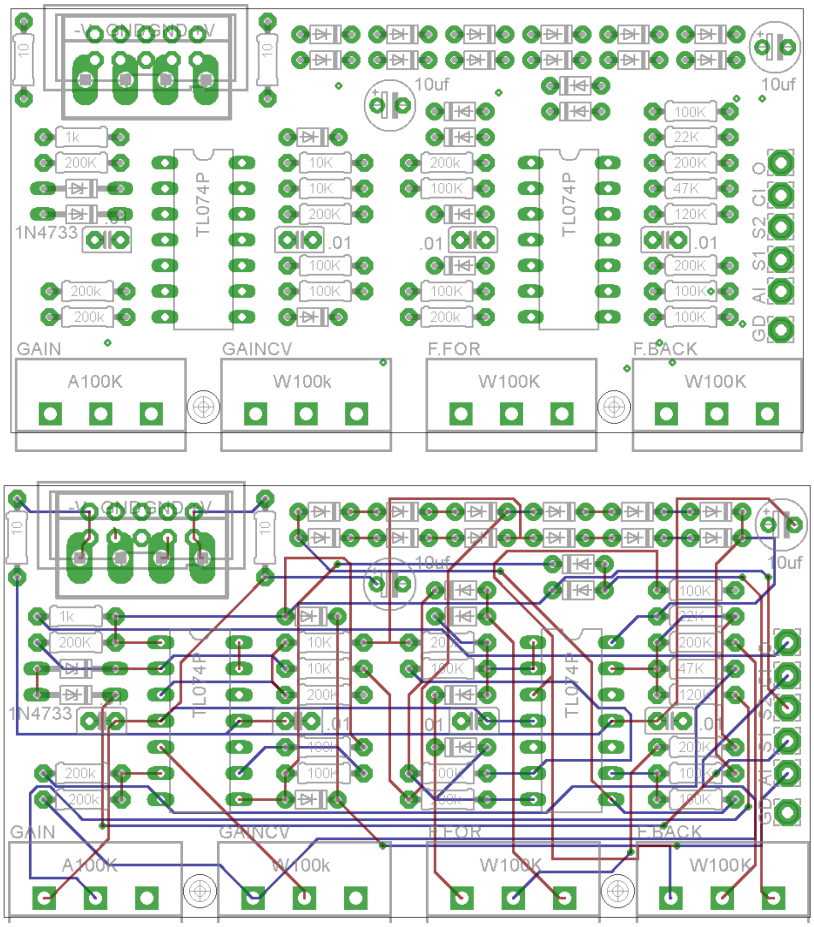
Other/Off Panel

Value	Quantity	Notes
Power connecter	1	Eurorack or MOTM style
Jacks	3	
SPDT Toggle	1	
14 pin DIP Socket	2	
Knobs	4	

B. PCB Layout

Below are renderings of the PCB. The rendering showing the traces does not show the ground fill plane, so assume any missing connection is a ground fill.

The PCB measures 78mm x 42mm and the pots are spaced 20.32mm apart.



C. WIRING

Connect the wirepads as follows:

GD – Ground – wire to the sleeve of any jack

AI – Audio Input – Wire to the tip of your input jack.

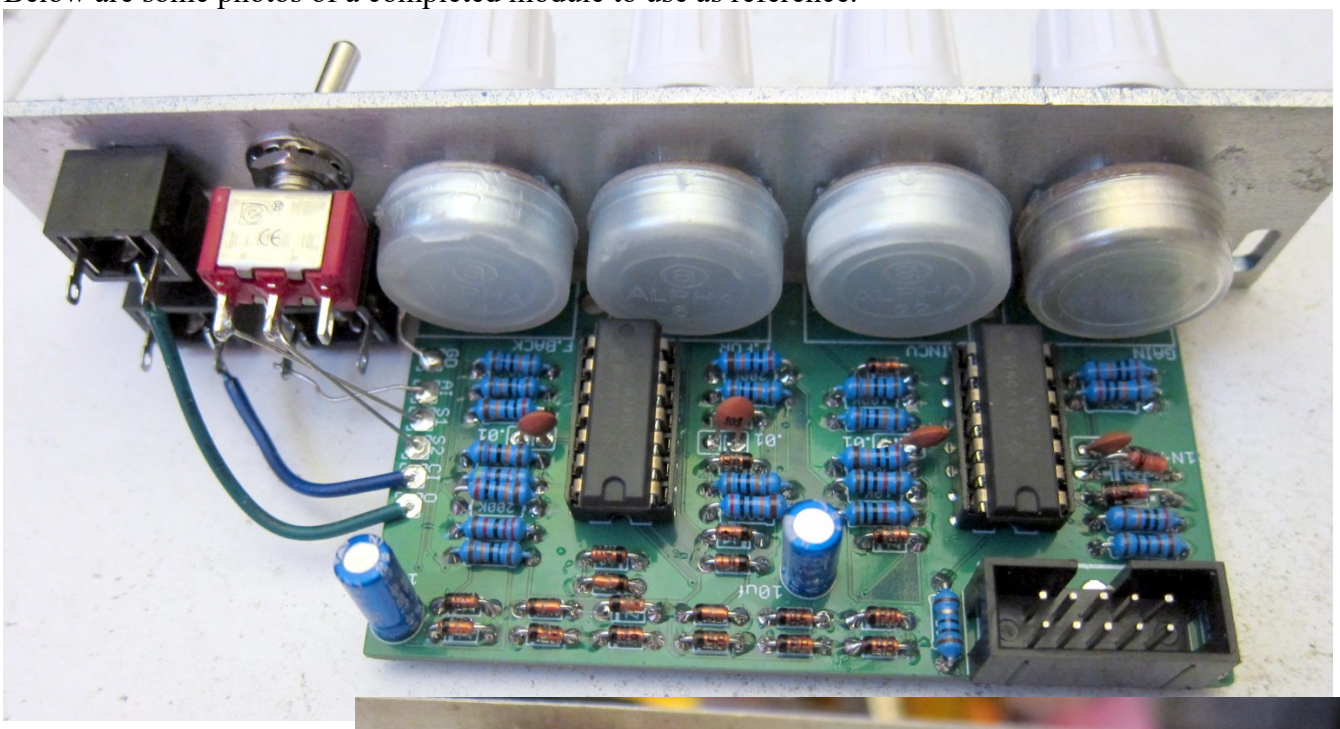
S1 – Switch 1 – Wire to the middle lug of the Zener toggle

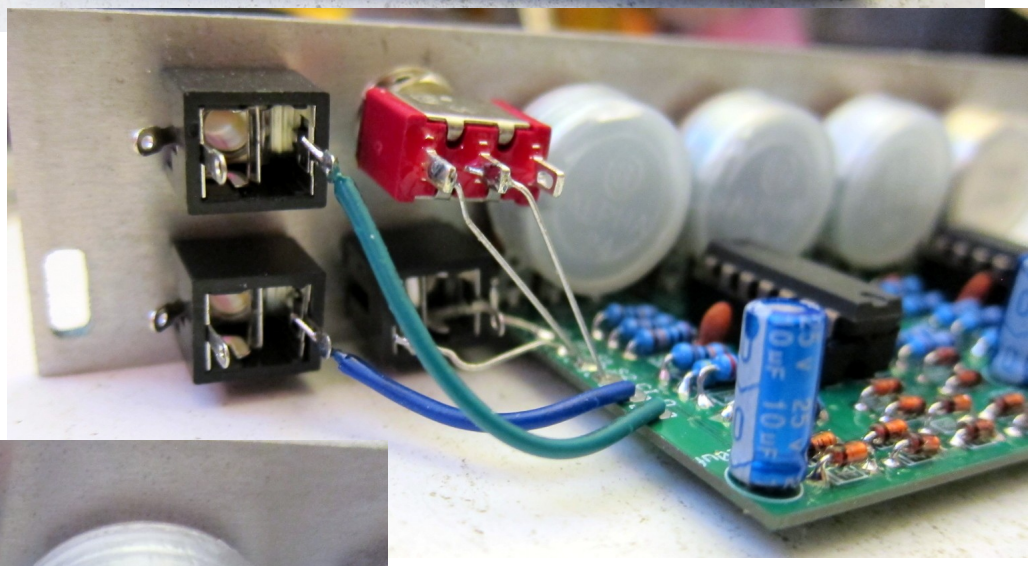
S2 – Switch 2 – Wire to the bottom lug of the Zener toggle

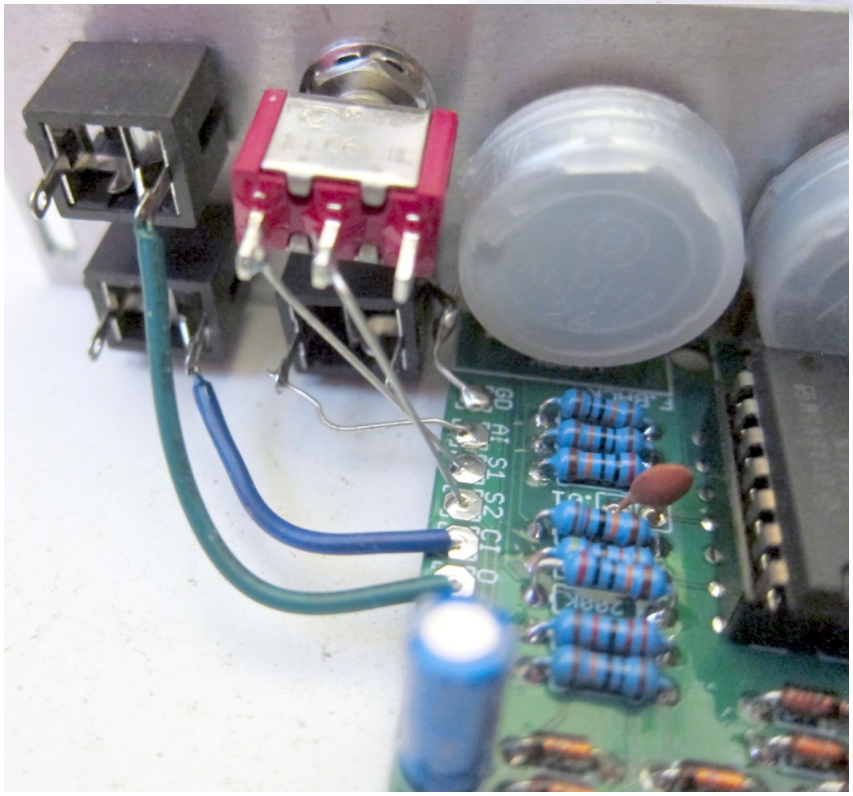
CI – Control Input – Wire to the tip of the CV input jack

O – Output – Wire to the tip of the output jack.

Below are some photos of a completed module to use as reference.







D. Tweaks/ Modifications

0. +/-15V Systems – The module should work with 15V systems without modification, the gain knob may heave some dead space on it. Increasing the 120K resistor to a 150K should help with this.

1. AC coupling the input – You can add a .1uf capacitor between the Input jack and the "AI" wirepad to AC couple the input. This will make feedback/forward work more symmetrically with waveforms that have slight unintentional DC offset.

If you find you don't use the Zener switch very often, you could rewire things to make AC coupling switchable. This would be done as follows:

Step A – Remove the wires going to the zener switch, this will leave the switch permanently disengaged. If you wanted it permanently engaged, then jumper S1 to S2.

Step B – Solder a .1uf capacitor from the center lug to the bottom lug of the SPDT

Step C – Wire the input jack to the center lug of the SPDT and then the bottom lug to the "AI" wirepad. This will make it so that when the toggle points up, you're DC coupled and pointing down you're AC coupled.

2. Softening the Zener – If the zeners are choking the signal too much for your liking, you can put a resistor in series with them so that they'll affect the signal less, allowing for more dynamic range. The value of the resistor should be between 1K and 200K. The larger the resistor value, the less the signal will be compressed by the zeners, try a 47K to start with if you're really not sure.

The easiest way to install this is to remove a wire going to the zener switch, then solder one end of the resistor to the now empty lug. Then solder the wire to the other end of the resistor.

3.Adjusting control balance – Adjusting the resistor values at the CV summing point for the 4 knobs can help you adjust how fine or coarse the controls work. Below is a rendering of the PCB with the appropriate resistors highlighted. Increasing a resistor value will make that knob have less effect on the signal and lowering the resistor value will increase that knob's effect.

Yellow – CV Knob
Blue – Gain Knob
Green – Feed Forward
Orange – Feed Back