Vulpus Labs

Pow!

Introduction

Pow! is a simple non-linear voltage-to-voltage converter which applies a power function to the input signal, with a curve that maps 0v to 0v and +5v to +5v while passing through a midpoint (*x*, *y*) where +*x*V is mapped to +*y*V.

The values of *x* and *y* can be set via knobs or by dragging a control point on the display, and can also be modulated by input signals.

For negative voltages (-5v to 0v) either an inverse curve is applied, mapping -5v to -5v and -*x*V to -*y*V, or the signal is rectified, mapping -5v to +5v and -*x*V to +*y*V. Scaling and DC bias can also be added post-rectification.

Theory of Operation

Input voltages in the range -5v to +5v are mapped into the numeric range -1 to 1, and transformed with the power function

$$y = |x|^{\frac{log(mid_y)}{log(mid_x)}}$$

where $(0.001 \leq mid_x \leq 0.999,\ 0.001 \leq mid_y \leq 0.999)$ is the midpoint position through which we want the resulting curve to pass.

The alert reader will have noticed that the transformation is really governed by a single exponent $y = |x|^n$, in the range

$$\frac{log(0.999)}{log(0.001)} \leq n \leq \frac{log(0.001)}{log 0.999)}$$

which is naturally 1 whenever $mid_x = mid_y$.

We could have opted to control this with a single knob and/or CV input. However, having a controllable midpoint means we can combine modulation signals in some interesting ways, where the value of mid_x affects the influence of mid_y on the value of the exponent *n* (and hence the shape of the curve), and vice versa.

After the power function transform, the resulting value $0 \leq y \leq 1$ is mapped back into the range -5v to +5 in one of three ways:

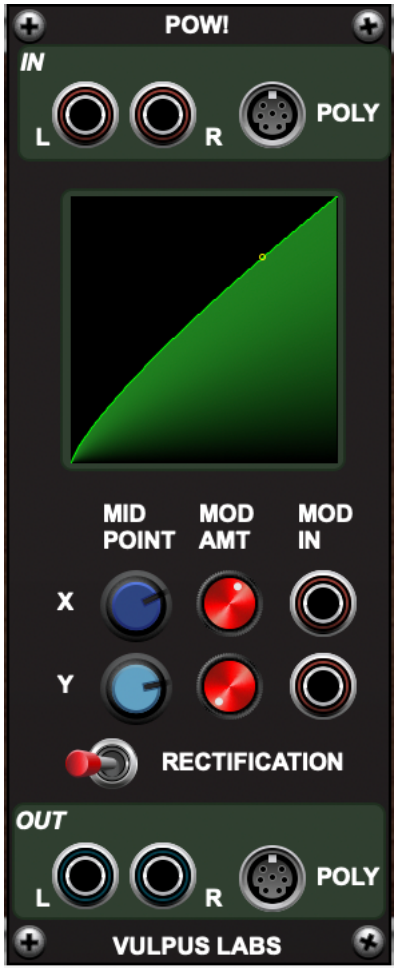
- **No rectification**: if $x < 0$ return $-5y$, else return $5y$
- **Rectified**: return $5y$
- **Rectified and scaled/bias corrected**: return $10y - 5$

Here are the some examples of the transformations these can produce on a simple sine wave:

	Unrectified, midpoint at (0.5, 0.5), signal is passed through unchanged
	Rectified - lower part of signal is inverted, doubling frequency
	Rectified with DC correction and scaling - rectified signal is boosted 100% and re-centred around 0v
	Unrectified, midpoint at (0.75, 0.5) - sine wave shape is “thinned”
	Unrectified, midpoint at (0.75, 0.5) - sawtooth wave is “non-linearised” (straight lines turn curvy)
	Uncertified, midpoint at (0.5, 0.9) - triangle wave is “fattened” and smoothed out
	Modulating the midX position with a second oscillator to create a more complex waveform

And here is a simple mono instrument with the output of an ADSR envelope generator fed into the midpoint *Y* control:

Controls



There are three **IN** jacks, **L**, **R** and **POLY**. If only the **L** jack is connected, a mono signal is processed and sent to both the **L** and **R** output jacks. If both **L** and **R** are connected, a stereo signal is processed. If **POLY** is connected, then all active polyphonic channels in the input are processed and sent to the **POLY** output jack.

The curve display shows the shape of the curve, with the midpoint marked out with a small circle. Click anywhere within the display to move the midpoint to that point.

The midpoint is also controlled with the **MID POINT X** and **Y** knobs. These can also be modulated by a CV signal connected to the **MOD IN X** and **Y** jacks, with the **MOD AMT X** and **Y** knob controlling how much the CV signal affects the midpoint.

The **RECTIFICATION** knob selects the rectification mode (*left* = no rectification, *middle* = rectified, *right* = rectified and scaled / bias corrected).

Take outputs from the **OUT** section at the bottom.

Credits and Acknowledgements

Pow! was written by Dominic Fox in October 2024.

Thanks to the developers at Cherry Audio for their great products, especially Voltage Modular.