SERGE

PAPERFACE

50TH ANNIVERSARY EDITION

A BASIC USER'S GUIDE TO THE
SERGE TCHEREPNIN SYNTHESIZER

V0.1

RANDOM×SOURCE

PAPERFACE

PAPERFACE 50TH ANNIVERSARY EDITION

INTRODUCTION

> *Designing the first generation of Serge modules in 1972-73 was a stab in the dark. Today, the redesign of these modules is like opening a door to a new universe. VCOs that track. Dual programmers featuring built-in sequencing and a metronomic clock. Silver on enamel panels, yet keeping to the spirit and patch-programmability of the original paperface panels. Glad to announce the first of several 50th anniversary Serge panels !*
>
> *Serge Tcherepnin*

In the early 70's, Serge Tcherepnin began to design and build a modular synthesizers while teaching at California Institute of the Arts. These synthesizes were quite unique in many ways - using banana jacks and test cords to connect elements on a grid-like structure with archaic-looking geometric graphics on the front panels. These new synthesizers stirred quite a bit of interest among other professors, students, and musicians and marked the beginning of Serge Modular Music Systems in San Francisco.

The way the front panels of these early systems were made would later be know as the "paperface": For each module, the panel graphics would be printed or copied onto a piece of paper. These would then be attached to pre-drilled aluminium panels so that top and bottom edges of these pieces of paper would fold over on to the back of the panel before they would be covered over with a single piece of transparent adhesive mylar film.

On the technical side, the Paperface systems were quite revolutionary for that time - the operational amplifier had only been invented a couple of years earlier.

Before you start

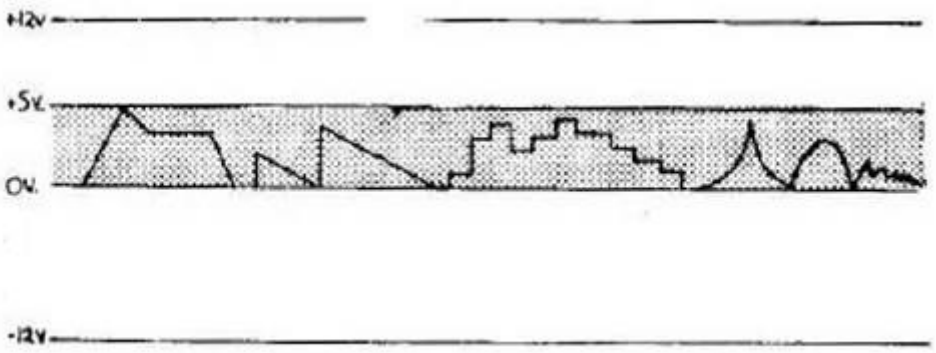
The Paperface 50 system is designed to be powered by a linear Serge PSU (providing +/-12V). Using any other PSU is not recommended and may damage the system. Feeding any of the inputs (or outputs) with voltages outside a +/-12V range may damage the module. This type of damage is not covered under warranty.

SIGNAL TYPES

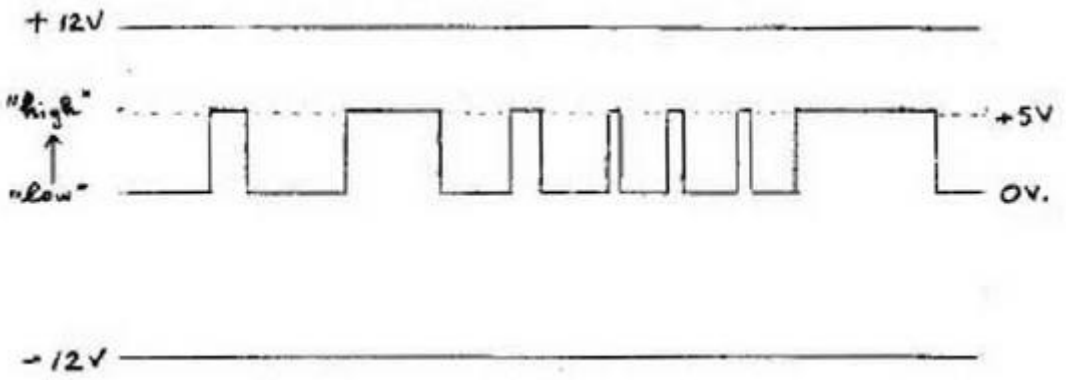
There are basically three types of Signals in the SERGE world: DC signals (CV, white), trigger pulses (logic, red), bi-polar (AC) signals (audio, black). Hoever, it's impotant to note that this is rather a recommendation than mandatory - essentially there is no difference between CV, logic and audio.

In general, do not connect OUTPUT to OUTOUT or INPUT to INPUT. In proper patching sequence, however, all voltage levels may be freely mixed. Equipment is equipped to handle that.

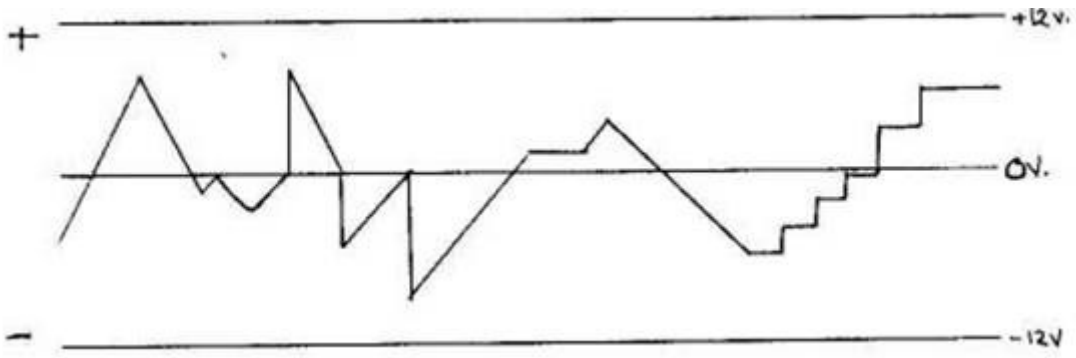
DC / COTROL VOLTAGES: WHITE is the color of the jacks (input or output) which handle signals in the D.C. control voltage range: 0 to (typically) +5V. D.C. is the abbreviation used in electronics ("direct current") meaning that a voltage is of one polarity only. The polarity for D.C. control voltages in the SERGE is positive. Their range falls typically from 0 to +V Volts, within a maximum voltage range of +/-12 Volts. This is the way D.C. control voltages look within the maximum range of the system:



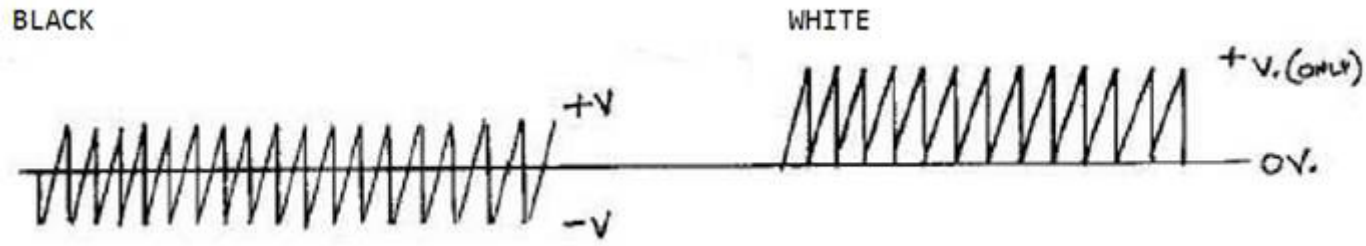
TRIGGER PULSES: RED. Red is the color of the jacks which handle logic signals, usually trigger (or gate) pulses. Trigger pulses fall in the same voltage range as D.C. control voltages, though there are modules which produce outputs of more than +5 Volts. Trigger pulses are either "high" or "low". The very fast transition from "low" to "high" defines the point in time something can be "triggered". The inverse transition, from "high" to "low" is ignored: it cannot be used to trigger anything. A second use of trigger pulses is to define how long something should be sustained. This is usually defined by how long a trigger pulse stays "high". Trigger pulses look like this:



BIPOLAR CONTROL VOLTAGES: BLACK. Black is the color of the jacks which handle bipolar control signals. The word bipolar denotes the ability of a control voltage tto be negative as well as positive (+/-). Bipolar control voltages in the SERGE are typically +/-2.5 Volts, but may fall anywhere within the entire voltage range of the system (+/-12 Volts). Bipolar control voltages typically look like the following:



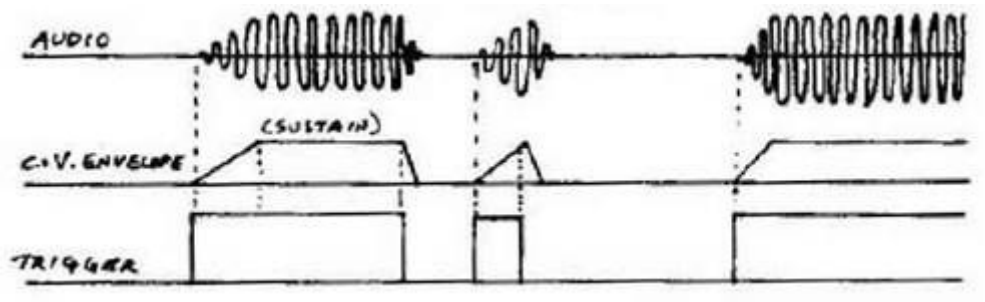
AUDIO SIGNALS: BLACK. Audio and bipolar signals share the use of the black jacks of the SERGE. This is done because both share the same bipolar range of +/-12 Volts. The main differences between the types is (1) audio is always bipolar, (2) audio always falls into the audible portion of the frequency spectrum (from about 16 to 16.000 cycles per second). In practice. modules deigned t o process audio signals are easily differentiated because they will start filtering out frequencies below about 16 cps.. Moreover, audio modules will generally restore the average D.C. voltage level of the signal to zero volts (centering the signal around 0 Volts). A graphic example of this effect is shown below, through a comparison of black (bipolar) and white (D.C., from 0 to +5 Volts) outputs of an OSCILLATOR.



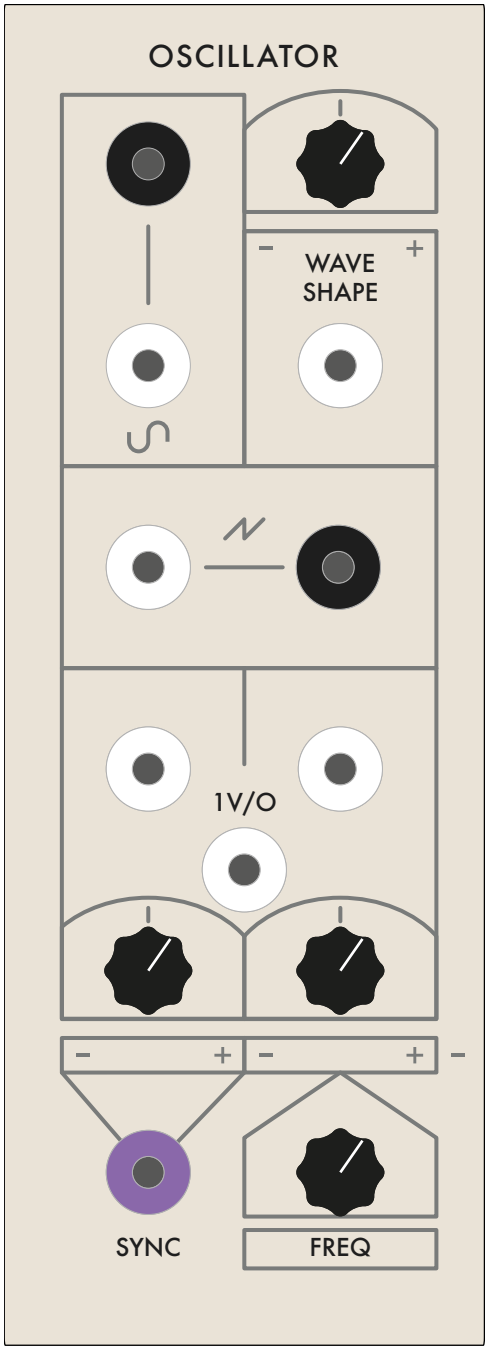
The SERGE system also utilizes pink, grey, and otherwise colored jacks. Such jacks are used to point out special functions which a number of modules perform, which do not fall into the standard categories of control, audio, or pulse. Examples of such functions are the “sync” input on the OSCILLATOR, and the COUPLER function of the SMOOTH & STEPPED GENERATOR (SSG).

HOW ARE THE VARIOUS SIGNALS USED?

The usual logic of synthesizer is that TRIGGERS are used to start and define the length of sustain of CONTROL VOLTGE ENVELOPES, whereas CONTROL VOLTAGES serve to specify and control the frequency, timbre or loudness of an AUDIO VOLTAGE. Thus for example:



OSCILLATOR (VCO)



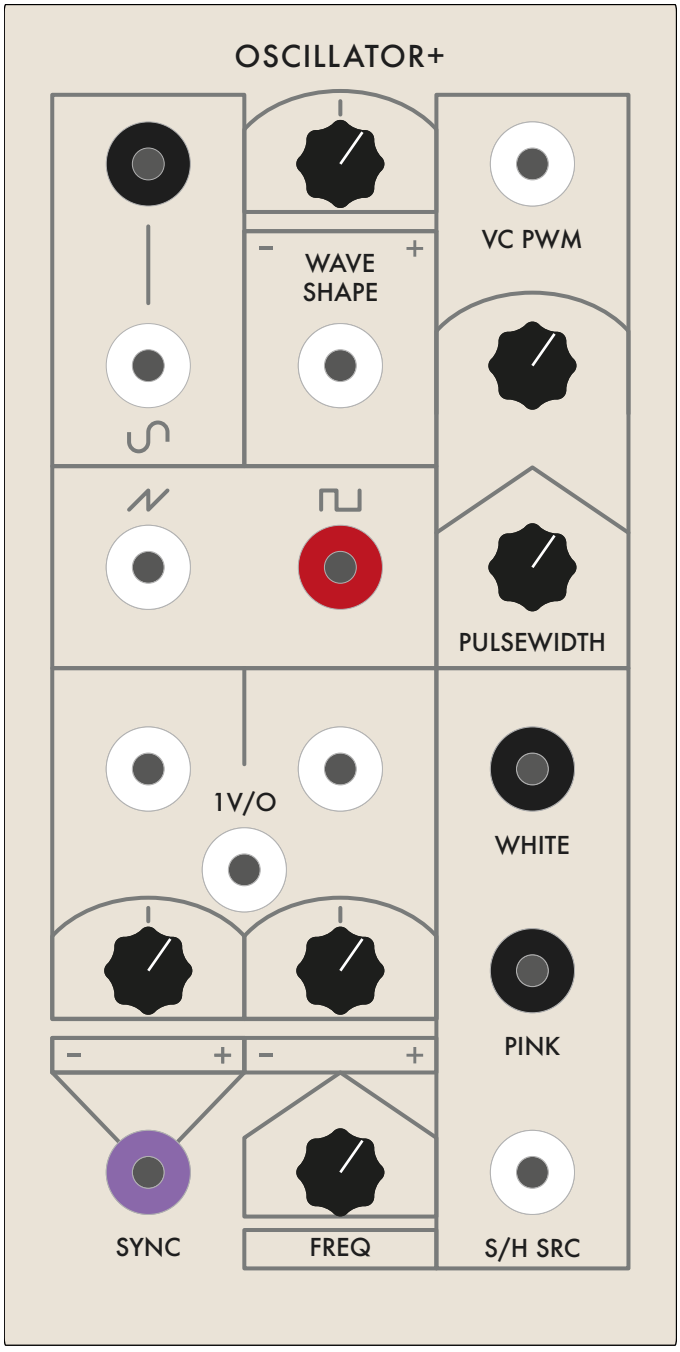
The original Serge VCO from 1973 has been given a powerful overhaul in 2022, now featuring a vastly **improved control voltage circuitry**. While keeping the flair of the original VCO's waveforms this version now offers an **1V/Oct input** with **excellent tracking and temperature compensation**, making it perfectly usable in a modern synthesizer environment.

The OSCILLATOR puts out simultaneously two wave forms - a sawtooth wave as well as a (more) sine-like wave, both at the same frequency, each in a unipolar and a bipolar version.

The frequency is controlled by the frequency pot, the 1V/Oct input and up to 2 additional control voltage inputs with processor (attenuverter). The leftmost processor pot for the control voltages, when not accepting a control voltage, is a fine tuning pot with a range of a major third.

The variable wave form's shape is controlled by an internal pot and a control voltage. Sync inputs permit the synchronizing of any two oscillators, or of an oscillator with any other pulse source. By applying a voltage to the control input of the oscillator which is being synchronized, that oscillator will only be able to produce frequencies which are along the harmonic series of the synchronizing oscillator. Generation of sub-harmonics is equally possible.

OSCILLATOR+ (VCO+)

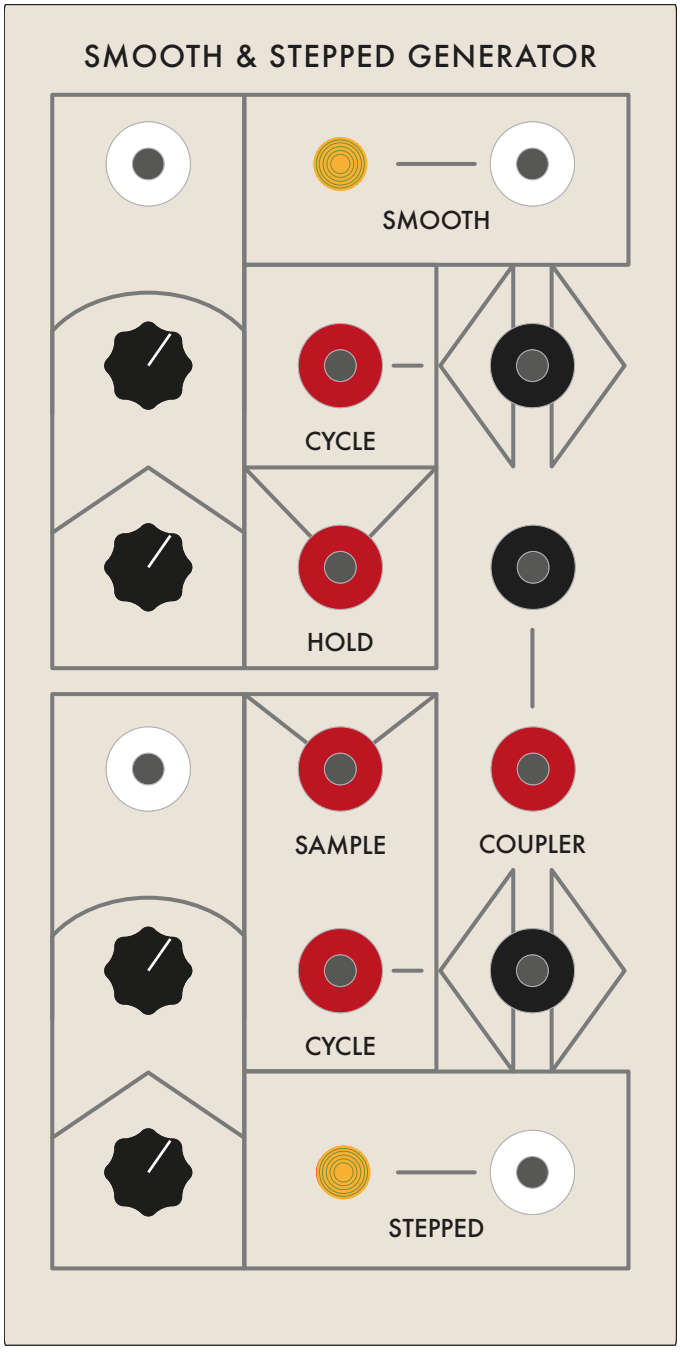


The OSCILLATOR+ is a new, extended version of the basic VCO:

A PULSE OUT with pulse width modulation (PWM) has been added. The pulse width can be set with the initial PULSEWIDTH knob and controlled by the VC PWM input via an attenuator.

In addition, a SERGE NOISE SOURCE provides white noise, pink noise as well as the classic SERGE Sample/Hold Source (S/H SRC). The latter is required to turn the SSG into the famous Random Voltage Generator.

SMOOTH & STEPPED GENERATOR (SSG)



This is The Serge Smooth & Stepped Generator (SSG) is an essential part of the Serge system. According to the 1979 catalogue, "it is a complex multi-functional module which can be patch programmed to provide various slew and sample functions."

The Smooth (*top*) section will place a postitve and negative slew on input voltage transitions for lag effects, voltage controlled portamento and for low frequency filter applications.

In **Cycle-mode** (CYCLE jack patched to the IN on the right of CYCLE), the Smooth side will oscillate yielding a voltage controlled traiangle wave LFO or even audio. A high level into the HOLD input will enable the Smooth Function to be used as a track-and-hold circuit with voltage controlled slew rate.

The Stepped funtion (*bottom section*) can be used as a sample-and-hold with voltage controlled slew rate limiting. In Cycle mode, a pulse applied to the Sample input will generate complex staircase waveforms for control voltage applications and for use as audio signals.

The **Coupler** is an internal comparator which compares the output levels of the Smooth and the Stepped Generators. This output is useful for generating complex control voltages or random voltages. The **Red Coupler** outputs a pulse wave in the range of 0V to 5V while the **Black "hot" Coupler** has an unlimited bipolar output level from -12V to +12V(!)

SSG First Steps

The SSG is a complex, highly versatile module which allows for a wide range of uses and abuses both in the audio and CV range, so it may require some time and experimenting to familiarize oneself with it - don't expect the module to reveal its secrets and power in a few minutes after you first power it up. Here are some very basic ideas to start with:

1. Patch the **CYCLE** jack into the **IN** of the Smooth section - the Smooth side then produces a triangle wave from about 0V to 4 to 5 V (depending on frequncy), the LED should indicate that. The **Rate** pot determines the frequency of the cycle / output - the range is very wide, going from below 1 Hz (depending on calibration above, possibly far below 1 Hz) to appr. 4 kHz. The **Cycle jack** provides a corresponding Pulse wave output.

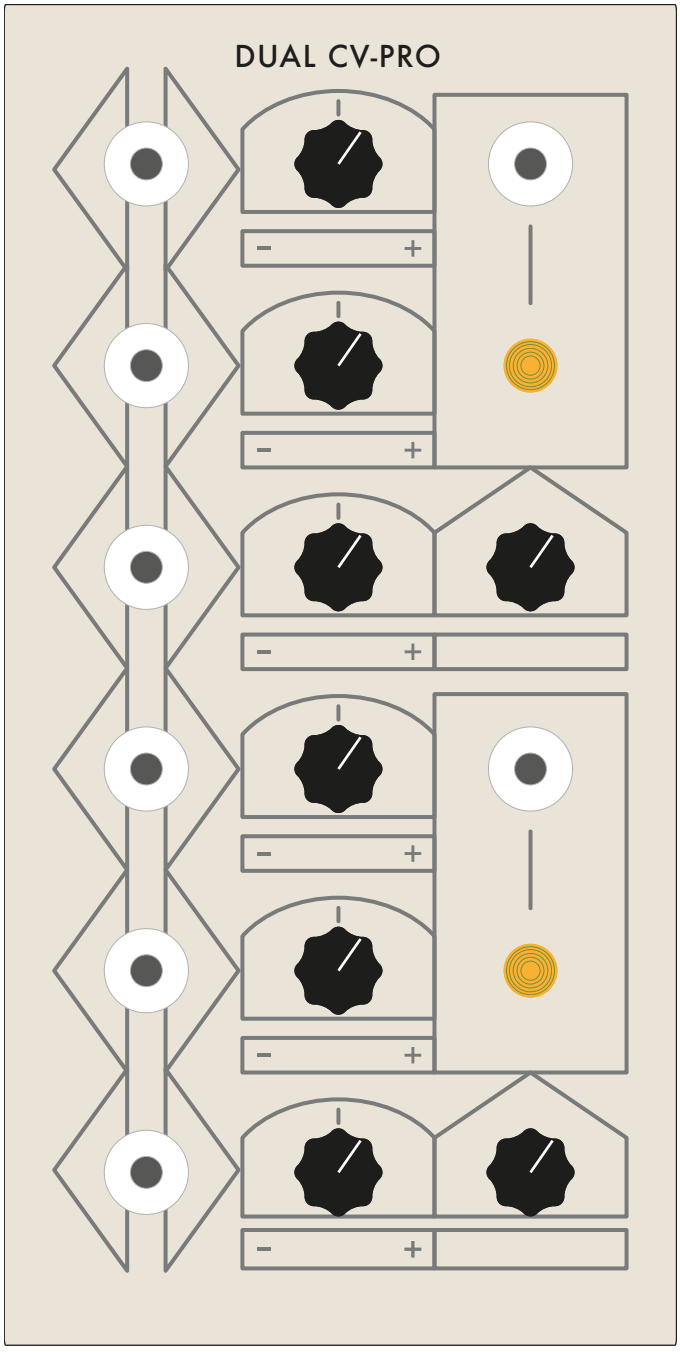
2. Patch the **CYCLE** jack into the **IN** of the Stepped side as well. Unlike the Smooth side, the Stepped side will not generate an output in Cycle mode (=LED stays dark) unless a Pulse wave is fed into the **Sample** jack. Patch a pulse wave - e.g. the **Cycle** output of the Smooth side - into the **Sample** jack to bring the stepped side to life. The stepped side is essentially a sample-and-hold circuit, the **Rate** knob determines how long each step is at the Stepped output. Changing the frequency of the pulse going into the **Sample** input and/or changing the **Rate** affects the output.

3. The Smooth Side can be used as a **Lowpass filter**. Feed an audio signal (e.g. a saw or pulse wave from an oscillator) into the **IN jack** (while not cycling) and listen to the signal coming from the **Smooth out** while you turn the **Rate knob**. At maxium position (full CW) the signal should sound pretty much unfiltered, turning the Rate down (counterclockwise) the harmonics get filtered / smoothed out, at minimum position the signal will disappear altogether.

4. Using the VC input jack in the same setup as before, this filter effect can be used to achieve the effect of a **Lowpass Gate / VCA**. Send an CV envelope (e.g. from a DUSG or an Extended ADSR module) into the VC jack and turn the VC knob sufficiently high. Tune the Rate pot to a position so that the output is silent when no CV is applied but clearly audible when the envelope is high. This causes a VCA effect, but the envelope not only determines the amplitude, but also the amount of filtering applied (like a lowpass gate).

5. SSG as **Faux Ring Modulator**: send an audio signal (e.g. sine wave) into IN and another signal at audirate (saw/triangle) into HOLD and play with the knobs. You can also send CV or an envelope into the CV (RATE) for some transposing or movement. In some sweet spots the sound resembles a ringmod (even though technically it is not ring modulation).

Dual CV-Processor / Mixer



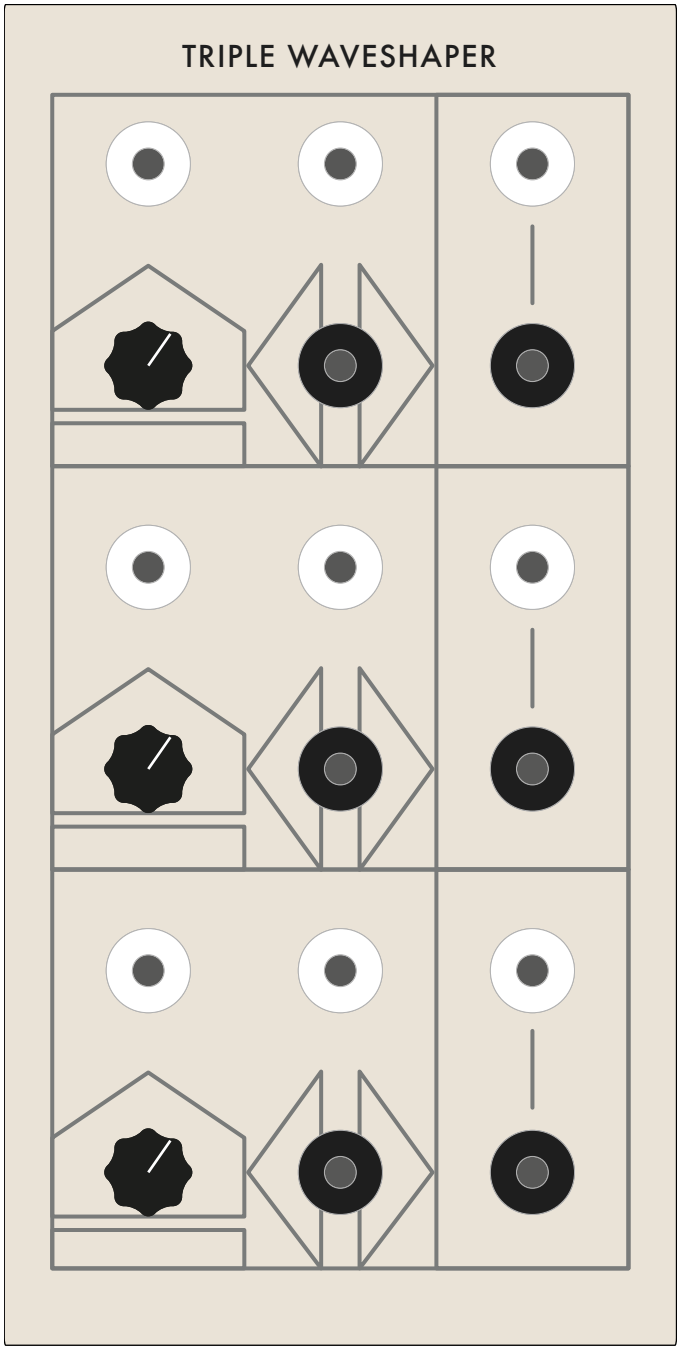
The Dual CV-Processor / Mixer is fully DC-coupled, making it suited for both control voltages and audio signals.

Each section has three inputs with attenuverters, allowing to invert each input. The knob below the output section provides a 0V to 5V DC offset which is primarily useful for control voltages.

The Serge CV-Processor has a unique circuitry that reduces (limits) the level when adding the signals would result in a very high level (> appr. 16V pp) and protential clipping - the amplitude of the resulting waveform is softly compressed.

An LED makes the output level visible.

TRIPLE WAVESHAPER

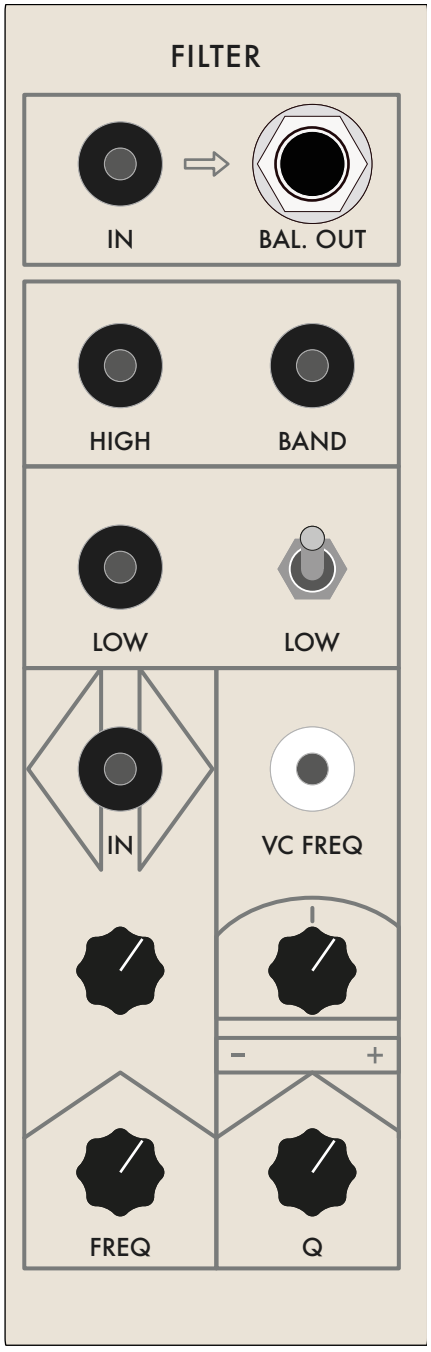


This might be the godfather of all waveshapers. The module comprises 3 identical sections which can be patched in sequence. The input can be any audible waveform. The output is a distorted form of that wave, basically, a full wave rectification with a lot of non-linearities. A triangle can be converted to a sine wave at 2F.

A saw can result in an approximate sine at 1F. The knpb is an input attenuator that has direct influence on the waveshape of the output. The two control voltage inputs affect two different aspects of the wave distortion and are equally affected by the attenuator pot. Each input affects differently the specific non-linearities involved. Each section has a unipolar (white, 0-5V) and a bipolar (black, AC coupled) output.

It may increase a certain kind of non-linearity and decrease another. The wave shaper is basically a distortion module with various areas of distortion.voltage controllable" When using the control voltage inputs, at times the sound output may disappear. This is because certain non- linearities may have been driven to the saturation point. This will be different with each sound, so experimentation is the best way to deal with this. The solution is usually attenuation of the incoming control voltage.

1973 Filter (VCF) and Balanced Output



This section contains 2 independent modules:

The top **converts an audio signal in banana form to a professional balanced signal (TRS jack)** for external use (AD-converter, mixing console etc.).

The **filter** below accepts an AC signal and simultaneously outputs 3 signals: A low-pass (12 db/oct); a high pass (12 db/oct) and a band pass with fixed band width.

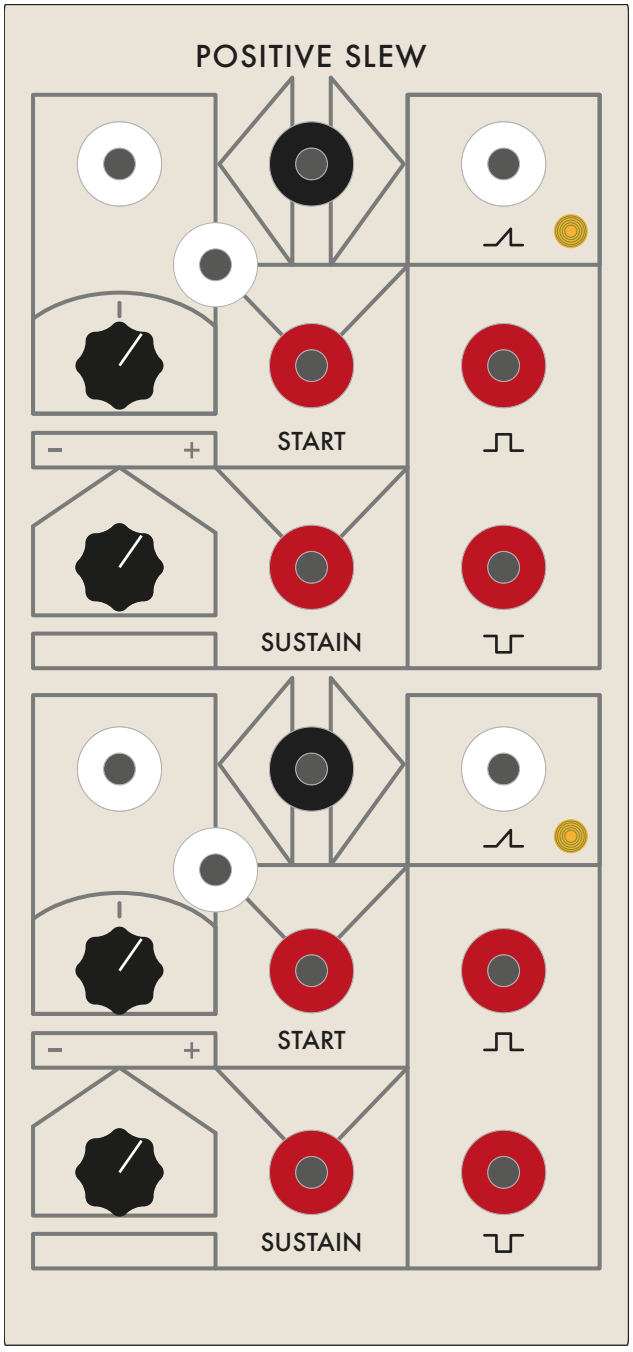
These 3 outputs are all centered around a common frequency which is controlled by the FREQ knob and a control voltage (VC FREQ). A Gain Pot is placed below the input. A Processor Pot (attenuverter) is placed below the control voltage input.

The Resonance (Q) is varied by the knob (only) and is not voltage controlled. The Q is Lowest at full left.

The filter can also be used as a very pure sine wave oscillator with the Q up and one of the band pass outputs fed back into the audio input.

Another interesting effect is with the input signal fully attenuated and the Q up high - a rapidly changing control voltage input will produce a series of water drop type sounds from the low-pass output.

POSITIVE SLEW



The Positive Slew accepts a voltage at the **INPUT** and follows (i.e., outputs) exactly any falling voltage but "slews" or "portaments" or "integrates" between any rising voltages.

This is similar to the negative slew except that it slews between rising voltages rather than falling signals.

The **START** input allows it to be triggered like an envelope generator. It's duration is controlled by both the knob and the CV IN above with a Processor (attenuverter). This module puts out a pulse when it reaches +5v.

The **SUSTAIN** input holds the voltage at +5V for the duration.of the input pulse.

The uses of this module include

1. ENVELOPE GENERATION (rise only)
2. monostable pulse source (triggered by a pulse, a pulse of a certain length determined by VC is generated.)
3. a source of voltage controlled delay of a second pulse.
4. Sawtooth oscillator.
5. Sub-harmonic generator (especially good when used with Waveshaping.)

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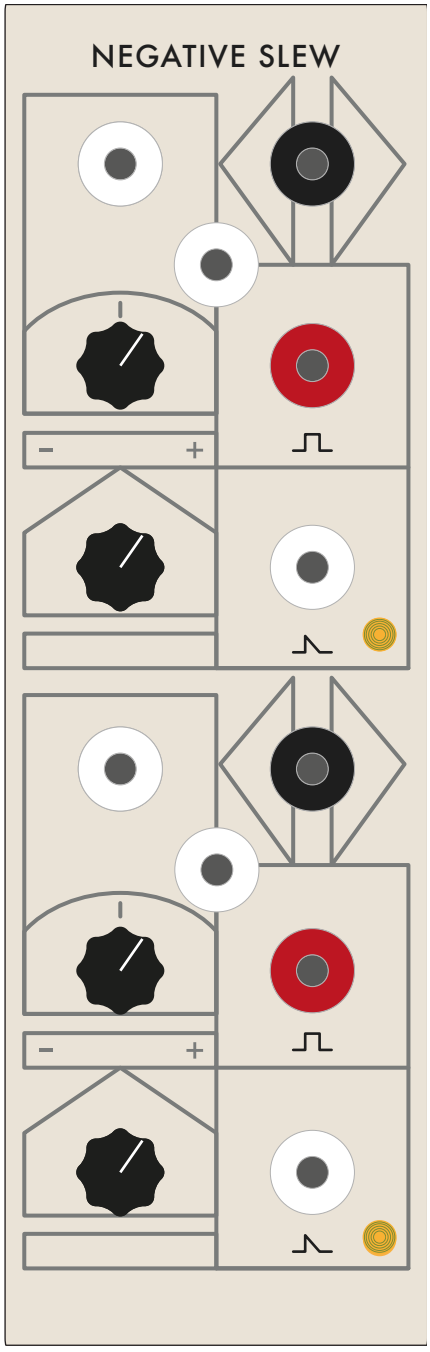
NEGATIVE SLEW



The Negative Slew is a dual module with 2 (almost*) identical sections. It accepts a voltage at the INPUT and follows (i.e., outputs) exactly any rising voltage but "slews" or "portaments" or "integrates" between any falling voltages. This module puts out a pulse when it reaches 0V.

Cycle mode: Patching the red PULSE OUT back to the INPUT above causes the Negative Slew to oscillate, creating an inverted saw wave.

The **Slew time** (i.e. the falling slope) is controlled by both the knob and the control voltage in with an processor pot.

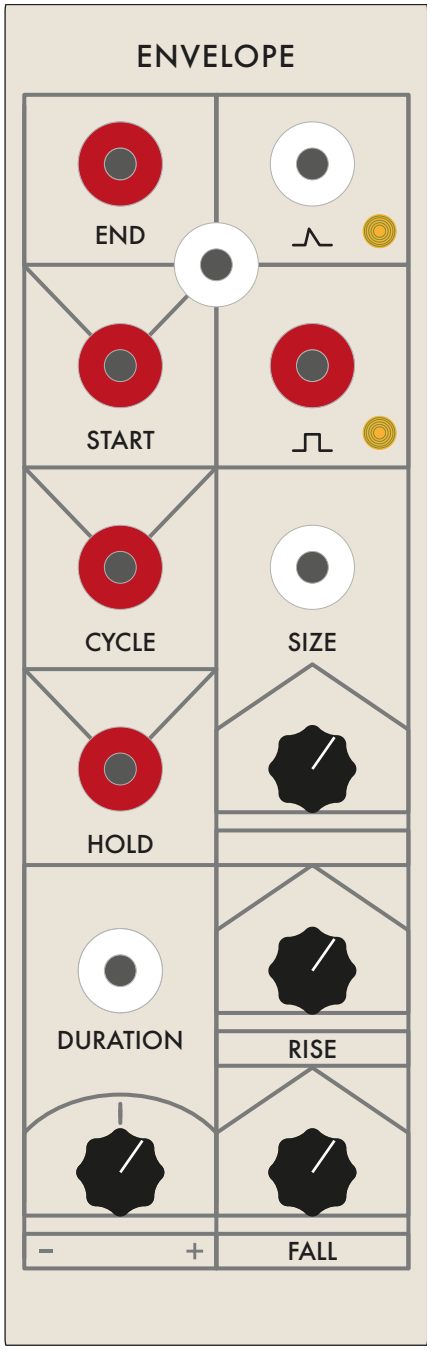
***The top section is faster than the bottom one**, having a range from about 10s per cycle to 3kHz in Cycle mode. The bottom section goes down to about 20s per cycle, however is still fast enough for most audio duties.

Anniversary Special: Unlike its historic predecessors, the Negative Slew now features an additional white "**Wildcard" Input** in between the columns: a control voltage applied to this input allows to change the shape of the slope from linear (at about 2.5V) to exponential or logarithmic using a range from 0 to 5V. Changing the slope does have an effect on the slew time (i.e. changes the frequency when using it as an oscillator). However, the wildcard input can still be used to introduce some waveshaping by sending a (tracking) waveform (e.g. from the OSCILLATOR) to the input (thereby granting a stable pitch) and then applying CV to the wildcard to manipulate the slew shape of the resulting waveform.

Uses of the Negative Slew include:

1. Envelope Generation - decay only
2. Audio oscillator sawtooth.
3. Negative "'sloping Voltage Control Slope Control (very accurate)
4. Envelope detection (half-wave) with Voltage Control of Decay Slope.
5. Trigger pulse source (with voltage control)

ENVELOPE GENERATOR



The envelope generator is a complex module. It can be used as a sub-harmonic generator, an (inaccurate) sample and hold (via window size) and as a staircase generator, among others.

Negative and positive slews can be concatenatcd with multiple envelope generators - to give ultra complex multiple output envelope generation.

Let's start with the basics.

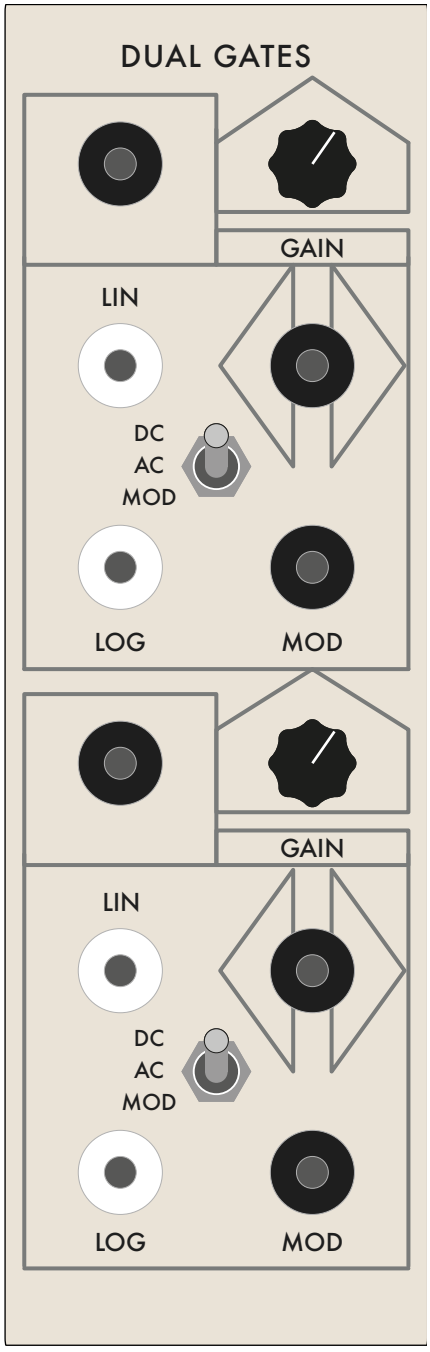
Connecting END (output) to START (input) makes the module cycle: the OUT provides an AR curve, RISE and FALL knobs control the steepness of each side. The END (out) send a very short trigger pulse at the end of the cycle. Window out () gives a delayed pulse that is high until the end of the cycle - the start of the pulse is determined by the Window Size knob (and CV).

Connecting CYCLE (output) to START (input) also makes the module cycle: **START** (input): a pulse re-starts the envelope generator every time a pulse is applied to it, unless the envelope is not finished.

CYCLE (input): if the cycle pulse is high at the **end** of the envelope the gencrator recycles itself.

The **END** (output) goes high at the end of the cycle, but only if triggered with the Start input - not if cycled.

DUAL GATES (2023)



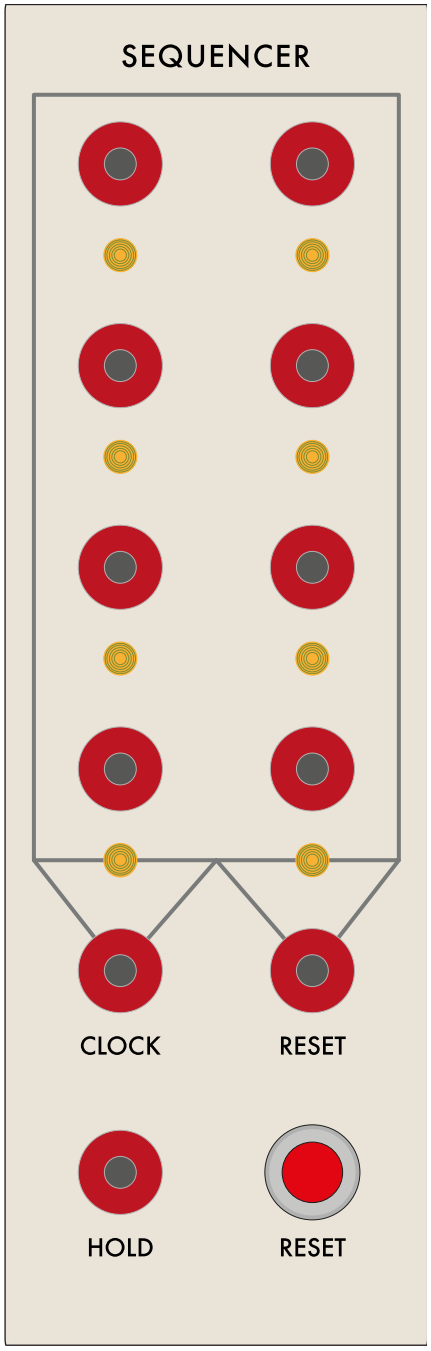
The DUAL GATES is a completely new Serge Design for the Anniversary Edition which goes far beyond the 1972 version, both in sound and function. Each side is independent and can act in 3 different modes (set with the toggle switch):

- **DC**: the Gate acts as a (linear) VCA for control voltages (or unipolar audio): the incoming signal is scaled depending on the GAIN knob and the LIN VC input.
- **AC**: intended primarily for audio signals, the input signal is amplified depending on the GAIN knob and the LOG VC input.
- **MOD**: the incoming signal is multiplied by the MOD input to an extent controlled by the GAIN knob: turning GAIN all the way up provides ring modulation.

So far the theory. However, interesting results can be obtained by using the other inputs as well, e.g. LIN and LOG at the same time or MOD in AC or DC mode.

Patch Tip: Ring Modulation works nicely when using the ENVELOPE output (triangle wave) as input and the SSG Smooth output (again triangle) as MOD.

GATE SEQUENCER



Triggerinq the CLOCK input with a repetitive pulse source sends out pulses one at a time from the eight pulse outputs of the GATE SEQUENCER. In other words, only one of the 8 outputs is high (+5V) - as indicated by the LED - and with each incoming clock signal the output jumps to the next stage.

CLOCK: Every time a pulse enters CLOCK, the next stage goes on, and the previous stage goes off. When stage 8 is reached, the next CLOCK sends the sequencer back to stage 1. Note that the sequencer runs counter clockwise (stage 1 upper left, stage 8 upper right).

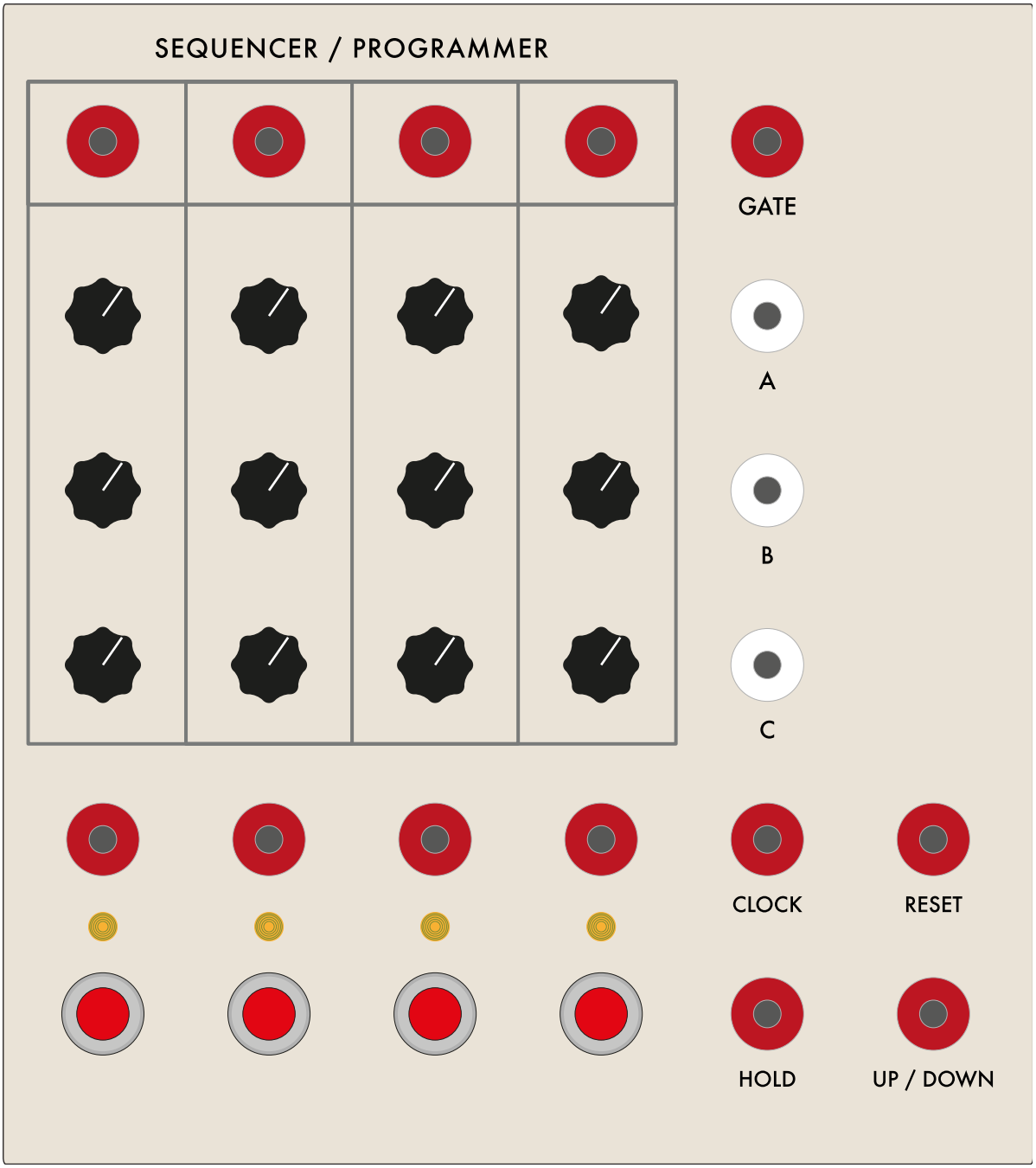
Both the RESET input (receiving a 5V pulse) and the RESET push button force the GATE SEQUNCER back to stage 1. This is typically used to achieve a cycle length smaller than 8 by patching one of the outputs back into RESET.

The HOLD overrides the CLOCK and freezes the sequencer (as long as the HOLD signal is high).

SEQUENCER / PROGRAMMER (SEQ4)

This is a modernized version of the four-stage Sequencer Programmer. Features include the ability to be used as push-button, manual programmers and/or as multi-versatile sequeencers The length of sequences can be programmed interractively via the pushbuttons: thus sequence lengths can be changed in performance while a sequence is running.

Other sequencing capabilities, include RESET, UP/DOWN and HOLD (pulse) inputs. The red PULSE STAGE SELECT inputs directly above the buttons achieve the same as pressing a button - this allows triggers from other modules to turn specific stages on.



There are 4 stages each with 3 levels (top. middle, bottom) corresponding to the outputs A, B and C. Depending on which stage the programmer is set to, each output provides the voltage set by the relevant knob for that stage and row. There is (only) one stage active at a time as indicated by the LEDs above the push buttons.

A stages can be selected directly by either using the push button for that stage or by sending a pulse into the corresponding SELECT STAGE input above the LED.

When a new stage is set via the push button, a gate signal is generated at the common GATE out - it stays high as long as the button is pressed.

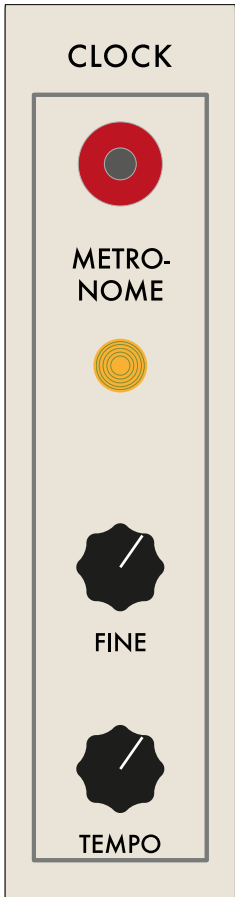
Selecting a stage also causes the GATE OUT for that stage (above the knobs) to go high and remain there until a new stage is selected.

CLOCK: While the classic Programmer had no sequencing option, this new version can now be driven by a CLOCK signal. The sequence starts at the stage that has been activated last by the push button.

RESET and HOLD work just like for the GATE SEQUENCER.

UP/DOWN: In general the sequence runs from left to right, UNLESS you plug a cable into the UP/DOWN logic input. With a cable plugged in, the sequencer runs from right to left with a logic LOW, and from left to right with a logic HIGH at the UP/DOWN input. If i.e. stage three has been activated with the push button, the sequence will be 3-4-3-4-3-4... only. With another logic signal applied to UP/DOWN, and depending on what the Programmer sees on this input, it will run forward or backwards, always starting at stage #3.

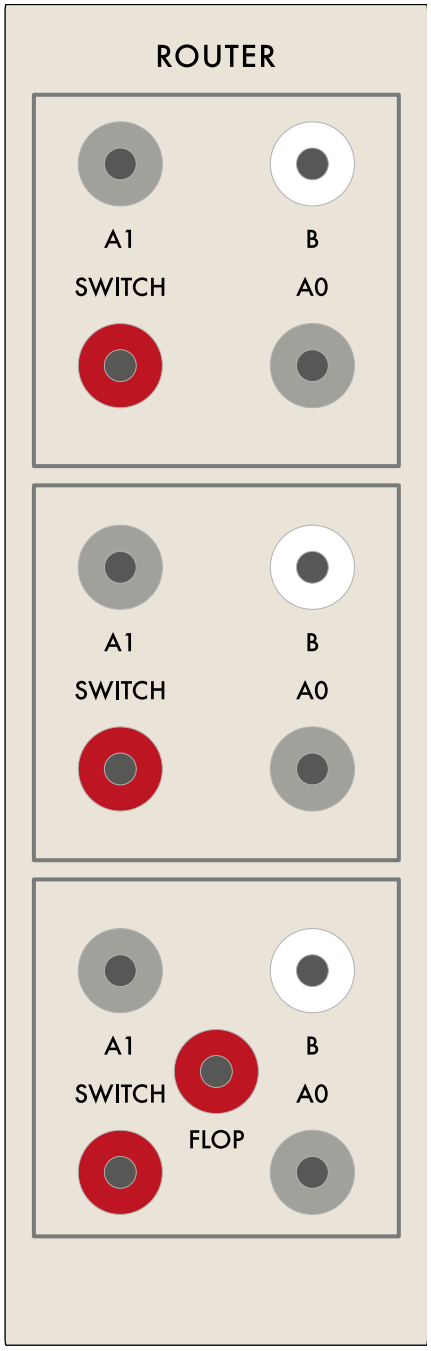
METRONOMIC CLOCK



The METRONOMIC CLOCK is a new 2022(!) Serge design that provides a simple, yet very accurate and temperature-stabilized analog clock source. It generates a chain of very short trigger pulses, ideal to drive the GATE SEQUENCER or the SEQ4.

The frequency is set using the FREQ knob and the FINE knob. The latter deliberately covers a very(!) small range so that tiny adjustments are possible.

BI-DIRECTIONAL ROUTERS (SWITCHES)



As the name suggests, these are analog switches that work in both directions: either to select one of two input signals (A0 and A1) at output B or to send a single input signal (B) to one of 2 outputs (A0 and A1), in each case dependent on the SWITCH input.

The SWITCH input determines the state: either ON or OFF:

OFF: If no signal is present or the signal at the SWITCH input is low, A0 and B are directly connected: a signal going into A0 will be present at B (as an output) and vice versa.

ON: When the signal at the SWITCH input is **high** (ON), A1 and B are directly connected: a signal going into A1 will be present at B (as an output) and vice versa.

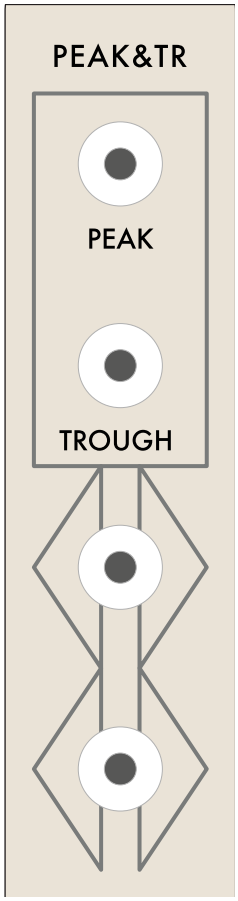
Please note that while the SWITCH input is for logic signals (pulses), **A0, A1 and B can be used for any kind of signals** (CV, audio or logic).

Patch tip: The switches can be used for waveshaping effects, for instance when sending a SINE and a SAW wave from the same oscillator into A0 and A1 while switching it with the PULSE output of that oscillator (or from another source).

Upper and middle switch: the switch is in ON state only as long as the SWITCH input remains high - i.e. when using a short trigger signal, the shwitch flips back very fast.

Bottom switch: works like a flip-flop, a pulse into sthe SWITCH IN turns the switch ON until the next pulse comes in which turns it OFF again. The pulse length of the incoming SWITCH signal is irrelevant. The additional FLOP output in the middle is ON as long as the switch is OFF. This can be used to control another switch or as a pulse divider for the incoming clock signal.

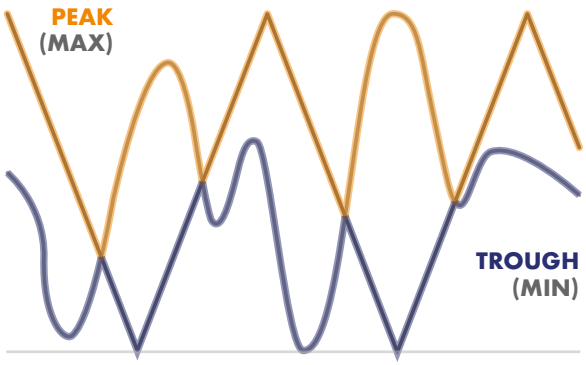
PEAK & TROUGH



PEAK and TROUGH (MAX and MIN) is a mathematical function that compares two waveforms (AC or DC - audio, CV or logic).

PEAK (MAX) returns whichever signal is highest at any given instant.

TROUGH (MIN) passes the lowest positive input voltage.



When using it **with logic signals, PEAK acts as a boolean OR** (either input being ON means the output is ON) and **TROUGH acts as a boolean AND** (both inputs have to be ON for the output to be ON).

Version 13. December 2023, 4:12 PM