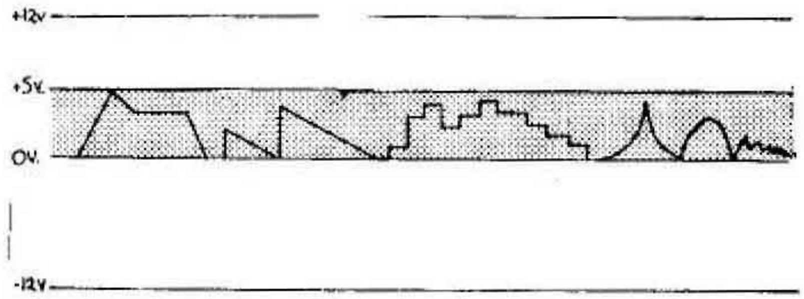
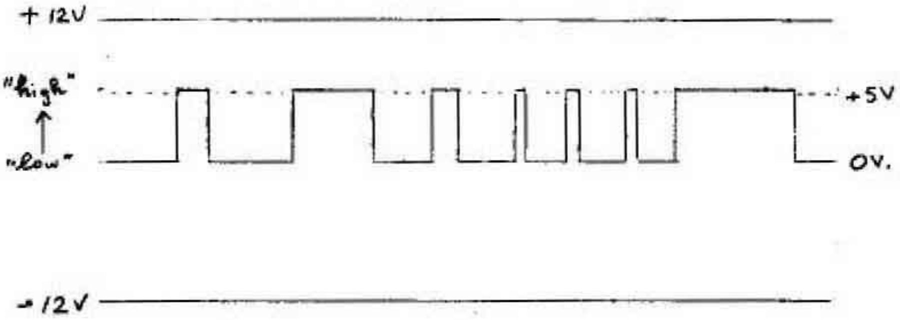
INTRODUCTION TO THE USE OF THE SERGE MODULAR MUSIC SYSTEM

There are four principal types of signals in the SERGE: D.C. control, trigger pulses, bi-polar control, and audio signals.

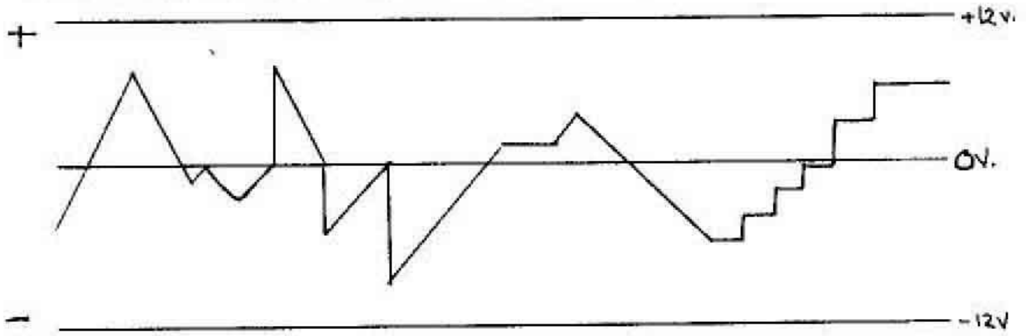
D.C. CONTROL VOLTAGES: BLUE. Blue is the color of the jacks which handle signals in the D.C. control voltage range. D.C. is the abbreviation used in electronics ("direct current") meaning that a voltage is of one polarity only. The polarity for D.C. control voltages in the SERGE is positive. Their range falls typically from 0 to +5 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 trigger 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:

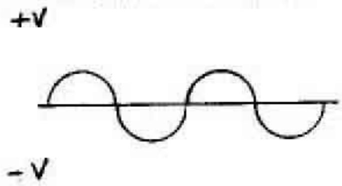


BIPOLAR CONTROL VOLTAGES: BLACK. Black is the color of the jacks which handle bipolar control signals. The word bipolar denotes the ability of a control voltage to be negative as well as positive (±). Bipolar control voltages in the SERGE may fall anywhere within the entire voltage range of the system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

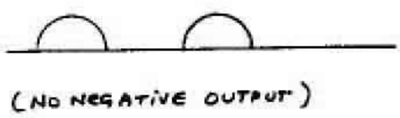


Special note concerning BIPOLAR CONTROL VOLTAGES: although many of the inputs (blue) that handle D.C. control voltages will accurately respond to bi-polar control voltages, others will not, and will cut out the negative part of the bipolar input signal. A graphic example of this effect is shown below, along with a list of the modules affected.

Input bipolar signal:



Output effect (typical of a PEAK & TROUGH):

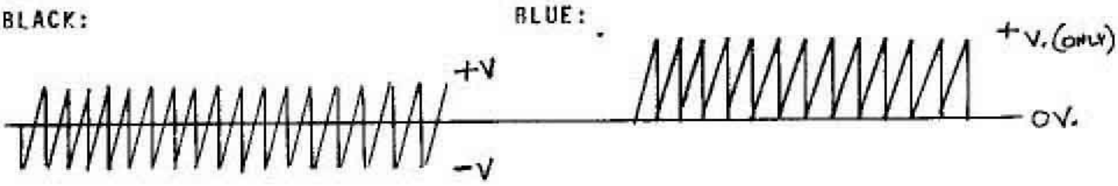


Modules affected:

PEAK & TROUGH
POS. & NEG. SLEW
WAVESHAPER
GATES & RING
ASR, "WINDOW SIZE", COMPARATOR
etc...

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 bi-polar, (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 to 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. A graphic example of this effect is shown below, through a comparison of black (bi-polar) and blue (D.C., from 0 - +5 Volts) outputs of an OSCILLATOR:

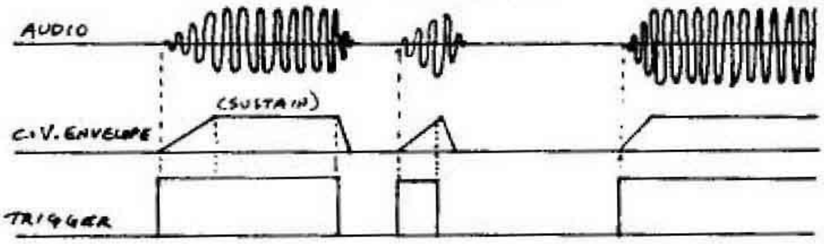
BLACK: BLUE:



The SERGE SYSTEM also utilizes white, yellow, green, and otherwise colored jacks. Suc 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. FXamples of such functions are the "sync" input on the OSCILLATOR, and the COUPLER function of the SMOOTH & STEPPED.

How are the various signals used?

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



One of the notable features of the SERGE SYSTEM is that only one system of patchcords is used. This is in contrast with a number of synthesizer systems which use two or more patchcord systems to handle the various types of signals, phone type jacks, for example, to handle audio, and cinch-jones to handle triggers. The advantage of a one patchcord system is that it allows signals to be used wherever useful, for example using control voltage envelopes as audio signals, etc... This is often done in the SERGE, especially since most modules in the system are extremely wide-range, and overlap the sub-audio and audio ranges of frequencies.

Where are TRIGGERS to be found on the SERGE?

TRIGGERS may be initiated externally through the use of manual controllers, such as the pushbuttons of the PROGRAMMERS, or from keyboards, or internally from repetitive sources of pulses such as the NEGATIVE & POSITIVE SLEWS, ENVELOPE GENERATORS, RANDOM, etc... TRIGGERS may also be gotten by using the COMPARATOR to sense the amplitude of the signal from external sources such as microphones, tape recorders, foot pedals, or sensors attached to instruments such as drums, etc.

Where are CONTROL VOLTAGES to be found on the SERGE?

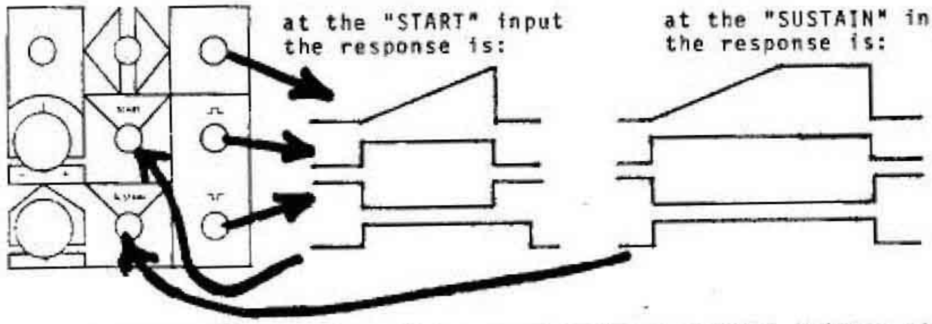
There are a wide variety of CONTROL VOLTAGES on the SERGE. These include triangular or trapezoidal envelope shapes from the wide variety of envelope generators available (NEG. & POS. SLEWS, VC SLEW, ENV. GEN., SMOOTH FUNCTION, etc.) These may be triggered through the use of an external TRIGGER, or be used in a self-recycling mode where the module provides its own TRIGGER. The way this works is shown in the following pages.

EXAMPLES OF MODULES WHICH CAN BE TRIGGERED TO PRODUCE ENVELOPES

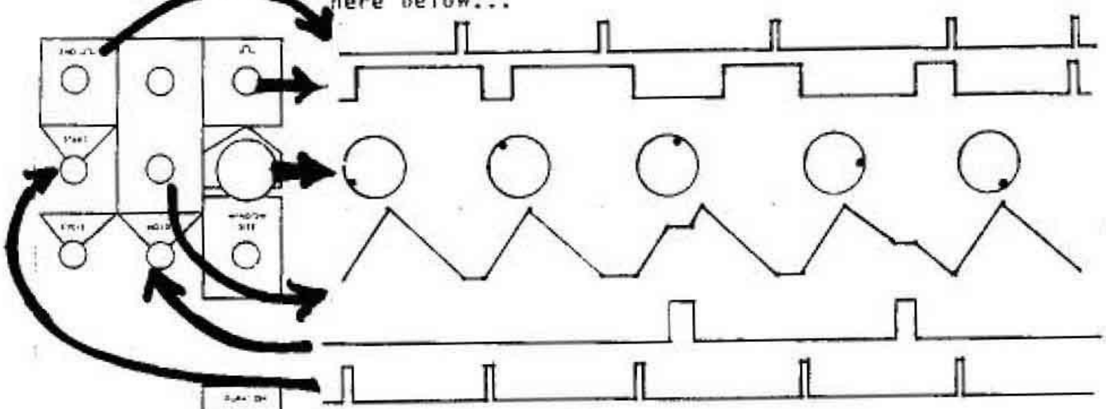
Triggering modules is usually done by putting a pulse source into a pulse input (red) marked "start" or "sustain". A pulse into the "start" input triggers an envelope through one cycle. A pulse into a "sustain" input will trigger an envelope and determine the length of time it remains at its maximum level.

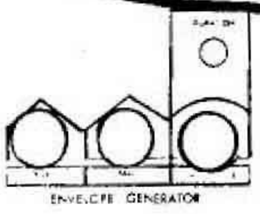
The following diagrams show how this operates for the POSITIVE SLEW, the ENVELOPE GENERATOR, and the POSITIVE + NEGATIVE SLEWS linked together to form an envelope generator.

POSITIVE SLEW (Note: arrows pointing away from the module signify outputs. Inputs have arrows pointing toward the module.)
The additional two output pulses are useful in a variety of triggering functions, delay, duration, and self-triggering (as shown in later pages).



ENVELOPE GENERATOR. Note: putting a pulse (or a control voltage above +2.5 Volts) into the "hold" input is also shown here below...

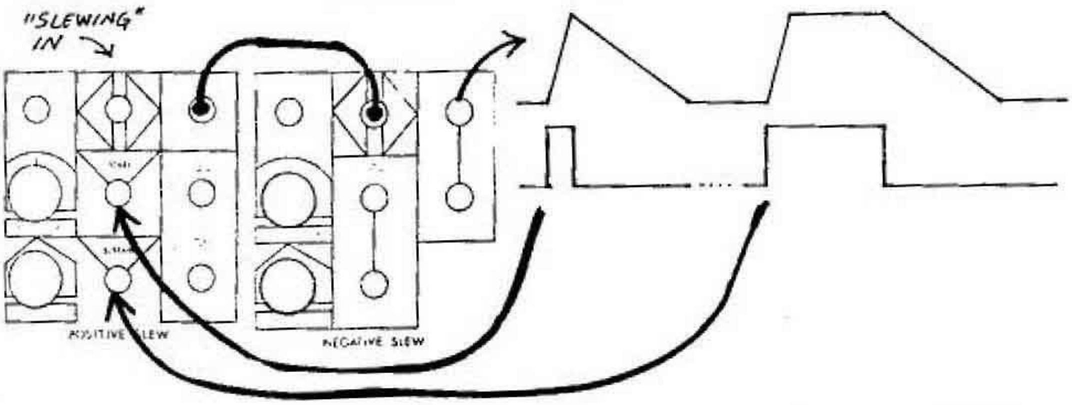




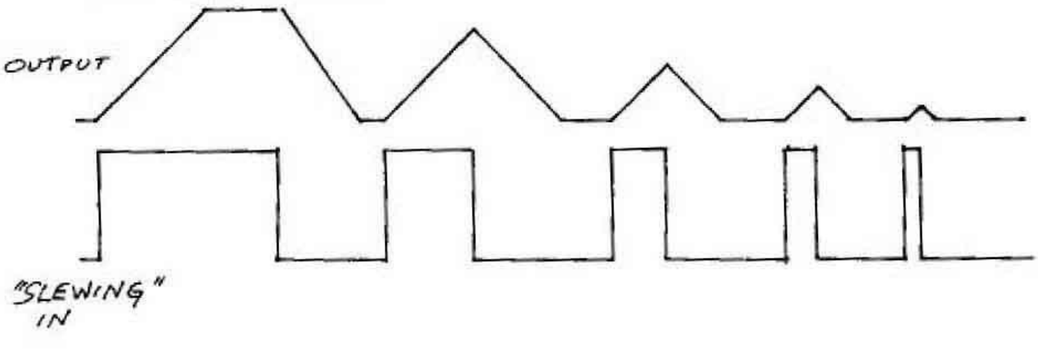
A more intricate function is also shown here: the "window size". This is a pulse trigger output which may be set to occur at any point in a cycle according to the position of the "window size" knob (as shown) or the level of a control voltage at the "window size" input (not shown). This is a very useful function in obtaining a variable time delay between different envelope generators.

EXAMPLES OF TRIGGERING, cont.

POSTIVE & NEGATIVE SLEWS (connected as an envelope generator)



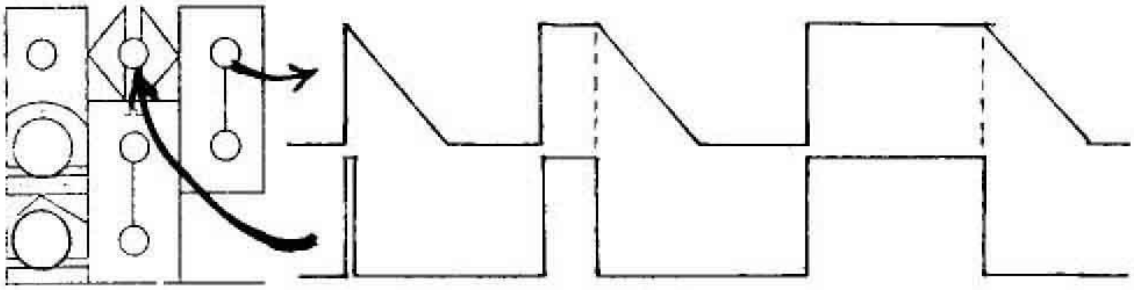
Another manner in which a pulse input may be used with the combination shown above, is through the main "slewing" input. While this is not really a true example of "triggering" since an envelope does not occur irrespective of the pulse length, nevertheless this is a very useful manner of generating envelopes for keyboard performance. What is generally wanted in keyboard work is making sure that the sound will enter its "decay" period (i.e., will die down) the moment that a finger is lifted.



By the way: "slewing" will be explained in later pages!

EXAMPLES OF TRIGGERING, cont.

NEGATIVE SLEW. As in the envelope generator connection of POSITIVE + NEGATIVE SLEWS, the following is not properly speaking "triggering", since in this case triggering depends on how fast an input moves. However, the following use of the NEGATIVE SLEW is often useful:

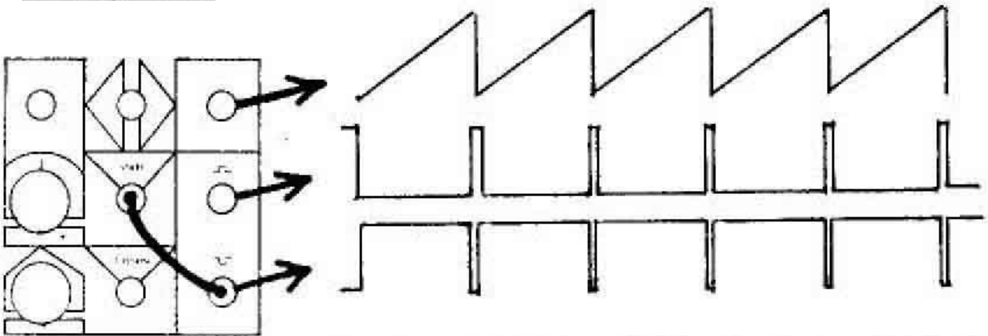


NEGATIVE SLEW

The previous examples of triggering are all performed through the use of pulses external to the module, as derived from keyboards, the PROGRAMMER, or other pulse sources. The following examples show how it is possible to feed a pulse back within a module so that it triggers itself repetitively. This is an extremely useful mode of operation which yields voltage controllable trigger pulse generators, repetitive envelopes, and even, whenever the need arises, to obtain additional audio oscillators. The process is called "self-triggering".

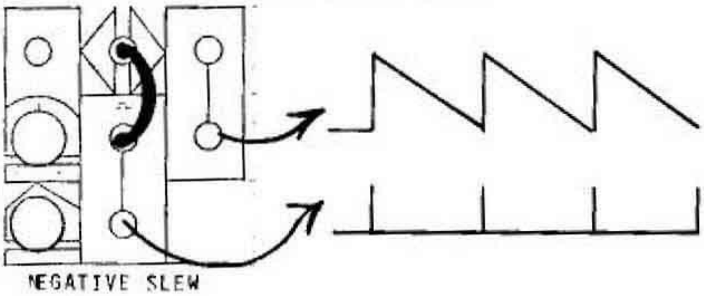
EXAMPLES OF SELF-TRIGGERING

POSITIVE SLEW



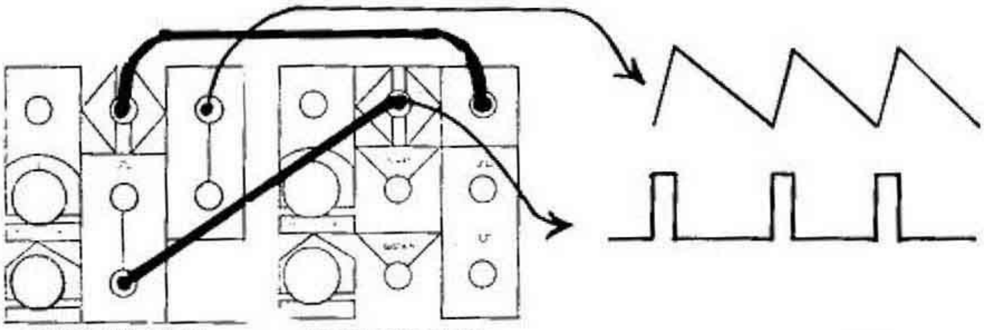
In this patch, the pulse output marked "⎺|_|⎺" may be used to trigger other functions, while the sawtooth output is useful to over 3000 Cps. as an audio source. Using a WAVESHAPER, furthermore, the sawtooth may be shaped into a sine-wave. With a COMPARATOR, pulse-width modulation may be gotten. Explanations are forthcoming in later pages...

ADDITIONAL EXAMPLES OF SELF-TRIGGERING

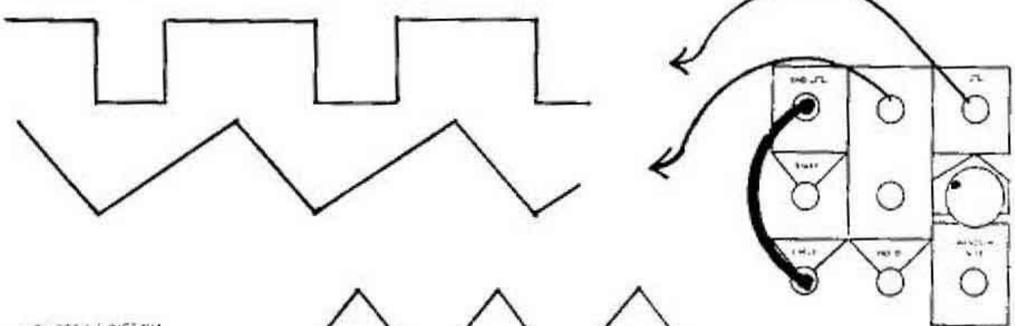


NEGATIVE SLEW

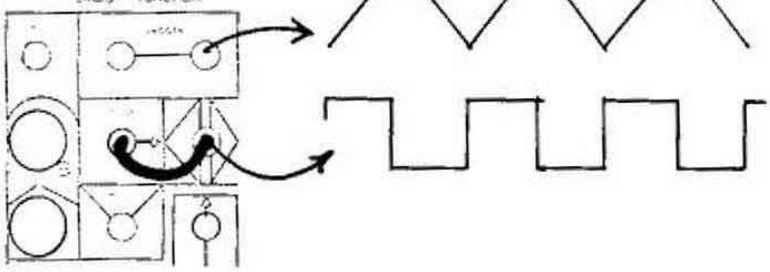
This patch is one of the most useful of the SERGE system, for use as a pulse source, as percussive attack-type sawtooth for the FILTER, and sometimes as an audio generator.

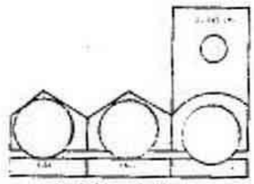


NEGATIVE SLEW POSITIVE SLEW



SMOOTH FUNCTION



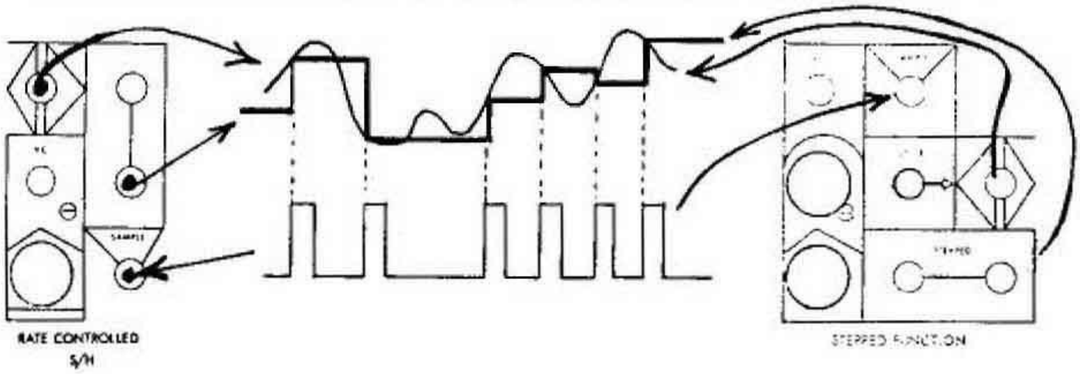


ENVELOPE GENERATOR

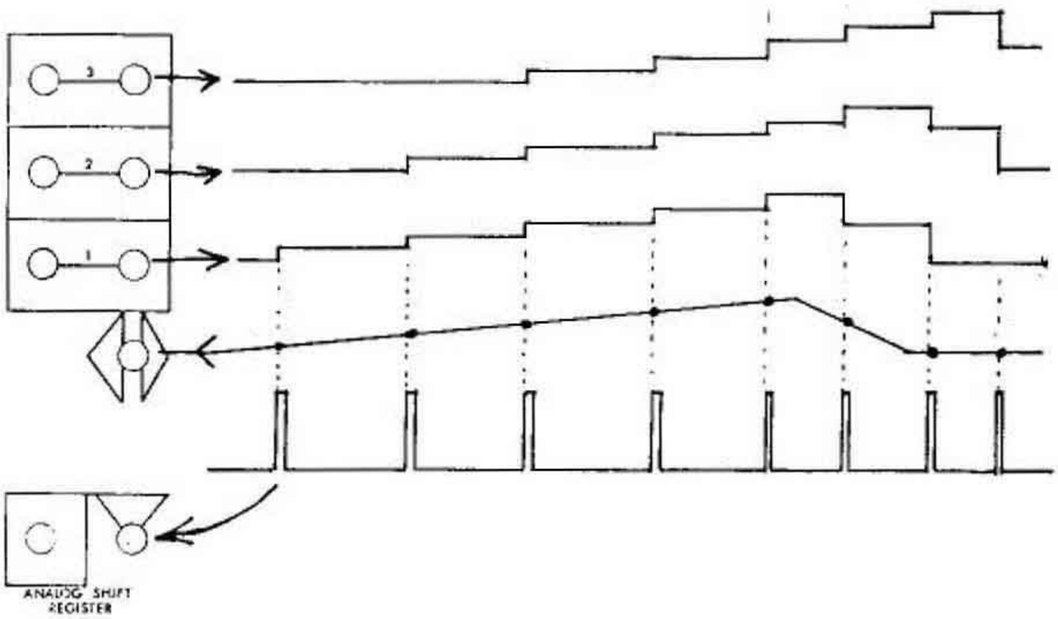
Apart from envelope generating functions, there are several additional functions in the SERGE that use trigger pulses. These include: sampling, sequencing, and selecting.

SAMPLING:

The SAMPLE & HOLD (also called the STEPPED FUNCTION, on the SMOOTH & STEPPED GENERATOR) will "sample" whatever voltage is present at its input at the moment it receives a trigger at the "sample" input. Thereafter, the module holds the voltage, until another pulse is received:

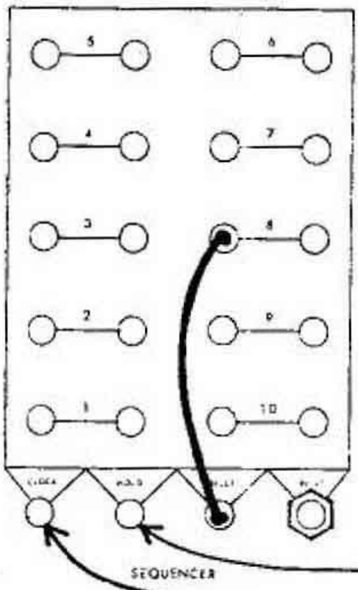


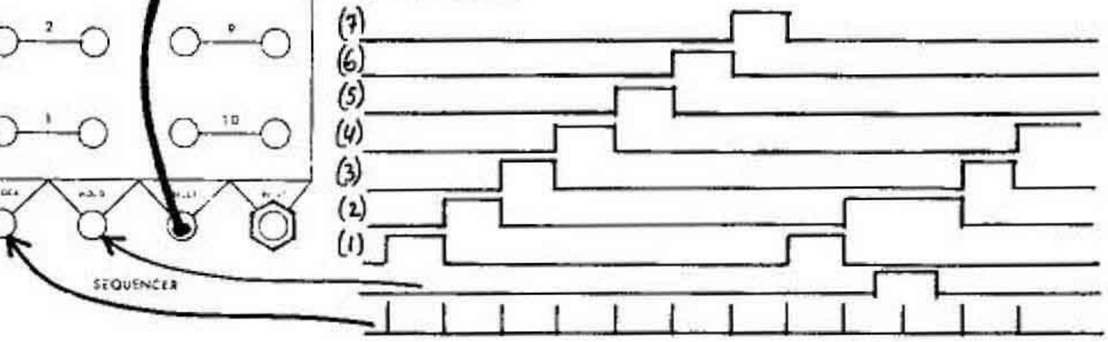
The ANALOG SHIFT REGISTER is a Sample and Hold with a twist, since at every pulse it samples the input voltage as above, but also moves whatever voltages was previously held at a stage down to its second and third stages:



SEQUENCING

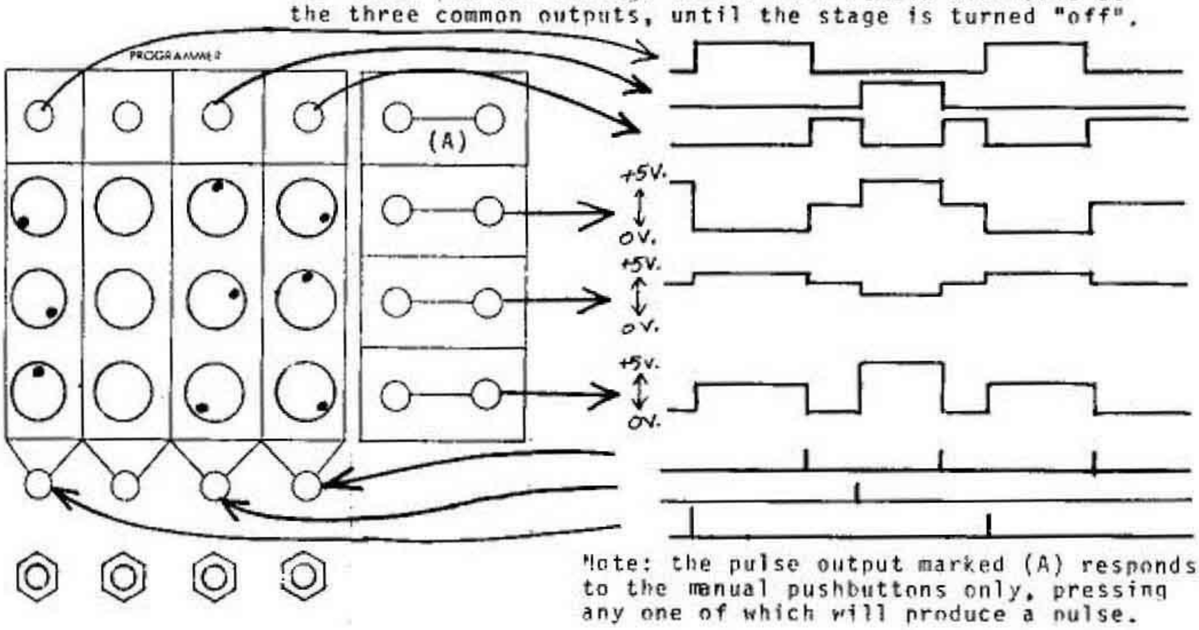
Triggering the "clock" input with a repetitive pulse source sequences pulses one at a time from the ten (or eight) outputs of the SEQUENCER. A pulse at the "hold" input stops the SEQUENCER. A pulse (or pressing the pushbutton) of the "reset" function immediately breaks the sequence and moves the output pulse back to stage 1. By feeding a pulse output from a stage, from stage 8 in the example below, back into "reset", the SEQUENCER can be made sequence through shorter sequences.
The SEQUENCER is excellent for frequency sub-division of audio, for rhythm generation, and for sequencing through a selection of stages on the PROGRAMMER (see below)





SELECTING.

Stages on the PROGRAMMER(s) can be selected through the application of trigger pulses at their pulse inputs. Once selected, a stage will stay "on" until another stage gets selected. The stage's pulse output will stay "high", and its three pre-set voltage levels will remain available at the three common outputs, until the stage is turned "off".

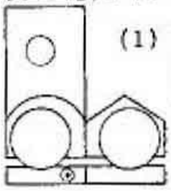


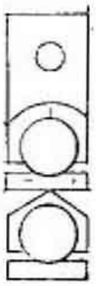
Note: the pulse output marked (A) responds to the manual pushbuttons only, pressing any one of which will produce a pulse.

HOW ARE THE CONTROL VOLTAGES USED, AND WHAT CAN THEY DO?

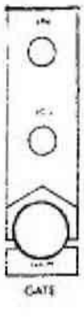
Control voltages are et the heart of synthesizer use. They are used to vary nearly all aspects of musical sound (audio). These aspects include frequency, timbre, amplitude, phase, modulation, blend (of one signal with another). Control voltages are also used to vary the amplitude, repetition rate, and shape of other control voltages.

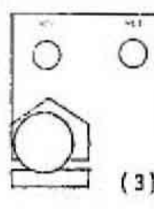
Control is achieved by patching voltages into the VC (voltage control) inputs of various modules. These inputs are, on the SERGE, generally associated with knobs which determine the depth and direction of the effects being controlled. Note however that there are many VC inputs which do not have input knobs. Here are samples of the graphics utilized in the SERGE to designate the VC inputs:



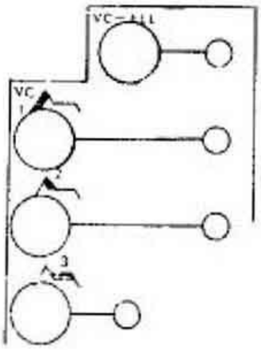


(1) VC inputs with full processing. The knob with the "roof-top" frame sets the level at which an effect starts, for example the initial amplitude, initial frequency, phase, waveshape, etc... The knob with the rounded frame is the processing knob. This knob may be used to set the depth of the effect of a control voltage patched into the VC input adjoining it if it has only one polarity mark (+). If the knob has two polarity marks underneath it (-/+), it can also be used to set the direction of the effect. This means that a 0 to +5 volts input into the processing VC input of an OSCILLATOR, for example, can be adjusted to effect an upward or downward change in frequency according to the position of the processing knob. To the left, the knob effects a downward (negative) change. To the right, the knob effects an upward (positive) change. In the middle, the knob may be adjusted to a null, where the control voltage at the input has nearly no effect.





(2) VC inputs with no processing. This type of input allows a 0 to +5 volts voltage to control an effect through its entire range. Examples of this type of VC input may be found on the GATE (log & lin), the WAVESHAPER (VC1 & VC2) the RATE CONTROLLED SAMPLE & HOLD, etc... A 0 to +5 volts input into the "waveshape" input of the OSCILLATOR will move the output waveshape through a continuous transition between sine wave to sawtooth wave, for example.



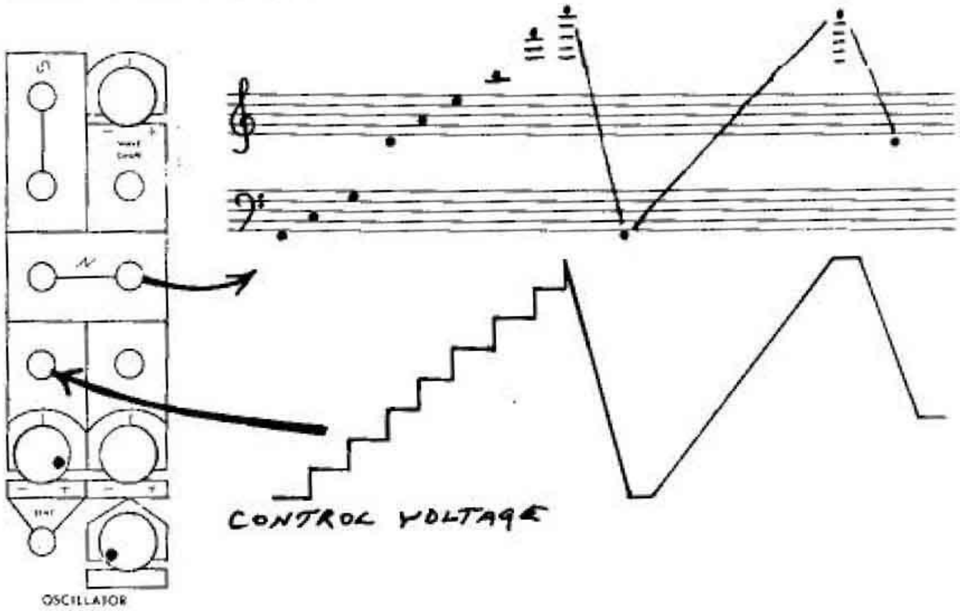
(3) Calibrated VC inputs. This type of input may be found on the keyboard or computer oriented SERGE modules. In these modules, the VC inputs are accurately scaled at 1 volt per octave. This means that a change of one volt at a VC input effects a change in frequency of one octave (i.e., a change in frequency of 2:1.) Here again, the VC input(s) are associated with knobs which affect the initial level of an effect. Examples of this type of module are the NEW TIMBRAL OSCILLATOR, and the KEYBOARD ENVELOPE GENERATOR.

Note: calibration is left open to be adjusted by the user on VC inputs with processing. This can easily be accomplished by following the rules set out in the accompanying page called: "PROCEDURE FOR ADJUSTING THE TRACKING OF TWO OR MORE MODULES".

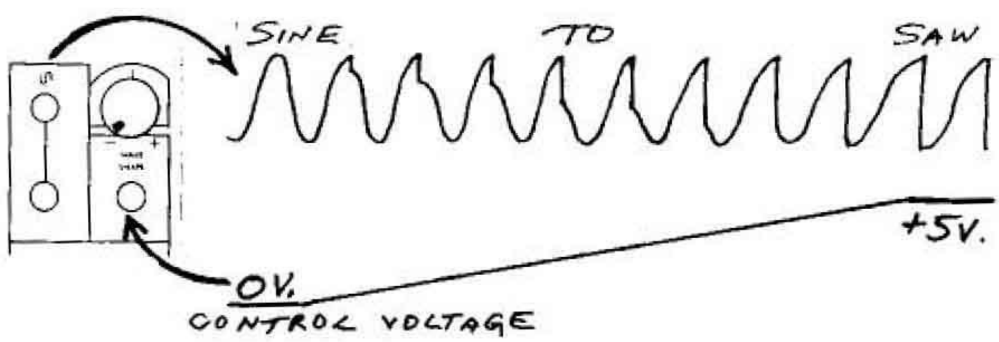
SOME EXAMPLES OF THE WAY CONTROL VOLTAGES WORK

In this list of examples, we are limited by the fact that many of the voltage controllable functions on the SERGE are irreducible to a graphic example. Phasing, modulation, & timbre are best heard rather than seen. In fact, the same may be said about all of the functions in a synthesizer. We therefore encourage the reader to try the following examples for himself, extending the principles here described to all those modules for which we can give no obvious example.

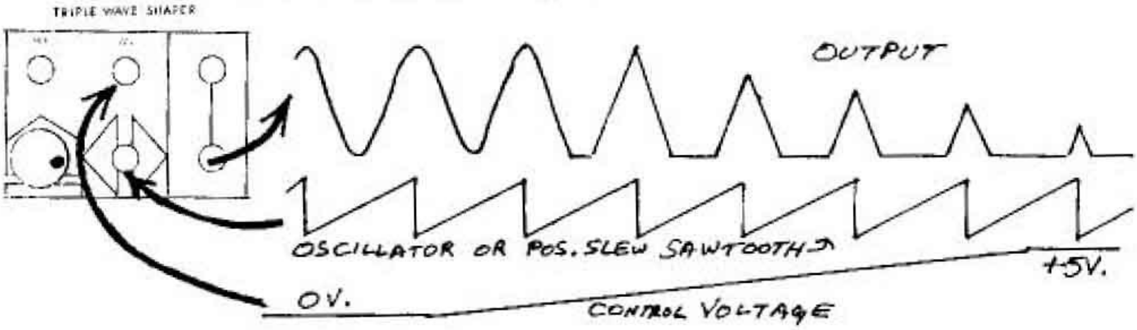
VC control of an OSCILLATOR's frequency



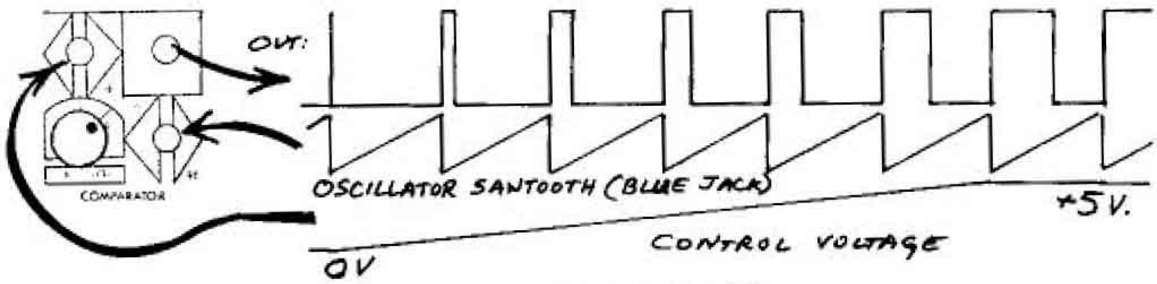
VC control of the waveshape of an OSCILLATOR



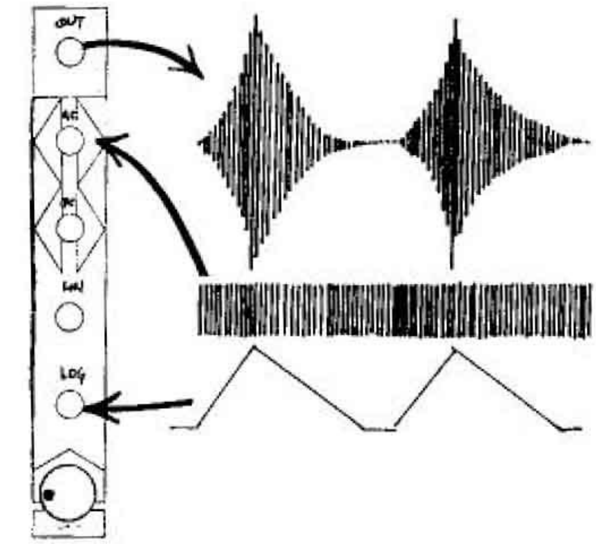
ANOTHER EXAMPLE OF VC WAVESHAPING (using VC2 on a WAVESHAPER)



VARIABLE PULSE-WIDTH (using the COMPARATOR)

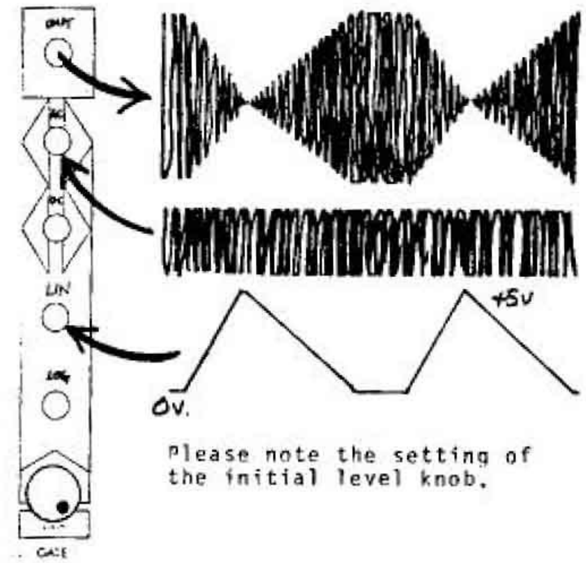


AMPLITUDE (LOUDNESS) CONTROL (using a GATE (VCA))



This is the standard manner of controlling loudness with a GATE, by using the "log" input for the control voltage. The resulting loudness contour shape is perfectly suited to the way we hear sound, since human perception is "exponential". As in the perception of frequency, where we hear an octave whether the actual frequencies are 100 - 200, or 1000 - 2000 Cps, our perception of loudness is such that a doubling of a loudness level is heard to be the same change in loudness, whether from p to pp., or from double forte to forte. Hence the contour to the left, which increases as an exponential function of the control voltage. The "lin" voltage control input provides for a linear function, as shown on the next page.

LINEAR AMPLITUDE CONTROL (using a GATE-(VCA))



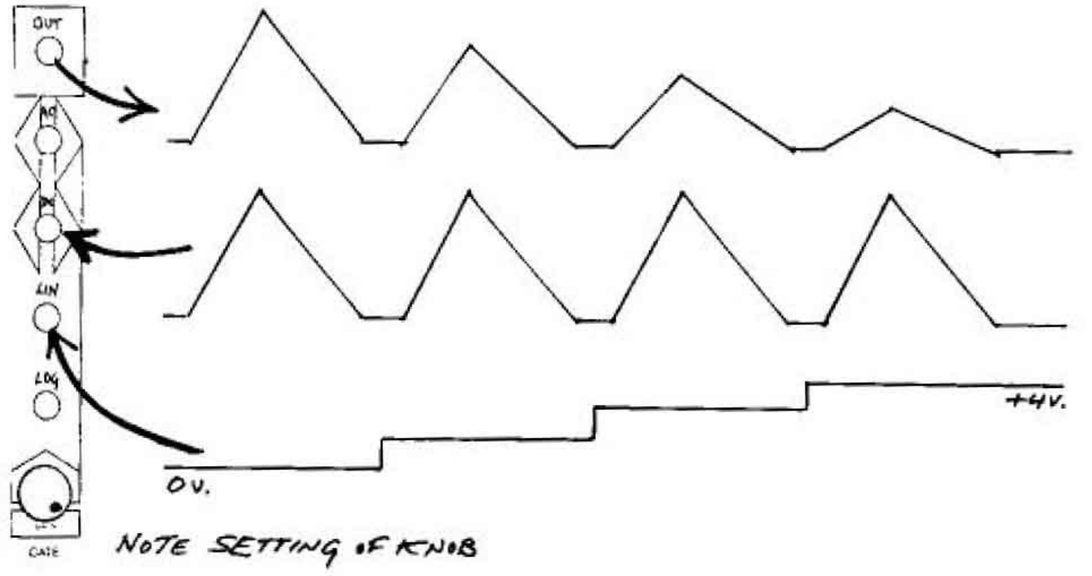
Please note the setting of the initial level knob.

Here the slope is linear. Note that on the SERGE, the "lin" control voltage input affects the audio signal in the inverse manner to the "log" input. That is: 0 Volts in the "log" is minimum amplitude; in the "lin" input, it engenders the maximum level.

The "lin" input of the GATE is useful in several ways. It simplifies the generation of "tremoloes" while the total effect is being controlled in the normal manner, since both "log" & "lin" inputs can be used simultaneously. Additional effects that can be gotten is gain controlled amplitude modulation (with an OSCILLATOR into the "lin" input), and controlling the amplitude of another VC with a VC. An example of this is shown below:

AMPLITUDE CONTROL OF A VC BY A VC

(this process is called two-quadrant multiplication, since one VC multiplies the other. In the SERGE, the transfer function is DC input X LIN input / 5.)



NOTE SETTING OF KNOB

This is about as far as we can go with graphic examples to describe the use and effects of control voltages. We simply cannot give graphic examples of the way the FILTER, PHASER, RING MODULATOR, etc. work and make any sense. The basic principles of operation remain the same as in the previous pages: a suitable audio input is patched into the main function input of a module; a control voltage is patched into the VC input of the module; and the output is monitored through a loudspeaker. We recommend that the user of the SERGE go through all the modules one by one, following this procedure:

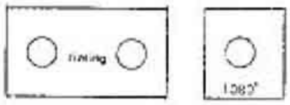
(1) patch a suitable audio voltage into the main input of the module and monitor the output through speakers while varying the module's knobs manually.

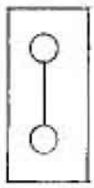
(2) patch a suitable control voltage into the VC input of the module and adjust the VC processing knob (if any) to get a feeling for the module. Of course, different control voltage types will affect the module differently, so that it is advisable to try several different types of control voltages, smooth, stepped, envelopes with fast rises, slow falls, & vice versa, random voltages, audio control voltages, etc...

Here is a recapitulation of what the graphic symbols on SERGE modules signify:

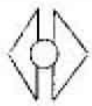
RED jacks: trigger pulses inputs or outputs
BLUE jacks: control voltage inputs or outputs
BLACK: bi-polar control voltages inputs or outputs
BLACK: audio inputs or outputs
OTHER COLORS: special function inputs or outputs

OUTPUTS are always enclosed in square or rectangular frames (single outputs are square, dual outputs are rectangles). The most important rule in the SERGE system is: NEVER, NEVER CONNECT TWO OUTPUTS TOGETHER!!!



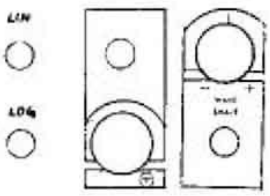


MAIN INPUTS are always enclosed within a diamond frame:



AUXILIARY FUNCTION INPUTS have a triangular shape: (for example: "hold", "cycle", "start", "sustain" "sync", "clock", "reset", "sample", etc. inputs)

CONTROL VOLTAGE (VC) INPUTS are usually labelled or, if they are associated in their use with a processing knob, they are directly adjoining the knob within a rectangular frame:



PROCESSING KNOBS have a rounded frame:

INTERNAL LEVEL KNOBS have a "roof top" frame:

TO REPEAT:

The one single most important rule
to observe in the SERGE system is:

<u>NEVER, NEVER CONNECT TWO OUTPUTS TOGETHER</u>!!!

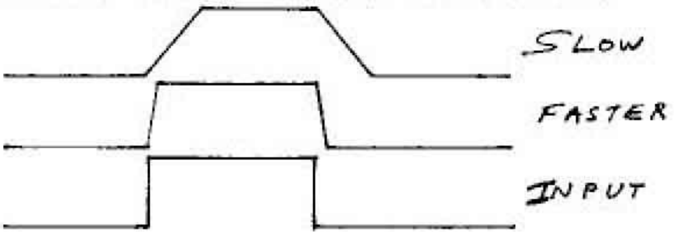
(The reason for this rule is that our outputs try to maintain their proper levels even if they have to expend a lot of power to do so. Connecting two outputs together results in a tug of war. In most cases, no damage will occur since protective circuitry is built into each of the outputs to prevent them from burning up. The specter of an exception exists, however, since the tug of war does stretch the power consumption to the limits of the protective circuitry. Don't worry if you find outputs misadvertently connected. Just disconnect the patch. The odds are 1000 to one in your favor...)

ABOUT SLEWING

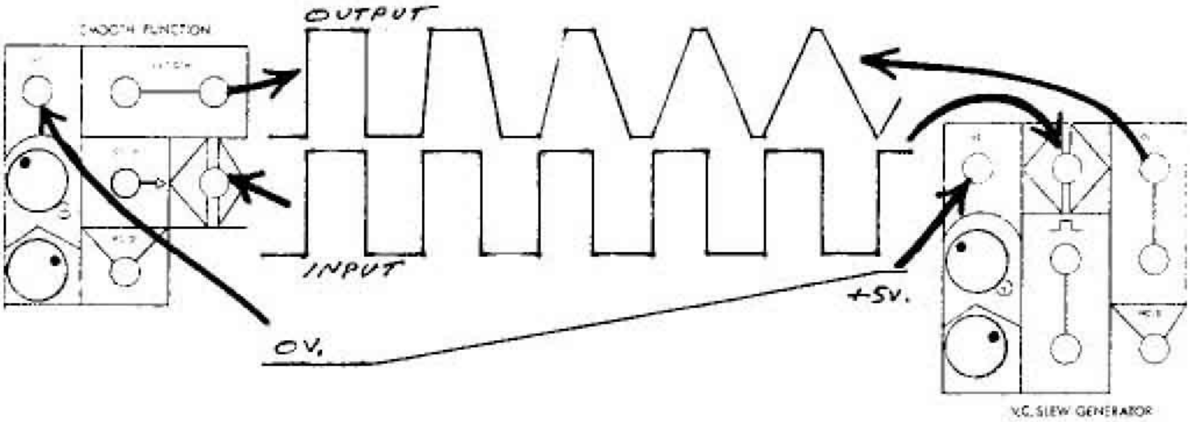
Among the features unique to the SERGE, none are as useful and versatile as the modules that perform "slewing". Indeed, "slewing" makes "programmability" possible. Programmability is the feature which permits a number of SERGE modules to emulate the functions which in more traditional systems would take several separate modules to perform. The savings in cost and space which result set the SERGE SYSTEM apart from all others.

What is slewing?

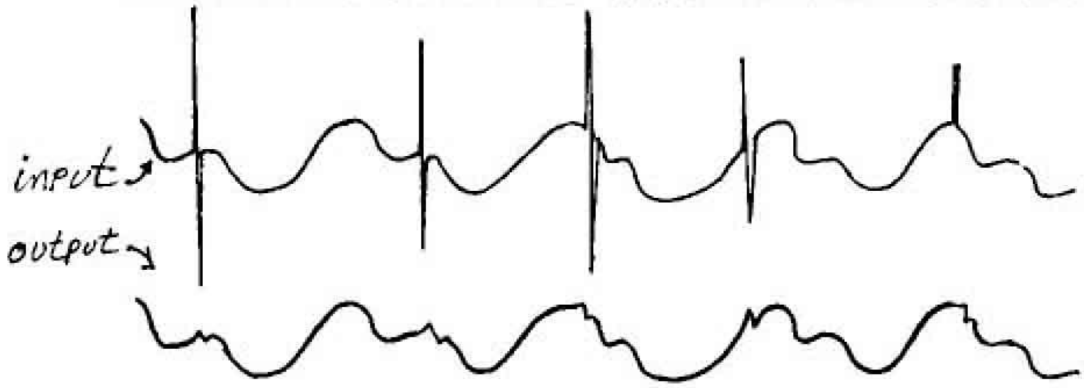
The word is the technical word used in electronics to describe the inability of an amplifier to follow, at its output, the changes presented to its input. All amplifiers suffer from this effect, some more than others. The effect depends on how fast an amplifier is able to respond. The illustration below shows the response typical of slewing of two amplifiers, one faster than the other, to a square wave:



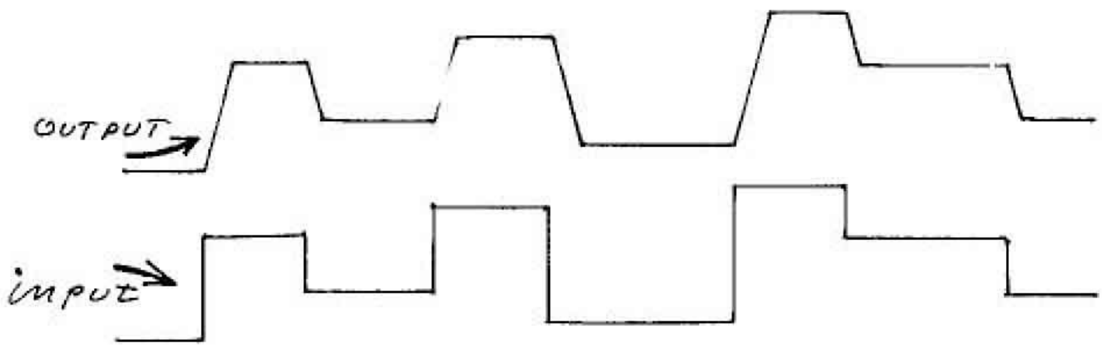
In the SERGE, we have incorporated this effect and have made it voltage controllable as to its speed over a very wide range (log-linearly). For example, the responses of the VC SLEW GENERATOR and the SMOOTH FUNCTION (from the SMOOTH & STEPPED VC GENERATOR) may be voltage controlled to respond in the following manner:



The uses of the SMOOTH FUNCTION and the VC SLEW are manifold. They may be patch-programmed to cycle, yielding a very wide range log-linear range triangle wave generator. They can be used as non-linear filters, in that decreasing their slew rate decreases the throughput of the faster moving input waves, while retaining whatever slower moving waves are present at the input. One interesting application of the modules has been to remove the clicks as found on old phonograph records, since clicks are very fast spike waves riding on slower moving audio:

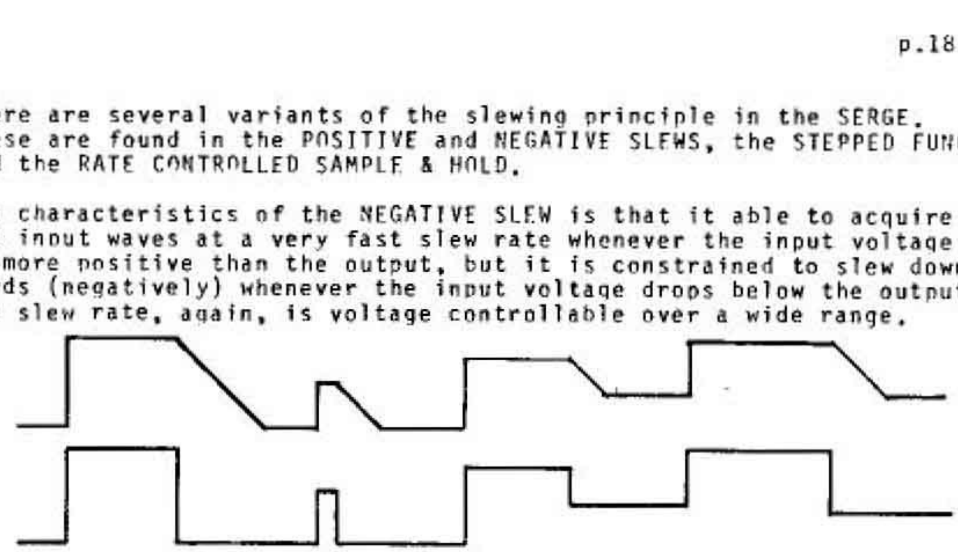


Another use of the VC SLEW and the SMOOTH FUNCTION is for linear portamento between voltage steps. This results in an effect directly related to musical portamento when a VC SLEW or SMOOTH FUNCTION is used to control an OSCILLATOR:

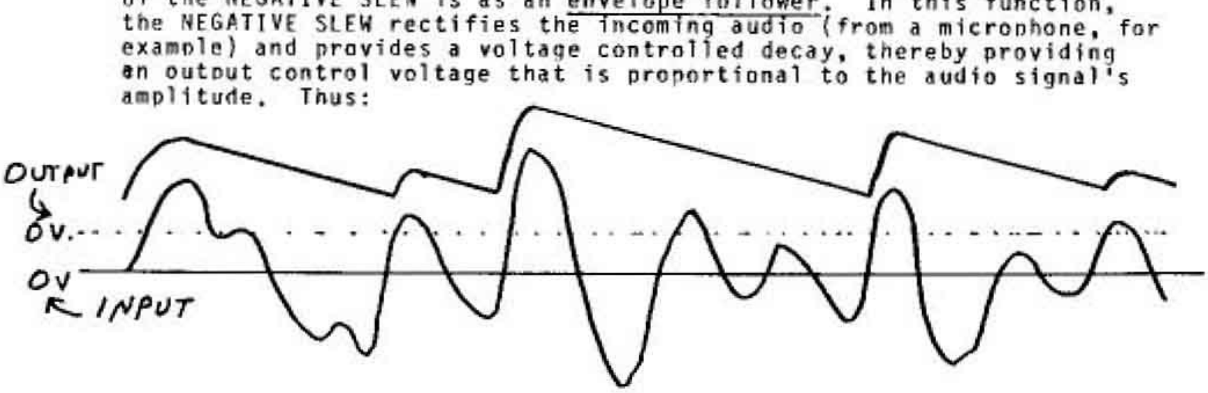


There are several variants of the slewing principle in the SERGE. These are found in the POSITIVE and NEGATIVE SLEWS, the STEPPED FUNCTION, and the RATE CONTROLLED SAMPLE & HOLD.

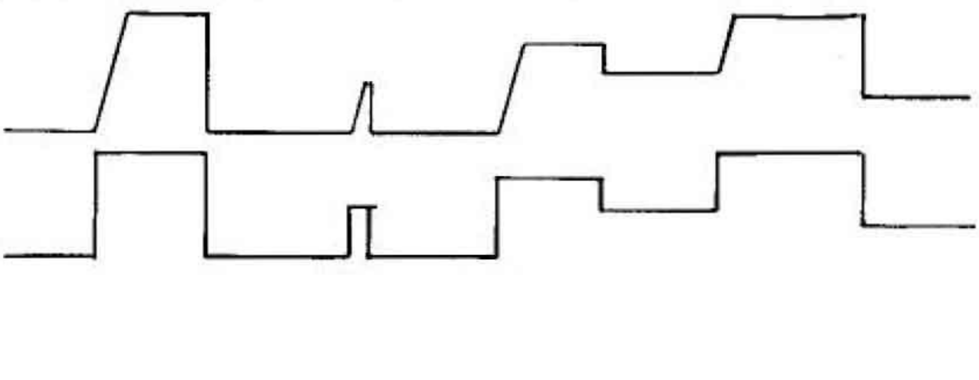
The characteristics of the NEGATIVE SLEW is that it able to acquire the input waves at a very fast slew rate whenever the input voltage is more positive than the output, but it is constrained to slew downwards (negatively) whenever the input voltage drops below the output. The slew rate, again, is voltage controllable over a wide range.



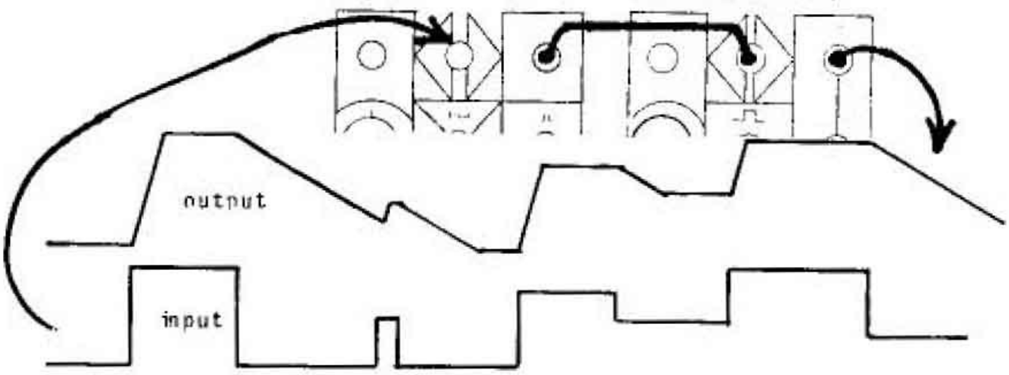
The basic accuracy of the NEGATIVE SLEW allows it to be used to follow keyboard voltages used to control an OSCILLATOR's pitch. Another use of the NEGATIVE SLEW is as an envelope follower. In this function, the NEGATIVE SLEW rectifies the incoming audio (from a microphone, for example) and provides a voltage controlled decay, thereby providing an output control voltage that is proportional to the audio signal's amplitude. Thus:



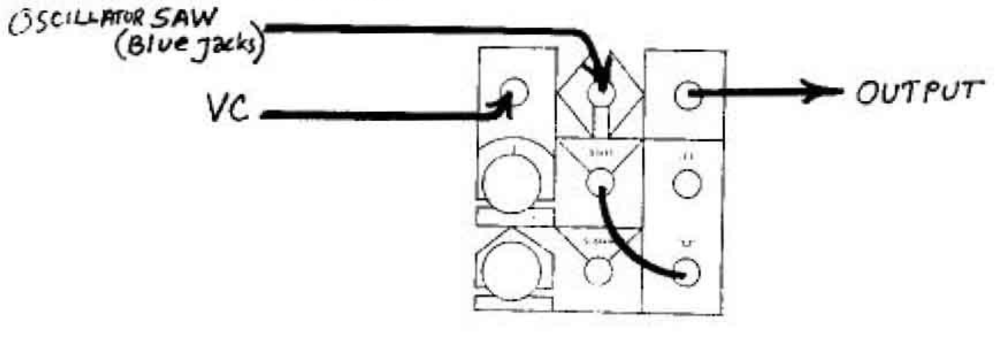
The POSITIVE SLEW functions in a manner inverse to that of the NEGATIVE SLEW. It is constrained to slew upward (positively) whenever the input exceeds the output, but is able to follow the input at whatever rate whenever the latter falls below the output. Thus:



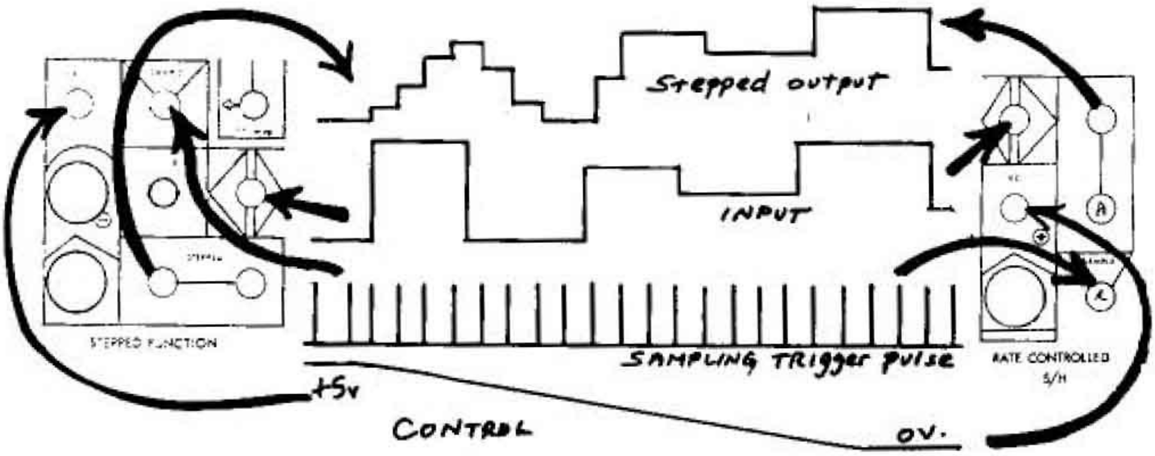
Linking POSITIVE and NEGATIVE SLEWS together produces a combined slewing function that has adjustable and separately controllable up and down slopes:



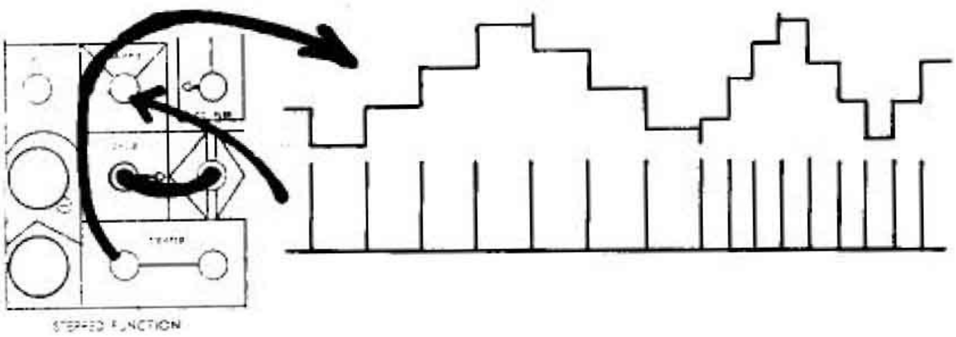
Both the POSITIVE SLEW and the NEGATIVE SLEW have pulse-type auxiliary functions which allow them to be used in a variety of ways already described in previous pages (VC envelope generator, pulser, sawtooth oscillators, pulse delay, etc.). An interesting set of applications of the POSITIVE SLEW arises because its slewing input is independent of the "start" and "sustain" auxiliary functions. One manner of using this multiple input is to have the POSITIVE SLEW follow an externally applied voltage envelope while, every so often, pulsing it into triggerable cycles. This process yields complex envelopes with interesting possibilities. Another use of the multiple input is in this patch for obtaining the sub-harmonic waves to an OSCILLATOR's frequency:



Another set of modules which uses the slewing concept are the RATE CONTROLLED SAMPLE & HOLD, and the STEPPED FUNCTION from the SMOOTH & STEPPED VC GENERATOR. Everytime these modules receive a trigger pulse at their "sample" inputs, they attempt to sample the voltages present at their main inputs. This action was demonstrated in earlier pages. However, the rate at which they are able to acquire the input is limited and controllable in a manner analogous to slewing. In this way they are able to produce a type of stepped slewing very useful for making staircase-type waveforms and portamenti.



The STEPPED FUNCTION has the added capacity of being patch programmable to function as a self-recycling triangular wave staircase generator: (See the page devoted to the SMOOTH & STEPPED GENERATOR for the uniquely varied ways this unusual generator may be patch-programmed!)

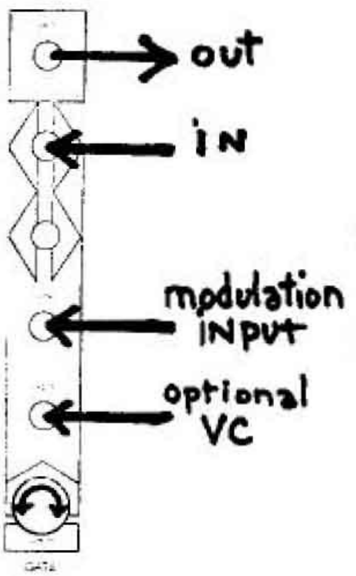


A FEW WORDS ABOUT MODULATION

Modulation in synthesizers is an amazingly powerful means of creating very rich and varied timbres. Modulation is basically a word meaning voltage control that is happening at an audio rate, i.e. where the control voltage is of an audible frequency. There are therefore as many forms of modulation as there are different types of voltage controllable modules. Pulse-width, waveshape, frequency, amplitude, ring modulation, can all be modulated in the SERGE. Exploration of these different forms will be richly rewarded with unique sounds.

In general, modulation of one signal by another results in the generation of added frequencies (called "sidebands") which are the sum and/or difference of the frequencies present in the original signals. The "cleanest" forms of modulation are types which are (1) linear, and (2) where the signals involved are clean of rich harmonic spectra. Pulse-width, waveshape, and other forms of modulation such as switching modulation (as available through the use of the BI-DIRECTIONAL ROUTER and the PEAK & TROUGH modules) are non-linear and/or involve signals already rich in harmonics. These are forms of modulation with limited usefulness, since the harmonic spectra they produce are often times too crowded to be fit for human musical consumption. The cleanest types of modulation available on the SERGE are (1) amplitude modulation (2) ring modulation and (3) frequency modulation.

(1) AMPLITUDE MODULATION. This is a modulation type best performed by the GATE-(VCA) or the RING MODULATOR. The following patch is best suited for modulation, and offers the advantage of keeping the "log" input free to be available for normal amplitude control:

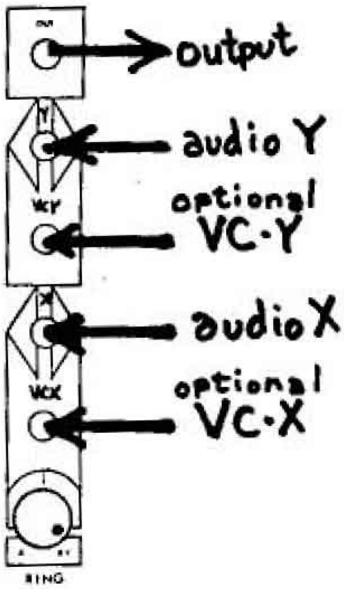


Note: to be effective, the signal patched into the "lin" input must be in the D.C. control voltage range of 0 to +5 Volts as is available from the blue jack outputs of the OSCILLATOR, POSITIVE & NEGATIVE SLEWS, and ENVELOPE GENERATOR.

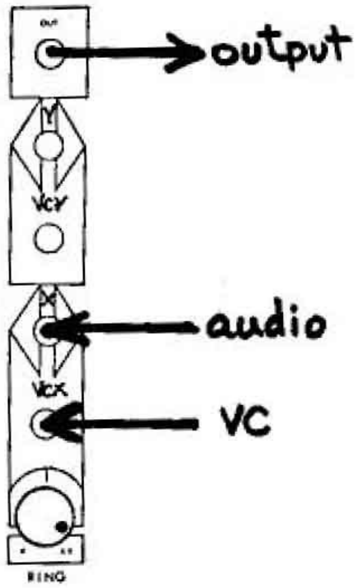
The output signal in this form of modulation features sum and difference frequencies plus the audio signal present at the main function input. The signal at the "lin" does not appear at the output, and is said to be "suppressed".

(2) RING MODULATION. The RING MODULATOR performs this type of modulation with a number of voltage controllable options not normally found in synthesizer equipment. Typically, as a simple ring modulator, the two signals are patched into the "X" and "Y" inputs, and the knob is set as shown, adjusted to provide a maximum suppression of the input signal a "X". (This is best performed by patching the "X" signal alone and adjusting the knob for an audible null before patching in the "Y" input). The response typical of ring modulation are the sum and difference frequencies resulting from the two input signals bereft however of either of the input signals. Hence this form of modulation is also known as doubly suppressed modulation. The "VCX" and "VCY" inputs offer the possibility of providing two unique and sonorously valuable voltage controllable transitions: a voltage input from 0 to +5 volts at the "VCX" input moves the output from full ring modulation through amplitude modulation (wherein the signal at "X" starts being heard) through non-modulation (wherein the only output heard is the signal at "X"). A VC of 0 to + 5volts at "VCY" performs the same effect vis a vis the signal at "Y". To the left is an illustration of the typical manner of using the RING MODULATOR. To the right is a patch which is useful whenever an additional GATE might be needed: in this patch, "VCX" is equivalent to the "log" input on a GATE, and the signal at "X" is functionally similar to the "AC" input. Note however that a null must be adjusted at the knob, and that there will be some (inevitable) feedthru of the gated audio in this patch.

RING as ring modulator



RING as gate



(3) FREQUENCY MODULATION. This is an exceptionally rich modulation type. It can be used wherever there is a voltage controllable frequency function. On the SERGE, these are legion: the OSCILLATORS, SLEWS, FILTERS, etc... can all be modulated. Two types of frequency modulation may be gotten by using the blue or the black outputs. Using the blue outputs (whose characteristic output will be in the D.C. control voltage range of 0 to +5 Volts) into the VC processing input of an OSCILLATOR, for example, will result in a form of unidirectional frequency modulation, where the apparent center frequency will shift along with the setting of the processing knob. Using a black output to frequency modulate an OSCILLATOR will have a steadier effect, since the voltages from typical audio outputs on the SERGE are bipolar audio (black jacks), and modulation will occur equally upward and downward in frequency. There is, however, still a small shift in frequency as the depth of the modulation increases. This has been shown in the work of several musical scientists such as John Chowning of Stanford University, to be an unavoidable result of the mathematics of frequency modulating a log-linear OSCILLATOR input. All frequency function in the SERGE are log-linear. Only recently have we designed an oscillator, the NEW TIMBRAL OSCILLATOR, which offers a linear (as opposed to log-linear) VC inputs specifically made available for frequency modulation. With a linear VC input, the small shift in frequency does not occur; and therefore the rich timbres made available through frequency modulation can be used in a musically coherent manner in conjunction with keyboards, etc... This does not by any means rule out the use of frequency modulation in the current SERGE modules, since the effects gotten if carefully handled can be superb...

PROCEDURE FOR ADJUSTING THE TRACKING OF TWO OR MORE MODULES

The procedure which follows uses two OSCILLATORS for the sake of an example. It can also be used for tracking POSITIVE & NEGATIVE SLEWS, VC SLEW & SMOOTH, ENVELOPE GENERATORS, FILTERS, etc...

Step (1): Without a voltage into the VC inputs, adjust very carefully the two OSCILLATORS for a perfect unisson at a given frequency. If the processing is to be positive, it is best to use a relatively low frequency such as 100 cps. (low A on the F clef). If the processing is to be negative, it is best to pick a higher frequency such as 1000 cps. (C two octaves above middle C). Use sawtooth outputs mixed into a single mixer for ease of listening for beats in adjusting for the unisson.

Step (2): Use a steady voltage such as may be gotten from the PROGRAMMER, PROCESSOR, or a keyboard, and patch into the VC input of only one of the OSCILLATORS. Adjust the resultant shift in frequency for the desired interval. (On a keyboard, the shift might be two octaves for a two octave stretch on the keys).

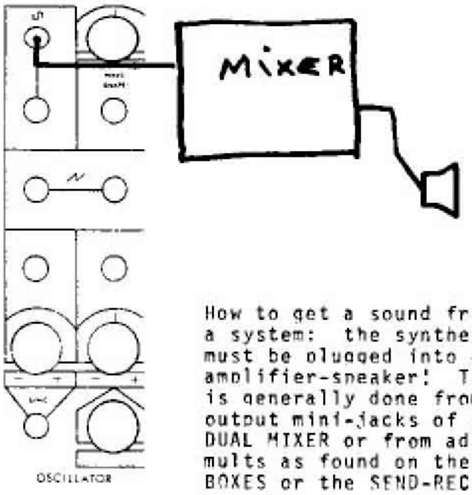
Step (3): Patch the same voltage into the VC input of the second OSCILLATOR and adjust the VC input processing knob to obtain a unisson at the higher (or lower) frequency.

Step (4): Unplug the voltage from both OSCILLATORS and test for the accuracy of the initial unisson. This may have to be re-adjusted, and steps (2) and (3) performed once again to attain maximum accuracy.

Notes:

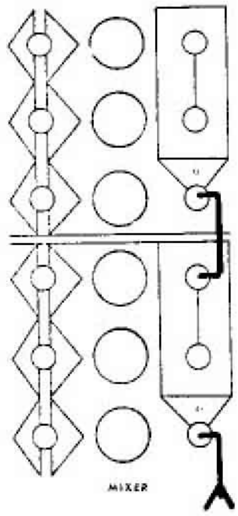
1. Tracking of FILTERS is best done while listening to the FILTERS set at a high "Q" (resonance), and pulsing the inputs with the sawtooth of a NEGATIVE SLEW. The NOISE SOURCE is an alternate sound source that can be used to render the FILTERS's frequencies apparent. Adjustment may then be performed as above.

2. Adjustment of the SLEWS and other ENVELOPE GENERATING modules is best done while re-cycling them in the audio frequency range. After adjustment, the internal rate control knobs may be returned to a sub-sonic range. The basic accuracy of the adjustment will remain good in that range. Do not, however, use the top most two octaves of audio in these modules, as their accuracy is somewhat degraded by the fact that they are operating at the very extreme of their range.

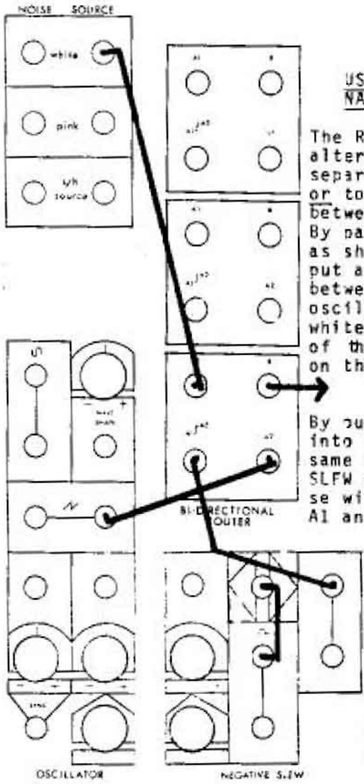


How to get a sound from a system: the synthesizer must be plugged into an amplifier-speaker! This is generally done from the output mini-jacks of the DUAL MIXER or from adapter mults as found on the CHASSIS BOXES or the SEND-RECEIVE.

Connect an OSCILLATOR with a MIXER as shown. Turn the volume controls on your amplifier and at the MIXER to a comfortable listening level. You should hear a tone. By turning the lowest knob on the OSCILLATOR, the "internal control", you can vary the output frequency from 16 to 16,000 Cps. Set the OSCILLATOR to a frequency in the middle of the range. Turn the knob just above the "internal control". This is the fine tuning knob. Now go to the "wave-shape" knob. This knob controls a transition from sine to sawtooth. This is a very useful feature of the OSCILLATOR, which can be used for many timbral effects.

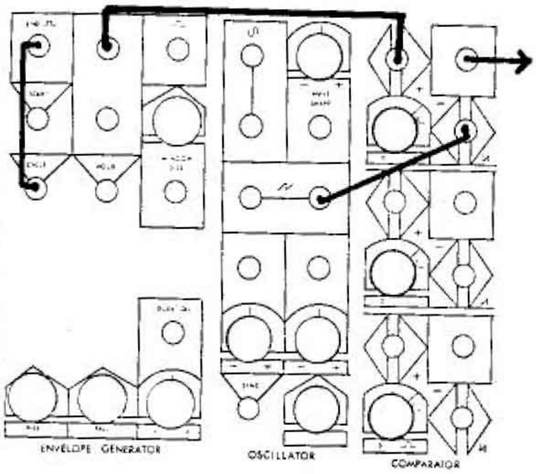


This is a very useful patch whenever a MIXER with more than 3 inputs is needed. Linking MIXERS via the "x1" input allows several MIXERS to form units with 6, 9, 12, etc. inputs. "x1" means "unity gain". This is the technical term describing a input on an amplifier or mixer which allows a signal to pass to the output at the same loudness level it enters the amplifier or mixer. In studio terminology, the "x1" input is called a "wild" input, because it does not have a control to vary loudness level.



USING THE BI-DIRECTIONAL ROUTER

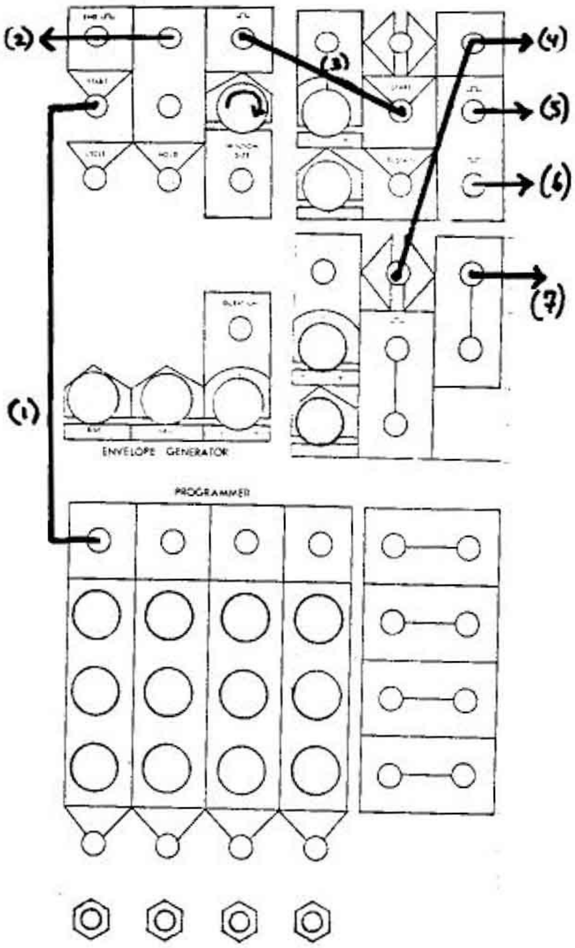
The ROUTER can be used to alternate between two separate incoming signals or to route one signal between two outputs.
By patching the diagram as shown, the signal output at "B" will alternate between the tone of the oscillator and of the white noise. The speed of the alternation depends on the speed of the cycling of the negative slew.
By putting the white noise into "B" and applying the same signal from the NEG SLEW as before, white noise will alternate between A1 and A2.



USING THE COMPARATOR

The COMPARATOR will square off any waveform or signal that is patched into it.
By putting a SAWTOOTH wave (NOTE! It's important to take the sawtooth from one of the blue jacks!) into the COMPARATOR's input (with a small sawtooth sign near it), variable pulsewidth square waves will result.
By patching as shown, the result is that of voltage controlling the pulse width by the envelope control voltage from the ENVELOPE GENERATOR. Note of course that any other control voltage source may be used.

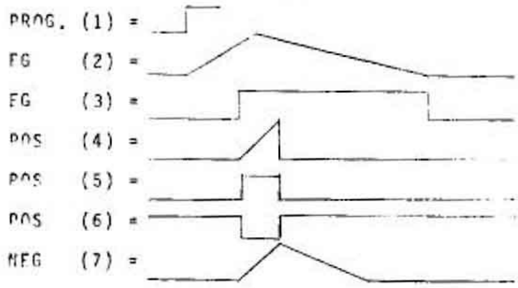
Another use of the COMPARATOR is that of detecting the level of a control voltage when it is plugged into the positive comparator input.



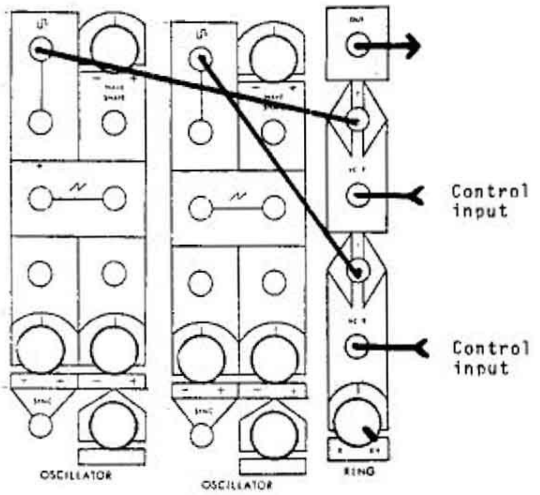
GENERATORS IN SERIES.

This type of patch allows you to get time-related multiple envelopes as shown. Uses of such envelopes is in multiple fades with VCAs, timbral transitions via Filters, Comparators, Waveshapers, Phasers, etc.

Waveforms look like this:



Many other combinations are of course possible in linking generators. Specifically, one may use the POSTIVE SLEW's various output pulses to provide delayed pulses as needed in setting up chain reactions of envelopes and rhythms.

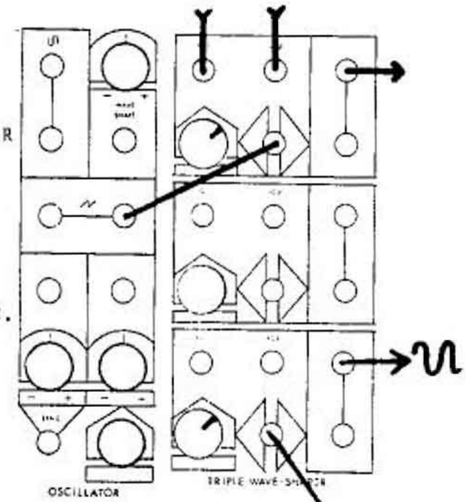


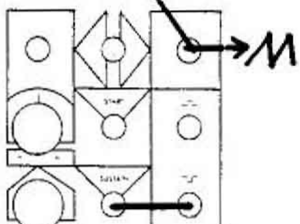
HOW TO USE THE RING MODULATOR

The "Y" and "X" inputs are the main inputs to the RING MODULATOR. Typically, the signal (such as the microphone output, & other material) is plugged into the "X" input, and the modulating signal (typically a sinewave oscillator) is plugged into the "Y" input. Turning the knob more and more of the "X" input to be heard ("feedthrough") The main "Ring Modulation" position on the knob is as shown above. VC X allows timbral changes to be made through the application of a control voltage which brings out the "X" input. VC Y does the same, bringing out the "Y" input to be heard.

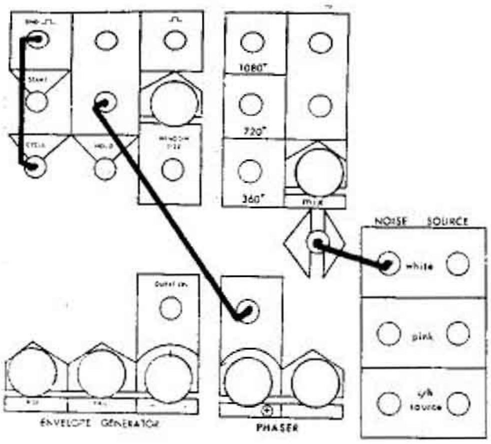
The RING MODULATOR can also be used as a GATE if need be. The knob must be turned fully clockwise and adjusted for a null. A Control voltage into VC X is used for amplitude control.

USING THE WAVESHAPERS



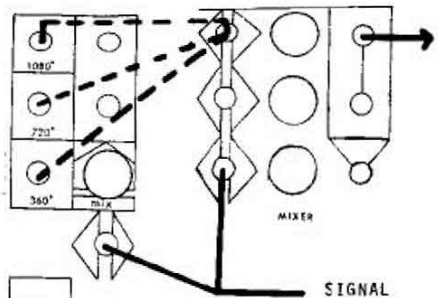


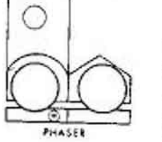
The WAVESHAPER has several interesting and useful functions. One of these is providing other waveshapes from an OSCILLATOR. Voltage control at VC1 and VC2 provide a means of varying the timbre. VC1 provides for a transition from rounded sinewave to sawtooth; VC2 provides a type of "pulse width modulated" sound that sounds very much like phasing. Patching a POSITIVE SLEW into the WAVESHAPER allows the POSITIVE SLEW's sawtooth wave to be shaped into sine-sounding voltage variable waves. This is especially useful when additional oscillators are needed. Another interesting use of the WAVESHAPERS is using them to provide distortion of instrumental sounds such as amplified flute, guitar, voice, etc.



USING THE PHASER

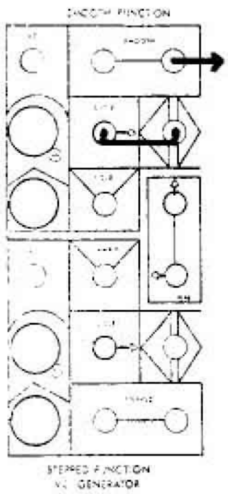
The PHASER needs to have a control voltage patched into it in order to be heard. The knob to the right of the PHASER adjust the internal frequency at which phasing begins. The processing potentiometer determines the depth of effect that a control voltage has on phasing. The "mix" control is a blending control which, when fully clockwise, lets pass only the phased signal by itself; while in its center position, it outputs a mixture of the original signal and its phase delayed image to provide the characteristic "phasing" sound. An interesting use is to patch into the PHASER an amplified singing voice and modulate it with a medium fast triangle control voltage. The result is a (doppler shift) vibrato of the original voice.

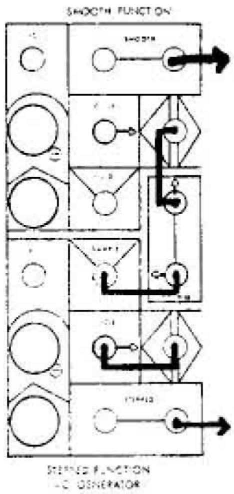


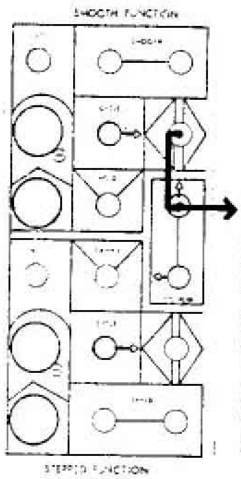


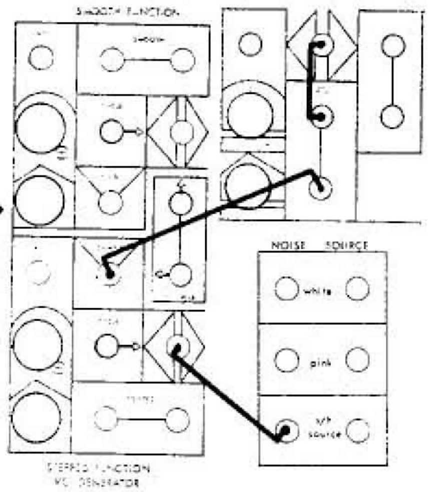
The additional outputs of the PHASER are useful in several ways. One of these is to get various degrees of the phasing effect. An external mixer must be used in order to mix the original sound with its phase delayed image. At 720° and 360° the phasing effect will be much less pronounced, as sometimes would be desirable (specifically when putting phasing on natural sounds, thereby getting some very subtle effects...)

The additional outputs of the PHASER are also useful when working stereo- or quadra-phonically. Typically, the original signal is placed on one speaker, and the 1080, 720, or 360° outputs are placed at the other speaker(s).







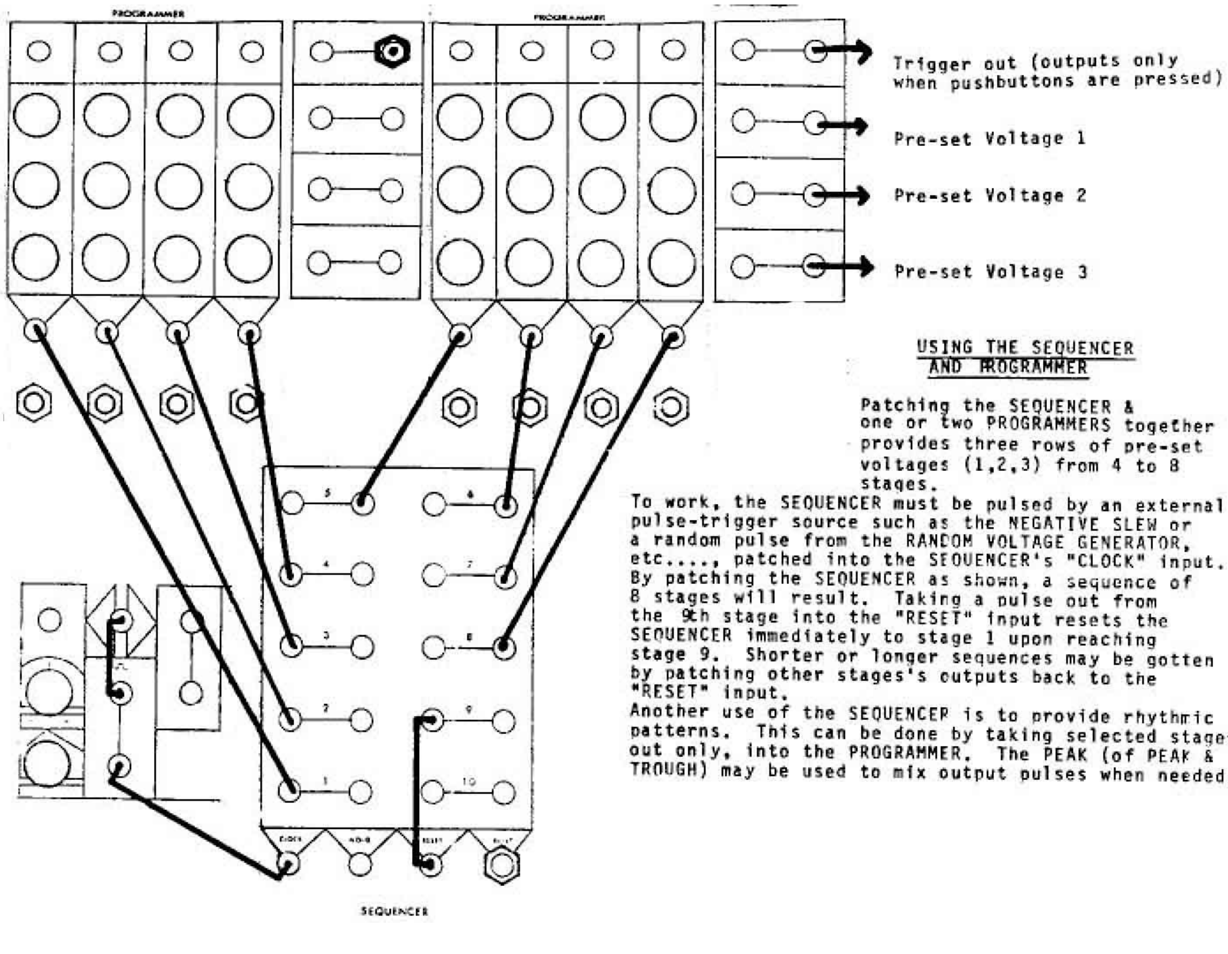


1. This patch re-cycles the SMOOTH FUNCTION and produces a triangular wave which may be voltage controlled over an extremely wide range. Note that the "HOLD" input simply stops the wave at whatever level it has reached at the moment a pulse is "high" plugged into the "HOLD" input.

2. This patch provides a very varied and unusual source of noise and rhythm type sounds. It must be experimented with to be fully appreciated!

3. This too is a unique patch providing rhythmic timbral sounds that have no counterpart in ordinary synthesizers. "Snare" type sounds can be gotten. VC of the SMOOTH and occasional pulsing of the "SAMPLE" input of the STEPPED produces changes in the sounds.

4. This is an example of the use of the STEPPED FUNCTION as a SAMPLE AND HOLD. Everytime the "SAMPLE" input receives a pulse, it samples the voltages present at the input and acquires it at the output. Note however that the setting of the "internal rate control" knob (lowest knob) is crucial. Fully clockwise, the module functions as a normal SAMPLE & HOLD with high accuracy. As it is turned counter-clockwise it limits the acquisition rate of the S/H in such a way that the output will lag the input. (This is a type of "stepped" slewing yielding a wide variety of staircase type waveforms, and of course, can be voltage controlled.)

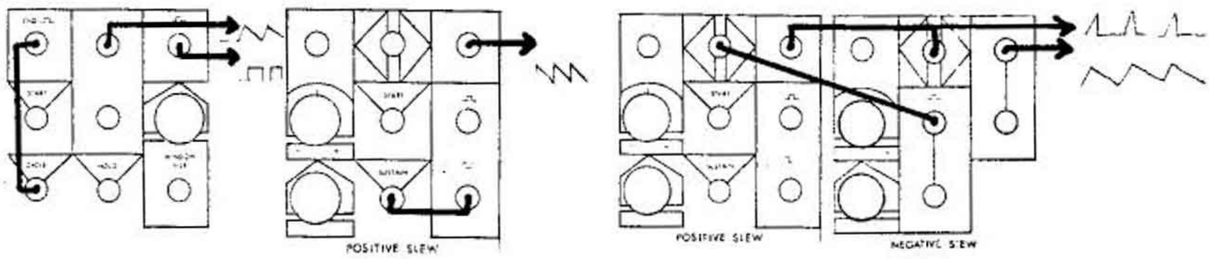


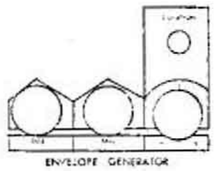
USING THE SEQUENCER AND PROGRAMMER

Patching the SEQUENCER & one or two PROGRAMMERS together provides three rows of pre-set voltages (1,2,3) from 4 to 8 stages.

To work, the SEQUENCER must be pulsed by an external pulse-trigger source such as the NEGATIVE SLEW or a random pulse from the RANDOM VOLTAGE GENERATOR, etc...., patched into the SEQUENCER's "CLOCK" input. By patching the SEQUENCER as shown, a sequence of 8 stages will result. Taking a pulse out from the 9th stage into the "RESET" input resets the SEQUENCER immediately to stage 1 upon reaching stage 9. Shorter or longer sequences may be gotten by patching other stages's outputs back to the "RESET" input.

Another use of the SEQUENCER is to provide rhythmic patterns. This can be done by taking selected stages out only, into the PROGRAMMER. The PEAK (of PEAK & TROUGH) may be used to mix output pulses when needed.





CYCLING

The ENVELOPE GENERATOR, POSITIVE SLEW NEGATIVE SLEW, POSITIVE + NEGATIVE SLEWS, SMOOTH GENERATOR, STEPPED VOLTAGE GENERATOR, VC SLEW GENERATOR, are all modules which can be made to cycle and produce a repeating envelope. Any one of the outputs from these modules provide control voltages that can be applied to any CV input in the system.

Note: To recycle the "STEPPED" VC Generator, it must be triggered at the "SAMPLE" input by a repetitive pulse source such as a NEGATIVE SLEW. The output of the STEPPED GENERATOR will be a trianqular staircase control voltage waveform.