EURO-SERGE - SELF-TEACHING PATCHES # 2

CONTENTS

Fast-Forward and Rewind

STEP ONE

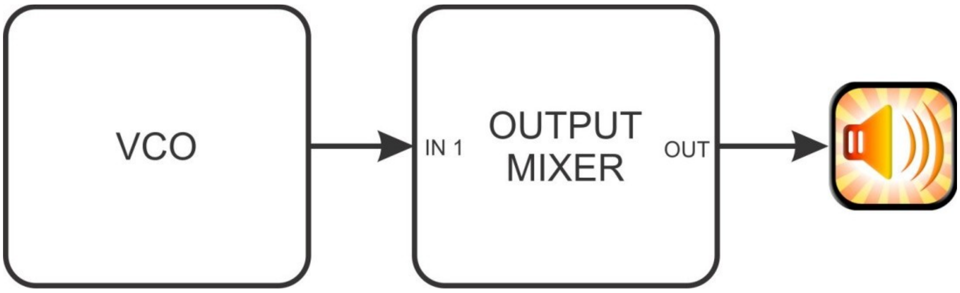


Figure 4.1.1

NOTE: The output mixer should be set the same as in the First Learning Patch. In this section, block diagrams will be used to represent patches. Each module is represented as a block. Its signal output is from the right side of the block. Signal inputs are shown going into the left side of the block. Control voltage inputs go to the bottom of the block, and control voltage outputs are shown coming off the top of the block. Each of these inputs/outputs will be labelled on the diagram. Any special pot settings necessary to make the patch work will be listed below the diagram. On some of the diagrams drawings of the waveforms will be drawn next to the appropriate patch cord.

There are three basic oscillators in the Euro-Serge system of which two currently are NOT from the Serge Modular System but have been used as 'nearest direct replacements' for the Serge New Timbral Oscillator (NTO) and the Precision VCO (PCO). All these oscillators are identical except for some control and output functions unique to each other. This discussion will concentrate on the ASM321 BASIC VCO which is a 'suitable replacement' for the PCO.

1.1 Set up the above patch on your Euro-Serge. The [SINE] out of the VCO (the abbreviation "VCO" will be used from now on to refer to any oscillator) should be patched to [IN 1] of the output mixer.

1.2 VCOs produce repetitive varying voltages referred to as "waves". These waves are produced in different "wave shapes" of which SINE, SAW, TRIANGLE and RECTANGULAR (sometimes called SQUARE) are the most common. A VCO can produce these wave shapes at different frequencies. The frequency of a wave determines its pitch. The higher the frequency of a wave the higher the pitch. The shape of a wave determines its timbre or sound quality. Each VCO on the Euro-Serge provides a number of simultaneous outputs, all at the same frequency but with different wave shapes.

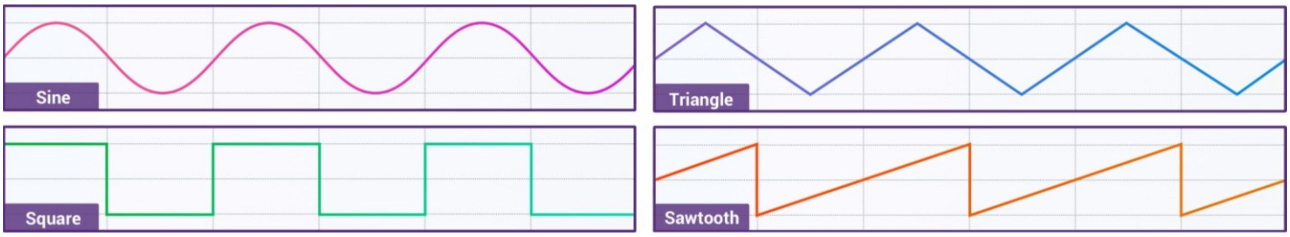


Figure 4.1.2

While most VCOs on most synthesizers can produce waves across the entire spectrum of human hearing - about 20Hz to 20kHz, some VCOs on the Euro-Serge synthesizer can go below this threshold. Waves of these low frequencies are useful as control voltages.

1.3 A sine wave is the simplest wave shape. Any wave shape except a sine wave can be treated as combination or mix of simpler waveforms. That is, ANY wave can be analysed as a mix of sine waves of specific frequencies and amplitudes.

1.4 One way of visualising this is with a chart that has audible frequencies across the bottom and amplitude on the vertical axis:

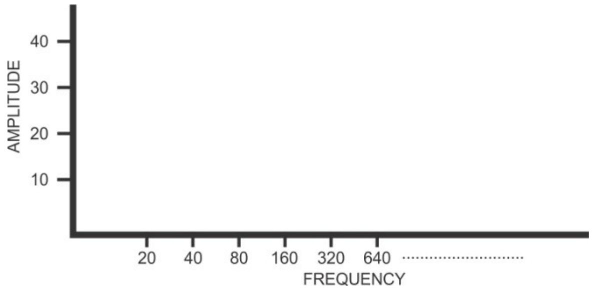


Figure 4.1.3

Note that the scale across the bottom is EXPONENTIAL; that is each interval marked off is TWICE the frequency of the previous interval even though the intervals are of equal lengths. This is the way we hear, with each interval having twice the frequency spread of the previous interval (e.g. 20, 4, 80, 160, 320, 640 ...) and yet these intervals sound identical to our ears/brains. The exponential scale controls with a LINEAR scale where each interval is a set distance from the previous interval. For instance, a linear scale would produce 20, 40, 60, 80, 100, 120, 140...

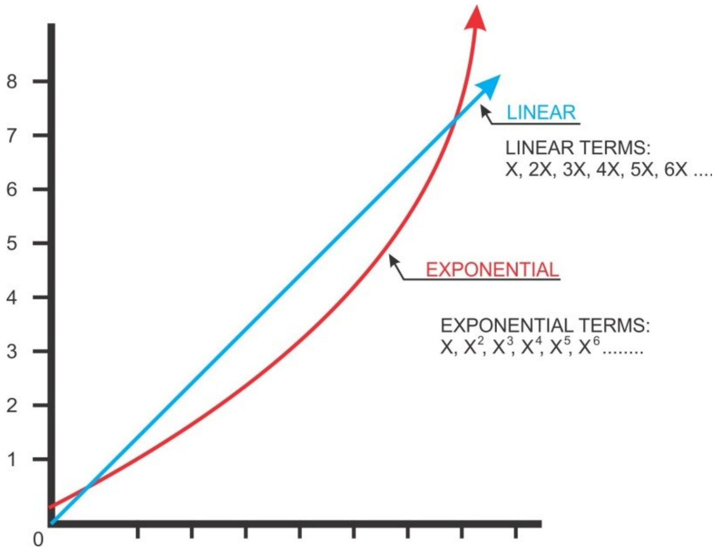


Figure 4.1.4

To notate a sound on this chart, place a vertical line at the point where each component sine wave occurs. The height of the line will indicate the relative amplitude of the sine wave. This vertical scale is also exponential and is measured in Decibels. Though our perception of loudness is not quite this simple (we are less sensitive, for instance, to frequencies at the top and bottom of the scale), generally speaking, the higher the decibels the louder the sound. For instance a pure sine wave with a frequency of 440Hz would be shown like this:

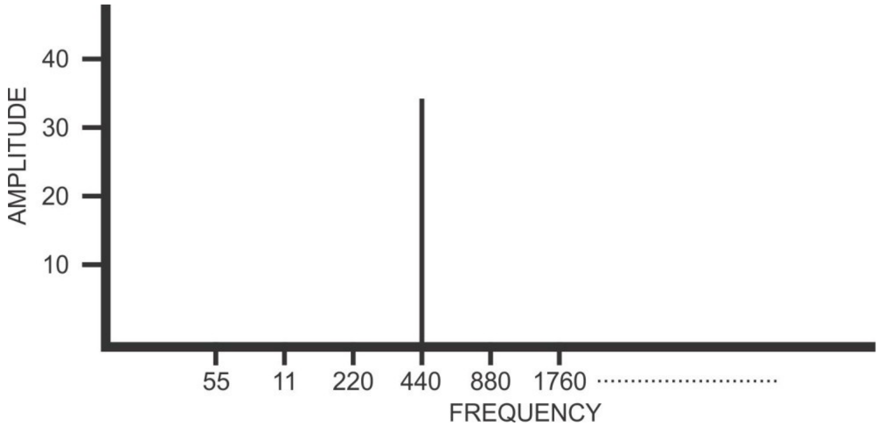


Figure 4.1.5

1.5 Most sounds, including electronics sounds, are composed of more than one sine wave. We now have two ways of picturing a sound, its pressure or voltage wave and its sine wave spectrum. The "shape" of a wave refers to its voltage as can be seen on an oscilloscope. This is called a time-domain display. The spectrum graph is called a frequency-domain graph and is an analysis of the voltage waveform. Below are a wave (Time Domain) and its hypothetical frequency-domain spectrum.

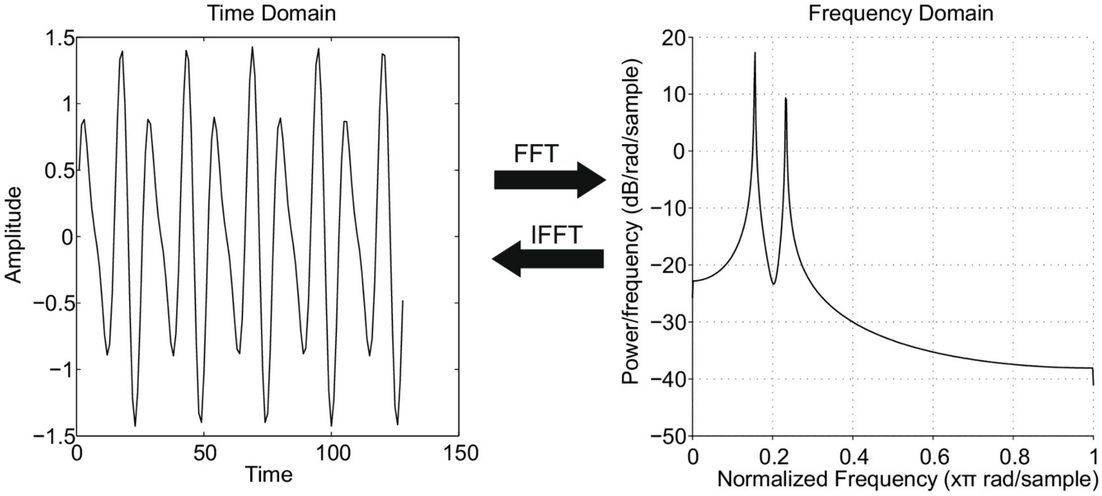


Figure 4.1.6 Time and Frequency Domain Graphs

1.6 To determine the overall shape of a wave from its component sine waves, the values of the component waves AT EACH INSTANT are added together. This also means that if two waves of identical frequency but of opposite "phase" (one goes up while the other goes down) are mixed together, they will cancel each other out resulting in silence.

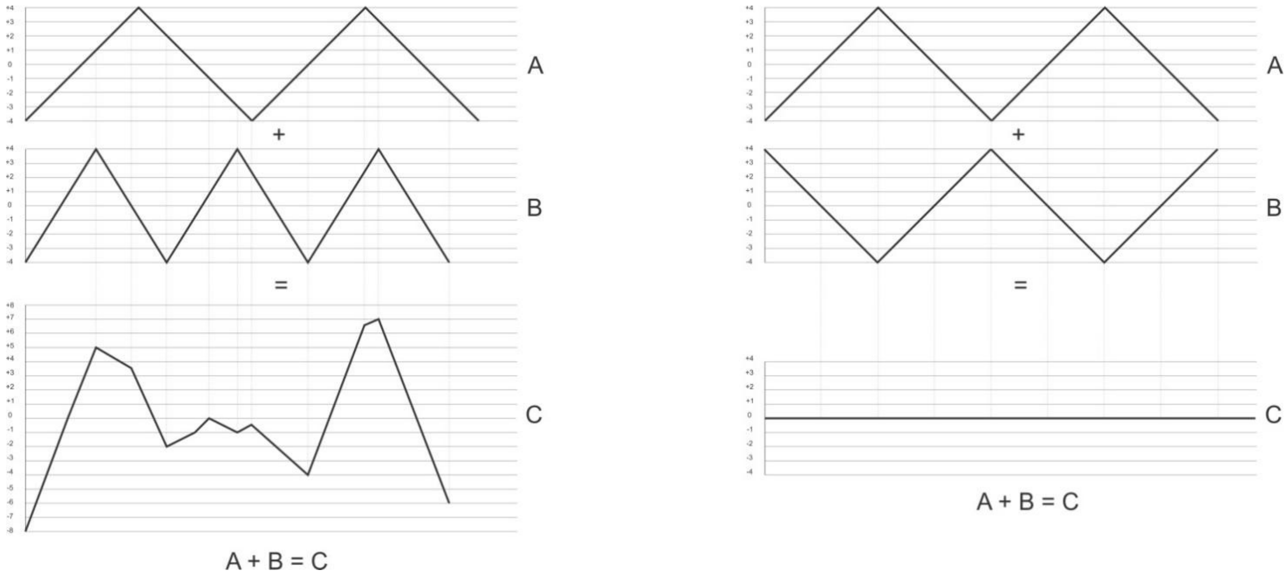


Figure 4.1.7

Phase is noted in degrees (symbol is ˚) where 360˚ brings a wave right back to where it started (see the black sine wave in the figure below).

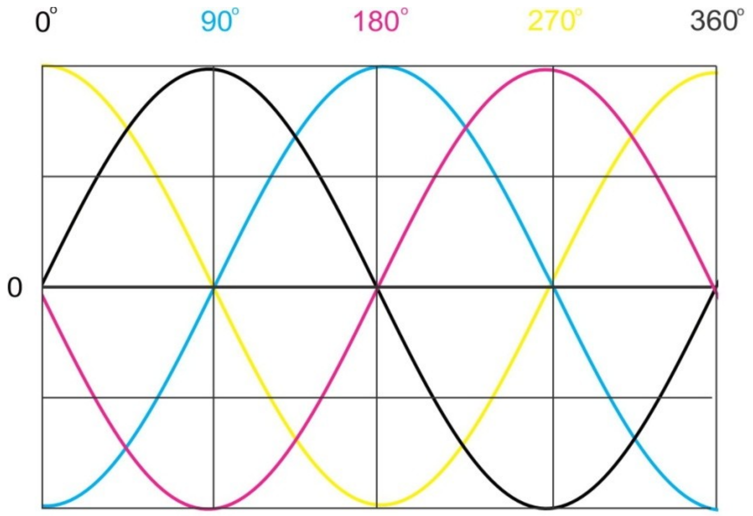


Figure 4.1.8

1.7 In theory, any sound can be created by adding together sine waves if the correct amplitude, frequency and phase. This is called "additive" synthesis or "Fourier" synthesis. This technique is of limited use in the synthesizer because the number of sine waves would have to be tremendous.

1.8 Another reason that this technique is not often used is that most sounds, and almost all musical sounds, are composed of sine waves in "harmonic" relationship to a "fundamental" The fundamental usually corresponds to the apparent pitch of a complex sound and is usually the lowest strong sine wave of the sound. If 'X' is the fundamental and the other sine waves are in a harmonic relationship to it, then there is a sine wave at 2X, 3X, 4X, 5X... etc. These sine waves are called "overtones" and they generally decrease in amplitude as they get higher in pitch. Below is the spectrum of a typical musical instrument such as a guitar:

Note that the overtones seem to be getting closer and closer together on the spectrum chart the further the get from the fundamental. We hear them in this fashion. Remember that the audio spectrum as we perceive it is exponential, but the overtone, or harmonic series is linear!

To calculate the positions of the harmonics add the fundamental frequency to itself to get the first overtone, add it again to the total to get the second harmonic, again to get the third and so on. An example would be: First = 100, Second = 100 + 100, Third = 200 + 100, Fourth = 300 + 100. Thus it can be seen that the frequencies are spaced at equal, absolute spacings, that is the harmonics fall on a linear graph.

1.9 Besides the sine wave the VCO also has a sawtooth output, a Triangle output and a Square wave. Below are the voltage or pressure diagrams of these waves and the spectrum charts of these waves.

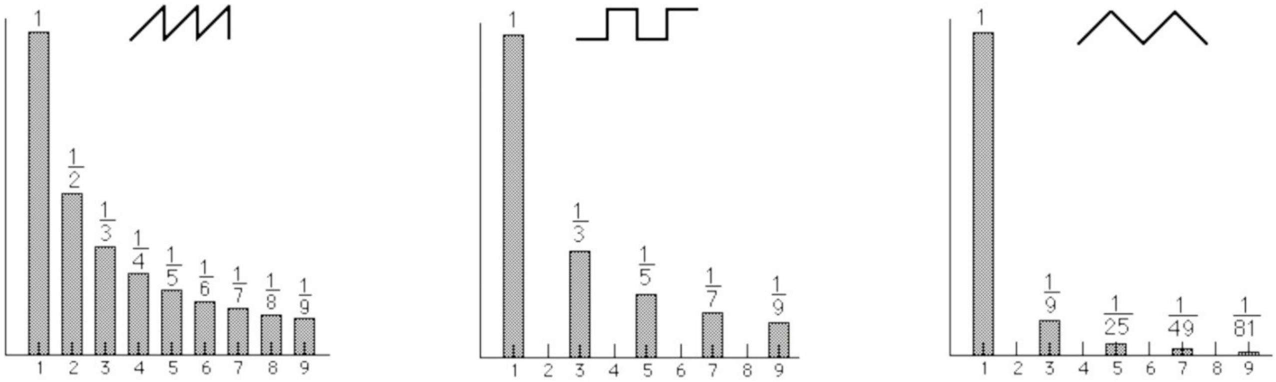


Figure 4.1.9

Additive synthesis can be greatly simplified by using these more complex sounds since these waves will often contain harmonics.

1.10 The triangle and the square wave contain only odd harmonics (harmonic #1, #3, #5, #7 etc), although the amplitude of these harmonics decreases more rapidly in the triangle that in the square. The sawtooth wave contains both even and odd harmonics that decrease at about the same rate as in the square wave.

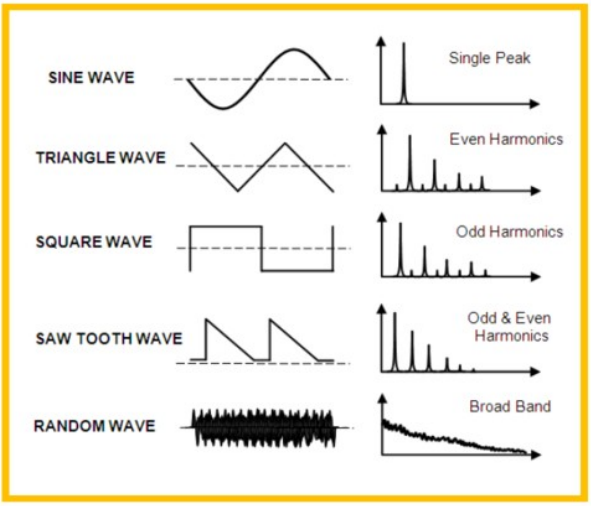


Figure 4.1.10 Common Wave Shape Harmonics

1.11 Try the different outputs of the VCO including, where available, the Variable or Shaped output.

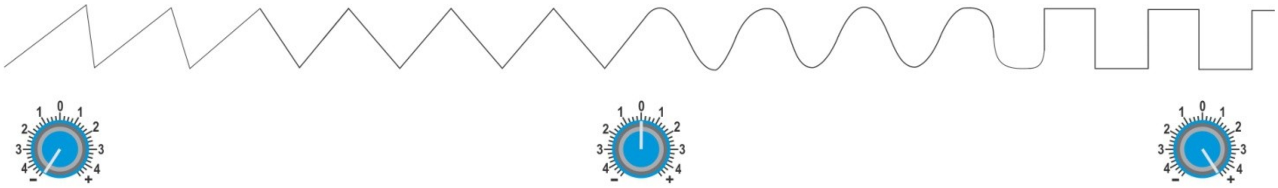


Figure 4.1.11

1.12 Though all outputs of the VCO are of the same amplitude, the saw and the square wave may seem louder because our ears tend to hear complex sounds louder than pure ones. All waveforms from the oscillators have a 4-5 volt peak-to-peak voltage. The sine output is from +2.5V to -2.5V. White jack outputs typically have this voltage range. The other outputs of the oscillator have a voltage range of 0V to 5V (still a 5V overall amplitude).

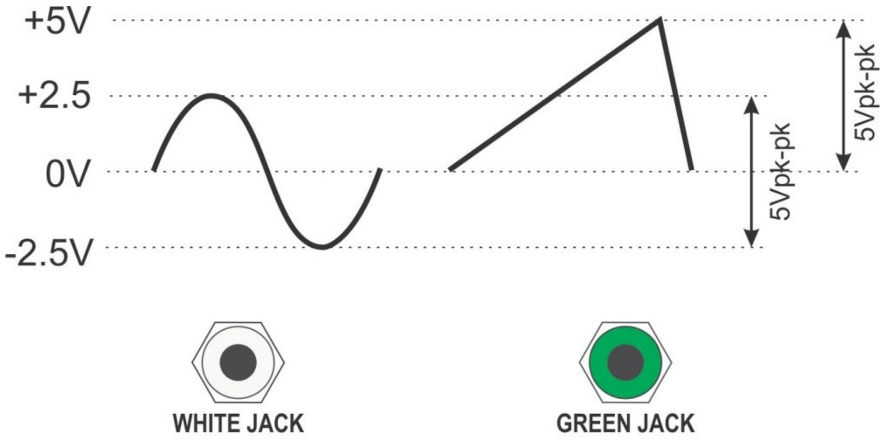


Figure 4.1.12

STEP TWO

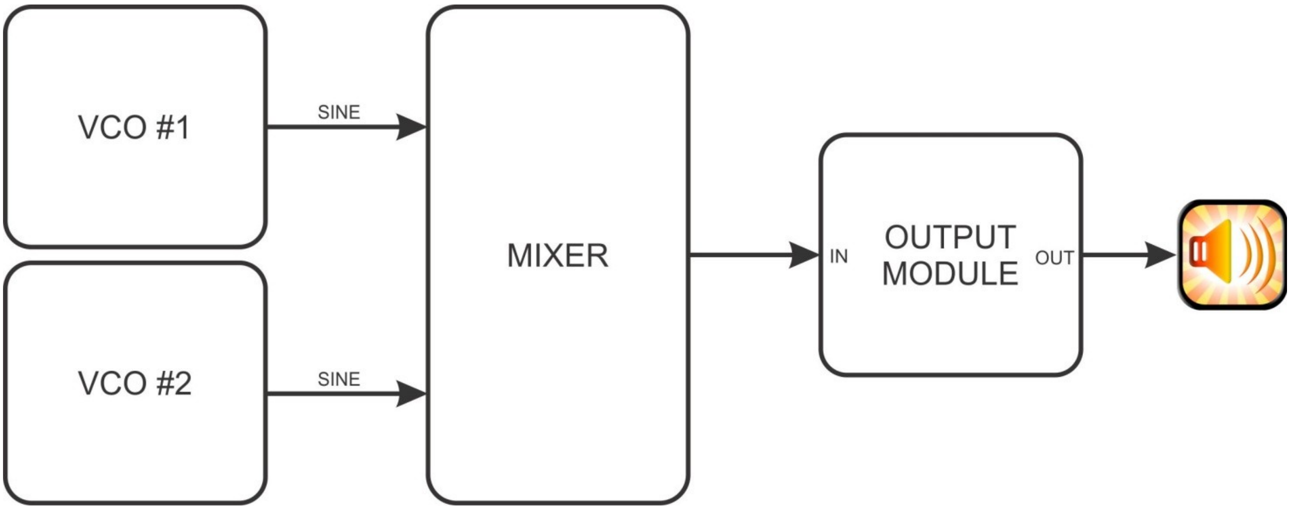


Figure 4.2.1

2.1 Patch the sine output of two VCOs to two inputs of the audio mixer. Patch the output of this mixer to the output mixer. Each of the inputs of the mixer has a pot associated with it that can limit, or "attenuate" the gain of its input. The output of this module is the summation of all its inputs at their assigned gain.

2.2 Tune the two VCOs so that they are very close in pitch and set their gains so that they are at the same level. When they are exactly the same pitch, they should sound like a single sound. If they are a few hertz apart, you will hear a "beating" between them. The frequency of this beating is the difference in frequency between the two sine waves.

2.3 Try adding a third sine wave to make a tri-tone.

2.4 Unpatch all but one of the VCOs. Turn up its mixer pot and note that the ear hears the sound as unchanging EXCEPT that it gets louder and louder. This is comparable to the way the eye sees a photograph and its blow-up as identical only the blow-up is larger.

2.5 Very few sounds in the world have a steady amplitude or gain. How a sound's gain changes is one of the clues as to what it is vibrating. It is one of the components of the overall feel of sound. For instance, a piano gets very loud very quickly when struck, and then slowly gets softer and softer. If the way this amplitude changes were altered, we would not easily recognise it as a piano sound. This amplitude shape is called the ENVELOPE of a sound, because like a letter in an envelope, the sonic information is contained within it.

2.6 Because of the way our ear/brains process sound, the amplitude of a sound must increase exponentially in order for us to perceive it as linearly increasing. For this reason the pots on the audio mixer are logarithmic.

2.7 When the pot of the associated input is turned to the right, the sound increases in level. Turning to the left will cause the sound level to decrease. The shape of the wave and its frequency remain the same except for this change in amplitude.

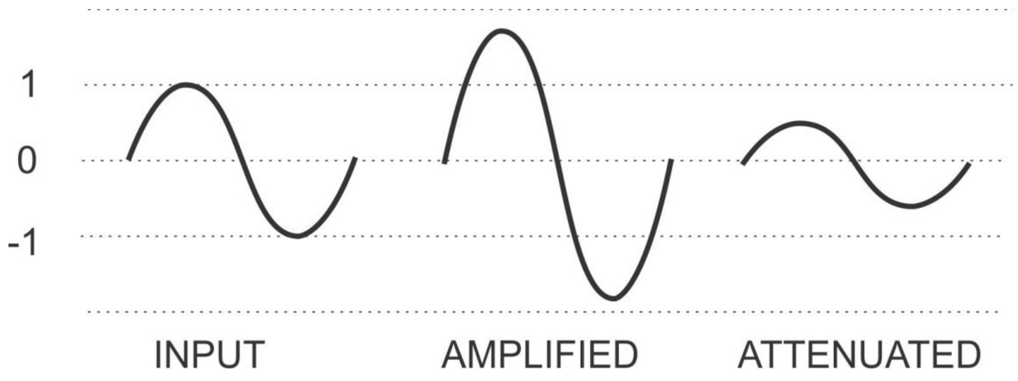


Figure 4.2.2

STEP THREE

3.1 A filter is a module which makes it possible to eliminate certain components of a sound, depending on its frequency. As we said earlier, every sound can be thought of as the summation of a number of sine waves, each with a different frequency. The filter allows us to listen to those sine waves in a sound which fall above, below or directly around a frequency set by the pot labelled [FREQUENCY] on the filter.

3.2 While there are a number of different outputs on the filter, all outputs can be thought of as different combinations of HIGH- and LOW- pass outputs.

3.3 A LOWPASS filter lets PASS through to the output all those sine wave components in the input sound which are LOWER than the frequency set by the [FREQUENCY] pot.

3.4 Slowly turn the [FREQUENCY] pot to the left and the "hissy" sounds will start to disappear. As turning the pot continues the mid-range will disappear, and finally there will be nothing left but a very low sound, the fundamental of the oscillator. If the [FREQUENCY] pot is turned even further, it will eliminate this sine wave as well, leaving no sound.

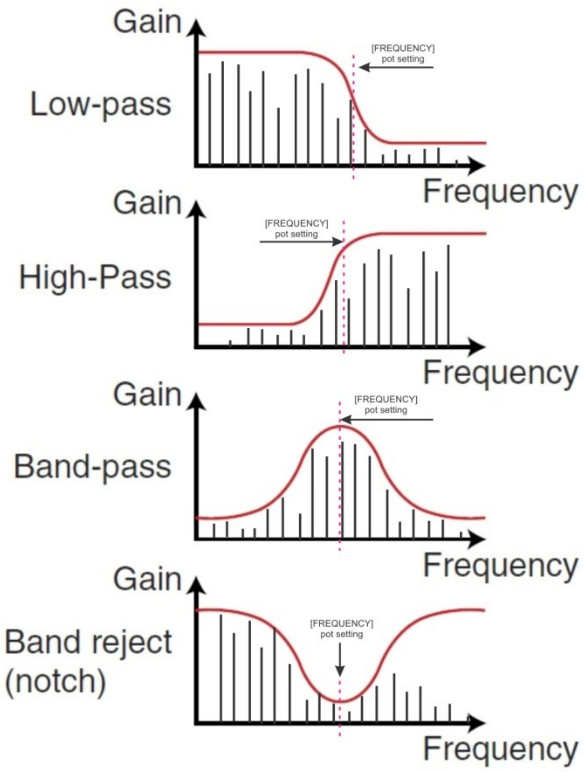


Figure 4.3.1

3.5 Re-patch the above patch using the [HIGHPASS] output. Now the filter lets pass only those sounds which are higher than the frequency set by the [FREQUENCY] pot. It lets pass to the output only the high frequencies of the input sound. Starting with the [FREQUENCY] pot full left and slowly turning right, the fundamental will drop out and then the mid-range. Only the hiss, or very top part of the spectrum, will be left of the input sound.

3.6 In terms of wave shape the LOWPASS filter SMOOTHS out a wave. It finds those components which change the least. Mathematically, it can be said to take the integral of the wave. The HIGHPASS filter takes the derivative of a wave. That is, the HIGHPASS filter finds those parts of the wave which change the fastest. Below are some typical waveform outputs from the [HIGHPASS] and [LOWPASS] filters:

3.7 An "ideal" filter would not allow any sounds higher or lower than its cut-off frequency to pass. It would look like this on a spectrum chart.

But all filters fall short of these ideals, not only because no technology is perfect but because such filters do not produce very musical sounds. The cut-off sharpness is measured in Decibels per Octave and represented as dB/Oct with 0dB/Oct being no cut-off at all and 60dB/Oct being about as sharp as we can hear. Most synthesizer filters are in the 3dB/Oct to 24dB/Oct range.

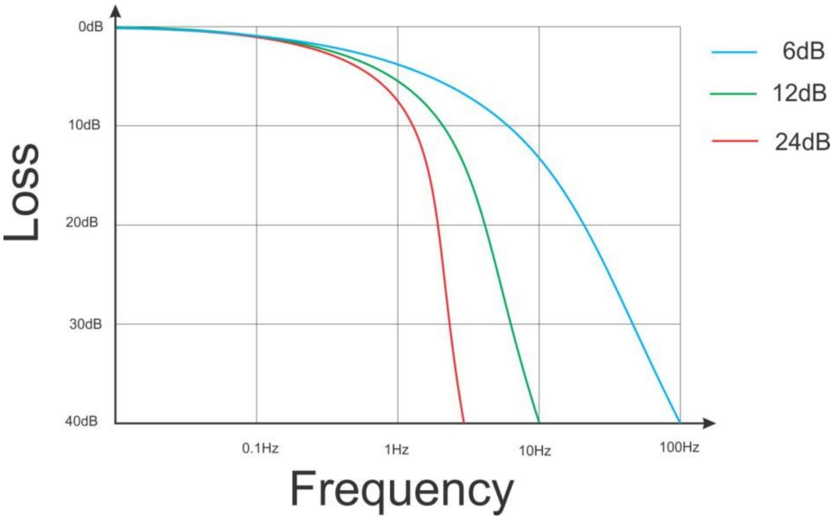


Figure 4.3.2

Another phenomenon of filtering available on the Euro-Serge is called the "Q". Most filters tend to amplify the frequencies near the cut-off frequency. The more these frequencies are amplified, the higher the Q of the filter. In most cases, the higher the Q, the sharper the cut-off. Knocking on a table is a typical low Q sound from the natural world. A drum head has a medium Q and a bell has a high Q.

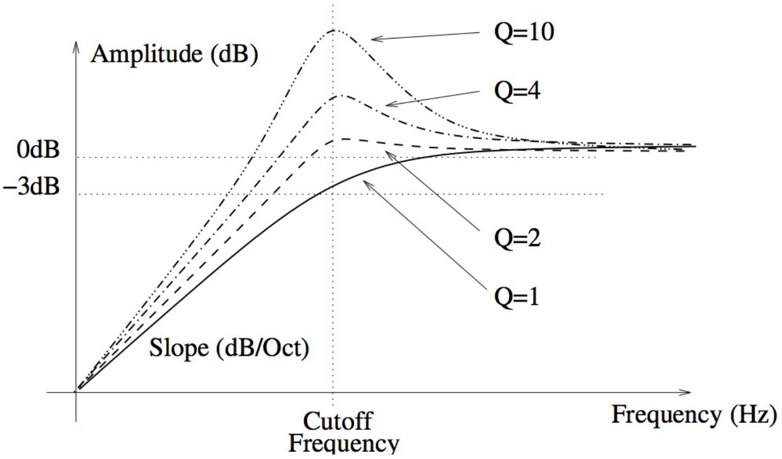


Figure 4.3.3

3.8 On the VCFQ the Q can be adjusted by using the pot just below the VCQ label. Using a very high Q it is possible to "scan" through the overtones of a sound by slowly turning the [FRQUENCY] pot of the filter. Every time the frequency is the same as an overtone it will amplify that overtone.

3.9 The [BANDPASS] output of a filter filters out everything but an area around the frequency set by the [FREQUENCY] pot. It is useful for listening to a single part of a more complex sound. Below is a diagram of how HIGHPASS, LOWPASS and BANDPASS are related to each other.

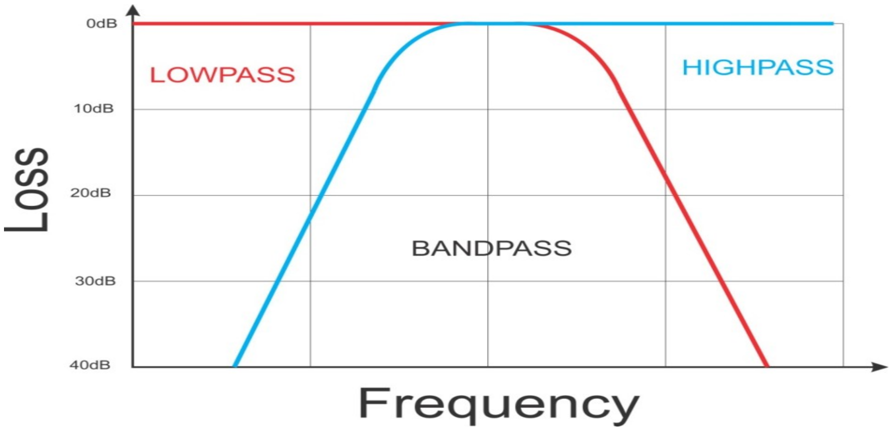


Figure 4.3.4

3.10 While HIGHPASS filtering occurs only rarely in nature (a cheap transistor radio tends to be a HIGHPASS filter to music by cutting out the lows), LOWPASS filtering abounds. In many musical instruments, a piano for instance, once the string is struck the highs tend to be filtered out leaving only the lows - the typical action of a LOWPASS filter. The human mouth is also a LOWPASS filter and is responsible for our vowel sounds, which are again LOWPASS filter sounds.

3.11 The [GAIN] pot on the VCFQ controls the level of the signal input exactly like the pot on a mixer. It must be turned up to hear any output. If the Q of the filter is set high, the GAIN should usually be turned down so that when the frequency of the filter and the frequency of an overtone coincide, the filter is not overdrive (sometimes this is the desired effect. Even though the filter will overload, no damage will be done).

STEP FOUR

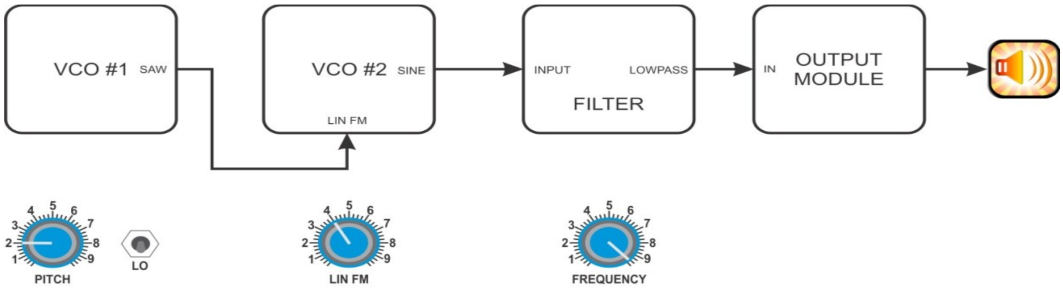


Figure 4.4.1

Steps One, Two and Three could have been set up in a classical music studio. STEP FOUR begins the exploration of Voltage Control, a technique which extends electronic synthesis to its modern form.

4.1 Patch the [SAW-AC] output of the VCO to the [LIN FM] input of a second VCO. A saw wave is a voltage which rises from 0V to 5V and then swiftly drops back to 0V. It does this over and over again.

When a VCO is voltage controlled it is like turning its [FREQUENCY] pot by remote control. When this controlling voltage is rising it is exactly like turning the pot to the right. When the controlling voltage is falling it is like turning the [FREQUENCY] pot to the left.

4.2 Turn the [LIN FM] pot on the second VCO full right and the GAIN up on the audio mixer until the sweeping sounds of the oscillator can be heard. The sound will rise higher and higher and suddenly fallback to a very low sound only to begin rising again. The pitch is produced by VCO #2 while the [SAW-AC] output of VCO #1 is causing it to rise and then swiftly fall.

Figure 4.4.2 shows a stylised picture of the pressure wave being produced.

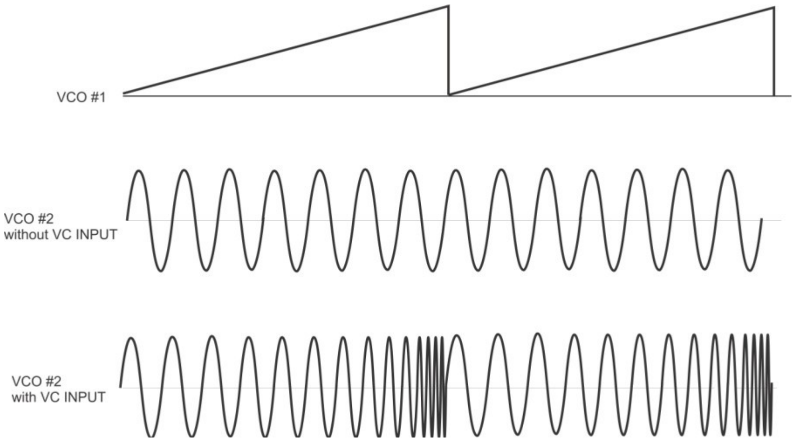


Figure 4.4.2 Click on image for audio

Replacing the [SAW] output of VCO #2 with a TRIANGLE or a SQUARE will produce noticeably different sounds. These can be heard as different patterns of rising and falling pitches.

Figure 4.4.3 Click on images for audio

4.3 Increase VCO #1's frequency slowly, listening carefully to the results. At first the sweeping will get faster and faster until a frequency approaching 20Hz is reached, at which point the sound takes on a multi-harmonic quality.

This is called Frequency Modulation, or FM, because the frequency of the second oscillator is being changed, or "modulated" at a rapid rate by the first. FM is a major technique of audio synthesis.

4.4 Set the [PITCH] of VCO #1 so that the sweep of the second takes a few seconds. As the pot associated with the control voltage input of VCO #2 is moved from its full right position to a '5' setting, the sweeps will become shallower and shallower, although the time taken remains the same. As this pot is turned to the left, the sweep will have a greater and greater gain but an inverted one. Whereas a pot set to the right causes the sweep to go upward and the suddenly fall downward, when it is set to the left the sweep is downward and the jump up. Control voltage inputs that have pots of this type associated with them are called "Processed Inputs" or “AttenuVerters”.

Figure 4.4.4

These pots control a device internal to the module which can amplify, attenuate and/or invert a control voltage input. It is because of their extreme usefulness that they are the typical control voltage inputs the Euro-Serge.
The Euro-Serge also has Processor Modules which can be patched to serve the same function.

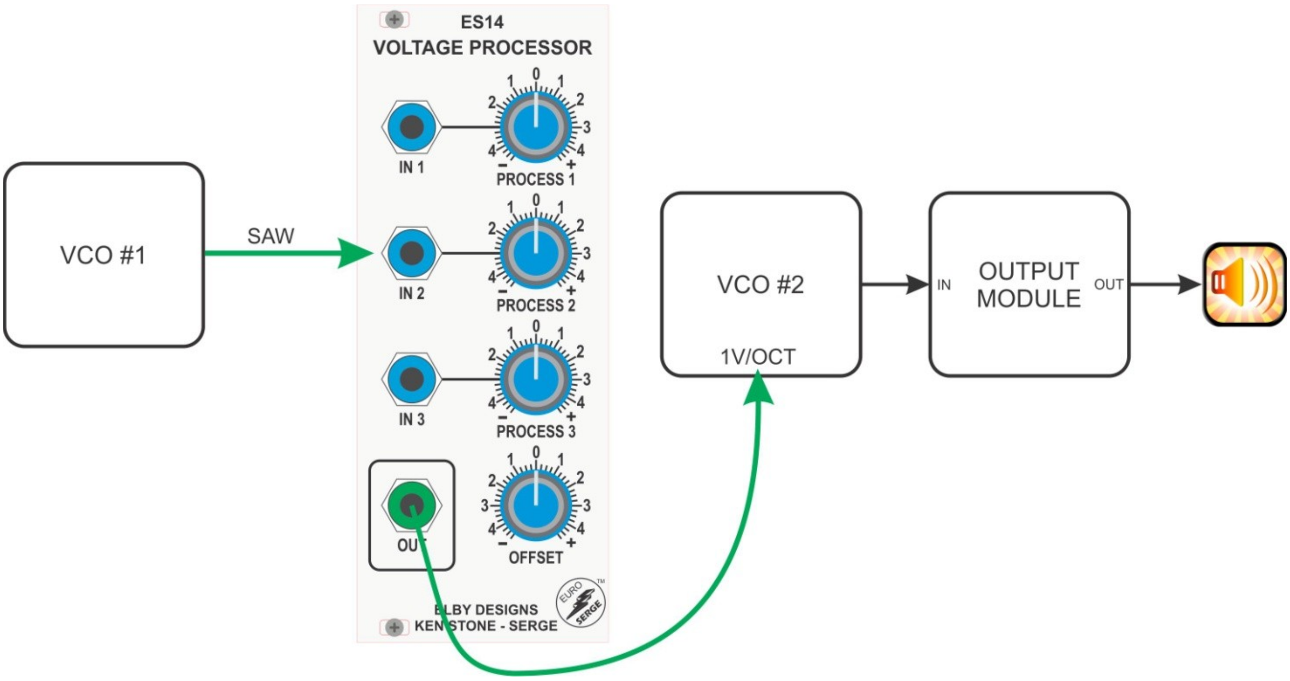


Figure 4.4.5

Below are some of the possible outputs of a processor with a sawtooth input.

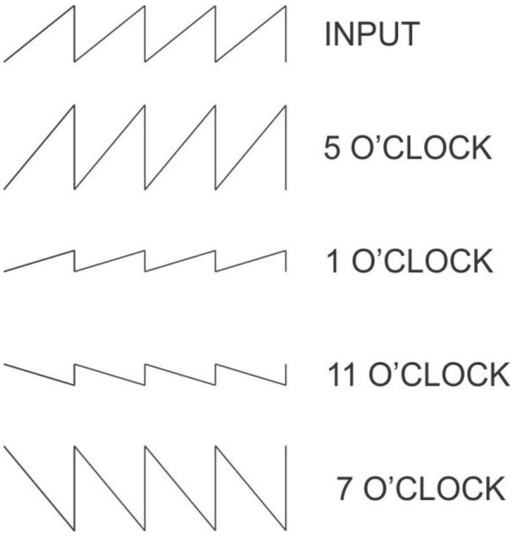


Figure 4.4.6

4.5 With the patch in Figure 4.4.5, an extremely wide range of sounds is possible with different combinations of the PITCH and [PROCESS x] pots. This range can be extended even further by using different waveforms.
VCO #1 is referred to as the Modulator (or the signal, a term from radio broadcasting); VCO #2 is referred to as the Modulated Oscillator, or the Carrier. The setting of the processor, which determines the relative gain of the two VCOs, is called the Index. The frequency of the two oscillators and the setting of the Index determine the output of the Modulated VCO (VCO #2). While the mathematics of FM (frequency modulation) is not simple, particularly with waveforms other Sine waves, in general the spectrum of the output look something like this:

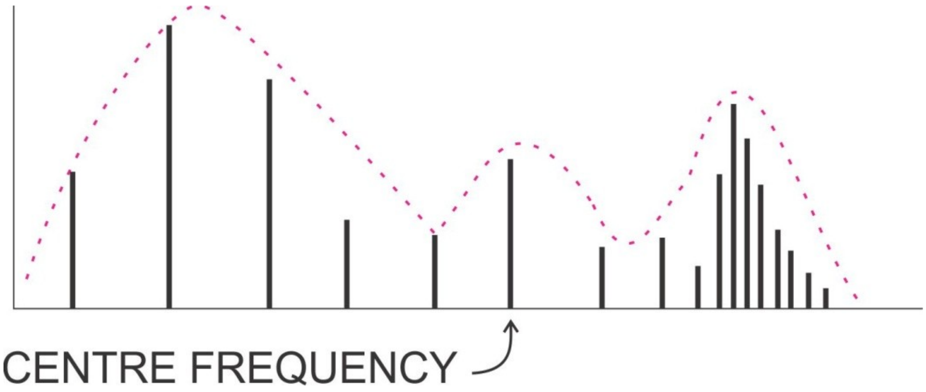


Figure 4.4.7

The frequency of the Modulated VCO (VCO #2) sets the centre frequency. There is an 'overtone' or 'undertone' every 'f' Hertz where 'f' is the frequency of the Modulator (VCO #1). The amplitude of these over/under-tones is determined by the Index and the frequencies of the oscillators. The overall shape of the amplitudes is butterfly and is called a Bessel function. In FM, the sub-harmonics which would fall below 0 Hertz are ‘folded back’ up to their ‘absolute’ value. If the Modulated VCO is set at 200 Hertz and the Modulating VCO is at 60 Hertz then there should be harmonics at 140, 80, 20, -40 and -100 Hertz. However these will be heard as 140, 100, 80, 40 and 20 Hertz. Such mathematical descriptions, while interesting, are not vital to electronic music. Working with the synthesizer is rather like clay sculpture – you can work at the sound until it is right.

Keeping in mind that the output of a VCO, either modulated or unmodulated, is a varying voltage, and that such voltages can be used to control the frequency of other VCOs there are innumerable complex patches available to the synthesist.

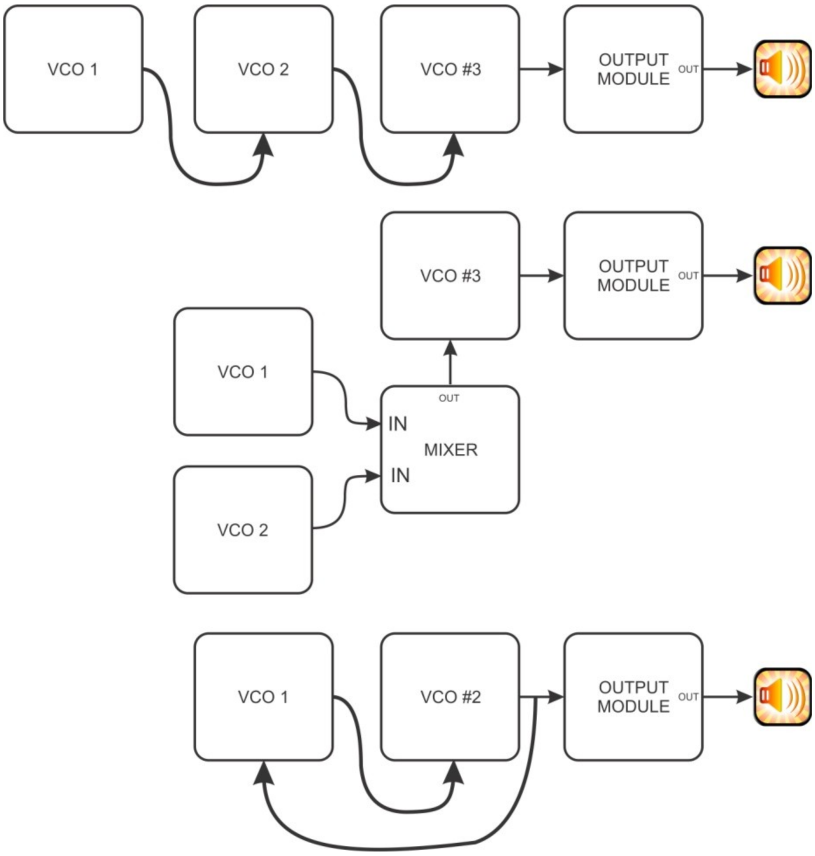


Figure 4.4.8

4.6 1V/Octave. The [1V/Octave] control voltage on the oscillators is an extremely precise voltage control input whose effect is calibrated with detailed attention. The relationship of input voltage and output frequency is this: for every 1V increase at the [1V/Octave] input the VCO will rise EXACTLY one octave. One reason that such an input is valuable is that many synthesizer keyboards and other electronic music devices have output voltages that are set exactly to this relationship.

4.7 LIN FM

In the patch in Figure 4.4.5, if both VCOs are set to audio frequencies, very interesting shifts in timbre occur when the Processing Pot is turned to different positions. However, when the [LIN FM] input is used, as shown in Figure 4.4.9, there are also apparent pitch changes.

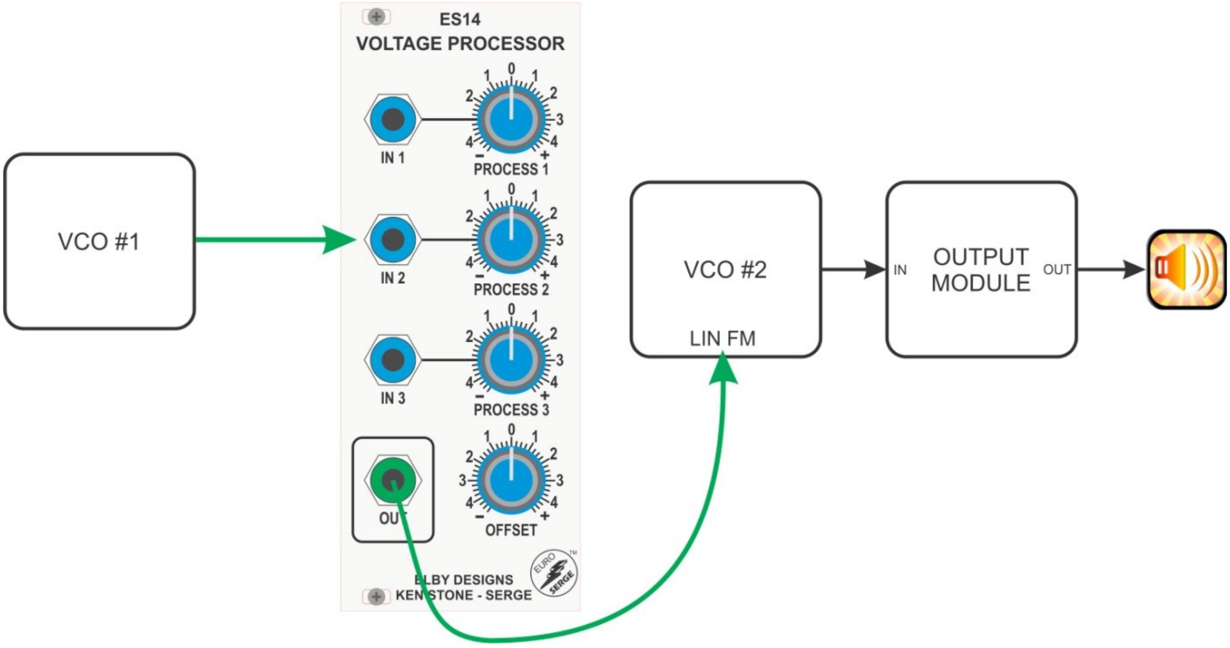


Figure 4.4.9

The sound produced should be similar to that produced by an audio voltage applied to the [LOG FM] except that the overall pitch does not seem to change as the Index is changed. The [LIN FM] signal inputs are LINEAR, that is, equal rises of voltage produce equal increases in cycles per second.

STEP FIVE

All the modules in the previous step could have been found in a classical music studio except for the voltage controlled oscillator (although it was found in some). It is a powerful group of modules, with the oscillators providing the basic pitch material, the mixers adding these sounds together and adjusting their volumes, and the filters altering the timbre of the sound. Yet with only these modules many of the simplest sounds and patterns in music could not easily be achieved. In most music styles there are discrete pitches whereas with the modules in the last step there were only sliding tones. Secondly, it was hard to get non-repeating patterns.

The ES28 TOUCH SEQUENCER is a module designed specifically to produce control voltages. As discussed earlier, there is no physical or electrical difference between audio and control voltages other than MOST audio voltages are between -2.5V and +2.5V, and all audio voltages are between 20Hz and 20kHz; while control voltages are between -12V and 0V or 0V and +12V, with frequencies anywhere between 0Hz and 500Hz. The actual difference between the two voltages are the uses to which they are put. The same voltage can be used in different ways. In once case it could be an audio voltage; in another it could be a control voltage. However, some voltages are simply more useful in one situation than the other. The voltages produced by the ES28 are designed to be used as control voltages.

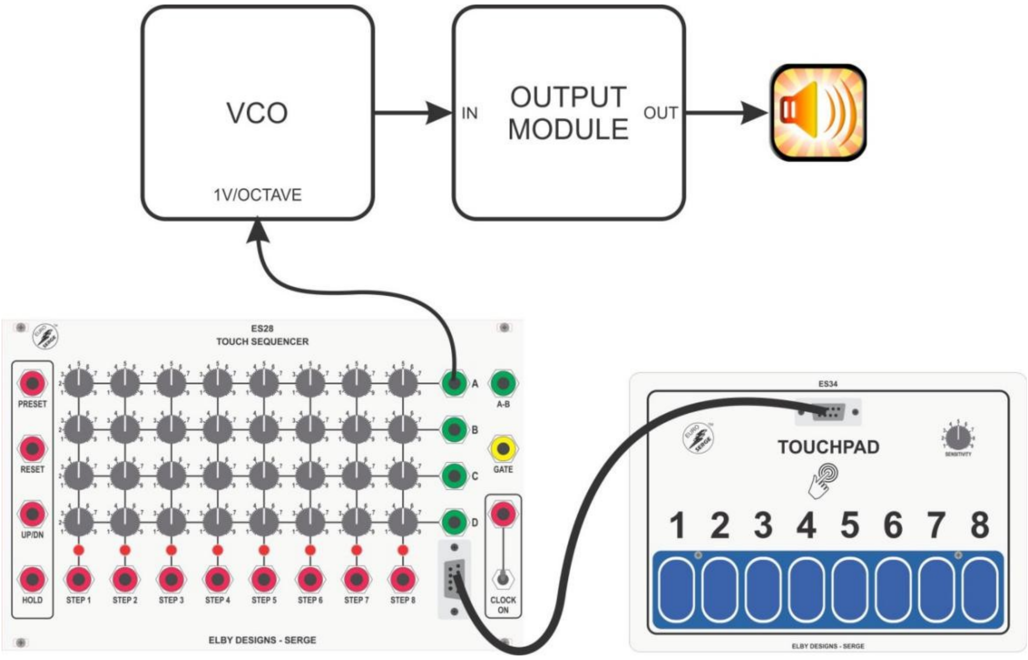


Figure 4.5.1

The ES28 has four rows of pots across, labelled [A], [B]. [C] and [D]. A set of keypads are provided by connecting the ES34 to the ES28 through the umbilical cord. There are 8 columns each with four pots (one for each row). At any given instant ONE and ONLY ONE column is activated and this is indicated by an LED (Light Emitting Diode) on the ES28 of the respective column. These columns will be referred to from now on as STAGES.

5.1 The main outputs of the ES28 are located in the last-but-one column on the right. There are five main voltage outputs (green jacks) labelled [A], [B]. [C] and [D] and [A+B]. Patch the [A] output of the ES28 to the [1V/OCTAVE] input of the VCO as shown in Figure 4.5.1. The VCO should be set to an audio frequency and its output sent to the output modules.

5.2 Touching keypad [1] activates stage [1] which is indicated by the LED in column 1 on the ES28. Turn the pot in stage 1 and in row A (the top pot in stage 1) right and left. The VCO's frequency should shift up and down correspondingly. This pot is now remote-controlling the frequency of the VCO using a voltage that is appearing at output [A] of the ES28.

5.3 Touch keypad [2] and set it’s [A] pot to a different setting than the [A] pot of stage [1]. By alternately tapping keyboards [1] and [2] you can get the VCO to produce two different 'notes' or pitches without sliding from one to the other. This same procedure can be used to turn all 8 pots in row [A]. This is a tuneable keyboard.

The output of the ES28 is NOT and audio voltage but rather a series of steady, or DC (direct current) voltages which are CONTROLLING the setting of the VCO (or whatever module or parameter the output is patched to). The VCO is designed to respond to these control voltages exactly like it responds to the turning of the pots. Just as the notes on a singer's score do not oscillate, so the voltages from the ES28 do not oscillate but merely specify the VCO frequency. Figure 4.23 shows the typical voltage outputs of the ES28, and the VCO.

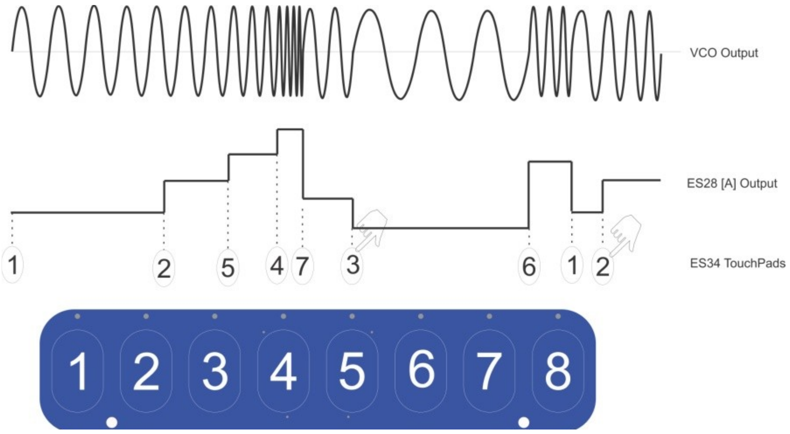


Figure 4.5.2

5.4 Patched in this fashion, none of the pots in rows [B], [C] or [D] have any effect. However if it is repatched so that the output of the ES28 is taken from output [B] instead of output [A] then only the pots in row [B] will be active. The same is true for rows [C] and [D]. It is possible to use all four of these outputs (or as many as needed) SIMULTANEOUSLY as in the patch in Figure 4.5.3.

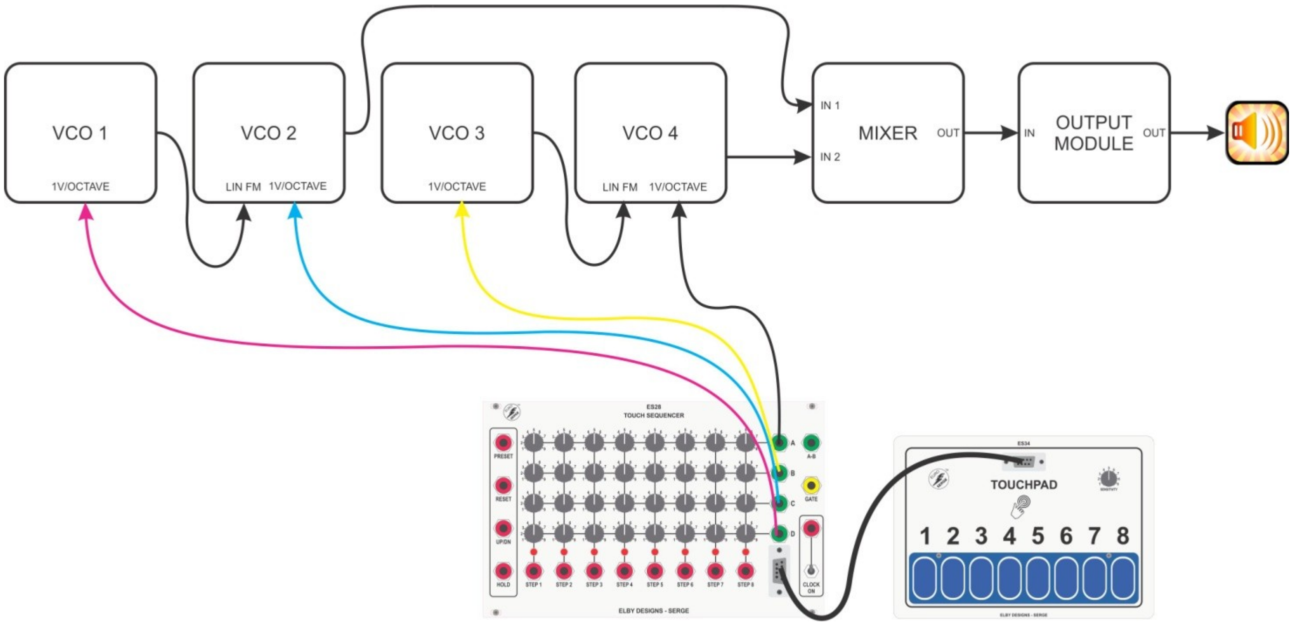


Figure 4.5.3

Now at each stage the pot in row [A] controls the frequency of the modulating oscillator VCO 1 while the pot in row [B] controls the base frequency of the modulated oscillator VCO 2. Similarly, row [C] controls the modulating oscillator VCO 3 while row [D] controls the modulated oscillator VCO 4. Row [A] and [B] could be replaced by any two rows. By touching the eight different keypads and setting the appropriate pots, eight different sounds can be set up in any order at the touch of a finger.

5.5 It is convenient to think of the ES28 in this manner: All the pots in each row are tied to a common output (output [A] for the pots in row [A] for instance) but only one pot is activated and that is determined by which keypad was last touched. Since there are four rows, four parameters or modules can be controlled in eight preset ways and these presets, or stages, can be accessed directly by the touch pads.

STEP SIX

When a piano is note is struck, a bell gonged, a table tapped, an airplane files overhead, a sentence spoken, a sink drained, an organ note sustained or when any other object makes a sound, that sound has an amplitude shape to it, an 'envelope', that grows louder and softer in various ways as time passes.

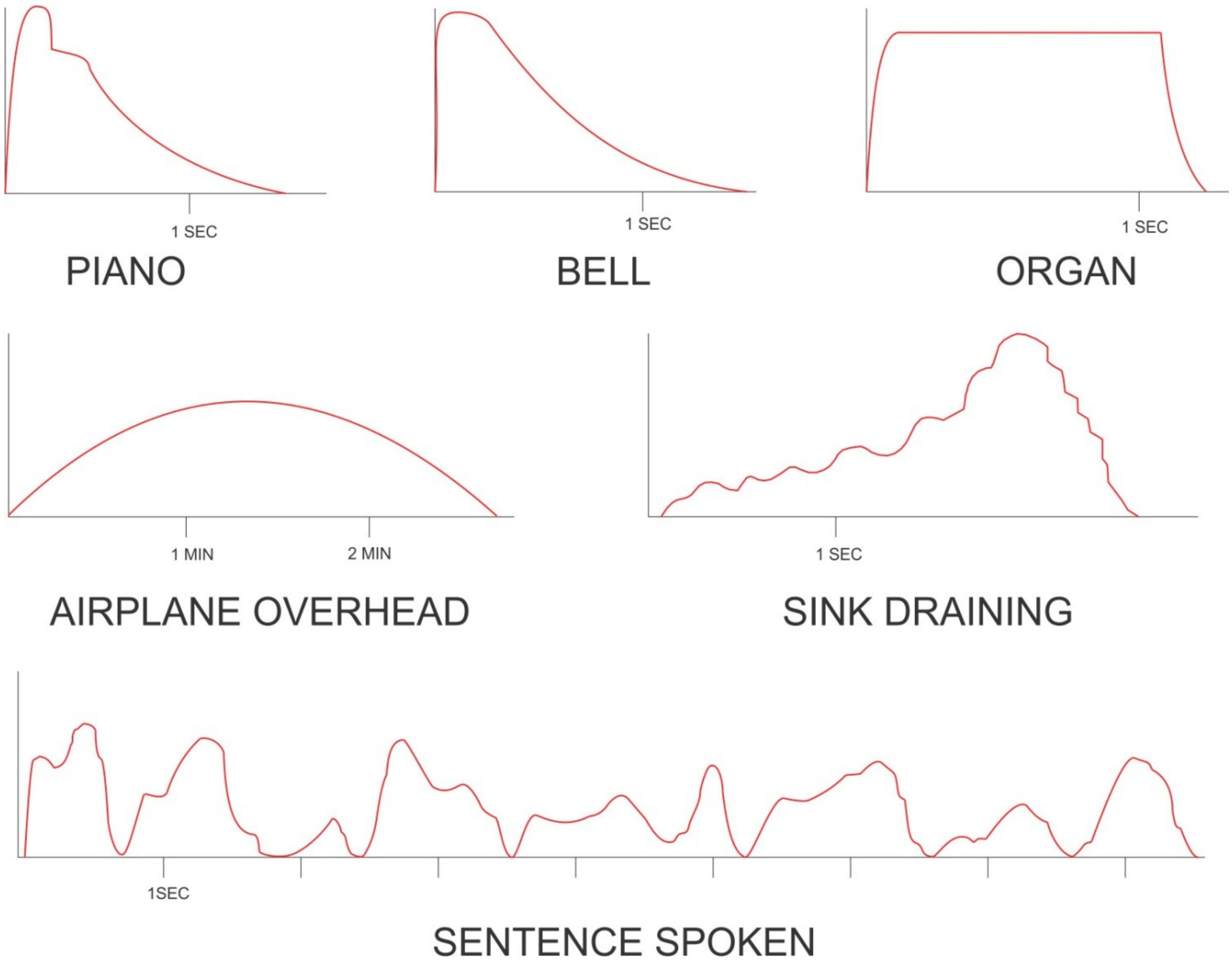


Figure 4.6.1

In the charts in Figure 4.6.1 the loudness of the sounds is measured in dB (decibels) while the duration is measured in units of time (seconds, minutes etc). The envelope refers only to the loudness of the sound, not to the frequency content of the sound. We can again compare this 'envelope to an envelope which holds a letter' and think of the content of the sound as the letter.

Every sound we hear has an envelope, and this is one of the various ways sounds are distinguished from one another. In this sense the envelope can be thought of as a part of the timbre of a sound. Even artificial sounds have envelops, for instance, this is the envelope of a piano, reversed:

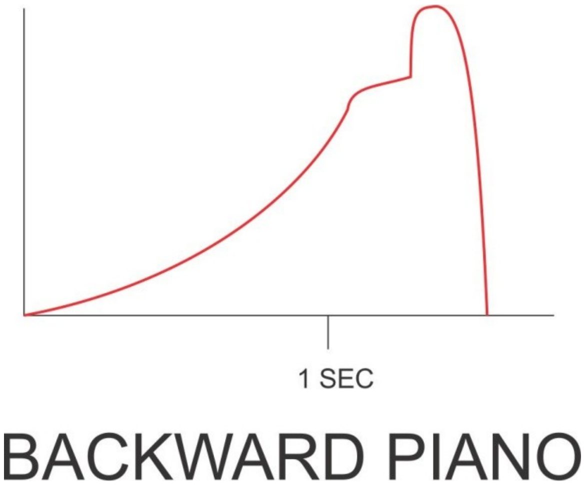


Figure 4.6.2

An ENVELOPE is the TRACE of the PEAK VOLTAGES or PRESSURES of a WAVE.

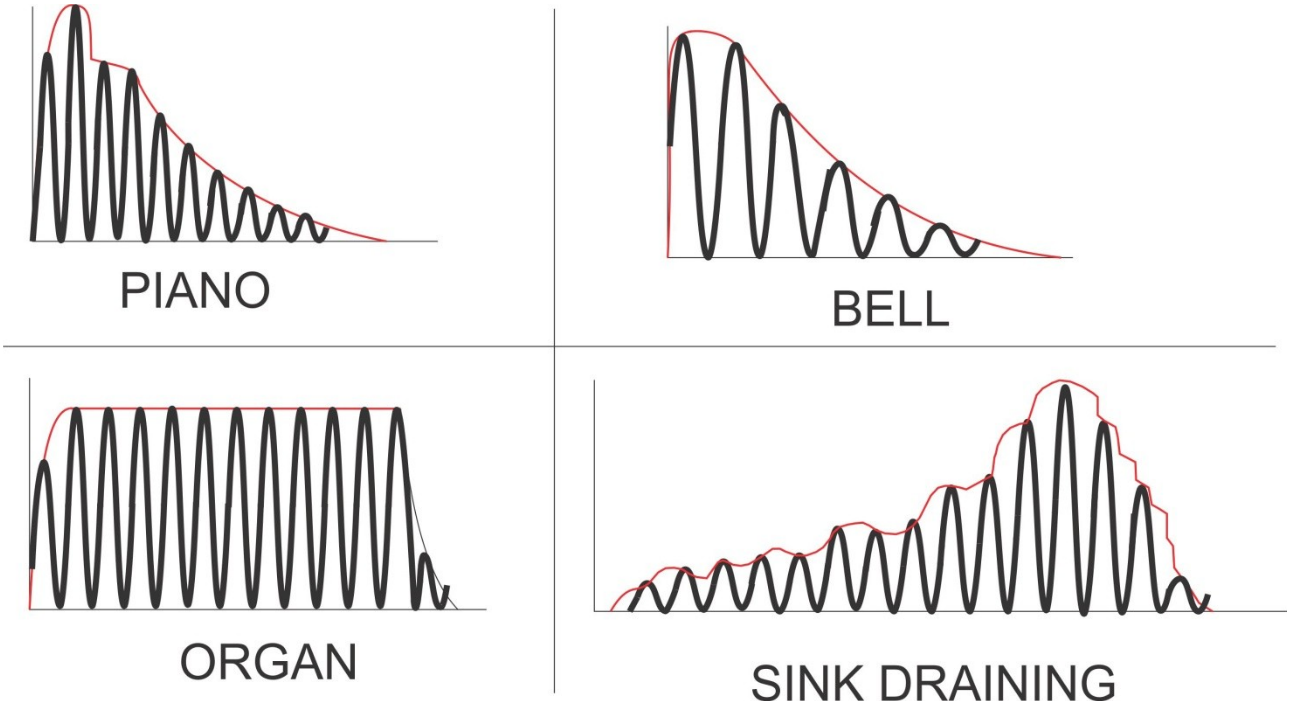


Figure 4.6.3

The GAIN pots on the mixer, when turned from left to right and then back to the left, can give the input signal an amplitude envelope. The device or module that automates this function is the Voltage Controlled Amplifier (VCA) or

GATE and can be found both as an independent module and/or as part of most output modules. These modules are listed in STEP SIX of the first learning patch.

Every VCA has a signal input and a signal output, and like a mixer, has a pot which can adjust the amplitude of the output in relation o the input without affecting and other parameter of the sound. In addition, the VCA has at least one Voltage Control input. As the control voltage rises, the amplitude of the output increases, as the control voltage falls so does the output amplitude. The control voltage, in effect, turns the [GAIN] pot of the VCA by remote control.

6.1 The Euro-Serge system has a range of VCAs, but for the purpose of this patch, the VCA's on the output module will be used. The signal input and output remain the same. Each input has an associated VC-in, usually located below the signal input. Since [IN 1] is used, its associated GAIN control must be used. Make sure there are no other patch cords connected to the module. The GAIN associated with the input should be set to '3'. At this time, no sound should be heard from the VCA.

If the system being used has a separate VCA module, that module may be used instead of the VCA's on the output module as shown in Figure 4.26.

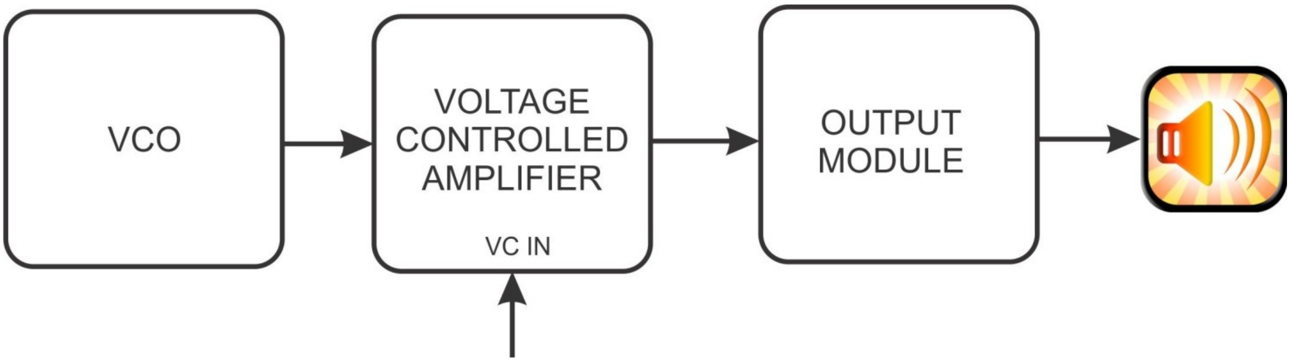


Figure 4.6.4

Create the patch shown in Figure 4.6.4.

The [GATE] output of the ES28 is in the same section as the [A] and [B] outputs. It has a YELLOW jack which indicates that it is a TRIGGER output which is the third kind of voltage in the system, Audio and Control being the other two. Its function is to turn something on or turn something off. A trigger voltage is always either 0V (its low-level state) or +5V (its high-level state). That moment when it goes from 0V to +5V is called its 'positive transition' or 'leading edge'. It is this transition which turns functions on and off. All trigger outputs are YELLOW jacks while all trigger inputs are RED jacks.

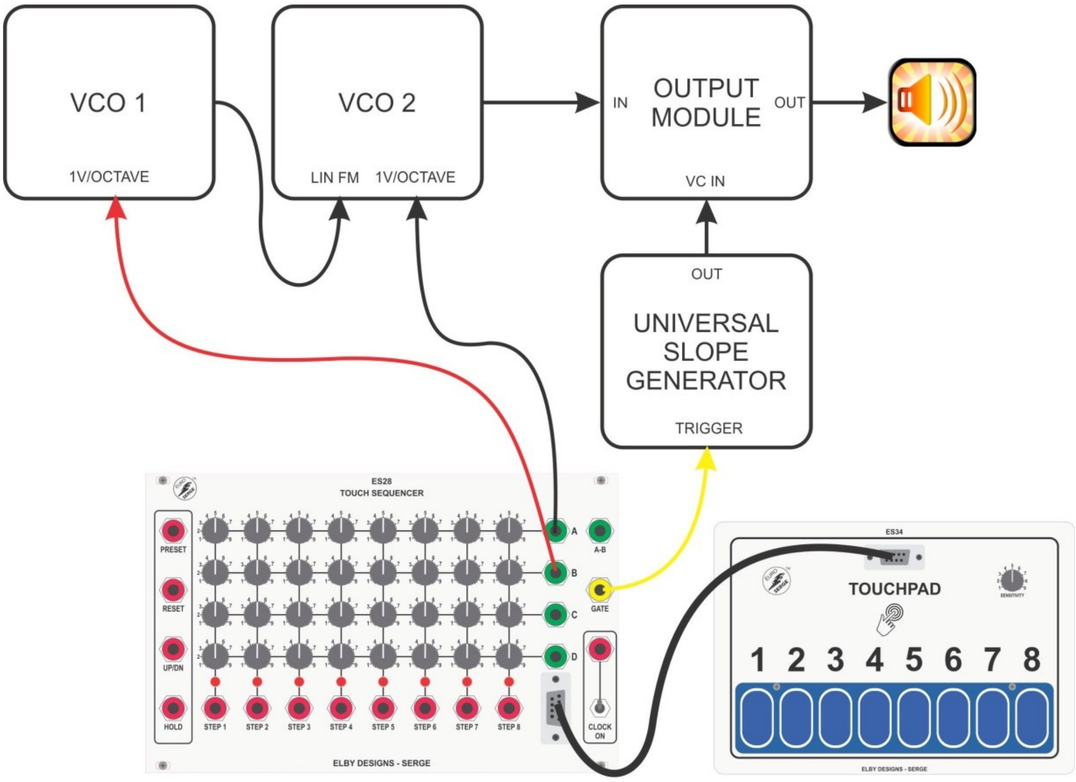


Figure 4.6.5

It is possible in some cases to use appropriate control voltages to trigger certain modules, particularly if the control voltage has a sharp leading edge (there are also a few places where these trigger pulses can be used as audio waves if they are fast enough, or as control voltages if a two-level control voltage is desired). If a control voltage can be thought of as turning a knob by remote control, a trigger is like pressing a button or tapping a key by remote control. A trigger signal looks like this:-

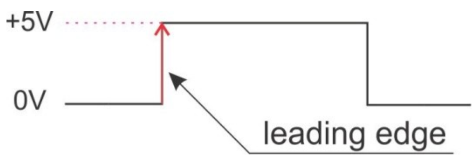


Figure 4.6.6

Each time a keypad is touched on the ES34, a trigger pulse appears at the [GATE] output of the ES28. It will remain in its HI state as long as the key is being touched.

In the above patch this trigger is sent to the [TRIGGER] input of the ES114. When this module received a trigger pulse it produces exactly one VOLTAGE ENVELOPE.

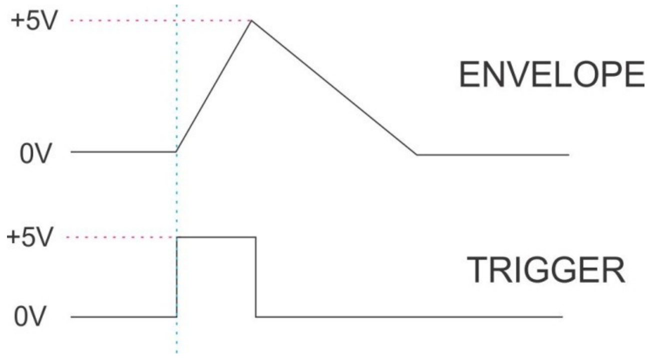


Figure 4.6.7

This envelope is a common, simple acoustic envelope similar to many musical envelopes such as piano, guitar etc. it has two basic parts: the RISE and the FALL:-

Figure 4.6.8

These two slopes are set by the two pots labelled [RISE] and [FALL]. With these two pots the rise and fall time can be set anywhere from 1/1000th of a second to about 5 seconds.

6.2 Patch from the [GATE] output on the ES28 to the [TRIGGER] input on the ES114 and tap a keypad on the ES34. Directly below the [DC OUT] jack on the ES114 is an LED whose brightness is proportional to the voltage on the envelope output. That is, as the envelope rises in voltage, the light gets brighter. Set the [RISE] and [FALL] pots to about '4'. The LED should take about one second to go from off to fully lit to off again. Different settings of the [RISE] and [FALL] pots will produce different times. Set them so that they produce an envelope of this type:-

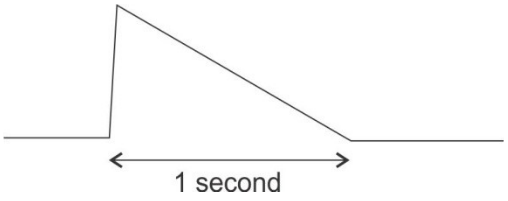


Figure 4.6.9

6.3 Complete the patch from the output of the ES114 to the [VC IN] of the VCA (the VC-controlled mixer will be referred to as a VCA when being used in that function). When doing so make sure that the [GAIN] pot is set to the appropriate setting. If there is a small amount of sound 'leaking' through, turn the [GAIN] pot slowly to the left until nothing is heard. Some VCA's can be overloaded if the initial gain is set too high. This will not damage the module, but it might overload your amplifier or speakers. Use caution with these modules, always starting out with the pot turned down, and then increasing the gain with the control voltage applied until the sound is the proper level.

6.4 Touch a keypad on the ES34. This will cause a number of things to occur simultaneously. First, as already discussed, it will cause the stages of the ES28 that has been touched to be activated. At the same instant it causes a trigger pulse to be produced at the [GATE] output of the ES28. This pulse triggers the ES114 to produce its envelope. This voltage envelope is patched to the [VC] input of the VCA where the effect is as if turning the [GAIN] pot up and then down by remote control. When the envelope starts its FALL, the gain of the VCA begins to decrease.

6.5 In general the voltage controllable parameters of a module are the same functions that can be controlled with its pots. For the VCA, then, the controllable function is its GAIN, where a HI-voltage to its [VC] input creates a high GAIN and a LO-voltage produces a low GAIN. Once again, any voltage can be used to control the VCA, including a VCO, For instance:

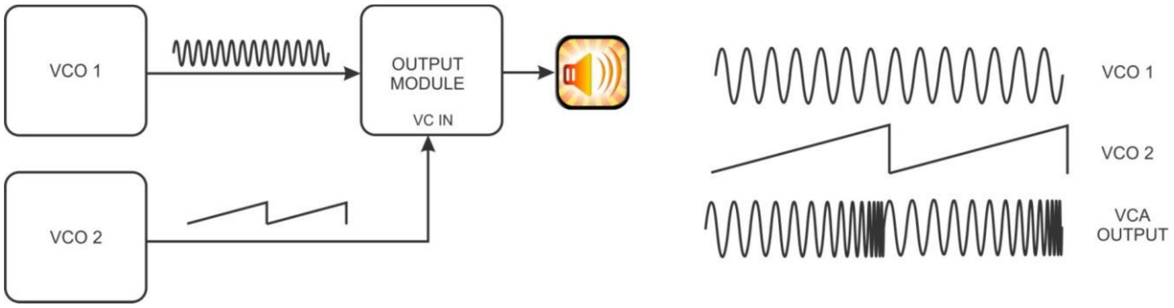
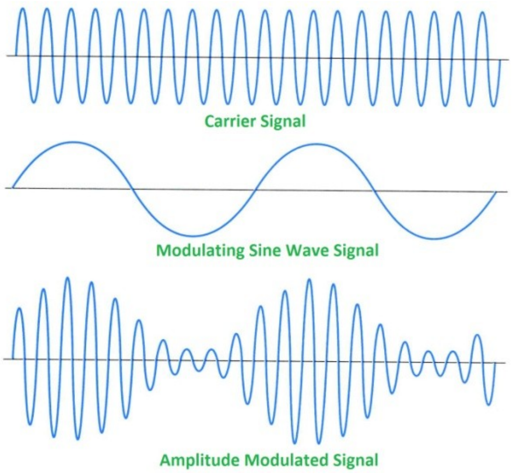


Figure 4.6.10 Click on image for audio

This will be heard, if VCO 2 has a low enough frequency, as a kind of backwards sound which slowly gets louder and louder and suddenly cuts off -- only to begin again.

Using a SINE wave as the controlling voltage produces this effect:-



AUDIO

Figure 4.6.11 Click on images for animation and audio

6.6 Slowly increase the frequency of VCO 2. As you do so the sound will 'beat' faster and faster. When this beating approaches 20 times per second (20Hz) a more complex sound appears that is somewhat similar to FM modulation. This sound is called Amplitude Modulation or AM. Like FM the sound is dependent on the frequency of both VCOs and the relative amplitude between them. This relative amplitude, or INDEX, can be set in the following manner:-

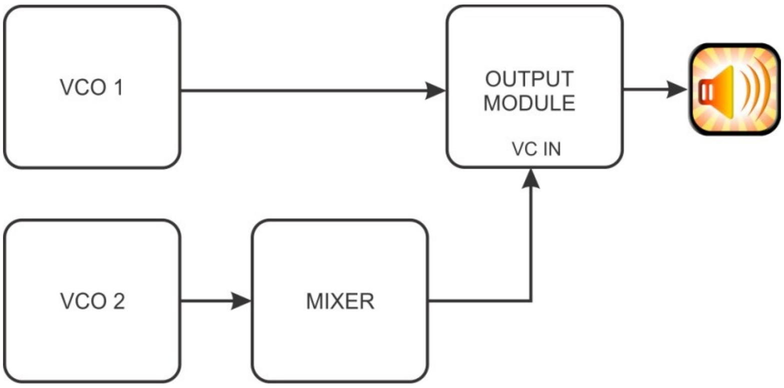


Figure 4.6.12

In these patches the GAIN of the mixer or VCA determines the INDEX. This technique can provide a wide range of sound types from tremolo to a hollow reedy sound to very complex sounds when non-SINE waves are used. In terms of the frequency spectrum, if a sine wave modules a second sine wave, two NEW frequency components are produced, one being the sum and the other the difference between the two original sine waves. The original frequency appears as well. That is, if the two original waves are 60Hz and 200Hz, then the output will be a mix of 60Hz, 200Hz, 260Hz and 140Hz waves.

A module closely related to the VCA is the RING Modulator, which provides a third type of modulation along with FM and AM. Ring modulation is one of the oldest electronic music techniques and it is useful for producing complex and 'odd' sounds similar to, but thicker than, the input sounds.

In its most basic mode a RING modulator takes two input frequencies and outputs the sum and the difference frequencies ONLY. That is, if one input is 500Hz and the other is 160Hz, then the output will be a mix of 650Hz and 350Hz waves. This differs from AM in that the original signals are cancelled out. If the input signals are complex, containing overtones, then every overtone of one wave is summed and differenced with every overtone of the other wave.

6.7 On the ES79 the two inputs are labelled [X] and [Y] (though in some ring modulators these inputs may be labelled as #1 and #2, or as signal and carrier). The pot on the ES79 is not a GAIN pot, but rather a pot that changes the function of the module from a standard VCA (full left) to a RING modulator when it is nearly full right.

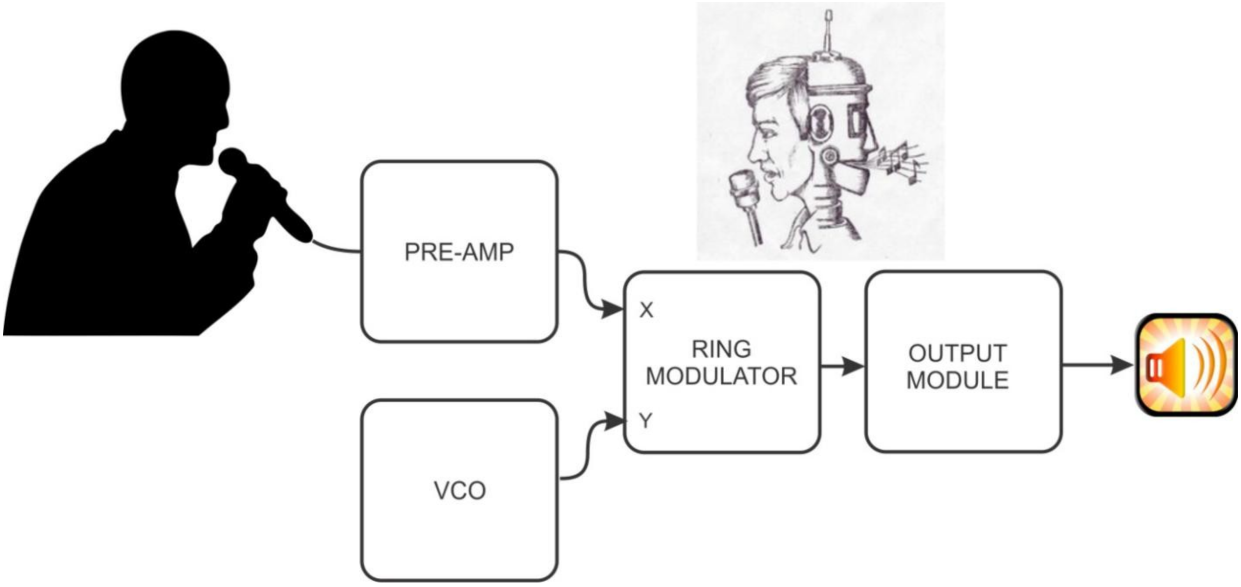


Figure 4.6.13 Click on image for audio

The RING modulator is often used in conjunction with sounds from the 'real world' ("concrete" sounds) to give them an electronic feel. In this case the 'concrete' sound is fed to one input of the ES79 and the electronic sound to the other. It can also be used as a kind of frequency shifter where a sound is shifted to a higher or lower frequency. For this, a filter must be used in conjunction with ring modulator to cut either the sum or the difference component. This kind of frequency shifting significantly alters the harmonic relations of the overtones of the sound being shifted.

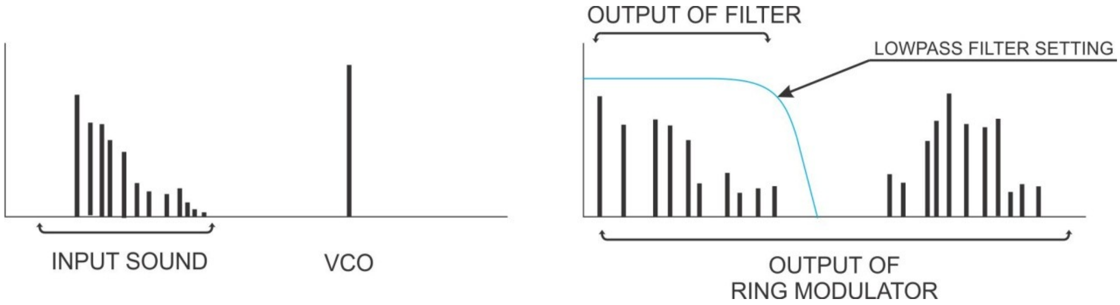


Figure 4.6.14

6.8 The ES79 has two auxiliary inputs labelled [VC-X] and [VC-Y], which act like VCA's for their respective input. They are useful for bringing out the original sound amidst the RING MODULATED sound.

6.9 While the simple voltage envelope discussed in 6.1 is often used to control the amplitude or gain of a sound, it may be used to control any controllable module. In the following patch the envelope is controlling the frequency of a VCO:-

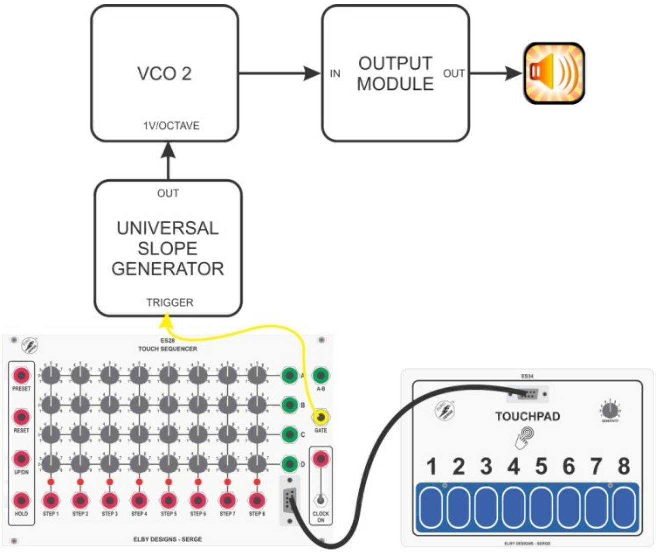


Figure 4.6.15

The following patch uses the ES28 to trigger the ES114 and control the amplitude of the output signal:-

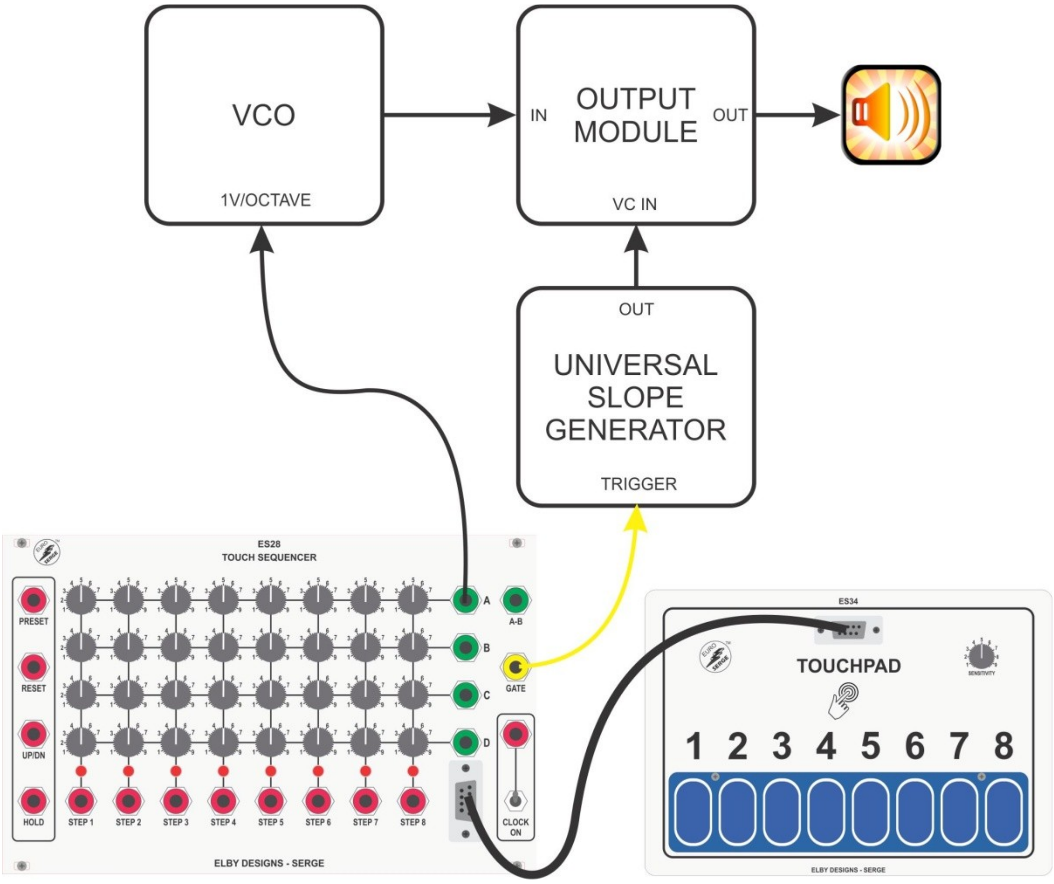


Figure 4.6.16

There are other features on the ES114 and other ways of controlling it to extend its use far beyond this simple control function.

TRIGGERING FROM OTHER WAVEFORMS. The ES114, and in fact all TRIGGER-activated devices on the Euro-Serge, are triggered by the positive or rising (or leading) edge of the Trigger pulse and not by the falling edge or the +5V voltage level itself. Not only a trigger output but any sufficiently fast rising edge will trigger the ES114. The SAW output of a VCO looks like this:-

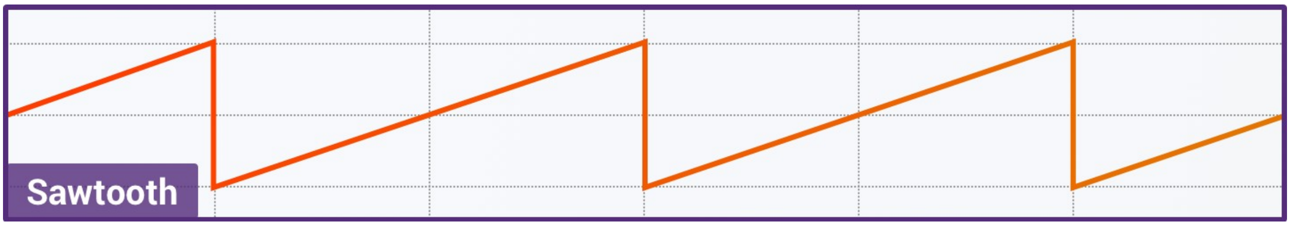


Figure 4.6.17

Note that is has a FALLING or trailing edge and therefore cannot trigger the ES114. However, this wave can be inverted by a Processor. The saw output of the VCO is patched in to any of the three inputs of the ES14. The associated pot of the input should be set full left. Settings to the left of '0' on a processing input produce inverted outputs. While Processors usually accept control voltages, they can also accept audio voltages.

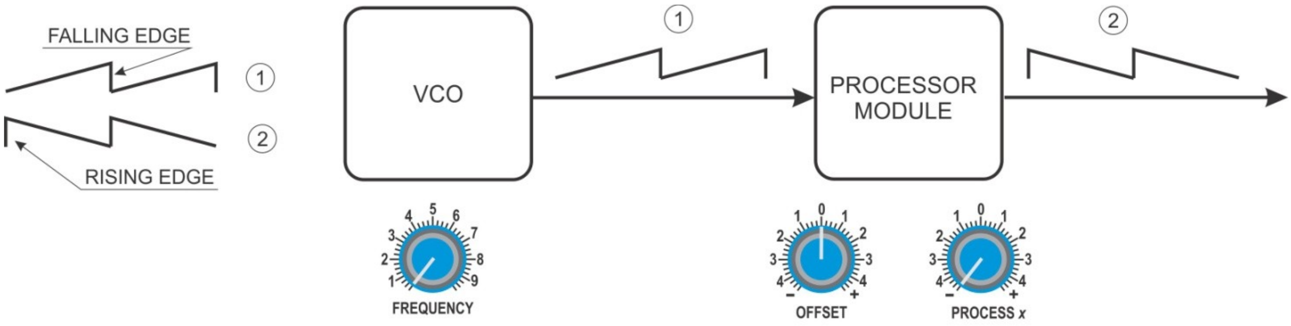


Figure 4.6.18

The VCO is set to a very low frequency; the output of the processor will be a series or 'train' of rising edges that can be used to trigger the ES114 over and over again.

Some processors have an OFFSET pot that adds a voltage to the output depending on its setting. If the processor being used in the above patch contains an offset pot it should be set at its 0V position ('0').

The ES114 should be set so that the duration of the envelope as a whole is shorter than the 'period' (the period of a wave is how long it takes to complete one cycle) of the VCO's sawtooth so that a full envelope can be generated before a new one is triggered. The ES114 will not respond to a new trigger until it completes its entire Rise-Fall cycle.

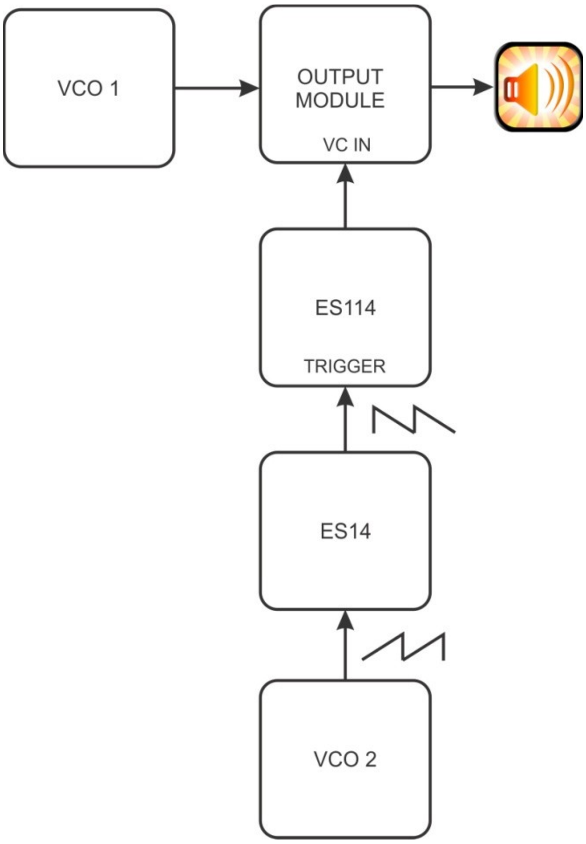


Figure 4.6.19

SELF-TRIGGERING and DELAY. The ES114 has an [END] output that generates a rising-edge at the completion of each envelope and remains high until after another envelope is triggered.

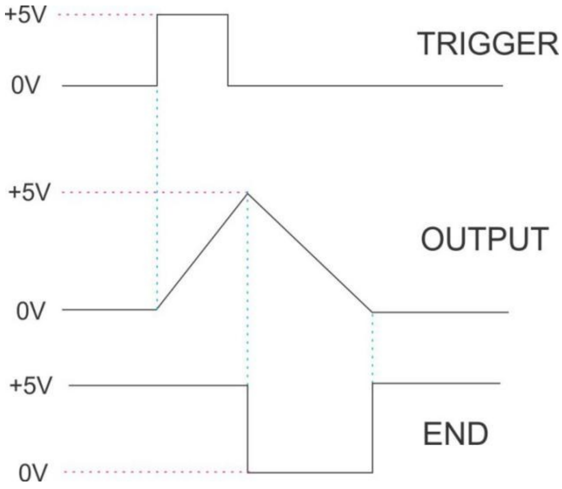


Figure 4.6.20

This [END] trigger can be used to trigger a triggerable module, including ITSELF.

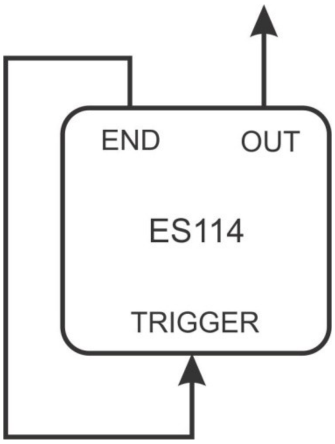


Figure 4.6.21

When the envelope has completed its cycle, a trigger appears at the [END] jack. Since [END] is patched to [TRIGGER], the module is re-triggered and the cycle begins again. This patch turns the ES114 in to an oscillator. When the RISE and FALL times are set short enough, so that the total rise and fall times is less than 1/20th of a second, this VCO is within the audio range and can be heard directly through the speakers.

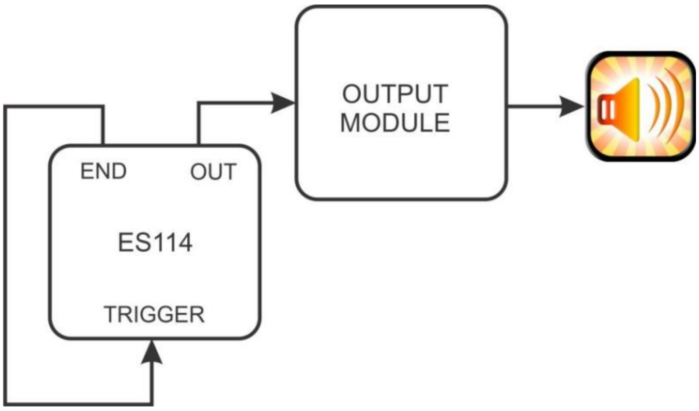


Figure 4.6.22

By adjusting the [RISE] and [FALL] pots different wave shapes can be achieved from saw to triangle.

Figure 4.6.23

By using two ES114 a delay can be created between a trigger and the generation of an envelope or between successive envelops of an ES114 that is oscillating.

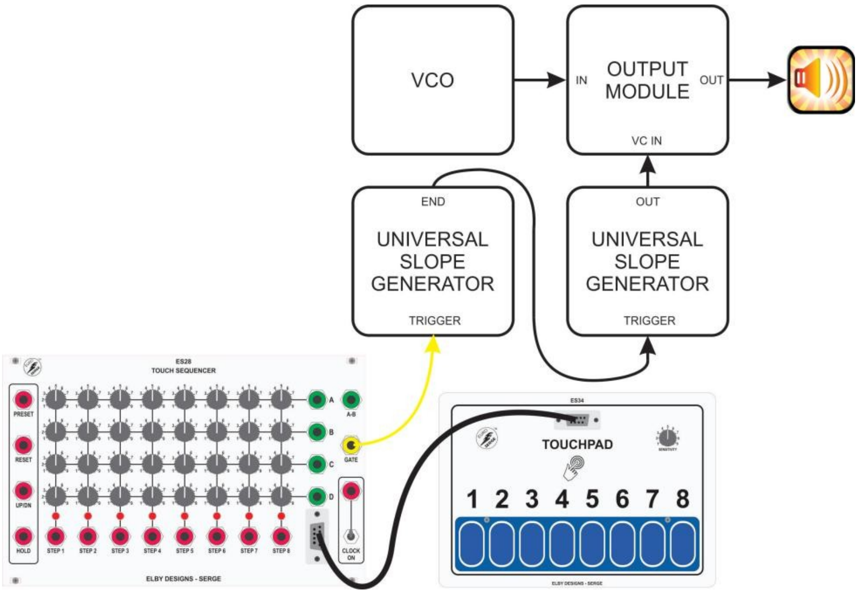


Figure 4.6.24

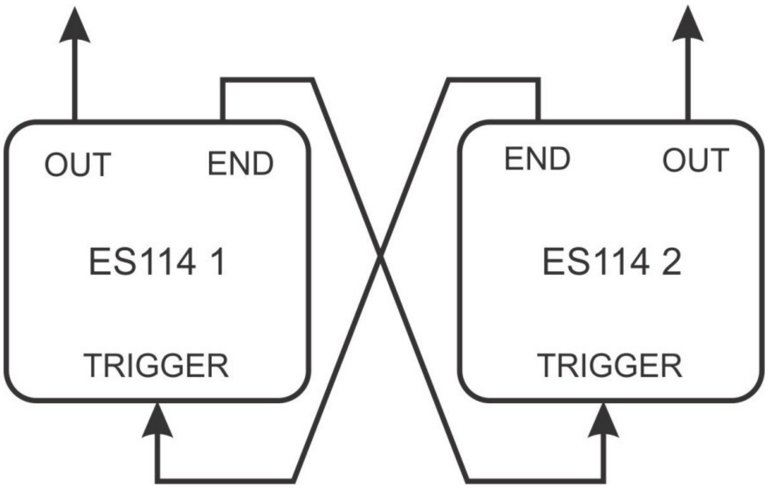


Figure 4.6.25

In these examples the length of the second envelope determines the delay. This envelope is not 'heard' in any other way.

VOLTAGE CONTROL. Naturally the ES114 can be voltage controlled itself. In this module different control voltages produce different RISE and FALL slopes and thus different length envelopes. The [VC IN} has an associated 3-way switch which allows for 3 possible modes of control. When the switch is positioned to either [RISE] or [FALL] the control voltage controls EITHER the RISE or the FALL. In the centre position a control voltage will control both RISE and FALL simultaneously. The [VC IN] has an associated control voltage processor so that the control voltage can be amplified, attenuated and/or inverted. One good place to get control voltages to control one ES114 is from another ES114.

In the patch in Figure 4.6.26 set the [RISE] and [FALL] pots to generate a VERY slow cycle. If the [RISE] and [FALL] times for ES114 2 are set for a fast cycle then the output of ES114 2 will be a voltage-controlled oscillator. If they are set for a slow cycle then the output will be a train of varying length envelopes.

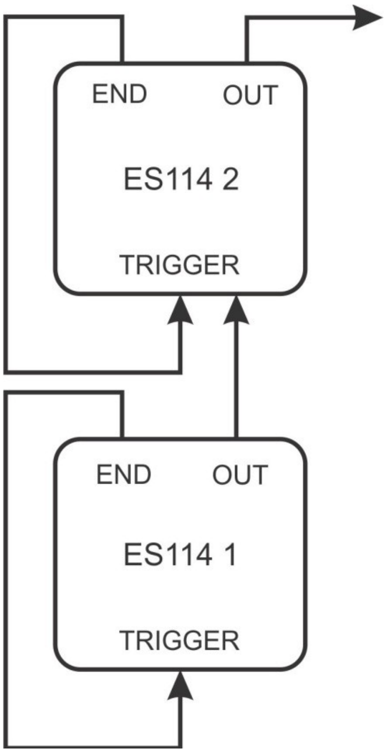


Figure 4.6.26

ENVELOPES WITH SUSTAIN. The ES114 has an input labelled [IN] which accepts a voltage. If this voltage is higher or lower than the output voltage of the ES114, then the output voltage will rise or fall to the input voltage at a rate set by the [RISE] and [FALL] pots. This input is useful for making envelopes which sustain as long as the trigger pulse remains high. For instance, the [GATE] output on the ES28 remains at HI at +5V as long as a finger is held down on a keypad.

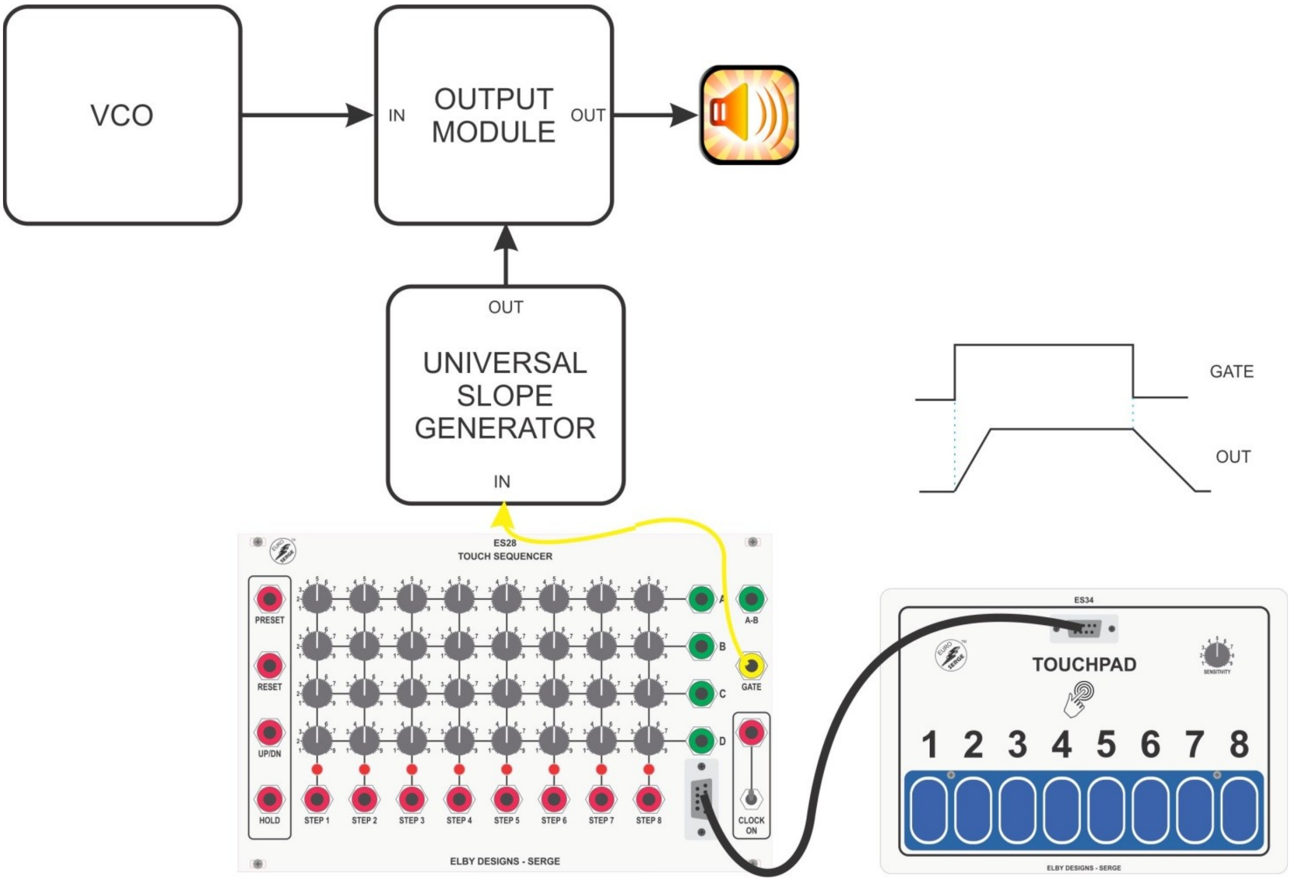


Figure 4.6.27

STEP SEVEN

When a piano note is sounded, not only does it have an overall amplitude envelope, but each harmonic or overtone has its own envelope. In most acoustic instruments the higher the frequency of the overtone the faster it dies away. The lowest tone, the fundamental, dies away last. This pattern is very much like closing down a fully opened LOW PASS filter.

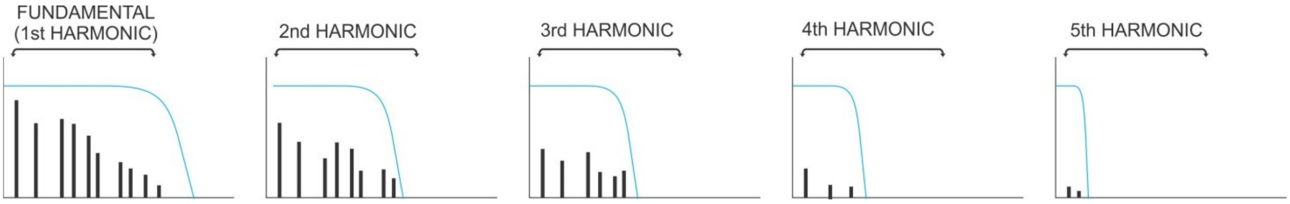


Figure 4.7.1

The control voltage applied to the filter sets the cut-off frequency. Usually the higher the voltage the higher the cut-off frequency. What makes it easier to simulate 'natural' sounds using a VCA and a filter is that the amplitude envelope is often similar to the 'harmonic spectrum envelope'.

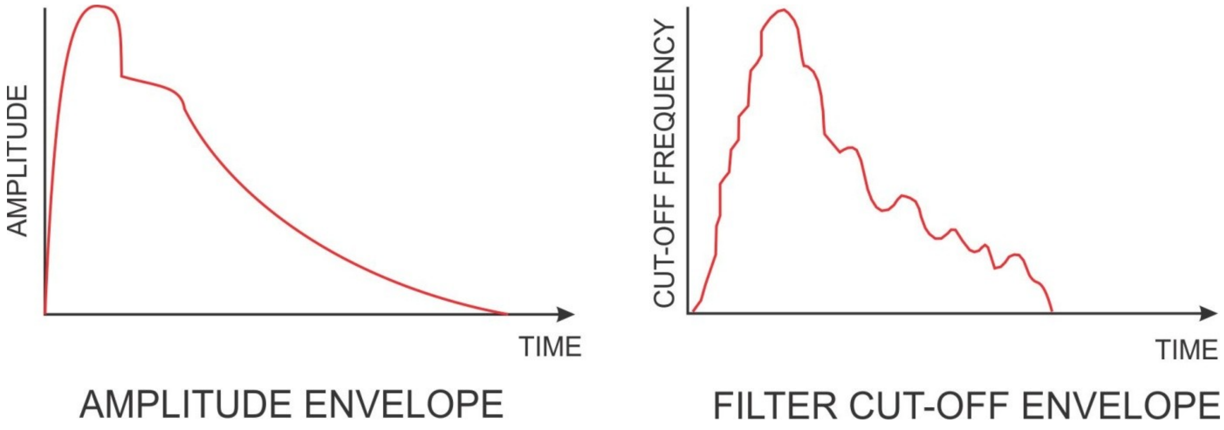


Figure 4.7.2

7.1 The similarities of these envelopes combined with the tautology 'if all the harmonics die away the sound has died away', make it possible to simulate natural sound even without the use of a VCA. The cut-off frequency of the filter should be set low enough so that no sound gets through unless and envelope is applied. The envelope should be set so that it rises rapidly and falls slowly. If the two VCO's are set to produce a fairly harmonic output, a bell-like sound should result.

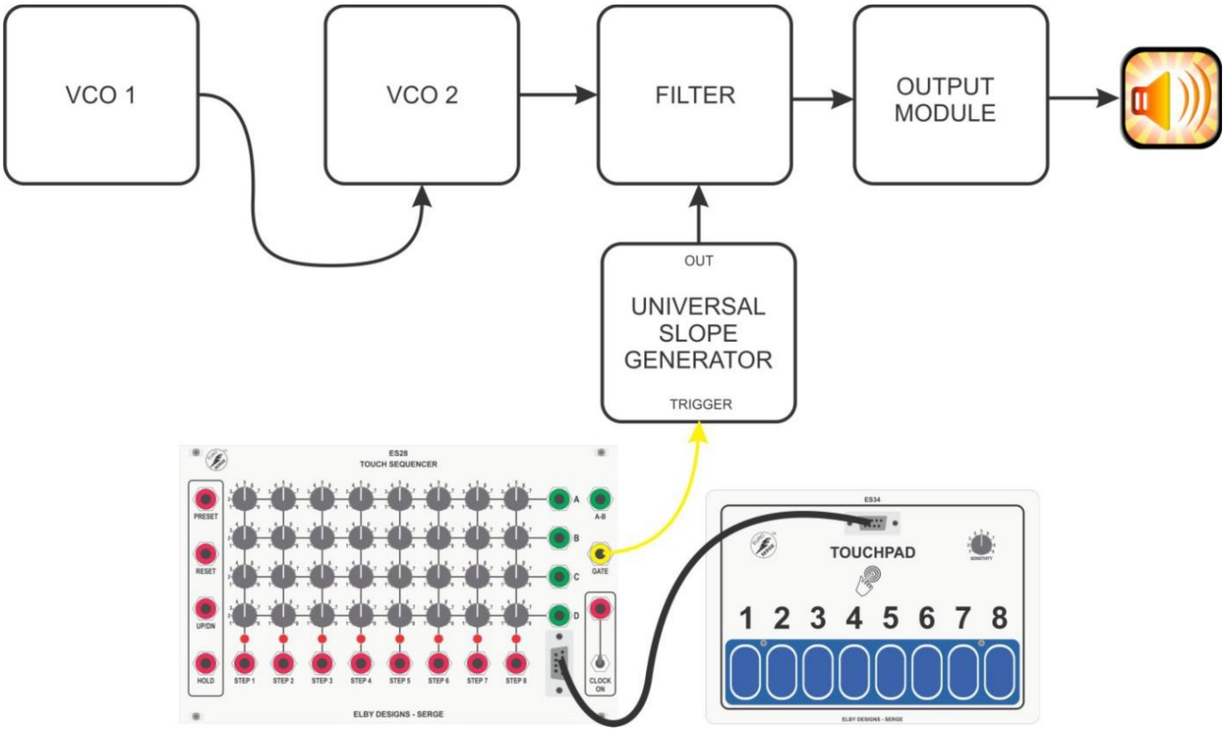


Figure 4.7.3

7.2 When the same patch is combined with a VCA controlled by the same envelope, and if the two VCOs are controlled by the [A] and [B] outputs of the ES28, the result can be an interesting keyboard instrument over which the composer has a lot of control.

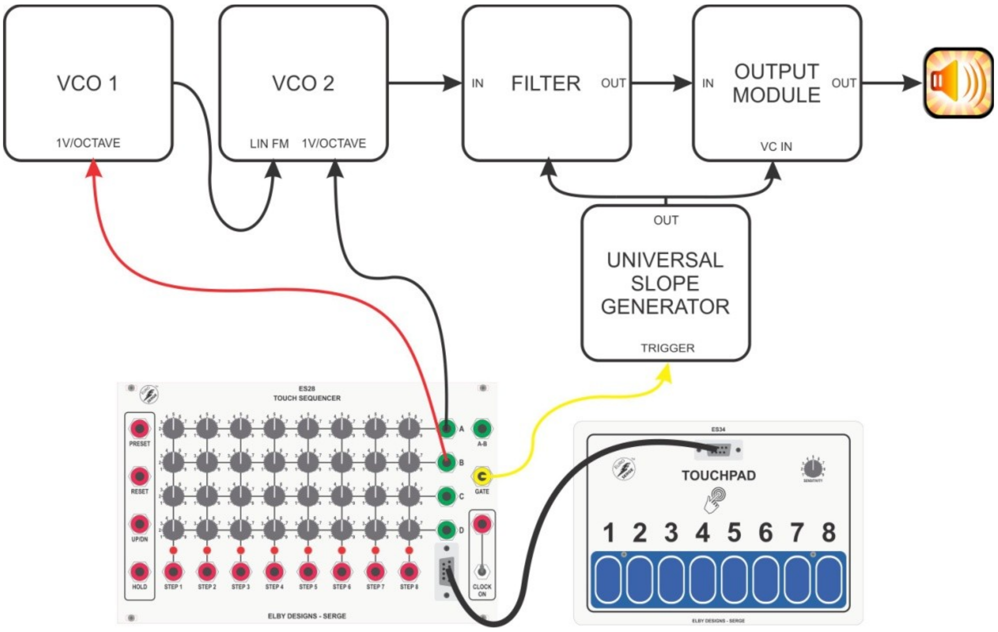


Figure 4.7.4

A limitation of this patch is that the initial cut-off frequency of the filter is always the same while the frequency of the VCO shifts under control of the ES28. A way to correct this is by patching row [A] not only to VCO 2 but to the

[1V/OCTAVE] input of the filter. Since these inputs are very precisely calibrated, and since they are being controlled by the same voltage, the filter and the VCO will 'track', so that the cut-off frequency of the filter will follow the frequency of the oscillator

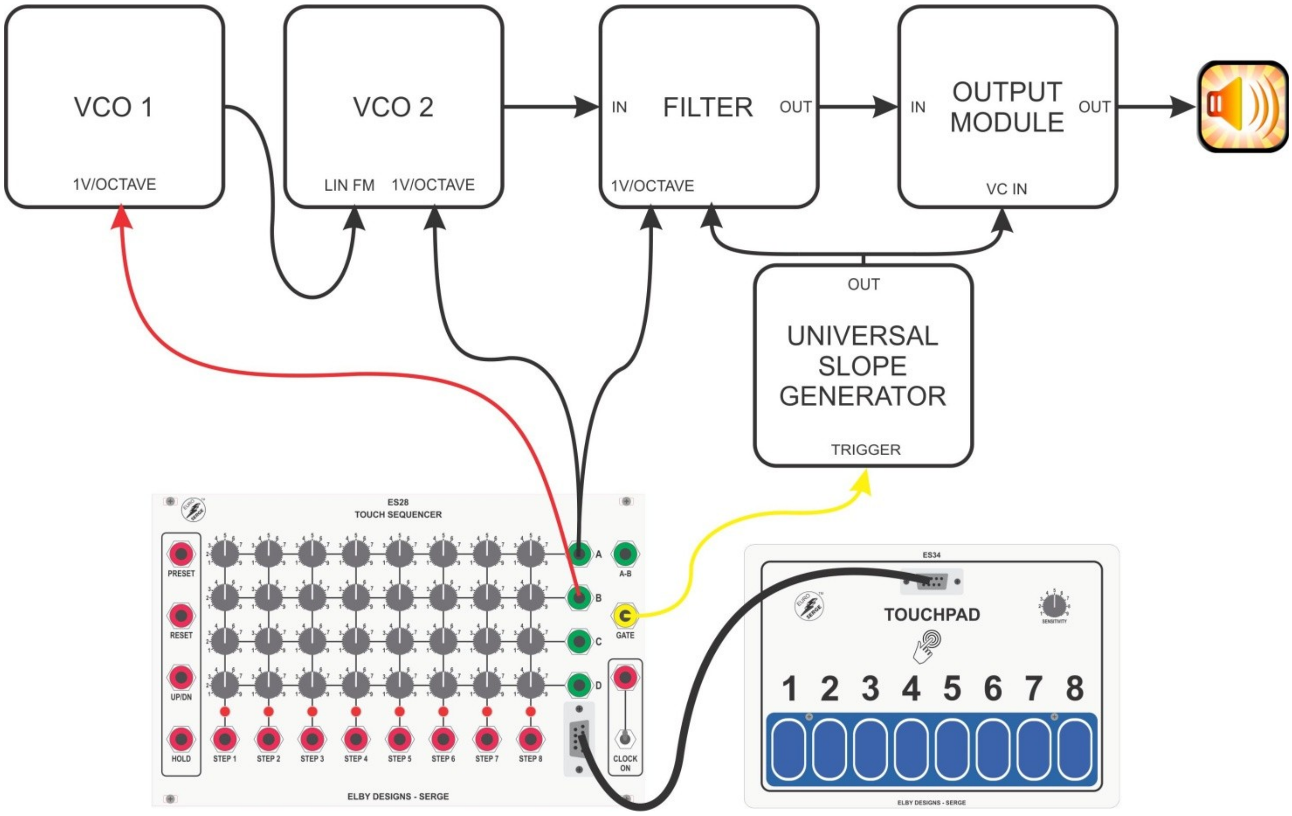


Figure 4.7.5

7.4 This patch uses the ES28 only one of its two major modes: the keyboard mode. It is possible to use it in an automatic or SEQUENCER mode where different stages are accessed automatically. In the right-most column of the ES28 is a [CLOCK] input which accepts a trigger pulse (it is RED, indicating a trigger in). Every time the ES28 received a trigger pulse at its [CLOCK] input it steps one stage to the right. If it is at stage '5' it will step to stage '6'. If it is on stage '8', however, it 'wraps around' to stage '1'. Using an ES114 set up as a slow oscillator to provide trigger pulses, the following patch will step the ES28 through its stages (make sure that the [CLOCK ON] switch is in the down position) :-

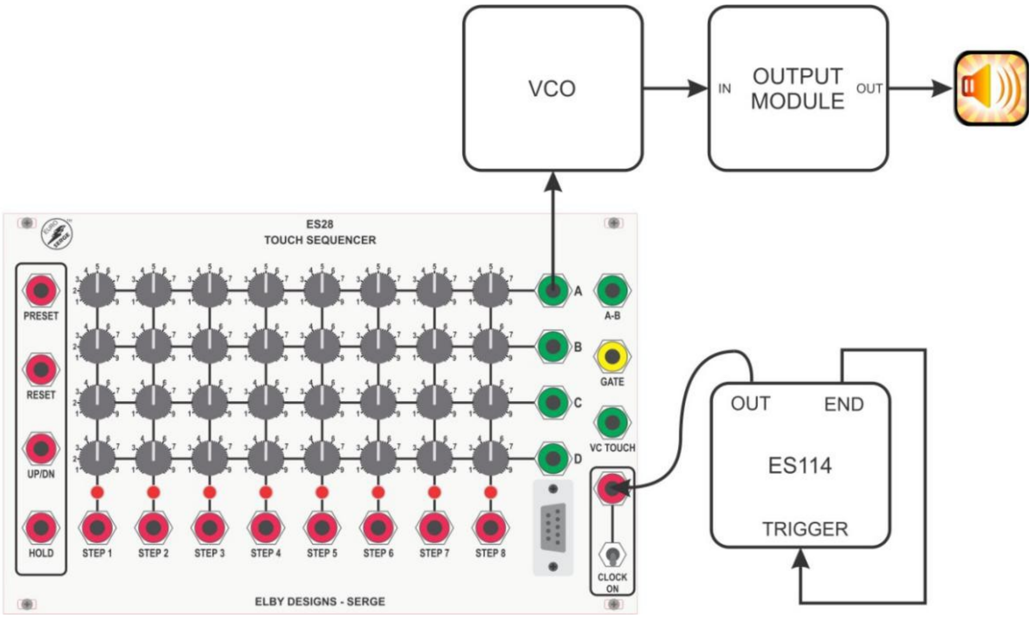


Figure 4.7.6

7.5 For this patch it is helpful to set all the pots in row [A] to different settings so that the different stages are distinguished from each other. Figure 4.7.7 shows the logical extension of this automated ES28 combined with the instrument sound we previously developed:-

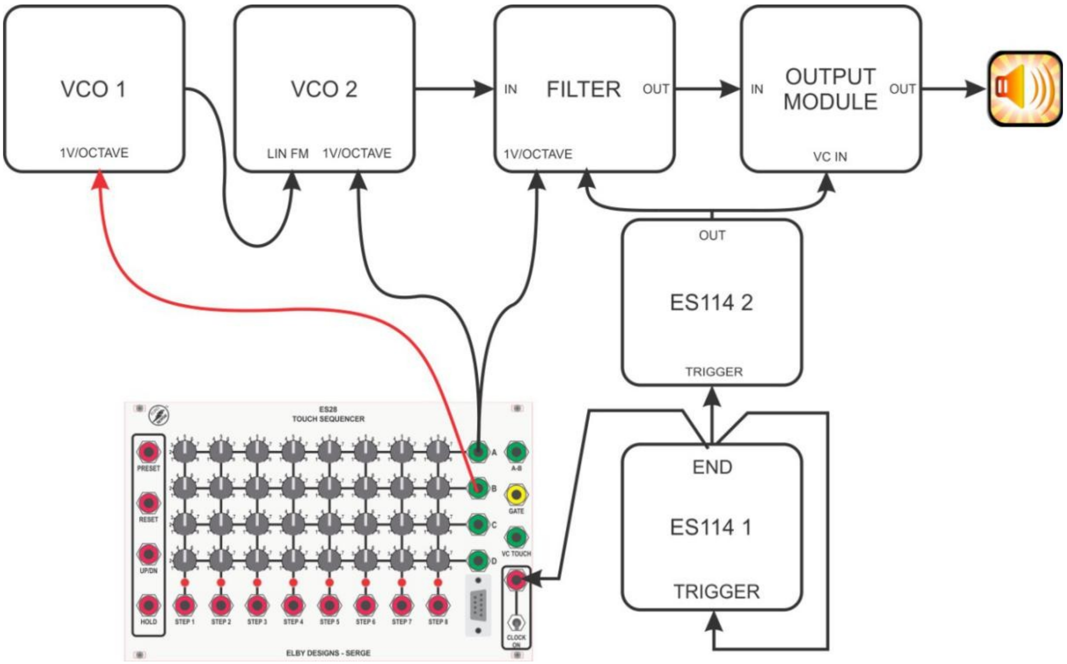


Figure 4.7.7

In this patch the ES114 1 acts like a clock for the whole system. As it 'ticks' it steps the ES28 along and simultaneously triggers ES114 2.

7.6 A musical drawback with this patch is the regularity with which the system moves along. But since the ES114 is voltage controllable, we have a way of altering the clock' rate by using a row of the ES28 to Voltage Control it. The speed of the clock now has become an integral part of the 'musical instrument' that was constructed by patching together modules. By setting the pots in the row controlling ES114 1, it is possible to set the time at each step - in other words, to control the rhythm. Furthermore, row C can be used to control the length of ES114 2, the envelope to the VCA and to the filter. With a thoughtful setting of the pots, 8 different sounds in a desired order, in any rhythm, can be produced and repeated.

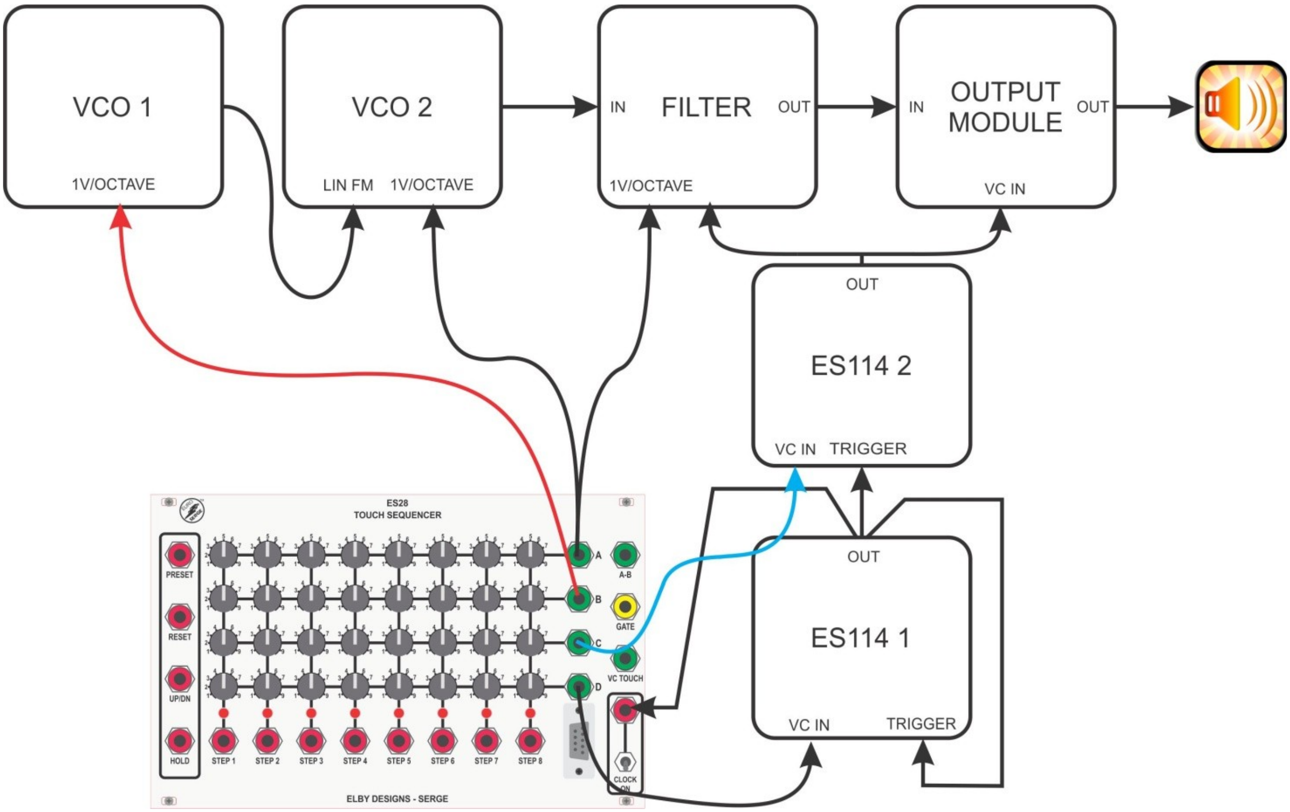


Figure 4.7.8

Chapter 5
The Euro-Serge System Modules