Erik Bartmann

Discover modulare Synthesizer with **VCV-Rack 2**

An exponential control voltage

V/OCT

Author	Erik Bartmann
Internet	https://erik-bartmann.de/
Topic	Exponential Control Voltage
Version	1.01
Date	February 18, 2022

Table of contents

An exponential control voltage - CV

What is it all about?

The following topics are discussed in this paper.

- Something about the history
- Different control signals (CV, gate, trigger)
- What does V/OCT mean?
- Exponential control voltage

Historical

Modular synthesizers are composed of a large number of individual modules. These modules must communicate with each other in a certain way and exchange information. So you can say that a common language must exist for them to understand each other. *Bob Moog* was a pioneer of electronic music and the founder of the *Moog synthesizer*. He developed and used what is called a control interface, which was widely used, which involves analog voltages. These control voltages - called control voltages (CV) - are the key to modular synthesizers communicating with each other. The following figure shows modules that are connected to each other via patch cables (interconnecting cables) and exchange voltages through them to achieve certain effects (events).

Figure 1 Two modules are connected via a patch cable

The green cable connects the left USB MIDI module with the right VCO module (Voltage-Controlled Oscillator) to change the pitch. The name VCO already shows that this is a module that can be controlled by voltages. Now imagine a modular synthesizer with a multitude of modules, as shown in the following illustration.

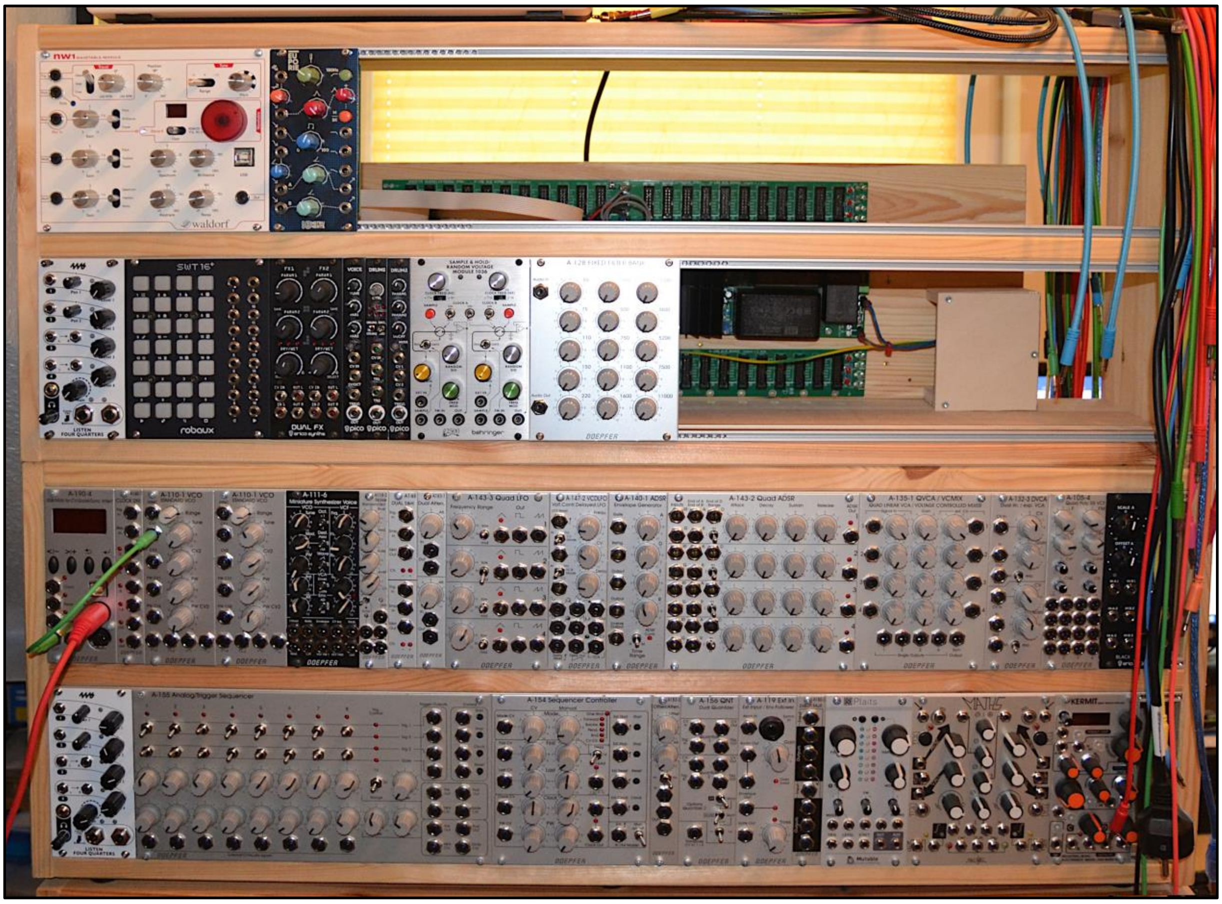

Figure 2 A modular Synthesizer

In order to get the desired sound experience, you would have to manually move the necessary knobs and/or switches, and preferably all at the same time, which is simply not feasible with two hands of a musician for anatomical reasons. So you need several musicians to operate the modular synthesizer?! No, of course not, because now the already mentioned patch cables come into play, which can influence the most different parameters of a synthesizer if they are wired over it appropriately. Such parameters can be, for example, the pitch, volume, filter settings or other sonic aspects, of which there are many.

Basics of the control voltages

Since the control voltage CV is an analog signal, it can assume any value in a certain predefined range, where voltages are measured in volts. The greater the prevailing voltage, the stronger the signal and the more decisively a certain parameter can be influenced. Such an influence is called *modulation*. The possible voltage range is mostly in the limits of -10V and +10V, where the negative range is usually used for attenuation and the positive range for amplification. A voltage of 0V does not influence the respective parameter. In modular synthesizers, the control voltage is used for different applications, which I would now like to discuss in more detail.

A continuous control voltage

An analog signal can take on different voltage values in time, whereby the whole thing takes place smoothly and there are no jumps. It is called value and time continuous. The following figure shows such a signal.

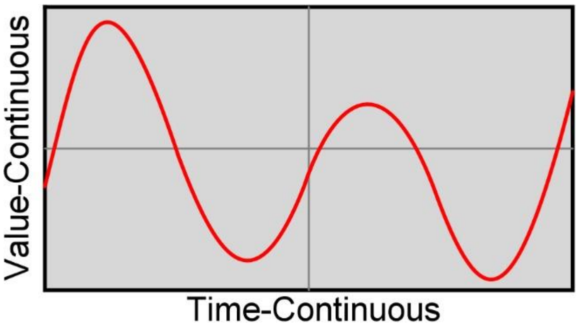

Figure 3 An analog signal - value and time continuous

This signal can be used to cause all kinds of modulations. There are various modules that generate such signals to then influence the sound in a certain way in a more or less automated way. These modules can be, for example, an *LFO* (low frequency oscillator), a *Noise* or an ADSR envelope generator.

On or Off - The Gate

Gate signals can switch certain parameters on or off. The name *Gate* describes the function of this signal very aptly: If a gate is open, it allows voltages to pass; if it is closed, no forwarding occurs. Pressing a key on a keyboard triggers certain gate signals. On the one hand, it must be transmitted which key was pressed in order to determine the pitch (V/OCT) and on the other hand, of course, the duration (gate) of the keystroke. The following figure shows the actual gate signal, which shows a keystroke on the keyboard.

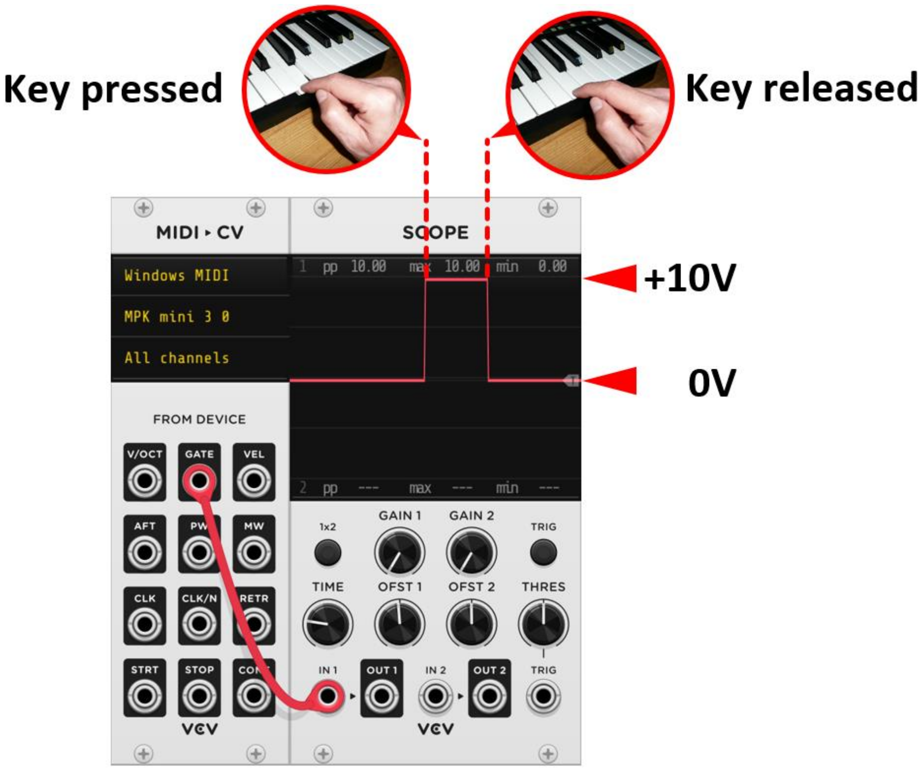

Figure 4 The gate signal of the keyboard

Such a gate signal can be in different voltage ranges - depending on the synthesizer. There are modules that are between 0V and +5V and others that are in the range of 0V and +10V. Gate signals tell the synthesizer when a certain event should start and how long it should last. As I said, with regard to keyboard gate signals, there is another voltage level that carries the information of which key (V/OCT) is pressed on the keyboard and represents the pitch, yes the actual subject of this paper. On the following figure it can be seen that different voltage levels prevail depending on the keys pressed.

Figure 5 Different voltage levels

Only very briefly On - The trigger

If you look at a trigger signal, you will notice that it is a very short pulse. It usually has the same voltage range, but it is intended not to do anything because of the pulse duration, but to trigger something by a very short HIGH-LOW level, which causes a said triggering. The following figure shows both a gate signal (red curve) and a trigger pulse (yellow curve). Note the difference in wording between *signal* and *pulse*.

Figure 6 Gate-Signal and Trigger-Pulse

In contrast to a gate signal, a trigger pulse only defines the start of an event, but not its length. A start shot in a 100m race signals the beginning of the race and the length of the shot or bang is not important. The most common applications for a trigger pulse are, for example, the triggering of envelopes, the initiation of a *reset* (the start of an oscillation) or a *sync* (the synchronization of several modules with regard to the start of the oscillation) in a VCO or LFO or the resetting of sequencers, for example, to the first step. Trigger pulses also play a very important role in drum modules, forcing them into a certain pattern.

The pitch control - V/OCT

Now we come to the actual topic, the control of the pitch via the control voltage. A fundamental parameter of a synthesizer is the characteristic curve of the control voltage in relation to the frequency. In many applications, a linear characteristic is required, i.e. *n* volts per Hz. However, musicians do not deal with linear frequency ratios, but with musical intervals, the fundamental of which is the octave. With each increase of an *octave*, the frequency of a note doubles. According to this system, increasing the voltage on a voltage-controlled oscillator - called a *VCO* - by 1 volt - for example, from 0.5 V to 1.5 V - would raise the pitch by an octave. That is, if you plot the absolute frequency in hertz against the relative frequency in octaves, you get an exponential curve, as shown in the following figure.

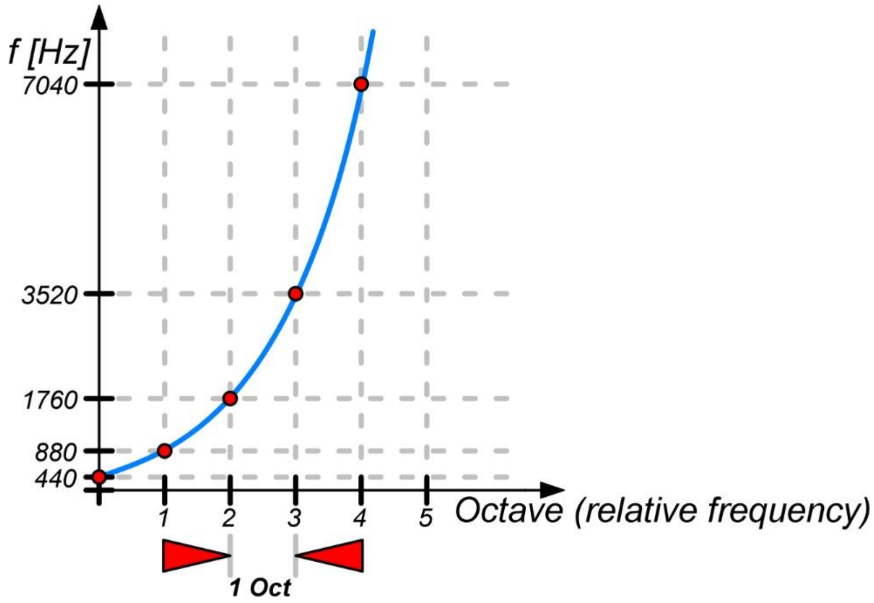

Figure 7 Exponential curve OCT/frequency

It is easy to see that for every increase of 1 octave (X-axis) the frequency doubles (Y-axis). However, if the control voltage is used instead of the octave, the linear behavior between the units *Volt* and *Hertz* can be seen, whereby the frequency on the Y-axis is no longer linear, but exponential. What is meant here is the doubling of the frequency on the Y-axis per graduation mark.

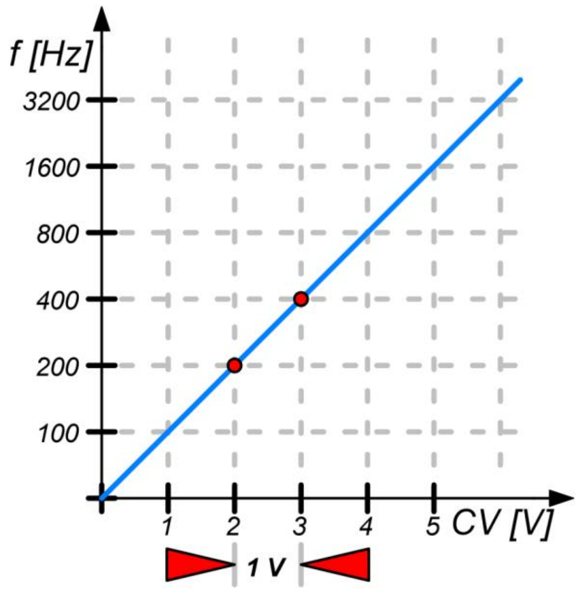

Abbildung 8 Lineare Kurve V/Frequenz

Because of its widespread use, it can be said that 1V/octave has become the de facto standard for control voltages. The following figure shows a few keyboard keys of the notes C3 to C4 and the corresponding voltage values. These different voltage levels cause an oscillator to change pitch exactly according to the defined 1V/octave scheme. V/OCT thus describes the relationship between voltage and pitch.

1 Octave = 12 Semitones

1V / OCT ⇨ 1 Semitone = 1V / 12 = 0,083V

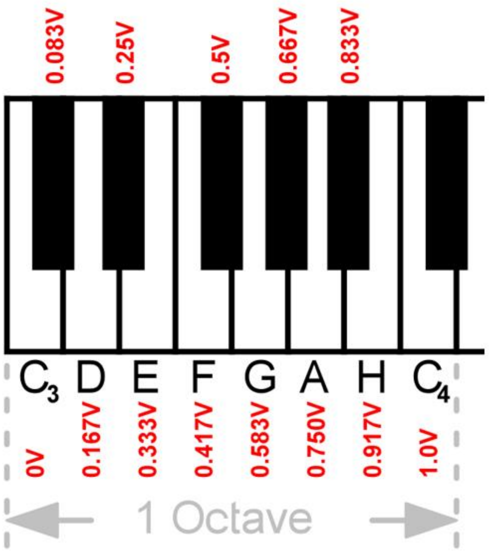

Figure 9 Keyboard keys and their voltage values

Let's see this in a patch, where I pressed the note F3 on the keyboard. The prevailing voltage of 0.42V can be read in the upper part of the scope module and the detected note is displayed in the HOT-TUNA module. For the display to work correctly and to match my keyboard, the OCTAVE on the HOT-TUNA module still needs to be adjusted down by an octave. Unfortunately there are two different standards regarding the supposed 0V standard. With some the note C3 is set at 0V, with others C4. Be that as it may!

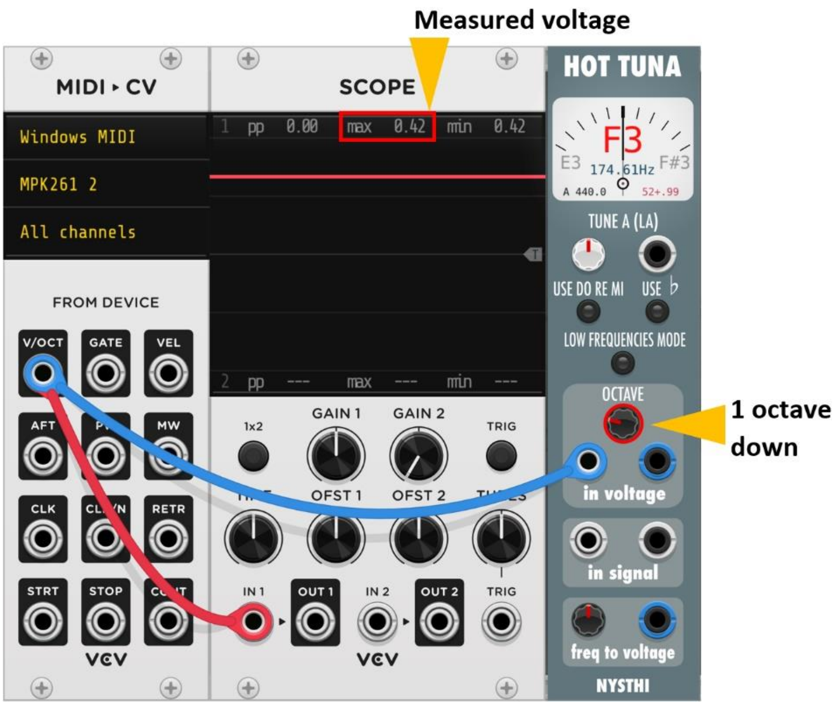

Figure 10 The HOT TUNA-Module

More information can be found on my website.

Hyperlinks!

https://erik-bartmann.de/

https://erik-bartmann.de/?Musik   VCV-Rack

Happy Frickeling!

Erik Bartmann