FG-VCO

Circuit Analysis

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Before you read!

What is this manual about?

The purpose of this manual is to explain in every aspect the design of different diy eurorack modules, more specifically, every design choice and how every circuit works. Ultimately the reader will be able to understand how the circuits are built, how they work and how they can be replicated and/or modified as needed.

The reader is assumed to already have a basic understanding of electronics and electronic components.

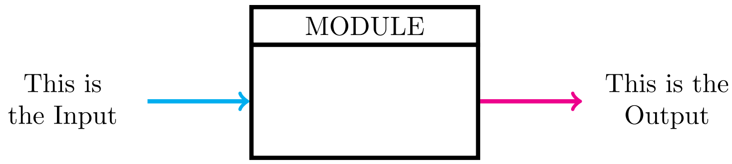
Finally, almost every module could be easily built with digital microcontrollers or DSPs, although the challenge here is to take as much as possible an analog approach.

Notation and Terminology

In order to better comprehend what is going on, there are going to be a lot of drawings, schematics and diagrams in this manual, so here are some tips on how to interpret what you see:

- **Audio signal**: a signal that can be fed into an amplifier. Ultimately almost every synth module is built to create and modify this kind of signals (with a few exceptions);
- **Digital signal**: a signal is either logically high (higher than a fixed value), or logically low (lower than a fixed value). These kind of signals are used to control various different modules functions, such as gates for envelope generators, clocks for step sequencers and so on;
- **Control voltage**: an analog signal that can assume every value between two different fixed references, often $\pm V_{cc}$. Much like a digital signal, a control voltage is used to control modules' functions, but it can controls a specific parameter with a much higher flexibility and with particular relationships (such as linear or exponential).

Usually the colors will be used in block diagram's arrows to show what kind of signal they bring, like this:



As for the terminology:

- **Interface**: it refers to the front panel components such as knobs, connectors, LEDs and everything that can be manipulated from the final user.
- **Core**: it refers to all the circuitry that makes the magic happens. It is usually kept behind the interface board.

Structure

Every module will be treated as follows:

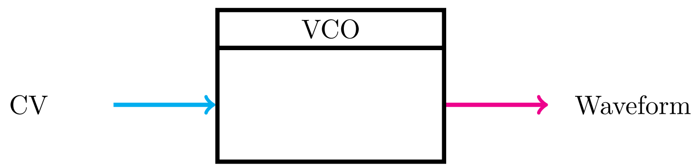
1. General introduction and presentation of the module (I/O configuration, function principle and possible variants);
2. Project specifics and general block diagram of the module;
3. General blocks analysis and implementation;
4. Final choice of the circuit, final complete block diagram and front panel design;

Contents

Chapter 1

Itroduction to the VCO

A **voltage controlled oscillator** (or **VCO** for short), is a module capable of turning a given **control voltage** to a specific waveform **audio signal** at a certain frequency, proportional to the value of the input voltage.



Chapter 2

Interface Definition

2.1 Interface Definition: Input

Frequency modulation

First thing first, we need a way to control the frequency of the VCO. This can of course be achieved through simple knobs or sliders, however a more interesting feature is an LFO or CV control input.

We will then take an hybrid approach by having:

- Frequency modulation knobs, coarse and fine to adjust and tune the frequency as we please;
- Frequency LFO/CV gate input and attenuator knob to have a for dinamic control;

As the human ear perceives music and sound in a logarithmic fashion, we will also need a linear to exponential converter, since an exponential voltage would be hard to manually control.

Mode selection

A VCO can be used either as a sound generator (VCO) or as a modulator (LFO), simply by changing the range of frequencies it can outputs, therefore we can add a switch to choose the device's functioning mode.

2.2 Interface Definition: Output

Waveforms

As we've already discussed, a VCO could theoretically give us almost any waveform, if designed to do so, obviously. However we will limit the outputs to the five fundamentals wave shapes:

- Sine wave;
- Triangle wave;
- Square wave;
- Ramp wave;
- Sawtooth wave;

With those five basic waveforms we can then get really far with all the available effects and modulations that other modules can offer.

We would like parallel aoutputs (although you can certainly get an analog multiplexer to have only one output channel instead of five), and that all of our waves have the same frequency.

Also we would like all of our outputs to have an attenuator just to give us the possibility to adjust the amplitude of the signal before going inside another module.

Other miscellaneous outputs

A sync pulse may come in handy to trigger effects or with a PLL module. We can also add an LED to see the state of the pulse.

LEDs showing the current function mode can also come in handy to quickly see how the module is behaving.

2.3 Module Block Diagram

Summing all of the requirements described in the previous chapters we can now draw a preliminary block diagram to better understand how we need to tie everything together.

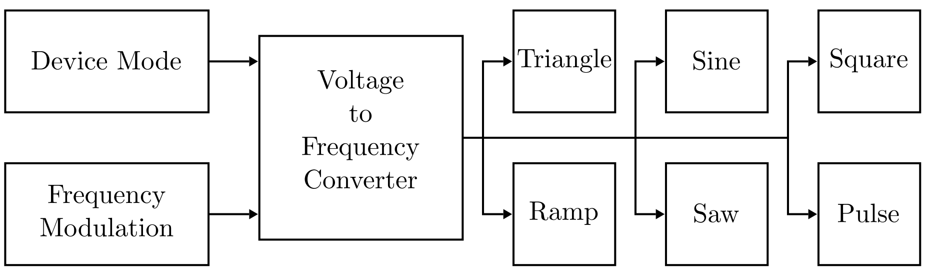


Figure 2.1: Full Module Block Diagram

Chapter 3

Blocks Design

3.1 Frequency Modulation

As we have previously discussed, we want our frequency modulation input as a combination of a manual voltage (using a knob) and an arbitrary control voltage from the outside.

We will also add a clipper to prevent unwanted voltages in the exponential converter.

Also, components values will be better explained further in the manual.

This is what we want to achieve:

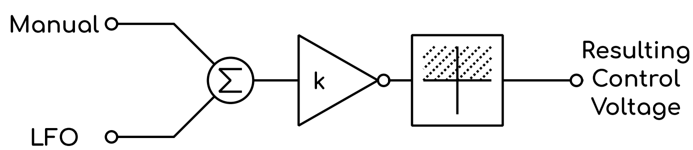


Figure 3.1: Frequency Modulation Block Diagram