

dSpec

Direct spectral synthesis VCO

User Guide

version 1.1

Introduction

dSpec is a two channel digital voltage controlled oscillator that generates waveforms using additive spectral synthesis. This means that the waveform is built up from a set of sine waves of various frequencies and amplitudes.

The pitch of each note is defined by a sine wave at the notes's fundamental frequency, for example middle-C on a piano keyboard has a frequency of 261.63Hz. The harmonics, also called partials, are sine waves with frequencies that are odd or even multiples of the fundamental frequency. The timbre or sound of the note depends on the amplitude or loudness of these harmonics relative to the fundamental frequency. The waveform can also include sine waves unrelated to the fundamental frequency adding to the range of sounds that can be synthesized. This set of sine waves of various frequencies is called the spectrum of the waveform, hence the term spectral synthesis.

The amplitude of the harmonics can be modulated in various ways to dynamically, and sometimes radically, change the sounds that dSpec synthesizes.

Front panel controls

The front panel has thirteen input jacks, eleven knobs, a 128x128 RGB OLED display, and a push button rotary encoder.



VPO Inputs and Audio Outputs

There are three volt-per-octave inputs, these jacks have blue dress nuts. VPO1 and VPO2 control the pitch of the two audio channels Out1 and Out2. The audio output jacks have green dress nuts. The third volt-per-octave input is the Transpose input which adjusts the pitch of both audio channels simultaneously in semitone steps up or down.

CV Functions

There are four CV inputs identified by black dress nuts. These inputs modulate the spectrum of the waveforms for each of the audio channels. The CV input range is +/- 5V. Each CV input has an attenuation and offset knob. When the CV input jack is not patched the offset knob directly controls the modulation level.

The Low Pass input and knobs control an exponential curve filter that attenuates the higher frequency harmonics.

The Noise Mix input adds randomness to the spectrum. There are two noise modes: Spectral and Harmonic, selected via the OLED display. Spectral mode adds random frequencies between the fundamental frequency and the low pass cutoff frequency. Harmonic mode randomly modifies the amplitudes of frequencies already present in the spectrum which produces a tremolo-like effect.

The O/E Mix input controls the relative amplitudes of odd and even harmonics. This is the ratio of odd multiples of the fundamental frequency to even multiples of the fundamental frequency. Odd harmonics have a bright reedy tone while even harmonics sound warmer and more musical.

The bottom CV function controls a comb filter that shapes the harmonic spectrum. A comb filter has a series of peaks and valleys that boost or attenuate groups of harmonics. The Comb Width input gives CV controls over the width of the teeth of the comb. In one direction the Comb Depth knob controls the depth of the teeth, in the other direction the comb is effectively inverted so the valleys become peaks and visa-versa. In the center position the comb filter is effectively off.

Customizable Inputs

The inputs AUX CV and AUX_Π_ have yellow dress nuts and can be configured to automate various control functions. This is covered later in the OLED display section.

Audio Modulation Inputs

The two remaining inputs Mod1 and Mod2 identified by red dress nuts are audio inputs that can independently modulate the harmonic spectrums of their corresponding audio outputs. The strength of the modulation is set by the Mod Depth knob. In simple terms, the harmonic spectra of the Mod1 and Mod2 inputs change the amplitude of the corresponding harmonics in each of the audio channels. Modulation does not add any new frequencies to the spectrum but can dramatically change the sound.

OLED Display

These functions are accessed via the OLED display and the rotary encoder:

- **Quantizer** controls which notes are synthesized.
- **Algorithm** defines the frequencies in the spectrum.
- **Visualizations** two different ways to see the synthesized audio.
- **System** a menu of subpages for accessing system settings.

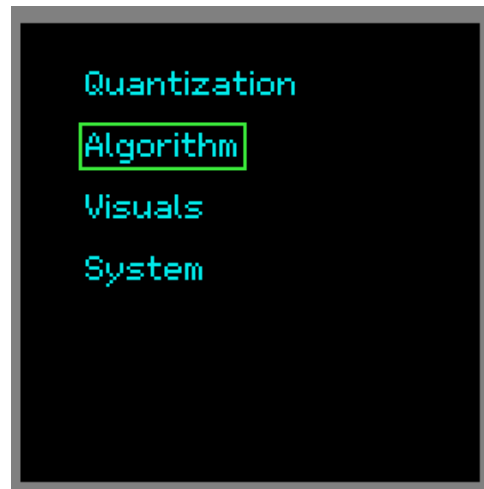
These are described in detail in the sections below.

Display Controls

The OLED display and the rotary encoder are the primary means for controlling which notes are synthesized in response to changes in the volt-per-octave inputs and how the harmonic spectrum is constructed and modulated.

User Interface Operation

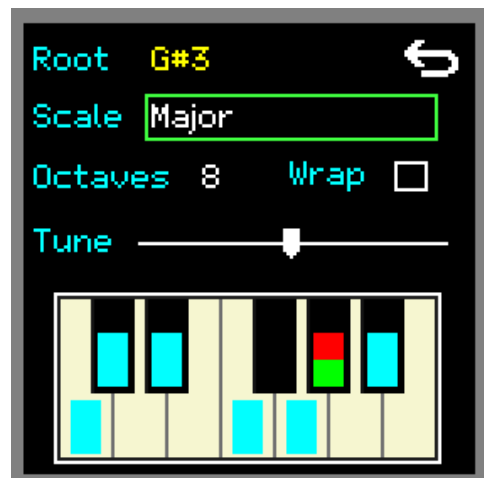
The user interface is organized into pages. The top level page is a menu of the pages that access the primary functions.



All interaction with the display is via the rotary encoder knob and integrated push button. Turn the encoder knob to move the focus between the controls on the current page. The control that has focus is highlighted with a green border. Click the encoder push button to select or activate the control. If the border around the selected control turns yellow, rotate the encoder to step through the control values. Click the encoder again to confirm the selected value. For some controls a long-press, that is holding the button down for a while rather than just clicking it, accesses a secondary function. This is described in the detailed descriptions below. To exit the current page, rotate the encoder to set focus to the back button at the top right of the page and click the encoder button.

Quantization Page

The Quantization page controls which notes get played. The quantizer forces notes to fit within a chosen scale or chord. The Scale control has a list of pre-defined scales and four that are user defined. Selecting Open Tuning from the Scale list turns quantization off.



dSpec has an eight octave range from A0 to C8 on the piano keyboard. The root note shown at the top of the page is selected by the Transpose CV input or knob.

The quantizer can constrain the synthesized notes to a specified octave range relative to the root note. The exact behavior depends on the setting of the Wrap checkbox. If Wrap is not checked, out of range notes are transposed to the highest or lowest note in the octave range as quantized by the Scale. When Wrap is checked, notes retain their quantized note value but are shifted into the upper or lower octave of the range. For example, if Octave is set to 1 and Wrap is checked, a voltage sweep from -5V to +5V will repeatedly arpeggiate the quantized scale in the octave surrounding the root note.

Interesting musical variations can be generated by changing or modulating the Octave and Wrap controls.

The Tune slider is for fine tuning the output pitch, it has a range of -50 to +50 cents (a cent is a hundredth of a semitone). The selected offset in cents from the root frequency is shown next to the root note at the top of the page.

The keyboard display at the bottom of the page shows which notes will be voiced. The two currently playing notes are highlighted in red and green. The keyboard display is also used to input notes for user defined scales.

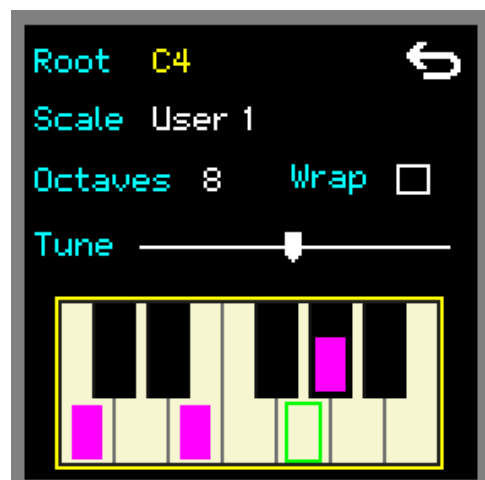
User Defined Scales

To define a custom chord or scale choose one of the user scales. The keyboard display then becomes an active control for editing the scale.

With focus on the keyboard control clicking, the encoder button selects it and focus shifts to one of the piano keys. Rotating the encoder moves the focus across the keyboard. Holding the encoder button down adds or removes a note from the scale. A normal short click of the encoder button confirms the note selections.

The user scales are stored in non-volatile memory.

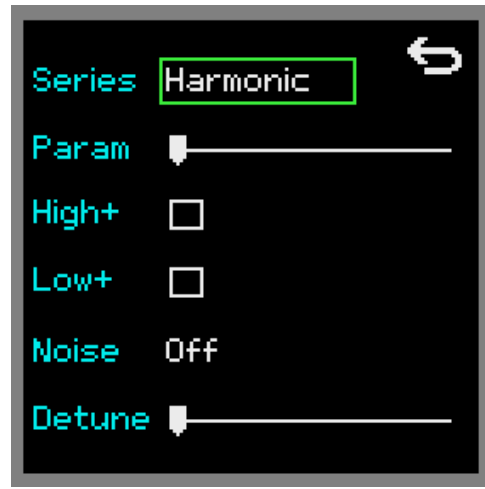
Note: in VCV Rack double-click the mouse instead of holding the mouse button down.



Algorithm Page

The Algorithm page defines how dSpec generates a core harmonic spectrum for synthesizing a waveform. This spectrum and subsequent CV and modulation inputs determine the waveform and therefore the sounds that are synthesized.

The core spectrum is derived from some relatively simple integer series: Harmonic, Fibonacci, Primes, Polygonal, Linear, and Octaves which tend to generally sound musical. The Random and Discordant series are, as their names suggest, often very unmusical.



The behavior of the Param slider is specific to the selected series with values chosen to provide interesting variations in the generated spectrum. For the Harmonic series the Param setting controls the spread of the harmonics. For the Fibonacci sequence Param sets the starting value of the series which are more correctly referred to as Lucas series.

The High+ and Low+ check boxes add or boost harmonics above or below the harmonics produced by the selected series.

The Noise control selects the Harmonic or Spectral noise effect or turns noise off.

Each Series option has its own settings for Param, High+, Low+, and Noise. These settings are stored in non-volatile memory.

The Random series is generated from a combination of the Param slider setting and a pseudo-random number (PRN). The seed value for the PRN is stored in non-volatile memory for reproducible behavior across sessions. If the Param slider is moved all the way to the right the PRN is reseeded. The new seed value replaces the value stored in non-volatile memory.

The Detune slider adds a copy of the waveform slightly pitch-shifted to fatten the sound or create a chorus-like effect. Detune is applied to both channels and all algorithms.

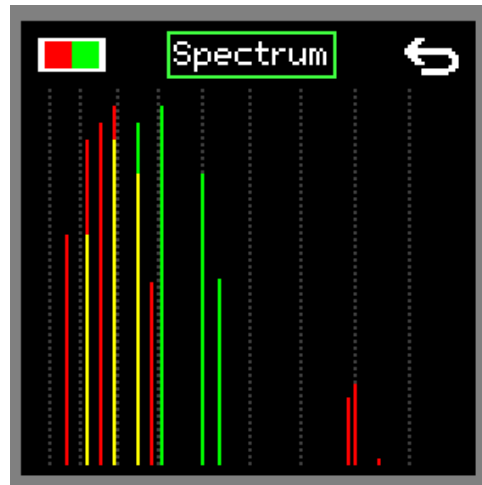
Visuals Page

The Visuals page displays either the waveform shapes or the spectrum of the notes currently being synthesized. The waveform display can be configured to show both voices or one voice by clicking on the red/green box. Click on the middle button to toggle between the Spectrum and Waveform views.

Spectrum View

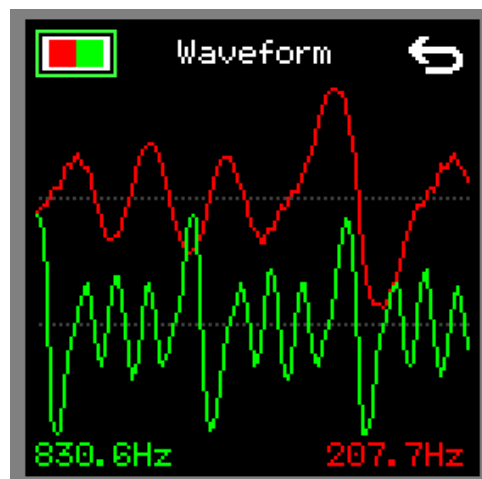
The Spectrum view displays a graphic spectrum of the notes currently being synthesized. It can be useful for getting an understanding between the relationship of the harmonic content and the sound that is generated. The horizontal axis is plotted on a logarithmic scale, the midpoint is approximately 5KHz, the vertical axis is linear.

When both voices are displayed, areas where the two spectrums overlap are shown in yellow.



Waveform View

The Waveform view displays the frequencies and shapes of the waveforms currently being synthesized. The display is scaled to always show at least one complete waveform cycle. When both channels are displayed the relative width of the waveforms does not reflect their relative frequencies.



Customized Controls

Most of the controls on the OLED display can be mapped to either the AUX CV or the AUX Π inputs. Multi-valued controls such as the quantization scale or the algorithm selection can be mapped to AUX CV. The single value controls High+ and Low+ can be mapped to AUX Π . The voltage range for AUX CV is 0V to 5V which is mapped in equal increments to the full range of values of the control. Negative voltages are inverted so, for example, -3V and +3V will map to the same control value. Pulses on the AUX Π input toggle the mapped control on or off.

To map a control in the UI hold down the encoder until the text of the control name turns yellow. Repeating this operation reverts the control to its normal operation. Multiple controls can be mapped to the same input.

Note: In VCV Rack double-click the mouse instead of holding the mouse button down.

System Pages

Note: There are no system pages in VCV Rack. Use the initialize context menu to perform a reset.

The System page lists a collection of sub-pages for hardware system related functions unrelated to sound synthesis.



Display Page

The Display page has controls for setting the display brightness and for automatically dimming the display after a specified timeout period. Dimming the display can improve the long-term brightness of the OLED display and also reduce power consumption. The dimmed display will return to normal brightness if the encoder is turned or clicked.



Firmware Page

The Firmware page displays the current firmware version and can be used to initiate a firmware update.

Firmware Update Procedure

dSpec is based on the Electrosmith Daisy Patch Submodule. To update the firmware you will need a PC and a micro USB cable. The update does not require Eurorack power.



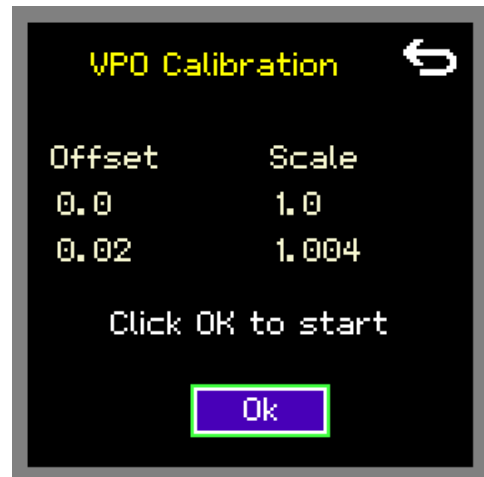
Download the new dSpec firmware from <https://www.gregsbrain.co/download>

Connect the USB cable to the micro USB port on the submodule and dSpec should start up. Navigate to the Firmware page and click on the Ok button. dSpec will wait for the firmware downloader.

Open <https://flash.daisy.audio> in a browser and follow the instructions on the Daisy Programmer webpage to upload the dSpec firmware file. Click the FLASH button to start the update. This only takes a few seconds after which dSpec will restart with the new firmware. Navigate to the firmware page and check that the new version was successfully installed.

Calibration Page

The Calibration page is for calibrating the VPO inputs to compensate for small voltage offsets due to differences in the electronic componentry. Calibration is performed during production and although it is unlikely it will be needed again this page gives the option to recalibrate. All patch cables should be removed before attempting calibration.



Reset Page

The Reset page is used to restore all settings to their original factory values. This includes clearing all user scales. This operation can not be undone.

