USER MANUAL

_CS-80 V

ARTURIA

_The sound explorers

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Thank you for purchasing CS-80 V4!

This manual covers the features and operation of Arturia's **CS-80 V4**, one of our many powerful virtual instruments.

Be sure to register your software as soon as possible! When you purchased CS-80 V4, you were sent a serial number and an unlock code by e-mail. These are required during the online registration process.

Special Messages

Specifications Subject to Change:

The information contained in this manual is believed to be correct at the time of printing. However, Arturia reserves the right to change or modify any of the specifications without notice or obligation to update the hardware that has been purchased.

IMPORTANT:

The software, when used in combination with an amplifier, headphones or speakers, may be able to produce sound levels that could cause permanent hearing loss. DO NOT operate for long periods of time at a high level or at a level that is uncomfortable.

If you encounter any hearing loss or ringing in the ears, you should consult an audiologist.

Introduction

Congratulations on your purchase of Arturia's CS-80 V4!

We'd like to thank you for purchasing CS-80 V4, a virtual instrument recreation of the Yamaha CS-80 analog synthesizer: a groundbreaking keyboard that introduced the world to incredible new sonic horizons, with a massive sound that no synth – well, no *hardware* synth – has ever managed to mimic.

We've carefully studied and modeled every nuance of the original CS-80 to fully recreate the rich sound of this legendary keyboard. We then took things one step further, by adding expanded features for the modern studio, as well as entirely new sound programming options that take the CS-80 experience to a new level.

As with all of our products, we believe in offering the best of both worlds in a single package and letting you choose how you want to use it. You can choose to focus on the Main Panel and get a (slightly improved) vintage CS-80 experience, or pop open the Advanced Panel and discover a universe of sounds that the original CS-80 designers could only dream of.

Here's to a beautiful blend of the old and the new – and the beautiful music you'll make with it!

Peace, love, and music,

The Arturia team

Be sure to visit the www.arturia.com website for information about all of our other great hardware and software instruments. They have become indispensable, inspiring tools for musicians around the world.

Table Of Contents

1. INTRODUCTION

Arturia would like to thank you for purchasing our modeling synthesizer, CS-80 V4. We're confident that it will become a valuable addition to your music production studio.

If you've purchased our products before, you know we take great pride in recreating the sound and feel of the original instruments – and then we add 21st Century features these products might have had, if only the technology had been available at the time. And if this is the first of our products you have owned, well, you're in for a treat!

The Yamaha® CS-80, the synthesizer upon which this model is based was the absolute pinnacle of analog synthesizer technology at the time, light-years ahead of the competition. There's never been anything like it, before or since, and it's a legend among legends, with working units commanding astronomical prices today. Here's some history to explain how this legend came to be.

1.1. The CS-80: its birth and its parent

Yamaha, Japan's oldest musical instrument manufacturer, was born at the end of the 19th century in Hamamatsu, Japan.

The first Yamaha electronic instrument, the Electone D-1 electronic organ, was designed and built in 1959. But the history of the CS-80 began in 1974, when Yamaha released the GX-1.

The GX-1

Like the many flagship Electone organs that came before and after it, the GX-1 was a testbed for new technologies under development. However, the GX-1 was far more than an organ: it was an analog polyphonic synthesizer that was unlike anything that came before it, and (almost) anything that came after it.

Everything about the GX-1 was larger than life. It was a triple-manual monster that weighed almost a half ton, when you included its seat, stand, bass pedals, and the gigantic speaker towers that were purpose-built to go with it. It was 18-voice polyphonic, and its small Solo manual was sensitive to velocity, aftertouch, and side-to-side motion for vibrato. It was famously delicate and difficult to move safely despite its bulk, and cost $60,000 (in 1974 dollars – enough to buy a small house at the time).

No one knows precisely how many were made, but units were quickly purchased by the likes of Keith Emerson, Rick Wright of Pink Floyd, Benny Andersson of ABBA, John Paul Jones of Led Zeppelin, Jurgen Fritz of Triumvirat, and Stevie Wonder, who bought two of them and called the GX-1 his "Dream Machine".

Yamaha refined the technology in the GX-1 to create three (somewhat) more affordable versions, which were released in 1976. The CS-50 and CS-60 were impressive on their own, but the CS-80 offered far more than they did in terms of sound and playability.

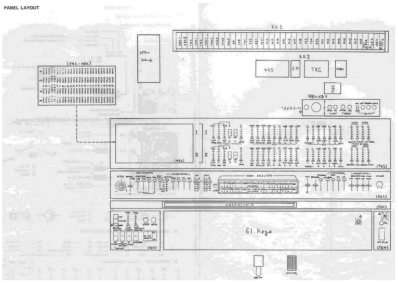
It was far cheaper than the GX-1, but its $6,900 price tag put it out of the reach of most musicians, and its 83 kg weight made it hard to set up and hard to transport, a problem complicated by the fact that if it was tilted too far or turned on its back or side, it would go out of tune. But even with all of those issues, the CS-80 was considered by many to be Japan's first truly great synthesizer. It immediately became famous, and its fame only grew over the years.

The CS-80

The CS-80 was made popular in the late 1970s and early 1980s by a number of A-list pop groups and master keyboardists. Famous artists and bands included Electric Light Orchestra, Paul McCartney & Wings, Toto, and Bon Jovi. Eddie Jobson played for UK and Jethro Tull with the CS-80 as his only keyboard other than a piano and Minimoog. Jean-Michel Jarre used one heavily, as did Geoffrey Downes of Asia, Jon Tout of Renaissance, and of course Stevie Wonder. But ultimately, the musician most responsible for its iconic status all over the world was Vangelis, whose early albums were rich with CS-80 sounds. He bought several of them, and made the CS-80 the center of his studio... and the sound of the legendary film Blade Runner among other soundtracks.

With two analog oscillators per voice, the CS-80 has the potential for incredible sounds. Independent highpass and lowpass resonant filters, a powerful yet musical ring modulator, and plenty of modulation controls further enhance its sonic potential. There are 22 preset sounds, selected from bright colored buttons above the keyboard, with pairs of them (called Lines) mixable to form layered timbres. A three-octave ribbon controller runs along the top of the weighted 61-note keyboard, which is sensitive to velocity and *polyphonic* aftertouch – the first of its kind and the last for years afterward.

The first edition of the service manual has a lot of hand-drawn pages, including the main panel layout.



The CS-80 Service Manual

In the legendary reference book, The A-Z of Analogue Synthesizers (Susurreal, 1996), Peter Forrest says of the CS-80:

"When it comes to trying to decide which of the top-flight synths is the best ever, it's not easy. From almost any practical viewpoint, and in terms of versatility of sound, there are a lot of instruments which wipe the floor with the CS-80. But if you are looking at richness of sound coupled with performance power, and sheer overkill, maybe nothing can touch it."

In a more modern reference, SYNTH GEMS 1 (Bjooks, 2021), Mike Metlay writes:

"The keyboard not only has Initial Touch (velocity) but polyphonic After Touch, with one sensor under each key so subtle changes in pressure can emphasize different notes in a chord. This level of hands-on synth control was unheard of at the time, and is what makes the CS-80 such a welcoming synth to play. Combined with all this, there is the sound itself, which is stunningly rich and deep, capable of everything from chiming highs to thundering lows, the keyboard and other controls rendering each note exquisitely expressive."

CS-80 V4 provides all the features of the original CS-80, and adds many new features to bring this iconic synthesizer into the 21st Century. We hope you'll enjoy it as much as some of the world's greatest musicians enjoyed the original.

1.2. Why a virtual CS-80?

Only 3,000 CS-80s were manufactured. Even though few have had the opportunity to play one, much less own one, it remains a favorite among musicians and amateurs alike. Some famous artists have gone as far as buying several, so as to have a permanent stock of spare parts, and there are repair technicians around the world whose overall expertise is judged by how well they can repair and tune a CS-80.

Why was it such a success? With two independent Lines of synthesis, the CS-80 offers an original sound structure that's simple yet rich. Its ergonomics offered an approach that inspired musicians: moving a knob or touching one of its unique lever controls a tiny bit can be enough to radically transform a sound.

Many musicians have lamented the fact that nobody's building the CS-80 anymore, and argue over whether any of the attempts to recreate its sound are any good. But even if it could be precisely reproduced – in hardware *or* software – how would it fare in a modern studio?

Arturia has remained faithful to the CS-80's sound and functionality, but has then taken its capabilities far beyond anything its creators could have imagined, giving it a new lease on life in the world of plug-ins and DAWs.

Multi mode, the ability to assign a different sound to each of the polyphonic voices, an onboard effects chain to supplement the original's built-in effects, independent keyboard management, positioning in stereo space and controllable detuning and circuit characteristics – all lead to a new presentation of this unique keyboard's presence and sonority. This is our vision for CS-80 V4: respecting the past while looking toward the possibilities of the present... and the future.

1.3. Arturia's secret ingredient: TAE®

TAE® (True Analog Emulation) is Arturia's outstanding technology dedicated to the digital reproduction of the analog circuits used in vintage synthesizers.

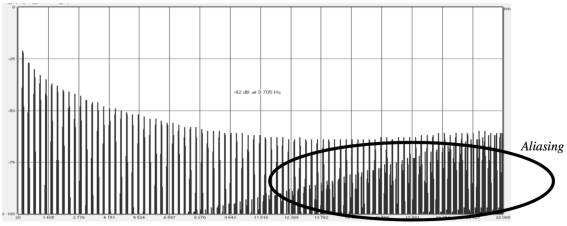
TAE®'s software algorithms result in spot-on emulation of analog hardware. This is why CS-80 V4 offers an unparalleled quality of sound, as do all of Arturia's virtual synthesizers.

TAE® combines three major advances in the domain of synthesis:

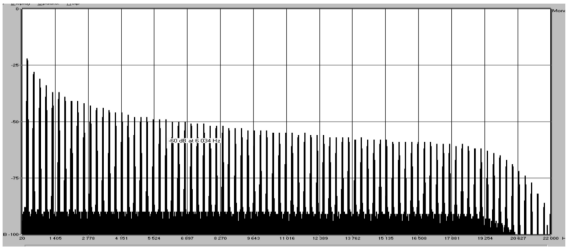
1.3.1. Aliasing-free oscillators

Standard digital synthesizers produce aliasing in high frequencies, especially when using Pulse Width Modulation (PWM) or Frequency Modulation (FM).

TAE® enables the generation of oscillators which are completely free of aliasing in all contexts (PWM, FM...), and at no extra CPU cost.



Linear frequency spectrum of a current well-known software synthesizer

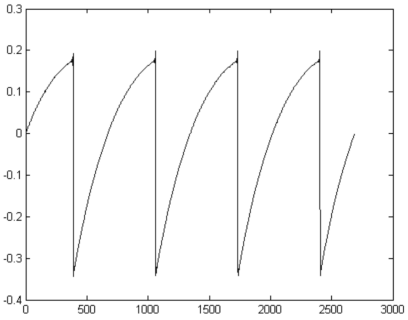


Linear frequency spectrum of an oscillator modeled with TAE®

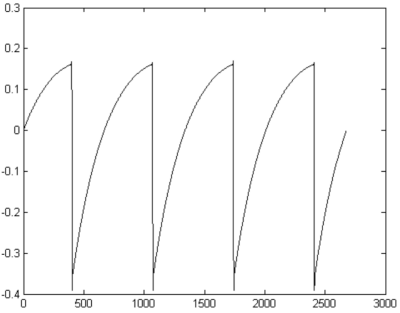
1.3.2. A better reproduction of analog oscillator waveforms

The waveforms produced by the oscillators in analog synthesizers are affected by the presence of a capacitor in the circuits. The discharge of a capacitor results in a slight 'bend' in the original waveform (most notably for sawtooth, triangular and square waveforms). TAE® reproduces the result of this capacitor discharge in software.

Below is the analysis of a waveform from one of the five original instruments Arturia's software emulates, followed by one made by TAE®. They are both equally deformed by the low-pass and high-pass filtering.



Temporal representation of the slightly distorted sawtooth waveform of a hardware synthesizer



Temporal representation of that same synthesizer's sawtooth waveform as reproduced by TAE®

What's more, hardware analog oscillators were and are unstable: in fact, their waveforms vary slightly from one period to the next. If we add to this the fact that the starting point for each period (in Trigger mode) can vary with the temperature and other environmental conditions, we see why vintage synthesizers have such a unique character.

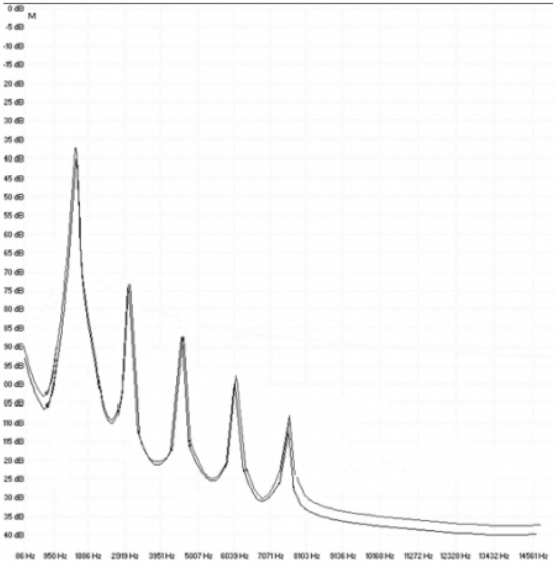
TAE® reproduces the instability of oscillators, resulting in a fatter, richer, and overall "bigger" sound.

1.3.3. Direct Filter Circuit Modeling

Due to advances in computer processing power, TAE® can now employ direct filter modeling techniques to achieve unprecedented accuracy in the emulation of a hardware synthesizer's filter. By modeling the operation of the individual hardware components of the filter circuit, the warm nuances synonymous with analog sounds are recreated.

The following graph shows a single example of direct circuit modeling in action. The peaks represent the generation of harmonics at multiples of the resonant frequency when a particular filter is in self-oscillation mode. These harmonics are characteristic of hardware synthesizer filters; they come from the non-linear behavior inherent to their analog circuitry. Anomalies such as these add to the richness and warmth of the sound produced by the filter.

Notice there are two lines on the graph. Those are the superimposed frequency domain plots for one of Arturia's virtual instrument filters, and of the hardware filter it's emulating. They are practically indistinguishable, both on the graph and to the human ear. The direct recreation of this analog circuitry causes the same characteristics of the sound to be present, thus giving the user a truly analog sound.



So here's the bottom line: when you bring together a bunch of music lovers who also have a deep understanding of the characteristics of electronic circuits, you wind up with Arturia. And when Arturia decides to honor the colorful history and stunning sound of one of the most famous synthesizers ever, you wind up with CS-80 V4.

We take great satisfaction in knowing this great synthesizer will help you explore previously unknown musical territory, and we can't wait to hear what you do with it!

2. ACTIVATION AND FIRST START

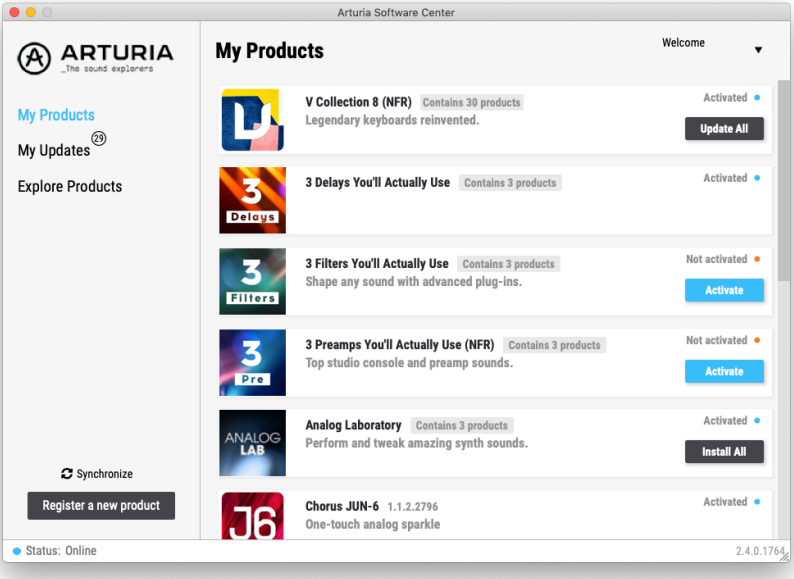
2.1. Register, Activate, and Install CS-80 V4

CS-80 V4 works on computers equipped with Windows 8.1 or later and macOS 10.13 or later. You can use it as a standalone version or as a plug-in for your favorite DAW, in Audio Units, AAX, VST2, or VST3 format.

Before you install or register the software, you'll need to create a My Arturia account here, using an email address and password of your choice: https://www.arturia.com/createanaccount/

While it's possible to handle registration, activation, and other tasks manually online, it's far simpler to download and use the Arturia Software Center app, which can be found here: https://www.arturia.com/support/downloads&manuals

You'll enter your email address and password to set up Arturia Software Center, which acts as a central location for all of your Arturia software registrations and activations. It also helps you install and update your software by keeping tabs on current versions.



Arturia Software Center

You can register, activate, and install your product inside Arturia Software Center by pressing the **Register a new product** button, and clicking the boxes to **Activate** and then **Install** your software. The registration process will require you to enter the serial number and the unlock code you received when you bought your software.

You can also do this online by logging into your account and then following the instructions here: http://www.arturia.com/register

Once you've registered, activated, and installed CS-80 V4, it's time to get it to talk to your computer.

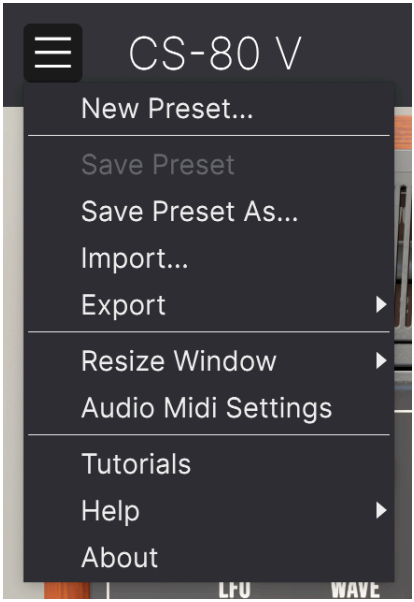
2.2. Initial setup for standalone use

If you would like to use CS-80 V4 in standalone mode, you will need to ensure that MIDI input and audio output are being routed properly to and from the software. You'll generally only need to do this once, unless you change your MIDI controller or audio/MIDI interface. The setup process is the same on both Windows and macOS.

> ! This section only applies to readers that plan to use CS-80 V4 in standalone mode. If you are only going to use CS-80 V4 as a plug-in inside a host DAW or other music software, you can safely ignore this section – your host music software handles these settings.

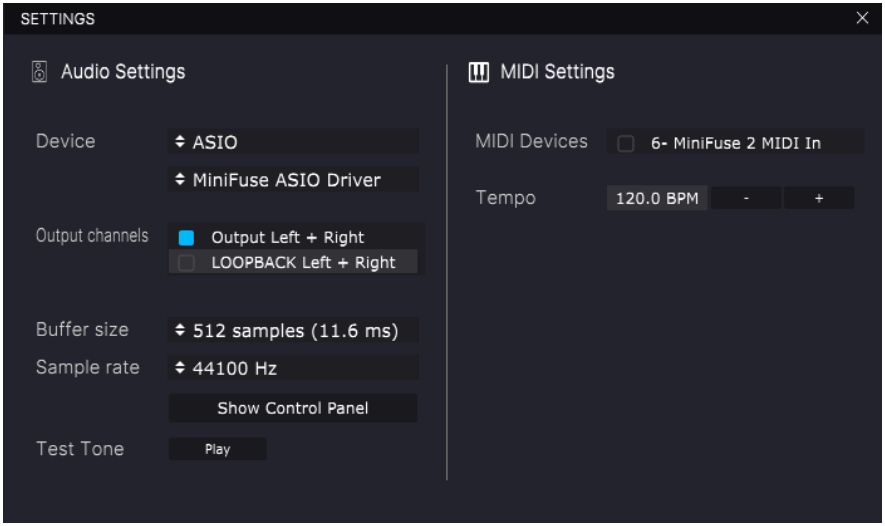
2.2.1. Audio and MIDI settings: Windows

At the top left of the CS-80 V4 application is a pull-down menu. It contains various setup options.



CS-80 V4 Main Menu

Click on **Audio Midi Settings** to open the following window. This works in the same way on both Windows and macOS, although the names of the devices available to you will depend on the hardware you are using. Remember, this option is only available (and needed) in the standalone version of CS-80 V4.



Audio and MIDI Settings for Windows

Starting from the top, you have the following options:

- **Device** selects which audio driver and device will handle playback of CS-80 V4. This can be your computer's internal driver, a generic ASIO driver, or an external soundcard or interface driver. The name of your hardware interface may appear in the field below, depending on your selection.
- **Output Channels** lets you select which of the available outputs will be used to route audio out. If you only have two outputs, this selection box will not be shown. If you have more than two, you can select a specific pair of outputs.
- The **Buffer Size** menu lets you select the size of the audio buffer your computer uses to calculate sound. The latency in milliseconds is displayed after the buffer size setting.

! A smaller buffer means lower latency, i.e. a shorter delay between pressing a key and hearing the note, but loads your CPU more heavily and can cause pops or clicks. A larger buffer means a lower CPU load, as the computer has more time to think, but can result in a noticeable delay between playing a note and hearing it. A fast, modern computer should easily be able to operate at a buffer size of 256 or even 128 samples without clicks, but if you do get clicks, enlarge the buffer size until they stop.

- The **Sample Rate** menu lets you set the sample rate at which audio is sent out of the instrument.

! The options here will depend on what your audio device can support; nearly every device can operate at 44.1kHz or 48kHz, which will be perfectly fine for most applications. If you have a specific need to use a higher sample rate, up to 96kHz, CS-80 V4 will happily support that.

- The **Show Control Panel** button will jump to the system control panel for whatever audio device is selected.

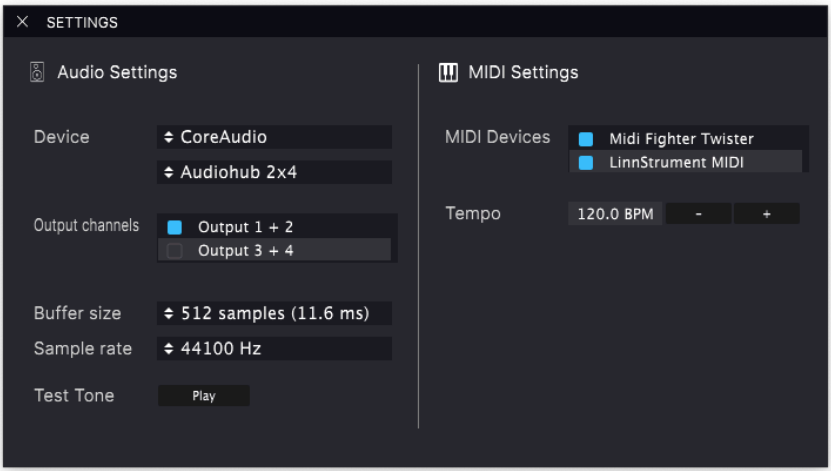
! Note that this button is only available in the Windows version.

- **Test Tone** sends a short test tone when you click the **Play** button, to help you troubleshoot audio issues. You can use this feature to confirm that the instrument is routed correctly through your audio interface and that audio is playing back where you expect to hear it (your speakers or headphones, for example).
- The **MIDI Devices** area will display any MIDI devices you have connected to your computer (if any). Click the check box to accept MIDI from the device(s) you want to use to control the instrument; you can select multiple MIDI devices at once with the checkboxes.

! In standalone mode, CS-80 V4 listens for all MIDI channels, so there's no need to specify a channel.

- **Tempo** sets a base tempo for features inside CS-80 V4 such as LFO and effects sync. When using CS-80 V4 as a plug-in, the instrument gets tempo information from your host software.

2.2.2. Audio and MIDI settings: macOS



Audio MIDI Settings for macOS

The menu for setting up audio and MIDI devices for macOS is accessed in the same way as for Windows, and the setup process is nearly identical. All options work the same way as described above in the Windows section; the only difference is that all macOS devices, including external audio interfaces, use the CoreAudio driver built into macOS to handle routing. In the second dropdown menu under **Device**, choose the audio device you wish to use.

2.2.3. Using CS-80 V4 as a plug-in

CS-80 V4's interface looks the same in plug-in mode as in standalone mode.

CS-80 V4 comes in VST2, VST3, Audio Unit (AU), and AAX plug-in formats, for use in all major DAW software such as Ableton Live, Cubase, Logic, Pro Tools, Studio One, and more.

When using CS-80 V4 as a plug-in, all audio and MIDI device settings are handled by your host music software. Please refer to your host music software's documentation if you have any questions about loading or using plug-ins.

Note that when you load CS-80 V4 as a plug-in instrument inside your host software, its interface and settings work the same way as in standalone mode (see below), with a few small differences:

- CS-80 V4 will synchronize to your DAW's host tempo/BPM when sync is desired
- You can automate numerous parameters using your DAW's automation system
- You can use more than one instance of CS-80 V4 in a DAW project (standalone mode can only launch one instance)
- You can run the outputs of CS-80 V4 through any additional audio effects available to your DAW, such as delay, chorus, filters, etc.
- You can route CS-80 V4's audio outputs creatively inside your DAW, using the DAW's own audio routing system.

2.3. Playing CS-80 V4 for the First Time

Now that you have CS-80 V4 up and running, let's take it for a quick test drive!

If you haven't done so already, launch CS-80 V4 as a plug-in or as a standalone instrument. If you have a MIDI controller set up, use it to play some notes on CS-80 V4. If not, you can play from your computer's keyboard. You can also use your mouse to play the on-screen keyboard.

The up and down arrows at the top of the instrument let you step through all of CS-80 V4's available presets. Try playing a few, and when you find one that you like, try adjusting some of the other on-screen controls to see how they affect the sound.

Play with the controls, and don't worry – nothing is saved unless you specifically save a preset (described later in this User Guide), so there is no chance of messing up any of CS-80 V4's factory presets.

We hope this chapter has gotten you off to a smooth start. Now that you're up and running, the rest of this guide will help you work your way through all of CS-80 V4's features on a section-by-section basis. By the time you reach the end, we hope you'll understand all of CS-80 V4's capabilities – and will be using this fantastic instrument to create equally fantastic music!

3. THE USER INTERFACE

In this chapter, we'll walk you through the features of CS-80 V, how to find them and how to use them. As with every Arturia product, we have gone to great lengths to make the use of this software instrument as simple and as much fun as possible, while also striving to make sure you never run out of new things to do with it as your knowledge expands. After reading this chapter, you should be ready to dive into CS-80 V as deep as you like.

Before we do anything else, let's take a look at the whole picture: a bird's eye view of the CS-80 V interface.

3.1. Overview

The full interface of CS-80 V. Don't worry, we'll teach you what all the sliders and buttons do.

The CS-80 V interface is dominated by the virtual instrument itself, but we also need to learn about the functions surrounding it:

1. **The Upper Toolbar [p.18]:** This is where you access global settings, work with presets, access the Advanced features of CS-80 V, and open the Side Panel (see below).

2. **The Main Panel [p.52]:** Here is where you will likely spend most of your time when playing with CS-80 V. It contains a detailed reproduction of the original CS-80 front panel, with all of the original hardware's controls (plus a few extras). We will go over this panel in the Main Panel [p.52] section of this guide. Clicking on the lid reveals many more features that we'll cover in the Advanced Panel [p.72] section later on.

The **virtual keyboard** in the Main Panel lets you play a sound without an external MIDI device. Just click on a virtual key to hear the corresponding note, or drag the cursor across the keys to hear a glissando.

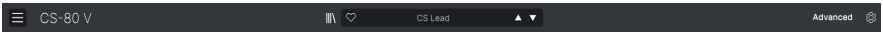
The virtual keyboard also displays notes played on an external controller, like the two C Minor chords shown here.

> ♪ Your computer's keyboard can also play CS-80 V. The top row of letters acts as the black keys on a piano keyboard, the next row of letters acts as the white keys, and the first two keys on the bottom row act as octave shift keys, down/up. Depending on your language, the actual keys may be different – for example, on an English QWERTY keyboard, the octave down key is Z, but on a French AZERTY keyboard it's W.

3. **The Lower Toolbar [p.24]:** This section provides quick access to several useful functions and information displays, including Polyphony settings, Undo/Redo functions and history dropdown, CPU usage (with a hidden Panic button), and Macro controls.

4. **The Side Panel [p.25]** is normally hidden, and pops out to the right of the main window when the **gear icon** in the Upper Toolbar is clicked. It contains four tabs to access low-level settings, MIDI control assignments, the four Macro controllers, and a set of tutorials.

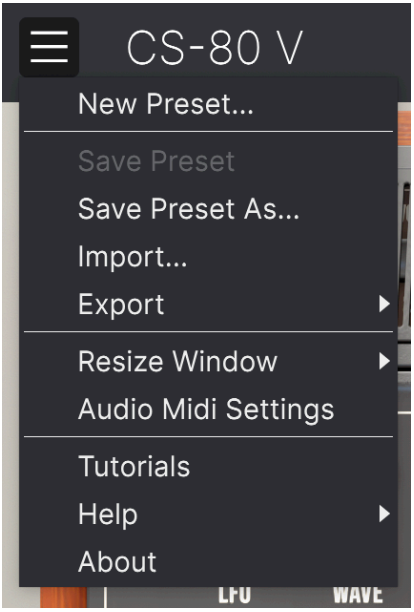
3.2. The Upper Toolbar



The Upper Toolbar

3.2.1. The CS-80 V menu

In the top left corner of the window, the icon of three horizontal lines labeled CS-80 V leads to a drop-down menu for important global operations.



The CS-80 V menu and its various functions (see below)

3.2.1.1. New Preset...

The first option sets CS-80 V to a basic Default preset, a "blank slate" from which you can create your own sound. Note that if you haven't saved the previous preset first, any edits you have made to that preset will be lost.

> If you forgot to save the preset you were working on before starting a new preset, you can use the undo/redo menu to reload the first preset's previous state. The latter is only lost if you load a new preset, quit, and relaunch the plugin.

3.2.1.2. Save Preset

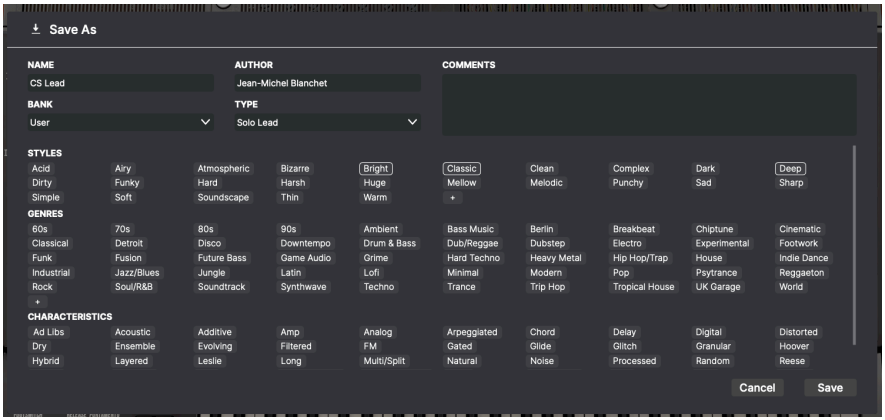
The next option lets you save a preset. If you select this option, you are presented with a window where you can enter information about the preset. In addition to naming it, you can enter the author name, select a bank where it will be stored, give it a general preset type, and select one or more tags that describe the sound.

> Note that tags are read and filtered by the Preset Browser, so a wide selection of tags is vital for effective searches later. You can click as many tags as you want, and when in doubt, click more rather than less. If you skimp on tags, your patch might never come up in a search!

You can also enter your own notes in the Comments field, which is handy for more detailed descriptions or performance notes.

3.2.1.3. Save Preset As…

This works in the same way as the Save command, but lets you save a copy of the preset instead of saving over the original. It's useful for creating variations on patches while keeping individual copies of each one.



The Save Preset As... popup window. Remember, the more tags the better!

3.2.1.4. Import...

This command lets you import a preset file, which can be either a single preset or an entire bank of presets. Both types are stored in the .cs4x format.

After selecting this option, the default path to these files will appear in the window, but you can navigate to another folder if needed.

3.2.1.5. Export

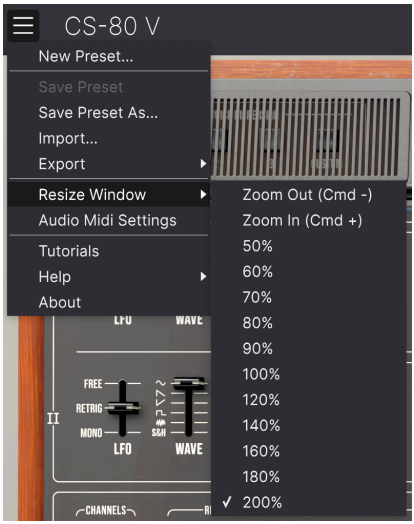
You can export and share a single preset, or an entire preset bank, using this command.

The Export pop-up

- **Export Preset**: Exporting a single preset is handy when you want to share a preset with someone else. The default path to these files will appear in the "export" window, but you can create a folder at another location if you like.
- **Export Bank**: This option can be used to export an entire bank of sounds from the instrument, which is useful for backing up or sharing presets.

3.2.1.6. Resize Window

The CS-80 V window can be resized from 50% to 200% of its default size without any visual artifacts. On a smaller screen, such as a laptop's, you might want to reduce the interface size so it doesn't dominate the display, although some smaller controls might be harder to see and click/drag. On a larger screen or a second monitor, you can increase the size to get a better view of the controls. The controls will work the same at any zoom level.



With the keyboard shortcuts shown, you can resize on the fly for various tasks.

> While working with CS-80 V, you can also use keyboard shortcuts to quickly adjust the window size. **Ctrl** + and **Ctrl** - (Windows) and **Cmd** + and **Cmd** - (macOS) change the size by one step larger or smaller. Note that in some DAWs, the same key commands may be used for zoom. In this case, the DAW takes priority.

3.2.1.7. Audio Midi Settings

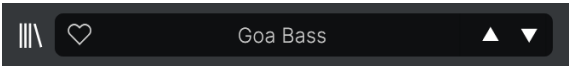
This is where you manage the way the instrument transmits sound and receives MIDI. This menu item only appears in the standalone version, as the plug-in's audio and MIDI settings are handled by its host application. Full details on how to do this, for Windows and macOS, are found here [p.11].

3.2.1.8. Tutorials / Help / About

The Tutorials control opens the Side Panel [p.25] and displays a set of tutorials to help you learn how to use CS-80 V. The Help button lets you open this User Manual or access Arturia's online FAQ. And if you're curious about who's responsible for this beautiful instrument, click the **About** button. (It will also show you the software version you're currently running.)

3.2.2. Preset Browser

CS-80 V comes packed with lots of useful factory presets, and of course you'll create many more of your own. To help you search through this large preset library, the Preset Browser [p.36] is designed to help you catalog, filter, and search for the perfect preset in just a few clicks. There's a whole chapter on it later on, so for now, we'll focus on the set of functions that you can access directly from the Upper Toolbar.



Basic controls for the Preset Browser, as they appear on the Upper Toolbar

This part of the Upper Toolbar (shown above) includes:

1. The **Preset Browser Button** (the icon of four lines that looks like books on a shelf) opens and closes the Preset Browser. This is covered in detail in the next chapter, The Preset Browser [p.36].

2. The **Like** button has a heart icon; just click it to instantly mark the current preset as a Liked Preset for easy access later.

3. The **Preset Name** is listed next in the toolbar. Clicking on the name opens the Preset Filter. If an asterisk* appears next to the Preset Name, it means that the settings of CS-80 V have been changed so the sound no longer matches the saved preset. It's a reminder to save the edited version if you like it, overwriting the original (**Save**) or with a new name (**Save As...**).

4. The **Preset Filter** (set to "All Types" in the image above) helps you narrow down your preset search quickly – for example, looking only for presets tagged with *Keys*, *Lead*, or *Pad* . To use this feature, click the Preset Name to open a drop-down menu of various Types (Keys, Lead, Pad, etc.). Hold your mouse over any Type to pop up an alphabetical list of presets; click the one you want or mouse away to close the pop-up. Selecting a preset will load it, and set the Preset filter to focus on sounds of that Type. You can now use the Arrow Icons to step through the filtered options. To reset the filter and show you all available patches, open the menu and select any preset from the *All Types* pop-up list.

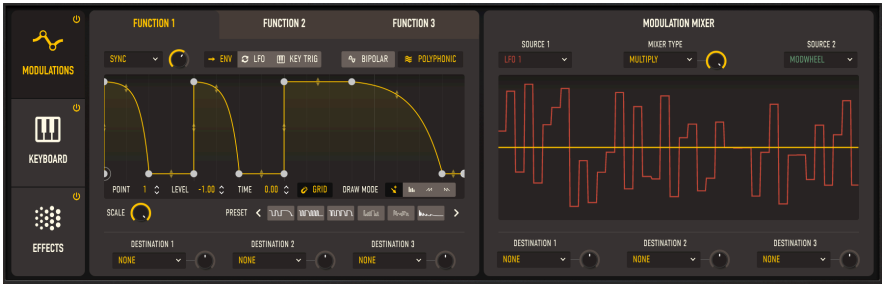
5. The **Arrow Icons** select the previous or next preset in the filtered list. This is the same as clicking on the Preset Name and selecting the next option in the list, but does it with only one click.

The Previous and Next arrows can be MIDI mapped. This means you can use buttons on your MIDI Controller to easily step through the available presets without having to use the mouse at all.

3.2.3. Advanced Panel Access

CS-80 V goes well beyond the capabilities of the original hardware, adding new functions like a modulation mixer, keyboard response adjustments, and a powerful effects chain. Since the front panel of the original CS-80 doesn't have room for all these extra controls, they've been hidden away in a pop-up window that you can hide when it's not needed.

Just press the **Advanced** button in the Upper Toolbar to access these functions. This section is covered in detail later in this manual, in the Advanced Panel [p.72] chapter.



The Advanced Panel, which we'll cover in Chapter 6

3.2.4. Side Panel Settings

At the far right of the Toolbar next to the **Advanced** button is the **Side Panel Button (gear icon)**, a gear-shaped icon that opens and closes the panel on the right side, containing four tabs:

• **Settings**: Global settings such as MIDI receive channels, Envelope mode, Noise mode, and MPE settings.

• **MIDI**: MIDI Learn functions for use with external controllers.

• **Macro**: Assignments for four Macros that control multiple parameters with a single knob twist.

• **Tutorials**: In-app interactive tutorials, also accessible from the main menu.

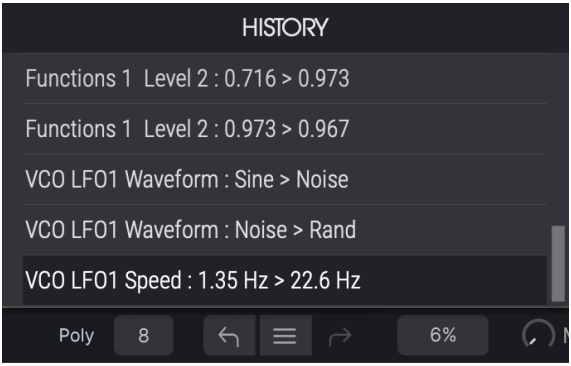
These topics are covered in the Side Panel [p.25] section later in this chapter.

3.3. The Lower Toolbar

The Lower Toolbar runs along the bottom of the CS-80 V user interface and provides quick access to several important parameters and useful bits of information.

The Lower Toolbar, showing a tool tip for a parameter under the cursor

- **1. Parameter Name:** Displays the name of the parameter being edited as you adjust or hover over controls. The current value of the control is listed in a pop-up tool tip that appears next to the control.
- **2. Poly:** Determines the polyphony. The original CS-80 was an 8-voice instrument; here, you can set the software to generate fewer notes, including only one (with **Mono** and **Mono Legato** options). More polyphony allows more notes to play without cutting each other off; less polyphony minimizes the risk of CPU overloads that can lead to stuttering and dropouts. You can find the setting that works best for you; if you have a relatively new computer, don't be surprised if CS-80 V handles all 8 notes smoothly!
- **3. Undo/Redo:** Keeps track of your edits and changes.
    - **Undo (left arrow):** Undoes the last edit.
    - **Redo (right arrow):** Redoes the last edit.
    - **Undo History (center menu icon):** Displays a pop-up list of recent changes. Click on a change to restore the patch to that state. This will be useful in the event that you've pushed your sound design one or two steps too far, and want to revert to an earlier version.



The Undo History pop-up, with the CPU meter next to it

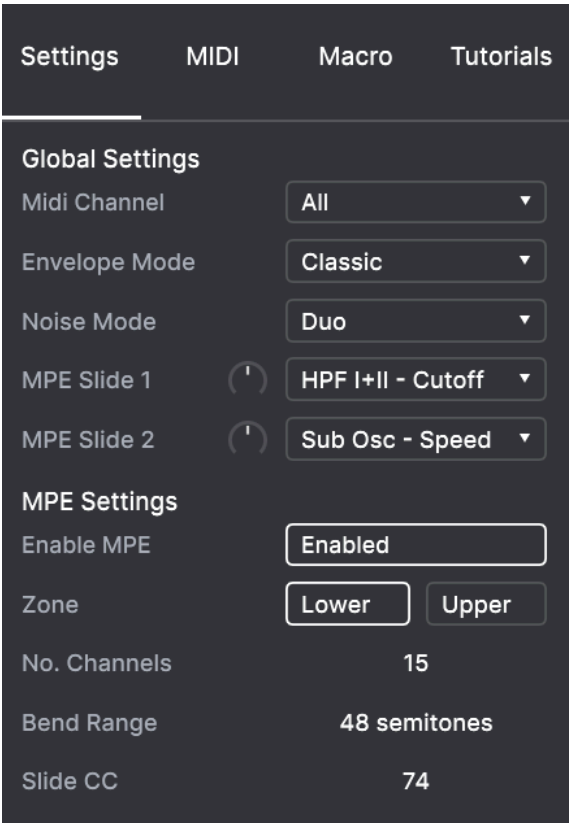
- **4. CPU Meter and Panic Button:** Displays the current CPU usage of the instrument. Clicking on the CPU meter window will send a **Panic** message, silencing all currently playing notes and all sounds, and resetting MIDI Control Change values in the event of stuck notes or other issues.
- **5. Macro Knobs:** These four knobs control multiple parameters with a single turn. Assigning parameters to them is covered in the Macros section of the Side Panel.

3.4. The Side Panel

The **gear icon** at the top right of the Upper Toolbar opens the Side Panel, which in turn contains four tabs covering important subsystems that you won't have to access quickly when you're playing or editing sounds on CS-80 V. Let's look at them from left to right.

3.4.1. Settings Tab

This tab covers settings to control how a Preset responds to incoming MIDI, along with other options specific to CS-80 V4.



The Side Panel's Settings tab

- **MIDI Channels:** Selects the MIDI channel(s) on which CS-80 V will receive MIDI input. You can select a particular channel, or choose "All" for Omni Mode.

- **Envelope Mode:** Selects either Classic or Long envelope times. The original CS-80's envelopes had a fairly broad range of available times, but the Long settings greatly increase their range. Just for one example, the decay time for the VCA envelope can go up to 7.35 seconds in Classic, but up to 25.00 seconds in Long. This lets you use CS-80 V for slowly evolving ambient soundscapes that would have been impossible on a vintage CS-80.

- **Noise Mode:** Sets Single or Duo. In single, one Noise oscillator is shared on the two channels. Duo sets one different Noise oscillator per channel, allowing you to use a stereo effect, and to make binaural sounds.

- **MPE Slide 1 and MPE Slide 2:** Using the pop-up menu, you can select which modulation destination(s) will receive MPE 'Slide' messages, and set their positive or negative amounts with the associated dial.

- **MPE Settings** Enables or disables MPE. When enabled, a drop-down menu for basic MPE functions appears. For many players, this raises the question: what exactly *is* MPE?

3.4.1.1. MPE: MIDI Polyphonic Expression

MPE (MIDI Polyphonic Expression) is a relatively new addition to MIDI, which adapts control data for modern controllers that deliver multi-dimensional expression data for each finger. Here are the basics:

A number of new controllers offer five 'dimensions' of touch sensitivity. In addition to the usual *velocity* and *release velocity* per key, there are also *X* (side-to-side movement, sometimes called *Glide*), *Y* (back-and-forth movement, sometimes called *Slide*), and *Z* (pressure, also called *aftertouch*).

The five dimensions of MPE, shown on a conventional piano keyboard

On a fully implemented MPE controller, you can hit a key and release it with variable velocity; move a finger from side to side in order to create pitch bend or vibrato; slide a finger on top of a key away from you or toward you (the key acts like a data slider); or press harder or softer on the key... and you can do this all at the same time, with each key sending information that doesn't depend on what's happening on any other key!

Imagine a whole keyboard where every key is a pressure-sensitive joystick, and you'll start to get the idea.

You don't have to use all of these parameters at once, of course, but the ability to alter one note inside a chord in various ways can bring out amazing expressive possibilities. The CS-80 was one of the first hardware synthesizers to do anything like MPE, so CS-80 V is a natural fit for it.

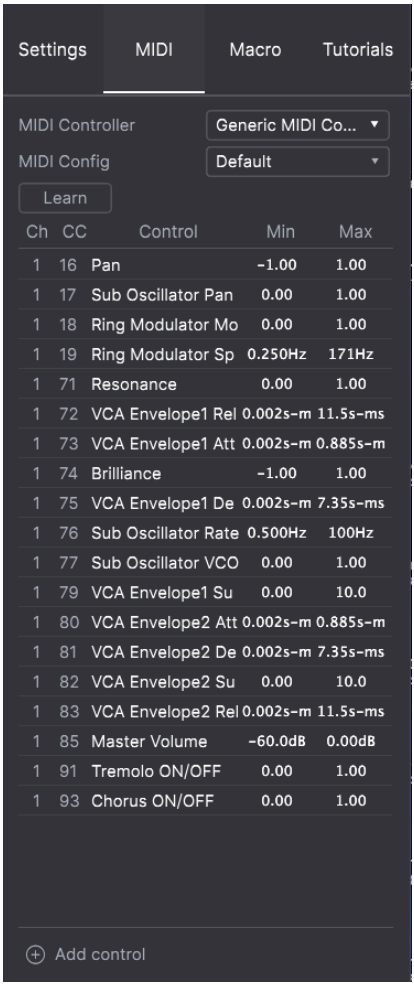
If you obtain an MPE controller, you'll have to research precisely how it sends these different types of data; here, we'll just cover what CS-80 V's particular settings do.

- MPE can be enabled on either the Lower or Upper Zone;
- you can decide how many MIDI Channels it will watch (MPE uses a Master Channel for global MIDI messages, and assigns other channels to each voice as it plays);
- the range of each finger's pitch bend (48 semitones is the default for most controllers);
- and which MIDI Control Change number is sent for Slide (the default is CC 74, filter cutoff frequency). Note that you can select two different MPE Slide destinations and scale each one positively or negatively.

If you have a non-MPE controller, don't worry: you can still get almost all of the nuance of the original CS-80 when you play it – and if your controller sends polyphonic aftertouch, then it's *all* in your hands. Literally.

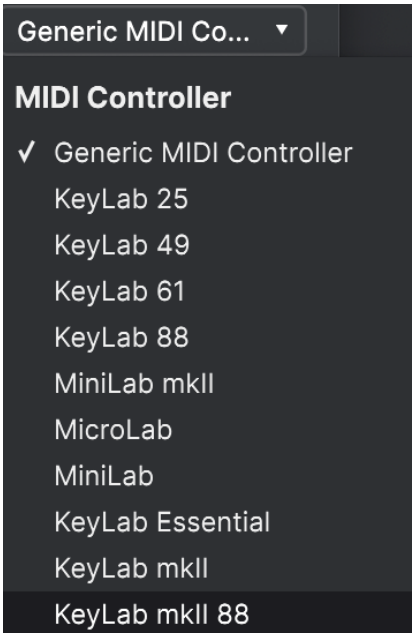
3.4.2. MIDI Tab

This is where CS-80 V may be placed in MIDI Learn mode. In this mode, all MIDI-assignable parameters on the main panel are highlighted and you can map physical controls on your MIDI controller to them. A typical example might be to map a physical knob on the MIDI controller to the Frequency knob of the Filter section.



The Side Panel's MIDI tab

3.4.2.1. MIDI Controller Menu



The MIDI Controller menu

At the top right of the MIDI tab is a drop-down menu where you can select templates for many Arturia MIDI controllers. These map physical controls to many "most wanted" parameters in CS-80 V for a plug-and-play experience. A Generic template is also provided for third-party MIDI controllers.

3.4.2.2. MIDI Config Menu

The MIDI Config menu

Another drop-down lets you manage different sets of MIDI maps for controlling CS-80 V from MIDI hardware. You can Save/Save As the current MIDI assignment setup, Delete it, Import a configuration file, or Export the currently active one.

This is a quick way to set up different hardware MIDI keyboards or controllers with CS-80 V, without having to build all the assignments from scratch each time you swap hardware.

For example, if you have multiple hardware controllers (small live keyboard, large studio keyboard, pad controller, etc.), you can create a profile for each of them, save them, and then quickly load them here. This saves you from having to redo the MIDI mapping assignments from scratch each time you swap hardware.

Two options in this menu are especially powerful:

- **Default:** Gives you a starting point with predetermined controller assignments.
- **Empty:** Removes the assignments of all controls.

3.4.2.3. Assigning and Unassigning Controls

Click the **Learn** button in the MIDI tab to put CS-80 V into Learn mode. Controls available for assignment are purple. Controls that are already assigned are red, but can be reassigned if desired. The screenshot below shows the assigned and unassigned controls for CS-80 V's Default configuration.

When MIDI Learn is active, available parameters are purple and already-assigned parameters are red.

Click any purple control and its name will appear in the list. Now, move a control or operate a switch on your MIDI controller. The corresponding control onscreen will turn red and the assigned MIDI CC number will appear in the list to the left of the parameter name.

To unassign a control onscreen, control-click or right-click it. Alternative methods of assignment are available in the MIDI Parameter Menu [p.32] described below.

3.4.2.4. Min and Max Values

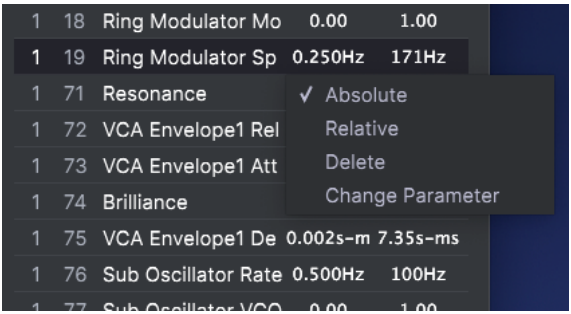
The **Min** and **Max** value columns for each parameter in the list let you scale the amount by which a parameter in CS-80 V changes in response to a physical control movement. For example, you may wish to limit the range of a filter sweep, even though you're probably going to turn the knob all the way during a live performance.

Drag up or down on a value to change it. Values for some parameters are expressed as percentages from 0.00% to 100%, while other parameters have values in appropriate units (dB for levels, ms for times, etc.) Setting the maximum lower than the minimum reverses the polarity of the physical controller; i.e. turning it *up* will turn the assigned parameter *down*.

Switches that only have two positions (On/Off, etc.) would normally be assigned to buttons on your controller, but it's possible to toggle those with a fader or another control if you like.

3.4.2.5. MIDI Parameter Menu

Control-clicking or right-clicking on any item in the list of assigned parameters brings up a convenient menu with the following options, which can be different for each parameter.



Right-clicking a parameter gives you these options

- **Absolute:** The assigned parameter in CS-80 V tracks the literal value your physical controller is sending out.
- **Relative:** The assigned parameter in CS-80 V will go up or down from its current value in response to physical controller movements. This is often useful when using endless 360-degree encoders that don't have physical motion limits.
- **Delete:** Removes the assignment and turns the corresponding onscreen control purple again.
- **Change Parameter:** Brings up a large sub-menu of every assignable parameter in CS-80 V. This lets you change the assignment of the current CC/physical control manually, and is useful when you know exactly the destination you're looking for.

3.4.2.6. Reserved MIDI CC numbers

Certain MIDI Continuous Controller (CC) numbers are reserved and cannot be reassigned to other controls. These are:

- Pitch Bend
- Aftertouch (Channel Pressure)
- All Notes Off (CC #123)

All other MIDI CC numbers may be freely assigned to control any parameter in CS-80 V.

3.4.3. Macro Tab

This tab handles assignments for the four Macro knobs on the right side of the Lower Toolbar. You can assign multiple parameters to each one, then use MIDI Learn [p.28] to assign the Macro itself to a physical control if you want.

The Side Panel's Macro Tab

> Macros are saved at the Preset level.

3.4.3.1. Macro Slots

Click one of the Macro knobs to select which Macros you want to work with. The default names are *Macro 1* through *Macro 4*, but you can rename them by double-clicking the name field. The knob above the name corresponds to the knob of the same name in the Lower Toolbar.

3.4.3.2. Making Macros

Click the **Learn** button in the Macro tab and you will see that the process works much like MIDI assignments – available destinations turn purple and ones already assigned turn red. Click on a purple control onscreen and its name will appear on the list.

To remove a parameter from the Macro, right-click its name in the list and select **Delete**. Parameters under Macro control have **Min** and **Max** values and may be scaled by dragging up or down directly on the number, just as is done with MIDI assignments. To reverse the polarity of a parameter (i.e. have it go down when you turn the Macro knob up and vice-versa), set the minimum value higher than the maximum.

> On the CS-80 V4, all the middle-section sliders (shown below) are inverted. You will need to invert the macro curve in order to have the correct amount sent when assigning a macro.

Some example Macro curves

> There are no rules for naming and assigning parameters to Macros. Keep in mind, though, that while it may seem funny to name a Macro "Chartreuse", that might not be terribly useful when you're playing the patch in a recording session next year. When in doubt, go for clarity!

3.4.3.3. Macro Curves

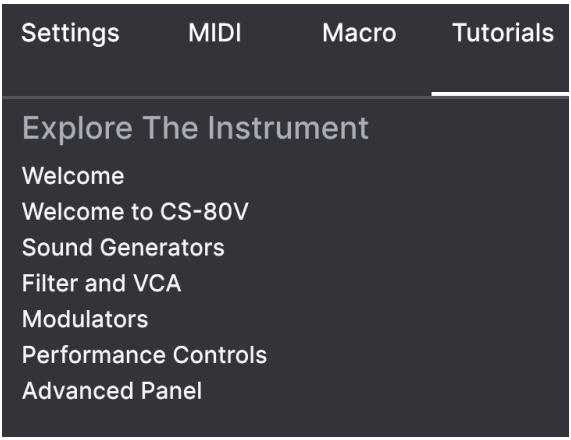
Beyond simple scaling, you can customize a curve that determines how each parameter under the Macro's control proceeds from its minimum to maximum value and back when you turn the Macro knob. Click the **>** icon next to the parameter name to open the curve window.

Some example Macro curves

Click on the curve to add a breakpoint, represented by a small circle. You can then drag the point and the curve segments between it and its nearest neighbors will change accordingly. Right- or control-click on a point to remove it. The first and last breakpoints cannot be removed.

> ♪ A simple diagonal line would produce a linear curve, but the potential fun here is to make things non-linear.

3.4.4. Tutorials



The Side Panel's Tutorials tab

In this tab, which can also be opened by selecting **Tutorials** from the CS-80 V menu, you can click on titles for the individual chapters, which in turn will take you through different areas of CS-80 V in steps. The parts of the panel to focus on are highlighted as you go.

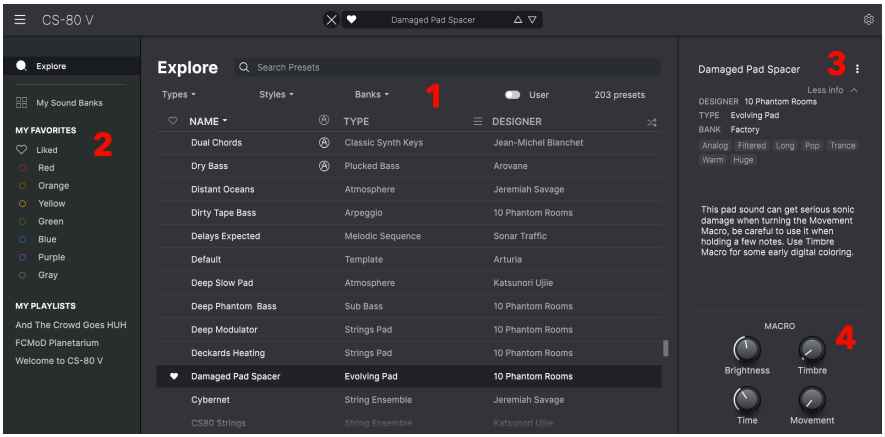
> If you're editing a Preset, make sure to save it before opening the Tutorials, because doing so will load a new Preset and overwrite your changes. The Tutorials also take over the Side Panel space when in use.

4. THE PRESET BROWSER

The Preset Browser is how you search, load, and manage sounds in CS-80 V. It has different views but they all access the same banks of Presets.

To access the search view, click the browser button (the icon looks a bit like books on a library shelf). To close the browser, click the X that appears in its place.

The browser has four main areas:



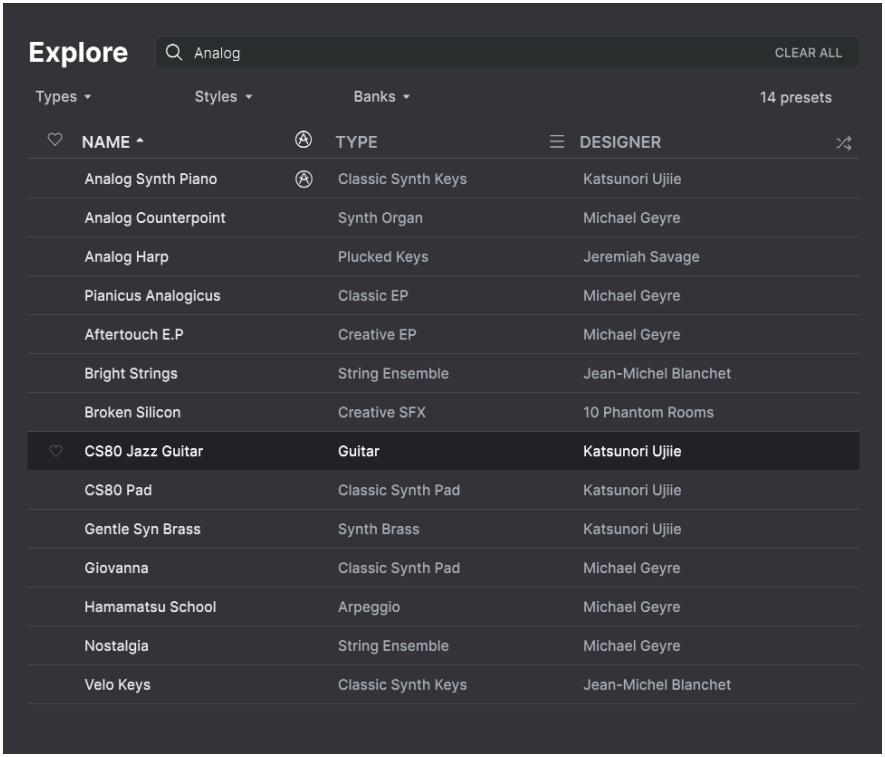
The full Preset Browser window

Number	Area	Description
1.	Search and Results [p.37]	Search Presets with text strings, and by tags for Type and Style.
2.	Sidebar [p.42]	Manage Banks and Playlists.
3.	Preset Info [p.45]	Summary of Bank and Tags, Designer name, and description info for current Preset.
4.	Macro Knobs [p.47]	Large size duplicates of Macro knobs in Lower Toolbar.

4.1. Search and Results

Click on the Search field at the top and enter any search term. The browser will filter your search in two ways: First, by matching letters in the Preset name. Then, if your search term is close to that of a Type or Style [p.38] it will include results fitting those tags as well.

The Results list beneath shows all Presets that fit your search. Click the X icon at right to clear your search terms.



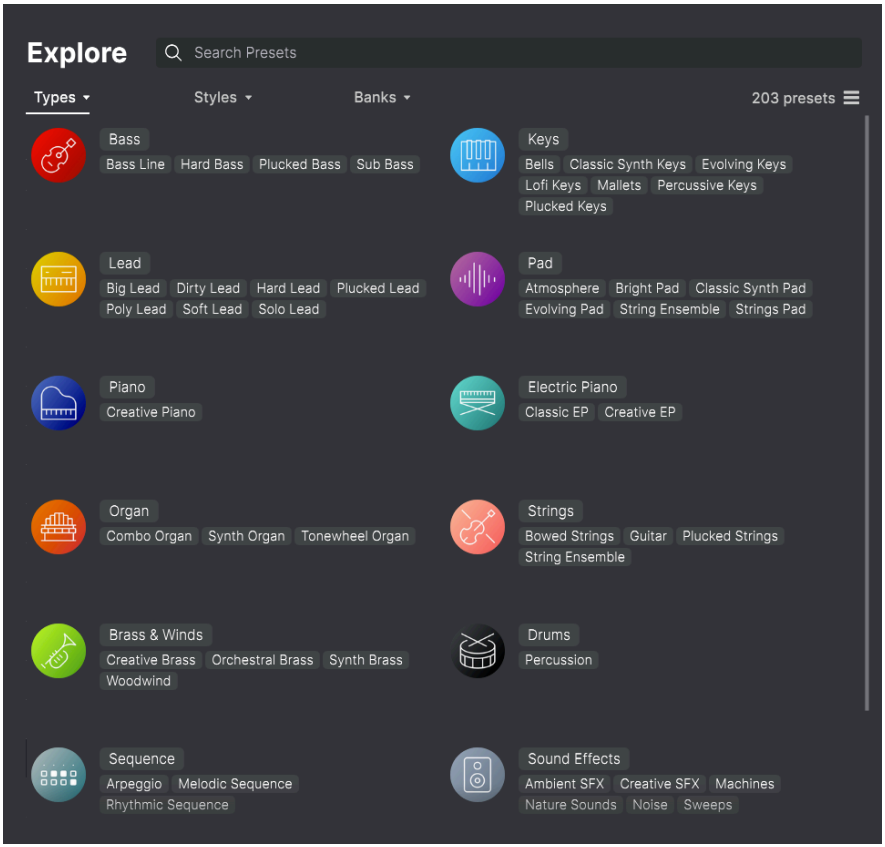
Filter by typing text in the Search field

4.2. Using Tags as a Filter

You can narrow (and sometimes expand) your search using different tags. There are two kinds of tags: *Types* and *Styles*. You can filter by one, the other, or both.

4.2.1. Types

Types are categories of instruments and musical roles: bass, leads, strings, pads, organs, and more. With a clear search bar, click the **Types** button to bring up a list of types. Notice that each type also has several sub-types:



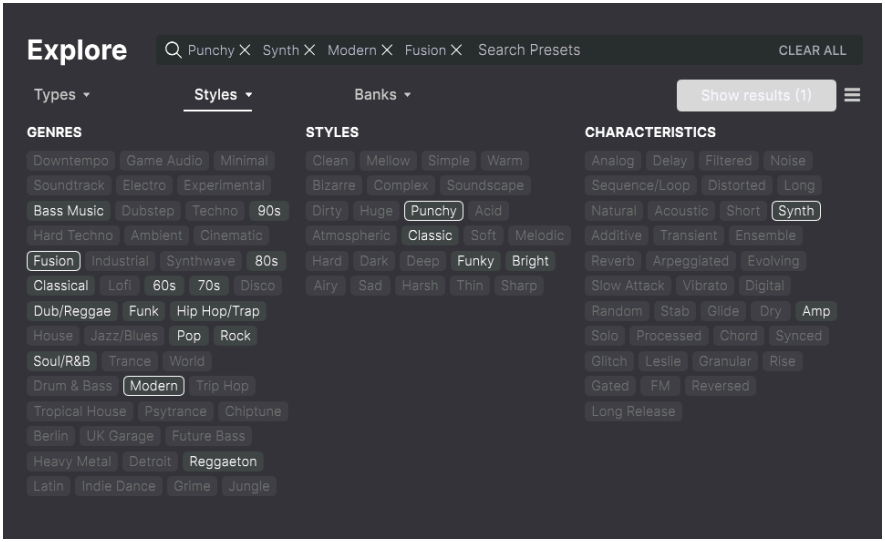
Click any one of them, and the results will show only Presets that match that tag. You can also select multiple Types using Cmd-click (macOS) or Ctrl-click (Windows). For example, if you aren't sure whether the Preset you're looking for was tagged with Keys or Pad, select both to broaden the search.

Results columns can be inverted by clicking the arrow buttons to the right of their titles (Name, Type, Designer).

4.2.2. Styles

Styles refine your search according to further musical attributes. Accessed by the **Styles** button, this area has three further subdivisions:

- *Genres*: Identifiable musical genres such as decades, Trance, Techno, Synthwave, Disco, etc.
- *Styles*: General "vibe" such as Atmospheric, Dirty, Clean, Complex, Mellow, etc.
- *Characteristics*: Sonic attributes such as Analog, Evolving, Distorted, Dry, Rise, etc.



Click on any tag to select it. Click again (or right-click) on any selected tag to de-select it. Notice that when you select a tag, several other tags usually disappear. This is because the browser is narrowing your search by a process of elimination. De-select any tag to remove that criterion and widen the search without having to start all over again.

4.2.3. Banks

Next to the **Types** and **Styles** buttons is the **Banks** button, which lets you do your search (using all the methods above) within the factory bank or user banks.

4.3. Search Results window

Click the **Show Results** button if you cannot already see your list of results. Click the sort arrow to reverse the alphabetical order of any column.

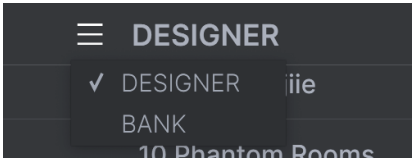
4.3.1. Sorting the Preset Order

Click the **NAME** header in first column of the Results list to sort Presets in ascending or descending alphabetical order.

Click the **TYPE** header in the second column to do the same thing by Type.

Click the **Arturia logo** to the left of **TYPE** to bring factory-featured Presets to the top of the list. These will appear just under any Presets you have liked [p.41].

The third column has two header options: **DESIGNER** and **BANK**. Click the icon with three lines to choose between the two. Then click either header name as with the other two columns to switch the alphabetical order.

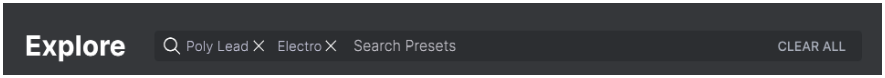


Click the ♥ to sort by liked presets.

Click the two intertwined arrows to sort presets at random.

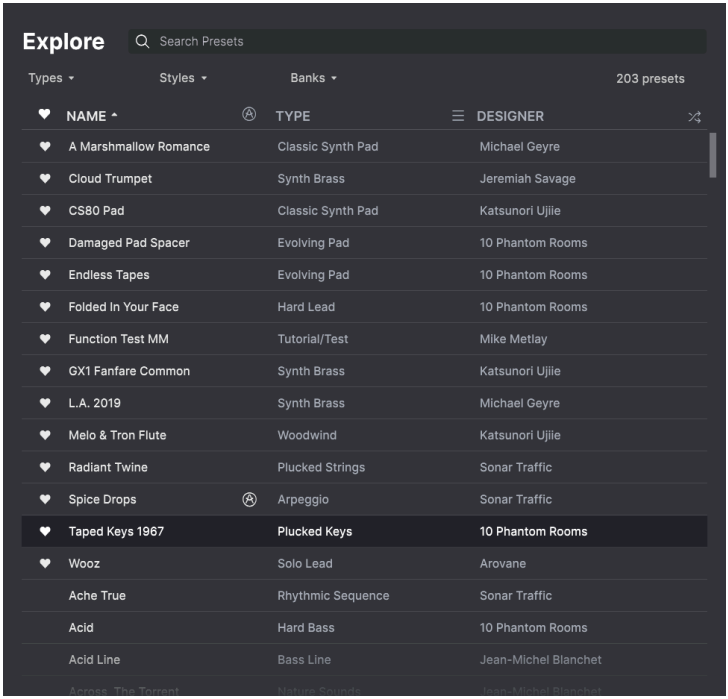
4.3.2. Clearing Tags

Just above the Types, Styles, and Banks buttons, you will see labels for all the active tags in a search. Click the X next to any one to remove it (and thus broaden the results). Click **Clear ALL** to remove all tags.



4.3.3. Liking Presets

As you explore and create Presets you can mark them as Liked by clicking the **heart** next to their names. later, click on the heart icon to put all of your favorites at the top of the Results list.

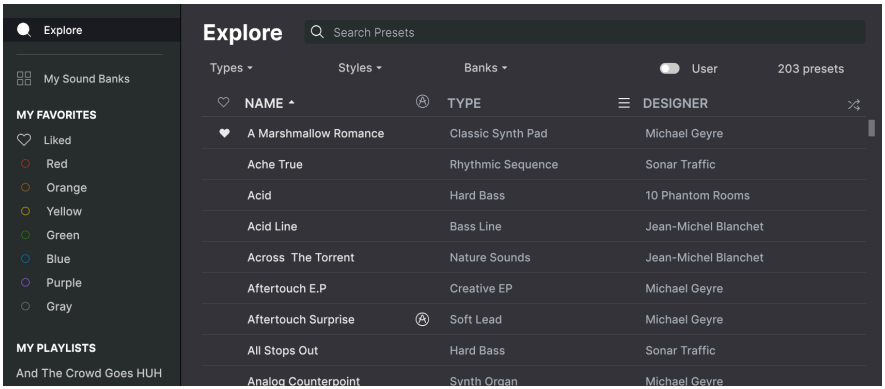


Use as many of the sorting and filtering features as you need and you will find the exact sound you want every time.

4.4. Sidebar

The leftmost section of the Preset Browser determines what is displayed in the Search and Results [p.37] section.

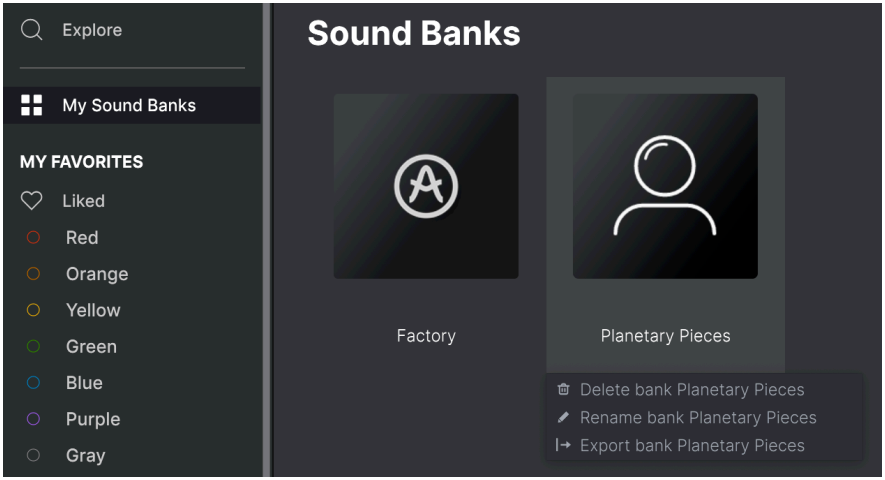
The topmost option is:



The **Explore** section is the default, letting you search the current bank of Presets loaded into CS-80 V as we did in the previous section.

4.4.1. My Sound Banks

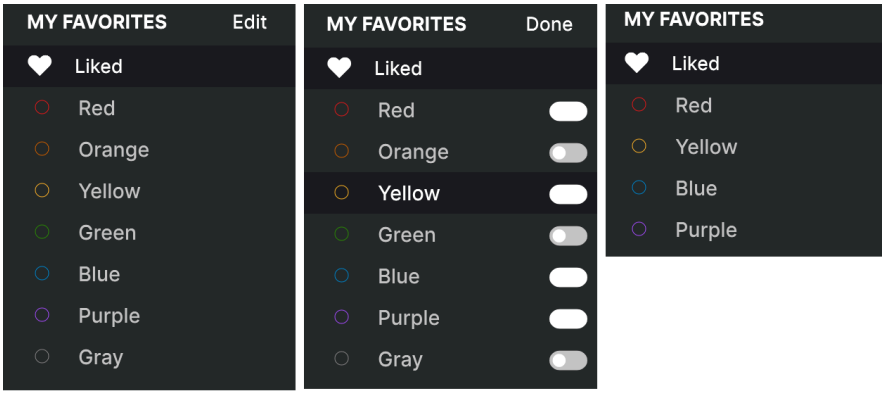
Clicking **My Sound Banks** brings up a window with all of the currently available Sound Banks, starting with the Factory bank. User banks appear next to it, and can be deleted, renamed, or exported by right-clicking them.



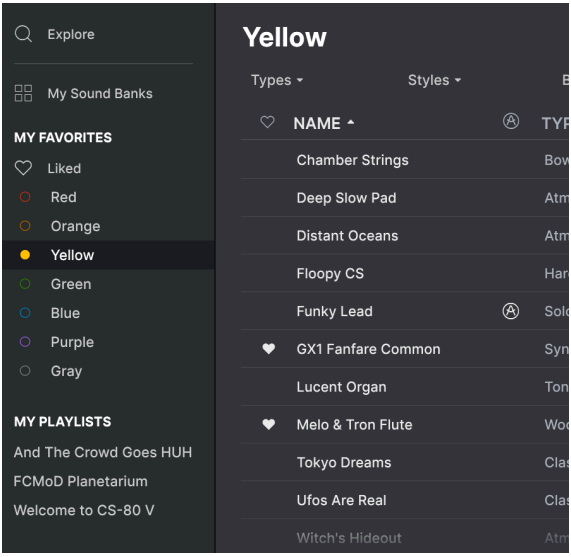
4.4.2. My Favorites

The middle part of the Sidebar has a menu called **My Favorites**, which allows you to color-code certain groups of Presets for easy access. It also includes the **Liked** group, so you can quickly find Presets you've marked with the heart icon.

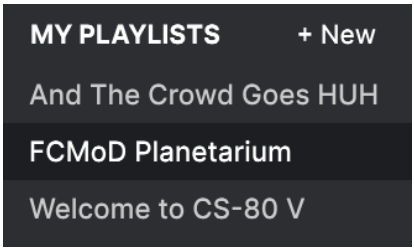
To decide which colors you'd like to display, hover over **My Favorites** and click **Edit**. Then use the buttons to select which colors you'd like to see or hide, and then click **Done**.



To add Presets to a particular set of Favorites, simply drag and drop them over the appropriate color. Then click on the color itself to display your grouping.



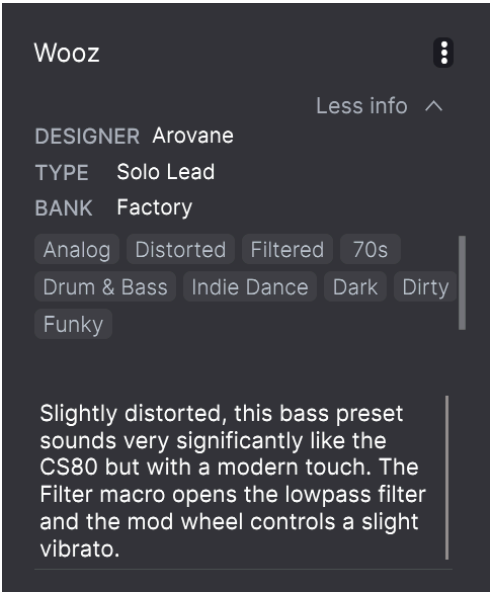
4.4.3. My Playlists



The bottom part of the sidebar displays any Playlists you have created or imported. Playlists are a very powerful management tool for set lists for gigs. Learn more about them in the Playlists section [p.48] below.

4.5. Preset Info Section

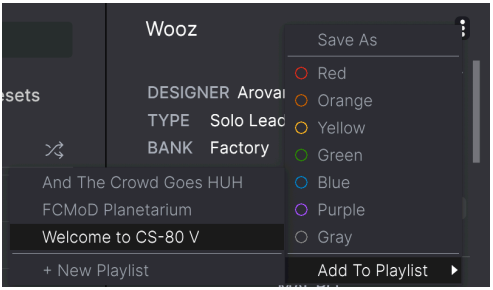
The right side of the browser window shows specific information about each Preset. The information for User Presets (but not Factory ones) may be changed here: Name, Type, Favorite, etc.



To make the desired changes, you can type in the text fields, use one of the pull-down menus to change the Bank or Type, and click the + sign to add or delete Styles.

Types and Styles changes you make here are reflected in searches. For example, if you remove the "Funky" Style tag and then save that Preset, it will not show up in future searches for Funky sounds.

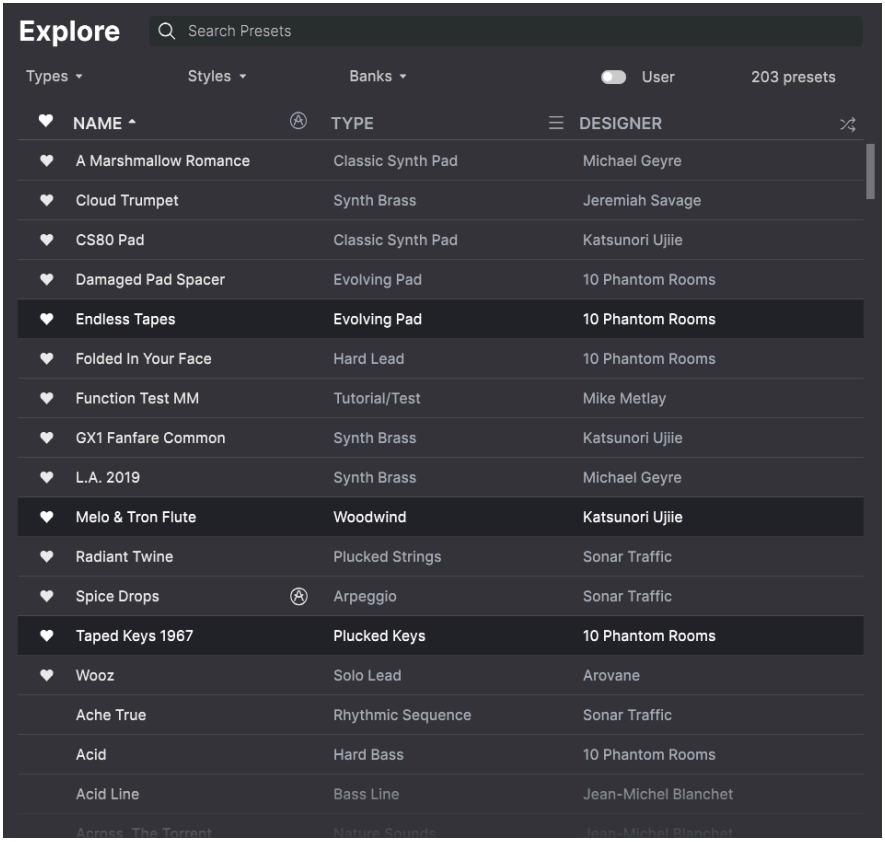
Clicking on the three-dots icon at the top right pops up a menu with organizational options for the Preset.



Options include **Save Preset**, **Save Preset As**, **Delete Preset**, and **Add to Playlist**, complete with an option to create a new Playlist. The lines with color icons allow you to add the Preset to a particular group of Favorites, which we'll describe below.

4.5.1. Editing Info for Multiple Presets

If you'd like to move several Presets to a different bank while preparing for a performance, or enter a single comment for several Presets at the same time, it's easy to do. Simply hold command (macOS) or ctrl (Windows) and click the names of the Presets you want to change in the Results list. Then enter the comments, change the Bank or Type, etc., and save the Preset.



You can also select all following/preceding presets with shift + click.

♪ If you want to alter the information for a Factory Preset you must first use the *Save As* command to re-save it as a User Preset. After this the Info section will gain Edit and Delete buttons at the bottom of the window.

4.6. Preset Selection: Other Methods

Click on the Preset name in the center of the Upper Toolbar to bring up a drop-down menu. The first option in this menu is **All Types**, and it brings up a submenu of literally every Preset in the current bank.

Below this are options that correspond to the Type tags. Each of these brings up a submenu of all Presets of its Type.

If you have an active search by Type and/or Style, the up/down arrows to the right of the Preset name will step through only the results that conform to your search.

However, "All Types" in the drop-down menu always ignores those criteria. Likewise for the Type choices below the line – they always include all Presets within that Type.

4.7. Macro Knobs

These are simply larger duplicates of the Macro knobs in the Lower Toolbar. Move one and its partner moves with it.

Assigning parameters to Macros is covered in the Macro Tab [p.33] section of Chapter 3.

4.8. Playlists

Playlists are a way to collect Presets into different groups for different purposes, such as a set list for a particular performance or a batch of Presets related to a particular studio project. Within a Playlist, Presets can be reordered and grouped into Songs, a handy addition to a set list.

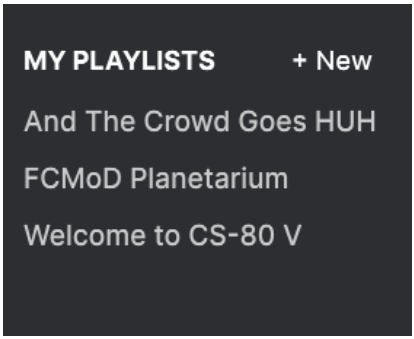
The **My Playlists** subheading appears under **My Favorites** in the Sidebar. However, when you first start using CS-80 V, you'll have no Playlists yet, and the **My Playlists** subheading won't be there yet. To make it appear, you'll have to create your first Playlist.

4.8.1. Create your first Playlist

To get started, drag any Preset to the Sidebar. The **My Playlists** heading will appear, along with a **+ New** icon. Drop the Preset onto the **+ New** icon, and you will then be given a pop-up to name your first Playlist. Once you've created one Playlist, the **My Playlists** heading will become a permanent part of the Sidebar.

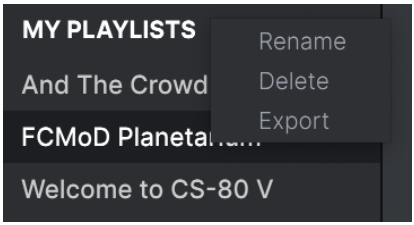
4.8.2. Add a Playlist

To add a Playlist, hover your mouse over the **My Playlists** heading and click the **+ New** icon when it appears.



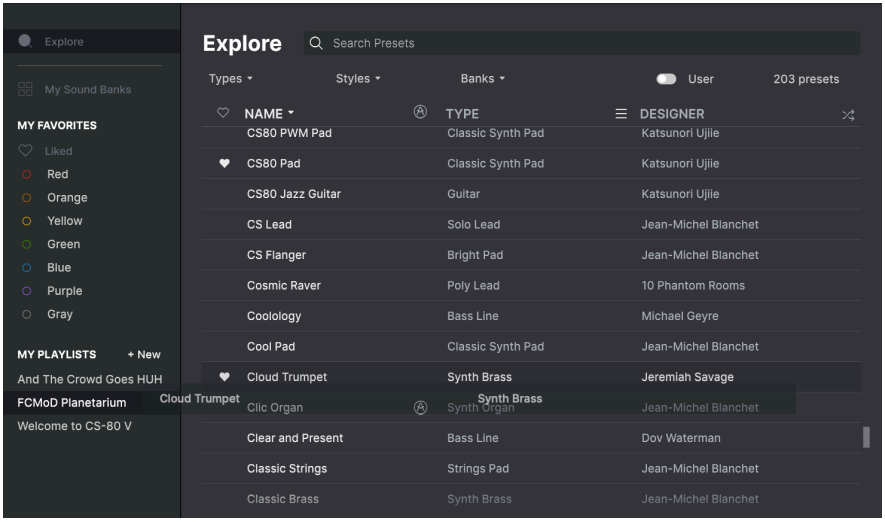
Give the Playlist a name and it will appear in the Playlists menu in the Sidebar.

Once you've created some Playlists, right-clicking on a Playlist name will pop up a set of options – you can **Rename**, **Delete**, or **Export** the Playlist to your computer, as a file with the .aplist extension.



4.8.3. Add a Preset

You can use all of the options in the Explore window to locate Presets for your Playlist. When you find a desired Preset, click-drag it onto the Playlist name.

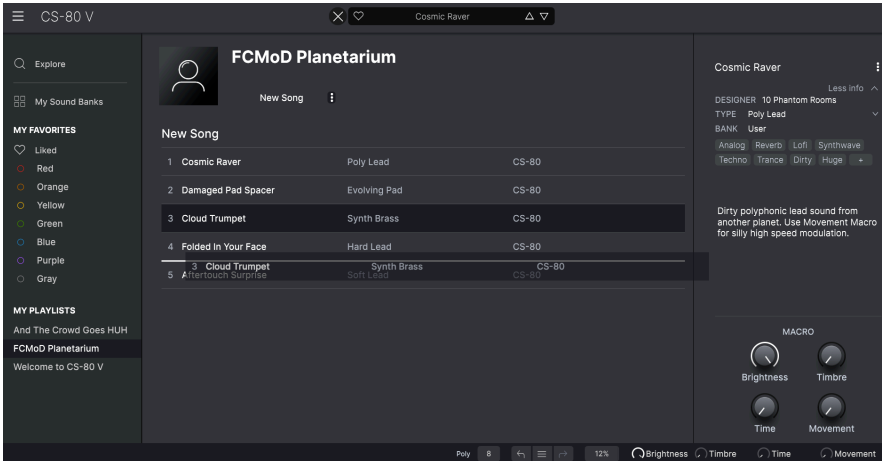


Click and drag from the Search Results list onto one of the playlists

To view the contents of a playlist, click on the playlist name.

4.8.4. Re-order the Presets

Presets may be reorganized within a Playlist. For example, to move a Preset from slot 3 to slot 4, drag and drop the Preset to the desired location.

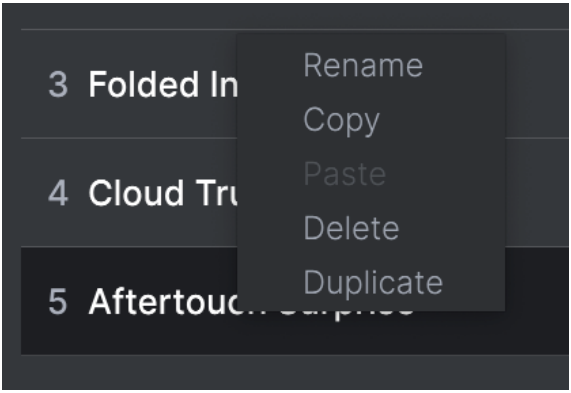


The white line indicates the final destination of the Preset you're dragging.

This will move other Presets up in the list to accommodate the new location of the Preset you just moved. A bright white line will briefly appear at the "insert point."

4.8.5. Remove a Preset

To delete a Preset from a playlist, right-click on its name to bring up a pop-up menu.

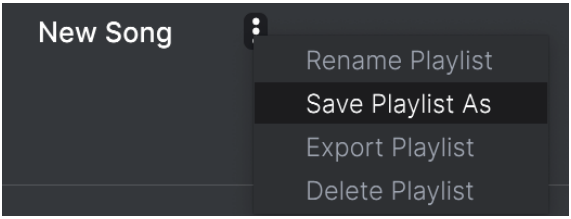


This menu also includes **Rename**, **Copy**, **Paste**, and **Duplicate** options. More management options are described below.

4.8.6. New Song and Playlist Management

The **New Song** button creates a new Song at the bottom of the Playlist. You can name it, then click and drag it to position it in the Playlist and add Presets to it in the desired order.

To access other Playlist management options, click on the three dots icon next to the **New Song** button. This brings up a pull-down menu:



- **Rename Playlist**: Renames the current Playlist without making a copy.
- **Save Playlist As**: Creates a duplicate of the playlist with "Copy" appended to the name. You can change the name before saving.
- **Export Playlist**: Exports your Playlist to a location on your computer, with the filename extension "aplst."
- **Delete Playlist**: Deletes the current Playlist but does *not* delete any of the Presets in it.

5. THE MAIN PANEL

Now that we've figured out what all the controls around the edges do, you're probably eager to get to the main event – the controls we use for sound creation on CS-80 V, both original and modern. These are found on the Main Panel, as shown above.

One thing to note before we begin is that CS-80 V's layout preserves the dramatic (to be polite) color scheme of various controls on the original hardware. This color coding is actually useful once you get used to it.

- **GREEN**: Filter cutoff (Brilliance) and Pulse Width/Pulse Width Modulation (PW/PWM)
- **RED**: Filter resonance
- **YELLOW**: Release time
- **GREY**: volume/level
- **WHITE** and **BLACK**: Other parameters, including LFO speed, detune/pan, non-release envelope stages, arpeggiator and effect controls, etc.

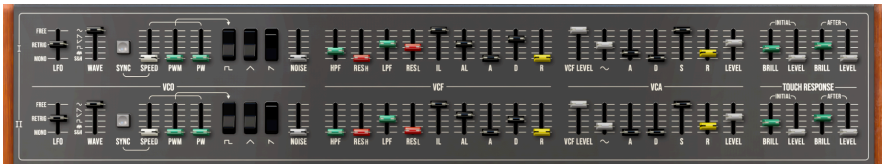
> As we carry out our tour, we'll be using a lot of synth terminology that you might not be familiar with if you're new to this sort of thing. To get yourself up to speed, check out The Basics of Subtractive Synthesis [p.110] later in this manual.

5.1. Overview

Before we detail what all these buttons and sliders do, let's make sure we can find them. Here's a top-to-bottom tour of the Main Panel.

5.1.1. Channels I and II

The primary sound-shaping controls on the Main Panel are located in the top two rows (called **Channels**), each of which contains 30 synthesis parameters, which will allow you to create a nearly infinite variety of sounds. Each Channel forms a basic synthesis voice, and they can be combined in a variety of interesting ways to create huge timbres.



Channels I+II

Each Channel has:

- A *voltage-controlled oscillator* (**VCO**), which provides the basic audio signal. It has four waveforms, selectable individually or all at once: **square**, **sawtooth**, **triangle** and **noise**. (There's also a **sine** wave output that we'll get to in a minute.) This section's controls handle the *pulse width* of the waveforms.

- A *low-frequency oscillator* (**LFO**) that modulates the pulse width of the square waveform.

- Two resonant *voltage-controlled filters* (**VCFs**) in series: a high-pass filter (**HPF**) followed by a low-pass filter (**LPF**).

- An unusual 5-parameter *envelope* that modulates both filters' cutoff frequencies.

- A *voltage-controlled amplifier* (VCA) that controls the level of the sound output, with separate level settings for the output of the VCFs and for the sine wave, which bypasses the VCF.

- An *ADSR* envelope that modulates the signal going through the amplifier.

- And finally, **Touch Response**: individual settings for how much the **BRILLIANCE** (VCF cutoff) and **LEVEL** (VCA amount) are modulated by the Initial Touch and After Touch (Yamaha's original terms for velocity and key pressure, although 'aftertouch' has entered common usage today).

5.1.2. The Controller Panels

The next two rows of the front panel, the ones just above the keyboard, are (almost) entirely devoted to controlling the sounds of the two Channels in real time.

The upper Controller Panel has the following sections:

- The **Channels** section controls special global detuning and panning functions that affect Channels in different ways. It's worth noting that detune only affects channel II.
- The **Ring Modulator** is the exception to the 'controllers in this row' rules; it's an audio processor that's a major source of the CS-80's unique tonalities.
- The **Sub Oscillator** is a global LFO that can be routed to control multiple parameters in differing amounts.
- The **Feet** (oscillator octaves and fifths) for both Channels.
- The **Tone Selector** is a collection of 24 'presets' that set the two Channels to predetermined parameter values. Each Channel has 11 such Tones, plus **INIT** (an initialized patch). There are also controls for manipulating the Tones and moving them around.
- **MIX**, **BRILLIANCE**, and **RES** are global controls for the mix between the two Channels, the overall Brilliance (filter cutoff) of the sound, and the overall filter resonance.
- The **Global Touch Response** controls set how Initial and After Touch modulate various global parameters.
- The **Keyboard Control** section lets you fine-tune the Brilliance and Level for the high and low ends of the keyboard range.

The lower Controller Panel has the following sections:

- The **Modulation** section sets the amount of control that the modulation wheel and Sub Oscillator have over various global parameters.
- The **HOLD** button sustains any notes played until it's pushed again.
- The **Arpeggiator** turns sustained notes into arpeggios (sequences of notes) that play in particular order. This is a nice addition that wasn't available on the original CS-80 V.
- The horizontal Ribbon is a fantastic pitch controller unlike anything that had existed before the GX-1 and CS-80 came along! Its **RANGE** control does more than set bend range, as we'll see.
- Finally, there are global **TUNE** and **VOLUME** knobs whose values can be stored with each preset.

5.1.3. The Left-Hand Section

The section to the left of the keyboard offers a variety of controls related to **Footswitch**, **Unison**, **Portamento**, and **Tremolo/Chorus**:

5.1.4. The Service Panel

Oh, and if you look closely at the top left of the Main Panel, you'll see some mysterious-looking controls hidden behind the grille of the **Service Panel**:

We'll get to those later...

5.2. Controls and parameters

Now that we have our road map in front of us, let's check out the sights! As with the overview, we'll go block by block, top to bottom, left to right.

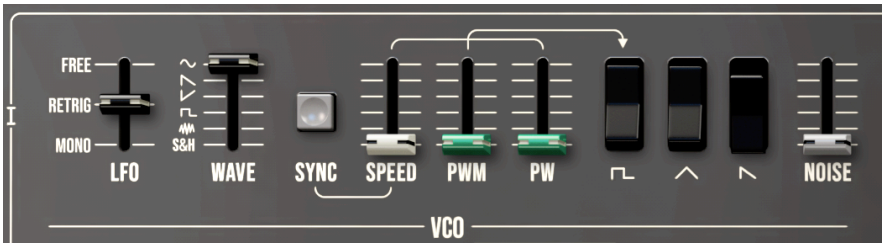
The Main Panel's controls are, for the most part, set up to look and work like those on the CS-80. Toggle switches work the same way as buttons, and sliders either have a smooth travel or select from several options, as with LFO waveform. Knobs respond to vertical mouse movement.

Levers – which look like sliders, but have a shorter throw and no markings – work like sliders, but often their values get larger when you move them downward rather than upward. Because levers aren't always intuitive to use, they have 'default' settings – you can reset them to those by double clicking them.

> The original CS-80's levers have never been equaled on any other synthesizer. Hand-assembled and fabulously expensive, each lever moved in a gentle arc with incredible smoothness, allowing for instant yet delicate control over critical real-time functions. Their reversed direction of travel is a nod to the CS synths' origins in organ design, where drawbars' values rise as they are pulled toward the player.

5.2.1. Channels I and II

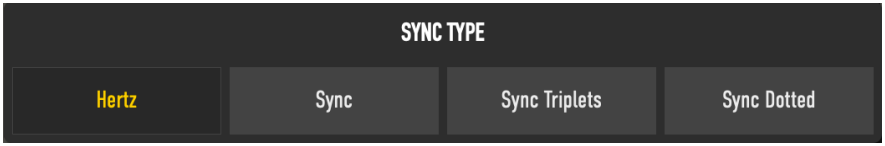
The two Channels' controls are identical.



5.2.1.1. LFO

The LFO for each Channel has the following parameters:

- A choice of three trigger modes: **FREE** (all of the voices' LFOs run independently of each other), **RETRIG** (the LFO attached to the current voice retrigger every time any key is pressed), and **MONO** (the LFO is mono, and there is only one LFO for all voices. If you let go of all voices, it continues to cycle).
- **WAVE** offers a choice of six waveforms: sine, sawtooth down, sawtooth up (ramp), square, noise, and S&H (*sample & hold*, a randomized signal). By the way, the original CS-80 only offered a sine wave.
- **SYNC** opens a pop-up where you can determine if the **SPEED** of the LFO will be synchronized to divisions of the global tempo – whether in straight time, triplets, dotted notes – or unsynchronized. When synced, SPEED ranges from 1/32 of a bar to 8 bars, a range you'll find on nearly every other CS-80 V control that offers sync. When it's turned off, SPEED can be set from 0.100 to 127 Hz.



> Higher SPEED values are well within the range of human hearing, which can produce fascinating timbral changes.

- **PWM** and **PW** set the pulse width of the pulse wave, and the amount by which the pulse wave is modulated by the LFO. PW ranges from 0.500 (a square wave) to 0.900 (a very narrow pulse). PWM ranges from 0.00 (no effect, for a static wave shape) to 10.0 (a pretty drastic PWM).

> By adjusting the two sliders, you can create PWM with different rhythmic cycles and different extreme values.

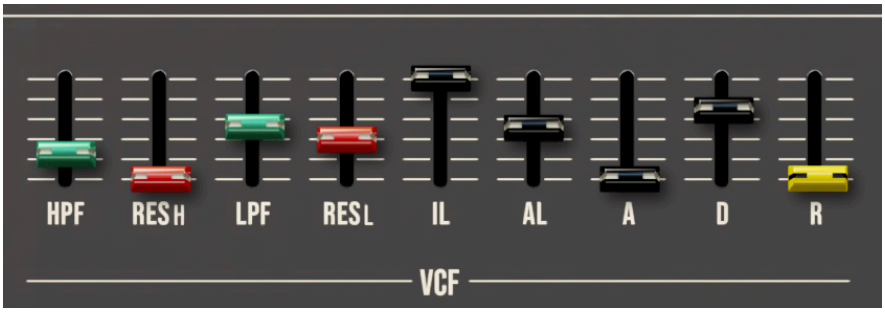
5.2.1.2. Waveforms

This section's pretty straightforward. Three available waveforms are selected here: press down on the switch to turn on the **pulse**, **triangle**, and **sawtooth** waves. Any or all can be active at once.

- The **NOISE** slider adds *noise*, an unpitched signal containing every audible frequency, to the oscillators. This can be used to roughen up a sound or simulate natural sounds like wind and surf.

> You can choose one noise oscillator for both channels, or two per channel. By doing so, you can create stereo fields using panning on Noises. Keyboard tracking is always present on the filters. Using only noise source and sweeping the keyboard then acts like a cutoff control.

5.2.1.3. VCF



The VCF controls are followed by settings for the VCF Envelope, an unusual design seen on the GX-1 and CS-series synthesizers and pretty much nowhere else.

- **HPF** sets the cutoff frequency of the high-pass filter. (26.8 to 16155 Hz)
- **RESH** sets the resonance of the high-pass filter. (0.00 to 1.00)
- **LPF** sets the cutoff frequency of the low-pass filter. (37.1 to 22298 Hz)
- **RESL** sets the resonance of the low-pass filter. (0.00 to 1.00)

> If you set the HPF and LPF properly, you create a *band-pass filter*, where only a limited frequency range gets through the filters. This is useful for a variety of sounds imitating acoustic instruments.

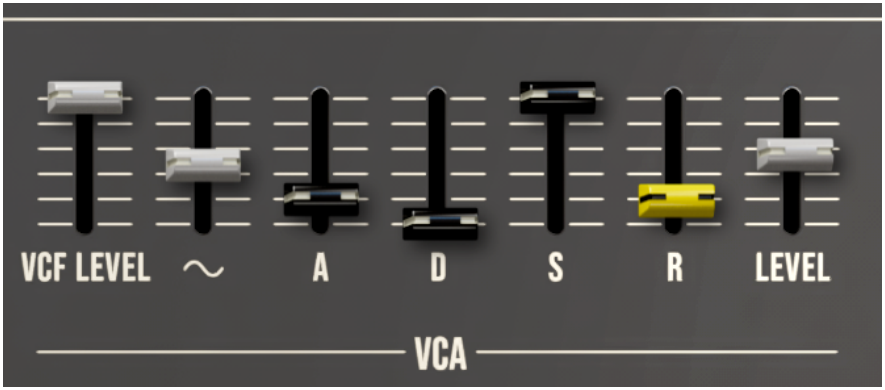
The parameters for the VCF envelope are:

- **IL** (Initial Level), the level *below* 0 where the envelope starts. (0.00 to -5.00)
- **AL** (Attack Level), the level *above* 0 where the envelope peaks at the top of the Attack segment. (0.00 to 5.00)
- **A** (Attack Time), the time it takes to go from IL to AL. (2 ms to 580 ms in Classic mode, 2 ms to 10.00 sec in Long mode)
- **D** (Decay Time), the time it takes to drop from AL to 0. (2 ms to 8.75 sec in Classic mode, 2 ms to 25.00 sec in Long mode)
- **R** (Release Time), the time it takes to drop from 0 to IL. (2 ms to 11.00 sec in Classic mode, 2 ms to 40.00 sec in Long mode)

Remember that Classic vs. Long Envelope Modes are chosen in the Settings tab of the Side Panel [p.25]. This is a *global* choice; it affects all envelopes in all presets.

> If this envelope design seems strange to you, that's okay – because it is! It originated on the GX-1, and the CS synths were the only other ones to ever use it.
>
> The idea here is that the VCF envelope works exactly like a conventional ADSR, but it's offset *downward* (by the IL amount) – so after the attack and decay are done, *the sustain level is automatically and always equal to 0*. This makes the envelope cover a range both above and below 0, which leads to a variety of interesting modulation possibilities beyond what a conventional ADSR can offer.

5.2.1.4. VCA



The VCA controls are followed by a conventional ADSR envelope that controls loudness.

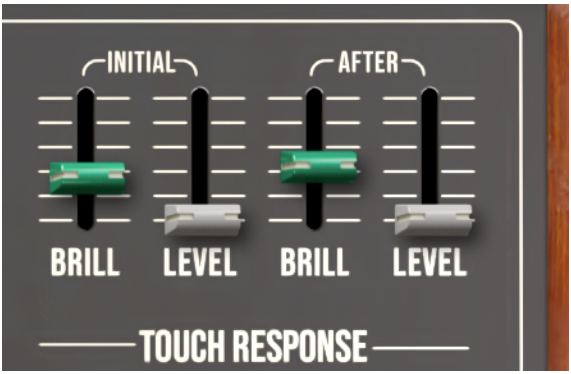
- **VCF LEVEL** is the amount of the VCF output that is fed into the VCA. (0.00 to 10.0)
- The slider with the sine wave icon controls the amount of sine wave from the VCO fed into the VCA. (0.000 to 10.0)

> The sine wave bypasses the VCF because with only one frequency, a sine wave through a filter is either heard or it isn't. It's useful for adding a bit of low-end heft to sounds or reinforcing deep fundamentals – a pretty obvious extra feature, but one that practically no other synthesizer had.

- **A** (Attack Time), the time it takes to go from 0 to the peak level. (2 ms to 885 ms in Classic mode, 2 ms to 10.00 sec in Long mode)
- **D** (Decay Time), the time it takes to drop from the peak level to the sustain level. (2 ms to 7.35 sec in Classic mode, 2 ms to 25.00 sec in Long mode)
- **S** (Sustain Level), the level at which the sound sustains until the key is released. (0.00 to 10.0)
- **R** (Release Time), the time it takes to drop from the sustain level to 0. (2 ms to 11.50 sec in Classic mode, 2 ms to 40.00 sec in Long mode)
- **LEVEL** controls the overall level of the VCA output. (0.00 to 10.0)

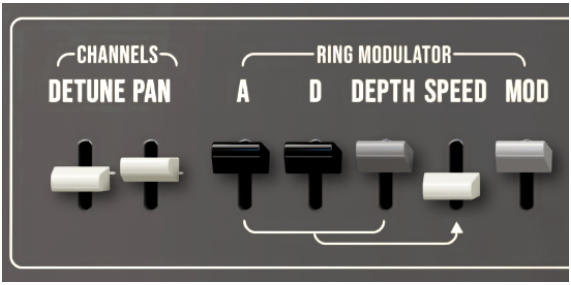
5.2.1.5. Touch Response

These controls set the amount of modulation that the Channel receives from the keyboard's Initial Touch (velocity) and After Touch (pressure/aftertouch).



The sliders set the amount of **BRILLIANCE** and **LEVEL** control for each type of touch sensitivity. (0.00 to 10.0)

5.2.2. The upper Controller Panel



5.2.2.1. Channels

These two levers control functions that are applied to the two Channels with respect to one another.

- **DETUNE** changes the pitch of Channel II, with Channel I's pitch remaining steady.
- **PAN** spreads Channels I and II to the left and right of the stereo soundstage.

5.2.2.2. Ring Modulator

A ring modulator is a circuit that takes two input sounds and outputs the sum and difference of their frequencies. When one input is a very slow LFO, the ring modulator produces a slow and smooth tremolo; at higher frequencies, it outputs clangorous, metallic effects that don't share harmonics with the original sounds. Both types of effects can be musically useful when applied properly, and the CS-80's Ring Modulator was famous for how remarkably musical it was in comparison to those on modular synthesizers, which were usually good for nothing but sci-fi sound effects.

In CS-80 V, as on the original, one input to the ring modulator is the mixed output from the two Channels, and the other is a dedicated LFO. The LFO speed can be set by hand, or modulated with a dedicated AD envelope so it changes the character of the ring modulation for each note.

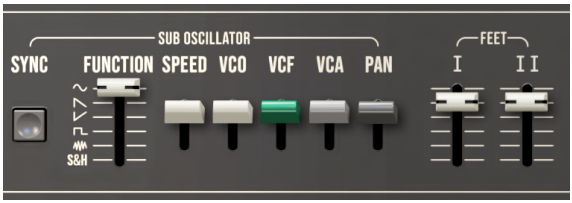
The range of this envelope is not clipped, meaning that it goes above the value set on the speed lever. Envelopes are also always retrigged, except when playing in legato.

The controls are:

- **A** is the LFO speed envelope attack time. (3 ms to 530 ms)
- **D** is the LFO speed envelope decay time. (7 ms to 4.50 sec)
- **DEPTH** is the amount of LFO envelope modulation. (0.00 to 1.00)

> Remember that levers for both unipolar and bipolar parameters have their smallest values at the top and their largest values at the bottom!

- **SPEED** sets the speed of the internal sine wave (carrier). (0.250 to 205 Hz)
- **MOD** sets the amount of ring modulation applied to the input signal. (0.00 to 1.00)



5.2.2.3. Sub Oscillator

The Sub Oscillator is a global (or mono) LFO that can be applied to several destinations, but all voices will be modulated by the same LFO. Its parameters are:

- **SYNC** opens a pop-up where you can determine if the **SPEED** of the LFO will be synchronized to divisions of the global tempo – whether in straight time, triplets, dotted notes – or unsynchronized. When synced, SPEED ranges from 1/32 of a bar to 8 bars. When it's turned off, SPEED can be set from 0.500 to 100 Hz.
- **FUNCTION** selects the Sub Oscillator's waveform. It offers a choice of six waveforms: sine, sawtooth down, sawtooth up (ramp), square, noise, and S&H.
- **VCO**, **VCF**, **VCA**, and **PAN** set the amount of Sub Oscillator modulation sent to pitch, cutoff, amplitude, and panning offset.

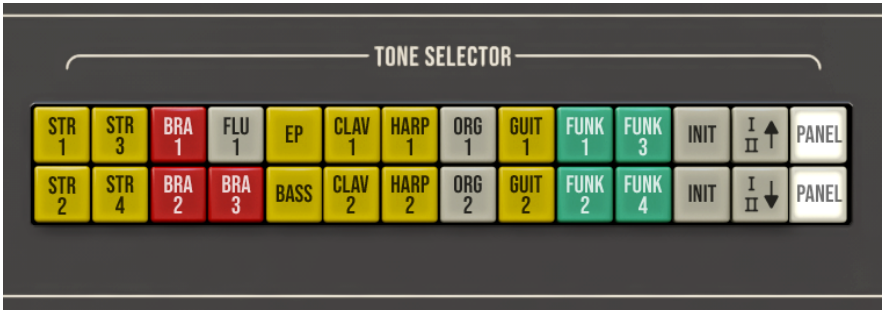
5.2.2.4. Feet

This control sets the octave for each of the two Channels' VCOs. The control settings are: -1 octave, Default, +1 fifth, +1 octave, +1 octave 1 fifth, +2 octaves. Either slider can be set to Default by double clicking.

> Why 'Feet'? This is another nod to the CS-80's origins in organ design. Octave settings are measured in feet because they originated with pipe organs, whose pitch would drop by an octave if the pipe length was doubled. Many synthesizers today use the actual octave designations 32', 16', 8', 4', and 2', but nobody calls the control 'Feet'!

5.2.2.5. Tone Selector

The Tone Selector was the heart of the original CS-80. While none of its 22 preset Tones much resembled what they were named for, they could be used in combinations that created some of the instrument's most iconic sounds.

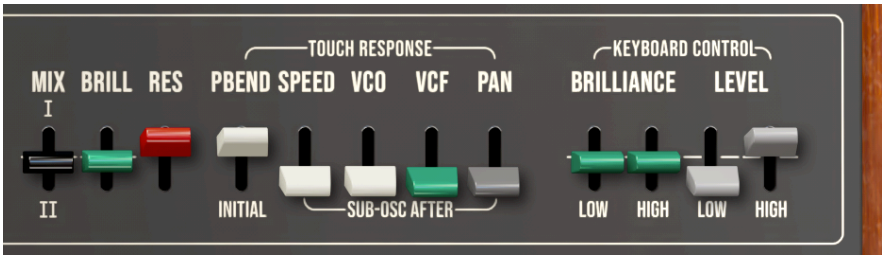


Channels I and II have 11 Tones each, arranged by rows:

- Channel I: Strings 1, Strings 3, Brass 1, Flute 1, Electric Piano, Clavichord 1, Harpsichord 1, Organ 1, Guitar 1, Funky 1, Funky 3
- Channel II: Strings 2, Strings 4, Brass 2, Brass 3, Bass, Clavichord 2, Harpsichord 2, Organ 2, Guitar 2, Funky 2, Funky 4

Each row also has an **INIT** button to set a Channel to a simple default patch, a pair of buttons to copy the settings of Channel I to Channel II and vice versa (try *that* with an original CS-80!), and two **PANEL** buttons. If any control in a Channel is moved once a preset Tone has been selected, the Panel button lights to show that it's been changed.

5.2.2.6. Global Controls and Touch Response



Just to the right of the Tone Selectors are three of the most useful real-time controls on the Main Panel. Meant to be played with during performance, they offer quick and expressive global adjustments for:

- **MIX**: the relative levels of Channel I vs. Channel II (-1.00 to 1.00)
- **BRILLIANCE**: the overall filter cutoff (-1.00 to 1.00)
- **RESONANCE**: the overall filter resonance (-1.00 to 1.00)

Note that the Brilliance and Resonance controls are offsets, not absolute numbers – they interact with the settings in both Channels.

The Touch Response controls offer even more Initial Touch and After Touch control of global parameters:

- **PBEND INITIAL** controls the amount of pitch bend that's applied when the keys are played with higher velocity. Notes start out ever so slightly flat, and quickly 'swoop' up to the actual pitch, a gesture reminiscent of brass instruments.

The other four controls adjust the interaction of the Sub Oscillator with After Touch:

- **SPEED** controls After Touch influence on the Sub Oscillator's Speed
- **VCO**, **VCF**, and **PAN** control how much After Touch increases the Sub Oscillator modulation of those three parameters.

> With the input being polyphonic, and since it responds to polyphonic aftertouch and MPE, you can have different values for those parameters on each voice.

5.2.2.7. Keyboard Control

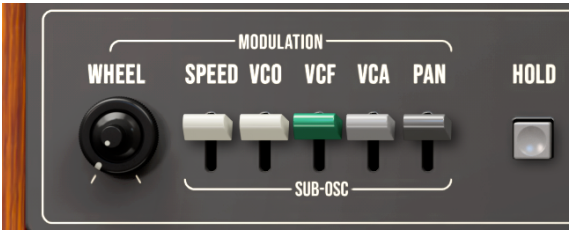
Sometimes it's useful to alter how a sound responds to high vs. low notes. Keyboard tracking of VCF cutoff has been a staple of analog synthesizers for decades. The CS-80, and CS-80 V, offer a take on this that has been a huge influence on later synthesizers.

Rather than a single tracking amount for Brilliance (VCF cutoff), CS-80 V has four levers to offset both Brilliance and Level for Low vs. High notes. As they're adjusted in various ways, you can make a patch soft at the extremes of the keyboard and louder in the middle, roll off the bass for high notes while boosting the treble for low ones, and much more.

> This idea of keyboard scaling was one that Yamaha later put to very good use. It became one of the critical elements of FM synthesis, with a graph of keyboard level scaling boldly printed on the front panel of the DX7 – one of the most successful synths in history.

5.2.3. The lower Controller Panel

5.2.3.1. Modulation



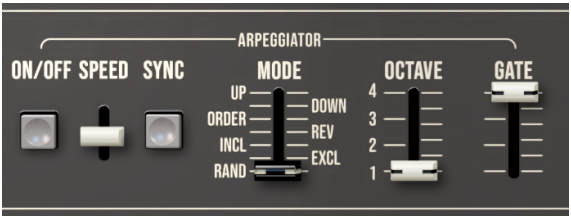
The original CS-80 didn't have a modulation wheel; it relied entirely on Initial Touch, After Touch, and expression pedals to shape note behavior. These days, mod wheels are on every controller, so why not teach CS-80 V to use them in various ways?

The **WHEEL** can be used instead of an actual mod wheel. On the original CS-80, this dual knob was for coarse and fine tuning.

The five levers control how much the mod wheel controls the Sub Oscillator **SPEED**, and how much it turns up the Sub Oscillator's modulation of the **VCO**, **VCF**, **VCA**, and **PAN**.

The **HOLD** button causes notes that you play to sustain indefinitely – or at least until you push the button again.

5.2.3.2. Arpeggiator



An arpeggiator is a fun way to create runs of notes interactively by holding down chords. It's well suited to percussive sounds, but with **RELEASE** turned up (see below), it can also create flowing chords that gradually change shape. It has the following controls:

- **ON/OFF** does what you think it does.
- **SPEED** sets the speed at which the arpeggiator plays the next note.
- **SYNC** opens a pop-up where you can determine if the **SPEED** of the arpeggiator will be synchronized to divisions of the global tempo – whether in straight time, triplets, dotted notes – or unsynchronized. When synced, SPEED ranges from 1/32 bar to 8 bars. When it's turned off, SPEED can be set from 0.500Hz to a 100Hz.
- **MODE** determines the order in which notes are played:
    - **UP** (ascending),
    - **DOWN** (descending),
    - **ORDER** (the order in which notes were played),
    - **REV** (reverse order),
    - **INCL** (up and down, with the top and bottom notes played twice),
    - **EXCL** (up and down, with the top and bottom notes played only once),
    - **RAND** (notes are played in random order).
- **OCTAVE** changes octaves at each arpeggiator cycle.
- **GATE** controls the steps length.

5.2.3.3. Ribbon and Master

The CS-80's pitch ribbon, like many other things about it, had never been seen before. It ran along the top of the keyboard's bottom three octaves and was used for pitch bend. Unlike other ribbon controllers, it started to bend from where you touched it, making for very natural gliding play.

The ribbon has only one control: **RIBBON RANGE**. It can be set to a bend range of 1 to 24 semitones (2 octaves), but it can also be set to **CS Linear Mode**, a model of the original ribbon's behavior, which was (you guessed it) unique.

> The ribbon is hard mapped to the pitchbend, and it is also a VST parameter. It means that you can now record automations when tweaking the Ribbon with your computer mouse.

The pitch voltage control of most synths uses a *logarithmic* scale, usually 1 volt per octave, so to go up one octave, you turn up the voltage by one volt, and to go down one octave, you turn down the voltage by one volt. That's how conventional pitch ribbons or wheels do bends. Simple, right?

However, the ribbon on the CS-80 uses a *linear* scale, in Hertz per volt. What does that mean in practical terms? Just this: with a full upward bend in CS Linear Mode, you double the voltage, which takes the pitch one octave up, no matter what pitch you start with. But a full downward bend takes the keyboard voltage all the way down to zero – and that's what happens to the pitch. You get an enormous divebombing whammy bar bend, all the way down below the lowest frequency we can hear.

The technical term for this sound is 'epic'.

It's hard to follow that dramatic effect, but we're at the end of the lower Controller Panel now. Last but not least are knobs for **MASTER TUNE** (400 to 480 Hz, double click to set to the default 440 Hz) and **MASTER VOLUME** (-60.0 to 0.00 dB).

5.2.4. The Left-Hand Section

On the original CS-80, there were no pitch or modulation wheels, so the area to the left of the keyboard was used for an assortment of miscellaneous controls that might be used during a performance, as well as a small built-in effects processor. These functions have all been reproduced in CS-80 V.

5.2.4.1. Pedals, Unison, Footswitches, and Portamento

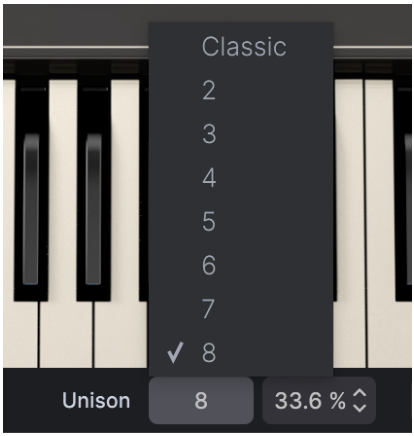
The CS-80 had a variety of expression modes that could be controlled by an attached foot pedal and footswitch. CS-80 V reproduces those controls for use with your keyboard controller's MIDI expression pedal and footswitch.

There are two buttons to control the destination of a MIDI foot controller:

- When **EXP** is pressed, the pedal controls overall volume.
- When **WAH** is pressed, the pedal controls overall volume and filter cutoff for a simultaneous swell and wah-wah effect.

> On the real unit, you could only control the overall volume and wah all at the same time. In CS-80 V4, we've made the choice to make it possible to access both parameters individually. It allows for more flexibility, and for a total control over the wah !

UNISON is a great feature we decided to have on CS-80 V4.



When the Unison button is pressed, The Lower Toolbar display changes from Poly to Unison, and you can select the number of voices that play back every time you press a key, from 1 (**Classic**) to 8. Next to that is a numeric display of the detuning between voices in Unison mode.

Here is an explanation of the different options:

- Classic: for polyphonic unison. By choosing this option, one note play 8 voices, 2 notes play 4 voices each, 3 notes play 2 voices each, and 4 notes play 2 voices each. For 5 notes and above, unison doesn't work anymore.
- 2, 3, 4, 5, 6, 7, and 8: plays unison monophonically. Each number corresponds to the number of voices played at once.
- Unison Detune (displayed in %): offset the tuning of all voices among each other, from 0% to 100%.

The four **FOOTSWITCH** toggles interact to provide Sustain, Release, or Portamento/ Glissando control from a single footswitch. Their interaction can be a little confusing at first, so let's break it down, first by defining our terms:

- *Sustain* is when a note holds for as long as you hold down a pedal. This can also be done with the **HOLD** button (see above).
- *Release* is an extra release stage that can be added to sounds' programmed Release Times. If the two Channels' ADSR Release Times are set to 0, you can choose between notes stopping abruptly and having the Release at the end.
- *Portamento* is a smooth 'glide' in pitch from a note you play to the next note you play.
- *Glissando* is like Portamento, but the pitch change happens in semitone steps, as if you're playing a run up or down the keyboard and hitting every note.

There are four toggles and two sliders:

- **SUSTAIN** and **PORTA/GLISS** under the **FOOTSWITCH** label. These determine whether the footswitch controls Release or Portamento/Glissando when you step on it.
    - If the **SUSTAIN** toggle is off (up), then Release is always active, and can only be defeated if you set the **RELEASE** slider to 0. Switching the toggle down puts Release under the control of the footswitch.
    - If the **PORTA/GLISS** switch is off (up), then portamento/glissando is always on, and can only be defeated if you set the **PORTAMENTO** slider to 0. Switching the toggle down puts portamento/glissando under the control of the footswitch.
- The **RELEASE** slider determines the length of the extra Release stage. (0 ms to 9.00 seconds in Classic mode, 0 ms to 30.00 seconds in Long mode) It is paired with the **MODE** toggle under it.
- The **MODE** toggle controls two different kinds of Release behavior. When it's up, every note you play will finish its Release when you let go of it. When it's down, if you let go of all notes then immediately play something else, the Release of the previous notes will be chopped off.

> Some additional information about the **MODE** toggle: when up, the Ribbon will not affect released notes, while when it is down, the Ribbon will affect released notes.

- The **PORTAMENTO** slider determines the portamento or glissando rate. (0.00 to 2.00 seconds per octave) It is paired with the switch underneath it, which switches between the two settings of **PORTAMENTO** (up) and **GLISSANDO** (down).

There are lots of possible combinations – lots of power for a single footswitch!

5.2.4.2. Tremolo/Chorus

The Tremolo/Chorus on the CS-80 was a relic of the era of electric organs, a simple and rich-sounding pair of effects that could thicken up the instrument's final sound in a very tasty way. The two effects have a somewhat different character, but they both operate in the same way:

- **SPEED** controls the rate of the LFO driving the effect. (Tremolo: 1.18 to 16.3 Hz; Chorus: 0.400 to 1.55 Hz)
- **DEPTH** controls the amount of effect. (0.00 to 1.00)

The **TREMOLO** and **CHORUS** tabs turn the two effects on and off – and you can turn on both at once.

5.2.5. The Service Panel

And now, we get to click on the Service Panel grille at the top of the Main Panel and see what's hiding underneath!

This is a new feature in CS-80 V that's designed to take the model's authenticity to a new level: **Voice Dispersion.**

> This feature cannot be accessed when the Advanced panel is opened.

5.2.5.1. Voice Dispersion

For all its amazing properties, the CS-80 was an astoundingly finicky instrument. It could go out of tune if you looked at it wrong, and retuning wasn't an easy job at all. Yamaha recommended that you not even try to play it until it had warmed up for at least 10 minutes, preferably a half hour, and even then it wasn't guaranteed to behave itself.

Every voice card in the CS-80 had its own performance parameters, calibration, and quirks, that would lead to one voice sounding noticeably different than all the others. This behavior is now modeled in Voice Dispersion.

The left panel has buttons for three preset levels of Dispersion: **1**, which represents an accurately calibrated machine; **2**, representing a sort-of-decently calibrated machine; and **3**, which models a fairly sloppy calibration. These are subtle differences, but they're there.

There is also a **CUSTOM** button where you can set your own Dispersion characteristics. The right panel has a set of seven trimpots per Channel, to represent the Dispersion for seven types of circuits: VCO pitch stability, Pulse Width uniformity, the shape of the sine wave, envelope parameters, filter cutoff from voice to voice, filter resonance alignment, and overall stability of modulation routings. Each of these trimpots goes from a perfect 0.00 to a totally out-of-whack 1.00, so you can make your own particular CS-80 sound as filthy as you want... and get back to perfection with one push of a button.

> All parameters found on the dispersion panel are set per voice.

How cool is that?

6. THE ADVANCED PANEL

Pressing the Advanced button on the Upper Toolbar causes the **Advanced Panel** to pop up.

The Advanced Panel, currently showing the Modulations tab

The Advanced Panel contains a variety of powerful functions that take CS-80 V well beyond the capabilities of the original CS-80. Let's go through them in detail, starting at the top.

The Advanced Panel is organized into three tabs, selected at left: **Modulations**, **Keyboard**, and **Effects**. Each tab's functions can be globally defeated by clicking the Power button at the top right corner of each tab.

6.1. The Modulations tab

The Modulations tab offers several tools to create finely tuned and very complex modulation routings that greatly expand CS-80 V's power. These are contained in two sub-tabs: the three **Functions** and the **Modulation Mixer**.

> Note that the Modulations tab doesn't cover *all* of the modulation routings that CS-80 V is capable of; in fact, many of the simplest and most common ones are found on the Keyboard tab, which we'll get to later.

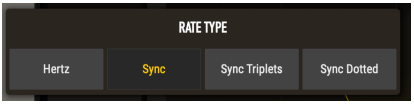
6.1.1. Functions

CS-80 V offers three separate **Functions** that can be saved with each preset. These functions are modulation sources that can affect up to three different destinations in a variety of ways. Each one has its own control panel, selected by the top tabs.

The three Functions are identical in features; Function 1 is shown here.

Across the top of the Function sub-tab are the following functions:

SYNC controls if, and how, the Function is synchronized to the master tempo of your DAW or to other parts of CS-80 V. Clicking it pulls up a small pop-up menu that shows the different units available for the Function's sync: **Hertz** (cycles per second, not tied to any sync clock), **Sync** (standard divisions of notes and bars), **Sync Triplets** and **Sync Dotted** (for triplet and dotted-note sync timing).



The knob next to the **SYNC** pop-up controls the time division: 0.1 to 50 Hertz, and 8 bars to 1/32 note for the three Sync options.

Next are three switches and two modifiers for the Function **Mode**. This is a powerful feature that lets you determine what kind of modulation source the Function is: an Envelope or an LFO, with various types of behavior. These behaviors are reflected in the Function Visualizer [p.75] display below the buttons.

Selecting **ENV** turns the Function into a multi-stage envelope; selecting **LFO** makes the function an LFO with a freely definable waveform; selecting **KEY TRIG** causes the LFO to retrigger with every keypress. Envelopes and Key Trigger settings can be monophonic (any keypress causes the Function to retrigger for all notes already held down) or **POLYPHONIC** (new keypresses don't affect currently held notes).

Clicking the **BIPOLAR** button causes the Function to operate both above and below O (the start/endpoint); otherwise the Function is *unipolar*, with all values above O. The shading of the Visualizer background subtly indicates whether unipolar or bipolar behavior is selected.

The **SCALE** knob determines the overall strength of the Function's effect.

To help get you started creating your own Function, the **PRESET** selector offers 24 'starter' shapes, including a flat line, traditional LFO waveforms and envelope types, rhythms, pseudo-random behavior, and combinations of all of them. Use the arrows to scroll through the options.

Once your Function is ready, you can send it to three different *destinations* to modulate them. Each destination has its own Destination Amount knob, with a range from -1.00 to 1.00. Double click the knob to set it to O.

Clicking on the name of the Destination pops up a window with a choice of 87 parameters (or pairs of parameters for both Channels at once), as shown:

This pop-up is identical for every Destination selection in the Modulations and Keyboard tabs.

6.1.1.1. The Function Visualizer

The *Function Visualizer* is a graphical representation of the Function's behavior. The waveform or envelope shape can be changed directly with the mouse according to various Draw Modes, and individual stages can be altered at will.

1. A hand-drawn Function; 2. an envelope; 3. an example of the Draw Modes

The Function can be shaped to taste using the mouse. Click and drag any of the white *breakpoints* to move it and reshape the wave; click anywhere on the curve to add another breakpoint. Right click on a breakpoint to delete it.

A pair of vertical arrows appears in the middle of the curve between each pair of breakpoints; click and drag up and down to reshape the curve itself. Example 1 shows a complex Function with different curves between each breakpoint.

Controls under the curve let you manually select a point and precisely change its level and place on the curve. Note that the first and last points must always be at the same level so the waveform or envelope starts and stops at the same place. Example 1 shows some of the things you can do.

When you select **ENV** mode, one stage is designated as Sustain and is shown with an **S** in its breakpoint. See Example 2 above.

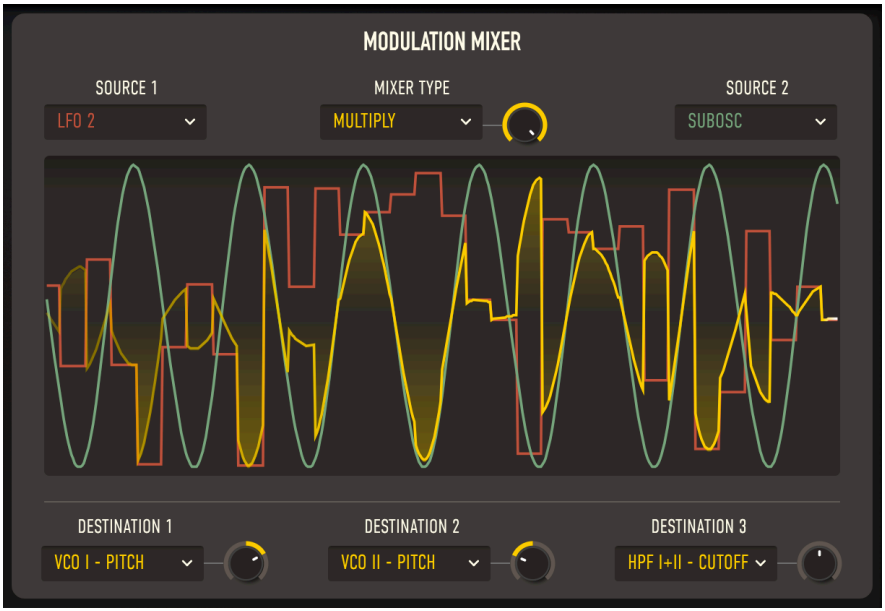
> Double-click on a point to set it as a sustain point.

The **DRAW MODE** control lets you quickly choose between three ways of drawing the curve. The first button operates as described above; the other three buttons let you quickly draw in periodic waveforms, with 16 levels per cycle, simply by drawing a line from left to right with the cursor. Your choices are square (stepped), upward sawtooth (ramp), or downward sawtooth. This is a great way to create rhythmic pulses or other shapes that follow your song's tempo.

Once that's done, you can return to the first Draw Mode and edit each step by hand as usual. Example 3 above shows a sine wave that's been redrawn in various sections using the three different draw modes.

The Function Visualizer also features a grid mode that magnetizes points to a 16-step grid.

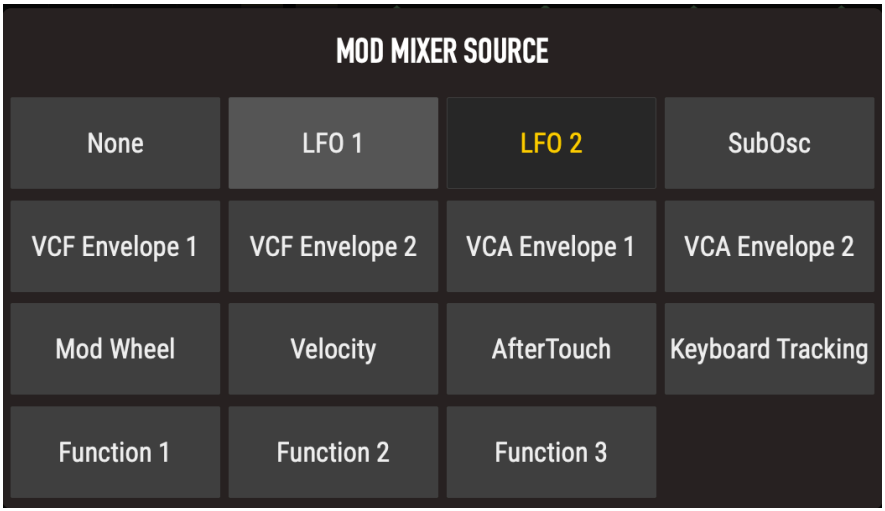
6.1.2. The Modulation Mixer



The Modulation Mixer

Most modulations in a CS-80 preset can be performed by Functions, or by settings in the Keyboard tab, but to create more complex interactions, the **Modulation Mixer** lets you blend two *Sources* in various ways and send the resulting waveform to three Destinations.

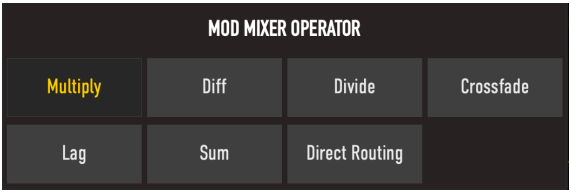
Click on **SOURCE 1** or **SOURCE 2** to select the two modulation Sources from the following pop-up:



The 14 choices (other than None) include the LFOs and Envelopes from the Main Panel [p.52], as well as all four modulations from the Keyboard tab and the three Functions.

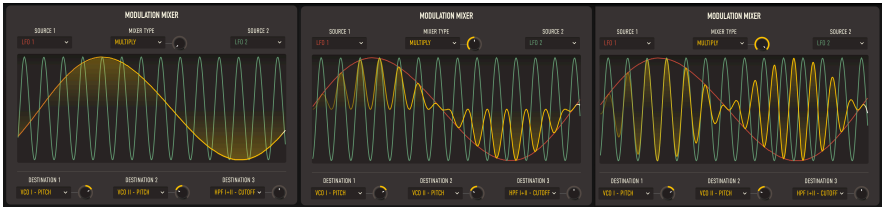
The Modulation Mixer's Visualizer will show Source 1 in red, Source 2 in green, and the Mixer output in yellow.

The **MIXER TYPE** determines how Source 2 modulates Source 1. The Amount knob lets you control the amount of mixing, which will have a different effect depending on the Mixer Type you've chosen. Clicking on the Mixer Type name pops up a window with seven choices:



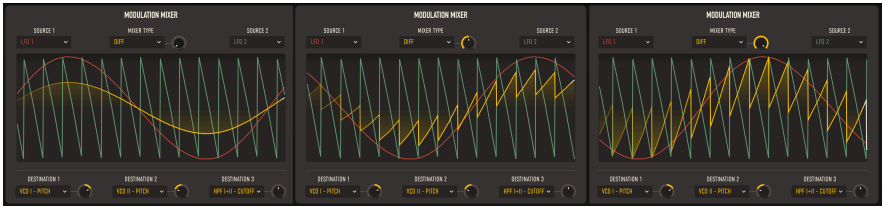
The seven Mixer Types are:

6.1.2.1. Multiply



Multiply: Source 1 and Source 2 are multiplied together. In the example below, LFO 1 (a slow sine wave) is being modulated by LFO 2 (a faster sine wave), with the Amount set to 0, 0.5, and 1.0.

6.1.2.2. Diff

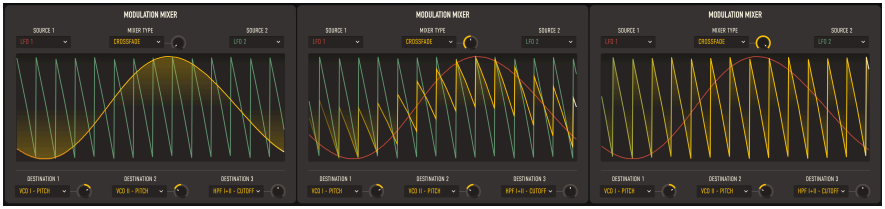


Diff: Source 2 is subtracted from Source 1. In the example below, LFO 1 (a slow sine wave) is being modulated by LFO 2 (a faster sawtooth wave), with the Amount set to 0, 0.5, and 1.0. Note that the waveshape of the difference has the opposite polarity; compare it with **Sum**.

6.1.2.3. Divide

Divide: Source 2 is divided by Source 1. In the example below, LFO 2 (a fast S/H wave) is being modulated by LFO 1 (a slow sine wave), with the Amount set to O, O.5, and 1.O. The division causes wild voltage swings when Source 2 is low and milder ones when it's high; turning up the Amount lessens the effect. This is a great option to experiment with – try it on VCF envelopes!

6.1.2.4. Crossfade



Crossfade: This one is straightforward: as you turn up the amount, Source 1 simply crossfades into Source 2. In the example below, LFO 1 (a slow sine wave) is being crossfaded with LFO 2 (a faster sawtooth wave), with the Amount set to O, O.5, and 1.O.

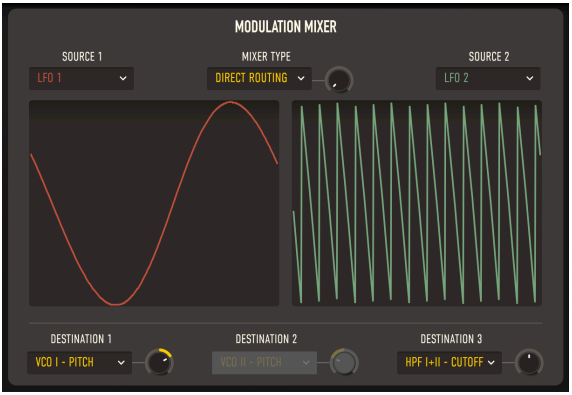
6.1.2.5. Lag

Lag: A *lag processor* takes abrupt voltage changes and smears them out over time. Source 1 has the lag applied, and Source 2 isn't used. In the example below,

6.1.2.6. Sum

Sum: Source 2 is added to Source 1. In the example below, LFO 1 (a slow sine wave) is being modulated by LFO 2 (a faster sawtooth wave), with the Amount set to 0, 0.5, and 1.0. Compare with **Diff**; here, the resulting waveform has the same polarity as Source 2.

6.1.2.7. Direct routing

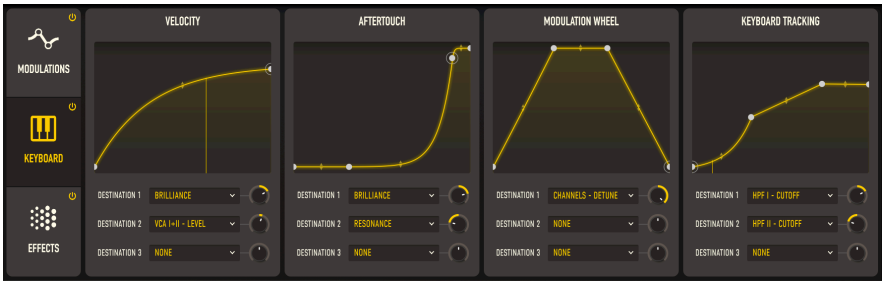


Direct Routing: This option subdivides the Mixer into two separate sources, which can be routed to Destinations 1 and 3 (Destination 2 is deactivated). This is useful when you need a couple more basic modulation paths.

6.2. The Keyboard tab

Some of the most common modulations you'll want to perform are linked to the keyboard and its functions. The **Keyboard tab** provides an easy way to set up these modulations without having to use the Modulations tab.

The Modulations tab is divided into four windows: **Velocity**, **Aftertouch**, **Modulation Wheel**, and **Keyboard Tracking**. Each window has identical features and functions.



The Keyboard tab with its four modulation sources

Each window has its own Visualizer, similar to the Function Visualizer [p.75]. Up to four breakpoints can be placed by clicking with the mouse (right-click to remove a breakpoint), and they can be dragged to appropriate positions, with the small up/down arrows to change the curves between them.

Up to three Destinations can be set, each with its own positive or negative Amount. The window that pops up when you click a **DESTINATION** field is the same as the one for the Modulations tab, with 87 possible Destinations.

The four windows are:

6.2.1. Velocity

This window tailors the chosen Destinations' response to how hard you play the keyboard. In the example shown above, the velocity curve has been set to get louder more quickly at lower velocities, then slowly level out to a maximum output value that is slightly below the full range of MIDI velocity. You might use this to tame the response of a keyboard whose behavior at higher velocities isn't very smooth.

6.2.2. Aftertouch

This window tailors the chosen Destinations' response to how hard you press into the keybed after playing a note. CS-80 V supports *polyphonic aftertouch*, which is a different amount for every note. Keyboards' aftertouch response can vary widely from product to product, so getting a certain keyboard to play the way you want it to can be quite challenge – unless of course you have this window. Here, an overly-sensitive aftertouch response has been "dumbed down" to something more like an on/off switch: there is no response until the player presses hard, then it rises quickly to maximum just a bit before it would normally get there.

> Not all parameters are polyphonic: you cannot have a polyphonic amount on every parameter using this window. We highly recommend using the Hardware view for that.

6.2.3. Mod Wheel

The modulation wheel is the one hands-on controller that's closest to your hands when you play. It's good for gradual or set-and-forget modulations that aren't appropriate for the keyboard. The original CS-80 had no mod wheel, but CS-80 V has MIDI mod wheel data (Control Change 1) as an assignable source. In this example, the mod wheel changes the Detune of both Channels from zero to maximum, a "dead zone" where the wheel doesn't change anything, and then a decrease back down to zero, making it easy to sweep through a zone of detuning and back.

6.2.4. Keyboard Tracking

Keyboard tracking is how a modulation responds to whether the note you're playing is high or low. This is most common in adding brightness to notes that are higher on the keyboard. This window gives you the opportunity to finely tailor how your modulation is affected across the keyboard – something that Yamaha would revisit in great detail with its later FM synthesizers like the DX7.

6.3. The Effects tab

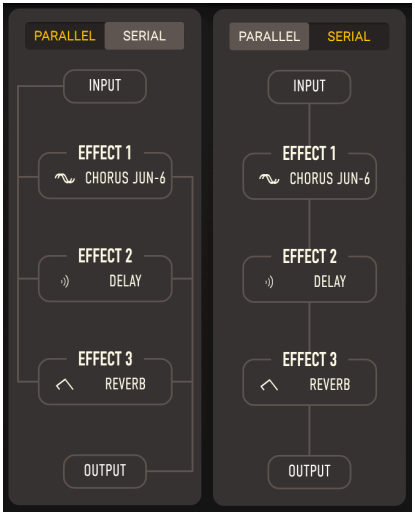
As a final polish to the CS-80 V sound, the **Effects tab** adds up to three different effects (**FX**) to a preset. These can be chosen from a set of 16 different effect types, and routed in various ways suitable to the patch.

The Effects tab

There are a couple of worthwhile general functions that apply to the tab and its individual effects. We'll cover those before getting to meet the effects themselves.

6.3.1. Effects Routing

Guitarists are used to having their effects pedals in long chains, and audio engineers are used to having effects on Auxiliary buses so each input channel can be routed to them in different amounts. Both approaches have their advantages, and the Effects tab allows you to choose between them for each preset.



The Effects tab

The two available routings are **PARALLEL** and **SERIAL**, chosen by clicking the buttons above the graphic.

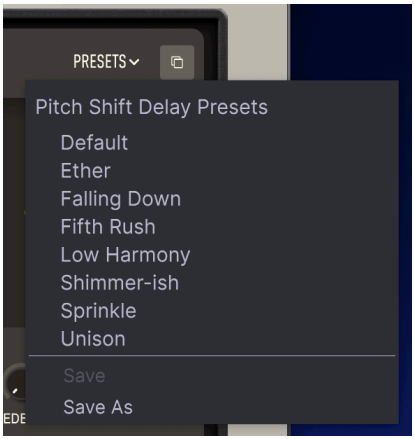
- **Parallel** is similar to how a mixing console works: the input signal is routed to each of the three FX separately, and then those three processed signals are mixed back together and sent to the output. Each of the FX has its own **DRY**/**WET** setting, so the relative amounts of processed (*wet*) to unprocessed (*dry*) sound can be adjusted to taste for each effect. In Parallel routing, the FX don't affect one another's sounds.

- **Serial** is similar to how a guitar pedal chain works: The input signal is sent to FX 1, then FX 2, then FX 3, then to the output. This is important because in Serial routing, FX 2 processes both the wet and dry sound from FX 1, and then FX 3 processes the combined wet and dry sounds from FX 1 and FX 2. Any guitarist can tell you that effects ordering is critical – for example, distortion through reverb doesn't sound much like reverb through distortion! This provides an extra layer of creativity for shaping your sound if you wish.

Certain effects are usually used in serial mode, as you'll want them entirely processed by what comes before them. A good example is distortion, which not only goes before most other effects but is also run 100% wet. Others, like reverb, are usually placed in parallel so that each instrument can be affected by them without influence from the others. There are no set rules – feel free to experiment!

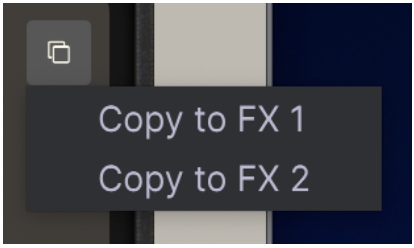
6.3.2. Presets and FX Copy

Every one of the FX has its own menu of **Presets** that drops down when clicked:



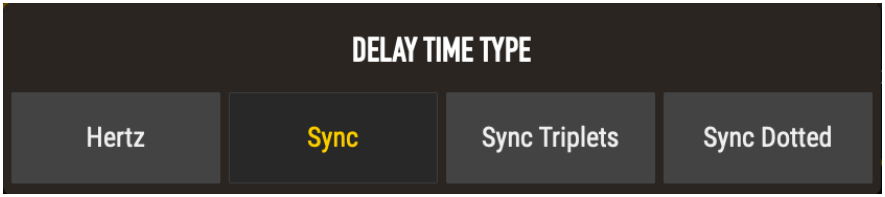
As is common elsewhere in CS-80 V, the option to **Save** an edited preset under the same name, or **Save As** a new name.

If you have one of your FX set up just as you like it but you want to put it elsewhere in the signal routing, click the **Copy FX** icon to get a little drop-down menu of the two other FX in the chain. Click the FX slot where you want to copy your current effect and settings.



6.3.3. FX Sync

As with other time-related operations in CS-80 V, some of the effects offer a variety of sync options. When these are available, you can click the down arrow next to the parameter, which shows the current choice, and change it from this little pop-up:



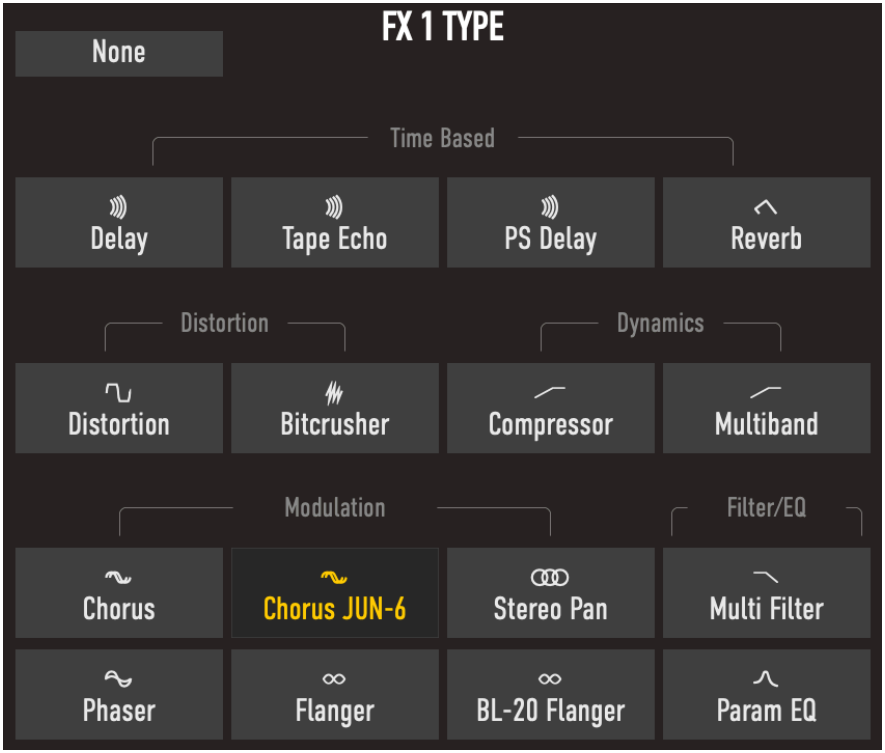
The options are:

- **Hertz**: no sync – time is set in Hertz (Hz), cycles per second
- **Sync**: sync to values of notes or bars
- **Sync Triplets**: sync to triplet values of notes or bars
- **Sync Dotted**: sync to dotted values of notes or bars

> Note that these parameter ranges will be different for every FX type – never be afraid to experiment!

6.3.4. Meet The FX Types

Each of the three FX can be bypassed with the power button at the top left corner of its window. Alternatively, if you're sure you don't need anything in a particular slot, you can select **None** from the pop-up menu of available effects:



Of course, even though "none" might sometimes be the right choice for a certain preset, it's not very much fun. So let's learn about your 16 other options: the FX Types.

6.3.4.1. Delay

DELAY is a generic term for any effect that makes a copy of an input sound and repeats it a short time later. There are several delay FX in CS-80 V, and this first one is a good-sounding digital delay for all kinds of applications.

- **TIME** is the time between echoes. It can be set without sync or with different types of sync, as explained in FX Sync [p.85]. (2 ms to 2 seconds, or 1/32 bar to 8 bars)
- **FINE** is a fine-tuning of the basic Time. Sometimes, having a time just slightly off other synchronized effects can give a sense of richness to the overall sound. (-50 to +50 ms)
- **FEEDBACK** is how much of the delayed sound gets fed back to the input. This produces repeating echoes that fade away, rather than a single delayed copy of the input sound (called *slapback*, useful for some cases). High feedback settings lead to longer trails of echo. (0.00 to 1.00)
- **STEREO SPREAD** controls how much the echoes spread out in the stereo soundstage, from full mono to massive panning. (0.00 to 1.00)
- **HP FREQ** and **LP FREQ** control two filters that shape the tone of the delayed sound. Darker echoes die away with less 'clutter' in the audio, and brighter echoes carry a lingering sense of presence. (HP Freq 20 Hz to 10000 Hz, LP Freq 250 Hz to 20000 Hz)
- **PING PONG** is an effect where echoes alternate between the left and right sides of the stereo field. This effect is easy to overuse, and can cause listener fatigue, but when combined with very subtle echoes it can produce a beautiful sense of extra space.

6.3.4.2. Tape Echo

Tape Echo is a type of delay characteristic of early tape-based delay machines such as the Roland Space Echo. Input sounds are recorded to a loop of tape with one or more playback heads to create the echoes. Because tape loops can be unstable and shift in pitch and timbre, they produce an effect that is warmer and less 'precise' than a conventional digital delay.

- **TIME** is the time between echoes, which has a narrower range than the Delay FX because of the limitations of tape. It can be set without sync or with different types of sync, as explained in FX Sync [p.85]. (10 ms to 1 second, or 1/32 bar to 8 bars)
- **FINE** is a fine-tuning of the basic Time. Sometimes, having a time just slightly off other synchronized effects can give a sense of richness to the overall sound. (-50 to +50 ms)
- **INPUT VOL** is an adjustment of the input gain, not only to make the sound louder or softer, but to gently saturate the tape and produce a warm character at higher settings. (-12 dB to +12 dB)
- **INTENSITY** is another word for feedback – the intensity and persistence of the echoes. The parameter ranges from 0.00 (slapback) to 1.20. Settings above 1.00 can cause the echoes to be louder than the input. This phenomenon is called *runaway* and leads to an ever-increasing audio level that will eventually overload, then distort, then clip... and will keep getting louder until it eventually destroys your headphones, your speakers, and your ears. Please use it responsibly and be ready to turn it down.

- **STEREO SPREAD** provides a sense of spaciousness by having one side of the stereo image have a slightly different delay time than the other. (0.00 to 0.20)
- **PING PONG** is an effect where echoes alternate between the left and right sides of the stereo field.

6.3.4.3. Pitch Shift Delay

Pitch Shift Delay is a classic effect dating back to the early years of digital audio processing, popularized by the Eventide Harmonizer. It works like a conventional delay, but in addition to being fed back to create echoes, the delayed audio signals are subjected to a pitch shift, either up or down.

- **TIME** is the time between echoes. It can be set without sync or with different types of sync, as explained in FX Sync [p.85]. (16 ms to 2 seconds, or 1/32 bar to 8 bars)
- **STEREO OFFSET** is a positive or negative time difference between the left and right Time settings. This produces a realistic widening of the sound due to a psychoacoustic phenomenon called the *Haas Effect*. (-50 to +50 ms)
- **FEEDBACK** is how much of the delayed sound gets fed back to the input. Settings range from 0.00 (slapback) to 1.00 (infinite repeats without runaway).
- **STEREO DETUNE** controls how different the left and right channels' pitches are. (-100 to +100 cents, where 100 cents equals one semitone)
- **PITCH SHIFT** is the base amount that echoes are shifted by. As they repeat, they will be shifted repeatedly, producing an endless spiral upward or downward in pitch. Very subtle amounts can produce a feeling of anticipation (up) or relaxation (down); larger amounts can produce strange, inharmonic results or smoother and more musical 'boom' or 'shimmer' (try setting it to octaves). Pitch shift can be set to 24 semitones (2 octaves) up or down.

- **SPRAY** sets up a 'scattering' effect across the soundstage for each successive echo, with slightly randomized echo times. It's especially noticeable at higher amounts of pitch shift. (0.00 to 500 ms)

- **HP FREQ** and **LP FREQ** control two filters that shape the tone of the delayed sound. Darker echoes die away with less 'clutter' in the audio, and brighter echoes carry a lingering sense of presence. (HP Freq 20 Hz to 10000 Hz, LP Freq 250 Hz to 20000 Hz)

You also have three modes available in the upper-left corner of the visualizer: Normal, Oct. Up, and Oct. Down, as shown below.

6.3.4.4. Reverb

Reverb (or *reverberation*) is the sound of a space – a recording studio, a concert hall, a stairwell, a tiled bathroom, the inside of an empty oil tanker, you name it. Reverb is often considered the most essential effect for the CS-80, and so there's an easy-to-use one as our first choice for CS-80 V.

- **SIZE** is the overall size of the space, a general sense of how open it is. (0.100 to 1.50)
- **PREDELAY** is how long it takes for the first reflected sound to come back to our ears. Longer predelays imply a larger space. (0.00 to 0.20 seconds)
- **DECAY** is how long the reverb takes to decay to silence. It interacts with Size to define the shape of the ambience. (0.00 to 0.925)
- **DAMPING** is how quickly high-frequency sounds roll off before low-frequency sounds in the space. More damping implies a space full of objects or materials that absorb highs first: carpets, ornate wood, even people. Less damping implies a more 'ringy' space with concrete or tile walls. (0.00 to 1.00)
- **STEREO WIDTH** is just what it sounds like: how wide the reverberant image is. It may seem strange to want anything less than full stereo, but remember that old spring and plate reverbs were all mono, as were the earliest 'echo chambers' in studios. Sometimes less width means more depth. (0.00 to 0.500)

- **INPUT HP** rolls off the low frequencies of the input before it hits the reverb. This takes out low-end mud and makes the reverb brighter-sounding. Like any high-pass filter, this one has a cutoff frequency setting: 30 Hz to 10000 Hz.

- **INPUT LP** rolls off the high frequencies of the input before it hits the reverb. This softens the overall sound and removes overly tinny treble effects. Its cutoff frequency ranges from 100 Hz to 20000 Hz.

6.3.4.5. Distortion

Distortion offers the most options of any CS-80 V FX type. It might seem strange to you that all this effort should be put into a 'fuzzbox', but electronic musicians have known for years that there are many different kinds of signal distortion, each with its unique sonic signature – and they can transform sounds in ways ranging from subtle warmth to all-out audio holocaust! This effect can be supplemented by a multi-mode filter that can be applied either before or after the distortion.

Nearly all of the FX parameters are common to all 16 distortion types:

- **DRIVE** controls the amount of overdrive pushing the input signal through the processor. It has a very wide range, from slight saturation to massive boost. (0.00 to 48.0 dB)
- **TONE**: This control, found only in the **Overdrive** type, adjusts the frequency response of the overdrive from mellow to bright. (0.00 to 1.00)
- The **AUTO** button engages automatic gain compensation to prevent *unintended* overload peaks. (Yes, those happen, even when you're using distortion.)
- **OUT GAIN** sets the output gain of the distorted sound, either lower (to prevent clipping) or higher (to add power) than the input level. (-24.0 to 3.00 dB)

The filter controls are:

- **CUTOFF** sets the filter cutoff frequency. (20.0-20000 Hz)
- **RESONANCE** controls the filter's resonant peak. (0.500 to 15.0)
- The **FILTER TYPE** pop-up sets the filter to Low Pass, High Pass, or Band Pass.
- The **PRE**/**POST** pop-up controls whether the filtering takes place before or after the distortion.
- **DARK** tames the extreme high-end content that some of the distortion types can produce.

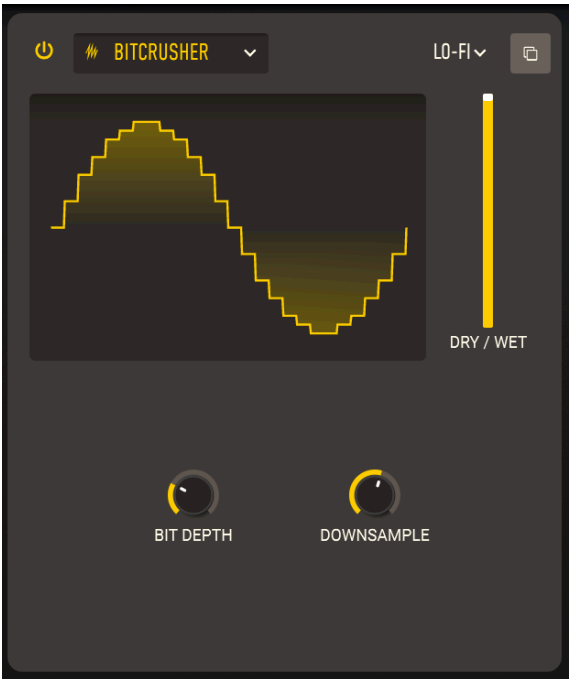
A pop-up menu lets you select from among 16 different types of distortion.

Some of these algorithms come from familiar types of analog distortion – examples include gradually increasing amounts of gain (**Overdrive**, **Exponential**, **Soft Clip**, **Distortion**, **Hard Clip**), **Tape** saturation, and **Germanium** transistor preamp tone.

Other distortions are more digital in character – in addition to **Wavefolder** and **Dual Fold**, which 'fold over' the peaks of waveforms to create more harmonics, there are unusual types such as **Asymmetrical**, **Wiggle**, **Stairs**, **Howl**, **Core**, **Push**, and **Climb**.

Want to know how all these funky shapes sound? Try them for yourself!

6.3.4.6. Bitcrusher



A bitcrusher does what it sounds like: it crushes bits! This FX simulates the 'dirty' audio of old digital converters, whose bit depth and sample rate were limited by the power of current processors. It gives you anything from a slight lo-fi haze to utter destruction of your precious sound.

- **BIT DEPTH**: Sets the resolution of the output from 16 bits (CD quality) down to 1.5 bits (barely recognizable as audio).
- **DOWNSAMPLE**: sets the ratio by which the instrument's internal sample rate is divided, from 1.00 x (highest quality) to 80.0 x (trashed). The more downsampling, the more *aliasing* affects the sound, with inharmonic frequencies 'folding down' below the highest frequency the bitcrusher can deliver.

6.3.4.7. Compressor

The **Compressor** is used to control the dynamic range of a sound: it reduces the difference between the softest and loudest levels a sound can have.

Audio that goes above a certain **Threshold** is automatically turned down a bit; the amount it's turned down is the **Ratio**. Ratio of what? If a sound would have gone 6 dB above the threshold but the compressor only lets it rise 2 dB, that's a 3:1 ratio. If a sound would have gone 20 dB above the threshold but it can only go up 1 dB, that's a 20:1 ratio.

While this does lower dynamic range, it also lowers the overall level of the signal. The compressor then adds *makeup gain* to bring the average level of the signal up to where it was before the processing. The loudest sounds stay about where they were, but the softest ones are all louder.

Sometimes it's practically or musically useful for compression to not start or end immediately when a signal passes the threshold. For instance, it might be nice to let the snappy attack of a drum come through before the compressor controls the rest of its sound, or to have the compressor not turn on and off rapidly as new notes are played. In these cases, the compressor will have controls for **Attack** and **Release** to delay the onset or finish of compression.

Sometimes it's useful to blend the dry sound with the compressed sound, making the compression an added effect rather than a 100% control of dynamics. You can do this with the **DRY/WET** slider.

- **ATTACK** controls the onset of the compression. (0.010 to 1000 ms)
- **RELEASE** controls how quickly the compression 'lets go' of the audio. (1.00 to 2000 ms)
- **THRESHOLD** controls the level at which compression begins. (-60 to +20 dB)
- **OUTPUT GAIN** controls how much gain will be added or removed from the output. (-36 to +36 dB)
- **MAKEUP** is an automatic makeup gain control that you might find works very well for you.
- **RATIO** The ratio of uncompressed to compressed level changes. (1.00 to 100)

At 1.00, no compression occurs. Most of the range of the **RATIO** knob happens between 1.00 and 20.0; this covers everything from very light and musical to more forceful compression. Above 20, compression becomes *limiting*, where the idea is to prevent a signal from never going above a certain amount. Hard limiting can have a strong effect on the sound, which might or might not be useful. The top of the range is 100 to 1, which is effectively *brickwall limiting*, where no signal is ever allowed to go above a certain level. This is often used for digital mastering to prevent clipping.

6.3.4.8. Multiband

A multiband compressor works like a series of regular compressors, but each one works on a separate range of frequencies (*band*). First used in hardware to allow mastering engineers to squeeze the absolute maximum level out of recordings, these compressors are now used for subtle sculpting, sound design, special effects, and much more.

As you can see in the screenshot above, the display shows controls for three different frequency bands from left to right. The crossover frequencies for the boundaries between the low and mid bands (30-3000 Hz), and for the mid and high bands (300-15000 Hz), are shown below the display. If the low and/or high bands are turned off, the compressor will cover two bands, or the full range of frequencies.

Each band's compressor can work to compress signals above one threshold and/or expand signals below another threshold. The bar graphics control the threshold and ratio for each band/compressor/expander.

Set the threshold amount by clicking and dragging the top/bottom edges of a bar – a pop-up tooltip will show the current value. Set the ratio by clicking and dragging up and down inside a bar; the density of horizontal lines will increase until it becomes solid as the ratio goes up. For ratios under 1:1 (expansion), the lines will be further apart than the 1:1 reference lines shown outside the bars.

- **AMOUNT**: Rather than wet/dry mix, this FX type has an Amount control.
- **OUT LOW**, **OUT MID**, and **OUT HIGH** control the makeup gain for each of the three bands.
- **INPUT** and **OUTPUT** control the overall input and output gain.
- **ATTACK** and **RELEASE** adjust the onset and removal of compression (-1.0 to 1.0)

A drop-down menu lets you choose between combined compression and expansion (**ABOVE & BELOW**) and compression alone (**BELOW ONLY**).

6.3.4.9. Chorus

Chorus is an effect first developed in the mind-1970s by Roland for the Jazz Chorus amplifier and CE-1 pedal. In a chorus, the dry signal is mixed with one or more slightly delayed copies of itself (called *voices*), whose amount of delay is gently varied by an LFO to create a sense of thickness.

- **RATE** controls the speed of the LFO, which is the most important parameter when adjusting the sound of the chorus. Several famous chorus pedals have had nothing more than a Rate control! (0.1 to 5.0 Hz)
- **DEPTH** controls the relative spacing of the delayed voices, with longer delays leading to thicker, more detuned sounds. (0.00 to 10.0 ms)
- **DELAY** is the length of the basic delay, which is modulated by the LFO and spread out by the Depth knob. It changes the character of the sound, and is a relatively recent addition to chorus pedal designs. (0.600 to 20.0 ms)
- **FEEDBACK**, as the name implies, feeds back some of the delayed signal to be delayed again. This creates a noticeable metallic 'ringing' tone that makes the chorus sound more like a flanger. (0.00 to 0.900)
- **LFO Wave Shape** lets you choose between a sine wave and triangle wave for the LFO, which produces a distinctly different set of motion to the sound.
- **MONO/STEREO** chooses whether or not the delay voices are output on the far left and right sides of the stereo field.
- **VOICES** chooses whether the dry signal is followed by one, two, or three delayed copies. This is an important setting, because the overall power of the chorus effect needs to be adjusted to the preset and the song. Sometimes one voice is all you need for a tiny bit of thickening or vibrato, but three voices is overwhelming. (Of course, getting overwhelmed can be fun, too.)

6.3.4.10. Chorus JUN-6

One of the most famous chorus effects is the one built into the Roland JUNO-6 synthesizer and its successors. Designed to thicken the sound of the single VCO, this 2-voice stereo chorus' controls were kept extremely simple: just three buttons for three presets, I, II, and I+II. This version provides bit more control while saving the rich timbre of the original.

- **RATE** is the speed of the LFO that varies the delay time. It can be set without sync or with different types of sync, as explained in FX Sync [p.85]. (0.05 to 15 Hz, or 1/32 bar to 4 bars)
- **DEPTH** is the amount of variance in the set delay time. (0.00 to 10.0 ms)
- **PHASE** allows the phase of one voice to be offset from the other by up to 180°. The two voices are sent to the left and right sides of the stereo field for a wider effect.

> Note that if a stereo patch where Phase is turned all the way up is mixed to mono, the two sides will cancel each other out and the chorus will disappear – a common and annoying discovery for guitarists whose stereo chorus pedals always worked this way!

6.3.4.11. Stereo Pan

Stereo Pan lets you automatically control and move the stereo position of each voice, to provide motion and breadth.

- **AMOUNT**: Rather than wet/dry mix, this FX type has an Amount control to control the width of the panning effect. (0.00% to 100%)
- **RATE** controls the movement of sounds in the stereo field. It can be set without sync or with different types of sync, as explained in FX Sync [p.85]. (0.100 to 20.0 Hz, or 1/32 bar to 8 bars)
- **MONO BASS** and **CUTOFF**: Sometimes, autopanning very low sounds can cause a mix to feel seasick and unbalanced. Clicking Mono Bass keeps low frequencies centered, and Cutoff controls the highest frequency that's mono. (50.0 to 200 Hz)
- **Pan Mode (LINEAR/NATURAL)** lets you choose between two types of pan motion, either of which might sound better with any particular preset. Use your ears!
- **INVERT** inverts the LFO output. The sound is the same, but if another Stereo Pan is set up in Parallel routing, inverting one LFO and synchronizing the two panners produces centered effects that widen and shrink the stereo field, as one panner moves the sound left while the other moves the sound right.

6.3.4.12. Phaser

The **Phaser** or *phase shifter* is not a time-delay effect, although it can sound like one. The dry signal is mixed with copies of itself that have been sent through a set of *all-pass filters*. Why would anyone need a filter that doesn't filter anything? Because another property of filtering is that regardless of what frequencies you do or don't remove, filters introduce a *phase shift* with respect to the original input. Each pair of these filters (called *poles* or *stages*) will create a notch in the frequency spectrum, whose relative movement to other notches can be varied with an LFO. The resulting effect has many fewer notches than flanging, and a much different sonic character.

- **RATE** is the speed of the LFO that varies the delay time. It can be set without sync or with different types of sync, as explained in FX Sync [p.85]. (0.10 to 10 Hz, or 1/32 bar to 4 bars)
- **FREQUENCY** varies the overall position of the cluster of notch filters. Best heard with Stereo turned down, Frequency causes the overall tonality of the phasing to go from fairly dark to quite bright. (30 to 15000 Hz)
- **FEEDBACK** controls how much of the phase-shifted audio is fed back into the input to be phased again, intensifying the effect and giving it a resonant character. (0.00 to 0.990)
- **LFO AMOUNT** sets the depth of the LFO's modulation control. Turn it down for a more subtle movement and up for more dramatic effects. (0.00 to 1.00)
- **N POLES** controls how many poles the circuit will have. Each two poles adds another notch to the frequency response, letting you design simpler or more dramatic sounds. (2 to 12, for 1 to 6 notches)
- **STEREO** spreads out the effect with a slight time delay between the left and right sides. It can go from very slight spread to a ping-pong effect. (0.00 to 180)
- **LFO Wave** is selected from the waveform button on the display. It opens a drop-down menu of six different waveforms, each of which will produce a significantly different phasing.

6.3.4.13. Flanger

The **Flanger** is the most intense of the time/modulation effects. It originally came from audio engineers gently pressing on the flange (rim) of a moving tape reel to slow down the playback a tiny bit. When combined with the original sound, this effect produced *comb filtering*, a set of regularly spaced notches in the frequency response that look like the teeth of a comb. Varying the pressure on the flange would cause the notches to move, producing the effect we hear as flanging. Later, analog delays controlled by an LFO were used to create the same sort of effect.

- **RATE** is the speed of the LFO that varies the delay time. It can be set without sync or with different types of sync, as explained in FX Sync [p.85]. (0.010 to 10 Hz, or 1/32 bar to 8 bars)
- **DELAY** is the length of the basic delay, which is modulated by the LFO and spread out by the Depth knob. Flanger delays are the shortest of any modulation pedal – longer delays become chorus, then echo. Originally called *Manual* on early flangers, this parameter sets the overall tonality of the flange from bright to dark. (0.001 to 10.0 ms)
- **DEPTH** is the amount of variance in the set delay time. (0.00 to 10.0 ms)
- **FEEDBACK** controls the amount of delayed sound fed back into the input to be delayed again. Unlike chorus, where feedback is an unusual added control that's best used sparingly, Feedback on a flanger is essential to creating its distinctive resonant timbre. (0.00 to 0/990)

- **HP FREQ** and **LP FREQ** control two filters that shape the tone of the delayed sound. This control, unusual on a flanger, allows the effect to focus on a particular tonal range or to ignore extreme lows and highs. (HP Freq 30 Hz to 800 Hz, LP Freq 1000 Hz to 20000 Hz)

- **MONO/STEREO** chooses whether or not the delay voices are output on the far left and right sides of the stereo field.

- **LFO Waveform and Feedback polarity**: These two buttons appear on the flanger display. One changes the LFO waveform from a sine to a triangle, producing a dramatically different flange; the other inverts the polarity of the feedback, producing two different tonal spectra.

6.3.4.14. BL-20 Flanger

The **BL-20 Flanger** is based on the sound of Arturia's Flanger BL-20 plug-in, which is in turn based on the sound of a rare but beautiful-sounding hardware flanger from the 1970s. It doesn't provide all of the BL-20's capabilities, but it still sounds amazing!

- **RATE** is the speed of the LFO that varies the delay time. It can be set without sync or with different types of sync, as explained in FX Sync [p.85]. (0.017 to 5.00 Hz, or 1/32 bar to 8 bars)
- **DEPTH** sets how much the internal LFO modulates the delay time. (0.00 to 1.00)
- **DELAY** is the length of the basic delay, which is modulated by the LFO and spread out by the Depth knob. (0.00 to 1.00)
- **FEEDBACK** controls the amount of delayed sound fed back into the input to be delayed again. Unlike chorus, where feedback is an unusual added control that's best used sparingly, Feedback on a flanger is essential to creating its distinctive resonant timbre. (0.00 to 0/990)
- **WIDE**: This button flips the LFO modulation in the right channel, making the flange sound wider and more three-dimensional... but beware of summing the two sides to mono, or the flanging will cancel itself out!
- **MONO INPUT**: This switch selects whether the circuit's input is mono or stereo.

6.3.4.15. Multi Filter

Sometimes it's nice to have an extra filter handy for tweaking your tone before it gets to the output. The **Multi Filter** FX gives you five to choose from!

- **Filter Type** is selected from the dropdown menu by clicking the arrow next to the type name. Types include: lowpass (**LP**), highpass (**HP**), bandpass (**BP**), feedback comb filter (**CombFB**), and feed forward comb filter (**CombFF**). The comb filters simulate the behavior of a flanger with two different tonal qualities – CombFB produces a series of evenly spaced peaks, and CombFF produces evenly-spaced notches.

> Evenly spaced? You can see on the display that they're not. Well, actually they are – by *frequency*, not by octave. The display is scaled in octaves, and each octave is *double* the frequency of the one below it. As a result, the display shows a series of peaks that gradually get closer together.

- **CUTOFF**: sets the cutoff frequency from 20.0 Hz to 20000 Hz (LP, HP, BP) or 2000 Hz (CombFB, CombFF)
- **RESONANCE**: sets the resonance of the filter. (0.500 to 15.0)
- **SLOPE**: lets you choose between 12dB/octave slope, 24 dB/octave slope, and 36 dB/octave slope.

6.3.4.16. Parametric Equalizer

A **Parametric Equalizer** lets you sculpt tone very precisely, as opposed to the very broad tonal strokes you get from a graphic equalizer or the tone controls on a guitar or amp. It can be used to gently or surgically boost or cut certain frequencies to alter a track's overall sound or remove problem frequencies.

Each of the five bands has its own controls for the center frequency, amount of boost or cut, and bandwidth (Q). These can be dialed in on the knobs for the selected band. Frequency and gain for each band can also be set by clicking and dragging the mouse.

- **SCALE**: Rather than wet/dry mix, this FX type has a Scale control.
- **Band Select**: Selects the band being adjusted. The Parametric EQ has five bands: **LS** (a *low shelf*, where every frequency below the set one is raised or lowered by a certain amount), three *peaking* bands with full control over all parameters, and **HS** (a *high shelf* that works in the same way as the low shelf).
- **FREQUENCY** sets the center frequency of each band: 50.0-500 Hz for LS, 40.0-20000 Hz for the three peaking bands, and 1000-10000 Hz for HS.
- **GAIN** sets the amount of boost or cut. (-15.0 to 15.0 dB)
- **Q** sets the bandwidth of the peak or steepness of the shelf. (0.100 to 2.00 for LS and HS, 0.100 to 15.0 for the three peaking bands)

> In the screenshot above, the Parametric EQ has been set to tightly notch out hum at 60 and 120 Hz, gently boost the lows and lower the highs, and provide a broad bump in the upper mids.

6.4. The end (for now)

And with that, we've concluded our tour of CS-80 V, and now it's time to get programming!

Even though you've learned enough to find your way around CS-80 V, you might want to learn a bit more about the basic synthesis principles behind it, especially if you're new to subtractive synthesis. If so, head over to the next chapter.

7. THE BASICS OF SUBTRACTIVE SYNTHESIS

There are many forms of synthesis available today. The most common form, *subtractive synthesis*, was pioneered on the first commercial synthesizers in the 1960s and has become a guideline for the designers of many synths that came afterward. If you learn the basics of subtractive synthesis, you'll find yourself able to find your way around the vast majority of synthesizers – even new ones based on digital processes like sampling, ROM playback, wavetable scanning, and vector synthesis.

While the original CS-80 (and therefore, naturally, also the CS-80 V model) has a few unique elements to its architecture – after all, it was one of the very first polyphonic synthesizers in the world, and Yamaha's engineers were making it up as they went – it still serves as an excellent platform for learning the basics of how synthesizers work.

7.1. The Signal Path and its elements: VCO, VCF, VCA

When we talk about the *signal path* of a synthesizer, we're referring to the path that sound takes from its moment of creation until it leaves the synthesizer to be heard. While there are endless variations, the basic signal path looks like this:

- First, we must create the basic waveform of the sound, with a certain harmonic structure. We do that with an *oscillator*.
- Next, we shape the tone of this waveform by altering its harmonic content over time. We do that with a *filter*.
- Finally, we shape the amplitude (loudness) of the waveform to create individual notes. We do that with an *amplifier*.

In analog synthesizers like the CS-80, these three elements can have their properties changed in real time by electrical signals called *control voltages*. We therefore say that these elements are *voltage controlled*. Let's learn about them now, one by one.

7.1.1. The Voltage Controlled Oscillator (VCO)

The VCO is where we create the initial waveform that we then sculpt to form our synthesized sound.

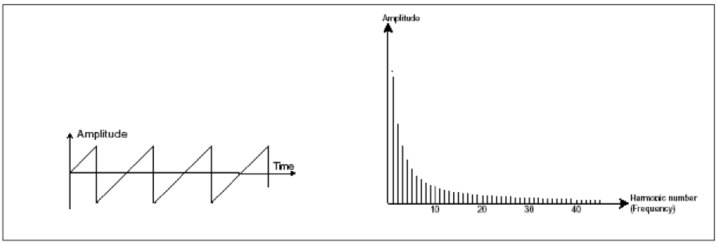
The main properties of a VCO are:

- The **frequency**, which determines the *pitch* that we hear. You can set the frequency of the oscillator with two controllers:
    - First, we set the *octave* of the oscillator. On various synthesizers, it may be named **Frequency**, **Coarse Frequency**, **Octave**, **Range**, or even (as on the CS-80) **Feet**.
    - Second, the **Detune** setting (also called **fine tune**) allows you to tune the oscillator more precisely, from tiny amounts to intervals like a fourth or fifth.

! Why "Feet"? When developing synthesizers, many manufacturers indicated octaves the same way they were indicated on electric organs, which in turn got their settings from pipe organs: by the length of the pipes. Doubling the length would drop the pitch by one octave: 2', 4', 8', 16', etc. Many companies used the numbers, but few actually called the control "Feet".

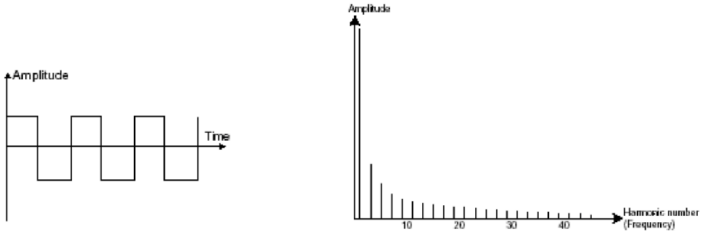
On the CS-80V, the octave (FEET I/II) and detune (DETUNE) are found to the left of the Tone Selector buttons.

- The **waveform**, which determines the harmonic richness of the audio signal. On the CS-80V, 4 waveforms are available:
- The **sawtooth** presents the richest audio signal of the 4 waveforms (it contains all of the harmonics at decreasing volume levels in higher frequencies). Its sound is ideal for brass sounds, percussive bass sounds, or rich accompaniments.



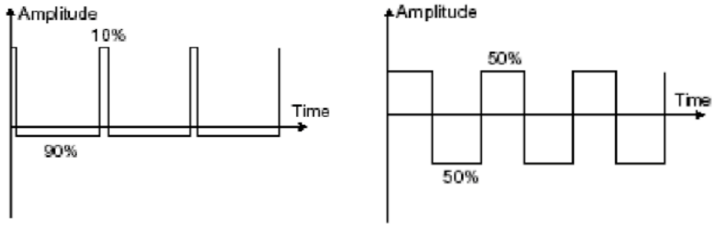
Shape and harmonic content of a sawtooth wave

- The **square** possesses a hollower sound than the sawtooth (it only contains odd harmonics). Nonetheless, its rich sound (notably at lower frequencies) can be used for bass sounds that will come out well in the mix (the square oscillator is often set an octave below that of the sawtooth), 'woody' sounds (like a clarinet, if the square signal is filtered), etc.



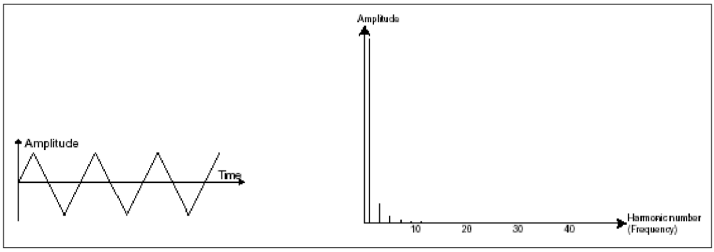
Shape and harmonic content of a square wave

- **Pulse Width** (**PW**) and **Pulse Width Modulation** (**PWM**) refer to setting the shape of a square wave to be asymmetric, with the "up" part of the wave a different length than the "down" part. This causes a change in harmonic content to make the sound "thinner". We could say that a square wave is a special case of a **pulse** wave, where the pulse width is 50%.
  Pulse Width Modulation (**PWM**) changes the pulse width over time, causing a sweeping change in harmonic content. The change can be controlled with an envelope to have it happen once per note, or an LFO to have it happen in a repeating cycle.



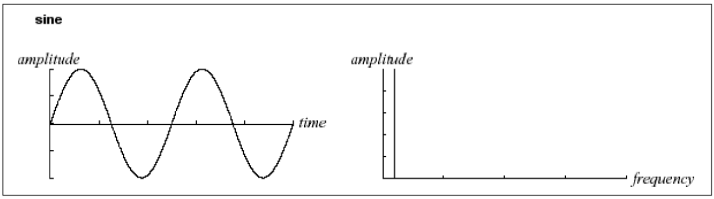
Pulse waves with different pulse widths

- The **triangle** is a wave with few (and only odd) harmonics. It's a very soft sound that's useful for creating sub basses, flute sounds, etc.



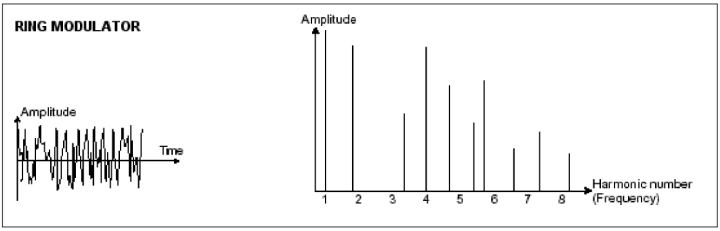
Shape and harmonic content of a triangle wave

- The **sine** is the purest of all waveforms: it has only one harmonic, the *fundamental*, and nothing higher. Because it contains a single frequency, it can be used to modulate another oscillator to create specific harmonics, or just sent out on its own to provide an extra boost of power for a bass sound. On the CS-80, the sine wave bypasses the filter because there's nothing to filter but one harmonic, and that can be turned up and down manually to set its level.



Shape and harmonic content of a sine wave

- A **ring modulator** can be created when an oscillator modulates another oscillator. On CS-80 V, the **Ring Modulator** controls are to the left of the Tone Selector buttons. The ring modulator combines the VCO sounds with another VCO built into it, and outputs the sum and difference of their frequencies. If the ring modulator **Speed** is set very slow, it produces tremolo; if the **Speed** is increased, it creates powerful and clangorous extra harmonics that are great for bells and other metallic sounds.



Ring modulation

- There's one more sound source available on CS-80 V: **Noise**. Noise is a combination of all frequencies at the same time. When the distribution of frequencies is equal, we call that *white noise*. Changing the frequency distribution changes the *color* of the noise; a common alternative to white noise is *pink noise*, which has more lower frequencies than higher ones and sounds more "natural" to the human ear. Noise can also be used as a control voltage signal to alter the behavior of other modules.

On modular synthesizers, a noise source is usually a separate module. On internally-wired synths, noise can be a choice of one VCO's waveform, a separately mixable part of one VCO's output, or a separate source that is mixed in later. On CS-80 V, both VCOs have a mixable noise waveform, and the Sub Oscillator can be set to produce noise.

7.1.2. The Voltage Controlled Filter (VCF)

The waveform from a VCO can change over time in some ways (e.g. sync or PWM), but the real power to shape its tonal content comes when its output is sent to a VCF. The filter lets us change the harmonic content of the waveform over time in predictable ways that shape its overall tonality. In analog synthesizers, the VCF is often considered the most important sonic element, as its character colors nearly every sound the synthesizer makes.

Depending on its settings, a filter removes (subtracts) certain ranges of frequencies from the sound. That's where the term *subtractive synthesis* comes from!

The main parameters of a VCF are:

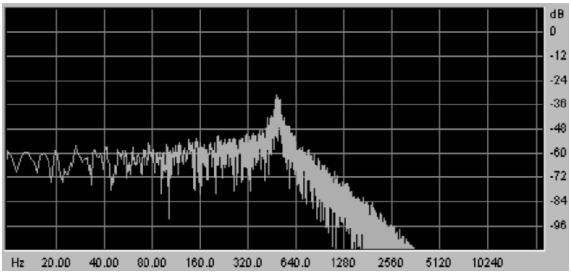
- The **Cutoff Frequency**, sometimes called **Cutoff** or even just **Frequency**, is the frequency where the filter starts to remove audio. It's the primary control for all types of filters.

> ! Cutoff is considered by many to be the single most important control on the entire synthesizer – in fact, on some synths its knob is deliberately made much larger than all other knobs so it's quick to get at.

- The **Filter Type** controls whether frequencies are removed above, below, or around the cutoff frequency.

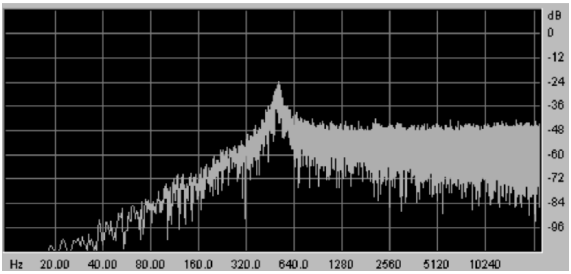
On the CS-80V, you have access to three filter types:

- The **low-pass filter** (**LPF**) removes frequencies above the cutoff frequency. Lowering the cutoff causes a sound to become "warmer" or "duller" as high frequencies are gradually removed. The LPF is by far the most common filter type, and many synthesizers only have an LPF.



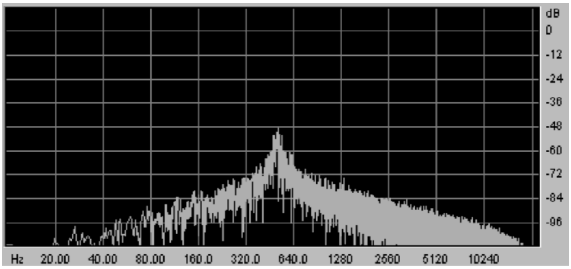
The low-pass filter

- The **high-pass filter** (**HPF**) removes frequencies below the cutoff. Raising the cutoff makes a sound get "brighter" or "thinner"; it's useful for removing low frequencies from sounds that would otherwise be too bass-heavy. It's somewhat common for a synthesizer to have a HPF before the LPF, as the CS-80 does. (You won't find a synthesizer with only an HPF; they're not that useful for making conventional sounds on their own.)



The high-pass filter

- The **band-pass filter** (**BPF**) technically isn't a filter of its own on the CS-80 or CS-80 V. It's what you get when you put the two filters, HPF and LPF, in series and adjust their cutoffs so that only a certain band of frequencies around the cutoff gets through.

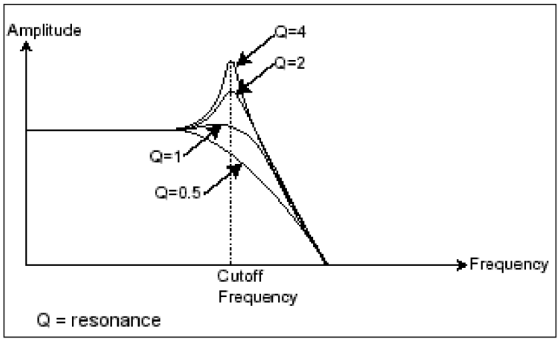


The band-pass filter

- The **Slope** determines how quickly sound is attenuated as you move away from the cutoff frequency. A shallow slope is gentler at removing frequencies than a steep slope. Slopes are measured in decibels of attenuation per octave past the cutoff frequency.

- The **Resonance**, (sometimes called **Emphasis**, **Peak**, or even just **Q**) determines how the filter adds harmonic content right at the cutoff frequency.

Resonance is a natural property of filter circuits. As you turn it up, the cutoff frequency itself is strongly emphasized over the frequencies on either side of it, bringing out a precise tone over the sound of the VCOs. If you turn the resonance up high enough, the filter will begin to *self-oscillate*, creating a sine wave "whistle" right at the cutoff frequency, with the VCO sound nearly or completely gone. If you set up the filter cutoff to follow the keyboard's pitch, you can "play" the filter as a sound source.



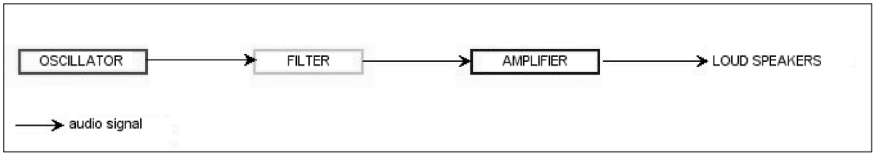
Resonance: low vs. high amounts

7.1.3. The Voltage Controlled Amplifier (VCA) and the full signal path

The VCA receives the audio signal coming from the VCF (or directly from the oscillators, if they bypass the VCF) to adjust the signal volume.

Many synthesizers have only an overall VCA volume control, or no direct controls at all; they rely on the VCA envelope to start and stop notes and control their loudness over time. The CS-80 VCA has a final **Level** control after its envelope.

When we put all the pieces together, our signal path looks a bit like this:



The CS-80 V signal path

7.2. Modulation: making the sound change

We now have a sound we can change in various ways – we can alter its pitch, its waveform and harmonics, its overall frequency spectrum, and its loudness. All we have to do is turn *all* the knobs at once in *just* the right way, to create *every* note we want to play, right?

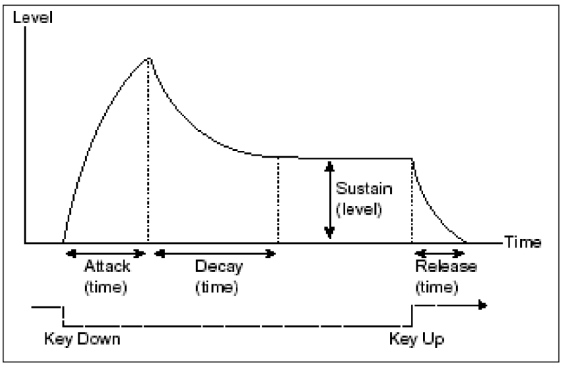
Fortunately, there are elements built into the synthesizer that we can set up to do all of this for us automatically, by sending control voltages to each element in the signal path. We call these changes *modulation*, and there are a few simple modulators that do most of our work.

7.2.1. The envelope generator

The **envelope generator** (or just **envelope**) is a control voltage that starts, changes, and then stops, according to settings for several *stages* that it passes through.

The most common envelope type, as found on the VCA of the CS-80, is the ADSR:

- The **Attack** is the time that the sound will take to reach its maximum volume once we start the envelope;
- The **Decay** is the time that the sound will take to drop from its maximum volume to the Sustain level;
- The **Sustain** is the volume level that the sound will reach when a key is held down long enough to get through the Attack and Sustain;
- The **Release** is the time that the sound will take to drop back to silence once we stop the envelope.



ADSR envelope

The CS-80's VCF envelope has an unusual envelope that has two additional parameters:

- The **Initial Level** (**IL**) is the start level of the envelope relative to the frequency of the filter, and it's usually lower than the cutoff frequency. This produces interesting behavior: after the Attack and decay, the envelope settles in at the cutoff frequency (so it doesn't have a Sustain control), then drops back down to the initial level during the release.
- The **Attack Level** (**AL**) is the maximum level of the filter envelope; we need to add this parameter to control the shape of the envelope relative to the cutoff frequency.

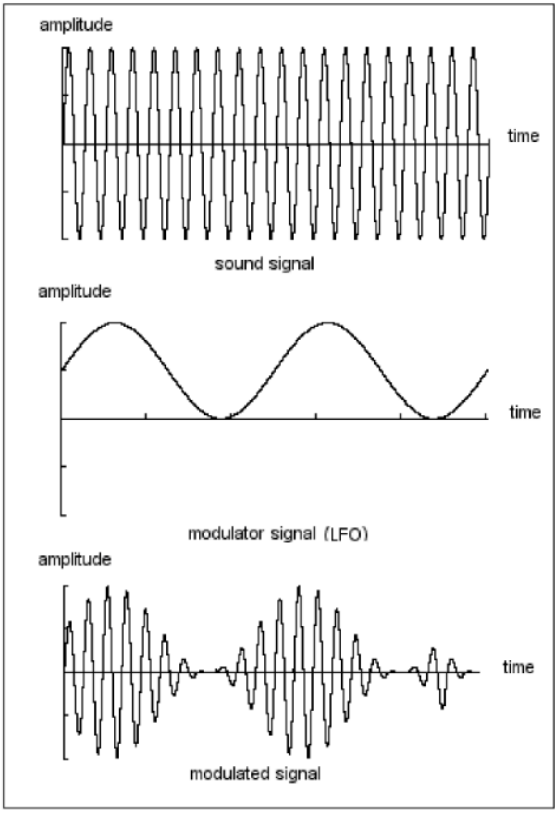
7.2.2. The keyboard

The usual way we start and stop a note is to play the keyboard. On an analog synthesizer, the keyboard sends at least two signals: a control voltage to set the frequency of the VCOs (so they play the right pitch), and a *gate* signal that opens when the key is pressed and closes when it's released. When we play a note, the attack and decay happen, followed by the sustain. When we let go of the key, then the release happens. These signals shape the volume of a note (starting and stopping it) and its tone over time (to simulate the behavior of acoustic instruments, etc). Naturally, on CS-80 V, these signals come from a MIDI controller.

> Important to note: the keyboard has filter tracking.

7.2.3. The Low Frequency Oscillator (LFO)

The LFO is just another VCO with most or all of the same parameters. The main difference is that its range of frequencies drops well below 20 Hz, the lower limit of human hearing. When a waveform's frequency is that low, you can't hear it anymore, but you can use it to control (modulate) the behavior of other parts of the synth in a cyclic and predictable way. The CS-80 has one LFO per **Channel** (signal path), plus a commonly shared LFO called the **Sub Oscillator**.



Low frequency oscillator modulation

The simplest examples are when an LFO is applied directly to each of our signal path modules:

- If we apply the LFO to the VCO frequency, the pitch we hear goes up and down and we have *vibrato*.
- If we apply the LFO to the VCF cutoff, it goes up and down in an effect similar to a *wah-wah* pedal.
- If we apply the LFO to the VCA level, the volume goes up and down and we have *tremolo*.

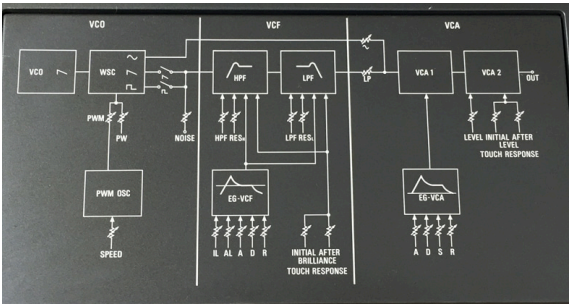
The CS-80 V offers six different waveforms on the Sub Oscillator; the extra waveforms account for the fact that an LFO often needs more ways to control a signal than the waveforms we listen to at higher frequencies. The waveforms include sine, sawtooth down, sawtooth up, square, noise, and *sample & hold* (a randomly changing signal).

7.3. Seeing the whole picture...

Here's a diagram of a complete synthesis voice on the CS-80V.

Each of the two Channels (**I** and **II**) contains:

- 1 VCO with selectable sawtooth, square (with PWM), and sine wave outputs (the sine wave bypasses the VCF)
- 1 noise source
- 1 mixer (mixing of the 2 VCO and the noise module towards the low-pass and high-pass filters)
- 2 VCFs, a HPF followed by an LPF, with 1 envelope controlling the cutoff of both
- 2 VCAs, the first with 1 envelope controlling the loudness and the second modulated by touch response
- 1 LFO (used for PWM)



A complete CS-80 synthesis voice

The common voice structure (both Channels mixed) shares two more elements:

- 1 ring modulator
- 1 LFO (the Sub Oscillator)

Put it all together and you have a synthesis architecture with the potential for some pretty amazing sounds!

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