



User Manual

The modular software synthesizer

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BARANT Technology Group

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1 Introduction

synthmax is a modular synthesizer. Like a hardware modular system, it does not have a fixed signal path. You place *modules* (oscillators, filters, envelope generators, effects, and so on) on a workbench and connect them with patch cables. The way you wire them decides the sound.

A few ideas run through the whole instrument:

- **Everything is a voltage.** Audio, pitch, envelopes, LFOs and gates are all signals that any input can accept. An envelope can sweep a filter, and an oscillator can just as well modulate an effect.
- **One volt per octave.** Pitch signals use the 1 V/octave standard, with 0 V at middle C (MIDI note 60). Add 1 V and the pitch rises an octave.
- **Polyphony is automatic.** Each note you play gets its own copy of the patch, called a *voice*. You can have up to 16 voices. You patch one voice, and synthmax builds the rest.
- **Some modules work on the whole mix.** Effects such as reverb, the Leslie and the compressor run once on the sum of all voices, as a pedal or rack unit would. Their panels carry a **MIX BUS** tag.
- **No samples.** Every factory patch is synthesized from the modules themselves, including the pianos, guitars, saxophones and organs.

synthmax is a VST3 and CLAP instrument plugin for hosts such as REAPER, Bitwig Studio and Ardour, on Linux and Windows. The patches, modules and workbench are the same on both.

2 Installing and Running

synthmax is available from <https://barant.com/vst/synthmax> as a VST3 and CLAP instrument plugin for Linux and a VST3 instrument plugin for Windows, both 64-bit.

2.1 Linux (VST3 and CLAP)

Download `synthmax-0.1.0-linux-x64.tar.gz`, unpack it and run the installer. No root access is needed:

```
tar xzf synthmax-0.1.0-linux-x64.tar.gz
cd synthmax-0.1.0-linux-x64
./install.sh
```

This installs `~/vst3/synthmax.vst3` (the plugin with every module, factory patch and impulse response inside it) and `~/clap/synthmax.clap`. `./uninstall.sh` removes both. Your own patches are saved in `~/Documents/synthmax` and survive reinstalls and uninstalls.

Requirements: 64-bit Linux with glibc 2.35 or newer (Ubuntu 22.04, Debian 12, Fedora 36 or later), and an X11 or XWayland desktop with OpenGL.

2.2 Windows (VST3)

Run the installer, `synthmax-0.1.0-x64.msi`. It installs the VST3 plugin to `C:\Program Files\Common Files\VST3\synthmax.vst3`, with every module, factory patch and impulse response inside the bundle.

Your own patches and SoundFonts go in `Documents\synthmax`. Installing a newer version replaces the old one, and uninstalling removes it completely.

The installer is not code-signed, so Windows SmartScreen may show “unknown publisher”. Choose *More info* and then *Run anyway*. No SoundFonts are included. Put your own `.sf2` files in `Documents\synthmax\soundfonts`.

2.3 In your host

Rescan plugins in your host (REAPER, Bitwig Studio, Ardour, Carla, ...) and insert synthmax as an instrument. It has MIDI in, a stereo output, and a stereo audio input that feeds the **AUDIO IN** module, so you can process a track or play the **PITCH TRACKER** from a recorded guitar. The current patch is saved inside your host project, along with which patch file it came from. When you reopen the project, the patch keeps its name, shows as loaded in the palette, and **SAVE** writes back to that file. Your edits are in the project even if you never saved them to the file. The palette’s **PATCHES** list loads the factory patches and your own, and **SAVE/SAVE AS** write to your own patch folder.

Restart the host after an update

A host that already has synthmax loaded keeps running the old version until you restart it, or remove the plugin and insert it again.

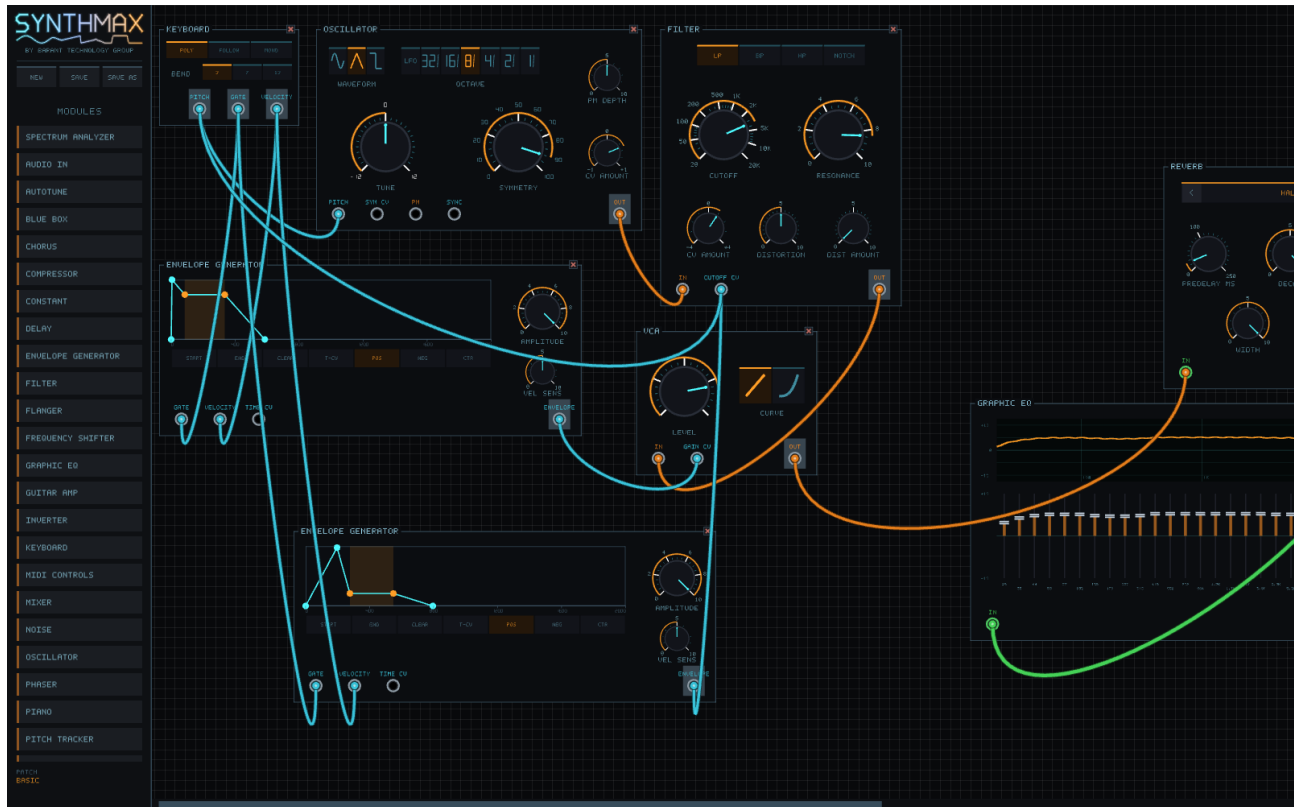
REAPER keyboard input

To type into synthmax’s editor (**SAVE AS** names, the SoundFont player’s file prompt), open the FX window’s menu and turn on *Send all keyboard input to plug-in*. Otherwise REAPER keeps the keystrokes for its own shortcuts.

Low latency

For the most responsive playing, run your audio system at a buffer of 128 frames or less. On Linux, run PipeWire/JACK at a real-time priority: your user should be in the `audio` (and, with PipeWire, `pipewire`) group, and the CPU should use the *performance* power profile. A 128-frame buffer at 48 kHz is 2.7 ms per period.

3 The Workbench



The workbench with the basic patch loaded: the palette on the left and the modules on a 1/8-inch grid.

3.1 The palette

The column on the left of the window is the palette:

- **Logo and file buttons.** **NEW** clears the bench. **SAVE** writes the current patch back to its file in your patch folder. **SAVE AS** opens a name field: type a name using letters, digits and hyphens, then press Enter. When either has finished, a message window shows the patch's name and the folder it went to, or why it couldn't be saved. Click **OK** (or press Enter, Escape or Space) to carry on; the rest of the window waits until you do.
- **MODULES.** Every available module. Drag one onto the bench to add it.
- **PATCHES.** The factory patches and your own saved ones. Click one to load it. They are grouped by category, each group under an orange heading and sorted by name. Your own patches come first, under **MY PATCHES**. The factory groups follow: pianos and keys, organs, synths, guitars, bass, the orchestra's strings, woodwinds and brass, saxophones, mallets and bells, drums and percussion, splits and layers, and tests. The groups are defined in `patches/categories.txt`, a plain text file you can edit: a `[NAME]` line starts a group and each line below it names a patch. The list refreshes every second, so a file saved by another program appears without a restart.
- **Status.** At the bottom, the name of the current patch. **FREE VOICE** appears here when the patch has no keyboard (see section 5.4).

Use the mouse wheel over the palette to scroll it.

3.2 Working with modules

Action	How
Add a module	Drag it from the palette onto the bench.
Move a module	Drag its title bar.
Remove a module	Click the small x at the right of its title bar. Its cables go with it.
Bring a module to the front	Click anywhere on it.
Turn a knob	Drag up to increase or down to decrease.
Flip a switch	Click the segment you want.

Every knob has a scale around it in the units it sets: hertz on a frequency knob (20, 200, 2k, 20k), decibels on a gain, milliseconds or seconds on a time (the knob's label names the unit), and 0–10 on a plain amount. The value you set lands between the marks, as on a hardware synth.

3.3 Moving around

Action	How
Scroll vertically	Mouse wheel over empty bench
Scroll horizontally	Shift + wheel, or swipe sideways on a touchpad
Pan	Drag on an empty part of the bench
Zoom	Ctrl + wheel (zooms around the mouse, 50%–125%)
Scrollbars	Drag the thumbs, or click the track to page

When you drag a module or cable near the edge of the bench, the view scrolls on its own. The closer you get to the edge, the faster it scrolls. A module that uses the wheel itself (such as the envelope editor's time zoom) takes the wheel while the mouse is over it.

3.4 Keyboard shortcuts

Ctrl+N	New (empty bench)
Ctrl+S	Save
Ctrl+Shift+S	Save As

4 Patching

4.1 Jacks

Each module has a row of jacks along its bottom edge. Input jacks have a dark plate; outputs sit on a lighter plate. The label is above the jack, so the cable hanging below never hides it.

4.2 Making and breaking connections

- **Connect:** drag from any jack to another, either output-to-input or input-to-output. While you drag, the loose end snaps to any compatible jack under the mouse.

- **Move a cable:** grab it at its input end and drop it on another input. The output end stays where it is.
- **Remove a cable:** grab it at its input end and drop it on an empty part of the bench.
- **Summing:** an input accepts any number of cables, and their signals are added. For example, the keyboard's pitch plus a **CONSTANT** transposes, and an LFO plus an envelope modulates a cutoff. If an input carries several cables, grabbing it lifts the newest one.
- **Refused connections:** if a connection is not allowed, the jack flashes red and the cable returns to where it was. The reasons are listed below.

4.3 Cable colours

A cable takes its colour from the output that drives it:

orange	Mono audio
cyan	Control voltage: pitch, gates, envelopes, LFOs, CV
green	A stereo pair: left and right carried together in one cable

Colour is a guide, not a rule. Any output can go into any input. Audio into a CV input is audio-rate modulation, and a CV into an audio input is a perfectly good way to look at it on the oscilloscope.

4.4 Stereo (green) cables

Stereo-capable modules have a stereo jack, drawn with a green nut. One green cable carries both sides.

- **Stereo into stereo:** each side goes to its own side.
- **Mono into a stereo input:** the mono signal feeds the left side. Most effects then process it into a full stereo result.
- **Stereo into a mono input:** the left side is used.
- To build or take apart a stereo pair, use **STEREO MERGE** (two mono signals in, one green cable out) and **STEREO SPLIT** (one green cable in, two mono signals out).

4.5 Per-voice modules and mix-bus modules

This is the most important rule in synthmax.

Per-voice modules (oscillators, filters, EGs, VCAs, delays, ...) are copied for every note. Each copy hears only its own note. They run only while that note sounds, including its release tail.

Mix-bus modules (panels tagged **MIX BUS**: reverb, phaser, Leslie, compressor, graphic EQ, guitar amp, ...) exist once. They work on the sum of all voices and keep running after the notes stop, so a reverb tail rings out naturally.

The rule: **a mix-bus module that is fed by voices cannot feed a per-voice module.** After the voices are summed, there is no way back into a single voice. A few global modules are exceptions, because they have no per-voice inputs and so run *before* the voices: **AUDIO IN**, **MIDI CONTROLS** and **BEAT CLOCK**. Their outputs can drive anything. For example, the mod wheel can open every voice's filter.

SEQUENCER, **STEREO SPLIT** and **STEREO MERGE** *follow their inputs*. They run per voice when fed from voice modules, and once on the mix when fed from mix-bus modules.

4.6 Other rules

- **No feedback loops.** A cable path may not lead back to where it started. For feedback, use a module's own **FEEDBACK** control (delay, flanger, phaser, frequency shifter) or the mixer's FX buses (section 8), which are built to close the loop safely.
- A module cannot be patched into itself.
- The same cable cannot be patched twice.

4.7 The OUTPUT module

Every patch has one **OUTPUT**. It cannot be deleted. Its jacks are **LEFT**, **RIGHT** and **STEREO** (green). They are normalised like a stereo mixer's inputs:

- **Only LEFT patched.** A stereo module's output (a reverb's, a delay's, a mixer's) brings its own right channel with it, so it stays in stereo. A mono source plays in both speakers.
- **Only RIGHT patched.** The sound plays in both speakers.
- **Both, or STEREO.** Each channel gets exactly what is patched to it.

All output passes through a fixed -12 dB master trim. This leaves headroom, so many loud voices don't clip.

5 Playing

5.1 The KEYBOARD module

KEYBOARD is how MIDI notes enter a patch. Each voice's copy outputs the note that voice is playing:

pitch	1 V/octave, 0 V = middle C. Includes pitch-wheel bend.
gate	1 while the key is held, 0 after release. On a retrigger it drops briefly, so envelopes restart.
velocity	Note-on velocity, 0–1.

Pitch and velocity hold their values after release, so a release tail keeps its pitch.

Voice mode

POLY (default) Every note gets a fresh voice. When all 16 are busy, the oldest *released* voice is stolen first, then the oldest held one.

FOLLOW Replaying a note that is still sounding reuses and retriggers its voice, instead of stacking a second one. Good for pianos and plucked strings.

MONO One voice, legato. Play a new note while holding another and the pitch moves without retrigging the envelopes. Release it and the pitch returns to the note still held. Used for leads and solo instruments.

Bend range

The **BEND** switch sets the pitch-wheel range to 2, 7 or 12 semitones. Bend works in every patch with a keyboard; you don't need to patch anything.

5.2 Sustain pedal and MIDI controllers

The **sustain pedal** (CC 64) works in every patch automatically. While it is down, released notes keep sounding until the pedal comes up. In MONO mode the held note stays. All Notes Off and All Sound Off (CC 123/120) are honoured.

To use the other controllers in a patch, add the **MIDI CONTROLS** module. It turns them into patchable signals:

mod	Mod wheel (CC 1), 0–1
bend	Pitch wheel, −1..+1 (for patching it somewhere other than pitch)
pressure	Channel aftertouch, 0–1
expr	Expression pedal (CC 11), 0–1. Reads 1 if no pedal is connected.
breath	Breath controller (CC 2), 0–1
sustain	Sustain pedal, 0 or 1
cc_a...cc_d	Four assignable controllers, 0–1

MIDI learn. Each of A–D shows its CC number; the defaults are 74, 71, 73 and 72, common on controllers for cutoff, resonance, attack and release. To assign one, click its **LEARN** button and move a knob or fader on your controller. Continuous outputs are smoothed over about 5 ms, so controller steps don't zipper.

5.3 Splits and layers

One **KEYBOARD** can play several sounds, each on its own part of the keyboard. Patch the keyboard's pitch, gate and velocity into a **KEY ZONE** for each sound. Each sound then takes its gate (and its pitch and velocity) from its zone instead of from the keyboard.

Split	Zones side by side: a bass from the bottom up to B2, strings from C3 up.
Layer	Overlapping zones: strings across the whole keyboard, brass doubling them on top.
Velocity layers	Two zones on the same keys with different velocity ranges: a soft sound up to 90, a harder one from 91.
Drum kit	A one-key zone per drum (LOW = HIGH), each opening its own sound.

The factory patches `split-bass-and-strings` and `layer-strings-and-brass` are ready-made examples.

Costs and limits

Every voice runs every zone's sound; a zone outside the note just stays closed. A split therefore uses the CPU of all its sounds together. The keyboard's voice mode (**POLY**, **FOLLOW** or **MONO**) applies to the whole patch, so one zone can't be mono while another is polyphonic.

5.4 Free voice: patches without a keyboard

A drone, a sequenced pattern, or a patch that processes audio through **AUDIO IN** doesn't need a keyboard. If a patch has *no* **KEYBOARD** module, synthmax runs a single *free voice*: it plays continuously, without waiting for a note. The palette shows **FREE VOICE** beside the patch name, and MIDI notes are ignored. Add a keyboard and normal note-driven voices take over.

6 Signals and Conventions

Pitch	1 V/octave, 0 V = C4 (middle C), 1/12 V per semitone. Unplugged pitch inputs sit at middle C.
Gates and triggers	0 = off, 1 = on. Inputs detect a rising edge at 0.5 V.
Envelopes	0–1 (or –1..+1 in an EG's NEG/CTR modes).
Audio	Nominally ± 1 . Modules have plenty of headroom inside; the output trim takes care of the sum.
Exponential CV	"1 V/oct" CV inputs (filter cutoff, delay time, flanger sweep, ring-mod frequency, ...) double or halve per volt, so they track the keyboard.
Unplugged inputs	Read as 0, except where noted (an EG's velocity reads as full, an oscillator's pitch as middle C).

7 Module Reference

The modules are listed by role. Panel controls are named as on the panel. "Per voice" modules are copied for every note; "mix bus" modules exist once. Each entry shows the module's panel as it looks when first placed on the bench, with its default settings.

Sound sources

7.1 OSCILLATOR

Runs Per voice (on the mix when nothing per-voice feeds it)
 Inputs pitch (1 V/oct), sym_cv, pm (phase modulation), sync
 Outputs audio_out (audio)



A true VCO that runs freely and never resets its own phase. Its waves are band-limited, so high notes stay clean rather than gaining a harsh, inharmonic fizz (aliasing); in LFO mode the edges stay sharp, as a clock needs.

- **WAVEFORM**: sine, triangle, ramp/saw, square.
- **OCTAVE**: 32' to 1' footages, with **TUNE** ± 12 semitones on top.
- **SYMMETRY**: reshapes the wave, from saw through triangle to reverse saw. On a square it sets the pulse width. **SYM CV** with an attenuverting **CV AMOUNT** gives PWM.
- **PM DEPTH**: DX7-style FM. Another oscillator into **pm** shifts this one's phase, so the timbre changes while the pitch stays put. Patching into **pitch** instead gives exponential FM.
- **SYNC**: hard sync. Each rising edge restarts the wave.
- **LFO**: the leftmost octave cell. It turns the oscillator into a 0–20 Hz LFO (**RATE** replaces **TUNE**). LFOs keep time with a shared clock, so every voice's LFO moves together (one tremolo for the whole chord) unless **sync** is patched.
- **Where it runs**. With nothing per-voice patched into it (no keyboard pitch, no gate on **sync**), an oscillator runs once, on the mix, and every voice reads it. So an LFO patched into a mix-bus module (a **ROOM** position, a **PHASER** sweep) moves it whether or not notes are playing, and by the same amount however many notes are sounding.

An oscillator never goes quiet by itself: put a VCA driven by an EG after it.

7.2 NOISE

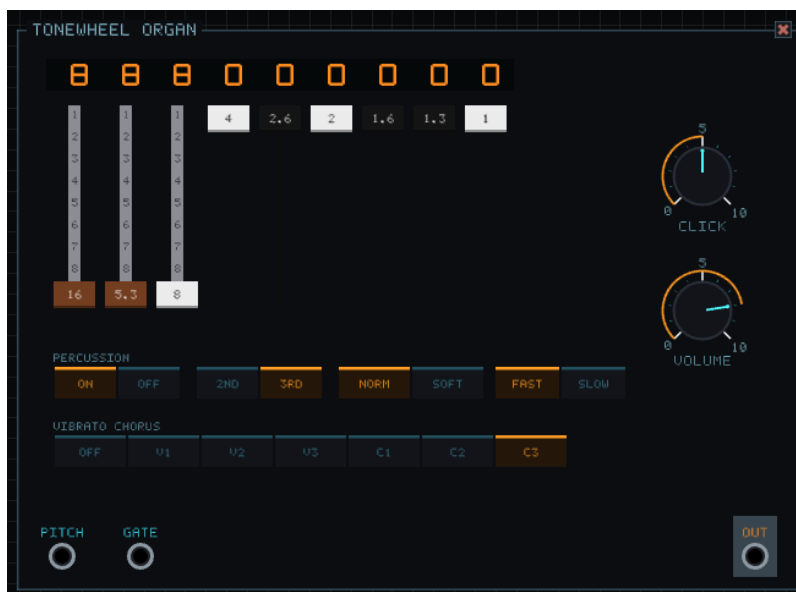
Runs Per voice
 Inputs clock
 Outputs white, pink, brown, blue, violet, random_out



Five noise colours, all at the same loudness: white is flat, pink falls 3 dB per octave, brown 6 dB, blue rises 3 dB and violet 6 dB. **LEVEL** scales them all. **random_out** jumps to a new random value on each rising edge at clock, for stepped random CV. Each voice has its own random seed, so every note sounds fresh.

7.3 TONEWHEEL ORGAN

Runs Per voice
 Inputs pitch, gate
 Outputs audio_out



A model of the Hammond C3 tone generator.

- Nine drawbars, 0–8 at 3 dB a step: 16', 5 1/3', 8', 4', 2 2/3', 2', 1 3/5', 1 1/3' and 1'. They use the C3's tempered tonewheel pitches, with top-octave foldback.
- Free-running wheels, so two notes sharing a wheel are in phase.

- Key **CLICK**.
- **PERCUSSION** (2nd/3rd harmonic, soft, slow). As on the organ, turning percussion on cancels the 1' drawbar.
- Scanner vibrato and chorus, V1–V3 and C1–C3.

The organ ignores velocity, like the real one. Pair it with the **LESLIE 122**.

7.4 PIPE ORGAN

Runs Per voice
 Inputs pitch, gate, velocity, swell
 Outputs left_out (stereo)



A large church or concert pipe organ with real stops. Each stop is a *rank* of pipes with its own voicing and pitch. The pitch is given in feet, as on an organ console: 8 ft sounds at the key, 16 ft an octave below, 4 ft an octave above, 2 2/3 ft at the twelfth. Click a stop tab to draw it (the tab lights) or push it in, and build the sound from a single flute up to the full organ.

- **GREAT** (the manual):
 - **PRINCIPAL 16, PRINCIPAL 8, OCTAVE 4, TWELFTH 2 2/3** and **FIFTEENTH 2**: the principal (diapason) chorus, the organ's own sound.
 - **MIXTURE IV**: four high ranks of octaves and fifths. They break back an octave near the top of the keyboard, so they never squeal. The mixture is the brilliance of a full organ.
 - **BOURDON 8** and **FLUTE 4**: stopped and open flutes, soft and hollow.
 - **CELESTE 8**: a string rank paired with a second one tuned a few cents sharp, so the two shimmer against each other.
 - **TRUMPET 8** and **BOMBARDE 16**: the reeds, bright and blaring. Reed tabs have red lettering.

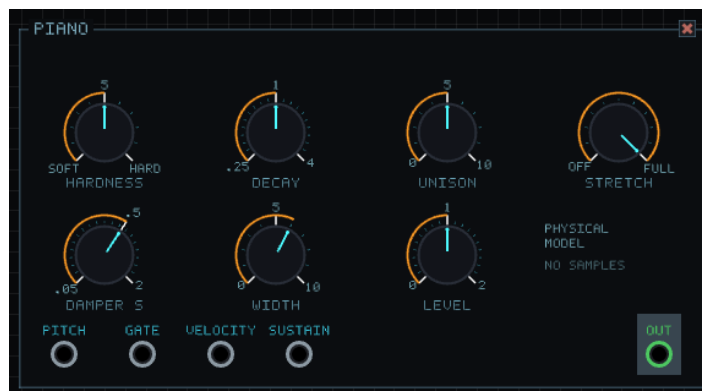
- **PEDAL: SUBBASS 32, BOMBARDE 32 and PRINCIPAL 16.** They play the keys below **SPLIT** (C3 by default). A 32 ft stop reaches 16 Hz, which you feel as much as hear. With no pedal stop drawn, the manual's stops play the whole keyboard. Set **SPLIT** to OFF to put the pedal away.
- **TREMULANT:** shakes the wind at about 5.5 Hz. As on a real organ, one tremulant shakes every pipe together.
- **VOLUME, WIND** (the breath of air, or “chiff”, as a flue pipe speaks), **DRIFT** (how far each pipe is out of tune) and **SWELL** (the swell box, setting both level and brightness; its shutters move smoothly however fast the pedal does, across about 13 dB). The swell jack multiplies the knob; patch the expression pedal (**MIDI CONTROLS** `expr`) into it.

It behaves like a real organ in other ways too:

- Velocity does nothing, because an organ key is an on/off valve.
- Every pipe is slightly out of tune with its neighbours, by its own fixed amount, so chords and stop combinations beat and come alive.
- The pipes stand left and right of the façade by alternate semitones (the C side and the C# side), which gives the stereo spread.
- More stops are louder. Full organ is overwhelming, so leave headroom or follow it with a compressor set to catch only the peaks, as the factory patches do. A compressor that works all the time would undo the swell.
- The pipes are band-limited wavetables, so even the top of the mixture is clean.

7.5 PIANO

Runs Per voice
 Inputs pitch, gate, velocity, sustain
 Outputs left_out (stereo)



A physically modelled piano that uses modal synthesis.

- **Strings.** Each note computes the partials of a struck stiff string. These include inharmonicity (upper partials run sharp), stretch tuning (**STRETCH**), and two detuned unison strings (**UNISON**), which give the piano's two-stage decay.

- **Hammer.** A harder strike (**HARDNESS**) excites higher partials, so playing harder is both louder and brighter.
- **Decay.** Bass notes ring about 30 s, middle C about 10 s (**DECAY** scales this).
- **Dampers.** **DAMPER** stops a note after release, except the top octave and a half, which has no dampers.
- **Stereo and sustain.** **WIDTH** spreads notes from bass-left to treble-right. A repeated note restrikes the string that is still sounding.
- **Sustain.** The synth's own pedal handling already holds notes in every patch. Patching **MIDI CONTROLS'** sustain into this module's sustain input also lifts its dampers, as a real pedal does.

7.6 BOWED STRING

Runs Per voice
 Inputs pitch, gate, velocity, excite, pressure
 Outputs audio_out



A physical model of a bowed string. It isn't an oscillator: the string is two travelling waves, between the bow and the bridge and between the bow and the nut, and the bow drives it by friction. The bow grips the string and drags it until the string's pull wins and it slips back, the stick-slip motion that is the bowed sound itself. So it behaves like a string: the tone grows out of the bow's scratch, and changing the bow changes the tone.

- **PRESSURE:** the bow's force. Low is airy and floating (flautando, the string slipping twice per cycle), the middle a full, clean tone, high a pressed, gritty edge.
- **POSITION:** where the bow sits, from near the bridge (**PONT**, glassy and bright) to over the fingerboard (**TASTO**, soft and round).
- **BRIGHTNESS** (gut to steel strings), **ROSIN** (bow-hair noise), **ATTACK** and **RELEASE** (how fast the bow gets up to speed and stops), **LEVEL**.
- velocity is the bow speed, so harder notes are louder and richer. excite adds bow speed on top: an expression pedal or breath controller there gives swells. pressure adds to **PRESSURE**.
- Each new stroke starts with the player's "bite": a little extra bow speed and weight for the first few tens of milliseconds, so the note speaks promptly. There is less of it on hard strokes, which are already fast.

- The string stays in tune all the way to the top of the violin's range.

Patch its output into a **BODY** for the instrument's resonances. The orchestra's string patches are built this way.

7.7 REED

Runs Per voice
 Inputs pitch, gate, velocity, excite, pressure
 Outputs audio_out



A physical model of a reed woodwind. Breath pushes a reed that opens and closes against the mouthpiece, and the pressure wave returning down the bore pushes the reed in turn. That feedback is what sounds.

- **CYLINDER**: a clarinet. The bore is closed at the reed end, so it sounds mostly odd harmonics: the clarinet's hollow, woody tone.
- **CONE**: a saxophone, oboe or bassoon. All harmonics, brighter and reedier. **REED POS** sets where the reed sits on the cone, which changes the overtone balance.
- **PRESSURE** (breath: soft and pure to loud and edgy), **STIFFNESS** (the reed: warm to buzzy), **NOISE** (breath noise), **ATTACK**, **RELEASE**, **LEVEL**.
- **EVENS (CYLINDER)**: a perfect cylinder sounds only odd harmonics, but a real clarinet's mouthpiece, bell and tone holes let some even harmonics out, about 20–30 dB down in the low register. **EVENS** sets how much; the clarinet patches use 5.
- On a cone, keep **REED POS** at 0.35 or above: the factory oboe, English horn and bassoon patches do, so they hold their pitch at every dynamic. Nearer the reed, a cone can jump up an octave, like an overblown note.
- Each note starts with a tongued kick of breath, so it speaks at once.
- velocity is how hard the note is blown; excite adds breath on top (a breath controller), pressure adds to **PRESSURE**.

7.8 BRASS

Runs Per voice
 Inputs pitch, gate, velocity, excite, pressure
 Outputs audio_out

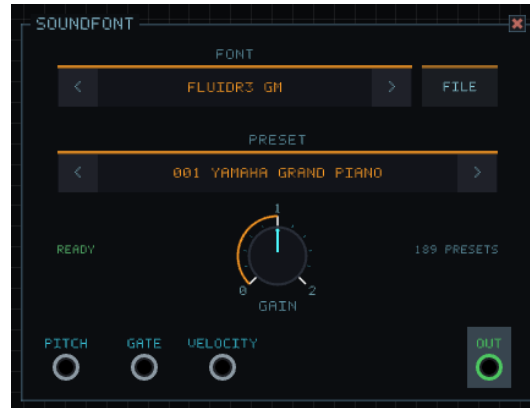


A physical model of a lip-buzzed brass instrument. The player's lips, a mass on a spring, buzz against the mouthpiece, and the bore locks the buzz onto one of its resonances: that's the note. It speaks like brass, with a rasp of lip buzz at the start, and gets brighter and brassier the harder it's blown.

- **PRESSURE**: from mellow to blaring.
- **LIP**: the lips' tension against the note, ± 1 semitone. Off-centre colours the tone.
- **MUTE**: a straight mute, thinner and quieter. **ATTACK**, **RELEASE**, **LEVEL**.
- **BELL** and **BELL HZ**: the bell's radiation. A real bell radiates high harmonics far better than low ones: the sound that leaves it rises about 6 dB per octave up to the bell's cutoff (about 1.5 kHz on a trumpet, lower on bigger bells), so even the fundamental comes out weaker than the harmonics above it. That is where brass gets its brassy brilliance. 0 is the much duller sound inside the tube, 1 the full radiation curve; the note's level is compensated so low notes don't drop away.
- The lips close completely once per cycle, cutting the air off, as real lips do. That abrupt closing is the buzz.
- **BLARE**: at high pressure the peaks of the wave travel faster than the troughs, so it steepens toward a shock front on its way to the bell. That is why a loud trumpet is so much brighter than a soft one. **BLARE** sets how much, scaled by how hard each note is played and by its register: high notes are blown with more pressure, so they blare more, as on the real instrument.
- Notes start with a tongued attack and stop cleanly when the key is released.
- It plays in tune across the whole range, from tuba pedal notes to high trumpet.

7.9 SOUNDFONT

Runs Per voice
 Inputs pitch, gate, velocity
 Outputs left_out (stereo)



Plays presets from .sf2 SoundFont files. Load one with the **FILE** button or put it in the soundfonts folder inside your synthmax folder (Documents/synthmax/soundfonts). Fonts load in the background without interrupting audio. Factory patches never use SoundFonts; this module is for your own.

7.10 AUDIO IN

Runs Mix bus (runs before the voices)
 Inputs none: synthmax's audio inputs
 Outputs left_out, right_out



Brings external audio into the patch, with **VOL L/VOL R** (unity at about 7). Because it runs before the voices, it can feed both mix-bus effects (a microphone through the reverb, always on) and per-voice modules (for example, the mic gated by the keyboard through a VCA).

Control and modulation

7.11 KEYBOARD

Runs Per voice
 Inputs none (MIDI notes)
 Outputs pitch, gate, velocity



See section 5.1.

7.12 KEY ZONE

Runs Per voice
 Inputs pitch, gate, velocity (from the KEYBOARD)
 Outputs gate_out, pitch_out, velocity_out



Splits and layers: a sound patched from a KEY ZONE's gate plays only for the notes inside its zone.

- **LOW** and **HIGH** set the keys, and **VEL LOW** and **VEL HIGH** the velocities (1–127), that the zone passes. The note names show over the knobs.
- **LEARN**: press it, then play a key, and that key becomes the edge.
- **TRANPOSE** shifts the pitch output ± 24 semitones, for example to play a bass zone an octave up.
- The keyboard strip shades the zone and lights the keys being held in it.

A note's zone is decided when it starts, so a pitch bend can't move it out of its zone. See section 5.3 for how to build splits, layers, velocity layers and drum kits.

7.13 MIDI CONTROLS

Runs Mix bus (runs before the voices)
 Inputs none (MIDI controllers)
 Outputs mod, bend, pressure, expr, breath, sustain, cc_a–cc_d



See section 5.2.

7.14 BEAT CLOCK

Runs Mix bus (runs before the voices)
 Inputs none (the host's tempo and transport, or its own)
 Outputs clock, beat, bar, reset, run



Tempo for your patch: gates that clock sequencers, fire envelopes or step a sample & hold, in time with your song.

- **SYNC HOST** (default): in a DAW, the clock follows the host's tempo and transport. It runs while the song plays, locked to the song's beats and bars, so starting playback anywhere puts it in step with the grid. It stops when the song stops.
- **SYNC INT**: its own tempo, set with the **BPM** dial (20–300), running while **RUN** is on. The standalone app has no host, so it always uses the internal clock; the panel shows **NO HOST – INT**.
- **DIVISION**: the clock output's rate, from whole notes to 1/32, plus eighth- and sixteenth-note triplets (**8T**, **16T**).
- The display shows the tempo in use (the host's when following it), and four lights step through the beats of the bar, the downbeat in red.

Outputs (all 0/1 gates):

- **clock**: one per division, high for the first half of each.
- **beat**: one per quarter note.
- **bar**: high for the first beat of each bar, in the host's time signature (4/4 on the internal clock).
- **reset**: a short pulse whenever the clock starts or restarts, including transport start, a loop going round, a jump back, or turning **RUN** on. Patch it into a sequencer's **reset** so patterns always start on the bar.
- **run**: high while the clock is running.

It runs before the voices, so it can clock per-voice modules and mix-bus ones alike.

7.15 ENVELOPE GENERATOR

Runs Per voice
 Inputs gate, velocity, time_cv
 Outputs envelope_out



A graphical multi-point envelope: any number of points joined by straight segments.

- **Editing**: drag points. Double-click empty space to add one; double-click a point to delete it. The mouse wheel zooms the time axis. Long envelopes zoom out to fit automatically.
- **Loop zone**: select a point and press **START** or **END** to mark the loop (**CLEAR** removes it). While the key is held, playback repeats between the two points. The default 5-point shape is an ADSR whose “sustain” is a flat loop. On release, playback jumps to the loop end and continues from the level that is actually sounding, so releases never click.
- **Range**: **POS** (0..1), **NEG** (-1..0), **CTR** (-1..+1).
- **AMPLITUDE** scales the whole envelope. **VEL SENS** sets how much velocity matters: at 1 the softest note is up to 40 dB below the hardest, and 0 ignores velocity.

TIME CV. Any segment can have a second, alternate length. Select the point that ends the segment and press **T-CV**. A hollow magenta “ghost” of the point appears; drag it sideways to set the alternate length. The **time_cv** input (0..1) then slides each such segment between its normal length (at 0) and the alternate (at 1). The CV acts as a rate, so a CV that changes mid-segment speeds it up or slows it down smoothly. *Example*: patch velocity into **time_cv** and give the attack a ghost at 0 ms, and the harder you play, the snappier the attack. Patch the mod wheel there to stretch the release in real time.

7.16 CONSTANT

Runs On the mix (every voice reads it)
 Inputs none
 Outputs cv_out



A steady voltage. **VALUE**, **BIPOLAR** and **SCALE** (1, 5 or 10 V) set it. Use it for transposing (add to pitch), a fixed filter CV, or holding a VCA open. It runs once, on the mix, and every voice reads the same value, so a mix-bus module it's patched into (a sound's position in a **ROOM**, say) follows the knob whether or not any notes are playing.

7.17 SEQUENCER

Runs Follows its inputs
 Inputs clock, reset
 Outputs out1...out8, gate, clk1...clk32



A step sequencer.

- **Steps and rows.** It starts with 4 steps and 3 rows, and each step has a small knob per row ($-1..+1$ V). Click + at the right of the steps to add a step (up to 32), or – over a step to remove it. Click + under the rows to add an output row (up to 8, each with its own OUT jack), or – beside a row to remove it.

- **Quantize.** **Q** on a row snaps it to semitones, for melodies.
- **Clock.** Each rising edge on `clock` advances one step. An LFO-mode oscillator is the usual clock. `reset` returns to step 1, and `gate` is high while the clock is, for driving an EG.
- **Step clocks.** Under the knobs, every step has its own **CLK** output, which passes the clock only while that step is playing. Patch one into an EG's gate to fire an envelope on just that step, or into another sequencer's `clock` so it advances once each time this one reaches that step (a slower sequence, or a pattern that changes every bar). Several step clocks into one input add together, so you can fire an EG on any selection of steps. When you remove a step, its **CLK** cables go with it, and the later steps' cables move along with their steps.
- **Per voice or free.** Clocked from a per-voice LFO, each note starts its own run. Summed with the keyboard's pitch, the melody transposes to the key you hold. Clocked from a mix-bus source, or in a free-voice patch, it runs on its own.

7.18 SLEW LIMITER

Runs Per voice
 Inputs `audio_in`, `rise_cv`, `fall_cv`, `time_cv`
 Outputs `audio_out`



The output follows the input, but no faster than **RISE/FALL** allow (1 ms–10 s each). **SHAPE** runs from linear (constant rate, classic glide) to exponential (RC curve). The CVs are exponential, at 10× faster per volt. Uses: portamento (keyboard pitch, then slew, then oscillator pitch), smoothing stepped CV, softening gates.

7.19 SAMPLE & HOLD

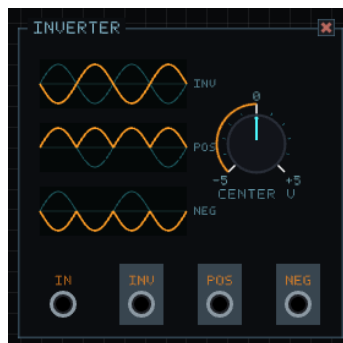
Runs Per voice
 Inputs audio_in, trig
 Outputs audio_out, clock_out



- On each trigger it grabs the input and holds it. With nothing at IN, it samples built-in noise: the classic random “computer” filter sound.
- With `trig` unplugged, an internal clock runs it at **RATE** (0.1–50 Hz).
- **MODE**: SAMPLE or TRACK (track and hold). **GLIDE** smooths the steps.
- `clock_out` is the trigger as a gate.

7.20 INVERTER

Runs Per voice
 Inputs audio_in
 Outputs inv_out, pos_out, neg_out



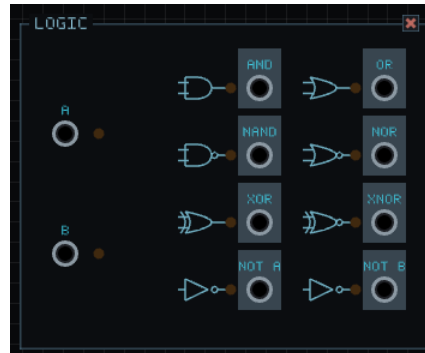
Inversion and full-wave rectification around **CENTER** (−5..+5 V). With center 0.5, a 0..1 envelope inverts to 1..0. On audio, POS/NEG rectify, giving the octave-up “octave fuzz” trick.

7.21 LOGIC

Runs Per voice or on the mix (follows its inputs)

Inputs a, b

Outputs and_out, or_out, nand_out, nor_out, xor_out, xnor_out, not_a, not_b



Digital logic gates for 0 V/1 V signals: gates, clocks, triggers and square LFOs. Every gate's output is live at once, each next to its standard symbol and a light that is lit while it is 1.

- **AND** is 1 when A and B are both 1; **OR** when either is. **NAND** and **NOR** are their inverses.
- **XOR** is 1 when exactly one input is 1; **XNOR** when they agree.
- **NOT A** and **NOT B** invert each input.
- An input reads as 1 at or above 0.5 V, with a little hysteresis (high above 0.52 V, low below 0.48 V), so a slow LFO or an envelope switches cleanly. An unplugged input is 0.
- Outputs are exactly 0 V or 1 V and accurate to the sample. Use them to clock a **SEQUENCER**, gate an **EG**, or switch a **VCA**.

Some ideas:

- A key gate AND a fast square LFO gives a trill or ratchet only while the key is held.
- Two clocks at different rates through XOR give a new, syncopated rhythm.
- An envelope into A, read through NOT A, gives a gate that opens when the envelope has died away.

Filters and amplifiers

7.22 FILTER

Runs Per voice
 Inputs `audio_in`, `cutoff_cv`
 Outputs `audio_out`



A resonant 12 dB/octave multimode filter modelled on the Korg MS-20.

- **LP, BP, HP, NOTCH**, with **CUTOFF** 20 Hz–20 kHz and **RESONANCE**.
- **DISTORTION** and **DIST AMOUNT** clip the filter's own output and resonance node. This is the MS-20 "growl": at high resonance the ringing itself snarls.
- **CV AMOUNT** (−4..+4 octaves per volt, default 1) scales `cutoff_cv`. At 1, keyboard pitch makes the cutoff track the keys; an envelope at 4 sweeps four octaves.
- The filter runs 2× oversampled.

7.23 VCA

Runs Per voice
 Inputs audio_in, gain_cv
 Outputs audio_out



Multiplies the input by the control signal. **LEVEL** and **CURVE** (linear or exponential response). An EG into gain_cv is what makes a note start and stop.

7.24 MIXER

Runs Per voice (FX returns on the mix bus)
 Inputs in1...in16 (mono), FX returns (stereo)
 Outputs left_out (stereo), fx_send1...fx_send8 (stereo)



See section 8.

Delay and modulation effects

7.25 DELAY

Runs Per voice
 Inputs `audio_in`, `time_cv`
 Outputs `audio_out`



- **Ranges.** **SHORT** (0.1–50 ms) is for flanging, combs, doubling, and Karplus-Strong plucked strings. **LONG** (10 ms–10 s) is for echoes. Each range remembers its own time.
- `time_cv`: +1 V halves the time. With keyboard pitch patched in, a short delay with high feedback becomes a tuned string; synthmax's guitars are built this way.
- **FEEDBACK** (−1..+1, soft-limited, so even 100% is safe), **DAMP** (darkens the repeats), **MIX**.
- The loop is pitch-compensated, so strings stay in tune however dark they are damped.
- Echoes keep their voice alive until they have died away.

7.26 STEREO DELAY

Runs Mix bus
 Inputs audio_in (stereo; a mono source feeds both sides)
 Outputs left_out (stereo)



A stereo echo for the whole mix. **DELAY**, above, is the mono one: per voice, mono in and out. The timeline at the top shows where the echoes land: left above the line (orange), right below it (cyan), the LCR center across it (white), each repeat smaller as the feedback takes it down.

- **Modes.**

- **STEREO**: a delay on each side, with its own time (**TIME L**, **TIME R**). **CROSS** sends each side's repeats into the other side's loop: at 0 the sides stay apart; at 10 every repeat swaps sides.
- **PING-PONG**: the input, summed to mono, starts on the left, and each repeat bounces to the other side: left after **TIME L**, then right **TIME R** later, and so on. Equal times give the classic even bounce.
- **LCR**: the studio left-center-right delay. One delay line has three taps, left, center and right, each with its own time and **LEVEL**. Only the center tap feeds back, so the center repeats while the side taps add a rhythm around it.
- **Sync.** With **FREE**, the times are in milliseconds and seconds (1 ms–4 s). With **HOST**, they are note lengths from 1/32 to a whole note, including dotted (D) and triplet (T) values, at the DAW's tempo. Running standalone, with no host, **HOST** uses 120 BPM. Each time shows its value under its knob, and the panel shows the tempo in use. Both sets of times are kept, so switching between **FREE** and **HOST** loses neither.
- **FEEDBACK** (0–10): how much of each repeat comes back. It is soft-limited, so even 10 is safe.
- **LOW CUT** (20 Hz–2 kHz) and **HIGH CUT** (1 kHz to off) filter each repeat as it comes back, so the echoes get thinner and darker in turn, as on tape or an analog delay.

- **MOD** adds a slow tape-style wobble to the delay times, the two sides out of step, for movement and a wider image.
- **DUCK** turns the echoes down while you play and lets them swell back in the gaps, so they don't crowd the part.
- **WIDTH** sets the echoes' stereo width, from mono (0) to full (10). **MIX** sets dry against wet.
- Turning a time knob glides the echoes already in the line, the way a tape delay does, instead of clicking.

7.27 CHORUS

Runs Per voice
Inputs `audio_in` (stereo)
Outputs `left_out` (stereo)



One to three drifting delayed copies (**VOICES**) with **RATE**, **DEPTH**, **DELAY** (5–30 ms), **SPREAD** (stereo width, Juno-style at full) and **MIX**.

7.28 FLANGER

Runs Per voice
Inputs `audio_in` (stereo), `sweep_cv`
Outputs `left_out` (stereo)



- A swept short delay mixed with the dry signal: the jet-plane whoosh.
- **MANUAL** (0.1–10 ms), **DEPTH** (up to ± 3 octaves of sweep), **RATE**, sine or triangle sweep.
- **FEEDBACK** ($\pm$), **SPREAD**, **MIX**.
- **THRU ZERO** mode recreates tape flanging, with total cancellation where the delays cross.
- `sweep_cv` moves the sweep at 1 V/oct.

7.29 PHASER

Runs Mix bus
Inputs audio_in (stereo), sweep_cv
Outputs left_out (stereo)



A 70s stomptbox phaser.

- **STAGES:** 4, 6, 8 or 12.
- **RATE**, **DEPTH** and **CENTER** (100 Hz–4 kHz) set the sweep.
- **FEEDBACK** (“colour”), **MIX:** 0.5 gives the deepest notches, 1 gives vibrato.
- **SPREAD** sweeps the notches across the stereo field.
- An envelope into sweep_cv makes an envelope phaser.

7.30 LESLIE 122

Runs Mix bus
Inputs audio_in (mono)
Outputs left_out (stereo)



A rotary speaker cabinet.

- Tube preamp **DRIVE** into an 800 Hz crossover feeding a rotating horn and drum, picked up by two virtual mics.
- **SPEED**: CHORALE, TREMOLO or STOP. The rotors have inertia: the horn speeds up in about a second and the drum takes several, which gives the famous swirl on a speed change.
- **BALANCE** (horn against drum), **RATE** trim.

7.31 RING MODULATOR

Runs Per voice
 Inputs `audio_in`, `mod`, `freq_cv`
 Outputs `audio_out`



- Multiplies the input by `mod`, or by a built-in sine at **FREQ** (1 Hz–5 kHz, `freq_cv` 1 V/oct): metallic, bell-like tones.
- **CHARACTER** runs from an ideal multiplier to a vintage diode ring.
- **BLEED** lets some of the carrier through. **MIX**.
- Runs 2× oversampled.

7.32 FREQUENCY SHIFTER

Runs Per voice
 Inputs `audio_in`, `shift_cv`, `lin_cv`
 Outputs `up_out`, `down_out`, `mix_out`



A Bode/Moog-style shifter.

- It moves every frequency by the same number of Hz (**SHIFT** 0.1 Hz–5 kHz). A few Hz gives slow phasing; more gives clangorous inharmonic tones.
- **MIX** crossfades DOWN, BOTH (ring modulation) and UP.
- `lin_cv` (100 Hz/V) can sweep through zero.
- **FEEDBACK** gives the barber-pole spiral.

7.33 REVERB

Runs Mix bus
Inputs `audio_in` (stereo)
Outputs `left_out` (stereo)



Convolution reverb. Four built-in spaces (ROOM, HALL, PLATE, CATHEDRAL) plus any `.wav` impulse responses you put in `Documents/synthmax/impulses` (reload the plugin, or place a new reverb, to pick them up). **PREDELAY** (0–250 ms), **DECAY** (shortens the tail), **TONE**, **WIDTH** and **MIX**.

7.34 ROOM

Runs Mix bus
 Inputs in1...in8 (audio), x1, y1 ... x8, y8 (position CV)
 Outputs left_out (stereo: the two microphones)



A room simulator. Your sounds stand at points in a room, and two microphones listen to them. What the mics hear is computed from the room itself.

- **The floor plan** is the room seen from above, north up, on a 1 m grid. Each input is a numbered dot: drag it to move that sound. The two microphones, **L MIC** and **R MIC** (green, in the middle of the room to start with), drag the same way, and the knob at the end of each one's line aims it. The outline around each shows its pickup pattern. The default pair stands 17 cm apart, so the two sit close together; each one's name is drawn out to its own side.
- **The 3D view** (the **PLAN / 3D** switch in the corner) shows the room in perspective: the floor grid, the walls tinted by their materials, and every source and mic with its shadow and height.
 - Drag an object to move it across the floor.
 - Drag the small diamond above an object to raise or lower it; heights are part of the simulation.
 - Drag empty space to orbit the camera around the room; the mouse wheel zooms.

Everything you move is heard as you move it.

- **The room:** **WIDTH**, **DEPTH** and **HEIGHT** in metres, and a material for every surface. Click a wall on the plan to change its material; the floor and ceiling have selectors. The materials are concrete, brick,

plaster, wood, glass, carpet, curtains, acoustic foam, audience and open (no wall at all). Each absorbs lows, mids and highs differently. A new ROOM starts as a treated music room, about 0.9s of reverb: a wood floor, plaster walls, curtains behind the microphones and an acoustic ceiling. Hard surfaces all round (concrete, brick, plaster) make a much longer reverb, and the farther a sound is from the microphones the more that reverb, the same in both ears, washes out its left-right position. Lower **LATE**, or move the sound nearer the mics, for a sharper image.

- **Inputs grow like the mixer's channels:** the panel shows the sources in use plus one empty input. Plug into it and the next appears, up to eight. Unplug one and the rest close up.
- **Moving sounds with CV:** each source's x and y inputs add to its position, 1 V for the whole width or depth of the room. An LFO circles a sound around the room, an envelope walks it in. The dots follow on the panel.
 - The voltage moves the sound *from* where you put it. With a CV patched in, a hollow ring marks the sound's own spot and a line runs out to where the CV has taken it, marked **CV**. Dragging the sound sets its own spot so the sound lands under the mouse, as far as the CV allows.
 - A **CONSTANT**, or an oscillator LFO with nothing per-voice patched into it, runs on the mix, so it moves the sound whether or not notes are playing.
 - A per-voice source, such as an envelope or an LFO synced to the keyboard's gate, moves the sound only while notes are sounding, and the voltages of all the sounding notes add together.

Movement is smooth for gestures and slow sweeps; it is not meant for fast fly-bys.

- **MIC PATTERN** (omni, cardioid, figure-8), **EARLY** and **LATE** (the reflections' and reverb tail's levels), **MIX** (dry/room) and **LEVEL**.
- The readout shows the room's reverb time (RT60) in the low, mid and high bands. The **echogram** plots both mics' response to the first source over one second.

How it works. The early reflections are computed exactly, by the image-source method. Every bounce off the six surfaces is a mirror image of the source, arriving with its own delay and level and filtered by every material it hit, by the air, and by the microphone's pattern. The late reverberation is statistically exact: its decay time per band comes from the room's volume and absorption (the Eyring formula), and its level matches the reflections where the two meet. Together they make an impulse response for every source and mic, which the sound is convolved with. The responses are rebuilt in the background whenever anything changes and crossfade in, so you can move things while you play. The default microphones are an ORTF pair: cardioids 17 cm apart, angled $\pm 55^\circ$, the classic natural-stereo setup, about 1.4 m in front of the sources. The direct sound and the early reflections carry each source's position. The reverberant tail is the same from every direction, equally loud in both microphones and decorrelated between them, so it surrounds the sound without pulling it to one side. Move the microphones back for more room and a softer image, or closer for a sharper one. Latency is 128 samples.

Dynamics, tone and amplification

7.35 COMPRESSOR

Runs Mix bus
 Inputs audio_in (stereo), sidechain
 Outputs left_out (stereo), gr_out



A mastering-grade compressor and expander.

- **Compression:** THRESHOLD, RATIO, KNEE, ATTACK, RELEASE (or AUTO RELEASE), LOOKAHEAD, MAKEUP up to 30 dB (or AUTO GAIN), and MIX for parallel compression.
- **Downward expander/gate:** with its own threshold, ratio, range and timing.
- **Detection:** PEAK or RMS, LINK, and a sidechain high-pass (SC HPF). LISTEN lets you hear the sidechain.
- **Styles:** CLEAN, BUS (console glue) and OPTO (LA-2A-like).
- gr_out is the gain reduction as a CV (1 V per 10 dB), for ducking other things.

7.36 BODY

Runs Mix bus
 Inputs audio_in
 Outputs left_out (stereo)



The resonant body of an acoustic instrument, what turns a bare string (or any source) into a violin, a cello or a guitar. The body is modelled as its modes, each a resonance at its own frequency, with its own sharpness and level:

- the air resonance (a violin's at about 275 Hz, a guitar's about 100 Hz);
- the main wood modes (the violin's corpus modes around 400–550 Hz, a guitar top's at about 200 and 400 Hz);
- above about 1 kHz, ever denser modes, shaped for the violin family by the bridge's own resonance around 2.5 kHz (the “bridge hill”).

Each mode radiates a little differently to the left and right, as a real body does, so the body adds a natural width.

- **TYPE:** violin, viola, cello, double bass, guitar or acoustic bass.
- **SIZE** (a smaller or larger body), **RESONANCE** (a dead, damped body to a lively, ringing one), **BRIGHT** (the bridge hill and treble), **WIDTH**, **BODY** (body against the bare input) and **LEVEL**.

The level is normalized so the body's average gain is 1, so changing type or size doesn't jump in level. As on a real instrument, notes that land on a resonance ring out louder than those between.

7.37 GRAPHIC EQ

Runs Mix bus
Inputs audio_in (stereo)
Outputs left_out (stereo)



24 bands at ± 12 dB, with an output **GAIN** of ± 12 dB. The curve you draw is the curve you get, because the bands are solved together. Drag across the faders to paint a curve in one stroke; double-click a fader to zero it.

7.38 GUITAR AMP

Runs Mix bus
 Inputs audio_in (mono)
 Outputs audio_out



A full guitar or bass rig in signal-chain order.

- **COMP.**
- **PEDAL:** OFF, SCREAMER, RAT, MUFF or FUZZ, with **DRIVE**, **TONE** and **LEVEL**.
- **Amp:** CLEAN, CRUNCH or LEAD channels, with **GAIN**, **BASS/MID/TREBLE**, **MASTER** (power-amp drive with sag) and **PRESENCE**.
- **CAB:** off, 1×12 open, 2×12, 4×12 closed, bass 4×10, or bass 1×15.
- **VOLUME.**
- The pedal and the amp run 8× oversampled.

7.39 BLUE BOX

Runs Mix bus
Inputs audio_in (mono)
Outputs audio_out



The MXR Blue Box octave fuzz: a fuzz plus a square one or two octaves below what you play. **BLEND**, **OCTAVE**, **TONE**, **OUTPUT**, **GATE**. Single notes track cleanly; chords sputter, as on the original.

Voice and pitch processing

7.40 VOCODER

Runs Mix bus
Inputs carrier audio_in (stereo), mod
Outputs left_out (stereo)



A channel vocoder: the voice on mod (usually from **AUDIO IN**) imposes its formants on the synth on the carrier input, so the synth “talks”.

- **BANDS** (90 Hz–9 kHz, 4th-order bandpass filters), with **ATTACK** and **RELEASE**.
- **FLATTEN** lets any carrier speak clearly.
- **SIBILANCE** adds noise for “s” and “t” sounds, the biggest single help to intelligibility.
- **EMPHASIS**, **GATE**, **SHIFT** (formant shift), **WIDTH**, **MIX** and **OUTPUT**.

A bright, sustained carrier (a saw chord) works best.

7.41 AUTOTUNE

Runs Mix bus
 Inputs audio_in
 Outputs audio_out, pitch_out



Automatic pitch correction, from natural tightening to the hard “robot” effect.

- **KEY** and **SCALE**: chromatic, major, minor, the two pentatonics, or blues.
- **SPEED**: 0 = instant snap (the robot); 50–150 ms keeps vibrato.
- **AMOUNT**, **TRANPOSE**, **REF** (A4 = 430–450 Hz), **MIX**, and **INPUT** (voice range).
- Formants are preserved, so there is no chipmunk effect.
- **pitch_out** is the corrected pitch as 1 V/oct CV, so a singer can drive a synth voice.

7.42 PITCH TRACKER

Runs Mix bus
Inputs audio_in (or the hex string inputs)
Outputs audio_out



Plays synthmax's voices from a guitar or bass, as if they were MIDI notes. The keyboard module and its voice mode apply as normal.

- **SOURCE:**
 - MONO: single notes, with bends followed.
 - POLY: chords from one pickup. Rougher, with longer latency.
 - HEX: a hexaphonic pickup, one input per string. Each string gets its own voice and its own bends; this is the reliable way to track chords. (The per-string inputs are not yet available in the plugin.)
- **INSTRUMENT** (guitar, bass 4, bass 5), **THRESHOLD**, **DYNAMICS**, **BEND**, **OCTAVE**.
- The output is the input audio, for blending the real instrument with the synth.

Utilities and test equipment

7.43 ATTENUATOR

Runs Follows its input
Inputs `audio_in`
Outputs `audio_out`



A plain attenuator: the input times **LEVEL**, out. The knob runs 0–10 and is linear, so 5 is half the voltage (–6 dB); the gain in dB shows under it. Use it on audio (a quieter copy of a sound) or on a control voltage (how far an LFO swings a pitch, how much an envelope opens a filter). It runs per voice or on the mix, wherever its input does.

7.44 STEREO MERGE

Runs Follows its inputs
Inputs `left_in`, `right_in`
Outputs `left_out` (stereo)



Two mono signals in, one green cable out. A lone left input goes to both sides.

7.45 STEREO SPLIT

Runs Follows its inputs
 Inputs `audio_in` (stereo)
 Outputs `left_out`, `right_out`



One green cable in, two mono signals out.

7.46 OSCILLOSCOPE

Runs Per voice
 Inputs `audio_in` (CH1), `ch2`
 Outputs `audio_out` (CH1 passed through)



TIME/DIV 0.1–50 ms, a **V/DIV** per channel, a rising-edge **TRIG** level, and Y-T or X-Y display. It shows the sum of all sounding voices. It sits inline anywhere without changing the signal.

7.47 SPECTRUM ANALYZER

Runs Mix bus
 Inputs audio_in (L), R
 Outputs left_out (stereo, passed through)



Shows the frequency content of what passes through it, including the final mix after the reverb. Response speed, peak hold, slope and range are display settings that are saved with the patch.

7.48 VU METER

Runs Mix bus
 Inputs audio_in (stereo)
 Outputs left_out (stereo, passed through)



A stereo level meter shown as two LED bars, L over R, from -48 to $+6$ dB. 0 dB is a signal peaking at 1.0 (full level). Segments are green, then yellow from -9 dB and red from 0 dB. It sits inline anywhere, and a mono input reads (and passes on) as centred stereo.

- **MODE:** **VU** shows the RMS level with classic VU timing (about 300 ms to settle), the average loudness you hear. **PEAK** shows the true peaks, rising instantly and falling back about 20 dB in 1.7 s. Both read a sine wave peaking at 1.0 as 0 dB.

- **PEAK HOLD**: when ON, a brighter segment marks the highest recent peak for 2 s, then falls.
- **OVER** lights red for 1.5 s whenever a peak goes past 0 dB.

Like the spectrum analyzer, it runs on the mix: on a voice signal it reads all sounding voices together.

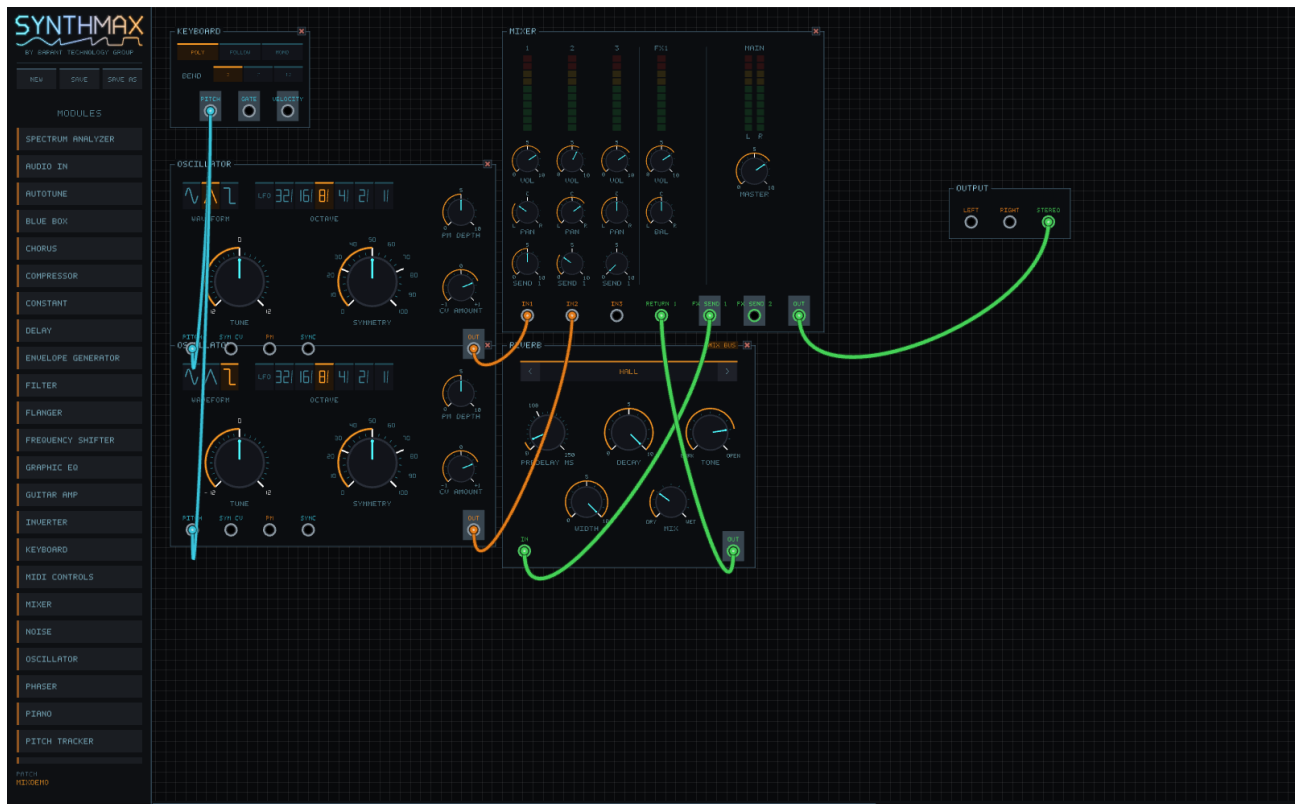
7.49 VOLTMETER

Runs Per voice
 Inputs audio_in
 Outputs audio_out (passed through)



Reads DC, RMS or PEAK voltage, from the most recently played voice. Useful for checking a CV.

8 The Mixer and FX Buses



Two oscillators into channels 1 and 2. **FX SEND 1** goes to a reverb, whose output comes back on **RETURN 1**. **FX SEND 2** has appeared, ready for a second effect.

8.1 Channels that appear as you need them

A new mixer shows just one channel. Plug something into it and a fresh, empty channel appears beside it, ready for the next source, up to 16. Unplug a channel and it is wiped away; the channels to its right slide down to close the gap, keeping their settings and cables.

Each channel input is **mono**. Its controls are:

- **VOL**: a fader taper, unity at about 7, +6 dB at full.
- **PAN**: equal-power placement in the stereo field.
- A **SEND** knob for each FX bus in use.

LED meters show each channel and the main output. **MASTER** sets the final level, and **OUT** is a stereo (green) output.

8.2 FX buses

An FX bus sends part of each channel to an effect and brings the result back into the mix. This is the studio “aux send” arrangement: one reverb shared by everything, at a different amount per channel.

1. Patch **FX SEND 1** (a green, stereo jack) into an effect, such as a **REVERB**. Each channel grows a **SEND 1** knob, and a **RETURN 1** channel appears.
2. Patch the effect's output back into **RETURN 1**. The return channel has its own volume and pan (**BAL**) and meter. Set the effect's own **MIX** fully wet.
3. An empty **FX SEND 2** has appeared. Patch it to add a second bus, and so on, up to 8.

Sends are **post-fader and post-pan**: a channel's send follows its volume knob, and its stereo placement carries into the effect. Return channels always sit to the *right* of the regular channels.

Why this isn't a feedback loop

mixer, effect, then mixer again looks like a cable cycle. synthmax runs the returns in a hidden companion module on the mix bus, after the effect, so the loop is legal. You never see this companion; it appears in the patch file only as the return cable.

9 Patch Techniques

9.1 The basic subtractive voice

KEYBOARD pitch → **OSCILLATOR** pitch; oscillator → **FILTER** → **VCA** → **OUTPUT**. **KEYBOARD** gate/velocity → an **EG**, whose output goes to the VCA's **gain_cv**. A second EG into the filter's **cutoff_cv** gives a filter sweep. Adding the keyboard's pitch to **cutoff_cv** too makes the brightness track the keys. This is the basic patch.

9.2 Transposing and detuning

Sum a **CONSTANT** into a pitch input: $1/12\text{ V}$ per semitone, 1 V per octave. A second oscillator with a slightly offset **TUNE** thickens the sound.

9.3 Vibrato that fades in

LFO (oscillator in LFO mode) → a VCA whose gain comes from a slow EG → the oscillator's pitch. `violin-section` does this. Alternatively, route **MIDI CONTROLS** `mod` to the VCA's gain for mod-wheel vibrato.

9.4 Plucked strings (Karplus-Strong)

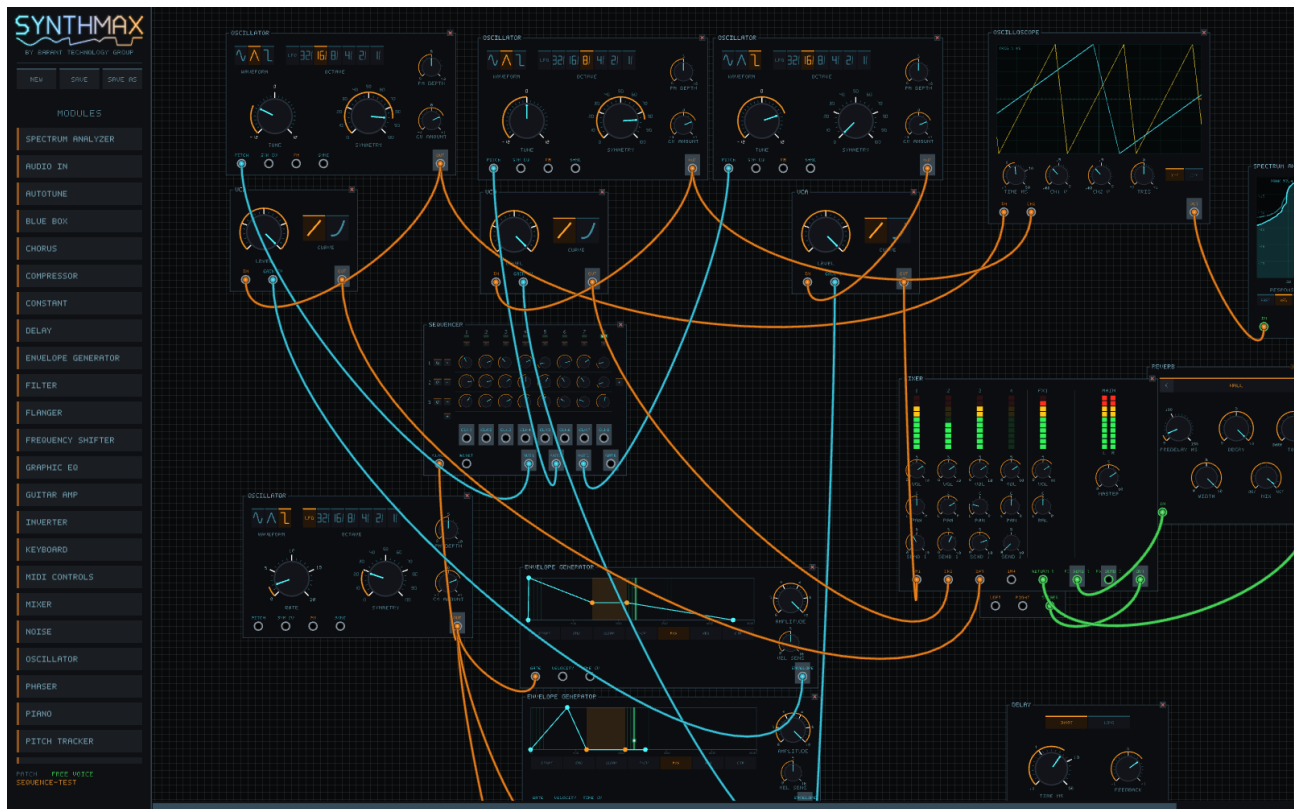
A short burst of **NOISE** (shaped by a fast EG and VCA) → a **DELAY** in SHORT range with high **FEEDBACK** and a little **DAMP**, with the keyboard's pitch on `time_cv`. The delay rings at the note's pitch. The guitar, 12-string and metal patches are built this way.

9.5 FM / electric piano

Two sine oscillators at the same pitch, one into the other's `pm`. An envelope on the modulator's level gives a bright “bark” that decays to a pure tone. This is the `rhodes-suitcase` recipe.

9.6 Sequenced patterns

Patch a **BEAT CLOCK**'s `clock` into the **SEQUENCER**'s `clock` and its `reset` into the sequencer's `reset`. In a DAW the pattern then plays in time with the song, from the top of the pattern at every start or loop. Without a beat clock, an **OSCILLATOR** in LFO mode works as a free-running clock: patch it to the sequencer's `clock`. Send `out1` to oscillator pitch (turn on **Q**) and `gate` to an EG. For accents, patch some steps' **CLK** outputs to a second EG that opens the filter further. To chain sequencers, patch the last step's **CLK** into a second sequencer's `clock`: it moves on once per pass of the first, so it can transpose the first, change its pattern, or play a bass line under it. Remove the keyboard for a free-running pattern, or keep it to transpose the pattern from the keys.



sequence-test: a sequencer clocked by an LFO in a keyboard-less patch. Note **FREE VOICE** in the palette.

9.7 Processing external audio

AUDIO IN → **GUITAR AMP**, **REVERB**, **AUTOTUNE** or the **VOCODER**'s mod. With no keyboard in the patch, the free voice keeps everything running.

10 Factory Patches

All are synthesized from modules; none use samples. Recordings of many of them are on the synthmax page at <https://barant.com/vst/synthmax>.

Patch	Description
grand-piano	A concert grand voiced after the Steinway Model D: warm and singing, with a big full bass and a soundboard EQ.
imperial-grand	A concert grand voiced after the Bösendorfer Imperial: dark, round and deep, with the longest sustain.
studio-grand	A 6'7" grand voiced after the Yamaha C5: clear and bright with a crisp attack, for cutting through a mix.
plain-piano	The bare piano module, a starting point.
rhodes-suitcase	1:1 FM tine with velocity "bark", stereo tremolo, compressed for punch.
wurlitzer-200a	Hollow, nasal reed electric piano with its characteristic bite.
hammond-c3	Tonewheel organ through the Leslie 122 (CHORALE/TREMOLO).

Patch	Description
gulbransen	A simple combo-organ voice.
bright-perc-leslie	Bright, percussive saw stack into an amp and rotary cabinet.
glass	Rubbed-glass: a beating sine pair with an airy breath.
tubular-bells	Inharmonic chime partials with a long, slowly decaying tail.
nylon-guitar	Karplus-Strong string, warm and round, with a body resonance.
steel-guitar	The same, crisp and ringing long.
12-string-guitar	Each key plays a course: a string plus an octave string 3 cents sharp.
metal-lead	One bright string through the amp, MONO legato for solos.
metal-rhythm	Power chords (root, fifth, octave) per key, palm-mute friendly.
thrash-80s	Tight, palm-muted power-chord chugs.
doom-sludge	Power chords dropped an octave through a phaser and a fuzzy amp.
slap-bass	Snappy saw-and-pulse bass with a percussive pop.
saxophone	Solo sax: a saturated reed with breath noise; expression pedal and mod wheel are live.
sax-section	Three detuned players per note, for a section.
trumpet	A trumpet from the BRASS physical model (also part of the orchestra).
french-horn	A French horn from the BRASS model, mellow, slightly muted.
violin-section	Four BOWED STRING players in a violin BODY.
woodwind-section	Flute, clarinet, oboe and bassoon layered on a mixer.
4op-fm	A four-operator FM voice.
wisp-o-willow	An airy, chorused stereo pad.
plain-3-voice	Three oscillators into a mixer, a simple starting point.
concert-hall-piano	The grand piano on a stage, heard from the hall through a ROOM.
lcr-delay-lead	The rock lead through an LCR delay synced to the DAW (STEREO DELAY).
ping-pong-rhodes	The Rhodes with dotted-eighth echoes bouncing between the speakers (STEREO DELAY).
wide-delay-sax	The saxophone with a wide stereo delay, 320 ms left and 480 ms right (STEREO DELAY).
split-bass-and-strings	A keyboard split: a bowed bass below C3, a violin section from C3 up (KEY ZONE).
layer-strings-and-brass	Layered zones: strings across the keyboard, brass doubling them from C3 up (KEY ZONE).
basic	One oscillator, filter, two EGs, VCA, reverb and EQ: the default patch.
sequence-test	Keyboard-less sequencer demo (free voice).
tester	A test bench of modules.

10.1 The guitar collection

Guitars for every style, all built from one plucked-string model (the same Karplus-Strong string as the nylon, steel and 12-string guitars). Each style changes the pick, where the string is plucked, how it rings and darkens, the body or pickup, the amp, pedals and effects. Together with the acoustic and metal guitars above, every style is covered.

- **Chords:** the guitars use **FOLLOW**, so repeating a note re-plucks its string. Roll a chord's notes in quickly, low to high, for a strum.

- **Leads and slides:** rock-lead, pedal-steel, resonator-slide and fretless-bass are **MONO** legato. The slide patches glide between notes you play legato.
- **Vibrato:** the blues, lead and steel patches add vibrato to held notes. The pitch wheel bends, as on any patch.

Type	Patch	Sound
Electric	jazz-archtop	A hollow-body archtop on the neck pickup - warm, round, mellow, through a clean amp.
Electric	funk-clean	A bright single-coil, compressed and choppy - funk rhythm.
Electric	country-twang	A Telecaster bridge pickup - bright and snappy, with slapback echo.
Electric	blues-guitar	A humbucker through an overdrive pedal into a crunchy amp - singing blues, with vibrato on held notes.
Electric	classic-rock	A cranked British-style amp on its crunch channel, 4x12 cabinet - big rock chords and riffs.
Electric	sixties-fuzz	A germanium fuzz pedal into a clean amp - 60s psychedelic rock.
Electric	surf-guitar	A bright single-coil drenched in spring-style reverb with amp tremolo - surf instrumentals.
Electric	eighties-chorus	A clean, chorused guitar with dotted-eighth echoes - 80s new wave arpeggios.
Electric	ambient-swells	Volume-pedal swells into long echoes and a cathedral - ambient and shoegaze textures.
Electric	rock-lead	A singing, sustaining rock lead - overdrive into the lead channel, delay and hall; MONO legato for slurs.
Electric	electric-12-string	A jangly electric 12-string - octave and unison pairs, compressed and bright.
Electric	pedal-steel	A pedal steel - glides between notes (MONO legato), swells in, sustains for days.
Acoustic	flamenco-guitar	A flamenco guitar - nylon strings, bright, dry and percussive.
Acoustic	dreadnought	A big-bodied steel-string dreadnought - deep, booming, for strumming.
Acoustic	resonator-slide	A resonator (dobro) played with a slide - nasal and metallic; MONO legato glides.
Acoustic	mandolin	A mandolin - paired steel courses, bright and short.
Acoustic	ukulele	A ukulele - soft nylon, small body, short and sweet.
Acoustic	banjo	A five-string banjo - very bright, plucked near the bridge, over its drum-head body.
Bass	fingered-bass	A fingered electric bass (P-bass) - round and solid, through a 4x10 cabinet.
picked-bass	A picked electric bass - punchy and articulate, with grit.	
fretless-bass	A fretless bass - singing, gliding between notes (MONO legato), chorused.	

Type	Patch	Sound
prog-hammond	A Hammond C3 driven hard into a fast Leslie (drawbars 88 8800 008, key click up): the snarling, overdriven organ of 70s progressive rock.	
hitech-rock-jam	A polyphonic hi-tech rock voice built for velocity. Soft notes are clean and round, sliding up into pitch. Dig in for drive, bite and FM growl. Accents above about 75% velocity (found by a LOGIC gate) add a pinch-harmonic squeal.	
modular-lead	A 70s modular-synthesizer lead: three detuned saw-tooths through two low-passes in series (a steep 24 dB slope), swept by their own envelope, with portamento and delayed vibrato. MONO legato.	
organ-full-cathedral	PIPE ORGAN, every stop drawn (32 ft reeds in the pedal, mixtures blazing) in a cathedral: the full organ, huge and a little nasty. Expression pedal on the swell.	
organ-principal-chorus	The organo pleno: principals 8, 4, 2 2/3 and 2 with the mixture; 16 ft and 32 ft in the pedal.	
organ-reeds	Trumpet 8 and bombarde 16 over principals, with a 32 ft bombarde in the pedal: the French toccata sound.	
organ-foundations	16 ft and 8 ft principals with flutes: warm, dark and enormous without being loud.	
organ-flutes-tremulant	Bourdon 8 and flute 4 with the tremulant: gentle and chifty.	

Type	Patch	Sound
organ-celeste	The string celeste over a soft bourdon, with the swell half shut.	
organ-principal-8	One 8 ft principal, a starting point for your own registration.	
harpsichord	A harpsichord: Karplus-Strong strings plucked by quills, damped on release.	
harpsichord-2x8	Two 8 ft choirs, slightly apart: the fuller continuo harpsichord.	

10.2 The orchestra

Every instrument of the orchestra has two patches: a **solo** player and an **ensemble**, a section of 2–4 players in unison. All the orchestra patches are set to the same loudness, so they can be layered or mixed together without rebalancing.

- **Solo string, wind and brass patches** are **MONO** legato, like a real soloist. Play legato to slur, or detach the notes to re-articulate.
- **Ensembles** are polyphonic. Their players are slightly detuned, each with its own vibrato and intonation drift, starting a few milliseconds apart, with a hall, so chords sound like a section rather than one instrument.
- **Every patch sounds at the key you press** (concert pitch). Play each instrument in its real range: piccolo and glockenspiel up high, contrabass, contrabassoon and tuba down low.
- On the string, wind and brass patches, the **mod wheel** adds vibrato. On the strings, reeds and brass the **expression pedal** (CC 11) is the bow speed or breath, so it swells the tone as well as the level; on the flutes it is a volume pedal.

Family	Solo	Ensemble	Section size
Strings	violin	violin-section	4 players
	viola	viola-section	4 players
	cello	cello-section	4 players
	contrabass	contrabass-section	3 players, bowed
Woodwinds	harp	harp-ensemble	2 harps
	piccolo	piccolo-section	2 players
	flute	flute-section	3 players
	oboe	oboe-section	3 players
	english-horn	english-horn-section	2 players
	clarinet	clarinet-section	3 players; no vibrato
	bass-clarinet	bass-clarinet-section	2 players
	bassoon	bassoon-section	3 players
	contrabassoon	contrabassoon-section	2 players

Family	Solo	Ensemble	Section size
Brass	trumpet	trumpet-section	3 players
	french-horn	horn-section	4 players
	trombone	trombone-section	3 players
	tuba	tuba-section	2 players
Percussion	timpani	timpani-pair	2 timpanists
	glockenspiel	glockenspiel-ensemble	2 players
	xylophone	xylophone-ensemble	2 players
	celesta	celesta-ensemble	2 players
	tubular-bells	tubular-bells-ensemble	2 sets

The recipes: the strings are **BOWED STRING** physical models in a **BODY** of their own type; the oboe, English horn, clarinets and bassoons are **REED** models; the trumpet, horn, trombone and tuba are **BRASS** models. The flutes are oscillators shaped by a brightness envelope, with breath noise. Every player's intonation wanders a few cents on its own, so no two notes start at quite the same pitch. A section's players are also slightly detuned, each with its own vibrato, and come onto the note a few milliseconds apart, so a section sounds like several players, not one copied. The harp is a plucked string, the same Karplus-Strong model as the guitars. The percussion is built from each instrument's own inharmonic partials, ringing for their own times. Each patch's comments describe its recipe.

10.3 Percussion

Drums and hand percussion from rock, Latin and African music: three kits and four melodic instruments. Like everything else in synthmax, they are synthesized from the modules, not sampled. Drum heads are oscillators whose pitch drops as they are struck; hi-hats, cymbals and bells are square waves beating together; snare wires and shakers are filtered noise.

The kits put each drum on its own key, with a **KEY ZONE** for each drum (or each group of drums). Each drum has its own channel on the kit's **MIXER**, so you can rebalance the kit or pan a drum. The rock and Latin kits follow the **General MIDI drum map**, so the drum tracks a DAW writes play the right drums.

Patch	Keys
rock-drum-kit	Kick 35/36, snare 37–40, toms 41 43 45 47 48 50 (floor tom to high tom, tuned by the key), closed hi-hat 42/44, open hi-hat 46, crash 49/57, ride 51/53.
latin-percussion-kit	Cowbell 56, bongos 60 (high) and 61 (low), conga 62 (muted) and 63 (open), tumba 64, timbales 65 (high) and 66 (low), maracas 70, guiro 73/74, claves 75. The guiro keeps scraping for as long as you hold the key.
african-percussion-kit	Djembe bass C2 (36), tone D2 (38) and slap E2 (40); the three dunun: dun-dunba F2 (41), sangban G2 (43) and kenkeni A2 (45); talking drum C3 (48); iron bell C#3 (49); shekere D3 (50).

The melodic percussion plays across the keyboard:

Patch	Description
talking-drum	The West African talking drum. Strike it, then roll the mod wheel to squeeze the drum, raising its pitch by up to an octave. The pitch bend works too.
steel-drum	A Caribbean tenor steel pan. Each note is tuned with its octave and twelfth.
balafon	A West African balafon: wooden keys over gourd resonators.
kalimba	A kalimba (mbira): plucked steel tines on a wooden box.

11 Patch Files

Patches are plain-text `.graph` files. Yours are saved in `Documents/synthmax/patches` in your home folder (on Windows, `Documents\synthmax\patches`). You can read, write and comment them by hand:

```
# synthmax patch
version 2
view zoom=0.75 scroll=0,0
output @2154,1090

node kb modules/Keyboard.so @210,40 voice_mode=0
node osc modules/Oscillator.so @470,40 waveform=1 octave=0
node vca modules/VCA.so @1000,540 level=0.79

cable kb.pitch -> osc.pitch
cable osc.audio_out -> vca.audio_in
cable vca.audio_out -> out.stereo
```

- `#` lines are comments. The factory patches use them to explain how each sound is built.
- `node name module @x,y` followed by `parameter=value` pairs. Any parameter left out takes its default.
- `cable source.port -> dest.port`. The main output is `out.left`, `out.right` or `out.stereo`.
- `version 2` marks the stereo-cable format. Older files load and are converted automatically: **STEREO SPLIT/MERGE** modules are inserted where the old separate left/right cables need them. Saving writes version 2.

12 Troubleshooting

No sound • Is something patched into **OUTPUT**?

- Is your MIDI keyboard routed to the synthmax track?
- Is there a VCA after the oscillator, with an EG on its gain and the keyboard's gate on the EG?
- Is the track armed (record-enabled or monitoring) so it receives MIDI?

A cable won't connect (the jack flashes red)

Either it would make a loop, or a mix-bus module is trying to feed a per-voice one. See section 4.6.

Notes hang

Is the sustain pedal down, or inverted? Some pedals report reversed polarity. All Notes Off from your controller clears everything.

The patch only plays one note at a time

The keyboard is in **MONO**. Switch it to **POLY**.

Notes don't play at all, but the patch is making sound

The patch has no **KEYBOARD**, so it is in free-voice mode. Add a keyboard.

Crackles or dropouts

Raise your host's audio buffer, or lower polyphony by playing fewer notes. Reverb, piano and guitar amp are the heaviest modules. Mix-bus effects go to sleep when their input is silent.

Plugin behaves oddly after an update

Restart the host. See section 2.2.

Typing doesn't reach SAVE AS in REAPER

Turn on *Send all keyboard input to plug-in*.

A new impulse response doesn't appear

Remove the reverb and place it again, or reload the plugin.