



Sawbench Owner's Manual and specifications

Congratulations! You are now the proud owner of a fully assembled Saw Bench Synthesizer, or you assembled it yourself. Either way, you should be ready to use it now. This manual explains how.

Main Features:

VCO (saw, 4 Hz – 4 kHz (LFO range – around the highest piano note))
VCF (four pole low-pass, diode ladder)
VCA (80 dB)
Frequency Modulation
LFO (four wave forms, 200 mHz – 20 Hz)
2 ADSR Envelopes
Direct control: 6 rotary knobs, 2 buttons and 2 toggle buttons

Interfaces:

Power Supply:

9-12V DC, 2.1mm, center positive, 1A or more

MIDI input:

DIN-5, full size

Audio output:

6.35 mm phono jack, line output (-cannot- drive a headphone!)



The back side of the Sawbench: MIDI in and power jacks.



The left side of the Sawbench: the phono jack (audio out).

Hooking up:

Connect the MIDI out of your MIDI device up to the DIN-5 port on the back side of the Sawbench. A MIDI controller or keyboard are preferred for the first quick test.

Tested MIDI sources:

- Ableton Mac + Focusrite Saffire pro 40
- Ableton Mac + Focusrite Saffire LE

- AKAI MPK25, MPK49
- Arturia Beatstep
- Atari ST running custom step sequencer
- Casio HT-700 🤪
- Kawai K4
- Midistart2
- Renoise Mac + M-AUDIO USB UNO
- Roland PC-160A
- Yamaha RM1X
- Yamaha SY-35
- Propellerheads Reason + Nektar Panorama P6
- Korg SQ-1 Sequencer

Hook up the Audio output using the 6.35 mm phono jack on the left hand side of the Sawbench. This can be either a mixer or an amplifier. Be sure to turn it up a little.

The Sawbench requires a suitable DC power supply like specified above. Connect it up to the power jack on the back side. NOTE: Supply plug must be center-positive. wrong polarity may result in permanent damage to the internal regulator!

If everything is right the Sawbench should show a little introduction: It should start scrolling through the LEDs faster and faster, and eventually they will stop and settle. Then, after one second, the LFO LED should start pulsing. This means the Sawbench has calibrated its VCO and is now ready to receive MIDI input!

Manual controls:

Now that the Sawbench is up and running, it's time to make some sounds! First of all, take a look at this overview of the manual controls:



Photo of the Sawbench from the top. Knobs and toggles set to "factory default".

The knobs are the usual type: turned completely to the left means it's off or closed or zero, while completely turned up the right means it's maximum.

As you can see there are cutoff and resonance controls on the top. Just turn the cutoff completely to the right (what we like to call "open"), which means the filter cutoff is at maximum and hence will not filter out any frequencies from the sound. I.e. you will actually be able to hear notes! Wow!

In the same way, you can set VCA Attack (the bottom-left knob) to zero. Set VCA Sustain (again a knob in the bottom row, the one just left of the rightmost) to full.

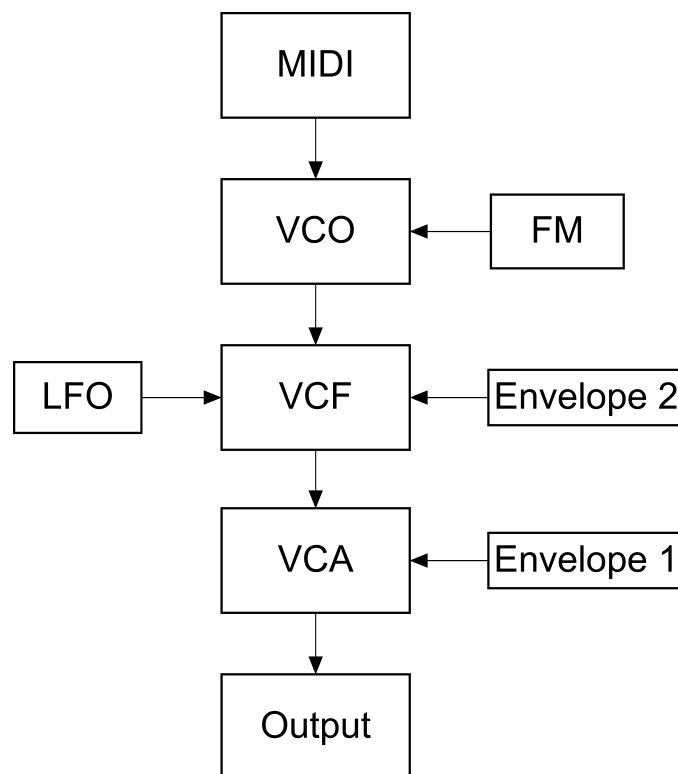
See the picture above if you're lazy and don't like to read.. These settings are also how the Sawbench is configured in the factory.

Then.. hit a key on your MIDI controller.. And you should be hearing notes play. How nice! If you don't: feel free to visit the Forum or write us an e-mail at tastychipselectronics@gmail.com.

Not a bad start.. now for the rest.

Feature-by-feature and step-by-step overview:

Now for a more detailed overview. Below you find the a schematic of the signal path.



Simplified block diagram of the Sawbench's signal path.

VCO (Voltage Controlled Oscillator):

Short:

The VCO on the Sawbench is a Sawtooth oscillator.

The pitch is controlled by MIDI (note on + pitch bend). There is also an option to add Frequency modulation using MIDI : modulation wheel + CC.

Detailed:

All synthesis starts with oscillation. In this case we have just one true analog VCO which can generate just one type of wave: the sawtooth. The sawtooth is ideal for filtering, as it has many harmonics.

As you have already found out the VCO's pitch is controlled via MIDI note on/note off and may also be influenced by several other MIDI commands: pitch bend, modulation wheel and glide. The modulation wheel controls Frequency Modulation (FM). FM may be used to generate a whole range of sound effects: growling bass, overdrive-like effects, and oldschool telephone type sounds.

VCF (Voltage Controlled Filter):



The VCF cutoff and resonance knobs.

Short:

The VCF on the Sawbench is a four pole diode ladder low-pass filter.

Cut-off:

Manually controlled

Controlled by envelope 2

Controlled by LFO

Resonance:

Manually controlled

Detailed:

After the VCO has created a sawtooth wave at the desired pitch, this signal is then filtered by the Voltage Controlled Filter (VCF). The filter for a large part defines the character of the sound. Since the sawtooth has so much harmonics, a slight change in cutoff frequency is immediately noticed. The VCF is a 4-pole diode ladder filter with high resonance. The diode ladder has the characteristic sound of the classic EMS or 303 synths. Resonance may be used to make it squeal or whistle.

The VCF is controlled primarily by the on-board (manual) controls of the Sawbench. This includes manual cutoff, manual resonance, Low Frequency Oscillation (LFO) and envelope controls. The VCF also has keyboard pitch tracking, which can be influenced via MIDI (see MIDI CC table at the end). Overall, the VCF has a large amount of controls for filter sweeps.

The typical wawa and slapped bass sounds are of course possible, but utilising looped envelopes some crazy drones can be made as well. To top it all off, it is possible to turn off filter envelope sweeps when playing legato (that is, the glueing together of notes). See the section about ADSR envelopes further on.

VCA (voltage controlled amplifier):**Short:**

The VCA is an amplifier controlled by envelope 1 and by MIDI velocity.

Detailed:

The VCA is an analogue amplifier based on the LM13700. This allows for a high dynamic range (80 dB) and good linearity.

The amplitude of the VCA = (roughly) MIDI amplitude * envelope

(The MIDI amplitude is computed from MIDI note on velocity.)

Note that the VCA envelope can also be looped. For more information see the envelope section further on in this manual.

LFO (low frequency oscillator):

The LFO can be turned on/off by the LFO toggle switch.
The switch has the following states:

ON state:

The LFO now modulates the VCF cut-off.

OFF state:

The LFO is now bypassed.



The Sawbench toggles: used to enable or disable VCF controls LFO and envelope.

Waveforms:

Different waveforms can be selected using the wave select button.
Using this button you can scroll through the waveforms. The 4 LED's next to the button indicate which of the following waveform is selected:

- 1: Random (sample-and-hold alike)
- 2: Sine wave
- 3: Sawtooth
- 4: Square wave



The LFO wave select button, LFO activity LED (left) and the 4 LFO waveform LEDs (right)

The frequency and amount of the LFO can be set manually. See the “Function” button explanation for more info.

Envelope (ADSR):

There are 2 Envelopes on the Sawbench. Both envelopes are triggered by MIDI note-on information. They are scaled by MIDI velocity and the amount knob in state 3.

The envelope uses the classic ADSR (Attack Decay Sustain Release) model. ADSR envelopes on Wikipedia. The knobs at the bottom of the Sawbench individually control the ADSR parameters.



The ADSR knobs and their functions.

Envelope controls use a cubic function. We feel it's better than an exponential function, as it allows for smoothness through the entire range of operation. This applies for the manual controls (knobs) as well as MIDI.

Envelope 1:

This envelope controls the amplitude of the VCA.

See the “Function button” explanation for more info on how to control ADSR + amount.

Envelope 2:

This envelope modulates the Cut-off of the VCF.

You can bypass this using the ADSR toggle switch.

See the “Function button” explanation for more info on how to control ADSR + amount.

Envelope 2 can be kept on its sustain when multiple notes after played (glued) after each other. See the legato MIDI CC in the table below.

Note that both envelopes can be set to looping mode by using a MIDI CC (see table below).

LFO and amount controls:

LFO amount: controls LFO depth, linear

LFO speed: controls LFO speed, linear (0.2 Hz minimum)

VCA amount: controls VCA envelope amplification, linear

VCF amount: controls VCF envelope amplification, linear

The Function button:

The Function button can scroll through different states.

The 3 LED's next to this button indicate which state is selected.

The 4 rotary knobs have different functions in each state (see pictures and table below)



The function button and its three state LEDs.

Knob	State	Function
Knob 1	1	VCA Attack
knob 2	1	VCA Decay
Knob 3	1	VCA Sustain
Knob 4	1	VCA Release
Knob 1	2	VCF Attack
Knob 2	2	VCF Decay
Knob 3	2	VCF Sustain
Knob 4	2	VCF Release
Knob 1	3	LFO Speed
Knob 2	3	LFO Amount
Knob 3	3	VCA Envelope amount
Knob 4	3	VCF Envelope amount



The ADSR knobs and their functions.

Supported MIDI commands and controls:

The Sawbench listens to MIDI data on channel 1 (some customers got it set to a channel of their choice, though!). It supports note on/off, pitch bend and a wide range of control changes. Everything that can be changed by the ADSR knobs and on-board LFO controls can also be done with MIDI. Furthermore, it also allows parameters which are not changeable by on-board controls (VCF keyboard tracking, for instance). See the table below:

Sawbench command	MIDI control number (CC)	Value information
Modulation Depth (FM)	1	0=no modulation. 100=full modulation, >100=over modulation
Relative modulation frequency(FM)	12	127=0.99*note pitch, 64=0.5*note pitch, 0=Off
Envelope 1(VCA) Attack time	73	0=0.0s 127=4.0s
Env 1(VCA) Decay time	75	0=0.0s 127=4.0s
Env 1 (VCA) Sustain level	80	0=mute 127=max
Env 1 (VCA) Release time	72	0=0.0s 127=4.0s

Sawbench command	MIDI control number (CC)	Value information
Env 2(VCF) Attack time	81	0=0.0s 127=4.0s
Env 2(VCF) Decay time	82	0=0.0s 127=4.0s
Env 2(VCF) Sustain level	83	0=mute 127=max
Env 2(VCF) Release time	84	0=0.0s 127=4.0s
LFO speed	85	0.2Hz - 20Hz
LFO amount	86	0=mute 127=full
Envelope 1(VCA) amount	87	0=mute 127=max
Envelope 2(VCF) amount	88	0=none 127=full
VCF keyboard tracking	89	0=none 64=1.0 127=1.99
LFO Waveform	90	0=Random 1=Sine 2=Saw 3=Square
Glide Speed	91	0=Play previous note(lol) 1=Slowest 127=Instantaneous
Legato	92	0=Off(always trigger envelope) 1=On(Only trigger in case no other notes are pushed)
Looping ADSR	93	0=Off 1=VCA loop 2=VCF loop 3=VCA and VCF loop
Linear/Exponential Envelopes(v1.2 onwards)	94	0=VCA and VCF linear 1=VCA exp/VCF linear 2=VCA linear/VCF exp 3=VCA and VCF exp

Tips for effectively using MIDI:

While it's true that there's no filter cutoff CC, there is however a VCF keyboard tracking CC. This will also effectively shift the cutoff frequency, only in a relative way. Try it!

While running an automated live setup: It's probably a good idea to control a single "Function" on the Sawbench itself manually, for instance the VCA envelope.. and leave the MIDI sequencer to do LFO speed/depth and VCF envelope parameters.

Frequency modulation can be a tricky beast. To get it to growl correctly it might be necessary to play around with the relative modulation frequency (CC 12). Not all Sawbench VCO's are identical, due to small variations in the analog circuitry. Some may be digitally tuned higher or lower and the FM system is unaware of this, so may need some tuning over MIDI. This tuning can also be used to make it growl in lower or in higher octaves, if you like.

The glide CC may be used to achieve the typical TB-303 acid sound or sliding bass effect.

Troubleshooting:

Firmware v1.0 is known to have serious MIDI problems, especially with high data rates. Version 1.1 solved this problem, but still it didn't support MIDI clock commands. Version 1.2 does support them. In case of missing notes gone missing: please upgrade. We supply sawbench microcontroller chips with the latest firmware in our shop (TODO: link), or you can use the Arduino IDE and upload the code yourself: Sawbench firmware on Github.