

THREE Tom
Modular

Steve's MS-22

User manual

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Introduction

Steve's MS-22 is a dual voltage controlled filter (inspired upon the classic Korg MS-20 OTA filter) with an innovative modulation matrix and one of the highest function-to-hp ratios in the land of Eurorack. This module was inspired by many pleasant chats with tech journalist Steve O'Hear.

What makes the MS-22 unique

The MS-22's is different from most MS-20 inspired filters as it contains two dedicated filter circuits (instead of one), one low-pass and the other a high-pass. These are configured to be in series, the high-pass going into the low-pass. This configuration allows a unique duophonic fighting resonance behaviour. The cutoff frequencies of both filters can be CV'ed. So, compared to most MS-20 clones out there, the MS-22 is twice the amount of filter condensed down into half the package (4HP).

Additionally, the MS-22 has the following advantages (compared to your typical bread and butter Korg MS-20 filter clone) :

- The MS-22 offers CV control over input gain, basically this allows you to either CV the level of filter overdrive or use it as a VCA for signal going into the filter
- The MS-22 offers CV control over resonance
- The MS-22's resonance can be pushed way further than the original
- The MS-22 has a link switch, which links the cutoff frequencies of the low-pass and high-pass in two different ratios. This creates two flavours of band-pass filter, of which the bandwidth can be tweaked and CV'ed. The switch itself also serves as an awesome performance effect as you can use it to create an instant drop.
- The MS-22 has a unique modulation matrix that allows you to configure many internal patches without using cables. Furthermore the modulation matrix inspires happy accidents!

Front panel

#	Name	Front panel layout
1	Audio input	
2	Audio output	
3	Frequency CV (FCV) input (normalised to 0V)	
4	Auxiliary CV (ACV) input (normalised to FCV)	
5	LPF cutoff frequency offset	
6	HPF cutoff frequency offset ("Spread")	
7	Resonance offset	
8	Gain offset	
9	FCV attenuator	
10	ACV attenuator	
11	LPF-HPF link switch	
12	HPF mod switch	
13	Resonance mod switch	
14	Gain mod switch	
15	LP LED	
16	HP LED	
17	Resonance LED	
18	Gain LED	

Installation

Before you begin, please note the following :

- Even though the module is protected against reversing the power supply, this is not a situation that should be sustained any longer than necessary.
- Sometimes it may require a little bit of force to connect the power cable to the module. While doing so, it is recommended to support the PCB on which the power connector is mounted. This minimizes any stress caused by applying force to the module, prolonging its lifetime.

Now that we got that out of the way, please follow the installation procedure below :

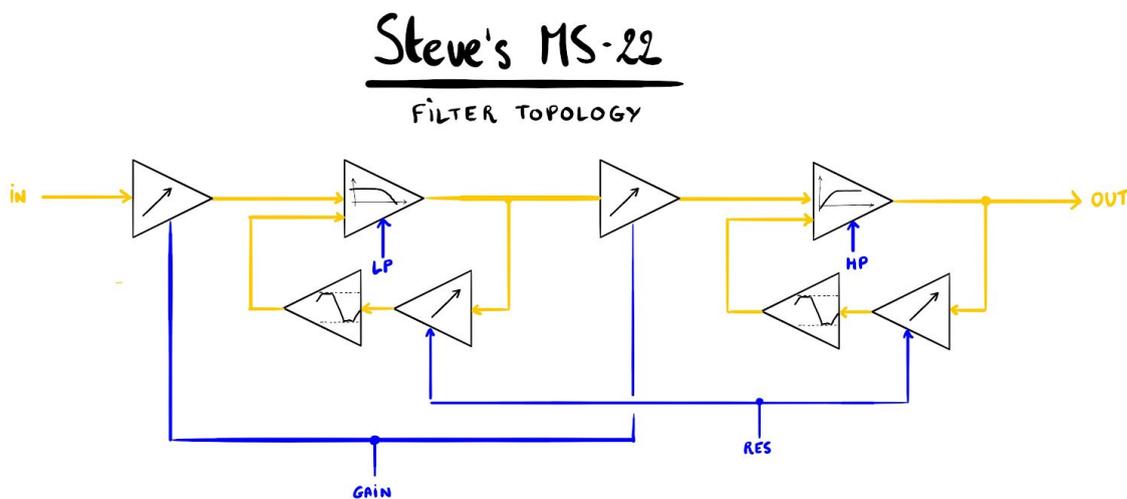
1. Turn off your case's power supply
2. Locate 4HP of space.
3. Confirm the +12V and -12V sides of the power distribution lines.
4. Plug the connector into the power distribution board of your case, keeping in mind that the red band corresponds to -12V. The power cable should be connected to the module with the red band facing the -12V / lightning bolt mark.
5. Without turning the power on, configure the [Default setting](#).
6. Turn on your case's power supply. If none of the module's LEDs are lit, immediately turn off the power and go back to step 3.
7. Enjoy!

Filter topology

The topology of the MS-22 is that of a 12dB/oct low-pass filter (LPF) in series with a 6dB/oct high-pass filter (HPF). Both filters are voltage controlled OTA filters, inspired by the filter of the later Korg MS-20. What's remarkable is that the LP actually goes into the HP, so the order is reversed when compared to the classic configuration of the Korg MS-20. The cut-off frequency of each filter is controlled by their respective control voltages (**LP**) and (**HP**).

Both the LPF and HPF have a voltage controlled amplifier (VCA) at inputs, allowing voltage control over how hard the filter is driven. Both input VCAs are driven by the same internal control voltage (**GAIN**).

Both the LPF and HPF also have VCAs in their feedback paths, offering voltage control over the resonance. Both feedback VCAs are driven by the same internal control voltage (**RES**). Even though the amount of feedback/resonance of both the LPF and HPF will be identical, the behaviour of the MS-22's resonance is very complex.



Behaviour of the filter's resonance

The MS-22's resonance behaviour is surprisingly deep, but it does follow a few general rules that are balanced against one another.

Moderate settings

For moderate resonance **(7)** settings (below 10 o'clock) the resonance of the LPF and HPF will have the same characteristic. However, because the LPF and HPF are in series, the gain setting is what will truly affect the balance of their resonances. The more gain, the more prominent the LPF's resonance will become w.r.t. the HPF's. Of course, the more gain, the dirtier it will sound as well. In case of a moderate setting, the HPF's resonance will also disappear as you turn its setting down past sub bass frequencies (<10 Hz or so?).

Pinging

When the resonance **(7)** setting is on the edge of self-oscillation (around 12 o'clock), the MS-22 can be pinged by connecting a gate to the input.

Self-oscillation

For self-oscillating settings (resonance **(7)** past 12 o'clock) the behavior gets more complex as the resonances of the LPF and HPF will fight for dominance over the final output. The following rules apply:

- If **(LP) > (HP)**, the LPF's self-oscillation will dominate.
- If **(LP) < (HP)**, the HPF's self-oscillation will dominate
- If **(LP) ≈ (HP)**, you will hear the HPF and LPF fight for dominance. This results in chaotic "dial-up modemesque" sounds.
- Higher gain **(8)** helps the LPF win its struggle to dominate
- Lower gain **(8)** helps the HPF win its struggle to dominate
- The further you push the resonance **(7)** setting, the lower the self-oscillation frequency of both the HPF and LPF will become. It also makes the self-oscillations sound dirtier.
- Pushing the gain **(8)** also adds more grit and warmth to the oscillations

So, you see, there's an amazing amount of unexpected depth here, there are A LOT of different timbres that can be dialed in, even without modulating parameters.

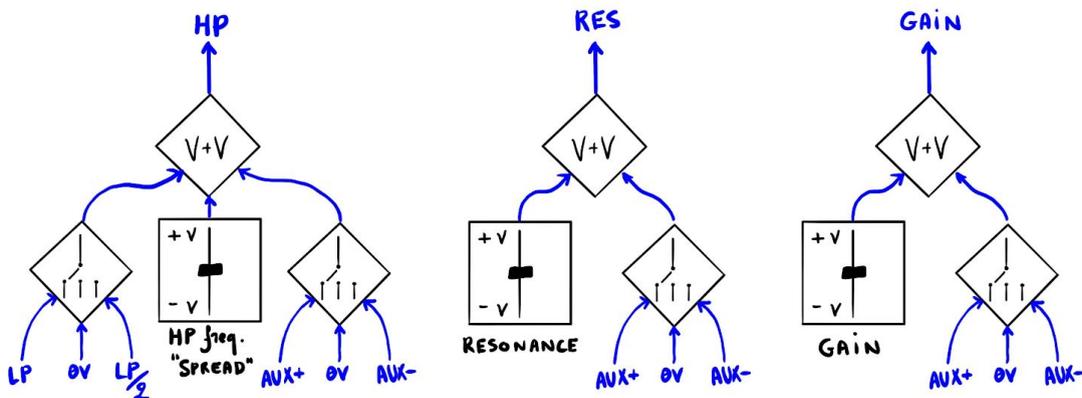
Modulation matrix

Simply put, the modulation matrix (12-14) lets you route whatever modulation source you have connected to the ACV (auxiliary) input (e.g. an external envelope, LFO, S&H etc) to any or all of the following: HPF cutoff frequency, resonance amount, and input gain amount, either inverted or not. In addition, the link switch (11) optionally adds the LPF cut off frequency CV to that of the HPF for a band-pass filter effect.

The key to getting the most from the modulation matrix is to experiment and have fun. However, if you want a more technical explanation of what is going on under the hood, continue reading. Otherwise, feel free to jump to the next section and revisit this section later.

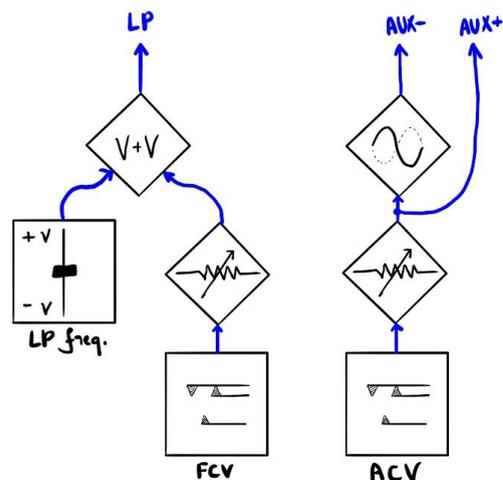
Block schematic

To revisit the statement above more rigorously, the MS-22 has two CV inputs (FCV, ACV) and four internal control voltages (**LP**), (**HP**), (**RES**) and (**GAIN**). The modulation matrix, allows the user to configure different routings between the CV inputs and the internal control voltages. Below is a block diagram of the modulation matrix.



Steve's MS-22

MODULATION MATRIX



In the next few subsections we will dive into the nitty gritty of modulation matrix. Please note that you might want to read the following sections a few times over. It's also a good idea to regularly refer back to the block schematic. The explanation on the inner workings of the modulation matrix is a bit of mindfuck, as you'll start to understand how deep the MS-22's rabbit hole truly goes.

Indicator LEDs

Each of the internal CV sources have a bipolar indicator LED **(15-18)**. The LED becomes red for negative voltages, goes dark at 0V and becomes green for positive voltages. The purpose of these LEDs is to help you understand what's going on inside the modulation matrix and contribute to making informed patching decisions.

LP (LPF cutoff frequency)

The cutoff frequency of the LPF is controlled by the sum of the following control voltages :

- The LPF cutoff frequency offset potentiometer **(5)**
- An attenuated **(10)** version of the FCV input **(3)**

AUX+ and AUX-

The attenuated **(9)** version of the ACV input **(4)** is called **(AUX+)**. We also make an inverted copy of the **(AUX+)** signal, which we call **(AUX-)**. Both **(AUX+)** and **(AUX-)** are internal control voltages that can be routed to **(HP)**, **(RES)** and **(GAIN)** through some of the switches of the modulation matrix **(12-14)**.

HP (HPF cutoff frequency)

The cutoff frequency of the HPF is controlled by the sum of the following control voltages :

- The HPF cutoff frequency offset potentiometer **(5)**
- **(AUX-)**, **(0V)** or **(AUX+)**, selected through the HPF mod switch **(12)**
- 0%, 50% or 100% of the **(LP)** control voltage, selectable through LPF-HPF link switch **(11)**. This allows you to configure the MS-22 as a band-pass filter with a variable bandwidth, set by the HP control voltage.

Because the internal control voltages are bipolar, the resulting bandwidth of the 50% linked band-pass configuration is minimal when the LPF frequency offset is at 12 o'clock, LP LED **(15)** fully dimmed. The bandwidth grows larger as the maximum and minimum settings for the LPF frequency offset are approached, causing the LP LED **(15)** to be at maximum brightness, either green or red.

RES & GAIN (Resonance and input gain)

The resonance and gain behave in the same way. They are both controlled by the sum of the following control voltages :

- The respective resonance/gain offset potentiometer **(7/8)**
- **(AUX-)**, **(0V)** or **(AUX+)**, selected through the respective mod switch **(13/14)**

Note that because **(RES)** and **(GAIN)** are control voltages for VCAs, you will only get useful results if **(RES)** and **(GAIN)** are positive, so monitoring LEDs **(17/18)** in the green.

Patch ideas

Okay, my apologies for the headache you may have suffered from the previous section. Let's now synthesize (pun intended) all of that with some practical patch examples.

Default setting

Here's the default setting that should pass the input through to the output without too much distortion and at a reasonable level. All other patches below describe the differences w.r.t. this default setting.

Parameter	Configuration
Audio input	An oscillator of your choosing, preferably one with lots of harmonics (e.g. a saw wave)
FCV input	Disconnected
ACV input	Disconnected (normalised to FCV)
FCV attenuator	Fully CCW
ACV attenuator	Fully CCW
LPF offset	Fully CW (green indicator LED)
HPF offset	Fully CCW (red indicator LED)
Resonance offset	Fully CCW (dark indicator LED)
Gain offset	Around noon (light green indicator LED), tweak to taste.
Link switch	0%
Mod switches	0V (center position)

Low-pass gate

With this setting, an envelop controls both the LPF cutoff frequency and the input gain, resulting in a low pass gate. Also try flicking on the link switch for a band-pass gate.

Audio input	An oscillator of your choosing, preferably one with lots of harmonics (e.g. a saw wave)
FCV input	An envelope
Gain mod switch	AUX+ (top position)
FCV attenuator	Turn CW until the envelop fully opens the LP filter
ACV attenuator	Around noon, turn up higher for grittier sounds

Sequenced pings

For this patch, you need two CV sequences A & B (melody and modulation) and one gate sequence (rhythm). The gate sequence goes into the audio input to excite the MS-22s resonant response. Sequence A will modulate the pitch of your pings, sequence B will modulate the resonance. The setting of the attenuator should be such that some pings are very short, others longer and some are fully self-oscillating. This provides a wide diversity of percussive sounds. I particularly enjoy this patch with a Turing machine + volts and pulses expanders.

Audio input	A gate sequence
FCV input	CV sequence A
ACV input	CV sequence B
FCV attenuator	At noon
ACV attenuator	A small increase from fully CCW
LPF offset	To taste
HPF offset	Start fully CCW
Resonance offset	Somewhat past noon, just into self-oscillation territory
Link switch	50%
Resonance mod switch	AUX-

Performance drops

In the following patch you'll use the MS-22 as an end-of-line performance effect. Grab the LPF offset potentiometer, slowly sweep it's setting to a fully CW position. You'll hear a resonant upward motion of the 50% linked band-pass setting. At the highest setting, the created tension becomes maximal. Flick the link switch back to 0%, reverting to low-pass filter action, adding back all that low-end goodness and releasing all the built-up tension. Slowly turn the LPF offset back CCW, set the link back to 50%. Rinse and repeat until orgasm :).

Parameter	Configuration
Audio input	A sound source with a lot of low end, e.g. a drum loop with a very present and low kick.
LPF offset	Somewhere around noon, a setting that lets through some muffled bass and rhythm from your input
HPF offset	Fully CCW (red indicator LED)
Resonance offset	At 11 o'clock
Gain offset	Around noon (light green indicator LED), tweak to taste.
Link switch	50%

Antipolar modulation of gain and resonance

When experimenting, try antipolar routing of the gain and resonance modulation. When applying audio rate modulation this can help clean up your sound as modulation of resonance and gain with same signed CV tends to muddy things up.

Parameter	Configuration	
Resonance mod switch	AUX+ (top position)	AUX- (bottom position)
Gain mod switch	AUX- (bottom position)	AUX+ (top position)

Slowly morphing band-pass

Good for ambient sounds! Add some reverb too!

Parameter	Configuration
Audio input	An oscillator of your choosing, preferably one with lots of harmonics (e.g. a saw wave). Noise scapes can also be very cool in this situation
FCV input	A slow moving LFO
ACV input	Another slow moving LFO with a different frequency
FCV attenuator	Tweak to taste
ACV attenuator	Tweak to taste
LPF offset	If FCV input is bipolar, at noon If FCV input is unipolar, fully CCW
HPF offset	Fully CCW
Resonance offset	10-11 o'clock
Gain offset	Around noon (light green indicator LED), tweak to taste.
Link switch	Tweak to taste
HP mod switch	All three options sound interesting, experiment!

Cinematic drones

This patch builds from the previous one. Add a ton of gigantic hall.

Parameter	Configuration
Audio input	Disconnected
FCV input	Extremely slow moving LFO
ACV input	Another very slow moving LFO with a different frequency
FCV attenuator	Tweak to taste, but small amounts in general
ACV attenuator	Tweak to taste but small amounts in general
LPF offset	Rather past noon
HPF offset	Close to fully CCW so you get a low drone
Resonance offset	Well past 12 o'clock, gently increase to taste
Gain offset	Around noon, increase for more apocalyptic vibes!
Link switch	Tweak to taste
HP mod switch	All three options sound interesting, experiment!

Formant like tones

Parameter	Configuration
Audio input	An oscillator of your choosing, preferably one with lots of harmonics (e.g. a saw wave).
FCV input	An envelope with a slow attack, fast release
FCV attenuator	Tweak to taste
LPF offset	Quite a bit before noon
HPF offset	Start fully CCW, increase to taste
Resonance offset	10-11 o'clock
Gain offset	Around noon, tweak to taste.
Link switch	50%

Calibration

Calibration trimmers (gain and offset) for the HP and LP filter are available from the side of the module. These trimmers are used to map the physical minimum and maximum angles of the HP and LP pots to the most sensible minimum and maximum HP and LP filter behaviour. **I strongly advise to not touch these trimmers.**

To calibrate the module you need the following tools:

- A small screwdriver
- An audio interface
- A DAW (e.g. Ableton, Logic, etc...)
- A white noise source (e.g. MeldaProduction MNoiseGenerator)
- A spectrum analysis VST (e.g. MeldaProduction MAnalyzer)

To calibrate Steve's MS-22 use the following process:

1. Connect the white noise source to the audio input
2. Connect the output to an input of your audio interface
3. In your DAW, monitor the MS-22's filter with the spectrum analyzer
4. Set the LPF to the maximum frequency and the HPF to the minimum frequency
5. Set the resonance to a moderate setting (10 o'clock) so you can see the resonance peak in the filter response
6. HP calibration
 - a. Tweak the HP offset and gain trimmers so that the minimum setting of the HP pot corresponds with the cutoff being around 10-20 Hz
 - b. Tweak the HP offset and gain trimmers so that the maximum setting of the HP pot corresponds with the cutoff being around 20kHz
 - c. Repeat a and b until both hold true. The gain trimmer influences how strongly the response reacts to the setting of the potentiometer, the offset trimmer translates the response along the frequency axis.
7. LP calibration
 - a. Set the HPF cutoff to the minimum frequency
 - b. Follow the same procedure as with the HPF

Note : Please be aware that it is possible to trim the HPF to such low frequencies that it will start to behave strangely. When this is the case you'll observe strange glitches in the low end of the spectrum.

Specifications

- Construction
 - 4 HP wide
 - 45 mm deep (skiff friendly)
 - High quality aluminum knobs with grippy surface
 - 2 mm thick matte black front panel with white and metallic print
 - A tasty 4-layer PCB sandwich, containing 350+ components
- Protection
 - Reverse power protection
 - Buffered high impedance inputs
 - Output is protected by a 1K output resistor
- Power consumption
 - +12V : 100mA max
 - -12V : 100mA max

Support

In case your module isn't functioning as it should, make sure to check your Eurorack power supply and all connections first. If the problem persists, send an email to info@threetom.com. Please mention your serial number, which can be found on the module's rear side.

Warranty

This product is covered by ThreeTom Modular's warranty, for one year following the date of manufacture. This warranty covers any defect in the manufacturing of this product. This warranty does not cover any damage or malfunction caused by incorrect use (such as, but not limited to, power cables connected backwards, excessive voltage levels, or exposure to extreme temperature or moisture levels). The cost of shipping a module back and forth for servicing is paid for by the customer.

Revision History

- Dec 2019 : First version for product release

If you find any mistake in this manual, please be so kind to let me know by sending an e-mail to info@threetom.com.