HEXINVERTER. NET

galilean moons

dual amplitude transmutator

USER MANUAL v1.02

Contents

Introduction

Thank you for your interest in/purchase of a hexinverter.net Galilean Moons eurorack synthesizer module or DIY project! It is my hope that you find this module design a fun addition to your modular synthesizer.

This user manual exists to aid you in utilizing the Galilean Moons to its fullest potential as well as to explain the various features, functions and limitations of the design.

A huge thank you to **Hannes Pasqualini of papernoise.net** for his excellent graphics design and artwork used for this project! (http://papernoise.net).

As always, please email me with any tech support or questions you may need answered. I can be reached directly via email at hex[at]hexinverter.net!

Please read on!

--Stacy Gaudreau
hexinverter.net Electronics

Module Features and Specifications

Module Description

Galilean Moons is a dual amplitude transmutator. It transmutates the amplitude of incoming signals through the use of voltage controlled envelopes and VCAs. It is designed primarily to create voltage controlled percussive sounds when fed with a sound source (in particular, its sister module, Jupiter Storm), but can be used for all sorts of other tasks in your modular system as well as to generate typical synth sounds.

Galilean moons features two *moons*. Each *moon* is composed of a voltage controlled attack/decay envelope with its own dedicated low-distortion linear VCA. Each envelope can also act as attack/sustain/release or can go into LFO/automatic looping mode with the flick of a switch.

Galilean Moons can normalise its VCA inputs to a Jupiter Storm cosmic noise oscillator through a simple expansion cable at the back, but it can also function standalone in any modular system. Of course, the new Jupiter Storm noise output, "XOR", which is activated by connecting a Galilean Moons to your Jupiter Storm, will not function when you use Galilean Moons alone in a system. This is the only feature which requires a Jupiter Storm to be connected.

The XOR noise output sounds similar to (but not exactly like) Jupiter Storm with the Noise Core Disruptor is engaged, even when it is not engaged. This allows you to get both flavours of noise from Jupiter Storm simultaneously, making it a lot more versatile.

The VCAs and voltage controlled envelopes can each be used on their own in your system when you don't want to use them the way they are internally linked together. Plugging a signal into any of the respective jacks will break the internal connections and let you use the components on their own. You can use the linear, DC-coupled VCAs to control DC signals in your system when not using the module for its intended use, for example.

Features List

- Two voltage controlled digital functions (envelopes), each normalised to their own low-distortion linear, DC-coupled voltage controlled amplifier
- Each envelope function offers percussive attack/decay, attack/sustain/release or looping (LFO) mode
- Each function can each be linear or the classic exponential shape
- Enables a new noise output, "XOR", if plugged into a Jupiter Storm behind the panel. (everything besides the XOR output works with or without a Jupiter Storm!)
- VCA inputs are normalised to the newly-enabled XOR and main ("I") output of Jupiter Storm when nothing else is plugged in
- The envelopes and VCAs can be fully utilised elsewhere in your system by plugging into the corresponding function's jacks
- Perfect for synthesizing voltage controlled percussion and other effects!

Technical Details

- 18HP width (eurorack)
- Requires approximately +88mA, -65mA @ 12V
- 30mm deep eurorack module design is skiff friendly
- ~1V trigger threshold inputs
- 0-5V response control voltage inputs for attack/decay CV
- Outputs approximately 0-8V envelope levels
- Accurate 12bit digital function generators
- Approximately 0.5mS to 10s envelope stage durations

Controls and Quick Reference

Control Descriptions
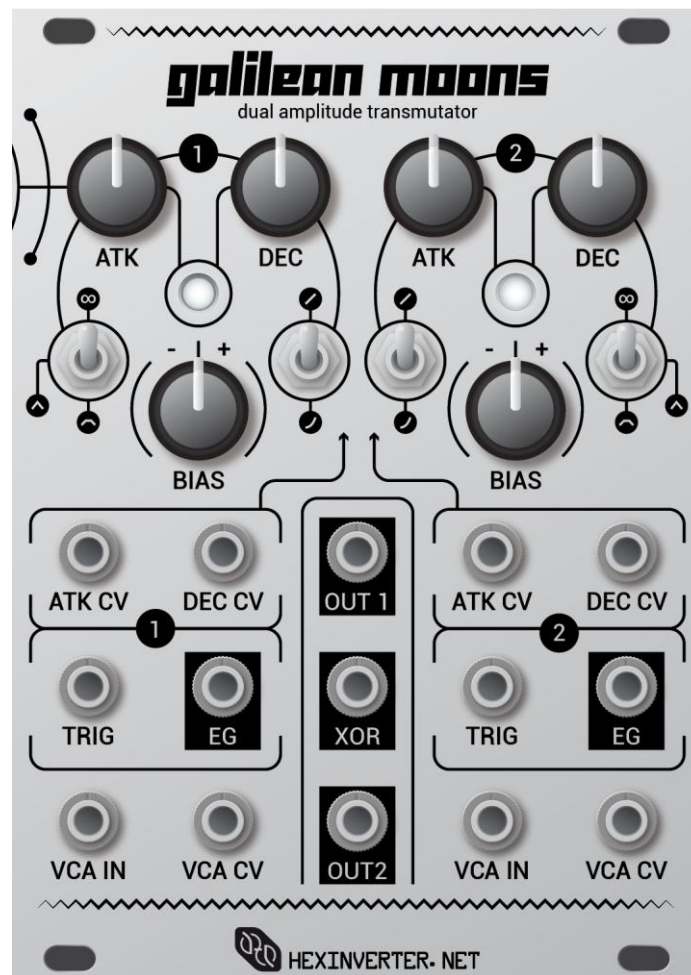
ATK CV: This input responds to 0-5V CV and alters the duration of the attack/upwards slope of the envelope. Higher CV = longer duration, lower CV = shorter duration. The response of this input is NOT perfectly linear as this allows for a more useful range of envelope times to be used. ***This input expects slowly moving CV signals and may respond in a chaotic manner if driven at higher (ie: audio) frequencies, but feel free to experiment!***

DEC CV: This input behaves the same as the Attack CV input, however it affects the decay/downward slope parameter instead.

ATK/DEC Knobs: These controls allow you to set the duration of the envelope stage (attack or decay) from approximately 0.5mS to 10S.

Mode Switches: These outermost switches set the function mode for the corresponding moon:

<div align="center">

∞ = LFO mode
Centre = attack/decay mode
Down = attack/sustain/release mode

</div>

Shape Switches: The two innermost switches are the Shape switches. They set the shape of the function as either linear or exponential.

BIAS Knobs: These knobs apply a bias to each moon's VCA control voltage input. They allow you to zero out the output of the VCA when no CV is present. This allows a wide variety of signals to be used with the VCAs.

TRIG Jack: Use this input to trigger the envelope. This input accepts a wide variety of signals ***and requires approximately 1V as a logic HIGH to trigger.***

EG Jack: Galilean Moons' envelopes are present at these outputs for use elsewhere in your system. The envelope outputs are about 0-8V.

VCA IN Jack: The is the VCA's signal input.

VCA CV Jack: This is the control voltage input for the VCA. Apply an envelope or other voltage source here if you don't want to use the internal envelope. Plugging something into this jack will break normalisation to Galilean Moons' envelope.

OUT 1 / OUT 2 Jack: These jacks are the VCA signal outputs.

XOR Jack: This noise output jack is only active when a Jupiter Storm cosmic noise oscillator is plugged into Galilean Moons behind the panel. See the section in this manual about using Galilean Moons with Jupiter Storm for more information.

Quick Reference

Width: 18HP
Depth: 30mm
Current draw: +88mA, -65mA @ 12V

Use the BIAS controls to **zero out the VCAs** when no envelope is active

Each envelope can be **linear** or **exponential**

Use the ATK and DEC controls to **set the duration** of the slope in each envelope

There are **3 modes of operation** for each envelope: Attack/ Decay, Attack/ Sustain/ Release and looping (LFO) mode

Use **control voltages** to modulate the ATTACK and DECAY!

Plug in a gate or trigger to the TRIG inputs to **start the envelopes**

Each envelope can be **used elsewhere in your system** from the EG outputs

Plugging in an **external audio source** to the low distortion VCA IN jack will break the normalisation to *Jupiter Storm*

Galilean Moons activates a new **high frequency noise** output if you have a *Jupiter Storm* too, called **XOR**. Use this as an audio source elsewhere in your system.

Use other envelopes/ **voltages** in your system with the VCAs by patching into the VCA CV jack

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ATK   DEC   ATK   DEC

BIAS   BIAS

ATK CV   DEC CV   OUT 1   ATK CV   DEC CV

TRIG   EG   XOR   TRIG   EG

VCA IN   VCA CV   OUT2   VCA IN   VCA CV

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# Usage Guide

The Functions

Each of Galilean Moons' functions can operate as an AD (attack/decay), ASR (attack/sustain/release) or looping envelope (LFO). This makes it an extremely versatile module. Each function can produce linear or exponentially shaped slopes.

The function can be changed with the MODE switch, and the shape of the function can be changed with the SHAPE switch.
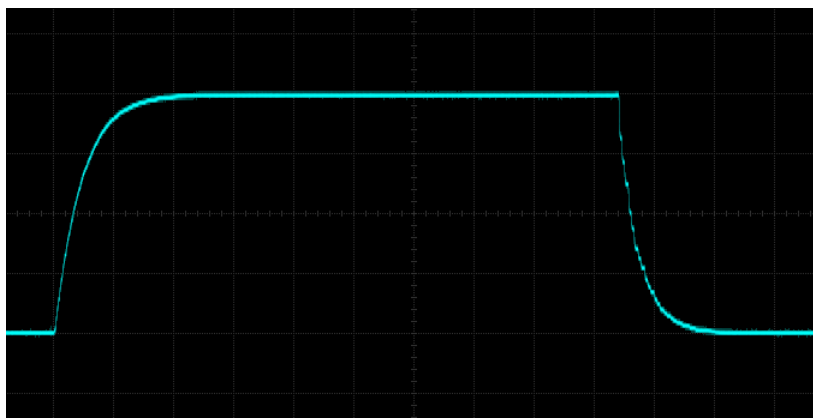
AD Envelope Mode

AD Envelope mode is best for making percussive and triggered sounds. When a trigger arrives at the TRIG input, the envelope begins and continues through its course regardless of whether the trigger signal continues to be a logic HIGH or not. The envelope will rise and fall through its attack and decay length until it ends, if left alone. If a new trigger arrives while the envelope is still progressing, the envelope will be reset to 0V and the attack slope will begin again.

Linear AD Envelope
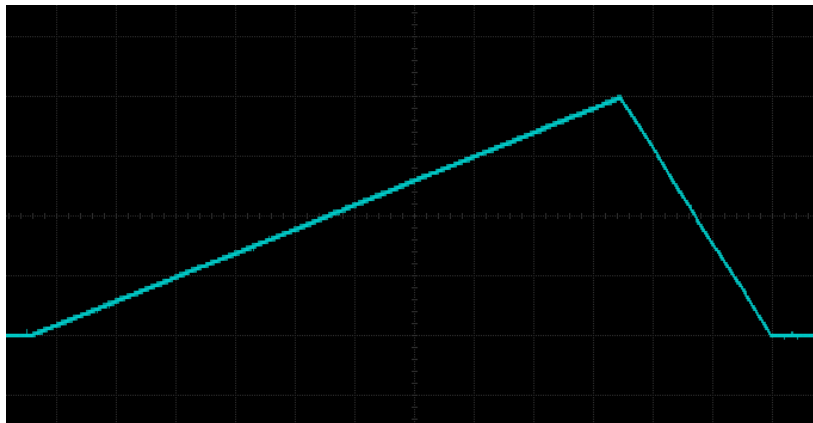
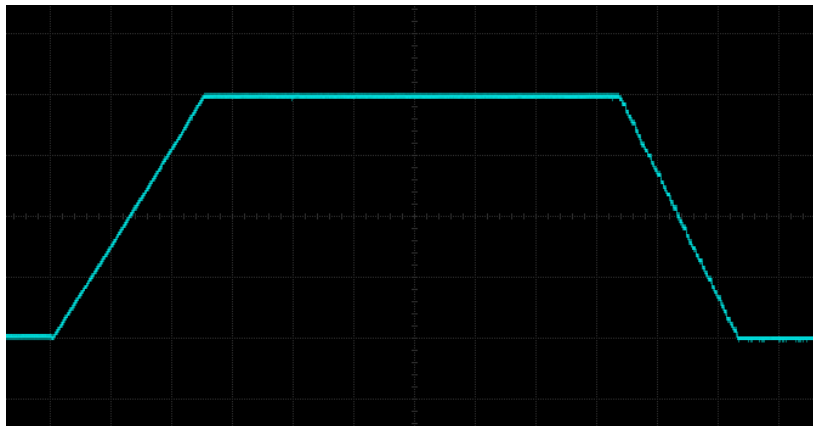**Exponential AD Envelope**

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ASR Envelope Mode

ASR mode is tailored for expressive playing with a keyboard or other varied-length gate/trigger control source. This is because the envelope length/sustain duration is determined by the control trigger length (unlike the previously discussed AD mode where the envelope is the same length no matter the shape of the trigger signal).

In ASR Envelope mode, the function acts like an attack/sustain/release envelope. When a logic HIGH is received at the TRIG input in the form of a gate or trigger signal, the envelope begins the attack phase at the rate set by the ATK control and CV input. The envelope will continue the attack phase until the maximum value is reached (~8V) and then will sustain at this value for as long as the signal at the TRIG input remains at logic HIGH. At any point during the envelope, the function will enter the release phase and fall back towards 0V at the rate set by the DEC control. During any point in the function, if a new trigger or gate is received at the TRIG input, the envelope will reset to 0V and begin a new attack phase. This mimics the way the majority of classic ADSR envelopes in monophonic analogue synthesizers work.

**Linear ASR Envelope**

Exponential ASR Envelope
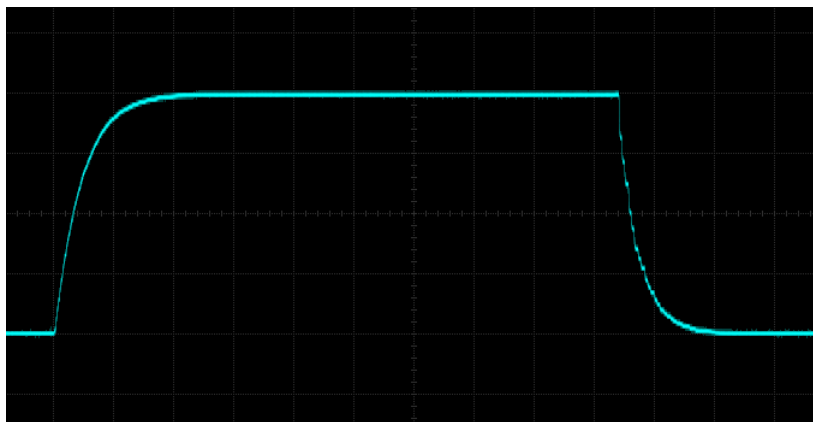
LFO/Looping Envelope Mode

In Looping Envelope mode, Galilean Moons produces a function that can operate as an LFO in your system. The frequency of the LFO is determined by the combination of the attack and decay slope duration, as set by the ATK and DEC controls. Adjusting either of these parameters will affect the frequency since either one affects the time taken to complete the function and start over again. The function runs freely while in LFO mode and is reset to 0V at any time when a logic HIGH arrives at the TRIG input.
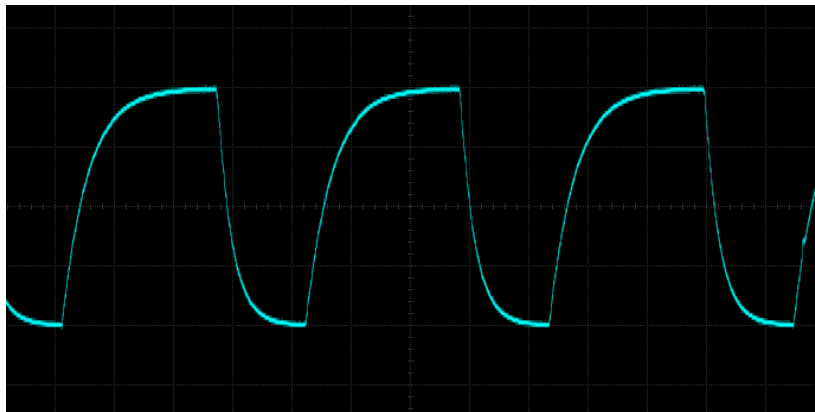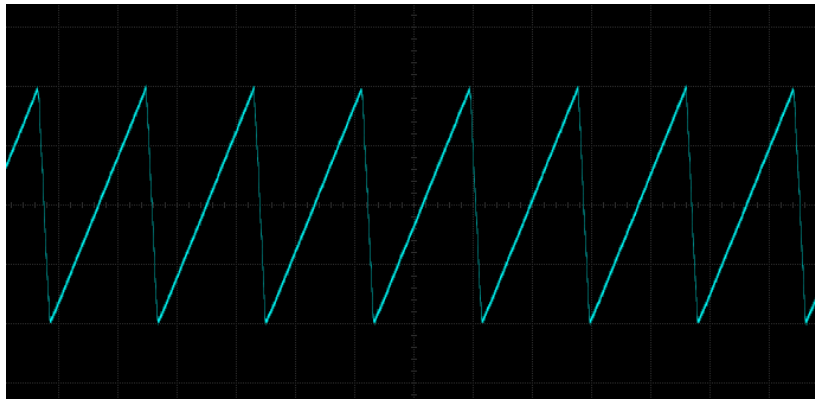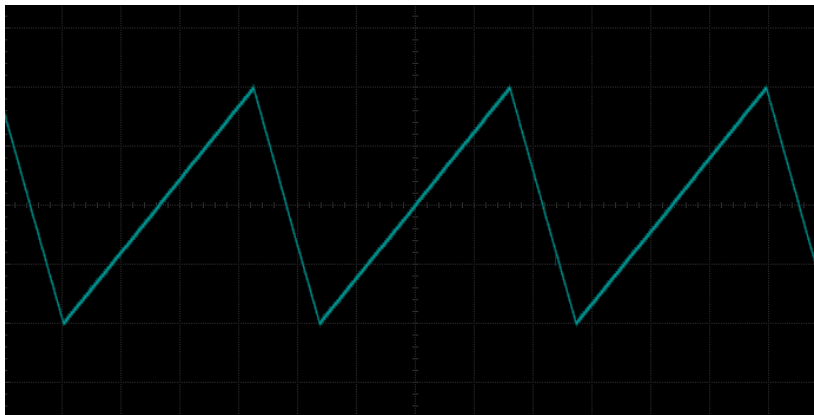

Dynamic LFO waveforms can be generated by varying the SHAPE control and applying voltage control to the ATK/DEC inputs over time:
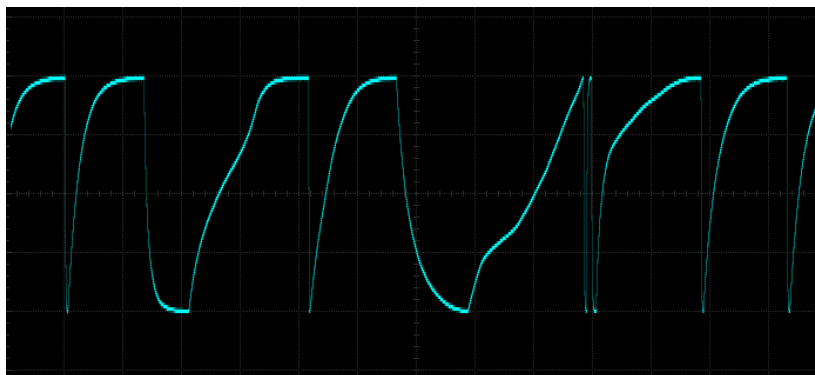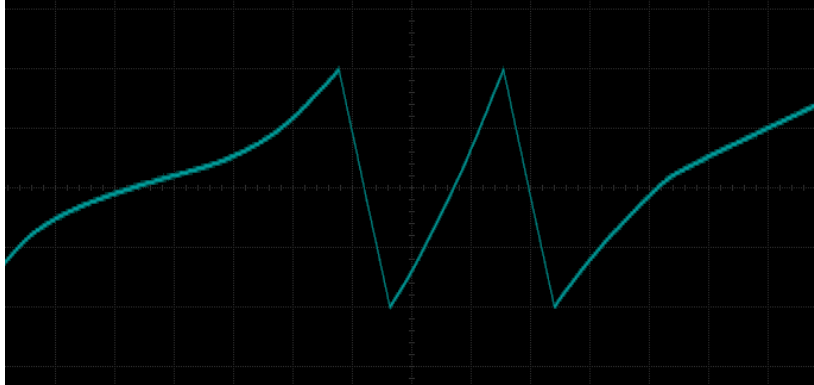
The LFO can be synced to a clock signal by resetting the LFO with the clock signal at the TRIG input. This is a freely running linear LFO:

This is the same LFO setting, except a square wave clock (shown in yellow) is applied to the TRIG input. The LFO is reset to 0 and starts over each time the TRIG input's clock signal transitions to a logic HIGH. The LFO is now synced to the clock signal!
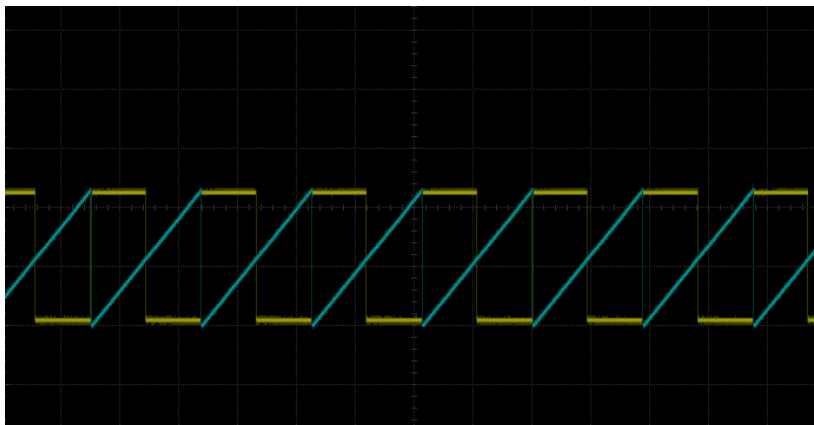
The VCAs

Each of Galilean Moons' function generators (moons) is accompanied by a hi-fi, low-distortion, linear voltage controlled amplifier. The VCA is internally normalised to the internal function's CV output. In this way, the VCA's output amplitude is by default controlled by the output of the corresponding moon's function. Plugging in a patch cord to the VCA CV input for the moon will disconnect the internal function generator and allow you to patch in other CV sources (envelopes, LFOs, whatever!).

The VCAs can be used completely independently of the rest of Galilean Moons in your system, making them very versatile.
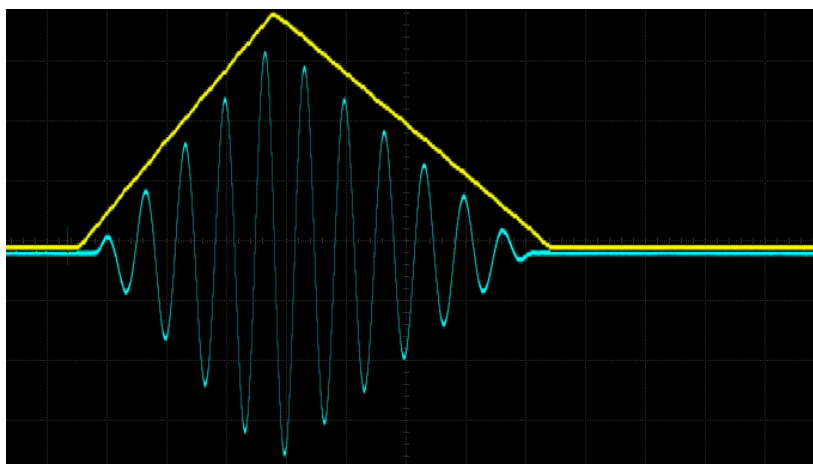
The BIAS controls allow you to zero out the output of the VCA for use with a wide variety of input signals.

The VCAs are DC coupled. Signals **other than** AC (audio) can therefore pass through the VCAs.

Using an exponential envelope (yellow) is a great way to modulate an audio signal (blue):
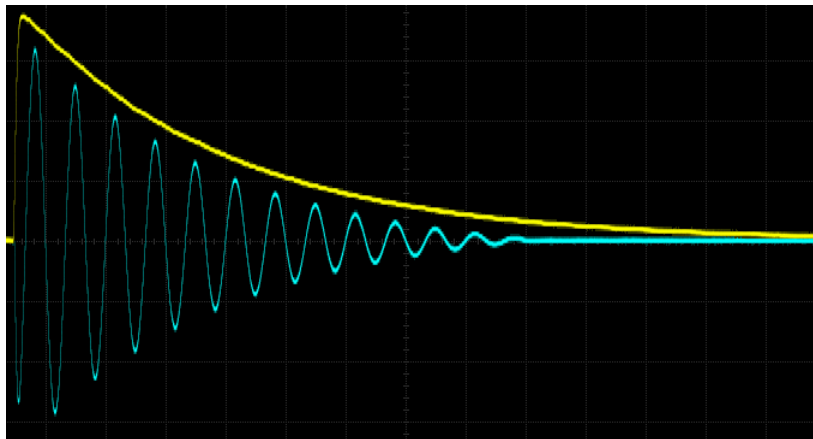
You can also modulate signals (blue) in a linear fashion as well, via linear CV (yellow):

Expanding a Jupiter Storm

Galilean Moons can be used to expand a Jupiter Storm cosmic noise oscillator. Doing so activates the XOR noise output on Galilean Moons, and, normalises some of Jupiter Storm's noise outputs to the VCA inputs of Galilean Moons. This arrangement forms a rather powerful synthesis engine with minimal external patching.

Connection via Expansion Cable

NOTE: Do NOT try to mix a commercially built JS module with a DIY (do it yourself) home built GM module, or vice-versa. The expansion cable pinout is not the same. Only connect DIY modules to DIY modules, and commercial modules to commercial modules.

Jupiter Storm is expanded with a Galilean Moons module by connecting the two modules together behind the panel with the included expansion cable. *Both modules still require their own power cable connected to the eurorack power bus.*

To connect the modules together…

- Ensure power is not applied to the modules.
- With both modules removed from the case, connect Jupiter Storm and Galilean Moons together with the expansion cable, being sure to follow the polarity marked by the wording on the expansion port of each module: line up the red strip with the "RED" text on each port when you plug in the cable.

- Put the modules back in your case and turn them on!
- Test the modules are connected together properly by listening to the "XOR" output of Galilean Moons. If you hear sound from the newly activated Jupiter Storm XOR noise output here, then you know it's working right!
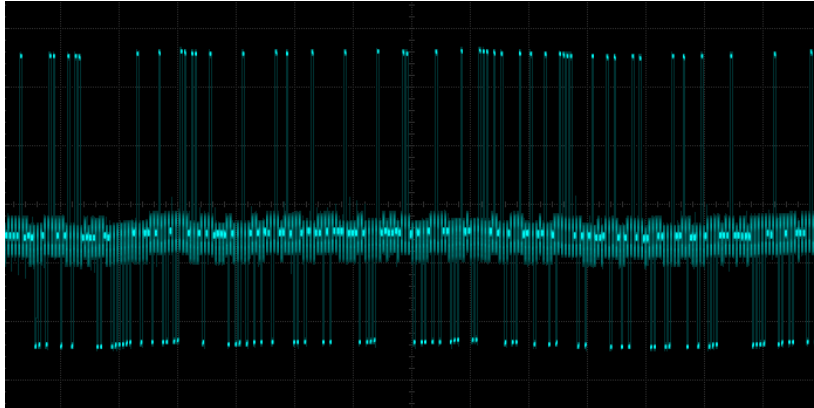
The XOR Noise Output

One of the primary features enabled by expanding a Jupiter Storm is the activation of the XOR noise output seen in the centre of the panel jacks on Galilean Moons.
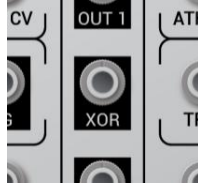

This audio output is a harsh XOR gate feedback noise source that can be used to synthesize all manners of unique sounds. The frequency and tone of this noise is determined by Jupiter Storm's 3 oscillator frequencies, just like the other outputs on Jupiter Storm. Use it like you would a waveform output from a VCO in your system! Plug it into VCAs, VCFs and otherwise.

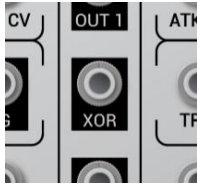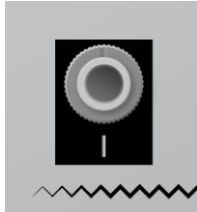**The audio from the XOR noise output is quite unlike most other noise sources:**

With the above image enlarged, you can see just how unique of waveforms the XOR noise output can generate!
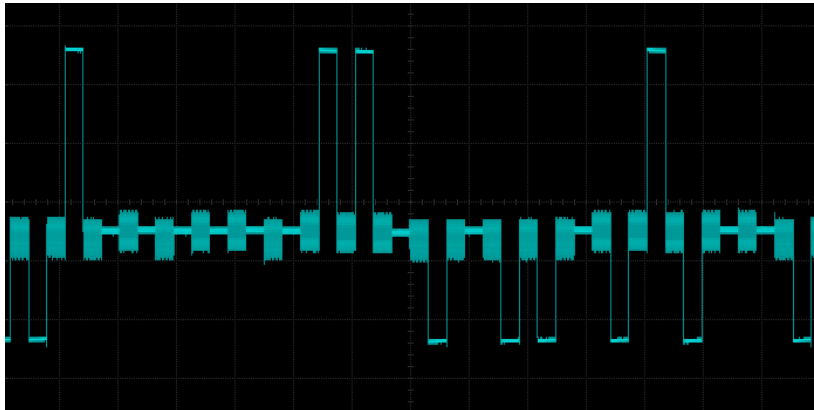
VCA Normalising from Jupiter Storm

Expanding a Jupiter Storm with Galilean Moons normalises two of Jupiter Storm's noise outputs to the VCA inputs of Galilean Moons. This saves you some patch cables and makes for a really clean, standalone synthesis engine if desired.

Jupiter Storm Output	Galilean Moons Input
	VCA 1
	VCA 2

Should you wish to use a different source with one of Galilean Moons' VCAs, simply plug a different signal into the VCA IN jack for the appropriate channel of Galilean Moons!

Module Calibration

If purchased assembled, Galilean Moons comes calibrated from the factory. Calibration is somewhat dependent on your power supply's voltage levels, however. Because power supplies vary a small amount from system to system, you may wish to calibrate Galilean Moons yourself to dial it in perfectly.

If you built your own Galilean Moons, you will definitely have to perform these steps.

LED Calibration

Calibrating the LEDs in Galilean Moons is a simple affair. You do so by tuning the trim pots on the back of the module while the module is turned on and no envelope is running. The location of the trim pots depends on whether your module is built by you or came assembled.

- Remove the module from your case, but keep the power cable attached. Make sure the back of the module is not touching anything metal it can short out on.
- Look for the trim pot marked "LED #" where "#" is the channel of Galilean Moons the pot corresponds to.
- Turn the power on, and with no envelope running, tune the LED's trim pot until the LED just begins to light.
- Now, turn the LED trim pot back a bit so the LED is not lighting up at all.
- Repeat for the other LED.

VCA Calibration

To ensure optimal VCA performance, the VCAs in Galilean Moons can be calibrated for least distortion. **This is probably not a necessary step unless you've built your own module, since it's been done at the factory for you.**

*You will need at least a **2 channel oscilloscope** to perform this calibration. You will also need an **audio rate oscillator or function generator** (test instrument).*

- Begin by generating a sine wave around 1KHz (a musical note of approximately C6). Do this either with a function generator or an audio rate oscillator/VCO.
- The sine wave should be oscillating around 0V. That is, it should contain equal parts negative voltages and positive voltages.
- Set the amplitude of the sine wave to -5 to 5V if you're using a function generator. If it's coming from a VCO, don't worry about this step. It should be fine since it's already around modular levels coming out of the VCO.
- Plug this sine wave into the VCA IN of the VCA you are going to calibrate. Locate the VCA trim pot on the back of the module.
- Turn the power to the module on, **being careful not to short out the back of the module on anything metal.**
- Set up your oscilloscope so that you are viewing the sine wave going in on one channel, and also the output of the VCA you are calibrating on the other channel.
- Place the two oscilloscope channels directly over eachother for viewing and comparison.
- Now, adjust the VCA BIAS control on the **front panel** of Galilean Moons until the amplitude of the output signal is approximately the same as the input signal.
- Adjust the VCA trim pot **on the back of the module** to make the output waveform look **proportioned** the same as the input waveform. We're adjusting the PROPORTION here; don't worry about the amplitude yet!
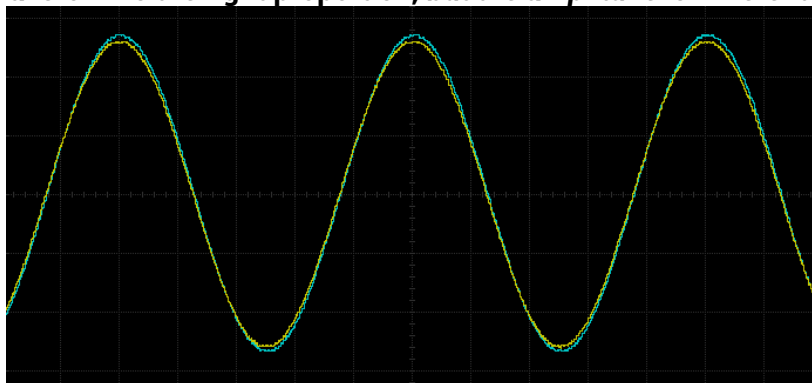
The output waveform is adjusted too high:
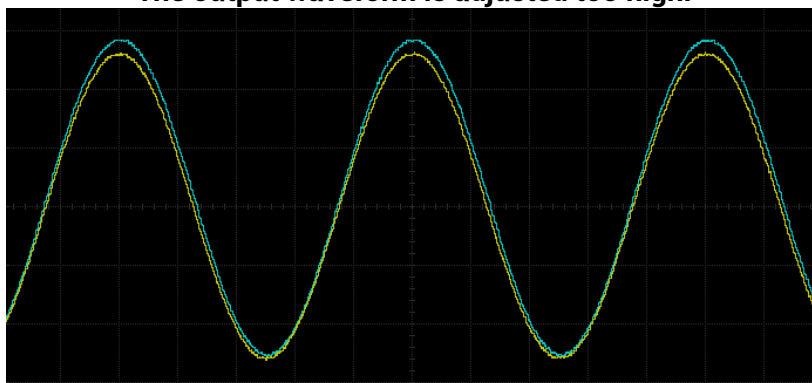
The output waveform is adjusted too low:
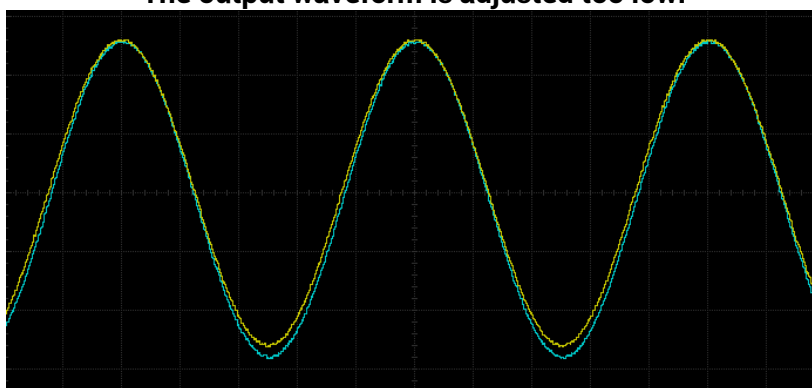
The output waveform is the right proportion, but *the amplitude is different* (that's okay!)

- Don't worry if it's not perfect yet. There's still more to do!
- Once the **proportion** looks right, you will probably have to adjust the VCA BIAS control on the **front panel** of the module to match the input waveform.
- Once the amplitudes of the waveforms are the same, readjust the **proportion** using the trim pot on the back **if necessary** to get the waveform as good as it can be!

- Keep adjusting the VCA BIAS and VCA trim pot on the back of the module until you are satisfied.

This is what a well-trimmed VCA should look like. While not 100% perfect (no circuit is!), it's a much better result than if it was not trimmed.