Quad Operator Manual

The Quad Operator offers 4 variable waveshape operators for linear FM synthesis. Implementing frequency modulation synthesis completely from scratch in firmware, the Quad Operator is able to provide a modern take on frequency modulation synthesis.

Features include:

- One knob per function design for true ease of use
- Any FM algorithm is possible via modulation matrix
- The Algo expander provides algorithm save/recall and crossfading capabilities
- Independent output per operator

- Virtual VCA per operator for both animating modulation and output volume control
- Includes a dedicated “AR FM” input with its own modulation sends, designed to bring an audio rate signal in from your rack for use as a modulator. Try processing a phase locked operator, and feeding it back in!
- Each operator can also be unlocked then tuned and patched independently, making the module a great general purpose oscillator bank
- Convincing digital emulation of classic analog waveshapes—sine, triangle, square, and saw
- An LFO mode, enabled the generation of phase locked, complex modulation signals

Where the unexpanded Quad Operator maintains a one knob per function design discipline, we nevertheless recognized the value of some more advanced algorithm-oriented functionality.
The Algo expander for the Quad Operator provides:

- Saving and loading of modulation send knob positions for FM algorithm design reuse
- Crossfade between pairs of saved algorithms, or a saved algorithm and the live knob positions

Master Controls

Coarse knob — master tuning like most module oscillators. Affects all operators in *lock state*. Follows exponential curve through 8 octaves (1 degree of turn results in same amount of change in tones regardless of position).
Fine knob — + / - 6 semitones of control relative to frequency defined by *coarse*.
VCO / LFO switch — Affects the base frequency of the *coarse* tuning control
1V / Oct CV — 1 volt per octave frequency control over all operators in *lock* state
LF FM CV — + / - 6 semitones of frequency modulation best for low frequency rate CV effects like vibrato, bends, pitch envelops, etc.
AR FM — Audio rate input that allows you to use signals from your rack as modulators. Especially useful for feedback patches with lock mode operators.
Reset CV — trigger input for resetting all operators phase. Great when using quad operator as a modulation source. operator’s *lock* versus *free* state does not affect behavior
Operator Functions

Lock Versus Free State

In *lock* state, each operator adheres to a strict integer frequency ratio relationship to the master coarse and fine tuning. This is the state in which you will want to keep your operators for most classic FM sounds. This is essential to achieving waveshapes with harmonic overtones. The detune control remains available for introducing subtle as well as extreme inharmonic effects.

In *free* state, each operator essentially becomes its own independent oscillator. The ratio knob becomes a coarse tuning control, and ratio CV becomes 1 volt per octave control for the operator. With modulations all at 0, this allows you to use each operator as its own oscillator in up to 4 independent patches. Modulation nevertheless remains intact if you wish to use it. Without frequency / phase locking, frequency modulations will tend to be inharmonic.

Knobs and Control Voltage

- Ratio knob & CV — two modes:
  - *Lock* state — 1/11th to 11 multiplier relative to master coarse/fine in integer steps
  - *Free* state — knob is continuous coarse tuning for the operator, CV is 1 volt per octave
- Detune knob — + / - 6 semitones of continuous fine tuning
- Shape knob & CV — continuously variable shape from sine>triangle>square>saw
- Gain CV — affects both the output level of the operator signal as well as how intensely it modulates other operators via its modulation sends. Normals to gain of 1 (signal is full volume and modulation is static and active)
- Mod 1-4 — Affects how intensely the operator modulates the frequency of other operators, (including itself) at maximum gain. Think of each as a modulation send—when you turn up “Mod 1”, you are send modulation from the source in that row to Operator 1

Algo Expander

The Algo expander allows you to save and crossfade between values of the modulation matrix parameters—all the positions of the “Mod x” knobs for each of the 4 operators and the AR FM input. Conceptually, you can think of each slot is

equivalent to an *algorithm* in the parlance of classic FM synthesizers. The Algo provides 3 save slots—A, B, and C as well as the Live slot which represents the current true modulation knobs.

Using the Algo

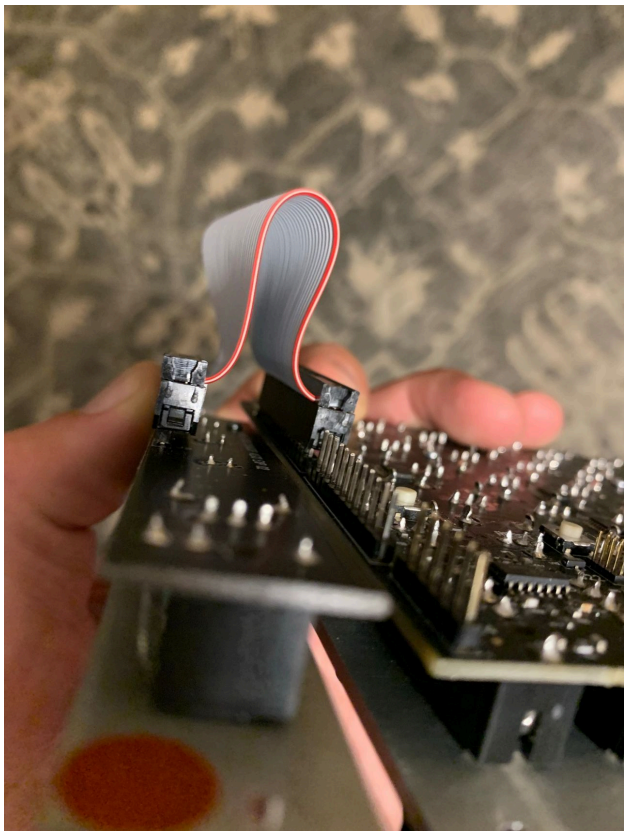
Saving an Algorithm. Long pressing on the A, B or C slot of the expander until its LED blinks twice to save into that slot.

Selecting an Algorithm. Quick pressing an Algo slot's button causes that Algo to become the "right" in the crossfade. The previous "right" then becomes the "left" slot in the crossfade. Thus, to effectively a new left and right simply quick press any two slots you like. The the left and right may be the same slot. This is good, for instance, to ensure that you are using only the live knob positions by double tapping the Live slot.

When using A, B, or C slots without the Live slot, the positions of the "Mod x" parameter knobs on the Quad Operator are ignored.

Connecting the Algo

We used a 15x2 pin header for connecting the Algo to the Quad Operator because they're cheaper and off the shelf than 15x1. As long as you're consistent in using the same 15 pin edge on each header, the Algo will function properly. If you didn't connect it properly, the Algo simply will not light up and you'll know you need to adjust one of the headers. When first powered on, the Live slot LED will be light up



External Modulation Functions

- AR FM — the position into which to patch your modulation signal. Accepts audio rate modulation sources.
- Gain knob — modifies gain via analog input circuit to allow maximum gain while avoiding clipping. Tuned to handle signals that range from +-5v to +-10v.
- Clipping indicator LED — the red LED indicates that the input signal is being clipped, leading to distortion of the input signal. Modify gain knob to reduce clipping
- Gain CV — affects the intensity with which external modulation source modifies the frequency of the internal operators. Normals to a gain of 1 (signal is full volume and modulation is static and active)
- Mod 1-4 —Like each internal operator, the external modulation input comes with 4 modulation sends that determine the amount of frequency modulation each operator receives from the external source at maximum gain

Patching and Programming

Patch Examples

MORE INFORMATION HERE

Achieving Harmonic Frequency Modulation Results

The Quad Operator can be confusing at first. The multitude of parameters can easily lead a user to noisy, dissonant outputs. This section provides some tips on obtaining more restrained, harmonic results. It's always easy to indulge in more aggressive and harsh sounds from here.

The Neutral Position
Set your parameters as described below as a good starting point. If a parameter isn't mentioned, it's up to you and well within the bounds of normal frequency modulation techniques.

Another way to thing about this list—these are the parameters you should modify when you want to make sounds that are noisier, dissonant, and aggressive.

- Set the VCO/LFO switch to VCO
- Set all operators in *lock* state
- All Detune knobs at 12 o'clock — this ensures integer frequency relationships determined only by the Ratio knobs, which is essential for harmonic results in FM
- All Shape knobs at full counterclockwise — start with sine waves, the classic FM starting waveshape. Waveshapes with overtones together with modulation can quickly add aliasing and noise, so it's a good idea to start with no modulation and go from there
- All modulation sends at full counterclockwise — this turns off all modulation, ensuring we have a "sane" beginning. Lots of modulation can add aliasing and noise, so it's a good idea to start with no modulation and go from there

Translating Algorithms to Modulation Matrix

MORE INFORMATION NEEDED

User Maintenance

Firmware Updates

Firmware updates can be loaded on the Quad Operator via a micro USB port located on the back. The latest version of the firmware is version 1.0.4.

Read the Firmware Update Instructions Here

Calibration

Calibration is important so that the *v/o* and *ratio* inputs (when an operator is running in *free* state) accurately interpreting 1 volt changes. If you're Quad Operator sounds like it might not be tracking pitch properly on one of these inputs, try the calibration procedure described here.

The Quad Operator is equipped with a precision DAC output, which allows it to generate output signals for each operator output at precise voltages. This is especially useful for calibrating the Quad Operator without an external precision reference voltage. The Quad Operator can thus be calibrated with a simple feedback patch and a few quick switch flips to trigger the calibration procedure.

Step 1: Patching the Module

Patch outputs back into inputs in the following manner:

- "op 1" → "ratio 1"
- "op 2" → "ratio 2"
- "op 3" → "ratio 3"
- "op 4" → "ratio 4" and "v/o" via an *unbuffered splitter* such a starfish or stackable cables *

* It's very important that "op 4" out is used for the split, *not* one of "op 1", "op 2" or "op 3". The calibration procedure does some extra compensation for this split. The unbuffered split is important—a buffer splitter can apply a small amount of gain that changes the output voltage, which will adversely affect the measurements taken during calibration

Step 2: Triggering the Calibration Procedure

Once you've properly patched the module as described above, flipping the switches according to the following "cheat code" to trigger the calibration procedure.

1. Flip operator 1's free/lock switch one time
2. Flip operator 2's free/lock switch one time
3. Flip operator 3's free/lock switch one time
4. Flip operator 4's free/lock switch one time
5. Flip the vco/lfo switch 5 times quickly

When the calibration procedure is triggered, the gain indicator LEDs will blink twice before returning to normal operation within a few seconds.

Specifications

Parameter Ranges

Ratio and shape parameters are the aggregate of the knob and CV inputs. 5 volts of CV range corresponds to a full turn of a knob. Thus, it's possible to "turn" a knob through it's full range in either direction with a bipolar CV input (e.g., a fully clockwise knob can be turned fully counterclockwise by applying a -5v CV signal).

Parameter	**Range**
Coarse (VCO mode)	16.35 Hz (C0) to 2093 Hz (C7)
Coarse (LFO mode)	0.511 Hz (C-5) to 65.41 (C2)
Fine	+ / - 6 semitones relative to coarse tuning
Ratio 1-4 (lock state)	x1/11 to x11 relative to master coarse & fine
Ratio 1-4 (free state & VCO mode)	16.35 Hz (C0) to 2093 Hz (C7)
Ratio 1-4 (free state & LFO mode)	0.511 Hz (C-5) to 65.41 (C2)
Detune 1-4	+ / - 6 semitones
Shape	Crossfades between sine, triangle, square, sawtooth
Gain 1-4	0 to 1 gain multiplier

Signals Specifications

Patch Point	Type	Voltage Range	Normal Voltage	Sample Rate
Reset	Gate in	0v, 5v (threshold ~2.5v)	0v	6 kHz
1V / Oct	CV in	-1v to 5v	0v	6 kHz
LF FM	CV in	-5v to 5v	0v	6 kHz
Ratio 1-4	CV in	-5v to 5v	0v	6 kHz
Shape 1-4	CV in	-5v to 5v	0v	6 kHz
Gain 1-4, Gain AR FM	CV in	0v to 5v	5v	6 kHz
AR FM	Audio in	Trimmable for ranges between -5v to 5v and -10v to 10v	0v	48 kHz
Op 1-4	Audio / CV out	-5v to 5v	n/a	48 kHz

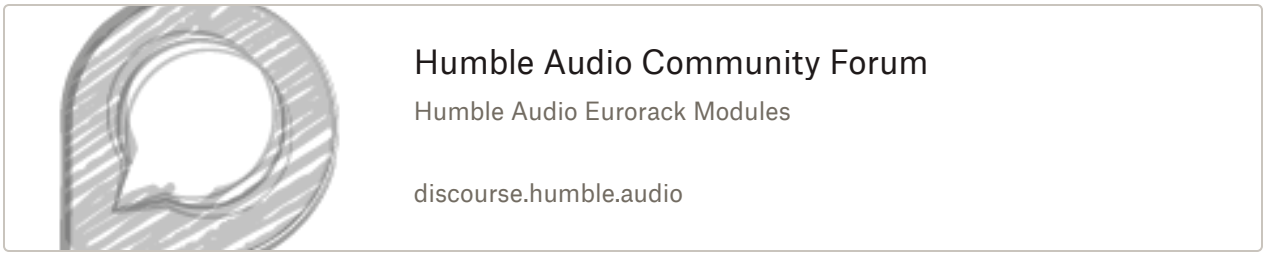
Physical Dimensions and Current Consumption

- Quad Operator
  - Width: 30hp
  - Depth: 25mm
  - +12V: 140mA, -12V: 13mA

- Algo expander
  - Width: 4hp
  - Depth: 25mm
  - +12V: 5mA, -12V: 0mA

Customer Service and Support

Please address your questions and issues to us on our community forums so that other users may benefit from the answers to your questions!



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Warranty

Humble Audio products are warranted for 12 months from date of purchase. If you're having an issue with your device that you're unable to address via the community forums, please contact us directly.