BugBrand Modular Frames

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Synth Voice

The Synth Voice is the first of a range of pre-configured BugBrand Modular Frames and contains multiple building-block elements for synthesised sound generation. It is largely based on quite traditional 'Subtractive Synthesis' methodology (VCO->VCF->VCA), but with a number of tricks up its sleeve and, being freely patchable, you are never limited to such linear approaches. It is designed to be played standalone, within a larger BugBrand Modular setup or controlled by signals from external devices such as MIDI-to-CV converters or analogue sequencers.

Most modules feature one or more Voltage Controlled (VC) elements, with the main functional blocks being :

- Oscillators (VCOs) – Waveform generators for sonic or modulation purposes.
- Filters (VCFs) – Tonal shapers which subtract and emphasise frequencies.
- Amplifers (VCAs) – Signal controllers which govern waveform amplitude.
- Envelopes (Envs) – Contour waveform generators with distinct differences from the VCOs.
- Mixers – Signal combiners and output mix controller.
- Powered Frame – The system exoskeleton with internal power distribution.

Patching within the system is free flowing due to the use of stackable 4mm banana cables and standardised signal amplitudes.

Audio output is on balanced 1/4” jack sockets to interface with standard line level devices such as mixers, soundcards and rack effects.

External control signals (eg. 1V/Oct source, Gate signals) can be used or signals taken from the modules to external destinations – see the section on Interface Cables.

All modules follow the Frac Rack size standard of 5.25” height (3U) and multiples of 1.5” width. The front panels are made of PCB material which provides clear, eye-catching appearance combined with durability.

The system is housed in an aluminium enclosure (frame) which also holds a DCDC power unit and internal power distribution. The 12VDC worldwide external power brick is internally converted to a bipolar +/-15V supply which is distributed to individual modules. The Frame is designed for free-standing desktop use, but can be fitted with 19” Rack Ears for rack mounting (though typically the position of the power input will need to be changed too).

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System Approaches

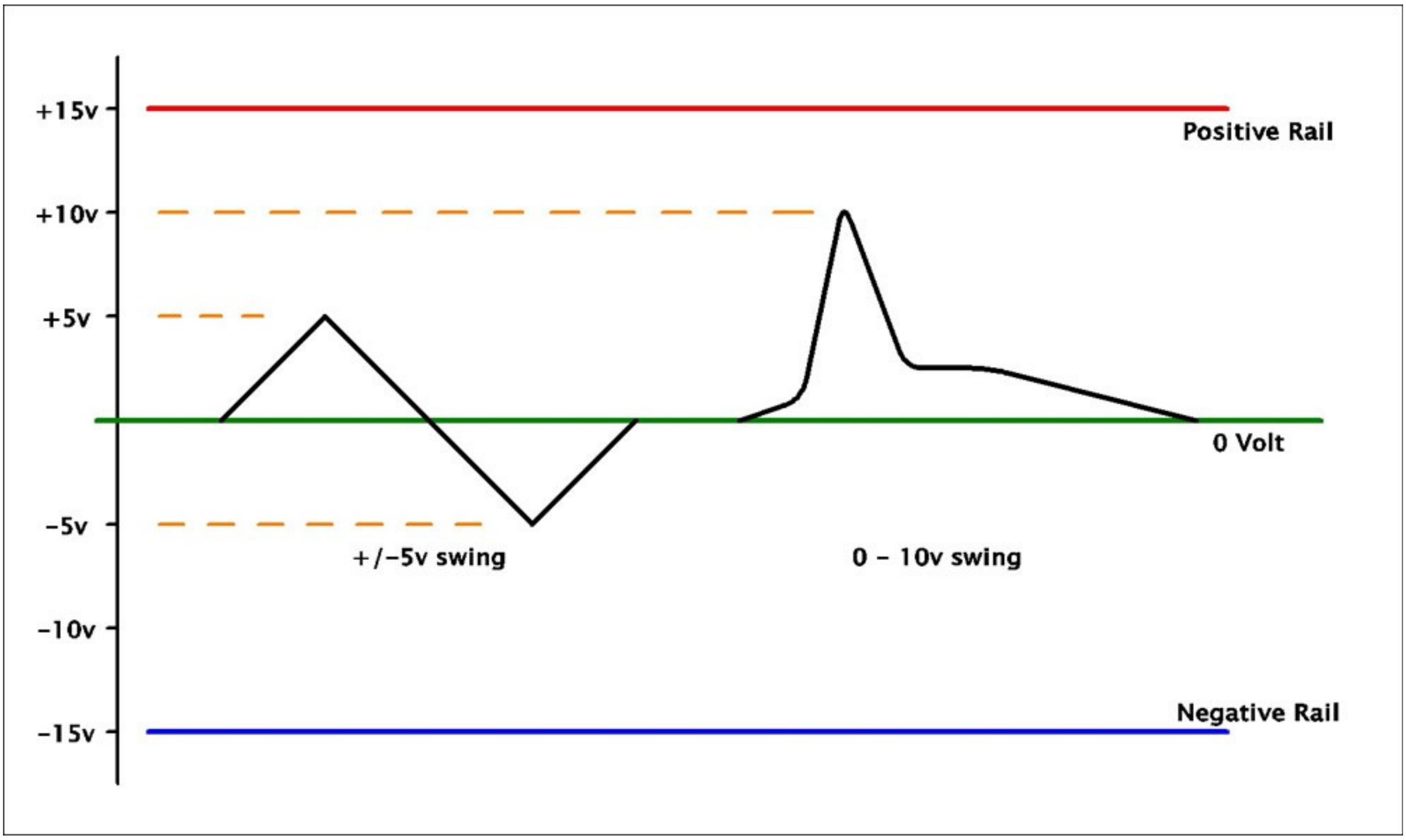
I feel that a mix of technical understanding and experimentation is the best way to approach a system like this. The modules are very much designed as distinct building-blocks with quite basic functionality but which, when combined via subtle patching approaches, offer a wealth of possibilities.

The system is built around voltages – static or fluctuating – and gaining an understanding of approaches and behaviours should help to demystify such terminology. Remember that an electronic sound is simply a voltage oscillating at a rate between 20 and 20,000 times per second (20Hz to 20kHz).

The system Power is based on an external 12V DC brick connected to the rear DC socket, while inside the frame this is converted to the bipolar (twin rail) +/-15V system power via a DCDC converter. This supply is then distributed internally on a PCB distribution bus to individual MTA100 power headers to which the module power cables are connected.

These system power voltages can be considered as 'boundaries' for signals within the system with the 0 Volt being the central point. Signal amplitudes within the system are standardised to 10V peak-to-peak (10V P-to-P) with the approach of outputting signals at full amplitude and applying any attenuation at the destination. Signals are generally either Unipolar or Bipolar and it is important to note these differences when it comes to patching:

- +/-5V = *BIPOLAR* – the signal swings from -5V to +5V, centred around 0V
  eg. VCO
- 0-10V = *UNIPOLAR* – the signal moves from 0V to +10V
  eg. Envelope



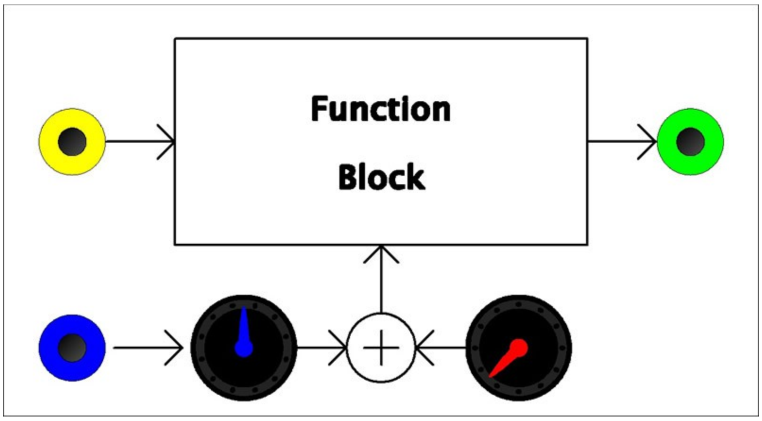
Of course, there can be slight exceptions to note – signals coming from a VCA may well be less than 10V P-to-P (unless the VCA is 'fully open'), adding resonance via the Filters can increase amplitude and mixing several full-scale signals together can result in larger total swings. But you always have plenty of headroom before 'hitting the rails' (as signals can never exceed the bounds of the system power).

Connections

All signals within the system are patched with 4mm Banana cables and sockets. All signals, being voltages, can be freely patched, but it can help to distinguish between the two major groups of functions:

- ***Main Path*** – Typically a signal input / output functional block to which some form of process is applied. A Filter, for example, could have one Main Path input and one Main Path output and within the functional block the process of filtering is applied. I have previously called this the Audio Path, but most modules are DC-coupled, meaning that they can equally process audio or sub-audio voltages.
- ***Control*** – This is a signal which combines with the settings of the function control dials to automate processes and is the basis of 'voltage control'. Again taking a Filter as an example, the Frequency CV input (attenuated and/or inverted via the modulation depth setting) is summed with the setting of the main Frequency control dial to determine the operating Cutoff Frequency. You can think of a Control signal as being an automated knob twiddler and these can work at sub-audio or audio rates.

If you consider a module as a functional block, it will generate or process an audio (or sub-audio) signal via the Main Path, with the behaviour being governed by combination of knob settings and any Control signals applied.



Colours play a key role in helping to quickly identify functions within the system. Sockets can generally be classified as follows:

	Main Path	**Control**
Input	Yellow	Blue
Output	Green	Red

Colours also help identify the function of dials:

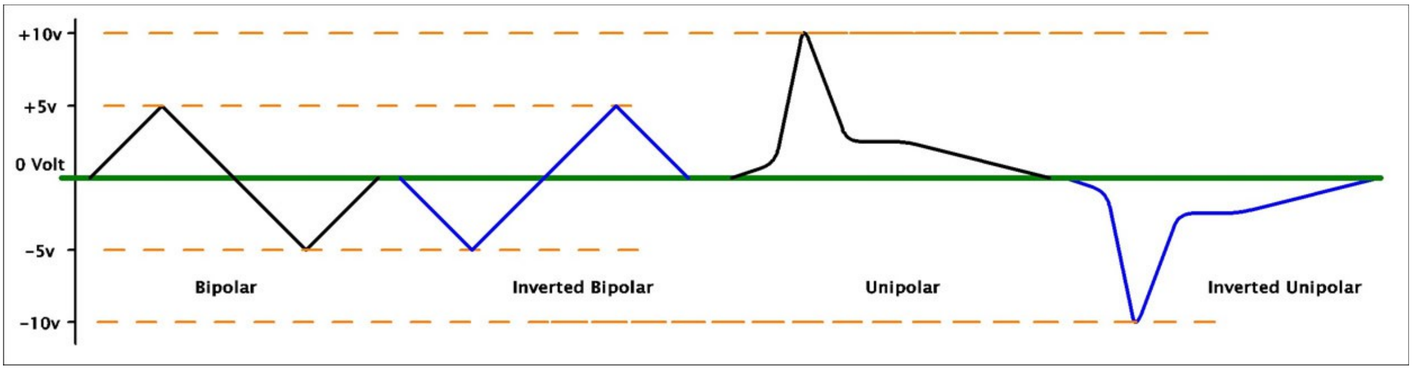
- Red/Orange – for the main module control functions
- Yellow/Green – for input/output level control (eg. Mixing)
- Blue – solely for CV modulation depth

In all areas there can be exceptions and blurred boundaries – full details are given in individual Module sheets. Simply note that voltages can function as Main Path and/or Control signals depending on what they are patched to – a VCO can be sound source and a modulator, for example.

Any parameter that can be voltage controlled will have at least two control dials plus one or more CV input. One dial (typical colour Red/Orange) will act as the Master control, sweeping the function over its typical range, while the blue Modulation Depth control will set the amount of modulation from its respective CV input. Some modules have an additional 'full-range' CV input without level control, with these typically being for unattenuated or 1V/Oct response.

Blue controls are typically 'attenuverting' – a combination of Attenuating and Inverting – to allow detailed modulation possibilities. Moving from the central zero position, clockwise rotation gives increasing modulation to unity (times one), while moving anti-clockwise inverts the modulation signal up inverted unity (times minus one). [Note that it can be hard to dial in exactly zero modulation via the dial – in such cases, the input cable can easily be removed for true zero.]

When considering inversion, note that it occurs around the 0V centre so unipolar or bipolar signals will behave as follows:



It is important to consider the waveform's behaviour when applying it as a modulation signal. The modulation voltage (after input attenuverter) is summed with the value set by the main control dial, with positive voltages adding to the main sum and negative voltages subtracting. As such:

- A bipolar +/-5V signal will add and subtract from the master control setting.
  For full control sweep, set the main control to a central position with CV full (or inverted).
- A 0 to +10V signal will add to the master control setting.
  For full control sweep, set the main control to zero and apply full positive CV modulation.
- An inverted unipolar signal (0V to -10V) will subtract from the master control setting.
  For full control sweep, set the main control to full and apply full inverted CV modulation.

As previously mentioned, signals are generally output at full 10V p-to-p amplitude allowing them to be split to more than one different destination, with the possibility of different attenuation settings at each destination. Banana cables allow quick and easy stacking of connections with the proviso:

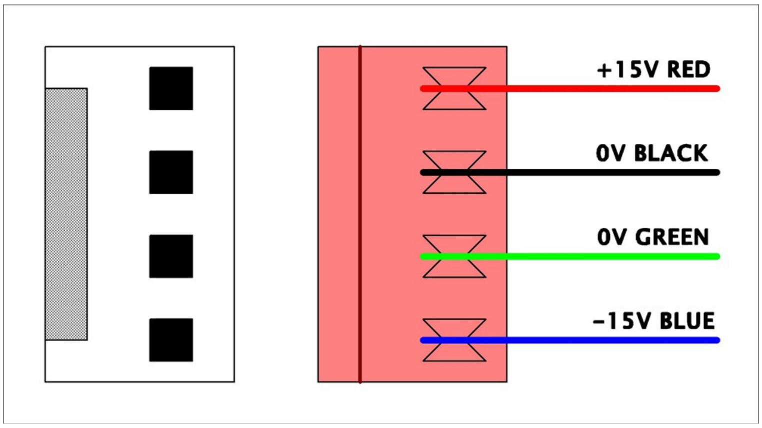
You can split one signal to several different destinations
Eg: The output of a VCO could be patched both to the Main Path input of a VCF and also to the Frequency Modulation CV input
but
You cannot combine more than one signal into one input
Eg: Two VCO outputs should not be combined by 'mixing' at the VCF's main path input – use a mixer (eg. DC Mixer in Dual Mixing module)

Saying that, all outputs feature a universal output impedance (470 ohms) and built in short-circuit protection – so 'passive' / 'stack' mixing can be experimented with, it just won't give 'proper' results.

Powered Frame

The modules are housed in a custom aluminium frame (16” x 5.25” x 2.3”) with PCB (or 19” rack) end-cheeks.

An external 12V DC power brick with standard IEC C14 input socket and able to provide at least 1.5A (per Frame), is plugged in to the rear DC input socket (2.1mm, Centre Positive). Internally this is converted to bipolar a +/-15V at 500mA per rail. Power is distributed internally via a PCB bus board with MTA100 power headers and modules are attached via 5” 4-way power cables. The power connections are polarized so cannot be plugged in back-to-front but care should always be taken to ensure that connections are correct (eg. Not 'offset') and power should be disconnected when adding or removing modules.



External Connections

The main audio outputs (via the Dual Mixing module) are on impedance balanced 1/4” sockets.
Tip = signal, Ring = 47 Ohm to 0V, Sleeve = Chassis 0V
Unbalanced connections can be used without problem.

There is no preamp for external audio signals within the Synth Voice frame – this will be achieved in a future frame module. An external source could be connected following the Interface methods detailed below, ensuring that it was externally brought up to suitable 10V P-to-P amplitude.

Interfacing with External Systems

The Synth Voice can easily 'talk' with other systems or external control devices such as Midi-to-CV converters or sequencers. As banana connections only carry the signal (no 0V connection) two steps are required:

- **A common 0 Volt connection must first be established**
  The 0V lines of the two systems need to be joined so they share a common reference. This is achieved using the black 4mm banana 0V socket on the rear of the unit.
  If a third system is to be joined, that will require a further connection to the 0V reference.
- **Signals can then be patched to or from the external system**
  It is always worth considering the voltage behaviour of any signal and note, of course, plug type conversion may be required. The voltages within the BugBrand system will work just fine with, for example, a euro-rack system – though some euro signals may only be 5V p-to-p amplitude.

To use my custom Interface Cables (60 cm Banana to Minijack):
- Make the first connection using the twin-cable 'grounded' cable. Plug the black cable into the BugBrand 0V rear socket, then plug the white 'signal' connection to the source/destination.
- Further connections with the same piece of gear then simply require a 'signal' cable.

Dual Envelope

The module contains two Voltage-Controlled Envelope Generators – identical other than the left-hand one having a slower 'slow' range.

An Envelope begins when the Manual Trigger button is pressed or when the Gate Input rises above roughly +1V (via internal comparator). As such, any waveform can be used as trigger source (not just square wave / gate).

The Envelope Output is unipolar between 0V and +10V with an exponential shape.

The Mode can be set as:

- *Gated – Attack/Sustain/Release*
  When a gate occurs, the Envelope Output ramps up to +10V at a rate determined by Attack and sustains at that level until the gate ends, at which point it releases at a rate determined by Decay.
  If the Attack phase has not completed by the time the gate ends, the Release phase starts immediately without reaching +10V.
  If a new gate occurs during Release phase, the envelope starts rising again without resetting to 0V.
- *Triggered – Attack/Decay*
  When a gate occurs, the attack phase is triggered and the output rises to +10V before immediately entering the decay phase.
  It is only the rising edge of the gate that is of importance – if any further gates occur during the attack phase, they are ignored, while a gate during the decay phase changes the envelope back into attack phase without resetting to 0V.
- *Loop*
  The output continuously oscillates between 0V and +10V. Any gate inputs behave like in Triggered mode – ignored during attack, triggered to attack (without reset) during decay.

The Fast range offers audio rates, primarily for use in Loop mode, while the Slow(er) range offers sub-audio rates for more typical Envelope usage. Note that faster Attack/Decay rates are achieved by turning the dials clockwise – this may seem counter-intuitive, but makes more sense if thinking of it raising the frequency of an oscillator.

Fast –	Atk 34 mS – 60 µS	Dcy 50mS – 90 µS
Slow -	Atk 3.5 S – 5 mS	Dcy 5 S – 8 mS
Slower -	Atk 15 S – 22 mS	Dcy 25 S – 35 mS

Rates can be further expanded downwards by patching a fixed DC voltage (eg. -5V) to any CV input.

Patch Ideas

Oscillator Overtones – Set Mode to Loop, Range to Fast and feed a VCO to the Gate Input. With Attack turned fully clockwise, adjust Decay to hear 'Sync' Waves. Works at LFO rates too.

Sub-Oscillator / Clock-Divide – Set Mode to AD, Range to Fast and feed a VCO to the Gate. With Decay turned fully clockwise, adjust Attack to hear audio sub-divisions. Works at LFO rates.

Envelope Shape Bending – By patching the Envelope output back into the CV inputs, you can bend the envelope shape into more linear or logarithmic shapes (note - also changes the frequency).

There are no internal adjustment parameters for this module.

Compact VCO
Built around a Triangle-Core Oscillator with waveshapers, this module is designed as a small and stable source of Voltage-Controlled waveforms at audio (Osc) or sub-audio (LFO) rates.

The Frequency is determined by a summation of Tune (10 Oct Range), Fine Tune (1 Oct Range), Octave Switch (-1/0/+1 Oct) and two Exponential CV inputs – EFM (Exponential Frequency Modulation) with Polarizing Attenuator and precision 1V/Oct input.

Ranges [with Fine Centred, Octave Switch centred]:

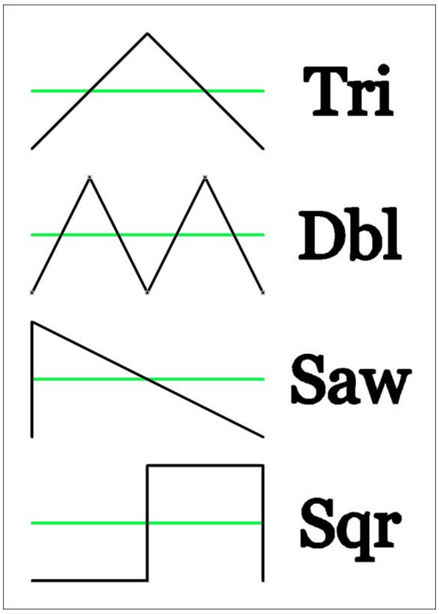
- Osc approx. 20 Hz to 20 kHz
- LFO 40 mHz (25 S) to 50 Hz

The output Waveform Shape can be manually swept from Triangle or Double Frequency Triangle to Saw-Tooth or Square dependent on the switches.
All waveforms are bipolar +/-5V.

The Sync input resets the Triangle to 0V whenever the input rises above +1V (via internal comparator). The waveform may then move in either an upwards or downwards direction (dependent on where in the waveform charging cycle the Sync occurs). The waveform diagram shows where the Triangle centre points correspond to for the other waveforms.

The bicolour LED indicates the Triangle wave.

Patch Ideas
Self-modulation – patch the Wave output back into the EFM CV input. Waveforms are skewed as positive or inverted modulation is brought in – Tri/Saw produce Log/Exp shapes, while Sqr produces different pulse-widths. Note that it will alter the frequency.



Cross-modulation – patch the Wave output from one VCO into the EFM CV input of a 2nd VCO and the Wave output from the 2nd into the 1st one's EFM CV input. Experiment with rates and depths. Something approaching tuned noise can be achieved when both EFM depths are set to maximum.

Calibration
The three VCO modules are tuned together during calibration to track 1V/Oct at around +/-1 cent over at least a 5 octave range.

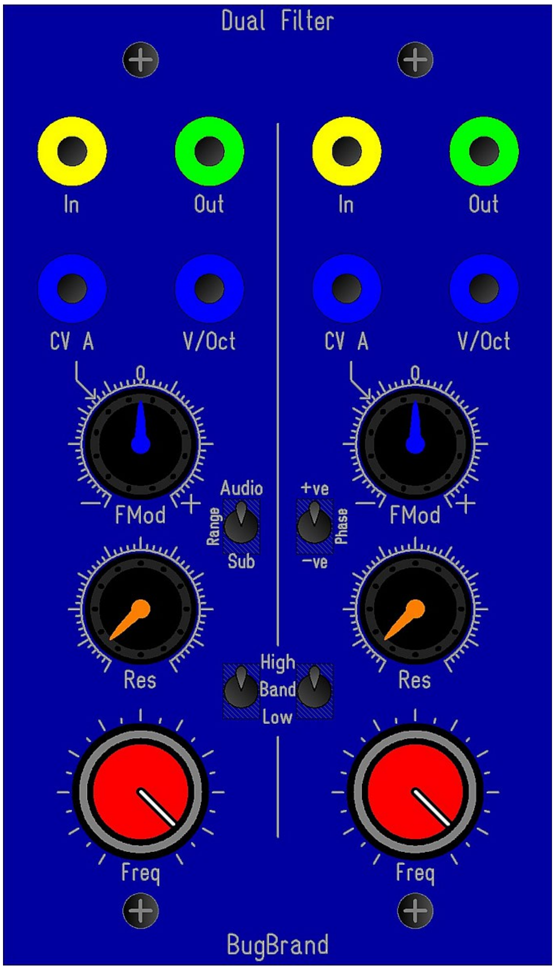
Any user calibration should be performed with caution, a fine touch and care to avoid adjusting the wrong parameter. Let the unit warm up for 1 hour before adjusting the tracking. All trimmers are multi-turn and require adjustment with a small flat-head screwdriver.

Trimmers from top to bottom:

Offs – adjusts the base frequency of operation – preset to make lowest Osc Tune setting to 20 Hz.
Scale – adjusts the 1V/Oct tuning response.
HFTrm– adjusts the High Frequency tracking response for the 1V/Oct tuning.
RmpOffs – nulls the switching error glitch at the centre of the Saw wave.
+1V – adjusts the +1 Octave setting
-1V – adjusts the -1 Octave setting

Dual Filter

This module offers a pair of State-Variable Filters with Low, Band or High Pass responses and variable Resonance up to self-oscillation. The Filters are largely identical except that the left-hand one features a range switch while the right-hand one offers output phase inversion.



Each Filter has a DC-coupled Input typically expecting a bipolar +/-5V input signal. The Output is also DC-coupled, with in-phase unity gain when no filtering or resonance are applied.

The Low and High pass responses are 2-pole 12dB/Oct, while the Band pass is 1-pole 6dB/Oct.

The Cutoff Frequency is determined by a sum of the Frequency dial and the two Exponential Control Sources – CV A via Polarizing FMod Attenuator and V/Oct.

With Resonance turned up full, the Filters will self-oscillate, producing a pure sine-wave which will track over several octaves via the V/Oct input. Note that the oscillation amplitude increases with frequency:

20 Hz – 3V P-to-P,	200 Hz – 4V P-to-P,
2 kHz – 6V P-to-P,	12 k Hz – 8V P-to-P,

The Sub mode on the left-hand section switches in extra filter capacitors to shift the range into sub-audio frequencies.

Low-pass corresponds to integration and functions like a Voltage-Controlled Glide when resonance is set to minimum.
High-pass corresponds to differentiation and can create variable exponential decay (instant attack) envelopes from a Squarewave input.
[Who knows what the Band-pass corresponds to.?. experiment]
Adding resonance will cause oscillations to be superimposed on the resulting waveform – akin to waveform wobble, it gives strange results in the VC-Glide areas.
The output will oscillate as in Audio mode, though you may need to turn the frequency up first to allow oscillations to build up to full amplitude.

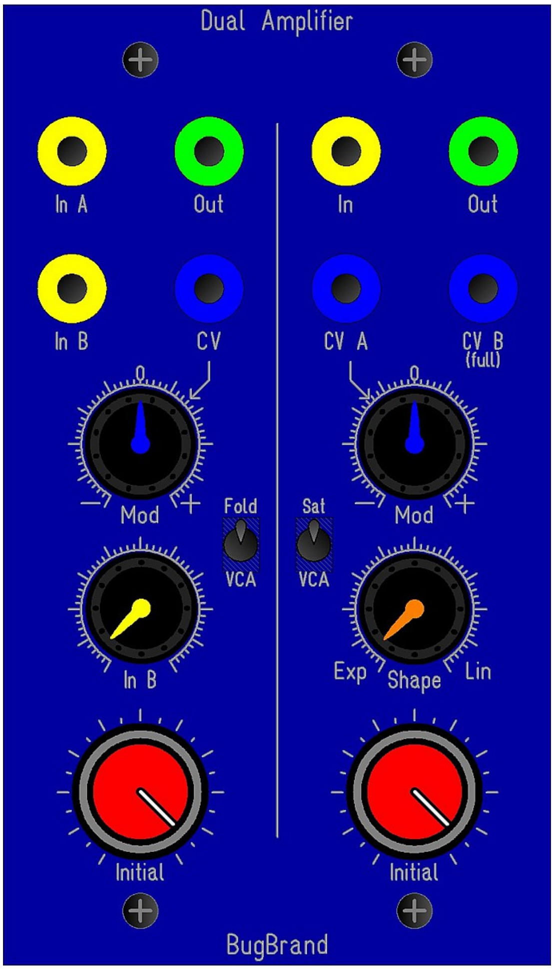
The Phase switch on the right-hand section is a simple polarity inverter for the Main Path output. You can experiment with the switch while mixing (externally) the input/dry signal with the Filter output.

Calibration

Note that the module is not temperature compensated and that best tracking stability is achieved after around 2 hours warm-up time.

Each filter has a multi-turn trimmer to adjust the V/Oct response.

Dual Amplifier



The basis of the module is a pair of DC-coupled Voltage-Controlled Amplifiers (or, more accurately, attenuators – gain is variable from 0 to +1) each with a form of waveshapping which can be switched in to follow each VCA. The Initial controls sweep the VCAs from fully closed to fully open.

The left-hand unit features a Linear response and two Main Path inputs – one full scale (In A) and one with attenuator (In B) allowing two inputs to be mixed.

The Fold switch brings in a 4-stage Wavefolder which folds the waveform tips back in on themselves as amplitude is increased [does not work with squarewaves!] resulting in extra harmonics.

The Fold mode works fine with sub-audio signals and folding kicks in around 9 o'clock on the Initial dial.
Try mixing a sub-audio signal into In B while running an audio signal into In A for a width modulation effect.
A passable white-noise source can be made by patching the Out to In A and turning the Initial dial up to near full.

The right-hand unit has only one Main Path input (again DC-coupled), but the response can be swept between Linear and Exponential which gives a sharper response from envelope modulation. It also features a 2nd unattenuated modulation input.

The Sat(uration) switch brings in an amplification stage with zener limiting at +/-5V. Soft-clipping begins to occur after around 9 o'clock on the Initial dial.

A 4 quadrant multiplier (Ring Modulator) can be patched using the two sections combined with the DC Mixer.

- Switch both to VCA mode with Initial control set to around mid point
- Feed the same signal (carrier) to each side (In A and In)
- Feed a bipolar signal (modulator) to the centre CV inputs (CV and CV A) but set them to opposing modulation depths (one fully clockwise, one fully anti-clockwise)
- Take the two Out signals to the DC Mixer and combine them with one inverted
- Tweak the Initial dials to minimise carrier and modulator bleed-through

There are no internal adjustment parameters for this module.

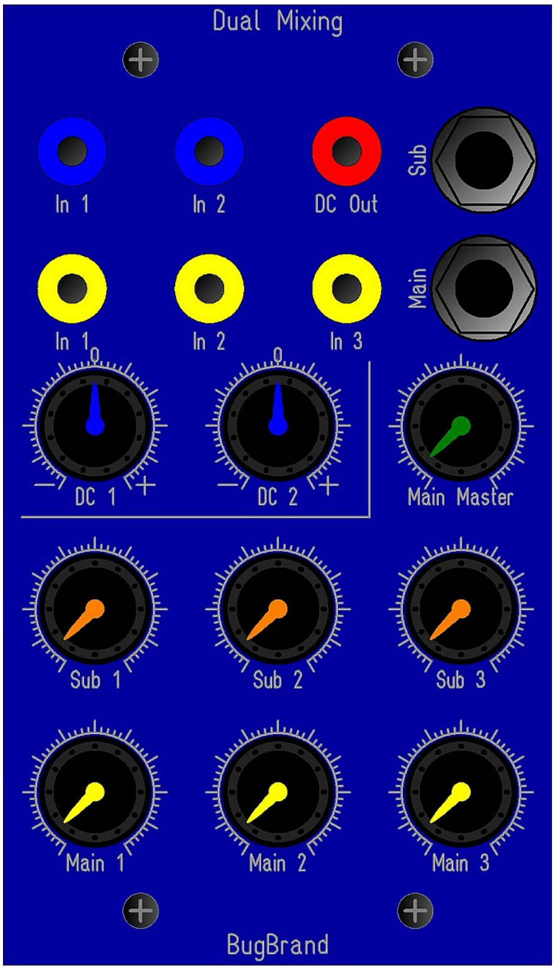
Dual Mixing
This module combines two different forms of utility mixer – a two channel DC summing mixer and a three channel, two bus output mixer.

The DC Mixer section takes two DC-coupled inputs, passes them through polarizing attenuators before summing them to the DC-coupled output. This section is useful for scaling and combining control signals, but can equally be used for audio signals.

The Output Mixer has three DC-coupled inputs which feed two separate summing buses via individual Level controls. Both 1/4” outputs are AC-coupled and are Impedance Balanced. The lower Main sum features an extra Master level control before output, while the Sub sum passes out at full amplitude.

This arrangement allows signals to be output either to independent destinations or in a stereo arrangement (set Main Master to full).

Internal jumpers can be set to attenuate the two outputs independently by approximately 12dB if required.



System Specifications

External Supply Voltage: +12V DC, 1.5A (per Frame), 2.1mm, centre-positive, polarity and over-current protected
Internal System Voltage: Bipolar +/-15V, 500mA per rail per frame
Power Bus Connections: 4 Way MTA100, 5" power cables

Waveform Voltages: 10V peak-to-peak (unipolar 0-10V or bipolar +/-5V)
Gate Input Threshold: approx. +1V

Main Path Input Impedance: 30K Ohm Typical
Control Input Impedance: 100K Ohm Typical
Output Impedance: 470 Ohm Typical

Signal Connections: 4mm Banana Socket, Impedance Balanced 1/4" socket

Module Size: Frac Rack Standard
Modules are measured in multiples of FracWidth (FW) with 1FW being 1.5" width.
Modules are 5.25" tall (3 rack unit) and a maximum of 1.65" deep.

Module Fixing: M3 x 10mm Bolt.
The Frame Chassis and PCB Panels are all connected to Chassis 0V which joins the System 0V by the DCDC converter.

Thanks to Palle Dahlstedt for his diverse and detailed observations during beta-testing.
And to the old-blue crew for allowing me to bounce ideas off them for the last few years.

Guarantee

The SynthVoice comes with a 2 year 'reasonable' warranty. If any mechanical or electronic failure occurs within the period, I will repair the fault free of charge. This excludes failure from maltreatment or modification and any cosmetic degradation. Contact should first be made via email to discuss the problem. Shipping to return the device is paid by the user and I cover return shipping. Failures that are not covered by this guarantee may be fixed at standard rates.