Brunswick

brunswick synthesiser

kit op manual

user manual

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FUTURE SOUND SYSTEMS

v.1

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Introduction

Hello and thank you for buying a Future Sound Systems Brunswick. We hope you enjoyed the fabulous build guide and process of creating your own musical instrument.

The Brunswick was commissioned for a DIY synth workshop by Bristol Experimental Expanded Film (BEEF), based at the Brunswick Club in Bristol. BEEF are an organisation who we feel are doing really important work educating people about experimental film and music, and providing a forum for it to be enjoyed and appreciated.

http://www.beefbristol.org/

This user's guide is intended to tell you more about the idea behind Brunswick, why it is the way it is, how it works and how you might use it to make music.

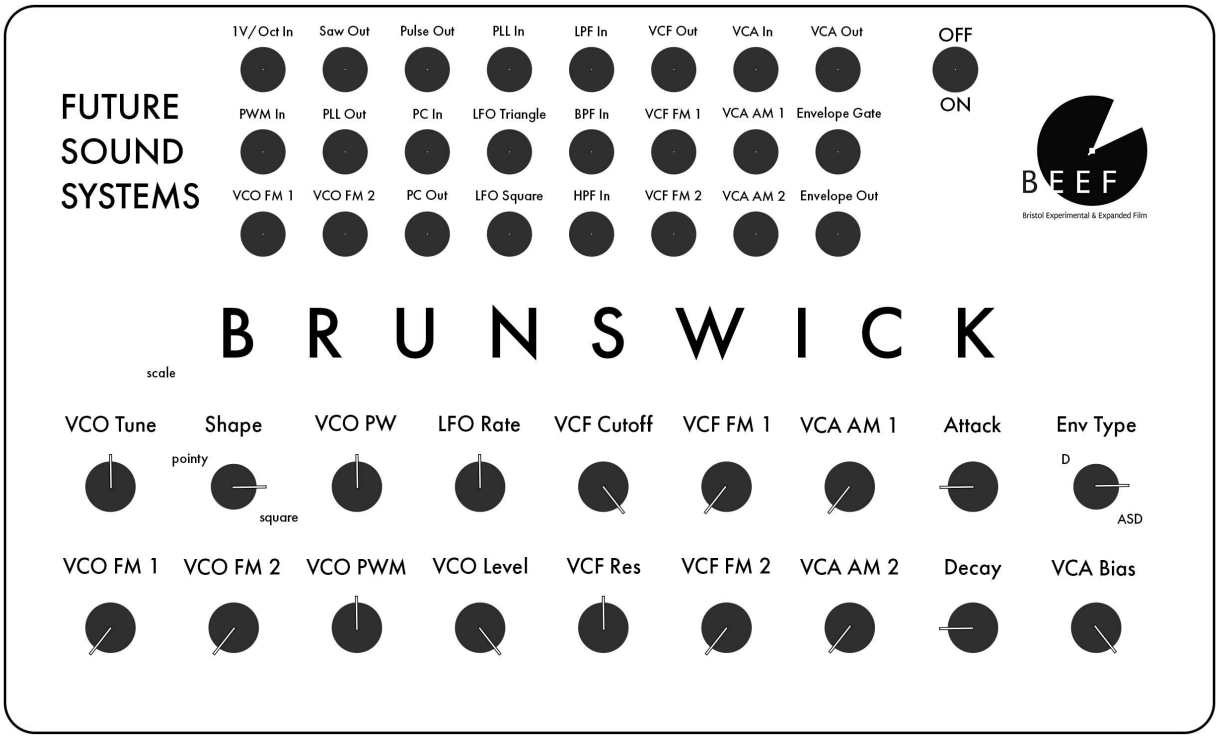
Brunswick was intended to be an introduction to analogue subtractive synthesis, but it has plenty of novel features and flexibility that makes it interesting in its own right, and means that it can be used together with other instruments or for audio processing.

http://www.futuresoundsystems.co.uk

Did I build it good?

Probably - the Brunswick was designed to be as simple to build as possible. In order to make sure your build is indeed perfect, here are a few simple checks you can make to be sure that everything is working correctly.

Start with your Brunswick set up like this:



In order to check that the oscillator is working and passing through the elements of the synthesizer correctly, listen to it at each stage: “Saw Out”, “Pulse Out”, “VCF Out”, “VCA Out”. You should be able to hear the oscillator at each stage.

After this, check the operation of the envelope by turning “VCA AM 2” and “VCF FM 2” to maximum, then as you turn down “VCA Bias” you should hear the envelope working on the VCA. Note that without anything patched into the “Envelope Gate Input”, the LFO’s square wave output will trigger the envelope.

If you then turn the “VCF Cutoff” down you should be able to hear the filter cutoff being modulated by the same envelope shape.

To check the LFO, turn the “VCO PWM” control to hear this pulse width be modulated by the LFO. If your Brunswick does all this, then we know that all the elements are working.

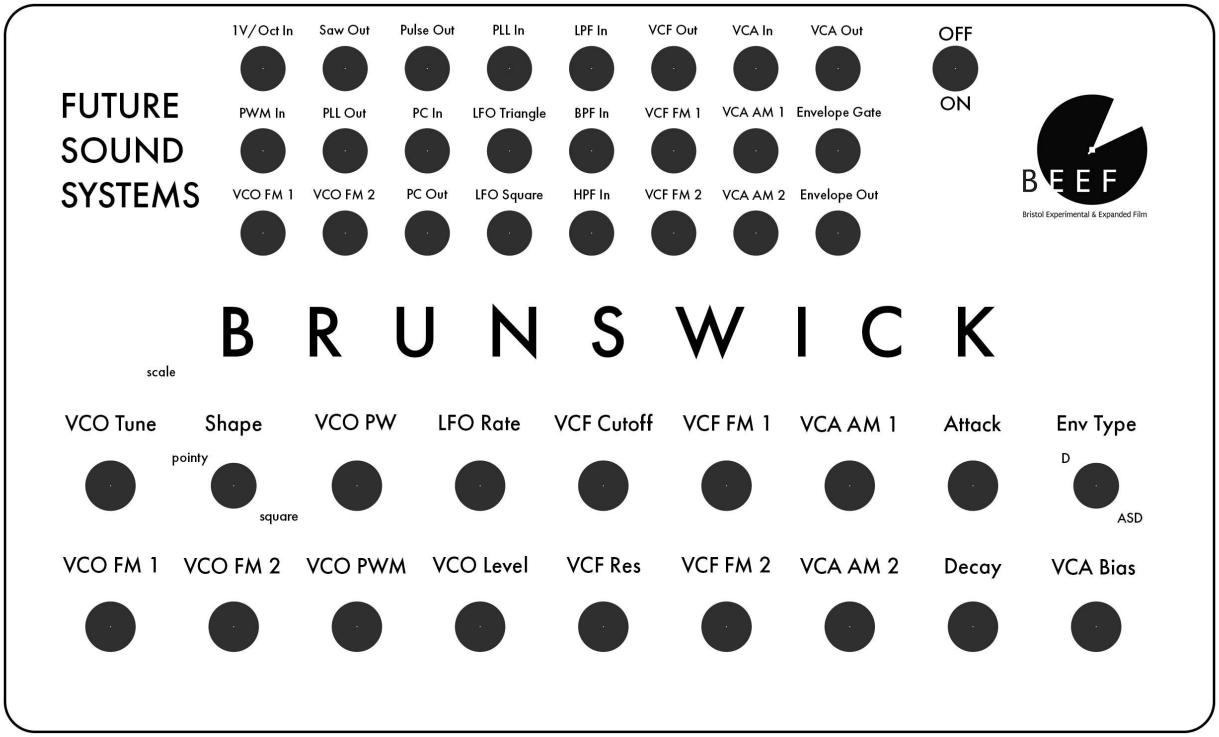
If there are any parts of your Brunswick that are not working correctly, or if any of the modulation controls are not working, it is most likely that this will be caused by a component being bypassed or connected somewhere it shouldn’t be by a solder bridge. It is very unlikely to be component failure unless they have been been abused (even then they will probably still be fine).

As such, if there are any faults you should start narrowing it down by inspecting all the solder joints and checking for solder bridges between pads. We find that nearly all faults are down to this sort of thing.

If you’re still having trouble, then by all means get in touch and we will try and help.

Technical Description

These are Brunswick's controls and patchpoints. Please feel free to use this as a template to remember your patch settings.



Brunswick is a monophonic subtractive synthesizer featuring one voltage controlled oscillator (VCO), one low frequency oscillator (LFO), one voltage controlled filter (VCF), one voltage controlled amplifier (VCA) and an envelope generator.

The VCO is based around a CD4046 integrated circuit which is designed to create phase locked loop circuits (PLLs). Using CD4046's phase locked loop (PLL) and phase comparator (PC) inputs and outputs, Brunswick can be used able to create a few more interesting wave shapes and timbres than normally available from a subtractive single oscillator synthesizer.

The VCF and VCA are fully patchable, which means they can be used on their own to process external signals without using the rest of the synthesizer. For instance the VCA can be used to perform amplitude modulation (AM), and the VCF can be used for distortion and filtering effects.

Brunswick features six patchable modulation busses, two which allow for frequency modulation (FM) of the VCO (VCO FM 1 and VCO FM 2), two which allow for modulation of the cutoff of the VCF (VCF FM 1 and VCF FM 2), and two which allow for modulation of the VCA (VCA AM 1 and VCA AM 2).

The fact that a broad range of sounds that can be made with no patching is thanks to the normalling of the modulation and control signals in the instrument, this can be seen in more detail in the signal flow diagram.

Because Brunswick was intended as an introduction to synth building, designing it was an exercise in simplification. Given the simplicity of the circuitry and low component count, some aspects of the design are not entirely “ideal”.

Powering the device from a pair of 9V PP3 batteries, one acting as the positive supply rail, and the other acting as the negative, means that as the batteries are depleted the synth’s behaviour may change slightly.

The fact that the instrument has no enclosure means that touching the circuitry can sometimes affect the synth (particularly when there is moisture on the skin).

We hope that you embrace the quirks and appreciate the design for what it is: inexpensive, simple and very characterful. However, we have included a section later in this manual explaining how to tame some of the non-ideal characteristics with the addition of some complexity.

Specifications

Power

2x PP3 9 volt batteries in bipolar configuration

or FSS BS9V Battery Simulator (soon to be available from Thonk)

+35mA, -20mA current draw

Inputs

1V/Oct In: Pitch CV input, tracking dependent on VR5 (see build manual for calibration instructions)

PWM In: +/-4V gives full duty cycle sweep with “VCO PW” set to 12 o’clock

PC In: The action happens between 2.50V and 3.50V

PLL IN: +4.20V activates PLL

LPF in: Clipping level 5.00V pk-pk

BPF in: Breaks time all the time

HPF In: Clipping level 5.00V pk-pk

VCA In: Clipping at 4.00V, breaks through VCA at 10.00Vpk-pk,

Envelope Gate: 3.70V with R5=47K

Outputs

Saw Out: 9.70V pk-pk

Pulse Out: 14.50V pk-pk

PC Out: +8.20V

PLL Out: +8.20V

LFO Triangle: 6.60V pk-pk

LFO Square: 14.80V pk-pk

VCF Out: 10.80V pk-pk

VCA Out: 5.70V pk-pk

Envelope Out: 6.70V (includes 1.20V DC offset)

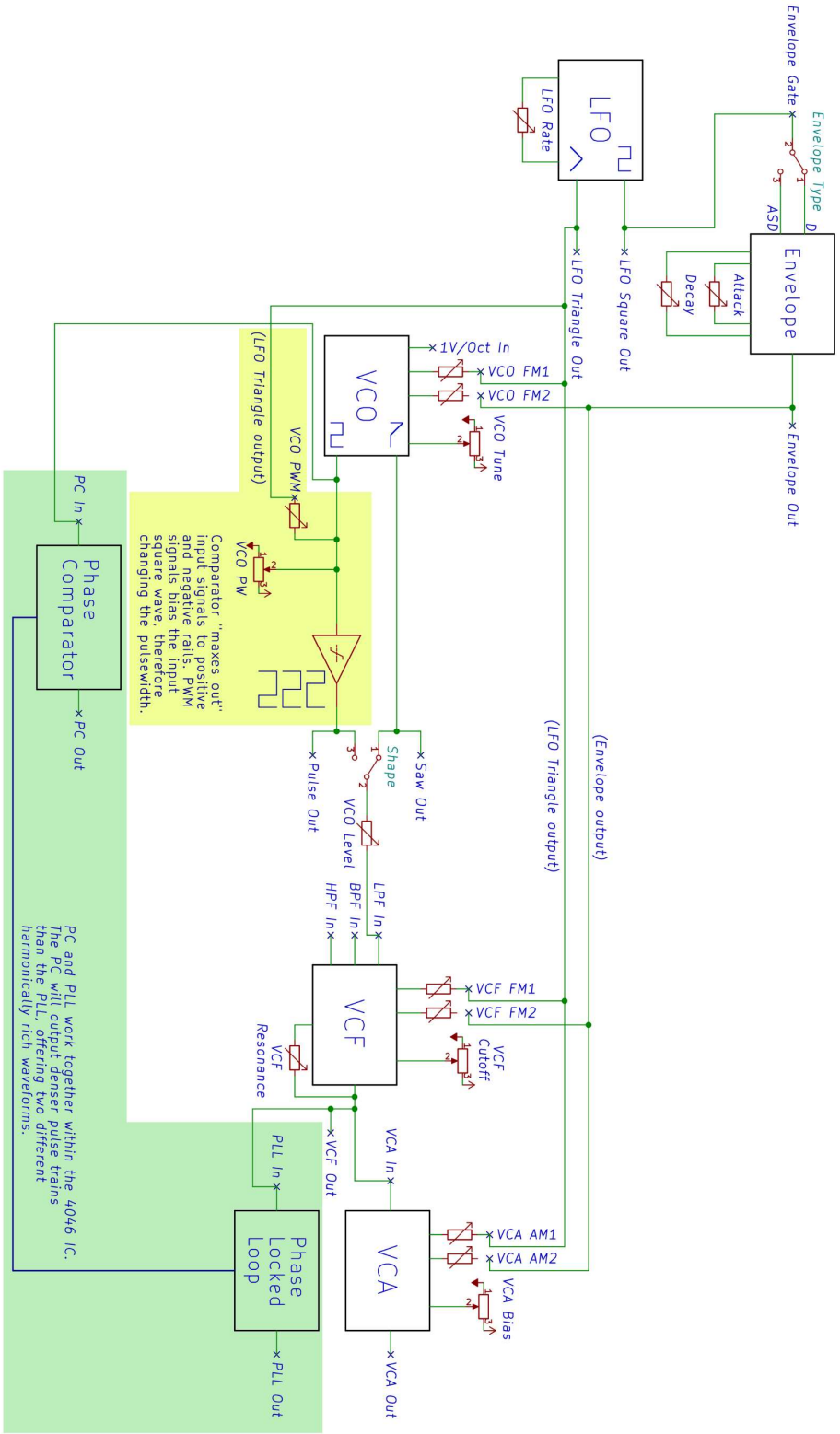
Physical

PCB dimensions: 194mm x 120mm

0.270 kg without batteries

0.361 kg with batteries

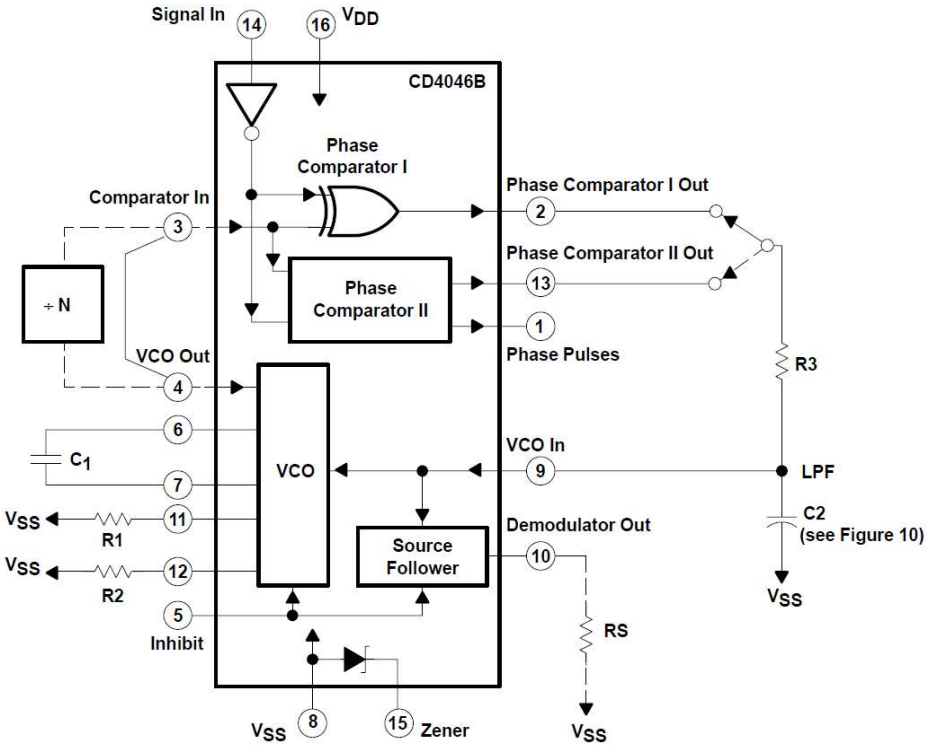
Signal flow


LFO
LFO Rate
Envelope Gate
Envelope Type
ASD
Envelope
Attack
Decay
LFO Triangle Out
LFO Square Out
Envelope Out
VCO
1V/Oct In
VCO FM1
VCO FM2
VCO Tune
(LFO Triangle output)
VCO PWM
VCO Pw
Comparator "maxes out" input signals to positive and negative rails. PWM signals "bias the input square wave therefore changing the pulsewidth.
PC In
Phase Comparator
PC Out
Pulse Out
Shape
Saw Out
VCO Level
HPF In
BPF In
LPF In
(LFO Triangle output)
(Envelope output)
VCF
VCF FM1
VCF FM2
VCF Cutoff
VCF Resonance
VCF Out
PC and PLL work together within the 4046 IC. The PC will output denser pulse trains than the PLL, offering two different harmonically rich waveforms.
PLL In
Phase Locked Loop
PLL Out
VCA In
VCA
VCA AM1
VCA AM2
VCA Bias
VCA Out

Components of Brunswick

VCO

The VCO uses a CD4046 integrated circuit, intended for use in PLL circuits. It consists of an internal VCO and a circuit which measures the phase difference between the output of the VCO and an external signal (pin 14 below). The output from the VCF is normalled to this signal input (pin 14).



Unlike this diagram, in Brunswick, the Phase Comparator I Out (pin 2) is not connected back to the VCO input, otherwise the VCO would always be frequency modulated in proportion to phase differences between the output of the VCF and the VCO's output. The VCO In (pin 9 above) is only available via the VCO FM modulation patch points. Pin 2 above is available on the patchbay as "PC Out", here you will find a pulse which corresponds to the phase difference between the VCO's output and the VCF's output (it is high when the signals are not in phase). The CD4046 needs a relatively high peak to peak voltage at the signal in pin (pin 14 or "PLL In") in order for it to detect phase, so to produce a signal at the "PC Out" and "PLL Out" without patching, the filter will usually have to be self resonating.

“PC Out” can be treated as another waveform, or be used to modulate another part of the instrument. “PLL Out” on Brunswick’s patchbay is connected to pin 1 of the CD4046 IC, which in most cases a pulse which occurs as the “PC Out” changes state.

The “PC In” and “PLL In” inputs can be used to modulate the VCO’s frequency and to alter the shape of the waveforms coming out of “PC Out and PLL Out”. These two outputs can be used to cross modulate other parts of the instrument, or as new waveform outputs. Usefully, they bear a harmonic relationship to the VCO.

LFO

The LFO in Brunswick is based around a simple RC circuit, the charging and discharging ramps of the capacitor form the triangle wave. The square wave LFO output is generated by feeding this triangle wave into an op-amp configured as a comparator. The square wave therefore alternates between high and low states when the triangle reaches a peak or a trough.

VCF

The VCF in Brunswick is a 12dB/Octave Sallen-Key filter with opto-FET control. The opto-FETs are the source of the filter’s character as they can behave quite non-linearly.

The resonance control is set up to also act as a gain control within the filter.

The filter is multi-state but has only one output. The inputs to each of these states are available on the patchbay.

VCA

The VCA is an extremely basic design based around a single FET. Because of the lack of supporting circuitry around the FET, all of its nonlinearities are imparted on the signal passing through it. Generally this means that it causes more distortion the lower the signal level going into the VCA.

Envelope

The envelope is a simple Attack/Decay envelope. The mode switch converts the gate signal going into the envelope into a brief trigger pulse, meaning the envelope will only generate the decay portion if the attack is set to zero.

Controls

Normalling and Patching

Connections in the patchbay of Brunswick are normalled, this means that the elements of the instrument are connected together even when there are are no cables connected to any of the patchpoints.

Specifically the patchbay is half normalled, this means that the normalled connection is broken when a cable is connected. Hence connecting a cable will stop signal flow beyond that point in the synthesizer.

Details of the normalled connections can best be seen in the signal flow diagram in the “Signal Flow” section of this manual.

Modulation Busses

Brunswick has six modulation busses allowing for AM, and FM without patching. Any modulation control numbered “1” controls a send of the LFO to whatever destination is labelled on the control. Any modulation control numbered “2” controls a send of the envelope’s output to the labelled destination.

Modifications

Powering Brunswick - BS9V

Brunswick was designed to be powered by a pair of 9V batteries, so that it can be portable and in order to embrace some of the oddities that arise with changing supply voltages.

If you want to power Brunswick from the mains, you can use the Future Sound Systems BS9V Battery Simulator. This board will snap in to the existing battery terminals allowing you to power Brunswick from any 12VDC supply (13.2VDC maximum) . It has a DC barrel jack, bare wire terminals and a Eurorack header to supply it with power, and is capable of powering up to two Brunswicks. The BS9V is a available as a kit from Thonk.

The BS9V is an unregulated supply and so its output will sag as the load on it varies, much like a battery as it becomes depleted.

As stated the BS9V accepts a 12VDC input, so could also be powered from a car battery (but beware of alternators).

Alternatively, if you have a Eurorack system already, you could power your Brunswick directly from the +/-12V DC of your eurorack power supply. Whilst this is above the design voltage of the instrument, there is no reason why this would cause any damage or problems with the functionality, thanks to the fact that the voltage ratings of the components in Brunswick are over-specified by at least 50% in most cases.

Cleaning up the filter

By design, the VCF of Brunswick features an aggressive and distorted sound. This is found particularly at high resonance settings, where the oscillation of the filter becomes clipped, resulting in a squared-off waveform. If desired, however, there are a couple of modifications which can be applied to calm the filter down.

Firstly, a second diode can be added to the filter's gain loop in order to make the distortion of the filter symmetrical, i.e. clip at the same voltage above and below zero. One "limiting" diode already exists at D6, and is located below the VCF Resonance control. The second diode can be strapped across D6, but in the opposite orientation.

Secondly, an RC network can be added to the filter's gain loop to smooth out the response of the filter's resonance somewhat. Both a 33k resistor and a 47pF capacitor are recommended, and can be connected in series across pins 1 and 2 of U6 (the right-most TL074 IC). The resistor will reduce the gain of the resonance, whilst the capacitor will cause the filter to reject frequencies slightly further down the spectrum.

Changing VCA gain

The VCA of Brunswick was designed as its final output stage, as well as controlling the dynamic of the signal at its input. Therefore, the VCA will attenuate incoming signals in order to bring “modular” voltages down to line level. However, this attenuation can be removed, and the VCA’s output level made “hotter” by a simple resistor change.

One of two options can be taken in order to boost the output level. Either the value of R35 can be decreased, or that of R36 can be increased. If you are comfortable de-soldering components, then we suggest replacing R36 (100k) with a 220k resistor. If you would rather “strap” a new resistor across an existing one, we would suggest placing a second 100k resistor across R35 (also 100k).

Using Brunswick

As a standalone synthesizer

As mentioned in the “Normalling and Patching” section, the key synthesis elements of subtractive synthesis are connected together by default through normalled connections on the patchbay. Without any patching, the output of the VCO passes through the Level control, into the low-pass filter input, and the output of the filter into the VCA. The envelope can then open both the VCA and the VCF through the VCA AM 2 and VCF FM 2 respectively.

However, this normalling can be overridden. For example, an output of the oscillator can be connected into the BPF In for band-pass filtering, then the normalled input to the low-pass filter can be silenced by turning the VCO Level down to minimum.

To use the Brunswick as a typical synthesizer “voice”, external 1V-per-octave pitch CV and envelope gate sources can be connected. The pitch CV should be connected to the 1V/Oct In jack, and the gate source should be connected to the Envelope Gate jack. The VCA Bias should then be turned down to the point where audio no longer passes through, as long as the Gate isn’t active. The VCA AM 2 control can then be increased until the envelope fully opens the VCA when the Gate becomes active.

As a synth voice

With other Brunswicks

If you are lucky enough to have more than one Brunswick then there are a few things interesting things could do with the modulation sources. With independent copies of all of Brunswick's features you could for instance modulate different parameters of one VCO at different rates, or modulate the VCF in a different way to the VCO or VCA.

If you have a suitably equipped CV controller, you could emulate the structure of instruments like the Oberheim Four Voice. In this configuration you could have each Brunswick producing different sound, with the additional possibility to cross-patch various control signals and audio between the voices.

With Eurorack and other systems

Brunswick is patchable, and so it goes without saying that it can control or be controlled by any instrument that also has the ability to receive or supply control voltages or audio. One of the ideas behind making Brunswick patchable was for it to provide the basic elements of a voice very inexpensively, to compliment under-construction eurorack systems that might not yet have all the elements required to make a synth voice.

As an audio processor

The VCF and VCA of Bunswick can be used independently for audio processing, the VCA allowing for amplitude modulation and the VCF allowing for filtering and distortion.

Modulation and distortion with the VCA

Brunswick's VCA can be used for amplitude modulation, when fed an external control signal. This control signal could be one of the oscillators in Brunswick, or an external modulation source such as an oscillator or simply some audio. The control signal to the VCA is protected from DC by the decoupling capacitor C16, which reduces its sensitivity to low frequencies. If you want to experiment with the VCA you could bypass C16 to improve its response to LF, probably sacrificing stability.

As mentioned in the section about the VCA, it is an incredibly rudimentary design and so will introduce unpredictable, level dependent distortion. The signal is most distorted near the point where the JFET switches off, so feeding it lower level signals and adding gain afterwards will give you more of this effect.

Filtering and distortion with the VCF

When the VCF is set to high resonances it will introduce large amounts of distortion to the signal. When applied to external audio signals this can be produce interesting effects.

When in a self-resonating state, the tone generated can be modulated with an external source to create a new frequency modulated sound, which can be tuned to interact with the processed signal in an interesting way.