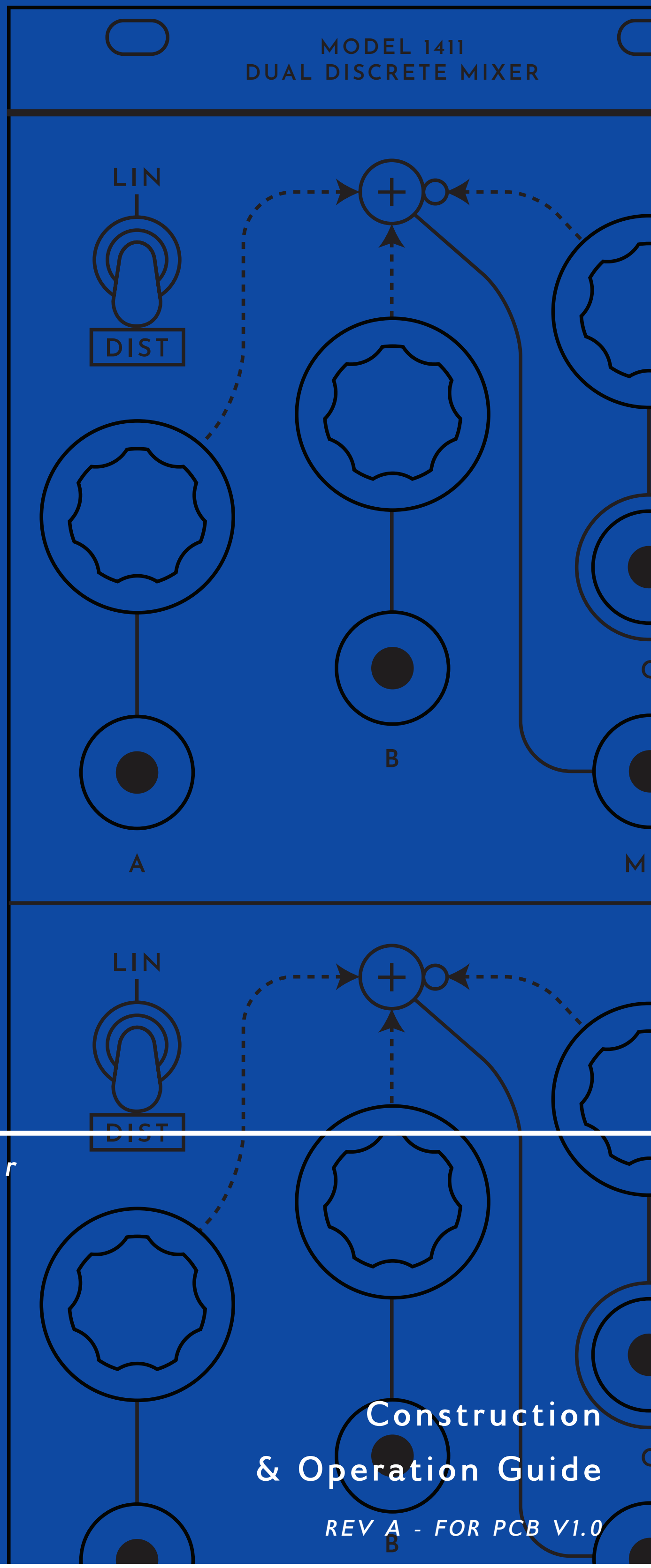
MODEL 1411

Dual Discrete Mixer

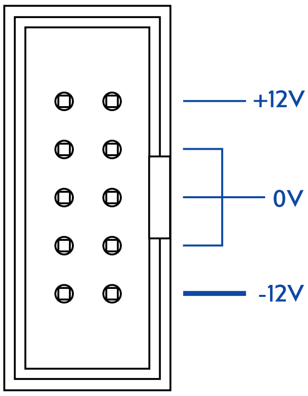


Construction & Operation Guide

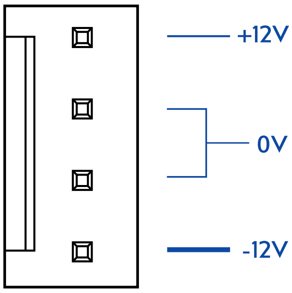
REV A - FOR PCB V1.0

SLIGHTLY NASTY ELECTRONICS   ADELAIDE, AUSTRALIA

SPECIFICATIONS



IDC power connector pinout.



MTA-156 power connector pinout.

PHYSICAL

FORM FACTOR:	Loudest Warning / 4U
WIDTH:	3NMW / 75.5mm
HEIGHT:	175mm
DEPTH:	~25mm from panel front inc. components
PCB:	70 x 75mm, Double Sided
CONNECTORS:	4mm Banana

ELECTRICAL

POWER:	+12V, 0V, -12V
CONSUMPTION:	~20mA +12V Rail, ~10mA -12V Rail
CONNECTOR:	IDC 10-pin Shrouded Header, Eurorack Standard **or** MTA-156 4-Pin Header
I/O IMPEDANCES:	100K input, 1K output (nominal)

INPUT RANGES (nominal)

SIGNALS:	+/- 5V

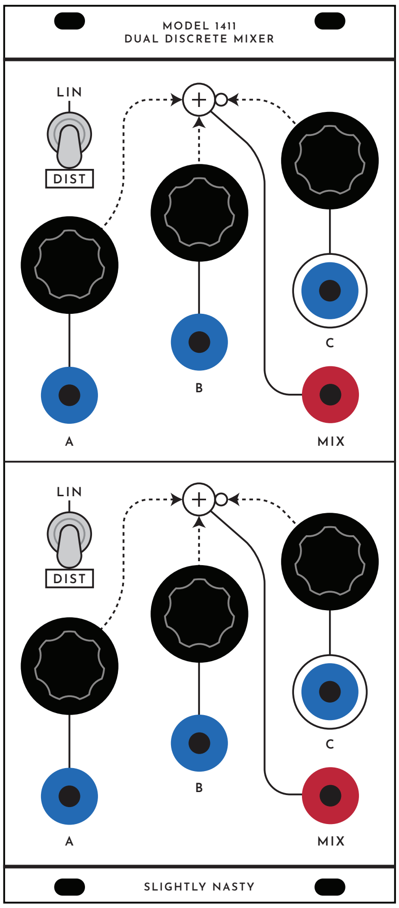
OUTPUT RANGES (nominal)

OUTPUT (ALL):	+/- 5V

TABLE OF CONTENTS

This document is best viewed in dual-page mode.

INTRODUCTION



The **Slightly Nasty Model 1411 Dual Discrete Mixer** is a basic mixer module that provides two independent 3:1 mixers, with switchable soft-clipping overdrive distortion and both inverting and non-inverting inputs.

The circuitry in each half of the 1411 is based around a pair of discrete opamp-type circuits that operate as summing amplifiers - providing signal isolation between the inputs. Additionally, when in "Linear" mode, input C is inverted, allowing for more CV mixing and phase cancellation options.

Inputs A and B can also be fine-trimmed to have better unity gain when turned up to maximum - which is useful when mixing pitch CVs that require accurate scaling.

The "Distortion" mode engages a soft-clipping diode circuit with an asymmetric high-frequency response, to emulate the sort of distortions found in some early synthesiser mixers. This is useful for adding just a touch of saturation and overdrive to sounds like bass percussion that might otherwise struggle to be heard in a mix, as well as providing a nice aggression to detuned oscillators.

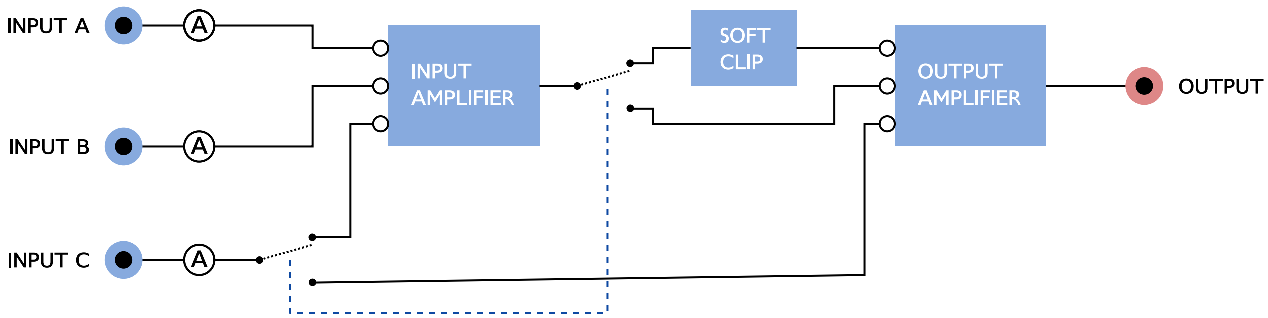
Because the Model 1411 is a true summing mixer (inputs are added together rather than averaged), the distortion may be overdriven further by bridging the inputs together, thus amplifying the input signal by a factor of three. Additionally, feeding the output back to one of the inputs creates a more aggressive distortion, going into self-oscillating feedback at higher levels. Experimenting with different modules in the feedback path opens up a whole world of interesting distortion timbres and feedback effects.

CIRCUIT OVERVIEW

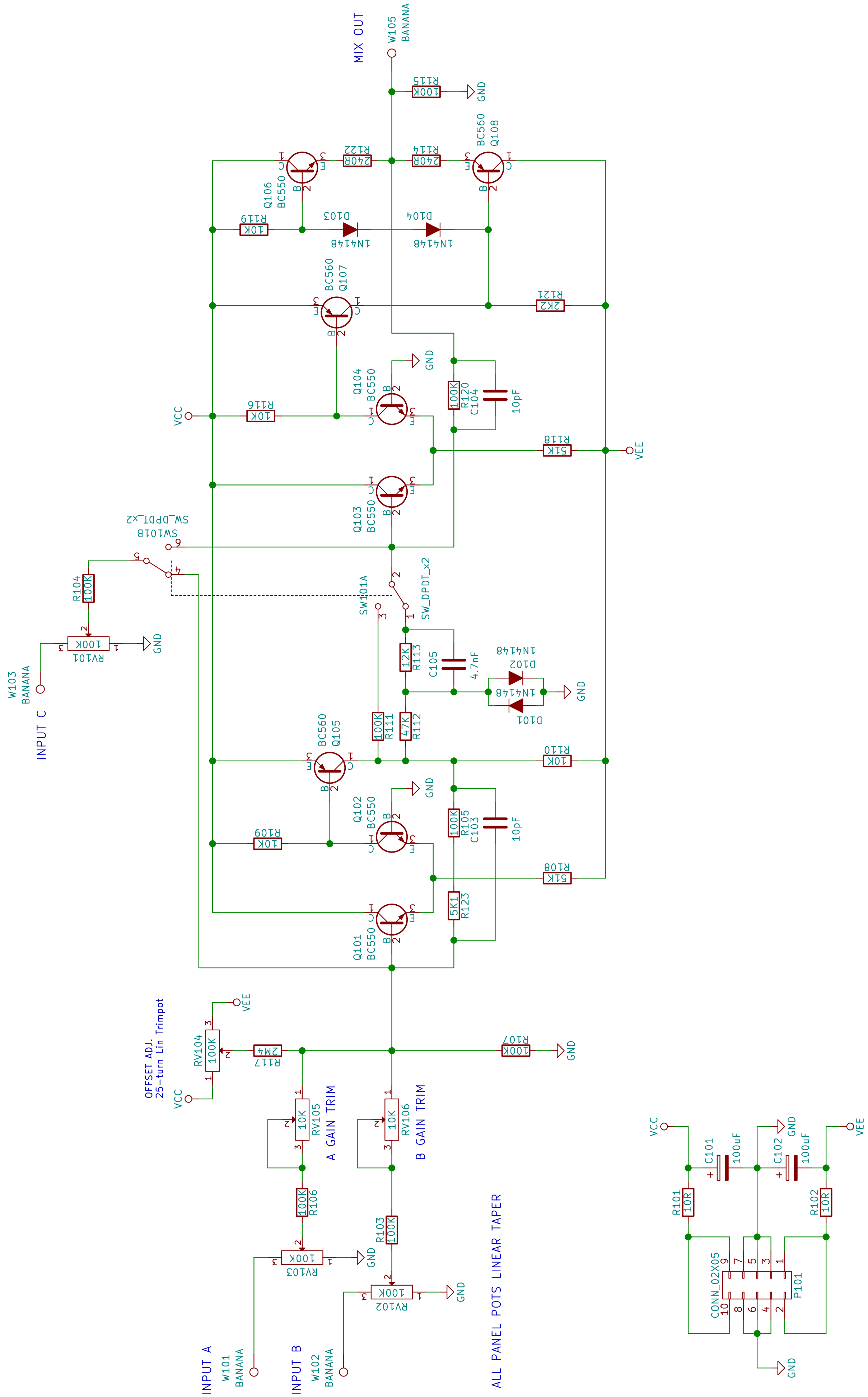
For full schematics, please download the separate schematics PDF. Excerpts shown in this manual may be outdated and are provided for reference only.

Unsurprisingly for a mixer, the 1411 is an incredibly simple module consisting of essentially three small elements:

1. **Input amplifier** - In "Linear" mode this sums together inputs A and B, while in "Distortion" mode it sums all three inputs.
2. **Soft Clipping Stage** - This is inserted between the input and output amplifiers when in "Distortion" mode, and provides a soft-clipping non-linearity to the signal, with some asymmetry to the high-frequency response.
3. **Output Amplifier** - This operates similarly to the input amplifier, but with an addititional output stage to handle more substantial output currents. In "Linear" mode this sums the output of the input amplifier together with input C, while in "Distortion" mode it buffers the output of the soft-clipping stage.



Block diagram of the Model 1411. Circles marked "A" are attenuators.



Circuit Overview

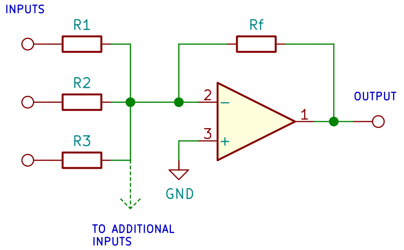
INPUT AMPLIFIER

The 1411's input amplifier is a classic three-transistor opamp circuit consisting of a differential pair (Q101 and Q102) that control an output transistor (Q105). The best way to understand the operation of the differential pair is to consider the fact that they both share a common emitter resistor (R108) - if one transistor has a higher voltage at the base, it will conduct more current through this resistor, raising the voltage across it and consequently *reducing* the base-emitter voltage on the other transistor,

As Q102 passes current, it increases the voltage across R109, pulling the base of Q105 down and turning it on. Because Q105 has no resistor on its emitter to provide negative feedback, it provides a massive gain boost to the signal, essentially switching on hard any time a minor current flows through R109/Q102. What controls this large gain and makes the output voltage across R110 a meaningful value is the negative feedback path flowing through R105/R123.

As an opamp, the overall circuit around these three transistors can be understood as a basic inverting summing amplifier as illustrated on the right. This topology provides isolation between the three inputs by feeding them all into a "virtual ground" - a common summing node that the opamp automatically adjusts to be equal to 0v regardless of the currents entering through the input resistors. Because of this, even though the inputs are all tied to a single point, there is no way for an individual input signal to bleed into any other as occurs in purely passive mixing circuits.

Because input C is provided as an inverting input, it bypasses the input amplifier in LINEAR mode so that it only gœs through a single inverting amplifier stage. In DISTORTION mode it is rerouted to the front of the input amplifier and becomes a normal non-inverting input.

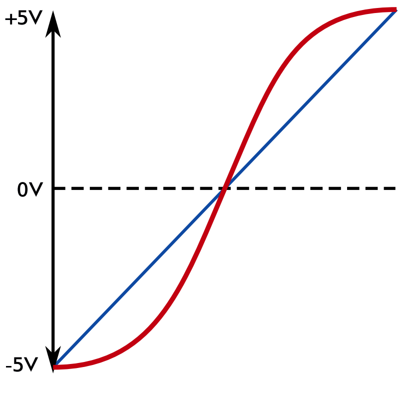


Typical topology of a summing amplifier. The negative feedback through Rf cancels any voltage shift at the opamp's inverting "-" input and thus holds it at the same voltage as the non-inverting "+" input. This means that each input signal sees only a resistor connected to 0v, even though multiple input signals are connected to the same circuit node.

One way to think of this is that the signals are each converted into a current by the input resistors, and the opamp adjusts the current through Rf to make it equal to the sum of all the input currents. As the same current is flowing both into and out of the node connected to the opamp's inverting input, the voltage at that point cannot change.

SOFT-CLIPPING STAGE

The soft-clipping stage is a very simple diode-clipper that takes advantage of the virtual ground node of the output amplifier to avoid needing to explicitly scale the signal down and then back up again as is normally required in clipping circuits. The best way to understand how this works is to imagine that R112 and R113 are a single normal input resistor feeding an inverting summing amplifier - we know that at one end will be the input signal, and at the other end will be the 0V virtual ground - therefore we know that across the length of the resistor there should be a signal that steadily descreases in amplitude from unity down to nothing. If we want to gently clip the signal, we need only to "tap off" the resistor at the point



Voltage response of the soft clip stage with the input in blue and the output in red.

where the amplitude is relatively close to the usual diode drop voltage of ~0.7V. This is done by splitting the one resistor into two, and ensuring their combined resistance is lower than the summing amp's feedback resistor in order to supply makeup gain at the output.

the capacitor C105 provides a bypass route for high-frequency signals, and in practice has the effect of providing a degree of asymmetry to the clipping of treble content - creating "spikes" on one side of transient content that roughly emulates the behaviour of certain early synth mixer stages when overdriven. If desired, this capacitor can be left off for a slightly cleaner overdrive.

OUTPUT AMPLIFIER

The output amplifier operates in essentially exactly the same way as the input amplifier, but with an additional output stage that can handle the larger and more variable current draw expected from an output jack. This consists of Q106 and Q108, which are biased by the diodes D103 and D104 to operate as a class-AB output stage. The emitter resistors R114 and R122 limit the maximum output current to deal with occasional short circuits etc. that are expected when making patches in a modular system.

(Quantities listed are for **one** PCB)

RESISTORS		
10R	2	R101, R102
240R	2	R114, R122
2K2	1	R121
5k1	1	R123
10K	4	R109, R110, R116, R119
12K	1	R113
47K	1	R112
51K	2	R108, R118
100K	8	R103, R104, R105, R106, R107, R111, R115, R120
2M4	1	R117

CAPACITORS		
10pF	2	C103, C104
4.7nF	1	C105
100uF **electrolytic**	2	C101, C102

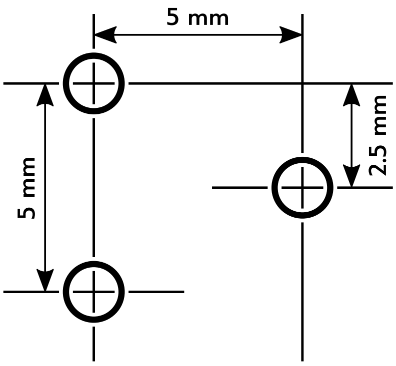
POTENTIOMETERS		
100K **linear**	3	RV101, RV102, RV103
100K **trim**	1	RV104
10K **trim**	2	RV105, RV106

ELECTROMECHANICAL		
DPDT	1	SW101

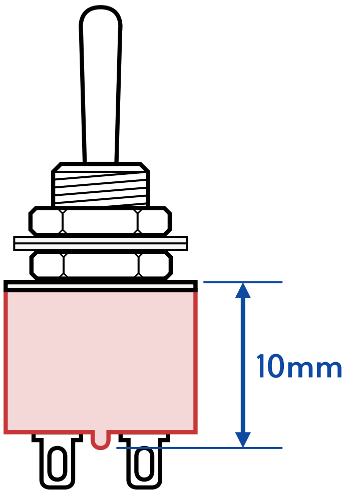
SEMICONDUCTORS		
1N4148	4	D101, D102, D103, D104
BC550 / BC547	5	Q101, Q102, Q103, Q104, Q106
BC560 / BC557	3	Q105, Q107, Q108

CONNECTORS		
IDC 10-pin Header	1	P101
Banana Socket	4	W101, W102, W103, W105

CHOOSING COMPONENTS



The mini trimpots should match the footprint shown here.



The height of the switch body before installation must be 10mm from the top of the body to the bottom of the moulded ridge that runs between the pins. On some switches this ridge may need to be filed down slightly with the edge of a flat needle file or similar.

Like all Slightly Nasty modules, the 1411 is designed to use common "jellybean" components wherever possible, so getting hold of parts is relatively straightforward. All resistors should be metal film 1% type, and capacitors are normal electrolytic and film types.

The DPDT On-On switch should be available at most decent suppliers, the main thing to note is that the top of the switch body (the part that sits against the front panel, needs to be 10mm from the top of the PCB when the switch is soldered into place. On some switches (such as those sold at **Tayda**) this will mean using a small file to file down the plastic ridge that runs between the solder terminals.

The trimmers for the gain and offset trimming are standard top-adjust mini trimpots (sometimes referred to as 6mm trimpots), which use the footprint shown on the left.

The front panel PCB fits Alpha brand 9mm vertical-mount round shaft potentiometers, these are widely available from stores such as Thonk, Tayda, Smallbear, Mouser etc. The module should fit a number of different banana jack sockets, but the "correct" parts are the Cinch Connectivity range of jacks.

The intended knobs are Davies Molding parts - the 1913BW, 1910CS, and 1900H - though given the outrageous pricing of the actual Davies 1900H I'd strongly recommend using a good quality clone. Avoid the cheaper clones without an internal brass bushing - **Thonk** sells an excellent brass-bushed 1900H clone for a very reasonable price that I use in all of my own builds.

Alternatively, feel free to use any knobs that have similar diameters and will fit the Alpha round shaft pots. The Davies parts are 29mm, 19mm, and 13mm respectively, and many other manufacturers make knobs of similar sizes. The classic silver top Moog-style knobs actually work quite well also for the larger diameters.

CONSTRUCTION

The majority of construction can be performed like any PCB build, starting with the lowest-profile components (resistors and diodes) and working through to the taller ones (Capacitors, transistors, etc.). The simplest way to populate the board is simply to work through the BOM, doing each component type and value in one chunk before moving on to the next.

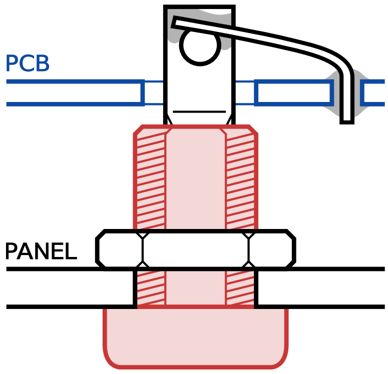
When soldering rectangular capacitors, I like to solder one leg on each, then hold the board in one hand while applying a *very* light pressure on top of the capacitor with a free finger, using the other hand to reheat the solder joint until the capacitor slides down tight against the PCB's surface. Continue this process for all the installed capacitors then go back and solder the remaining legs. This approach also works well to mount other components that need to mount securely onto the board, such as trimpots, IC sockets and pin headers.

When soldering transistors, my preferred approach is to populate the board with all the transistors of the same type, then solder only the centre leg of each one. The board can then be flipped over and all the transistors straightened up using tweezers before soldering the remaining legs. Generally I prefer to only solder one leg at a time on each transistor to avoid overheating the part, so that they have time to cool down between soldering operations.

Care must also be taken to ensure that the PCB-mounted potentiometers are mounted as vertically as possible on the board - one option is to click the potentiometers into place, then mount them to the front panel before soldering them. Also note that most potentiometers have a small anti-rotation tab on them that will need to be removed before soldering them into position, these can be cut off with a sharp pair of sidecutters, and I personally like to clean up any remaining protrusions with a few passes of a needle file as well.

The DPDT mode switch in the 1411 is probably the component that requires the most attention during construction . As mentioned in the "Component Selection" guide on the previous page, the switch itself must first be checked for correct height when mounted to the board. Soldering the switch into place should always be done with the face panel temporarily attached in order to ensure it is vertical, which means it should be left until after the potentiometers have been soldered in.

PHYSICAL ASSEMBLY



Connecting the banana sockets using an offcut component lead or similar.

Assembling the finished PCBs and front panel is very simple. Begin by fitting the banana sockets into their respective holes on the front panel - making sure to align the flat terminals vertically (if using the Cinch-style sockets). The banana sockets need to be tightened solidly to prevent them coming loose in use, something like a dab of hot glue between the nut and thread can also help prevent loosening.

Make sure that the nuts and washers have all been removed from the potentiometers on the PCB, as well as the anti-rotation tabs on the pots themselves (if present). Now you can join the front panel and PCB by pushing the pot shafts through their respective holes, fitting their washers and nuts, and tightening everything into place.

Now you'll need to connect the banana sockets to the PCB using either some offcut component leads, or tinned copper wire. The simplest way is to solder the straight pieces of wire vertically into the pad on the PCB, then bend them over to meet the banana socket and solder that end to the flat side of the terminal. This way they can be easily disconnected for servicing by simply heating the terminal with the iron and pushing the wire away once the solder melts.

CALIBRATION

BEFORE YOU BEGIN

Before powering up the module for the first time, use a multimeter to check the resistances between the three power rails. Make sure that they show a resistance higher than 1KOhm, any lower and it's possible there is a short circuit or incorrectly oriented semiconductor somewhere on the PCB.

Calibration of the 1411 is very simple, and consists of nulling out any small voltage offset that shows up on the output jack. then setting the correct gain for the A and B inputs at full scale. Remember to set the mode switch to "LINEAR" before carrying out these operations.

The discrete amplifier stages in the 1411 will generally show a small output voltage offset that will need to be nulled out, this is simply accomplished by setting all the input mix knobs to zero and measuring the voltage between a 0v point (the screw mounting holes are a good 0v reference point to use) and the output jack, then adjusting the "OFFSET TRIM" trimmer until you get as close to 0v as possible.

The gain adjustment for the A and B inputs is intended to allow them to be used as pitch CV inputs in instances where you might want to add pitch modulation (vibrato from an LFO for example). In this situation you want the input-to-output gain of that particular signal to be as close to 1:1 as possible, as any scaling of the signal will result in the loss of the correct 1V/Oct pitch tracking. This requires manual trimming owing to both the small value variations inherent in the resistors of the amplifier stages, as well as the considerable variations in resistance found in different potentiometers.

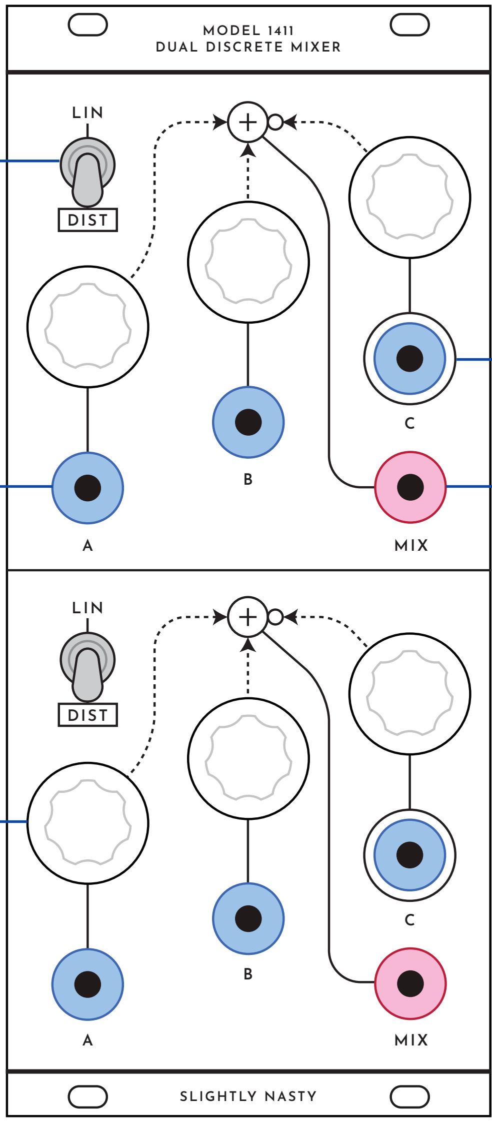
To set these trimmers, apply a stable voltage of around 5v to the A input (exact voltage is not important, anywhere between 4-6v will be fine), and then turn the A mix knob until it is at its maximum setting. Measure the voltage between the A input jack and the output jack, and adjust the "A GAIN TRIM" trimmer until you get a reading as close to 0v as possible. Set the mix knob back to zero, and then repeat the whole process for the B input.

CONTROLS

MODE SWITCH
Selects between LINEAR and DISTORTION modes of operation.

INPUTS
A and B are non-inverting inputs in both modes.

INPUT ATTENUATORS
Control how much of the input signal is sent to the output.



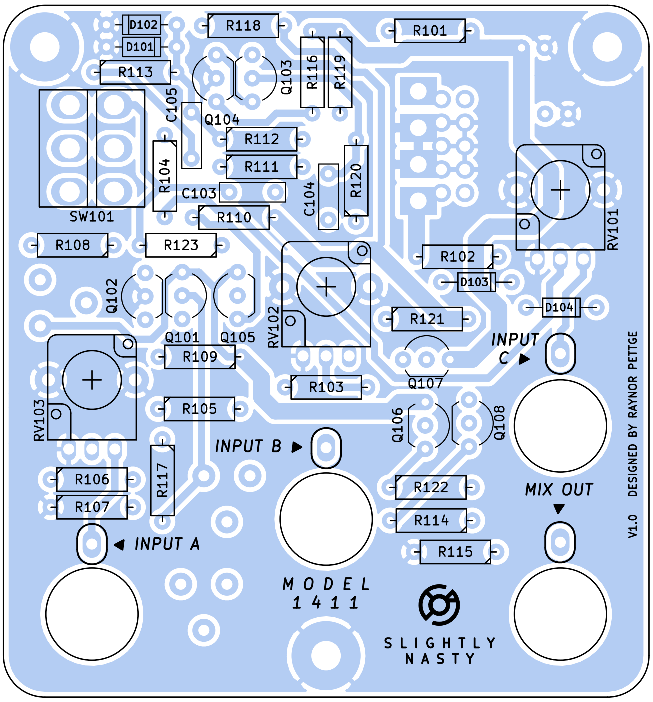
INPUT C
Inverted input when in LINEAR mode.

OUTPUT
Outputs the combined input signals.

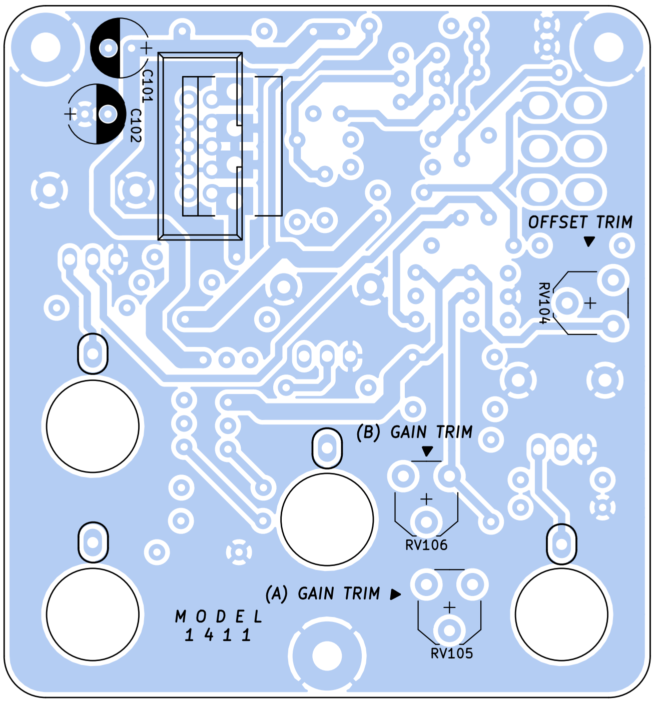
SLIGHTLY NASTY JACK COLOURS

RED	Bipolar signal output
BLUE	Bipolar signal input
YELLOW	AC-coupled input
BLACK	Logic output
WHITE	Logic Input

PCB GUIDE



LOWER BOARD - TOP



LOWER BOARD - BOTTOM

www.slightlynasty.com