Electric Druid Flangelicious Flanger Project

(Using either 4KNOBFLANGE or MULTIFLANGE chips)

Overview

Serving Suggestion

The Flangelicious flanger project comes in two flavours, depending on which FLANGE chip you fit - either the 4 KNOB FLANGE or the MULTIFLANGE. Additional tonal variation is possible by building the pedal with either a 256-stage or a 1024-stage BBD. All four options use the same PCB and components.

The 4 KNOB FLANGE is a fairly standard four knob flanger, as the name suggests. It offers Manual (Flanger frequency), Depth, Rate, and Resonance (Feedback) controls. You can get a wide range of classic flanging sounds from this pedal, from deep slow whooshes to rippling wobbles. With the Depth at zero, you can use the Manual control to set 'static flanger' sounds.

The MULTIFLANGE is a more experimental design. It offers Rate, Depth, Waveform, and Resonance controls. In place of the the sinewave LFO of the 4 Knob Flanger, this offers 7 different waveforms and a 'static' position, where the flanger folllows the Rate knob. It can also switch between top-down or bottom-up flanging.

Build Instructions

You're advised to have a read through of these instructions before starting work on the PCB. To keep these instructions reasonably brief, it is assumed that you know how to orientate common components.

Populate the PCB

The board should be populated in order from smallest components to tallest. The BOM on page 8 is arranged in this order, so start at the top and work your way down. You can tick off each line in the "Done?" column on the far right.

If you hold the PCB with the "flangelicious" and "electric druid" logos the right way up, you'll see that the components are arranged in three rows. The top row is passive components. The centre row is for the ICs, with a few other components. The bottom row is more passive components. Underneath the bottom row are the connections for off-board components.

1N4148 Diodes

Start with the two 1N4148 diodes. These need to be the right way around and point in opposite directions, so be careful. They're on the left in the centre row.

Resistors

Next come the resistors.

- 1K resistor x 1 - bottom row, far left
- 1M resistor x 1 - top row, far left

- 10K resistor x 6 - two on the top row, four on the bottom row
- 100K resistor x 9 - six on the top row, three on the bottom row
- 47K resistor x 7 - four on the top row, three on the bottom row
- 24K resistor x 2 - one on the top row, one on the bottom row, both in the centre
- 12K resistor x 1 - bottom row, on the right
- 3K3 resistor x 1 - bottom row, on the right
- 560R resistor x 1 - bottom row, far left

Cup of tea and soldering check

When you've finished doing the resistors, stop and have a cup of tea and spend a few minutes looking over your solder joints and making sure everything's ok so far.

Power protection diode

Install the fat black 1N4002 diode in the bottom right corner of the PCB. This protects the PCB against reverse voltage, so be sure to check the orientation carefully.

IC sockets

All four 8-pin DIP sockets are arranged the same way around down the centre of the PCB. It helps to solder only a couple of corner pins first, and then give the socket a check. If it's sitting correctly and orientated the right way around, you can solder the rest of the pins. If not, it's much easier to adjust it with only two pins soldered. Removing IC sockets from plated-through-hole PCBs like this one is difficult and not recommended.

Regulator

The 78L05 +5V regulator REG1 is in the bottom right corner next to the power protection diode. Be sure to line up the flat side and the curved side with the markings on the PCB. Don't mix it up with the similar-looking transistor.

Transistor

The 2N3904 transistor TR1 is in the centre row, far left. Again, be sure to line up the flat side and the curved side with the markings on the PCB.

Ceramic bypass capacitors

There are three 100n ceramic power supply bypass capacitors, one beside the FLANGE chip, and two more one either side of the 5V regulator you just fitted. These are **not** the 100n film caps on the bottom row far left. Don't mix them up!

Film capacitors

There are quite a few of these. Take your time.

- 100n (104, 0.1u) capacitor x 2 - bottom row, far left
- 1n (102, 0.001u) capacitor x 1 - bottom row, centre left
- 150p (150) capacitor x 2 - one on the top row, one on the bottom, both centre left
- 33n (333, 0.033u) capacitor x 1 - top row, far left

- 470p (470) capacitor x 2 - one on the top row, one on the bottom, both in the centre
- 3n3 (332, 0.0033u) capacitor x 2 - one on the top row, one on the bottom, both in the centre
- 470n (474, 0.47u) capacitor x 3 - one in the centre row, far left, the other two on the top row and bottom row, both right of centre.

Electrolytic capacitors

There are only three of these, but you need to watch the polarity.

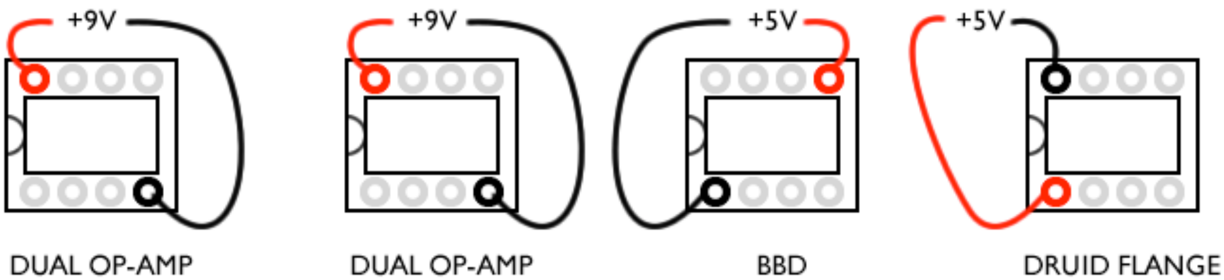
- 47u capacitor - bottom row, far right
- 47u capacitor - top row, left
- 1u capacitor - bottom row, right of centre

Preset resistors (Trimmers)

There are two trimmers, the 100K Resonance trimmer (marked "100K Res") and the 10K clock bleedthrough trimmer (marked "10K Bal"). The resonance trim is in the centre row, to the left of the op-amps. The clock balance trimmer is top-right, next to the electric druid logo.

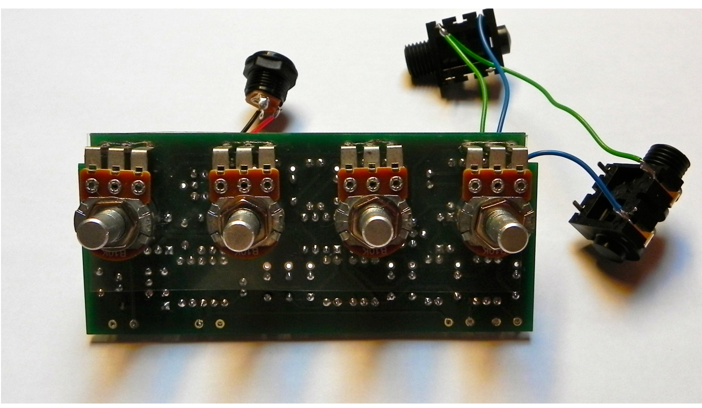
Second cup of tea and Power Test

Have a break. If you've got this far, you deserve it. Also, you need to be on top form for the next part- testing the power. At this stage, you can power the board up and check the voltages with a multimeter. There should be 9V power across pins 4 and 8 of each op-amp socket. There should be 5V power across pins 1 and pin 5 of the BBD socket and between pins 8 and 1 of the FLANGE chip socket.



Check the soldering over one last time, since after you fit the pots, it's a lot more difficult to get to some of the PCB.

Potentiometers



Note that the pots mount on the back (solder-side) of the PCB!

First, break the small anti-rotation tabs off the pots with pliers.

Something is required to prevent the pots from shorting out the back of the PCB. Many things work; all the way from expensive pot dust covers, to a couple of pieces of insulation tape stuck on the back of the pots, to a piece of cardboard stuck between the board and the pots. My current favourite solution is to cut a piece of stiff overhead transparency plastic and fit it between the PCB and the pots. If you make holes in it for the legs of the pots to pass through, they hold it in place once soldered and it can't fall out. This is cheap (steal the plastic from work), simple (get a grown-up to help you with the scissors), and effective (none have blown up yet).

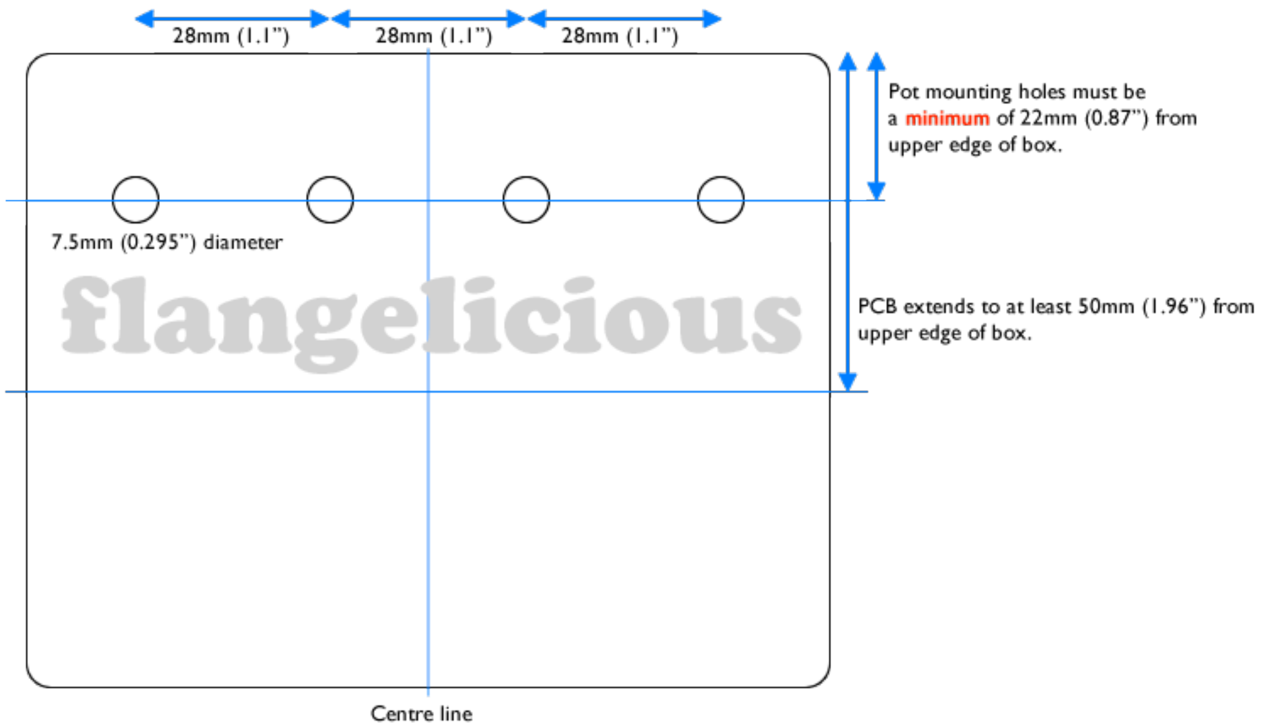
Install ICs

If the voltage check was ok, you can install the four chips; two dual op-amps, the BBD, and the Electric Druid FLANGE chip.

The PCB is done! Well done!

Drilling the enclosure

The PCB is designed to be mounted in landscape format in a Hammond 1590BB enclosure or equivalent. The board is held in place by the pots.

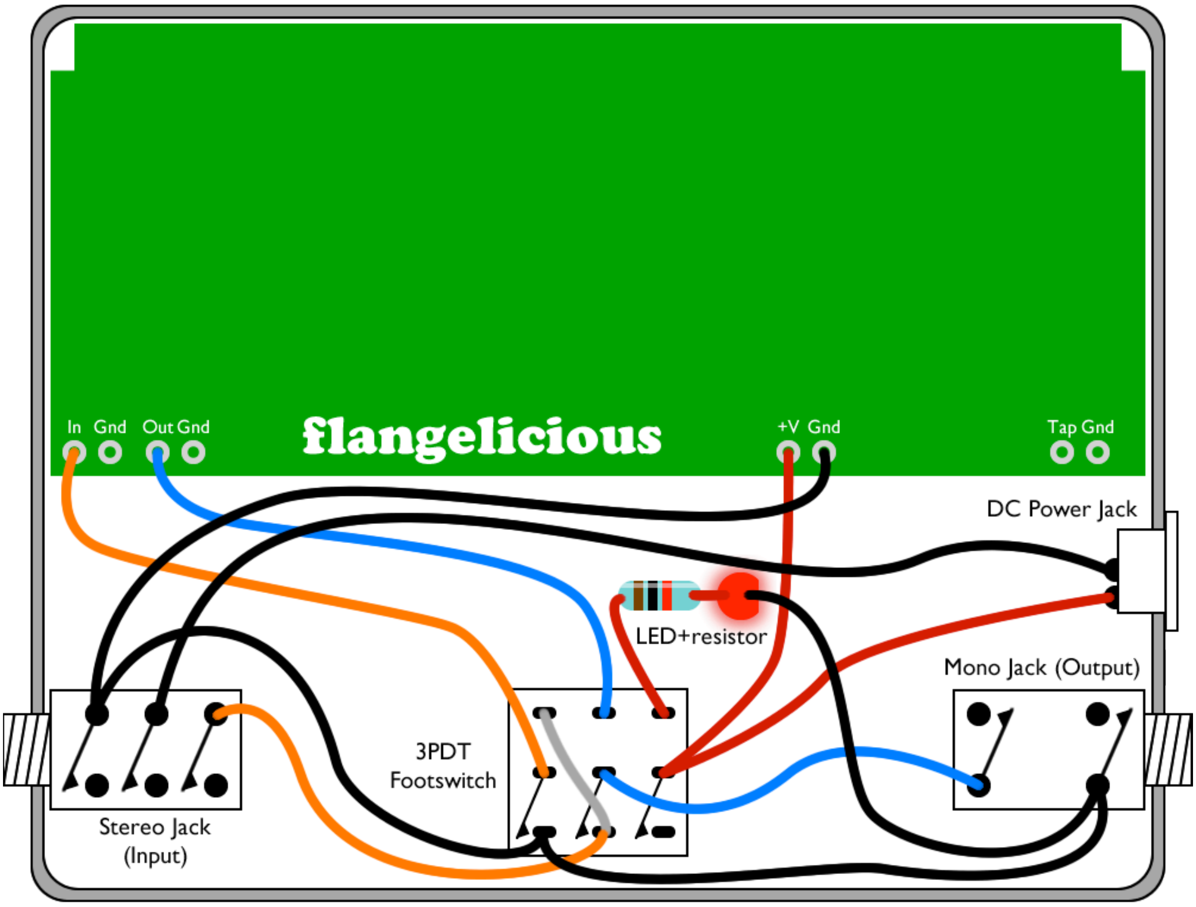


Off-board wiring

This is the same for all pedals, pretty much.

There's a power input, a stereo 1/4" jack which serves as the input and powers the pedal up when something is inserted, a mono 1/4" jack for the output, and either a DPDT stomp switch, or a 3PDT stompswitch if you want an LED to show you the on/off status of the effect.

Different requirements will need different wiring, and there are many ways to arrange things, but here's a basic 3PDT layout with indicator LED. The LED resistor will need adjusting for your particular LED.



Adjustments and final testing

Ok, it's the moment of truth. Power it up and plug it in. With a bit of care and attention, you should now have a working flangerlicious pedal! Let's get it tuned up.

There are two trimmers on the PCB that need adjusting. The first is the resonance trim ("Res"). Turn the resonance knob on the far right up to maximum. It's possible that the pedal will start to howl at you, but it's more likely that nothing much will happen. Tweak the resonance trim until the flanger starts to oscillate, and then back it off just a little. Or not, if you prefer. Up to you.

The other trimmer is the clock balance / bleedthrough trim ("Bal").

If you have an oscilloscope (or a friend who does!) you can put the 'scope probe on the test point (marked "TP1" in the centre of the board) and adjust the trim for minimum clock bleedthrough. If you don't have an oscilloscope, you can do the same with a multimeter on a AC voltage range - you should be aiming for 100mV or less.

You can also adjust the trim by ear. With no input signal (turn the guitar down to zero) turn the amp up loud until you can hear the background noise, and then adjust the trim to minimize the noise.

You're done! Congratulations and enjoy your new pedal!

PS: We appreciate any feedback, suggestions, or thoughts you have about this pedal or any other Druid project. Please get in touch through the website. Thanks!

Bill of Materials

Order	Ref	Description	Value	Quantity	Done?
1	D1, D2	Signal Diode	1N4148	2	
2	R1	1% Metal film resistor	1K	1	
3	R2	1% Metal film resistor	1M	1	
4	R3, R10, R12, R17, R28, R29	1% Metal film resistor	10K	6	
5	R4, R6, R13, R14, R15, R19, R22, R23, R26	1% Metal film resistor	100K	9	
6	R5, R7, R8, R16, R21, R24, R25	1% Metal film resistor	47K	7	
7	R9, R11	1% Metal film resistor	24K	2	
8	R18	1% Metal film resistor	12K	1	
9	R20	1% Metal film resistor	3K3	1	
10	R27	1% Metal film resistor	560R	1	
11	D3	Rectifier Diode	1N4002	1	
12	TL072, TL072, BBD, FLANGE	IC sockets	8-pin DIP	4	
13	REG1	+5V Regulator	78L05	1	
14	TR1	NPN Transistor	2N3904	1	
15	C14, C17, C19	Ceramic capacitor	100n	3	
16	C1, C2	Film capacitor	100n	2	
17	C3	Film capacitor	1n	1	
18	C4, C10	Film capacitor	150p	2	
19	C5	Film capacitor	33n	1	
20	C6, C8	Film capacitor	470p	2	
21	C7, C9	Film capacitor	3n3	2	
22	C11, C12, C15	Film capacitor	470n	3	
23	C13	Electrolytic capacitor	1u	1	
24	C16, C18	Electrolytic capacitor	47u	2	
25	PR1	Preset (Resonance Trim)	100K	1	
26	PR2	Preset (Balance Trim)	10K	1	
27	VR1, VR2, VR3, VR4	16mm Pots	10K Linear	4	
28	Unmarked	Pot dust covers or plastic			
29	IC2, IC3	Dual audio op-amp	TL072	2	
30	IC1	Bucket Brigade Delay	MN3209/07	1	
31	uP1	PIC 12F1501	FLANGE	1	

Additionally, you will need some/all of the offboard components listed on the next page.

Offboard components

Note that the BOM above doesn't include offboard components. These are a matter of taste, but the basics are listed below.

- Enclosure, PCB fits Hammond 1590BB or Eddystone 29830PSLA
- Stereo 1/4"/6.35mm Input jack
- Mono 1/4"/6.35mm Output jack
- Stomp switch, DPDT or 3PDT if you want an LED indicator
- Power Input socket, 2.1mm
- LED + LED holder + appropriate resistor
- 4 x Knobs
- Another switch for the 'Tap' option, if required (See "Adding more switches and options" on Page 10).

Because of the current drain of this pedal, we don't recommend using batteries instead of a power adaptor. Ok, *maybe*, if you've got 9V rechargeables.

Component choices and substitutions

Very few of the components in the circuit are especially critical and a unit built with non-ideal components will likely still work fine. However, in the interests of lowest noise, we recommend you use 1% metal film resistors and good quality polypropylene or polyester film capacitors. The board allows either 0.2"/5mm or 0.3"/7.5mm lead spacing for the film capacitors.

Transistor choice is not critical. Any medium gain, low noise NPN device will work. The board expects a transistor with the EBC pinout, like the 2N3904. If you only have transistors with the alternative CBE pinout like the BC547, you can fit the transistor back-to-front.

Similarly, op-amp choice is not critical. Choose any 8-pin dual audio op-amp with the standard pinout. TL072, LF353, or MC1458 will all work. Many more audiophile options are also possible!

Trimmer PCB layout Possible Trimmer footprints

The PCB is laid out with holes for various types of trimmer resistor. Any of the following layouts work fine. Multi-turn trimmers are recommended for fine adjustment.

The power protection diode suggested is 1N4002. Pretty much any diode from this series is ok. 1N4001 will work, 1N4003 or 1N4004 are fine too, although total overkill.

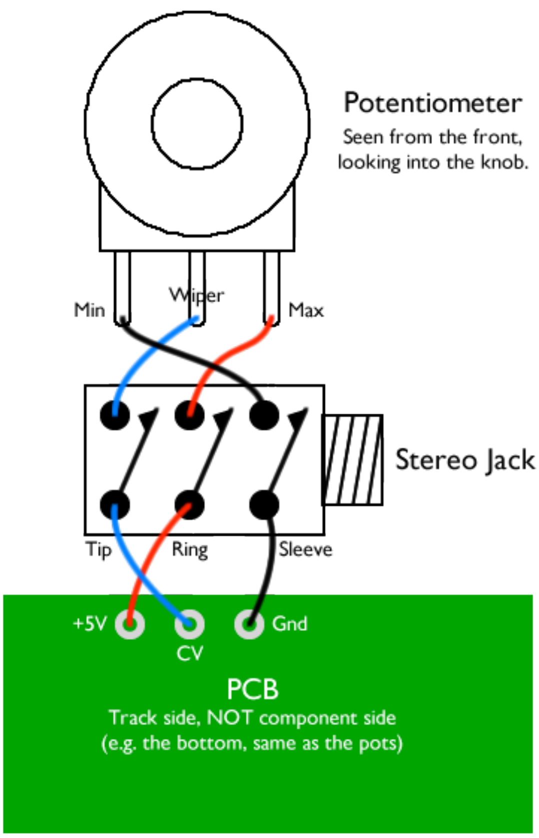
The 1N4148 signal diodes can be replaced with other small signal silicon diodes. 1N914 is a direct replacement and can be considered identical. Their role is to limit the signal to a level the BBD can handle (and to provide a soft clipping if driven too hard), so the forward voltage is the most significant parameter.

Ideas for potential upgrades or customizations

Adding CV inputs

Since the Electric Druid FLANGE chips operate using 0-5V control voltages like many other Druid chips, it is possible to add CV control of the Frequency, Depth, or Rate controls.

Adding Expression pedal inputs



It is also possible to use an expression pedal in place of the pots. If a normally-closed stereo/TRS jack socket is wired in, the front panel control can be used when an expression pedal is not inserted.

The typical expression pedal wiring is for the Sleeve to be grounded, the Ring to carry the reference voltage, and the CV return on the tip. The diagram shows how this wiring relates to the PCB, the jack, and the pot. **However, this is not the only possible wiring, and expression pedal may not be this way!**

Don't worry too much about this wiring. So long as you only use passive expression pedals, you can't hurt anything, even if it's completely wrong. If you get it back-to-front before you get it the right-way-around, no matter.

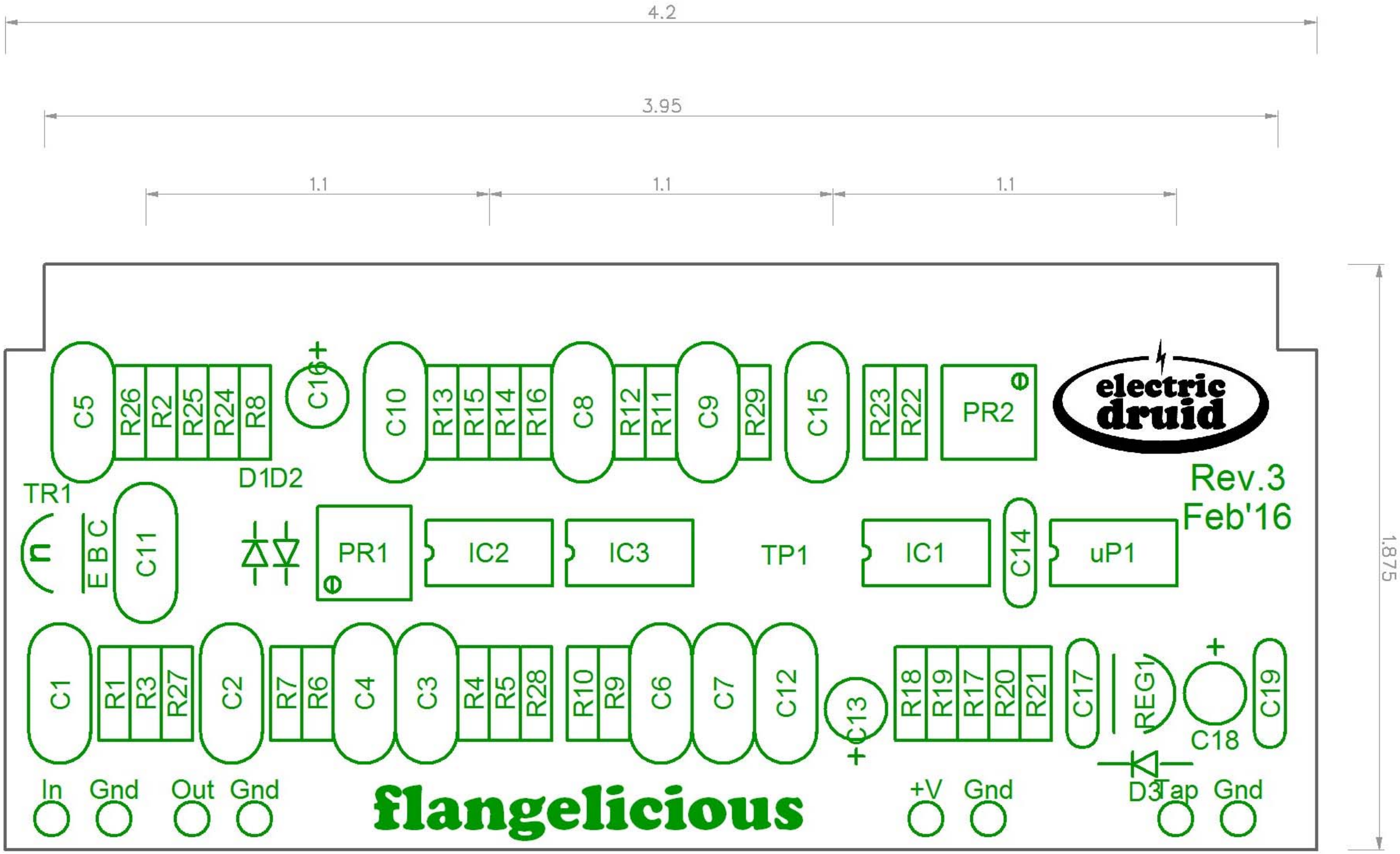
Both versions of the chip allow you to manually sweep the flanger with the farthest-left control (Manual or Rate). Connecting an expression pedal instead of this control would give you a foot-pedal wah-style flanger.

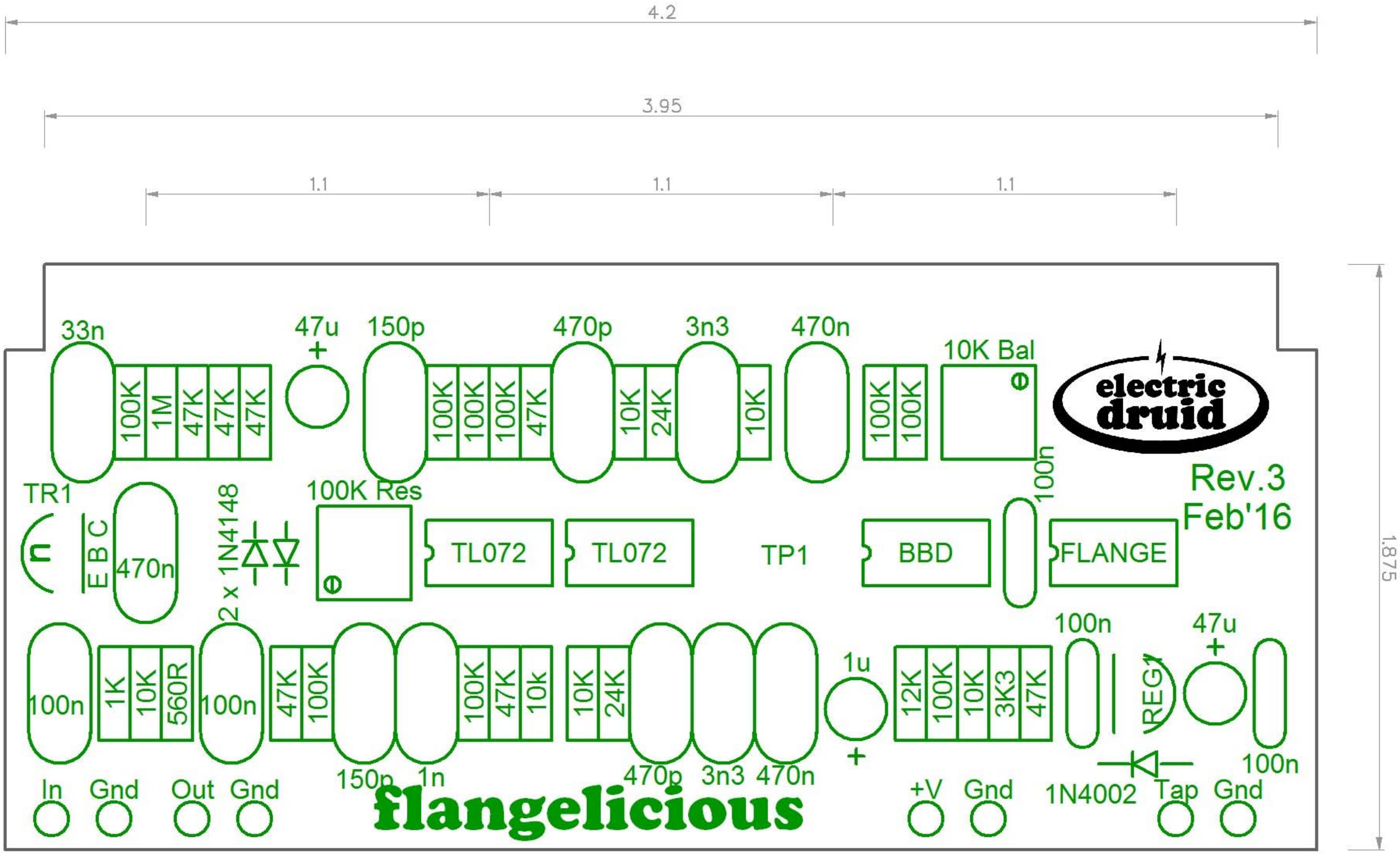
Adding more switches and options

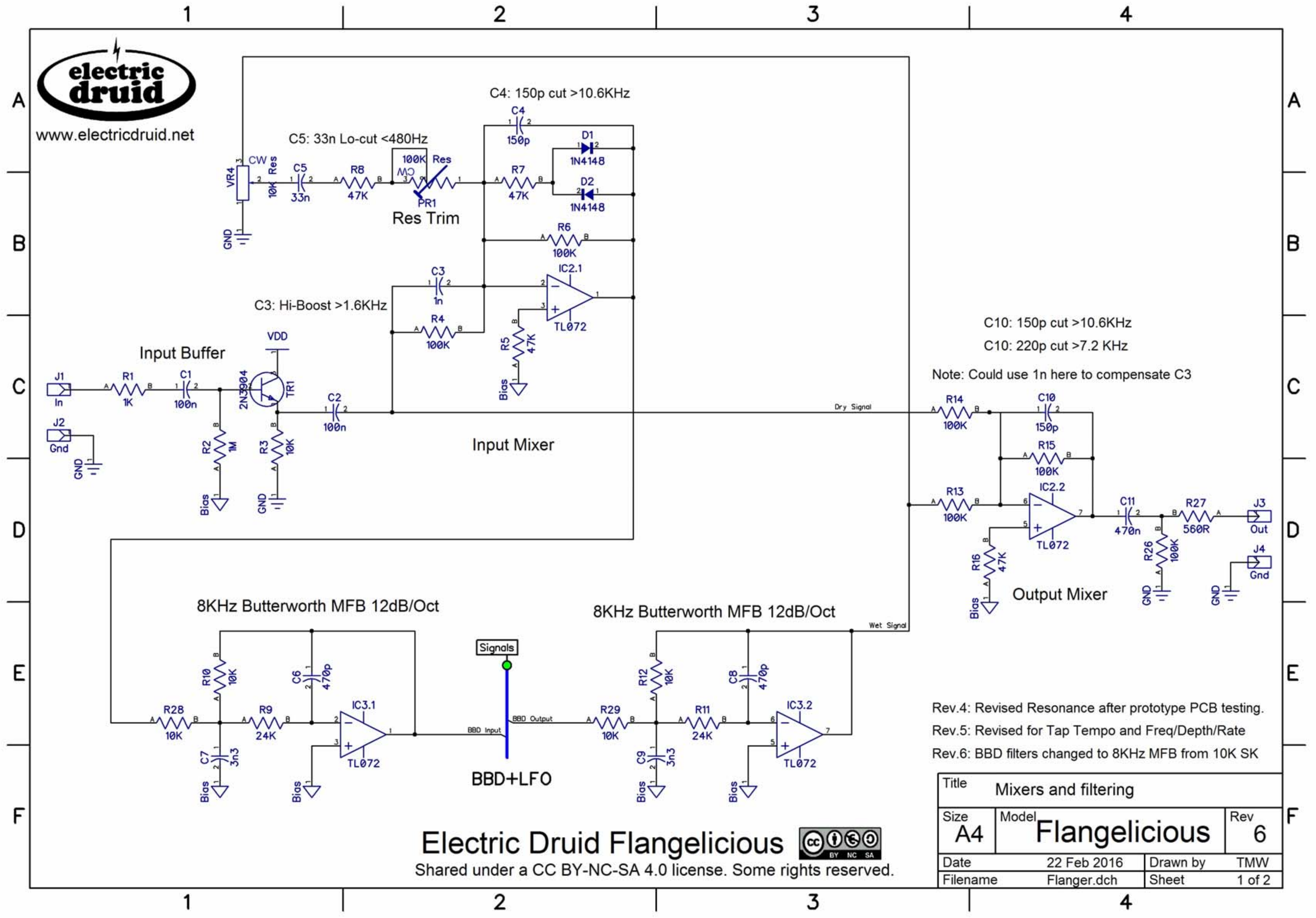
Both the MULTI FLANGE and the 4 KNOB FLANGE make use of the switch input marked "Tap" on the PCB. This input should have a switch which connects it to ground.

The MULTI FLANGE chip offers the option of top-down or bottom-up flanging. The switch could be a slide or toggle, or could be added as a footswitch. The switch should be latching.

The 4 KNOB FLANGE chip uses the "Tap" input to reset the waveform phase to zero. This allows you to keep the flanger in time, or can be used as a special effect, since you get a downsweep after you tap. This input needs a momentary switch, and might be most useful as a footswitch.


4.2
3.95
1.1
1.1
1.1
1.875
C5
R26
R2
R25
R24
R8
C16
C10
R13
R15
R14
R16
C8
R12
R11
C9
R29
C15
R23
R22
PR2
electric druid
Rev.3
Feb'16
D1D2
TR1
E B C
C11
PR1
IC2
IC3
TP1
IC1
C14
uP1
C1
R1
R3
R27
C2
R7
R6
C4
C3
R4
R5
R28
R10
R9
C6
C7
C12
C13
R18
R19
R17
R20
R21
C17
REG1
C18
C19
D3
In
Gnd
Out
Gnd
flangelicious
+V
Gnd
Tap
Gnd


4.2
3.95
1.1
1.1
1.1
1.875
33n
47u
150p
470p
3n3
470n
10K Bal
100K
1M
47K
47K
47K
100K
100K
100K
47K
10K
24K
10K
100K
100K
electric druid
Rev.3
Feb'16
TR1
E B C
470n
2 x 1N4148
100K Res
TL072
TL072
TP1
BBD
100n
FLANGE
100n
1K
10K
560R
100n
47K
100K
100K
47K
10k
10K
24K
1u
12K
100K
10K
3K3
47K
100n
REG
47u
100n
150p
1n
470p
3n3
470n
1N4002
In
Gnd
Out
Gnd
flangelicious
+V
Gnd
Tap
Gnd



electric druid
www.electricdruid.net
C5: 33n Lo-cut <480Hz
C4: 150p cut >10.6KHz
Res Trim
C3: Hi-Boost >1.6KHz
Input Buffer
Input Mixer
C10: 150p cut >10.6KHz
C10: 220p cut >7.2 KHz
Note: Could use 1n here to compensate C3
Dry Signal
Wet Signal
Output Mixer
8KHz Butterworth MFB 12dB/Oct
8KHz Butterworth MFB 12dB/Oct
Signals
BBD Input
BBD Output
BBD+LFO
VR4 10K Res CW
C5 33n
R8 47K
PR1 100K Res
C4 150p
D1 1N4148
D2 1N4148
R7 47K
R6 100K
C3 1n
R4 100K
IC2.1 TL072
R5 47K
J1 In
J2 Gnd
R1 1K
C1 100n
R2 1M
TR1 2N3904
VDD
R3 10K
C2 100n
R14 100K
C10 150p
R15 100K
R13 100K
IC2.2 TL072
R16 47K
C11 470n
R26 100K
R27 560R
J3 Out
J4 Gnd
R28 10K
R10 10K
R9 24K
C6 470p
C7 3n3
IC3.1 TL072
R29 10K
R12 10K
R11 24K
C8 470p
C9 3n3
IC3.2 TL072
GND
Bias
Rev.4: Revised Resonance after prototype PCB testing.
Rev.5: Revised for Tap Tempo and Freq/Depth/Rate
Rev.6: BBD filters changed to 8KHz MFB from 10K SK
Electric Druid Flangelicious
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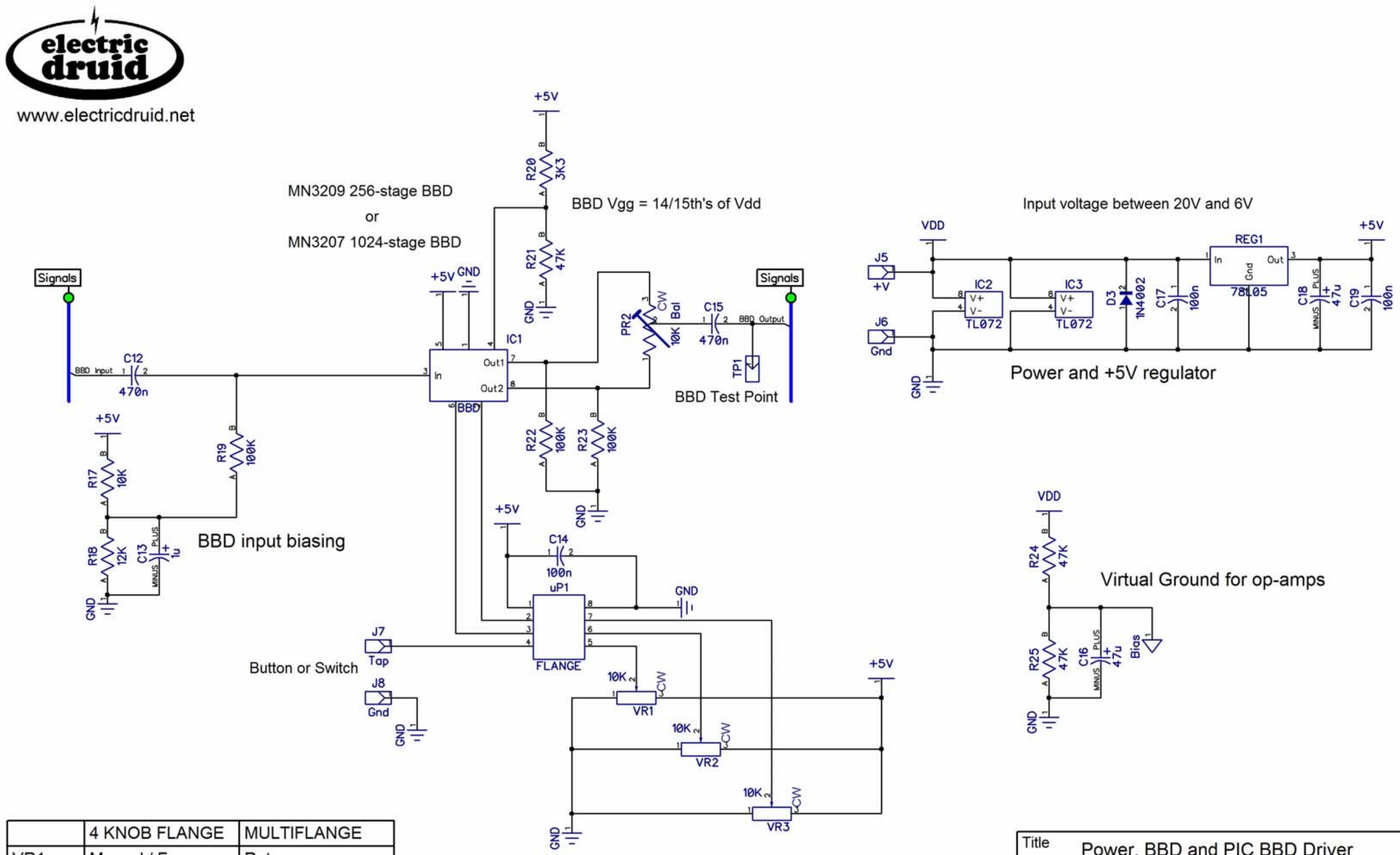
Title Mixers and filtering
Size A4
Model Flangelicious
Rev 6
Date 22 Feb 2016
Drawn by TMW
Filename Flanger.dch
Sheet 1 of 2



	4 KNOB FLANGE	MULTIFLANGE
VR1	Manual / Frequency	Rate
VR2	Depth	Depth
VR3	Rate	Waveform
Tap	Phase Reset	Up/Down

Electric Druid Flangelicious

Title	Power, BBD and PIC BBD Driver		
Size A4	Model Flangelicious		Rev 6
Date	22 Feb 2016	Drawn by	TMW
Filename	Flanger.dch	Sheet	2 of 2

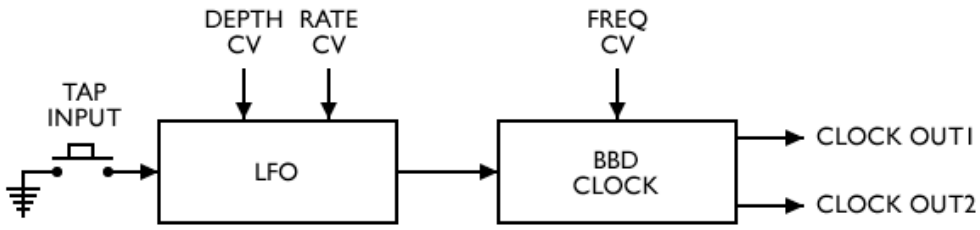
Electric Druid 4 KNOB FLANGE

Introduction

The Electric Druid 4 KNOB FLANGE flanger delay clock chip is a biphase high frequency clock suitable for driving MN32xx series bucket brigade delay lines (BBDs), combined with a wide-range LFO. All parameters are controlled by 0-5V control voltages. The chip is easy to use and helps simplify complex flanger designs.

The clock centre frequency can be adjusted with the Frequency/Manual control (FREQ CV).

The LFO has controls for the rate and depth of clock modulation (DEPTH CV and RATE CV). Additionally, the LFO can be reset to the top of the waveform using the TAP input.



Features

BBD Clock and LFO on one chip

The chip provides an LFO and a biphase BBD clock output suitable for directly driving MN32xx series bucket brigade chips on one chip. It can replace the MN3102 clock chip and the associated LFO in many modulation effects, reducing chip count and complexity.

Wide output frequency range of 20:1

The chip can produce clock frequencies from 25 to 500KHz. A wider range gives the best flanger effects.

Wide LFO range of 0.05Hz to 12Hz

The LFO provides frequencies from 0.05Hz to 12Hz. Its waveshape has been specially tweaked to provide the best sound, avoiding the abrupt changes of a triangle wave, and keeping the smoothness of a sine wave, but without the apparent "pause" at the peaks of the waveform.

Tap input to reset waveform

The chip also provides a tap input which resets the LFO to the top of the waveform so you can tap once for dramatic down-sweep effects or just to keep the LFO in time.

Fixed flanger effects

The depth of the LFO clock modulation can be turned down to zero, which allows "fixed flanger" effects (AKA "matrix filtering"). This gives a hollow, metallic sound which can be very effective on fuzzed or distorted tones.

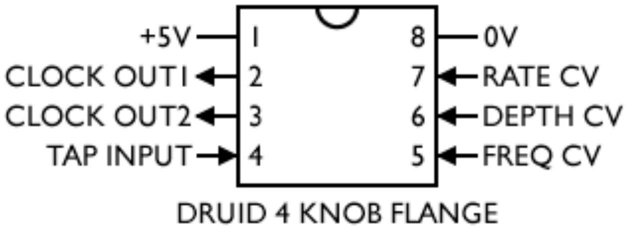
Exponential response for musical modulation

The clock modulation is exponential in character, based on octaves. This means that if you use a normal triangle wave for the LFO, you get the same smooth effect you get using a hypertriangle on a normal BBD clock. The whole point of the hypertriangle waveform is to compensate for the linear clock modulation by applying an exponential function to the triangle waveform. So if you don't use linear modulation, but rather use exponential "V/Oct" modulation, you don't need to bother with hypertriangles to get an even sweep.

The typical linear clock modulation is also the reason why chorus effects get "warbley". With linear modulation, the depth increases when the delay time gets longer. If the LFO modulates the clock by +/-25KHz around a 200KHz centre point, that's only 12% or so variation. If it does the same around a 50KHz clock (lower clock frequency equals longer delay, remember) then that +/-25KHz shifts the pitch by 50%. Keeping the modulation in the exponential world of octaves removes this problem - half an octave of mod depth is still half an octave whether it's from 50KHz or 200KHz.

The short version is our ears hear music in octaves, and musical modulation should work the same way. The 4 KNOB FLANGE chip does.

Pinout Diagram

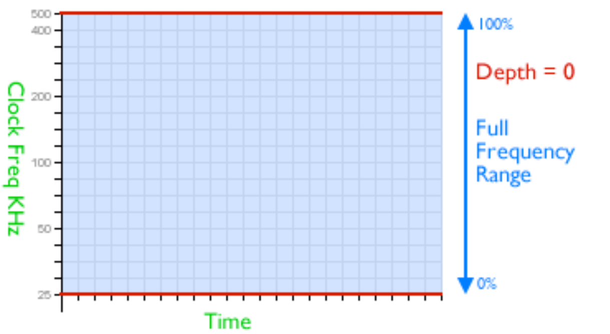


Pin	Function	Details	Notes
1	+5V	Power supply	
2	CLOCK OUT1	0-5V digital output	Biphase clock output suitable for directly driving MN3200 series BBDs
3	CLOCK OUT2	0-5V digital output	
4	TAP INPUT	0-5V digital input	Resets LFO to top of waveform Note this pin has an internal pull-up, so can be left unconnected. If used, it only requires a momentary switch to ground.
5	FREQ CV	0-5V analog input	BBD clock frequency (AKA "Manual")
6	DEPTH CV	0-5V analog input	Modulation depth (LFO->Clock) (AKA "Width")
7	RATE CV	0-5V analog input	LFO rate
8	0V	Power supply	

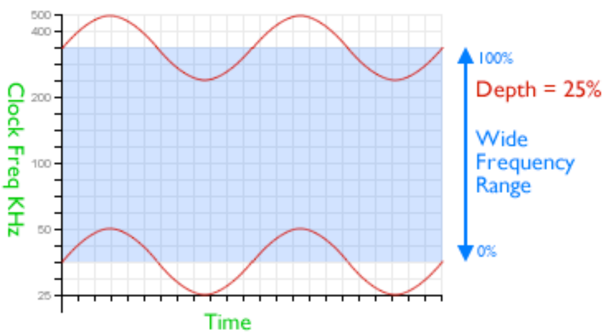
Application Notes

Interaction between "Frequency" and "Depth" controls

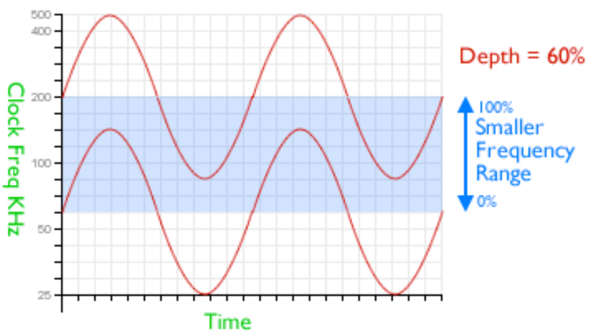
The Frequency (AKA "Manual") and Depth (AKA "Width") controls are not totally independent. The available range of Frequency adjustment depends on the position of the Depth control. As the LFO depth is increased, the available range for the Frequency control is reduced. The reason for this will become clear with a few diagrams.



At minimum depth, the LFO modulation is effectively turned off and the whole frequency range of the chip (25 to 500KHz) can be swept with the Frequency control. This gives a large range of fixed flanger sounds.

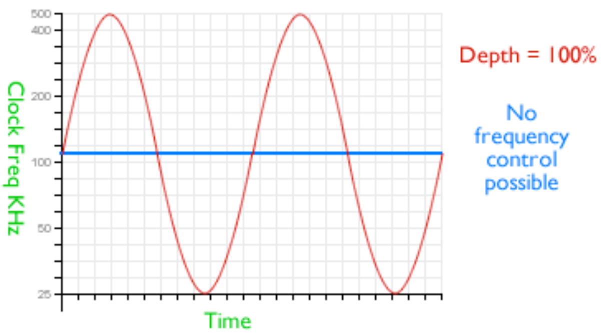


At low modulation depths, the centre position of the flanger can be swept over a wide range, allowing specific tuning of more subtle flanging sounds.



As the depth increases, the range of potential frequency adjustment decreases.

Note that the frequency control still goes from 0% to 100% - it's just that its range changes.



At maximum depth, the frequency control has no effect, since the entire range is being swept by the LFO already, and there is no room for further frequency adjustment

Delay times

The table below shows the range of delay times expected with some common lengths of BBD.

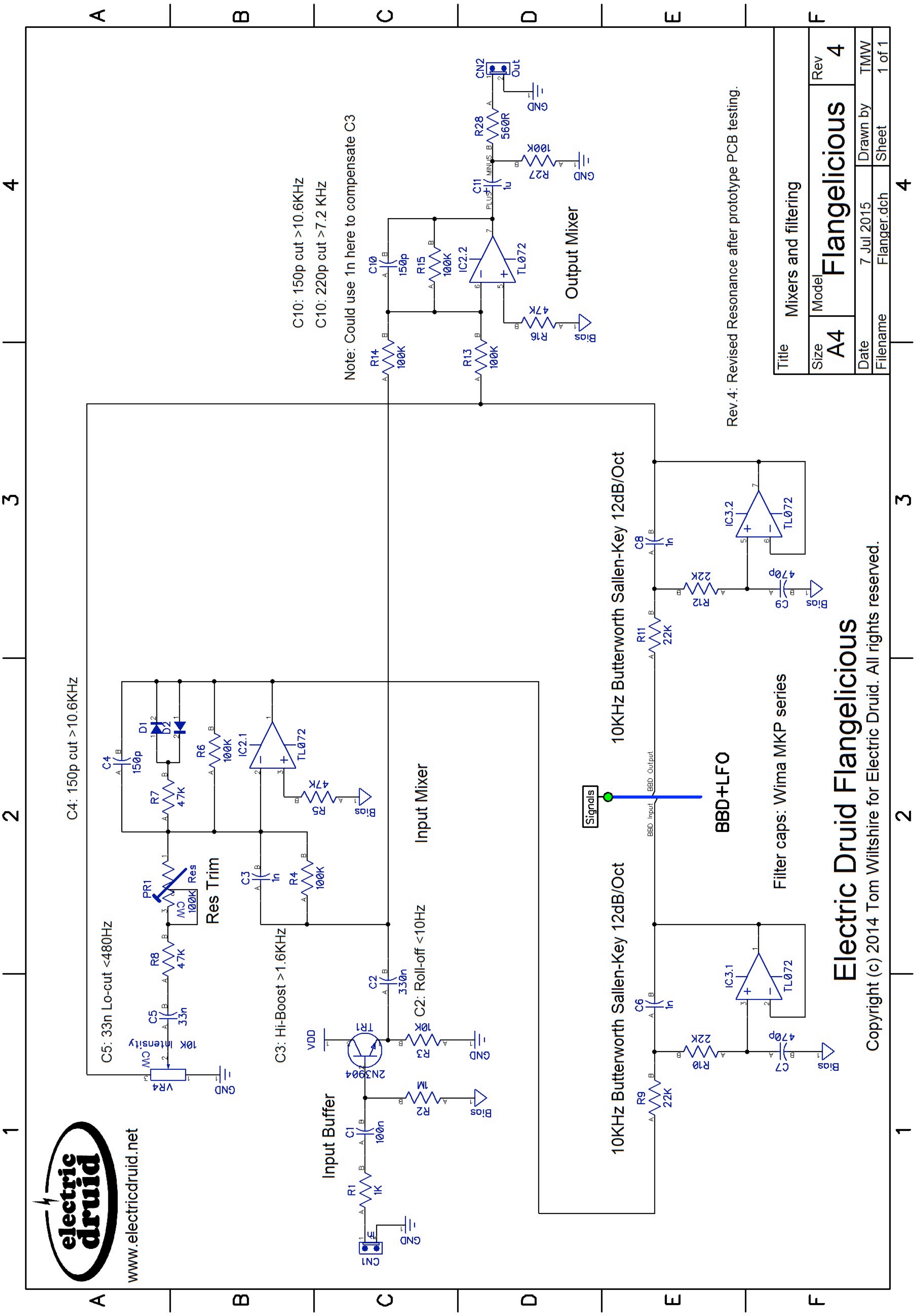
Clock Freq.	2048 stages	1024 stages	512 stages	256 stages
25 - 500KHz	40 - 2ms	20 - 1ms	10 - 0.5ms	5 - 0.25ms

Tap Input

The tap input resets the LFO to the top of its cycle when pressed. This can be used to produce a downwards sweep when required by simply tapping once.

Demonstration circuit

This demonstration circuit on the following two pages shows the features of the chip and can generate many different effects, from the lush to the loopy. PCBs for this circuit are available at http://electricdruid.net/shop


Electric Druid Flangelicious
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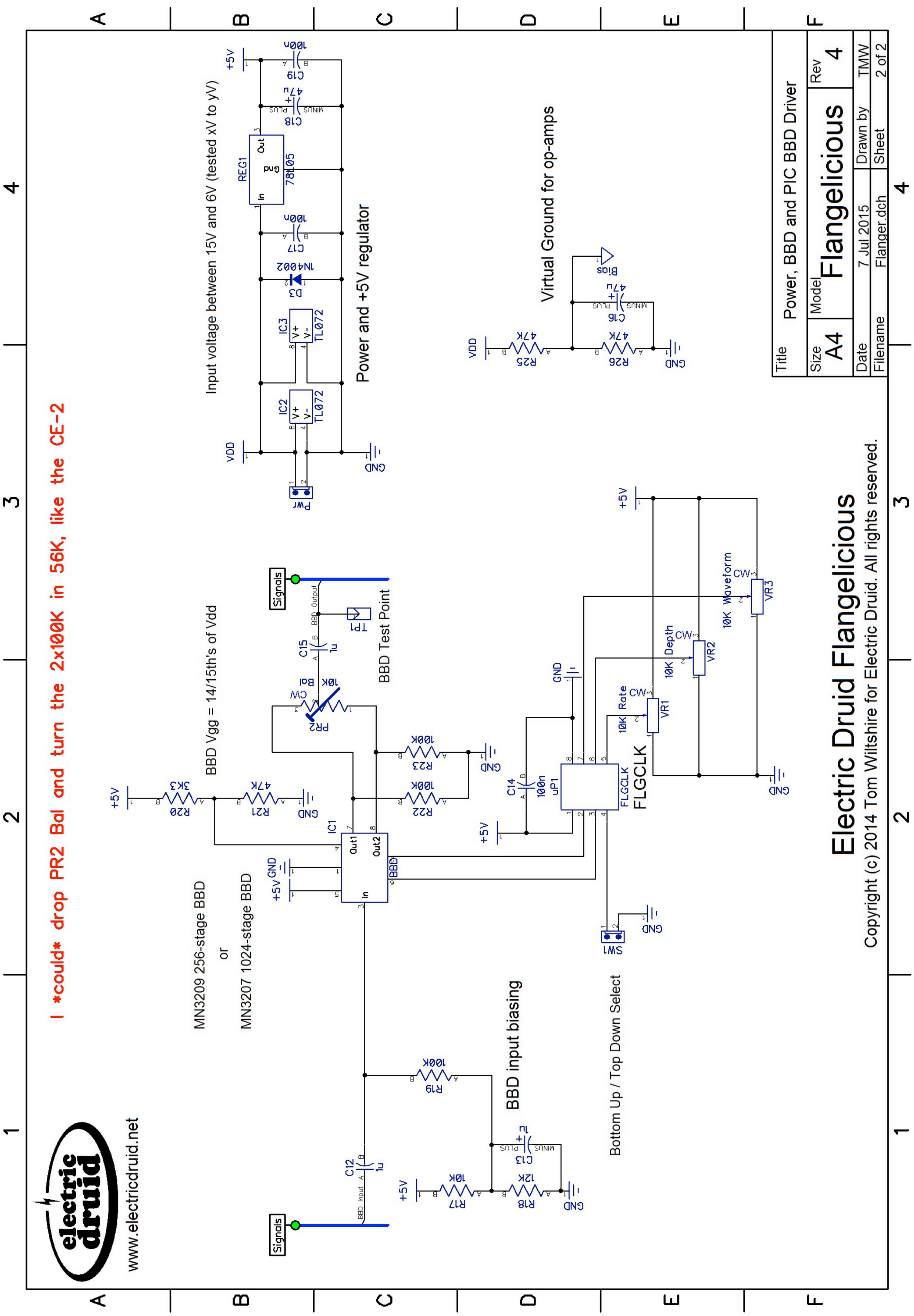
www.electricdruid.net
Input Buffer
Input Mixer
Res Trim
Output Mixer
10KHz Butterworth Sallen-Key 12dB/Oct
10KHz Butterworth Sallen-Key 12dB/Oct
BBD+LFO
Filter caps: Wima MKP series
C4: 150p cut >10.6KHz
C5: 33n Lo-cut <480Hz
C3: Hi-Boost >1.6KHz
C2: Roll-off <10Hz
C10: 150p cut >10.6KHz
C10: 220p cut >7.2 KHz
Note: Could use 1n here to compensate C3
Rev.4: Revised Resonance after prototype PCB testing.
Title
Mixers and filtering
Size
A4
Model
Flangelicious
Rev
4
Date
7 Jul 2015
Drawn by
TMW
Filename
Flanger.dch
Sheet
1 of 1


I *could* drop PR2 Bal and turn the 2x100K in 56K, like the CE-2
www.electricdruid.net
MN3209 256-stage BBD
or
MN3207 1024-stage BBD
BBD Vgg = 14/15th's of Vdd
BBD input biasing
BBD Test Point
Input voltage between 15V and 6V (tested xV to yV)
Power and +5V regulator
Virtual Ground for op-amps
Bottom Up / Top Down Select
FLGCLK
10K Rate
10K Depth
10K Waveform
Title
Power, BBD and PIC BBD Driver
Size
A4
Model
Flangelicious
Rev
4
Date
7 Jul 2015
Drawn by
TMW
Filename
Flanger.dch
Sheet
2 of 2
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