Charlatan24

FX Type: **MODULATION**
Build Level: Advanced
Based On: EHX® The Worm™

Last Updated: July 18, 2024 11:41 AM

Overview

The 2024 version of the Charlatan has no circuit changes and minor layout adjustments.

I bought a big-box Worm™ from a fellow DIY-er many years ago. I liked its unique features and being completely analog I appreciated having one pedal to cover a lot of ground. But, as I amassed my own collection of modulation designs and builds I decided to let the big boy go with thoughts of cloning it one day.

Well, that's today! The Charlatan keeps the essential features of the Worm™ and squeezes it into a 1590BB with top mounted jacks. The 24v wall wart used for power has been replaced with 9v operation and a charge pump design. A few tweaks and mods have been added, some made stock and others are optional. Please read the Notes section carefully so you fully understand what these are.

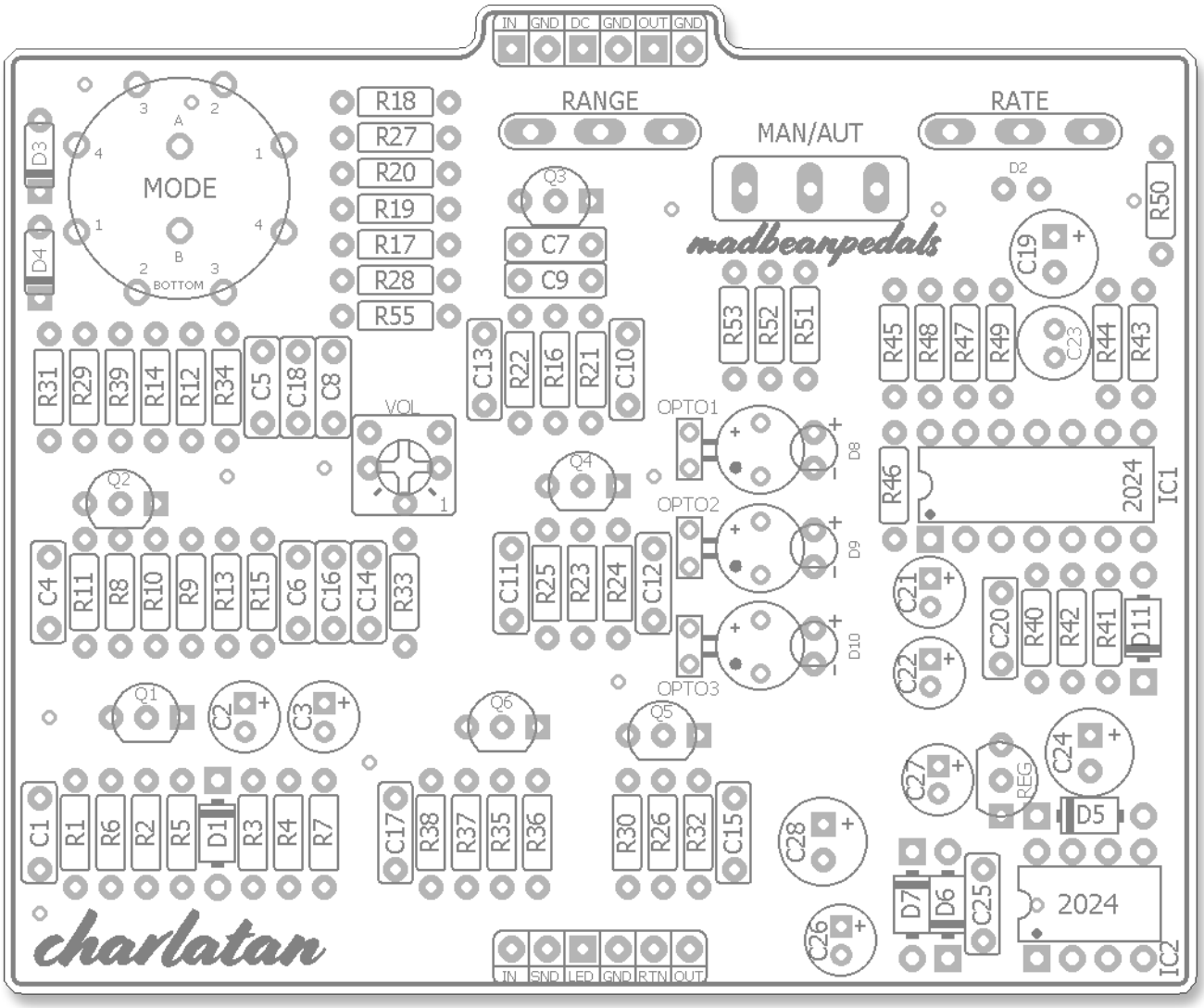
Note to the builder: while all of the effect modes sound great, none of these are as full-featured as individual pedals might be for each effect type. If you want an all-in-one and are okay with the limitations of the Charlatan, this is a great project with some really pleasant and musical sounds. If you want deep and lush phasing or square wave tremolo, this is not the right project for you.

Controls

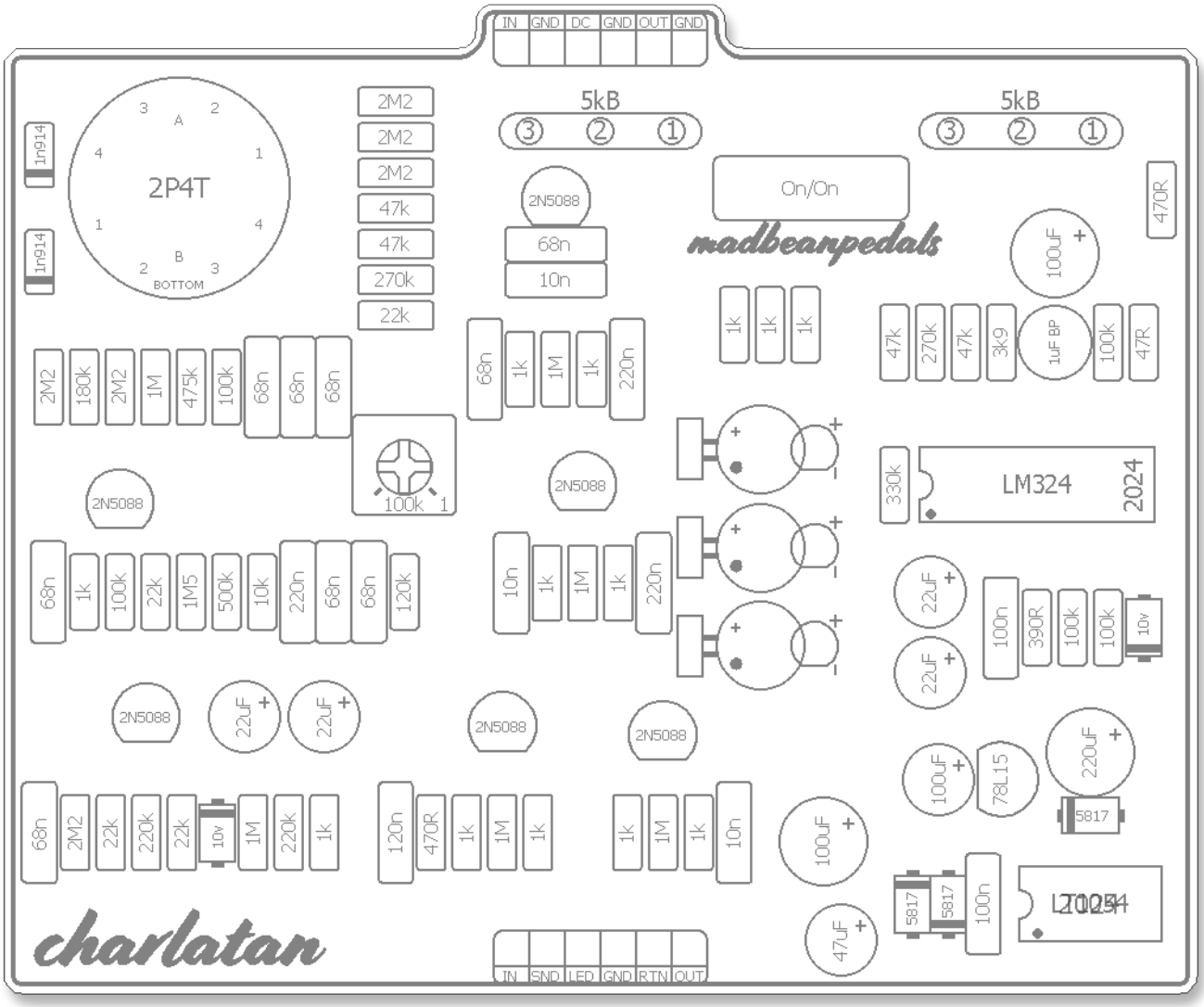
- **MODE:** A rotary switch that selects between Wah, Phaser, Tremolo and Vibrato from left to right.
- **RATE:** Speed of the LFO used for the selected Mode.
- **RANGE:** Sets the overall depth/intensity of the selected Mode.
- **MAN/AUTO:** In AUTO mode, the LFO is engaged. In MAN mode, the RATE pot is disengaged and the LFO no longer controls the effect. The RANGE control now sets fixed filter points in the Wah and Phaser modes. Manual mode has little to no effect in the Tremolo and Vibrato settings.
- **VOL:** This optional trimmer was added to control the output level. In most cases, it is probably not needed since the output is basically on par with the bypass signal. But, it may come in handy for some builders.

Old, but good demo: https://www.youtube.com/watch?v=34usT_FstBo

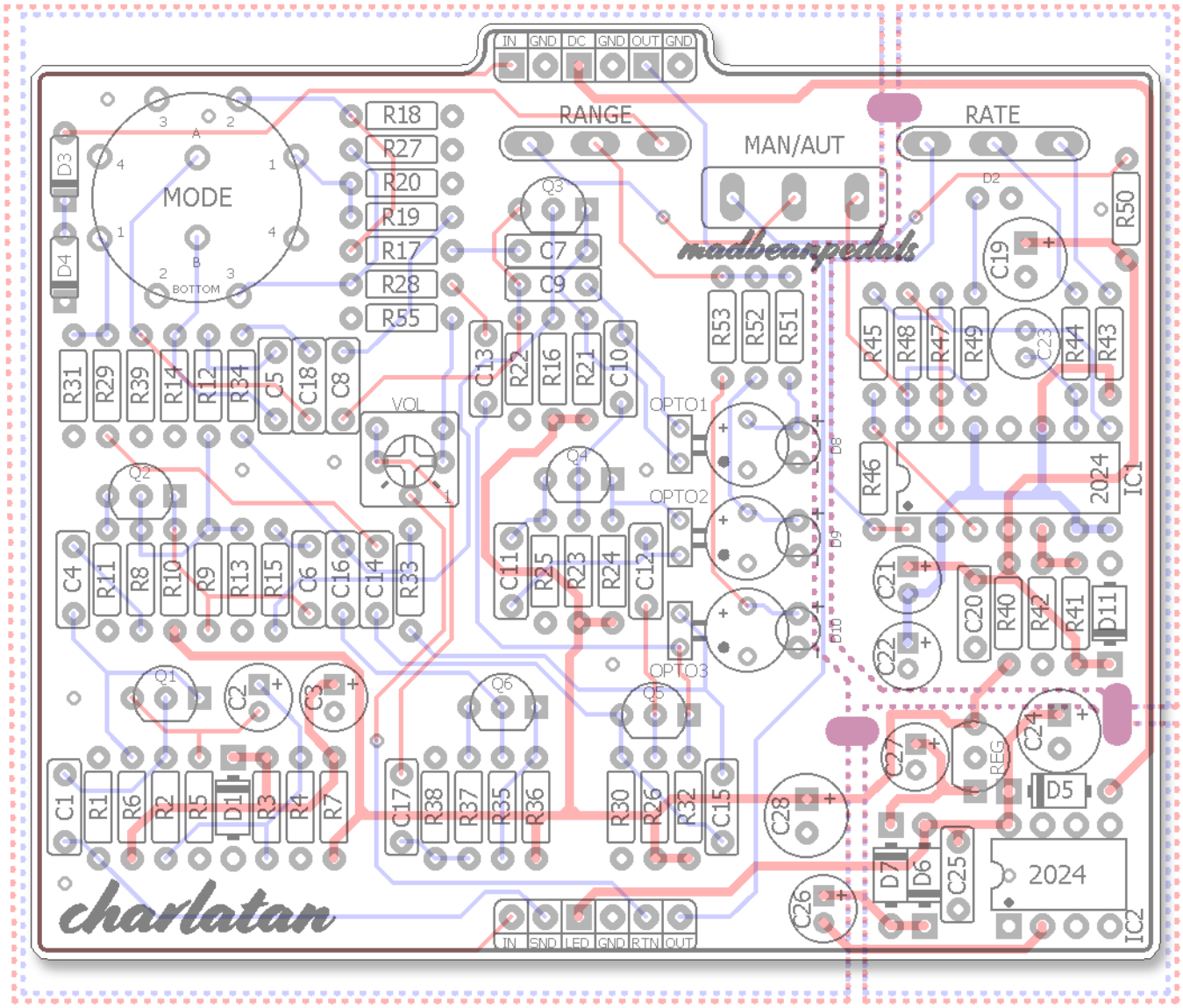
Parts Layout



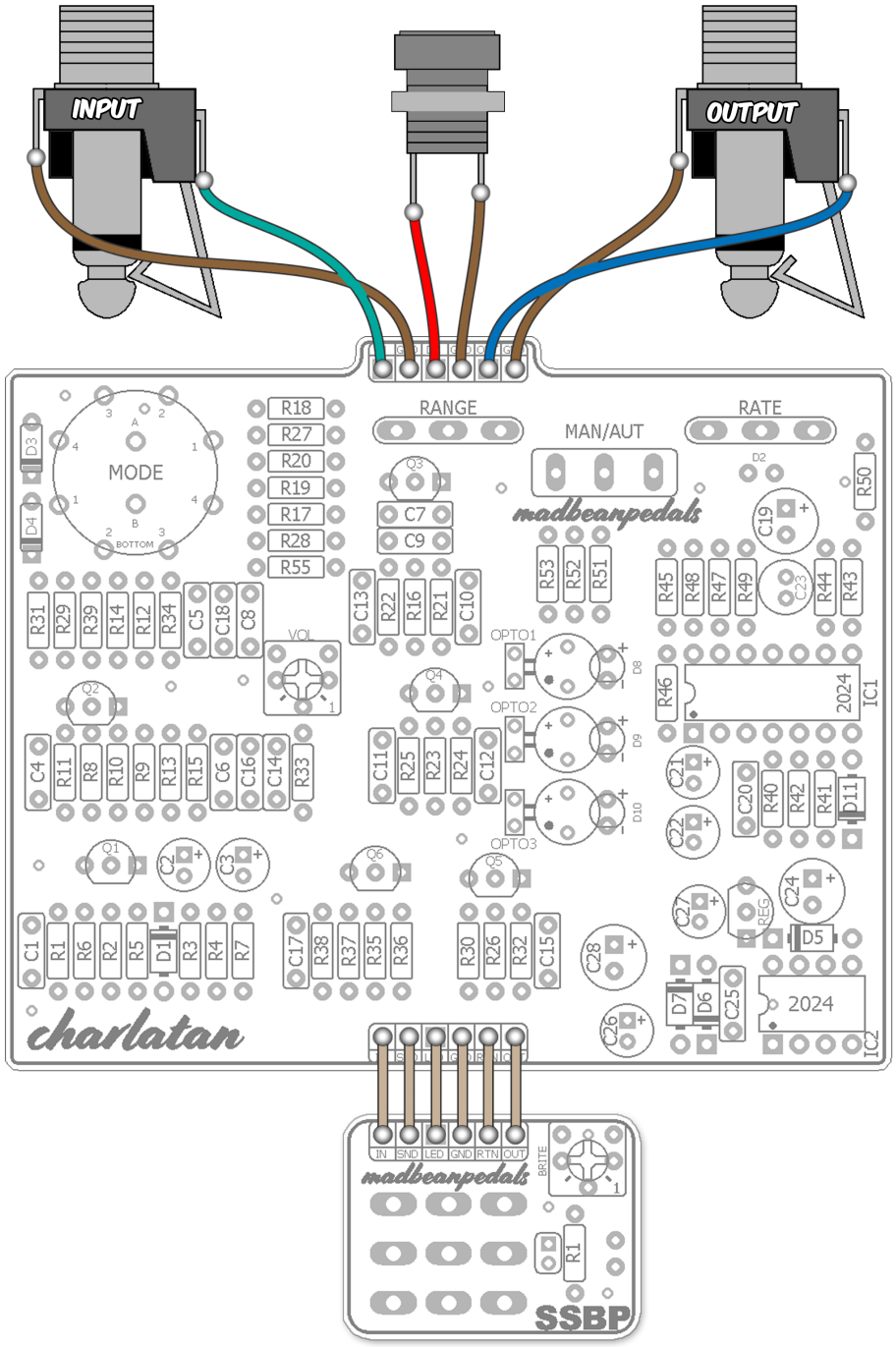
Component Values



Trace Layout



Wiring



The Charlatan is compatible with the **SSBP** and **SSABP** bypass boards offered at madbeanpedals. Both use the same wiring.

B.O.M.

Resistors		Resistors		Caps		Diodes	
R1	2M2	R29	180k	C1	68n	D1	10v Zener
R2	220k	R30	1k	C2	22uF	D2	LED
R3	1M	R31	2M2	C3	22uF	D3	1n914
R4	220k	R32	1k	C4	68n	D4	1n914
R5	22k	R33	120k	C5	68n	D5	1N5817
R6	22k	R34	100k	C6	220n	D6	1N5817
R7	1k	R35	1M	C7	68n	D7	1N5817
R8	100k	R36	1k	C8	68n	D11	10v Zener
R9	1M5	R37	1k	C9	10n	Transistors	
R10	22k	R38	470R	C10	220n	Q1 - Q6	2N5088
R11	1k	R39	2M2	C11	10n	REG	78L15
R12	475k	R40	390R	C12	220n	IC	
R13	500k	R41	100k	C13	68n	IC1	LM324
R14	1M	R42	100k	C14	68n	IC2	LT1054
R15	10k	R43	47R	C15	10n	Switches	
R16	1M	R44	100k	C16	68n	MAN/AUT	On/On
R17	47k	R45	47k	C17	120n	MODE	2P4T
R18	2M2	R46	330k	C18	68n	Optical	
R19	47k	R47	47k	C19	100uF	OPTO1-3	*see notes
R20	2M2	R48	270k	C20	100n	Trimmer	
R21	1k	R49	3k9	C21	22uF	VOL	100k
R22	1k	R50	470R	C22	22uF	Pots	
R23	1M	R51	1k	C23	1uF BP	RANGE	5kB
R24	1k	R52	1k	C24	220uF	RATE	5kB
R25	1k	R53	1k	C25	100n		
R26	1M	R55	22k	C26	47uF		
R27	2M2			C27	100uF		
R28	270k			C28	100uF		

You can sub a 1uF MLCC caps for the 1uF BP, if needed. Lead spacing is 2mm.

Shopping List

Value	QTY	TYPE	Rating	Value	QTY	TYPE	Rating
47R	1	Metal / Carbon Film	1/4W	10n	3	Film	25v min.
470R	2	Metal / Carbon Film	1/4W	68n	9	Film	25v min.
390R	1	Metal / Carbon Film	1/4W	100n	2	Film	25v min.
1k	13	Metal / Carbon Film	1/4W	120n	1	Film	25v min.
3k9	1	Metal / Carbon Film	1/4W	220n	3	Film	25v min.
10k	1	Metal / Carbon Film	1/4W	1uF BP	1	Film	25v min.
22k	4	Metal / Carbon Film	1/4W	22uF	4	Film	25v min.
47k	4	Metal / Carbon Film	1/4W	47uF	1	Film	25v min.
100k	5	Metal / Carbon Film	1/4W	100uF	3	Film	25v min.
120k	1	Metal / Carbon Film	1/4W	220uF	1	Film	16v min.
180k	1	Metal / Carbon Film	1/4W	1n914	2		
220k	2	Metal / Carbon Film	1/4W	1N5817	3		
270k	2	Metal / Carbon Film	1/4W	10v Zener	2	*included with PCB	
330k	1	Metal / Carbon Film	1/4W	LED	1	(optional) any diffused type	3 or 5mm
475k	1	Metal / Carbon Film	1/4W	2N5088	6		
500k	1	Metal / Carbon Film	1/4W	LM78L15	1	TO-92 style regulator	
1M	6	Metal / Carbon Film	1/4W	LM324	1		
1M5	1	Metal / Carbon Film	1/4W	LT1054	1		
2M2	6	Metal / Carbon Film	1/4W	SPDT	1	On/On, Solder Lug	
				2P4T	1	Mini Rotary	
				Opto	3	LDR/LED combo	
				100k	1	Bourns 3362p or 6mm	
				5kB	2	PCB Right Angle	16mm

Additional Hardware
(1) 1590BB enclosure
(2) 1/4” mono jacks
(1) Slim 2.1mm DC jack
(1) Standard 3PDT footswitch
(1) 5mm LED

Build Notes

The Circuit

The basic idea of this effect is to use a series of simple phase shifted gain stages which are varied with opto-couplers and driven by an LFO. Each mode selects from different output points in the circuit and mixes them together to produce the four options available (IOW, mixing inverted and non-inverted outputs from Q3-Q5 and also with the dry signal in some cases). This portion is bookended by an input gain stage (Q1/Q2) and output buffer (Q6). The LFO is not really anything special here. Probably several different ones could be substituted for the same result.

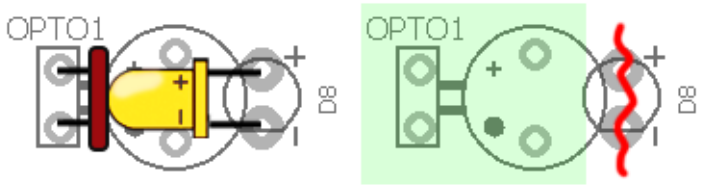
Optical Devices

I wasn't able to find out much about what type of LED/photocell combo was used in the Worm, so I went by route and tested different devices. In the end, the "roll your own" method won out over more expensive manufactured vactrols and optocouplers. All performed about equally except for the Phaser mode for which the NSL32R3 did not work as well. That may be due to its much lower light resistance than the 9203 photocell. Possibly the VTL5C3 would work perfectly, but there wasn't room in the layout for three of them.

For this build, you'll need to use three pairs of LEDs and photocells. Ideally these will be **3mm yellow or green LEDs and three 9203 photocells**. The latter have a light resistance ranging from 5-20k and dark resistance of about 20M. The yellow or green LEDs operate in the ideal wavelength for those particular photocells.

There's no room for a light shield on the PCB. So, you can either put a small length of heat shrink around each pair or just leave them exposed. Being inside an enclosure will provide enough of a light shield and all three LEDs flash no matter which mode is selected. I choose the latter because I only had 5mm LEDs when I built mine and space was too tight.

TIP: If you don't use heat shrink to shield the photocells, make sure you cover them up with a towel or something to block the light when *testing* your build. Otherwise ambient light will get to them and make the effect sound very weak. It's not weak.



The left image shows how to set up the LED and photocell for each of the three optos. The right image shows the outline if you use an NSL32 or 32R3 for some reason. The + and - pads are left empty in that case.

Build Notes

Power

The Worm was powered by the much hated 24v EHX wallwart. This was further regulated to 15v for the circuit operation. I chose to go with 9v power then use a charge pump/regulator combo to get the equivalent. Built to stock, this circuit is a surprising current hog. It clocked in at just over 100ma! This was confirmed over two builds. Since 100mA is pretty much at the limit of the LT1054 and 78Lx regulator capabilities I poked around to find a way to reduce the current consumption. Changing the current limiting resistor to the LFO (R40) from 220R to 390R reduced the draw by about 20mA and maintained voltage stability. Good enough.

If possible, use a low ESR electrolytic for R26. It's doesn't have to be 47uF, but should be no less than 10uF.

Baked Mods

Two mods I made permanent was reducing the three sets of two 100n parallel caps in the stock unit to three 220n caps. These are C6, C10 and C12. If you have a 200n cap you can use that instead. The tonal impact of either should be very minor. I also put in a volume trimmer at the output since there was no way to control effect volume. For the most part, it really isn't needed. The effect and bypass volume are pretty closely balanced. If you want to omit it make R55 2M2 and jumper all three pads of the volume trimmer together.

Optional Mods

D2 is available as an external LFO rate indicator. This is blinky-blinky all-the-timey so if you hate flashing lights omit it. If you want to use it but only when the effect is on, then omit the standard bypass LED indicator. Wire the cathode of D2 to the 3PDT switch where the bypass LED normally connects (on my wiring diagram this is the top upper left lug.)

One mod I highly suggest you do is the Headroom Maximizer MOD mode. Stock, the Worm has some distortion with higher output pickups in a few settings. This drove me crazy for a bit until I poked around the voltage readings. 1) Swap R2 and R3 values to reduce the disparity between collector and base voltages and raise the input impedance a bit (**Make R2 1M and R3 220k**). 2) This part is more critical: **reduce the R9 collector/base feedback resistor**. This is the main nasty clipping source. "Halving" it to 820k did the trick. It does reduce output a little but not enough to require a boost later on.

Final Thoughts

EHX did re-issue the Worm, of course. To what degree they maintained the original design I don't know. It may not even be optical anymore. Considering the restriction on cadmium (as found in photocells) in the European market they may have taken a different approach. Having completed this project I might take on a revision of this circuit at some point. It would be interesting to retain the optical portion, but convert it to op-amps and design better input and output stages. Maybe expand the functionality of each mode as well. It could also be designed to run at 9 or 18v by simply regulating the LFO voltage to 9v max. We'll see.

Circuit Voltages

Q1	2n5088
C	8.72
B	1.69
E	1.27
Q2	**2n5088**
C	5.28
B	1.02
E	442mV
Q3	**2n5088**
C	10.1
B	5.4
E	4.9
Q4	**2n5088**
C	10.1
B	5.54
E	4.9
Q5	**2n5088**
C	10
B	5.4
E	5
Q6	**2n5088**
C	11.6
B	5.4
E	3.9
REG	**78L15**
In	17.43
GND	0
Out	15.06

IC1	LM324
1	varies
2	~4.86
3	varies
4	9.72
5	~4.4
6	4.86
7	4.86
8	varies
9	4.87
10	4.87
11	0
12	4.87
13	~4.8
14	varies
IC2	**LT1054**
1	2.15
2	4.87
3	0
4	15mV
5	0
6	2.58
7	1.44
8	9.18

Headroom Mod	
Q1	**2n5088**
C	5.96
B	4.24
E	4.03
Q2	**2n5088**
C	3.75
B	1.1
E	514mV

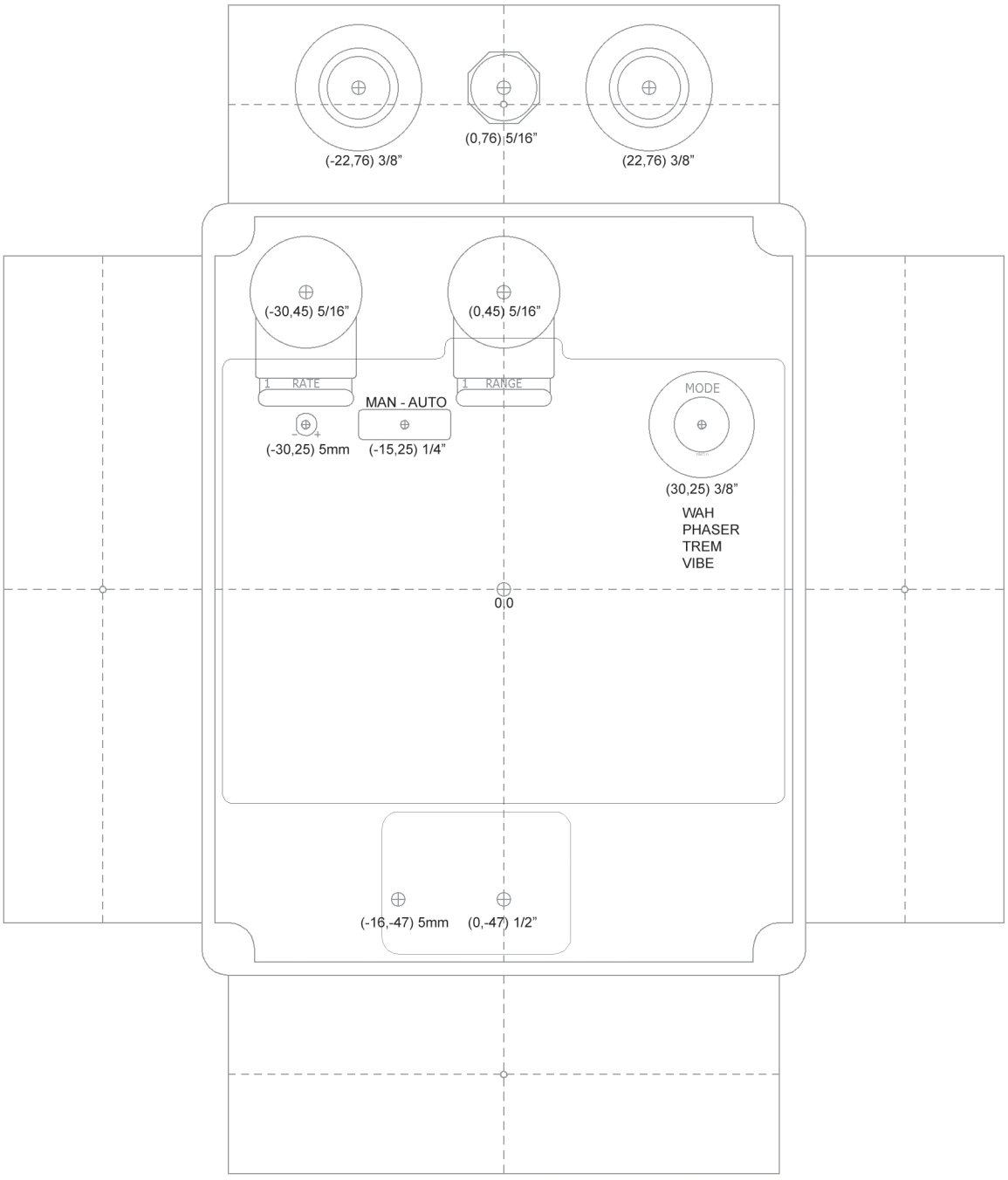
- 9.42vDC Power Supply
- Current Draw: ~84mA

- Testing Conditions: All knobs CCW, Switch in Auto position (right), Mode in Wah setting (1st position)

Drill Template

Coordinates are denoted in (X,Y), drill size format starting from the center (0,0) location of the enclosure.

Tayda drill link: https://drill.taydakits.com/box-designs/new?public_key=dGtlTGF1MGphcDFZOTZMUmliZmlmZz09Cg==

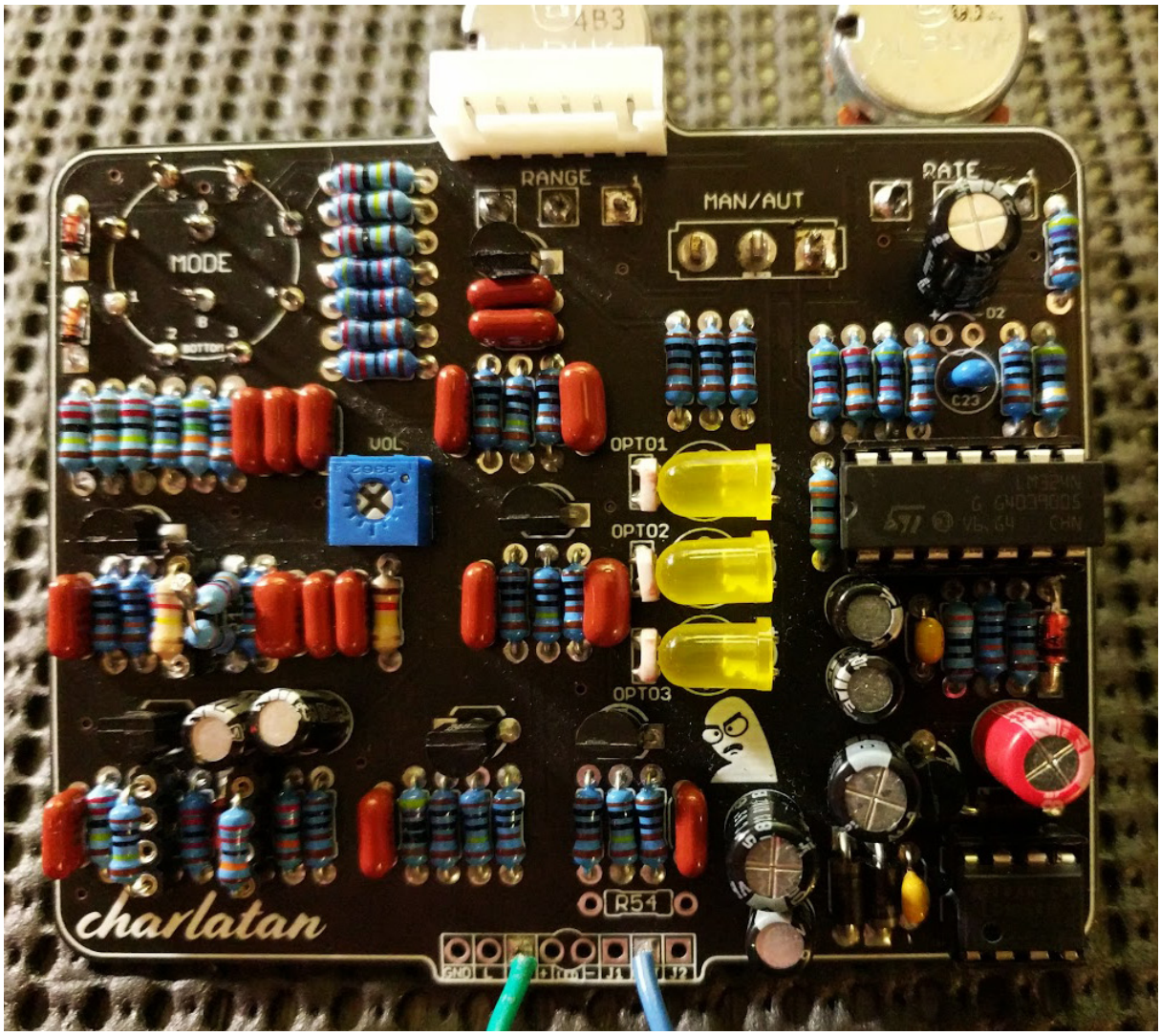


Hardware

1590BB enclosure
1/4” mono jacks
Slim 2.1mm DC jack
Standard 3PDT footswitch
5mm LED

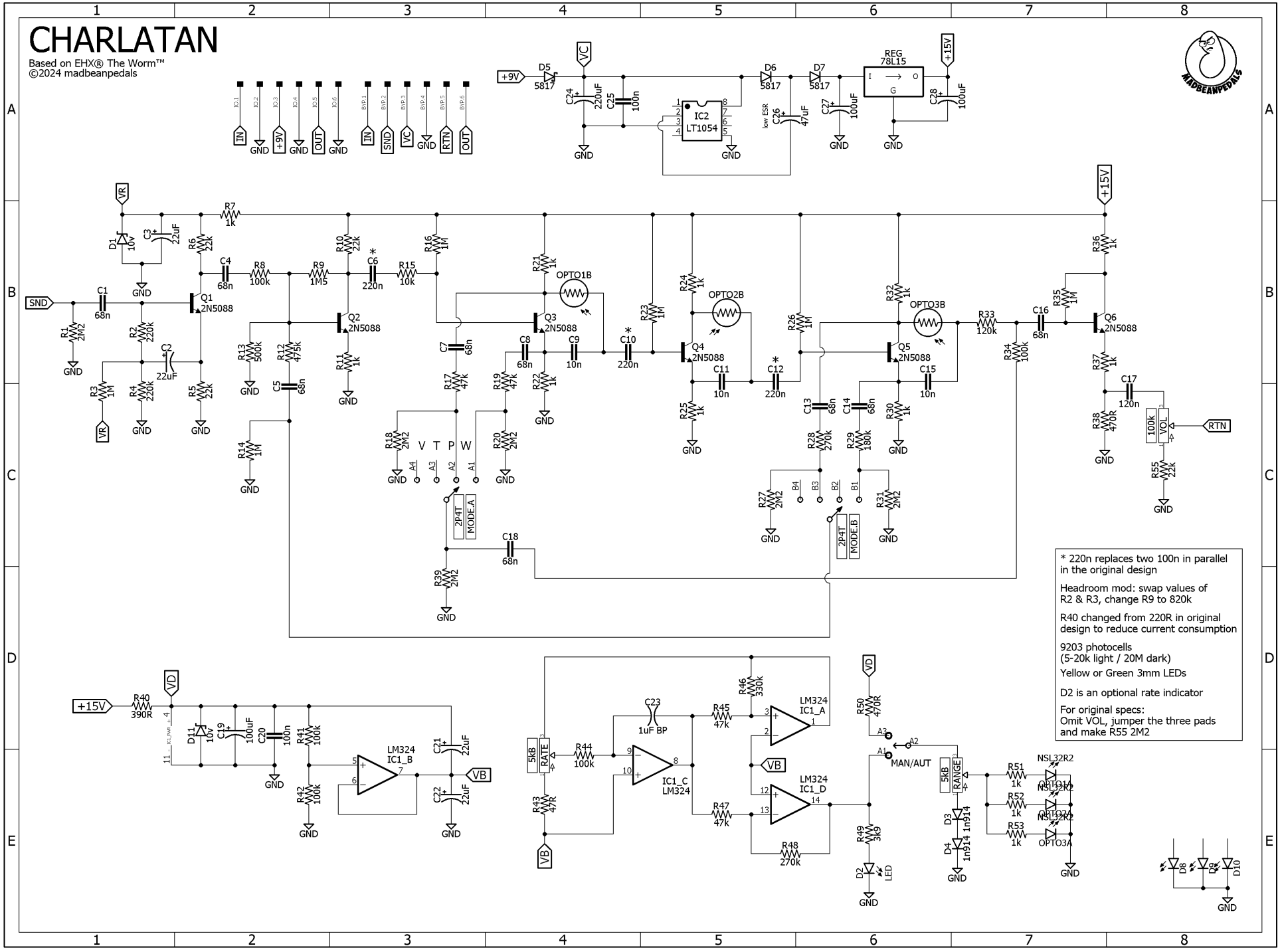
NOTE: Different 1/4” and DC jack styles may require different sized drill holes.

Build Pic



Previous version build.

Schematic


CHARLATAN
Based on EHX® The Worm™
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MADBEANPEDALS
IN
+9V
OUT
GND
BYP 1
BYP 2
BYP 3
BYP 4
BYP 5
BYP 6
SND
VC
RTN
D5 5817
C24 220uF
C25 100n
IC2 LT1054
low ESR
C26 47uF
D6 5817
D7 5817
C27 100uF
REG 78L15
C28 100uF
+15V
VR
D1 10v
C3 22uF
R7 1k
R6 22k
C4 68n
R8 100k
R9 1M5
R10 22k
C6 220n
R15 10k
R16 1M
C1 68n
Q1 2N5088
R1 2M2
R2 220k
C2 22uF
R3 1M
R4 220k
R5 22k
R13 500k
R12 475k
C5 68n
R14 1M
R11 1k
Q2 2N5088
C7 68n
R17 47k
R18 2M2
R19 47k
R20 2M2
V T P W
A4 A3 A2 A1
2P4T MODE:A
C18 68n
R39 2M2
R21 1k
OPTO1B
Q3 2N5088
C8 68n
C9 10n
C10 220n
R22 1k
R23 1M
R24 1k
OPTO2B
Q4 2N5088
C11 10n
C12 220n
R25 1k
R26 1M
R32 1k
OPTO3B
Q5 2N5088
C15 10n
C13 68n
C14 68n
R28 270k
R29 180k
R30 1k
B4 B3 B2 B1
2P4T MODE:B
R27 2M2
R31 2M2
R33 120k
C16 68n
R34 100k
R35 1M
R36 1k
Q6 2N5088
R37 1k
C17 120n
R38 470R
100k VOL
R55 22k
R40 390R
D11 10v
C19 100uF
C20 100n
R41 100k
R42 100k
LM324 IC1_B
C21 22uF
C22 22uF
C23 1uF BP
R44 100k
5kB RATE
R43 47R
IC1_C LM324
R45 47k
R46 330k
LM324 IC1_A
R47 47k
R48 270k
LM324 IC1_D
R50 470R
MAN/AUT
R49 3k9
D2 LED
5kB RANGE
D3 1n914
D4 1n914
R51 1k
R52 1k
R53 1k
NSL32R2
OPTO1A
OPTO2A
OPTO3A
D8
D9
D10
* 220n replaces two 100n in parallel in the original design
Headroom mod: swap values of R2 & R3, change R9 to 820k
R40 changed from 220R in original design to reduce current consumption
9203 photocells (5-20k light / 20M dark)
Yellow or Green 3mm LEDs
D2 is an optional rate indicator
For original specs: Omit VOL, jumper the three pads and make R55 2M2