POLYTROG

FX TYPE: MODULATION

Based on the EHX® Polyphase™

Enclosure Size: 1590BB

Softie compatibility: none

Overview

I don't think I can accurately describe just how much I grew to hate working on this project. Not that it is a bad effect (it's actually one of the best sounding optical phasers around). Rather, it turned into the longest development and most frustrating thing I've done for any pedal project, ever. I made numerous mis-steps and errors, put it aside for months at a time and built maybe seven prototypes to get it done. But, I never fully quit or gave up on it. Sometimes it does pay to stick with an idea even when you really want to give up!

The **Polytrog** is a clone of the vintage (big box) EHX Polyphase. At its core, the Polyphase is a six-stage optical phaser with a unique envelope control. This is the "quintessential" *lush* analog phaser, even though that term gets thrown around way too much. The combination of optical-based phasing with the high voltage operation puts the Polyphase in a unique category among many of its contemporaries and successors and a successful build on your part will no doubt find a good home on your pedalboard.

Controls

- **ENV/SWEEP -** The Polytrog has two modes: Envelope and Sweep. In sweep mode, the LFO is automatic and the phaser is controlled by the RATE and FDBK pots. In ENV mode, the Sweep LFO is disabled and a second, envelope driven LFO is enabled. Three controls (ENV SENSE, ENV MOD and MOD RATE) are available to change the dynamic response of the new LFO.

- **RATE -** The speed of the automatic LFO. This works only in the Sweep mode.

- **FDBK -** The amount of feedback sent from the output of the phase stages back to its input. IOW, a "swoosh" control. FDBK works regardless of what mode you are in.
-
- **ENV SENSE -** Controls the sensitivity of the envelope follower is in ENV mode. This is keyed off playing dynamics. The higher the control, the more sensitive it is.

- **ENV RATE -** This sets the upper limit (speed) of the envelope controlled LFO in ENV mode.

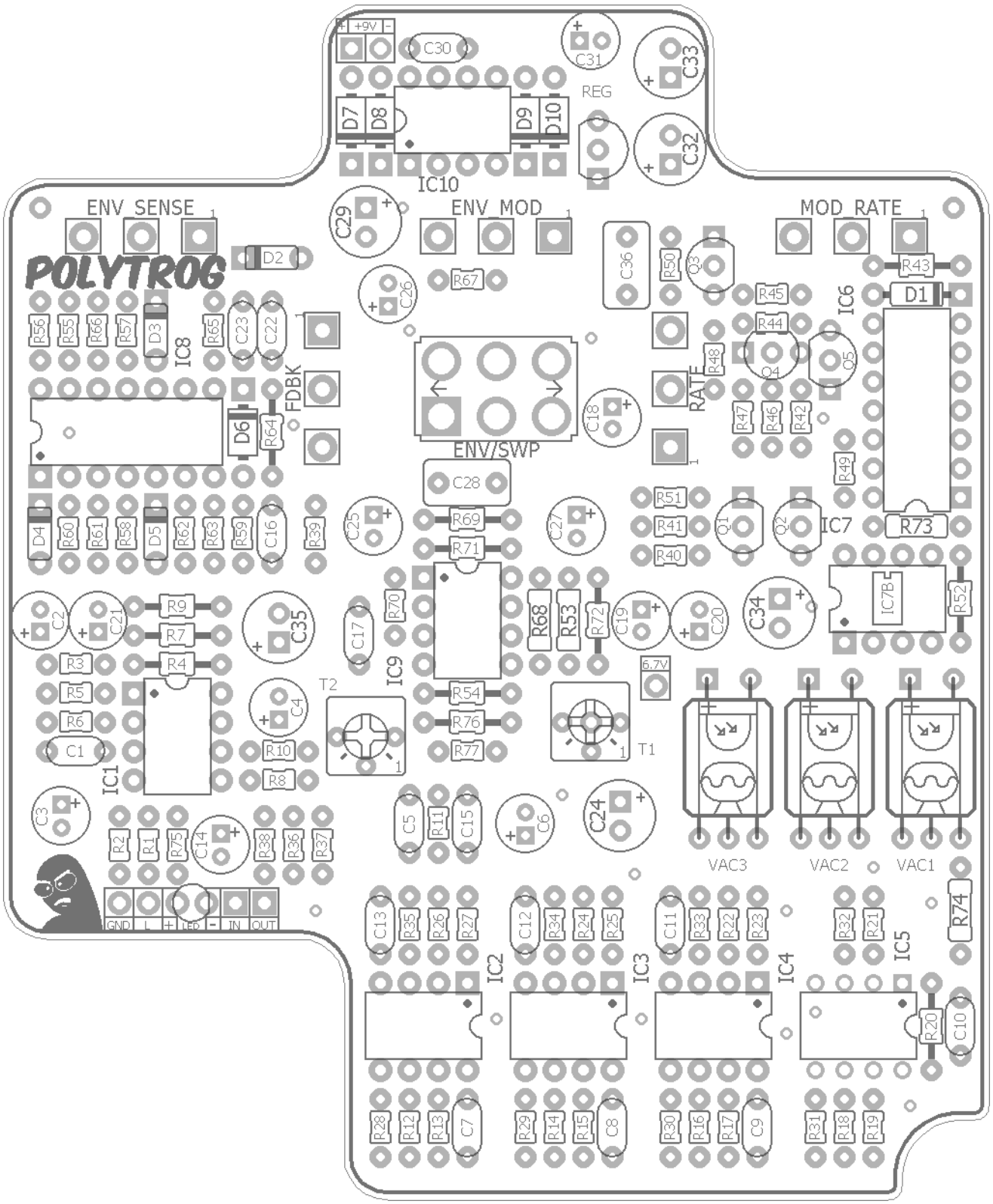
- **ENV MOD -** The depth or intensity of the envelope controlled LFO in ENV mode.

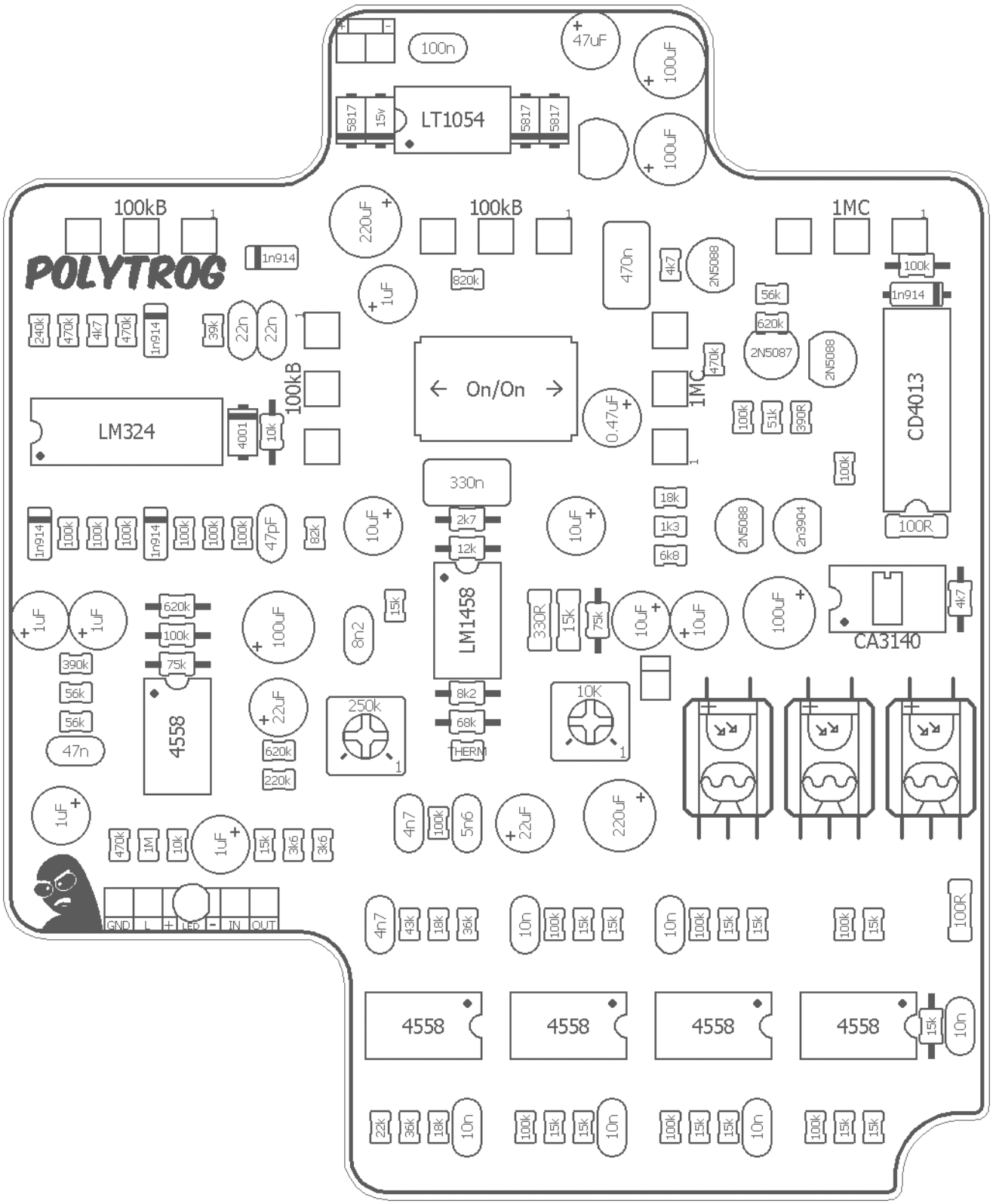
- **T1 -** This trimmer is used to set a fixed calibration point in the envelope circuit. See Notes.

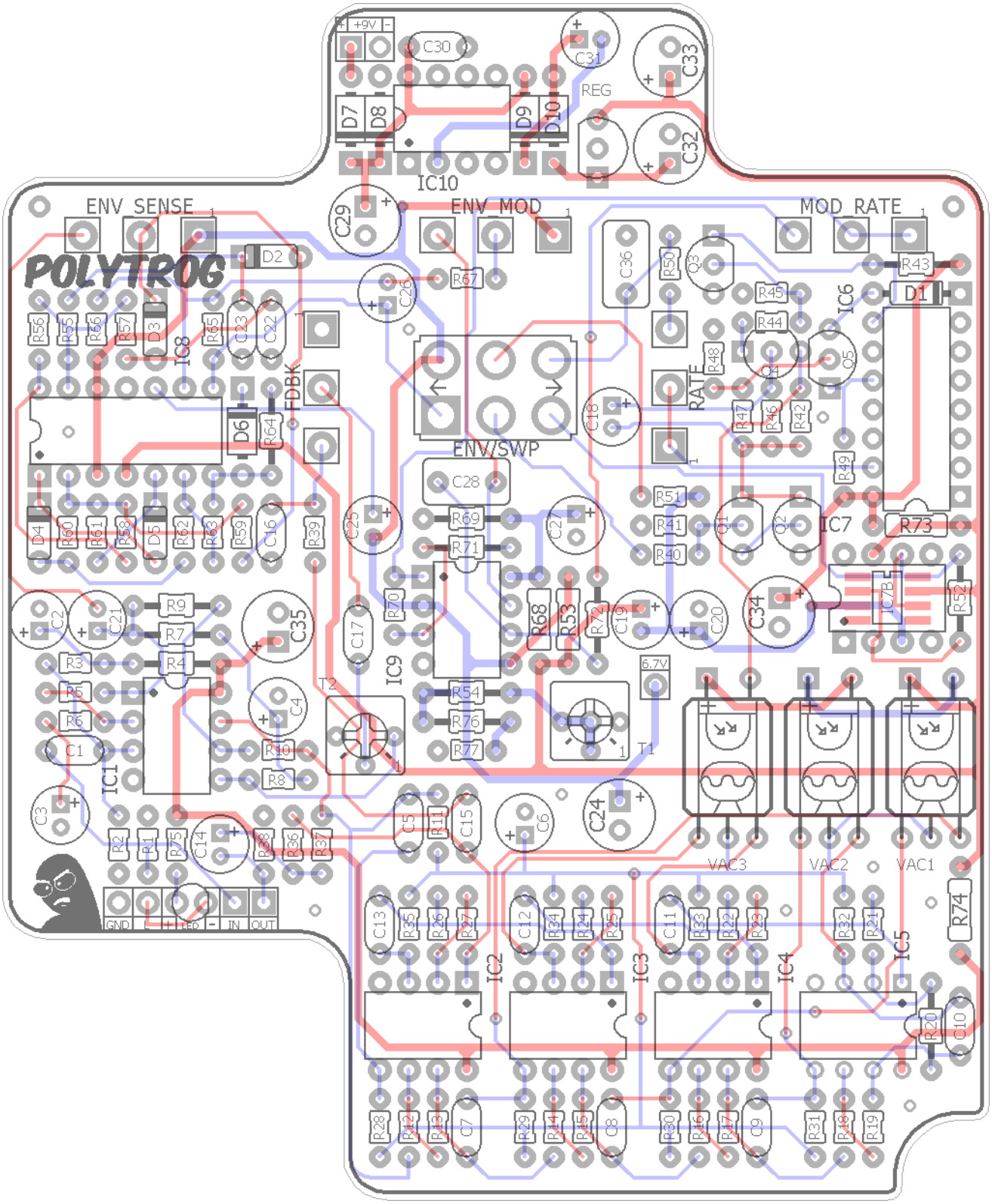
- **T2 -** This trimmer is to prevent runaway oscillation in the feedback path.

An older youTube demo: https://www.youtube.com/watch?v=f2wQstrdrfo

Technical assistance for your build(s) is available via the madbeanpedals forum. Please go there rather than emailing me for assistance on builds. This is because (1) I'm not always available to respond via email in a timely and continuous manner, and (2) posting technical problems and solutions in the forum creates a record from which other members may benefit.


POLYTROG
ENV SENSE
ENV MOD
MOD RATE
ENV/SWP
FDBK
RATE
REG
IC10
IC8
IC6
IC7
IC7B
IC9
IC1
IC2
IC3
IC4
IC5
T1
T2
6.7V
VAC3
VAC2
VAC1
GND
IN
OUT


POLYTROG
100n
47uF
100uF
LT1054
5817
15v
100kB
220uF
1n914
820k
470n
4k7
2N5088
1MC
56k
620k
2N5087
100k
CD4013
100R
LM324
4001
10k
On/On
0.47uF
330n
2k7
12k
LM1458
18k
1k3
6k8
10uF
47pF
82k
330R
15k
75k
CA3140
4k7
620k
390k
56k
47n
4558
22uF
220k
250k
8n2
8k2
68k
THERM
10K
4n7
5n6
GND
IN
OUT
43k
36k
22k
18k
10n
3k6
1M


POLYTROG
ENV SENSE
ENV MOD
MOD RATE
RATE
ENV/SWP
FDBK
IC10
REG
IC1
IC2
IC3
IC4
IC5
IC6
IC7
IC8
IC9
T1
T2
6.7V
VAC3
VAC2
VAC1
GND
LED
IN
OUT

Resistors		Resistors		Caps		Diodes		Trimmers	
R1	1M	R40	6k8	C1	47n	D1	1n914	T1	10K
R2	470k	R41	1k3	C2	1uF	D2	1n914	T2	250k
R3	390k	R42	390R	C3	1uF	D3	1n914	Pots	
R4	75k	R43	100k	C4	22uF	D4	1n914	ENV_MOD	100kB
R5	56k	R44	620k	C5	4n7	D5	1n914	ENV_SENSE	100kB
R6	56k	R45	56k	C6	22uF	D6	1n4001	FDBK	100kB
R7	100k	R46	51k	C7	10n	D7	1n5817	RATE	1MC
R8	220k	R47	100k	C8	10n	D8	15v Zener	MOD_RATE	1MC
R9	620k	R48	470k	C9	10n	D9	1n5817		
R10	620k	R49	100k	C10	10n	D10	1n5817		
R11	100k	R50	4k7	C11	10n	Transistors			
R12	36k	R51	18k	C12	10n	Q1	2N5088		
R13	18k	R52	4k7	C13	4n7	Q2	2n3904		
R14	15k	R53	15k	C14	1uF	Q3	2N5088		
R15	15k	R54	8k2	C15	5n6	Q4	2N5087		
R16	15k	R55	470k	C16	47pF	Q5	2N5088		
R17	15k	R56	240k	C17	8n2	ICs			
R18	15k	R57	470k	C18	0.47uF	IC1	4558		
R19	15k	R58	100k	C19	10uF	IC2	4558		
R20	15k	R59	100k	C20	10uF	IC3	4558		
R21	15k	R60	100k	C21	1uF	IC4	4558		
R22	15k	R61	100k	C22	22n	IC5	4558		
R23	15k	R62	100k	C23	22n	IC6	CD4013		
R24	15k	R63	100k	C24	220uF	IC7	CA3140		
R25	15k	R64	10k	C25	10uF	IC8	LM324		
R26	18k	R65	39k	C26	1uF	IC9	LM1458		
R27	36k	R66	4k7	C27	10uF	IC10	LT1054		
R28	22k	R67	820k	C28	330n	Regulator			
R29	100k	R68	330R	C29	220uF	REG	78L15		
R30	100k	R69	2k7	C30	100n	Opto			
R31	100k	R70	15k	C31	47uF	VAC1 - 3	VTL5C3/2		
R32	100k	R71	12k	C32	100uF	Switch			
R33	100k	R72	75k	C33	100uF	ENV/SWP	On/On		
R34	100k	R73	100R	C34	100uF				
R35	43k	R74	100R	C35	100uF				
R36	3k6	R75	10k	C36	470n				
R37	3k6	R76	68k						
R38	15k	R77	Thermistor						
R39	82k								

Value	QTY	Type	Rating
100R	2	Metal / Carbon Film	1/4W
330R	1	Metal / Carbon Film	1/4W
390R	1	Metal / Carbon Film	1/4W
8k2	1	Metal / Carbon Film	1/4W
15k	1	Metal / Carbon Film	1/4W
68k	1	Metal / Carbon Film	1/4W
1k3	1	Metal / Carbon Film	1/8W
2k7	1	Metal / Carbon Film	1/8W
3k6	2	Metal / Carbon Film	1/8W
4k7	3	Metal / Carbon Film	1/8W
6k8	1	Metal / Carbon Film	1/8W
10k	2	Metal / Carbon Film	1/8W
12k	1	Metal / Carbon Film	1/8W
15k	14	Metal / Carbon Film	1/8W
18k	3	Metal / Carbon Film	1/8W
22k	1	Metal / Carbon Film	1/8W
36k	1	Metal / Carbon Film	1/8W
39k	1	Metal / Carbon Film	1/8W
43k	1	Metal / Carbon Film	1/8W
51k	1	Metal / Carbon Film	1/8W
56k	3	Metal / Carbon Film	1/8W
75k	2	Metal / Carbon Film	1/8W
82k	1	Metal / Carbon Film	1/8W
100k	17	Metal / Carbon Film	1/8W
220k	1	Metal / Carbon Film	1/8W
240k	1	Metal / Carbon Film	1/8W
390k	2	Metal / Carbon Film	1/8W
470k	4	Metal / Carbon Film	1/8W
620k	3	Metal / Carbon Film	1/8W
820k	1	Metal / Carbon Film	1/8W
1M	1	Metal / Carbon Film	1/8W
Thermistor	1	*see notes	

Value	QTY	Type	Rating
47pF	1	Ceramic / MLCC	25v min.
4n7	2	Film	25v min.
5n6	1	Film	25v min.
8n2	1	Film	25v min.
10n	6	Film	25v min.
22n	2	Film	25v min.
47n	1	Film	25v min.
100n	1	Film	25v min.
330n	1	Film	25v min.
470n	1	Film	25v min.
1uF	5	Film	25v min.
0.47uF	1	Electrolytic	25v min.
10uF	4	Electrolytic	25v min.
22uF	2	Electrolytic	25v min.
47uF	1	Electrolytic (low ESR)	25v min.
100uF	4	Electrolytic	25v min.
220uF	2	Electrolytic	16v min.
1n914	5		
1n4001	1		
1n5817	3		
15v	1	Zener, 1W	
2n3904	1		
2N5088	3		
2N5087	1		
4558	5		
CD4013	1		
CA3140	1	through-hole or smd	
LM324	1		
LM1458	1		
LT1054	1		
78L15	1	TO-92 style	
VTL5C3/2	3	*see notes	
DPDT	1	On/On, Solder Lug	
10K	1	multi-turn - included with PCB	
250k	1	Bourns 3362p	
100kB	3	PCB Right Angle	16mm
1MC	1	PCB Right Angle	16mm

What's included with the Polytrog PCB:
10k multi-turn trimmer

15v Zener:
https://www.mouser.com/ProductDetail/512-1N4744A
https://www.taydaelectronics.com/1n4744a-1n4744-zener-diode-1w-13v.html

LM78L15:
https://www.mouser.com/ProductDetail/926-LM78L15ACZ-LFT4
https://smallbear-electronics.mybigcommerce.com/ic-78l15/
https://stompboxparts.com/semiconductors/lm78l15acz-voltage-regulator-15v/

CD4013:
https://www.mouser.com/ProductDetail/595-CD4013BE
https://smallbear-electronics.mybigcommerce.com/ic-cd4013/
https://stompboxparts.com/semiconductors/cd4013be-dual-flip-flop-ic/

CA3140:
https://www.mouser.com/ProductDetail/968-CA3140EZ
https://smallbear-electronics.mybigcommerce.com/ic-ca3140aez/

LM1458:
https://www.mouser.com/ProductDetail/595-MC1458P
https://stompboxparts.com/semiconductors/lm1458n-dual-op-amp-ic/

LM324:
https://www.mouser.com/ProductDetail/595-LM324N
https://smallbear-electronics.mybigcommerce.com/ic-lm324n/
https://stompboxparts.com/semiconductors/lm324n-quad-op-amp-ic/
https://www.taydaelectronics.com/lm324n-lm324-324-low-power-quad-op-amp-ic.html

LT1054:
https://stompboxparts.com/lt1054cp-charge-pump-ic/
https://www.taydaelectronics.com/lt1054-lt1054cp-charge-pump-switching-regulator-ic.html

VTL5C3/2:
https://cabintechglobal.com/vtl5c3-2
https://smallbear-electronics.mybigcommerce.com/photocoupler-dual-xvive-vtl5c3-2/
https://synthcube.com/cart/xvive-vactrol-vtl5c3-2-bag-of-2

16mm Right Angle PCB mount pots:
https://smallbear-electronics.mybigcommerce.com/alpha-single-gang-16mm-right-angle-pc-mount/
https://stompboxparts.com/pots/16mm-potentiometer-short-pcb-leg/
https://lovemyswitches.com/16mm-potentiometers-1-4-smooth-shaft-right-angle-pcb-mount/

DPDT (On/On):
https://lovemyswitches.com/dpdt-on-on-switch-solder-lug-short-shaft/
https://stompboxparts.com/switches/dpdt-toggle-switch-on-on-solder-lug-short-bat-1/

Low Profile DC Jack:
https://stompboxparts.com/power-connections/dc-power-jack-2-1mm-low-profile/
https://lovemyswitches.com/thinline-lumberg-dc-power-jack-2-1mm/

1/4" jacks:
https://lovemyswitches.com/1-4-mono-jack-lumberg-klbm-3/
https://lovemyswitches.com/1-4-mono-jack-neutrik-rean-nys229/

My preferred 3PDT switch:
https://lovemyswitches.com/pro-3pdt-latched-foot-switch-solder-lugs-feather-soft-click/

Power

Some of the oldest units used mains + transformer + regulator to operate the Polyphase at +15v. It would be better to require an 18v adapter for this project but since many people still consider that a “deal killer” I went with the conventional 9v power with charge pump as others have done. This circuit pushes the capabilities of the LT1054 slightly beyond its limit (which is 100mA current load). In Envelope mode is draws a modest 75mA. In Sweep mode current draw increases and appears to peak just north of 100mA. However, I’ve built the Polytrog several times over its production and feel confident the current draw does not hinder the performance or cause part failure. So, I stuck with the charge pump.

Optical

The Polyphase used 3 CLM8200/2 vactrol types for the optical phasing. These are hard to get (at least in the States) so I went with the modern Xvive reproductions of the VTL5C3/2 in the design. They work perfectly fine for the Polytrog. I was able to obtain three CLM from a fellow DIY’er after the design was completed and manufactured. I managed to fit them on my Polytrog board but it was nearly impossible. It simply wasn’t design for that footprint. So, I recommend stick with the VTL5C3/2. A/B’ing both versions gave very comparable results. Enough so that debate over any small difference between the two devices should be left to the purists.

Calibration

The envelope detector mode needs to be calibrated with the T1 10k multi-trimmer (included). The factory schem indicates this trimmer should be adjust to +6.7v. On the Polytrog PCB you will find a test point labeled “6.7v” that you can use for readings while adjusting the trimmer. I opted for the multi-turn trimmer because he calibration is very sensitive to small changes in voltage at the test point. When set to 6.7v, the MOD-RATE control produces very noticeable dynamic driven oscillation.

However, IF you set this voltage lower an interesting thing happens. The LFO becomes less sensitive and when you dial in high amounts of ENV_SENSE the response becomes a bit more like an auto-wah but with phaser. It sounds very cool and I liked it even more that the LFO. This happens around 6.3v-6.0v. Under 6v everything tends to wash out. So, I suggest playing with the calibration voltage a bit. In the end, I left mine at 6.3v because that gave a good balance between the LFO and quack.

Also note that the vintage Polyphase included a thermistor as part of the calibration circuit. This is a temperature sensitive resistor whose value changes according to the ambient temperature (the Polyphase one is spec’d 100k @ 25C). Having tested the Polytrog both with and without a thermistor it appears to not be needed, and many others have recommended the same in their clones. This is a compatible thermistor if you want to see for yourself. Just use a socket. The thermistor is labeled R77 on the Polytrog PCB.

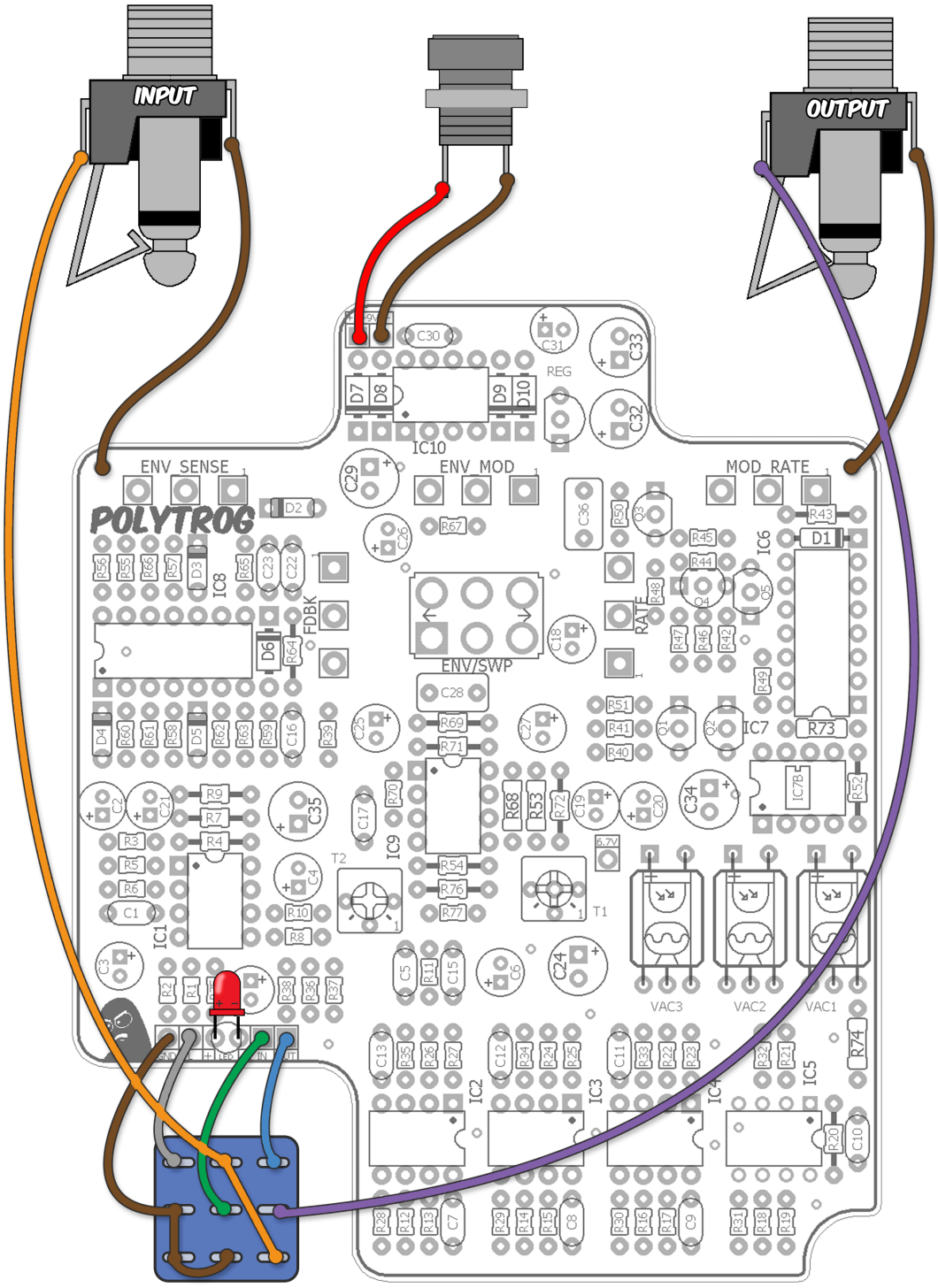
TIP: When calibrating T1, keep all the knobs in the middle position and the in ENV mode (switch left).

The T2 trimmer is prevent oscillation in the feedback path. Set to ENV mode, Rate to about 1/3rd up. Now adjust the FDBK control all the way up, but slowly. If you start to get oscillation, turn T2 CW until it stops. Set T2 a the lowest clockwise turn that prevents oscillation at the highest FDBK setting.

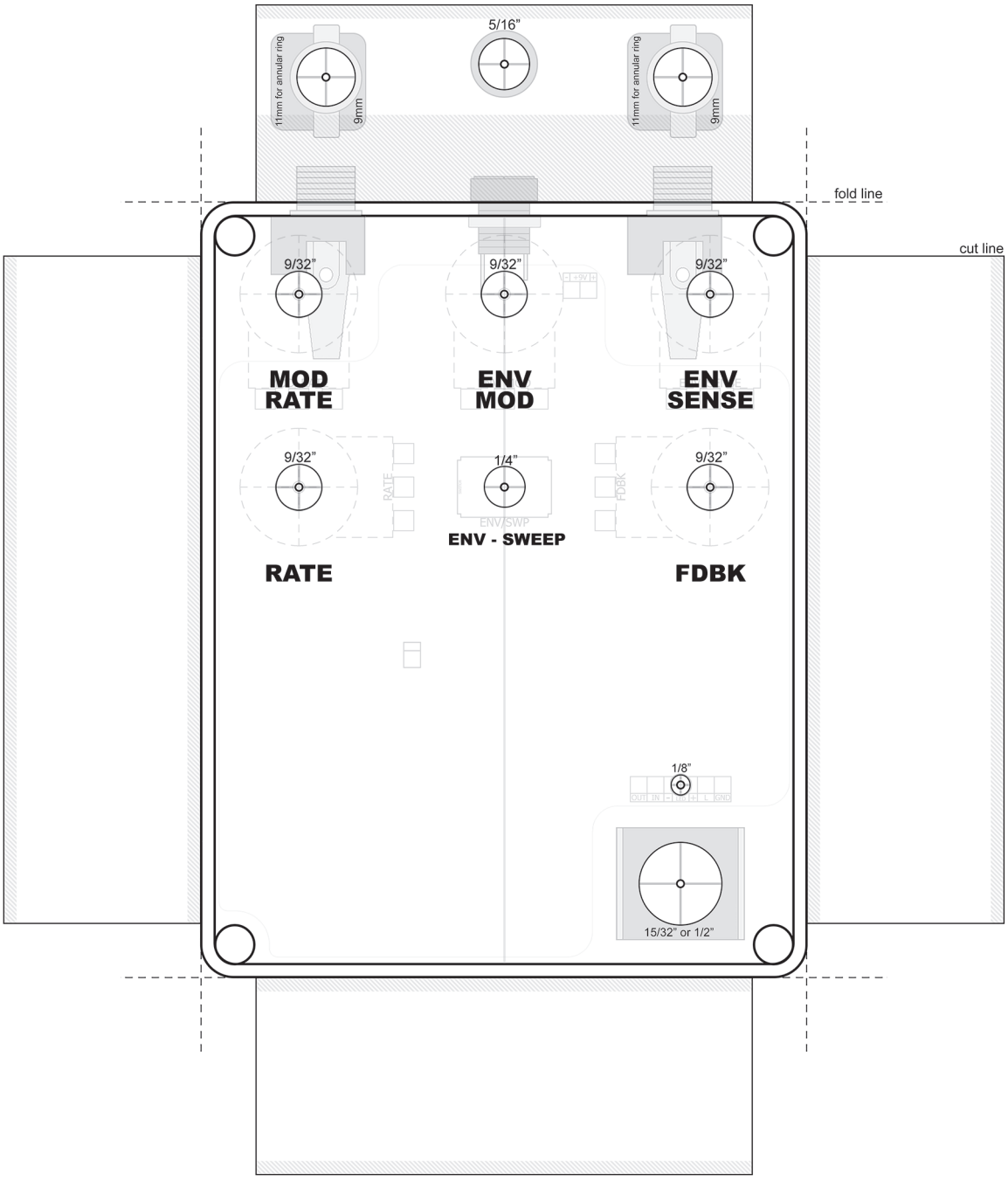
Mods

- C36 is indicated on the vintage circuit but it seems that this was marked DNP (do not populate) on the RI. My guess is that this cap was included to prevent any ticking from the main LFO circuit. Having tested the Polytrog, I could not detect any ticking even at max amp volume. You can use it if you like, or socket it and add it later if needed. I left an empty socket on my final build.

- It’s possible the current draw in Sweep mode might be reduced by increasing the value of R73. Maybe 220R or 330R might help here. I did not test this, however, since my build was already boxed by the time I thought about it.


INPUT
OUTPUT
POLYTROG
ENV_SENSE
ENV_MOD
MOD_RATE
ENV/SWP
FDBK
RATE
REG
IC10
IC1
IC2
IC3
IC4
IC5
IC6
IC7
IC8
IC9
T1
T2
VAC3
VAC2
VAC1

Note: *Drill Guides are approximate and may require tweaking depending on the types of jacks, switches and pots you use.*



IC1	4558
1	6.44
2	6.44
3	6.29
4	0
5	6.28
6	6.47
7	6.46
8	13.25

IC2	4558
1	6.4
2	6.32
3	6.28
4	0
5	6.3
6	6.33
7	6.27
8	13.25

IC3	4558
1	6.29
2	6.35
3	6.33
4	0
5	6.32
6	6.33
7	6.41
8	13.25

IC4	4558
1	6.41
2	6.36
3	6.34
4	0
5	6.33
6	6.34
7	6.3
8	13.25

IC5	4558
1	6.31
2	6.37
3	6.34
4	0
5	6.33
6	6.35
7	6.41
8	13.25

Q1	2n5088
C	varies
B	1.31
E	0.75

Q2	2n3904
C	varies
B	1.31
E	0.76

Q3	2n5088
C	varies
B	0.56
E	0

Q4	2n5087
C	~10v
B	9.8
E	~10v

Q5	2n5088
C	varies
B	~1.1
E	varies

IC6	CD4013
1	14.98
2	0
3	0
4	0
5	0
6	0
7	0
8	varies
9	0
10	varies
11	0
12	0
13	0
14	14.98

IC7	CA3140
1	ignore
2	8.17
3	varies
4	0
5	ignore
6	varies
7	15.01
8	ignore

IC8	LM324
1	5.79
2	6.98
3	6.18
4	15.01
5	7.2
6	7.01
7	6.2
8	6.8
9	6.2
10	6.2
11	0
12	6.14
13	7.01
14	6.2

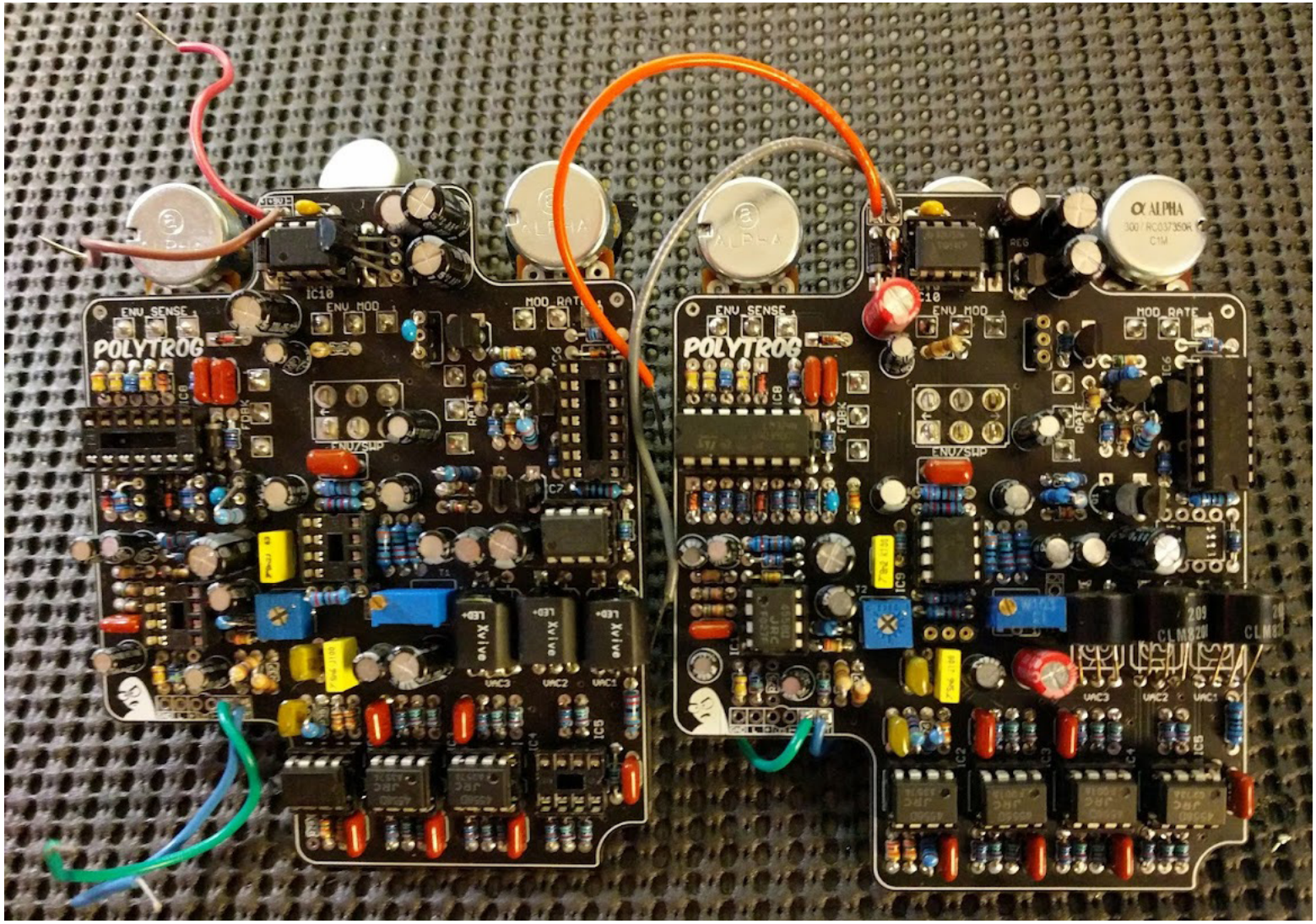
IC9	LM1458
1	varies
2	6.13
3	varies
4	0
5	6.13
6	6.14
7	varies
8	12.25

IC10	LT1054
1	1.98
2	4.89
3	0
4	0
5	0
6	2.57
7	1.34
8	9.18

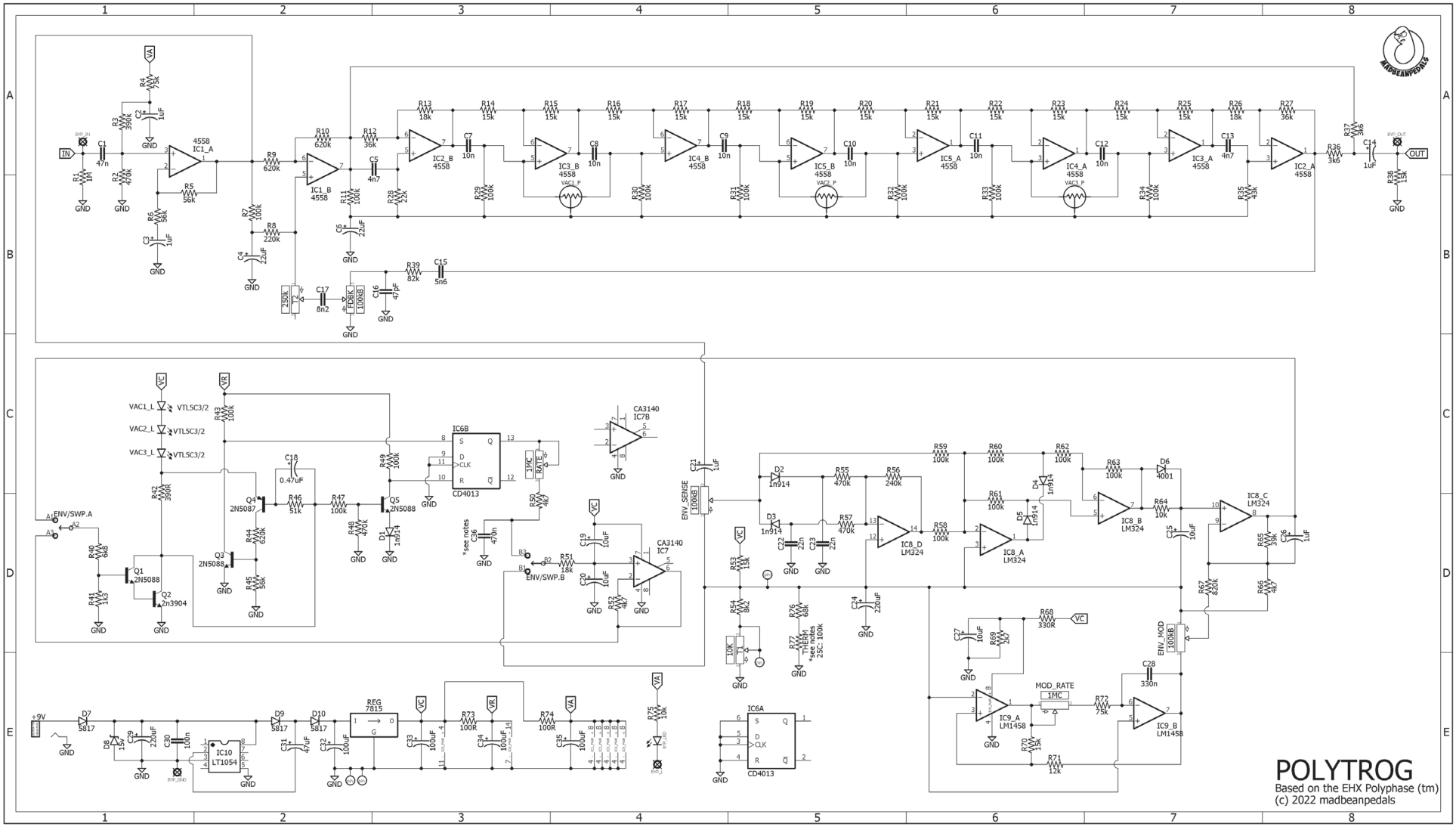
REG	78L15
I	17.11
G	0
O	15.01

- 9.42vDC Power Supply
- Current Draw: ~75 - 105mA

- Testing Conditions: All knobs CCW, switch in the right position.



On the left is the final prototype before the production PCB was made (right). The final board added the surface mount option for the CA3140. I was able to acquire the CLM optos right before my final build. It's a very tight fit since the board wasn't designed for them (the 5C3/2 fit perfectly however). Both builds are comparable but I do prefer the right one slightly more. I'll probably end up boxing the left one as well. After so many builds during the development I might as well come away with two pedals!


POLYTROG
Based on the EHX Polyphase (tm)
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