PROJECT NAME

ELYSIUM

aion DIY GUITAR EFFECTS

BASED ON
Ibanez® EM5 Echo Machine

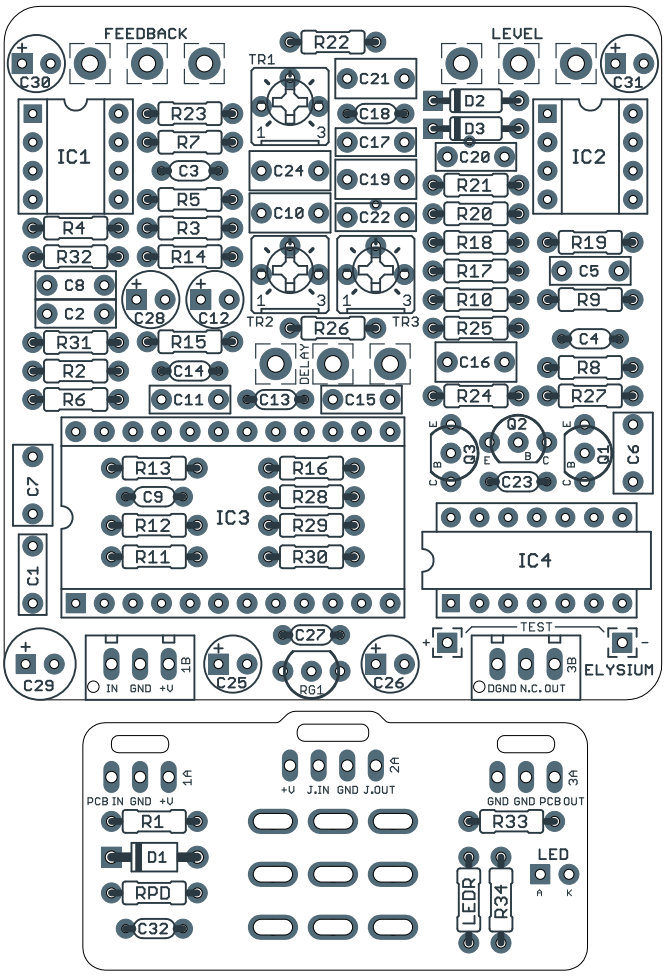
BUILD DIFFICULTY
Advanced

EFFECT TYPE
Delay

DOCUMENT VERSION
1.0.1 (2024-01-19)

PROJECT SUMMARY

An analog-voiced digital delay that emulates vintage tape echo units, with heavy filtering and a soft-clipping overdrive on the repeats.



Actual size is 2.3” x 2.42” (main board) and 1.78” x 0.86” (bypass board).

IMPORTANT NOTE

This documentation is for the **PCB-only** version of the project. If you are building the full kit from Aion FX, please use the kit build documentation instead. The instructions are more detailed and may differ in some areas due to the specialized parts and assembly methods used in our kits.

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INTRODUCTION

The Elysium Ambient Delay is an adaptation of the Ibanez EM5 Echo Machine, a late addition to the Soundtank "5 Series" produced from 1996 to 2000.

The EM5 was designed to emulate tape delay units from the 1970s. While the delay IC is technically a digital chip with an analog interface, similar to the PT2399, there is a great deal of filtering applied to the delay signal—including a diode-clipping overdrive stage, similar to the Tube Screamer—which gives it a warm, ambient, and very analog sound that adds depth and substance without getting in the way or muddying the tone, suitable for any style of playing.

Like the rest of the Soundtank series, it was generally overlooked during production, and could be found for $50-70 up until a few years ago. But it has slowly grown to mythical status, particularly after Dave Phillips of LA Sound Design brought attention to the fact that he includes it in many of his professional pedalboards and that it's his favorite always-on delay. Today, it rarely sells for less than $300.

The Elysium is an exact recreation of the EM5, except that the JFET switching has been converted to true bypass. The original EM5 was notorious for its unreliable switching, so this is a significant improvement on the Soundtank version while keeping the signal path identical.

USAGE

The Elysium has three controls:

- **Delay** (called "Speed" on the EM5) sets the delay time, going from short to long as you turn it up.
- **Feedback** (called "Repeat" on the EM5) sets the number of repeats. Due to the heavy filtering in the delay path, each repeat has degraded sound quality, especially the treble content, resulting in an ambient wash that doesn't conflict with the dry signal. Depending on how the unit is calibrated, the upper end of the Feedback range can get into self-oscillation or infinite repeats.
- **Level** sets the volume level of the delay signal. The dry signal is unaffected and always unity gain.

PARTS LIST

This parts list is also available in a spreadsheet format which can be imported directly into Mouser for easy parts ordering. Mouser doesn't carry all the parts—notably potentiometers—so the second tab lists all the non-Mouser parts as well as sources for each.

View parts list spreadsheet →

PART	VALUE	TYPE	NOTES
R1	1k	Metal film resistor, 1/4W	
R2	470k	Metal film resistor, 1/4W	
R3	47k	Metal film resistor, 1/4W	
R4	10k	Metal film resistor, 1/4W	
R5	22k	Metal film resistor, 1/4W	
R6	47k	Metal film resistor, 1/4W	
R7	47k	Metal film resistor, 1/4W	
R8	47k	Metal film resistor, 1/4W	
R9	10k	Metal film resistor, 1/4W	
R10	47k	Metal film resistor, 1/4W	
R11	22k	Metal film resistor, 1/4W	
R12	22k	Metal film resistor, 1/4W	
R13	22k	Metal film resistor, 1/4W	
R14	22k	Metal film resistor, 1/4W	
R15	30R	Metal film resistor, 1/4W	
R16	30R	Metal film resistor, 1/4W	
R17	22k	Metal film resistor, 1/4W	
R18	22k	Metal film resistor, 1/4W	
R19	33k	Metal film resistor, 1/4W	
R20	10k	Metal film resistor, 1/4W	
R21	1k	Metal film resistor, 1/4W	
R22	51k	Metal film resistor, 1/4W	
R23	75k	Metal film resistor, 1/4W	
R24	390k	Metal film resistor, 1/4W	
R25	9k1	Metal film resistor, 1/4W	
R26	390k	Metal film resistor, 1/4W	
R27	3k3	Metal film resistor, 1/4W	
R28	330R	Metal film resistor, 1/4W	
R29	5k1	Metal film resistor, 1/4W	
R30	10k	Metal film resistor, 1/4W	
R31	10k	Metal film resistor, 1/4W	
R32	10k	Metal film resistor, 1/4W	

PARTS LIST, CONT.

PART	VALUE	TYPE	NOTES
R33	470R	Metal film resistor, 1/4W	
R34	100k	Metal film resistor, 1/4W	
RPD	2M2	Metal film resistor, 1/4W	Input pull-down resistor.
LEDR	10k	Metal film resistor, 1/4W	LED current-limiting resistor. Adjust value to change LED brightness.
C1	47n	Film capacitor, 7.2 x 2.5mm	
C2	4n7	Film capacitor, 7.2 x 2.5mm	
C3	47pF	MLCC capacitor, NP0/C0G	
C4	47pF	MLCC capacitor, NP0/C0G	
C5	4n7	Film capacitor, 7.2 x 2.5mm	
C6	1uF	Film capacitor, 7.2 x 3.5mm	
C7	1uF	Film capacitor, 7.2 x 3.5mm	
C8	3n3	Film capacitor, 7.2 x 2.5mm	
C9	470pF	MLCC capacitor, NP0/C0G	
C10	1uF	Film capacitor, 7.2 x 3.5mm	
C11	100n	Film capacitor, 7.2 x 2.5mm	
C12	47uF	Electrolytic capacitor, 5mm	
C13	100n	MLCC capacitor, X7R	
C14	100n	MLCC capacitor, X7R	
C15	100n	Film capacitor, 7.2 x 2.5mm	
C16	1uF	Film capacitor, 7.2 x 3.5mm	
C17	3n3	Film capacitor, 7.2 x 2.5mm	
C18	680pF	MLCC capacitor, NP0/C0G	
C19	1uF	Film capacitor, 7.2 x 3.5mm	
C20	68n	Film capacitor, 7.2 x 2.5mm	
C21	1uF	Film capacitor, 7.2 x 3.5mm	
C22	100n	Film capacitor, 7.2 x 2.5mm	
C23	5pF	MLCC capacitor, NP0/C0G	
C24	1uF	Film capacitor, 7.2 x 3.5mm	
C25	47uF	Electrolytic capacitor, 5mm	Regulator filter capacitor.
C26	47uF	Electrolytic capacitor, 5mm	Regulator filter capacitor.
C27	100n	MLCC capacitor, X7R	Regulator filter capacitor.
C28	47uF	Electrolytic capacitor, 5mm	Reference voltage filter capacitor.
C29	100uF	Electrolytic capacitor, 6.3mm	Power supply filter capacitor.
C30	10uF	Electrolytic capacitor, 5mm	Power supply filter capacitor.
C31	10uF	Electrolytic capacitor, 5mm	Power supply filter capacitor.
C32	100n	MLCC capacitor, X7R	Power supply filter capacitor.

PARTS LIST, CONT.

PART	VALUE	TYPE	NOTES
D1	1N5817	Schottky diode, DO-41	
D2	1N914	Fast-switching diode, DO-35	
D3	1N914	Fast-switching diode, DO-35	
Q1	2N5089	BJT transistor, NPN, TO-92	Can also substitute 2N5088.
Q2	2N5089	BJT transistor, NPN, TO-92	Can also substitute 2N5088.
Q3	2N5087	BJT transistor, PNP, TO-92	Can also substitute 2N3906.
RG1	78L05	Regulator, +5V, TO-92	
IC1	LM833	Operational amplifier, DIP8	Substitute. Original used NEC µPC4570.
IC1-S	DIP-8 socket	IC socket, DIP-8	
IC2	LM833	Operational amplifier, DIP8	Substitute. Original used NEC µPC4570.
IC2-S	DIP-8 socket	IC socket, DIP-8	
IC3	M65831AP	Echo IC, DIP-24 wide	Available from Aion FX. See build notes for more information.
IC3-S	DIP-24 socket, wide	IC socket, DIP-24 wide (0.6")	See build notes for info on socket choice.
IC4	SN74HCU04	CMOS hex inverter, 6 circuit, DIP14	
IC4-S	DIP-14 socket	IC socket, DIP-14	
TR1	10k trimmer	Trimmer, 10%, 1/4"	Bourns 3362P
TR2	50k trimmer	Trimmer, 10%, 1/4"	Bourns 3362P
TR3	50k trimmer	Trimmer, 10%, 1/4"	Bourns 3362P
DELAY	50kB	16mm right-angle PCB mount pot	
FDBK.	100kB	16mm right-angle PCB mount pot	
LEVEL	100kB	16mm right-angle PCB mount pot	
LED	5mm	LED, 5mm, red diffused	
IN	1/4" mono	1/4" phone jack, closed frame	Switchcraft 111X or equivalent.
OUT	1/4" mono	1/4" phone jack, closed frame	Switchcraft 111X or equivalent.
DC	2.1mm	DC jack, 2.1mm panel mount	Lumberg NEB/J 21 C or equivalent.
FSW	3PDT	Stomp switch, 3PDT	Available from Aion FX.
ENC	125B	Enclosure, die-cast aluminum	Can also use a Hammond 1590N1.

BUILD NOTES

Sourcing the M65831 delay chip

The digital delay chip used in the EM5, the M65831AP, was first produced by Mitsubishi in the mid-1990s. Mitsubishi sold their semiconductor division to Renesas in 2003 while the chip was still in production. Because of this, you may find it under both brand names, but it's the same thing.

We've seen Renesas date codes as late as 2014, although it seems that production was somewhat limited after the 2003 sale—possibly special orders only—and most of the available stock is Mitsubishi. The only cosmetic difference between the two brands is the removal of the Mitsubishi logo.

We sourced a large quantity of unused old-stock ICs still in the original Mitsubishi packaging. They're not cheap, but they are reliable.

If you order them from somewhere else, be very careful of your source, since many sellers deal in used "pulls" from recycled electronics equipment. There's nothing inherently inferior about pulls, but they are rarely tested by the seller and have a much greater chance of being non-functional.

Installing the IC

The delay chip has eight components underneath it, seven resistors and a capacitor. The chip sits high enough in the socket that there is plenty of clearance for the capacitor if you use a small MLCC such as the one recommended in the Mouser parts list. If you use a larger ceramic disc type then you may need to fold it down over the top of R11 and R12.

In most projects you can get away with directly soldering the IC, but for this one a socket is required. It's recommended to install the IC socket before soldering R13 and R16. For some of the types of sockets we tried, the outer frame was wider than 0.1" as in a normal DIP socket, and overlapped the two resistors very slightly. If the socket is installed first, the resistors should still fit, but they'll be angled back toward C9 and R28.

However, if your socket's outer frame is even wider than the ones we tried, especially the "leaf" type, you may need to install these resistors on the underside of the PCB. Make sure to do a test fit first so you don't have to desolder anything later.

IC1 and IC2 substitutions

The original EM5 used the NEC µPC4570 for IC1 and IC2. You can use any dual op-amp here and shouldn't make much of a difference, but if you want an exact replacement, the **LM833N** is as close to identical as any two chips can be, with the same slew rate, noise figure and supply current.

Calibrating the delay range

TR2 and TR3 allow the low and high end of the delay range to be tuned for optimal performance. This is ideally done with test equipment that can measure frequency (e.g. an oscilloscope, frequency counter, or some multimeters), but it can be done by ear as well and the results are not noticeably different.

For either method, start with both trimmers at the 50% (noon) position. Set Level at full up and Feedback at 50%.

(continued on next page)

Calibrating by ear

Set Delay to minimum (shortest delay time, or fastest repeats). Adjust TR2 to preference. You can set it for a quick 30-50ms slapback delay, or go even farther and get pseudo-reverb sounds with the Feedback knob turned up.

Next, set Delay to maximum (longest delay time, or slowest repeats). Adjust TR3 to preference. The target is around 800-1000ms of delay time. At some point glitches or artifacts will start to appear in the repeats, so if you hear those then back off slightly until they go away—although if you like the sound of these artifacts, they won't cause any harm.

The two trimmers are somewhat interactive, so after adjusting TR3, turn the delay all the way down again and see if TR2 needs to be adjusted. If you do adjust TR2 a second time, go back and do TR3 again.

Typically, the 50% setting is pretty near the optimal range for both trimmers, so don't be surprised if it sounds pretty good before you adjust anything.

Calibrating by frequency measurement

Directly below IC4, there are two test pads marked "+" and "-". It's recommended to solder wires to these pads so you can easily clip probes or test leads to them. Short resistor leads will work fine.

Set Delay to minimum (shortest delay time, or fastest repeats). Adjust TR2 until the frequency on the + test point reads 4MHz. This is the factory setting for the original EM5, but it's reported that the chip works well up to 8MHz if you want a faster delay available, approaching reverb territory.

Next, set Delay to maximum (longest delay time, or slowest repeats). Adjust TR3 until the frequency reads 650kHz. Again, this is the factory setting for the original EM5, but you can go down to 450-500kHz for even longer repeats. If you hear artifacts or noise in the delay signal, turn the frequency up slightly until they go away.

Note that the frequency will likely drop slightly after the unit has been powered on for a few minutes. When we measured an original EM5, it measured 650kHz to 4 MHz across the delay range, but dropped to 625kHz and 3.8 MHz when we took a second set of measurements a bit later.

These are both well within normal operating range, so this behavior won't normally make a difference. But if you've trimmed out the artifacts and you notice they reappear once the unit warms up, then just trim them out again and they should stay out this time.

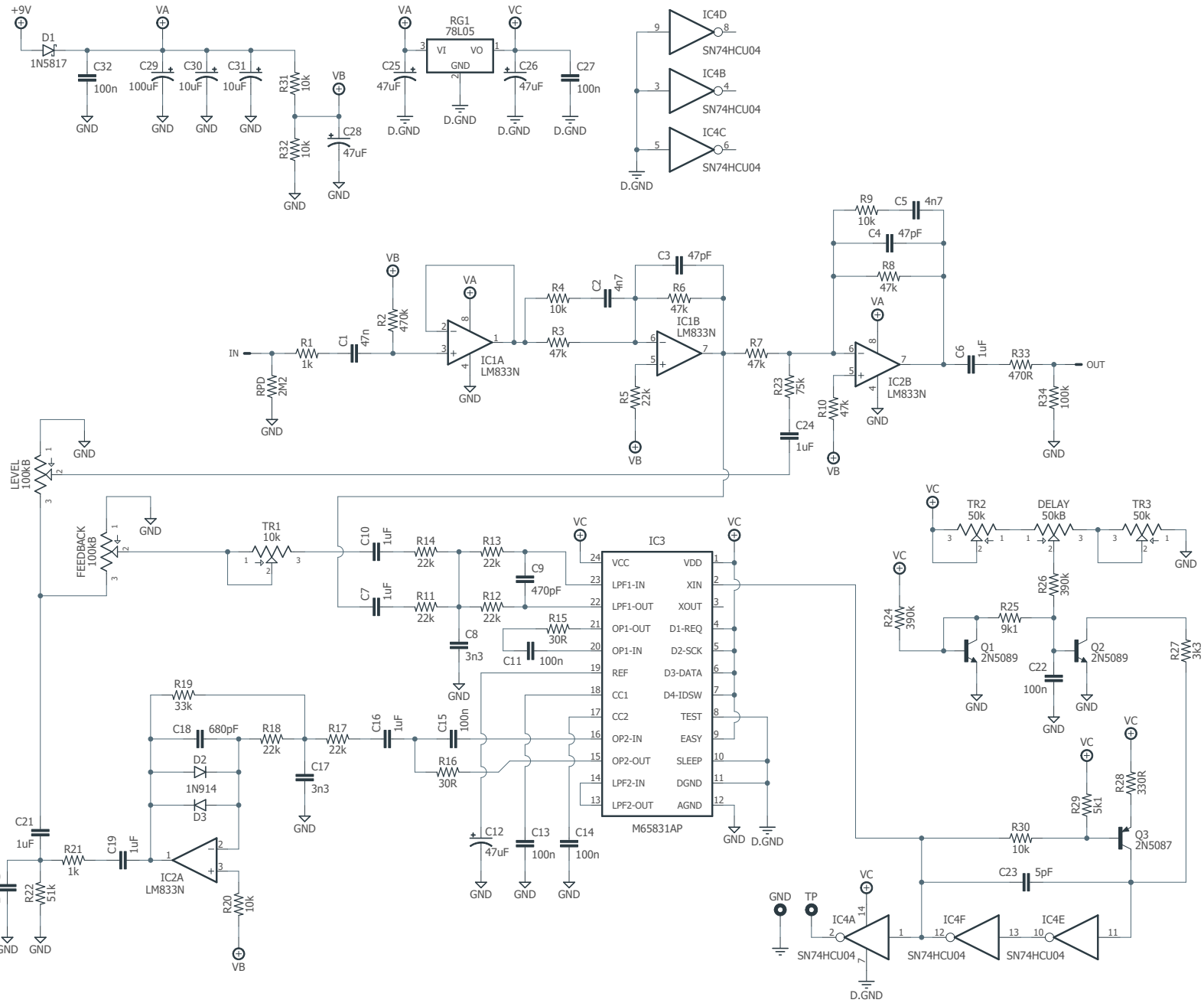
Setting the feedback (repeats) range

The maximum range of the feedback control is set by the TR1 trimmer. Begin by setting it to the 50% (noon) position, and set the Feedback knob to maximum.

On the original EM5, the repeats knob was set to maximize feedback without reaching self-oscillation or infinite repeats. So to match this, turn TR1 while listening for the point of self-oscillation, and then turn the trimmer down slightly once you get there.

Some people like infinite repeats in a delay, so if you want this sound available at the upper end of the range, feel free to set the trimmer a little higher. It won't cause any problems.

SCHEMATIC


+9V
D1
1N5817
VA
C32
100n
C29
100uF
C30
10uF
C31
10uF
R31
10k
R32
10k
VB
C28
47uF
GND
VA
RG1
78L05
VI
VO
GND
VC
C25
47uF
C26
47uF
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IC4C
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1k
C1
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R2
470k
IC1A
LM833N
RPD
2M2
R4
10k
C2
4n7
R3
47k
C3
47pF
R6
47k
IC1B
LM833N
R5
22k
R7
47k
R9
10k
C5
4n7
C4
47pF
R8
47k
IC2B
LM833N
C6
1uF
R33
470R
OUT
R23
75k
C24
1uF
R10
47k
R34
100k
LEVEL
100kB
FEEDBACK
100kB
TR1
10k
C10
1uF
C7
1uF
R14
22k
R11
22k
R13
22k
R12
22k
C9
470pF
C8
3n3
R15
30R
C11
100n
IC3
VCC
LPF1-IN
LPF1-OUT
OP1-OUT
OP1-IN
REF
CC1
CC2
OP2-IN
OP2-OUT
LPF2-IN
LPF2-OUT
VDD
XIN
XOUT
D1-REQ
D2-SCK
D3-DATA
D4-IDSW
TEST
EASY
SLEEP
DGND
AGND
M65831AP
TR2
50k
DELAY
50kB
TR3
50k
R24
390k
R26
390k
R25
9k1
Q1
2N5089
Q2
2N5089
C22
100n
R27
3k3
R19
33k
C18
680pF
D2
1N914
D3
R18
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R17
22k
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1uF
C15
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R16
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C17
3n3
C12
47uF
C13
100n
C14
100n
C21
1uF
R21
1k
C19
1uF
IC2A
LM833N
C20
68n
R22
51k
R20
10k
R28
330R
R29
5k1
Q3
2N5087
R30
10k
C23
5pF
TP
IC4A
IC4F
IC4E
SN74HCU04

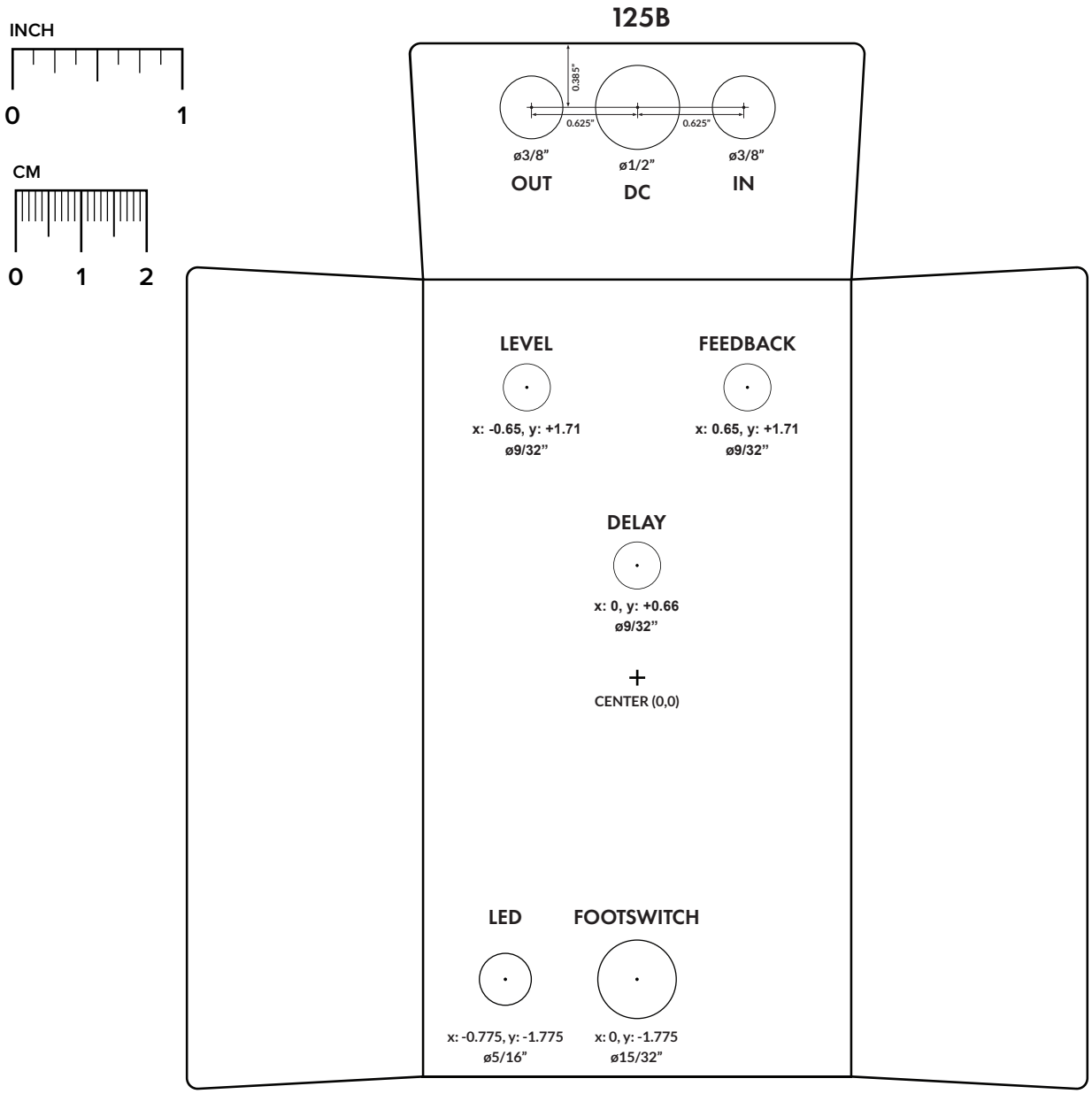
DRILL TEMPLATE

Cut out this drill template, fold the edges and tape it to the enclosure. Before drilling, it's recommended to first use a center punch for each of the holes to help guide the drill bit.

Ensure that this template is printed at 100% or "Actual Size". You can double-check this by measuring the scale on the printed page.

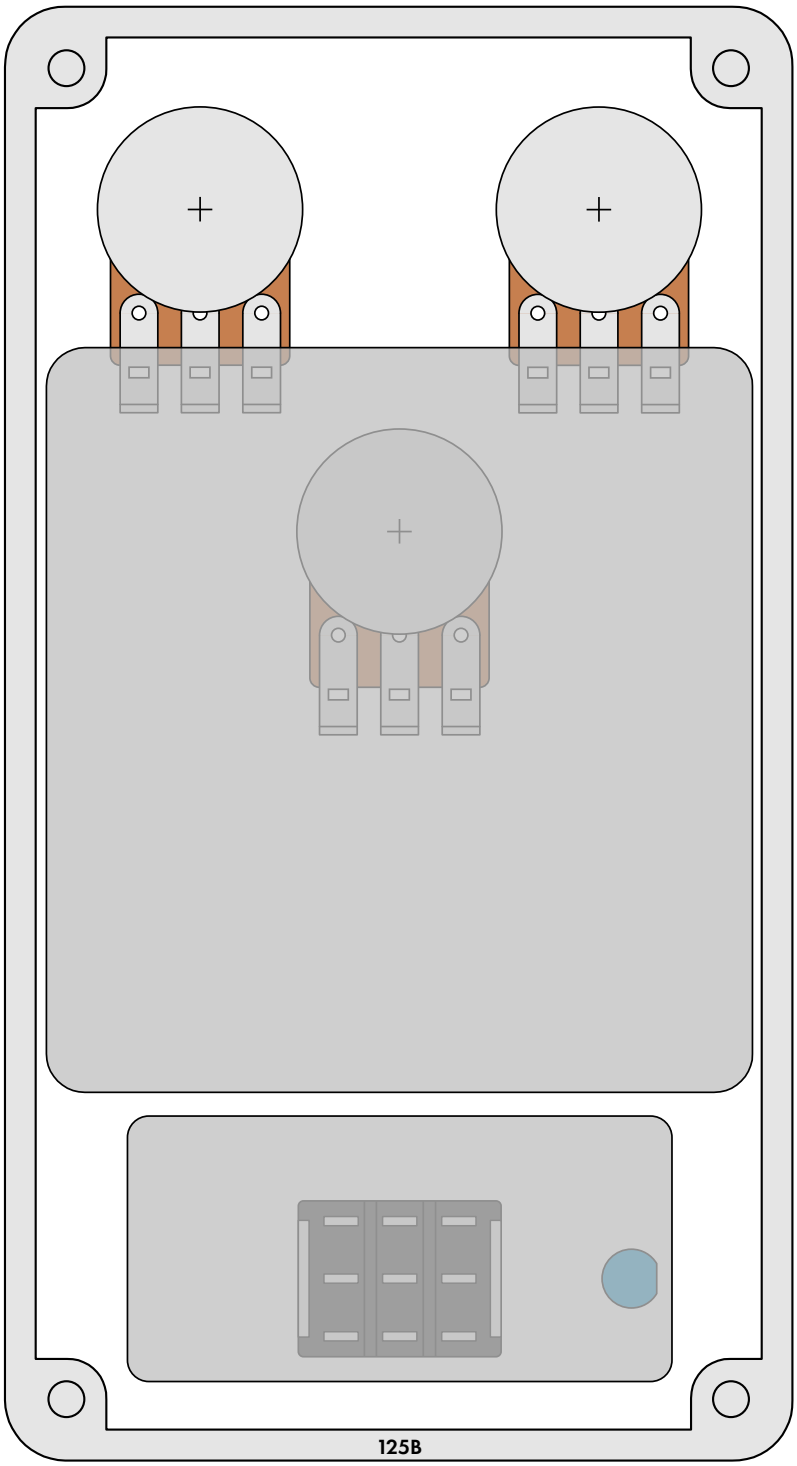
Top jack layout assumes the use of closed-frame jacks like the Switchcraft 111X. If you'd rather use open-frame jacks, please refer to the Open-Frame Jack Drill Template for the top side.

LED hole drill size assumes the use of a 5mm LED bezel, available from several parts suppliers. Adjust size accordingly if using something different, such as a 3mm bezel, a plastic bezel, or just a plain LED.

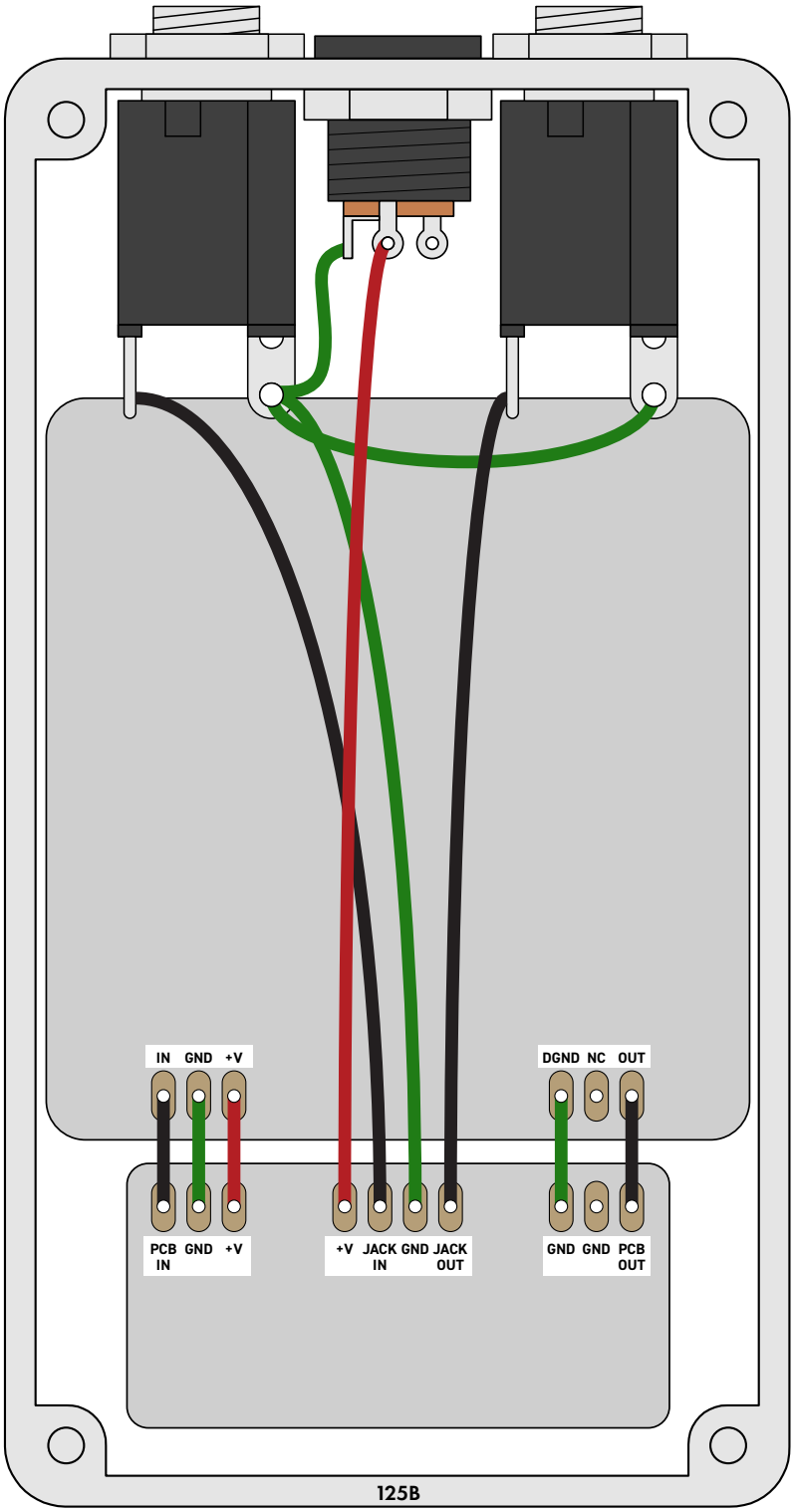


ENCLOSURE LAYOUT

Enclosure is shown without jacks. See next page for jack layout and wiring.



WIRING DIAGRAM



LICENSE & USAGE

No direct support is offered for these projects beyond the provided documentation. It's assumed that you have at least some experience building pedals before starting one of these. Replacements and refunds cannot be offered unless it can be shown that the circuit or documentation are in error.

All of these circuits have been tested in good faith in their base configurations. However, not all the modifications or variations have necessarily been tested. These are offered only as suggestions based on the experience and opinions of others.

Projects may be used for commercial endeavors in any quantity unless specifically noted. No attribution is necessary, though a link back is always greatly appreciated. The only usage restrictions are that **(1) you cannot resell the PCB as part of a kit without prior arrangement**, and **(2) you cannot "goop" the circuit, scratch off the screenprint, or otherwise obfuscate the circuit to disguise its source**. (In other words: you don't have to go out of your way to advertise the fact that you use these PCBs, but please don't go out of your way to hide it. The guitar effects industry needs more transparency, not less!)

DOCUMENT REVISIONS

1.0.1 (2024-01-19)
Changed LEDR to 10k to reduce LED brightness. Added information to build notes about sourcing the M65831 delay chip.

1.0.0 (2022-09-24)
Initial release.