Twin Coil Driver

Revision 1.0 February 22, 2021

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Revision History

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1 INTRODUCTION

Introduction

This document describes the Twin Coil Driver and how to assemble and install it.

A lot of people have told us that the last thing MRCS (think Arduino and similar "high tech" components) would be doing is working with ancient Twin Coil switch machines. However, we do a lot of custom work, including towers and staging controllers, and some of our clients have existing twin coil machines in place, and one (an old friend in the Coast Division) has a huge hoard of them under his layout, so we designed this interface to support those applications. Twin Coil Machines present some challenges:

- They tend to slam the points into the stock rails, eventually damaging the soldered connection to the throw bar, rip the points off PC Board throw bars, and break or loosen the spikes or solder holding the stock rails down.
- They make a lot of electrical noise when power is removed from the coils, which gets into nearby electronics, sometimes causing false operation.
- The coils can overheat and become damaged, if not catch fire, if current is applied for an extended period.
- In the past, Capacitive Discharge (CD) supplies were used to make an affordable supply that would protect the coil by not recharging while connected and limiting the constant current in case the controls failed and permanently connected the coil.

Our design drives both “mild” (Atlas, Bachmann, Lifelike, Peco) and "nasty" (PFM, Tenshodo, Ken Kidder, NJ International) Twin Coil type machines. The Twin Coil Driver (TCD) shapes the pulses driving the switch machines to soften both the physical and electrical blow, reducing physical impact and electrical noise. Pulse timing is done in hardware (so there’s no chance of a software hang leaving power on). The TCD works with CD power supplies as well as modern power supplies such as those used for LEDs, or inexpensive bench supplies.

The Twin Coil Driver has internal spike suppression (“snubber”) diodes. Input is logic level and the coils are fired on the rising and falling edge, so a simple toggle switch or logic level input can control the interface.

This circuit board has:

- An on-board regulator to drop 12V layout auxiliary bus power to 5 logic (you can omit the is building your own, but it does provide additional protection against noise).
- On-board LEDs for indicating when the board sending pulses to each coil.“Snubber” diodes to protect against reverse voltage surges when
- The Twin Coil Driver operates from 12V and draws about 3 mA idle.
- The Twin Coil Driver uses standard semiconductors available from Jameco, Digikey and similar suppliers.
- Provides a 1 second pulse to operate the coils
- Open drain active low outputs momentarily sinks up to 2A at 40V

All components are through-hole technology for ease of assembly and repair.

External connection pads are on 3.5mm centers.

2 IDENTIFICATION AND INFORMATION

2.1. BOARD IDENTIFICATION

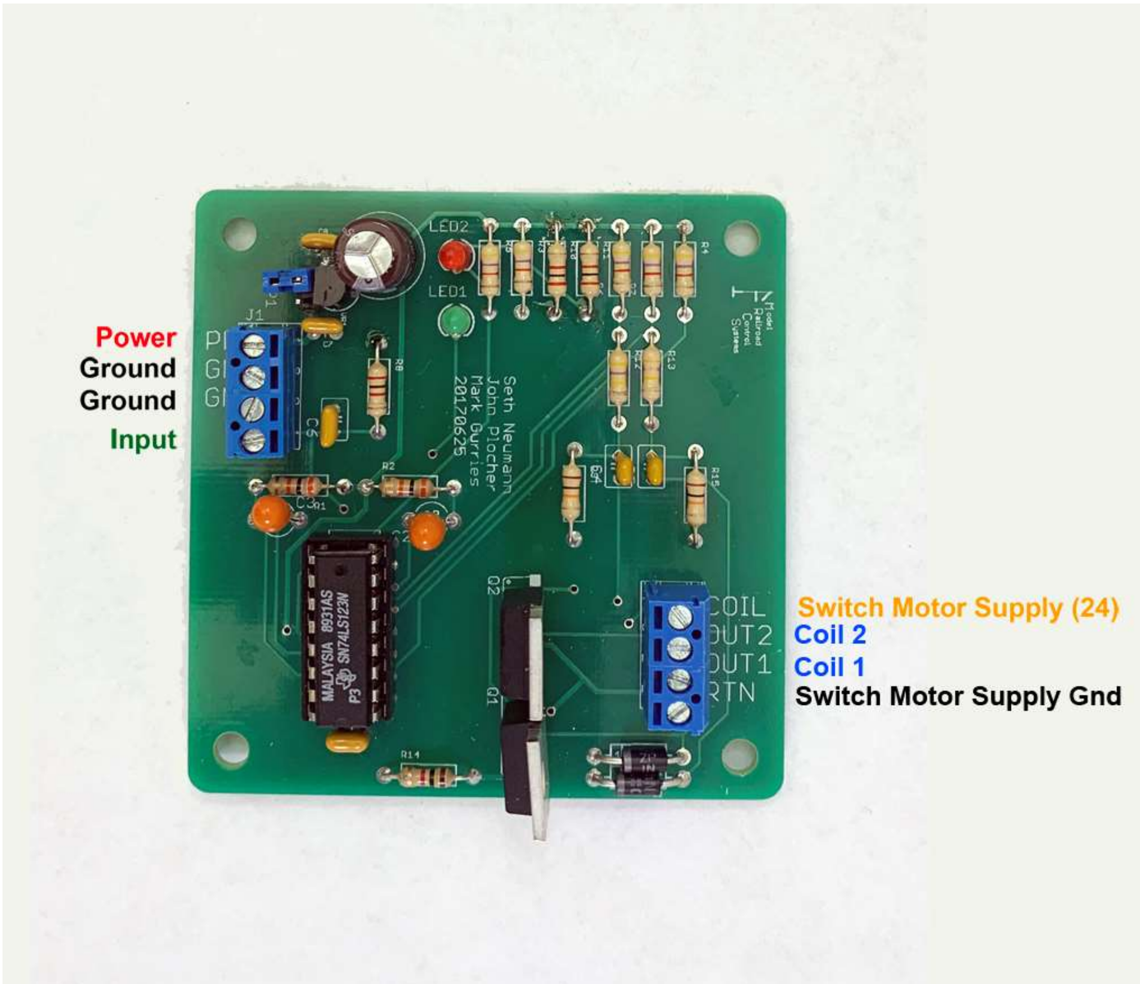

Figure 1 - Rev 3.0 (20170625) Board

Qty	Value	Device	Package	Parts	Description
1		BOARD69X70	BOARD-DINRAIL-2.7INX7CM	BOARD1	
2	.022 uF	C-US025-030X050	C025-030X050	C4, C5	CAPACITOR Monolithic .022 @ 50V 223
4	0.1uF	C-US025-030X050	C025-030X050	C1, C6, C7, C8	Capacitor - Monolithic 0.1 (104) @ 50V
2	10 uF Tant	CPOL-USE5-4	E5-4	C2, C3	POLARIZED CAPACITOR, American symbol
1	100uF	CPOL-USE3.5-10	E3,5-10	C9	POLARIZED CAPACITOR, American symbol
1	1K	RESISTORPTH-1/4W	AXIAL-0.4	R14	Resistor 1K 1/4W
2	10K	RESISTORPTH-1/4W	AXIAL-0.4	R9, R15	Resistor 10K 1/4W
2	1N4001	DIODEPTH	DIODE-1N4001	D1, D2	Diode 1N4004
3	2K	RESISTORPTH-1/4W	AXIAL-0.4	R8, 10,11	Resistor 2K 1/4W
2	30K	RESISTORPTH-1/4W	AXIAL-0.4	R1, R2	Resistor 30K 1/4W
5	4.7K	RESISTORPTH-1/4W	AXIAL-0.4	R3, R4, R5, R6, R7	Resistor 4.7K 1/4 W
2	470K	RESISTORPTH-1/4W	AXIAL-0.4	R12, R13	Resistor, 470K 1/4W
1	78L05	V_REG_78L05	TO-92	VR1	Voltage Regulator
1	74LS123N	74LS123N	DIL16	IC1	Re-triggerable monostable MULTIVIBRATOR
2	Input, output	4 pos 3.5mm screw	4 pos 3.5mm screw	J1, J2	4 position 3.5 mm
1	socket	16 pin DIP	16 pin DIP	IC1-s	16 pin DIP socket
1	No Regulator	JUMPER-2PTH_LOCK	1X02_LOCK	JP1	Jumper
2	RFP12N10L	RFP12N10L	TO220BV	Q1, Q2	N-CHANNEL MOS FET
1	red	LED3MM	LED3MM	LED1	LED Green
1	green	LED3MM	LED3MM	LED2	LED Red

Table 1- Bill of Materials Rev 3.0

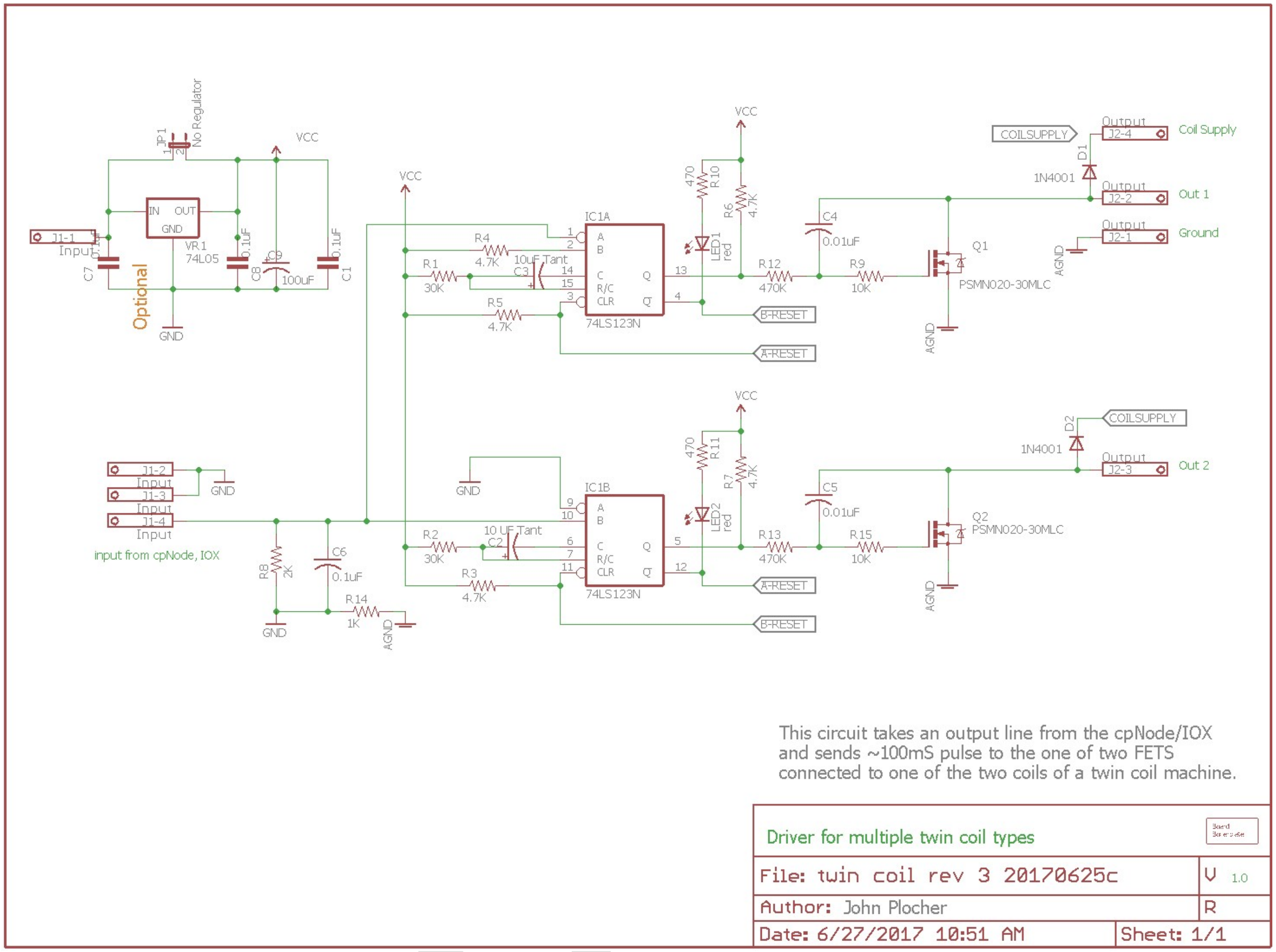

Figure 2 - Rev 3 Schematic

3 THEORY OF OPERATION

The Twin Coil Driver uses the venerable 74LS123 Dual Re-Triggerable Monostable Multivibrator https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwiFnNPXvP7uAhUGbc0KHYg3CB4QFjABegQIARAD&url=https%3A%2F%2Fwww.ti.com%2Flit%2Fgpn%2FSN54123&usg=AOvVaw2OBNbpGtIl8lUgvUmSXYhh (search on 74LS1223 data sheet) to develop a timed pulse on two outputs (one for each of the "twin" coils. Pulse width is set by R1/C3 for the rising edge and R2/C2 for the falling edge. You can adjust these values within wide limits (see also Designing with the 74LS123 https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwiFnNPXvP7uAhUGbc0KHYg3CB4QFjAAegQIBBAD&url=https%3A%2F%2Fwww.ti.com%2Flit%2Fpdf%2Fsdla006&usg=AOvVaw290aZH5QJTiBbbsXwO7Xow)

(Search on "Designing with the 74LS123")

The respective outputs (Pin 13 for the upward edge and Pin 3 for the downward edge) are coupled to high power FETs and drive the indicator LEDs. Other than the timing capacitors being tantalum, there is no magic to any of these components. Any handy N-channel MOS FET in a TO-220 package should do. If you are using a "mild" switch machine (most newer machines designed for N scale turnouts) you can probably get away with a smaller FET but check that the maximum drain current and voltage are compatible with your motor and power supply.

The output pulse will operate the twin coil machine and shut off before it can overheat. The board can be used in many "One Shot" applications: in one case we used it to operate relay to deliver a 3 second burst of ringing voltage to a telephone bell, this might also be used for an approach bell in an interlocking plant.

4 OPTIONS

4.1. TIMING

Pulse length is set by R1/C3 for the rising edge and R2/C2 for the falling edge. You can adjust these values within wide limits

(see also "Designing with the 74LS123" by Texas Instruments. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwiFnNPXvP7uAhUGbc0KHYg3CB4QFjAAegQIBBAD&url=https%3A%2F%2Fwww.ti.com%2Flit%2Fpdf%2Fsdla006&usg=AOvVaw290aZH5QJTiBbbsXwO7Xow

)

4.2. OUTPUT TRANSISTORS

I used Jameco part 787798, Fairchild RFP12N10L but any comparable N-Channel power MOSFET in a TO220 package will do. This is a "whatever is handy on the workbench" part.

4.3. PROTECTION DIODES

D1 and D2 are provided as snubbers to short out reverse spikes caused by collapsing magnetic fields on the solenoid coils. They are not required (but won't hurt) if there are existing snubbers in place across the coils.

4.4. OTHER CHANGES

This is a fairly low-volume board and is usually built to order. If you'd like a different layout, different connectors or a custom build, please contact us at sales@modelrailroadcontrolsystems.com. You can also follow the links on the product page to my Github page and download the EAGLE CAD files and make your own modifications subject to the Creative Commons License. We'd love to see what you come with!

5 DETAILED ASSEMBLY

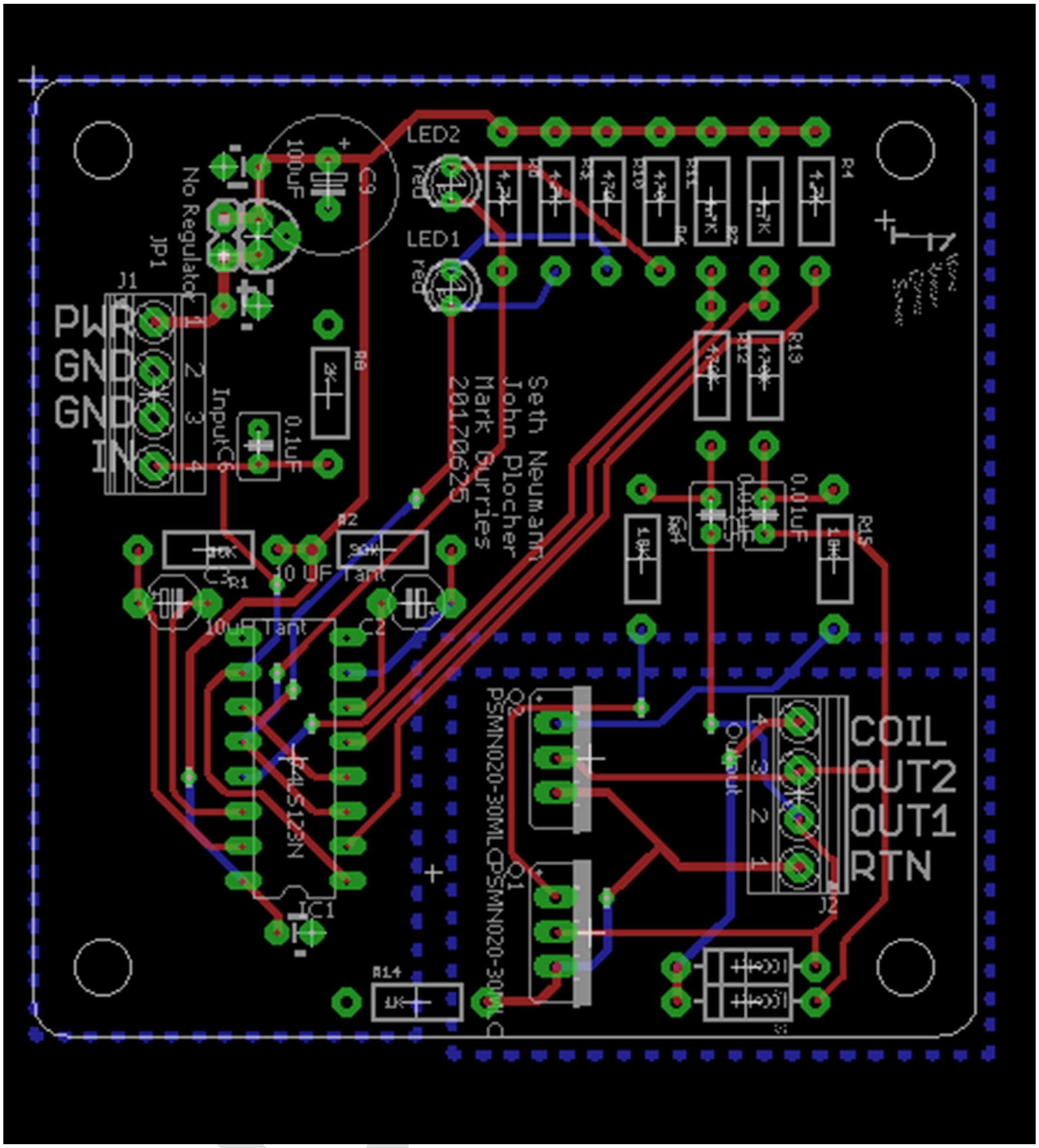

Figure 3 - Rev 3 Board Layout

All of the components are through-hole technology with wire leads. A lead bender is a useful tool is for forming the leads at 90 degrees for easy insertion into the pad holes. The general rule is installing the lowest components first, working towards components that are higher off the board. Start by inserting the lower height components (resistors and diodes). This helps you support the low components as you solder them from the bottom of the board. A small piece of cardboard may be placed over the component side as you flip it over to solder. I use thin (.015) solder to help control the amount of solder on the work.

[ ] Resistors, Diodes

[ ] Install Resistors R1 through R15. Try to keep the gold tolerance band on the right side or bottom for easier reading of values. Note that some values on the board are different from the BOM, I suggest using the BOM values.

[ ] Install diodes D1,D2 observe polarity. (You may omit these if the load already has snubbing diodes Installed – see options above)

[ ] IC Socket U1

[ ] install U1, notch pointing down in the layout above.

[ ] **LEDs LED1, LED2**

Install the LEDs observing polarity, they don't have to be different colors but I find it easier to see which is which when troubleshooting in the field when the colors are different.

[ ] Monolithic Capacitors

[ ] Install the .022 uF caps C4, C5

[ ] Install the .01 uF caps C1, C6, C7, C8

[ ] Voltage Regulator VR1

[ ] Install the 78L05 regulator – note if you will be powering from a local 5V source, you can omit the regulator and use a jumper on JP1 or just wire across the terminals of JP1. See options above.

[ ] Screw Terminals J1,J2

Install 3.5mm screw terminals J1, J2

[ ] Input Jumper JP1

Install JP1 - Used if no VR1 or if you want handy tie points for input power and +5

[ ] Tantalum Capacitors C2, C3

[ ] Install C2,C3, observe polarity

[ ] Electrolytic Capacitor C9

[ ] Install Electrolytic capacitor C9 100 uF @ 50V, observe polarity

[ ] Output Transistors Q1, Q2

[ ] Install Power N channel MOSFETs with the exposed metal fins to the bars on the silk screen.

[ ] **Integrated Circuit U1**

You may want to power up and check that there is 5V on pin 16 (lower left) before
[ ] insert the 74LS123.

[ ] Clean the board

I clean excess flux and bits of solder off with 91% isopropyl alcohol and an old toothbrush. If you have an ultrasonic cleaner, use it, in A WELL-VENTILATED AREA, do not breath fumes or put your hands in the bath with the cleaner on. If there is still a residual layer of scuzz, use the ultrasonic with distilled or RO water and soap and rinse. I've also had good luck with the top rack of the dishwasher.

6 TESTING

Testing your Twin Coil Driver:

1. Mount the board securely on standoffs or in a piece of our 7CM DINRail (Tyco Track)
2. Apply positive voltage (7.5-15 VDC) between PWR (+) and one of the GND terminals on J1 on the upper left of the board. Check that 5V is appearing on pin 16 of U1.
3. Remove power while completing Twin Coil Motor connections
4. Connect your motor's common lead (or one side of each coil) to your power supply + and run a jumper (22 Ga or larger) to the "Coil" terminal on J2 of the TCD.
5. Connect the other ends of the coils to Out 1 and Out 2 of J2 respectively.
6. Run a jumper from the supply ground to the RTN (return) terminal on J2.
7. Make a test jumper with a 4.7K resistor (or 10K it isn't critical) to the 5V terminal (top) on JP1and touch the "IN" terminal on J1. The twin coil should operate, and the green LED should flash. Remove the jumper from IN and the other coil should operate, and the red LED should flash.

7 INSTALLATION AND CONNECTIONS

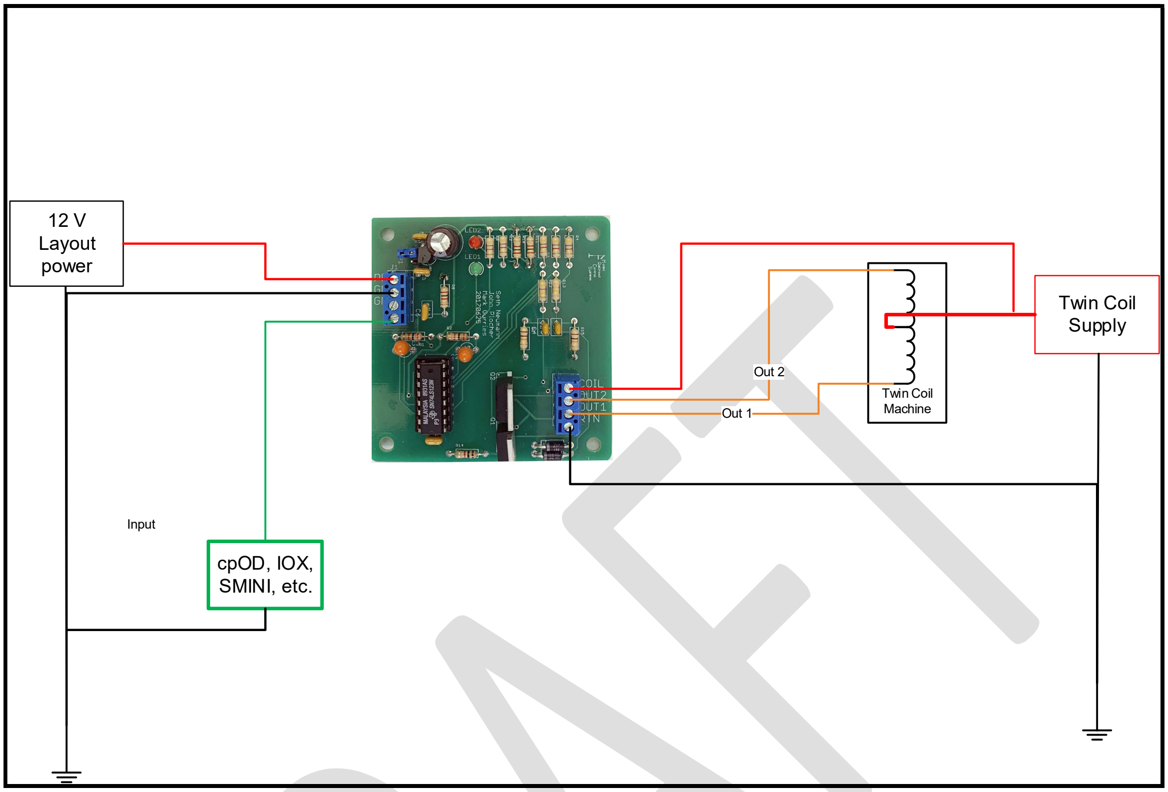

Figure 4 - Twin Coil Driver Connections

The Installation process is like the test procedure described above:

1. Mount the board securely on standoffs or in a piece of our 7CM DINRail (Tyco Track)
2. Apply positive voltage (7.5-15 VDC) between PWR (+) and one of the GND terminals on J1 on the upper left of the board. Use at least 22 Ga wire.
3. Connect your motor's common lead (or one side of each coil) to your power supply + and run a jumper (22 Ga or larger) to the "Coil" terminal on J2 of the TCD.
4. Connect the other ends of the coils to Out 1 and Out 2 of J2 respectively.
5. Run a jumper from the supply ground to the RTN (return) terminal on J2.
6. Wire the input to either a pushbutton (pull up to 5V through a 4.7K – 10K resistor) or to an Arduino such as a cpNode, IOX or other logic level output. If using an open collector output like an SMINI or DOUT, you may need a pull up as used for a push button.