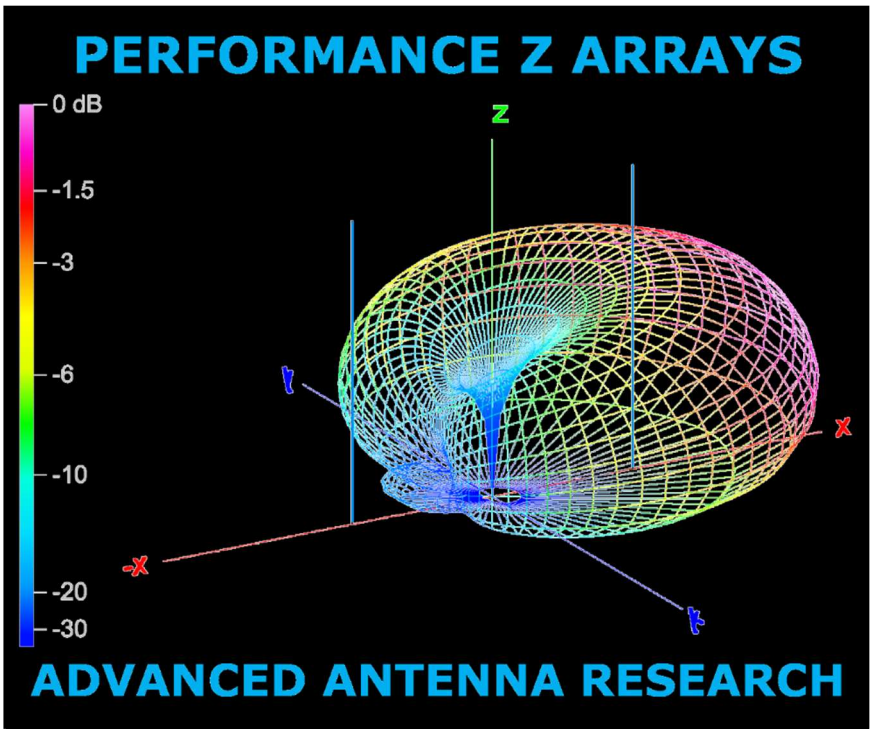


2 Element Phased Vertical Array

Phasing Relay Network and Controller Kit

Version 1.2 May 28, 2025

WARNING!

THIS IS AN EXPERIMENTAL RF KIT

WARNING: This is an experimental RF communications kit. Misuse or the failure to follow construction instructions of this kit may result in serious injury or death. Remember to follow all instructions precisely for the assembly of this kit. Remember to follow all RF EXPOSURE GUIDELINES as established by the Federal Communications Commission (FCC).

INSTALLATION OF ANY ANTENNA NEAR POWER LINES IS DANGEROUS

WARNING: Do not locate or construct antennas near overhead power lines, lighting poles, underground power lines or other power distribution devices, or where they may contact such devices. Serious injury or death can result from antennas or feedlines contacting such devices. Before digging be sure to have all utilities located (In the USA call 811).

Before beginning any work check for power lines. Check for clearances for ladders, long tools, etc. Never assume the purpose of a line is for telephone or cable. Remember to keep clear of ALL overhead lines, at a minimum of 10ft.

DO NOT SWITCH UNDER LOAD

WARNING: **DO NOT** switch directions of the array while transmitting. Switching under load may cause damage to the unit, your equipment and may cause injury or death.

POWER RATING

The components of this kit are rated to handle full US legal limit power, the completed assemblies will handle 1500wattts SSB, CW and 100 watts in digital modes.

TABLE OF CONTENTS

PERFORMANCE Z ARRAYS

2 Element Vertical Array Phase Network and Controller Kit

Gen 3 – April 2025 Version 1

ABOUT THIS KIT:

This kit is based on the Christman method of phasing invented by Alan Christman, K3LC and was popularized in ON4UN's Jon Devoldere's book "Low Band DX'ing." See page 11-83 in the 5th edition of the book, published by the ARRL. This kit is not a new antenna or phasing design, it is simply a refinement of the design and made for the beginner, intermediate or seasoned amateur for ease of construction. This kit includes printed circuit boards, relays, SO-239 connectors, enclosures, and other components to build a relay unit and controller for a 2-element end-fire and broadside vertical phased array. When constructed properly this kit along with 2 vertical antennas, radials, feedlines, delay line and control lines can be used as a 2-element phased array to produce gain and provide good signal isolation in one of two directions and provide a lower gain omni-directional pattern.

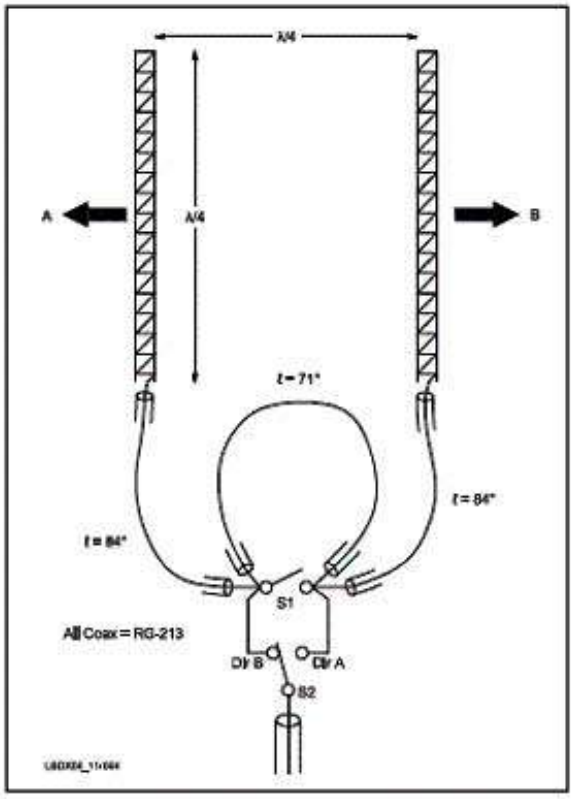


Fig 11-44—The 2-element vertical array (λ/4 spacing) can be fed in-phase to cover the broadside directions. I added switch S1 to the Christman feed system as described in Fig 11-8. When S1 is closed, both antennas are fed in-phase, resulting in bi-directional broadside radiation.

IS THIS KIT FOR YOU?

Some considerations when choosing to purchase this kit. The kit is designed for Amateur Radio and RF Hobbyists. It can be used for experimentation in RF transmission theory, Amateur Radio communications, an educational tool and a skill building tool.

It requires some basic understanding of:

A. electromagnetic radiation
B. radio frequency transmission.
C. arithmetic
D. basic circuitry

It requires some basic skills:

A. Soldering
B. Wiring
C. Coaxial Cable Terminations
D. Use of Volt Ohm Meter
E. Use of VNA (nano-VNA), SWR meter or other Impedance Measuring Device
F. Vertical Antenna Construction

The space required to erect the antenna system will depend on the desired wavelength of operation. Please consider the entire system including the radial systems, required guys, and plus an additional 10 ft of space for safety. Low band operations 160m, 80m and 40m will require quite a large space.

The area for the installed system should be as level as possible for the best performance. The area around the array should be reasonably clear of obstructions (buildings, vehicles, etc.) and metal construction for at least 1 wavelength of the operating frequency. Trees and shrubs, in general, will not affect the performance.

The performance of this array kit will vary depending on ground conditions, antenna construction, accuracy in building feed and delay lines and the assembly of the kit. **No performance guarantees are implied for this kit.**

Balance of page intentionally left blank.

PARTS CHECKLIST

ITEM	PART NUMBER	DESCRIPTION	QTY	Bag # / Box	CK
1	PZA-V2G3CTRLPCB	Controller Circuit Board	1	Master 1	
2	PZA-2T-20A5P-BETB	2-Pin Terminal Strip	1	Cntrl SB2	
3	PZA-4T-20A5P-BETB	4- Pin Terminal Strip	1	Cntrl SB2	
4	PZA-6T-20A5P-BETB	6-Pin Terminal Strip	3	Cntrl SB2	
5	PZA-8T-20A5P-BETB	8- Pin Terminal Strip	1	Cntrl SB2	
6	PZA-106-150-55ENC	Controller Enclosure	1	Box	
7	PZA-CTRLFC	Controller Front Panel	1	Master 1	
8	PZA-CTRLRC	Controller Rear Panel	1	Master 1	
9	PZA-3MCHX5MM	M3X6MM cap head screw	8	Master 1	
10	PZA-22MM-SLC3WLED	22mm LED 3Way Switch	1	Cntrl SB3	
11	PZA-22MM-SWSOCK	22mm switch socket	1	Cntrl SB4	
12	PZA-16MM-PWR-LED	16MM LED Push Button Switch	1	Cntrl SB3	
13	PZA-12V3MMLED	12v 3mm LED with leads	3	Cntrl SB1	
14	PZA-5MMLEDSOK3MM	12v 5mm socket for 3mm led	3	Cntrl SB1	
15	PZA-5.5x2.1-12MM-SOC	Power Socket 12mm with plug tail	1	Cntrl SB4	
16	PZA-2211-Rd	22AWG Stranded Wire -Red	12"	Cntrl SB4	
17	PZA-2211-Bk	22AWG Stranded Wire -Black	12"	Cntrl SB4	
18	PZA-2211-Bl	22AWG Stranded Wire -Blue	12"	Cntrl SB4	
19	PZA-2211-Wh	22AWG Stranded Wire -White	12"	Cntrl SB4	
20	PZA-2211-Gn	22AWG Stranded Wire -Green	8"	Cntrl SB4	
21	PZA-2211-Bn	22AWG Stranded Wire -Yellow	8"	Cntrl SB4	
22	PZA 4INTW	4" Tie wraps	5	Master 2	
23	PZA-M3x10SP	3mmx10mm spacer	4	Master 2	
24	PZA-3X6PHS	3mmX6MM Screw	8	Master 2	
25	PZA-V2G3RELAYPCB	Relay Circuit Board	1	Master 2	
26	PZA-16ASPST-RTD	SPST Delay Line Bypass Relay (RTD-34012F)	1	Relay SB 1	
27	PZA-16ASPDT-RTD	SPDT Direction Selection Relay (RTD14012F)	1	Relay SB 1	
28	PZA-1A-400V-4001	Diodes 1N4004	2	Relay SB 1	
29	PZA-CAP100PF3KV	100pf 3KV capacitor	2	Relay SB 1	
30	PZA-632.5-18-8	#6-32X.5" Pan Head Machine Screw (m3.5-0.6 X10mm)	3	Master 2	
31	PZA-SO-238PM(RM)	SO-239 Bulkhead Connector	5	Relay SB 2	
32	PZA-AC6P16MMP	16mm 6Pin Aviation Connector Female Plug	2	Master 2	
33	PZA-AC6P16MMS	16mm 6Pin Aviation Connector Male Socket	2	Master 2	
34	PZA-16MM-GROM	16mm Rubber grommet	2	Master 2	
35	PZA-5MM-912VLED	5MM LED	3	Relay SB 1	
36	PZA-ENC-9X9X4	9X9X4 UV-rated Junction box with cable entry	1	Box	
37	PZA - 08PCBMNT	Aluminum mounting bracket for Relay PCB	1	Box	
38	PZA – QD.250M	Quick Disconnect .250” Male	2	Master 2	
39	PZA – QD.250F	Quick Disconnect .250” Female	2	Master 2	

ADDITIONAL PARTS NOT INCLUDED FOR A FUNCTIONING ARRAY

- Two quarter-wave ground mounted vertical antennas for the intended band of operation.
- Radial wire, plates, bonding strap and connecting hardware for both vertical antennas.
- Feed point connections for the vertical antennas.
- Two 84deg 50Ω (RG-213U or equivalent) * feedlines properly constructed for the intended frequencies of operation.
- One 71deg 50Ω (RG-213U or equivalent) * delay properly constructed for the intended frequencies of operation.
- One 50Ω feedline (RG-213U or equivalent) * from the transceiver to the relay enclosure
- 6 conductor control cable (minimum of 22AWG (.64mm), maximum of 20AWG (.8mm)) from the array controller to the relay enclosure
- Electrical tape and weatherproofing tape for the coax connections
- 1 “to 2” diameter mounting pipe for mounting the relay enclosure and properly sized pipe mount hardware.
  ***For low power applications RG-8X, RG-240, or M&P Ultraflex 7 can be used for feedlines and delay lines.**

Pre-made Dealy line and feedline cables for 20m (centered 14.175MHz) and 40m (centered on 7.100MHz) are available from Performance Z Arrays

- **P/N: PZA – 20M Cable Kit - contains 2 X 84^{o} feedlines (14.175MHz) and 1 X 71^{o} delay line (14.175MHz)**
- **P/N: PZA – 40M Cable Kit – contains 2 X 84^{o} feedlines (7.100MHz) and 1 X 71^{o} delay line (7.100MHz)**

6 Conductor 22awg West Penn aqua-seal Control Cables are available from Performance Z Arrays, as well as lengths of the 22awg 6c Aqua-seal cable by the foot.

- **P/N: PZA-22-611-AS – priced per ft.**
- **P/N: PZA-226-50 – 50ft pre-made Control Cable terminated with GX16-6P plugs**
- **P/N: PZA-226-100 - 100ft pre-made Control Cable terminated with GX16-6P plugs**

Suggested Sources for other parts that are not included.

DX Commander Dual Vertical Array Kit available from DX Commander

P/N: XXXXXX

P/N: XXXXXX

Theory of Operation for the 2-Element Vertical Phased Array

This kit is designed to use the Christman method of phasing to produce 2 end fire patterns and one broadside pattern. **(See Figure 1)** When compared to a single vertical element, the end fire pattern will produce up to +3dB gain with as much as 20dB in front to back in one of two directions, and a +1dB gain broadside (omni-directional) pattern. The array consists of two (2) equal length quarter wave vertical elements and a radial field for each element. The elements can be wires that are supported by nonconductive masts or metallic vertical elements. The system can be ground mounted with a radial field or could be elevated with tuned counterpoises. The two elements are fed with 84deg feedlines and a delay line of 71 degrees used to delay signaling to one of the elements. This delay allows for the signal from the first element to constructively interfere with the signal from the delayed element in one direction and create deconstructive interfere in the opposite direction. Thus, allowing for positive gain in receive and transmit in one direction and degradation of receive and transmit in the opposite direction. The design of this system also allows for a broadside option giving a somewhat omni-directional pattern with higher gains in the direction of the antenna's broadsides.

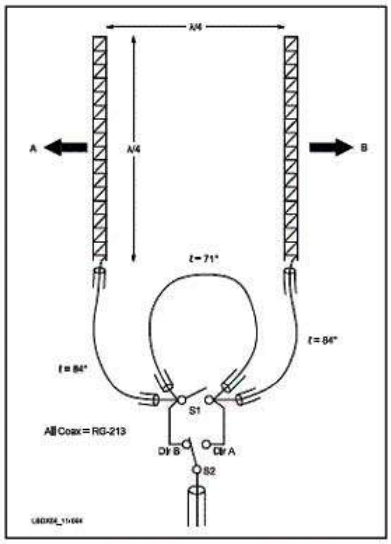


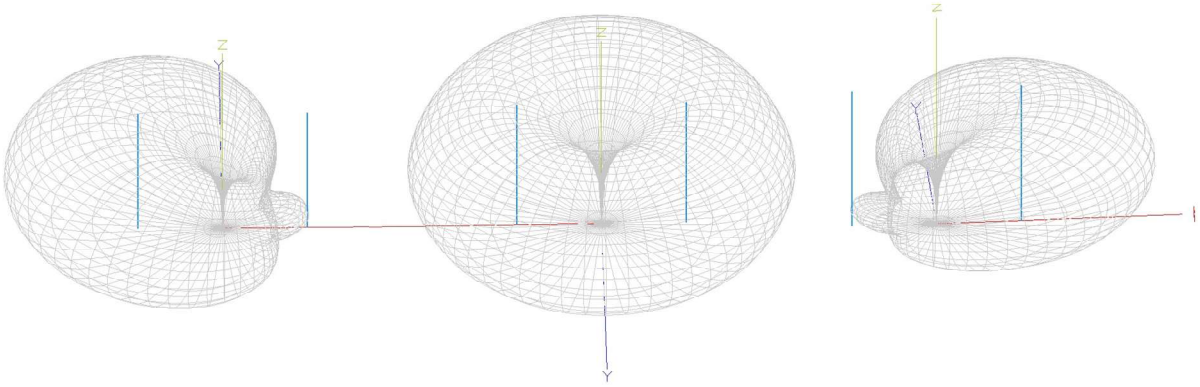
Fig 11-44—The 2-element vertical array (λ/4 spacing) can be fed in-phase to cover the broadside directions. I added switch S1 to the Christman feed system as described in Fig 11-8. When S1 is closed, both antennas are fed in-phase, resulting in bi-directional broadside radiation.

From ON4Un's Low Band DX'ing Book.

The end fired patterns from the array are produced by switching the 71 deg delay into the feedline of one of the two elements. This is achieved by using a high-power relay in the system. The broadside pattern is achieved by removing the delay line from the system using a second relay.

This system is a monoband system in operation but can be built to be used on any band with the use of properly constructed radiating elements, radial fields, feedlines and delay lines.

FIGURE 1



End Fire and Broadside Patterns Produced by a 2-element vertical array spaced at 1/4 wavelength.

Kit Assembly Tips and Information

This kit is designed so that it requires only basic soldering skills for the assembly. The components are thru-hole technology (THT) for the printed circuit boards (PCB), and there is minimal soldering required to connect wires to the switches, power connector and control connector.

First off keep safety in mind, wearing safety glasses to protect your eyes when cutting component legs, and possibly a glove to help protect your hands from the heat of the iron and parts that are being soldered. Please consider a fan or other device to remove solder smoke from your work area and face.

Here are some tips to make your soldering for this project a little easier and hopefully more successful.

1. Have a well-lit area to work in
2. Make sure to protect your work surface from solder and flux. A silicon solder map is ideal.
3. Make sure you use a quality soldering iron, with adjustable temperature settings. A minimum of 40 watts is required. It is also good to have interchangeable tips for your iron.
4. Please be sure to have a way to clean the tip of your iron, such as a damp sponge or metal (brass) wool station. Brass wool is preferred as it will not cool the iron's tip.
5. The use of a magnifying station or wearable magnifying glasses can help with the detail work.
6. Using a station with helping hands and/or a PCB vise can be beneficial in helping complete the project.
7. The choice of solder is important to any project. It is preferable to use a good quality 63/37 (tin/lead) rosin core solder, but non-lead solder can be used. Be aware non-lead solder has a higher melting point, and the heat can damage components if applied for too long a period. Always wash your hands for d-lead soap after working with solder.
8. For soldering components to the PCB's a diameter of 0.032" (.81mm) is recommended. A larger diameter like 0.062" (1.5mm) is recommended for the soldering and tinning of wires to be soldered to the switches and connectors.
9. The working temperature of the soldering iron is critical, allow the iron to come to temperature before you begin working. For this kit a working temperature of 325^{o} -375^{o} C (615^{o}-700^{o} F). Confirm working temperature with solder manufacturer.
10. Use blue tape or blue tack to hold several components in place before you begin to solder. Install smaller components first then moving on to larger components.
11. Make sure to tin the tip of your iron before beginning the soldering operation.
12. Use flux to help the solder flow easier on the component legs.
13. Apply the tip of the soldering iron to the pad and component leg and apply the solder, do not use too much your connection should look like a small "Hershey's Kiss.
14. Make sure to clean your soldering iron tip often.

Controller Assembly

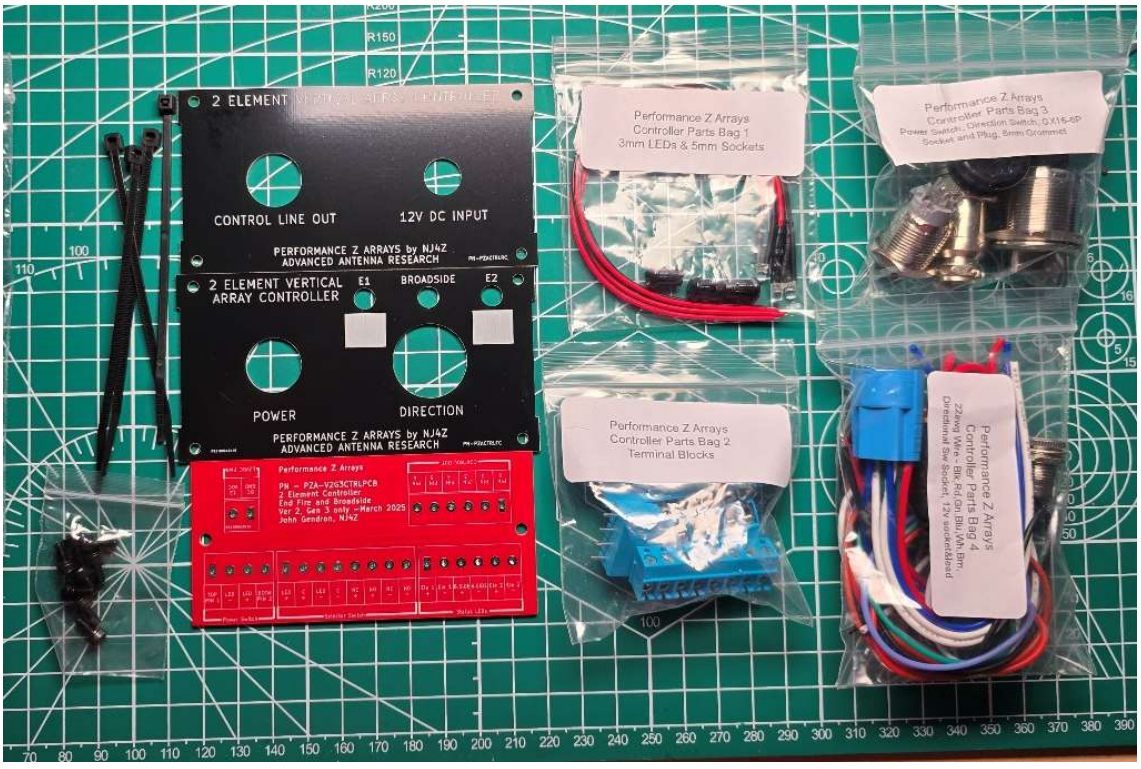
Parts required.

ITEM	PART NUMBER	DESCRIPTION	QTY	Parts Bag	CK
1	PZA-V2G3CTRLPCB	Controller Circuit Board	1	Master 1	
2	PZA-2T-20A5P-BETB	2-Pin Terminal Strip	1	Cntrl SB2	
3	PZA-4T-20A5P-BETB	4- Pin Terminal Strip	1	Cntrl SB2	
4	PZA-6T-20A5P-BETB	6-Pin Terminal Strip	2	Cntrl SB2	
5	PZA-8T-20A5P-BETB	8- Pin Terminal Strip	1	Cntrl SB2	
6	PZA-106-150-55ENC	Controller Enclosure	1	Box	
7	PZA-CTRLFC	Controller Front Panel	1	Master 1	
8	PZA-CTRLRC	Controller Rear Panel	1	Master 1	
9	PZA-3MCHX5MM	M3X6MM cap head screw	8	Master 1	
10	PZA-22MM-SLC3WLED	22mm LED 3Way Switch	1	Cntrl SB3	
11	PZA-22MM-SWSOCK	22mm switch socket	1	Cntrl SB4	
12	PZA-16MM-PWR-LED	16MM LED Push Button Switch	1	Cntrl SB3	
13	PZA-12V3MMLED	12v 3mm LED with leads	3	Cntrl SB1	
14	PZA-5MMLEDSOK3MM	12v 5mm socket for 3mm led	3	Cntrl SB1	
15	PZA-5.5x2.1-12mm-soc	Power Socket 12mm with plug tail	1	Cntrl SB4	
16	PZA-2211-Rd	22AWG Stranded Wire -Red	8"	Cntrl SB4	
17	PZA-2211-Bk	22AWG Stranded Wire -Black	8"	Cntrl SB4	
18	PZA-2211-Bl	22AWG Stranded Wire -Blue	8"	Cntrl SB4	
19	PZA-2211-Wh	22AWG Stranded Wire -White	8"	Cntrl SB4	
20	PZA-2211-Gn	22AWG Stranded Wire -Green	4"	Cntrl SB4	
21	PZA-2211-Bn	22AWG Stranded Wire -Yellow	4"	Cntrl SB4	
22	PZA 4INTW	4" Tie wraps	4	Master 1	
33	PZA-AC6P16MMS	16mm 6Pin Aviation Connector Male Socket	1	Cntrl SB3	
34	PZA-16MM-GROM	16mm rubber grommet *Optional Part	1	Cntrl SB3	

Tools Required

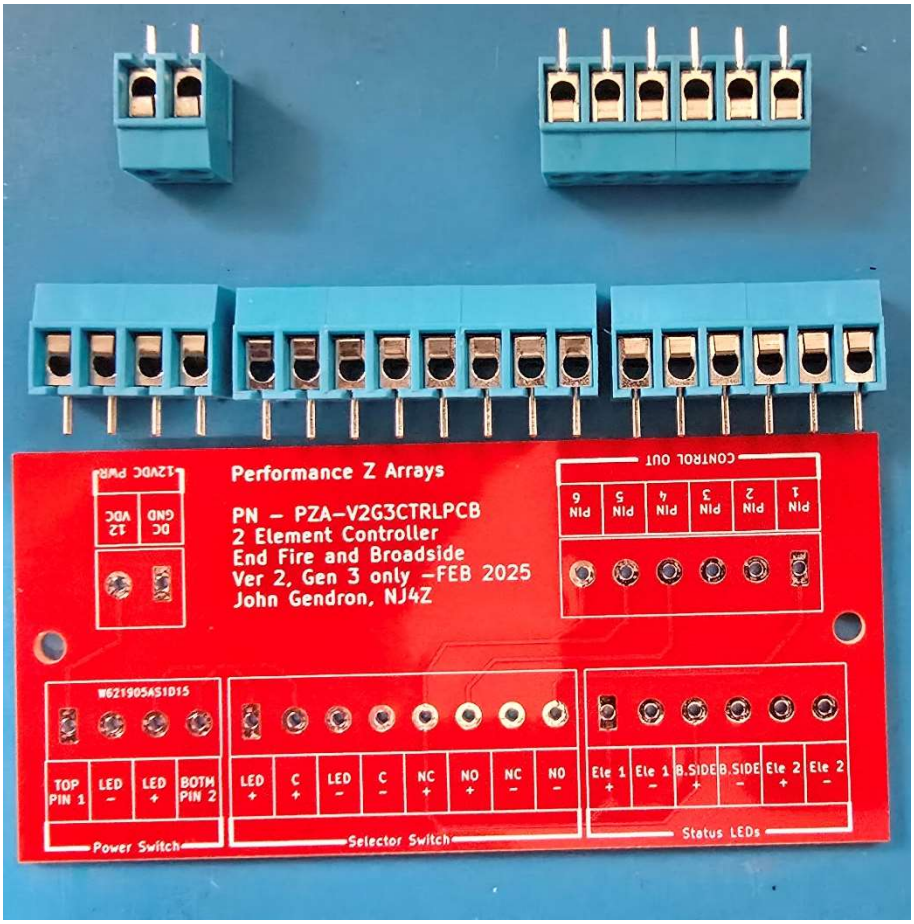
Vice /Helping hands	Needle nose pliers
Precision (Small) Flat Blade	Soldering Iron
Philips Screwdriver	Solder
Flush cutters	Blue Painters tape
Wire strippers	Blue Loctite thread locker (recommended)
3/4”-19mm Wrench or socket	Wire cutters / Cable Snips
Volt/Ohm Meter	1” or25mm wrench

Master Parts Bag 1 - Controller Parts



Contents of the master parts bag 1

STEP-1 Controller PCB Assembly

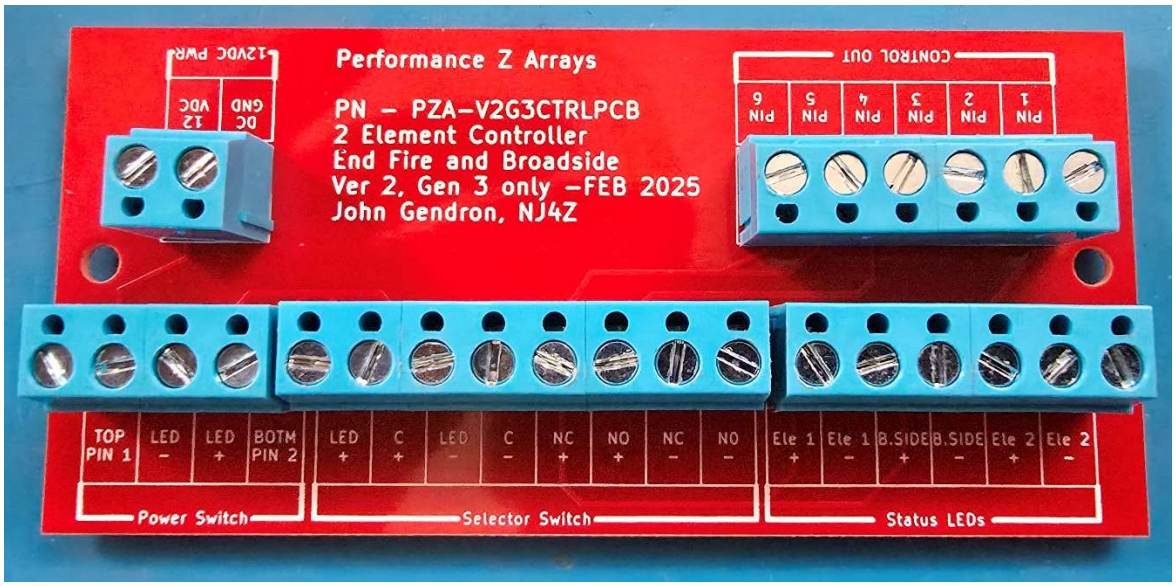


Controller PCB parts required.

NOTE: You can use blue painters' tape to secure the terminals in place for soldering. The Terminal Bocks can be found in Controller Parts SB2 Bag

- 1a. Solder a 2-terminal strip to the 12VDC PWR location on the controller board, pay attention to orient the openings for the screw terminals outward to the edge of the board.
- 1b. Solder a 6-terminal strip to the CONTROL OUT location on the controller board, pay attention to orient the openings for the screw terminals outward to the edge of the board.
- 1c. Solder a 4-terminal strip to the POWER SWITCH location on the controller board, pay attention to orient the openings for the screw terminals outward to the edge of the board.

- 1d. Solder an 8-terminal strip to the SELECTOR SWITCH location on the controller board, pay attention to orient the openings for the screw terminals outward to the edge of the board.
- 1e. Solder a 6-terminal strip to the STATUS LEDs location on the controller board, pay attention to orient the openings for the screw terminals outward to the edge of the board.



Completed Controller PCB

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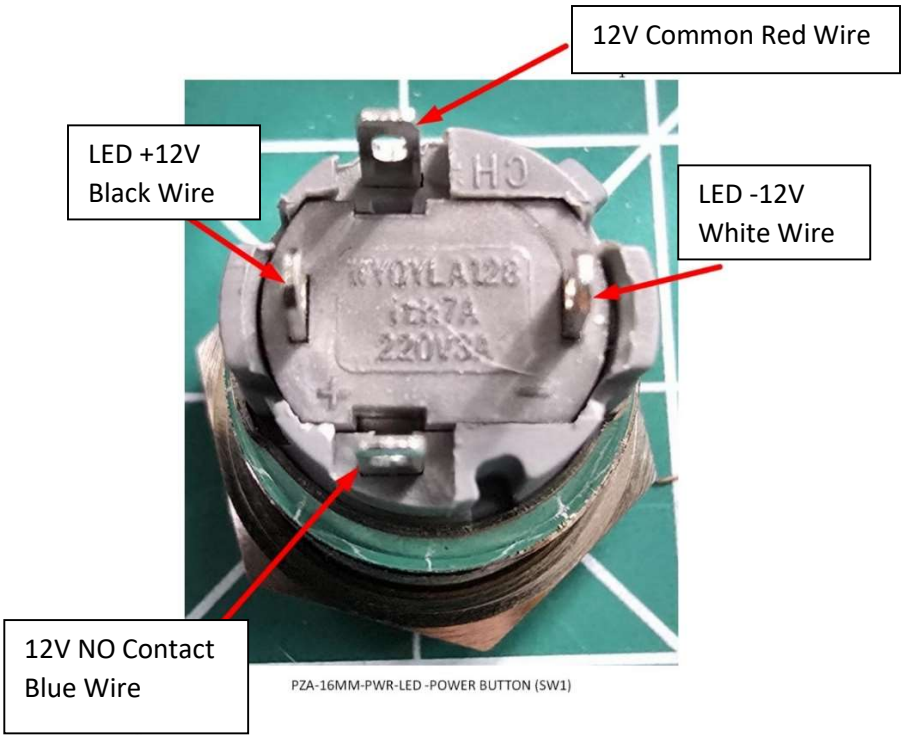
STEP-2 Power Switch Assembly

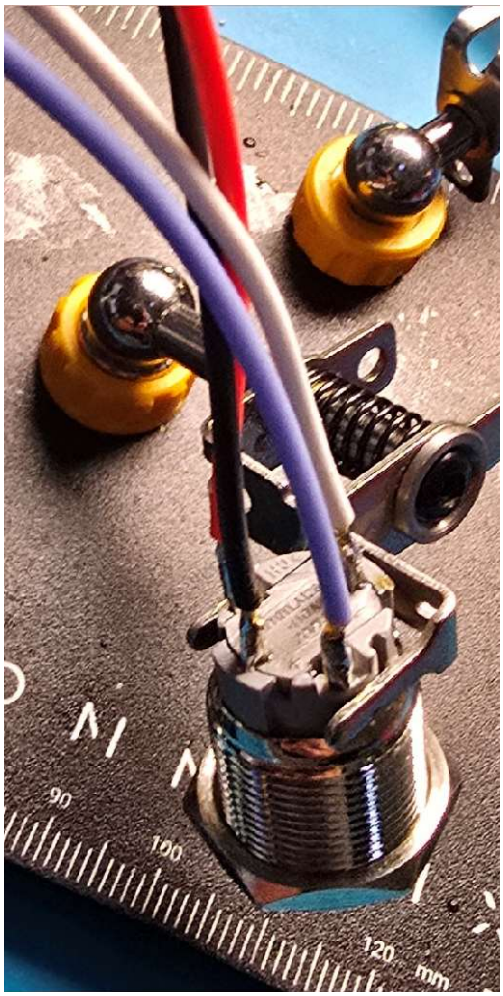
Power Switch assembly parts can be found in controller parts bags SB3 and SB4



- 2a. Cut the included 22 AWG wire to the following lengths.

Wire Color	Wire Gauge	Length to Cut (in)	Length to Cut (mm)	Solder Location
White	22AWG	4inches	101.6mm	Negative 12v right terminal
Red	22AWG	4inches	101.6mm	Pin 1 top terminal
Black	22AWG	4inches	101.6mm	Positive 12v left terminal
Blue	22AWG	4inches	101.6mm	Pin 2 bottom terminal

- 2b. Strip all 4 wires back both ends 1/8 inch (3mm)
- 2c. Tin ends of all 4 wires with solder
- 2d. Solder red wire to the top terminal of SW 1
- 2e. Solder blue wire to the bottom terminal of SW 1
- 2f. Solder Black wire to the terminal marked “+“
- **1g.** Solder white wire to the terminal marked “-”



Completed Power Switch Assembly

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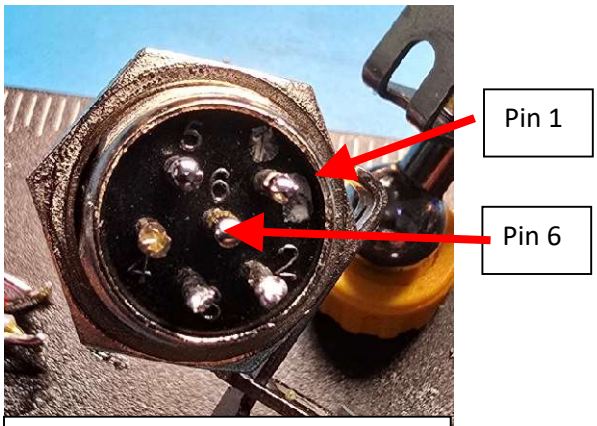
STEP-3 GX16-6P Control Out Line Socket Assembly

NOTE: This kit is supplied with two GX16-6 Pin aircraft connectors for use to construct the control cable. It also contains two 16MM wire grommets that can be used to seal the controller and connect the control cable directly to the terminal strip in the controller and the relay network. If you are going to directly connect to the terminal strip you can skip this step.

Parts for the GX-16-6P assembly can be found in Controller Parts Bag SB3 & SB4

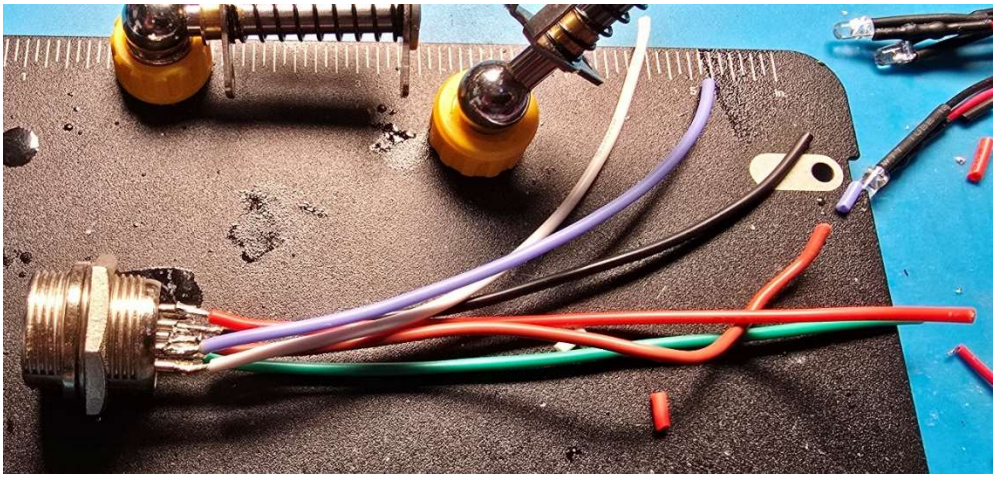


6 Pin aircraft connector

- 3a. Cut the included 22 AWG wire to the following lengths.

Wire Color	Wire Gauge	Length to Cut (in)	Length to Cut (mm)	Solder Location
Red	22awg	4inches	102mm	Pin 1
Black	22awg	4inches	102mm	Pin 2
Green	22awg	4inches	102mm	Pin 3
White	22awg	4inches	102mm	Pin 4
Blue	22awg	4inches	102mm	Pin 5
Brown	22awg	4inches	102mm	Pin 6

- 3e. Strip all 6 wires back on one end 1/8 inch (3mm)
- 3f. Tin ends of all 6 wires with solder
- 3g. Solder the red wire to pin 1 of the connector.
- 3h. Solder the black wire to pin 2 of the connector.
- 3i. Solder the green wire to pin 3 of the connector.
- 3j. Solder the white wire to pin 4 of the connector.
- 3k. Solder the blue wire to pin 5 of the connector.
- 3l. Solder the brown wire to pin 6 of the connector.



Completed GX16-6P 6 Pin Aircraft Connector

STEP-4 Selector Switch Socket Preparation

Parts for the GX-16-6P assembly can be found in Controller Parts Bag SB4

Step 4 – Preparation of the Selector Switch Socket (Found in Parts Bag SB4)

- 4a. Identify the 8 wires on the socket of the selector switch.
  1. Black wire LED negative
  2. Red Wire LED positive 12V
  3. 2 Green wires to common terminals (C) positive and negative
  4. 2 White wires to the normally open (NO) positive and negative
  5. 2 Blue wires to the normally closed (NC) positive and negative.

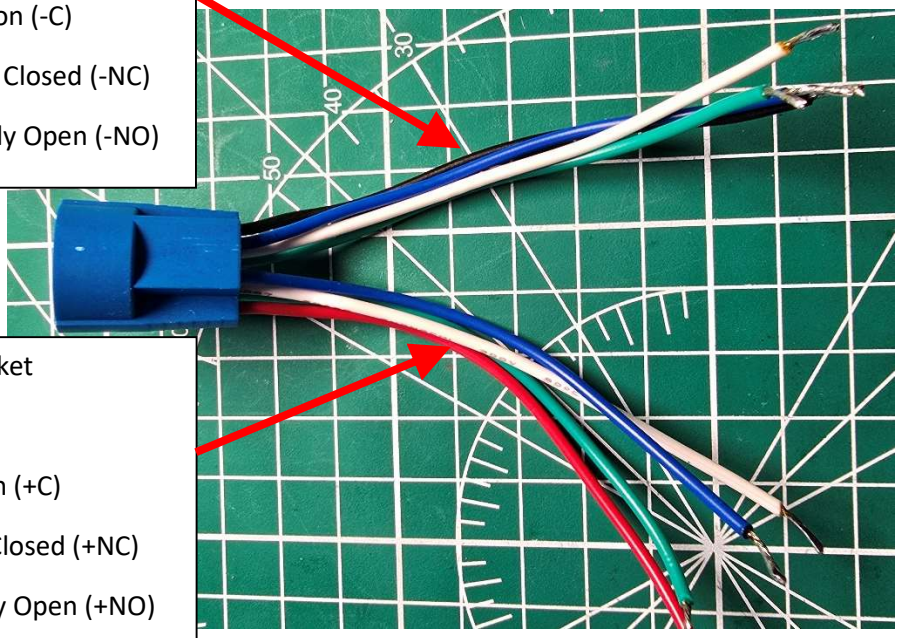
Positive side of the Socket

Black wire – LED Negative

Green wire – (-) Common (-C)

Blue wire – (-)Normally Closed (-NC)

White wire – (-)Normally Open (-NO)



Positive side of the Socket

Red wire – LED positive

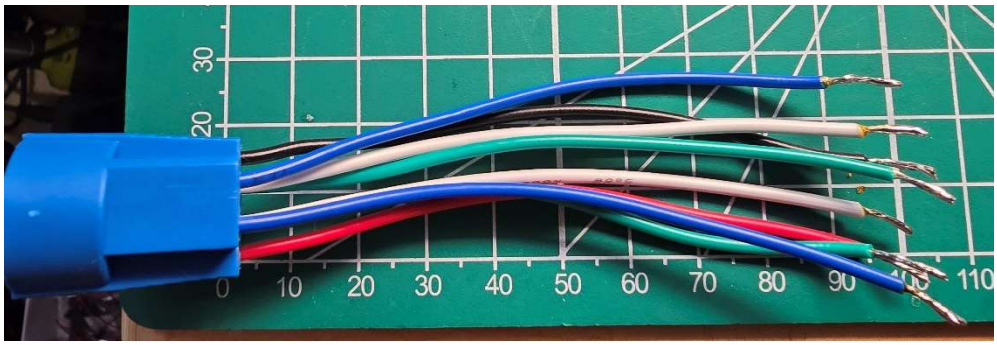
Green wire - + Common (+C)

Blue wire - +Normally Closed (+NC)

White wire - + Normally Open (+NO)

- 4b. Mark the Blue, Green, and White wires on the negative (black wire) side of the socket with an identifying mark, like a strip of tape or marker

- 4c. Trim 1.5” (40mm) of the wires off the socket assembly to leave the length of the wires at 4” (100)

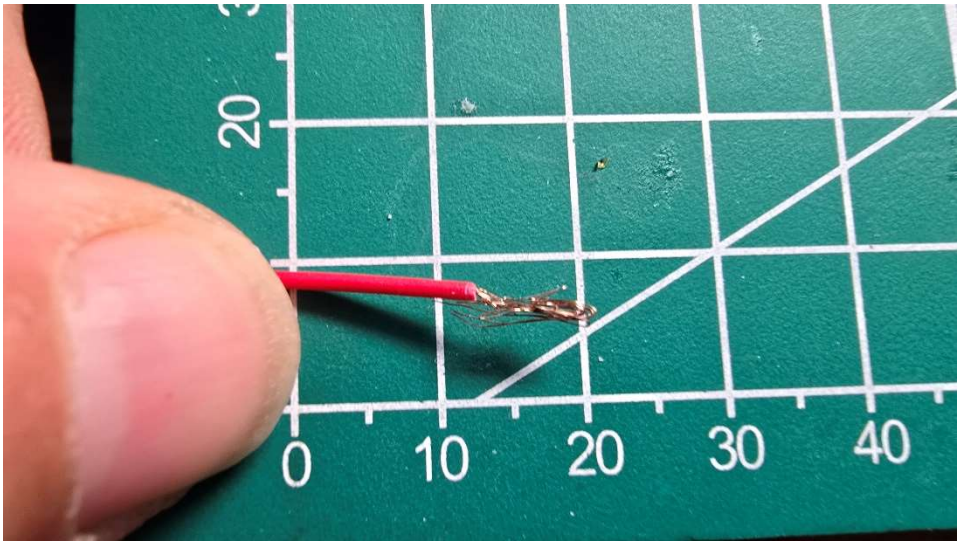


- 4d. Strip the wires and tin the ends.

STEP-5 Indicator LED Preparation

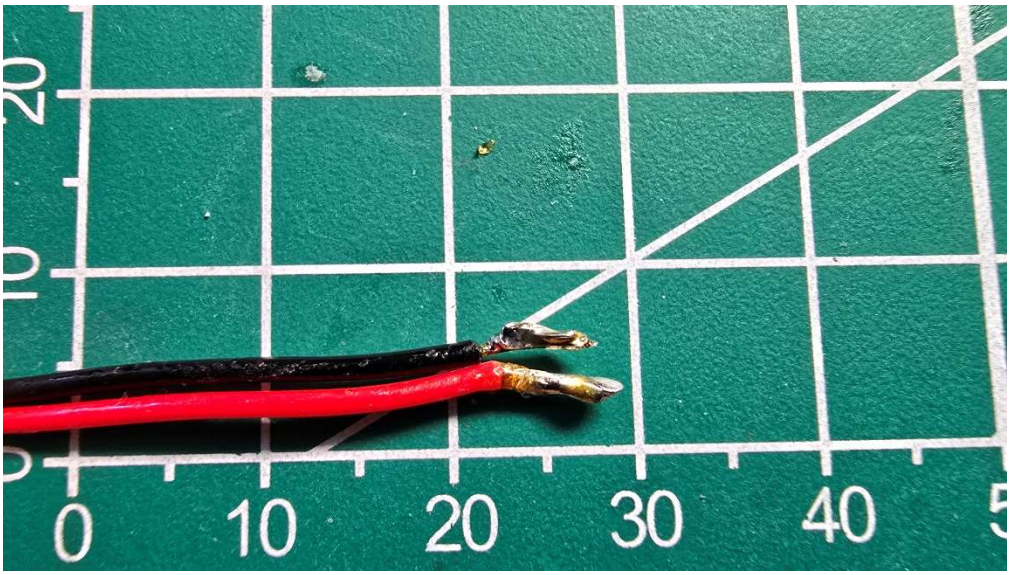
Step 5 – Preparations of the Indicator LED’s (Found in Parts Bag SB1)

- 5a Strip back the ends of the LEDs 1” (25mm) and fold the bare wire on to itself to create a larger conductor size.



LED Wire folded back on itself twice to create larger diameter of wire.

- 5b. Tin the ends of the LEDs.



LED Wire folded back on itself twice to create larger diameter of wire and tinned.

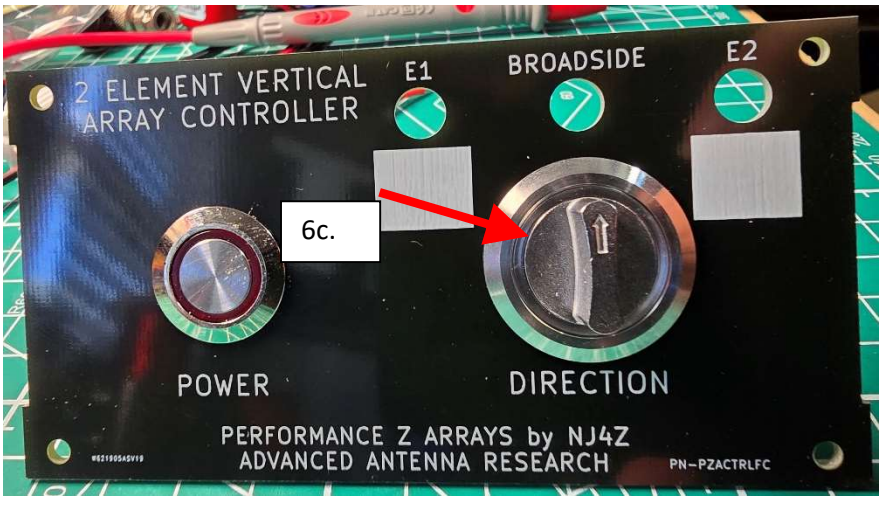
STEP-6 Controller Front Panel Assembly

Step 6- Front Panel of Case Assembly

- 6a. Insert the power switch into the front panel.

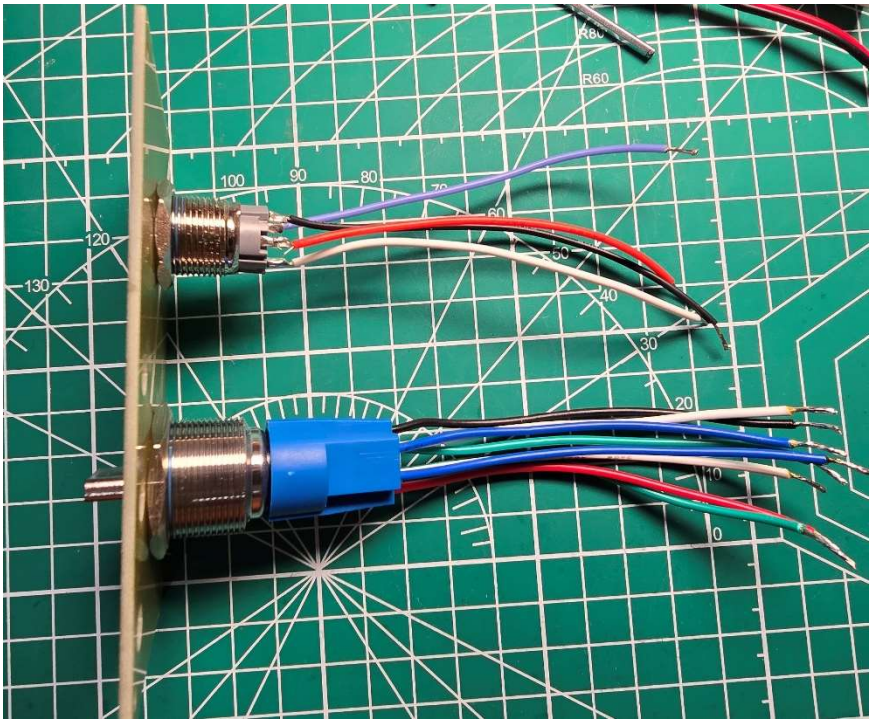
- 6b. Use a small amount of blue Loctite tread locker on the threads of the switch and tighten the locking nut from the rear of the panel making sure it is tight.

- 6c. Insert selector switch without the socket into the hole marker direction ensure that the switch is in the middle position and the indictor is facing up. (Locking latch for the socket should be facing down.)

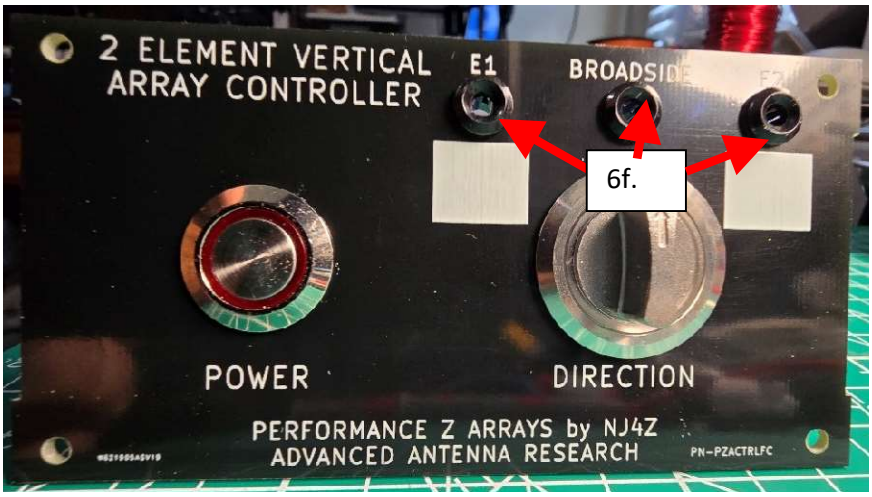


- 6d. Use a small amount of blue Loctite tread locker on the threads of the switch and tighten the locking nut from the rear of the panel to ensure it is tight.

- 6e. Inset the socket on to the rear of selector switch – please check to see the socket is oriented properly with the blue wires at the top and the locking tab down.



- 6f. Insert the LED sockets into the predrilled holes with the top on the outside of the panel.

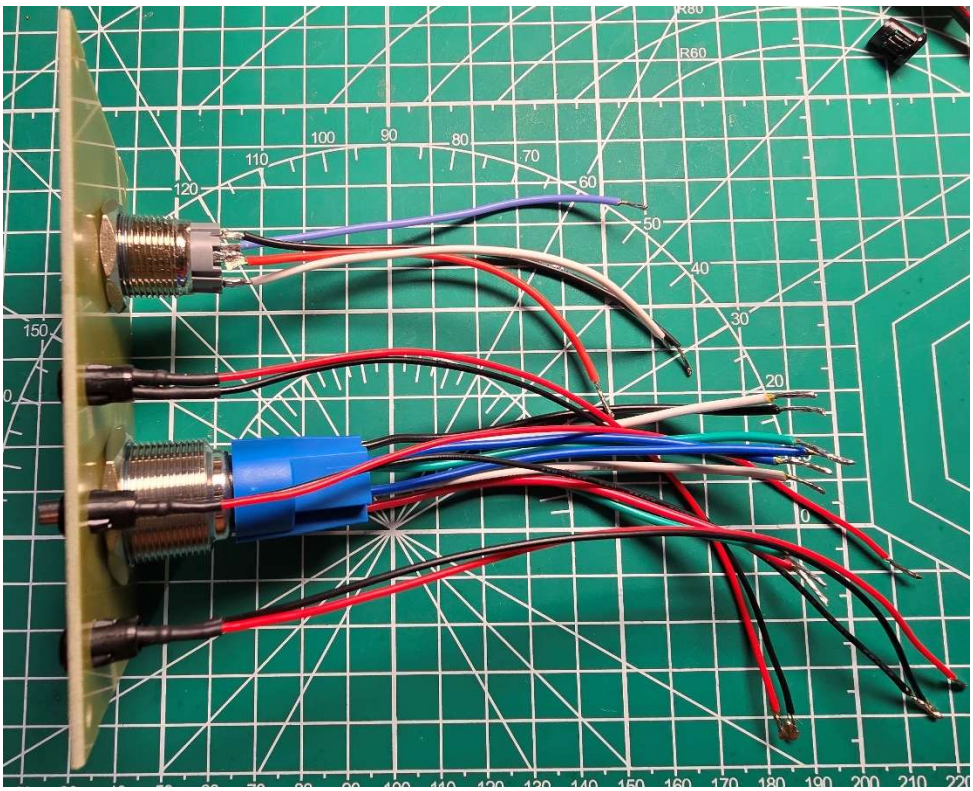


- 6g. Label or mark the 3 LEDs to identify each one as the following.
  - E1
  - B-Side
  - E2

- 6h. Insert the E1 Led from the rear of the panel in the socket in the hole marked E1 and make sure it seats in the socket (audible click).

- 6i. Insert the B-side Led from the rear of the panel in the socket in the hole marked B-Side and make sure it seats in the socket (audible click).

- 6j. Insert the E2 Led from the rear of the panel in the socket in the hole marked E2 and make sure it seats in the socket (audible click).

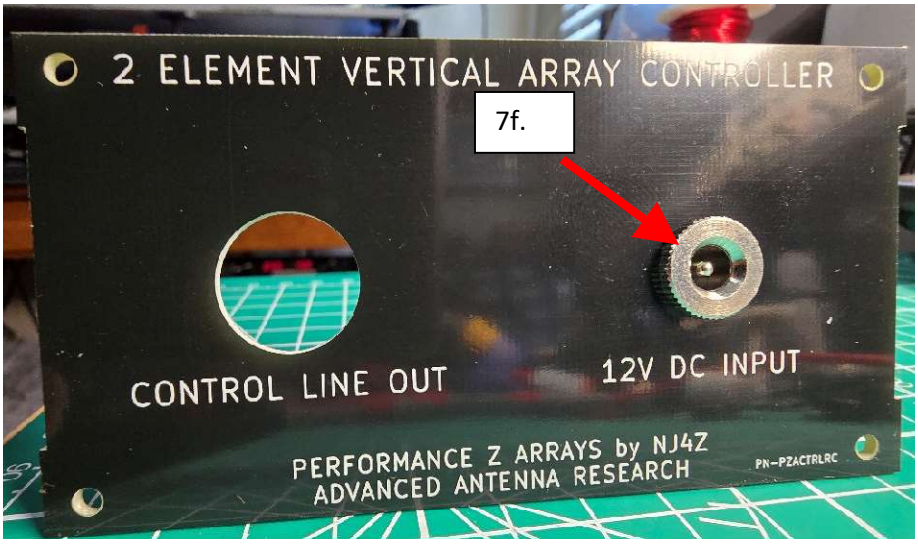


- 6k. **Optional:** You can use a little hot glue on the rear of the socket to ensure the LEDs stay in place.

STEP-7 Controller Rear Panel Assembly

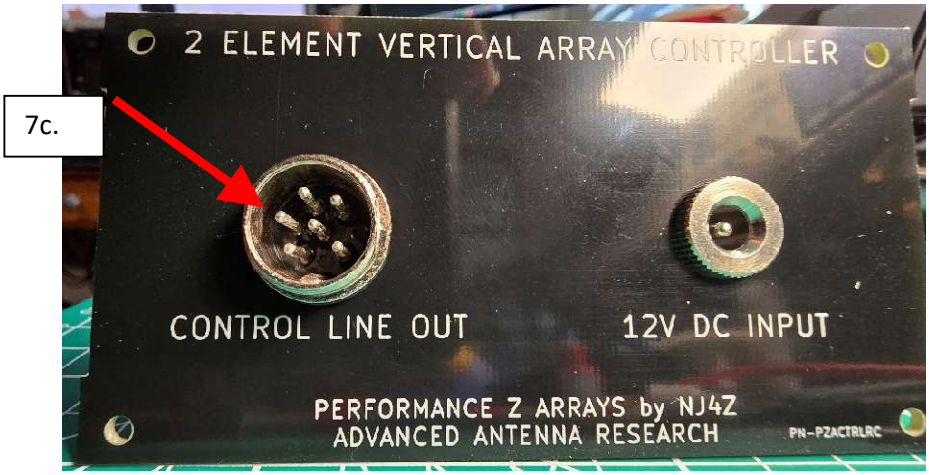
Step 7 – Rear Panel of Case Assembly

- 7a. Inset the pre-wired DC power Socket into the hole market 12v DC switch with the socket facing out.

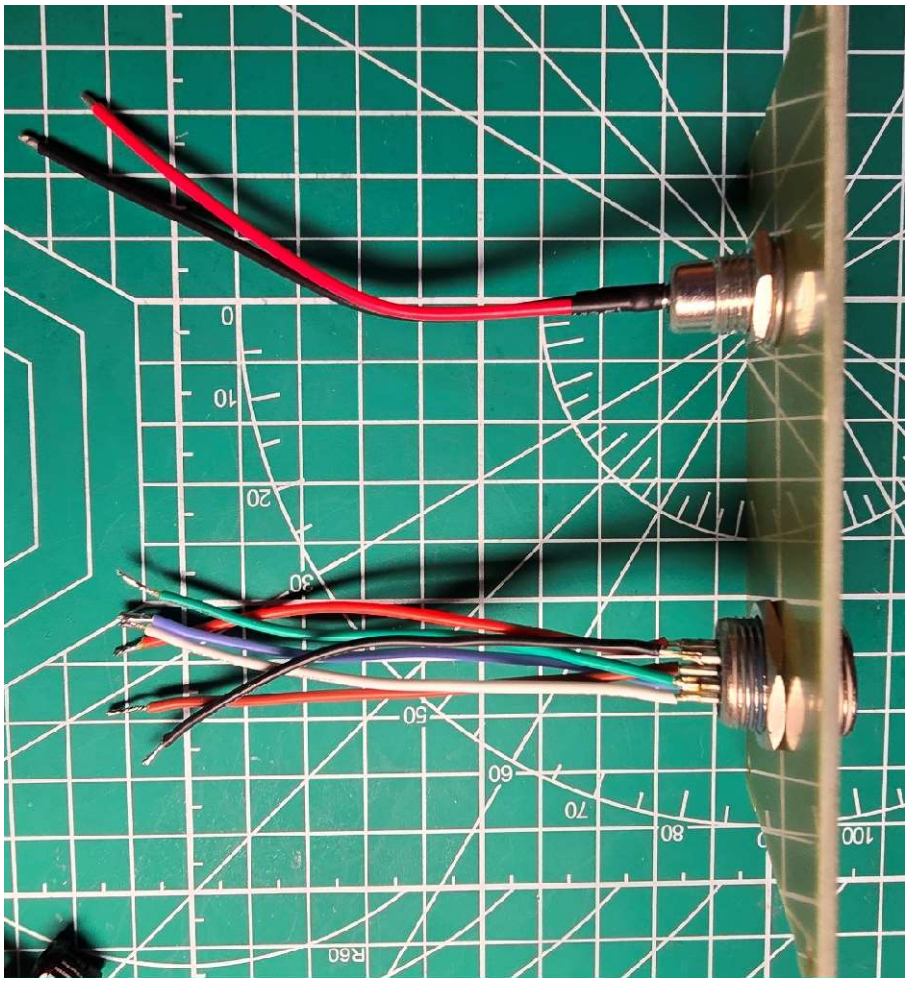


- 7b. Use a small amount of blue Loctite tread locker on the threads of the switch and tighten the locking nut from the rear of the panel ensuring it is tight.

- 7c. Insert the prepared 6 pin aircraft socket into the hole marker Control Line ensuring the proper orientation with the notch on the inside of the connector facing down. *** Optional You may install the 16MM grommet into this hole.**



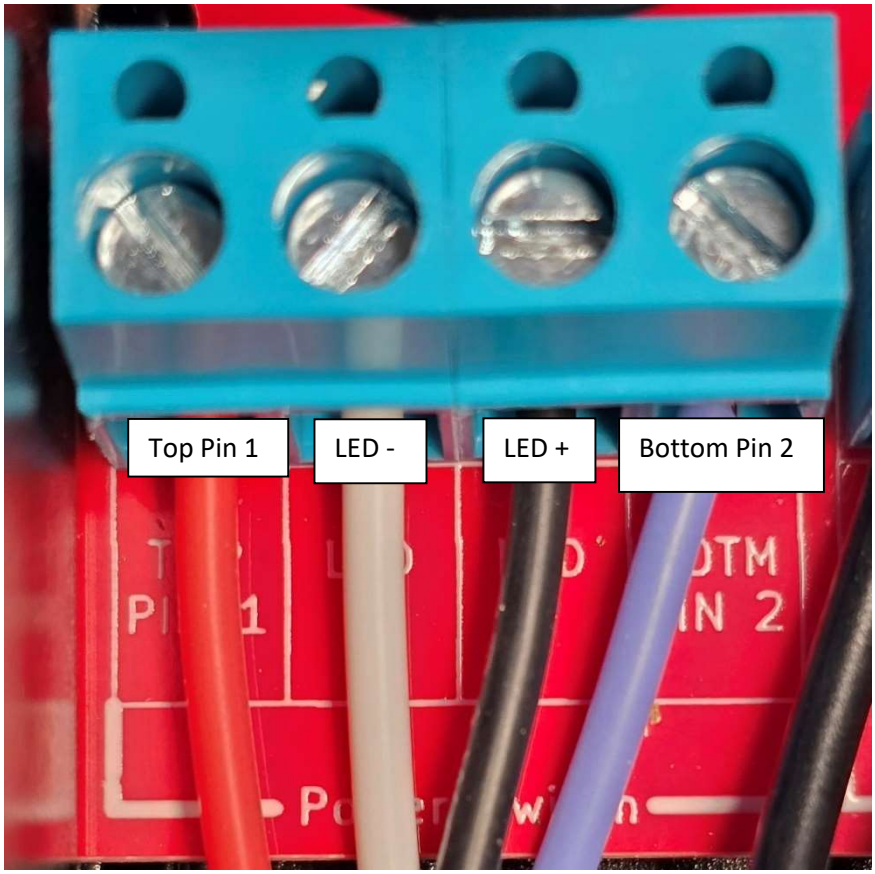
- 7d. Inset the GX16-6P plug in the socket and using pliers, or a ¾” (19mm) wrench (spanner), securely tighten the connector with Loctite blue thread locker.



STEP-8 Controller Case Final Assembly

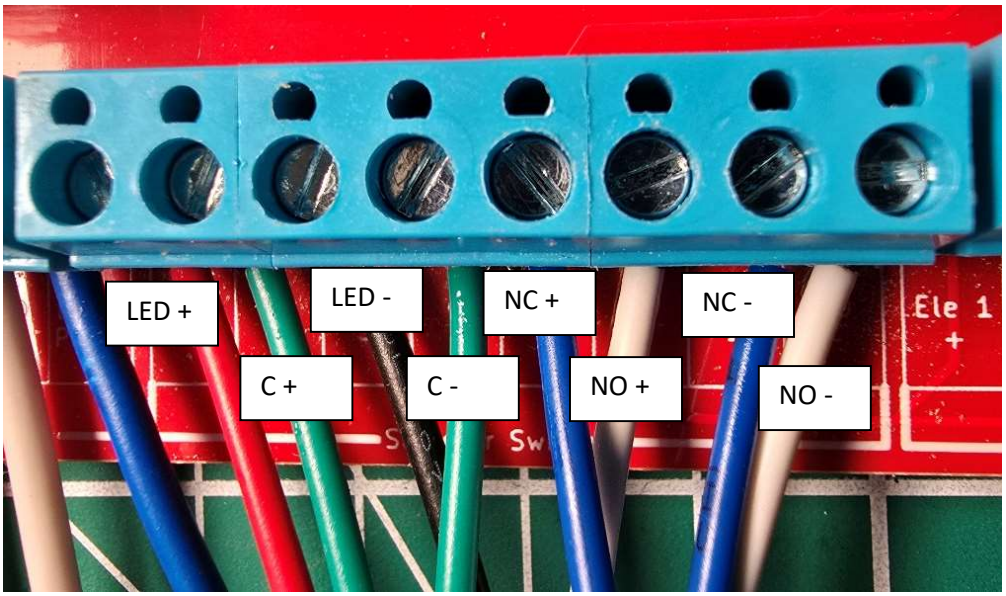
- 8a. Install the PCB board into the bottom flange of the case.
- 8b. Connect the terminals as follows for the Power switch:

Wire Color	Connection
White	LED -
Red	Top Pin1
Black	LED +
Blue	BOTM Pin2



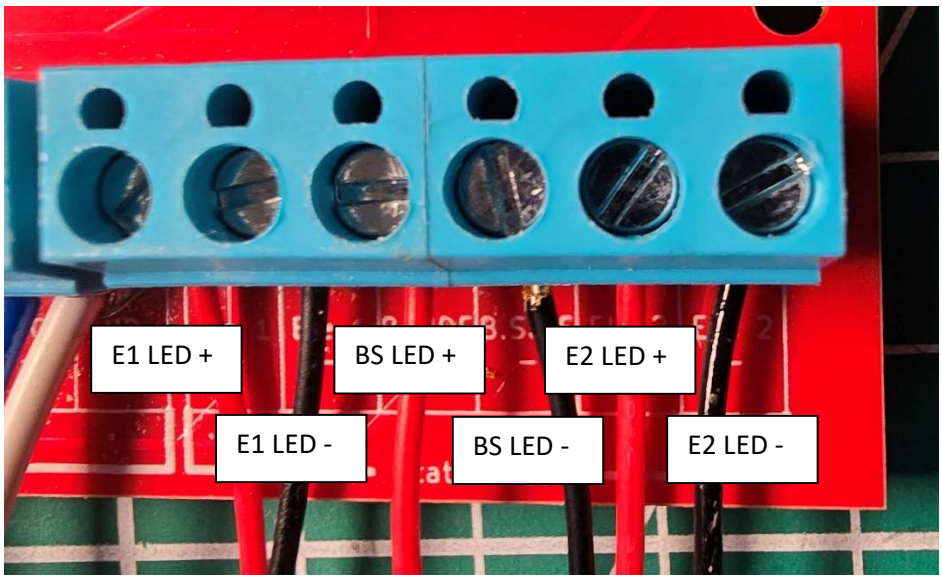
- 8d. Connect the terminals as follows for the Selector Switch

Wire Color	Connection
Red	LED +
Black	LED -
Green +	C +
White +	NO +
Blue +	NC +
Green -	C -
White -	NO -
Blue -	NC -



- 8e. Connect the terminals as follows for the Status LEDs

Wire Color	Connection
Red E1	Ele 1 LED +
Black E1	Ele 1 LED -
Red BS	BS LED +
Black BS	BS LED -
Red E2	Ele 2 LED +
Black E2	Ele 2 LED -

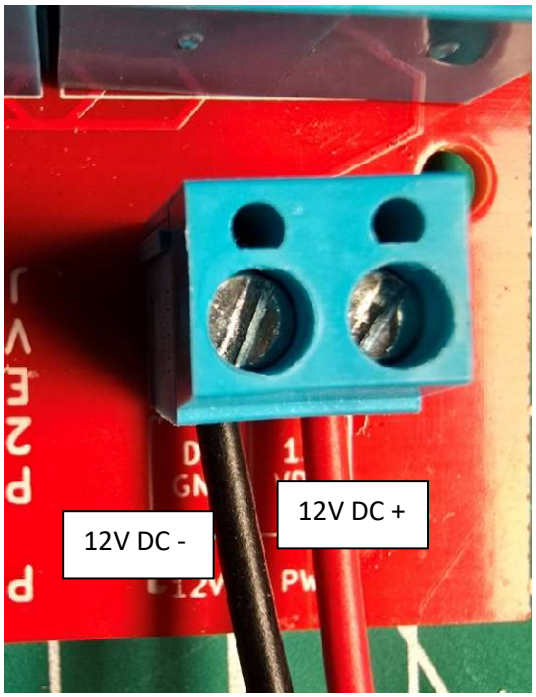


- 8f. Secure the front panel to the lower case with 2 M3X6 screws – secure excess wire using the 4” tie-wraps and trim the excess off the tie wrap.

- 8e. From the rear panel connect the terminals as follows for the 12VDC PWR terminals as follows:

  Red wire to 12VDC

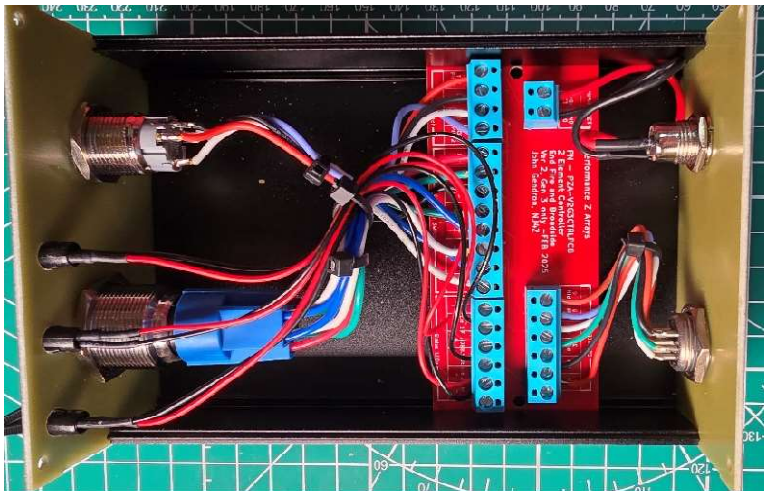
  Black wire DC GND



- 8f. Connect the terminals as follows for the Control out terminals:

Wire Color	Connection
Red	Pin 1
Black	Pin 2
Green	Pin 3
White	Pin 4
Blue	Pin 5
Brown	Pin 6

- 8e. Secure the rear panel to the lower case with 2 M3X6 screws – secure excess wire using the 4” tie-wraps and trim the excess off the tie wraps.



Completed assembly of the controller (without cover)

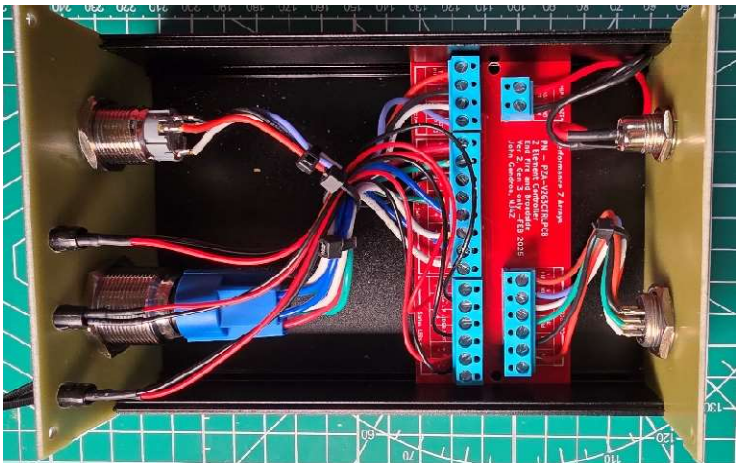
- 8f. Place the top cover of the case on to the completed bottom of the case and secure the rear panel to the case with 2 M3X6 screws.

- 8g. Secure the top of the front panel to the case with 2 M3X6 screws.

- 8h. Connectorize the end of the DC power lead with the proper connector for connection to your 12VDc power source.

STEP-9 Controller Function Testing

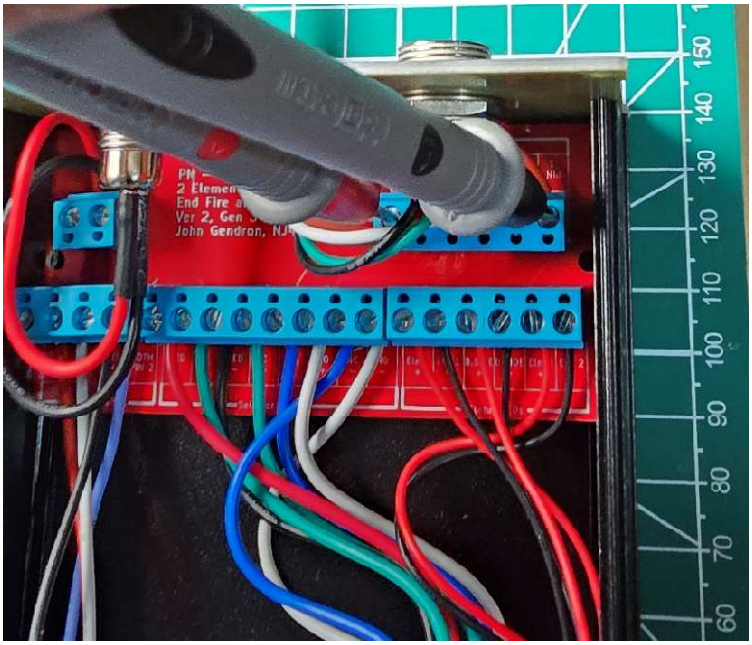
- 9a. Remove the screws from the top positions on the front and rear faceplates and remove the top cover of the controller.



- 9b. Connect a 12v DC Power source to the controller.
- 9c. Press the power button to turn on the unit, the power button, direction switch and one of the status LEDs should be illuminated.

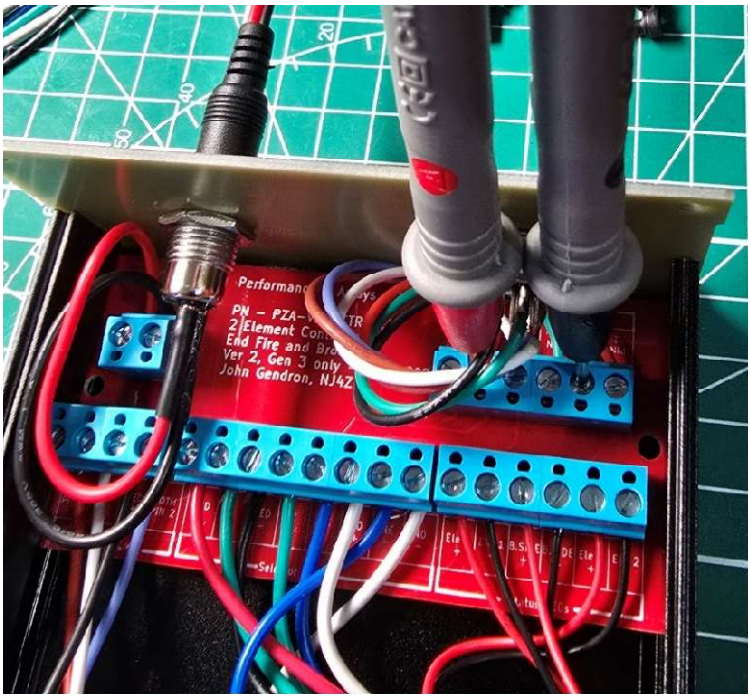
- 9d. Turn the selector switch to the left most position (E1) and the E1 status LED should illuminate.

- 9e. With a voltmeter check to see if there is 12v between pins 1 and 6 of the control out terminal block (black lead pin1, red lead pin 6)



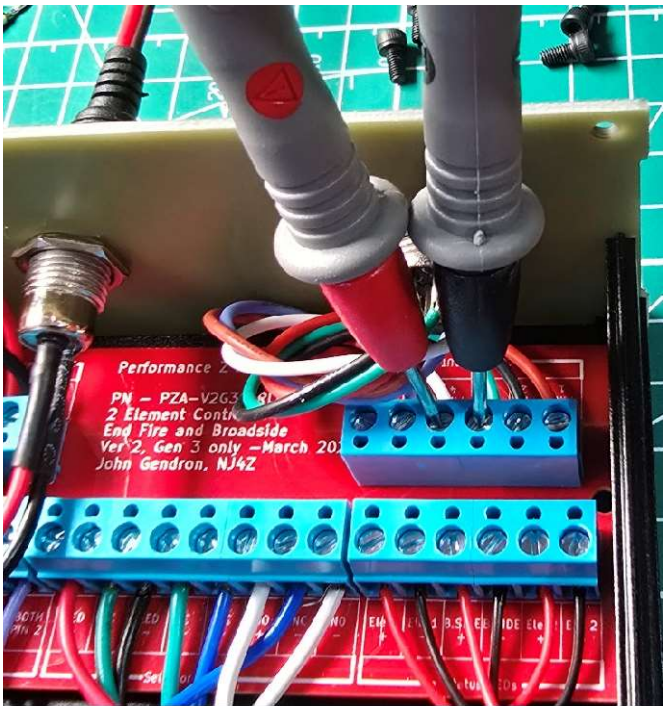
- 9f. Turn the selector switch to the center position (broadside) and the BS status LED should illuminate.

- 9g. With a voltmeter check to see if there is 12v between pins 2 and 5 of the control out terminal block (black lead pin2, red lead pin 5)



- 9h. Turn the selector switch to the right most position (E2) and the E2 status LED should illuminate.

- 9i. With a voltmeter check to see if there is 12v between pins 3 and 4 of the control out terminal block (black lead pin3, red lead pin 4)



- 9j. Depress the power button, turning the controller off. Remove the power cable, replace the cover.

Troubleshooting the Controller

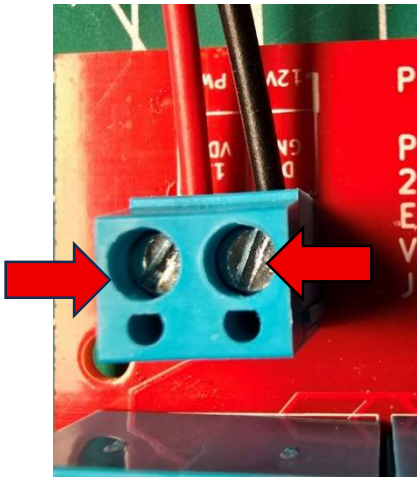
Symptom: **Power and Selector Switch do not illuminate when power button is depressed**

Remedies: **Check solder joint at for the terminal on the bottom of the PCB**

Check power lead is connected to 12V input on the rear of the controller.

Check wire polarity and connection to Power input Terminal Block

Using a Voltmeter verify voltage (12V DC) at the Power Input Terminal Block



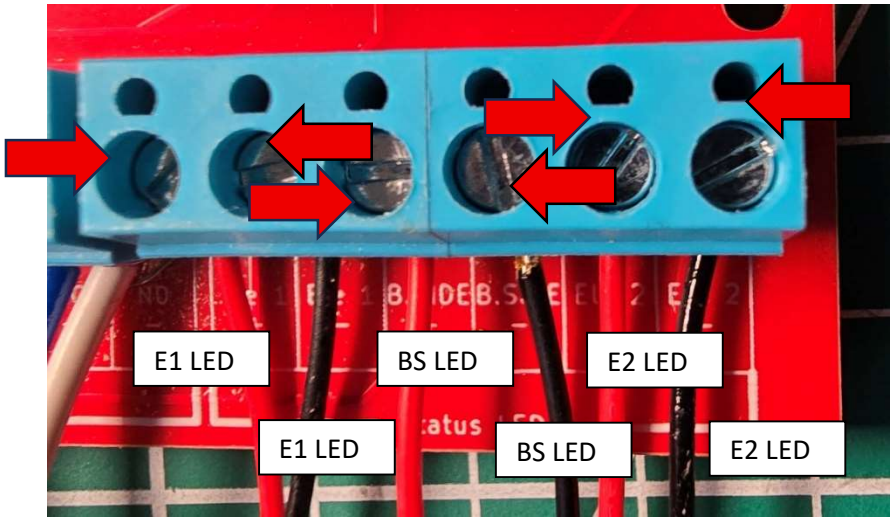
12V DC across terminals

Symptom: **Direction Status Led indicators do not Illuminate**

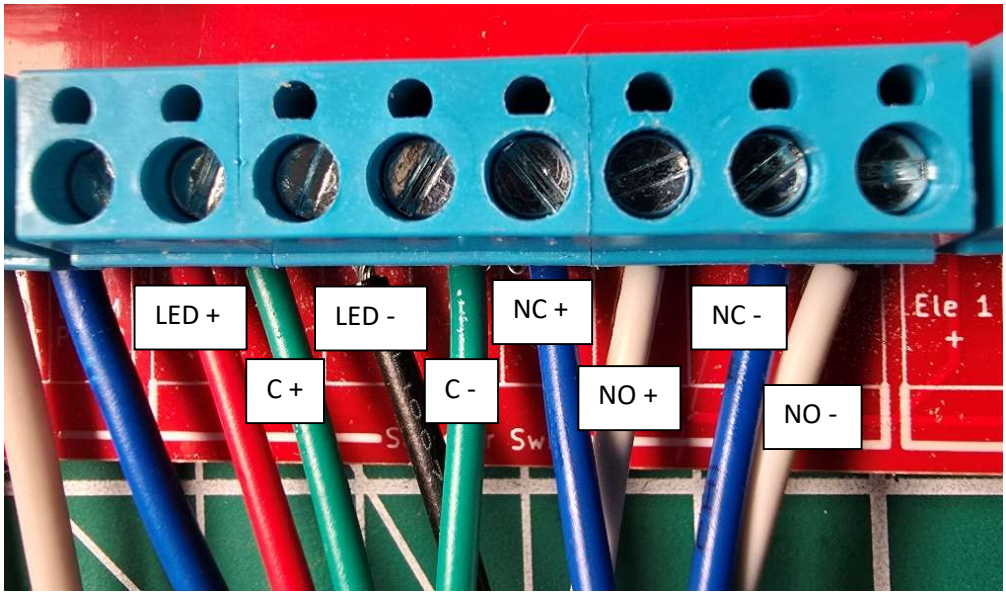
Remedies: **Check the solder joints on the bottom of the PCB**

Check wire polarity and connection to LED Status Terminal Block

Using a Voltmeter verify voltage at the Power Input Terminal Block



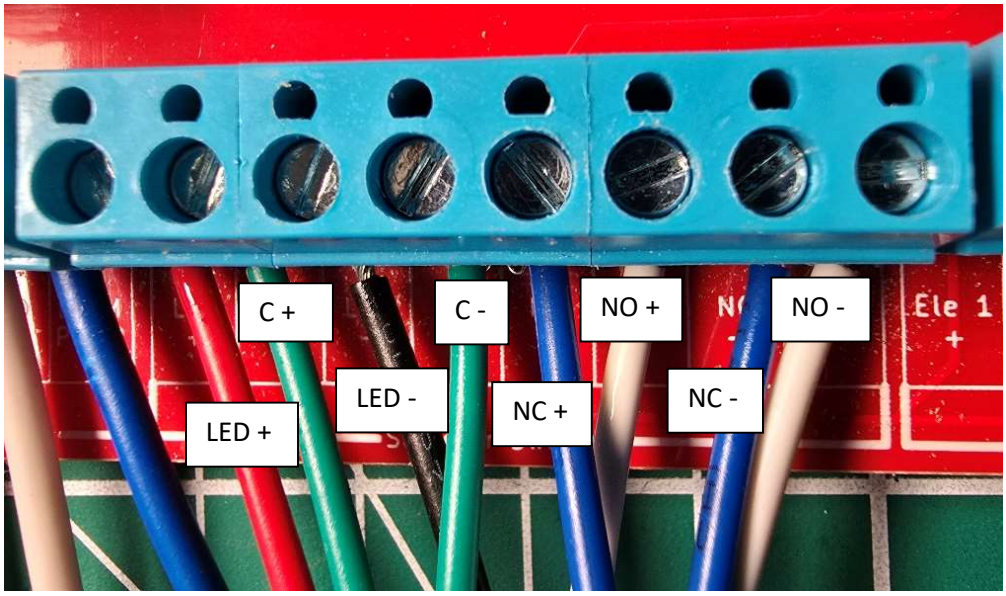
Verify proper wiring at Selector Switch Terminal Block



Symptom: **Direction Status Led do not illuminate in the right position**

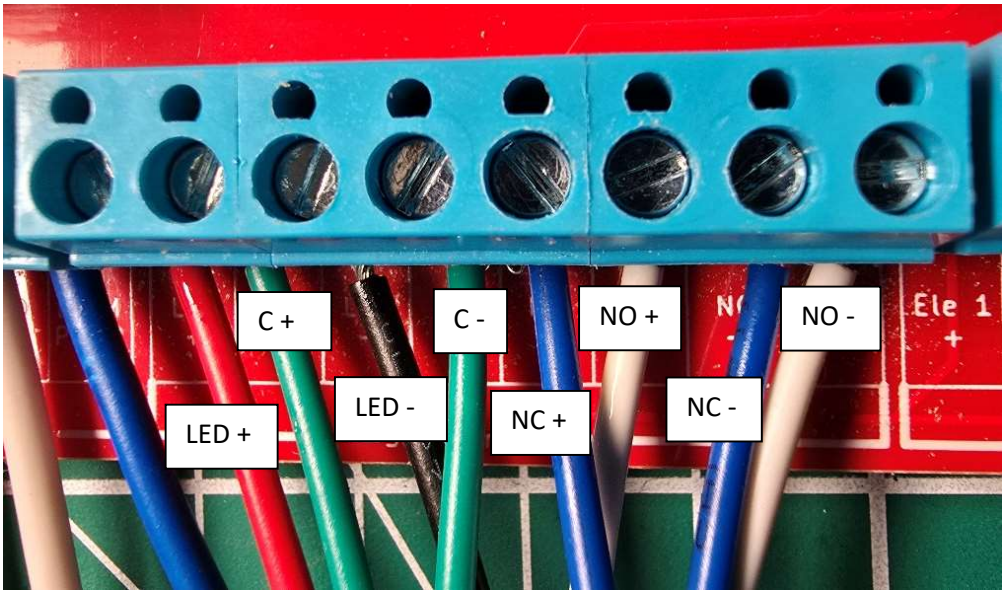
Remedies: **Check wiring position of the LEDs at LED Status Terminal Block**

Verify proper wiring at Selector Switch Terminal Block

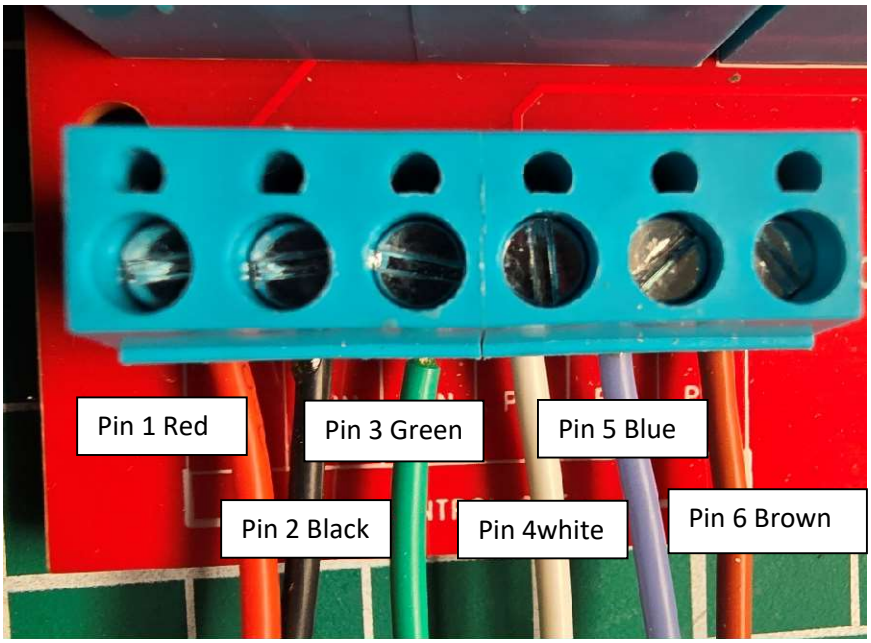


Symptom: **Improper or no voltage at Control Output Terminal Block**

Remedies: **Verify proper wiring at Selector Switch Terminal Block**



Verify proper wiring at Control Output Terminal Block



Verify Solder joints on the bottom of the PCB

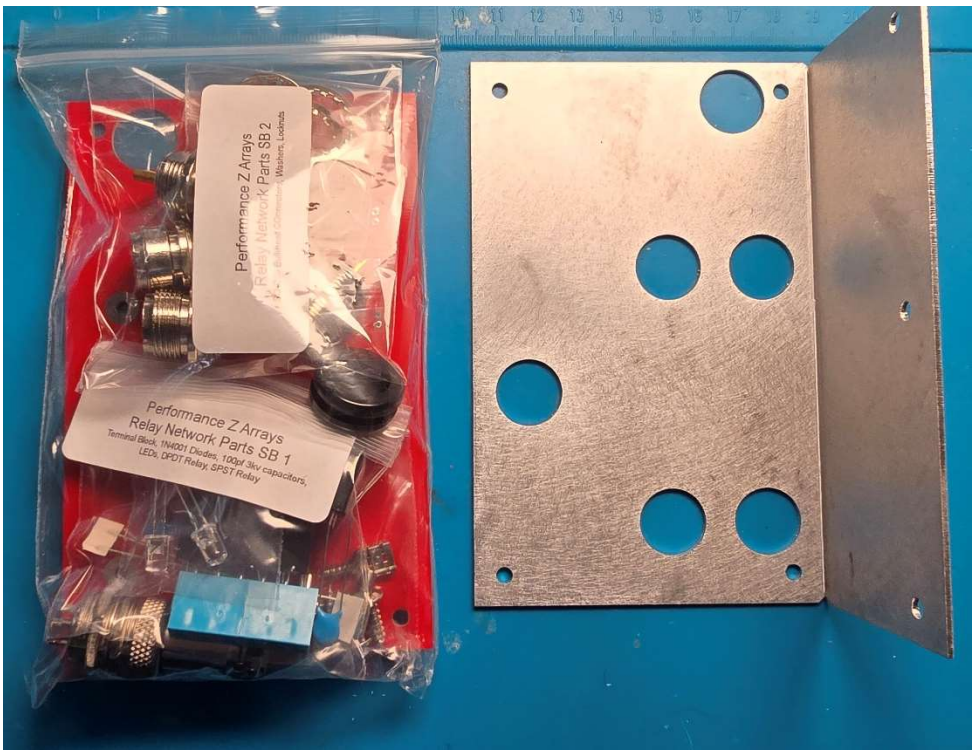
Relay Network Enclosure Assembly

Required Parts

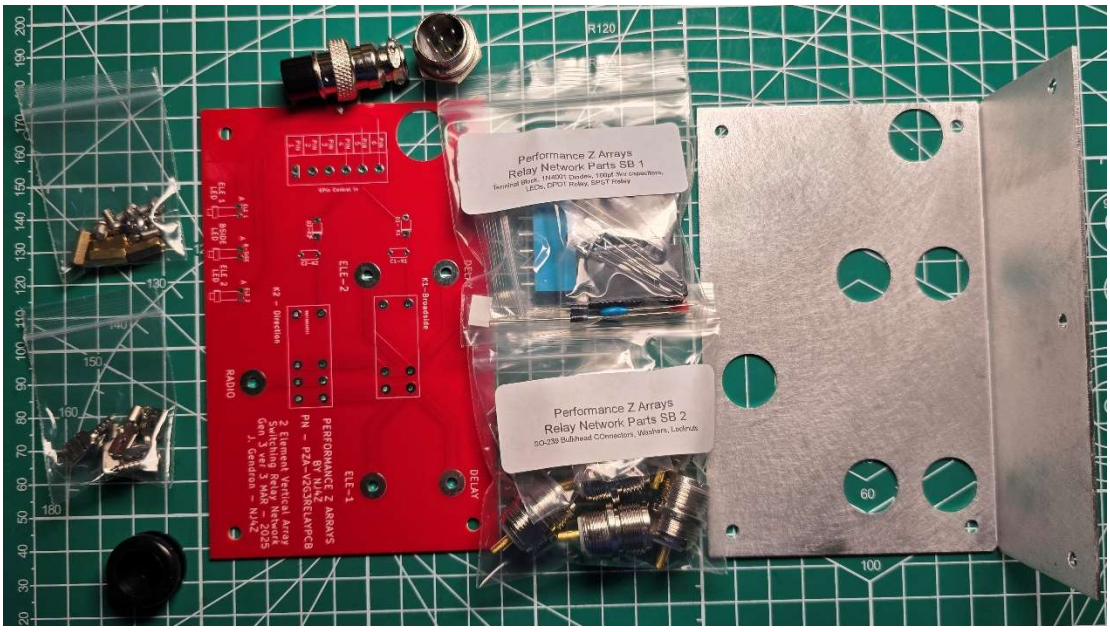
ITEM	PART NUMBER	DESCRIPTION	QTY	CK
4	PZA-6T-20A5P-BETB	6-Pin Terminal Strip	1	
16	PZA-2211-Rd	22AWG Stranded Wire -Red	4”	
17	PZA-2211-Bk	22AWG Stranded Wire -Black	4”	
18	PZA-2211-Bl	22AWG Stranded Wire -Blue	4”	
19	PZA-2211-Wh	22AWG Stranded Wire -White	4”	
20	PZA-2211-Gn	22AWG Stranded Wire -Green	4”	
21	PZA-2211-Bn	22AWG Stranded Wire -Yellow	4”	
23	PZA-M3x10SP	3mmx10mm spacer	4	
24	PZA-3X6PHS	3mmX6MM Screw	8	
25	PZA-V2G3RELAYPCB	Relay Circuit Board	1	
26	PZA-16ASPST-RTD	SPST Delay Line Bypass Relay (RTD-34012F)	1	
27	PZA-16ASPDT-RTD	SPDT Direction Selection Relay (RTD14012F)	1	
28	PZA-1A-400V-4001	Diodes 1N4004	2	
29	PZA-CAP100PF3KV	100pf 3KV capacitor	2	
30	PZA-632.5-18-8	#6-32X.5" Pan Head Machine Screw (m3.5-0.6 X10mm)	3	
31	PZA-SO-238PM(RM)	SO-239 Bulkhead Connector	5	
32	PZA-AC6P16MMP	16mm 6Pin Aviation Connector Female Plug	2	
33	PZA-AC6P16MMS	16mm 6Pin Aviation Connector Male Socket	2	
34	PZA-16MM-GROM	16mm Rubber grommet (optional part)	1	
35	PZA-5MM-912VLED	5MM LED	3	
36	PZA-ENC-9X9X4	9X9X4 UV-rated Junction box with cable entry	1	
37	PZA - 08PCBMNT	Aluminum mounting bracket for Relay PCB	1	

Tools Required

Vice /Helping hands	Needle nose pliers
Precision (Small) Flat Blade	Soldering Iron
Philips Screwdriver	Solder
Flush cutters	Blue Painters tape
Wire strippers	Blue Loctite thread locker (recommended)
¾””-19mm Wrench pr socket	Wire cutters / Cable Snips
Volt/Ohm Meter	



Relay Network Master Parts Bag and Mounting Plate



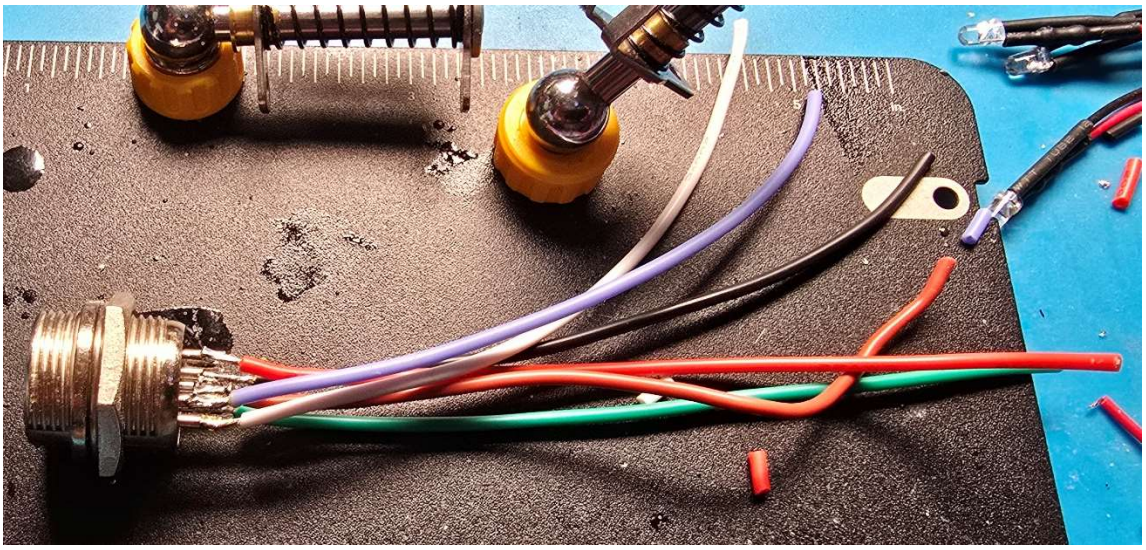
STEP-10 GX16-6P Control Input Line Socket Assembly

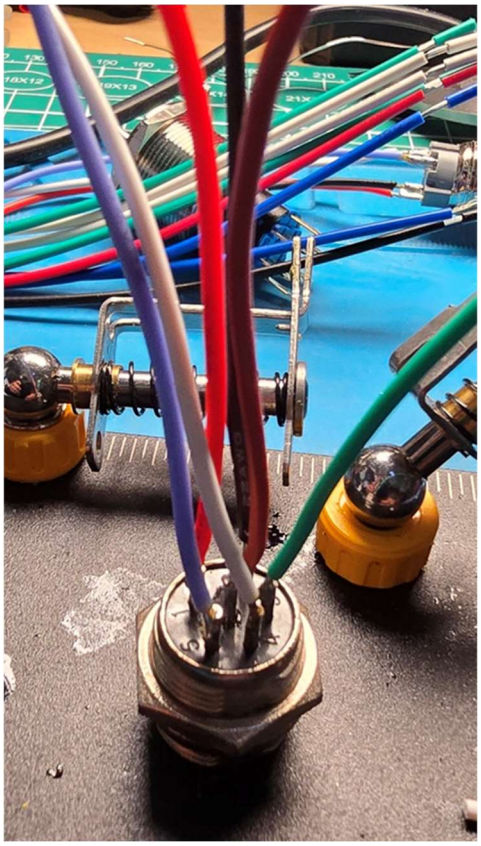
Step 10 – Control 6 Pin Aircraft Socket Assembly

- 10a. Cut the included 22 AWG wire to the following lengths.

Wire Color	Wire Gauge	Length to Cut (in)	Length to Cut (mm)	Solder Location
Red	22awg	4inches	102mm	Pin 1
Black	22awg	4inches	102mm	Pin 2
Green	22awg	4inches	102mm	Pin 3
White	22awg	4inches	102mm	Pin 4
Blue	22awg	4inches	102mm	Pin 5
Brown	22awg	4inches	102mm	Pin 6

- 10b. Strip all 6 wires back on one end 1/8 inch (3mm)
- 10c. Tin ends of all 6 wires with solder
- 10d. Solder the red wire to pin 1 of the connector.
- 10e. Solder the black wire to pin 2 of the connector.
- 10f. Solder the green wire to pin 3 of the connector.
- 10g. Solder the white wire to pin 4 of the connector.
- 10h. Solder the blue wire to pin 5 of the connector.
- 10i. Solder the brown wire to pin 6 of the connector.

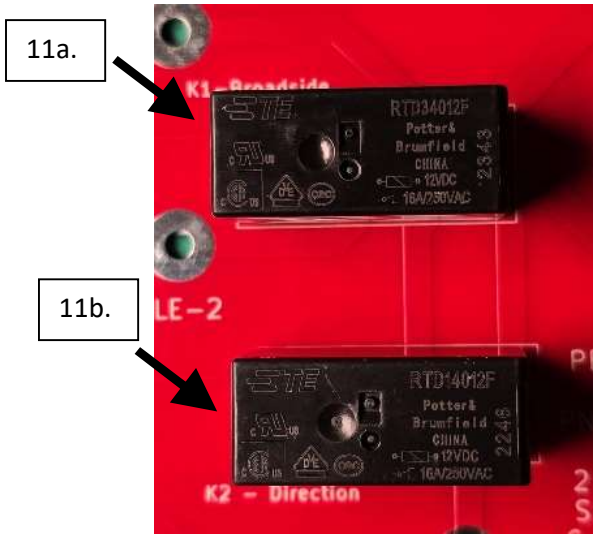




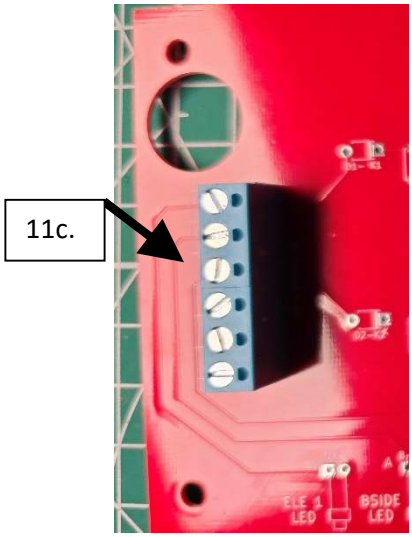
STEP-11 Relay Network PCB Assembly

NOTE: You can use blue painters' tape to secure the terminals in place for soldering.

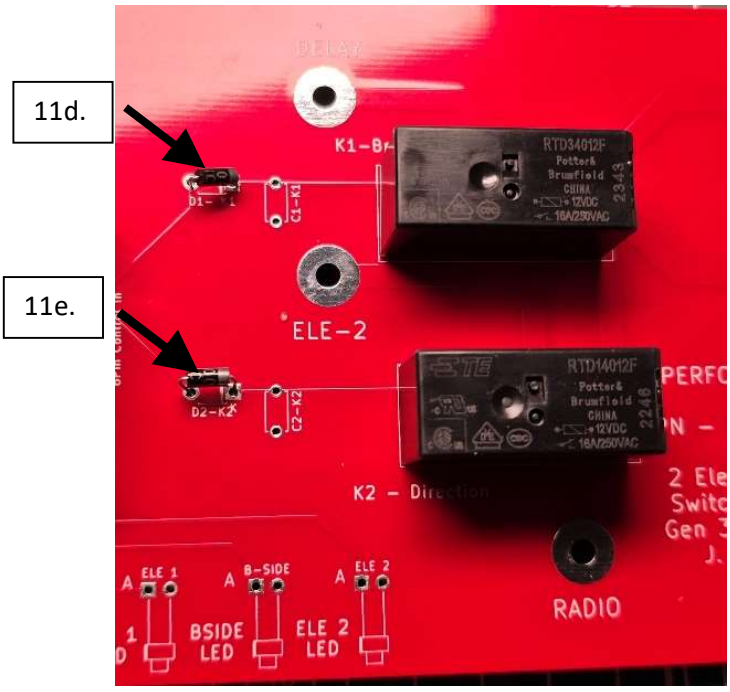
- 11a. Solder the SPDT Relay into the TE-RTD14012F location K2 on the board.
- 11b. Solder the SPST Relay into the TE-RTD34012F location K1 on the board.



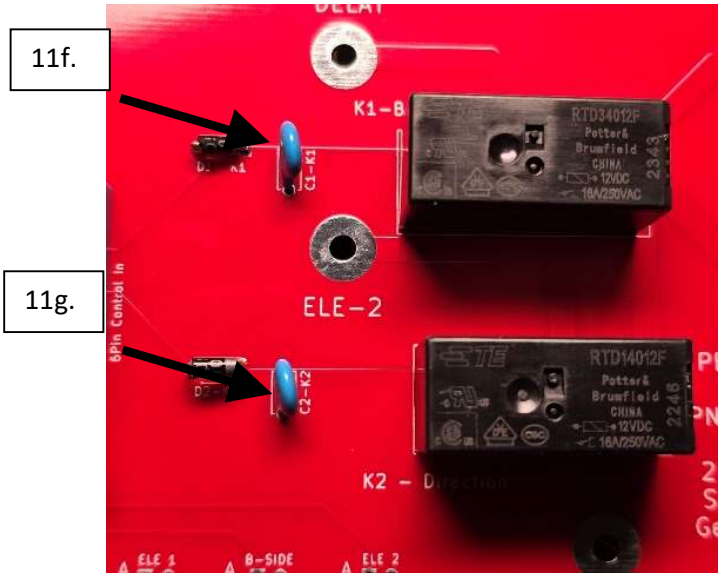
- 11c. Solder a 6-terminal strip to the CNTRL CONN location on the controller board, pay attention to orient the openings for the screw terminals outward to the edge of the board.



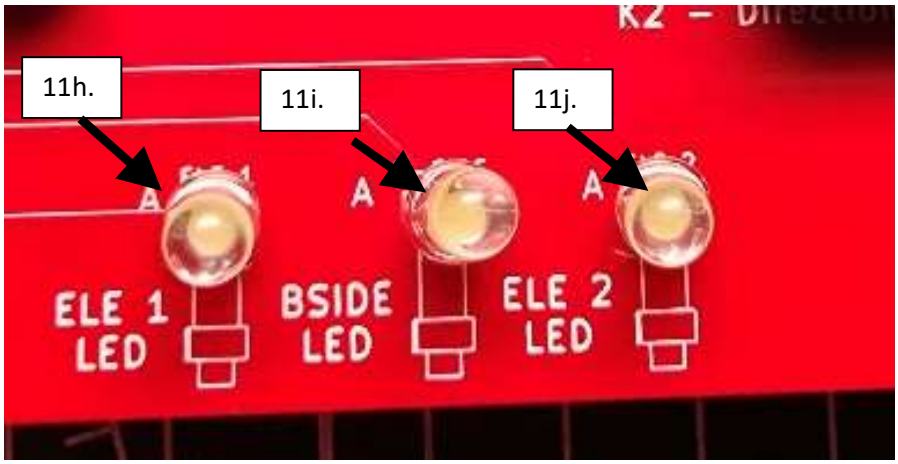
- 11d. Solder one of the 1N4001 diodes on to the PCB in position D1.
- 11e. Solder one of the 1N4001 diodes on to the PCB in position D2.



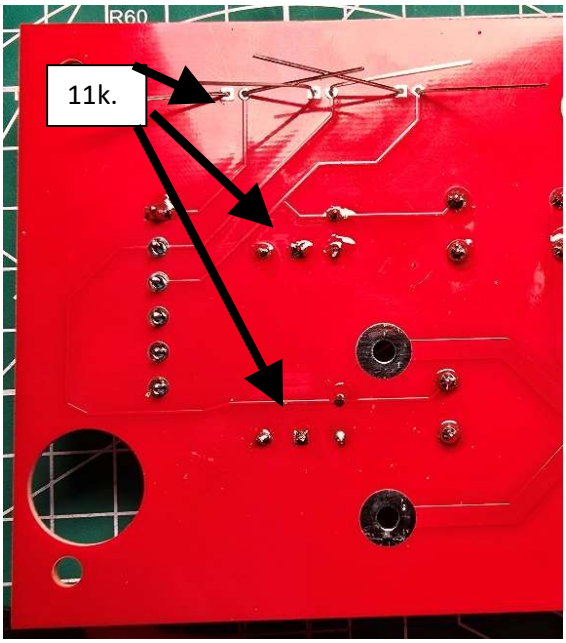
- 11f. Solder one of the 100pf capacitors on to the PCB in position C1.
- 11g. D1Solder one of the 100pf capacitors on to the PCB in position C2



- 11h. D2Solder one of the LEDs into the E1 position
- 11i. C1Solder one of the LEDs into the BS position
- 11j. C2Solder one of the LEDs into the E2 Position

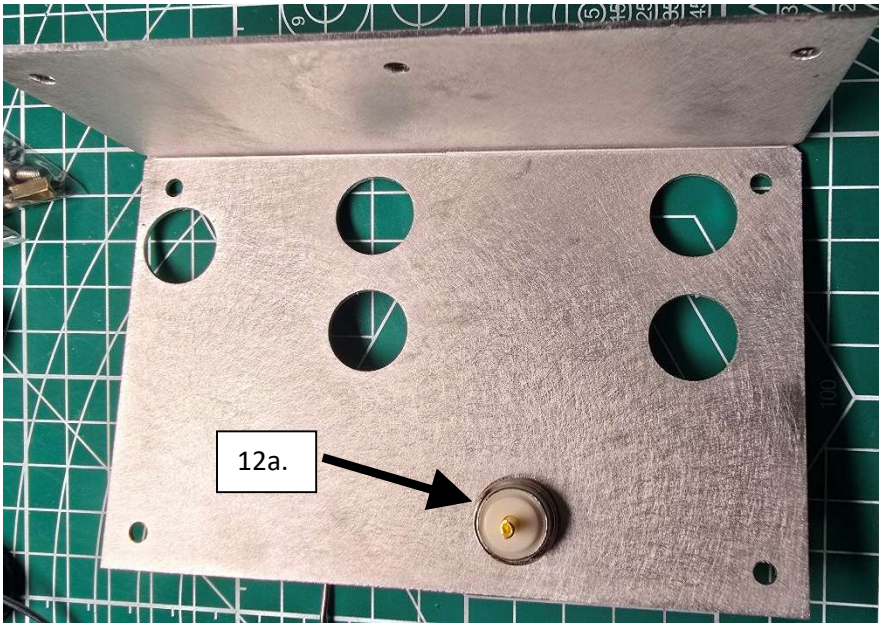


- 11k. Trim the tails off the diodes, capacitors and LEDs on the back side of the circuit board.

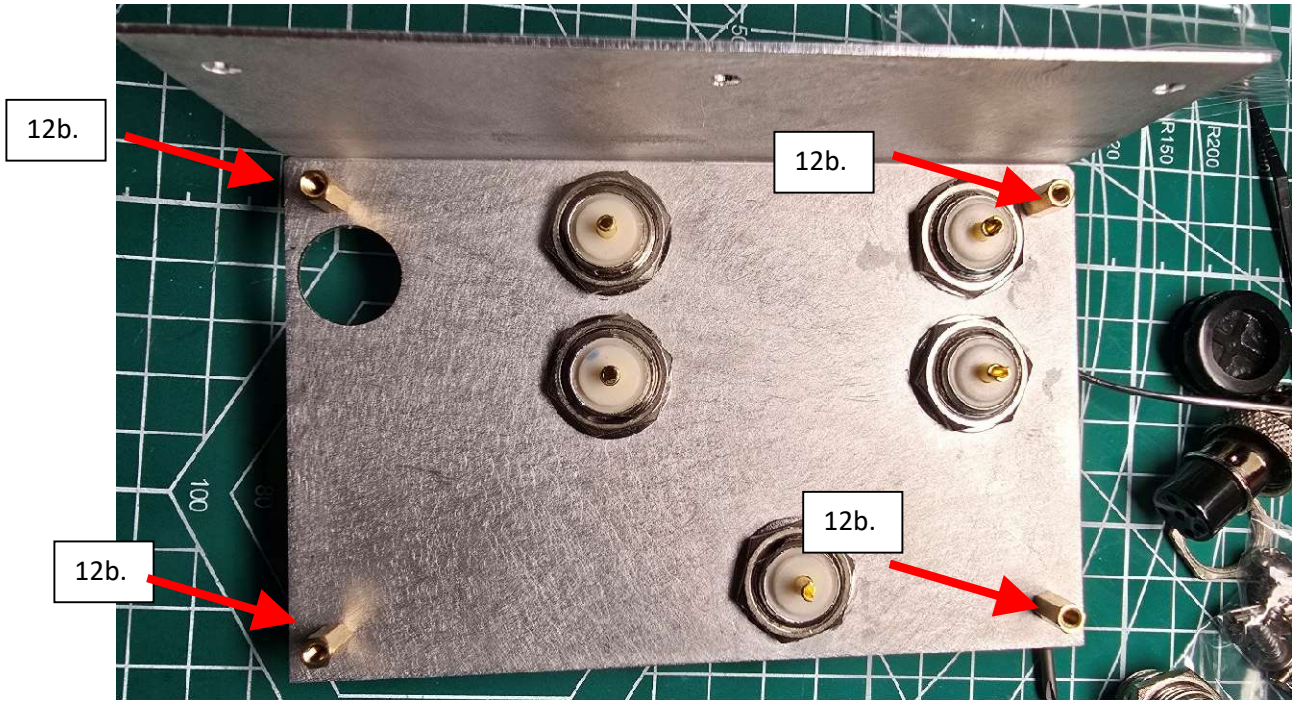


STEP-12 Relay Network PCB Mount Assembly

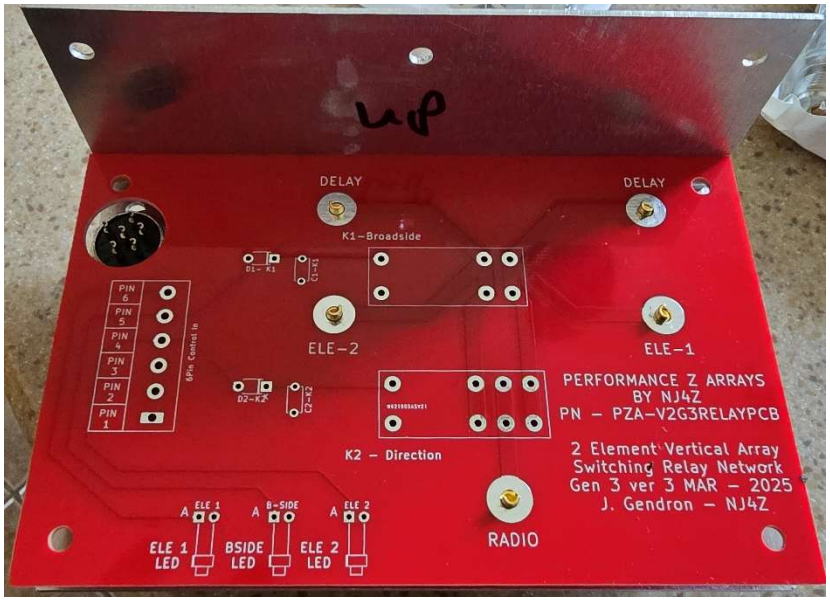
- 12a. Install the five SO-239 coax connectors in the opens on the aluminum PCB Mount, using the serrated washer (teeth down) and locking nut.



- 12b. Install the 4 - 10mm spacers in the corners of the aluminum PCB Mount. Using the 4 – M3x5mm machine screws

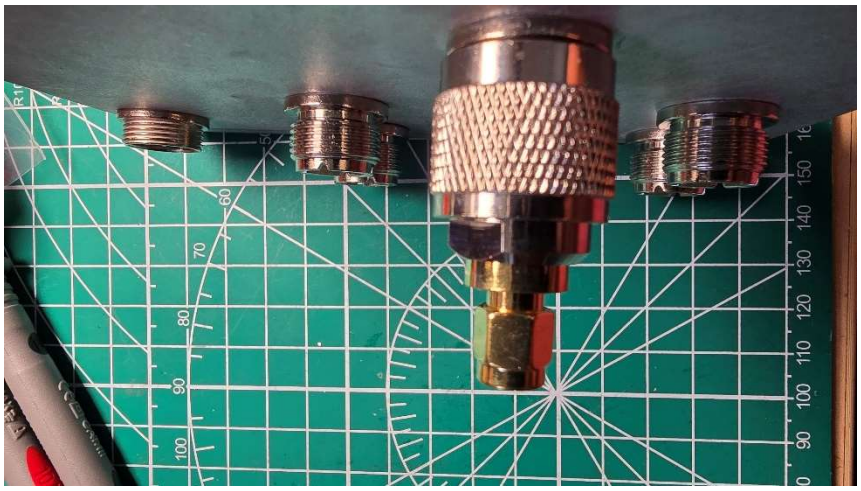


- 12c. Test fit the completed relay board over the SO-239 and GX16-6P* connecters. Adjusting the position of the connectors is critical to completing the project.



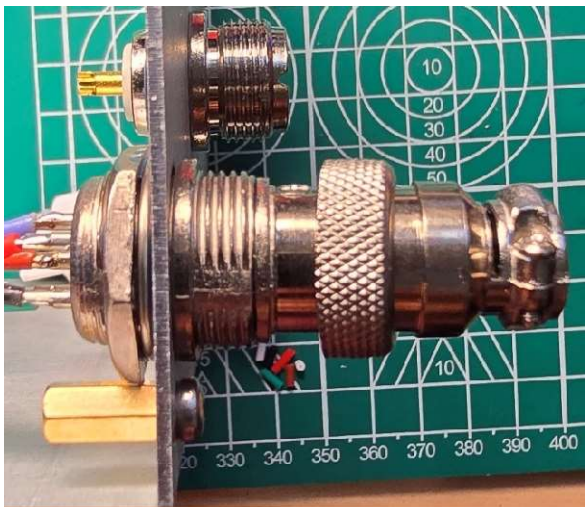
- 12d. Once the Relay PCB seats properly on the connectors, you can remove the board and using some blue Loctite thread locker, tighten the connectors one at a time in place. It is best to start with the 'Radio IN" connector It is very helpful to install a PL-259 connector onto the SO-239 to allow a better grip. Using the 19mm or ¾" wrench or socket, tighten the connector so it will spin in place. Once tightened perform a test fit

and adjust as necessary. I prefer to tighten the connectors one at a time, performing a test fit with each connector.

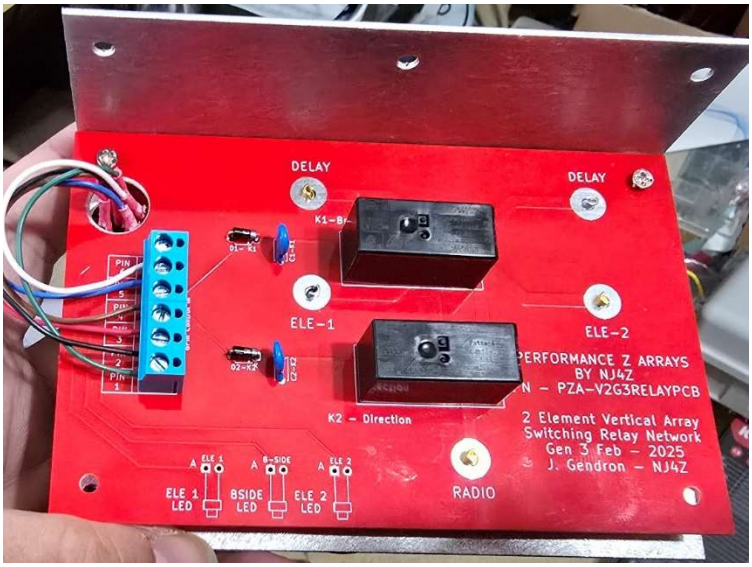


- 12e. Install the GX16-6P* aircraft socket in the opening on the aluminum PCB mount, the notch facing away from the mounting point. Inset the GX16-6P plug in the socket and using pliers, or a ¾" (19mm) wrench (spanner), securely tighten the connector with Loctite blue thread locker.

  **If you decide to hardwire the 22ga 6 conductor control directly to the terminal strip, make an opening in the 16mm grommet and insert it into the mount opening for the GX16-6P connector in the aluminum mount instead of the GX16-6P.*



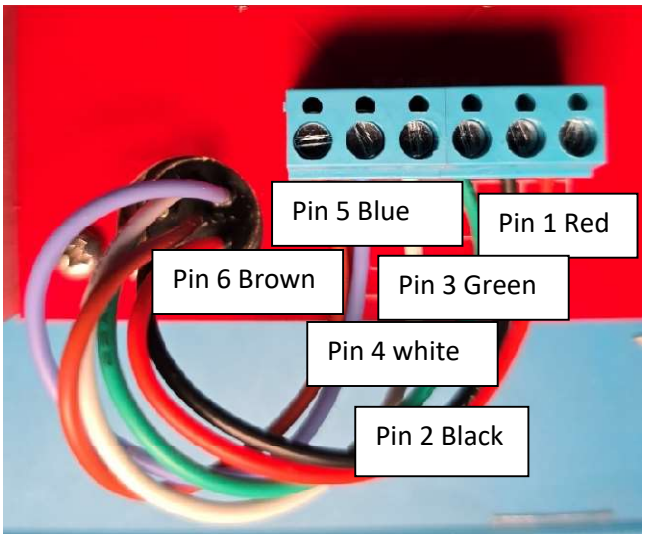
- 12f. Once all the connectors are securely fastened, reinstall the board on to the standoffs. Remember to carefully route to cables from the aircraft connector (or the raw 22ga 6 conductor cable) through the opening in the circuit board. Install the board.



- 12g. Trim excess wires from the aircraft connector, strip back 1/8” (3mm) and tin the ends of the wires.

- 12h. Wire the terminals as follows for the CNTRL CONN terminals:

Wire Color	Control In Terminal
Red	Pin 1
Black	Pin 2
Green	Pin 3
White	Pin 4
Blue	Pin 5
Brown	Pin 6



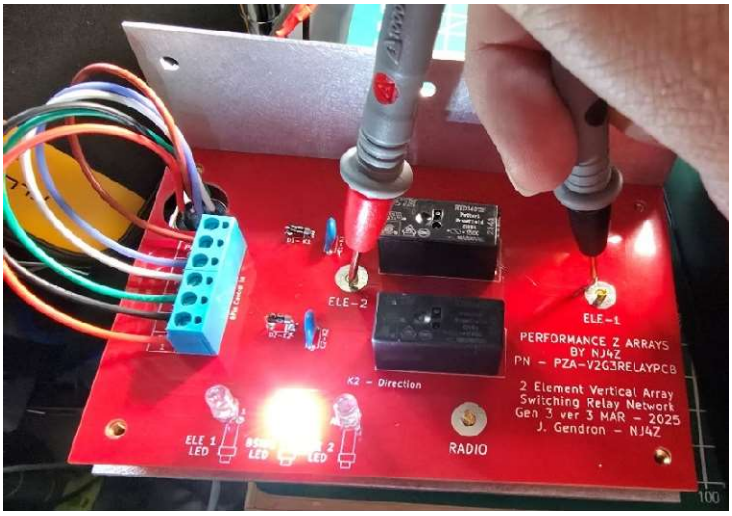
- 12i. **IMPORTANT: Before soldering the connectors into the pads, perform a function test of the relay board. See Step 13.**

STEP-13 Function Testing Relay Network & Final Assembly

This test can be performed connect a 12V DC power source to the Control input terminal block, or by connecting the assembled controller to the switching network with a control cable and 12VDC power connected to the controller.

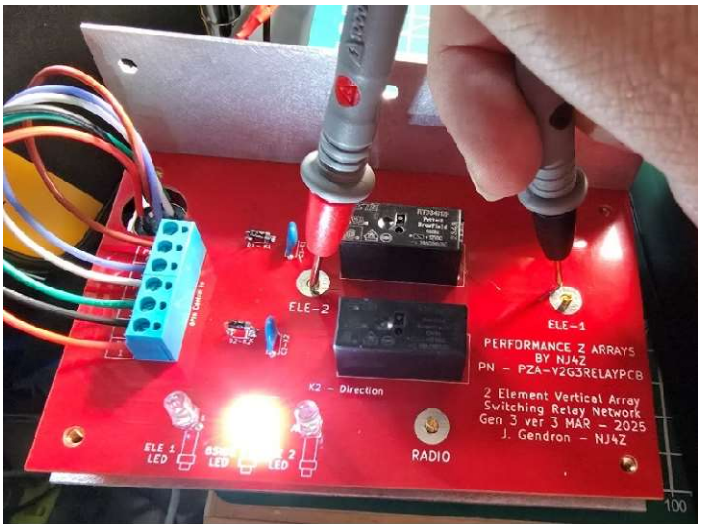
- 13a. Connect +12VDC power to pin 6 of the control terminal block and connect the -12V lead to pin 1 of the control terminal block – the ELE 1 LED should illuminate.

- 13b. Using a volt ohm meter check for continuity between the radio input pad and the ELE-2 pad. There should be continuity.
  Optional: To test with the controller power the controller and turn the direction selector switch left to the E1 position, the ELE 1 LED should illuminate and there should be continuity between the radio input pad and the ELE-2 pad.



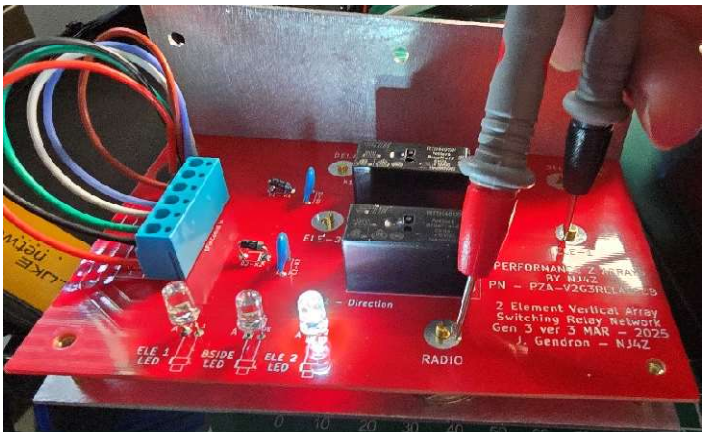
- 13c. Disconnect from Pins 1 and 6. Connect +12VDC power to pin 5 of the control terminal block and connect the -12V lead to pin 2 of the control terminal block – the Broadside LED should illuminate.

- 13d. Using a volt ohm meter check for continuity between the radio input pad and the ELE-1 and ELE -2 pads. There should be continuity. There should also be continuity between the ELE-1 and ELE-2 pads.
  Optional: To test with the controller power the controller and turn the direction selector switch to the broadside position (center) position, the Broadside LED should illuminate and there should be continuity between the radio input pad and the ELE-1 and ELE-2 pad. There should also be continuity between the ELE-1 and ELE-2 pads.



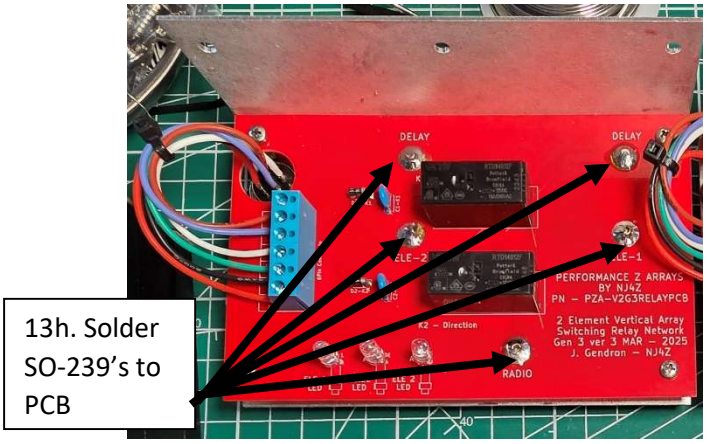
- 13e. Disconnect from Pins 2 and 5. Connect +12VDC power to pin 4 of the control terminal block and connect the -12V lead to pin 3 of the control terminal block – the ELE 2 LED should illuminate.

- 13f. Using a volt ohm meter check for continuity between the radio input pad and the ELE-1 pad. There should be continuity.
  Optional: To test with the controller power the controller and turn the direction selector switch right to the E2 position, the ELE 2 LED should illuminate and there should be continuity between the radio input pad and the ELE-1 pad.

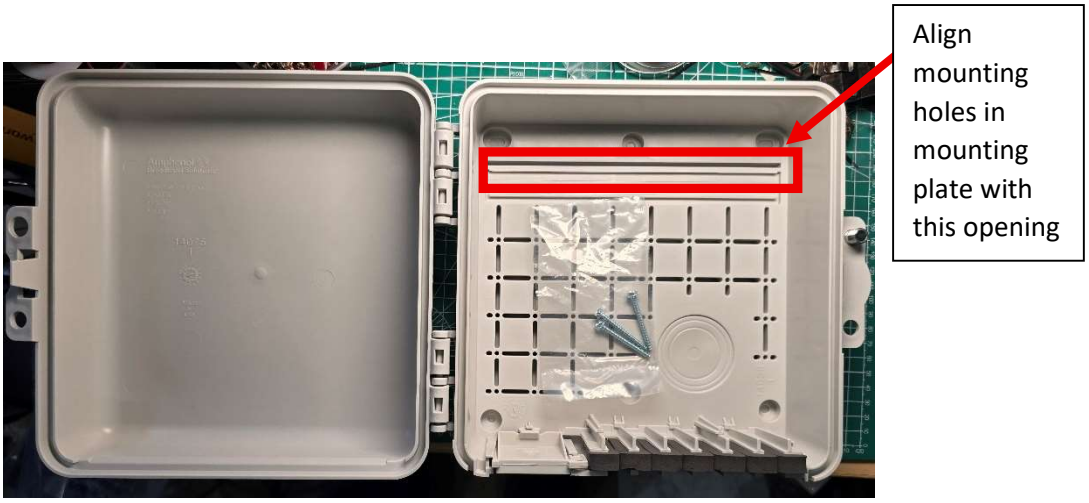


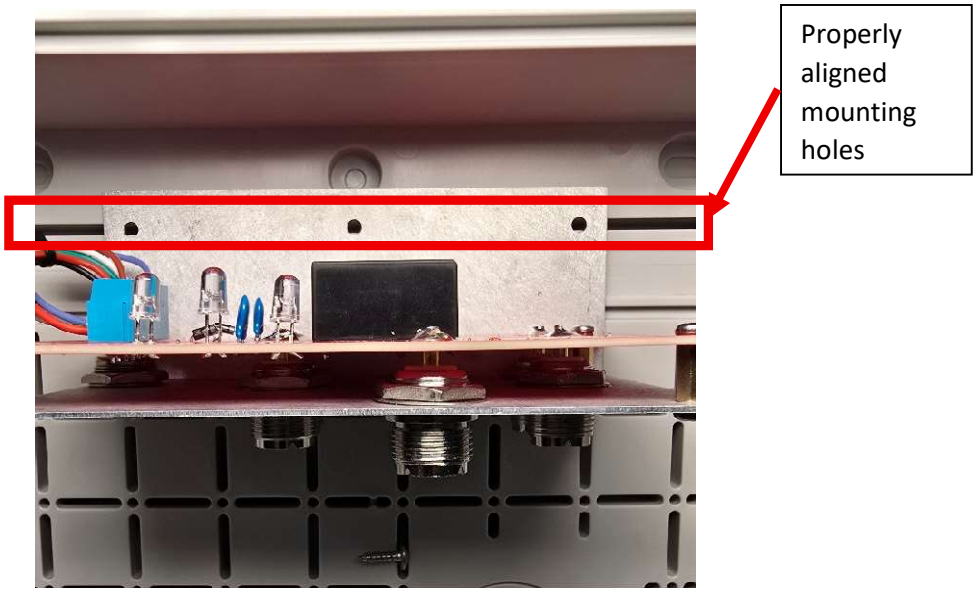
- 13g. Disconnect from pins 3 and 4 or the controller if connected to it.

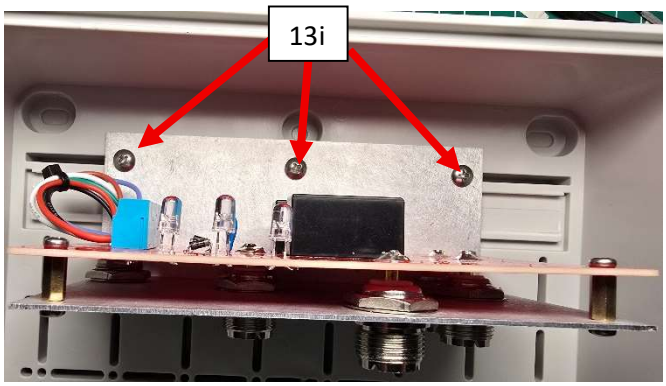
- 13h. If the function test was successful, then solder the SO-239 center pins into the pads on the board, **if not see the troubleshooting guide on page 53.**

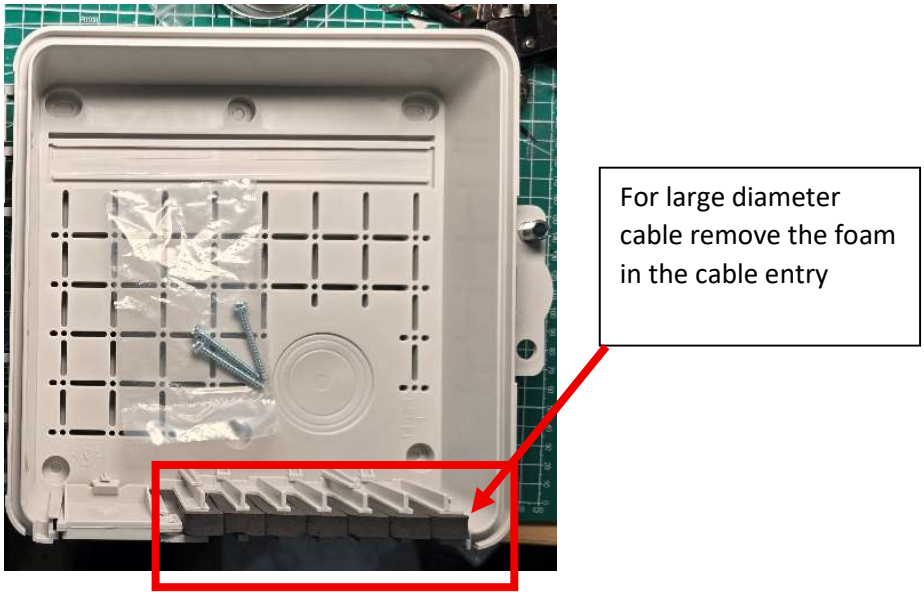


13i. Install the completed assembly into the housing using the three #6 x ½" screws. The screw holes should line up with the top mounting row in the housing, as pictured below.




Properly aligned mounting holes


13i


For large diameter cable remove the foam in the cable entry

Troubleshooting the Relay Switching Network

Symptom: **Status LEDs do not illuminate as the direction on selector switch on the controller**

Remedies: **Check solder joint at for the terminal on the bottom of the PCB for LEDs**

Verify controller cable is connected to the GX16-6P socket.

Verify polarity of the LED's

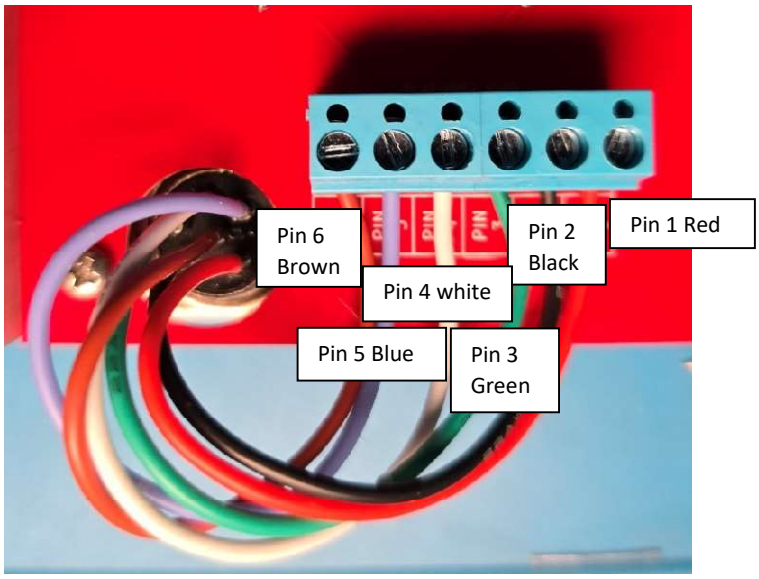
Verify the power termination of wires at the Control Input Terminal Block

Using a Voltmeter verify voltage (12V DC) at the Power Input Terminal Block

Ele - 1 LED (Positive Pin 6, Negative Pin 1)

Broadside LED (Positive Pin 5, Negative Pin 2)

Ele - 2 LED (Positive Pin 4, Negative Pin 3)



Symptom: **No Continuity Between Radio in and Ele-2 pads when Controller is in E1 Position**

Remedies: **Check solder joints at for the terminals on the bottom for the K2 Relay**

Symptom: **No Continuity Between Radio in, Ele -1 and Ele-2 pads when Controller is in broadside position**

Remedies: **Check solder joints at for the terminals on the bottom for the K1 and K2 Relays**

Verify controller cable is connected to the GX16-6P socket.

Verify the power termination of wires at the Control Input Terminal Block

Using a Voltmeter verify voltage (12V DC) at the Power Input Terminal Block

Broadside LED (Positive Pin 5, Negative Pin 2)

Symptom: **No Continuity Between Radio in and Ele-1 pads when Controller is in E2 Position**

Remedies: **Check solder joints at for the terminals on the bottom for the K2 Relay**

Verify controller cable is connected to the GX16-6P socket.

Verify the power termination of wires at the Control Input Terminal Block

Using a Voltmeter verify voltage (12V DC) at the Power Input Terminal Block

Ele - 2 LED (Positive Pin 4, Negative Pin 3)

Feed Line and Delay Line Construction

For the feedlines and delay lines I recommend RG-213, it was what the original designer of the array, Gary Christman, used. RG-213's .66vf requires less cable for each of the lines, while keeping them log enough to reach the elements. For lower power operations from QRP up to 100W RG-8X is a good substitute. Remember to change the Velocity Factor of the cable for the calculations. Cutting 50-ohm coax feedlines for an antenna array requires precision to ensure optimal performance. Here are some general steps to guide you:

Determining the Length of the Cables: Calculate the electrical length of the coaxial cable. For an 84-degree and 71-degree electrical length, use the formula:

84 Degree Feedline length is equal to L= (λ/360) x 84 x *vf*
71 Degree Delay Line length is equal to L= (λ/360) x 71 x *vf*
λ is the wavelength of the signal in Megahertz (MHz).
f is the Target frequency in MHz
vf is the velocity factor of the coax cable.
The wavelength can be calculated using:
λ = 299.8/f(MHz) for metric units
λ = 983.6/f(MHz) for imperial (feet) units

Example 1 - Target Frequency 14.175Mhz, Coax *vf* =.66
λ = 299.8/14.175= 21.15 meters
L= (21.15m/360) x 71 x .66 = 2.753 meters
λ = 983.6/14.175= 69.39 feet
L= (69.39ft/360) x 71 x .66 = 9.032 feet

Determining the Check Frequency: Calculate the frequency where the 84-degree and 71-degree lines will be 90 degrees.

The Check Frequency (CF) is equal to CF = (90/*Y*) x *f*

Y is the desired phase angle
f is the target frequency

CF = (90/71) x 14.175 = 17.968

Example: Target Frequency 14.175MHz, 71Degree Delay, Coax *vf* = .66

Feed and Delay Line Calculator- Mertic		
Phasing Angle Desired	71	Degrees
Target Frequency	14.175	MHz
Coax Velocity Factor	0.66	% of c
Phasing Multiplier	1.268	
Check Frequency	17.968	MHz
Length of Cable	2.753	Meters

Feed and Delay Line Calculator- Imperial		
Phasing Angle Desired	71	Degrees
Target Frequency	14.175	MHz
Coax Velocity Factor	0.66	% of c
Phasing Multiplier	1.268	
Check Frequency	17.968	MHz
Length of Cable	9.032	Feet

You can download the calculation spread sheet from www.performancezarray.com. Page 57 of this manual has a worksheet you can print and determine cut lengths and check frequencies.

1. **Cut the Coaxial Cable:** Measure and cut the coaxial cable slightly longer than the calculated length. Ensure the cut is clean and straight to avoid signal loss.

2. **Strip the Cable:** Carefully strip the outer insulation, shield, and dielectric to expose the inner conductor, on one end of the cable, to prepare it for termination. Be cautious not to nick the inner conductor.

3. **Attach Connector**: Solder or crimp the appropriate connectors to one end of the coaxial cable. Ensure a secure and stable connection to prevent signal degradation.

4. **Tuning the Cable:** connect the terminated end of the cable to a VNA or antenna analyzer. Leaving one end of the coax open, set your VNA or antenna analyzer to the check frequency. Trim the coax from the open end a little at a time until you see minimum X reactance (which should also be minimum Z Impedance). Typically, the reactance with be inductive +jX before you trim the cable. Trim the cable a bit at a time until you reach X=0.0Ω or go negative (capacitive reactance -jX).

5. **Attach Second Connector**: Solder or crimp the appropriate connectors to open end of the coaxial cable. Ensure a secure and stable connection to prevent signal degradation.

6. **Test the Cable**: Use a network analyzer or SWR meter to test the cable and ensure it is functioning correctly. Check for any signal loss or impedance mismatches.

Cut Length and Check Frequency Calculations Sheet

Cut length Calculations in Meters

λ= 299.8/_____MHz (desired frequency) = _____Meters

Wavelength (λ) per degree = _____ (λ from above)/360 = _____meters

Cut Length = _____ (λ per degree) X _____degrees (desired) X _____ cable *vf* = _____ meters

λ= 299.8/_____MHz (desired frequency) = _____Meters

Wavelength (λ) per degree = _____ (λ from above)/360 = _____meters

Cut Length = _____ (λ per degree) X _____degrees (desired) X _____ cable *vf* = _____ meters

Cut length Calculations in Feet

λ= 983.6/_____MHz (desired frequency) = _____Feet

Wavelength (λ) per degree = _____ (λ from above) / 360 = _____Feet

Cut Length = _____ (λ per degree) X _____degrees (desired) X _____ cable *vf* = _____ feet

λ= 983.6/_____MHz (desired frequency) = _____Feet

Wavelength (λ) per degree = _____ (λ from above) / 360 = _____Feet

Cut Length = _____ (λ per degree) X _____degrees (desired) X _____ cable *vf* = _____ feet

Check Frequency Calculations

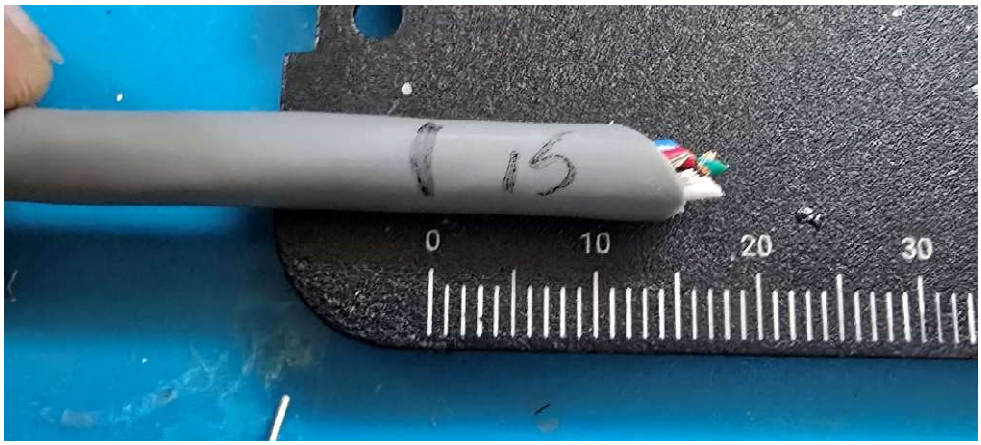
Check Frequency = 90 / ____degrees (desired) X _____MHz (desired frequency) = _____MHz

Check Frequency = 90 / ____degrees (desired) X _____MHz (desired frequency) = _____MHz

Control Line Construction

The control line for this unit is made of a 6-conductor cable suitable for your applications (outdoor rated cable like West Penn “Aqua Seal” or other rated cable). It is recommended that the cable conductors be 22awg (.64mm) or 20awg (.8mm). Cut the cable to the necessary length from the control box to the relay box position at the array. If the cable is over 250ft long, consider a cable with larger conductors such as an 18awg (1mm)

1. Once you determine the length of the cable, make the proper cut.
2. Prepare the aircraft connectors by removing the small screw in the side of the connector that holds the socket in place. Twist and pull the connector to release it from the connector body.
3. Place the body of the connector over the end of cable at each end.
4. Place a 1” (25mm) piece of glue lined heat shrink over the end of the cable.
5. Strip back the cable jacket 5/8th inches (15mm) at each end.

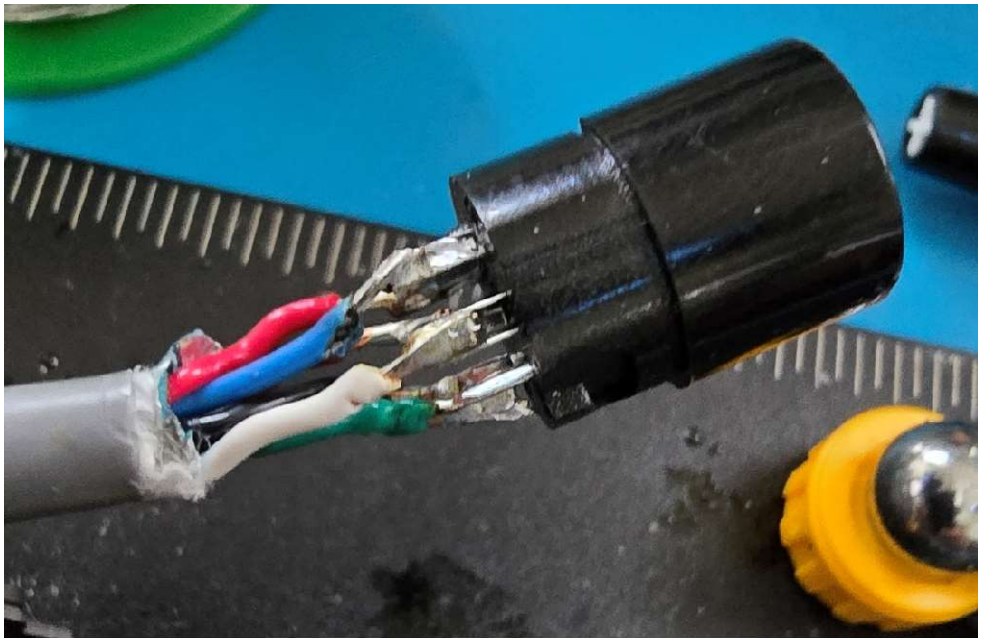


6. For each end of the cable, strip the individual conductors back 1/8” (3mm) and tin the ends of the conductors with solder.
7. Prepare the socket of the connector to accept the conductors by tinning the solder cups on the connector pins.
8. Mark the number one pin with a marker or tape so it is easy to identify.

9. Use the table below for the color Keep it consistent at each end of the cable.

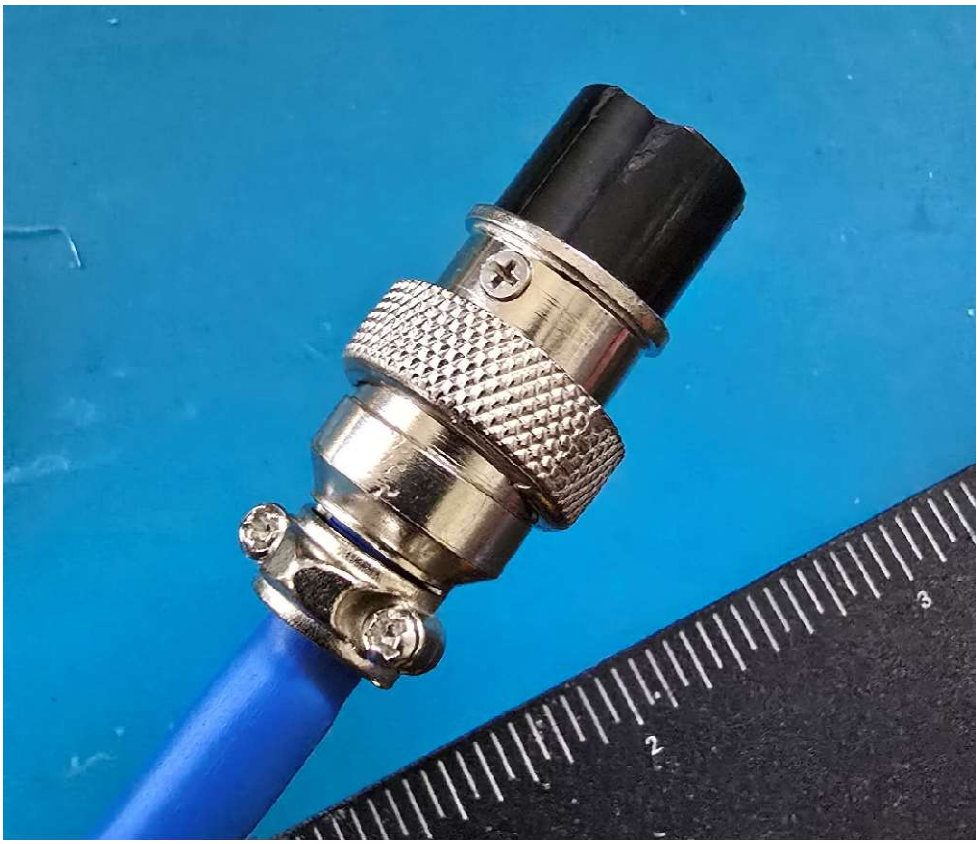
Pin Number	Color Conductor
1	RED
2	BLACK
3	GREEN
4	WHITE
5	BLUE
6	BROWN

10. Starting with the middle pin which #6, solder each conductor onto its proper pin.



11. Slide the heat shrink up the cable so that it is just short of the terminated pins.
12. Use a heat gun to shrink the shrink tubing.
13. Install socket into body of the connector, by sliding the connector body onto the socket and installing the small screw through the body into the socket.
14. Repeat this process to the second end of the cable.

15. When you are complete with both ends, test the cable with a continuity tester to verify all pin positions are straight through, and that there are no open or shorted pins.



Antenna Design and Construction

The antenna array requires 2 radiators for the intended band of operation. This can be metallic verticals, wire elements supported by nonconductive masts, or other appropriate vertical antennas. Each element should be installed per manufacturers' instructions. Each radiating element is one quarter wavelength (1/4 λ) of the desired frequency of operation. Once the first element is constructed, the antenna must be tuned for the center of the desired band of operation and an SWR below 1.2:1 ratio. **Remove the first element from area** and construct the second element and repeat the tuning process for the center of the desired band of operation and an SWR of 1.2:1 ratio for the second element.

IMPORTANT – do not try and tune the elements at the same time or with both elements standing.

NOTE: The construction of the elements is very important for performance of the array. The Elements should be of or as close to equal impedance as possible and practical. Equal impedances are extremely important to provide proper current division among the elements.

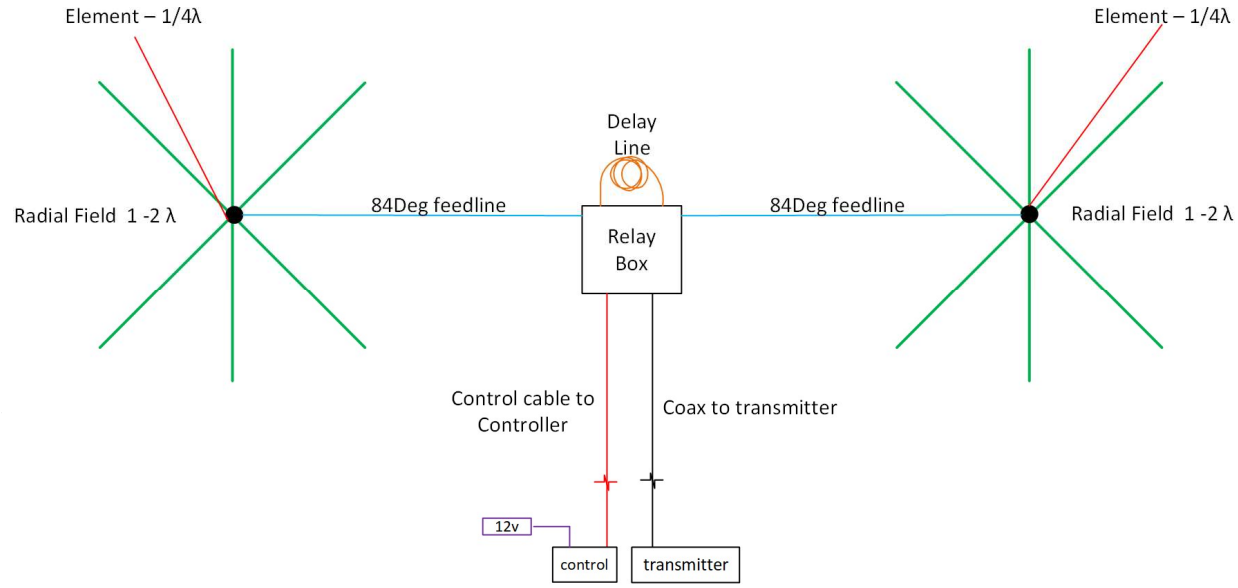
If you purchase the DX Commander Kits to build the radiating elements of the array, the kit includes 2 sets of .250 quick disconnects to connect the radiating elements and the SO-239 connector on the radial plate of the antenna.

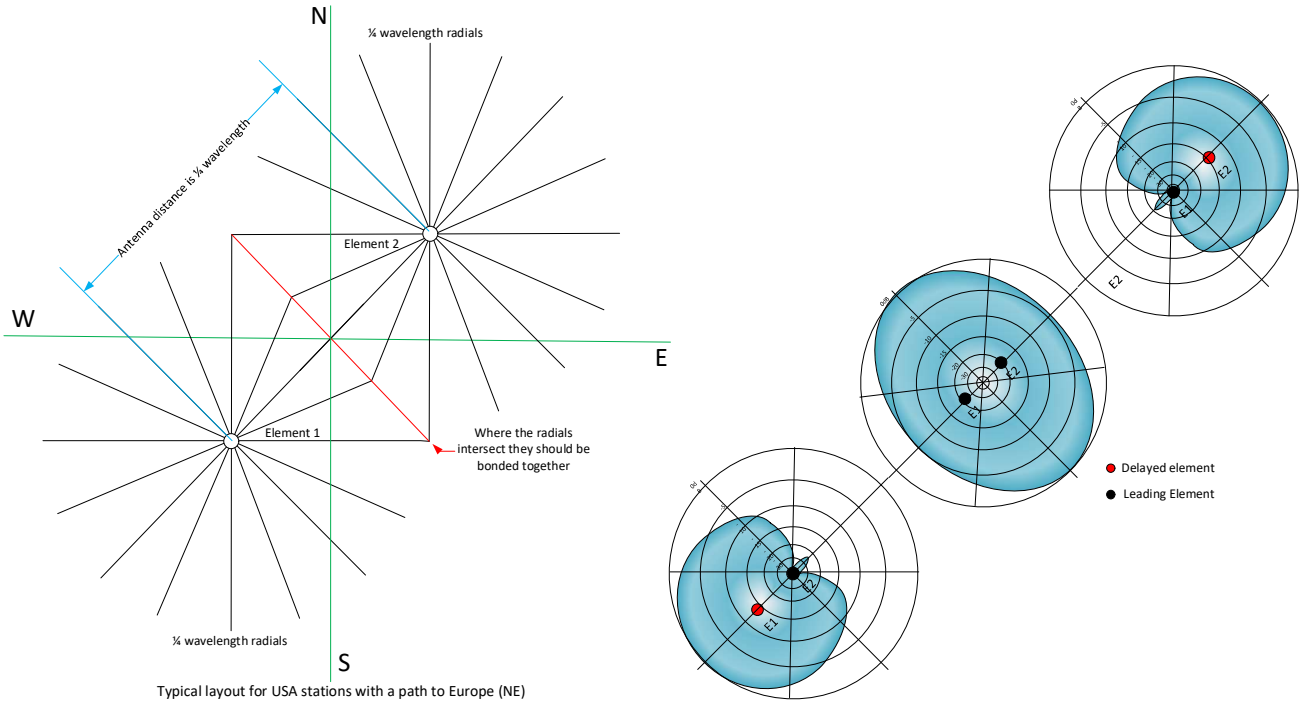
The topography of the selected installation site is very important. A large difference in the elevation of the elements may create undesirable radiation patterns. Level or gently sloping land is recommended for the installation of the array. There should not be a difference in elevation of the of more than 20% of the spacing of the elements in the array. **Example:** A 40-meter array centered on 7.150MHz will have a spacing of 34.4 ft (10.4 meters) and should not have more than 6.5ft (2meter) difference in mounting height.

Once both radiators are constructed, the radiating elements are to be placed one-quarter wavelength (1/4 λ) of the desired operating frequency apart **(Experimentation with distance of elements should be done to maximize F/B ratios. It may be found that slightly less or more than ¼ wavelength may provide better F/B and gain properties.)** Chart 1 on page 62 can provide some guidelines for distances for various bands and modes. A radial field should be placed on the ground below the masts. The radial field should be at a minimum total length of two times (2X) the wavelength of the operating frequency at each element. Optimal performance for effort would be to place four times (4x) the full wavelength of the operating frequency. For a permanent installation it is advised that the radials from each of the elements that intersect should be bonded together.

Once the radial field is installed you should connect an 84^{o} feedline to each element. The phasing relay network enclosure should be placed in the center of the elements. The box can

be hung vertically to a post or laid flat on the ground. Connect the radiating elements to the relay box utilizing one of the two prepared 50Ω (RG-213, or other suitable coax) 84° feedline cables. The tuned 50Ω (RG213, or other suitable coax) 71deg delay loop cable should be connected to the delay in and out so-239 connectors on the relay box.





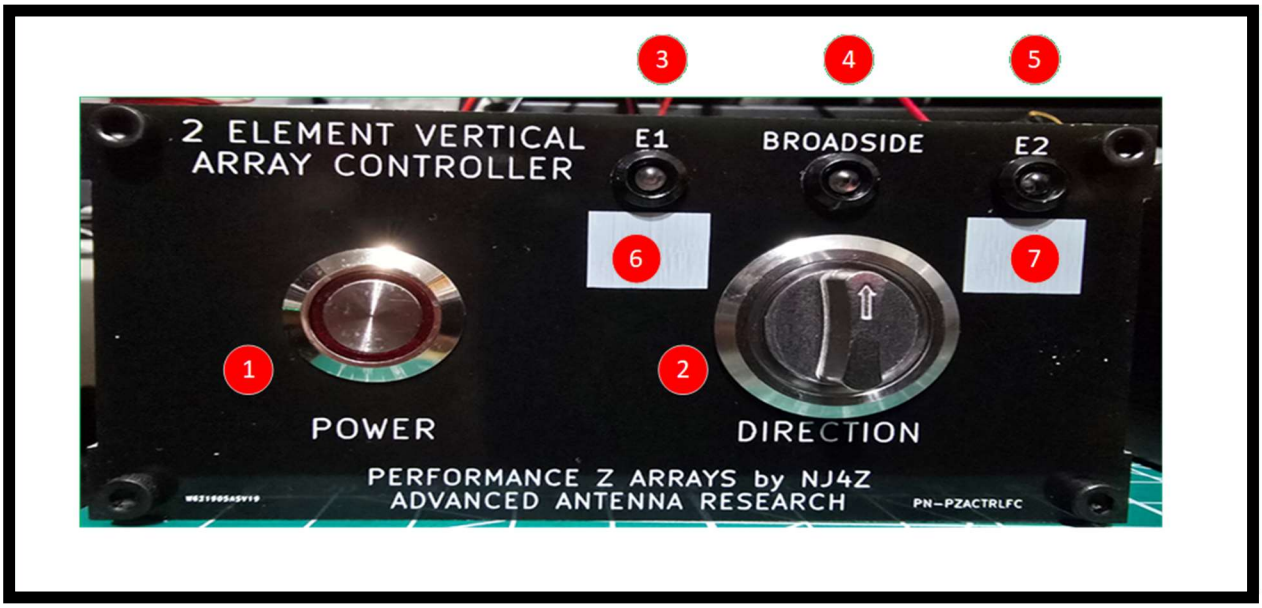
Typical layout for US stations to have gain to European stations.

CHART 1 – Typical 1/4λ System Distances

USA Operations 1/4 wavelength spacing						
Operational Band	Mode of Operation	Operational Target Frequency (MHz)	1/4 (λ) wavelength between antennas		Total System width with safety margin	
			Meters	Feet	Meters	Feet
160	CW/Digital	1.830	40.90	134.4	169.70	557.60
	SSB	1.845	40.60	133.3	168.50	553.20
80	CW/Digital	3.575	21.00	68.8	90.10	295.20
	SSB	3.710	20.20	66.3	86.90	285.20
60		5.357	14.00	45.9	62.10	203.60
40	CW/Digital	7.040	11.00	34.9	50.10	159.60
	SSB	7.150	10.40	34.4	47.70	157.60
30		10.125	7.40	24.3	35.70	117.20
20	CW/Digital	14.050	5.33	17.5	27.42	90.00
	SSB	14.225	5.27	17.3	27.18	89.20
17		18.120	4.15	13.6	22.70	74.40
15	CW/Digital	21.075	3.57	11.7	20.38	66.80
	SSB	21.200	3.54	11.6	20.26	66.40
12		24.940	3.02	9.9	18.18	59.60
10	CW/Digital	28.074	2.69	8.8	16.86	55.20
	SSB	28.500	2.59	8.5	16.46	54.00

Panel Description

Controller Front Panel



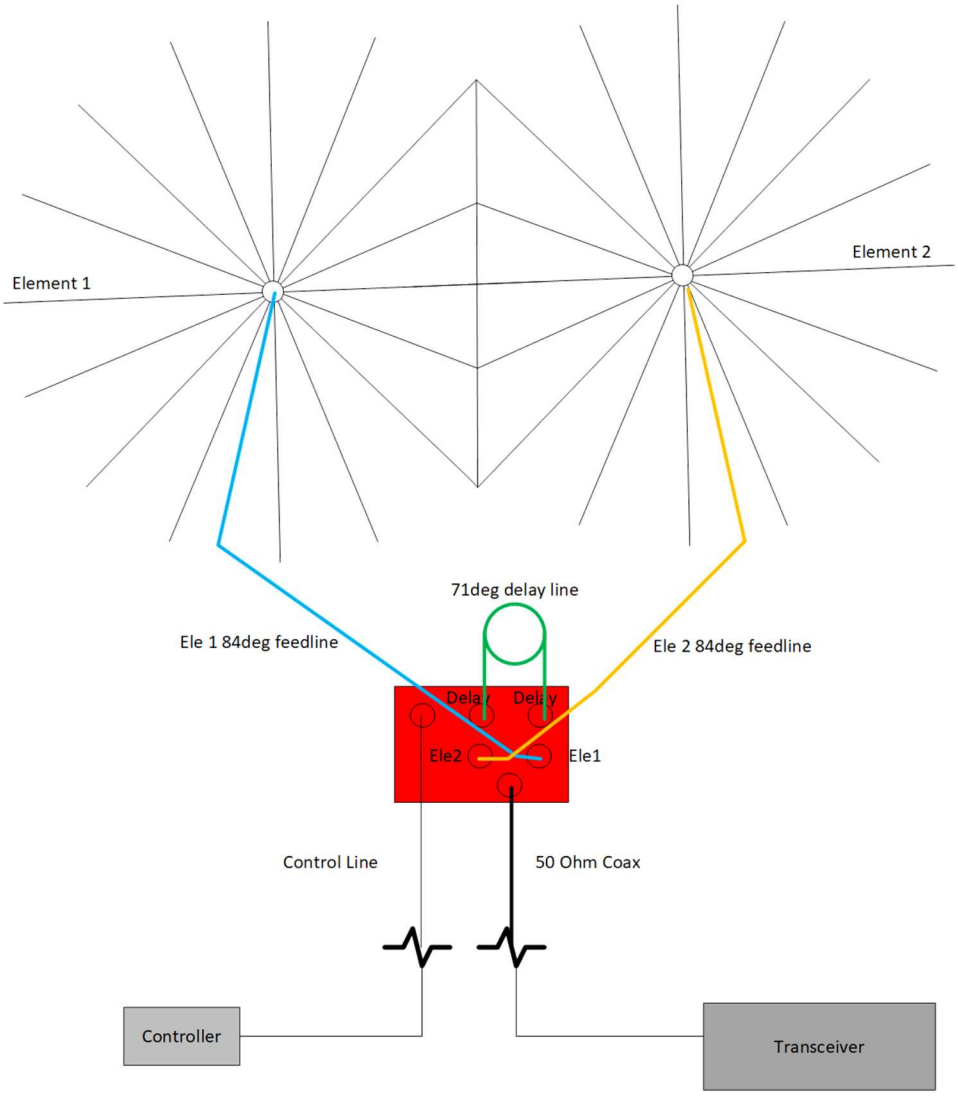
1. **Power Key – turns the unit (and relay network if connected) on/off. LED will illuminate red when on**
2. **Directional Selector Switch – Three position lighted switch to select the direction of the connected array. The arrow on the switch points to the direction of delay in the array.**
3. **E1 LED indicator – When illuminated element 1 of the array is in delay. Max gain on TX/RX will be in that direction.**
4. **Broadside LED Indictor – When illuminated both elements are in phase and the array will have an omnidirectional patter with slight gain broadside to the array.**
5. **E2 LED indicator – When illuminated element 2 of the array is in delay. Max gain on TX/RX will be in that direction.**
6. **Direction Indicator for Element 1 – space can be used to write on or use a label in this box to label the direction of element 1.**
7. **Direction Indicator for Element 2 – space can be used to write or use a label in this box to label the direction of element 2.**

Controller Rear Panel

1. **Control Line Out Port – Connect the 6 Pin plug on the control line. (optional can be a grommet to allow for a direct wire of the control line onto the internal terminals)**
2. **12VDC Power Input – Connect 2.1 X 5.5 mm power plug.**

Balance of page intentionally left blank.

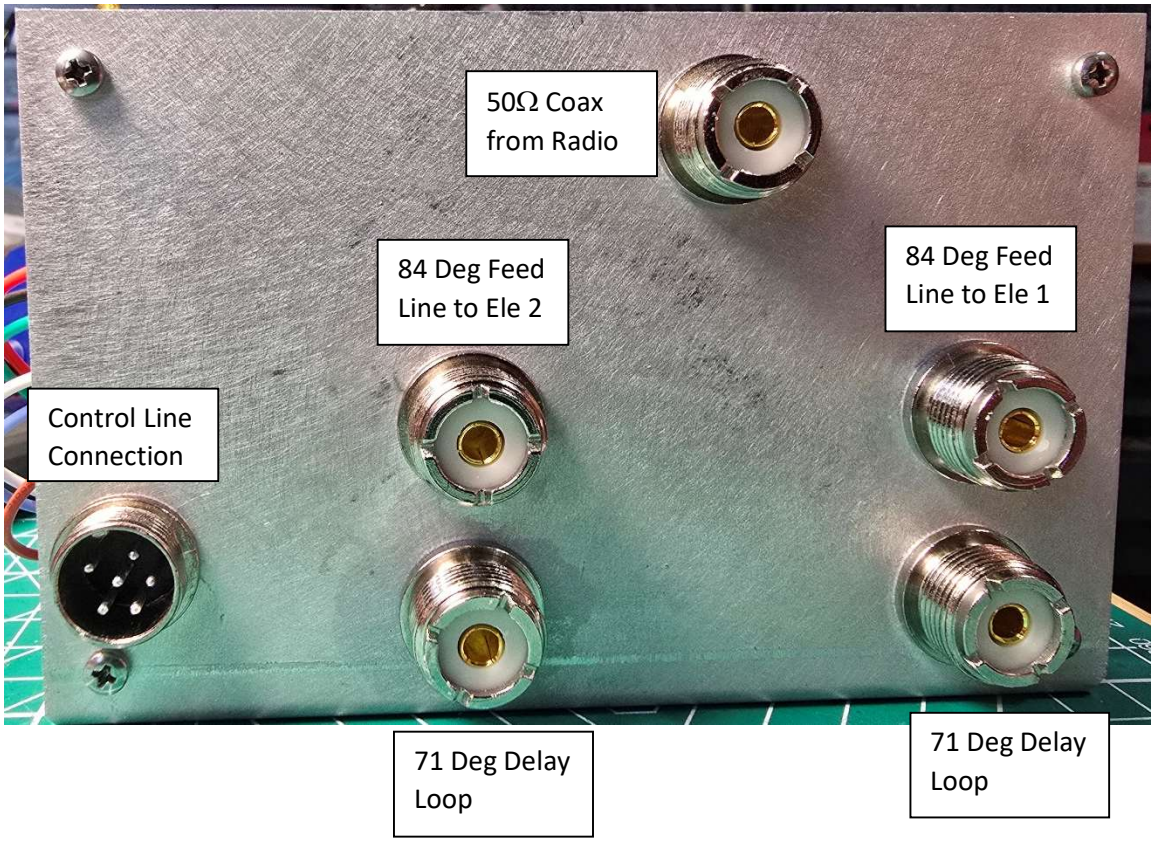
Operation Instructions



To begin operations

1. Set up the elements as required for the required band of operation. (See Antenna Design and Construction section and suggested spacing chart (PAGE 62).
2. Place the relay network box halfway between the elements.
3. Connect the 71-degree delay line to the delay SO-239 connectors in the box.
4. Connect one of the 84-degree feed lines to the SO-239 connection on element 1 and connect the other end to the ELE1 SO-239 connector in the relay box.
5. Connect the other 84-degree feed line to the SO-239 connection on element 2 and connect the other end to the ELE2 SO-239 connector in the relay box.
6. Connect one end of the control cable to the control cable 6-pin socket in the relay box.

7. Connect a piece of 50ohm coax (use proper cable for power level) to the Radio In (TX) SO-239 in the relay box.



8. Connect the end of the control cable to the Control Line Out port on the array controller rear panel.
9. Connect the 12v DC power cable to the 12V DC input port on the rear of the controller.
10. Connect the 12V DC power cable to a 12V DC power source.
11. Connect the 50ohm coax from the relay box to the Antenna SO-239 on the transceiver to be used.
12. Turn on the 12V DC power supply.
13. Press the power switch on the front panel of the controller. (The power switch, direction switch and one of the indicator LEDs should illuminate).
14. Turn on the transceiver.
15. Select the band of operation desired for the transceiver.
16. See below, match the array to the transmitter see below.

Matching the transceiver to the Array:

The array should present about a 2.2:1 SWR when constructed with 50ohm feedlines and delay lines in the broadside position.

To match the transceiver to the array the internal tuner of most transceivers or an outboard manual or automatic tuner can be used.

For digital operations:

1. Tune the transceiver to the desired frequency.
2. Turn the direction selector switch to broadside on the array controller.
3. Start the tuning operation, the tuner should provide a proper match.

For CW operations:

1. Tune the transceiver to the desired frequency.
2. Turn the direction selector switch to broadside on the array controller.
3. Start the tuning operation, the tuner should provide a proper match.

For Phone operations:

1. Tune the transceiver to the center frequency of the Phone part of the desired band.
2. Turn the direction selector switch to broadside on the array controller.
3. Start the tuning operation, the tuner should provide a proper match.

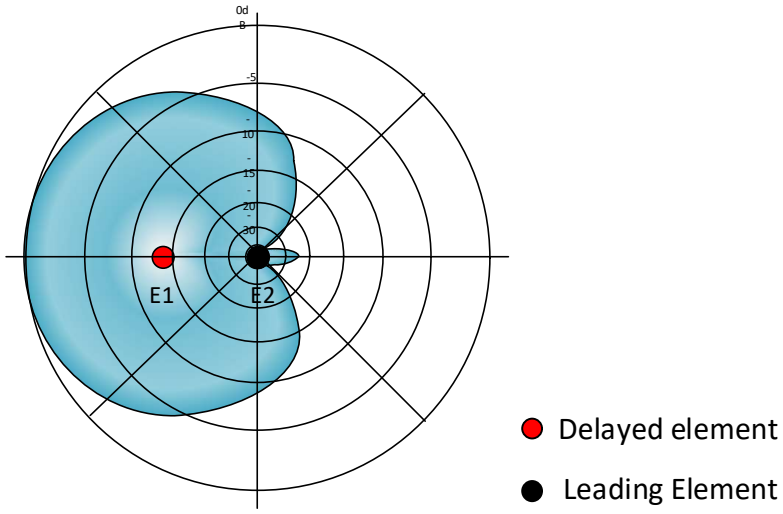
Controlling the direction of the array:

The array operates by delaying signals to one of the elements, creating a 90-degree phase shift. This phase shift allows for constructive interference in the direction of the delayed (lagging) element. It also produces deconstructive interference in the direction of the leading element. This interference creates gain in the direction of the lagging element and creates a null in the direction of the leading element.

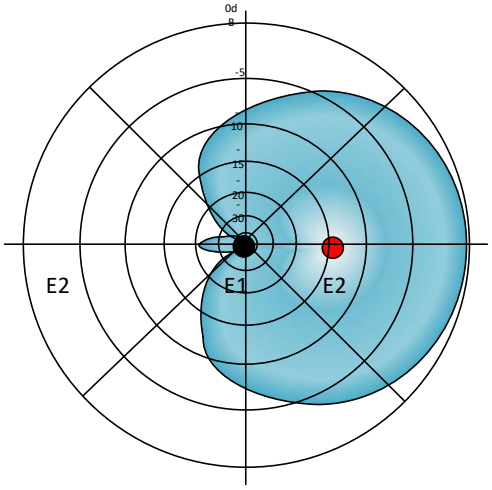
It is important to know which direction the array elements are facing when the array is constructed. It is desirable to note these directions for ease of operation. They can be noted on the front panel of the controller or on a piece of paper.

IMPORTANT NOTE: Nearby stations or RF signals that are received at a high angle of incidence (NVIS) or ground wave propagation will not exhibit a great deal of front to back isolation. DX station signals that arrive at a low angle will exhibit good traits of front to back isolation.

To create gain in the direction of element 1, move the directional selector switch to the left with the arrow pointing to the element 1 LED indicator. The indicator should illuminate. **(REMEMBER NEVER SWITCH THE ARRAY UNDER LOAD WHEN TRANSMITTING).** This will produce a cardioid pattern in the direction of element 1.



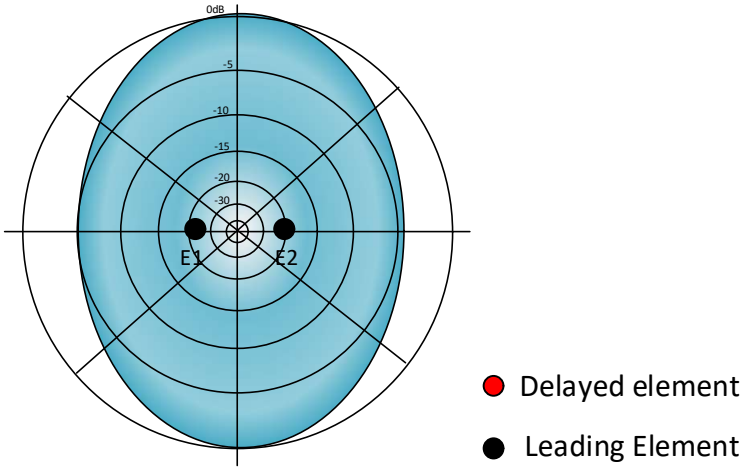
To create gain in the direction of element 2, move the directional selector switch to the right with the arrow pointing to the element 2 LED indicator. The indicator should illuminate. **(REMEMBER NEVER SWITCH THE ARRAY UNDER LOAD WHEN TRANSMITTING).** This will produce a cardioid pattern in the direction of element 2.



Delayed element

Leading Element

To create gain broadside to the array (omnidirectional, with slight gain broadside to the array) move the directional selector switch to the right with the arrow pointing to the broadside indicator. The indicator should illuminate. **(REMEMBER NEVER SWITCH THE ARRAY UNDER LOAD WHEN TRANSMITTING).** This will produce an omnidirectional pattern, with slight gain broadside to the array.



Warranty

All products manufactured by Performance Z Arrays (PZA) are warranted to be free from defects in material and workmanship for a period of 90 days from the date of shipment. PZA's sole obligation under these warranties shall be to issue credit, repair or replace any item or part thereof which is proved to be other than as warranted; no allowance shall be made for any labor charges of Buyer for replacement of parts, adjustment or repairs, or any other work, unless such charges are authorized in advance by Performance Z Arrays. If Performance Z Arrays' products are claimed to be defective in material or workmanship, Performance Z Arrays shall, upon prompt notice thereof, issue shipping instructions for return to Performance Z Arrays (transportation-charges prepaid by Buyer). Every such claim for breach of these warranties shall be deemed to be waived by Buyer unless made in writing. The above warranties shall not extend to any products or parts thereof which have been subjected to any misuse or neglect, damaged by accident, rendered defective by reason of improper installation, damaged from severe weather including floods, or abnormal environmental conditions such as prolonged exposure to corrosives or power surges, or by the performance of repairs or alterations outside of our plant, and shall not apply to any goods or parts thereof furnished by Buyer or acquired from others at Buyer's specifications. In addition, Performance Z Arrays' warranties do not extend to other equipment and parts manufactured by others except to the extent of the original manufacturer's warranty to Performance Z Arrays. The obligations under the foregoing warranties are limited to the precise terms thereof. These warranties provide exclusive remedies, expressly in lieu of all other remedies including claims for special or consequential damages. SELLER NEITHER MAKES NOR ASSUMES ANY OTHER WARRANTY WHATSOEVER, WHETHER EXPRESS, STATUTORY, OR IMPLIED, INCLUDING WARRANTIES OF MERCHANTABILITY AND FITNESS, AND NO PERSON IS AUTHORIZED TO ASSUME FOR PERFORMANCE Z ARRAYS ANY OBLIGATION OR LIABILITY NOT STRICTLY IN ACCORDANCE WITH THE FOREGOING.

Technical Support by E-mail: John@performancezarrays.com

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