RF Switch Users Manual
and
Assembly Instructions

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DRAFT

Designed and Produced to enhance your Amateur Radio Experience by

Team XCR

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1 Introduction

This project is an all-inclusive[1] Remote RF Switch (Antenna Selector) which provides a convenient way to remotely select HF and VHF antennas. The Switch uses Power-Via-Coax and WiFi (browser) for control. Thus eliminating the need to run an additional cable or control box. It provides a convenient user interface located on your existing logging PC or phone.

The User Interface is entirely via a browser. This can be a small window open on your logging PC. Simply click on the desired antenna and the connection will be made.

Additional information is displayed below the virtual buttons. Specifically, the DC voltage at the Switch and (optionally) the temperature, humidity and barometric pressure. The sensor is enclosed so the indicated values reflect the inside conditions of the enclosure.

1.1 Amateur Radio Kit

This project is presented for amateur radio use. As such, it is a collection of parts which, when properly assembled and operated, provide a useful operating tool. If the kit assembly or operation is beyond your skill level, please return the unassembled kit for a full refund (minus shipping).

Your assembly and operation is your acknowledgment and acceptance of the risks associated with amateur radio operations and kit assembly.

If you wish to use this project for other applications, please email the details of your intended operation.

1.2 License

This project is released under terms of the TAPR Non-Commercial License. You may build units for your own use, but may not sell units for a profit without a license.

1.3 Lightning

The Switch provides NO lightning protection.

Let me be totally honest with you. There COULD have been some ESD devices installed but they would mostly help advertising a capability which has no basis in the real world. A few MOV's could be sprinkled around, but without a very substantial path to ground they are nearly worthless.

Protection needs to be all or nothing. Protecting from all threats is a challenge. Best practice would be to install a metal plate with Polyphasers and a VERY SOLID path to Ground. Then route the coax to the Switch. Another protection installation should be placed prior to the coax entering the shack.

In the case of no user installed protection, the Switch will NOT serve as fuse for the coax to the shack. A direct strike will likely consume the switch and you will have to search for the remnants.

Protection is entirely a **USER RESPONSIBILITY.**

Installation of this Switch indicates your acceptance of this responsibility.

Notes

1. 1. This switch requires external +12VDC which may be supplied via a user supplied Bias T in the shack or at the site of the Switch installation. The user is responsible for providing power. A typical Bias T is the MFJ-4116 available from various dealers.
2. Refer to http://arrl.org for more information on ESD protection. The ARRL has excellent books on lightning protection.

1.4 Network Security

The switch works on your Local Area Network (LAN). There is no need to need to change any router settings to operate the Switch locally.

If you desire to operate the switch from beyond your LAN, it will be necessary to modify router settings. Since this IoT device is simply designed for LAN operation, there is no provision for protection from hackers. The same may be true for other amateur radio devices on your LAN.

If you desire to operate this IoT device from outside of your LAN, it is strongly recommended that you contact an IT professional and seek advice on providing firewall protection for your network.

1.5 SWR Caveat

This device is designed to switch antennas which are well matched **AT THE ANTENNA.**

Without using a Tuner, whether separate or internal to the radio, the SWR should be better than 2:1.

If your use a random wire or other antenna which is NOT 50 Ohms or has a SWR > 2:1, do NOT route the coax through this switch. The mismatch will result in high voltages which may be beyond the design parameters and may **damage the switch**.

2 RF Switch Assembly Instructions

In all cases where this text refers to “Install” components on the PCB, this indicates that the leads should be bent, the component installed on the PCB and that the component be soldered. Use only the minimum of solder necessary to ensure a good connection, not a large round ball of solder.

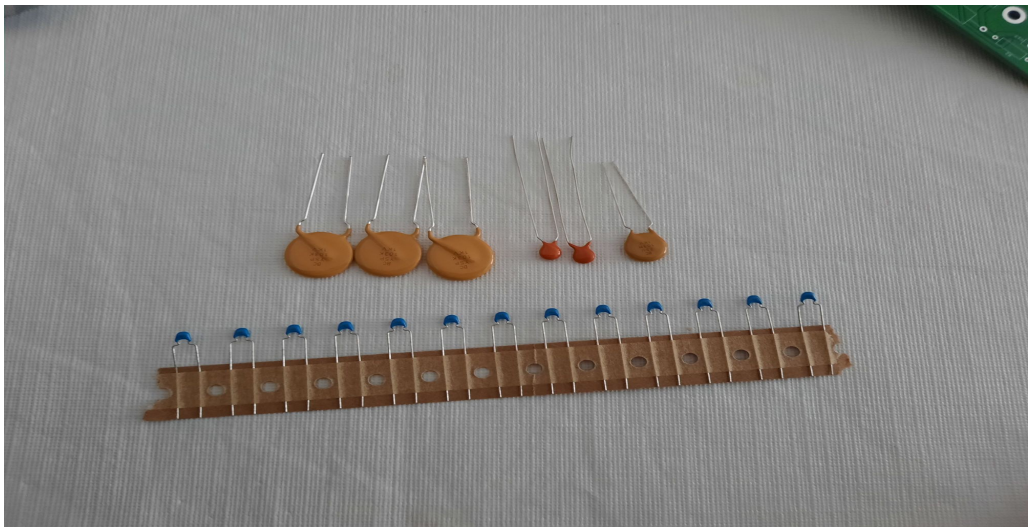
PLEASE read the Options section as you may want to incorporate some changes to the standard build.

2.1 PCB Assembly

The Switch PCB is user assembled and requires soldering. It is important to establish the Top and Bottom of the PCB. The relays and most components are mounted on the TOP side. The SO239 are mounted to the BOTTOM side. The silk screen indicates the Top and the Bottom.

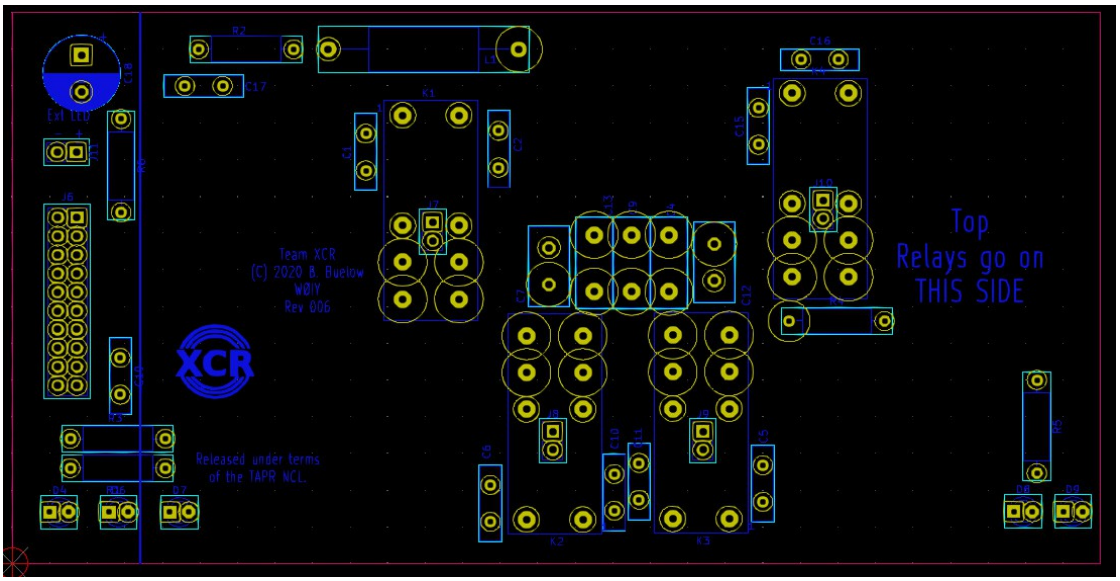
Do NOT install the SO239's at this time. They are installed on the metal shelf later in the assembly process.

1. Identify the various capacitors. Most of the caps are 0.01uF, but they have different voltage ratings.
   The long strip are .01uf @ 50V. Four of these will be installed first.
   The 3 large caps (C4, C9, C13) pass RF, but block the DC path in the Bias T portion of the circuit.
   A single medium size cap (C17, may be orange or yellow) is used as a bypass cap after the inductor.
   2 small caps (C12, C13) 6.8pF are used for impedance matching.



2. Install and solder 4x bypass caps (.01uf @50V) (C3,C8, C14, C20) on the Bottom side of the PCB. Apply a small amount of solder to the bottom side. After soldering, clip the Top side leads flush with the PCB as the relay will be mounted over the pads. Do no use a large amount of solder on the top side.

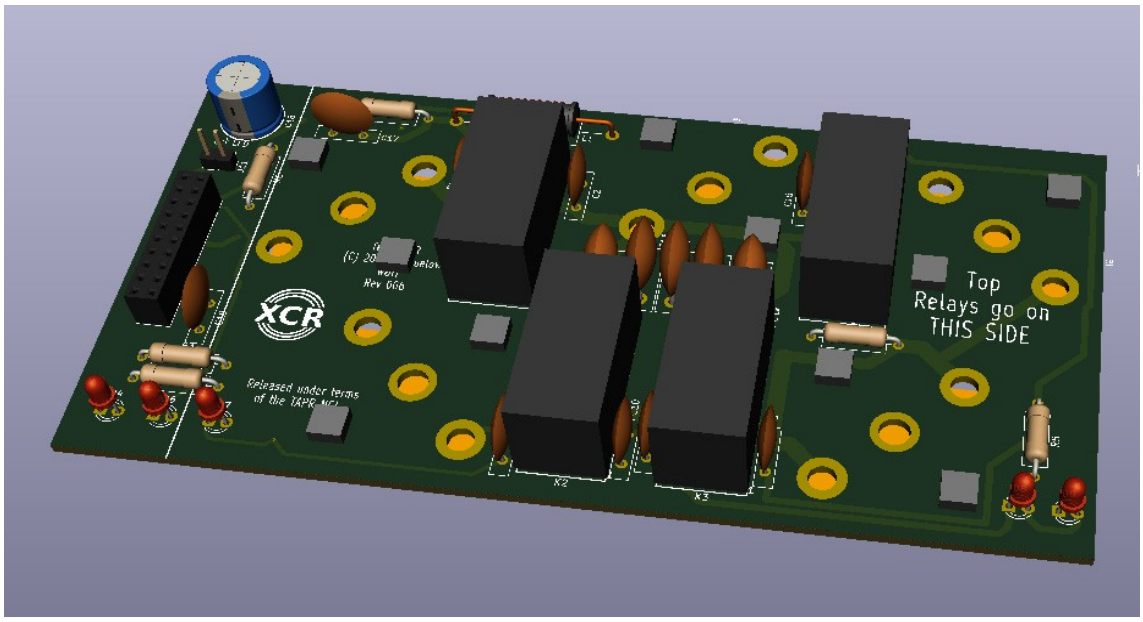
3. Install and solder the relay coil **bypass caps** (C1-C20) (.01uf @50V) on the TOP side of the PCB. These should be installed tight to the PCB and not interfere with the relay mounting.



4. Install and solder the Bias T components to the Top side.
   L1, R2, C17 are located towards the top rear of the PCB.
5. Install and solder the Series Caps (.01 1KV 3x) (C4, C9, C13) near the Top center of the PCB.
6. Install and solder the shunt caps (6.8pf 2x) (C7, C12) near the Top center of the PCB.
7. Install LED current limiting resistors (1.8K 3x) on the Top side of the PCB.
   R5 on the lower right
   R3 on lower left
   R1 immediately below R3
8. Install and solder the LEDs (5x).
   NOTE – LEDs are polarized and need to installed properly:
   SHORT lead goes in the SQUARE pad
   LONG lead goes in the ROUND pad
9. Install and solder J6 2x10 Female straight header connector.

10. Install and solder the relays (G2LR 4x) on the Top side of the PCB.

NOTE – check the section on Options (Section 4.2) if you do NOT want unused antennas to be Grounded.



2.2 PCB Testing

Do NOT install the Control PCB!

Note that J6 is on the Top Left of the PCB. Pin 1 is at the Top of the connector on the Inside. It has a square pad. Pin numbers are arrange:

2 1
4 3

1. Apply +12VDC via J6-19/20(+) and Ground J6-13/14/15/16.
   This should illuminate 1 LED (Power indicator).
   If the LED does not illuminate, check the voltage and polarity of the test power leads.
2. Prepare a 4” jumper wire with male pin on both ends.
3. Attach one side to Gnd (J6-19/20), momentarily connect the other end to J6-1 to engage Relay 1 and illuminate the associated LED D6.
4. Repeat using pin 3 for Relay 2 and LED D7
5. Repeat using pin 5 for Relay 3 and LED D8

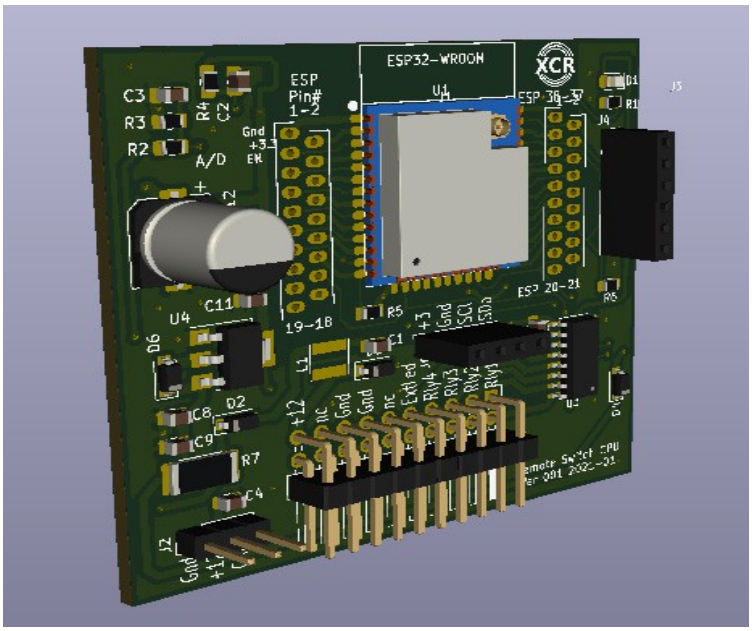
6. Repeat using pin 7 for Relay 4 and LED D9
   If you can hear the relay, but the LED doesn't illuminate, the LED may be installed backwards.

2.3 Control PCB

The Control comes mostly assembled, programmed and tested. You may have to install the male 90 degree header.

PLEASE PLEASE PLEASE USE CAUTION

When handling the Control as it is **static sensitive**.



2.3.1 Control Assembly

Install the 2x10 pin header by placing the shorter pins into the PCB. The black plastic should be positioned as shown in the figure.

1. Align the pins parallel with the PCB surface and Solder one pin.
   Examine the pin alignment. If necessary briefly heat the previously soldered pin and adjust the alignment.
   When it is correct solder the other pins.
2. Verify that the Switch assembly is NOT powered.
3. Install the Control by plugging it into the socket on the Switch assembly. Look at the notations on both PCB to ensure it is facing the correct direction. There is NO keying in this connector.

4. Early models of the switch are factory programmed with the users SSID, PW and Callsign.

2.3.2 WiFi Setup

1. Apply +12VDC to the Switch assembly.

   The primary means of providing power is via a Bias T (not supplied but available separately) or for testing, apply +12V to the LEFT side of L1. DO NOT APPLY RF
   The main power LED should illuminate and after a few seconds, the LED will illuminate for 500mS to indicate that Init is complete.

2. Once WiFi connection is established with the router, the LED on the Control assembly should blink. It will be on for about 100mS and repeat every second. If the LED is on constantly, the CPU has detected a problem. Try removing DC, wait 20 seconds and try again.

   During startup, each of the relays may momentarily engaged. This will also illuminate the associated LED on the Switch assembly.

3. Using a cellphone or laptop with WiFi capability, look for the WiFi signal with the SSID of "Switch". Connect to this device.

4. THE FOLLOWING IS NOT YET IMPLEMENTED

   You will now need to load the SSID and Password for your WiFi router. These are case sensitive!

5. Save the entry

6. Remove power from the Switch.

7. Wait 10 seconds.

8. Apply +12VDC

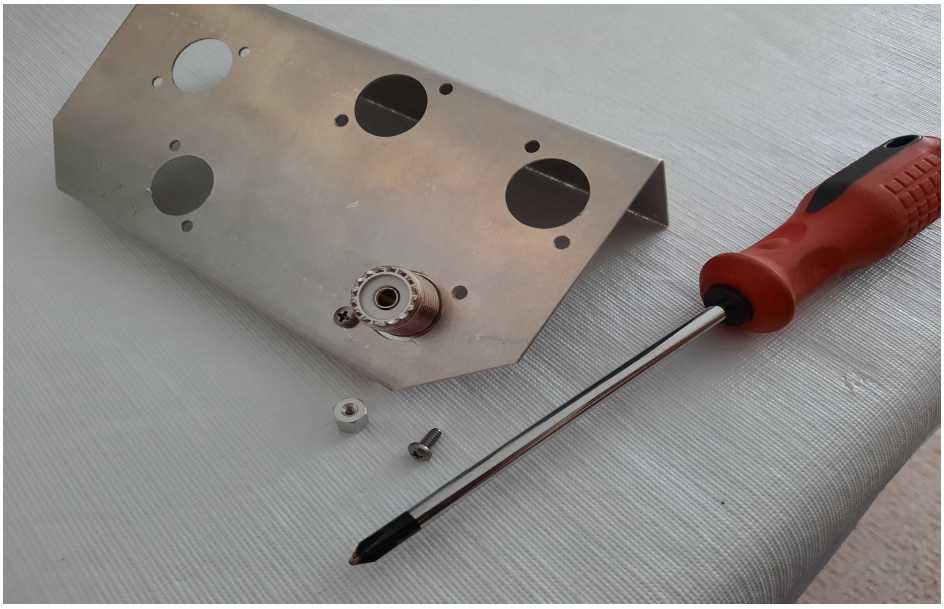
9. The Control will now connect to your WiFi LAN.
   During the connection process, the CPU LED will be on steady.
   Once connected, the CPU LED will blink.

2.4 Mechanical Assembly

1. Mount the 5x SO239s to the chassis using #4-40 x 1/4" screws (the slightly longer of the 2 sizes provided) and 4-40 x 1/4" hex posts.

   Carefully examine the following figure for proper placement of the SO239 body.
   The SO239 body must be mounted flush on the TOP side of the shelf.

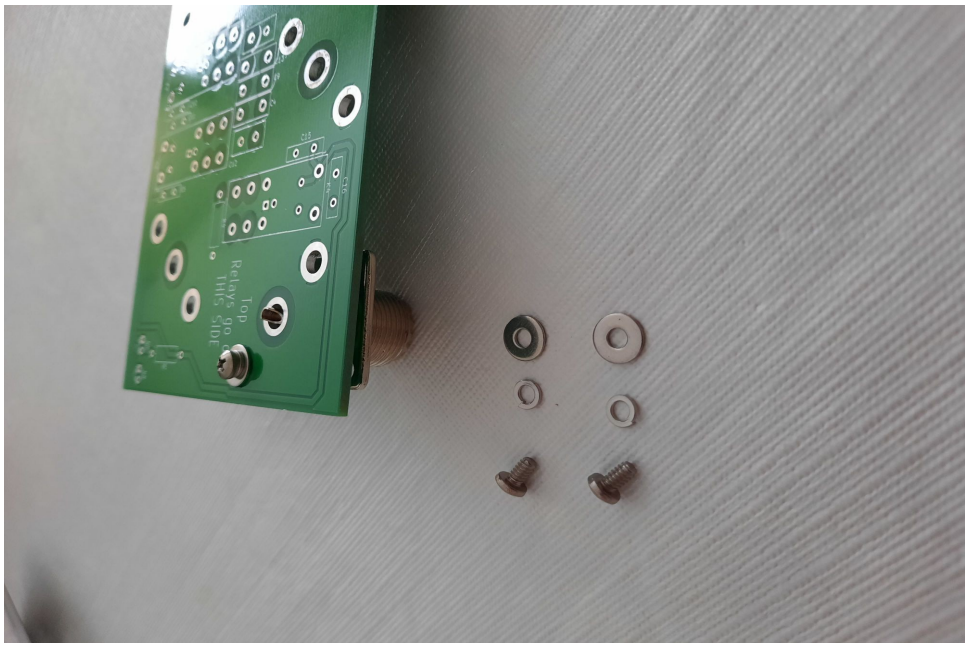
   GENTLY tighten the hex post. It may be necessary to adjust the connector position later.
   The SO239 body goes on the PCB (top) side of the shelf. The photo shows a view from the Bottom. .



<u>This view is of the SHELF BOTTOM.</u>

2. When all SO239 are installed, place the assembled PCB over the SO239s. You may find that not all of them are aligned. Adjust the SO239 as necessary and use a screw driver and nut driver to tighten the screws through the shelf and connectors. 10X

3. Mount the assembled PCB using #4-40 - 3/16” screws (slightly shorter than 1/4”) Tighten all of the screws top and bottom side. 20X



< needs a different photo with SO239 on shelf and PCB above it ??????????????????>

4. Solder the SO239 Center Pin to the PCB. Depending on the alignment, you may need to use a short piece of wire to bridge the gap from the center pin to the PCB ring. A short piece of #14 copper is suggested. Insert one end into the SO239 solder cup and the other onto the PCB ring. Bend the PCB end into an arc around the center pin.

   Do NOT apply a large amount of solder to bridge a gap as this will just run down and lay on the connector insulation. Potentially causing a path to Ground.

2.5 Installation in Enclosure

1. Remove power from the Switch.
   Observing Anti-Static precautions, carefully remove the Control assembly.
2. Install the completed assembly into the enclosure. The screw holes should align with a slot near the top of the enclosure.

NOTE – The shelf in this photo is bent the WRONG WAY. REPLACE PHOTO ?????????

3. Use the pointed metal screws (2X) to attach the shelf assembly to the enclosure. Use only the outside two holes, leaving the center hole for the metal shield. DO NOT OVER TIGHTEN as you will strip the plastic. Do NOT use longer screws which may penetrate the rear of the enclosure and allow moisture to enter.

4. Install the thin metal shield over the top of the PCB assembly.
   Install a 3rd screw, through the shield, through the shelf bracket assembly into the enclosure using the center hole in the shelf bracket. Lightly tighten the screw.

   The shield should cover the front and sides of the PCB assembly, but allow the CPU board to be installed in its socket. Ensure the shield does not cause any shorts on the Switch PCB or the CPU PCB. If you are concerned, wrap the CPU PCB in electrical tape or large heat shrink material.

< insert pix >

2.6 Bench Testing

The next step is to use your normal station PC to connect to the Switch. On your PC, go to the web page for you router and look for connected nodes. One of these will be the Switch. Click on that node or copy the IP address. (It will look something like “192.168.1.123”)

1. Using your standard web browser, go to the IP address of the Switch. This is done by entering the IP address into the URL box and hit/click ENTER.
2. You should see the Control Web Page which shows 4 buttons. Select any one of the antennas. The associated LED should illuminate. Test each of the virtual buttons.
3. You can use an Ohm meter to test the connection through the switch.

3 Install the Remote Switch

Determine a location for the Switch. Mount the enclosure using the top and bottom mounts. A piece of treated weather resistant plywood would make a suitable mount. Place the switch near the top of the wood panel and provide strain reliefs below it.

3.1 Install Station Coax

All coax cables entering/exiting the switch should have a 1 turn loop in the external coax cable and be attached to a suitable structure with a strain relief. The switch is alone is NOT a suitable mechanical structure to support long coax runs to dipoles and long wire antennas. The external loop assists in preventing moisture intrusion and provides some value for lightning protection.

The coax from the station MUST be connected to the proper SO239. It is the center connector in the back row. See the photo.

< insert pix >???????????

RG58 and RG8X will easily flex and allow attachment to the switch SO239s. RG8 and LMR are more rigid. These will take some effort to form within the enclosure. Route the more rigid cables to the more central connectors.

3.2 Station Bias T

Install a Bias T in the shack. NOTE the orientation of the device to route the +12VDC to the remote Switch (NOT INTO THE RIG!!!)

Apply +12VDC to the Bias T. The Switch should then power up and be available via your browser.

Do NOT apply a higher voltage to the Bias T as the Switch only needs 12v for the relays and an internal 3 terminal regulator makes 3.3v for the CPU.

There is over voltage protection in the switch which may be activated above +14VDC.

3.3 LED Indicator Installation

If the remote Switch is visible from the shack, you may chose to install the Blue LED.

1. Add small diameter Red/Black wires (not provided) to the 5mm LED. The wires should allow the LED to be placed out the about 1” out the bottom of the enclosure. Insulate the leads all the way to the LED plastic body to prevent shorts.
   Black wire to LONG LED lead

Red wire to SHORT LED lead

2. Connect the Red/Black wires) from the LED to the Switch PCB J11 located near C18. Note the polarity must be correct or the LED may be damaged.
3. Install the LED into the clear tubing (not provided).???????
4. < insert pix >??????????????
5. Route the wire through the bottom moisture barrier and orient the LED to point towards the shack. When the user commands the Switch to change antennas, the LED will blink the number of times associated with the selected antenna. Once for antenna 1. Twice for antenna 2, etc.

3.4 Cable Attachment

Attach the antenna coaxial cables through the bottom moisture barriers and attach to the desired position.

Provide a strain relief for the coax about 8-10” below the Switch to prevent the weight of the coax from pulling on the connections.

It is good practice to add 1-2 turns of the coaxial cable into a loop below the strain relief. This can have some minor positive effect for lightning. Polyphasor or other devices should be installed per recommended electrical codes and best practices.

A heavy ground wire, attached to a well installed ground rod may be connected to the shelf bracket. This SHOULD NOT be the primary grounding method for the tower.

4 Options

4.1 Optional Environmental Sensor

This is an optional small PCB that plugs into the Control. It senses temperature, humidity and barometric pressure. These parameters will be displayed on the web page when the sensor is installed. As the sensor is in the enclosure, it will read the internal temperature, humidity and pressure.

4.2 Ground UnSelected Antennas

By default, the UnSelected antennas are tied to Ground. When Power is removed, all antennas are tied to Ground. This may not be appropriate if you are switching the phase of an array.

IMPORTANT → Carefully read the section on Lightning!

If you wish to NOT have the antenna grounded, you can drill out the holes for the Normally Closed relay pads PRIOR TO INSTALLING THE RELAYs. Using a .25” drill bit, by hand, carefully remove a small amount of copper around BOTH the TOP and BOTTOM of the PCB. This is very easily done and

does NOT require the use of a power tool! Be sure to make a substantial gap, not just a thin cut, if you plan to do antenna phasing as there may be a high voltage across the gap. You do not need to drill through the PCB, only counter sink to remove the copper ring around the eyelet.

You should be able to solder a wire to the normally closed contacts if you have special phasing requirements. The relay is SPDT with each relay element (NO, NC, Com) connected to 2 pins. You MUST open BOTH pads of the NC contact to eliminate the connection to Ground.

4.3 High Power Operation

The relays are rated for 16A, which equates to 12.8KW. The PCB is NOT rated for 12.8KW.

If you intend to operate above 1.KW, you may want to add extra current carrying capability to the PCB. This can be done by placing a section of bare #14 wire across the PCB trace and soldering to the relay terminals and SO239 center pin. Avoid sharp points on the ends of the wire.

5 Need Help?

Please email questions to: barry.wØiy @ gmail.com

You can expect an answer in less than 24 hrs.

???? Start a Groups.io for support and discussion

6 BOM

This is the BOM for the Switch PCB.

Ref	Qnty	Value	Description
C1, C2, C3, C5, C6, C8, C10, C11, C14, C15, C16, C17, C19, C20,	14	0.01 @50V	Unpolarized capacitor
C4, C9, C13,	3	.01 1KV - Large Yellow	Unpolarized capacitor
C7, C12,	2	6.8pF Small Yellow	Unpolarized capacitor
C18,	1	100uF Can	Polarized capacitor, small US symbol
D4, D6, D7, D8, D9,	5	Green or other color	Light emitting diode
J1, J2, J3, J4, J5,	5	Conn_Coaxial SO239	coaxial connector (BNC, SMA, SMB, SMC, Cinch/RCA, ...)
J6,	1	Conn_02x10_Female on Switch, Odd_Even Note Male 90 deg goes on CPU board	Generic connector, double row, 02x10, odd/even pin numbering scheme (row 1 odd numbers, row 2 even numbers), script generated (kicad-library-utils/schlib/autogen/connector/)
J11,	1	Conn_01x02	Generic connector, single row, 01x02, script generated (kicad-library-utils/schlib/autogen/connector/)
K1, K2, K3, K4,	4	Relay-G2RL-HFKW	BBlib:Relay_G2RL_HFKW
L1,	1	100uH Large black	Inductor
R1, R3, R5, R6,	4	1.8K	Resistor, US symbol
R2,	1	10K	Resistor, US symbol
R4,	1	100K 1W	Resistor, US symbol

7 ToDo

1. Add feature to test a pin on PowerUp and go to factory reset (erase SSID and pw).
2. Ask Greg about Text Field for label for each antenna.
3. Is dev in Arduino IDE or VS Code?

4:1 RF Switch Kit

Remotely Deployable, Fully Enclosed

WiFi Control

Power of Coax

This is a very simple kit to assemble. All user-installed parts are Through-Hole-Technology (THT). Soldering required. There is mechanical assembly of the RF connectors and installation into the weather resistant enclosure. All documents are available online and include photos and testing procedures.

The CPU board is **SMD** and comes **completely assembled** and pre-programmed.

Setup is easy: Use your phones browser to enter your LAN SSID and Password.

Operation is simple.

1. Open a browser
2. Connect to the Switch
3. Click to Select

<insert photo of browser>

<insert pix of enclosure collage>

<insert pix of parts>