RF Switch Users Manual
and
Assembly Instructions

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DRAFT

Designed and Produced to enhance your Amateur Radio Experience by

Team XCR

Table of Contents

1 Introduction

This project is an standalone 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 (a Bias T is required and may be purchased separately). This eliminates 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 Limitations

1.3.1 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 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. Additionalprotection 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 destory the switch.

Lightning Protection is entirely the USER's RESPONSIBILITY.

Installation of this Switch indicates your acceptance of this responsibility.

Refer to http://arrl.org for more information on ESD protection. The ARRL has excellent books on lightning protection.

1.3.2 High SWR Antennas

Antennas with a high SWR have very high peak voltages. You should NOT connect a random long wire antenna through the switch as the high voltages can damage the switch. Your tuner will match the transmitter to the antenna. It **WILL NOT REDUCE THE ANTENNA SWR.**

There is a youtube video where a ham says his antenna switch is now permanently connected to his long wire. It won't switch to other antennas. That is likely because the relay is now welded.

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.

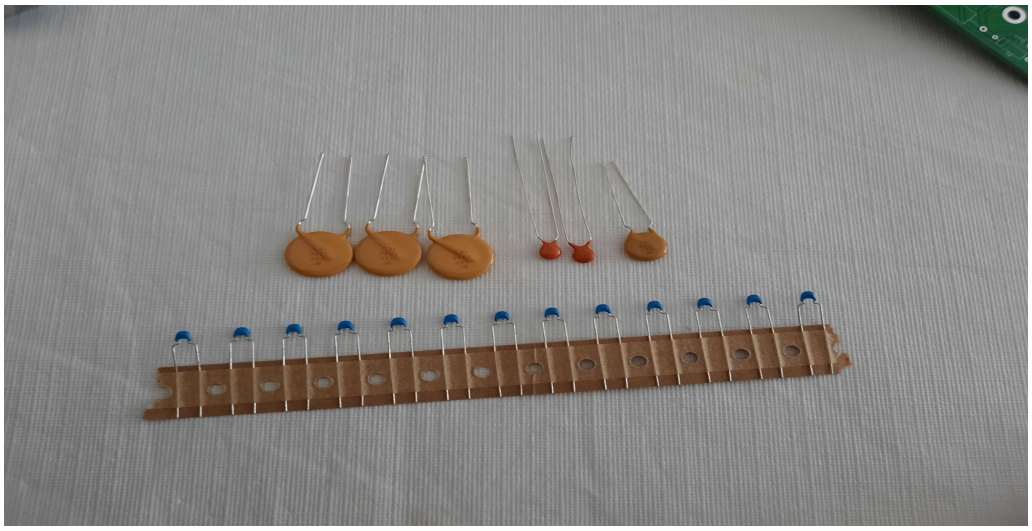
PLEASE read the Options section as you may want to incorporate some changes to the standard build.

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.

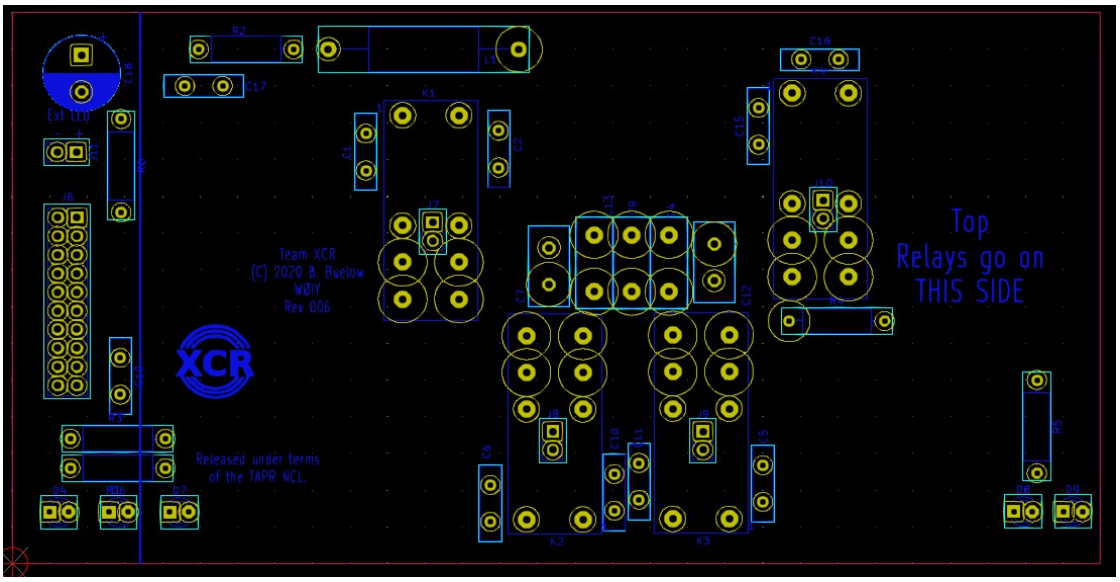
Do NOT install the SO239's at this time. They are installed on the metal shelf later in the assembly process.

1. Begin by comparing the parts to the Bill of Materials (BOM). Identify the various small parts. A copy of the BOM is attached to the end of this document.
2. Identify the various capacitors. Most of the caps are 0.01uF, but they have different voltage ratings.
   The long strip are .01uf @ 50V. These are bypass caps.
   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 L1.
   2 small caps (C12, C13) 6.8pF are used for impedance matching.



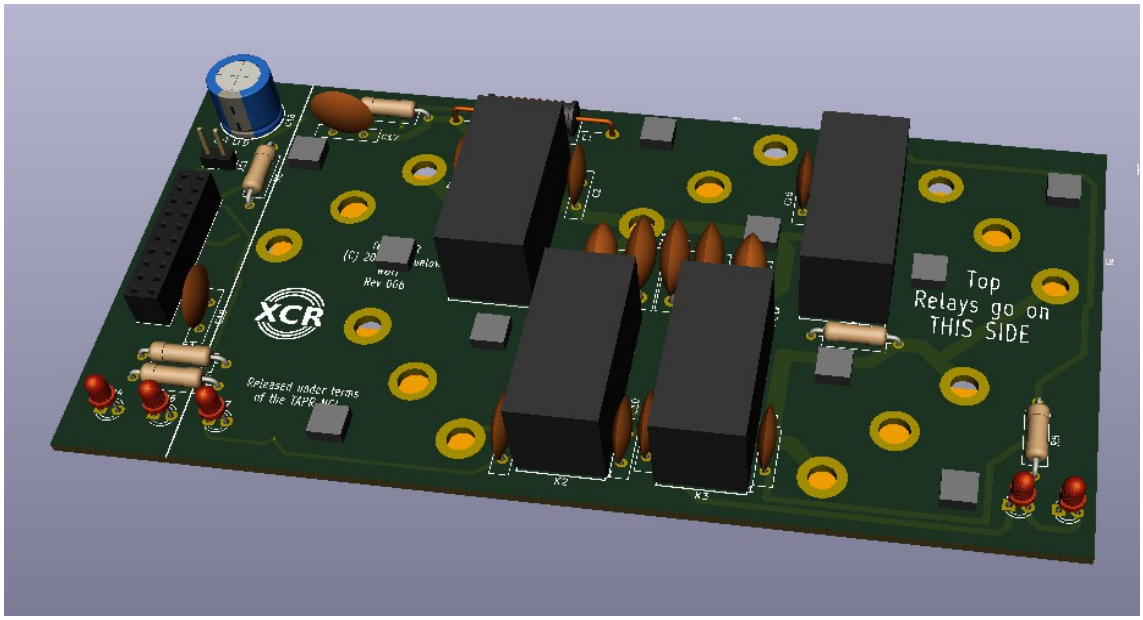
3. On the TOP side, install bypass caps: C1, C2, C5, C6, C10, C11, C15, C16. Solder these on the bottom and clip the leads.
4. Install and solder 4x bypass caps (.01uf @50V) (C3,C8, C14, C20) on the Bottom side of the PCB using a small amount of solder. After soldering, clip the Top side leads flush with the PCB as the relay will be mounted over the pads. You can solder the top side leads AFTER clipping them. Do no use a large amount of solder on the top side.

Install the relay coil **bypass caps** C1-C19 (minus C3, C8, C14) (.01uf @50V) on the TOP side of the PCB. These should be installed tight to the PCB and not interfere with the relay mounting. These may be soldered on the bottom side. Clip the leads.



5. Install and solder the Bias T components to the Top side.
   L1, R2, C17 are located towards the top rear of the PCB.
6. Install and solder the RF Series Caps (.01 1KV 3x) (C4, C9, C13) near the Top center of the PCB.
7. Install and solder the impedance matching caps (6.8pf 2x) (C7, C12) near the Top center of the PCB.
8. 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
9. 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
10. Install and solder J6 2x10 Female straight header connector.
11. 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!

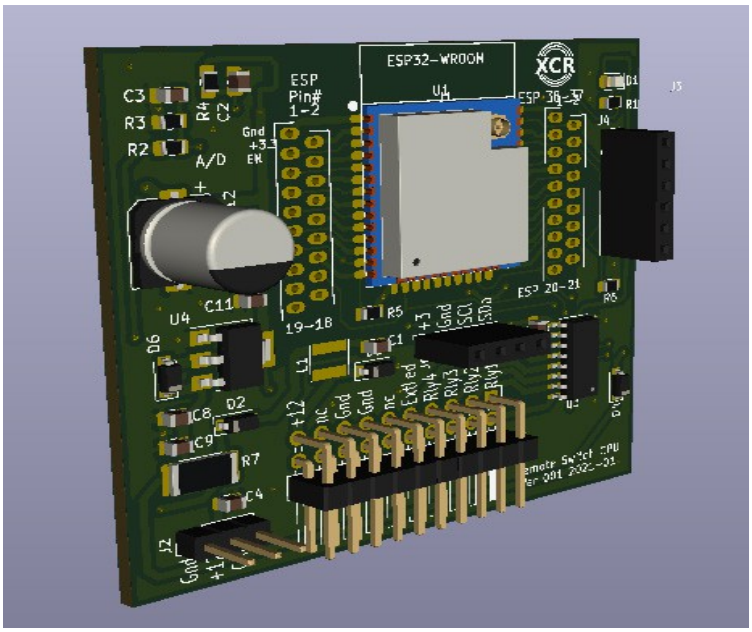
1. Using a clip lead, apply +12VDC to L1 (either end)
   Apply Ground to any of the SO239 Mounting holes (NOT THE CENTER PINT)
   This should illuminate 1 LED (Power indicator).
   If the LED does not illuminate, check the voltage and polarity of the test leads.
2. Prepare a 4” jumper wire using small gage wire. Strip both ends about 1/8”.
3. Attach one side to Gnd (J6-13..16), momentarily connect the other end to J6-1 to engage Relay 1 and illuminate the associated LED D6.
   If you can hear the relay, but the LED doesn't illuminate, the LED may be installed backwards.
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

2.3 Control PCB

The Control comes mostly assembled, programmed and tested. You only have to install the male 90 degree header and the options female header (not provided in basic kit).

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

For the initial release of software, the users SSID and Password are hard coded at the factory and loaded as part of the program. You should have provided this information as part of the ordering process. For security, once these parameters are programmed, they are deleted from the factory computer. Changes/error corrections require exchanging the CPU board for a modest fee.

1. Apply +12VDC to the Switch assembly.

   The primary means of providing power is via a Bias T (not supplied but available separately). F or 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.

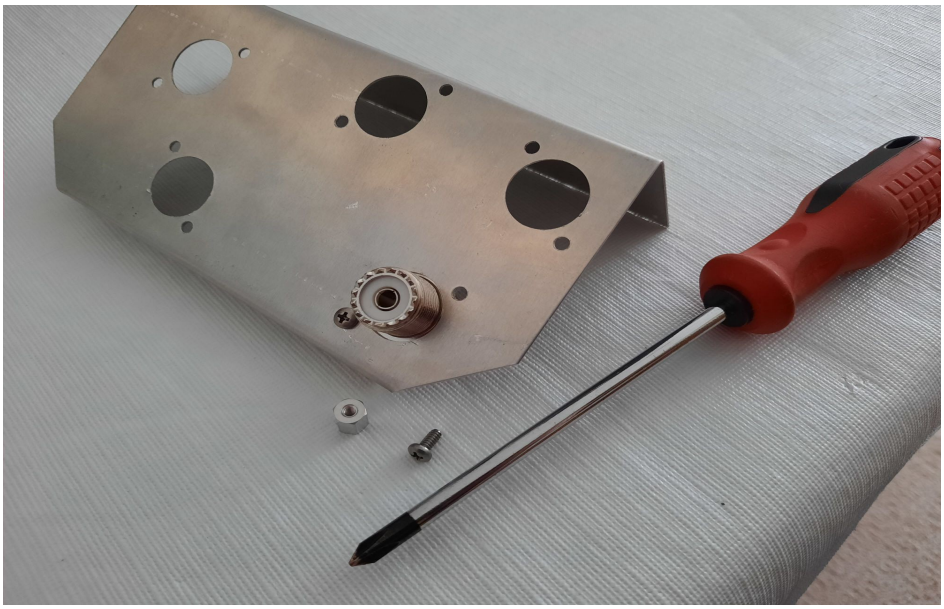
   During startup, each of the relays may momentarily engaged. This will also illuminate the associated LED on the Switch assembly.
3. Using a cellphone or laptop with WiFi capability, look for the WiFi signal with the SSID of “Switch”. Connect to this device.
4. Reserved for WiFi user config.
5. Remove DC power from the assembly.

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.

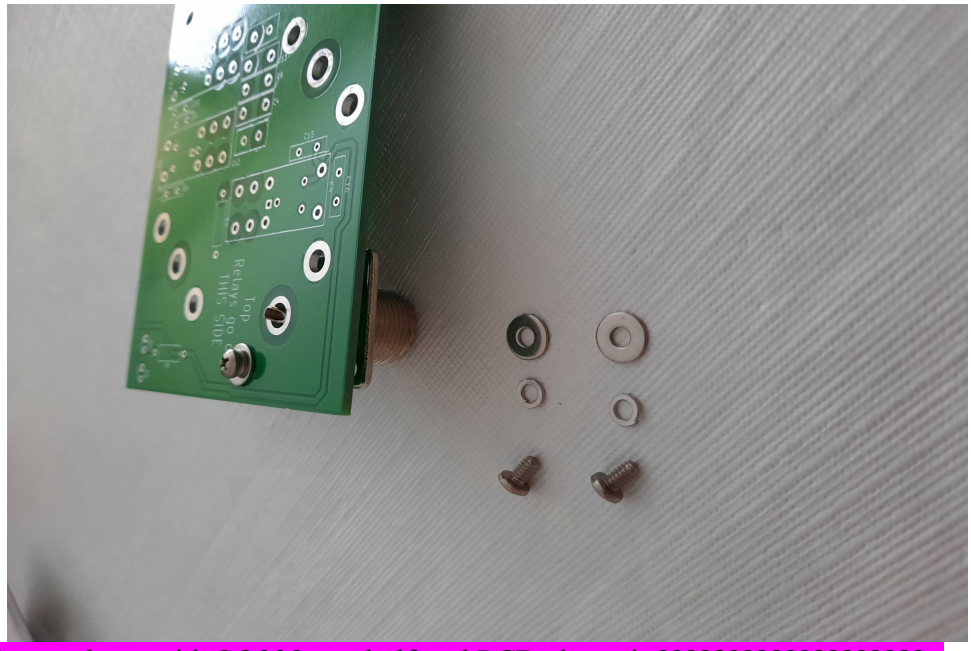
   GENTLY tighten the hex post. It may be necessary to adjust the connector position later.
   The SO239 body goes on the TOP side of the shelf. The photo shows a view from the Bottom. .



<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. Variations in the screw length may result in a screw being too short. If necessary acquire a 4-40x1/4” flat head screw. It may interfere with the other screw from the shelf and not provide a snug fit.



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

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 #14-16 copper is suggested. Insert one end into the SO239 solder cup and the other onto the PCB ring. Bend the wire as necessary to provide a short path. .

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.

1. On your PC, go to the web page for you Router and look for connected nodes. One of these will be the RFSwitch. Click on that node or copy the IP address. (It will look something like

"192.168.1.123")

2. 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.
3. You should see the Control Web Page which shows 4 Antenna Select buttons. Click on any one of the antennas. The associated LED should illuminate. Test each of the buttons.
4. You can use an Ohm meter to test the connection through the switch. Check from the center conductor of the Selected Antenna connector, to the lower pin of C4.
   Since there is a DC block on the Common SO239 to the shack, it is not possible to get a DC path through the entire 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 Remote Switch should then power up and you will see the CPU board LED blink for about 1 second, then begin blinking a short blink every 2 seconds. The External LED will blink once at power up.

DANGER: 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.

3.3 External LED Indicator Installation

If the RF Switch is visible from the shack, you may chose to install the Blue LED and locate it just outside the bottom of the enclosure. When a new antenna is selected, the software will blink the LED

one long blink, then short blinks to indicate the number of the antenna selected. This operation is not continuous, just after a new antenna selection. If the user selects All Anennas Grounded, there will only be a single long blink.

The provided LED has leads attached and operates from 12VDC.

1. Install and solder the LED Red wire to the upper connection for R6. This is +12V.
   Install and solder the Black wire to J11 Minus.

   Optionally, you may install your own LED which will likely require the installation of R6 (1K not provided)
2. Locate the LED just outside the bottom of the enclosure. Route the wires through the gasket and orient the LED towards the shack.
3. < insert pix >??????????????
4. 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 Operations

The Remote Switch can operate in either LAN Mode (using your home or station WiFi router) or in Access Point Mode (direct communications from a laptop to the Remote Switch. Most likely you will want to operate in LAN Mode, except for situations like Field Day or a DXpedition.

4.1 Initial Operation

When initially installed, the Remote Switch is programmed with all software. The user needs to determine the mode of operation: LAN Mode or Access Point Mode.

4.1.1 LAN Mode Setup

For LAN Mode, the RS will provide a WiFi Access Point. You can find this using your phone, a tablet or laptop. *

1. Search for WiFi signals, just as you would at a restaurant or other public location. You should see “RF_Switch”. Connect to this AP. Your device will say there is no internet, which is ok.
2. Once WiFi is connected, open your browser and in the URL window, enter “192.168.4.1” (no quotes). Press enter. The browser should connect to the server on the CPU board.
3. You will be directed to the WiFi Configuration page.
   Enter your LAN SSID and PASSWORD. These are case sensitive.
   You may also enter the IP address if you wish.
4. Save the entries. The RS will now close the AP connection and attempt to connect to the WiFI LAN using the credentials you provided.
   NOTE: If the server is unable to connect after 30 seconds, it will once again enter AP Mode. Repeat steps 1 and 2 of these instructions to connect again. Re-enter the SSID and Password.
5. You now need to connect to your LAN (either via WiFi or via ethernet). Then open a browser and connect to the RS. If you specified an IP address, then enter that address in the browser URL area. If you did not provide an IP, then go into your router configuration section and find the IP that was assigned by the router.

* Results with Android have been very simple. Iphone devices try to revert to other networks rather than the RS. Try using an Android or Win device if your iphone doesn't connect.

While in LAN Mode, the RS will NOT respond to connection attempts made from phones or other devices attempting to connect directly (via AP Mode).

4.1.2 User Station Configuration

This page, accessible from the Main Menu, allows you to enter a Name for each antenna. The field is limited to 20 characters. This will be displayed on the Normal Operations page along side each antenna.

You may also enter your callsign to personalize the webpage.

The RS is now ready for normal operation.

4.2 Access Point Mode

The RS should be in AP Mode. All functions are available. You can enter antenna names and operate normally. This is useful for Field Day where no LAN is available.

At any time during operation, if the RS is unable to connect to the LAN, it will revert to AP mode. There is no need to perform an external operation for this change.

4.3 Normal Operation

Open a browser window and enter the IP address from Step 5 above. You should see the Main Menu page. Navigate to the Normal Operation page.

Here you will see a table of antennas. Select an antenna by clicking on the checkbox.

The RS will support multiple controllers (think SO2R.) In a contest, with 2 operating positions. Both stations may connect and control antennas. Neither has priority.

5 Options

5.1 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.

5.2 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.

5.3 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 RF trace and soldering to the relay terminals and SO239 center pin. Avoid sharp points on the ends of the wire.

6 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

7 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 Used for bypassing stray RF to Gnd
C4, C9, C13,	3	.01 1KV - Large Yellow	Unpolarized capacitor. RF series cap. Passes RF, blocks DC.
C7, C12,	2	6.8pF Small Yellow	Unpolarized capacitor Impedance matching
C18,	1	100uF Can	Polarized capacitor Filter cap for DC
D4, D6, D7, D8, D9,	5	Green or other color	Light emitting diode Indicate selected antanna
J1, J2, J3, J4, J5,	5	Conn_Coaxial SO239	Coaxial connector SO239 supplied. Type N may be substituted
J6,	1	Conn_02x10_Female 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),
J11,	1	Conn_01x02	Generic connector, single row, 01x02 For external LED
K1, K2, K3, K4,	4	Relay-G2RL-HFKW	RF Switching Relay
L1,	1	100uH Large black	Inductor Passes DC, blocks RF
R1, R3, R5, R6,	4	1.8K	Resistor LED current limit
R2,	1	10K	Resistor Load
R4,	1	100K 1W	Resistor Load

8 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>