

RF Switch Users Manual and Assembly Instructions

**Rev 010C
04/04/23**

Designed and Produced to enhance your Amateur Radio Experience by

Team XCR

Note that Rev 010B of this document corresponds with Rev 010B of the PCB, which has SMD components. No doubt the document letter will increment as changes are suggested by users.

It is recommended that you join the Team XCR User Group on the web at:

<https://groups.io/g/team-xcr/topics>

This is a low noise group that will keep you up to date.

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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 antennas. The Switch uses Power-Via-Coax and WiFi (browser) for control. Thus, eliminating the need to an additional cable or control box. It provides a convenient user interface located on your existing logging PC.

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 (if installed) the temperature, humidity and barometric pressure. The sensor is enclosed so the indicated values reflect the inside 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 place 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. 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. See MFJ-4116 available from various dealers.
2. Refer to <http://arrl.org> for more information on ESD protection, in particular the ARRL has 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 is necessary to modify router settings. Since this IoT device is simply designed for LAN operation, there is no provision for protecting 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 protection for your network.

1.5 Warning - Limitations

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 or currents which
are beyond the design parameters and may damage the switch.**

This is NOT covered under any warranty!

1.6 Isolation

The measure of attenuation between switch ports (selected to unselected) is the isolation. Good isolation is only required when there are multiple RADIOS connected. The isolation prevents power from a transmitting radio from going into the receiver of another radio.

This switch is designed to switch ONLY antennas (not select from multiple radios). A single relay provides about 30db of isolation. Transmitting 1000W on antenna 1 results in 1 W going to antennas 2, 3, 4. This has essentially no impact on the intended operation.

HF antennas do not typically have big isolation in space (coupling from antenna 1 to antenna 2) as they are physically near each other. In a common yard, isolation may only be 20-40db.

2 RF Switch Assembly Instructions

Beginning in Rev 010B (Sept 2022) of this document, the assembly instructions refer to the SMD PCB.

Rev 010B is silk screened on the Top Right of the PCB.

The SMD PCB is derived directly from the KiCad for the original 001 (through-hole-technology) PCB. All of the non-critical small components have been converted to SMD and are factory installed. The components are:

- .01 bypass caps on the relay coils
- LEDs, Power and Antenna Selection indicators
- LED current limiting resistors

As the parts kits are already bagged, you may receive the full set of THT parts, many of which are now not needed. You may elect to add the parts to your inventory or dispose of them.

In all cases where this text refers to “Install” components on the PCB, this indicates the the leads should be bent, the component installed on the PCB and that it 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.

There have been, and continue to be, changes to the PCBs that facilitate the manufacturing and include improvements. The change to SMD components for the non-critical devices was a major upgrade. This also substantially reduced the number of hand installed components.

Additional changes are expected with only minor changes required to this Assembly Manual.

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 first installed on the metal shelf and mated to the PCB later in the assembly process.

All user installed electronic components are placed on the TOP side of the PCB.

1. Identify the various capacitors.
The 3 large caps (C4, C7, C9 usually yellow) pass RF, but block the DC path in the Bias T portion of the circuit. Install and solder the Series Caps (.01 1KV 3x) (C4, C7, C9 large yellow caps) near the **Top** center of the PCB.
2. Install and solder L1 located towards the top rear of the PCB.
3. Install and solder electrolytic cap C18 (top left). Ensure the polarity is correct.
4. Install and solder J6 2x10 Female straight header connector on the **TOP** side.

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

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

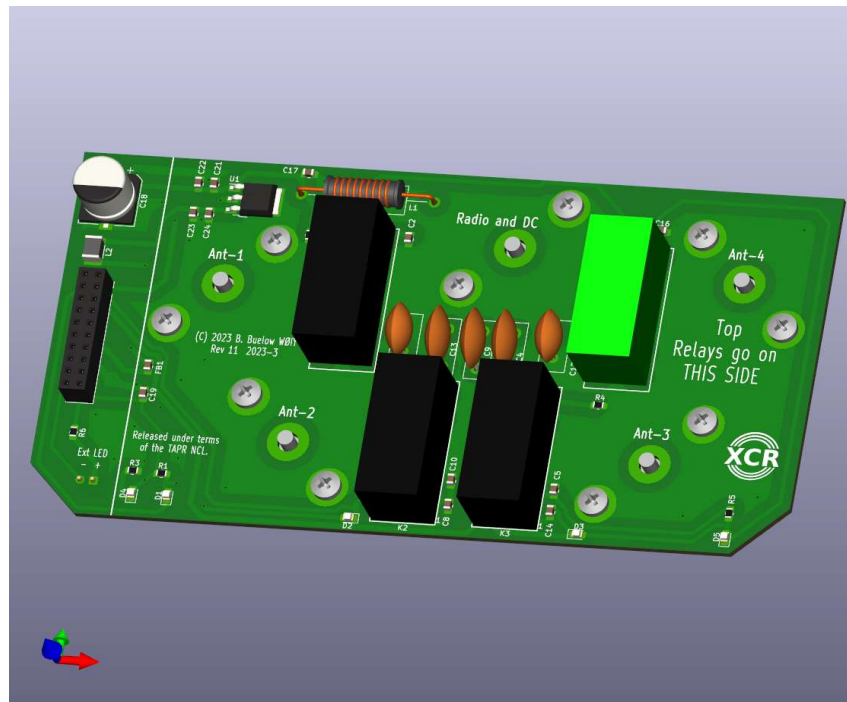
2.2 New SMD Components

1. A PPTC Fuse is installed (F1 SMD).
This is an automatically Resettable Fuse. It is a thermal device. It will open (become high resistance) in the event of a short on the PCB. In the event of a short, the user will notice that the WiFi connection is not responding. Examining the PCB, the Power LED will be off or dim.
1. Reverse polarity protection diode (D1 SMD).
This is located in series with L1. If the user supplied DC to the Bias T in the shack, this diode will prevent the reverse polarity from damaging the switch.
The user will notice that the Power LED is off.
1. Remote Power J8
In order to more easily accommodate external DC applied at the Remote Switch, a set of pads are provided for a 2 pin pluggable header or direct soldering of Red/Black wires. As viewed from the Top, the:
LEFT pin is +12
RIGHT pin is Gnd.

2.3 Unused Component Pads

There are pads on the PCB which are not populated.

1. C12, C13 were in the original design to compensate for some series inductance, but are not needed. These positions are left empty.
2. R4 was used for testing



2.4 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 arranged (as viewed from the Top):

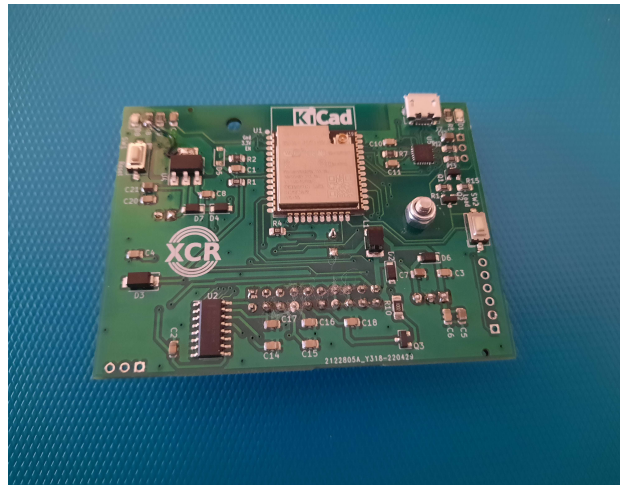
2 1
4 3 etc.

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, stripped on both ends.
3. Using the jumper wire: attach one side to Gnd (J6-13/14/15/16), 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.

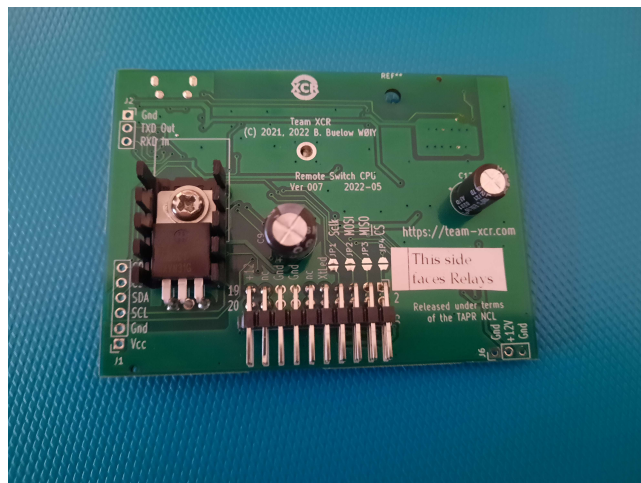
2.5 CPU PCB

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 CPU as
it is static sensitive!



The right angle header should be installed on side with the heatsink.



2.5.1 CPU PCB 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. Install the cable from the WiFi antenna to the CPU. Carefully align the small connector and snap it into place. This should be done once. The connector is fragile and is a surface mount device. Be Gentle!

2.6 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.

Note the orientation of the SHELF. When completed, the large surface will be horizontal and the smaller surface will be vertical bent DOWN.

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. .



Illustration 1: SO

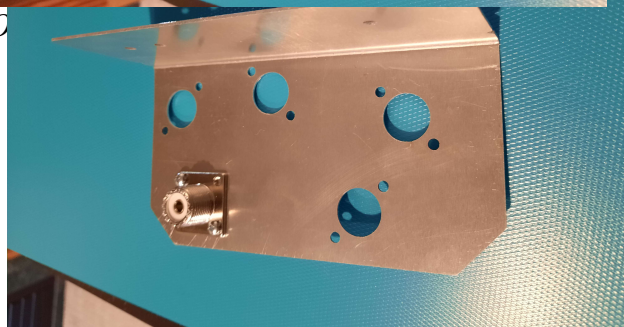


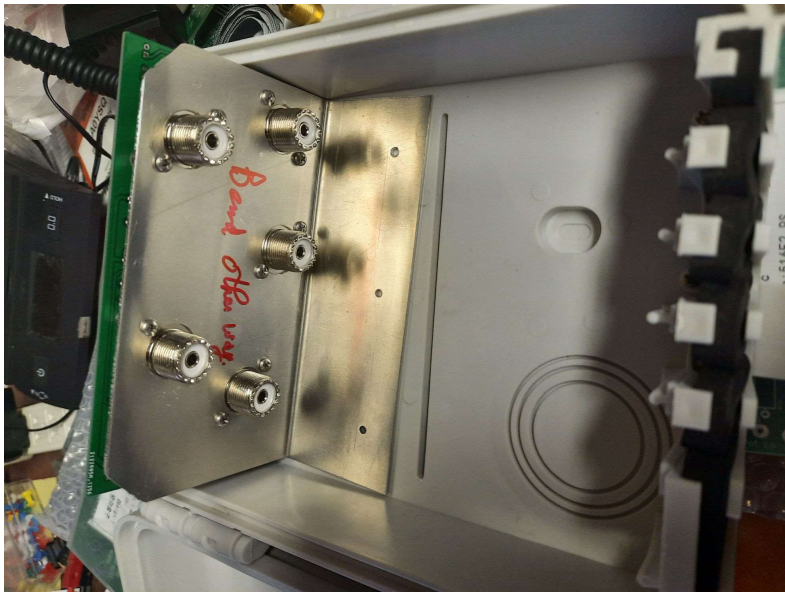
Illustration 2: Shelf Bottom View

2. When all SO239s 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
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.

2.7 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.



3. Use the pointed metal screws (2X) to attach the shelf assembly to the enclosure. **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. Verify that the Switch assembly is NOT powered.
5. Install the CPU PCB 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. The large metal CPU should be on the side **OPPOSITE** the relays. There is NO keying in this connector.

2.8 CPU PCB Installation

After the mechanical assembly of the RF PCB and the joining of the PCB and the shelf assembly is complete, the CPU PCB can be installed.

The right angle header should be installed on side with the heatsink.

2.8.1 WiFi Antenna

Attach the coax to the CPU board by aligning the coax connector and the ESP connector. GENTLY press the coax connector STRAIGHT down until it is seated. There may be a faint click as the connectors mate.

If you need to Remove the connector, carefully pull the coax connector directly up off the PCB.

Do NOT pry at an angle as you may damage the ESP PCB.

A pair of needle nose pliers can gently grasp the connector at 90degrees from the connector coax.

A damaged connector requires replacing the entire CPU PCB. This damage is not covered under any warranty.

2.9 Bench Testing

This step is to establish a connection to the RF Switch via WiFi.

This step is easiest to perform using a phone or tablet [1].

1. Apply power to the RF Switch either directly to the RF PCB or using the Bias T. Observe the main power LED is illuminated.
2. Have your phone search for available WiFi signals. One will be RF Switch. Select this Access Point.
3. Once connected, go to your browser and in the window for the URL, enter: **192.168.4.1** The browser should display the RF Switch Main Menu.

Note:

1. Some Apple iphone users have difficulty with this step as the RF Switch does not provide internet connectivity as would usually be the case when connecting to a WiFi hotspot or router. If you have trouble, try using a (non-Apple) phone, tablet or laptop.

2.9.1 WiFi Configuration

Refer to Section 5.1.1 for addition commentary on WiFi Configuration.

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.
The main power LED should illuminate.
2. After a brief startup period, the LED on the Control assembly should blink at a steady rate.
During startup, each of the relays will be 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. 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.

On your PC, go to the web page for your 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 ENTER.
2. You should see the Web Page. 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.

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 you browser.

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

3.3 Cable Attachment

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

Provide a strain relief (tie wrap or electrical cable clamp) on 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 considered the primary grounding method for the antenna system.

4 Options

4.1 ***Ground UnSelected Antennas***

By default, the UnSelected antennas are tied to Ground. When Power is removed, all antennas are tied to Ground. This may 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. 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.

Using a .25" drill bit, by hand, carefully remove a small amount of copper pad around BOTH the TOP and BOTTOM of the PCB. Do NOT drill through the board. This operation 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.

You should be able to solder a wire to the normally closed contacts if you have special phasing requirements.

High Power Operation

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

They should NOT BE HOT SWITCHED.

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 #18 or larger wire across the PCB trace and soldering to the relay terminals and SO239 center pin. Route the wire directly over the PCB trace.

Avoid sharp points on the ends of the wire.