RF Switch
and
RF Matrix

Operating Manual

Rev 011f
09/18/23

Designed and Produced to enhance your Amateur Radio Experience by

Team XCR

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 you 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 from Team XCR.

1.3 Lightning

The RF 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. 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 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**.

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.
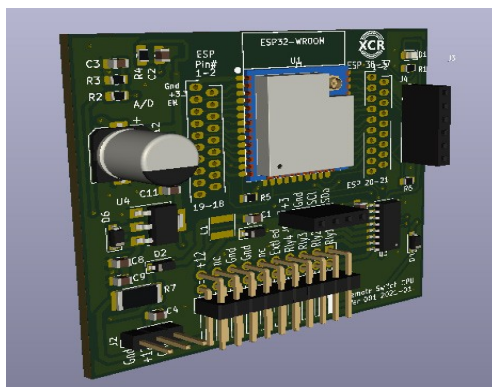
2 WiFi Configuration

2.1 AP Mode

To directly access the RF Switch, use your smart phone or laptop with WiFi capability. This discussion will consider that you are using your smart phone.

1. Apply power to the RF Switch either using 12V to the main PCB or powering just the CPU via a USB micro cable.

2. Open your phone and navigate to WiFi page.
   On Android you can do this by Swiping down from the top to expose some icons, then holding your finger on the WiFi icon for a few seconds.
   In the image below, press and hold the blue WiFi button on the top left until another screen appears.

3. There will be a list of available WiFi signals with their respective SSID displayed. One of the listed items will be the "**RF Switch**" Select this item.

4. You should see the page change to "Connecting to RE Switch". There may be a gripe that there is no internet connection. Allow the connection to proceed. Some phones OS are seriously unhappy with this.

5. Now open your browser. Where you usually enter a URL, enter" **192.168.4.1**
   You should now see the RF Switch **Main Menu**

The Main Menu page provides access to the configuration and operational pages. At the bottom of each page is a link back to the Main Menu.

You are now communicating directly from the phone to the RF Switch, without a network. You may continue to operate this way forever, if you so desire. However, it will be more convenient to operate in LAN mode.

2.2 LAN Mode

In LAN Mode, the RF Switch will be connected to your home WiFi router. Then all devices on the home LAN can control the RF Switch.

> NOTE: Beginning in software version 4.005 a new feature has been introduced which assists in accessing the RF Switch from your browser.
> In your browser URL window, enter   "**http://rfswitch**"
> The browser should be directed to the Main Menu page. If this doesn't work, use one of the methods below to determine the IP address of the RF Switch.

2.2.1 Preparing for Configuration

The following steps will configure the RF Switch to your LAN and shack. Before you begin, there is some information you will need regarding you network.

Network Name and Password.   (Note that ALL of these are CASE Sensitive)

- **SSID** – the name of your network

- **WiFi Password**

- You may need to be log into your router as the administrator. This will require the admin name and password, which may or may not be the same as your wifi password. It depends on how you setup the router.

IP Address

Your router determines the IP address of most devices on the LAN. The two most common IP address ranges are:

- 192.168.1.x

- 192.168.0.x

The 'x' is specific to each device, but the first three numbers need to agree with the router. This is how to determine your routers IP setting.

1. Using a Win computer, click on the Start icon.

2. Type "command".
   This should open a old style DOS window with a > prompt.

3. At the prompt, enter "ipconfig /all".
   There will be a page or two of data. Scroll down about 80% towards the bottom and look for the line: Default Gateway
   It will generally show one of the rangers listed above. The difference being either the '1' or '0' in the third position. Make note of the numbers. This is referred to as a subnet.

There is a useful tool for watching you local network. Go to:

https://github.com/angryip/ipscan/releases/download/3.9.1/ipscan-3.9.1-setup.exe

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Illustration 1: M
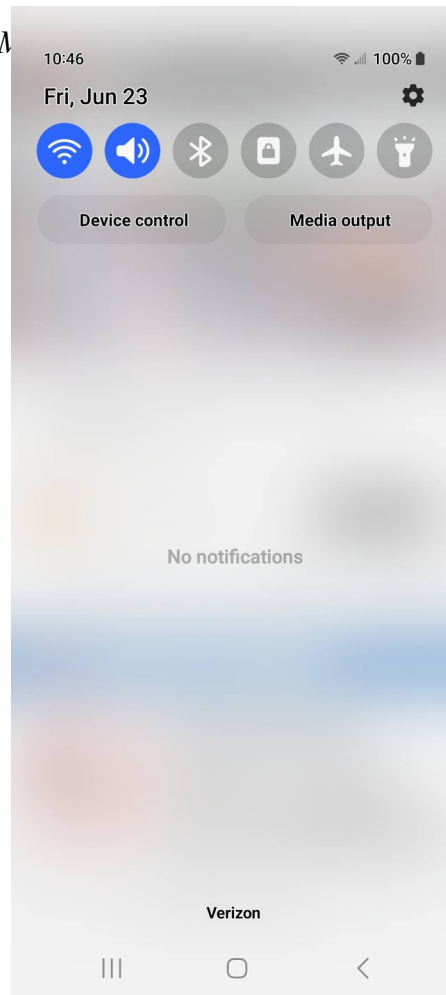
The WiFi configuration consists of entering your credentials: SSID, password, etc. These are then stored in memory on the CPU board. You should only need to do this once.

2.2.2 Data You Will Need

In order to do the WiFi Configuration, you will need some network info which you can easily get from your PC (Win).

    A) ON your Win PC, click START (the blue square blox on the toolbar).
    B) A window will popup. In the Search area, type   "terminal"   (minus the quotation marks).
       This will open a terminal window (like old style DOS) where you can type a command.
    C) Enter the command: "ipconfig /all".   Note the space before "/all"
       This will return a long screen full of information. Look about half way down for:

IPv4 Address. . . . . : 192.168.1.161(Preferred)
Record the first 3 sets of numbers, in this case "192.168.1"   This is the subnet of your LAN.

```
Ethernet adapter Ethernet:

   Connection-specific DNS Suffix  . : domain.actdsltmp
   Description . . . . . . . . . . . : Killer E2600 Gigabit Ethernet Controller
   Physical Address. . . . . . . . . : B0-4F-13-0A-2D-6F
   DHCP Enabled. . . . . . . . . . . : Yes
   Autoconfiguration Enabled . . . . : Yes
   Link-local IPv6 Address . . . . . : fe80::6edb:d5b8:8043:42de%10(Preferred)
   IPv4 Address. . . . . . . . . . . : 192.168.1.161(Preferred)
   Subnet Mask . . . . . . . . . . . : 255.255.255.0
   Lease Obtained. . . . . . . . . . : Monday, August 7, 2023 2:45:20 PM
   Lease Expires . . . . . . . . . . : Tuesday, August 8, 2023 2:45:18 PM
   Default Gateway . . . . . . . . . : 192.168.1.1
   DHCP Server . . . . . . . . . . . : 192.168.1.1
   DHCPv6 IAID . . . . . . . . . . . : 128995091
   DHCPv6 Client DUID. . . . . . . . : 00-01-00-01-29-80-9F-0F-B0-4F-13-0A-2D-6F
   DNS Servers . . . . . . . . . . . : 192.168.1.1
   NetBIOS over Tcpip. . . . . . . . : Enabled

Ethernet adapter Bluetooth Network Connection:

   Media State . . . . . . . . . . . : Media disconnected
   Connection-specific DNS Suffix  . :
   Description . . . . . . . . . . . : Bluetooth Device (Personal Area Network)
   Physical Address. . . . . . . . . : FC-B3-BC-AF-8E-7A
   DHCP Enabled. . . . . . . . . . . : Yes
   Autoconfiguration Enabled . . . . : Yes

C:\Users\iabar>
```

D) Enter a new command: "arp -a"
This will return a list of IP addresses known to the PC. For the RF Switch, you want to select a number which is NOT in use and is at the upper range between 200-250.
Determine an <u>unused</u> IP and record the value (200-250) by appending it to the end of the previously save LAN address (subnet).

```
C:\Users\iabar>
C:\Users\iabar>arp -a

Interface: 192.168.1.161 --- 0xa
  Internet Address      Physical Address      Type
  192.168.1.1           58-ef-68-ae-6f-06     dynamic
  192.168.1.101         20-ef-bd-60-04-fa     dynamic
  192.168.1.113         30-e3-7a-58-79-3d     dynamic
  192.168.1.142         40-a2-db-a6-20-27     dynamic
  192.168.1.144         30-05-5c-73-4d-11     dynamic
  224.0.0.22            01-00-5e-00-00-16     static
  239.255.255.250       01-00-5e-7f-ff-fa     static

C:\Users\iabar>
```
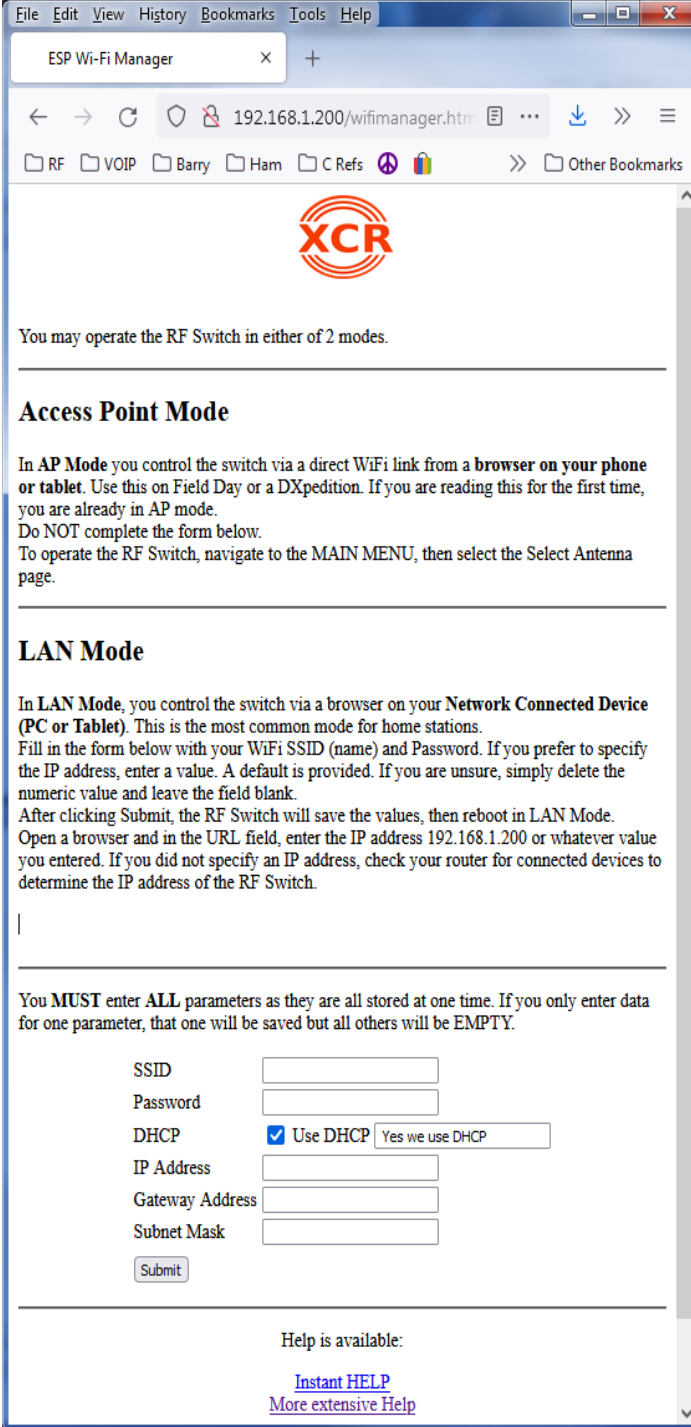
2.2.3 Programming the RF Switch

The RF Switch is accessed in AP Mode using your phone or tablet. Data you enter will be stored and the CPU will restart (may require cycling power to the RF Switch). Then the unit will connect to your LAN using the credentials you entered.

It is important to enter ALL of the data on the WiFi Config page as the data is all stored as a set. If you leave a field blank, the file will be created with no data for that parameter. This may cause the CPU to be unable to connect to your LAN. If the WiFi LAN connection fails, the CPU will revert to Access Point mode and you will be able to access the RF Switch via your phone, tablet or laptop.

The following table list the parameters you will need to connect to a LAN.

WiFi Parameter	Example	Enter YOUR data	Comment
SSID	w0iylan		UPPER/lower case matters! You can find the SSID by accessing you LAN router or buy scanning WiFi with a phone app.
Password	Abc123		This is the WiFi password. It is configured in your router when you did WiFi setup.
IP Address	192.168.1.200	___.___.___.___	This will be the IP address of the RF Switch. It is a combination of the 3 digit sets from ipconfig and the final 3 digits you select based on "arp".
Gateway	192.168.1.1	___.___.___.___	This is the IP address inside your router. For most folks 192.168.1.1 is the correct number. This will be the first line in the "arp" data table.
Subnet Mask	255.255.255.0		For 99.99% of users, the example is the correct answer.
DHCP	OFF (unchecked box)		If you want the router to assign a IP address for the RF Switch, enable this and then omit IP Address, Gateway and Subnet Mask. You will have to go into your router to find the IP address which was assigned.

Illustration 2: LAN Configuration Page

2.2.4 DHCP

This is an alternate method of configuring the RF Switch. You enter minimal data and then look for the IP address.

Accessing the RF Switch from your phone of laptop, Navigate to the WiFi Configuration page.

Enter the following two parameters (CASE Sensitive). This should be EXACTLY what you have in your router setup.

Parameter	Example	YOUR Data	Comment
SSID	w0iylan		UPPER/lower case matters! You can find the SSID by accessing you LAN router or buy scanning WiFi with a phone app.
Password	Abc123		This is the WiFi password. It is configured in your router when you did WiFi setup.

Select the button "**DHCP**"

Save your parameters by clicking Submit. The RF Switch should now reset.

To determine the RF Switch IP, you will look at the IP addresses on you PC without the RF Switch and then with the RF Switch enabled.

A. Power the RF Switch **OFF**.
B. ON your Win PC, click START (the blue square blox on the toolbar).
C. A window will popup. In the Search area, type   "terminal"   (minus the quotation marks). This will open a terminal window (like old style DOS) where you can type a command.
D. Return to the Search area and open a second terminal window. Arrange these side-by-side on your screen.
E. Ensure the RF Switch is powered OFF. If you had it on and just turned it off, wait a couple of minutes as the buffers in the PC and router to clear.
F. In the left terminal window, type the command: "arp -a" (minus the ", be sure to include a space after the "arp"). Hit return and a table will appear containing the IP addresses your PC can see on the LAN.
G. Apply power to the RF Switch. Wait 30 seconds for the RF Switch to complete power up and connect to the router. The LED on the RF Switch should be off and blink on every few seconds.
H. In the Right terminal window, type "arp -a". The table should be shown. Compare the left and right tables, there should be 1 more entry in the right hand table. This is the RF Switch. Record the IP address.
I. Open a browser. In the URL area, type the IP address you just recorded. You should see the RF Switch Main Menu.

NOTE: If the LED is on and blinks off for a short period, it is in AP mode. Use you phone to access the RF Switch and reprogram the WiFi SSID and PW.

Alternately, if you want to explore your LAN, try this free program.
On your PC, install the program:
    https://github.com/angryip/ipscan/releases/download/3.9.1/ipscan-3.9.1-setup.exe
Running this program will show you the IP of devices on your LAN.

2.3 Revert to Access Point Mode

In the event of difficulty with LAN mode, you can return to AP mode by temporarily removing power to your ROUTER and then cycling power to the RF Switch. When the Switch starts, it won't see the router and will default to AP mode, which you can access from your tablet or phone.

If you are having problems configuring LAN mode, access the RF Switch via AP mode from a tablet or phone and erase the existing WiFi configuration. Then enter a new set of WiFi parameters.

Restore power to the router.

Some later version CPU boards have a pair of pads near the 3 terminal regulator which, with the proper software, can be used to force AP Mode. Software version 4.004b6 and later supports this functionality. During the time when the Heartbeat LED is blinking, the CPU tests for a short on the pads marked "Factory Reset". Apply a short to the two pads and hold it until the Heartbeat LED blinks. This may require 2 cycles of the heartbeat. The CPU will then command AP mode, but it will NOT erase the stored WiFi credentials.

3 Operation

In order to provide the most rapid system availability, when power is applied, the RF Switch attempts to connect to the local LAN. This uses the stored SSID and parameters.

If there are no stored parameters or the RF Switch is unable to connect to the LAN, then it reverts to Access Point (AP) Mode.

3.1 User Customization

Users can enter their callsign and antenna names. Each is stored individually in CPU memory and will be retained. The strings are limited to 25 characters. UPPER/lower, numbers and figures are all ok.

Illustration 3: User Configuration Page

3.2 Program Update

WARNING

DO NOT SELECT THIS OPTION IF YOU ARE NOT READY TO LOAD.

YOU CAN BRICK THE CPU!!!

Once you begin the Program Update process, there is NO turning back. If you stop

A new addition to the RF Switch is the ability to update the software via WiFi. You need to have your browser open to the Main Menu. The URL at the top will be the IP address of the RF Switch. For this example it will be 192.168.1.1

Your stored credentials are not affected by this update.

Procedure:

1. Using your PC browser, go to https://github/com/team-xcr   (or https://github.com/w0iy)

2. Navigate to the 4 Way RF Switch repository

3. Select the file RF_Sw_xxxx.ino.esp32.bin   This is the executable
   This is a binary file compiled for the RFW CPU.
   Download the file and remember where it is located (sub-directory)

4. Select the file RF_Sw_xxxx.spiffs.bin
   This is a binary file with all of the supporting HTMl, TXT and PNG files.
   Download the file and remember where it is located (sub-directory)

5. Using the PC browser, go the RF Switch Main Menu.
   The URL will show   192.168.1.1/index.html (or whatever IP you are using)

6. Edit the URL to be: 192.168.1.1/update   and hit Enter

7. The page will update to show the Elegant OTA page.
   Select the FIRMWARE button
   Select Browse

   <<< insert pic ????????????????? >>>>

8. This will open a window with FILE EXPLORER.
   Navigate to the directory containing the RF_Sw_xxxx.**ino**.esp32.bin (**executable**) file you downloaded. NOTE the **INO** in the file name.
   <<< insert pic >>>>

9. Double click on the bin file.
   The OTA feature will begin to upload the file. It takes about 15 seconds.
   Wait for the BACK button to appear.

10. This shows the Elegant OTA page.
    Select the FILESYSTEM button
    Select Browse

11. In the File Explorer, navigate to the directory containing the RF_Sw_xxxx.**spiffs**.bin
(**executable**) file you downloaded. Note the **SPIFFS** in the filename.
<<< insert pic >>>>

12. Double click on the bin file.
The OTA feature will begin to upload the file. It takes about 15 seconds.
Wait for the BACK button to appear.

13. Using the Browser BACK arrow, return to the Main Menu.

At this point the CPU will reset and being to operate with the newly loaded software. All of your custom data will be retained. There is some chance the CPU will not return to LAN mode after a update. You may have to cycle power or reset the RF Switch once or twice before it returns to LAN mode.

You may retain .bin files and load a previous version if you desire. There is no configuration function to prohibit this process.

3.3 Factory Reset

This page allows you to erase the contents of the WiFi Configuration. If you change WiFi credentials or wish to use the RF Switch without a LAN, you may erase the data.

Note that if you operate the RF Switch away from your LAN, the device will attempt to connect, fail and switch to Access Point mode. When you return home, the LAN will be connected automatically.
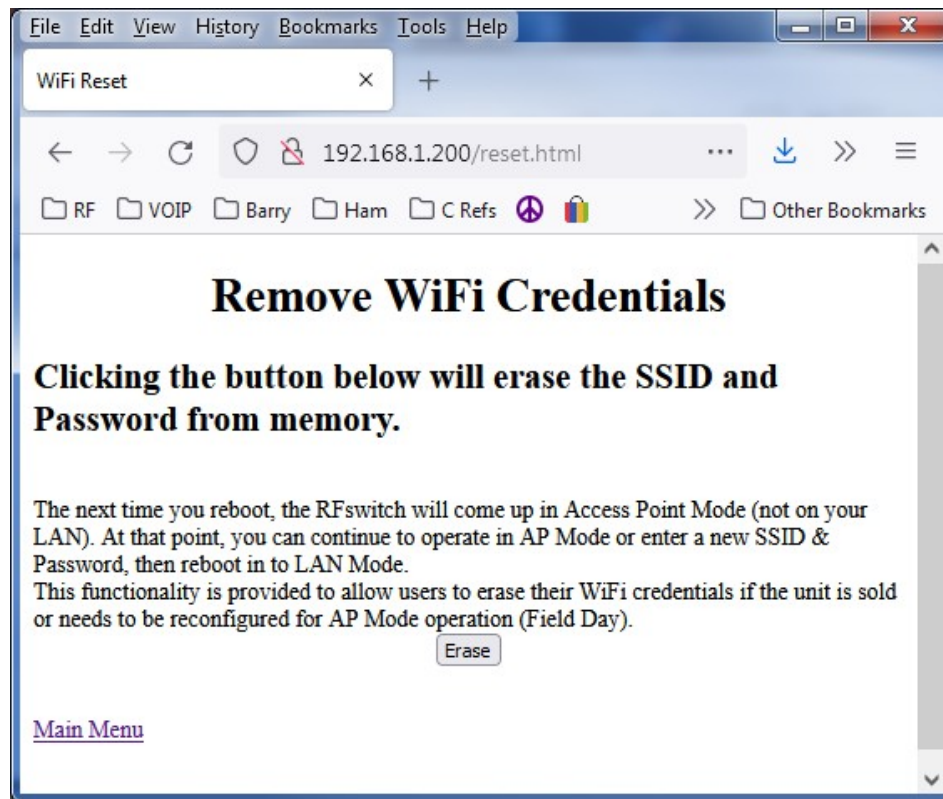
Illustration 4: LAN Reset Page

3.4 Help

This page has a minimal description which may be useful. There are also links which you may select to go the the Team-XCR web page (provided you have an internet connection).

3.5 LEDs

There are several LEDs on the RF Switch which convey different information.

3.5.1 CPU Power LED

This GREEN LED indicates that power is applied to the CPU PCB. It should be moderately bright. If it is dim or flickers, check the power source to the RF Switch.

3.5.2 CPU Activity and Status LED

As an indicator of CPU activity, the BLUE LED blinks every 3-5 seconds. This indicates the CPU is alive and performing as intended.

When the user selects and antenna, the BLUE LED illuminates for about 2 seconds, followed by brief flashes indicating the number of the antenna selected (1, 2, 3, 4). When Ground All is selected, there is a long flash, but no short blinks.

After a few seconds delay, the LED returns to showing normal activity blinks.

3.5.3 External LED

The external LED operation is identical to the BLUE activity LED when an antenna selection is made. There are no "activity" flashes as this may attract unwanted attention to the RF Switch. To visually confirm the RF Switch is operational, just select an antenna.

If no external LED is desired, simply omit the installation of the device.

4   Need Help?

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

You can expect an answer in less than 24 hrs.

4.1 Tips

1. You MUST have the WiFi antenna connected. Without the antenna range is only a few inches!

2. Check that the small coax cable is fully screwed into the SMA connector. The small hex nut needs to be fully into the body of the connector.

4.2 Serial Port Debugging

If you are having trouble with the WiFi setup or operation, the best thing to do is connect a computer to the USB port on the CPU board.

For Win PCs the open source Putty program is commonly used. It is available as a free download. You will need to install Putty and configure it for the RF Switch.

On the main Putty configuration screen, select "**Serial**" (round button)

Set the speed to **115200.** You may have to select a different Serial Line (Com port) depending on what is plugged into the   PC.

Select Open to activate.

The screen will display messages regarding the state of the program and WiFi parameters. This can be of value in determining if the WiFi connection to the LAN has been made or if the RF Switch is in AP Mode. Most of the data is shown during the initialization which occurs after powerup. Cycle power to the RF Switch and look at the captured data. It would be useful to capture the data and email it to WØIY.
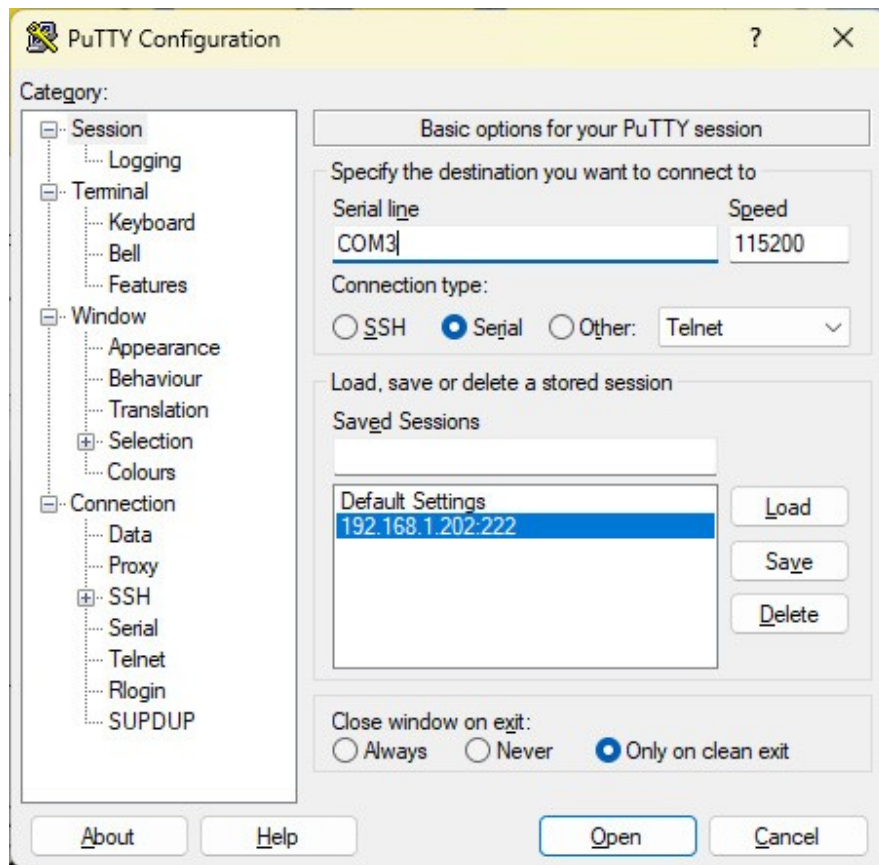
5   Appendix A   Network Topology

Here is a BRIEF discussion of networking and how it applies to the RF Switch. This is a GREATLY simplified discussion. You can research all of the network details on the web.

Cable Modem
This device is usually provided by
your Internet provider.

Home Router
This device is usually something you purchased
from Best Buy or Amazon.

Network User
This is a computer, TV, tablet, phone, etc.

A simplified network is shown. It consists of 3 items:

- Cable Modem
  This is the device provided by your Internet Service Provider. It may interface to coaxial cable, fiber or telephone lines. It may also be 5G service from a cellular company.
  It has an Ethernet connection and may provide WiFi.

- Home Router
  This device is something you likely purchased to provide additional Ethernet ports and WiFi. It is likely configured by you and has a custom SSID (network name) and password.

- Device

There are many home devices. Initially it was just computers, then tablets, now phones, TVs, robot vacuum cleaners, refrigerator, garage doors, etc. It can also be the RF Switch.
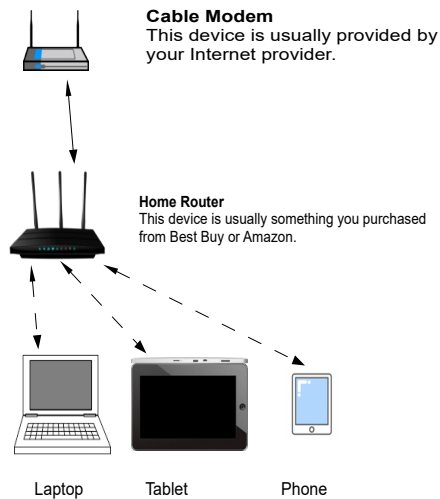
Connections

The Cable Modem interfaces to the ISP and provides an Ethernet jack for a users wired connection. Usually a special cable connects the modem to the Home Router. There may also be WiFi. This WiFi should NOT be used as it is NOT part of the Home LAN. *If the antennas can be easily removed, please do so.*

The Home Router connects to home devices via wire or via WiFi. The communications of devices via the Home Router constitutes the LAN.

Local Area Network (LAN)

The term LAN can be used somewhat generically or specifically. In this specific case, it refers to the connections via the Home Router. In the simplest terms, devices on the LAN can access the internet or other devices on the same LAN. *There can be a long discussion of subnets, which will be avoided for simplicity.*

In the case of the RF Switch, since it is a device on the SAME LAN as your computer or tablet, you are able to access it.

Cable Modem
This device is usually provided by
your Internet provider.

Home Router
This device is usually something you purchased
from Best Buy or Amazon.

Laptop　　　　Tablet　　　　Phone

Discouraged Configurations

For the simple case, the devices on the LAN can talk to each other. Devices NOT on the LAN can not[1]. In the following figure, there is a phone on the Cable Modem provided WiFi. It is not (easily or simply) accessible from the devices on the Home LAN.

The RF Switch should NOT be connected to the Cable Modem WiFi as it will not be accessible from the Home LAN.
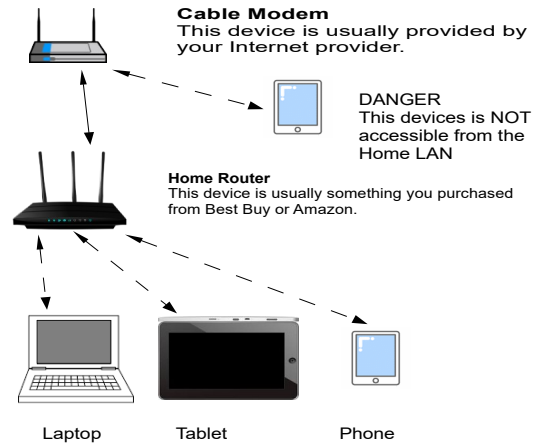
Notes:

1.　For those with advanced networking skills, communications with other subnets can be established via Static IP Routing Tables. *Which will not be discussed here.*