MOAS II

Intelligent Antenna Switch

Version 1.0 DRAFT 1

Yankee Clipper Contest Club

Legal Notices

Edit History

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Preface

MOAS stands for "Master Of Antenna Switching", or if you prefer, "Mother Of All Switches". The MOAS II is the second generation of this basic design and is more powerful and easier to construct than the original.

The MOAS II antenna switch and server are designed to automate antenna switching in an amateur radio station. They can handle very complex antenna topologies and can make operation relatively easy and intuitive.

Unfortunately configuring a complex antenna system so that it is easy to use is not trivial. This manual attempts to explain how to set up and configure the hardware and software.

There is a project underway to simplify the configuration. In the meantime, this manual will attempt to provide all of the necessary information.

Note: There are other software packages which use the MOAS II hardware. They are not described in this manual.

This document and the software are in active development. Expect features to be added and bugs to be fixed.

1. Overview

The MOAS II consists of three parts – the intelligent switch, the server program, and the clients.

1.1. Capabilities

The MOAS II switch, server, and clients provide significant capabilities.

1.1.1. Suitable antennas

The client can be set to only display antennas which are usable for the radio and for the frequency the radio is using. The configuration file controls which antennas to display.

If an antenna is being used by another radio that information also can be displayed. The operator will not be able to select that antenna unless it is configured to be shared.

1.1.2. Hot switch protection

The switch will not change relays for a radio which is transmitting. It will change relays for other radios if it is safe to do so.

1.1.3. Different TX and RX antennas

Transceivers close the amplifier keying line a few milliseconds before they output RF. This delay is necessary so the amplifier can switch to transmit. If the relays used for antenna switching are fast enough the switch can select a different antenna for transmit than receive. The ability to do this can be configured per antenna pair.

1.1.4. Conflicts

Most of the time if a station is using an antenna then other stations cannot use that antenna. Sometimes other stations cannot use other antennas as well, such as when they have a common feedline. The server will show antennas with conflicts as unavailable and the operator will not be able to select them.

1.1.5. Wait and interrupt modes

The switch can be configured so that if a radio is transmitting and an operator changes bands it briefly interrupts the transmission or it waits until the transmission is complete.

1.1.6. Inhibits

The switch can be configured so that when one radio transmits it inhibits one or more other radios.

1.1.7. Alternate paths

There may be multiple ways for an antenna to be connected to a radio. The MOAS server automatically uses a path which is not being used by other stations, if one is available. This is usually invisible to the operator.

1.1.8. Selection by frequency

Antennas are selected by frequency range. An antenna which covers multiple frequency ranges can use different relays for various parts of the frequency range.

1.1.9. Automatic selection

If a radio is tuned outside of the current frequency range of the antenna it is using the server will automatically select an antenna suitable for the new frequency.

1.1.10. Antenna systems

An antenna system is a group of antennas such as a stack of yagis. The MOAS II understands about antenna systems and provides methods for selecting antennas within a system.

1.1.11. Receive-only antennas

An antenna can be configured as receive-only. It will not be displayed as available for transmit and it cannot be selected for transmit.

1.1.12. Shared antennas

An antenna or an antenna system may be shared by more than one radio. The MOAS II supports shared antennas and systems. If an antenna system is shared then changing the selected antennas within the system will affect all users.

1.1.13. Alternate Antennas

There is a provision for configuring radios so that when one is transmitting another is switched to a different receive antenna. This is for receiver front end protection when two stations are operating on the same band and antenna separation is limited.

1.1.14. Same band protection

The server can be configured so that if a radio switches to a frequency within the range of another radio that radio will not be connected to an antenna. This protects the front end of a radio if an operator inadvertently switches it to a band being used by another radio.

1.1.15.   Functions

The server can be configured to make functions available to the client. These include things like storing and recalling an antenna selection, swapping antennas between radios, and setting the RX antenna to the TX antenna.

1.1.16.   Rotators

The server can control rotators. These can be physical rotators or when an antenna is electrically rotatable it can show that as an electrical rotator.

Note: The physical rotator code is not complete and does not connect to a rotator controller yet. The current plan is to leverage software which knows the protocols for the various rotator controllers.

2. Switch

The hardware was designed to do antenna switching. It handles all of the time critical functions.

2.1.   Power

The switch receives power through an Anderson PowerPole™ connector.

The board is intended to run from 13.8 volts, but will run on other voltages if desired. It is designed be run from a voltage as high as 30 volts if higher voltage high side switching is needed.   If the voltage is raised the value of R13 may need to be increased. If raising the voltage causes the voltage regulator, U3 to run warm a resistor can be added at R14 to drop the voltage.

2.2.   Relay Outputs

The switch can operate up to 64 independent relays. The relays may be switched on the high side or the low side. Which side is switched is determined at construction time.

Low Side   High Side
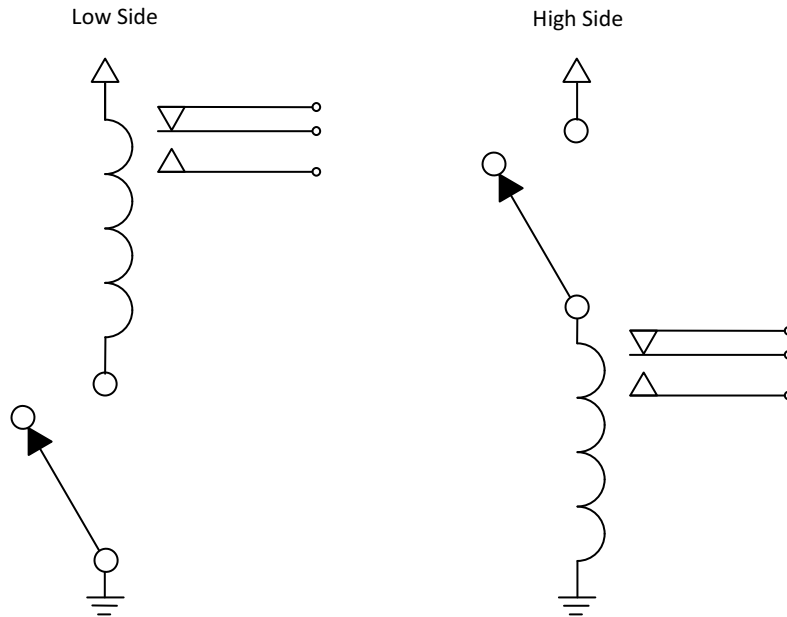
The relays are connected to pluggable block (Phoenix) connectors. Each connector supports eight relays. The connectors also have two pins which are connected to either +V or ground, determined at construction time.

The low side outputs are rated at 50 volts and 350 milliamps maximum. If the relays are supplied from an external voltage source their operating voltage is independent of the power supply voltage.

The high side outputs are rated at 50 volts and 500 milliamps maximum. The supplied voltage is the voltage supplied to the switch minus the drop in the output devices. The input voltage can be increased to accommodate high side switching of 28V relays.

If several relays within a group of eight draw current near the maximum the output device may overheat. In this case it is recommended that such loads be split among several groups. If the loads are high current power transistors or FETs could be used as current buffers. Relays could also be used as buffers but this adds to the time required to switch the antennas and may preclude using separate transmit and receive antennas.

2.3.   Amplifier Keying

The switch connects to the amplifier keying line of up to six radios. It can be connected in parallel with the amplifiers. It is designed to handle high voltage keying such as is used on the Heathkit SB-220 or Drake L4B.

Note: The amplifier keying voltage must be positive. The switch will not work and may be damaged by connecting it in parallel with an amplifier which has a negative keying voltage such as a Heathkit SB-200 or Collins 30L-1.

2.4.   Radio Inhibits

The switch connects to the inhibit inputs of up to six radios. The switch can be set up to pull the inhibit outputs down to inhibit transmission or to pull the outputs down to enable transmission. This can be set per-radio.

If a radio does not have an inhibit input or it cannot be connected to the switch then the switch will work but some capabilities must not be configured.

2.5.   Switching Speed

At worst case the time between when an amplifier keying line is opened or closed and when the relay outputs change is less than 200 microseconds. This is insignificant compared to the speed of a mechanical relay.

2.6.   USB

The switch connects to a computer through a standard USB port. It uses a USB B connector. It does not draw any power from the USB connector.

The switch requires an FTDI Virtual Com Port driver. Most versions of Windows will install this automatically. It can also be obtained from www.ftdichip.com. The port number can be viewed and changed using the Windows device manager.

3. Server

The MOAS II server runs on a PC running Windows XP or any newer version of Windows. The PC must have a USB port and networking capability.

The server can control multiple switches. The design limit is 99 but this has never been tested.

It does not use a lot of memory or CPU resources. It can be run on a PC which is also running a logging program or other programs.

It has one window. Once the server is started and a configuration file is opened it can usually be minimized and ignored.

The server program may be ported to Linux or Mac OS X if there is a reason to do so.

3.1. TCP/IP

The server communicates with clients using TCP/IP (Ethernet). The communication can be over a local or wide area network, wired or wireless. Remote connections are supported.

3.2. Configuration File

When the server starts it reads a configuration file. This file provides all of the information needed. Some of the configuration information is sent to the switches.

4. Clients

Clients provide the server with information about radios, are used to select antennas and control rotators, and display information about current and available antennas.

There can be many clients, and there can be more than one client for one radio.

Currently four clients have been implemented:

4.1. N1MM Logger Client

This is a small client which currently runs within the server. It gets radio frequencies from N1MM Logger.

4.2. Windows Client

This is a set of buttons which control antennas and a compass which controls rotators. It also has some special features for testing the server and the configuration file.

4.3. Windows Knob Client

This client uses a Phidget USB knob encoder. The physical encoder used on this device is not really suitable for antenna switching. Their suggested alternate is a bit better.

I am looking for a better knob to use with this client.

4.4. Android Tablet Client

This client runs on an Android tablet or phone. It provides buttons for one or two radios and a compass for rotator control.

A 7" android tablet is often less than $60, sometimes less than $40 on sale. If you aren't in a hurry you can order one from www.focalprice.com in China. Or you can get one in the US from www.newegg.com.

5. Concepts

5.1. Identifiers

Some items in the configuration are identified by number. For example, each antenna is given a unique number. These numbers can be any positive number from 0 through 2,147,483,647. There is no need for these numbers to be contiguous – you can skip numbers, or number your 80 meter antenna 80 and your 40 meter antenna 40 etc.

In most cases the number does not matter. However when the server is looking for an antenna to select for a radio which has changed bands it looks from low to high numbers. So you would want to give the preferred antennas lower numbers than the secondary antennas.

Numbers must be unique for each type of item. In other words, there cannot be two antennas with ID 0 but there can be an antenna with ID 0, an antenna system with ID 0, a rotator with ID 0, a station with ID 0 etc.

5.2. Stations and Radios

Each physical radio is given a station number and a radio number. Typically a station represents a computer. So if you had two radios set up for SO2R you might call them "station 1 radio 1" and "station 1 radio 2". If you had two radios each connected to a computer for multi-single you might call them "station 1 radio 1" and "station 2 radio 1".

The Android client is designed for SO2R and can show two radios on one station. It expects them to be numbered as radio 1 and radio 2.

The configuration file describes which station and radio are connected to which amplifier keying and inhibit connectors on the switch.

5.3. Antennas and systems

To the MOAS II, an antenna is anything that has a unique set of relays. And an antenna system is two or more antennas that are related.

Consider the following antennas, which are part of an SO2R station. The stack of three yagis is connected to an Array Solutions Stack Match or similar, with the top antenna on port 3, the middle on port 2, and the bottom on port 1. The Stack Match is connected to port 4 on the 2x6 switch.

The twelve relays in the 2x6 are connected to relay outputs 0-11 on the MOAS II switch. Relays 1-4 on the Stack Match are connected to outputs 16-19 on the MOAS II switch.
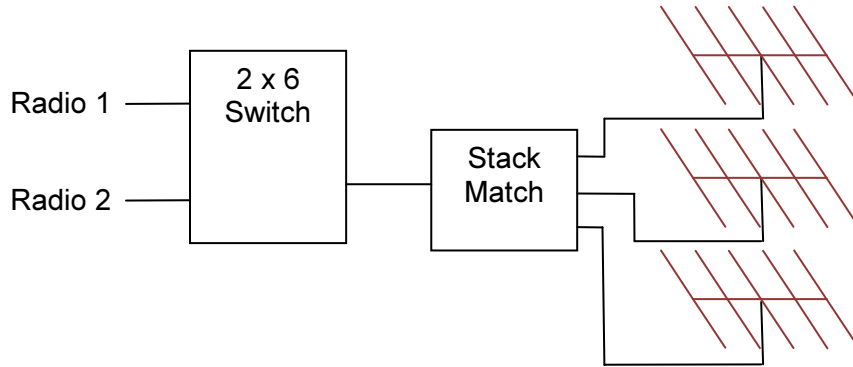
To the MOAS II this is seven antennas:

ID	Name	Station 1 Relays	Station 2 Relays
0	Top	3, 18, 19	9, 18, 19
1	Mid	3, 17, 19	9, 17, 19
2	Bot	3, 16, 19	9, 16, 19
3	Top Mid	3, 18	9, 18
4	Top Bot	3, 17	9, 17
5	Mid Bot	3, 16	9, 16
6	All	3	9

The 2x6 relay selection is straight forward. Ports 1-6 for radio 1 are selected by outputs 0-5. For radio 2 they are selected by outputs 6-11. The relay selection for each combination of antennas is not obvious. It is necessary to read the Stack Switch manual and schematic to figure it out.

The seven selections could be seven switch positions on a rotary switch. This is what Array Solutions builds for their mechanical controller:
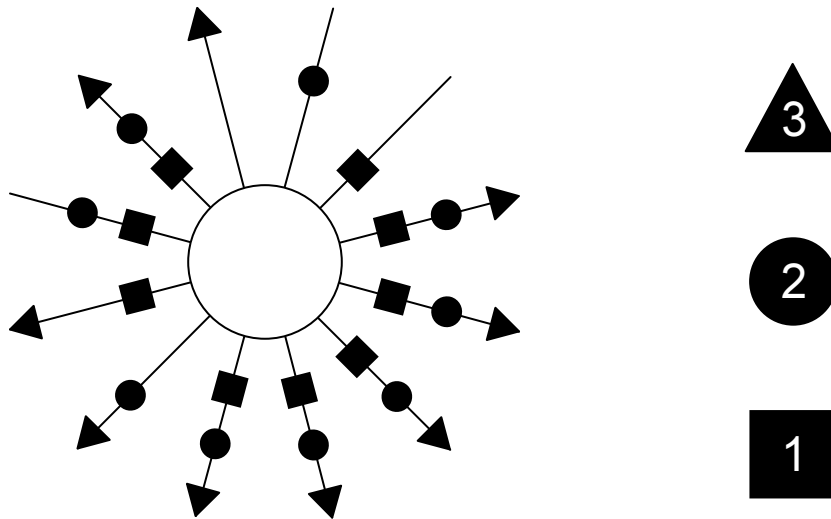
This scheme shows *exclusive antennas*. Each position selects an exclusive combination of antennas. (There are several positions which select all antennas because the switch they used had 12 positions).

There is another way this could be controlled. Three switches could be used, one for each yagi:
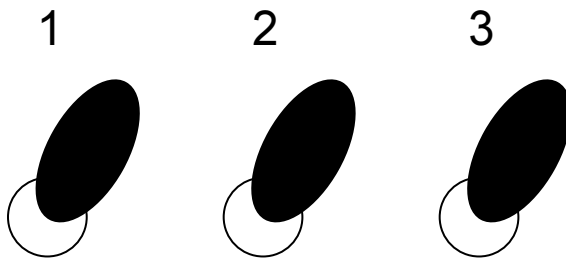
This scheme shows *additive antennas*. With all of the switches up, all of the antennas are connected. Move a switch down and that antenna will be removed from the stack.

The relay table above shows that there is no straightforward way to figure out which relays must be selected for each additive combination. The server solves this by finding the exclusive antenna which has the correct antennas. This requires some additional information:

ID	Name	Station 1 Relays	Station 2 Relays	Components
0	Top	3, 18, 19	9, 18, 19	
1	Mid	3, 17, 19	9, 17, 19	

2	Bot	3, 16, 19	9, 16, 19	
3	Top Mid	3, 18	9, 18	0, 1
4	Top Bot	3, 17	9, 17	0, 2
5	Mid Bot	3, 16	9, 16	1, 2
6	All	3	9	0, 1, 2

The new components column lists which single antennas are parts of which combinations. The server can use this information to find the exclusive antenna which is the combination of the additive antennas.

Some antenna systems are only exclusive. For example, a 4-square has four exclusive directions, NE, SE, SW, and NW. There is no additive antenna scheme which makes sense in this case. It is not even necessary to configure a 4-square as an antenna system in most cases.

The server can also handle antenna systems which include antenna systems. The Multi-Multi 20 Configuration example shows this.

5.4.   Frequencies

The MOAS II does not know anything about ham bands. All antenna ranges are specified by frequency.

Antennas have a lower and upper frequency range, expressed in KHz. The maximum frequency which can be specified is about 2 THz. An antenna can cover multiple frequency ranges and each frequency range can select different relays.

A tribander would have three frequency ranges. If it is connected through a switched bandpass filter the relays for the three ranges might be different because it is selecting a different filter for each range.

A 160 meter vertical might have two frequency ranges. The lower frequency segment might specify an extra relay which adds an inductor. This change would be transparent to the operator.

If an antenna covers multiple frequency ranges it is usually best to list them all rather than one large frequency range which covers all of them, even if the relays are the same for all cases. For example, it is better to list 14000-14350, 21000-21450, and 28000-29700 instead of 14000-29700. This is because the server uses the frequency ranges to decide if two stations are on the same band. When it makes these comparisons it only uses the frequency range that the radio is operating in (it also checks contiguous frequency ranges if there are any).

5.5.   Conflicts

It is possible that one radio using an antenna precludes another radio from using a different antenna. In the following example radio 1 cannot use the 15 meter beam when radio 2 is using the 10 meter beam. These two antennas have a conflict. In this case Radio 1 will show the 15 meter beam as unavailable and the operator will not be able to select it.
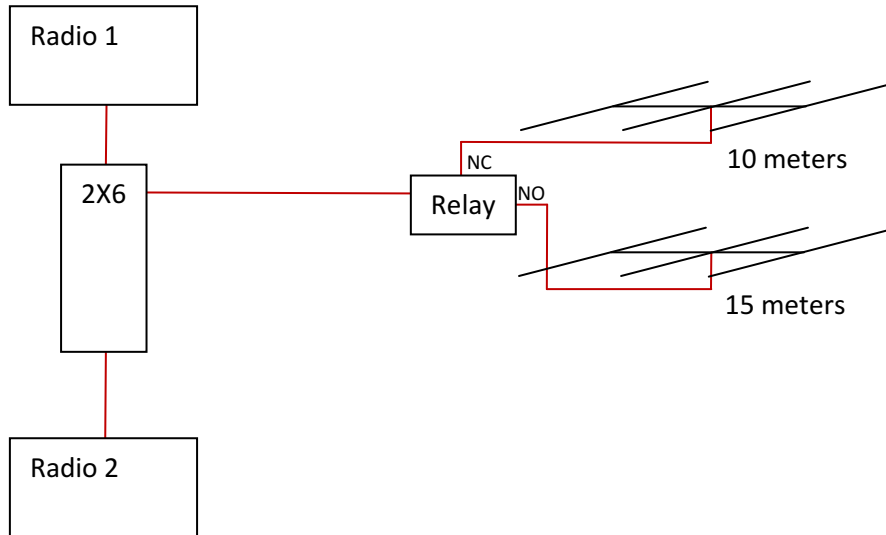
In the earlier example with the stack of three yagis there are seven antennas, none of which can be used when the others are in use. For that case antennas 0-6 have conflicts with antenna 0-6.

5.6.   Fast and Slow Transitions

If the relays that must be switched when changing between two antennas are fast enough that they can be changed between the time the amplifier keying line closes and the time RF comes out of the amplifier then one of the antennas can be used for transmit and the other for receive.

In the case above with three yagis, if the relays in the Stack Match are fast enough the station can transmit on some of the stack antennas and receive on different stack antennas. The speed of the relays in the 2x6 does not matter for this case because they do not change when switching between the stack antennas. If the relays are fast enough then antennas 0-6 have fast transitions with antennas 0-6.

5.7.   Persistent Relays

If an antenna system has internal relays, such as those used to select direction in a 4-square or to select individual antennas in a stack, and the antenna system is used for transmit and not receive or vice-versa, the internal relays will be selected and deselected each time the

radio switches between transmit and receive. If the internal relays are slow this will prevent using the antenna system for only transmit or receive. It also can cause the relays to wear out sooner.

This can be avoided by declaring the internal relays to be persistent. The persistent relays will not be changed between transmit and receive, provided that the other antenna being used is part of a different antenna system.   For example if you transmit on the 4-square and receive on a beverage the 4-square internal relays would not switch when changing between transmit and receive. However if you transmit on the 4-square northeast and listen on the 4-square southeast the internal relays will switch because the transmit and receive antennas are part of the same system.

5.8.   Alternate paths

It is possible to create an antenna system where more than one combination of relays will connect an antenna to a radio. For example in the following diagram radio 1 can be connected to the 15 meter beam through either coax 1 or coax 2. If radio 2 is using the 20 meter beam radio 1 must use coax 1 and if radio 2 is using the 10 meter beam radio 1 must use coax 2.
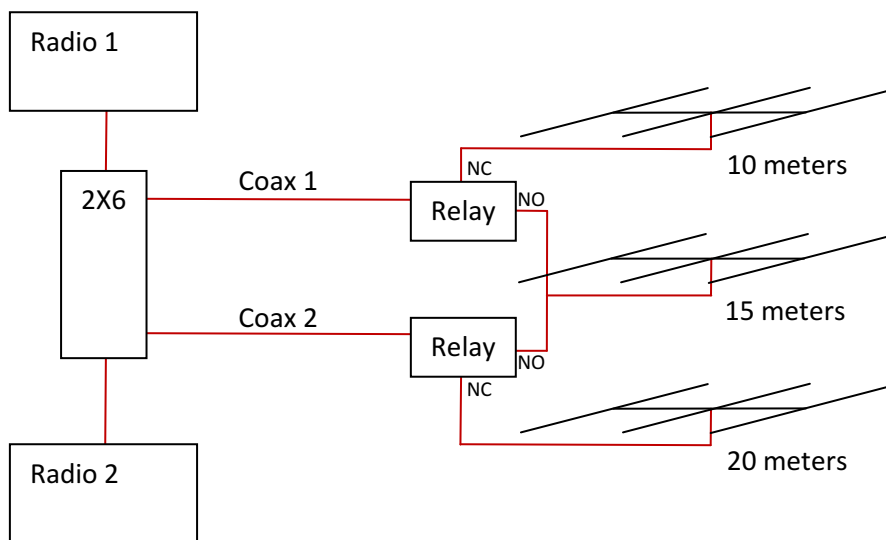
Since the two paths to the 15 meter antenna use different relays the MOAS server considers them to be different antennas. The configuration file specifies that they are alternates for each other and the server will automatically switch the 15 meter antenna path as necessary.

5.9.   Alternate Antennas

This feature is designed for cases where there might be a problem, such as a damaged receiver front end, if a station transmits on an antenna while another station is listening on another nearby antenna.

The configuration file for this case specifies a set of conditions – frequency, transmitting antenna or antennas, receive antennas, and an alternate antenna. If another station transmits on the specified antennas the switch will select the alternate antenna for the receiving station. If the alternate antenna is not available it will select no antenna for the receiving station.

5.10. Shared Antenna Systems

A shared antenna system is a system with multiple antennas which can be used simultaneously by more than one station. Examples are a 9-circle receive array or a set of switched Beverage antennas. Note that if each station can select a different beverage it is not a shared system but two systems using shared antennas. Another example of a shared system is a stack of tribanders with a triplexer.

The main feature of a shared antenna system is that changes affect all radios which are using the system. For example if the 80 meter operator changes a shared beverage system from northeast to south it changes the direction the 160 meter operator is listening too.

Because of this the shared antenna acts a bit oddly in one case. If a radio is using the shared antenna and another radio is switched to it, it will be connected but the shared antenna will not change. Once the radio is using the shared antenna the direction or the members of the shared antenna can be changed.

For example, suppose the 80 meter operator is listening on the northeast Beverage and the 160 meter operator is listening on his transmit antenna. The 160 operator selects a beverage. No matter which beverage he selects he will be connected to the northeast beverage. After he is connected to the beverage, if he selects the south beverage both 160 and 80 will be switched to the south beverage.

5.11. Inhibits

The inhibit capability is very flexible and can be configured in several ways.

It can be set up to be symmetric (radio A inhibits radio B and radio B inhibits radio A). With this configuration whichever radio transmits first will block the other. This can be used for SO2R or for two stations on a band.

It can be set up to be asymmetric (radio B inhibits radio A but radio A does not inhibit radio B). With this configuration radio A will block radio B whenever it transmits. This could be used for two stations on a band where station A is runs and station B chases multipliers. It

can also be used in CQ WW multi-2 where a station uses band changes to work multipliers on another band.

It can be set up for three or more radios, either in symmetric or asymmetric configurations.

These capabilities cannot be used with radios which do not have an inhibit input or where the switch is not connected to the inhibit input.

Each radio has two lists of which other radios will inhibit it from transmitting when they are transmitting. One list is for other radios which always inhibit, and one is for radios which only inhibit when they are on the same band. The latter is useful if a station has the ability to put two radios on the same band – when they are on the same band they can be automatically interlocked so only one can transmit.

5.12. Wait and Interrupt Mode

If a radio is transmitting and an operator selects a different transmit antenna the behavior depends on whether the switch is configured to wait or to interrupt.

If the switch is configured to wait the radio will continue to use the old antenna until it stops transmitting. The next transmission will be on the newly selected antenna.

If the switch is configured to interrupt the transmission then it will inhibit the radio, wait a few milliseconds change the antenna, wait a few more milliseconds, and unihibit the radio. This may sound useless but the entire time for this operation is typically less than 100 milliseconds, so very little is actually lost.

Interrupt versus wait mode is configured per-radio. Interrupt mode should not be configured for radios which do not have an inhibit input or where the switch is not connected to the inhibit input.

The delays for interrupt mode can be set in the configuration. The time is in milliseconds. The default is zero, which means the antenna will start to switch as soon as the inhibit line is set.

If an operator changes transmit antennas while he is transmitting another operator may see his old antenna as available and could try to use it. The switch recognizes this and will not switch the second radio to the antenna until the first radio finishes transmitting.

5.13. Rotators

The server is designed to be able to control antenna rotators. **This is not completely implemented.**

An antenna can be specified as being fixed or as having a rotator. If it has a rotator the client can change the direction. The configuration can include the offset of the antenna on

the mast in case some antennas are at right angles, and it can include the clockwise and counterclockwise limits in case a rotator is has limited travel.

An antenna system such as a 4-square can be electronically rotated. If the antenna is configured as having an electronic rotator then when a direction is selected the antenna selection having the closest direction will be used.

5.14. Button Clients

One way to display antenna selections is as an array of buttons. The buttons display antennas which could be selected and indicate whether an antenna is unavailable, available, or selected graphically. Pressing a button can select or deselect it. Buttons can also activate functions.

The number of rows and columns of buttons is dependent on the client. The Windows client has a fixed number – five rows and three columns. The Android client rows and columns can be changed through a setup menu. The number can be different depending on whether the phone or tablet is horizontal or vertical. Buttons are also available for selecting rotators.

The layout of the buttons is in the server configuration file. The client gets the information when it starts or when the information changes. The layout describes which antenna each button should show. The lists of buttons are specified by frequency range. The range 7000-7300 would show 40 meter antennas, the range 3500-4000 would show 80 meter antennas etc.

There can be multiple layouts for different numbers of rows and columns of buttons. The client requests a list for the number of rows and columns it will display and the server selects the closest match from the configuration file.

When a button for an exclusive antenna is pressed that antenna becomes selected and all others are deselected. This is an example of buttons for a 4-square:

4-Square NE

4-Square SE

4-Square SW

4-Square NW

The order and position is up to the writer of the configuration. The 4-square could also be done this way:

4-Square NW	4-Square NE
4-Square SW	4-Square SE

An antenna system which is additive offers more choices. For example, this is an exclusive set of buttons for a stack of three yagis:

Top	Top + Mid
Mid	Top + Bot
Bot	Mid + Bot
All	

This could also be a set of additive buttons. Pressing a button alternately adds an antenna to the stack or removes it.

```
┌─────────────┐
│    Top      │
│             │
└─────────────┘

┌─────────────┐
│    Mid      │
│             │
└─────────────┘

┌─────────────┐
│    Bot      │
│             │
└─────────────┘
```

It is possible to mix additive and exclusive buttons. If the entire stack is used most of the time it could have a button to quickly select it:

```
┌─────────────┐
│    All      │
│             │
└─────────────┘

┌─────────────┐
│    Top      │
│             │
└─────────────┘

┌─────────────┐
│    Mid      │
│             │
└─────────────┘

┌─────────────┐
│    Bot      │
│             │
└─────────────┘
```

Pressing the All button will select the entire stack. Pressing the other buttons will add and remove them from the configuration.

Both the windows and Android clients have a quick way to exclusively select an additive antenna. If you double-click an additive antenna in the Windows client or press and hold it in the Android client all other antenna will be deselected.

5.15. Display Clients

A display shows the currently selected antenna for one or more stations. The Windows button and knob clients have them built in – they display below the title in the window.

5.16. Knob Clients

Some operators prefer to turn a knob to select antennas. The Windows knob client interfaces with a Phidgets knob. Everything is configured the same as for a button client except that the list is 1 row by 50 columns.

It is usually not a good idea to assign a large number of antennas to a knob, as the operator will need to turn it a long ways. A 4-stack of yagis would be easy to set up as additive antennas on a button client but with a knob client there would be 15 switch positions. The station designer should consider whether the knob client should select fifteen choices or if some should be not be made available in order to simplify operation.

5.17. Relative Clients

Relative clients are designed to be used in logging programs and similar. The client does not need to know anything about the antennas. It can choose one antenna from a list or can choose the next or previous antenna in the list. For testing purposes there is a relative client built into the Windows button client. Click on the small icon in the upper left to access this client.

If there are more than a few antennas available on a band the relative client will be difficult to use. Normally only the most commonly used antennas would be set up for the relative client. The relative client's antenna list is separate from the lists used for the button and knob clients.

5.18. Functions

The server can be configured to make functions available to the client. These are the currently available functions:

RX=TX

If the transmit and receive antennas are different, set the receive antenna to be the transmit antenna.

Store and Recall

These are two functions. Store stores the current antenna selection and Recall recalls it.

Swap

Swap exchanges the antennas of two radios. This is only available if both antennas cover the frequency of the other radio.

An example would be a station with SO2R capability using a tribander and a multiband vertical. The operator might be running on the tribander and searching for multipliers on the vertical. If he finds a weak multiplier he may need to swap the tribander onto the multiplier station briefly.

Share

This function constructs and deconstructs a shared antenna system.

An example would be a station with a stack of two tribanders and a triplexer. The stack could be shared or it could be split into two antennas each connected to a different radio.

This function is turned on and off by alternate button presses.

6. Configuration File

6.1.   JSON

The configuration file uses a notation called JSON. This is an international standard notation. It doesn't matter what JSON stands for, but notice that it is not JASON.

The configuration files have the extension .MOAS. They are text files. They can be edited using Notepad or any other text editor. If you use a word processor you must save the result as a text file. There are also online web based JSON editors available for free.

The character encoding for the files is UTF-8. This will not matter to you unless you want to put non-English characters in the names. The MOAS II server will handle just about any character, as will the Android client. The Windows client needs some work in this area.

 The syntax is described on www.json.org. JSON was designed by computer programmers and most of the information on the Internet is written for computer programmers. This description is written for non-programmers.

6.1.1. Names and values

In JSON everything has a name and a value (with one exception).

Names are written in quotes. Case matters – `"Thing"`, `"THING"`, and `"thing"` are three names. In the configuration file all names start with a capital letter. If a name is more than one word all of the words start with capitals and the spaces are left out. For example a first name might be named "FirstName". "ID", which stands for identifier, is an exception – it is all capitals.

Names are separated from values with a colon. `"FirstName" : "Paul"` is proper JSON.

There are several types of values:

- **String**

  A string is always in quotes. A string can contain any UTF-8 characters. `"20 Beam"`, `"Stack"`, and `"42"` are all strings.

- **Number**

  A number is one or more decimal (base 10) digits, optionally with a minus sign in front. A decimal point and more digits are also allowed but currently no numbers in the configuration file use decimal points. Numbers are never in quotes.

The maximum value for a number is 2,147,483,647 and the minimum value is -2,147,483,648. Commas, the plus sign, and leading zeros are not allowed.

`1`, `-30`, and `65536` are valid numbers. `01`, `+30`, and `65,536` are not. `"2"` is not a number, it is a string.

- **Boolean**

A Boolean is a fancy name for a value that is true or false. The words `true` and `false`, all lowercase are Boolean JSON values. Boolean values are never in quotes.

- **Null**

JSON allows the word `null` as a value. It is not used in the configuration file.

- **Group**

A value can be a group of names and values surrounded by curly braces.

For example, `"Person" : { "FirstName" : "Paul", "LastName" : "Young" }`

An empty group is allowed. `"Nothing" : {}`

- **List**

A value can be a list of values surrounded by square brackets.

For example `"Relays" : [ 1, 2, 3, 20 ]`

A list with one value is not the same as that value. In other words, `[ 1 ]` is not the same as `1`. If a list has only one value it must still be written as a list.

An empty list is a valid value. `"Fast" : []` is acceptable.

Since a group is a value a list can contain groups. This allows for nesting:

```
"Antennas" : [
    { "ID" : 1, "Name" : "80 Dipole", "Relays" : [1] },
    { "ID" : 2, "Name" : "40 Dipole", "Relays" : [2] }
]
```

In the above example the value of Antennas is two groups, one describing an 80 meter dipole and one describing a 40 meter dipole. The configuration file looks like this but with more information and more nestings.

JSON allows values in lists to be of different type, such as `[ 1, "Fred" false ]` but in the configuration file all of the values of a list are of the same type.

6.1.2. Commas

The comma is used to separate name/value pairs in groups and values in lists. The comma must not be used after the last value. For example, these are all bad:

```
"Relays" : [ 0, 1, ]

"People" : [
    { "FirstName" : "Paul", "LastName" : "Young" }
    { "FirstName" : "Charlotte" "LastName" : "Richardson" }
]
```

The first example has an extra comma after the 1. The second example is missing two commas, one after the first closing curly brace and the second after Charlotte.

Misplacing commas is very easy to do, especially when cut and paste editing a configuration file.

6.1.3. Spacing, tabs, and new lines

JSON allows spaces, tabs, and new lines anywhere except in names and values. So this:

```
"Relays":[0,1]
```

Is the same as this:

```
"Relays" : [
    0,
    1
]
```

Spacing and lines can make the configuration file easier to read. There are many styles of indenting JSON.

6.1.4. Beginning and ending braces

It was mentioned above that there is one exception to the rule that everything has a name and a value. The entire configuration file is a value with no name. It is a group, so the configuration file must begin with an open curly brace and end with a close curly brace.

6.1.5. Debugging JSON

It can be difficult to spot errors in JSON text and the configuration file reader is not very good at explaining what is wrong. A much better file reader is online at www.jsonlint.org.

You can copy and paste the entire configuration file into the website and it will usually point to where the problems are.

6.2. Configuration file lists

The information in the configuration file is divided into nine major lists and a few miscellaneous names and values.

6.3. Templates

The templates list describes physical antennas. It is a list of groups. Each group describes one physical antenna. It contains information such as the manufacturer and model, type, and gain and beamwidth. This information is provided to clients, which could use it to provide better graphics and icons for the antennas. There is also a future plan which may use the gain and beamwidth in the server.

At this point no client uses this information so it will not harm anything if some or all is not provided.

If there are several identical antennas, such as in a stack of yagis, only one template is needed to describe all of them. Each template group name must unique because the antennas refer to the templates by the name.

Name	Required/Optional	Type	Meaning
Name	Mandatory	String	Antenna name
Manufacturer	Optional	String	Antenna Manufacturer
Model	Optional	String	Antenna Model
Type	Optional	String	Antenna type: dipole, vertical, yagi, etc.
Info	Optional	List	Frequency-specific information

6.3.1. Info List

The Info list contains the following:

Name	Required/Optional	Type	Meaning
LowerFrequency	Optional	Number	Lower frequency limit
UpperFrequency	Optional	Number	Upper frequency limit
Elements	Optional	Number	Number of elements
3dBWidth	Optional	Number	3 dB beamwidth

Lobes	Optional	Number	Number of main lobes

6.3.2. Examples

This describes a Cushcraft 15-4CD 4 element yagi

```
"Templates" : [
    {
        "Name" : "Cushcraft 15CD-4",
        "Manufacturer" : "Cushcraft",
        "Model" : "15-4CD",
        "Type" : "yagi",
        "Info" : [
            {
                "LowerFrequency" : 21000,
                "UpperFrequency" : 21450,
                "Elements" : 4,
                "3dBWidth" : 56,
                "Lobes" : 1
            }
        ]
    }
]
```

This describes a homebrew 4-square

```
"Templates" : [
    {
        "Name" : "80 M 4-square",
        "Type" : "vertical",
        "Info" : [
            {
                "LowerFrequency" : 3500,
                "UpperFrequency" : 4000,
                "Elements" : 4,
                "3dBWidth" : 99,
                "Lobes" : 1
            }
        ]
    }
]
```

This describes a Bencher Skyhawk tribander

```
"Templates" : [
    {
        "Name" : "Bencher Skyhawk",
```

```
            "Manufacturer" : "Bencher",
            "Model" : "Skyhawk",
            "Type" : "yagi",
            "Info" : [
                {
                    "LowerFrequency" : 14000,
                    "UpperFrequency" : 14350,
                    "Elements" : 3,
                    "3dBWidth" : 72,
                    "Lobes" : 1
                },
                {
                    "LowerFrequency" : 21000,
                    "UpperFrequency" : 21450,
                    "Elements" : 3,
                    "3dBWidth" : 72,
                    "Lobes" : 1
                },
                {
                    "LowerFrequency" : 28000,
                    "UpperFrequency" : 29700,
                    "Elements" : 4,
                    "3dBWidth" : 61,
                    "Lobes" : 1
                }
            ]
        }
]
```

6.4. Antennas

The antennas list describes antennas which can be selected. It is a list of groups. Each group describes one antenna. Each antenna must have a unique ID number because other antennas and groups refer to antenna using the ID number.

Antennas have a long name and a short name. The long name is used for display clients. The short name is put on buttons. If the short name is too long it won't fit. A length of a dozen or so characters is probably OK. It is difficult to give a general rule because some characters are much wider than others. The long name is used on display clients.

The radio RX antenna is designed to handle switching of receive antennas that are connected to the radio's RX antenna. The information is passed to the client which, if it is a logging program which controls the radio, could activate or deactivate the radio's RX Antenna connector. There is no client yet which implements this.

Name	Required/Optional	Type	Meaning
ID	Required	Number	Unique number for this antenna

Template	Optional	String	Antenna template
ShortName	Optional	String	Name of antenna
LongName	Optional	String	Descriptive name of antenna
Enabled	Optional	Boolean	True if antenna can be selected
RXOnly	Optional	Boolean	True if antenna is receive-only
InUse	Optional	Number List	If antenna is part of a system, the IDs of the antennas used
Rotator	Optional	Number	Rotator number
Offset	Optional	Number	Antenna offset from rotator position in degrees or the direction if the antenna does not have a rotator
Alternate	Optional	Number List	Antenna numbers of antennas which are an alternate path for connecting to this antenna
Conflicts	Optional	Number List	Antennas which cannot be used when this antenna is in use
Control	Optional	List	Relays used to control this antenna

The antenna numbers specified in the In use list are the antenna IDs of the additive antennas which make up the antenna, if any.

6.4.1. Control List

The Control list contains the following:

Name	Required/Optional	Type	Meaning
LowerFrequency	Optional	Number	Lower frequency for these relays
UpperFrequency	Optional	Number	Upper frequency for these relays
Stations	Optional	List	Per-station and radio information

6.4.2. Stations List

The Stations list contains the following:

Name	Required/Optional	Type	Meaning
Station	Optional	Number	Station number
Radio	Optional	Number	Radio number

RadioRXAntenna	Optional	Boolean	True if antenna is connected to radio RX antenna
Relays	Optional	Number List	Relays to select
RXRelays	Optional	Number List	Relays to select when receiving on this antenna (if different than TX)
PersistentRelays	Optional	Number List	Relays to select when the other (TX or RX) antenna is part of a different group

6.4.3. Examples

This is a 40 meter beam connected to port 3 on a 2x6 switch in an SO2R station. It is mounted on rotator 1. Relay 2 selects it for radio 1 and relay 8 selects it for radio 2.

```
"Antennas" : [
    {
        "ID" : 4,
        "Template" : "40 Beam",
        "ShortName" : "Beam",
        "LongName" : "40 Meter Beam",
        "InUse" : [4],
        "Rotator" : 1,
        "Offset" : 0,
        "Conflicts" : [4],
        "Fast" : [4],
        "Control" : [
            {
                "LowerFrequency" : 7000,
                "UpperFrequency" : 7300,
                "Stations" : [
                    {
                        "Station" : 1,
                        "Radio" : 1,
                        "Relays" : [2]
                    },
                    {
                        "Station" : 1,
                        "Radio" : 2,
                        "Relays" : [8]
                    }
                ]
            }
        ]
    }
]
```

This is a more complicated example.

Two stations are connected to a 2x10 switch. Station 1 is relays 0-9 and station 2 is 10-19.

A stack of three tribanders is connected to a micro stack switch. The main feedline is on switch port 2 and the secondary feedline is on switch port 10.

The micro Stack Switch uses relays 20-26.

Each station has a switched bandpass filter. The filters use relays 40-45 and 50-55.

Antennas 0-6 represent the choices on the main feedline. Antennas 7-9 represent the choices on the secondary feedline.

```
"Antennas" : [
    {
        "ID": 0,
        "Template": "Bencher Skyhawk"
        "ShortName" : "Top",
        "LongName" : "Bencher Skyhawk stack top",
        "InUse" : [0],
        "Rotator" : 1,
        "Offset" : 0,
        "Alternate" : [7],
        "Conflicts" : [0, 1, 2, 3, 4, 5, 6, 7],
        "Fast" : [0, 1, 2, 3, 4, 5, 6, 7, 8, 9],
        "Control" : [
            {
                "LowerFrequency" : 14000,
                "UpperFrequency" : 14350,
                "Stations" : [
                    {
                        "Station" : 1,
                        "Radio" : 1,
                        "Relays" : [1, 22, 25, 27, 43],
                    },

                    {
                        "Station" : 1,
                        "Radio" : 2,
                        "Relays" : [11, 22, 25, 27, 53],
                    }
                ]
            },
            {
                "LowerFrequency" : 21000,
                "UpperFrequency" : 21450,
                "Stations" : [
                    {
                        "Station" : 1,
```

```
                        "Radio" : 1,
                        "Relays" : [1, 22, 25, 27, 44],
                    },

                    {
                        "Station" : 1,
                        "Radio" : 2,
                        "Relays" : [11, 22, 25, 27, 54],
                    }
                ]
            },
            {
                "LowerFrequency" : 28000,
                "UpperFrequency" : 29700,
                "Stations" : [
                    {
                        "Station" : 1,
                        "Radio" : 1,
                        "Relays" : [1, 22, 25, 27, 45],
                    },

                    {
                        "Station" : 1,
                        "Radio" : 2,
                        "Relays" : [11, 22, 25, 27, 55],
                    }
                ]
            }
        ]
    },
    {
        "ID": 1,
        "Template": "Bencher Skyhawk"
        "ShortName" : "Mid",
        "LongName" : "Bencher Skyhawk stack middle",
        "InUse" : [1],
        "Offset" : 45,
        "Alternate" : [8],
        "Conflicts" : [0, 1, 2, 3, 4, 5, 6, 8],
        "Fast" : [0, 1, 2, 3, 4, 5, 6, 7, 8, 9],
        "Control" : [ <omitted from example>
        ]
    },
    {
        "ID": 2,
        "Template": "Bencher Skyhawk"
        "ShortName" : "Bot",
        "LongName" : "Bencher Skyhawk stack bottom",
        "InUse" : [2],
        "Offset" : 45,
```

```
        "Alternate" : [9],
        "Conflicts" : [0, 1, 2, 3, 4, 5, 6, 9],
        "Fast" : [0, 1, 2, 3, 4, 5, 6, 7, 8, 9],
        "Control" : [ <omitted from example>
        ]
    },
    {
        "ID": 3,
        "Template": "Bencher Skyhawk"
        "ShortName" : "Top Mid",
        "LongName" : "Bencher Skyhawk stack top + middle",
        "InUse" : [0, 1],
        "Conflicts" : [0, 1, 2, 3, 4, 5, 6, 7, 8],
        "Fast" : [0, 1, 2, 3, 4, 5, 6, 7, 8, 9],
        "Control" : [ <omitted from example>
        ]
    },
    {
        "ID": 4,
        "Template": "Bencher Skyhawk"
        "ShortName" : "Top Bot",
        "LongName" : "Bencher Skyhawk stack top + bottom",
        "InUse" : [0, 2],
        "Conflicts" : [0, 1, 2, 3, 4, 5, 6, 7, 9],
        "Fast" : [0, 1, 2, 3, 4, 5, 6, 7, 8, 9],
        "Control" : [ <omitted from example>
        ]
    },
    {
        "ID": 5,
        "Template": "Bencher Skyhawk"
        "ShortName" : "Mid Bot",
        "LongName" : "Bencher Skyhawk stack middle + bottom",
        "InUse" : [1, 2],
        "Conflicts" : [0, 1, 2, 3, 4, 5, 6, 8, 9],
        "Fast" : [0, 1, 2, 3, 4, 5, 6, 7, 8, 9],
        "Control" : [ <omitted from example>
        ]
    },
    {
        "ID": 6,
        "Template": "Bencher Skyhawk"
        "ShortName" : "Top Mid Bot",
        "LongName" : "Bencher Skyhawk stack top + middle +
bottom",
        "InUse" : [0, 1, 2],
        "Conflicts" : [0, 1, 2, 3, 4, 5, 6, 7, 8, 9],
        "Fast" : [0, 1, 2, 3, 4, 5, 6, 7, 8, 9],
        "Control" : [ <omitted from example>
        ]
```

```
            },
            {
                "ID": 7,
                "Conflicts" : [0, 3, 4, 6, 7, 8, 9],
                "Fast" : [0, 1, 2, 3, 4, 5, 6, 7, 8, 9],
                "Control" : [ <omitted from example>
                ]
            },
            {
                "ID": 8,
                "Conflicts" : [1, 3, 5, 6, 7, 8, 9],
                "Fast" : [0, 1, 2, 3, 4, 5, 6, 7, 8, 9],
                "Control" : [ <omitted from example>
                ]
            },
            {
                "ID": 9,
                "Conflicts" : [2, 4, 5, 6, 7, 8, 9],
                "Fast" : [0, 1, 2, 3, 4, 5, 6, 7, 8, 9],
                "Control" : [ <omitted from example>
                ]
            }
        ]
```

6.5. Systems

The systems list describes antenna systems. An antenna does not need to be part of a system. If it is not in a system is considered a single exclusive antenna. An antenna can be part of only one antenna system. An antenna system can be part of another antenna system. Each antenna system must have a unique ID number.

Whether an antenna behaves as an additive or exclusive antenna when selecting from a button client depends on whether its ID is in the additive or exclusive lists in the system.

The number of antenna in the system is used for display only. Use whatever number you think makes sense.

Name	Required/Optional	Type	Meaning
ID	Required	Number	Unique number for this system
Antennas	Optional	Number	Number of antennas in the system
AdditiveAntennas	Optional	Number List	Antennas which are treated as additive
ExclusiveAntennas	Optional	Number List	Antennas which are treated as exclusive

SharedAntennas	Optional	Number List	Antennas for shared use
AdditiveSystems	Optional	Number List	Systems which are treated as additive
ExclusiveSystems	Optional	Number List	Systems which are treated as exclusive
SharedSystems	Optional	Number List	Systems which are treated as shared (Not implemented yet)
Shared	Optional	Boolean	Initial state of antenna sharing

6.5.1. Example

```
"Systems" : [
    {
        "ID": 0,
        "AdditiveAntennas" : [0, 1, 2],
        "ExclusiveAntennas" : [3, 4, 5, 6]
        "SharedAntennas" : [10, 11, 12]
        "Shared" : False
    }
]
```

6.6. Functions

The functions list describes functions which can made available as buttons. It is a list of groups. Each group describes one function with a set of parameters. Each function must have a unique ID number because the layout refers to functions using the ID number.

These are specific functions of the server – the server recognizes them by their names. Additional functions may be added in future versions. Lists of numbers and strings tell the function what to do. It is possible to have more than one function which has the same name and uses the same server's function but uses different numbers. For example, there could be a function which swaps the antennas of station 1 radio 1 and station 1 radio 2 and a different swap function which swaps the antennas of station 2 radio 1 and station 2 radio 2.

Name	Required/Optional	Type	Meaning
ID	Required	Number	Unique number for this system
Name	Required	String	Function name as known by the server
ShortName	Optional	String	Name displayed for function
Longname	Optional	String	Fully descriptive name of function

IntParams	Optional	Number List	Function-specific parameters
StringParams	Optional	String List	Function-specific parameters

There may be several functions that use the same Name but have different parameters.

6.6.1. AntennaSwap

This function swaps the antennas of the two radios if both antennas are usable on the other radio's frequency.

The function uses a list of four numbers. The first two are the station number and radio number for one radio. The second two are the station number and radio number for another radio.

6.6.2. RXTX

This function sets the receive antenna for a radio to the transmit antenna.

It does not use the lists of numbers and names.

6.6.3. Store

This function stores the current transmit and receive antennas for a radio in memory where the Recall function can find them.

It does not use the lists of numbers and names.

6.6.4. Recall

This function recalls the transmit and receive antennas stored by the Store function if they are usable on the radio's frequency.

It does not use the lists of numbers and names.

6.6.5. Share

This function changes an antenna system between shared and not shared. It is useful with antenna systems which may be shared or may have their individual antennas split among several radios. An example would be a stack of tribanders with a triplexer and switching that allows the tribanders to be connected to the triplexer or to individual radios.

This function uses a list of numbers. The first number is the ID of the antenna system which will be switched between shared and not shared. Any other numbers are IDs of non-shared antennas which will be assigned preferentially to the radios when the antenna system is changed from shared to not shared. The preferred antenna IDs are only necessary if it is desired to override the function's default selections of antennas for the radios.

### *6.6.6. Examples*

This is one example of each of the functions.

```
"Functions" : [
    {
        "ID": 0,
        "Name" : "AntennaSwap",
        "ShortName" : "Swap",
        "LongName" : "Swap antennas between radios 1 and 2",
        "IntParams" : [1, 1, 1, 2],
        "StringParams" : []
    },
    {
        "ID": 1,
        "Name" : "RXTX",
        "ShortName" : "RX=TX",
        "LongName" : "Set RX antenna to TX",
        "IntParams" : [],
        "StringParams" : []
    },
    {
        "ID": 2,
        "Name" : "Store",
        "ShortName" : "Store",
        "LongName" : "Store current TX and RX antennas",
        "IntParams" : [],
        "StringParams" : []
    },
    {
        "ID": 3,
        "Name" : "Recall",
        "ShortName" : "Recall",
        "LongName" : "Recall stored TX and RX antennas",
        "IntParams" : [],
        "StringParams" : []
    },
    {
        "ID": 4,
        "Name" : "Share",
        "ShortName" : "Share",
        "LongName" : "Share tribander stack between two
stations",
        "IntParams" : [0],
        "StringParams" : []
    }
]
```

6.7. Layout

The layout list describes button or knob layouts which can be used by a client. It is a list of groups. Each group describes one layout. Layouts do not have an ID.

Each button is identified by a row and a column. The top left button is row 0 column 0.

Row 0 Column 0	Row 0 Column 1
Row 1 Column 0	**Row 1 Column 1**
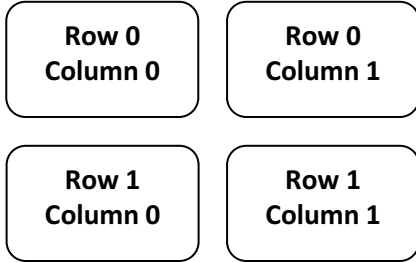
A knob client has only one row. Turning the knob to the right selects the next layout item. Turning the knob to the left selects the previous layout item. Turning past the end of the list of items wraps back to the other end of the list.

If a station and radio number are not provided then the layout will be used by all stations and radios.

If a row and column is not used it does not need an entry. The client will not put a button in a place where no antenna or function is specified.

Name	Required/Optional	Type	Meaning
Rows	Optional	Number	Number of rows
Columns	Optional	Number	Number of columns
Station	Optional	Number	Station number
Radio	Optional	Number	Radio number
Matrix	Optional	List	Button information

6.7.1. Matrix

The matrix list contains the following:

Name	Required/Optional	Type	Meaning
LowerFrequency	Optional	Number	Lower frequency limit
UpperFrequency	Optional	Number	Upper frequency limit
Buttons	Optional	List	Button position and function

If the frequencies are not specified the entry applies to all frequencies. This might be used, for example, to set up function buttons which are always displayed.

6.7.2. Buttons

The buttons list contains the following:

Name	Required/Optional	Type	Meaning
Row	Required	Number	Button row
Column	Required	Number	Button column
Type	Required	String	Must be Antenna or Function
ID	Required	Number	Identifier of antenna or function

6.7.3. Examples

This layout shows an 80 meter 4-square.

```
"Layout" : [
    {
        "Rows" : 4,
        "Columns" : 3,
        "Station" : 1,
        "Matrix" : [
            {
                "LowerFrequency" : 3500,
                "UpperFrequency" : 4000,
                "Buttons" : [
                    {
                        "Row" : 0,
                        "Column" : 0,
                        "Type" : "Antenna",
                        "ID" : 3
                    },
                    {
                        "Row" : 0,
                        "Column" : 1,
                        "Type" : "Antenna",
                        "ID" : 2
                    },
                    {
                        "Row" : 1,
                        "Column" : 0,
                        "Type" : "Antenna",
                        "ID" : 0
                    },
                    {
                        "Row" : 1,
                        "Column" : 1,
                        "Type" : "Antenna",
                        "ID" : 1
                    }
                ]
            }
```

```
            ]
        }
]
```

This example shows a layout with two antennas for 20-10 meters and two functions which will appear no matter what frequency the radio is using.

```
"Layout" : [
    {
        "Rows" : 5,
        "Columns" : 2,
        "Station" : 1,
        "Radio" : 1,
        "Matrix" : [
            {
                "LowerFrequency" : 14000,
                "UpperFrequency" : 29700,
                "Buttons" : [
                    {
                        "Row" : 0,
                        "Column" : 0,
                        "Type" : "Antenna",
                        "ID" : 6
                    },
                    {
                        "Row" : 0,
                        "Column" : 1,
                        "Type" : "Antenna",
                        "ID" : 0
                    },
                ]

            },
            {
                "Buttons" : [
                    {
                        "Row" : 1,
                        "Column" : 2,
                        "Type" : "Function",
                        "ID" : 3
                    },
                "Buttons" : [
                    {
                        "Row" : 1,
                        "Column" : 3,
                        "Type" : "Function",
                        "ID" : 4
                    },
                ]
```

```
                    }
                ]
            }
]
```

6.8.   RelativeAntennas

The relative antennas list describes which antennas to use with a relative client. It is a list of groups. Each group describes relative antennas for one or more stations. Relative antennas do not have an ID.

These describe which antennas to use as relative antennas for logging programs.

If the station and radio are not supplied the antennas apply to all stations and radios.

Frequency ranges should not overlap.

Name	Required/Optional	Type	Meaning
Station	Optional	Number	Station number
Radio	Optional	Number	Radio number
Antennas	Required	List	Relative antennas

6.8.1. Antennas

The Antennas list contains the following:

Name	Required/Optional	Type	Meaning
LowerFrequency	Optional	Number	Lower frequency limit
UpperFrequency	Optional	Number	Upper frequency limit
IDs	Required	Number List	IDs of antennas, in relative order
RXIDs	Optional	Number List	IDs of receive antennas

If the RXIDs are supplied the list must be the same length as the IDs. The specified antennas will be used for receive. If RXIDs are not supplied the transmit antennas will be used for receive.

6.8.2. Example

This example would select the all three antennas for 20-10 meters under control of a logging program which acts as a client. They could be the most combinations of a stack of three tribanders – all, top, and bottom two.

```
"RelativeAntennas" : [
    {
```

```
        "Station" : 1,
        "Radio" : 1,
        "Antennas" : [
            {
                "LowerFrequency" : 14000,
                "UpperFrequency" : 29700,
                "IDs" : [6, 1, 5]
            }
        ]
    }
]
```

6.9. Rotators

The rotators list describes antenna rotators. Each rotator must have a unique ID number.

There are three kinds of rotators. One is a physical device. Another other is electrical, where it involves the switching of an antenna system. The third is a simulated rotator, used for testing only.

The server will deal with several types of rotator control. The type is a string which is known to the server. Examples are "Electrical" which is for a system which is switched to different directions and "Test" which is used for testing. Additional methods may operate on serial ports or may communicate with external programs. The Communications string provides information on how to communicate with a port or a program.

Physical rotators are not implemented yet. The communications information specifics may change.

If the rotator is electrical then all of the antennas which use it must be part of an antenna system and all antennas within the system must specify the same rotator. When the rotator direction is changed the server will select the antenna with the offset closest to the requested direction.

Name	Required/Optional	Type	Meaning
ID	Required	Number	Unique number for this rotator
ShortName	Optional	String	Name of rotator
LongName	Optional	String	Descriptive name of rotator
Invisible	Optional	Boolean	True if rotator should not be shown to clients
CCWLimit	Optional	Number	Counterclockwise limit in degrees
Rotation	Optional	Number	Number of degrees the rotator can travel

Control	Optional	String	Type of rotator control
Communications	Optional	String	Communications information

6.9.1. Example

For this example rotator 0 turns a triband beam. Rotator 1 is a 9-circle receiving antenna. And rotator 2 turns a side mount which is limited in travel from 0 to 300 degrees.

```
"Rotators" : [
    {
        "ID": 0,
        "ShortName" : "Tribander",
        "LongName" : "Triband Beam on tower",
        "CCWLimit" : 180,
        "Rotation" : 360,
        "Control" : "DCU-1",
        "Communications" : "COM4",
    },
    {
        "ID": 1,
        "ShortName" : "9-Circle",
        "LongName" : "9-Circle receive array",
        "CCWLimit" : 0,
        "Rotation" : 360,
        "Control" : "Electrical",
    },
    {
        "ID" : 2,
        "ShortName" : "10 side",
        "LongName" : "10 meter side-mount",
        "CCWLimit" : 0,
        "Rotation" : 300,
        "HasStop" : true,
        "Control" : "Test",
        "Communications" : ""
    }
]
```

6.10. Radios

The radios list describes the radios. Each radio must have a unique station and radio number.

Name	Required/Optional	Type	Meaning
Station	Required	Number	Station number
Radio	Required	Number	Radio number

Interrupt	Optional	Boolean	True if interrupt mode, False if wait mode
InterruptModeDelay	Optional	Number	Interrupt mode delay
Always	Optional	List	Inhibit this station when one of these stations transmits
SameBand	Optional	List	Inhibit this station when one of these stations transmit within the frequency range of the receive antenna
Alternate	Optional	List	Alternate antennas to use for receive if another station is within the frequency range of the receive antenna
OutOfBand	Optional	Boolean	True if inhibit this station if there is no transmit antenna available which includes the transmit frequency
Ports	Required	List	Switches and radios

6.10.1. Ports

This describes the Ports, which are where the radio is connected on each switch:

Name	Required/Optional	Type	Meaning
Switch	Optional	Number	Switch number
Radio	Required	Number	Radio number on switch

6.10.2. Alternate

This describes the Alternate list:

Name	Required/Optional	Type	Meaning
LowerFrequency	Optional	Number	Lower frequency
UpperFrequency	Optional	Number	Upper frequency
ThisAntennas	Optional	Number List	Antennas this stations might use for receive
OtherAntennas	Optional	Number List	Antennas other stations might use for transmit
Antenna	Optional	Number	Alternate antenna to use

6.10.3. Always, SameBand, Stations

This describes the Always, SameBand, and Stations lists:

Name	Required/Optional	Type	Meaning
Station	Required	Number	Station number
Radio	Required	Number	Radio number

6.10.4.   Example

These are two radios connected in an SO2R configuration:

```
"Radios" : [
    {
        "Station" : 1,
        "Radio" : 1,
        "Interrupt" : false,
        "Always" : [
            {
                "Station" : 1,
                "Radio" : 2
            }
        ],
        "OutOfBand" : true,
        "Ports" : [
            {
                "Radio" : 1
            }
        ]
    },
    {
        "Station" : 1,
        "Radio" : 2,
        "Interrupt" : false,
        "Always" : [
            {
                "Station" : 1,
                "Radio" : 1
            }
        ],
        "OutOfBand" : true,
        "Ports" : [
            {
                "Radio" : 2
            }
        ]
    }
]
```

6.11. Switches

The switches list describes the MOAS II switches. It is a list of groups. Each group describes one switch. Each switch must have a unique ID number. Switch ID numbers must be in the range 1-99.

The number of the switch is used in determining which relay numbers it controls. Switch 1 controls relays 0-63. Switch 2 controls relays 100-163, etc.

Name	Required/Optional	Type	Meaning
ID	Required	Number	Switch number
Type	Optional	String	Type of switch
Method	Optional	String	Communications method
Port	Required	String	Communications port information
Echo	Optional	Number	Number switch will send
InhibitTime	Optional	Number	Slow transition milliseconds
InterruptModeDelay	Optional	Number	Interrupt mode delay

The type, if provided, must be "MOAS II". The method, if provided mus be "Serial".

Port is the OS-specific information needed to communicate with the switch.

Echo is the number the switch will send when queried. If it is not set the switch query will be ignored.

6.11.1. Example

```
"Switches" : [
    {
        "ID" : 1,
        "Port" : "COM8"
    }
]
```

6.12. Miscellaneous

The miscellaneous information is not a list. It is items within the main group.

The TCP port is the port clients use to talk to the server. There is no reason to set it unless the default conflicts with another program. The default port number is 12059.

The miscellaneous information also includes the information for the built-in N1MM Logger client. This includes where to listen and how to map the radio numbers from N1MM Logger into server station and radio numbers.

Name	Required/Optional	Type	Meaning
TCPPort	Optional	Number	TCP/IP port
UDPPort	Optional	Number	UDP port for N1MM Logger
UseN1MMLogger	Optional	Boolean	True if listening for N1MM Logger UDP messages
N1MMLogger	Optional	List	N1MM Logger translations
ProtectSameBand	Optional	Boolean	True if second station on a band should have no antenna

6.12.1. N1MM Logger

This describes the N1MMLogger information. The address is the address of a station computer. The station number is the station number used for that station in the configuration file.

Name	Required/Optional	Type	Meaning
Address	Required	String	IP address of client
Station	Required	Number	Station to use

6.12.2. Example

This example would cause the server to listen for N1MM Logger UDP messages on the default port. Commands which arrive from IP address 127.0.0.1 (the local host) would be for station 1.

```
"UseN1MMLogger" : true,
"N1MMLogger" : [
    {
        "Address" : "127.0.0.1",
        "Station" : 1
    }
]
```

7. Examples

There are several example configuration files supplied with the server. It is easier to start with one of these files, even if it needs extensive changes, than to start from scratch.

7.1. 2x6

This is a simple configuration. Six antennas are connected to a 2x6 switch. The antennas cover all frequencies.
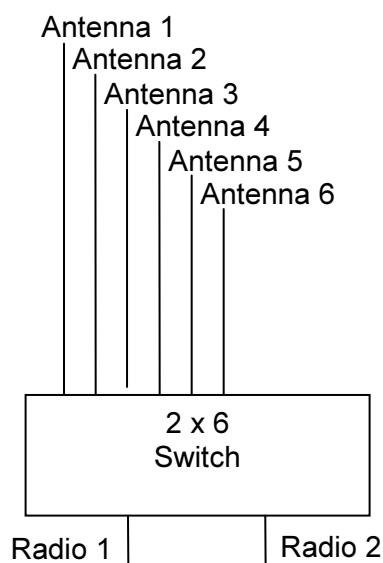
This example has all of the groups but some of them have no information. It can be a good configuration to use as a template.

7.2. Small Station Configuration

This station has four antennas:

- Triband Yagi for 10, 15, 20
- All-band vertical
- 40 meter dipole (also usable on 15)
- 80 meter dipole

The antennas are connected to a 2x4 switch and it has bandpass filters. It is capable of SO2R operation.
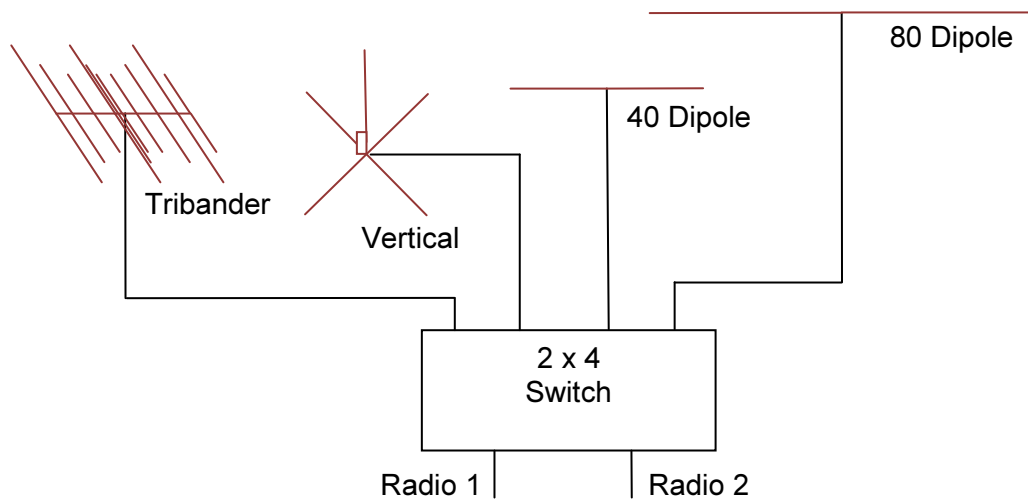
The Swap function has also been configured for this station. When selected on either station it will swap the antennas. It is only available if the antennas can actually be swapped. It is useful if one station is using the beam and one is using the vertical and the operator finds a pile-up on the vertical that he needs the beam to break.

7.3. Big Station Configuration

This station has three 4-squares, thirteen yagis, and three beverages:

- 160 – 4-square
- 80 – 4-square
- 40 – 3 element rotatable yagi, 4-square
- 20 – 4/4/4 yagi stack (top rotatable), 5 element rotatable yagi
- 15 – 6/4/4 yagi stack (top rotatable), 4 element rotatable yagi
- 10 – 5/5/5 yagi stack (all rotatable), 7 element rotatable yagi

There are also NE, S, and W beverages usable on 160 and 80 meters.

The illustration shows the 160 and 10 meter antenna systems and the beverages. Other antennas are similar.

4-SQ Array Controller

Stack Match

2-way Switch

2 x 6 Switch

Radio 1   Radio 2

3-way Switch

Beverage 1
Beverage 2
Beverage 3
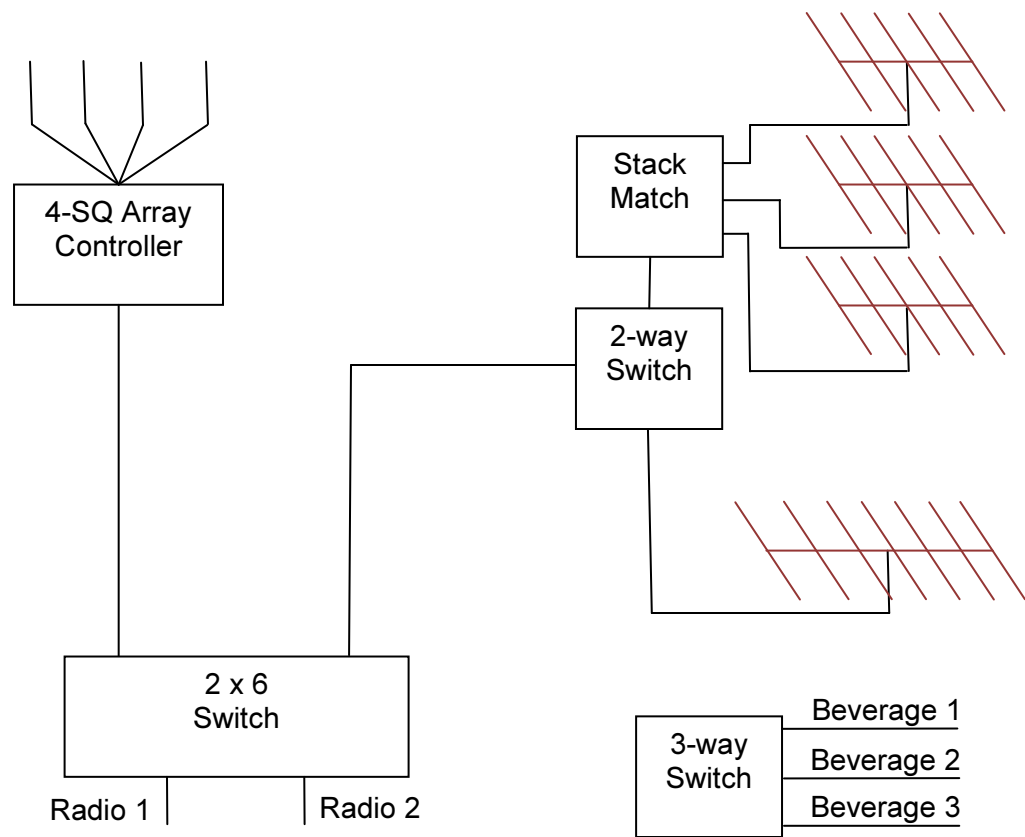
The beverages show antennas which are receive-only. It is not necessary to press the RX button before selecting one.

The beverages are connected to a single coax, so only one is available at a time. They can be shared between the stations. When antennas are shared changing the antenna for one station also changes it for the other. A station which is not using a shared antenna cannot change which antenna the other station is using – it must first start using the antenna and then it can change it. This behavior is a bit weird but the other choice would be that starting to use an antenna would also change it for the existing user and that is also weird.

This example shows the Store and Recall functions which will remember an antenna and return to it. For example, when running Europe the NE 4-square / NE beverage combination would likely be stored so it can be quickly recalled after picking off a Caribbean multiplier.

The stacks on 20, 15, and 10 use a combination of additive and exclusive antenna selection. It is not possible to turn off all of the antennas in the stacks. Attempts to do so will be ignored.

There is no way to select additive antennas with the knob client so it has all seven combinations of antennas for the stack.

This example also shows electrical rotators for the 4-squares on 160, 80, and 40.

7.4.   *Tribander Stack Configuration*

This is a part of a station (antennas for 40, 80, and 160 are not in the configuration). The antennas consist of:

- A stack of three tribanders (top rotatable)
- A separate tribander (rotatable)

The tribanders are connected to a microHam micro STACK SWITCH™.
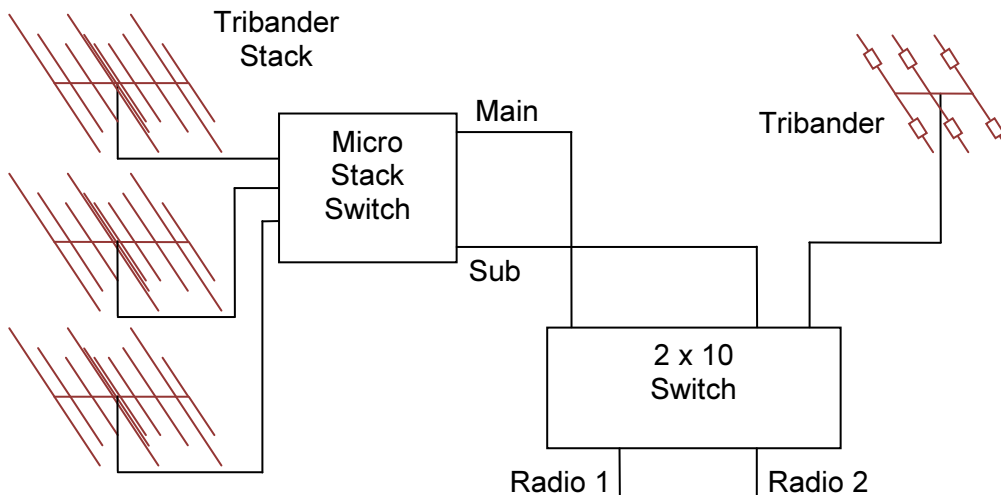
This switch is different than the common stack match because it has two feeds. The main feed has an impedance matching transformer and can connect to one, two, or all three tribanders. The sub feed has no matching network and can connect to one antenna at a time.

Either radio can be connected to the main or sub feed through the 2x10 switch.

If each radio is using one tribander it does not matter which is using the main and which is using the sub feeds. However if one station uses two tribanders it must have the main feed. This may require swapping which radio has which feed. The server does this automatically. This can be observed by watching the server's log window when switching which station has two tribanders.

Note that there are several relay combinations which will connect an antenna to a feed with this switch. microHam provides a chart showing which have the lowest SWR. The issue is apparently not with impedance matching but with RF paths within the switch. This configuration uses combinations which avoid switching relays which affect the other radio. These combinations may not have the lowest SWR in all cases.

7.5. Multi-Multi 20 Configuration

This station has eight yagis and a 4-square on 20 meters:

- 5/5/5 Europe stack – switchable angles 7°, 17°, 24°, 34°
- 5 element rotatable above Europe stack, can be phased with stack
- 6 element rotatable
- 5 element fixed on Africa
- 5/5 stack fixed on South America, both antennas fed in phase
- 4-square

The switching arrangement is complicated:
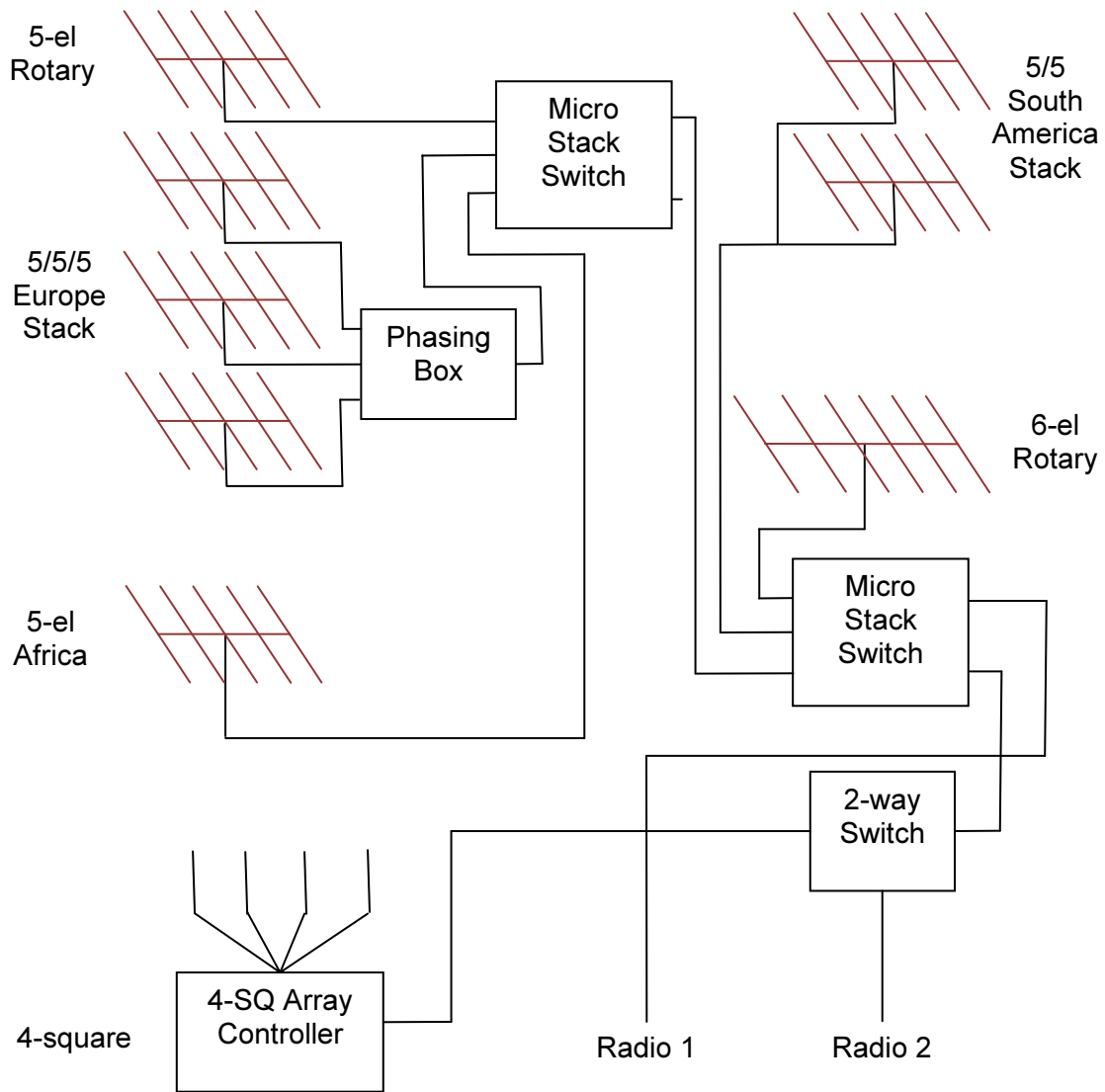
This is configured as one station with two radios to make it easy to demonstrate it using one copy of N1MM Logger. Normally it would be two stations, each with one radio. This is a simple thing to change in the Stations list in the configuration file.

The stack switches are used to combine antenna systems. The station can transmit in several directions at once. The ability to select so many antennas creates a large number of choices – station 1 can select one of 78 combinations.

The two stations do not have the same antenna capabilities. Station 1 is connected to the main feed of the switch and can combine antennas that station 2, which is connected to the sub feed cannot. The result of this is that the 6-el and Africa antennas are additive on station 1 but exclusive on station 2. And only station 2 has access to the 4-square array.

There is no visible difference between an additive and an exclusive button. This is a compromise between showing everything the operator might want to know and showing so much information that the operator cannot quickly figure out what to do.

The ability to double-click or long-press an antenna to select it exclusively is valuable with this system.

The Europe stack has four exclusive selections but the antenna system itself is additive because it can be combined with the 5 element yagi and the Africa antenna. Therefore the Europe stack buttons have a slight additive capability – if the Europe stack is selected and another antenna is also selected pressing the selected Europe stack button will deselect the Europe stack.

The Swap function is only available on station 1 because station 2 has more antenna buttons. If this is a significant problem the configuration could be changed.

The knob client cannot select all of the antenna combinations. The configuration gives it a limited set.

7.6. Triplexer Configuration

This is a expansion of the Tribander Stack Configuration. The difference is that a triplexer was added to the main coax:
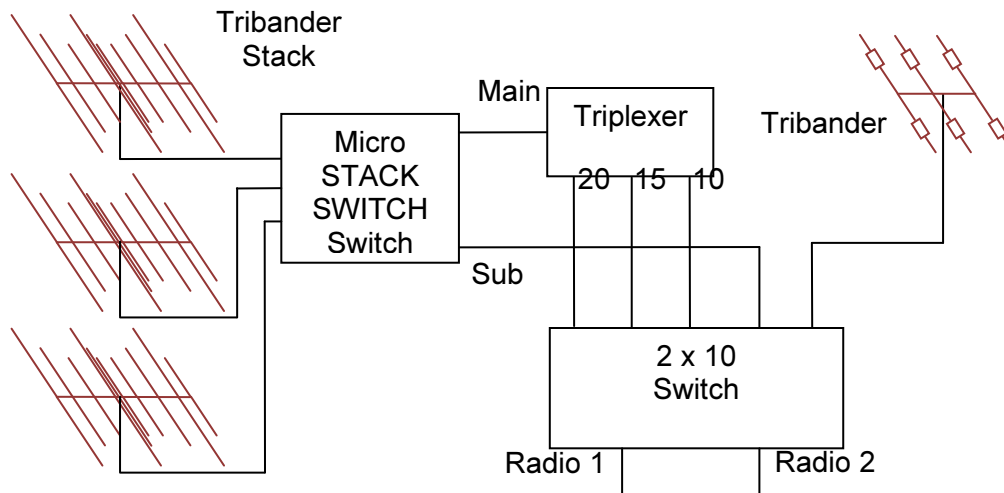
The triplexer allows both stations to use the same antennas.

The server handles this system by having two modes. In the unshared mode it behaves just like the Tribander Stack configuration above.

In shared mode both stations are connected through the triplexer to the main feed on the stack switch. This requires that neither station can be transmitting when the stack configuration is changed. It also means that a station cannot transmit on one stack configuration and receive on another. The switch enforces these restrictions automatically.

8. Multiple Switch Considerations

It is easy to connect several switches to a PC. However there are some limitations.

Each switch can connect to six radios. It is possible to connect more than one switch to the antenna keying line of a radio. But if more than six radios are used then some radios will not be connected to some switches. If a radio is not connected to a switch then that switch will not be able to provide hot switching protection for that radio.

When an antenna is changed the command is sent by the computer to all switches which have relays for the antenna being selected or deselected. The switches may not change relays at the exact same time.

It is recommended that relays that switch antennas used by a radio be connected to a switch or switches which are connected to that radio. If possible, all of the relays should be connected to the same switch.

The MOAS II Utility program can store a switch number in a MOAS II switch. This number is remembered by the switch until it changes. If this number is set it must match the echo value in the configuration file. This can be used to ensure that switches are not configured for the wrong communications port.

A Software Installation

The Windows software and configuration files are available in an installer from the website, http://www.k1xm.org/Antenna_Switch/MOAS_II/ . The Android client is available from the same website.
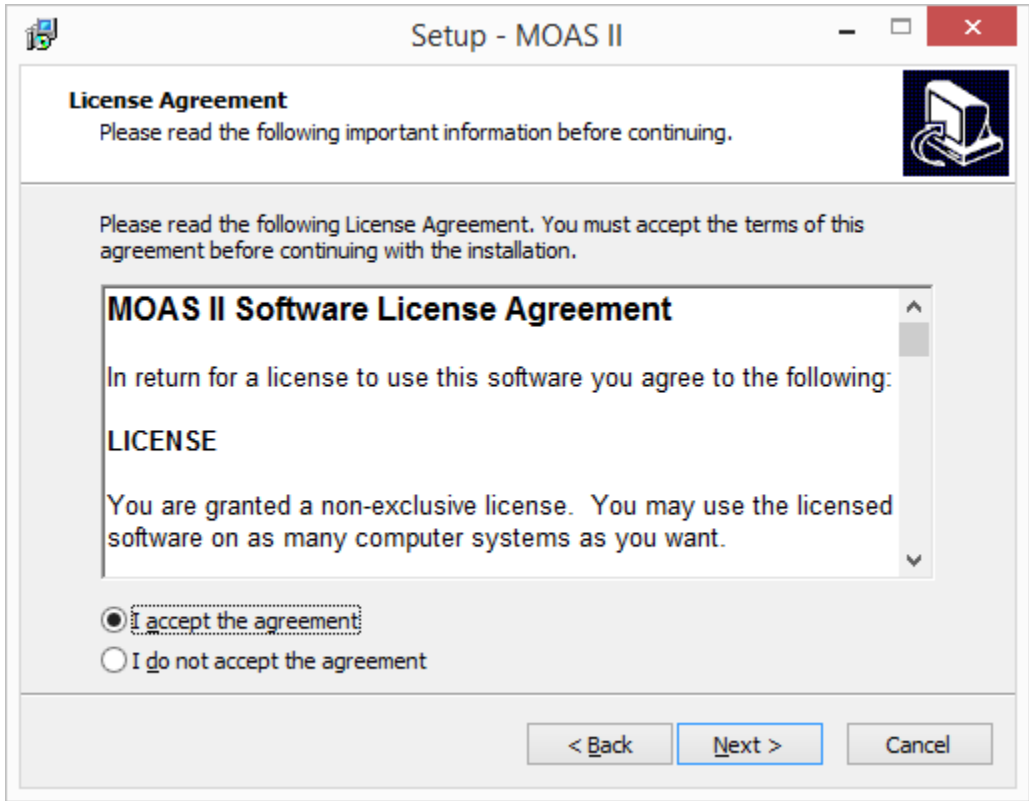
Windows Installation

The Windows installation is pretty standard. The example shown here is from a 64 bit Windows 8.1 system. Installation on other versions might look slightly different.
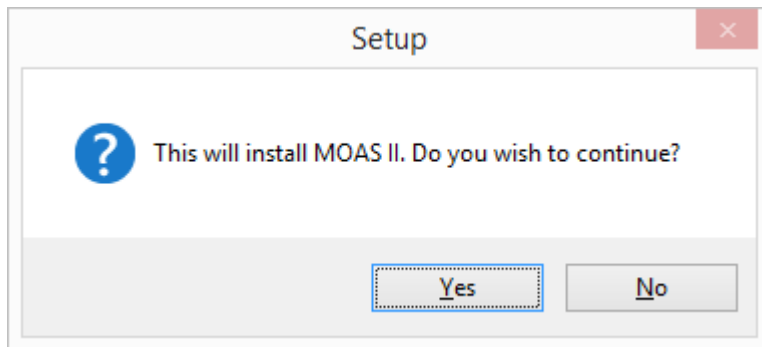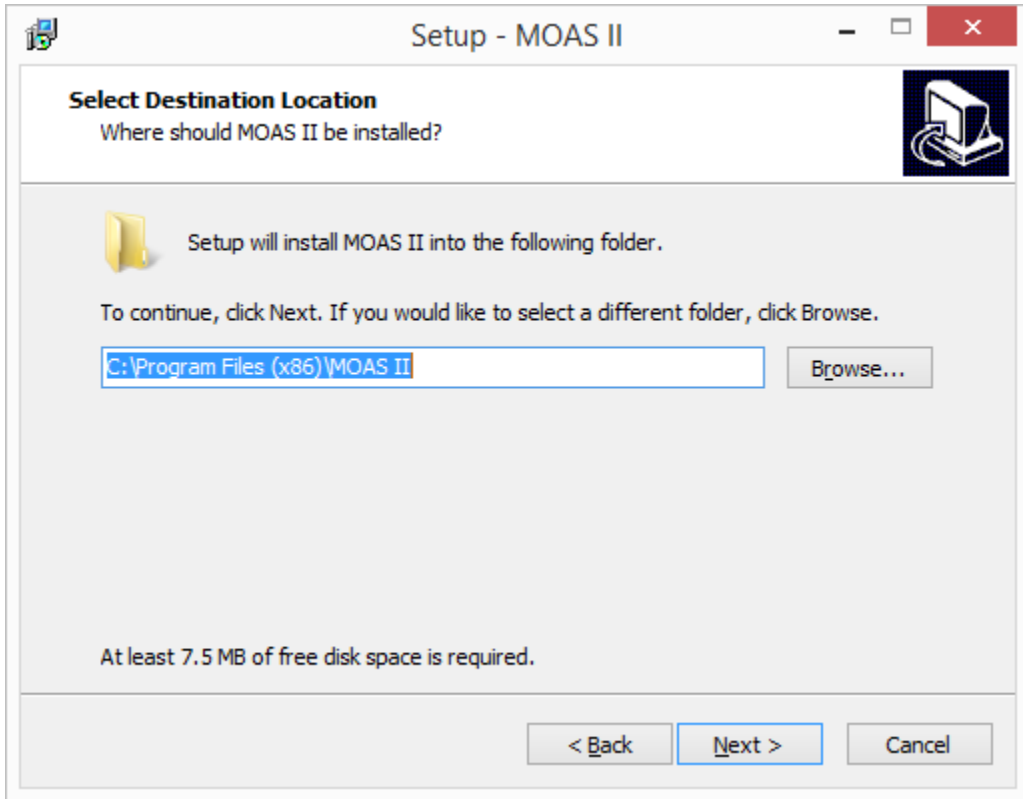

Click Yes. Depending on the version of Windows you may be asked if it is OK for this installer to make changes to the system. Allow the changes.
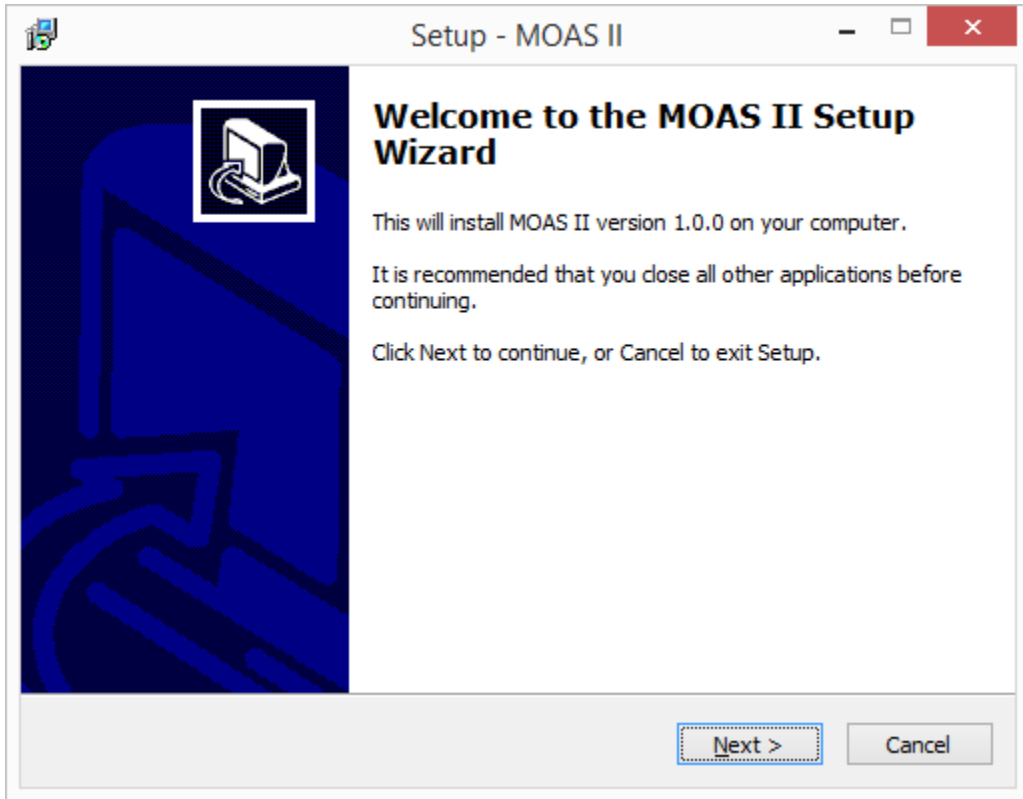
Click Next.

The license pretty much says you can use the software and if anything goes wrong you hold us harmless. But read it anyways, it is short. Then except it and click Next.

The director recommended will usually be Program Files on a 32 bit system and Program Files (x86) on a 64 bit system. The configuration files are placed in a subdirectory of the selected directory. You may not be able to edit the configuration files if they are in the default location but you can copy them to a different directory if you want to use them as the starting point for your configuration.
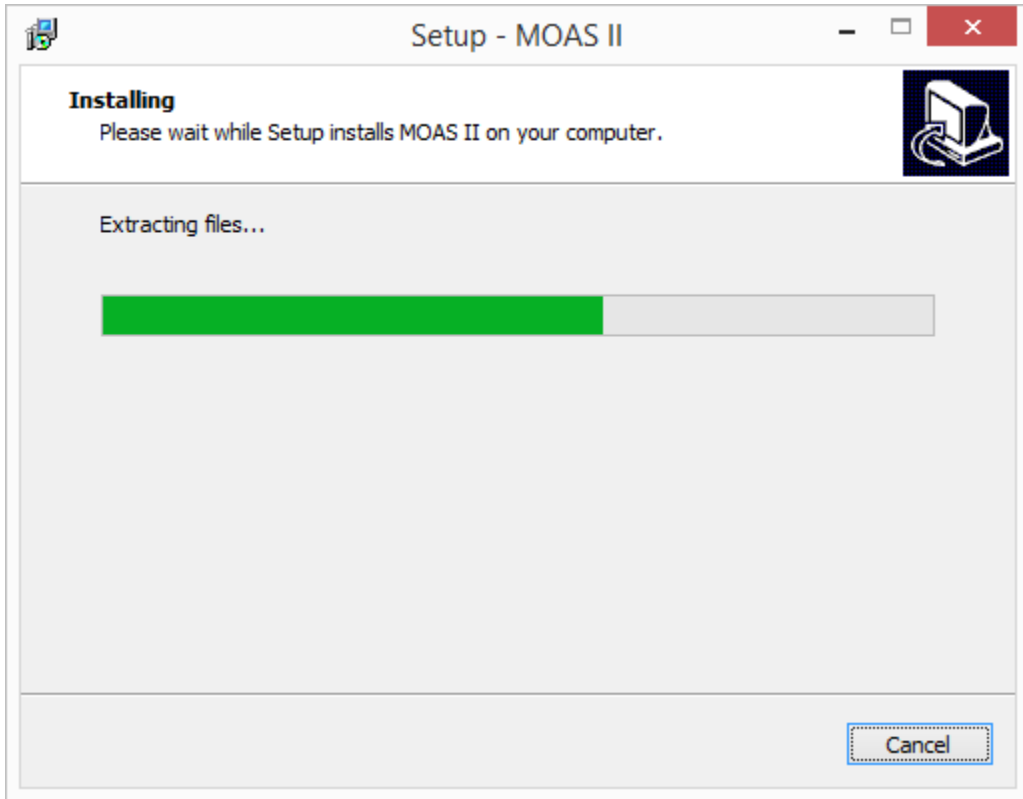
Click Next.
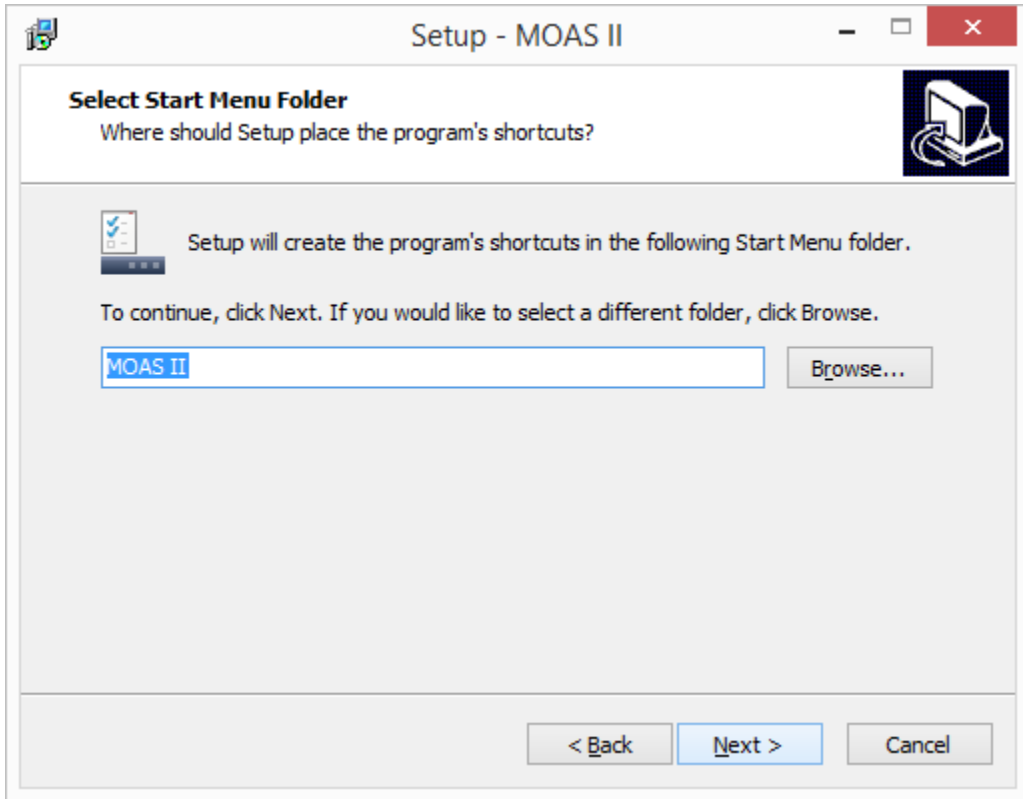
By default the programs will appear in MOAS II in the Start menu or programs screen. You can change this if you prefer a different name.
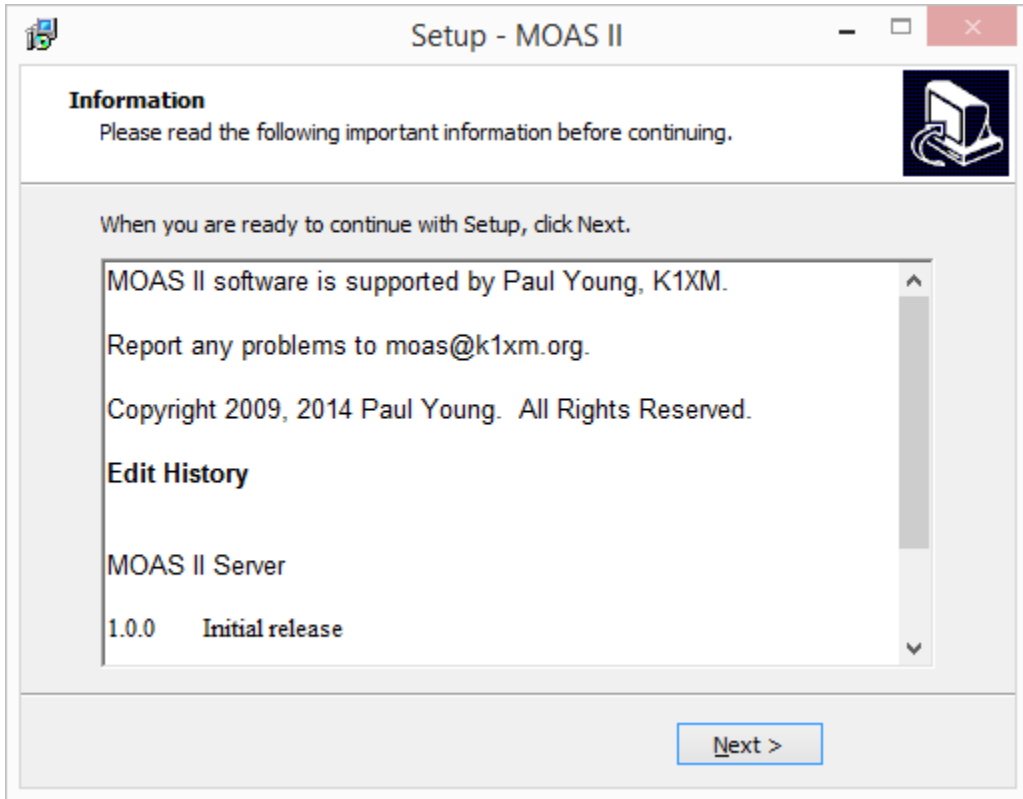
Click Next.
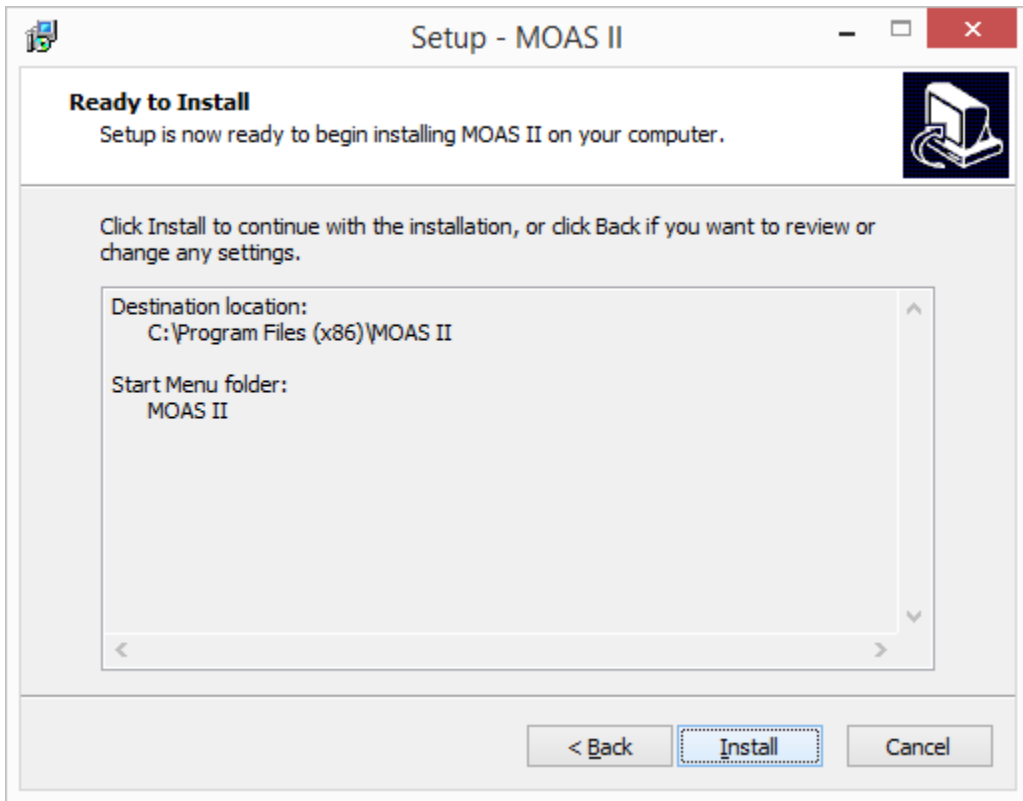
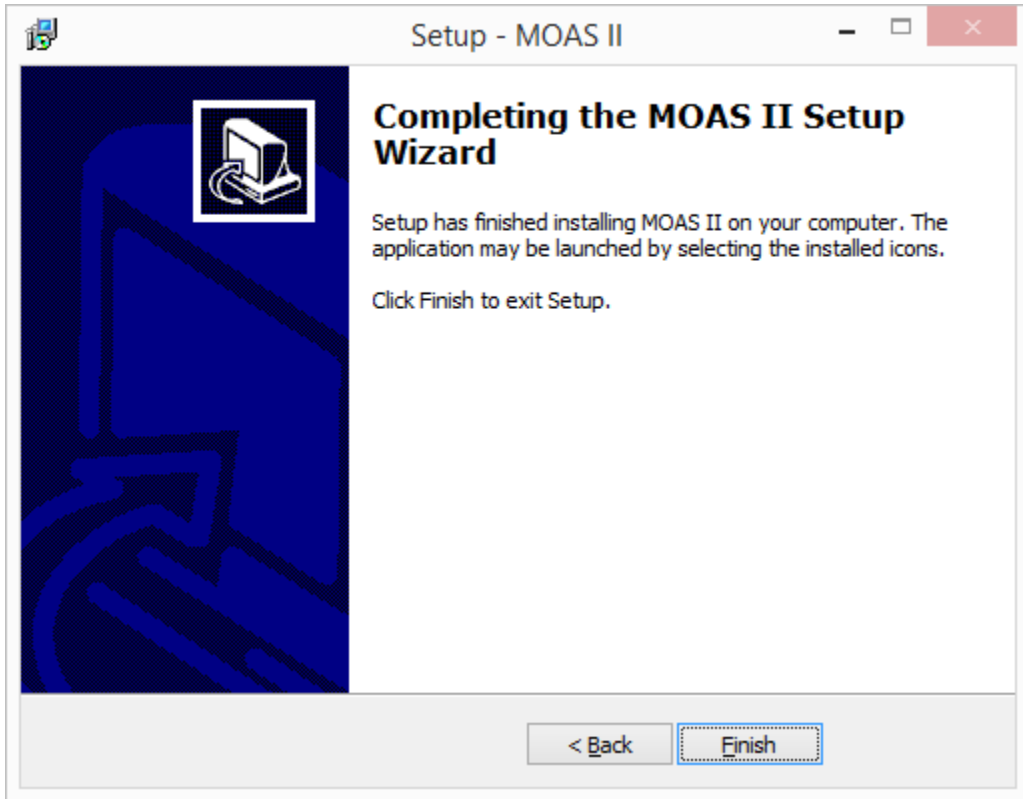If you are satisfied with your choices click Install.

The software will install. It should be pretty quick.

The information isn't very important.

Click Next.

Click Finish.

Android Installation

The android client will install as a normal Android application. However it is obtained from the web page above, not from the Google Play store.

In order to install a program from somewhere other than Google Play you must allow this in your Android preferences. This web page http://droidlessons.com/how-to-install-non-market-third-party-apps-on-android/ describes how to do this.

B Configuring N1MM Logger

If you want to use N1MM Logger to control the frequencies you must edit N1MM Logger.ini (in the folder where you installed N1MM Logger).

The destination IP address is the address of the computer which is running the MOAS II server. If the logging program is running on the same computer as the server you can use 127.0.0.1 as the address.

Add this to N1MM Logger.ini (changing the address as needed):

```
[ExternalBroadcast]
DestinationIPs=127.0.0.1
DestinationPort=12060
IsBroadcastRadio=True
```

If you are running logging software on several computers this must be done on all of them.

C MOAS II Emulator

The MOAS II emulator is a program which emulates the physical MOAS II hardware. It displays the relays which are selected and it has check boxes for setting each station to transmit. It can be used to run the server without any hardware and to test and debug configuration files.

The emulator supports all of the commands that a physical switch does. The main difference is that the emulator has no timers. For example in interrupt mode the switch will inhibit a radio for a few milliseconds, then change antennas, then uninhibit it. The emulator will immediately switch the antenna. This is OK because the emulator is not protecting any actual relays or radios But if you are watching the emulator display looking for the inhibit you won't see it.

Setup

The emulator uses a virtual COM port. If you do not have a driver installed you will need to get one. http://www.k1xm.org/SO2R/Downloads/Virtual_COM_Port_Drivers.pdf describes three which are used with the YCCC SO2R Box. Any of them will work with the emulator.

The virtual COM port software will create a pair of COM ports. One will be used by the MOAS II Server and the other by the emulator. The numbers do not matter but it is recommended that if your computer has COM ports used for another purpose you set these to fairly high numbers so they will not conflict. Both the server and emulator can use ports as high as COM32.

The server configuration files must contain the COM port number for the server's virtual COM port.

Running the Emulator

The emulator should be started before the server.

Start the MOAS II Emulator program. Select the port number and click start.

It is not necessary to restart the emulator when you restart the server.

D MOAS II Utility

The MOAS II Utility is designed to directly operate the MOAS II board. Most of the capabilities are beyond the scope of this manual. There are two that are useful.

The MOAS II Server should not be running when using the MOAS II Utility.

To connect the switch to the MOAS II Utility, select Switch=>COM Port. Set the port to the port that the switch is using and click OK. Then select Switch=>Connect.

To change the switch ID select Switch=>Unit ID. The Switch ID dialog will show the current ID for the switch. Set the number as desired and click OK.

To update the firmware select Switch=>Firmware. An Open dialog will appear. Select the new firmware file. Firmware update will take a moment. Both green LEDs on the board will blink while the firmware is uploaded and then verified.

E Antenna Selection Algorithm

When an operator changes the frequency of a radio to one outside the current range of the selected antenna (usually by changing bands) the server attempts to select a suitable antenna. The algorithm tries to be intuitive and to select the antenna which is most likely the one desired. This turns out to be a bit complicated.

1. If the current antenna covers a frequency range which includes the current frequency and is contiguous to the range that was being used, continue to use the current antenna.

    This takes care of the cases where an antenna needs to switch an inductor or capacitor for part of the frequency range.

2. The server keeps a history of what antennas were used on what frequencies. Check the history to see if an antenna was previously used for this frequency range. If an antenna is found and available use it.

    This means that if an operator changes from 20 to 15 and back to 20 he'll get the antenna he was using when he left 20.

3. Starting with the lowest numbered antenna in the configuration check each to see if it covers the frequency and is available. If so, use it.

    The configuration file author can control which antennas are likely to be chosen by giving them lower numbers. The numbering doesn't affect anything else important.

4. No antenna which covers the frequency range is available. Find the antenna which has a range closest to the radio's frequency. Start this check using the current antenna.

    Starting with the current antenna means that if an operator tunes from 14000 to 13999 the antenna won't change.

5. If no antenna at all can be found don't connect the radio to any antenna.

There's a bit more complexity.

If, in step 2, the history shows that different transmit and receive antennas were used it will try to use them again. If one or the other is not available it will try to use the remaining antenna if it is suitable.

If the selected antenna does not cover the radio's frequency then if another radio changes frequency and the antenna is the best choice for it the antenna will be selected by the other radio and a different antenna will be chosen for the radio that originally had the antenna.

Whenever a radio changes antennas a check is made for radios that have antennas that do not cover their frequency or that have no antenna. If one is found the antenna selection is restarted for that radio in case a suitable antenna is now available.

So far this seems to do the right thing. However if situations are found where it does not the server algorithms may be changed.

F Unimplemented Items

- There is no support for physical rotators.

- There is also no support for controlling the RX Antenna switch in a radio.