A Switch Box and Controller With BIP/BOP for Stacked 6M Yagis

Sherman Banks, W4ATL; Mike Stipick, KC4RI; Jim Worsham, W4KXY

Introduction

A paper was presented during the 2017 SEVHF Society Conference which examined the use of the High Frequency Terrain Assessment (HFTA) program included with the ARRL Antenna Handbook. The 6M antenna array used by the Fourlanders Contest Team was analyzed to look for possible reasons grids at certain distances were not being worked. The analysis of the terrain and antenna setup revealed possible nulls in the pattern at certain takeoff angles. Feeding the antennas out of phase increases the takeoff angle causing the nulls to become peaks, thus allowing the 6M station to cover all takeoff angles up to 35 degrees. This ability to quickly switch between Both in Phase (BIP) and Both Out of Phase (BOP) operation to eliminate nulls in the antenna pattern eliminate a possible cause for the missing grids. An additional omnidirectional stacked pair of loops is also used since the analysis suggested lower antennas may have better takeoff angle characteristics, in the higher elevations where the Fourlanders operate, for working close in stations.

This paper describes the design and construction of a switch box and controller to support Yagi BIP/BOP and omnidirectional antenna operation. Some early results of using the switch box and controller during the June 2017 contest are also presented.

Switch Box

On 6M the Fourlanders use a stacked pair of homebrew 5 element Yagis that were designed for easy assembly and disassembly. In addition, a stacked pair of omnidirectional M2 HO Loop antennas at a lower height, to give a higher takeoff angle, are available. This omnidirectional antenna has been found to be very useful for working close in stations and sometimes further out stations when the Yagis are not pointing in that direction. The switch box was designed to support BIP and BOP for the stacked pair of Yagis. It also switches to the omnidirectional antenna when desired. It was found in earlier experiments that being able to select an individual Yagi wasn't very useful when using only two, so this capability was not included in the design. The schematic for the switch box is shown in Figure 1.

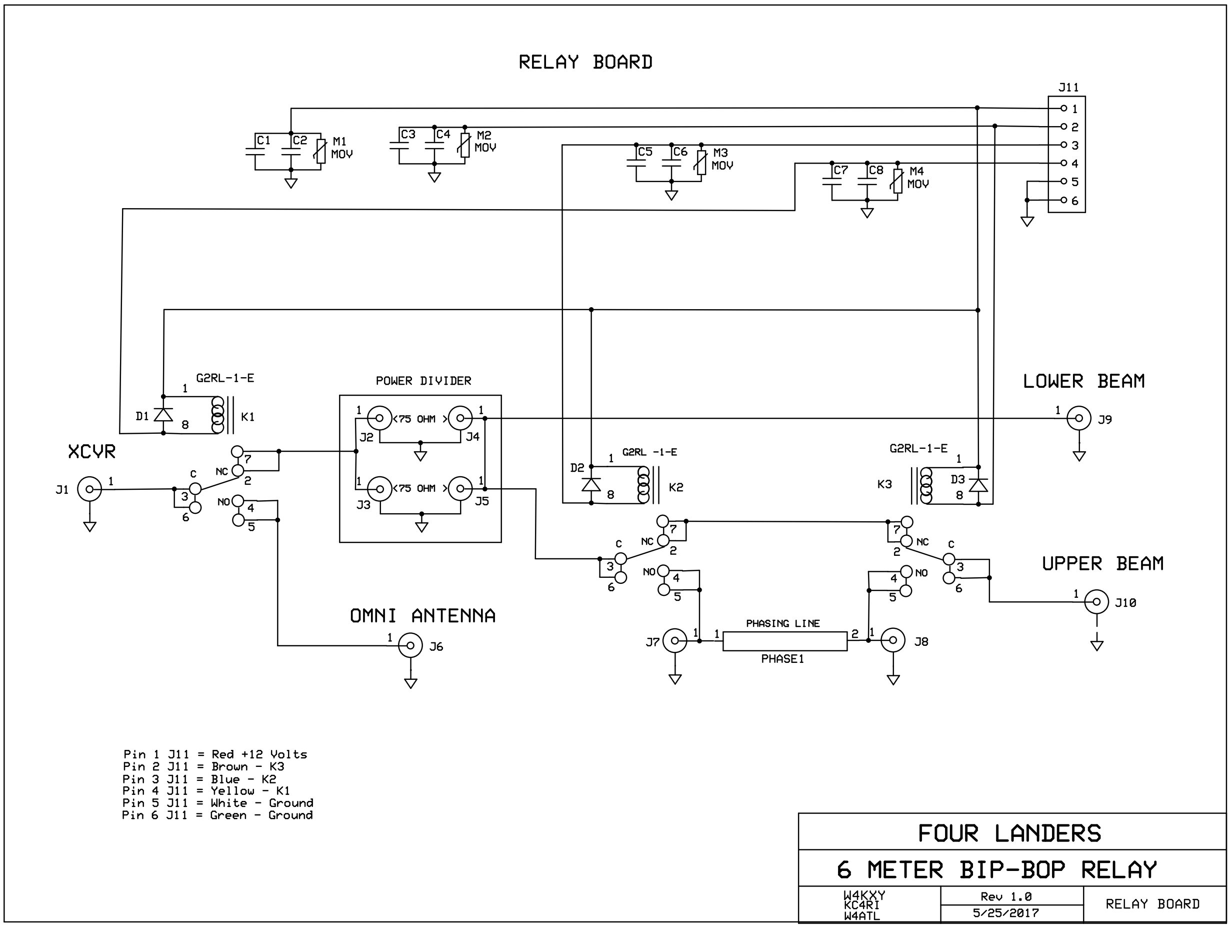

Figure 1- Schematic of the relay box mounted remotely at the base of the tower. This box has ten SO-259 connectors for connections for the transceiver, the stacked omni loops, power divider for the beams and the phasing line for the out of phase operation.

Relay K1 selects between the Yagi antennas and the omnidirectional antenna. When BOP is selected relays K2 and K3 insert a half wavelength 50 ohm coaxial phasing line for the upper Yagi in the stack. When BIP is selected the phasing line is removed.

The power divider/impedance match for the two stacked Yagis is implemented using a quarter wavelength of 35-ohm coaxial phasing line made with RG-83 (Zo=35 ohms) or two parallel RG-11 (Zo=75 ohms).

12 VDC power is supplied by the controller to one end of each relay coil. Each relay is individually energized when the other end of the relay coil is pulled to ground by the controller.

The relay used is an Omron G2RL-1-E. This particular relay was used because it has been vetted by W6PQL (http://www.w6pql.com/using_inexpensive_relays.htm#HPWRrelays) for 1500 Watts on HF and 6M. It can even be used on 2M by using two capacitors and an inductor to improve isolation and return loss.

Since PCB through hole mount relays are used, everything is assembled on a PCB that Mike, KC4RI designed to make assembly clean and easy and then mounted in a water proof Hammond aluminum box. It is mounted on the tower, at the base, with the connectors pointing downward to prevent water from leaking into the box through the connectors. The switch box is connected to the controller with an eight-conductor cable of the same type the Fourlanders use for rotators. Figure 2 through Figure 4 show photographs of the remote switch box.

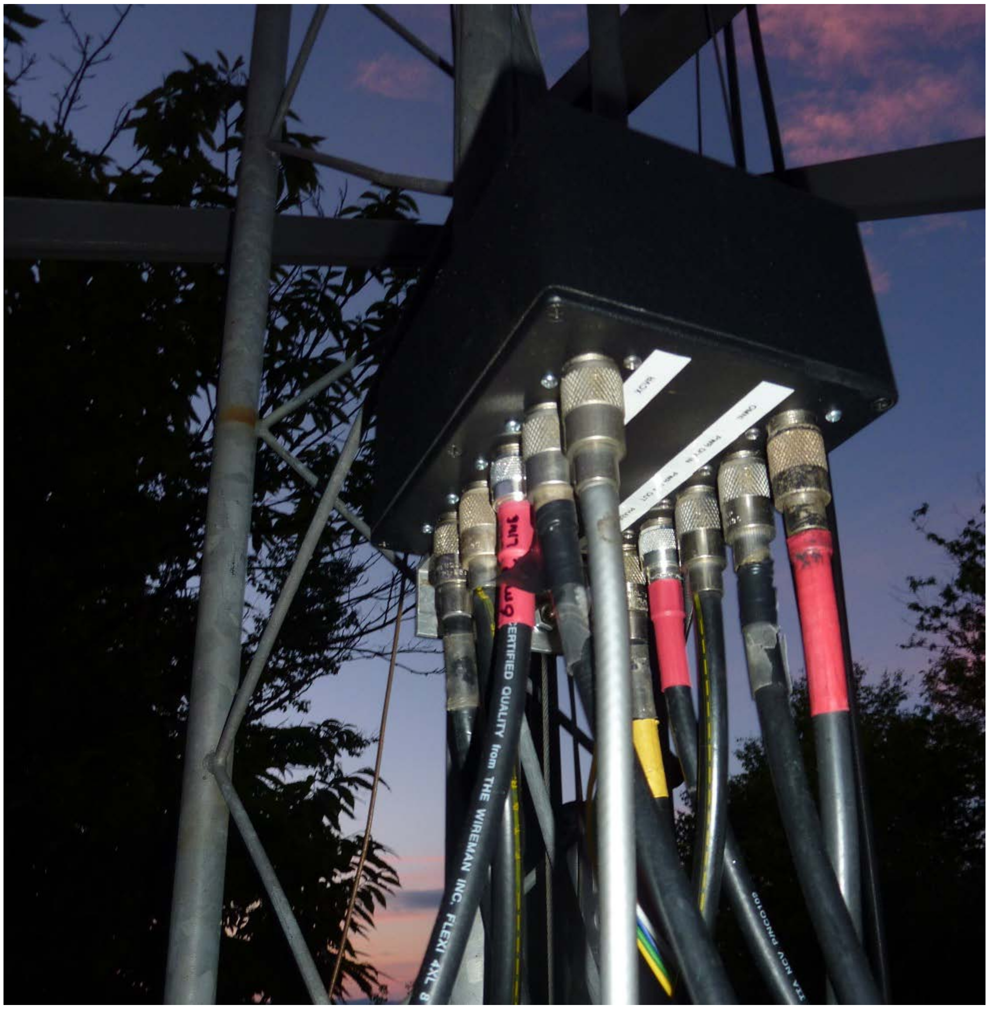

Figure 2- A view of the assembled relay box mounted at the base of the tower.

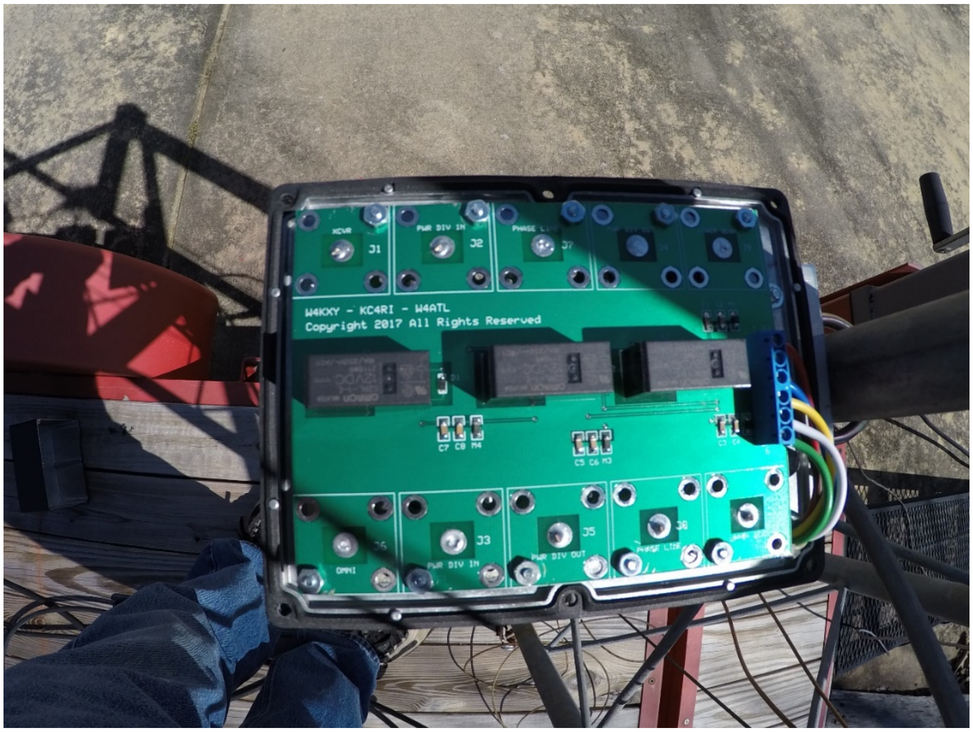

Figure 3- Inside of the relay box showing the PCB with the relays.

Figure 4- Side view of the inside of the relay box. The SO-239 connectors are mounted on the opposite side from the relays so they protrude out of the bottom of the enclosure.

Controller

Initially the controller was going to consist of two toggle switches that would power the relays in the switch box.

1. Yagis In Phase or Out of Phase
2. Yagis or Omni antenna

This box would be simple to build but had a major flaw that concerned the operators. The relay box could be “hot switched”, or switched while transmitting. Normally the 6M station is running at full legal limit during contests and switching the antennas during transmission could damage the relays.

A better way that prevented hot switching was developed. The new controller is centered on an Arduino 101 microcontroller board. The controller monitors the PTT line going to the amplifier and prevents antenna switching when keyed. LEDs are used to indicate whether the Yagis are in phase or out of phase or if the omni antennas are selected.[1]

Refer to Figure 5 for a photograph of the controller. The red LEDs to the left display whether the Yagis are fed in Phase or out of phase. Repeatedly pressing the red button will toggle the Yagis between in phase and out of phase. Pressing the green button will switch to the omni antenna. Pressing the red button will revert to Yagis in phase, since in phase is the normal mode of operation. If the radio is keyed either by the operator or the contest program then the amber LED will light telling the operator that the transmitter is keyed and no switching will be permitted.

The controller is powered with a 12 VDC wall wart procured from the junk box that supplies enough power for the controller and relays at the remote switch box. All connections from the switch box are protected with MOVs and opto-isolators to protect the Arduino board electronics. The opto-isolators are thru-hole DIP packages and inserted into DIP sockets for easy replacement in case of failure.

[1] The Arduino sketch (program) for the controller can be downloaded from http://www.w4atl.com or write to W4ATL. Information on Arduino and the 101 board can be found at https://www.arduino.cc/.

Figure 5 - BIP/BOP Controller Box. LEDs are up top with two large momentary push buttons at the bottom.

The interface electronics to the switch box are mounted on an Arduino shield. The schematic for this shield is in Figure 6. The shield plugs directly into the Arduino 101 microcontroller. The Arduino I/O pins are able to drive the opto-isolators directly for relay switching. Current limiting resistors are used for the I/O pins dedicated to the LEDs and selected to produce the correct level of brightness for the operating position. The switches are connected directly to Arduino I/O pins with internal pull-ups and debounced in software.

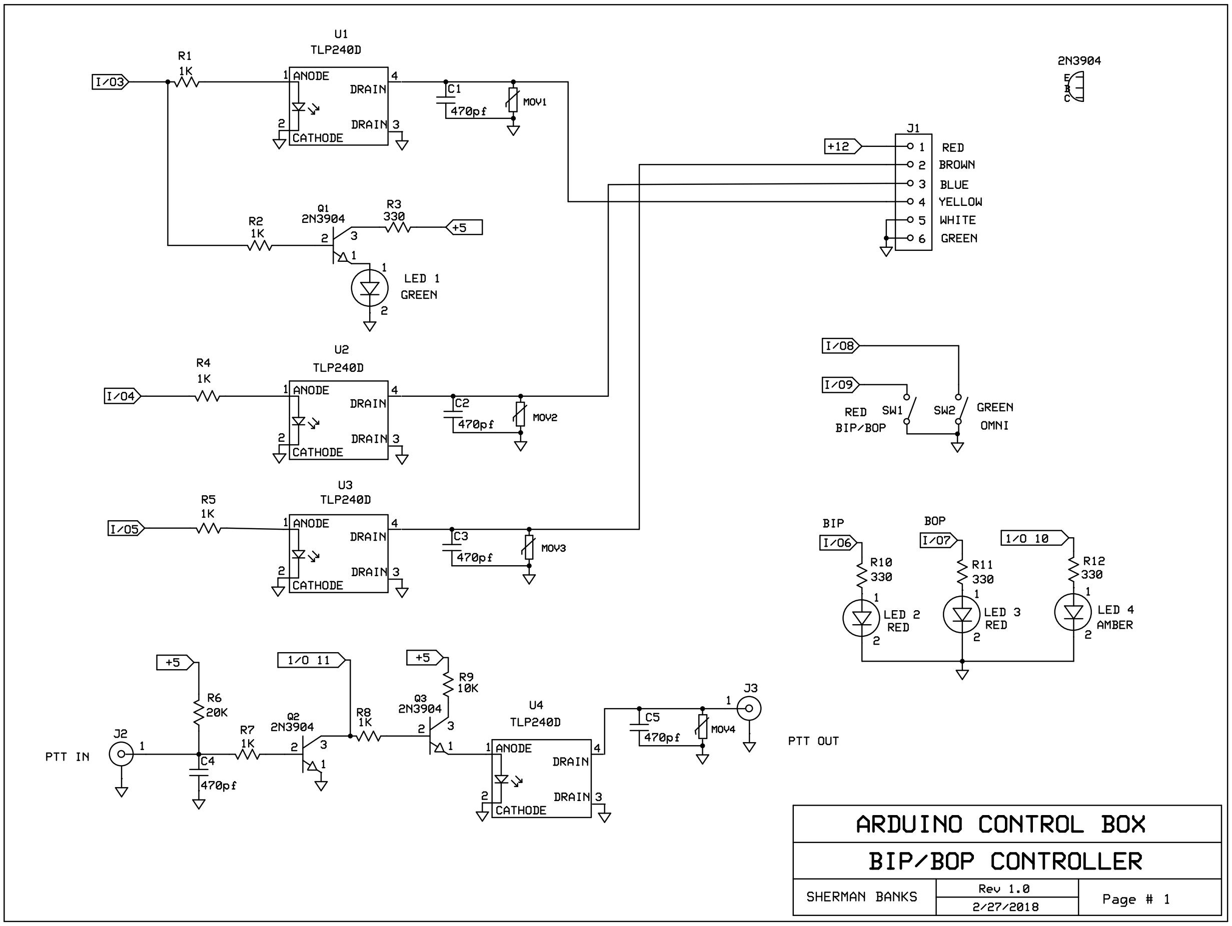

Figure 6 - Schematic of the Arduino Shield interface board that provides 12 VDC to the remote relay box. I/O connections identified are to the Arduino 101 microcontroller board.

A PTT input and output RCA connection is provided for the PTT sense feature. The Input is connected to the Amp Key line from the radio and the output goes to the amplifier Key input. This arrangement will allow PTT sensing whether the operator keys the radio through the foot switch of if the contest software keys the rig for voice keying, CW or data operation. The PTT output to the amplifier is opto-isolated to allow the connection of most any amplifier with up to 200 VDC keying requirements.

Figure 7 shows the location of the BIP/BOP controller in relation to the entire 6M station. It is positioned to easily switch antennas with minimal movement from the keyboard. The LEDs allow the operator to quickly see the status of the antenna network.

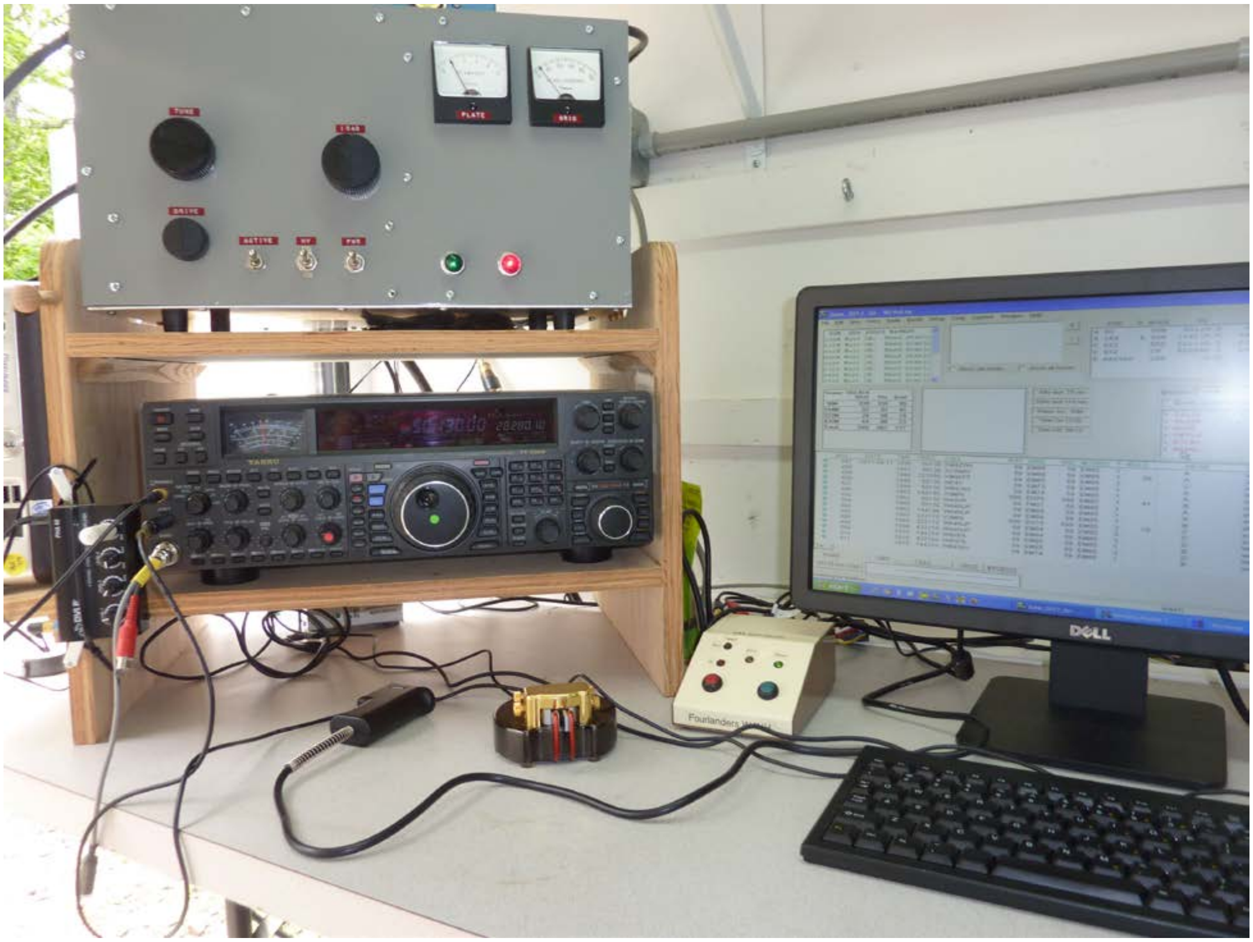

Figure 7 - The 6M station during the 2017 June VHF contest with the BIP/BOP controller between the computer and radio. The enclosure is angled to allow easy access and viewing or antenna status.

Conclusion

Operation of BIP/BOP was much easier than the original controller with the rotary style antenna selection switch. The operator can quickly switch between in phase, out of phase or omni without fear of hot switching to determine which antenna configuration is best for marginal signals.

Unfortunately, we were unable to confirm that the out of phase mode was helpful for close stations where the arrival angle may be higher. In no case did switching to out of phase cause an increase in the signal to noise of weak stations. Quickly switching to Omni was usually more helpful if the Yagis were pointed away from a calling station. Fourlanders will continue to use BIP/BOP for the increase in switching efficiency via pushbuttons and hot switch transmit protection.

Fourlander 6M Band Captain K4SQC suggested it may be possible to take advantage of electrically tuning the elevation via the out of phase mode for EME work without the need of an elevation rotor. At moonrise start in phase and then switch to out of phase as the moon rises to electrically change the elevation peaks of the array. This technique could be used until the moon gets above 20 degrees in the sky.