MonoStacker 2 & 4 Manual
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V1.0

This note describes the MonoStacker 2 and Monostacker 4 stacking boxes.

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Introduction

The MonoStacker 2 and MonoStacker 4 boxes combine 2 and 4 antennas, usually stacked Yagi’s on a single tower.

The designs are a repackaging of boxes used at K3LR.

The designs assume that the antennas are close to a 50 Ohm resistive impedance. This enables the computation of the assumed impedance values of antenna combinations at the internal junction point – the impedance is simply the parallel combination of some number of 50 Ohm loads.

Antenna Combinations Impedance	
# Antennas	**Junction Zo**
1	50 Ω
2	25 Ω
3	16.67 Ω
4	12.50 Ω

¼ wavelength lines of various impedances values are used to create an impedance match from the junction point to the 50 Ohm line that runs to the station. The line utilization is:

Matching Line Utilization					
# Antennas	**Junction Zo**	**¼ λ Zo**	**Composition[1]**	**Z_{final}**	**SWR**
1	50 Ω	50 Ω	RG-213	50 Ω	1.00
2	25 Ω	35 Ω	RG-83	49 Ω	1.02
3	16.67 Ω	30 Ω	RG-213 || RG-11	54 Ω	1.08
4	12.50 Ω	25 Ω	RG-213 || RG-213	50 Ω	1.00

¼ wavelength lines are used for impedance matching. RG-213 = 50 Ω, RG-83 = 35 Ω, RG-11 = 75 Ω. Lines are used individually, or as a parallel combination. Note that the 2 and 3 antenna combinations, even with perfect 50 Ohm antennas, do not produce a 50 Ohm output, although 54 Ohms is more than close enough.

Because ¼ wavelength lines are used, impedance matching of more than one antenna works only on a single band; hence the *MonoStacker* name – it is a stacker/combiner for a single band.

If you are not combining more than one antenna, then you can consider each box to be a general purpose multiple-band antenna switch, one with 2 inputs, the other with 4.

[1] Composition means what ¼ wavelength cables type are used individually, or in parallel.

The control signals that operate the relays in the boxes are not encoded. 5 wires are needed to fully operate the MonoStacker 2. 8 wires are needed for the MonoStacker 4. Diodes and ferrite are not used in the boxes, since they could lead to harmonic generation, and diodes are sensitive to destruction by surges.

12 VDC relay coils are used in the boxes.

Both designs, the MonoStacker 2 and MonoStacker 4, have the property that you must energize at least one relay to connect to an antenna. There is no provision for a default antenna. Without power, the usual behavior is that the antenna input is shorted to ground. The *Electrical Control Connection* section of each box describes the detailed behavior.

MonoStacker 2

The MonoStacker 2 combines 2 antennas. 4 different combinations are defined:

1. Top Antenna
2. Bottom Antenna
3. Both in Phase (BIP)
4. Both out of Phase (BOP)

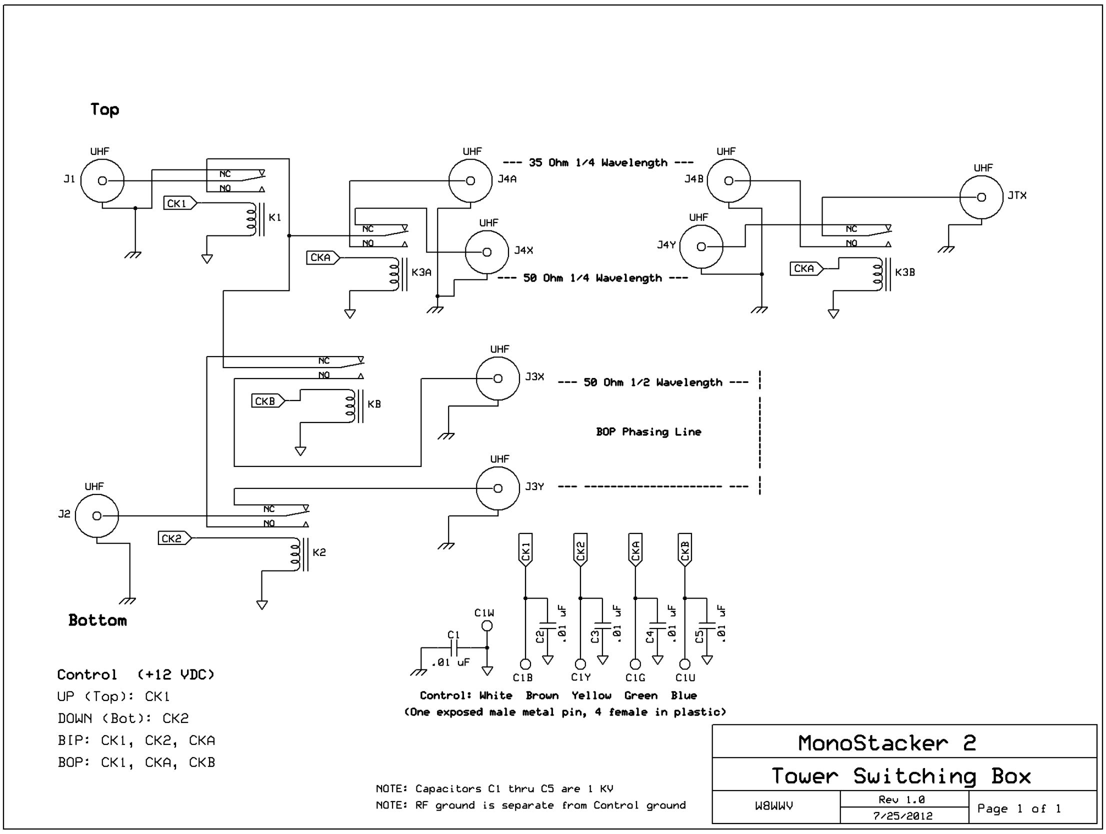


Figure 1 – MonoStacker 2 Schematic

When a single antenna is selected, the 50 Ohm ¼ wavelength line (J4X, J4Y) is used. When both antennas are combined, creating a 25 Ohm junction, the 35 Ohm ¼ wavelength line (J4A, J4B) is used. The relays on each side of the two impedance matching lines (K3A, K3B) are controlled by the CKA line. No voltage selects the 50 Ohm line, +12 VDC selects the 35 Ohm line.

The top antenna is selected by powering CK1 that controls K1. The bottom antenna is a little more complicated, since in the BOP case it must go through an extra 180 degrees of 50 Ohm cable to create the out of phase feed. As the table in the lower left corner of the schematic indicates, asserting CK2 selects the bottom antenna in the bottom and BIP modes. The BOP mode asserts CKB.

Impedance Matching/Out of Phase Lines

The box uses three external lines:

1. ¼ wavelength 50 Ohm (RG-213) line
2. ¼ wavelength 35 Ohm (RG-83) line
3. ½ wavelength 50 Ohm (RG-213) line (for BOP operation)

Details on cutting and trimming these lines are provided at the end of this note.

If you don't want BOP operation, then the ½ wavelength 50 Ohm cable will not be needed.

Box RF Connections

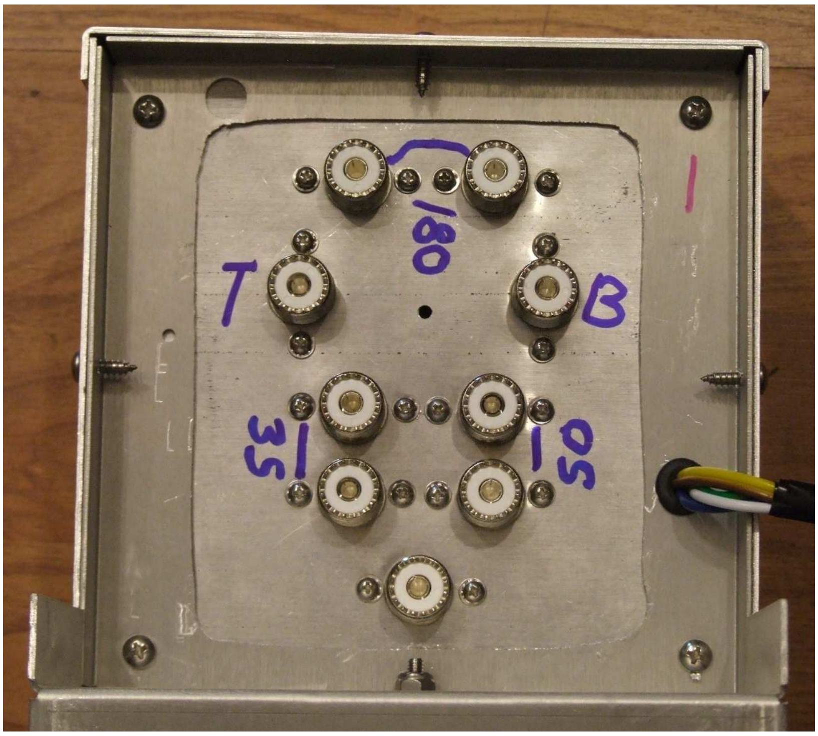


Figure 2 – MonoStacker 2 RF Connections

The ½ wavelength (180 degrees) 50 Ohm line is connected between the two horizontal connectors at the top of the picture.

Below that line is the Top antenna connector (T) on the left and the Bottom antenna (B) on the right. The weep hole is located between the two connectors.

Under the antenna connectors are columns for the two impedance matching lines. The 35 Ohm ¼ wavelength line connects between the left column connectors. The 50 Ohm ¼ wavelength line connects between the right column connectors. The markings on the panel suggest the connections.

The RF connection back to the station is the connector at the bottom of the picture, closest to the mounting point of the box.

Electrical Control Connection

The box connects to the outside world via a standard 5-pin trailer connector.

The connector coming from the box is the female gender (more holes than pins). The standard colors and the control functions are:

1. White: control ground, common for all relays
2. Brown: CK1
3. Yellow: CK2
4. Green: CKA
5. Blue: CKB

The control mapping is in the lower left corner of the schematic. It is:

Top: CK1 (brown)
Bottom: CK2 (yellow)
BIP: CK1, CK2, CKA (brown, yellow, green)
BOP: CK1, CKA, CKB (brown, green, blue)

When all relay controls signals are removed from the box (no power!), the 50 Ohm matching cable is selected. The Top antenna is grounded at the box. The Bottom antenna is left floating through the ½ wavelength 50 Ohm cable. The station will see the box as an open circuit from the RF port.

MonoStacker 4

The MonoStacker 4 combines up to 4 antennas. 10 different combinations are defined:

1. Top Antenna
2. Top-1 Antenna (first one down from the Top)
3. Top-2 Antenna (second one down from the Top)
4. Top-3 (Bottom) Antenna
5. All 4 Antennas
6. Top 3 Antennas
7. Bottom 3 Antennas
8. Top 2 Antennas
9. Middle 2 Antennas
10. Bottom 2 Antennas

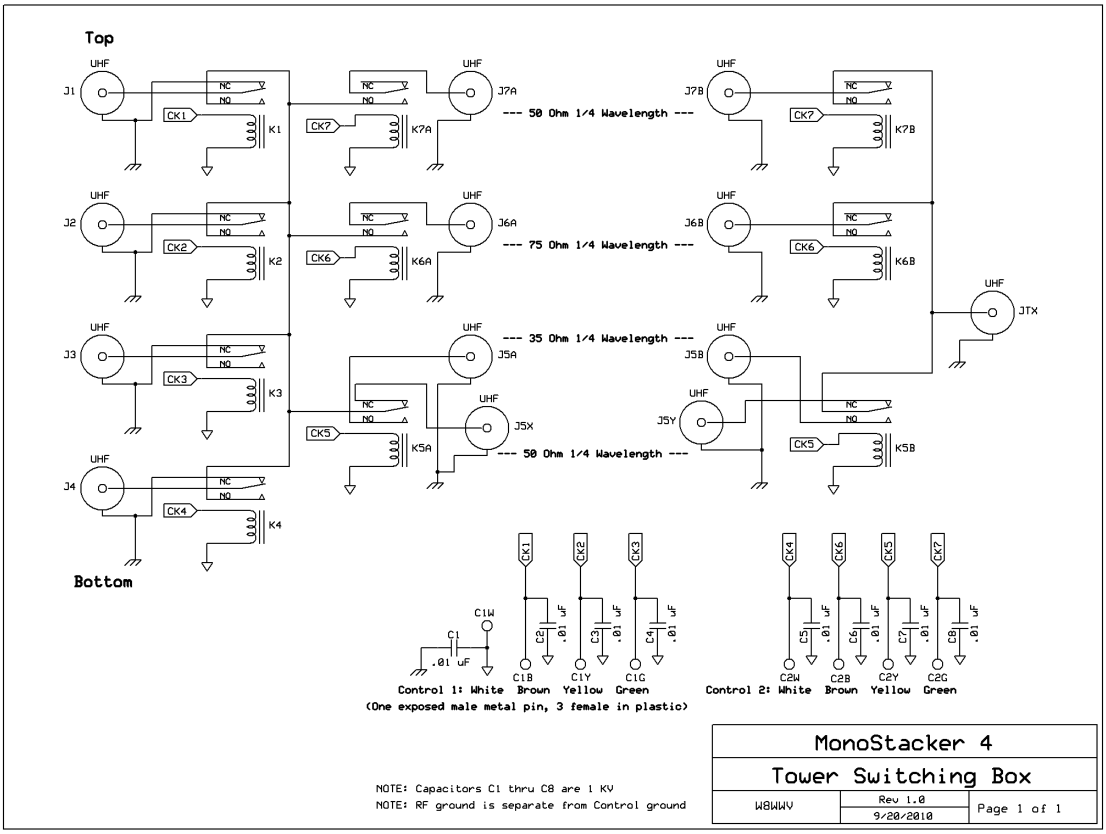


Figure 3 – MonoStacker 4 Schematic

Although this box has two additional antenna inputs, it is conceptually simpler than the MonoStacker 2 box.

Control signals CK1 through CK4 enable antennas Top to Bottom onto a shared junction. When one of these relays is not energized, the corresponding input will be shorted to ground. This transforms to an open circuit at the antenna[2], which reduces current flow in an unused antenna. When all power is removed from the box, all of the antenna inputs are grounded. This may provide some protection against lightning damage traveling beyond the box to the station. Unfortunately the box relay may be damaged providing that protection!

In addition to selecting the desired antennas via CK1 through CK4, it is necessary to select the ¼ wavelength lines that match the junction impedance back to 50 Ohms. This is done by using CK5 through CK7. The mapping is:

No control line: 50 Ohm default cable (J5X, J5Y). For a single antenna.
CK5: 35 Ohm cable. For a pair of antennas.

[2] The transformation is due to the fact that the lines to the antenna are an odd multiple of ¼ wavelength. A short at the box becomes an open at the antenna.

CK6: 75 Ohm cable (and default 50 Ohm cable). For three antennas.
CK7: 50 Ohm cable (and default 50 Ohm cable). For four antennas.

Impedance Matching Lines

The box uses four external lines:

1. ¼ wavelength 50 Ohm (RG-213) line
2. ¼ wavelength 35 Ohm (RG-83) line
3. ¼ wavelength 75 Ohm (RG-11) line
4. ¼ wavelength 50 Ohm (RG-213) line (same as #1)

Details on cutting and trimming these lines are provided at the end of this note.

If you want to use the box for a stack of 2 or 3 antennas, not all of these cables are needed. See a following section for details.

Box RF Connections

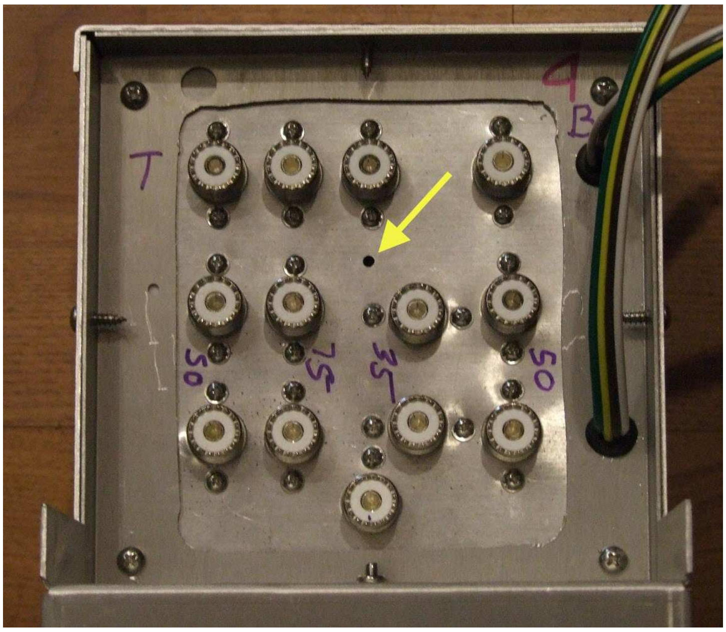


Figure 4 – MonoStacker 4 RF Connections

The 4 antennas are connected to the top row of connectors, with Top (T) on the left and Bottom (B) on the right. The two in the middle are in stacking height order, from Top to Bottom, left to right.

The 4 impedance matching cables use the 8 connectors below the top row. Each cable is in its own column. The impedance values, from the left, are 50, 75, 35, and 50 Ohms. The numbers written on the box indicate the impedance values for the column.

The 50 Ohm line going back to the station is the connector at the very bottom of the picture.

Electrical Control Connection

The box connects to the outside world via a pair of standard 4-pin trailer connectors. To reduce confusion on the tower, one connector is female, and the other is male. Control 1 is the female, Control 2 is the male. These names appear on the schematic.

Control 1 (female):

1. White: control ground, common
2. Brown: CK1
3. Yellow: CK2
4. Green: CK3

Control 2 (male):

5. White: CK4
6. Brown: CK6 (note the order of CK6 and CK5)
7. Yellow: CK5
8. Green: CK7

The control mapping is:

11. Top Antenna: CK1
12. Top-1 Antenna: CK2
13. Top-2 Antenna: CK3
14. Top-3 (Bottom) Antenna: CK4
15. All 4 Antennas: CK1, CK2, CK3, CK4, CK7
16. Top 3 Antennas: CK1, CK2, CK3, CK6
17. Bottom 3 Antennas: CK2, CK3, CK4, CK6
18. Top 2 Antennas: CK1, CK2, CK5
19. Middle 2 Antennas: CK2, CK3, CK5
20. Bottom 2 Antennas: CK3, CK4, CK5

If all control signals are removed, the 4 antenna inputs are grounded. The default 50 Ohm matching line will be selected. The station will see the box as an open circuit from the RF port.

Using 2 or 3 Antennas

There is nothing wrong with using the MonoStacker 4 with only 2 or 3 antennas. If you want to use it with 1 antenna, we need to have a talk!

For the three antenna case, the antenna junction will not reach 12.5 Ohms, which means that we won't need the 25 Ohm ¼ wavelength transformer cable created from the parallel combination of the two 50 Ohm cables. So, the second 50 Ohm ¼ wavelength cable is not needed. This is the cable that runs between J7A and J7B, which is controlled by CK7. On the previous picture of the box, this is the 50 Ohm cable on the **left**, next to the 75 Ohm cable.

For the two antenna case, the previous 50 Ohm cable is not needed, **and** the 75 Ohm cable is not needed. This leaves a 50 Ohm cable (on the right) and a 35 Ohm cable, which, in effect, turns a MonoStacker 4 into a MonoStacker 2, which requires those two impedance transformer cables. The world is round.

Power Ratings

The maximum power rating occurs when the first component fails due to an overload. Since the box has a number of signal paths, the maximum power rating is a function of the stacking combination.

All RF PCB traces are at least 0.1" wide, and are duplicated on both sides of the board. That results in an 8 amp minimum continuous rating. That is 8 amps with no heating. Allowing either some heating or less than a 100% duty cycle greatly increases the current rating.

The relay ratings are described below. At least 400 VAC and up to 16A is allowed, although not at the same time.

I suspect that if there is a failure, it would be when using a stack of two antennas. That creates a 25 Ohm junction impedance that is transformed to 50 Ohms with a single ¼ wavelength section of RG-83 (35 Ohm) cable. A low impedance implies more current and less voltage. Although there are two lower impedance configurations (stacks of 3 or 4), in those cases, two coax cables are used in parallel to create the impedance matching lines. This reduces the load on the lines and relays.

My quick estimate is that the box will handle at least 3 KW. At some point, especially if a stack of two antennas is in use, the RG-83 could be overloaded. Beyond that the two relays on each side of the 35 Ohm cable may be the first to go.

Enclosure Skirt Details

All connections come out of the bottom face of the box. That's a typical treatment intended to shed water. High up on a tower, wind can cause rain to be blown in an upward direction – towards the bottom face.

To discourage that behavior, a skirt can be added to the box. The skirts that have been used so far have been fabricated by a metal shop near K3LR. Contact Tim for details.

The skirt consists of two parts. The first is a panel that aligns with the mounting face (where the U-Bolt goes, up against the tower leg) of the box. It can in installed on the ground, although two mounting holes will need to be drilled in the mounting face. Here is a picture of the panel mounted on the face with two screws:

Figure 5 – Fixed Skirt Panel

After all of the cables are attached, the second piece (three sided) of the skirt can be attached. It attaches to the box using the three sheet metal screws that attach the box cover to the box base.

Here is a picture of the second skirt piece attached to the box:

Figure 6 – Second Skirt Piece

In this installation, the junction of the box and the skirt has been taped, since the skirt runs on the outside of the box.

The box is held together with 4 fasteners. To allow for tower installation of the skirt, 3 of the fasteners are #8 stainless steel sheet metal screws. The 4th fastener, on the mounting face, is a #8 stainless steel bolt and nylon lock nut. Here is a picture:

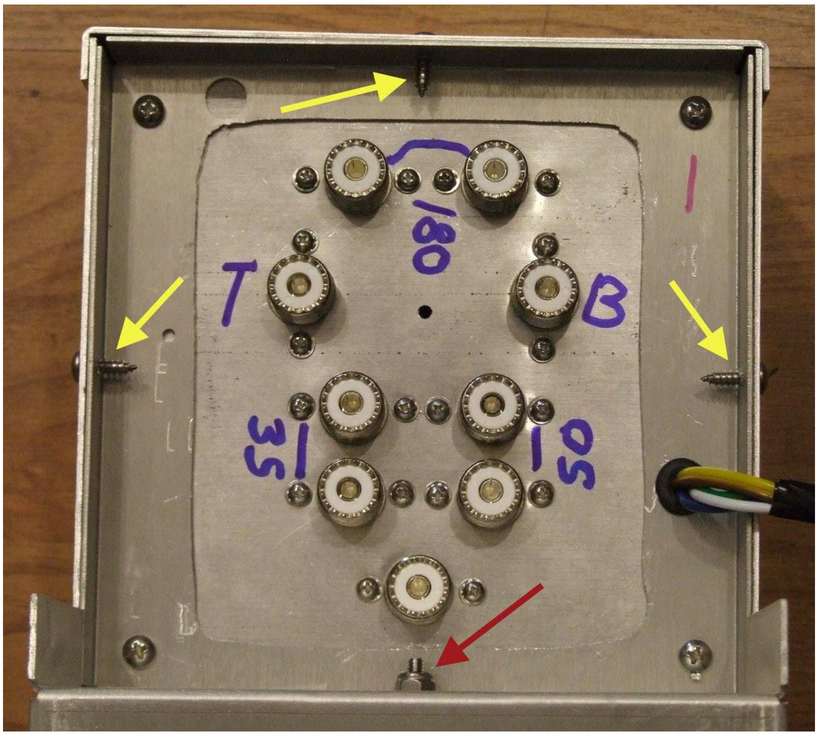


Figure 7 – Box Cover Screws

The three yellow arrow screws are the sheet metal screws, and the red arrow points at the lock nut. If you want to use a skirt, the yellow screws will have to be added on the tower, after the cables and then the skirt is attached. Since it would be very hard to reach up into the skirt to hold a nut, the skirt fasteners need to be sheet metal screws.

The hole size for the bolt is slightly larger than the hole for the self tapping screws. This means that there is an orientation for the top. If you remove the box top, be sure to put it back on with the correct orientation. I have drawn a mark on the back of the mounting face that shows the alignment. It will probably quickly fade or wash away. So, simply be sure that the larger bolt hole is matched between the two parts of the box. The bolt will not go through the incorrect (smaller) hole size.

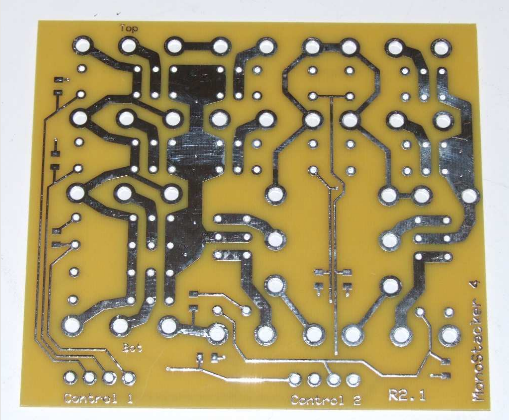
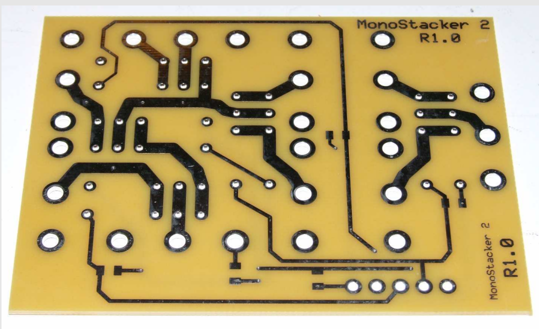
Key Components

The boxes are built from a shared set of components. They differ only in the PCBs and number of components used.

PCBs

The PCBs are made by ExpressPCB.

In order to maximize the upper frequency limit of the boxes, the layout has been made as compact as possible. This necessitated the use of 2-hole female flange UHF connectors so that they could be jammed together. High frequency performance is ultimately limited by the physical length between components.

	
MonoStacker 4 PCB	MonoStacker 2 PCB

All RF traces are duplicated on the bottom of the PCB in order to increase the current capacity. Some relay control lines run only on one side of the boards.

The UHF female connectors are mounted on an aluminum panel that is then mounted over a large cut out on the enclosure.

Figure 8 – PCB Mounted on Aluminum Panel via UHF Connectors

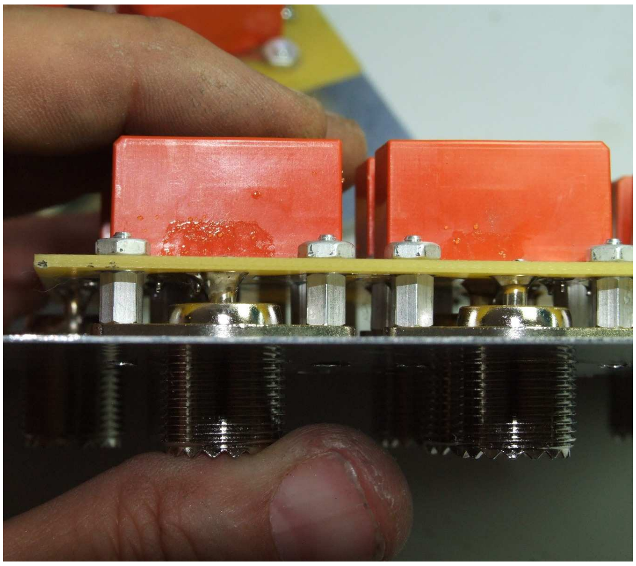


Figure 9 – PCB Standoffs

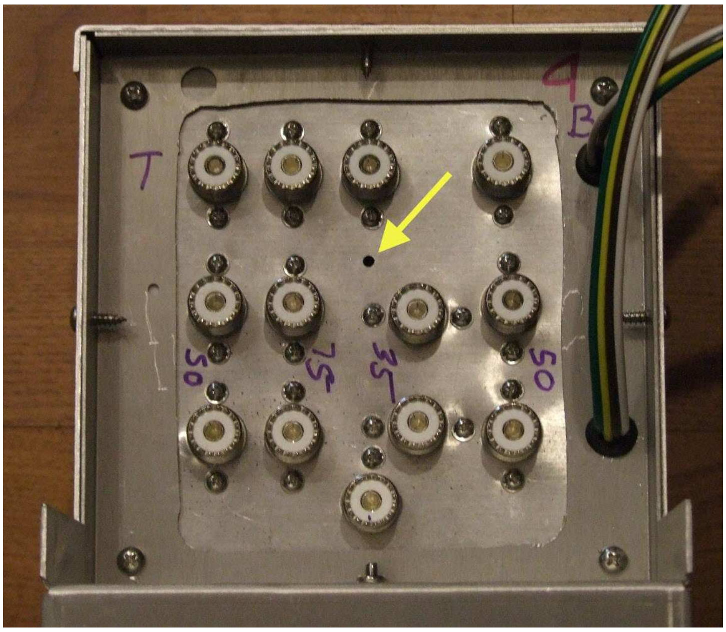


Figure 10 – Aluminum Panel over Enclosure Cutout (with weep hole)

The yellow arrow points at a 1/8” diameter weep hole. All MonoStacker 2 and 4 boxes have a similar weep hole.

Relays

The relays used in the boxes are the popular *appliance relays* used in a number of amateur radio applications. Although usually not specifically rated for RF use, they are effective (low SWR) up through 30 MHz, and even 54 MHz if the layout is appropriate (small, compact, short).

The relay coils are rated at 12 VDC, with a pull in voltage of 8.4 VDC. They drop out at 1.2 VDC. The typical relay current is 34 mA, implying a power dissipation of 400 mW, or a little less than ½ watt (per relay).

Many companies make relays that can be dropped in to this PCB and application. The relays have the 1 Form C form factor, with a rating of 16A/250 VAC. Assuming 50 Ohms, 1500 watts implies approximately 5.5 amps at 274 volts. At first blush, the voltage rating looks a bit too close for comfort. But, the AC switching voltage (hot switching) is 400 VAC, and the insulation is rated for at least 1000 VAC. I believe the intent of the 250 VAC rating is that if you pass 250 VAC **and** 16A through the relay contacts continuously you are OK (in an appliance, for example). In our case, we don’t have both 250 AC and 16A at the same time. 250 volts and 16A is 4000 watts at an impedance of 15.6 Ohm.

The particular relays used are made by Schrack. I have seen these used in Ameritron amps. Another popular brand is Potter and Brumfield. Both companies are owned by Tyco, now TE Connectivity. The relays are the RTD14012. They were purchased from Digi-Key, as their part number PB980-ND.

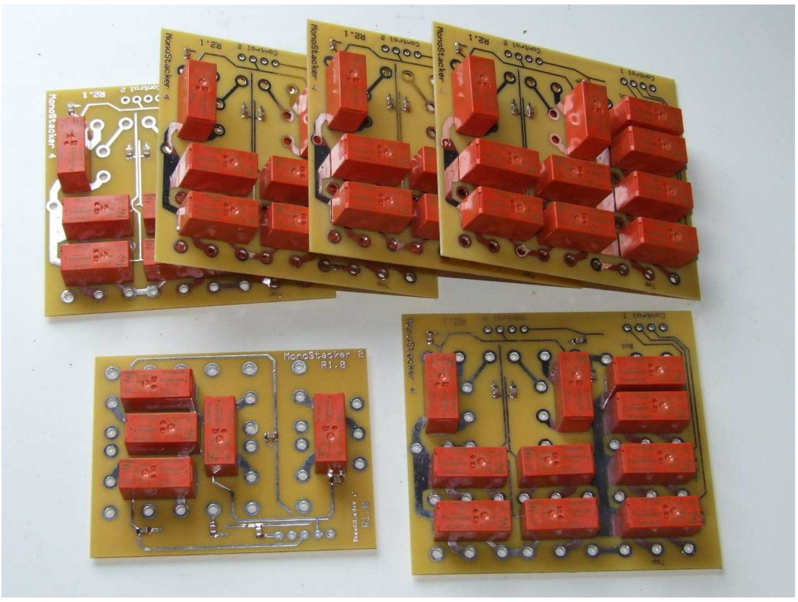


Figure 11 – Gaggle of Relays

UHF Female Connectors

It was necessary to use 2-hole female flange connectors so that they could be located as close to each other as possible. 2-hole females are much less common than 4-hole versions.

Figure 12 – 2-Hole Female Flange Connectors

The connectors are made by RF Industries, San Diego, CA, and are their part number RFU-522. They were purchased through Davis RF.

Capacitors

Capacitors are placed across each relay control line, from the +12 VDC control line to control ground. Control ground is connected to RF ground with a capacitor. The capacitors filter RF on the control lines, and direct surge energy towards ground.

The capacitors have a value of 0.01 uF, with a 1 KV rating. They are Murata GRM32QR73A103KW01L, in a 1210 SMT package, and an X7R temperature coefficient.

The capacitors were obtained from Digi-Key.

Enclosures

Comtek 4-Square controller boxes are used for the enclosures. These boxes are available as a special order item from DX Engineering.

A large rectangle has been cut out of the mounting face of the enclosure. The aluminum panel holding the UHF connectors is located over the cutout.

If you examine the folded top cover carefully, you can see daylight coming in to 4 small openings in the corners. To reduce water infiltration, I coated the inside corners with 3 layers of silicon sealant.

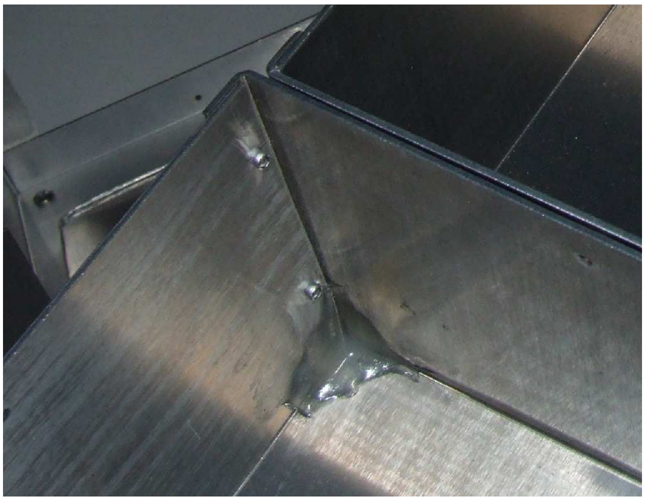


Figure 13 – Case Corner Gooping

An optional rain skirt can be used with the enclosure. Please see a previous section for details.

Trailer Connectors

Control connections coming out of the boxes are made using common trailer connectors. These are available in car parts and hardware stores, designed for outdoor use, and relatively inexpensive. I would tape them after installation for added insurance against water problems.

The MonoStacker 2 uses a single 5-pin female connector. The MonoStacker 4 uses one 4-pin female (Control 1) and one 4-pin male (Control 2) connector.

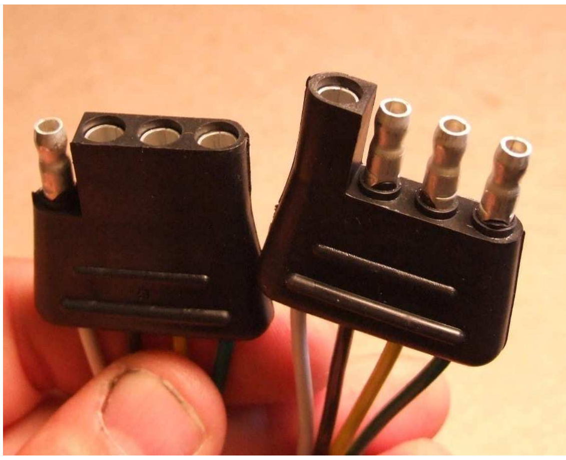


Figure 14 – 4 Pin Connectors, Female (L), Male (R)

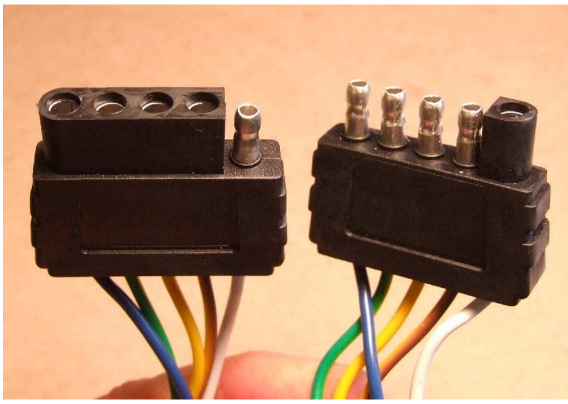


Figure 15 – 5 Pin Connectors, Female (L), Male (R)

A convention has developed where the same connectors are used inside the station. The gender of the connectors is selected so that the final station control box can be directly plugged into a MonoStacker box. This can be helpful for testing on the bench. In other words, the entire run of control cable from the station to the box is effectively a long extension cord, with opposite gender plugs on the ends. For box testing, I've built up a simply switch box that lets me exercise the relays. It has all of the connector combinations, and can plug in to either style of box. It looks like:

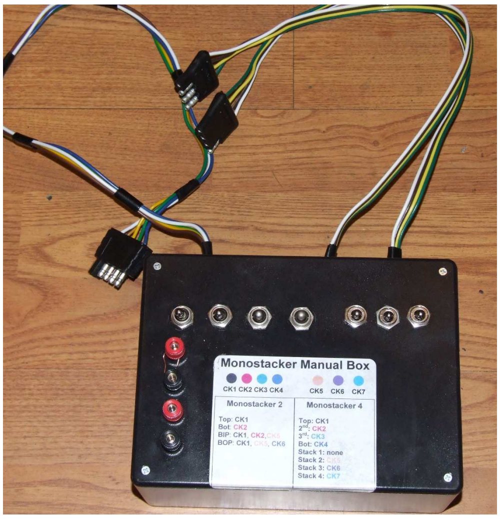


Figure 16 – MonoStacker Manual Box

Misc. Hardware

The UHF female connector standoffs and nuts are made of aluminum. All other fasteners are 18-8 stainless steel.

Feed Lines

The feed lines from the antennas to the MonoStacker boxes should be the same length odd multiples of ¼ wavelength at the target frequency. They should be the same length for obvious reasons (keeps all antennas in phase). The odd ¼ wavelength specification is made so that a shorted antenna input relay in the MonoStacker box transforms into an open circuit at the antenna feed point. This will discourage current flow in unused Yagi's, improving Yagi isolation.

The odd ¼ wavelength also creates the *current forcing* situation, which should encourage all antennas in the stack to accept the same current even if they are somewhat different.

Trimming Impedance Matching Lines

Cutting the lines based upon target frequency, velocity factor, and electrical length, is a good first step.

Because of conductor length inside the box, lines cut by formula will usually be a little long.

Another factor worth considering is that real antennas are not perfectly 50 Ohms across the band. So, the length of the matching cables really should come from being connected to the actual antennas, and then trimmed to minimize the SWR at the target frequency. This allows the lines to be custom trimmed for the real antennas. In this case, the lines might need to be slightly shorter or longer – it depends upon the impedance values of your antennas, and those can vary all over the map.

This approach is usually impossible, since the antennas are hanging on the tower.

The approach that has been used so far is to replace antennas with 50 Ohm dummy loads. Now, the only effect being measured is the length of the lines, since the loads are very well behaved at all frequencies.

After trimming various lines, I have the following guidelines. In the perfect world, all or the matching lines would be 90 degrees long at the target frequency.

Because of the wire length inside the box, the lines are shorter than an exact 90 degrees. Here is what I've been seeing:

1. 40m: 88 degrees
2. 20m: 86 degrees
3. 15m: 84 degrees
4. 10m: 82 degrees

MonoStacker 2 Trimming

The 50 Ohm ¼ wavelength line can be trimmed independent of the box, and to use an exact 90 degrees at the target frequency is fine. This line is not involved in impedance matching, but rather is a *placeholder*, that keeps the approximate length of the transmission lines the same, no matter what antenna combination is selected. This approach is intended to keep the overall system impedance more constant, hopefully to reduce to need to retune the amplifier driving the line when changing combinations. Let me say it this way – when you add or remove ¼ wavelength of line, it has a small impact on the SWR, but the largest possible impact on the impedance (due to the length being ¼ wavelength). Amp tuning is probably more sensitive to impedance and not simply SWR. Apart from this concern, the 50 Ohm ¼ wavelength line could be turned into a very short jumper.

The 50 Ohm ½ wavelength line can also be trimmed independent of the box, to a length of 180 degrees at the target frequency. This line is used to generate the BOP out of phase signal, and whether it is off by a few inches either way does not matter.

The 35 Ohm ¼ wavelength line is involved in creating an impedance match when both antennas are used – whether BIP or BOP. It can be trimmed.

The process begins by attaching two 50 Ohm dummy loads to the top and bottom antenna ports.

Then I attach a PL-259 coax connector to one end – the permanent end – of a RG-83 Ohm cable. The cable is cut a little long for 90 degrees at the target frequency. I then cut back the jacket and expose the center pin, which I hold into the MonoStacker 2 box coax connector. This allows me to sweep the SWR using the cable, although only one end is *normal.*

Hopefully your first attempt will be a little low in frequency, meaning that if you trim the cable you will raise the SWR dip. After the first cut it should be possible to determine how much total length must be removed by using a ratio.

I like to make the last test a little low in frequency, so that I can recut the end flush and install a PL-259 using the normal methods.

On a 20 meter MonoStacker 2 box I had the following results using this method:

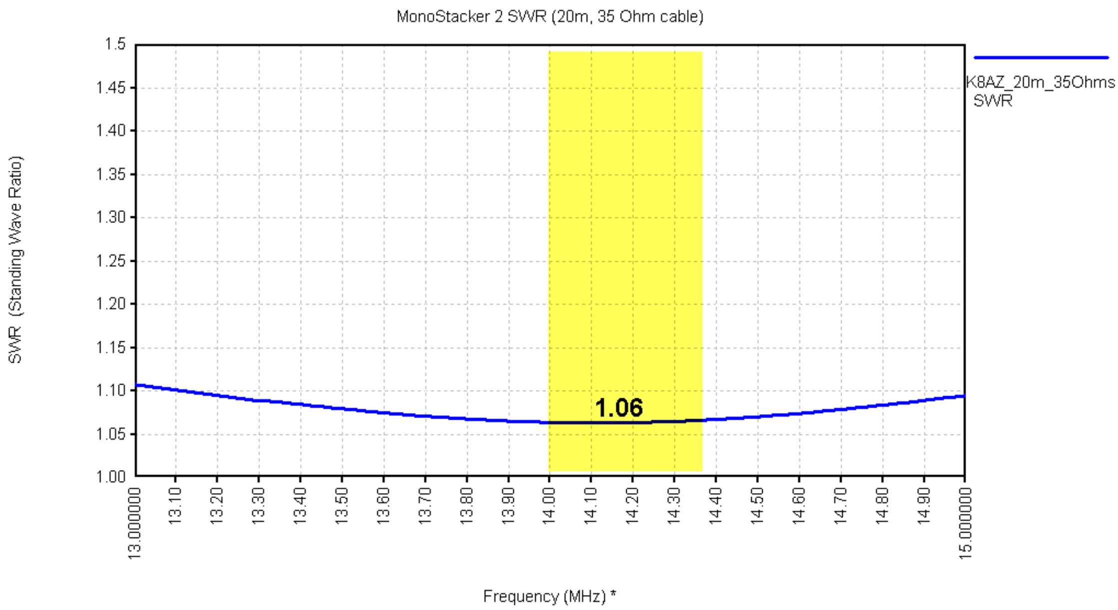


Figure 17 – Trimming the 35 Ohm MonoStacker 2 Cable on 20 Meters

We can learn several things from this graph. First, the impedance matching bandwidth is very wide. The sweep covers 13 to 15 MHz, the 20m band is highlighted in yellow. So, even if you are only close in your trimming you will not be far off. One of the reasons why the bandwidth is wide is that the impedance transformation is relatively small – a 1 to 2 (25 to 50 Ohm) transformation. This is the only transformation on the MonoStacker 2. With the MonoStacker 4, there are additional 1 to 3 and 1 to 4 transformations. Each one will have a relatively smaller bandwidth, as the ratio rises.

The second thing to note is that the minimum SWR is 1.06, not the 1.02 predicted by the math. In this case, my dummy loads were around 50 Ohms, but not precisely 50 Ohms. So, the final transformation is a little higher, at 1.06.

Again this procedure uses 50 Ohm loads as antennas. With actual antennas it is probably possible to trim for the impedance they provide. The hard part is that you need to be on the tower to do this[3].

MonoStacker 4 Trimming

The simplest line to trim on the MonoStacker 4 is the 35 Ohm cable. It is only used when two antennas are combined. The procedure is the same as used on the MonoStacker 2, since it's the same scenario – two antennas combined through a ¼ wavelength 35 Ohm cable.

Using this procedure on a 15 meter MonoStacker 4 I trimmed to the following point:

[3] Another procedure that could be used if you antennas are very far from 50 Ohms is to measure the antenna impedance values accurately at the box (using a quality handheld antenna analyzer), and then combine them in parallel mathematically and then use a Smith Chart or other aid to determine the best electrical length for the matching cable. I'm not saying this is easy, just possible. In an extreme case, the ¼ wavelength lines described here could be replaced with series matching sections composed of different impedance cables. This should allow you to achieve a 50 Ohm perfect match at one frequency no matter what.

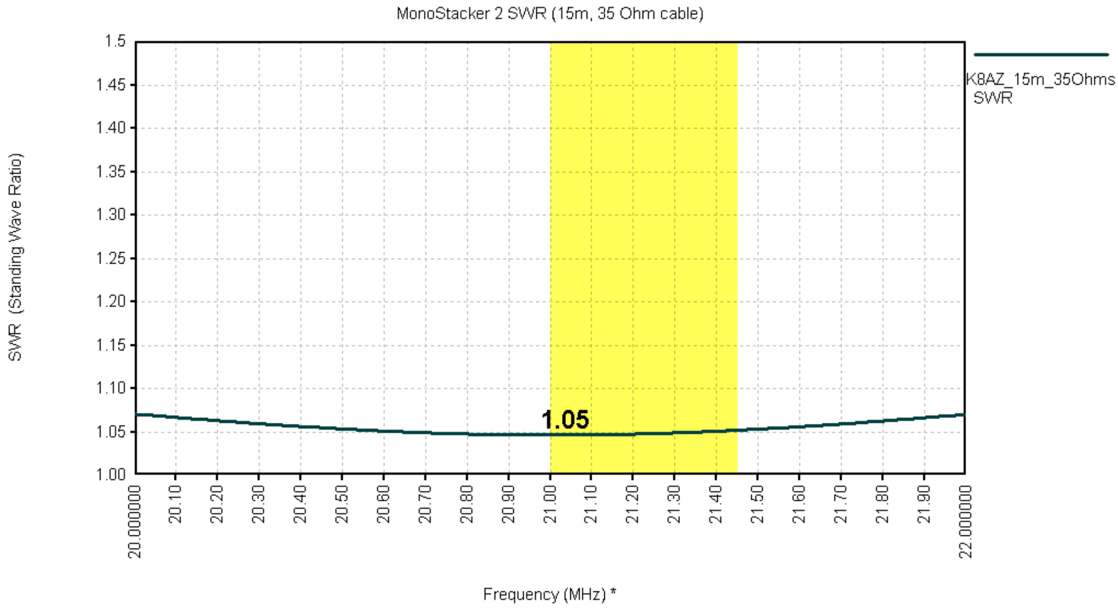


Figure 18 - Trimming the 35 Ohm MonoStacker 4 Cable on 15 Meters

The 15m band is highlighted in yellow. As before, the matching bandwidth is very wide. My target was 21.2 MHz, and this is a little low. But, this was the last sweep with the cable being manually held onto the box. After that measurement it's time to recut the end and that will raise the minimum SWR very close to the target.

All of the other lines have the property that they are used in parallel combinations of two lines. There may be some interesting and even useful aspects of parallel lines of different lengths. At this point it time, it only adds to the confusion.

Control Current Expectations

Each control line operates one or two relays. All relays consume around 34 mA. If you want to test your control connections, measure the current through the lines. You should measure either around 34 or around 68 mA. Other values are highly suspect. Consult the schematics to see what lines control two relays.

Bench Tests and Performance

During the summer of 2012, a batch of 6, MonoStacker 2's and 5, MonoStacker 4's was constructed.

Each unit was tested. The follow data is representative of what was found.

MonoStacker 2

The MonoStacker 2 was tested on 20 meters, since that was the first band for which cables were cut and available. All three cables were in place.

The first test is to measure the SWR of the box with 50 Ohm dummy loads connected in place of the antennas. There are 4 cases – Top, Bot (bottom), BIP, and BOP.

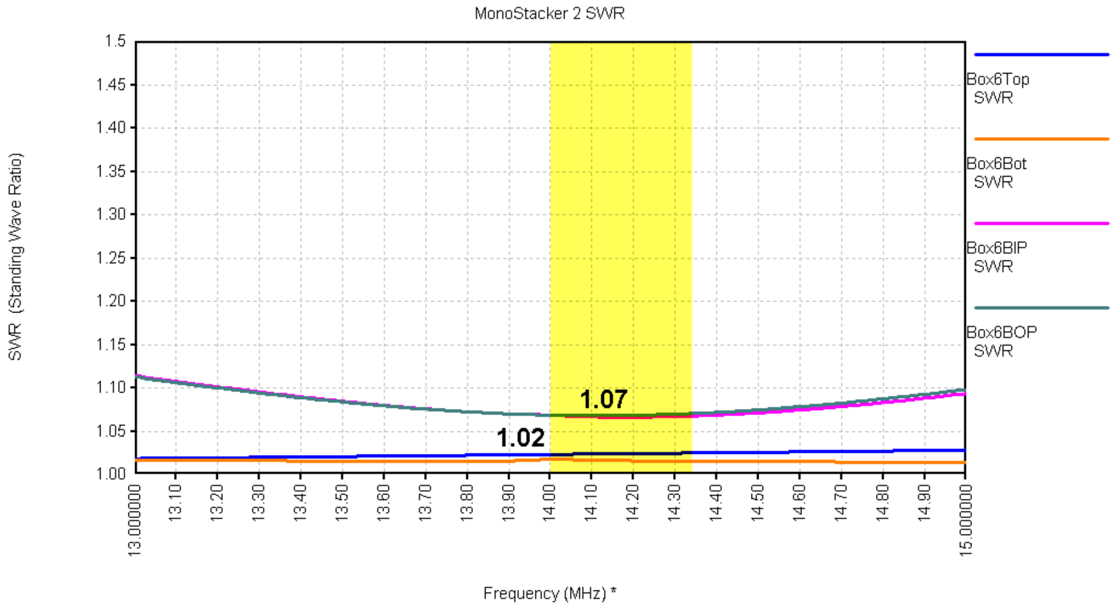


Figure 19 – MonoStacker 2 20m SWR Performance (50 Ohm Loads)

The band is highlighted in yellow.

The two direct cases, the Top and Bot antennas, had a low flat SWR of approximately 1.02 to 1.03. The BIP and BOP cases that use the 35 Ohm ¼ wavelength cable to transform the 25 Ohm junction to 50 Ohms had a minimum of approximately 1.07.

The next tests switched to a transmission measurement and measured the response going through the box.

The first two cases are the Top and Bot (single antenna) modes. The magnitude (loss) response is:

Figure 20 – Monostacker 2 Top, Bot Loss Comparison

The loss through the box was approximately 0.06 dB. The Bot antenna had a little more loss, and a funny little resonance wiggle near 14 MHz. This is the antenna that can be placed out of phase. So, a 180 degree cable is just a few relay contacts away. All I can think of is that there is some resonance effect going on with the ½ wavelength BOP cable that is telegraphing over to the Bot RF path.

Note that we are going through the ¼ wavelength 50 Ohm box cable for these measurements. Most of the loss is due to that cable.

For the same two paths the phase shift through the box is:

Figure 21 - Monostacker 2 Top, Bot Phase Shift Comparison

The phase shift through the box is approximately -96 degrees (lagging). 90 degrees of that are due to the ¼ wavelength 50 Ohm line. The remaining 6 degrees come from the box itself, in the traces, connectors, and relays.

The next tests look at the magnitude and phase shift at the two antenna ports for the BIP and BOP combinations.

The following graph compares the BIP signal levels through the box.

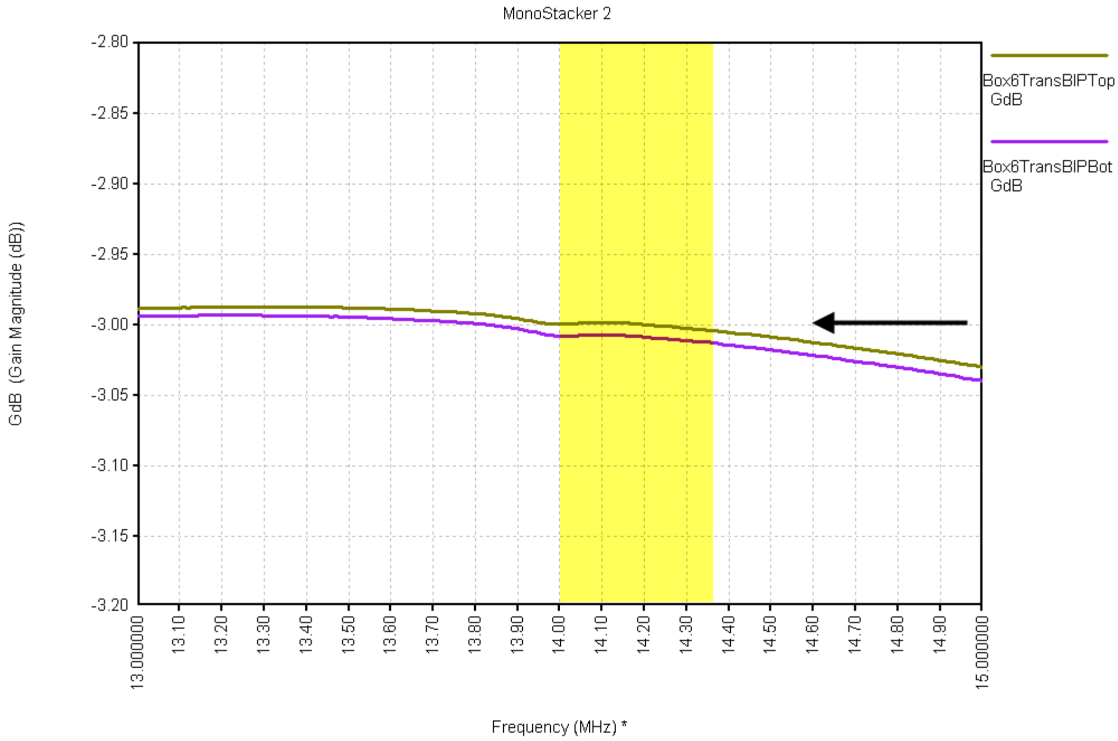


Figure 22 - Monostacker 2 BIP Magnitude Comparison

What we would like to see is an exact -3 dB split between the two ports. We are very close to that, with the Bot port showing a little more loss (0.01 dB!).

Switching to BOP, the magnitude comparison is:

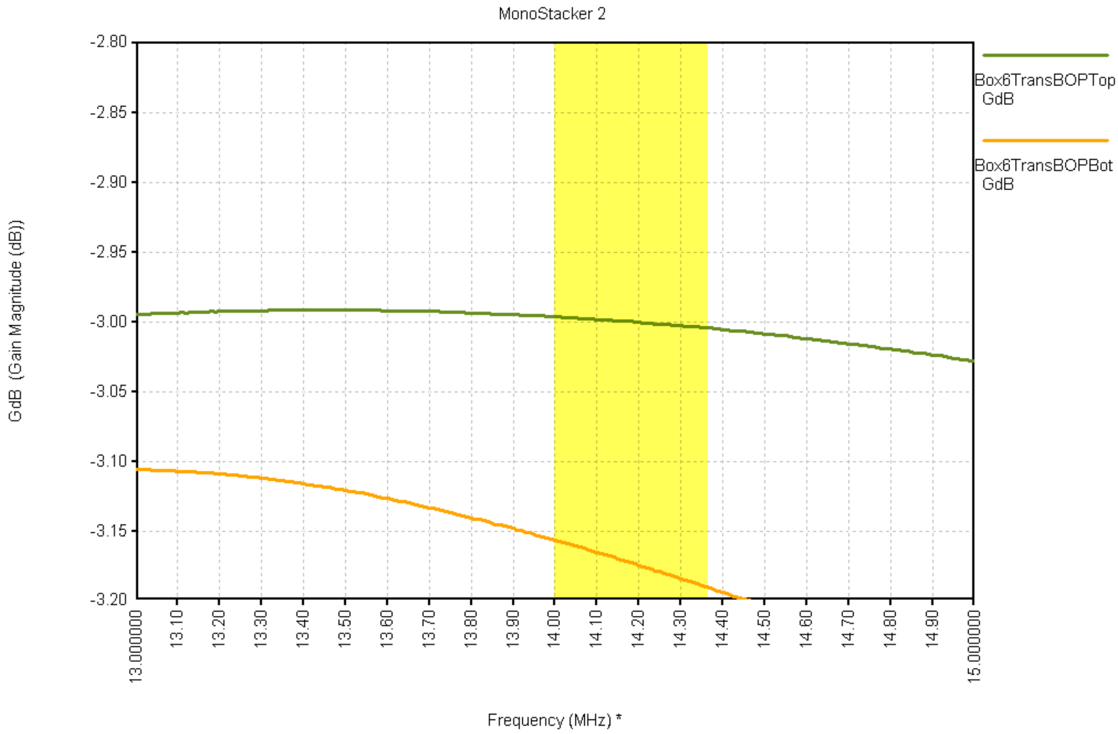


Figure 23 - Monostacker 2 BOP Magnitude Comparison

The ideal goal is again a -3 dB split. The bottom antenna in the BOP case goes through an extra ½ wavelength of coax to create the out of phase signal, and along with that comes about 0.15 dB of loss, shown in this split.

The final MonoStacker 2 test is the measurement of the 180 degree BOP phase shift. That showed:

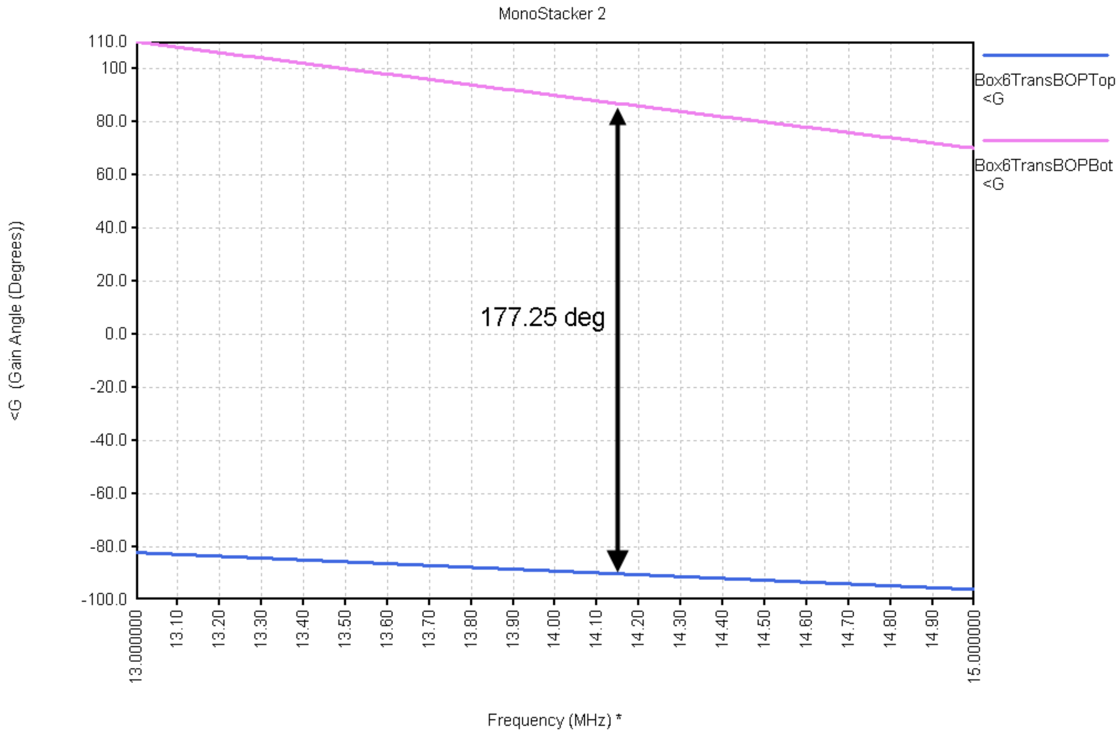


Figure 24 - Monostacker 2 BOP Phase Comparison

The phase shift was 177.25 degrees at 14.150 MHz. Since BOP is about redirecting lobes and not creating nulls, any value around 180 degrees does the job.

MonoStacker 4

The MonoStacker 4 has been around and on the air for two years (2010). The PCBs in this batch had a few changes, mainly to make the board a little smaller, which always reduces the cost. Keeping the RF traces as short as possible also helps as well.

The point is, this is not a 100% brand new box, as is the case for the MonoStacker 2. It has been exhaustively tested in the past, and that information is floating around.

For the testing of this batch of boxes, a number of SWR sweeps were made. The cables used were from a 15m stack of 3 Yagi's. That means that a normal stack of 4 measurement was not possible, but I did a similar test.

The first 4 sweeps were the single antennas through a ¼ wavelength 50 Ohm cable.

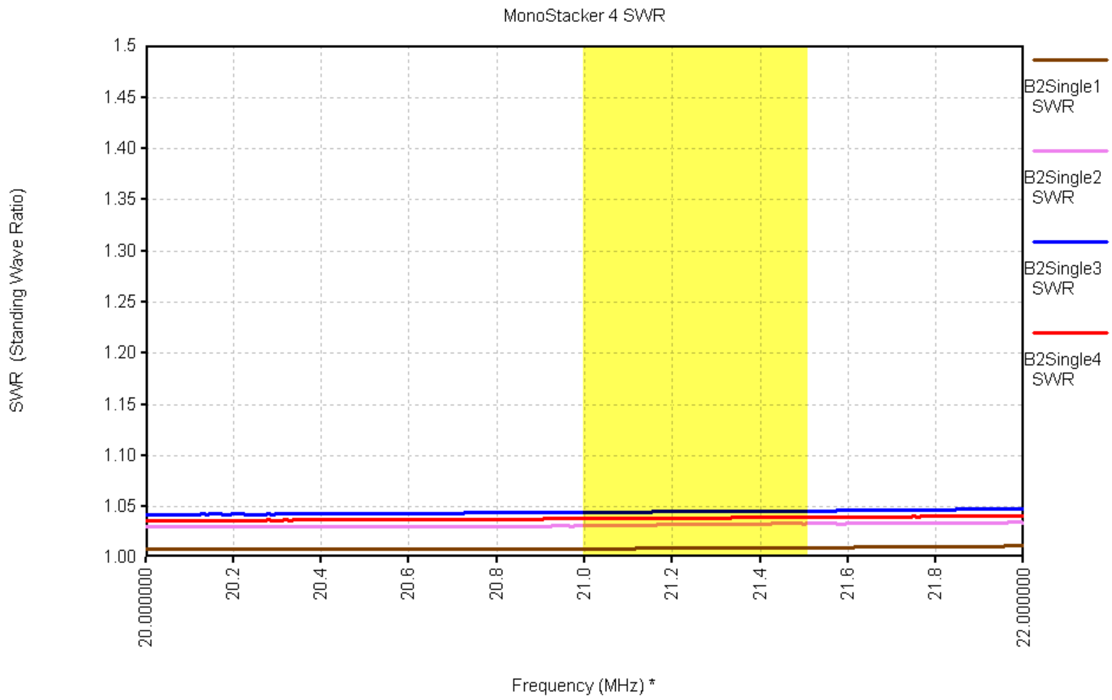


Figure 25 – MonoStacker 4 15m Single Yagi's

The next sweep is a stack of 2 Yagi's using the 35 Ohm matching line.

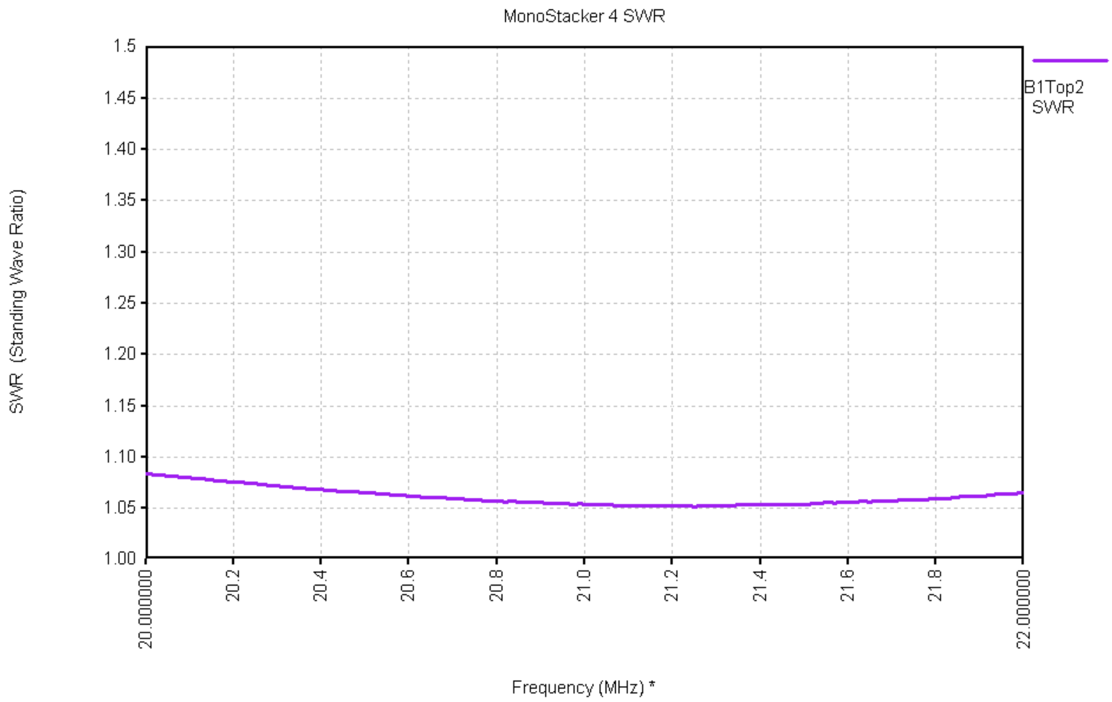


Figure 26 – MonoStacker 4 15m Top 2 Yagi's

The next sweep is the top 3 Yagi's, using the 75 Ohm cable in parallel with a 50 Ohm cable.

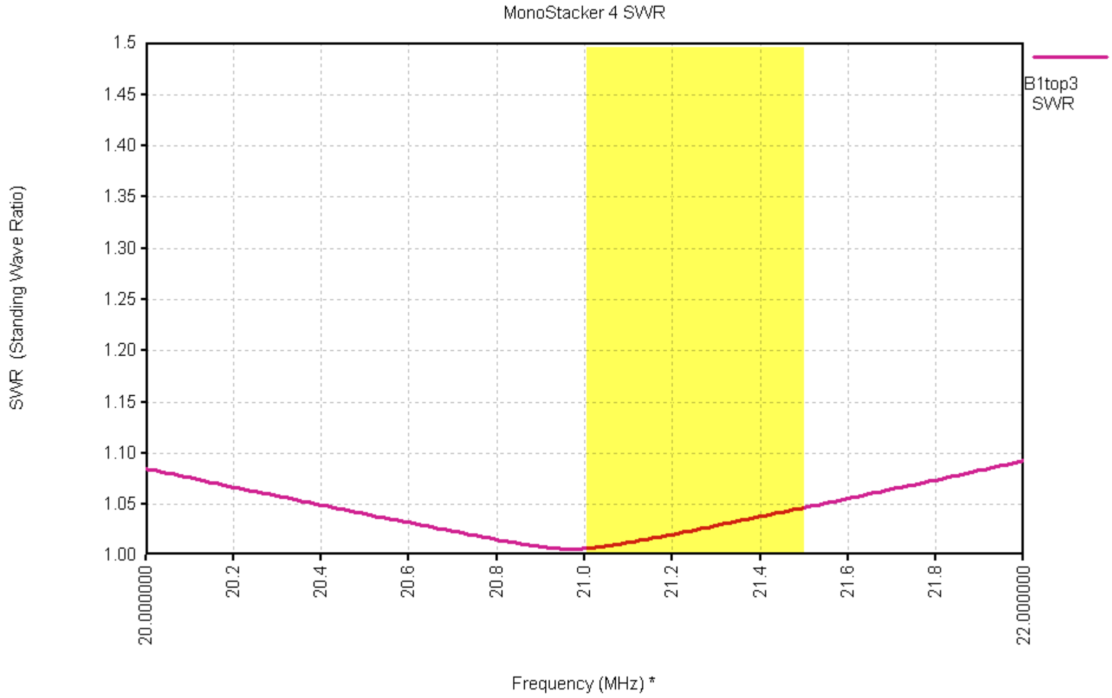


Figure 27– MonoStacker 4 15m Top 3 Yagi's

The SWR dip is a little low in frequency, but the cables I used did not have permanent coax connectors on one end. So, after the ends are recut for a connector, the DIP will rise up into the band.

The final test is all 4 Yagi's. Normally, that means that the two 50 Ohm cables are used in parallel to make a 25 Ohm cable that matches 12.5 Ohms up to 50 Ohms. I did not have the second 50 Ohm cable. So, I simple tried the all 4 combination through a single 50 Ohm cable. I used the *second* 50 Ohm cable connectors so as to test all of the hardware. Now, the 12.5 Ohm impedance will not be changed, and the result is an SWR of 4.

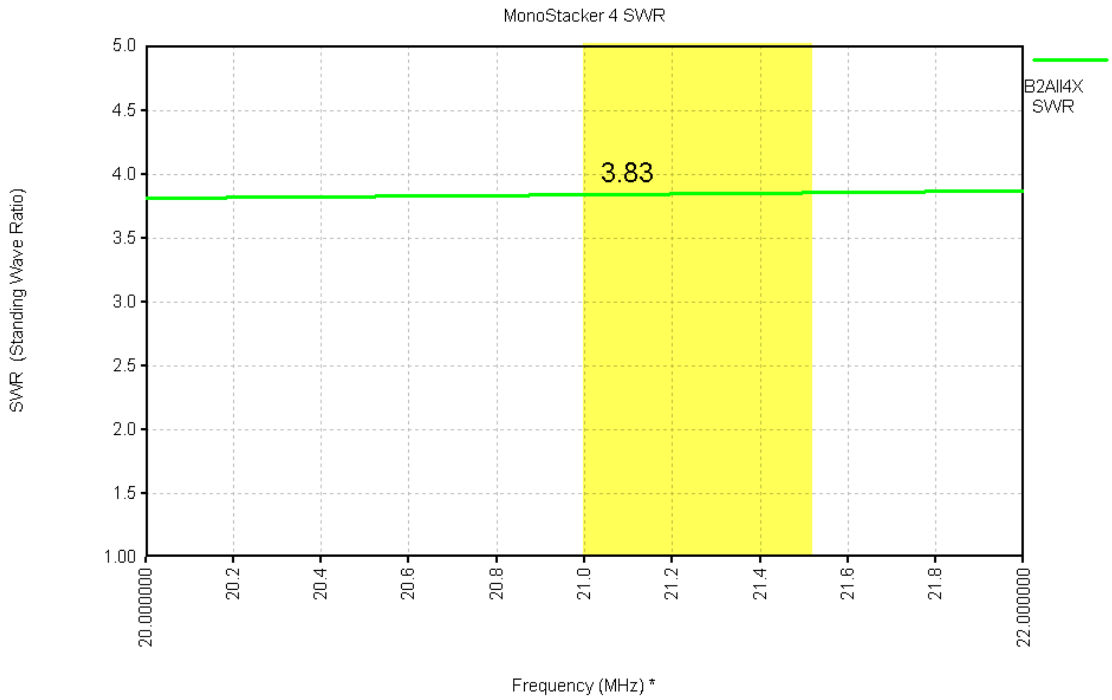


Figure 28 – MonoStacker 4 15m All 4 Yagi's

The SWR is 3.83, as opposed to 4.0. The main thing is that all of the signal paths were tested in the box.