

Background

Within the past several months additional yagis, fixed toward the Caribbean, have been placed on my towers. A three-element 15m at 60 feet, a four-element 10m at 30 feet, and a three-element 20m at 22 feet on a second tower. What is now required is a quick means whereby the RF can be directed to one of these three antennas, then returning the RF to the larger rotatable arrays.

Not wanting to run even more cables out to the towers, it was decided to run DC over the center conductor of the appropriate coaxes, utilizing bias-tees to introduce and pull-off the 12 VDC. The remainder of this document details how this is performed.

Approach

There are several solutions available, be it MFJ's 4712 2-Position Remote Antenna Switch or the remote unit from Array Solutions. Each comes with its own price and neither is inexpensive when switching between two or more pairs of antennas is needed. The design reviewed here is able to switch between four different pairs of antennas.

There are two key ingredients: a) suitable relay and b) low insertion loss bias-tees. An April 2005 QST article, "A Low-Cost Remote Antenna Switch" used American Zettler relays, AZ755-1C-12DE. The contact details are shown below in Figure 1.

CONTACTS

Arrangement	SPST (1 Form A, 1 Form B) SPDT (1 Form C)
Ratings	Resistive load: Max. switched power: 480 W or 5540 VA Max. switched current: 20 A Max. switched voltage: 150* VDC or 380 VAC *Note: If switching voltage is greater than 30VDC, special precautions must be taken. Please contact the factory.
Rated Load UL, CUR	20 A at 277 VAC N.O. resistive, 50k cycles 16 A at 240 VAC general use, 100k cycles 12 A at 277 VAC N.O. resistive., 100k cycles 20 A at 24 VDC resistive 1 HP 240 VAC TV-8 120 VAC N.O. (silver tin oxide only)
TÜV	16 A at 30 VDC, 250 VAC resistive, 30k cycles* 13 A at 420 VAC resistive, 30k cycles *
Material	*approval for form A, C, and Class F only Silver cadmium oxide (silver tin oxide available)
Resistance	< 50 milliohms initially (24 V, 1 A voltage drop method)

Figure 1 AZ755-1C-12DE Relay

Frequency, MHz	Series Impedance
1.83	50.6 + j1,480
3.488	3589 + j15,286
7.244	0 - j1,393
14.08	0 - j601
21.16	0 - j374
28.01	0 - j275

A general rule of thumb is to have 10X the system impedance for adequate isolation, in other words 500 Ω. We will see how the actual hardware performs and could, if needed, add a second 100 uH inductor in series with the first. This is contemplated for only the internal bias-tees of the KW bandpass filters.

At the 1,500 watt level, for a 50 Ω load, we find 273.9 V_{RMS} and 5.48 I_{RMS}. Fortunately all the antennas being switched have very good VSWRs, typically around 1.3:1, rarely approaching 1.5:1.

Simplifying the bias-tee construction is the fact that they can be easily incorporated into the output of each 2 KW bandpass filter. The SO-239 for input and output are already in place and in some cases, the filter is already AC coupled, in those cases not requiring separate DC blocks.

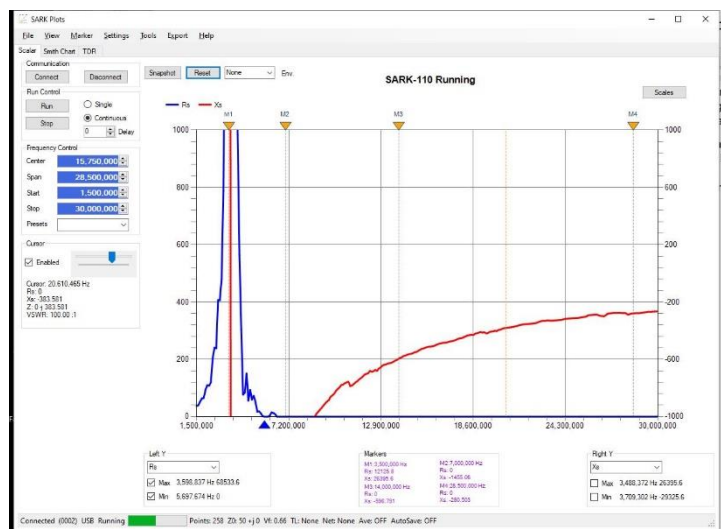
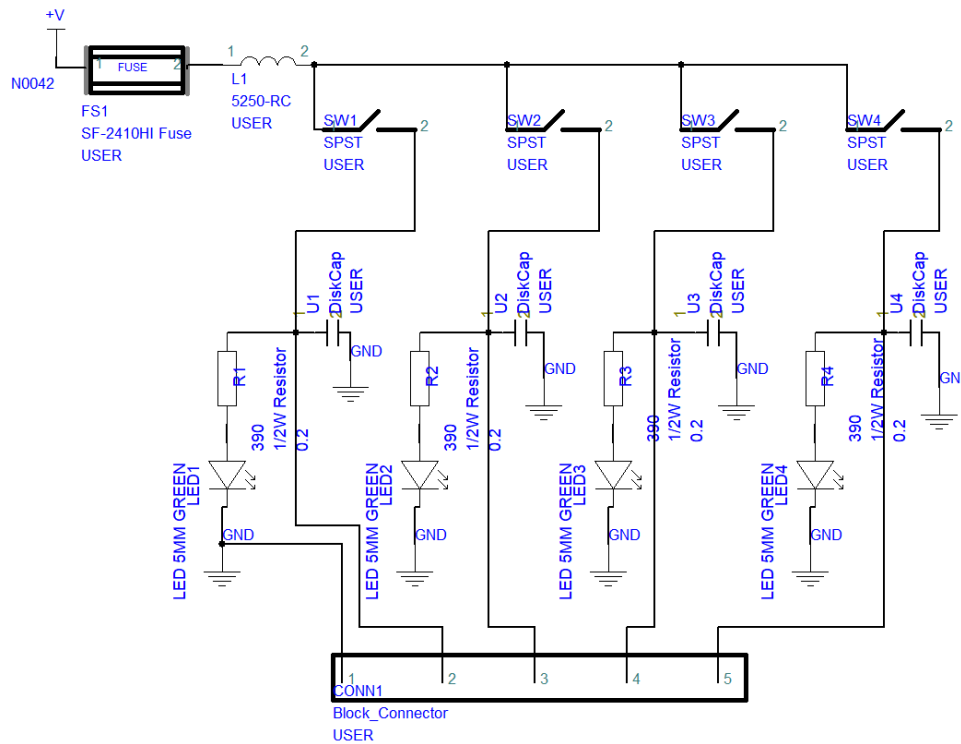


Figure 2 Series Rs and Xs of 100 uH

Switch Controller



The actual numbering used for the outputs varies from what is shown here.

- Pin 1 Brown
- Pin 2 Green
- Pin 3 Orange
- Pin 4 Blue
- Pin 5 Ground

CAT5 cable is used for the interconnect from the controller box to the KW filters in the basement.

The wires of "solid" color are as indicated above and the wires with "color-white" like brown-white are all ground. Therefore, there are four wires which go into Pin 5 as the ground connection.

Figure 3 Schematic of Controller

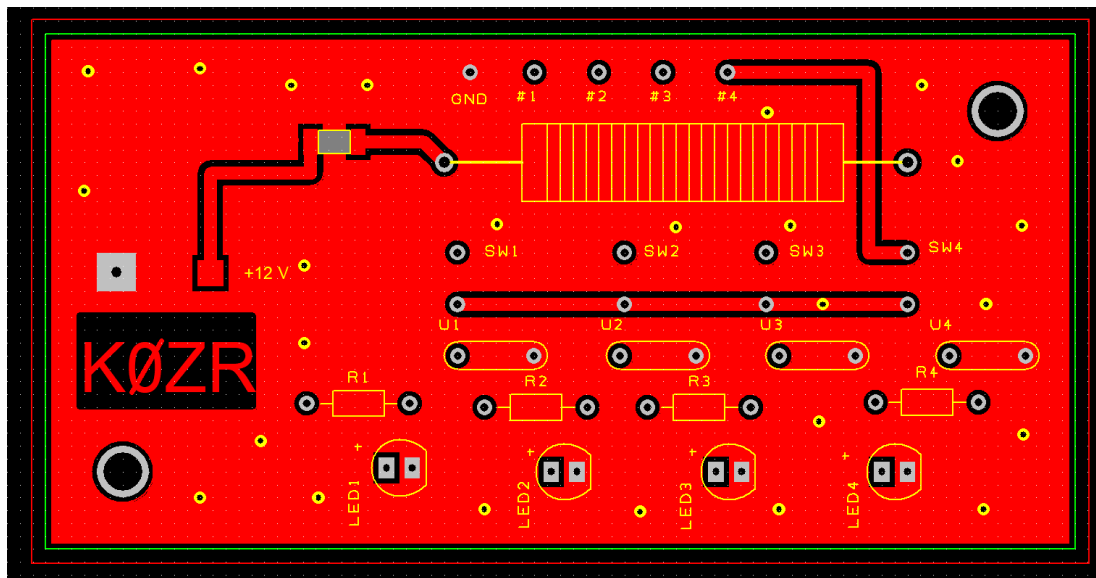


Figure 4 Top-Side of Controller Board

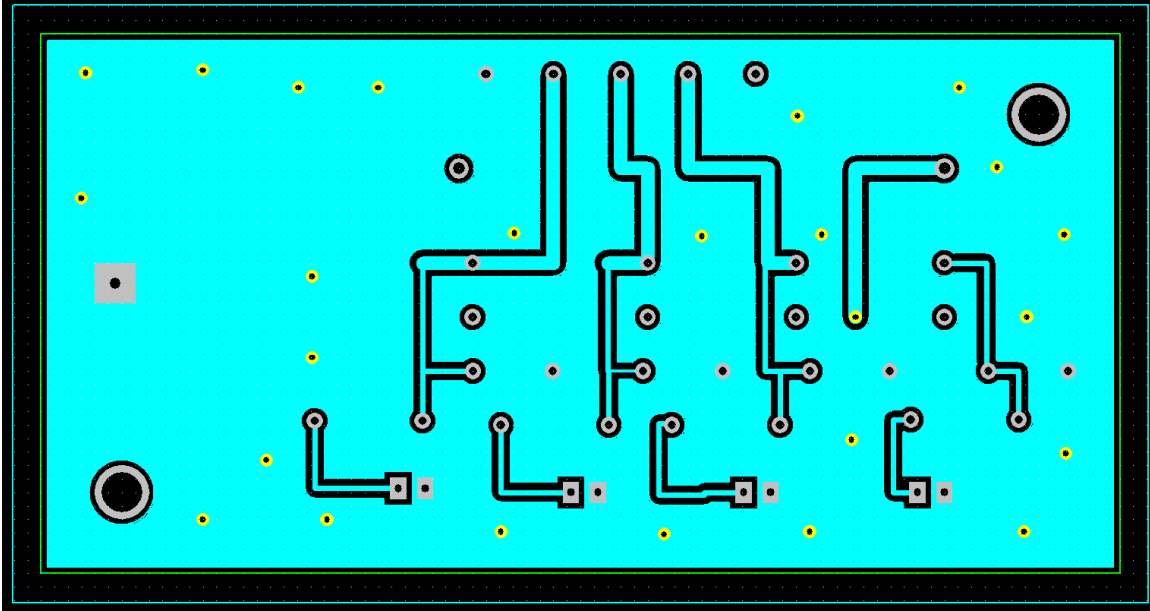


Figure 5 Bottom-Side of Controller

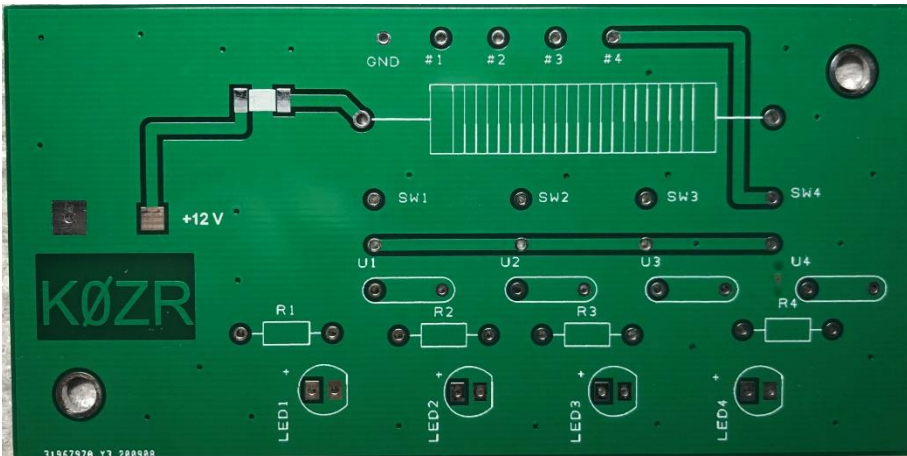


Figure 6 Top-Side Controller PCB

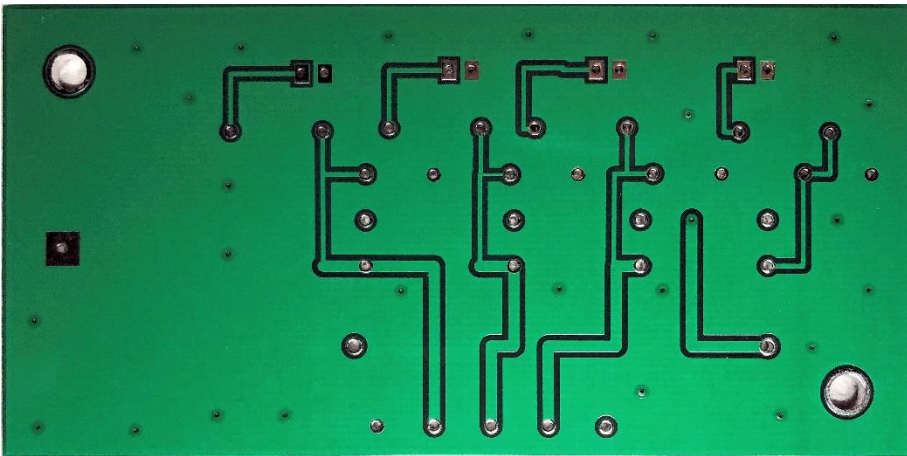


Figure 7 Bottom-Side Controller PCB

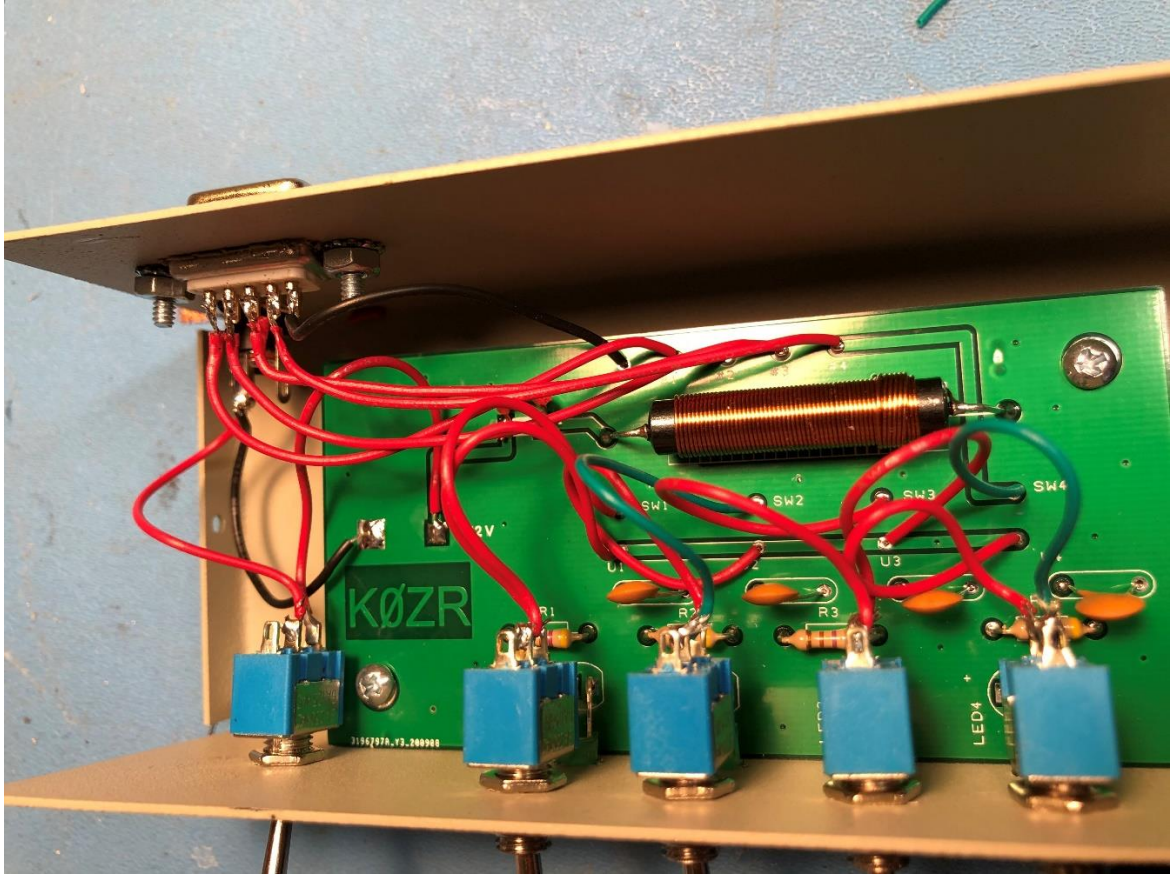


Figure 8 Assembled Controller

Figure 8 is the assembled controller. It uses the same 100 μH inductor to further isolate the incoming 12 VDC from RF which will be on the control lines. Only barely discernible are the LEDs which are mounted beneath each of the four switches.

Relay RF Switch

The main part of the RF switch is the American Zettler 1 x 2 relay cited earlier. Its very simple schematic is shown in Figure 9.

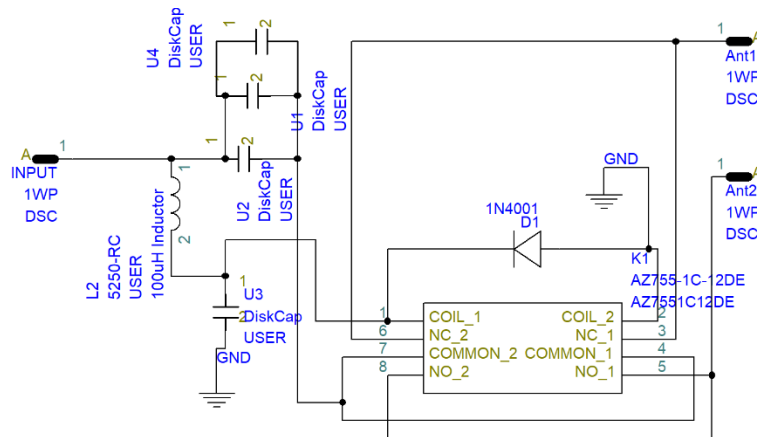


Figure 9 Schematic of Relay RF Switch

The schematic indicates three disk capacitors in use as blocking capacitors. As a matter of documentation, remote units #1, #2, and #3 use only two disc capacitors in parallel while #4 does use all three. The disc capacitor U3 is a 1 KV, 0.1 ufd as are the DC blocking capacitors. And as indicated, a flyback diode is used, being a 1N4004 in the actual design build. This diode has a higher reverse breakdown voltage than a 1N4001.



Figure 10 Top-Side Relay Board

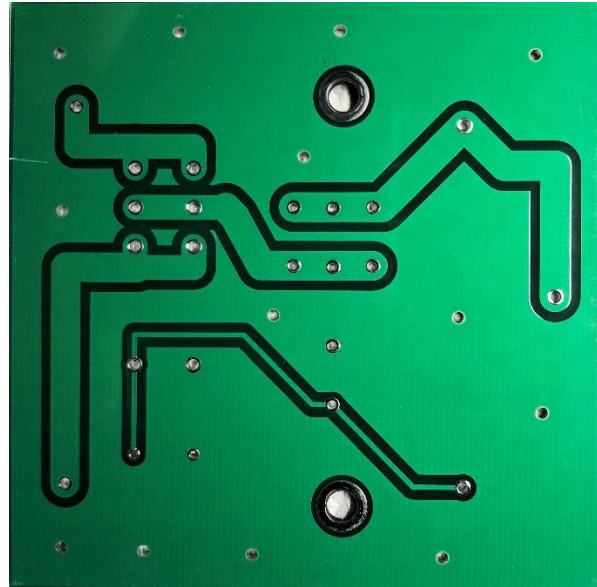


Figure 11 Bottom-Side Relay Board

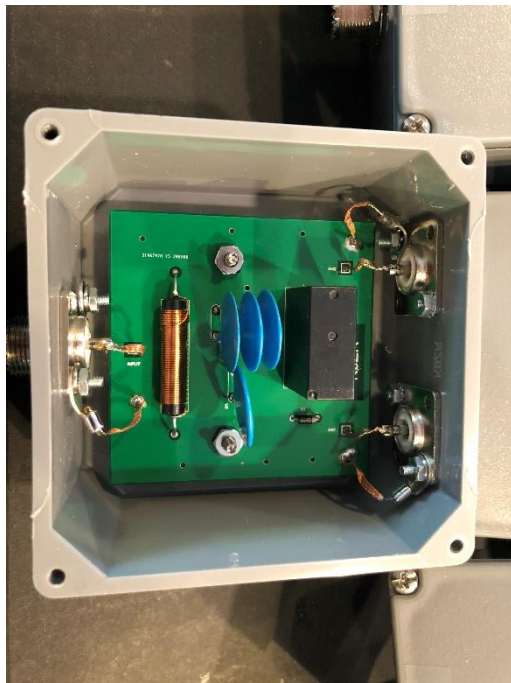


Figure 11 Assembled Relay Board RF Switch

Shown to the left is the assembled remote relay/RF transfer switch. This is #4 since there are three DC blocking capacitors in use. The conductors used for RF ground and RF connectivity are actually copper solder-wick lengths. The PCB is mounted above 3/8 inch standoffs. Standard SO-239 female connectors are used for the input and two output ports. The weatherproof boxes are from Lowes and Home Depot.



Figure 12 Four Remote RF Switch Units

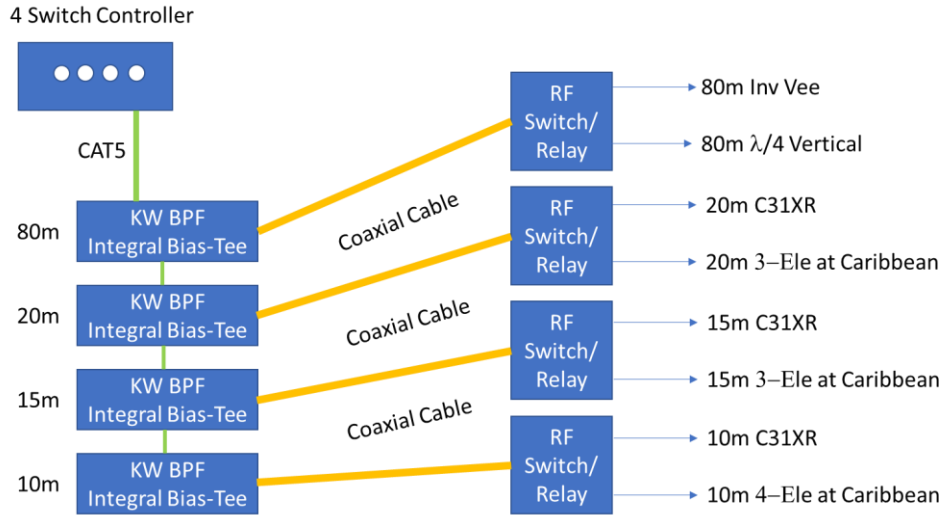


Figure 13 System Layout



Figure 14 Controller Activating All Four Alternate Antennas