Subject: Improved Triplexer Design **Date:** February 19, 2014
Reference(s): INRAD Design **Author:** Jeff Crawford

Several weeks ago I mentioned to several friends my intention to build some of the necessary bandpass filters for SO2R operation. In a different analysis I analyzed the six different filters, looking primarily for accompanying current and voltage requirements. This discussion lead to Gary, NC4S, asking if I would be interested in looking into building triplexer(s)[i] for our Field Day operation[ii]. I said, "Of course." The results of this brief review into such a design are outlined here.

The first design I considered comes directly from the just referenced QST article describing a triplexer for tribanders. I took that design, modified the resonator values for centering midway between the CW and SSB bands, and analyzed it for passbands accommodating 14, 21, and 28 MHz. I envisioned building each resonator separately, adjusting to the designed resonant frequency, connecting all three in parallel and making the necessary final adjustments to counteract any possible interaction.

The simulator I used for this simple analysis is TOPSPICE. Using it in AC mode I ascertained the accompanying through losses and attenuation at the other frequency bands. This is captured at three different frequencies in the following pages.

Once I completed this analysis, Gary came across a triplexer composed of three bandpass filters, thus affording one even greater isolation between three transmitters using the same antenna. Therefore, subsequenty, this "improved triplexer" design is analyzed and discussed as well.

Triplexer QST-Style

Transmission Characteristic for 14 MHz Path

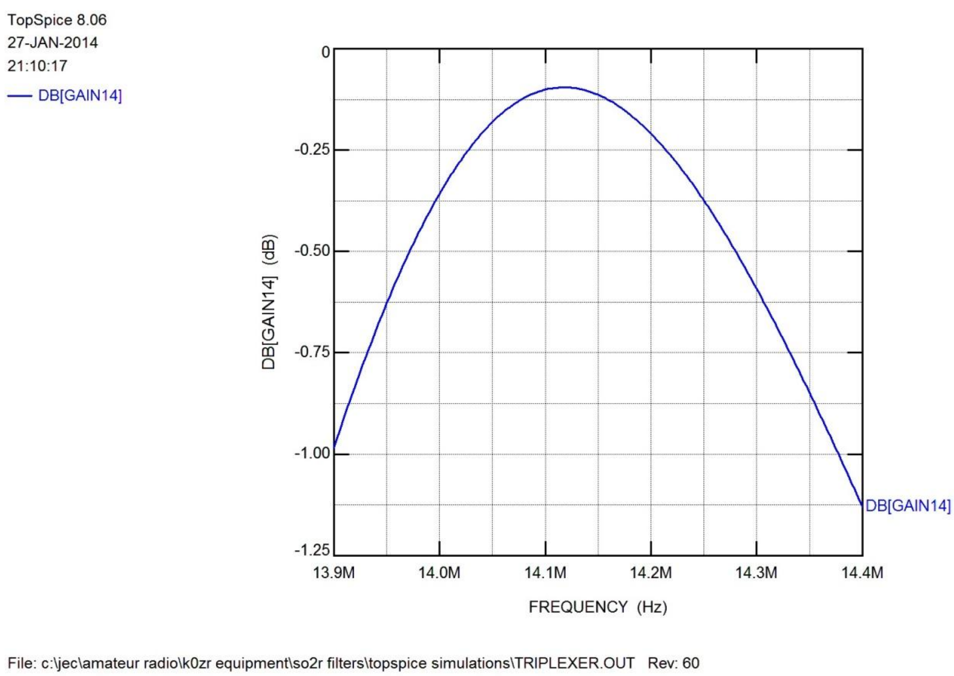


Figure 1

Transmission Characteristic for 21 MHz Path

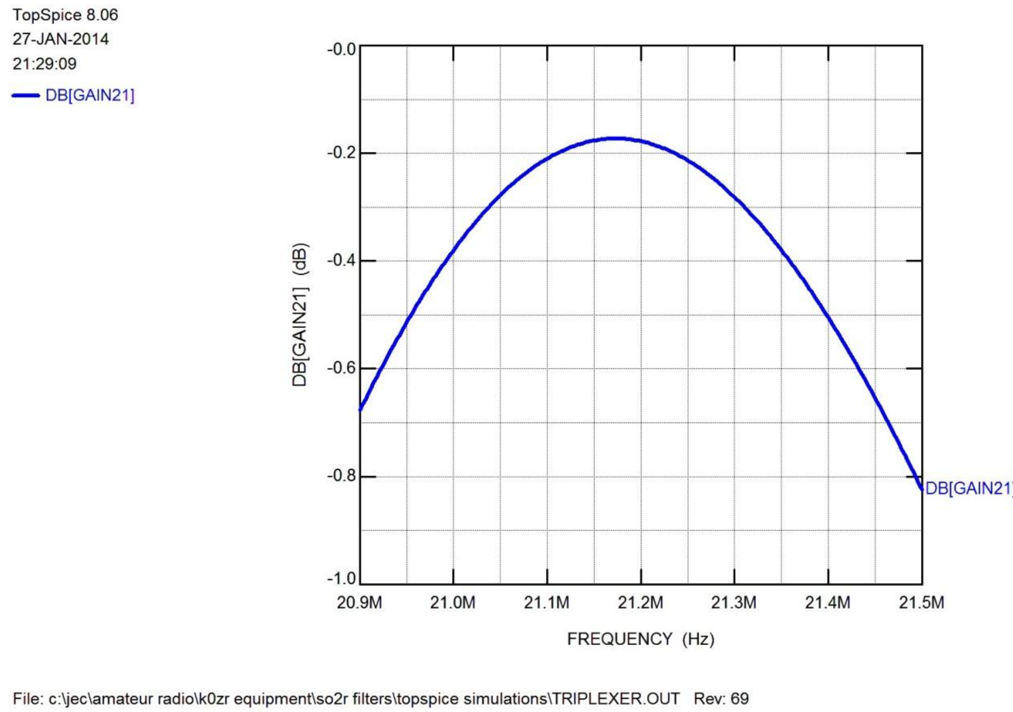


Figure 2

Transmission Characteristic for 28 MHz Path

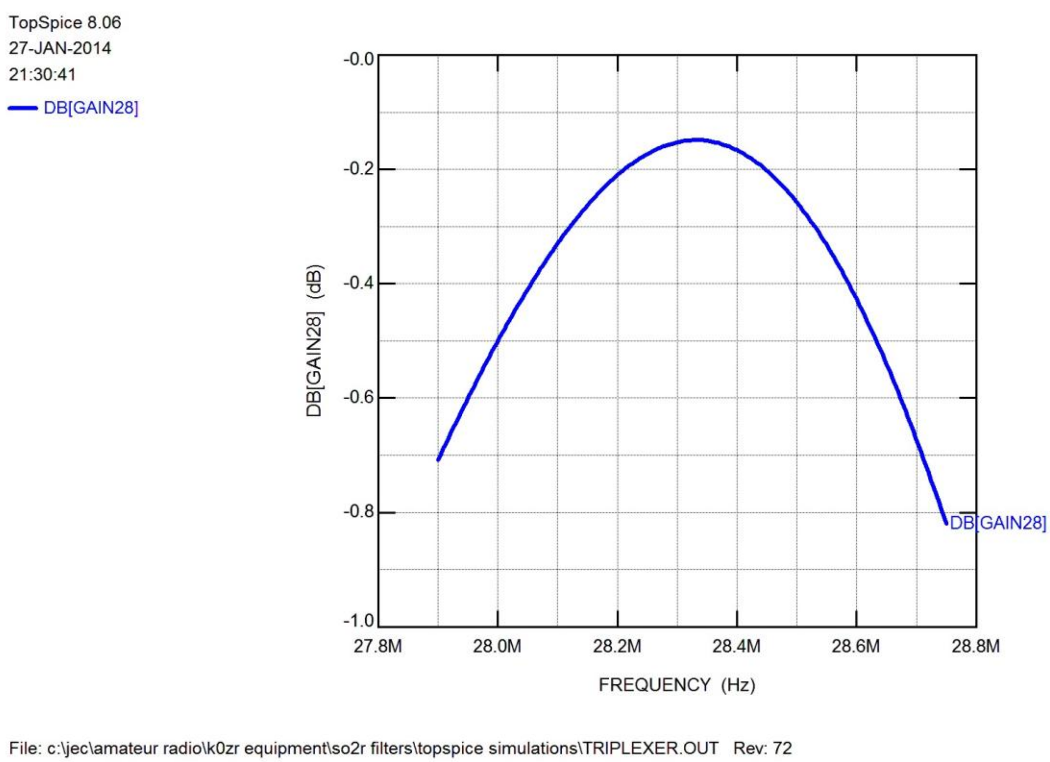


Figure 3

Overlay of All Three Passbands

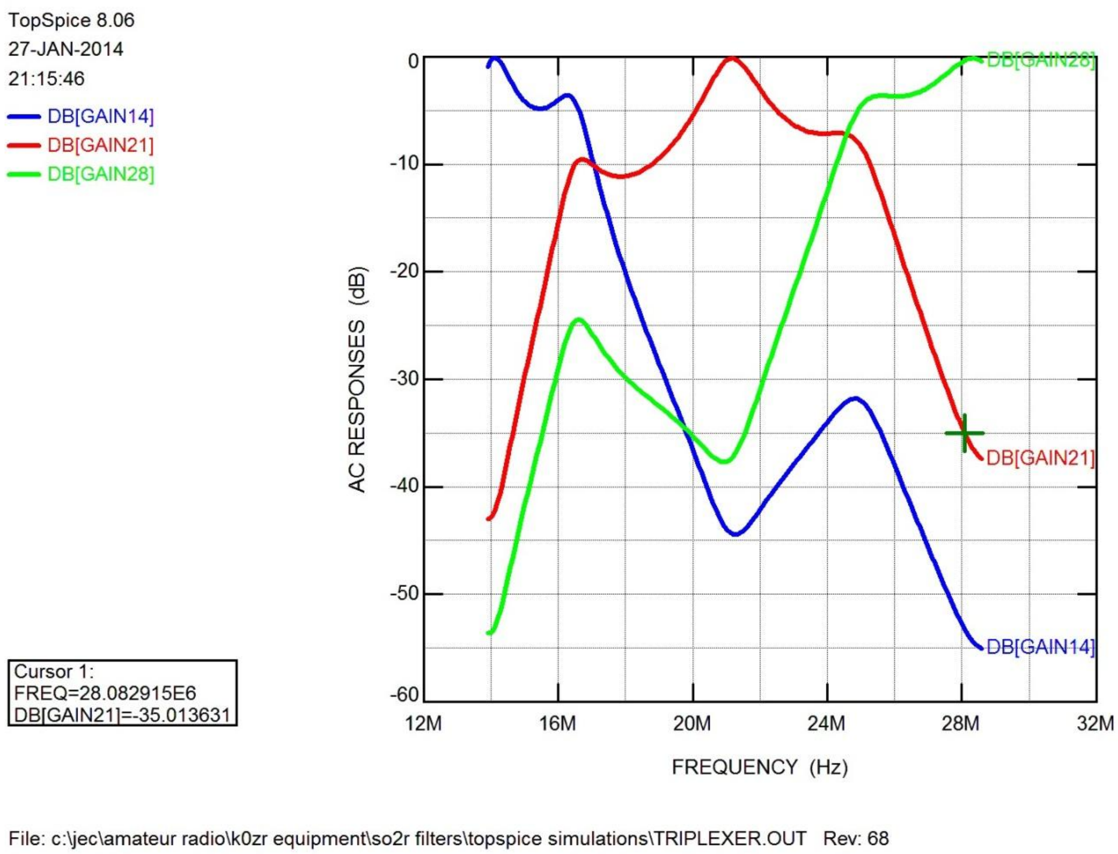


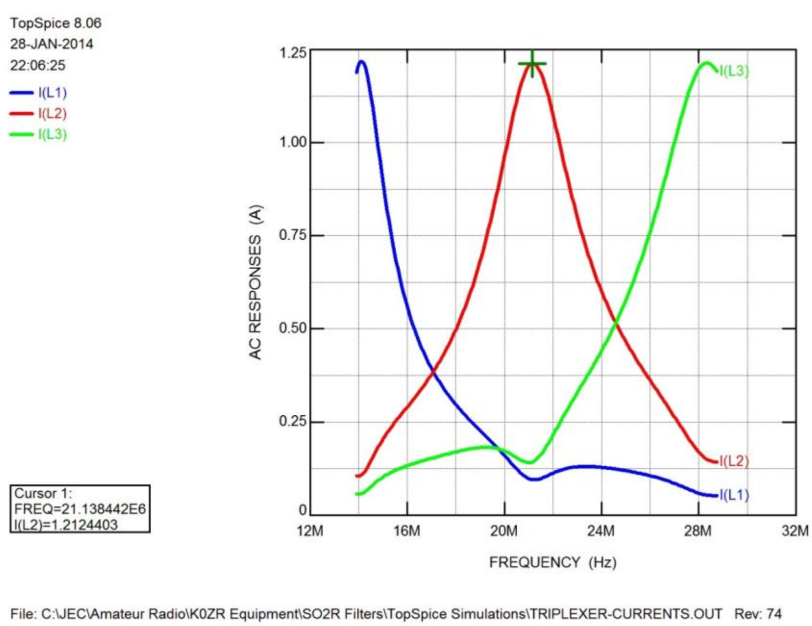
Figure 4

Accompanying Currents and Voltages

The following analyses were conducted using an input power of 150 W CW. Each path was terminated in a real 50 ohms.

Triplexer Currents for Each Triplexer Leg
Peak ~ 1.2 Amps

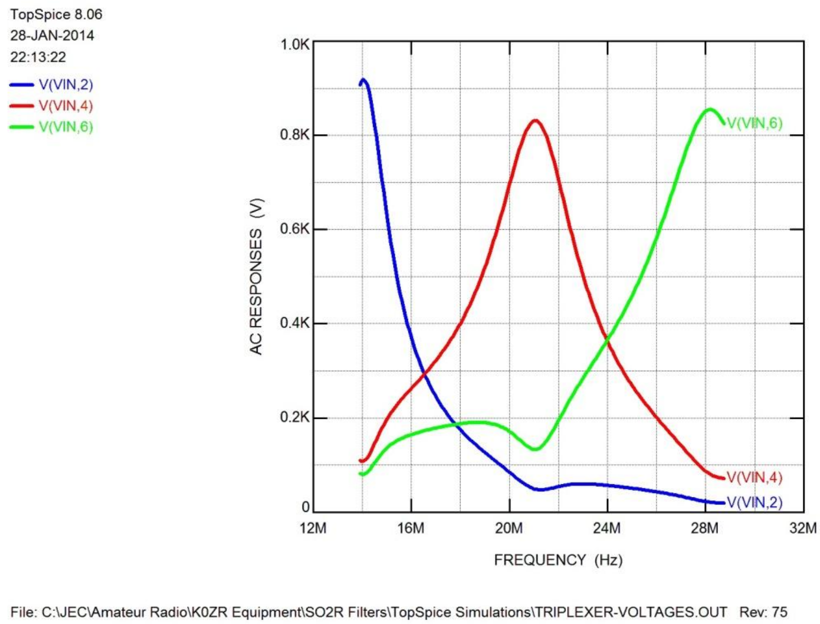
Figure 5



Triplexer Voltages Across Each Series Capacitor – Input 150 W CW

Figure 6

With no VSWR effects it is seen that peak voltages across each capacitor approaches 1 KV.



SPICE Schematic for QST Triplexer

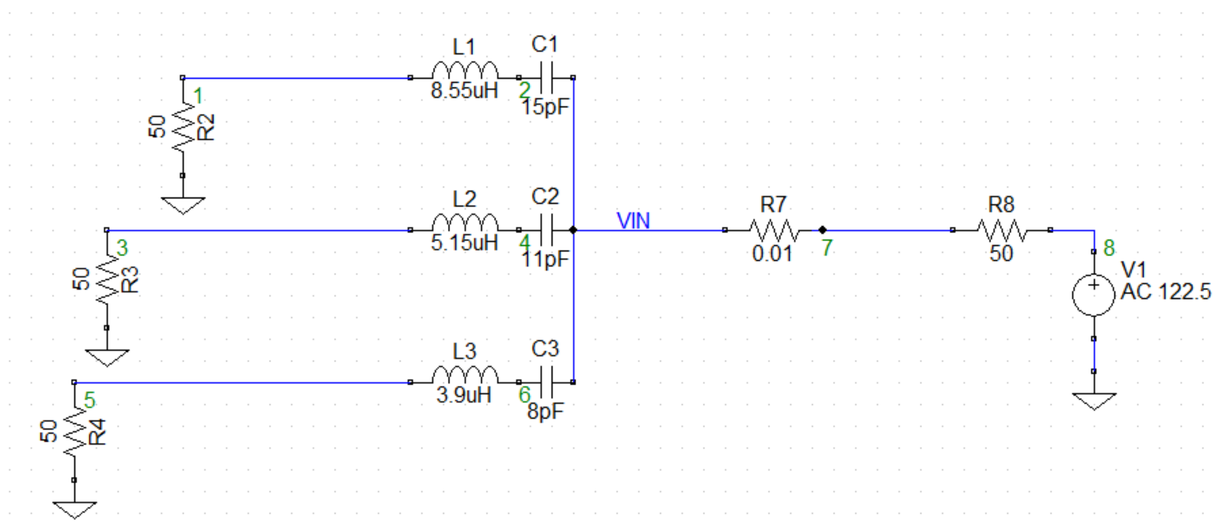


Figure 7

Frequency of Transmitter

	14.05 MHz	21.065 MHz	28.08 MHz
14 MHz Band Input	-0.173	-42.67	-53.4
21 MHz Band Input	-44.17	-0.25	-37.6
28 MHz Band Input	-53.2	-35	-0.36

Table 1
Passband Through Loss as a Function of Frequency
Reference Figure 7

The Improved Triplexer Design – INRAD Implementation[iii]

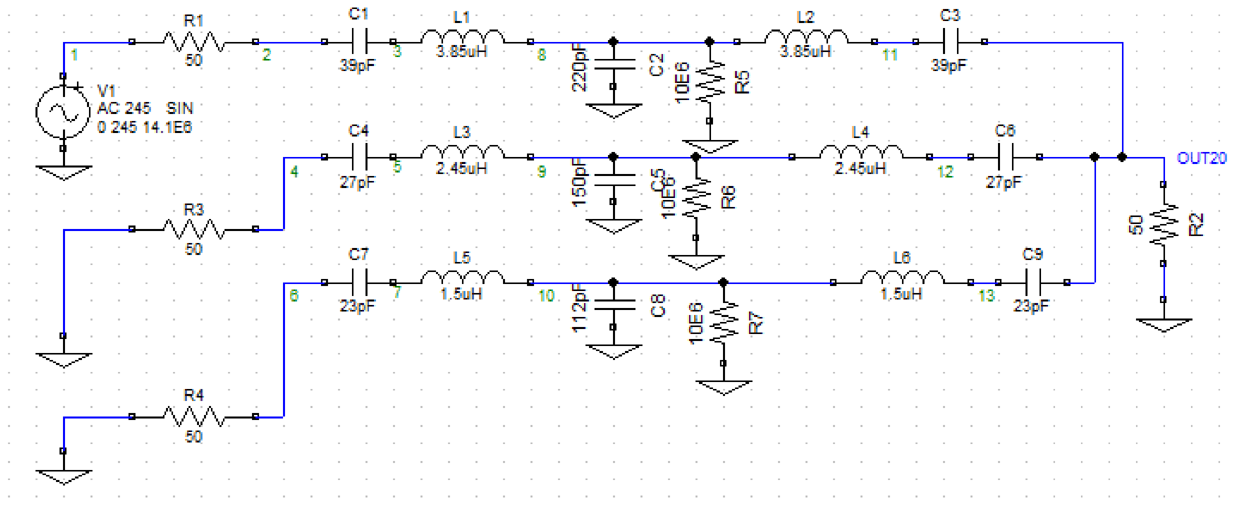


Figure 9

The schematic for the improved triplexer is shown above in Figure 9. As done in the first triplexer design, this version will be analyzed for voltages and currents, as well as its composite frequency response.

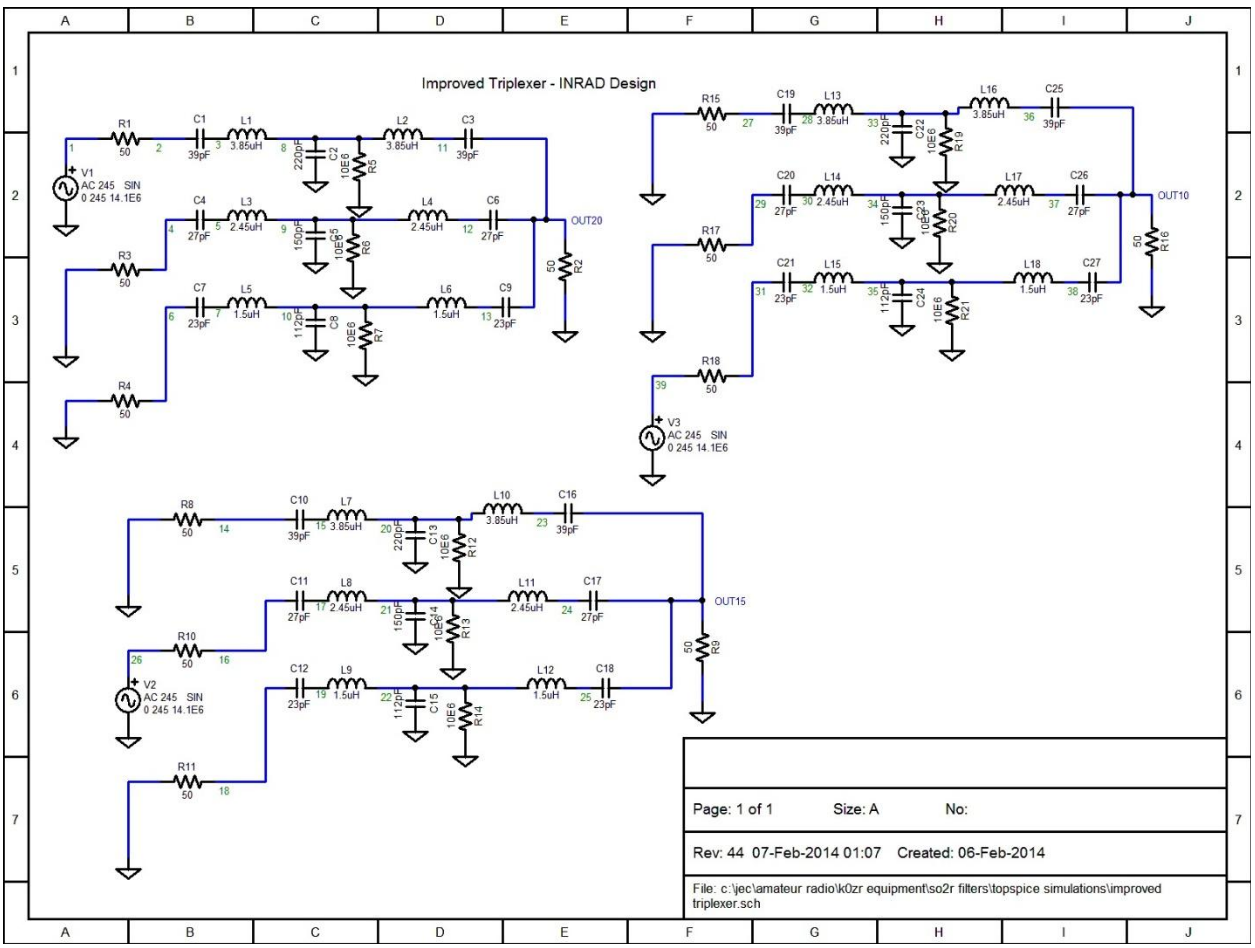


Figure 10

Figure 10 illustrates the circuit setup in SPICE to perform RF analysis for each of the three bands. Notice that each one of the three circuits has a "signal generator" on a different input port. In so doing, the responses for each leg of the triplexer are able to be analyzed separately.

In the following graphs you will notice designators such as V(21). This is the actual RF voltage occurring at node 21 in one of the three schematics shown in Figure 10. Similarly for a current, I(L1) is the accompanying RF current through inductor L1.

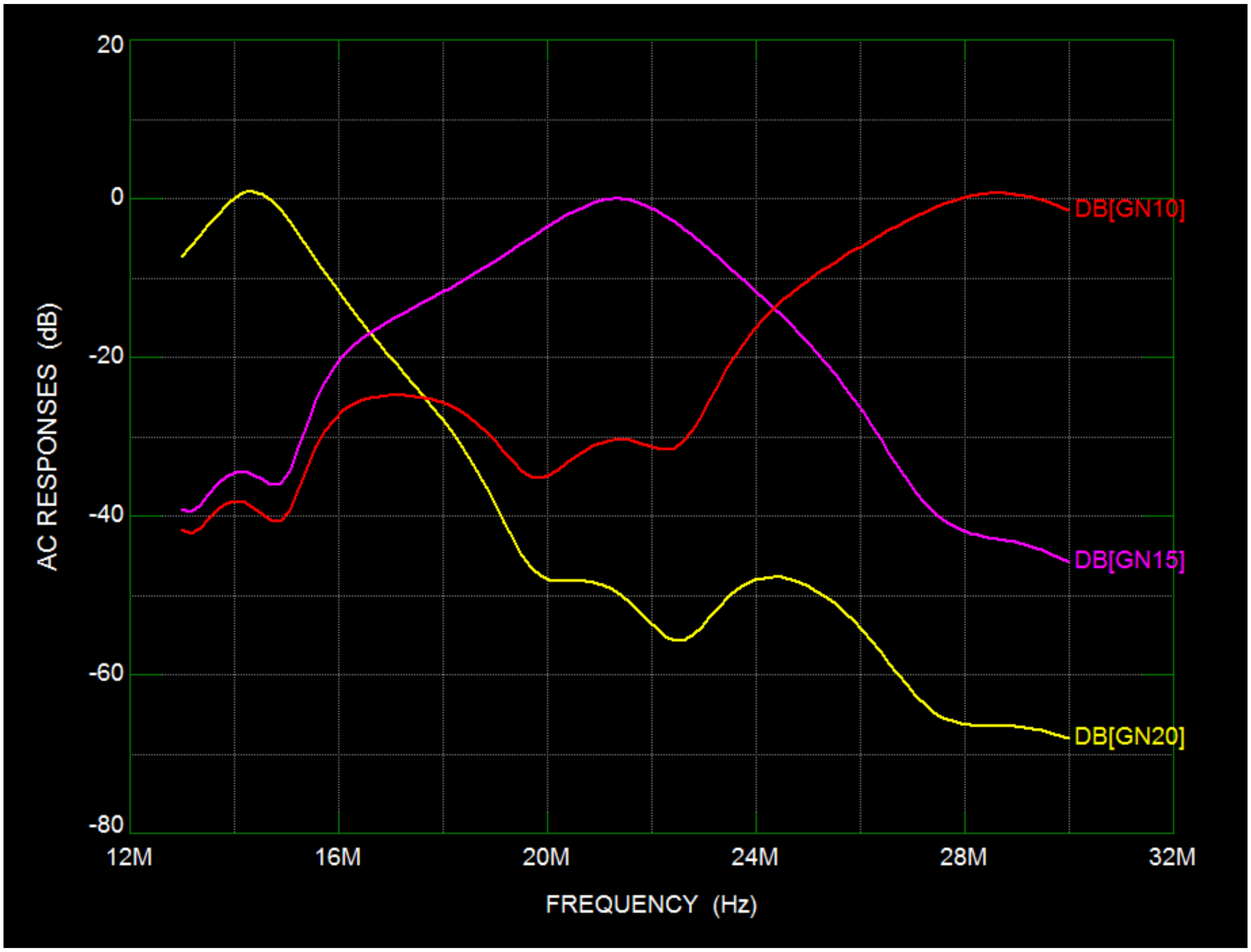


Figure 11

Shown in Figure 11 are the characteristic responses for the three desired passbands. Figure 12 determines the reverse isolation from one driven port to the other two ports which could be envisioned to be feeding two other receivers. This reverse isolation, in conjunction with dedicated bandpass filters at each transceiver, are essential to protect each receiver from the other transmitters sharing the tribander antenna. The scripts written to determine the reverse isolation are the following:

#CALC PWR1REV15=I(R3)*I(R3)*50/PWRIN20 Calculates amount of power from the 20m input port showing up as RF output at the 15m input port (this level is what goes back into the 15m receiver while the 20m transmitter is transmitting)

#CALC PWR1REV10=I(R4)*I(R4)*50/PWRIN20 Calculates amount of power from the 20m input port arriving at the 10m input port

#CALC PWR2REV20=I(R8)*I(R8)*50/PWRIN15 Calculates amount of power from the 15m input port arriving at the 20m input port

#CALC PWR2REV10=I(R11)*I(R11)*50/PWRIN15 Calculates amount of power from the 15m input port arriving at the 10m input port

#CALC PWR3REV20=I(R15)*I(R15)*50/PWRIN10 Calculates amount of power from the 10m input port arriving at the 20m input port

#CALC PWR3REV15=I(R17)*I(R17)*50/PWRIN10 Calculates amount of power from the 10m input port arriving at the 15m input port

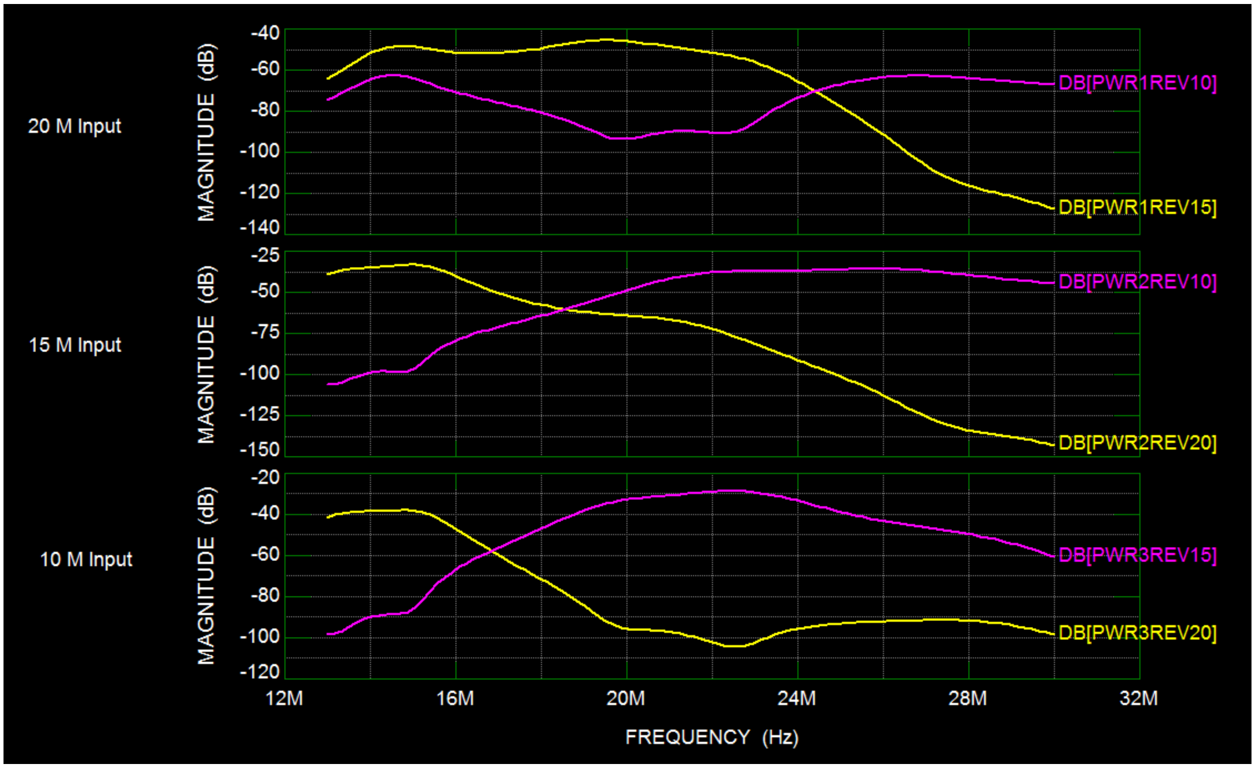


Figure 12

Figure 12 needs some further description. Due to the limitations of my SPICE, all three AC voltage sources in the simulation are swept over the same frequency range, 14 – 30 MHz. In actuality, the top two curves should span only 14 – 14.35 MHz, the next two curves 21 – 21.45 MHz, etc. The top two curves, for example DB[PWR1REV10] and DB[PWR1REV15], show the power from port 1 { 20 m } which is arriving at the other two input ports for 15m and 10m. Therefore, for the 15m input port there is a rejection level of ~ 51 dB to the signal coming from the 20m input port, while at the 10m input port the rejection level is ~ 64 dB. For further emphasis, the transmitter operating on port 1 operates only on 20 m and injects “unwanted RF” into ports 2 and 3, the 10 m and 15m inputs, only in the frequency range of 20m. This RF level, for this scenario, is what is of interest. Placing the results in a table facilitates a quicker overall assessment.

Transmitter Band	Receiver Band	Reverse Isolation, dB
20 m	15m	51.5
	10m	64
15 m	20 m	66.8
	10 m	41.2
10 m	20 m	91
	15 m	50

Table 2
Isolation Between a Particular Input Transmitter Band and the Other Two Input Ports
Essential to Receiver Protection

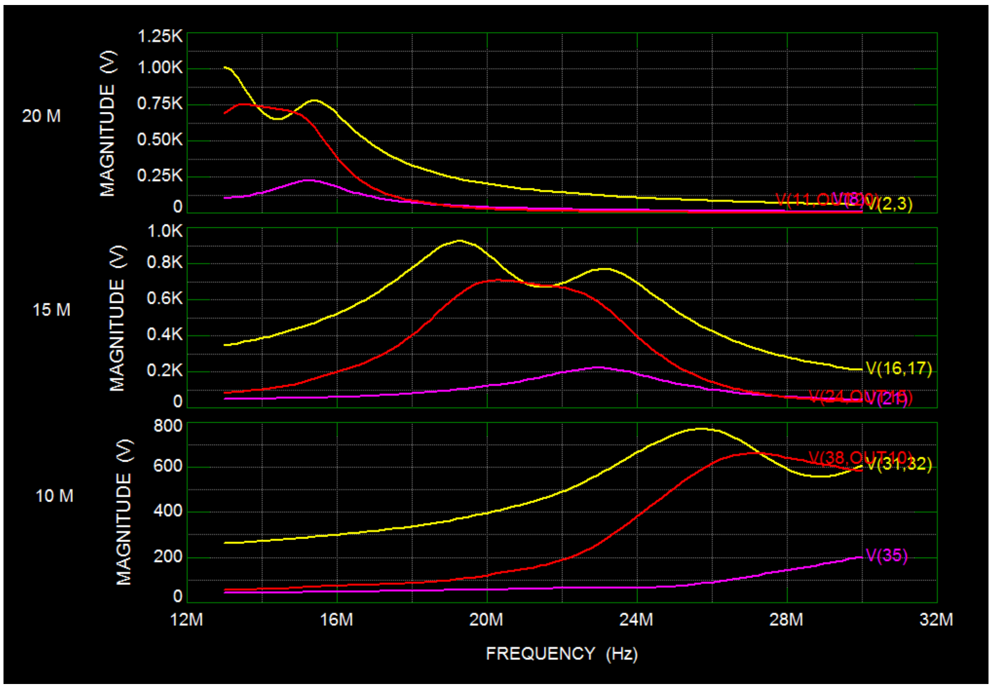


Figure 13

Figure 13 shows the range of voltages across the three capacitors in each leg of the triplexer. There is clearly a need for capacitor voltage ratings around 1500 V for the 20m and 15m legs, while 1000 V may be sufficient for the 10m leg. In each leg the capacitor needing the smallest voltage rating is the shunt capacitor; 500 V should be sufficient.

Figure 14 on the following page illustrates the case for inductor currents. The maximum RF current is around 3 amps, thus a capability of 4 amps would provide some safety margin.

Part Details

Each capacitor in series needs to have a composite voltage rating of at least 1,500 V while the capacitor in shut should find a 500 V rating adequate.

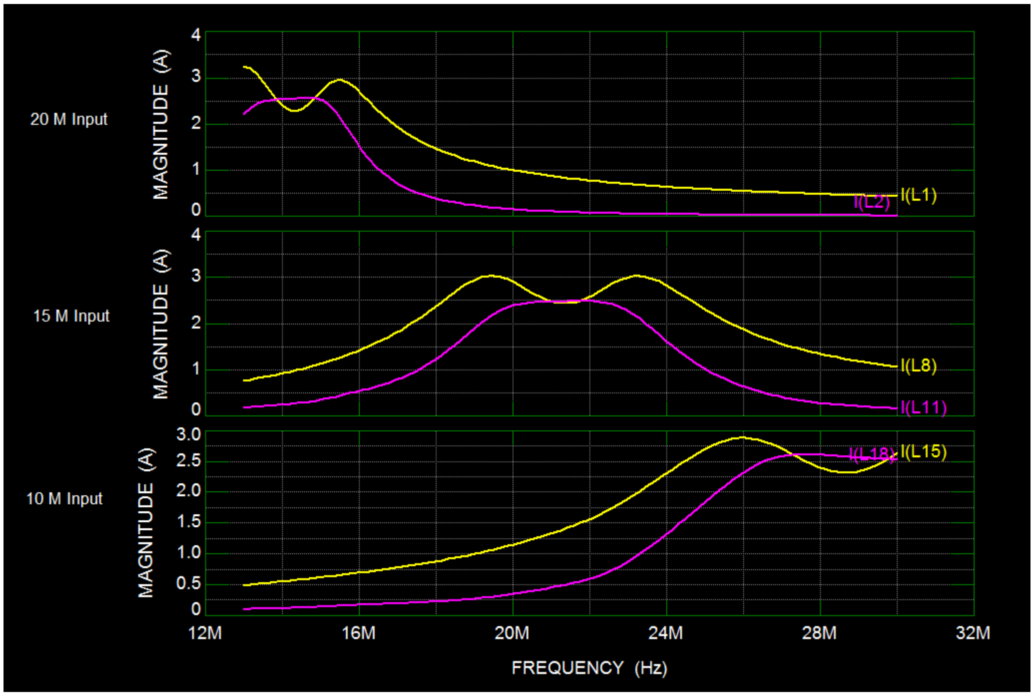


Figure 14
Associated Inductor Currents per Input Band

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[i] HF Yagi Triplexer Especially for Field Day, QST, June 2010, pp. 37-40

[iii] "A Commercial Triplexer Design", ARRL, Inc, George Cutsogeorge, W2VJN, 2013