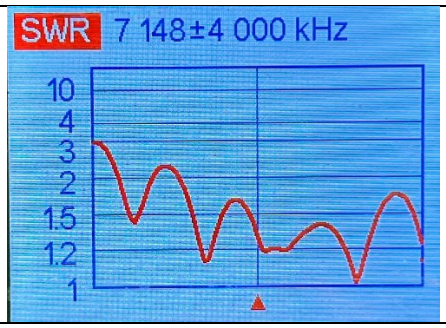
Preparations for Development of an Optimizing Tuning Stub

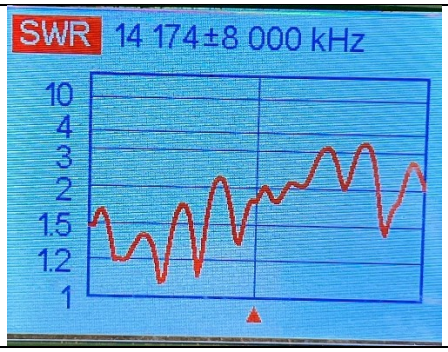
Wesley Cardone, N8QM

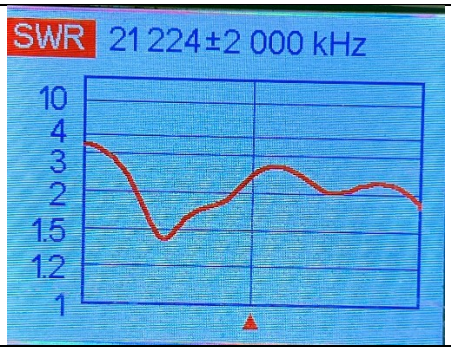
March 2024

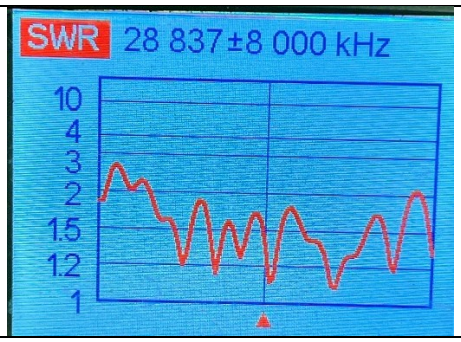
Proposal

It is proposed to design an optimizing tuning stub for the Hustler 4-BVP HF antenna owned

40 meters					
f_{low}	7.000 MHz		f_o	7.148 MHz	
f_{high}	7.300 MHz				
Z	45.1	+	j7.7	Ohms	
L	L = 171.7 nH				
Sweep	3.148 MHz	to		11.148 MHz	

20 meters					
f_{low}	MHz		f_o	14.174 MHz	
f_{high}	MHz				
Z	67.7	-	J35.7	Ohms	
L				C =314.3 pF	
Sweeps	MHz	to			

15 meters					
f_{low}	MHz		f_o	21.224 MHz	
f_{high}	MHz				
Z	81.7	-	J49.7	Ohms	
L				C = 150 pF	
Sweeps	MHz				

10 meters					
f_{low}	MHz		f_o	28.837 MHz	
f_{high}	MHz				
Z	49.1	-	J5.0	Ohms	
L	L = nH			C = 1096 pF	
Sweeps	MHz				

by Chelsea Amateur Club member James Grissom (KD8RFW). **The results of this study will be given at the March 2024 meeting of the Chelsea Amateur Radio Club (WD8IEL).**

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What We Did

Vector impedance measurements were made for each of the four bands at the transmitter feed point. There exists 150 feet of coax between the transmitter and the antenna. A single vector impedance measurement was also made at the antenna feed point but only for the optimal 40 meter frequency of 7.148 MHz. The instrument used to make these measurements with was the RigExpert AA-600 antenna analyzer.

A tuning stub will be designed intended to be placed at the antenna feed point. This will optimize the already excellent vector impedance at the antenna feed point.

It is hopped that having an optimal tuning stub at the antenna feed point will help not only the base 40 meter band operation, but provide a linear offset for the other bands such that their performance will improve.

Our initial evaluation of the subject Hustler antenna is that it is excellent across the board for all of the four bands it was designed to work for. However, we found that operation for 15 meters was its weak spot showing a vector impedance for 21.224 MHz of

$$Z_{21.224\ \text{MHz}} = 81.7 - j49.7 \text{ for an SWR of } 2.4{:}1$$

We also suspect that there exists an offset in the overall vector impedance that we hope that the tuning stub will correct. The suspected offset we observed was considered as a whole set of the measurements taken at the transmitter end of the 150 feet of coax cable. Please look at the SWR sweep for 40 meters shown above. Note that the SWR exhibits a downward trend as the frequency increases beyond 7.148 MHz. The SWR peaks at a frequency slightly greater than 7.148 MHz. The SWR seep taken at the antenna feed point does not contradict this observation.

We then looked at the performance at 20 meters and reached no conclusion. The SWR sweep suggests a contradiction to that of 40 meters but is otherwise inconclusive.

We then looked at how the antenna did at 15 meters (the antenna weak spot) and again, came up inconclusive.

Finally, look at 10 meters, the SWR plot suggests agreement with that of 40 meters.

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40 meters measured at the <u>antenna feed point</u>

f_{low}	MHz		f_o	7.148 MHz
f_{high}	MHz			
Z	21.2	+	J7.2	Ohms
L	L = nH			C = 1096 pF
Sweeps	MHz			

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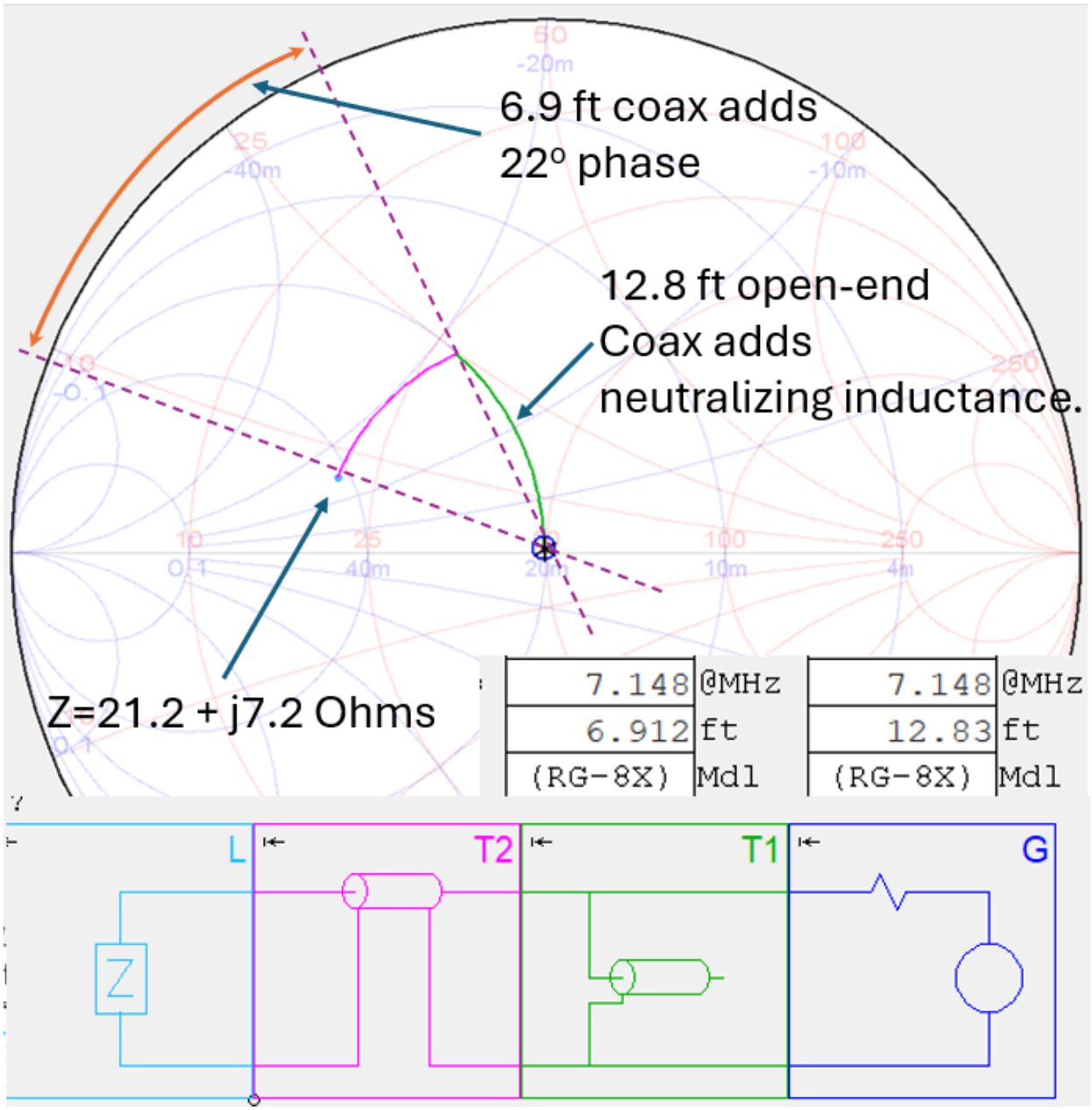

A tuning stub was designed based upon the vector impedance measured at the antenna feed point. This vector impedance showed 21.2 real Ohms resistance placing the Smith Chart dot to the left of "home-plate." It was also showing 7.2 Ohms inductive reactance which was neutralized with an open stub that was 12.8 feet long. But the coax feed was lengthened by 6.9 feet so as to add 22o phase getting the vector impedance to a conductive line leading to home-plate.

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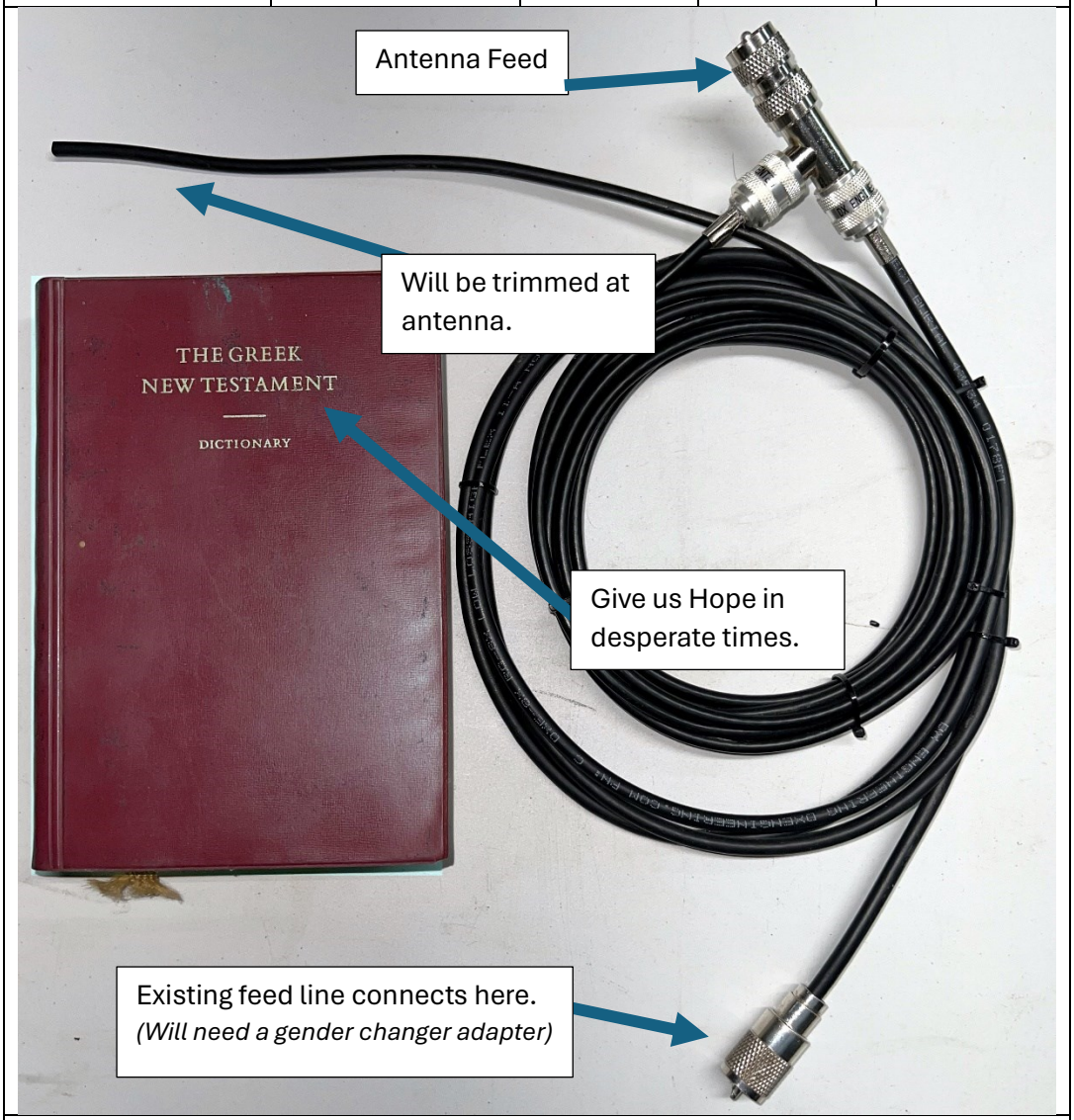
Tuning Stub Design Parameters				
Transmission Line Type	**Part Number**	**RG-213/U**	**RG-8X**	**RG-58U**
	vf	**0.66**	**0.82**	**0.66**
Feed Length Adder	Feet	5.696	6.978	5.357
	Centimeters	173.6	***212.7***	163.3
Pigtail	Feet	10.57	12.98	10.92
	Centimeters	322.2	395.6	***332.9***



Pictured above is the tuning stub fabricated according to the above prescription. It consists of two pieces of coax that were laying around the house, otherwise being

unused. One is the feed line extender. This one simply causes a delay in the signal reaching the antenna creating a phase difference (22°). This cable was constructed using RG-8X that was literally laying around on my basement floor (but out of the way). It's length is cut so as to introduce the required 22° phase shift.

The other coax was taken from a non-performing 2 meter antenna that I bought from Amazon a couple of years ago. It is open-ended so as to become an inductor neutralizing the net antenna capacitance at 40 meters. The antenna NEVER worked and has been sitting in my basement collecting dust and sometimes getting in the way. I cut this one too long so that it can be trimmed in the field. The design specification called for a length of 333 centimeters. We will hook this up to Jim's HF antenna input and take a vector impedance measurement. We will trim the coax at that time for an optimal cut.

What Is Success?

The object of this tuning stub is to place a linear offset at the antenna feed point such that vector impedances shift linearly across the board for the entire range of operation from 40 to 10 meters. To explain further, consider the observed operation for 40 meters. The SWR sweep suggests that an optimal resonance exists at a frequency slightly greater than 7.148 MHz. A tuning stub will shift the vector impedance down such that the minimum SWR will occur at 7.148 MHz. It is known that the tuning stub will accomplish that. What is not known, however, is if that same tuning stub will shift the entire spectrum of vector impedance linearly such that a benefit will be realized for the other bands that the antenna operates on.

If Successful

If this tuning stub is successful, the performance improvement may not be noticed except for 15 meters. Succes will be known to exist at 40 meters. But the success of this venture will rest on what happens at 15 meters. The present operation at 15 meters is marginal hanging in at around roughly 2:1 which is barely acceptable. Our success will be if that SWR measurement noticeably improves without adversely affecting the operation on 20 and 10 meters.