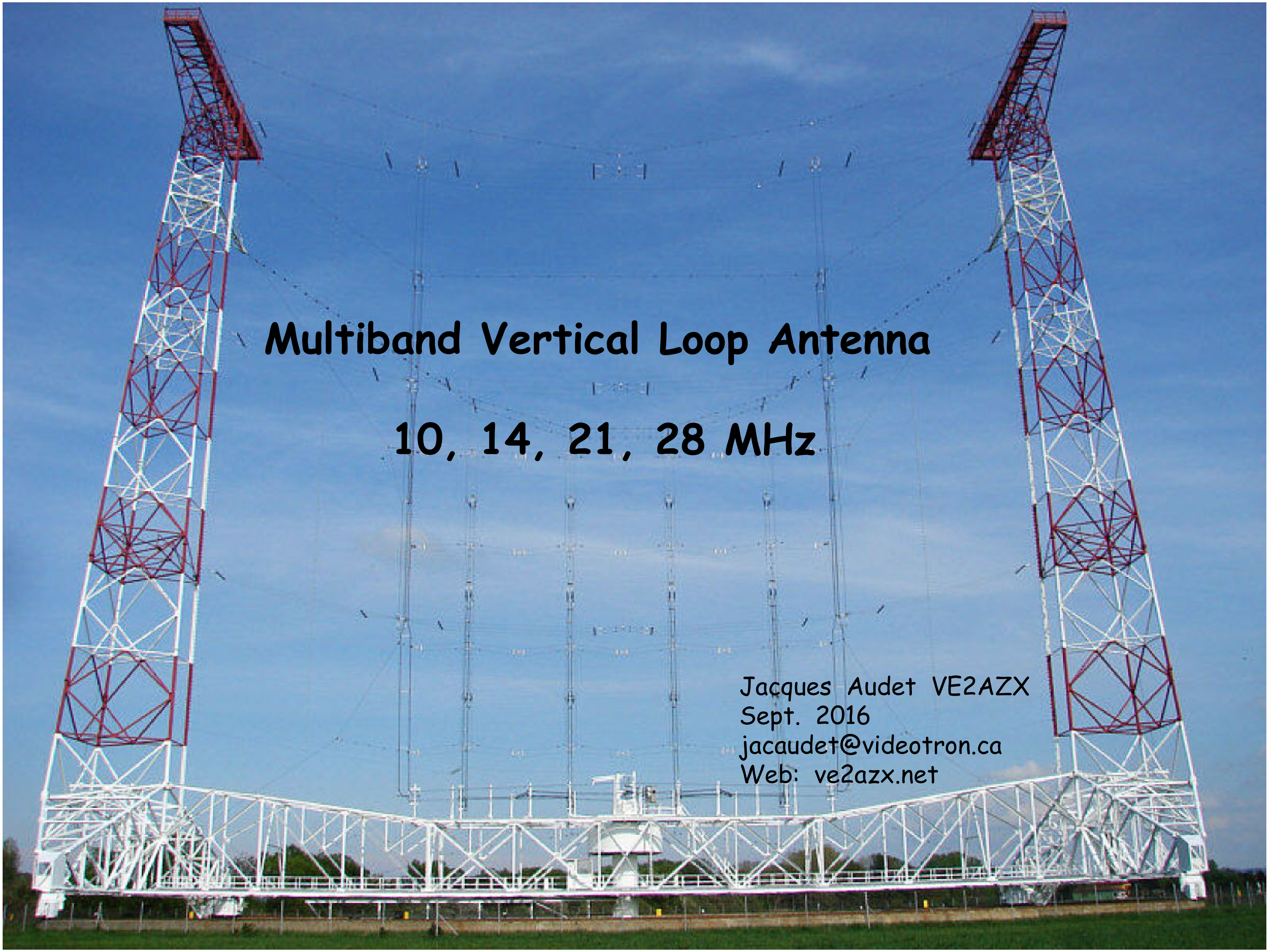


Multiband Vertical Loop Antenna

10, 14, 21, 28 MHz

Jacques Audet VE2AZX
Sept. 2016
jacaudet@videotron.ca
Web: ve2azx.net

DX Wire Antennas – Comparisons

Antenna	Plus	Minus
Vertical Delta Loop	- Low height and low radiation angle - Portable and compact - No radials - Lower Noise	- Essentially a mono-band antenna - Depends on ground quality - Very large on 80m and 160m
Dipole	- No radials	- Needs Height for DX
Monopole	- Low height and low radiation angle - Good on low bands - Higher Noise	- Many radials required - Depends more on ground quality

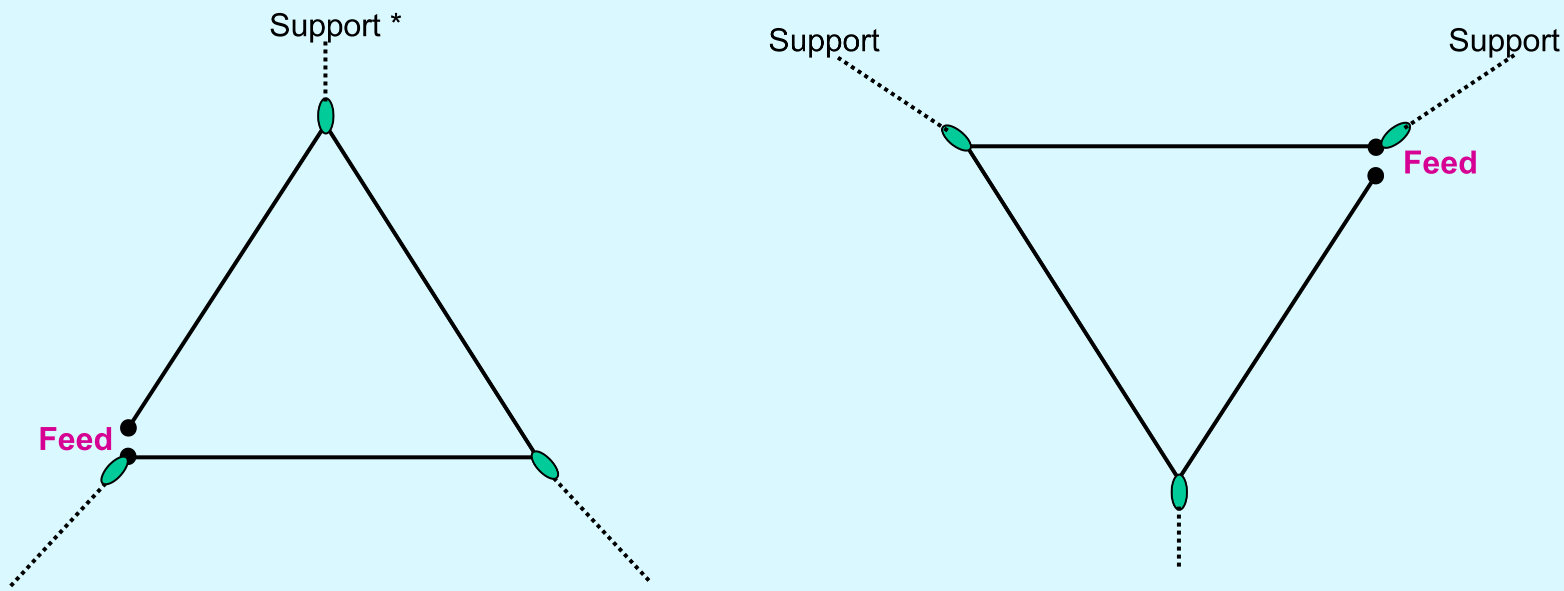
Vertical Loop Antenna Polarization

- The wave emitted by the vertical loop may be polarized vertical or horizontal depending on the feedpoint location
- Vertical polarization is preferred when the antenna is low
- Select the feed-point for low radiation angle for best DX results

One wavelength Delta loops

$$\text{Length (ft.)} = \frac{1005}{f_{MHz}}$$

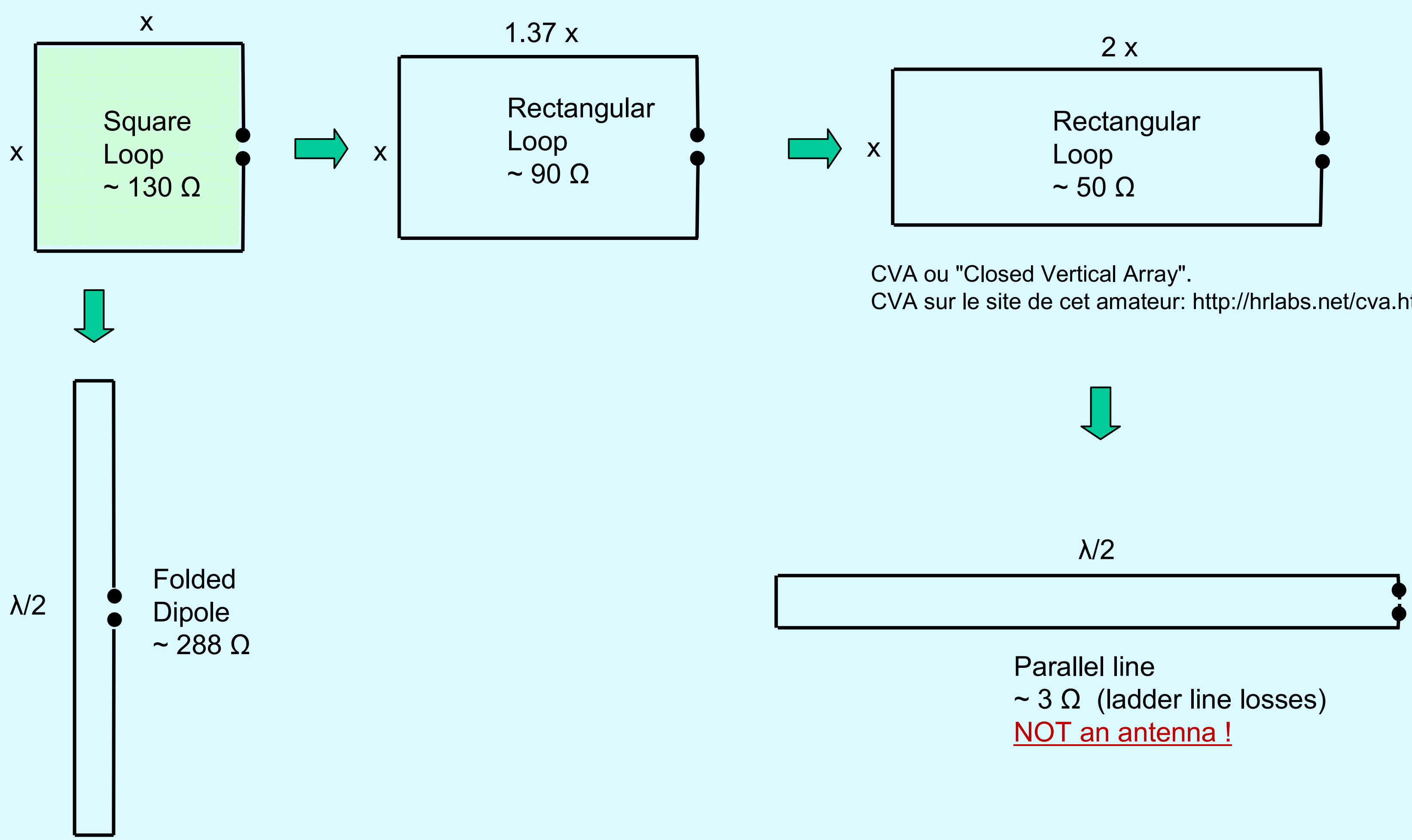
Feed point for low angle radiation
VERTICAL Polarization
Impedance: ~ 100 Ω



* Preferably not conductive

One wavelength Square or Rectangular loops – What shape ?

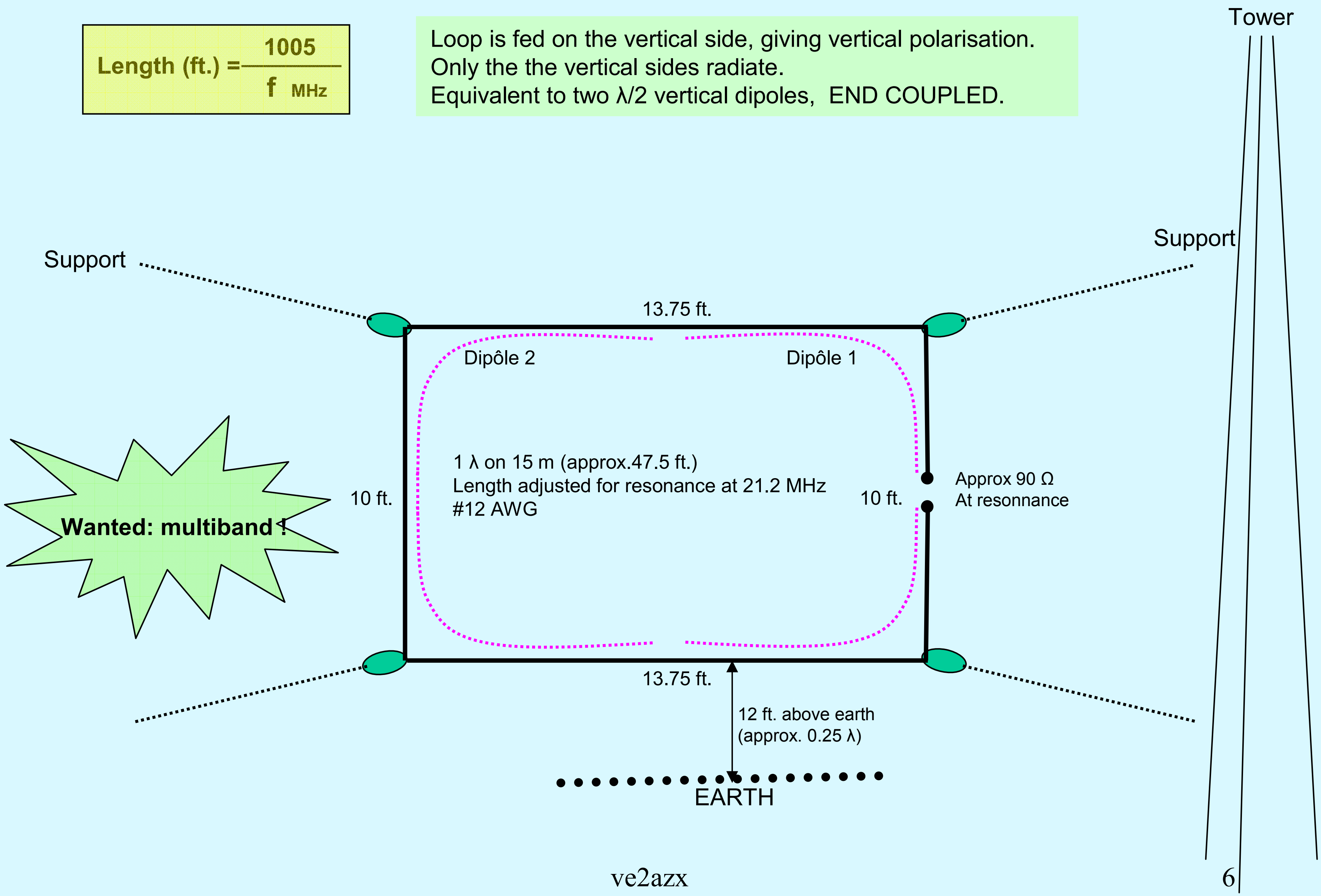
Feed points for low angle radiation
VERTICAL Polarization



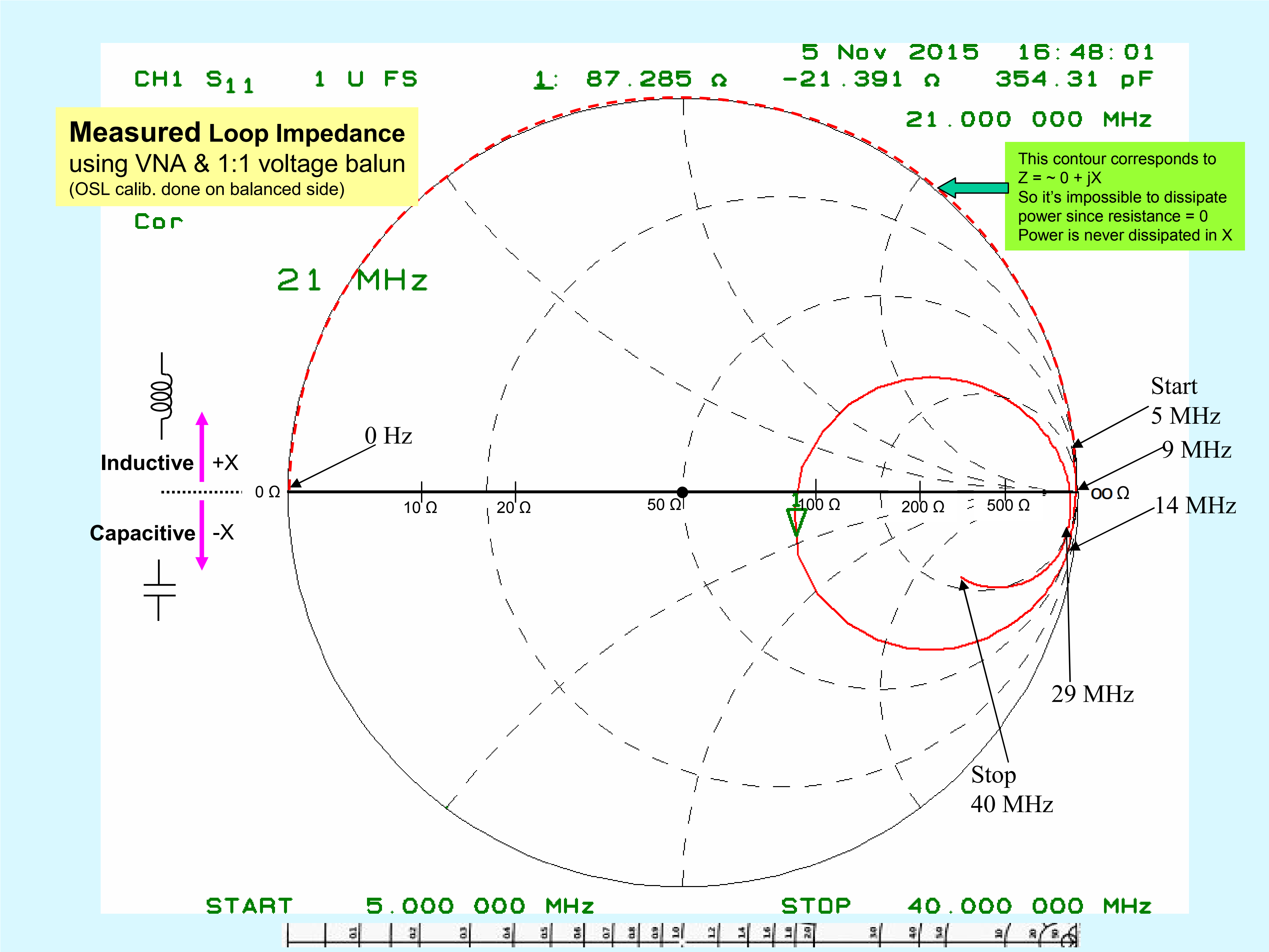
One wavelength Rectangular loop for 21 MHz

$$\text{Length (ft.)} = \frac{1005}{f_{MHz}}$$

Loop is fed on the vertical side, giving vertical polarisation.
Only the the vertical sides radiate.
Equivalent to two λ/2 vertical dipoles, END COUPLED.

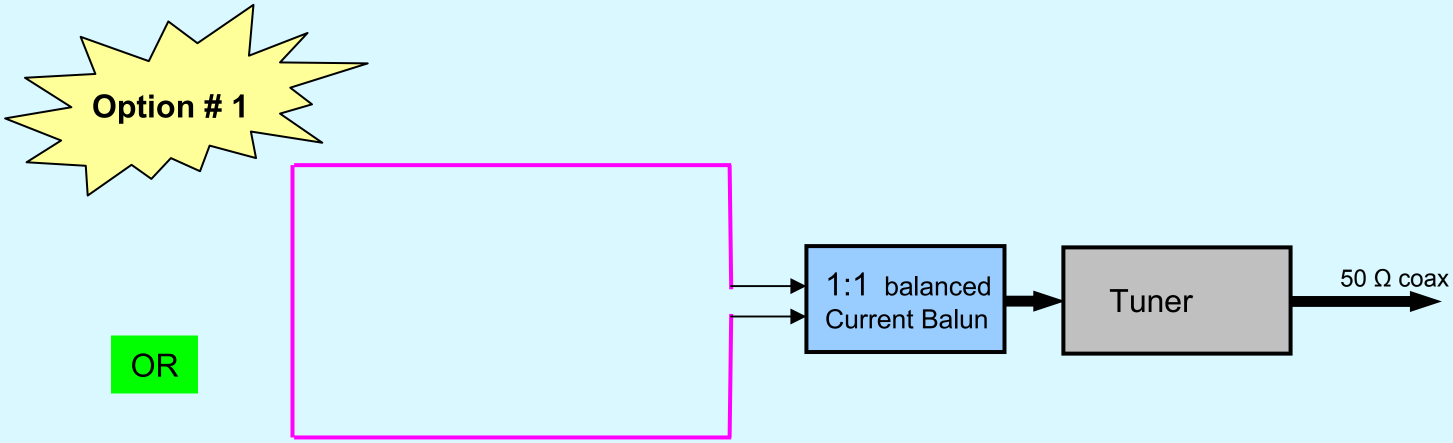


ve2azx

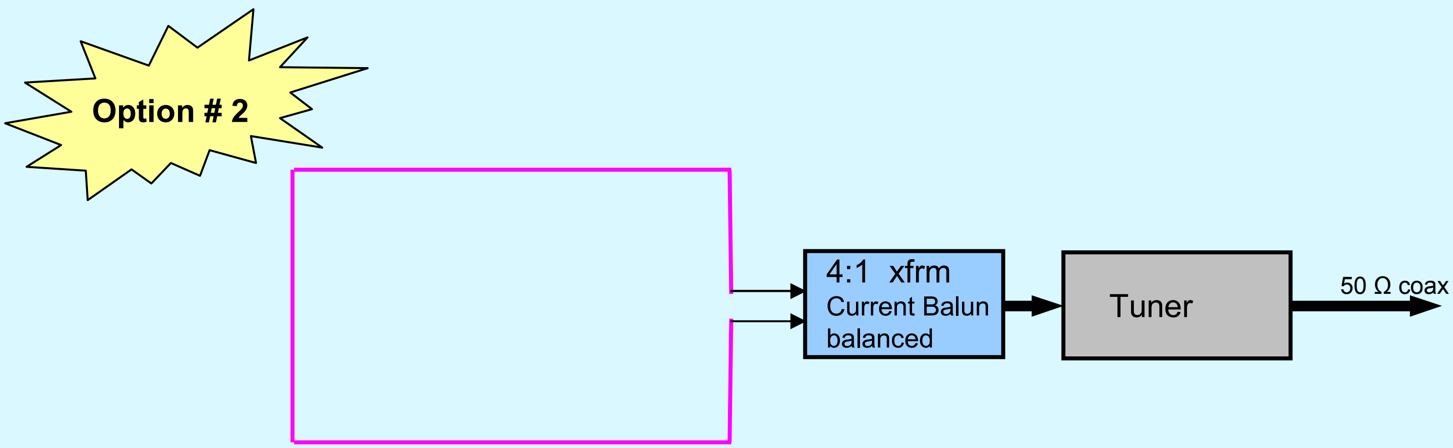


5 Nov 2015 16:48:01
CH1 S11 1 U FS
1: 87.285 Ω -21.391 Ω 354.31 pF
21.000 000 MHz
Measured Loop Impedance
using VNA & 1:1 voltage balun
(OSL calib. done on balanced side)
Cor
21 MHz
This contour corresponds to
Z = ~ 0 + jX
So it's impossible to dissipate
power since resistance = 0
Power is never dissipated in X
0 Hz
Inductive
+X
0 Ω
Capacitive
-X
10 Ω
20 Ω
50 Ω
100 Ω
200 Ω
500 Ω
oo Ω
Start
5 MHz
9 MHz
14 MHz
29 MHz
Stop
40 MHz
START 5.000 000 MHz
STOP 40.000 000 MHz

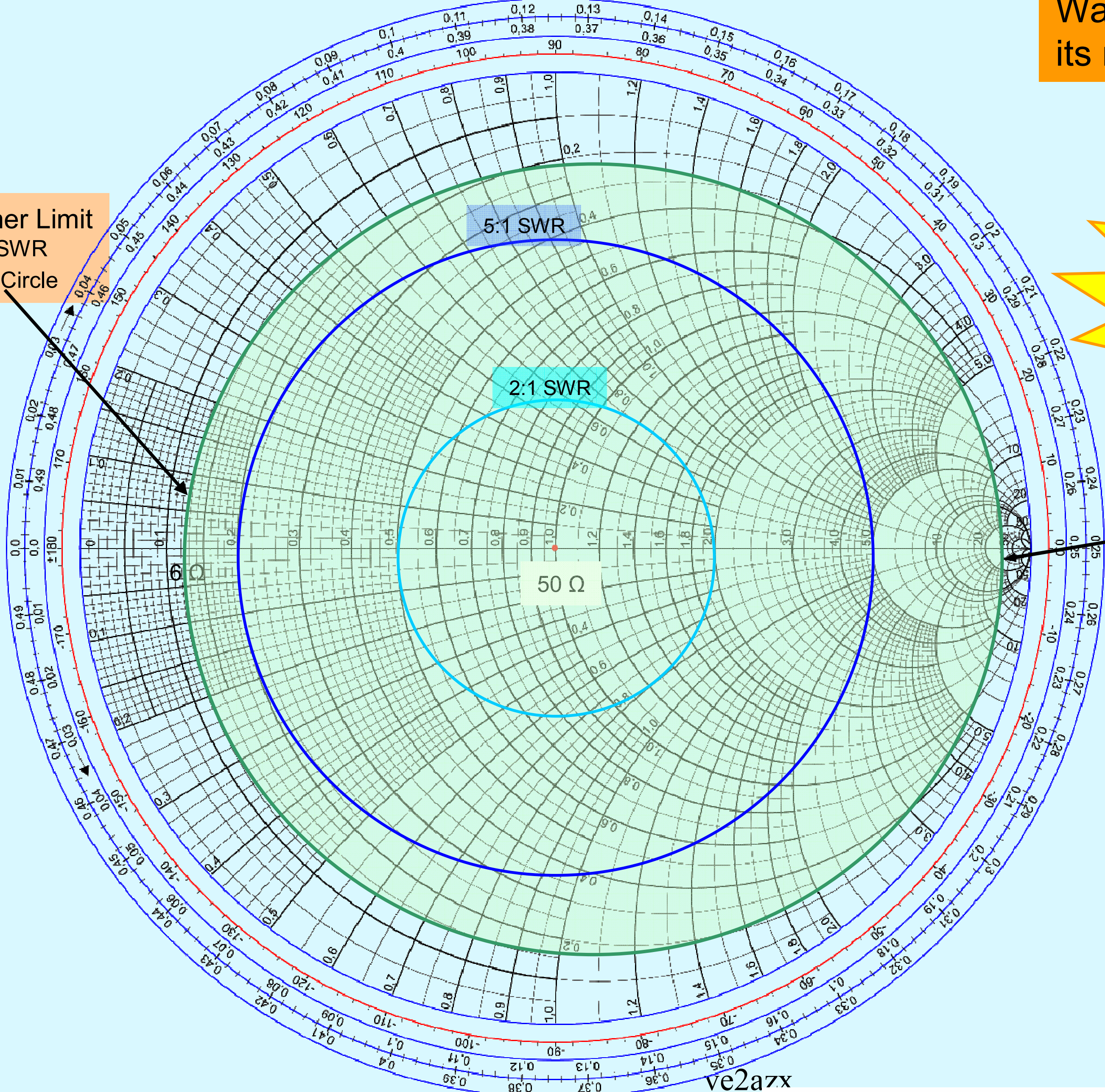
Using a Tuner at the loop feedpoint



OR



Warning ! The tuner has its matching Limits



Tuner Limit
8:1 SWR
6 Ω Circle

Tuner Limit
32:1 SWR
1600 Ω

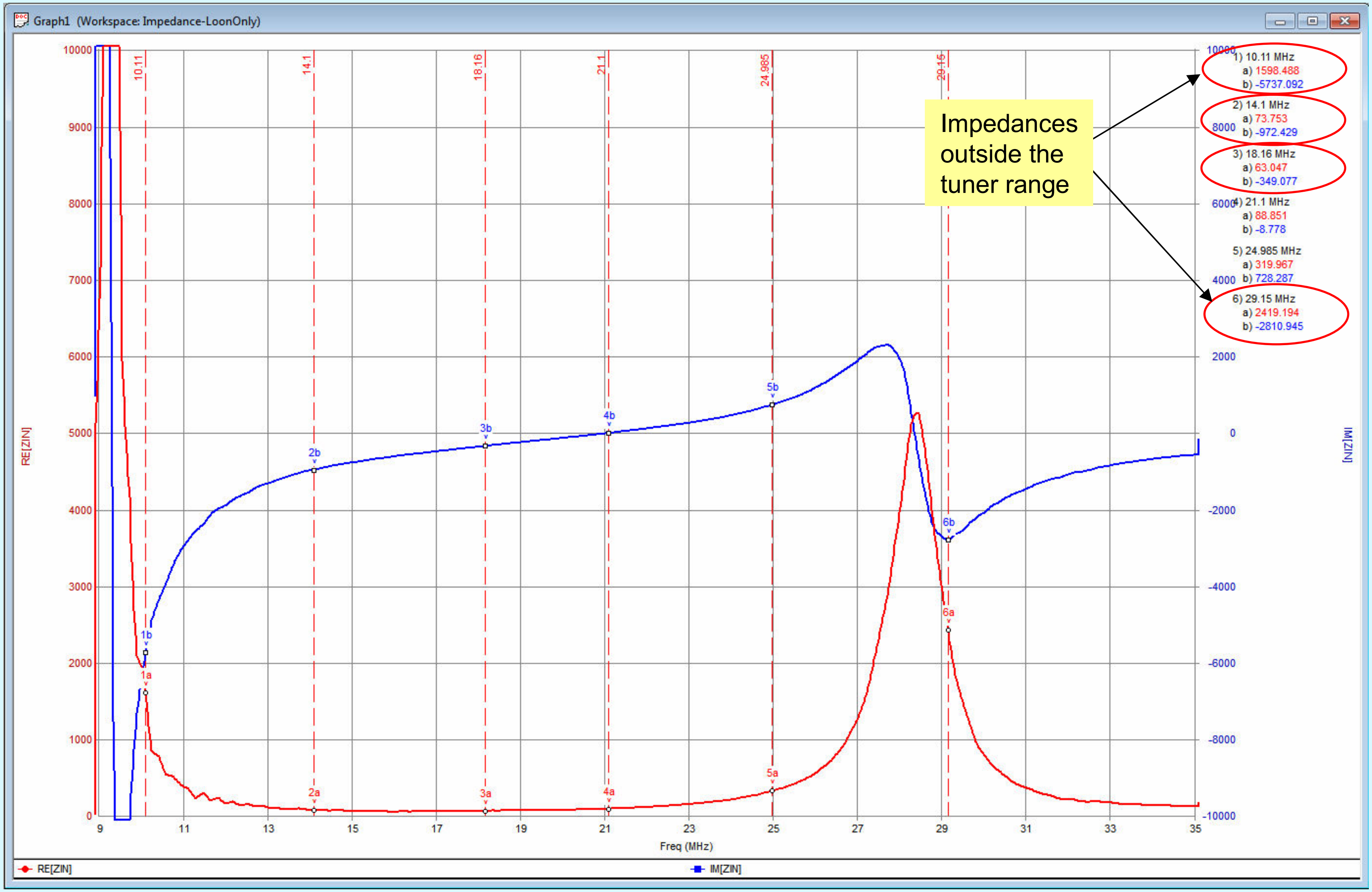
Tuner losses increase as you get closer to the limits.

MFJ 929 Tuner

- Impedance matching range : 6 to 1600 ohms
- SWR matching range : Up to 8:1 for < 50 ohms and up to 32:1 for > 50 ohms

Measured Loop Impedance using 1:1 Balun

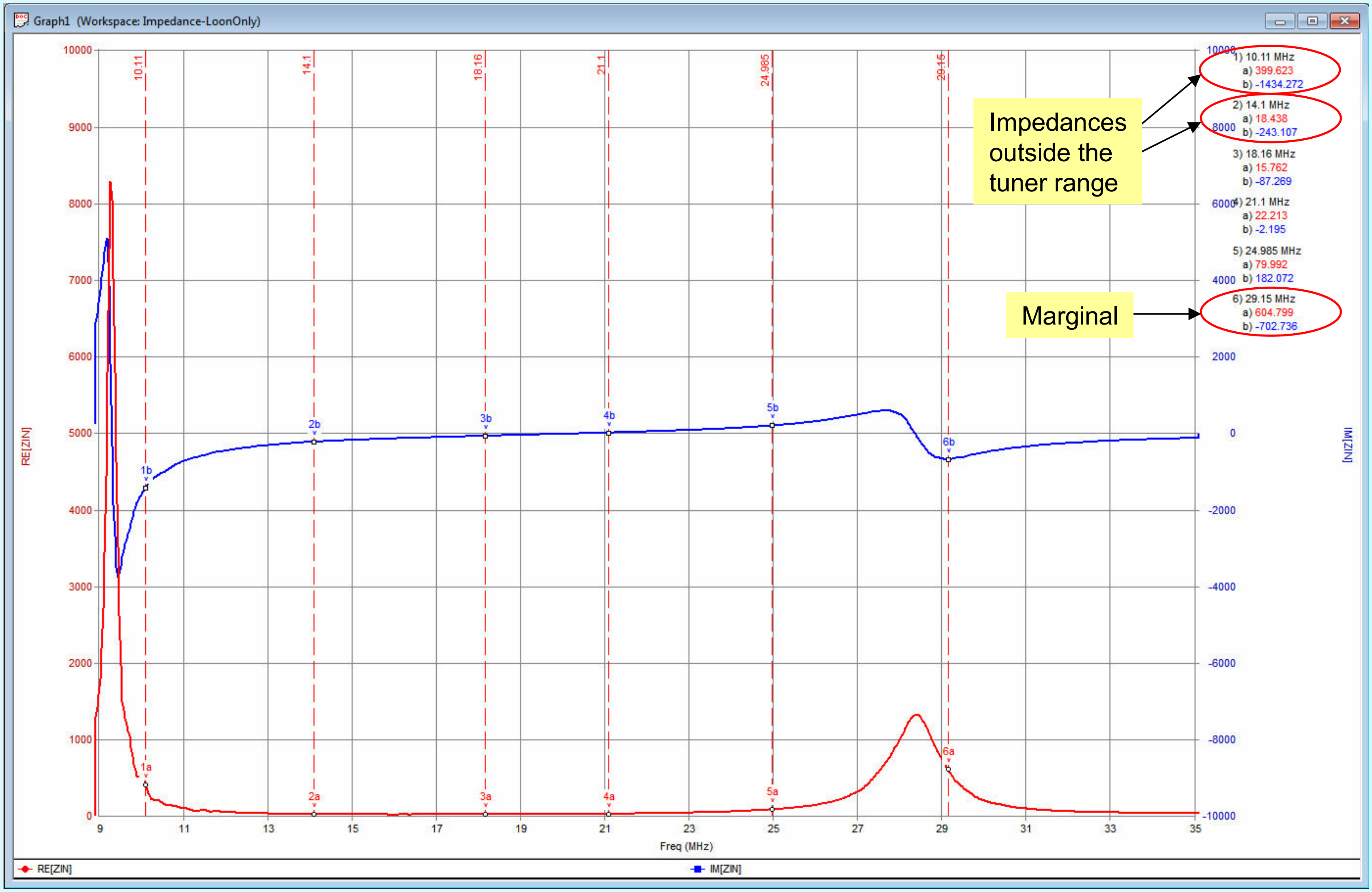
Option # 1



Measured Loop Impedance + 4:1 balun / xfrm added

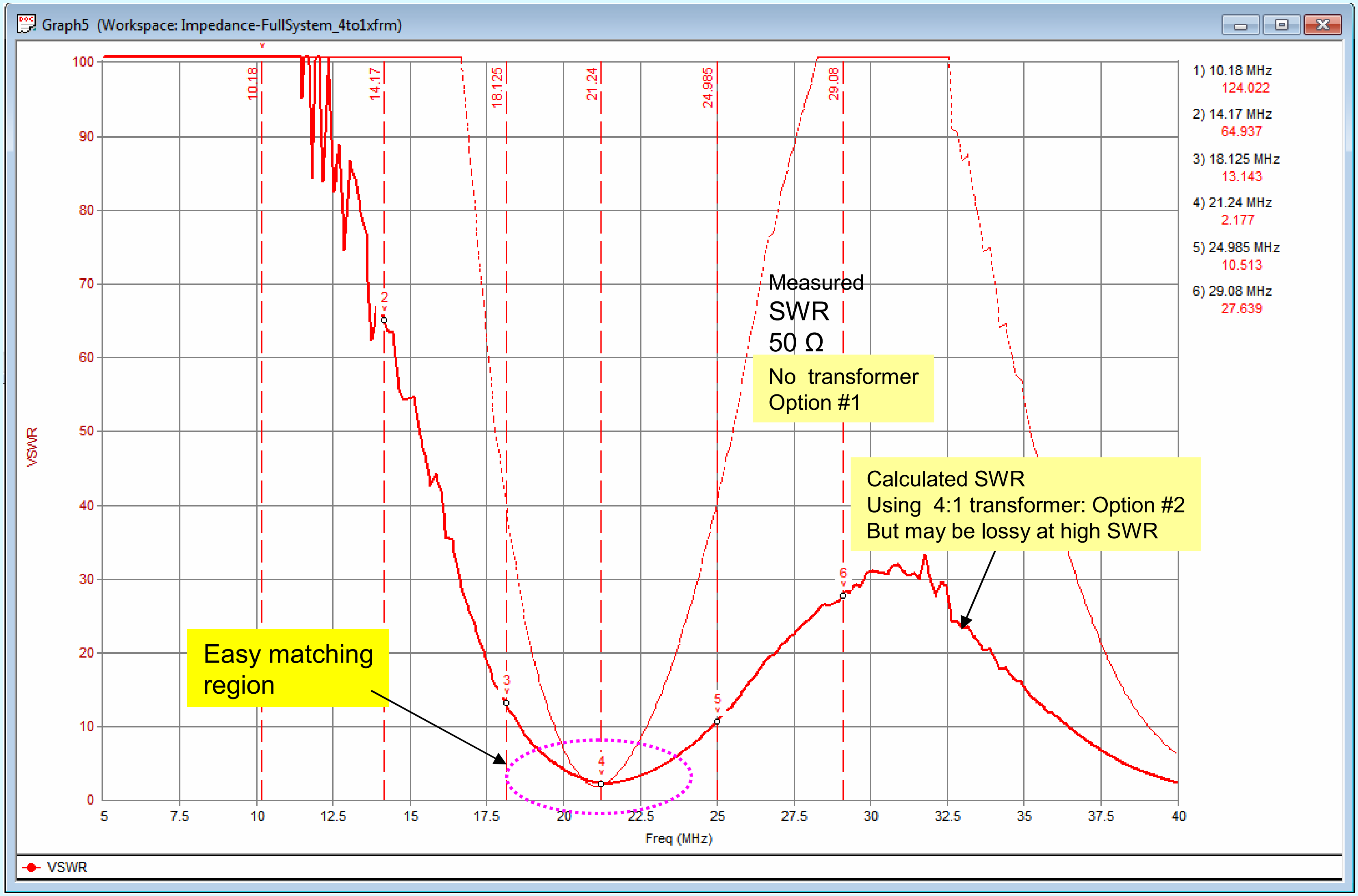
Option # 2

- Still have impedances outside tuner range
- Connecting the Tuner + Balun at feedpoint <u>NOT convenient</u>
- <u>Losses in 4:1 balun</u>



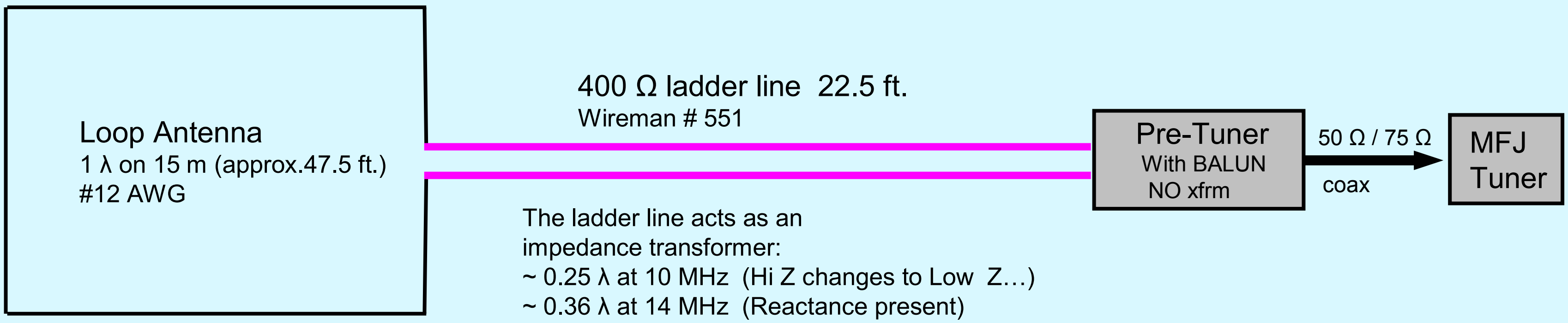
Measured Loop SWR curves with / without 4:1 balun / xfrm added

Options # 1 & 2



Option # 3

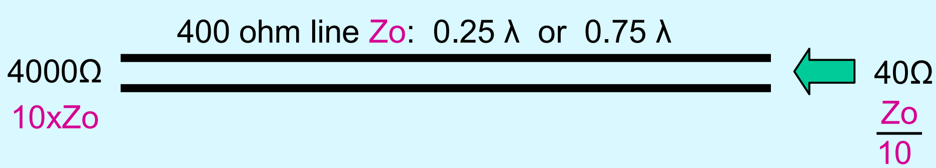
Impedance Transformations with a 400 Ω balanced line



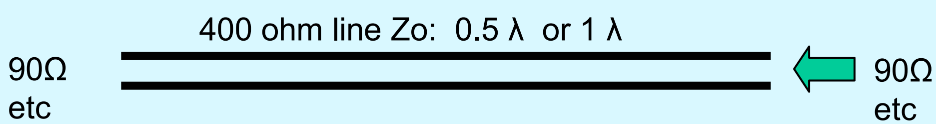
The ladder line acts as an impedance transformer:

~ 0.25 λ at 10 MHz (Hi Z changes to Low Z…)
~ 0.36 λ at 14 MHz (Reactance present)
~ 0.54 λ at 21 MHz (Little change in Z)
~ 0.74 λ at 29 MHz (Hi Z changes to Low Z…)

Examples



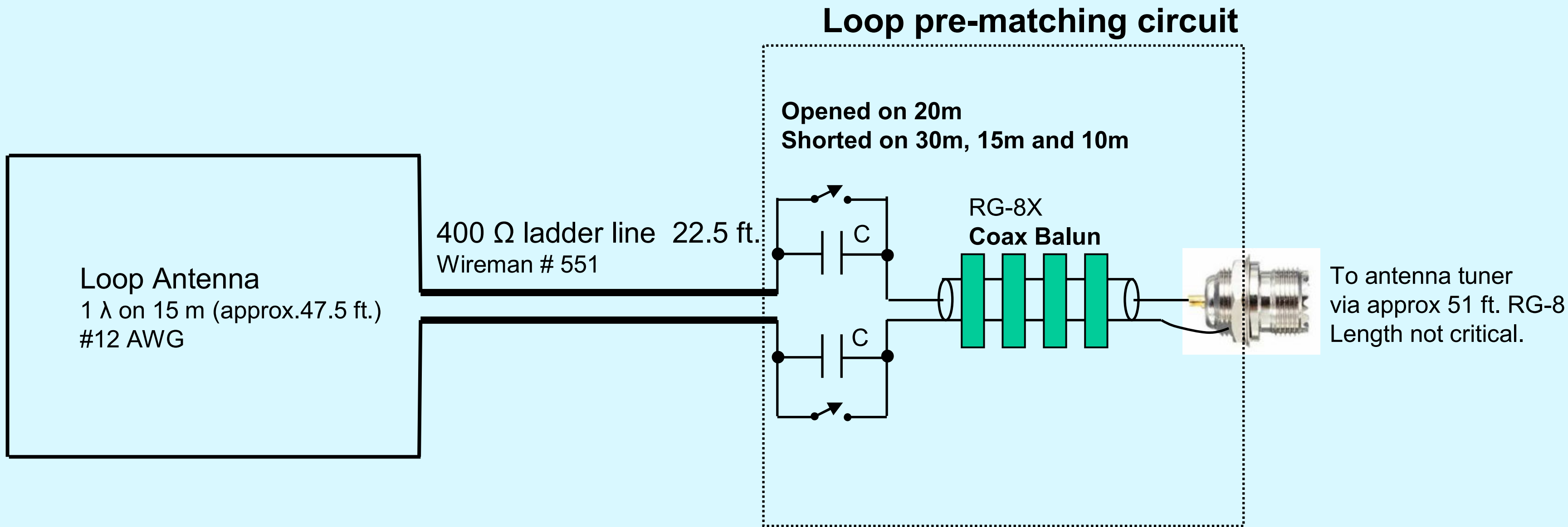
Odd multiples of λ/4



Even multiples of λ/2

Loop and pre-matching circuit

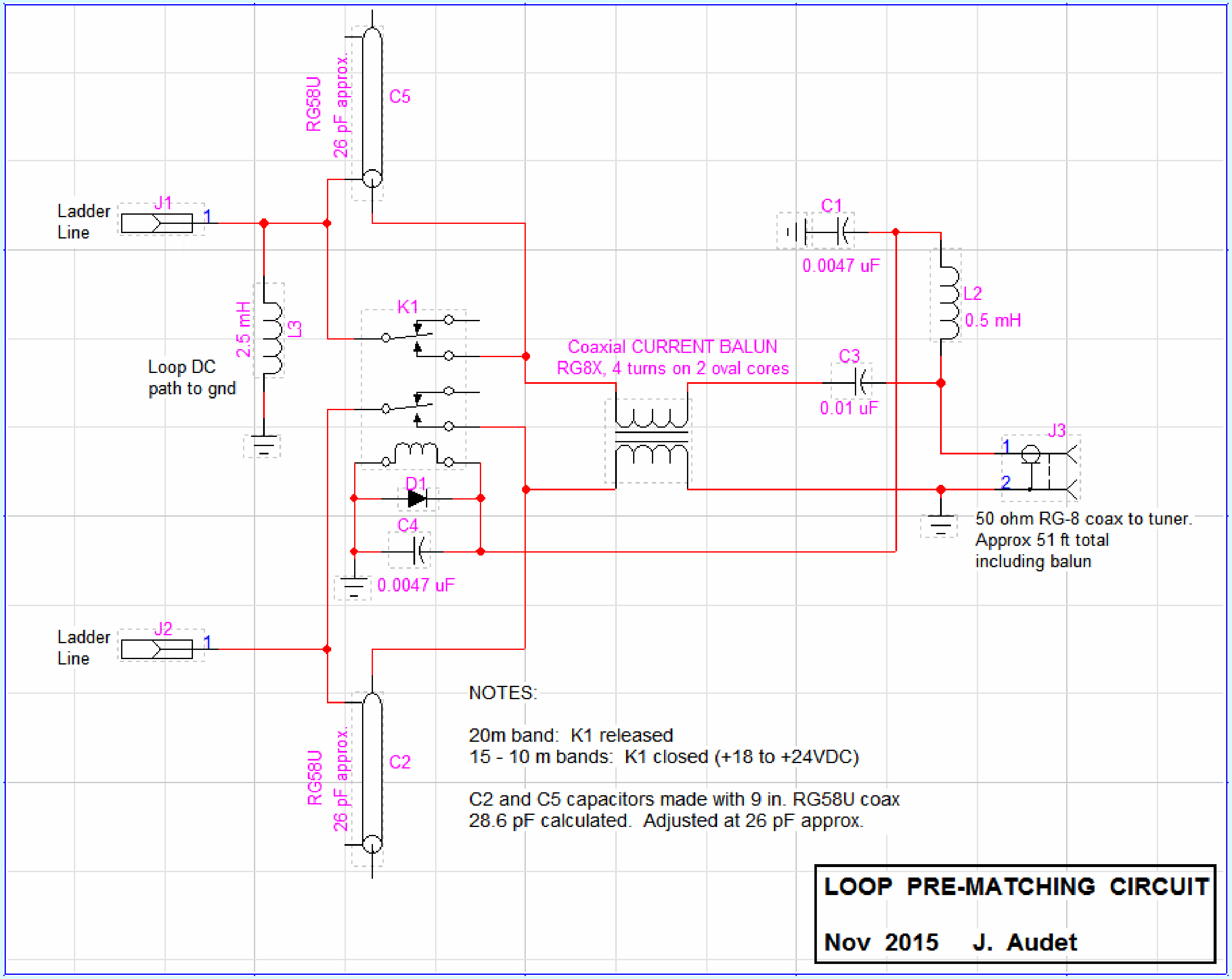
Uses a ladder line as impedance transformer



The length of the ladder line is approx. λ/2 at 21 MHz. **Obtained from simulations.**
The 90 Ω loop impedance is transformed to about the same value on 21 MHz.

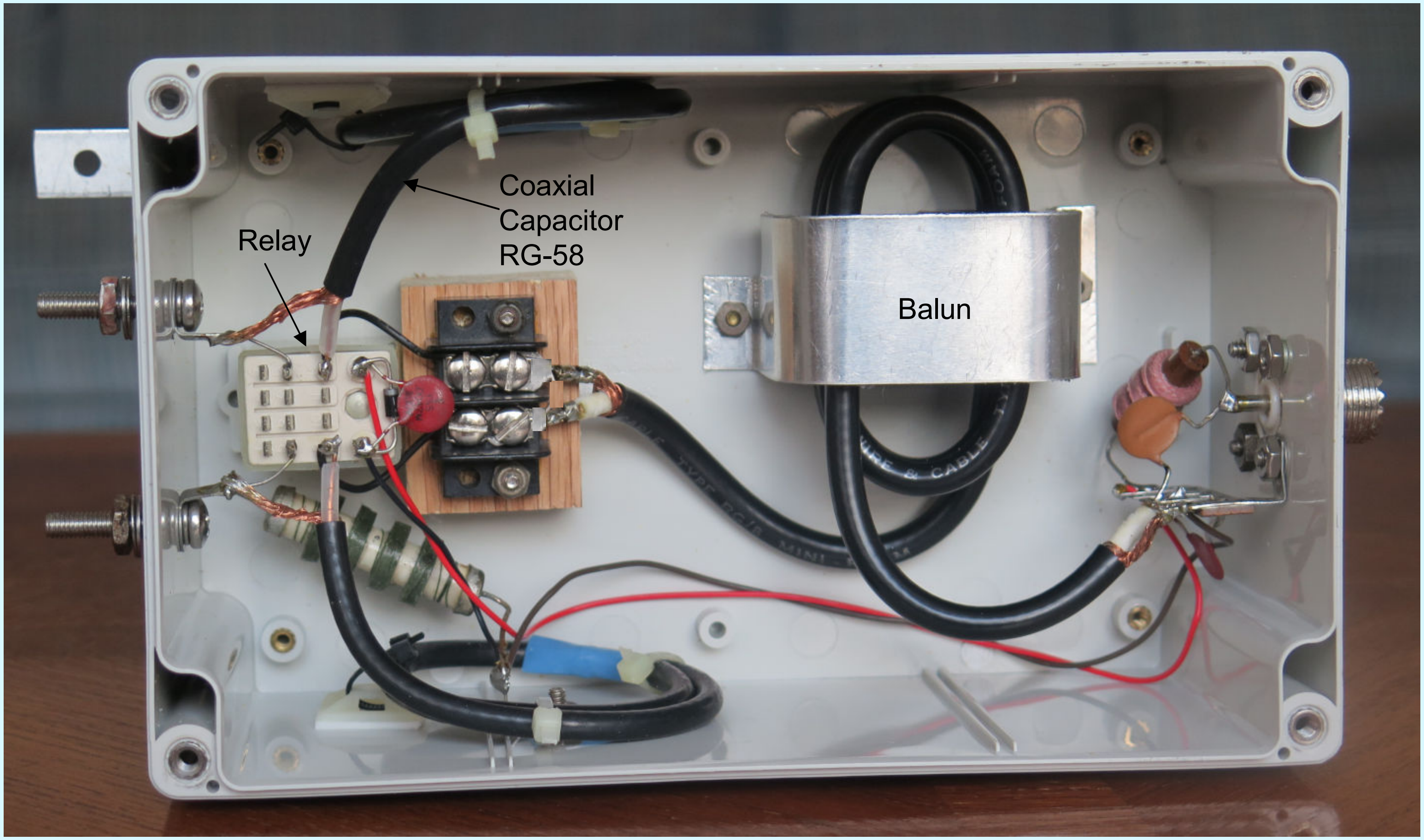
On 29 MHz, the ladder line transforms the loop high impedance to a value around 30 Ω

On 14 MHz, the impedance seen at the pre-matching circuit is 60 + j 750 Ω.
This reactance is cancelled by the series capacitors: C.



RG58U
26 pF approx.
C5
Ladder
Line
J1
1
C1
0.0047 uF
L2
0.5 mH
2.5 mH
L3
K1
Loop DC
path to gnd
Coaxial CURRENT BALUN
RG8X, 4 turns on 2 oval cores
C3
0.01 uF
J3
1
2
D1
C4
0.0047 uF
50 ohm RG-8 coax to tuner.
Approx 51 ft total
including balun
Ladder
Line
J2
1
RG58U
26 pF approx.
C2
NOTES:
20m band: K1 released
15 - 10 m bands: K1 closed (+18 to +24VDC)
C2 and C5 capacitors made with 9 in. RG58U coax
28.6 pF calculated. Adjusted at 26 pF approx.
LOOP PRE-MATCHING CIRCUIT
Nov 2015 J. Audet

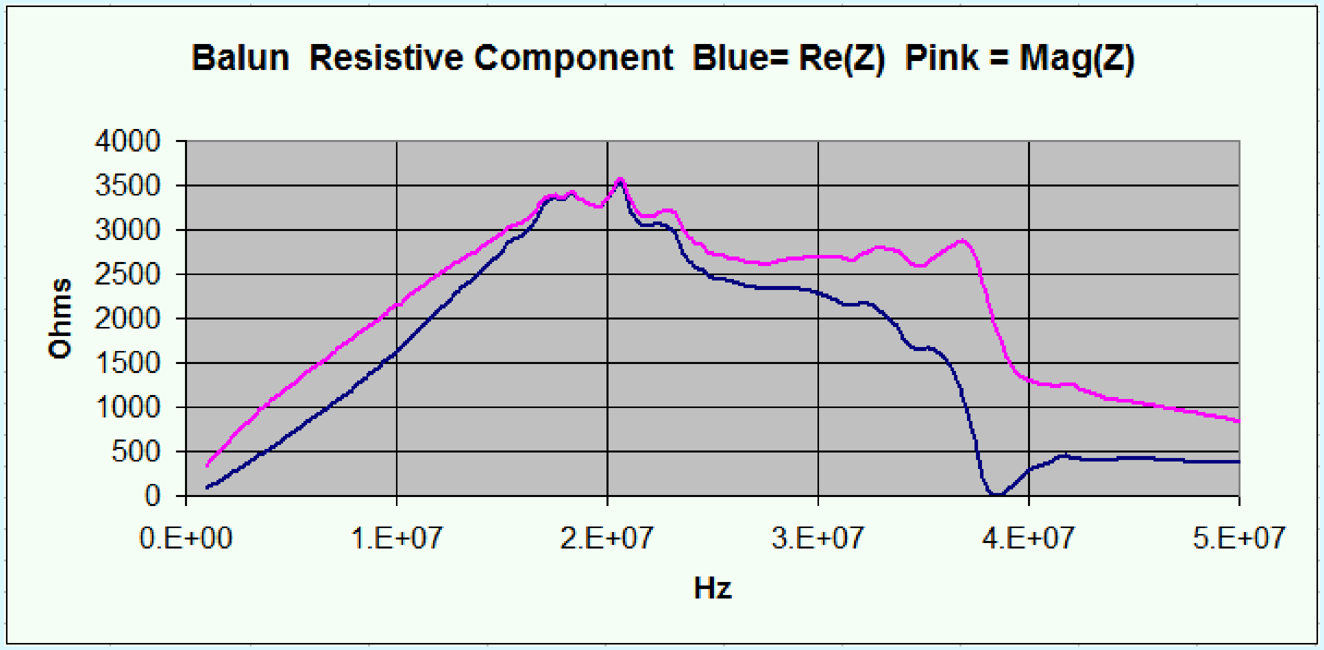
View of the Loop Pre-Matching Circuit

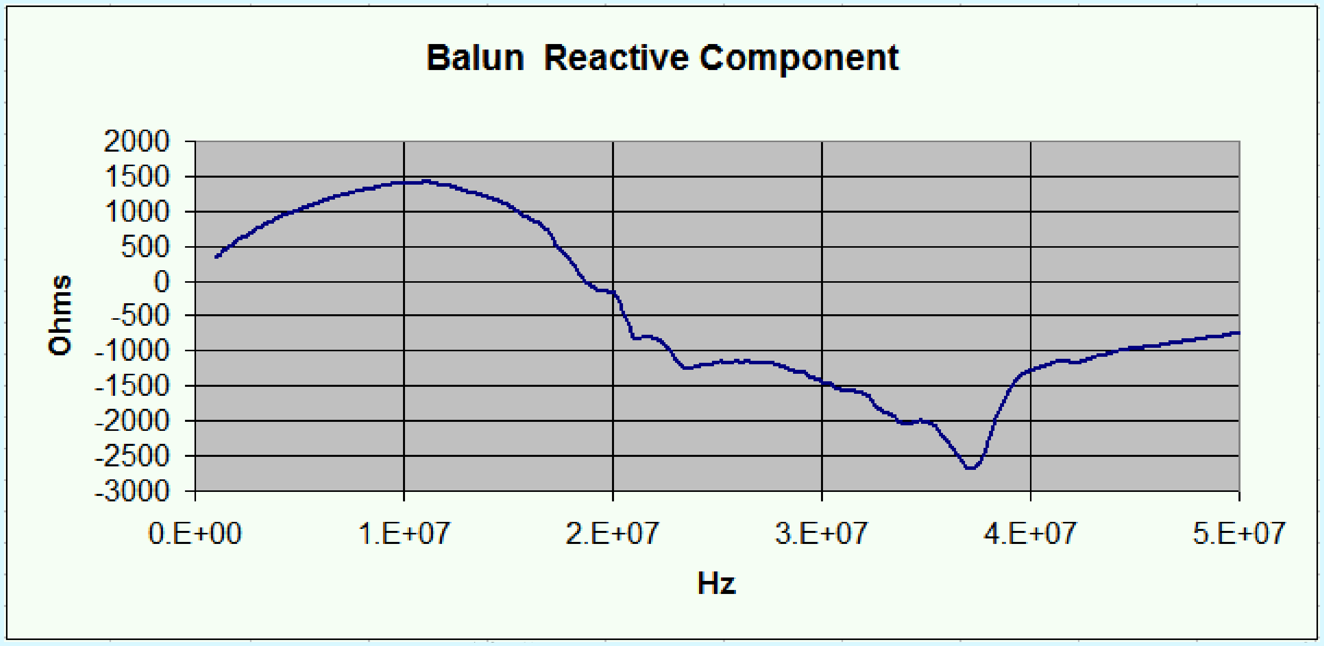


VIEW OF BALUN

4 Turns RG-8X on two oval ferrite cores #43 type
Fair-Rite # 2643167851
(#43 mix)

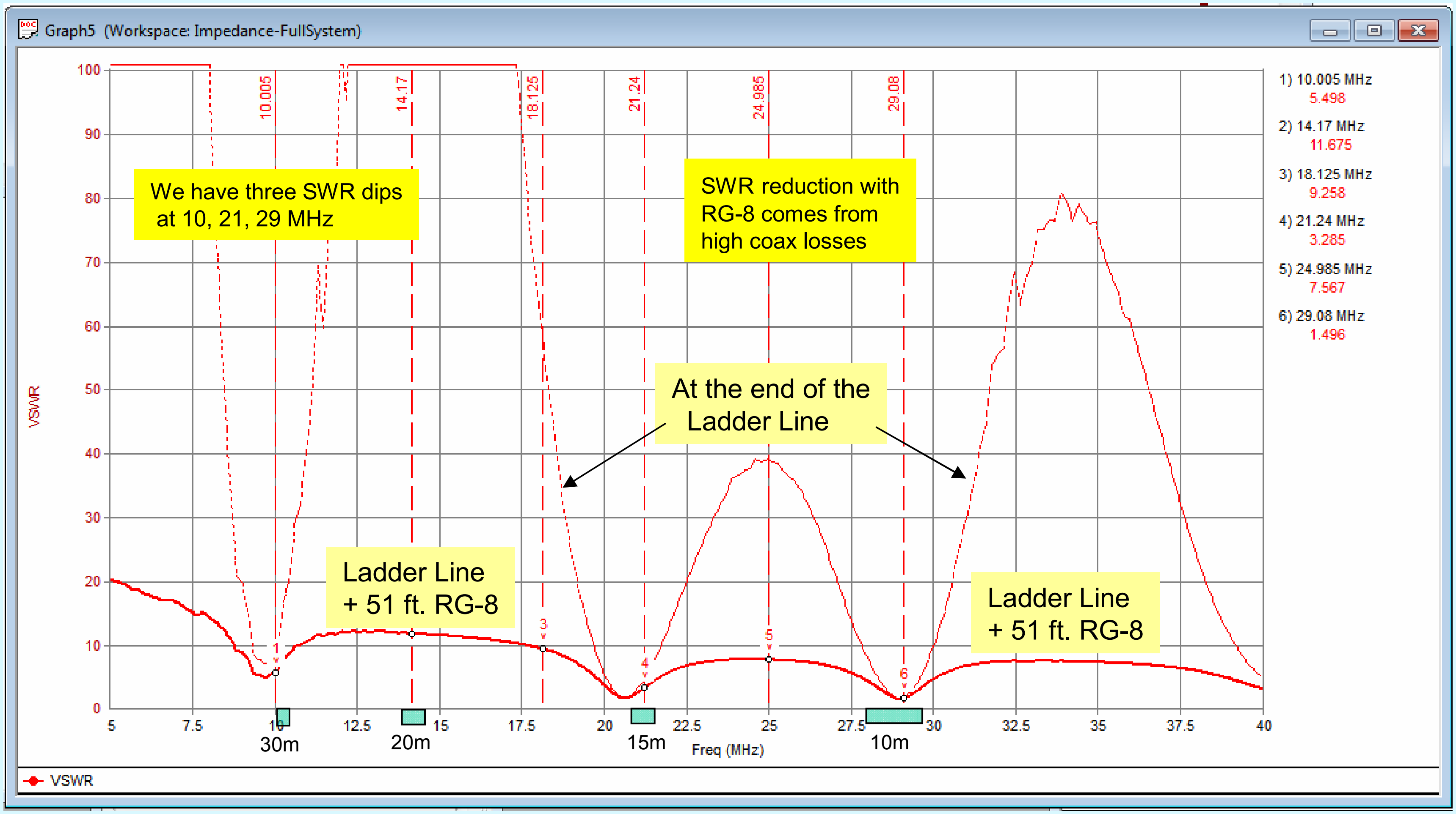
BALUN Measurements





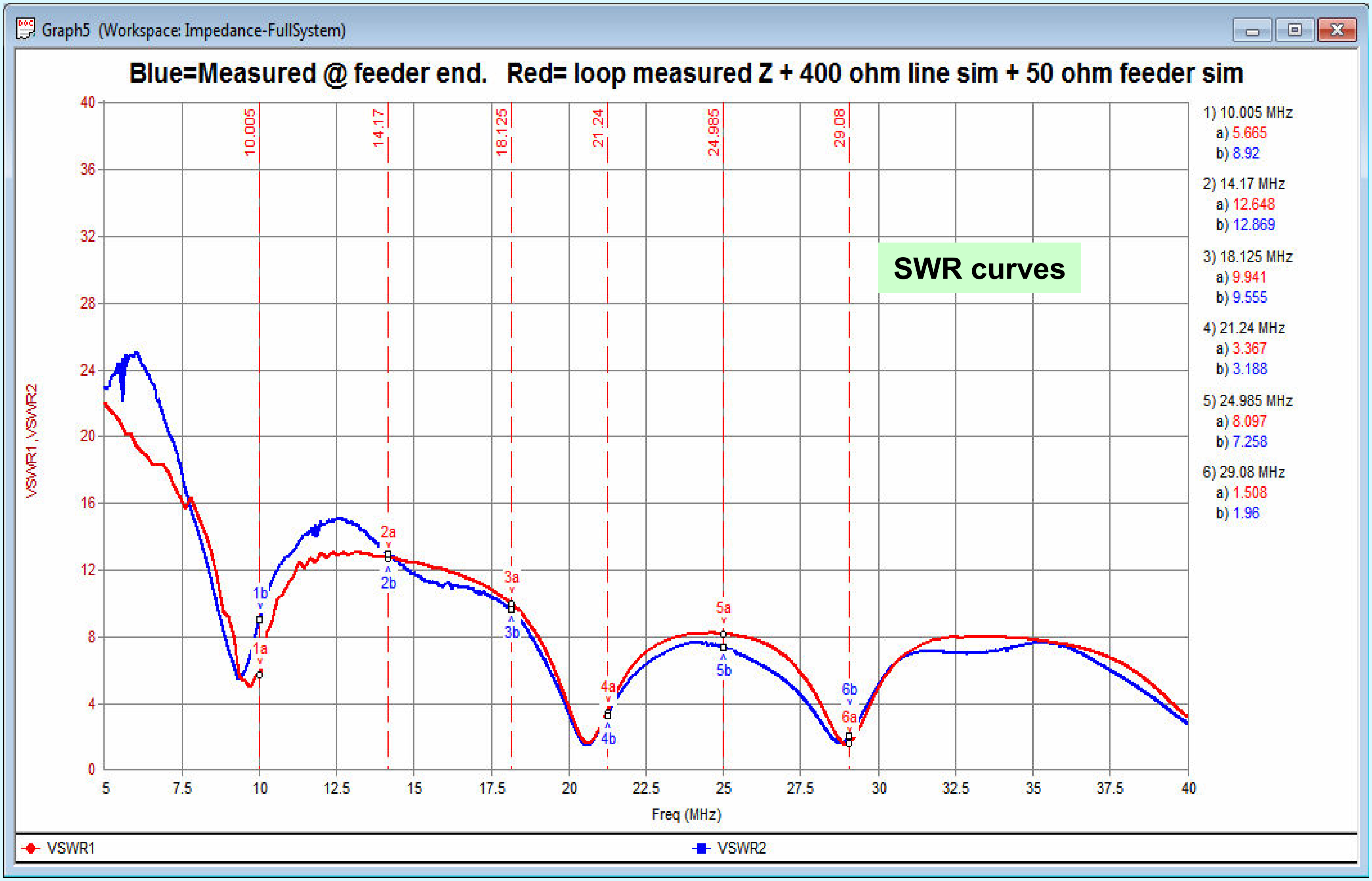
30m, 15m and 10 m coverage

Loop SWR curves with 22.5 ft Ladder Line + 51 ft RG-8
We have low SWR on 3 bands



MEASUREMENTS vs SIMULATIONS

Show good agreement

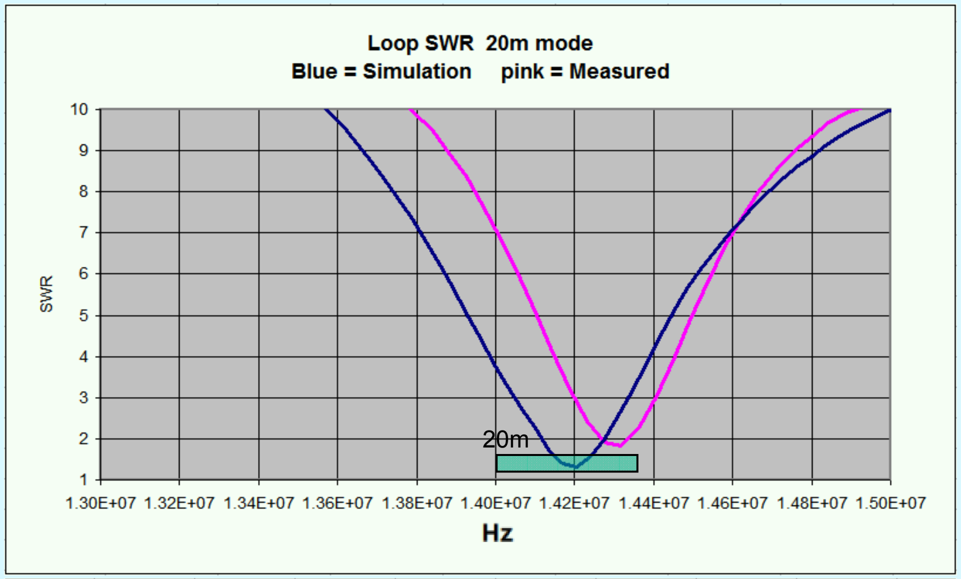


MEASUREMENTS vs SIMULATIONS

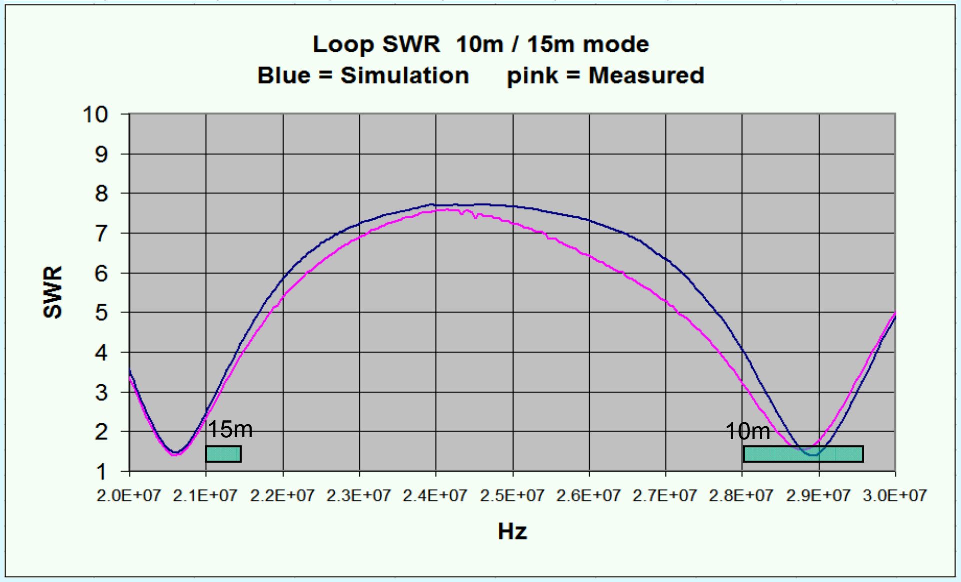
(At the shack end of the RG-8 feeder)

-Uses series capacitor

- Loop resonance has moved up in frequency as measured in dry conditions. It is affected by humidity (rain) which decreases the center frequency by about 200 KHz.



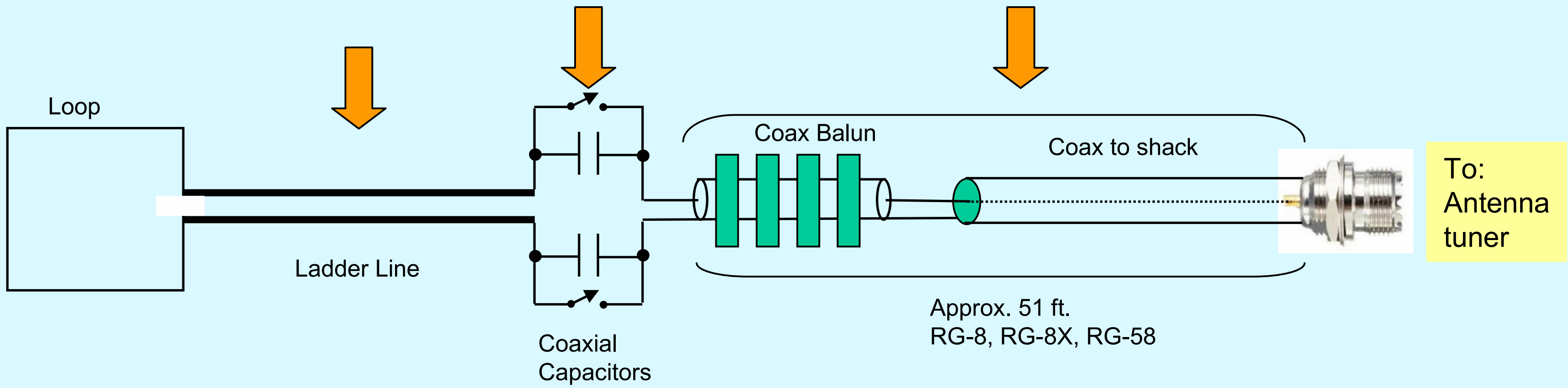
No adjustment done here
Shows resonance on 15m and 10m



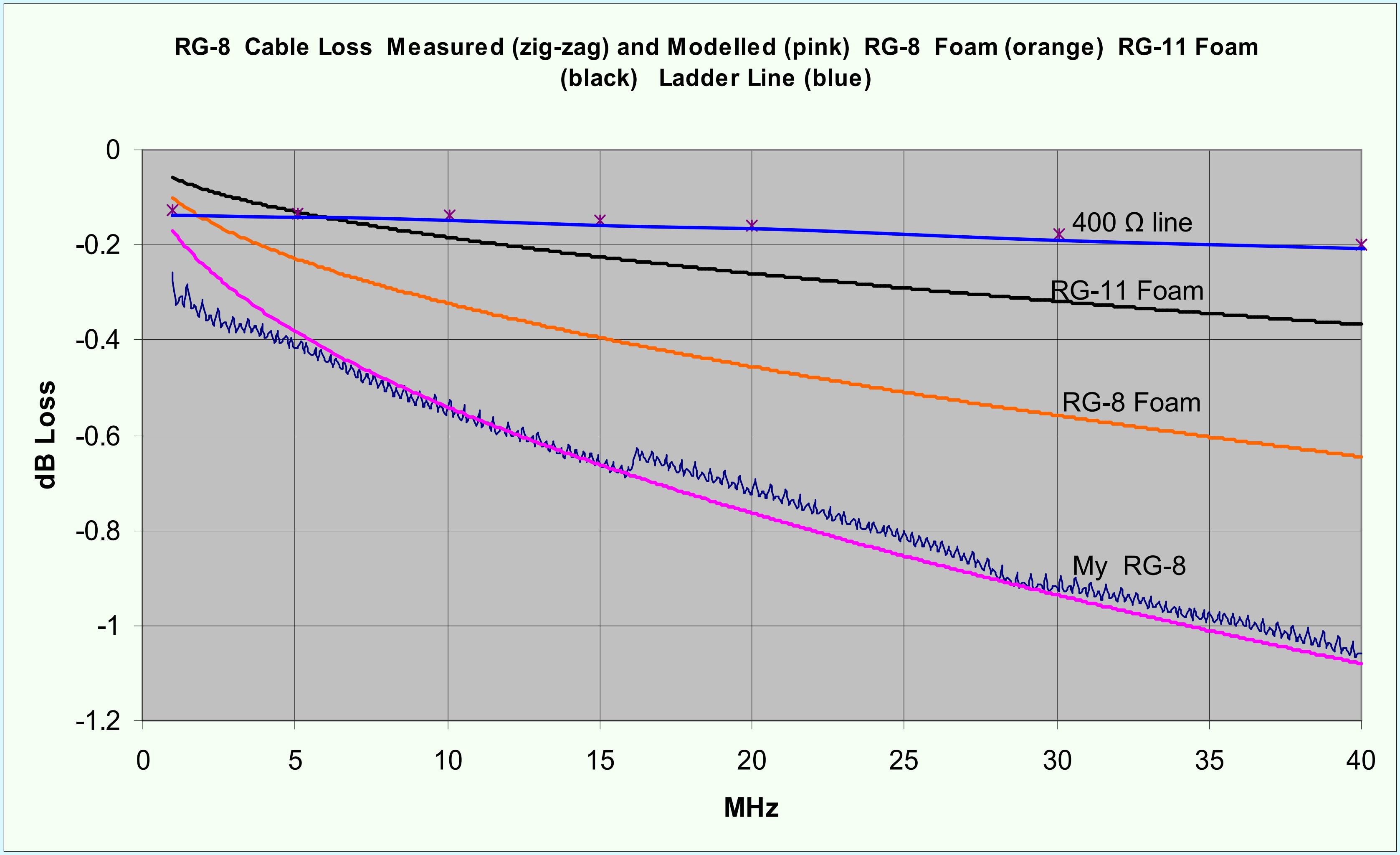
In ALL cases…
An antenna tuner is used to bring the residual SWR close to 1:1

Computing the Losses

How much power is lost in the transmission lines ?

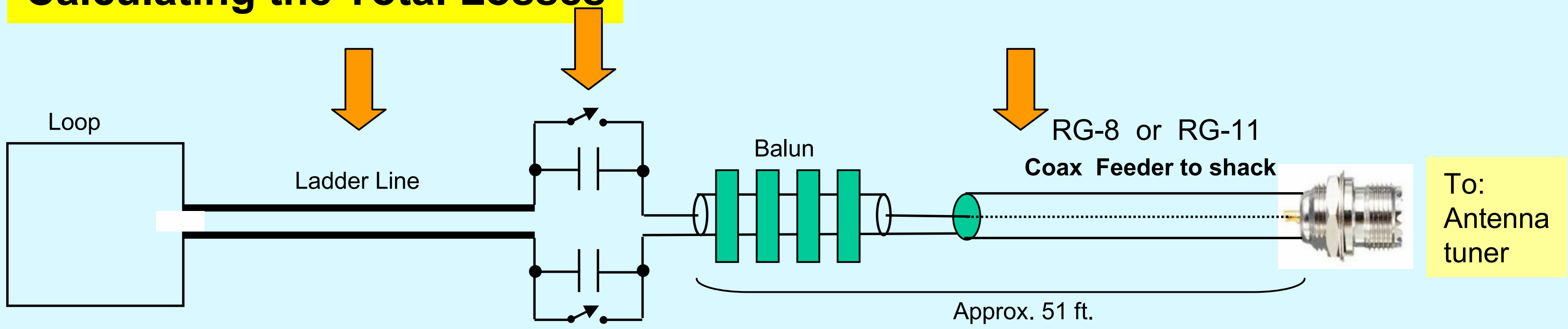


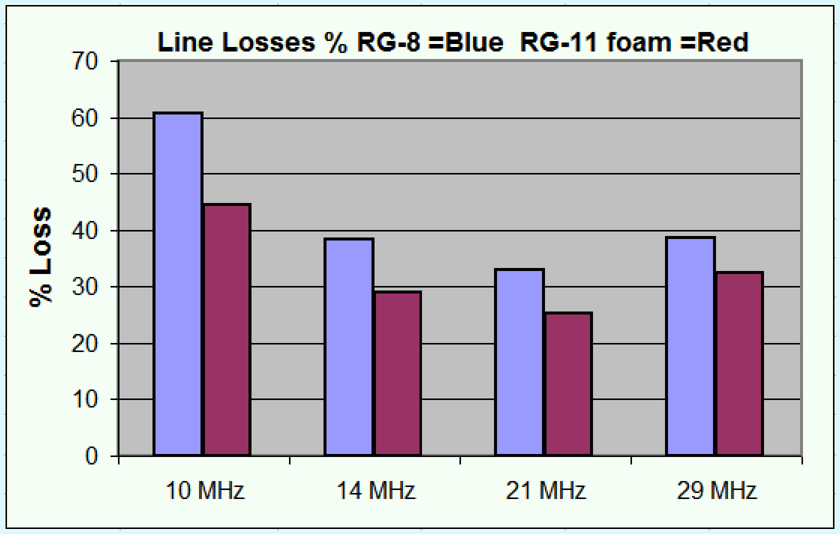
Feeder Losses Compared

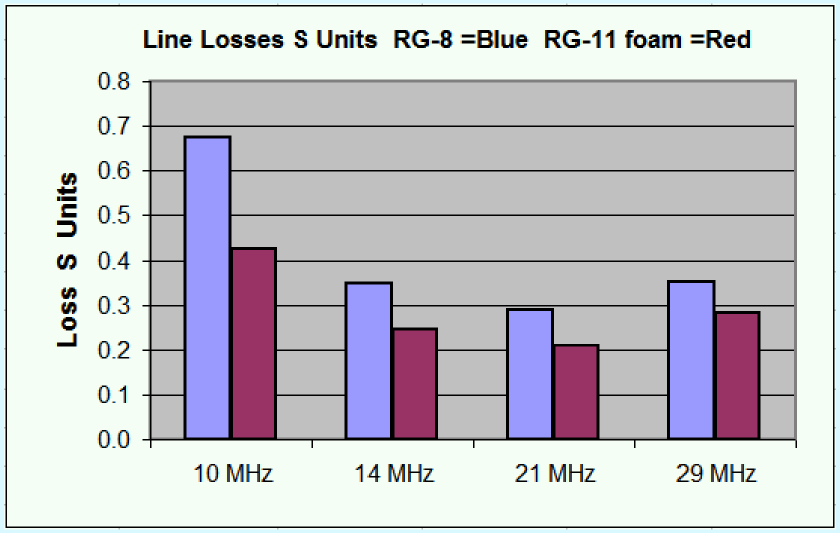


Ref.: RG-8_Losses.xls

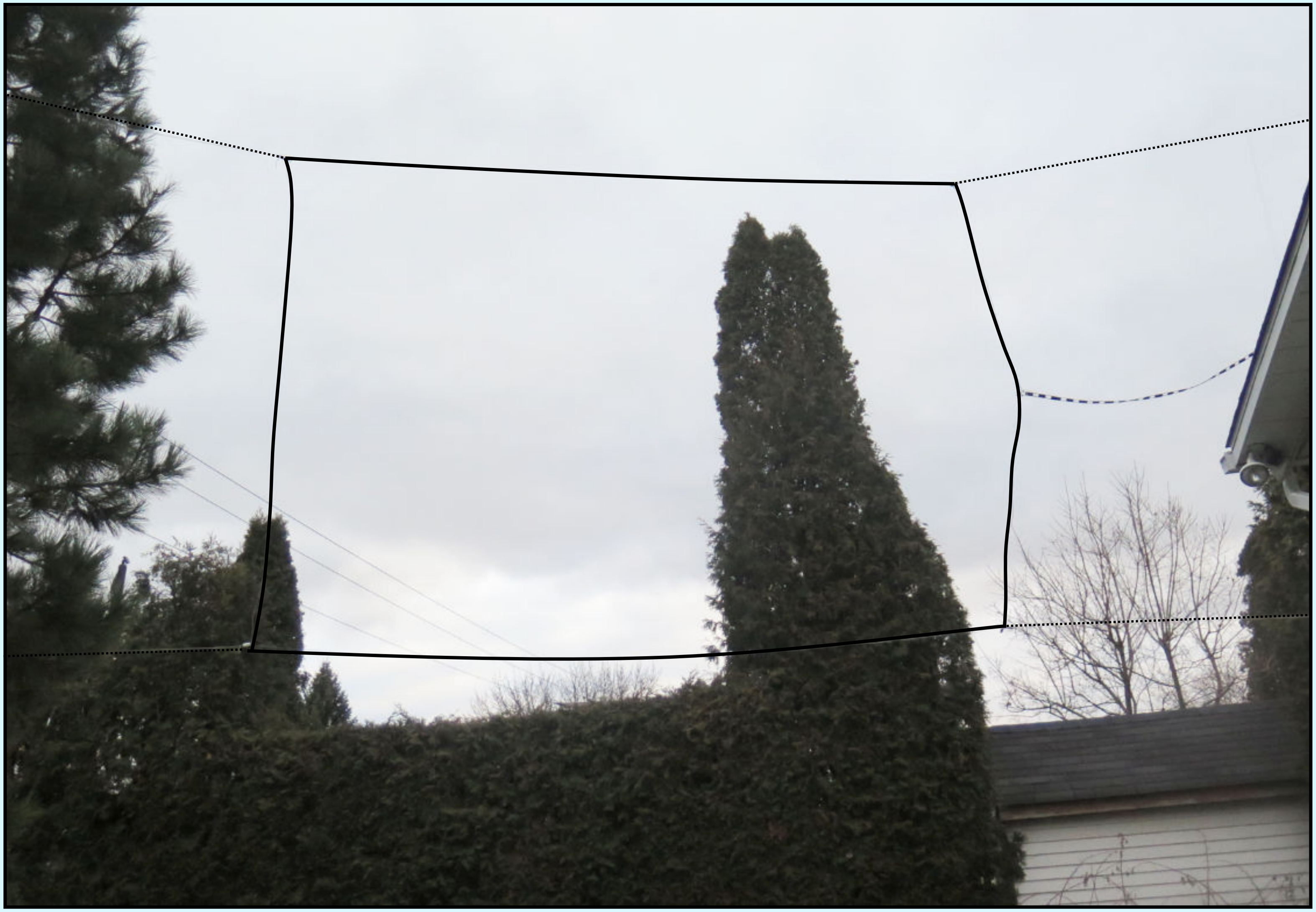
Calculating the Total Losses







My Loop Antenna

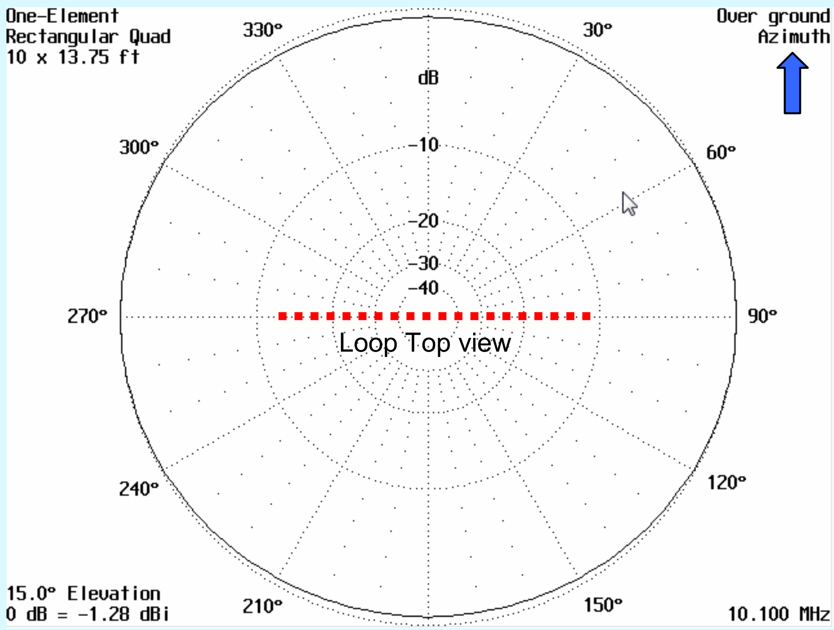


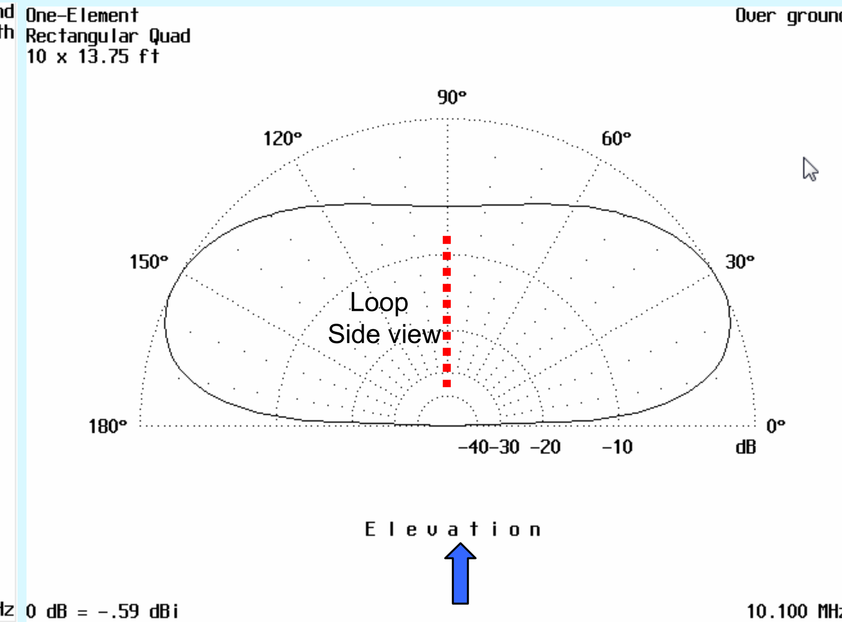
The Balun / Pre-Tuner

Radiation Patterns

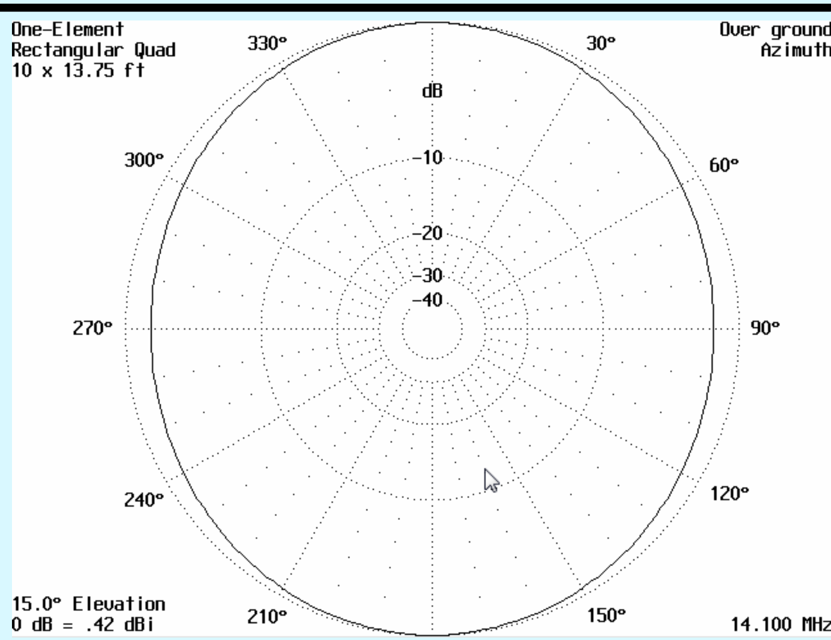
Bottom wire 12 ft. above ground

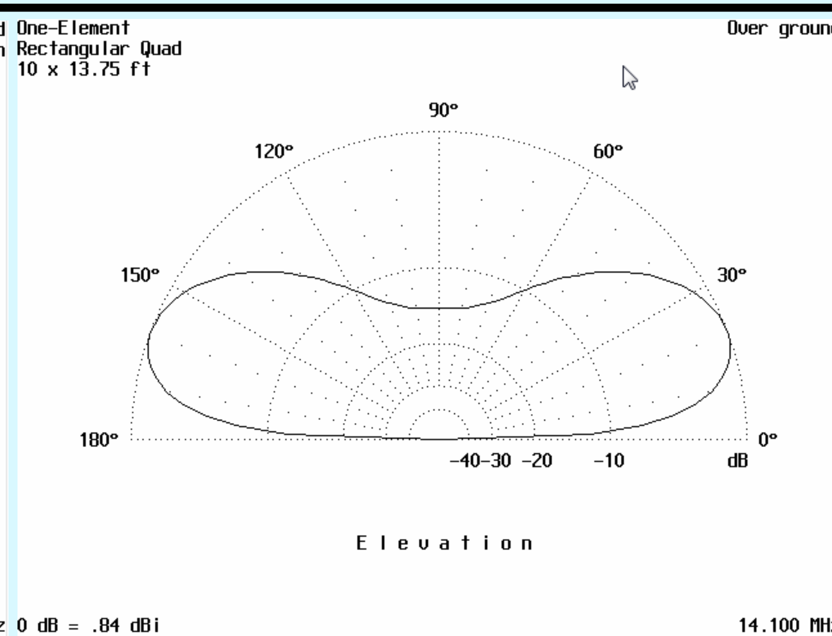
10 MHz





14 MHz

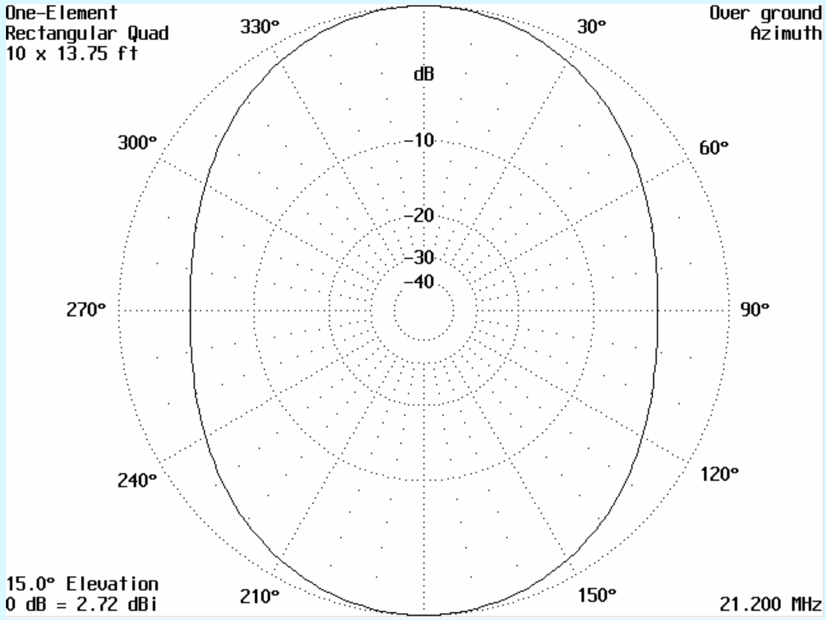


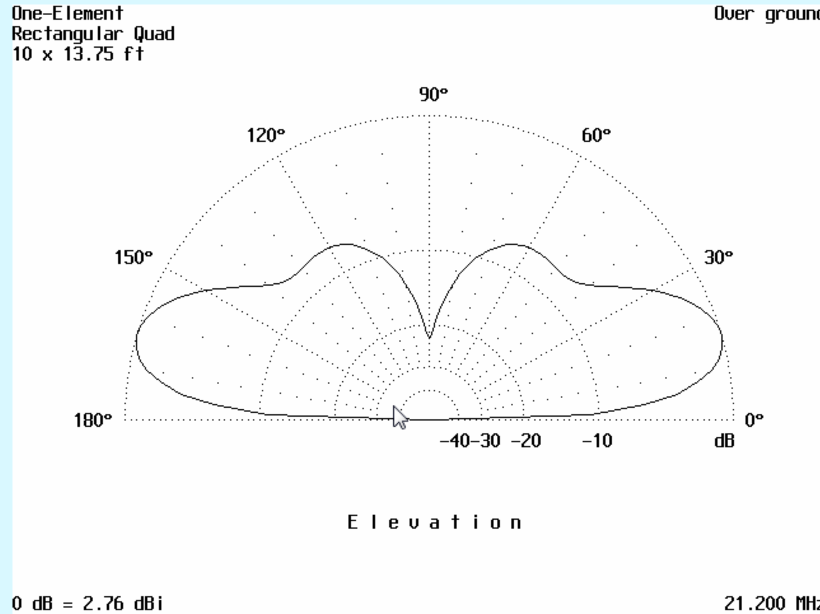


Radiation Patterns

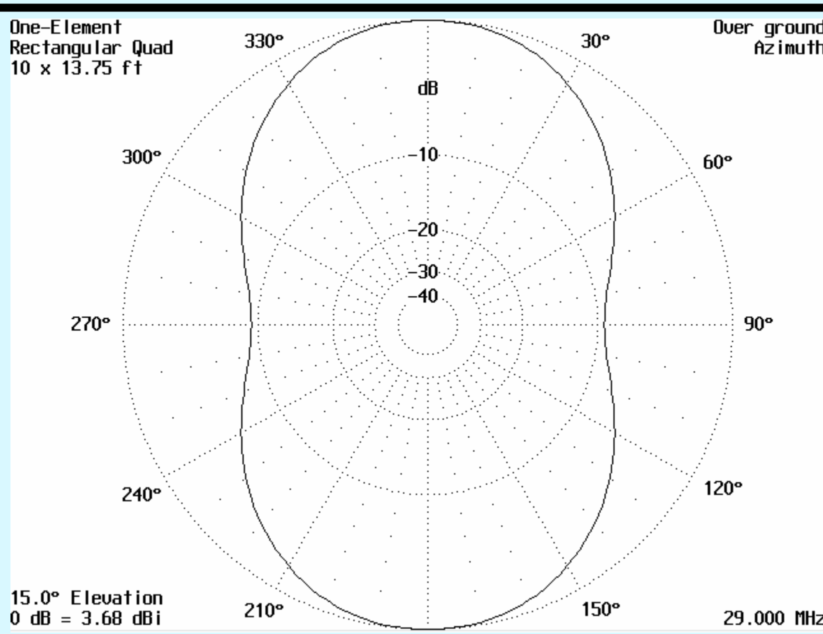
Bottom wire 12 ft. above ground

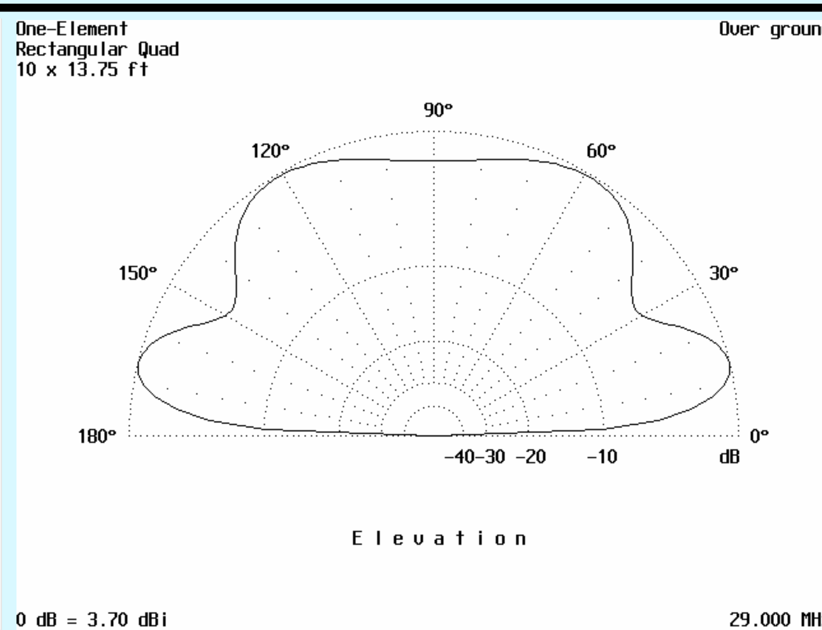
21 MHz





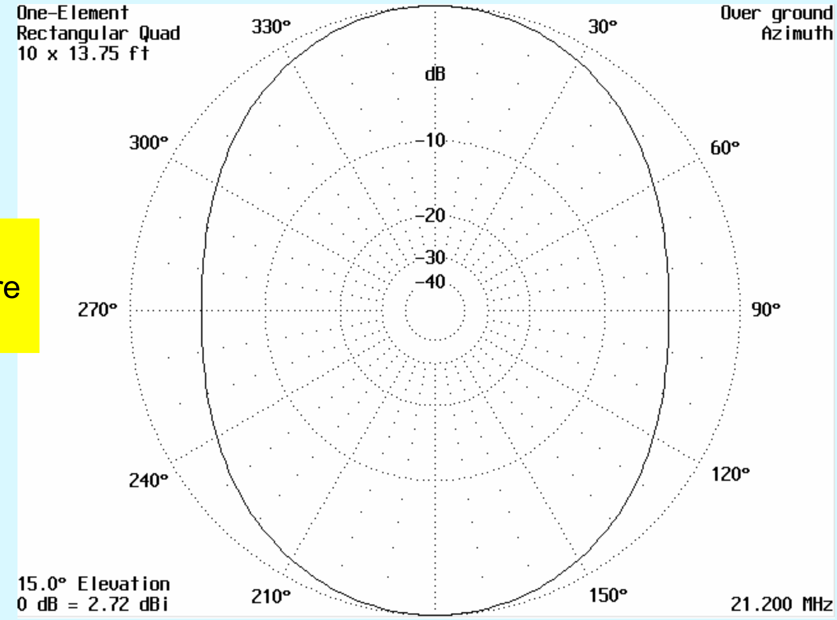
29 MHz

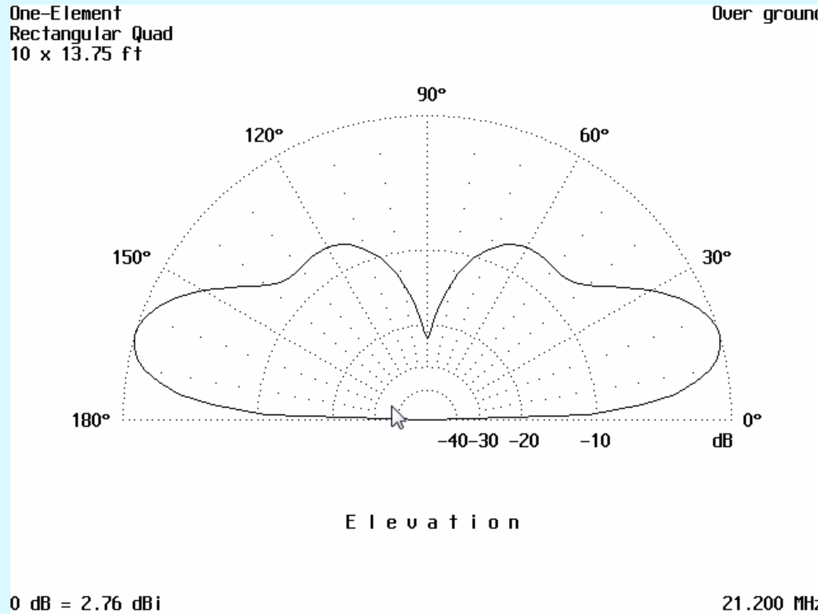




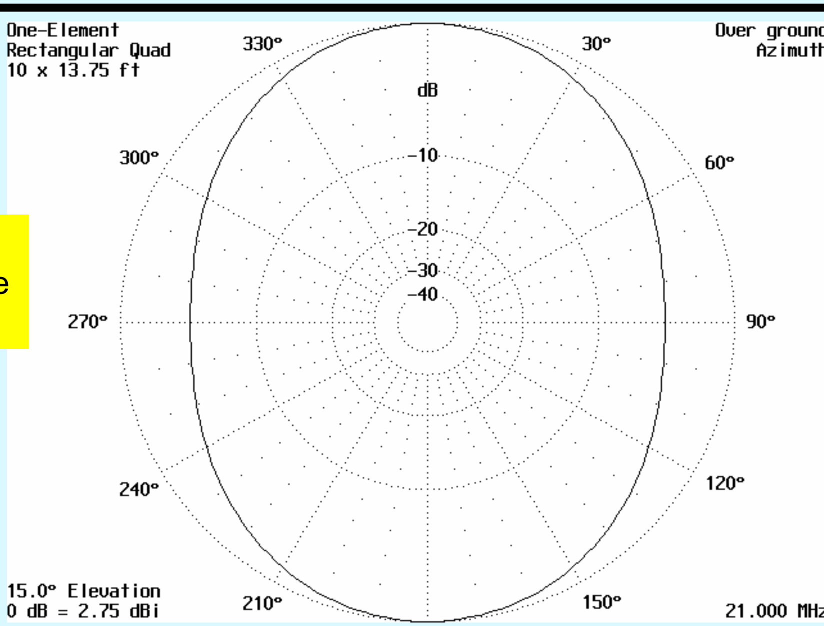
Radiation Patterns @ 21 MHz   Changing the height

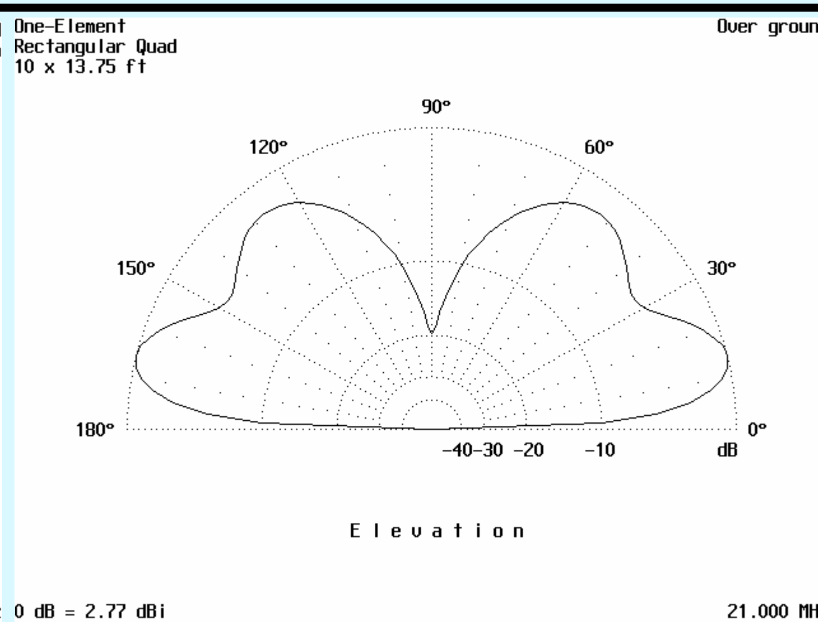
21 MHz
Bottom wire
@ 12 ft.





21 MHz
Bottom wire
@ 17 ft.

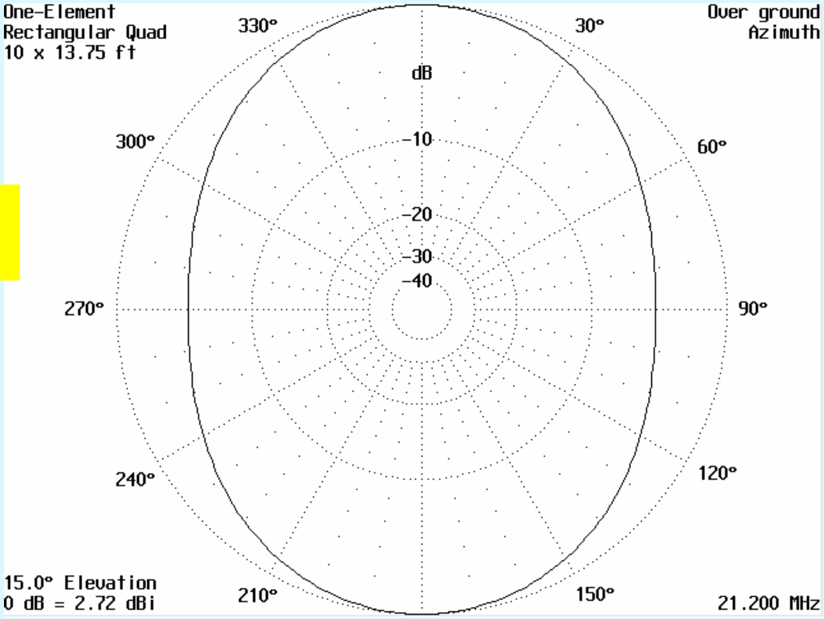


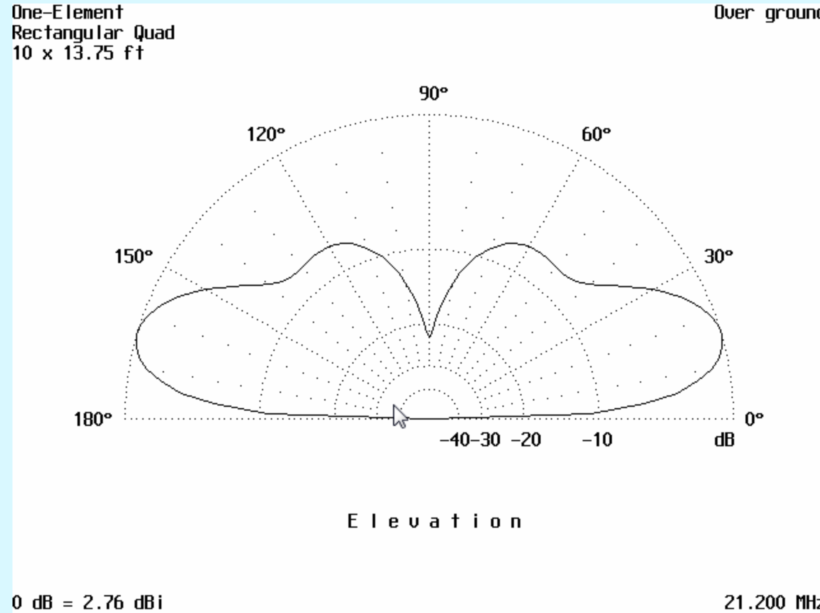


Radiation Patterns @ 21 MHz Vertical pol. vs Horizontal pol.

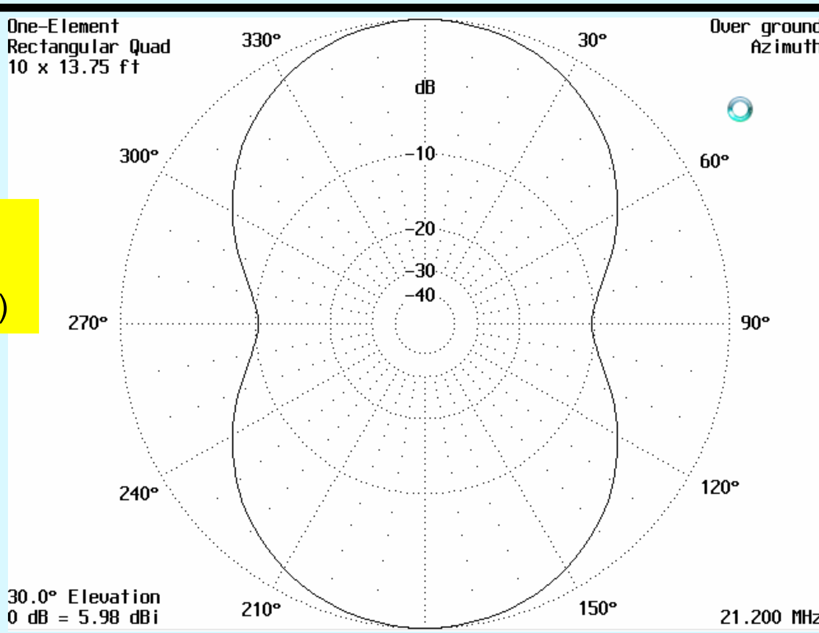
21 MHz Bottom wire @ 12 ft.

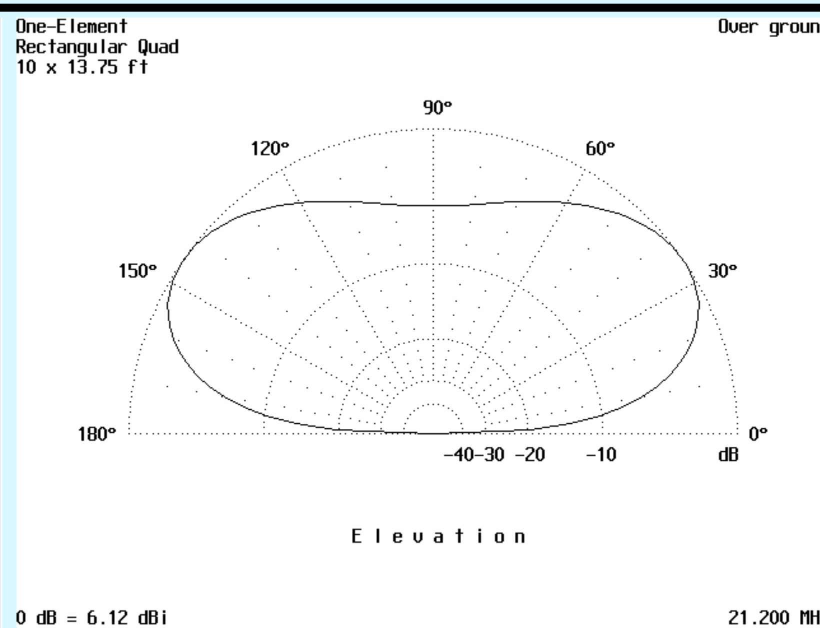
Vertical Polarization





Horizontal Polarization (Bottom fed)

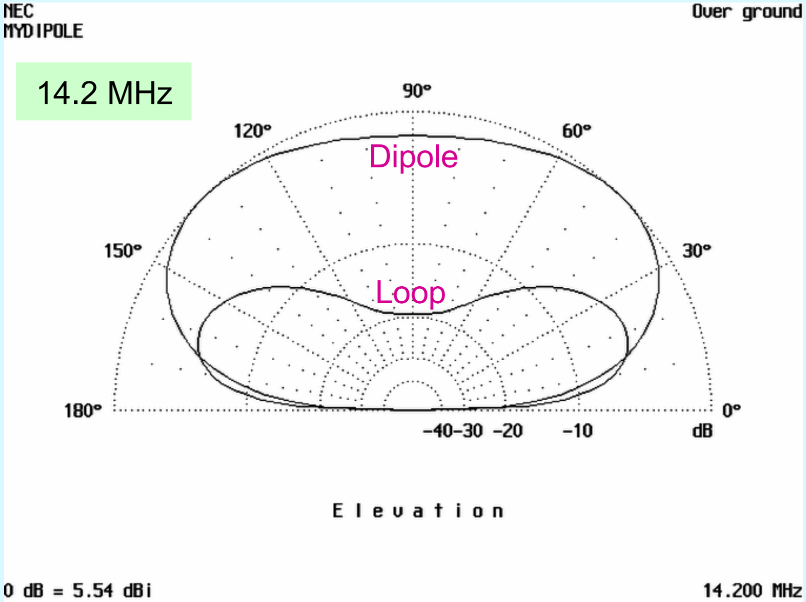


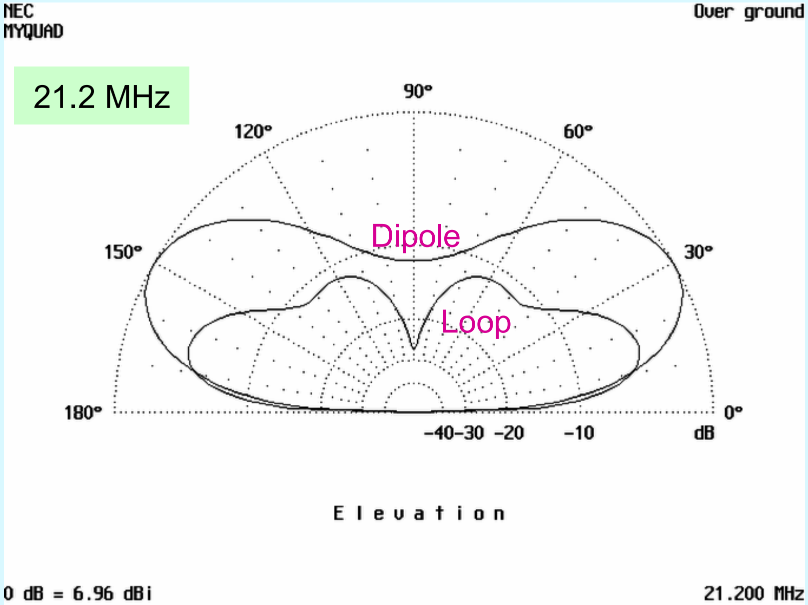


Radiation Patterns Vertical Loop vs Dipole at Top Wire Height (22 ft.)

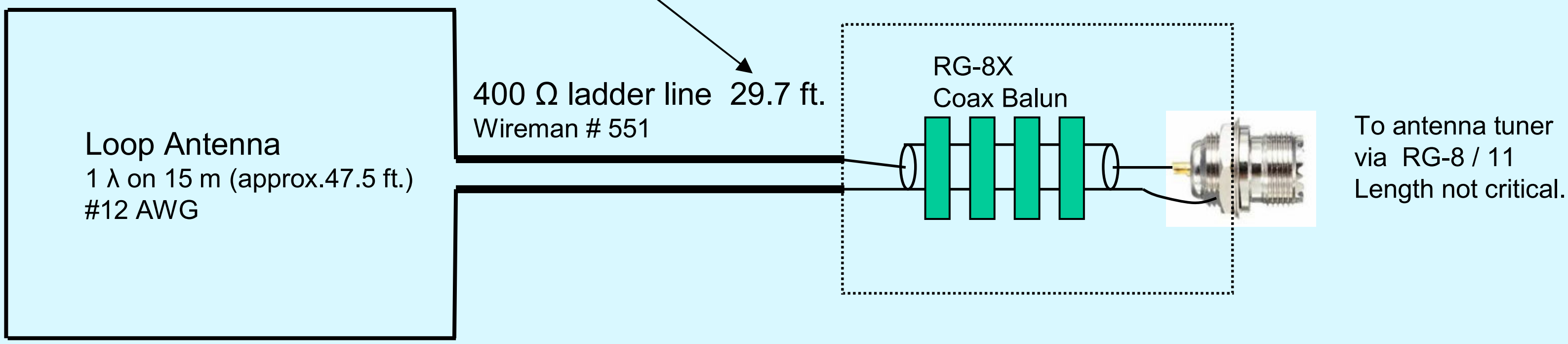
- The Loop rejects high angle signals

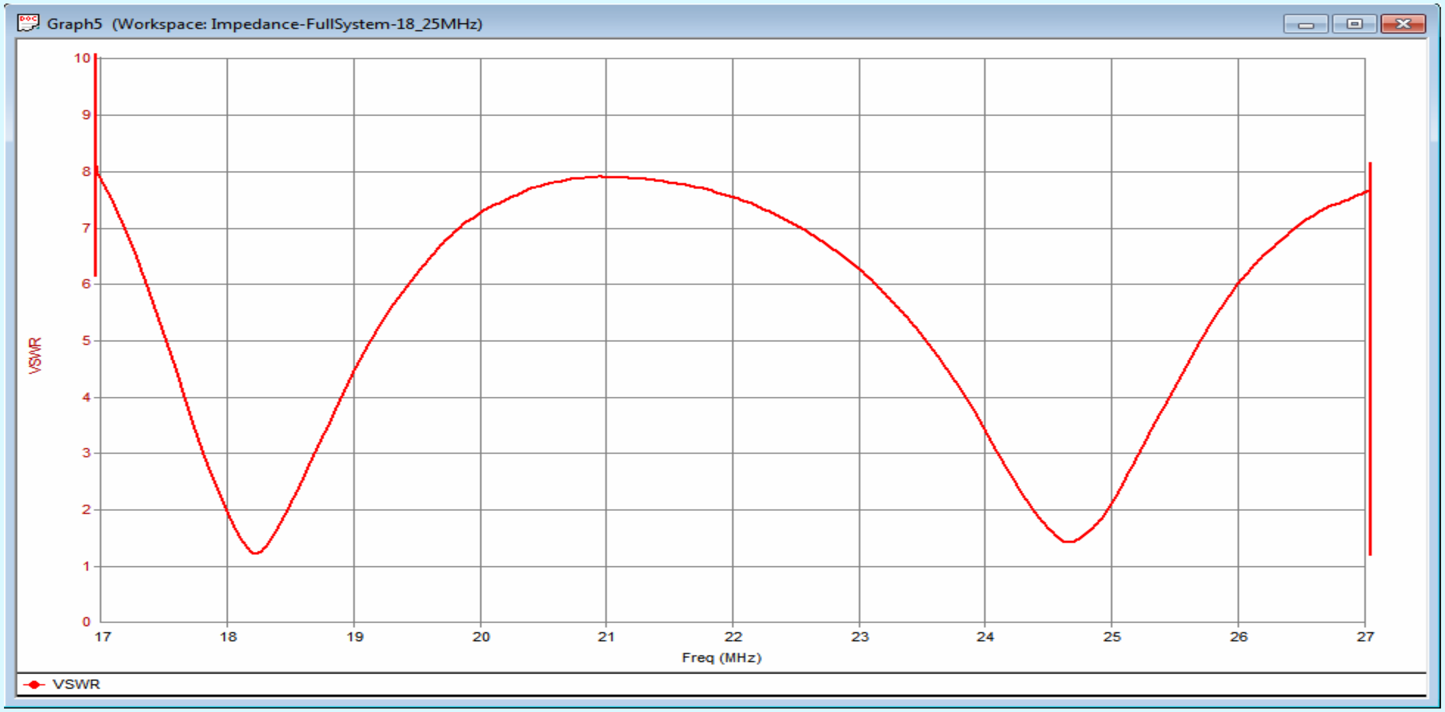
- Rejection is best at 14 MHz



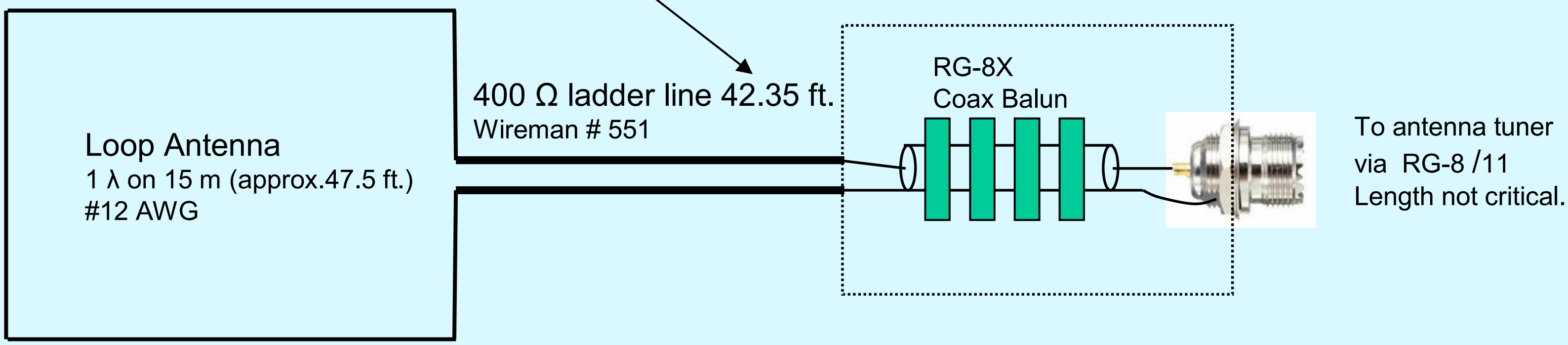


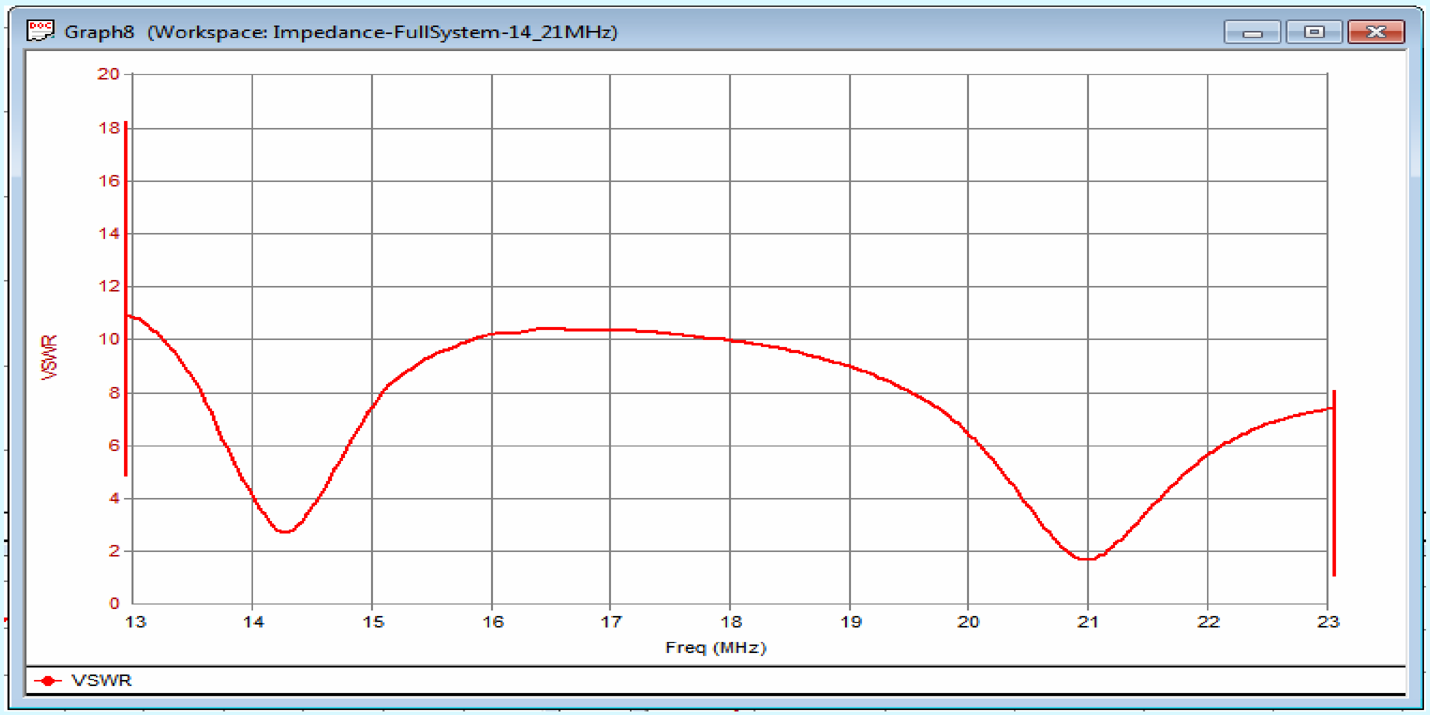
Operating the loop at 18 and 25 MHz by changing the length of the ladder line



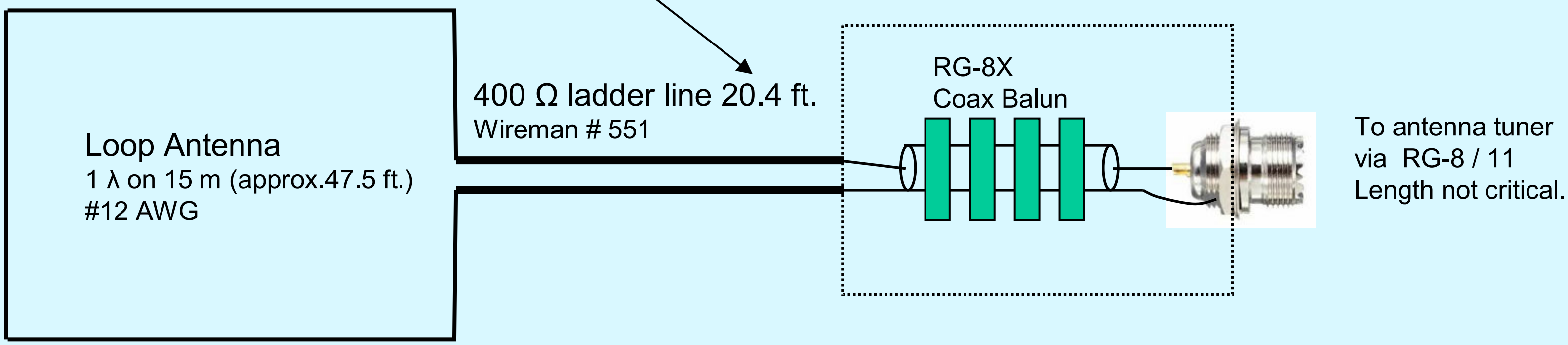


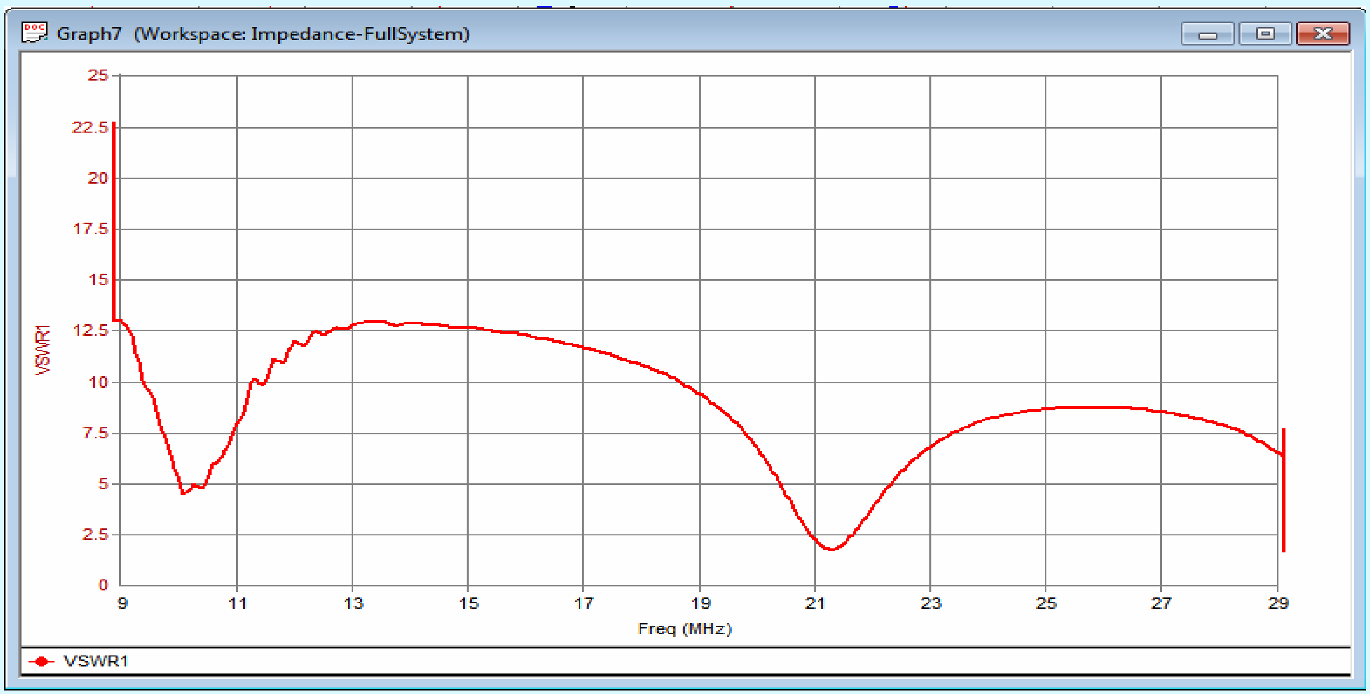
Operating the loop at 14 and 21 MHz by changing the length of the ladder line





Operating the loop at 10 and 21 MHz by changing the length of the ladder line

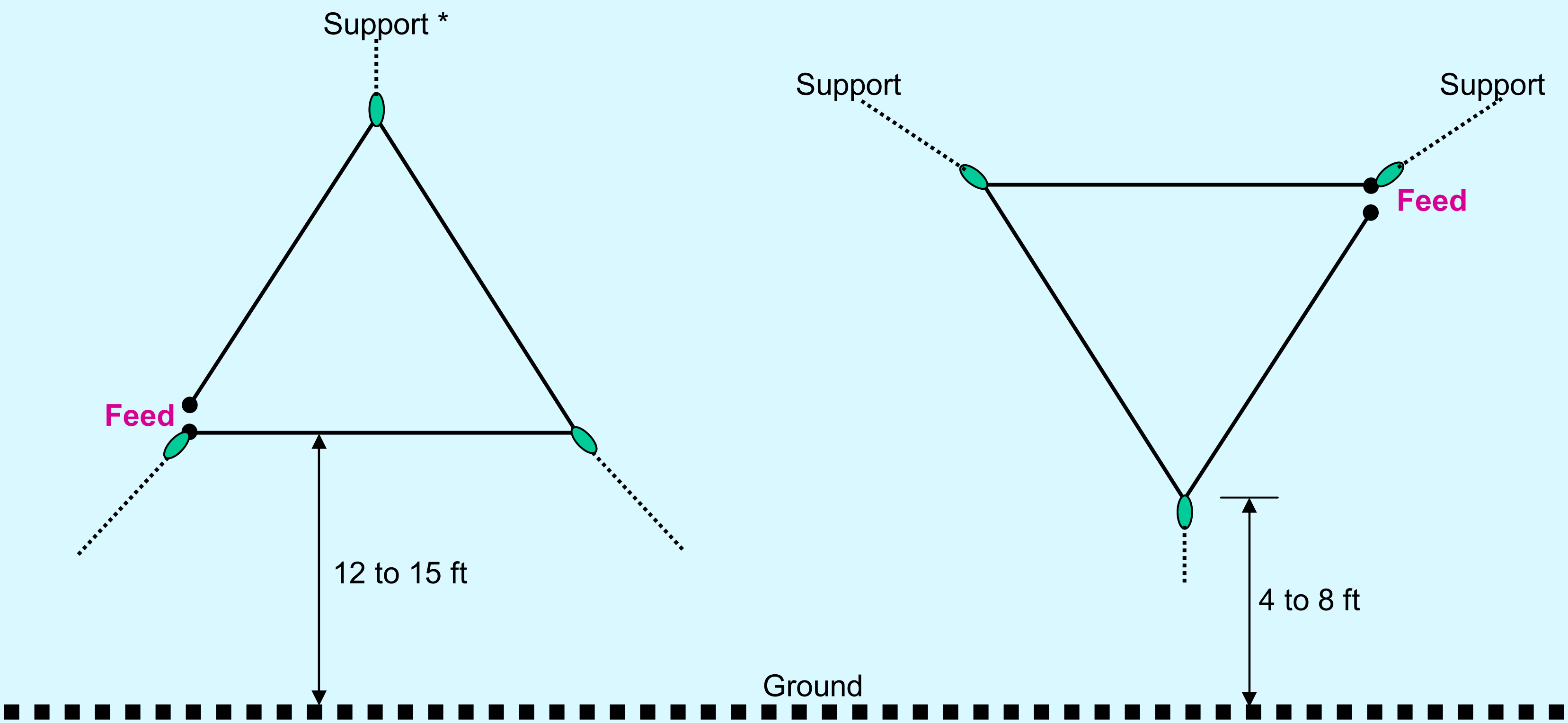




One wavelength Delta loops
Recommended Height above ground for a Loop Resonant @ 21 MHz

$$\text{Length (ft.)} = \frac{1005}{f_{MHz}}$$

Feed point for low angle radiation
VERTICAL Polarization
Impedance: ~ 100 Ω

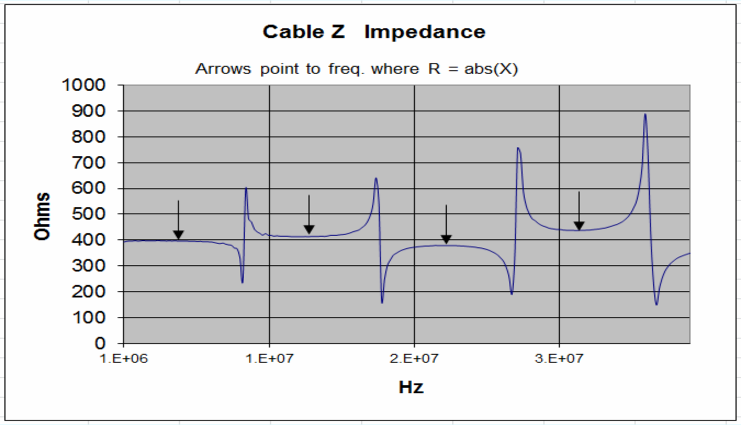


Ladder Line Impedance Measurement

Computing the cable impedance as:

$$Zo = \sqrt{Zopen \times Zshort}$$

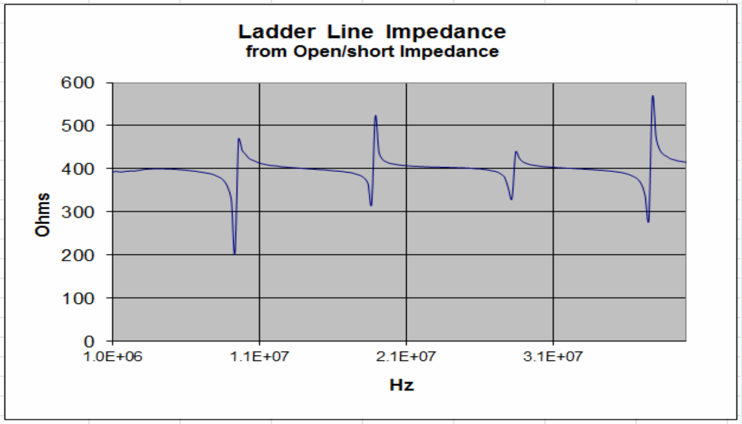
Using 50 Ω VNA in S11 mode
and **1:1 balun**



Computing the cable impedance as:

$$Zo = \sqrt{Zopen \times Zshort}$$

Using 50 Ω VNA in S11 mode
and **4:1 balun**

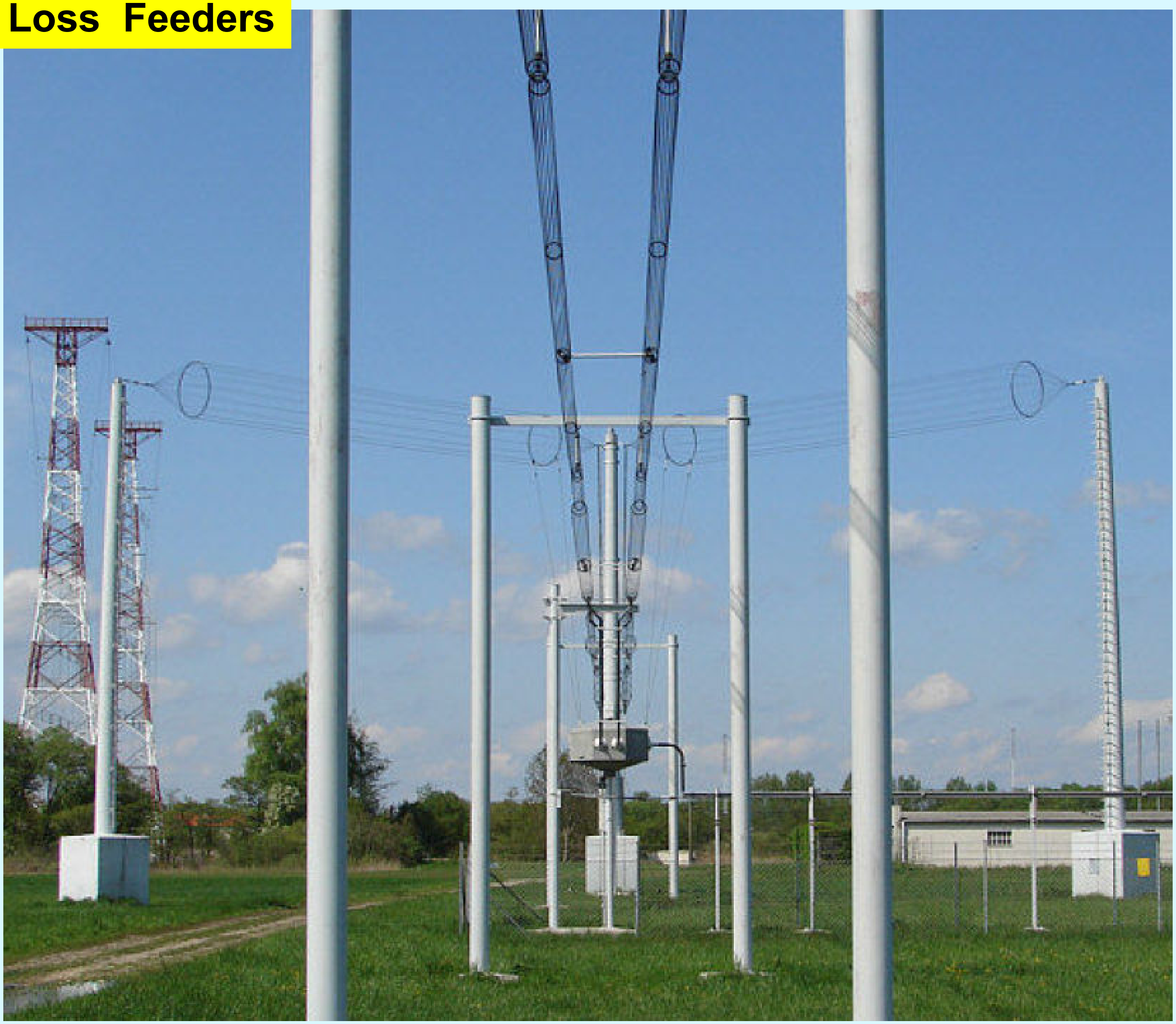


Computing the cable impedance as:

$$Zo = \sqrt{\frac{L\ short}{C\ open}}$$

- Gave 400 Ω
- Done at 100 KHz
- **Quick and easy !**

Low Loss Feeders



Get rid of the Feeder

Conclusion

Compact, Low height - vertically polarized DX antenna.
Takes less space than dipole. (22 ft. At 21 MHz)
Bottom wire at 12 ft is ~ optimum at 14 and 21 MHz.

Clean low angle radiation patterns useful for DX.
Omni radiation from 30m to 15m, somewhat directional on 10m.
The rectangular loop has somewhat better patterns than the delta loop.

No radials

Low noise

Operates multibands: 10, 15, 20 and 30 m
Changing ladder line length allows:
- 17 and 12 m or
- 20 and 15 m or
- 30 and 15 m

Works from one half the resonant frequency to 1.5 x resonant frequency

Using low loss (foam) RG-8 /11 feedline will minimize losses.

References

- Vertical Delta Loop Elmer Hour
  http://www.k4vrc.com/uploads/1/0/1/5/10156032/delta_loop_140918.pdf

- Basic Wire Antennas
  http://www.wa1wa.net/filespdf/basicantennaspartii.pdf

- Build a Multi-Band Mono Delta Loop
  http://kb9gsyar.weebly.com/uploads/1/0/3/0/10309607/multi-band_20mono_20delta_20loop_20ant.pdf

- The Horizontal Loop – An Effective Multipurpose Antenna QST Nov. 2006

- ARRL Antenna Book

- Transmission Line Details free software: http://www.ac6la.com/tldetails1.html

- Mesure Complex Impedances using a Signal Generator and a Scope: (on my web site ve2azx.net)
  http://ve2azx.net/technical/RBridgeCalculations-en.zip

My 2016 Project …

High Voltage Differential Probe

- Based on the AD8479 Precision Difference Amplifier
- Very High Common Mode > 90 dB @ 100 Hz
- 500V pk max
- X1 Gain provides high sensitivity
- Use 9V battery (500 hours)