Our “Magic” Formula
L=468/F

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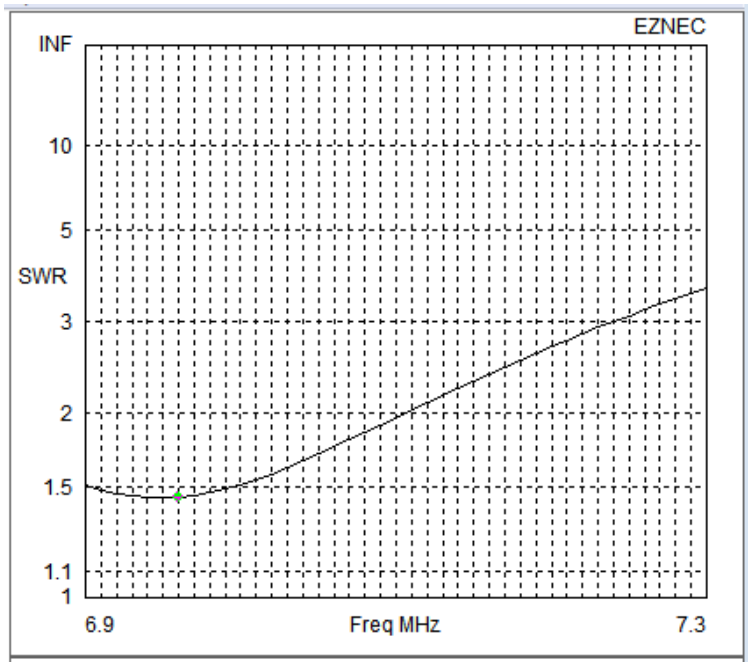
Where did it come from?
Design - 40M dipole, 7.15MHz

- How long is one-half wave in free space @7.15MHz?
- C = Speed of light = $299.7*10^8$ m/sec ~ $300x10^8$ m/sec
- C = 984 ft/usec
- Wavelength = C/F (ft/usec)/(cycle/usec) = C/MHz = X ft
- L(Half wave) = (984/2)/MHz = 492/MHz
- L = 492 / 7.15 = 68.8 ft
- We have a roll of #14 copperweld ready to go.
- Shall we start cutting wires now?

Simulate First (#14 bare Cu, free space)



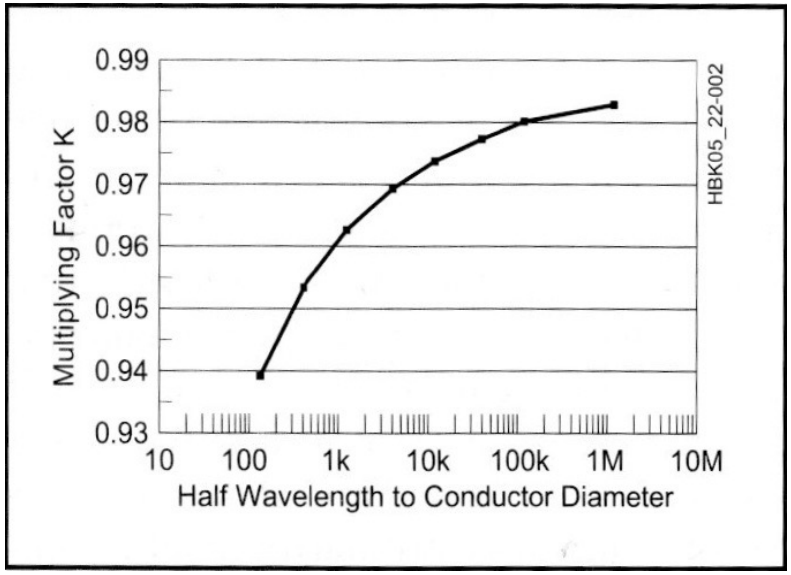
- Resonance is below the band, 6.96 MHz
- Looks like 492/F isn't the right formula, why?
- End Effect and "Velocity Factor"
- Good thing we didn't start cutting.

End Effect

- When we drive our antennas, we propagate wave along the wires.
- At the ends – no place to go. Discontinuity
  - End of wire has lower inductance & higher capacitance
  - Current is zero at the very end & very high voltage (don't touch!)
  - High voltage looks for a place to share the charge – like lightning
  - As wave is reflected current near the end of the wire flows
  - Current flow makes Electrical length longer than Physical length
- How much longer?

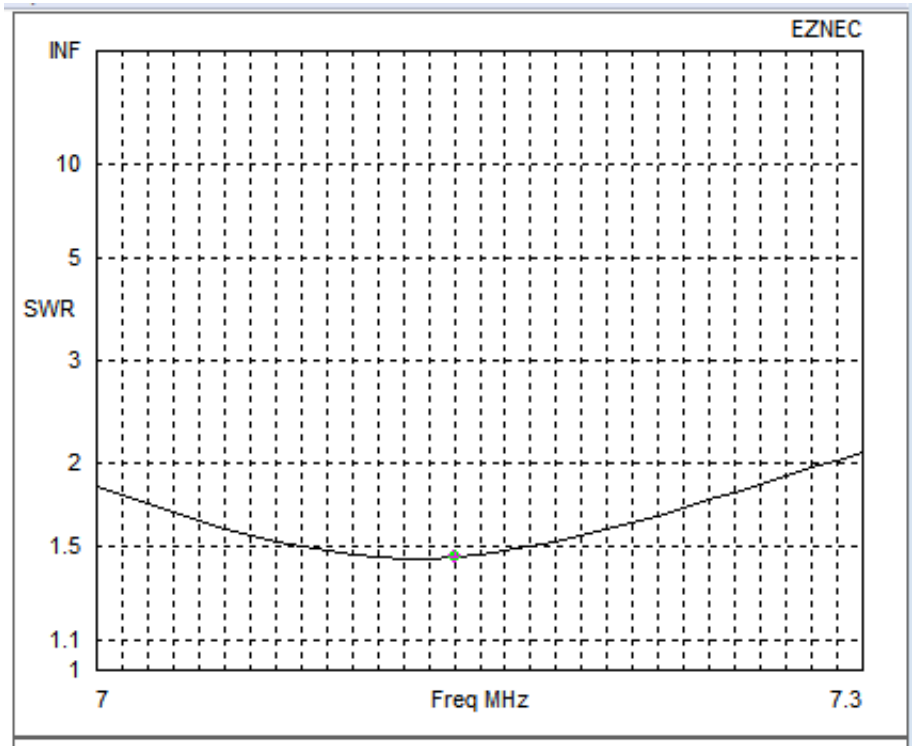
New Formula

- L = K*492/F
- K is dependent on the length/diameter ratio of the radiating element.
- Wire antennas < 20 MHz L / d > 4,000
- L/d(40M/#14wire) = 67*12/.0641= 12,500
- K(40M) = .975
- .975*492 = 470
- L = 470/F = 67.1 ft
- How does that work?

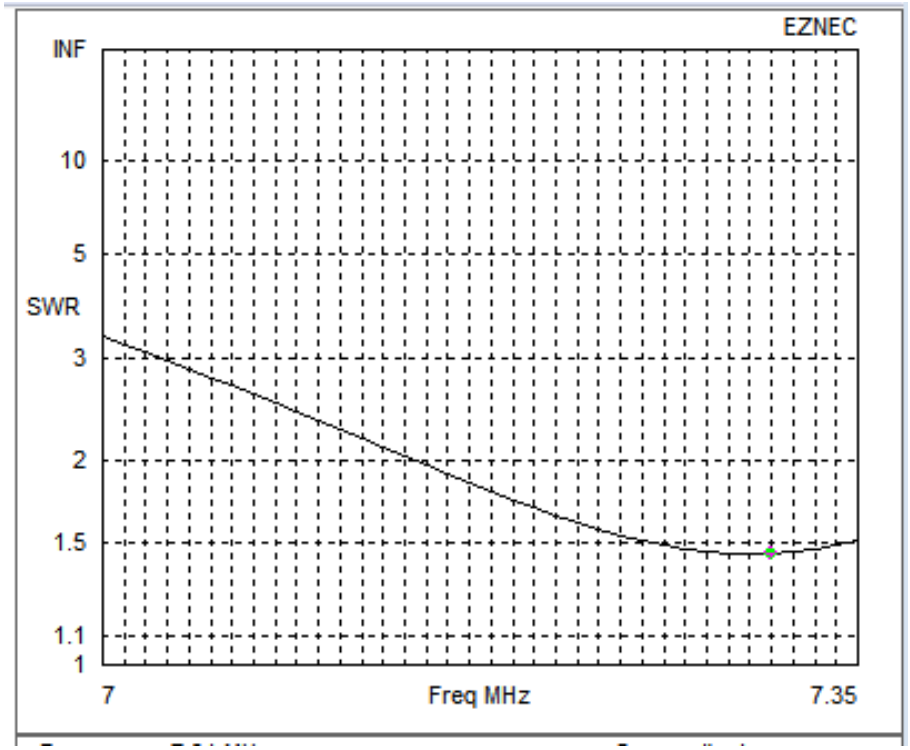


Simulation: L =470/F vs L=468/F

#14 bare wire, Free Space



On this side: 470, F_r = 7.14 MHz



On this side: 468, F_r = 7.31 MHz

Velocity Factor or is it?

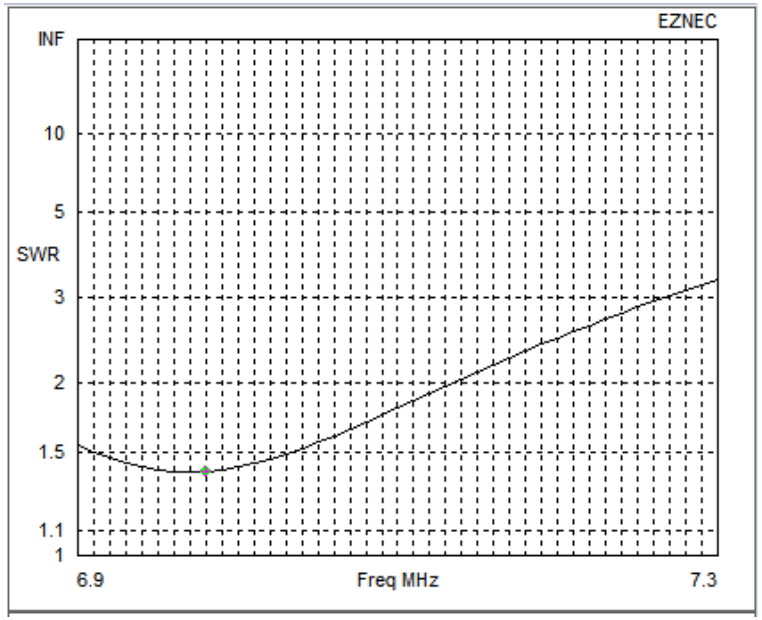
- VF is ratio of perceived velocity of propagation on the element to speed of light.
- For long thin bare copper wire, VF ~ 1
- Insulated wire any length, VF < 1
- Can you find VF for your wire?
- Not part of wire specs.
- Experiment –
  - Put antenna up with bare wire, measure F_r
  - Put same antenna up with insulated wire, measure F_r
  - Simulate it. Simulators accommodate insulated wire

What causes VF?

- Dual Discontinuities in Dielectric Constant, DC
  - Change in DC from wire to insulation
  - Change in DC from wire to free air
  - Makes wire look thicker (Different K!)
- DC of Insulation Material & Thickness
  - THHN, PVC, DC = 3.5, .02” thick
  - FlexWeave PVC, DC = 3.5, .03” thick
  - FlexWeave Polyethylene (Rope), DC = 2.25, .03” thick
  - PTFE (Teflon), DC = 2.1

Simulation #14 THHN Wire, 67.1 ft., free space

- DC=Dielectric Constant = 3.5
- Insulation Thickness =.02 inches
- F_r = 7 MHz
- Shorten to 65.5 ft, F_r = 7.15 MHz
- How to put up in free space?
- Sorry that's above my pay grade!
- How about my back yard? OK.



- What would you expect near earth?
- High Voltage looks for partners: earth, trees, extra wire wrapped on insulator, support ropes, etc.
- Near the ground < ½ wavelength, expect F_r to decrease.

Resonant Frequency & Height

Height, ft.	Resonant Frequency, MHz
20	7.06
30	7.07
40	7.12
50	7.18
60	7.20

Observation: Resonance is close to desired at heights we can easily achieve, 40-50”

Summary

- Two Factors: End Effect and “Velocity Factor”
  - End Effect is related to L/d
  - VF depends…..
- L= 468 / F can leave you short.
- L = 470 / F gets closer.
- Solution – Cut the wire long and be prepared to tune it in your environment.

Epilogue: So where did 468 originate?

- 468/F goes back to early 20th century
- Most Hams then used open wire feeders & broad range tuners. (W1IS still has one.)
- SWR bridges were only available to professionals, Bird, and expensive.
  - Hams didn't care.
  - Tube finals handle high SWR.
  - Tuning done with neon bulbs on the feed line or RF Current meter

- SWR awareness grew in late 1950s with Heathkit SWR Bridge.
- Concern grew with Solid State Finals not as SWR Tolerant as Tubes.
- BUT - Hams built/bought beams. K for large d tubing, 20-10M is low ~.95
- 492*.95 = 468
- That's our story and we're sticking to it until something better comes along!