https://www.dreamstime.com/stock-images-welcome-back-to-class-image25766814

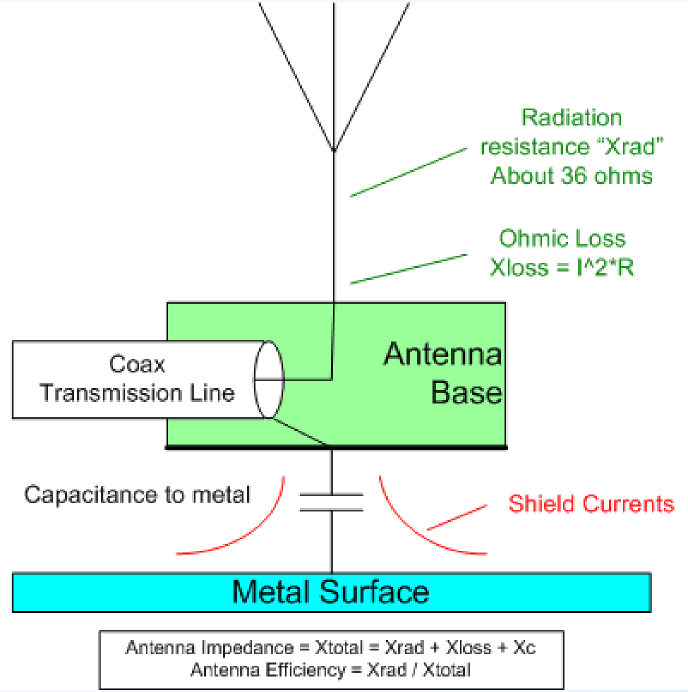
With W4EEY

https://madisonlib.org/story-time/

Antenna Efficiency

- Radiation resistance vs Total Resistance

https://www.w8ji.com/radiation_resistance.htm



http://www.cosjwt.com/index.php?a=3

A Tale of……..

Ohmic Loss

https://www.sermoncentral.com/church-media-preaching-sermons/powerpoint-template-backgrounds/good-battery-bad-connection-857-detail

- Avoid Ohmic Losses – in antennas and in automotive electric systems!

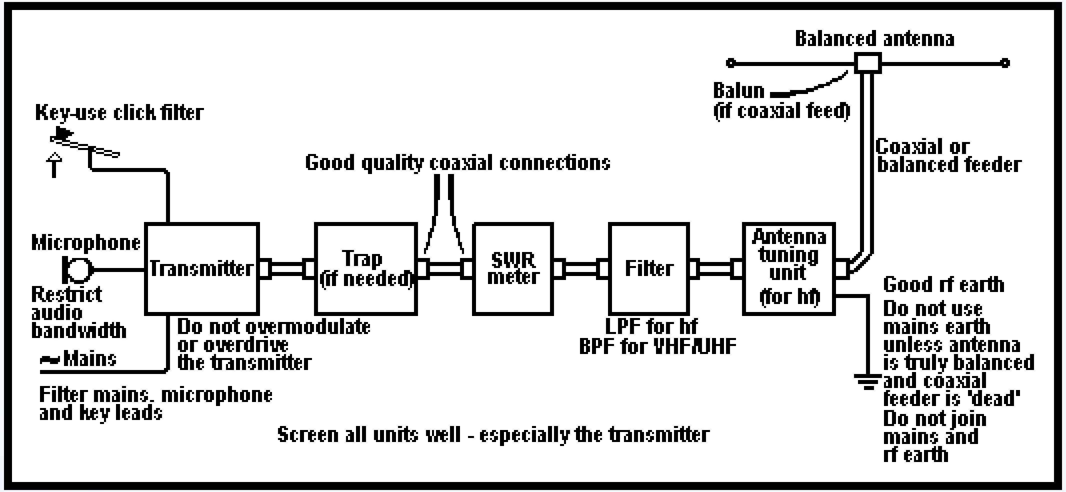
- Tighten your battery terminals!

Section 9.3

Antenna Systems

Transmission System

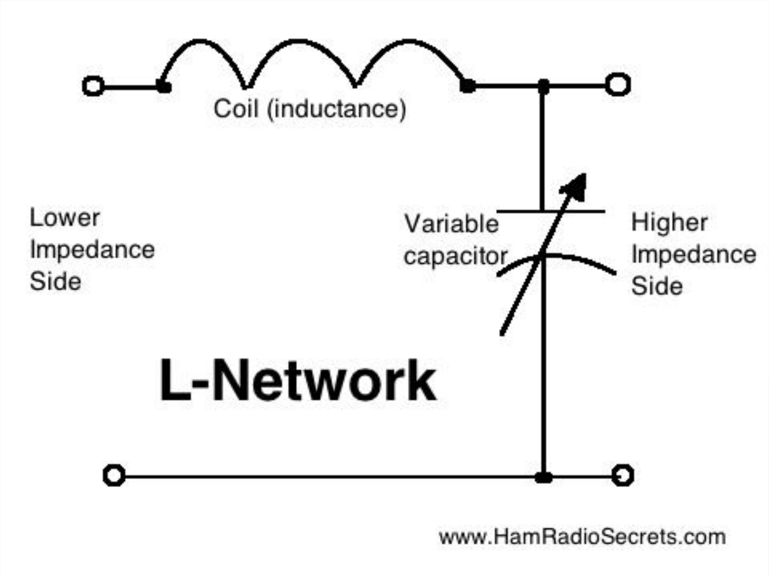
- Everything from the radio's RF output is part of the Transmission System



http://www.ukradioamateur.co.uk/full/html/c9-1-3.htm

Why Impedance Matching?

- To minimize losses!



http://www.antiqueradios.com/forums/viewtopic.php?f=12&t=262563

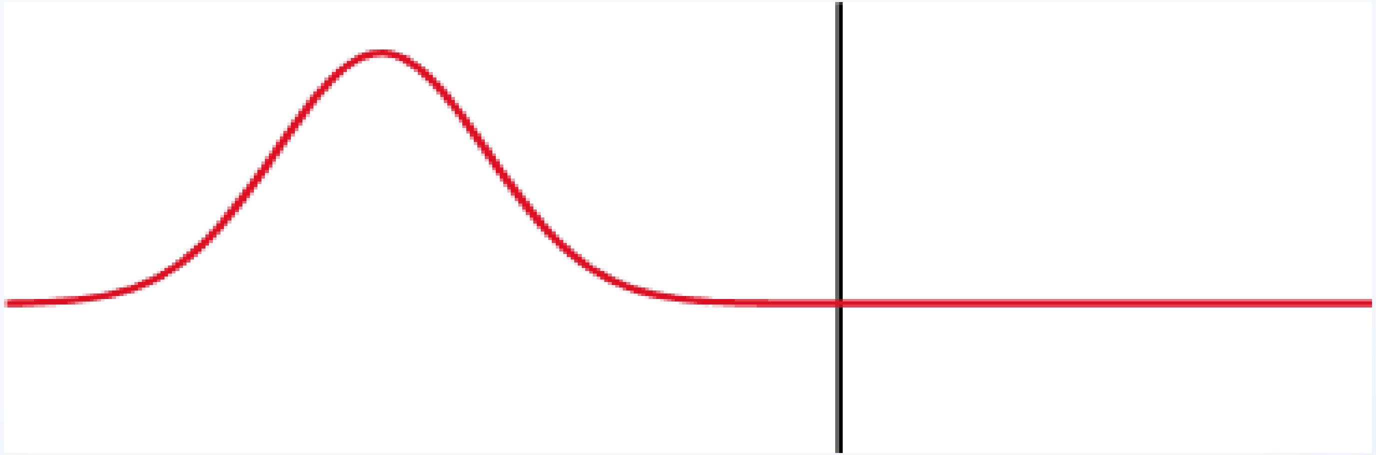
Matched Impedance

http://www.acs.psu.edu/drussell/Demos/reflect/reflect.html

100% Reflected Power

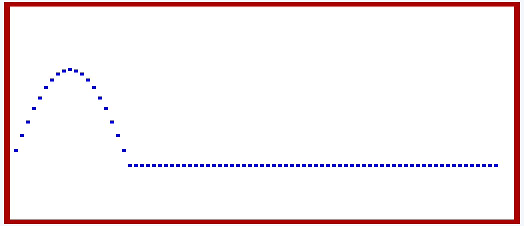
https://electronics.stackexchange.com/questions/235886/impedance-matching-for-high-speed-pulse-generators/235891

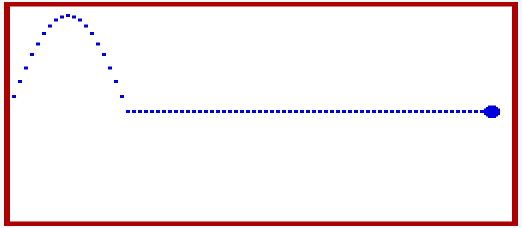
Partial Reflection



https://electronics.stackexchange.com/questions/235886/impedance-matching-for-high-speed-pulse-generators/235891

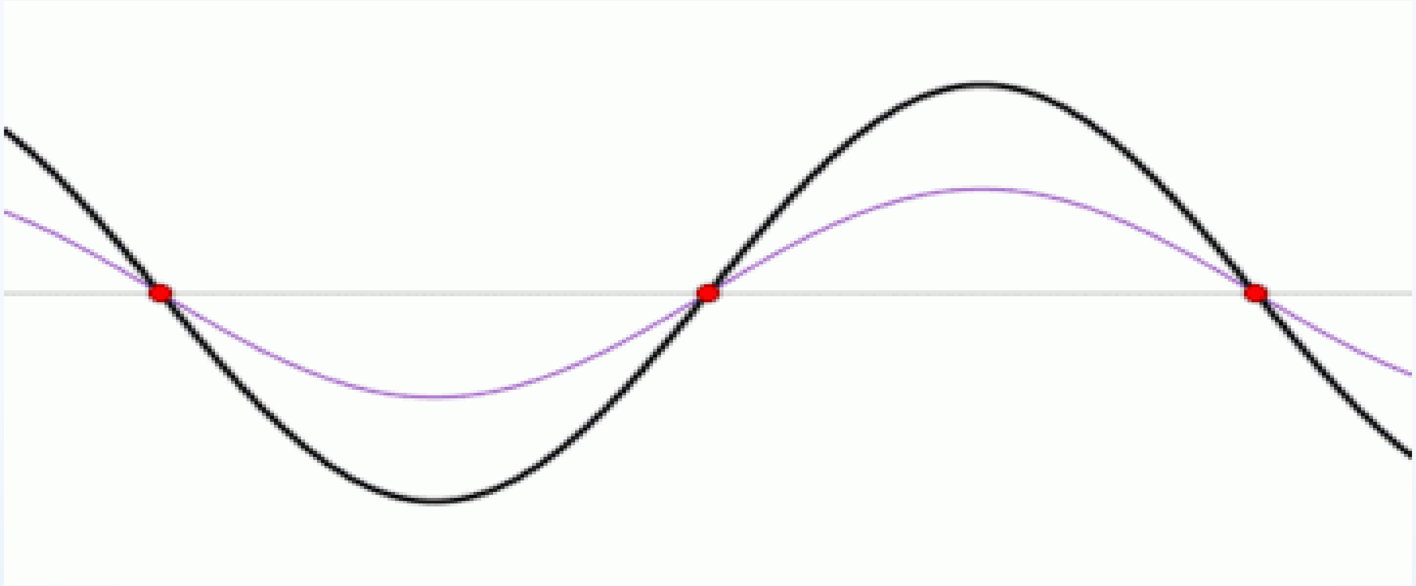
Hitting an Open or Shorted End





https://electronics.stackexchange.com/questions/235886/impedance-matching-for-high-speed-pulse-generators/235891

Standing Waves



https://giphy.com/search/standing-waves

https://www.youtube.com/watch?v=7mOQb3E8ob0

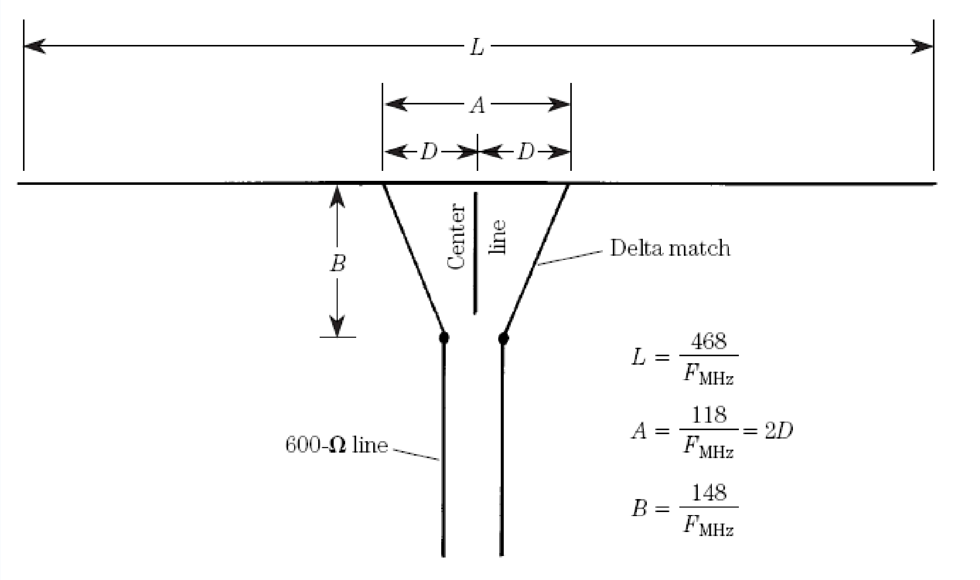
Δ

https://en.wiktionary.org/wiki/%CE%94

Delta Match

∇

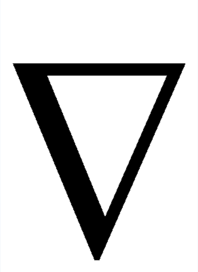
- Balanced impedance converter
- High to Low Impedance (Feedline/Antenna)

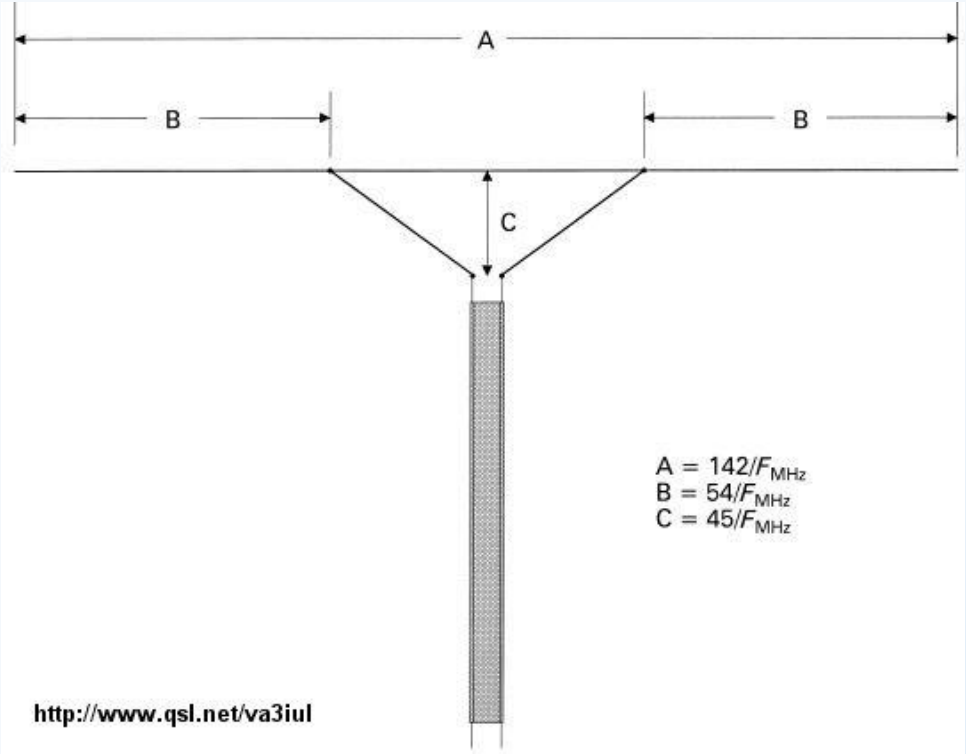


http://www.hs8jyx.com/html/vhf_uhf_matching.html

Delta Match

- Delta Fed Dipole





http://www.qsl.net/va3iul/

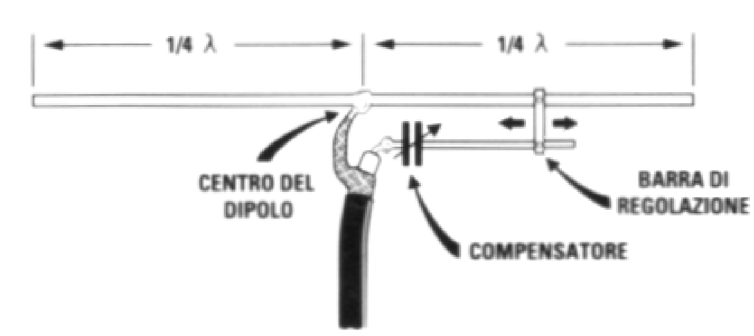
Γ

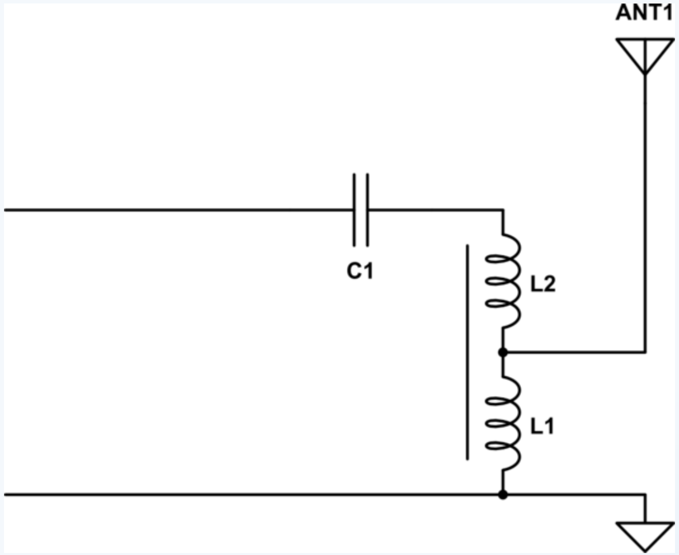
https://commons.wikimedia.org/wiki/File:Greek_uc_gamma.png

Gamma Match

Γ

- Unbalanced to Balanced
- Steps Up the Impedance
- Grounded Driven Element/Shield
- Capacitance cancels the Inductance





http://fucimin.altervista.org/en/old-yagi-pmr446.html

https://ham.stackexchange.com/questions/1804/what-is-a-gamma-match-in-the-context-of-the-driven-element-of-a-yagi-antenna

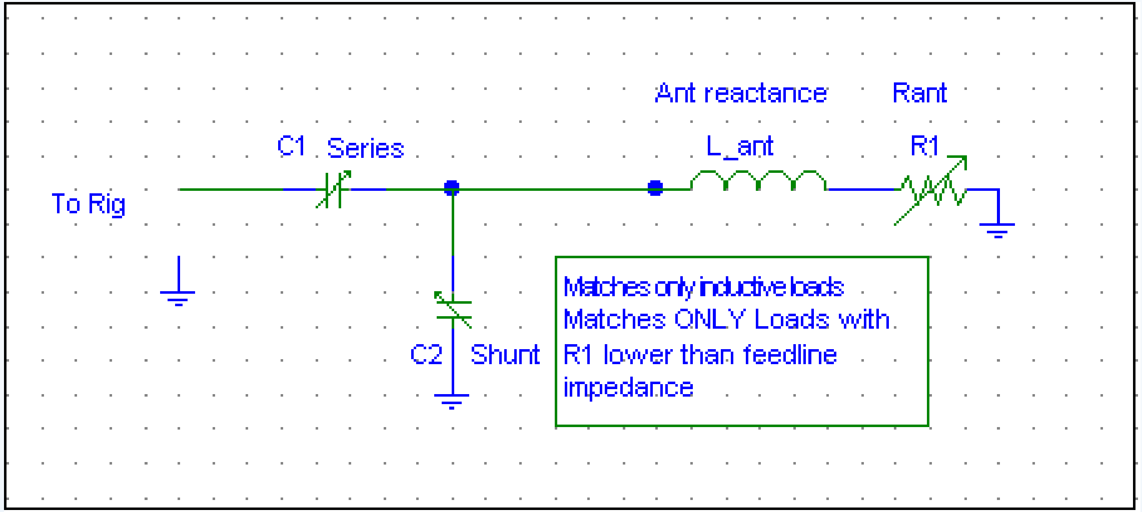
Ω

https://en.wiktionary.org/wiki/%CE%A9

Omega Match

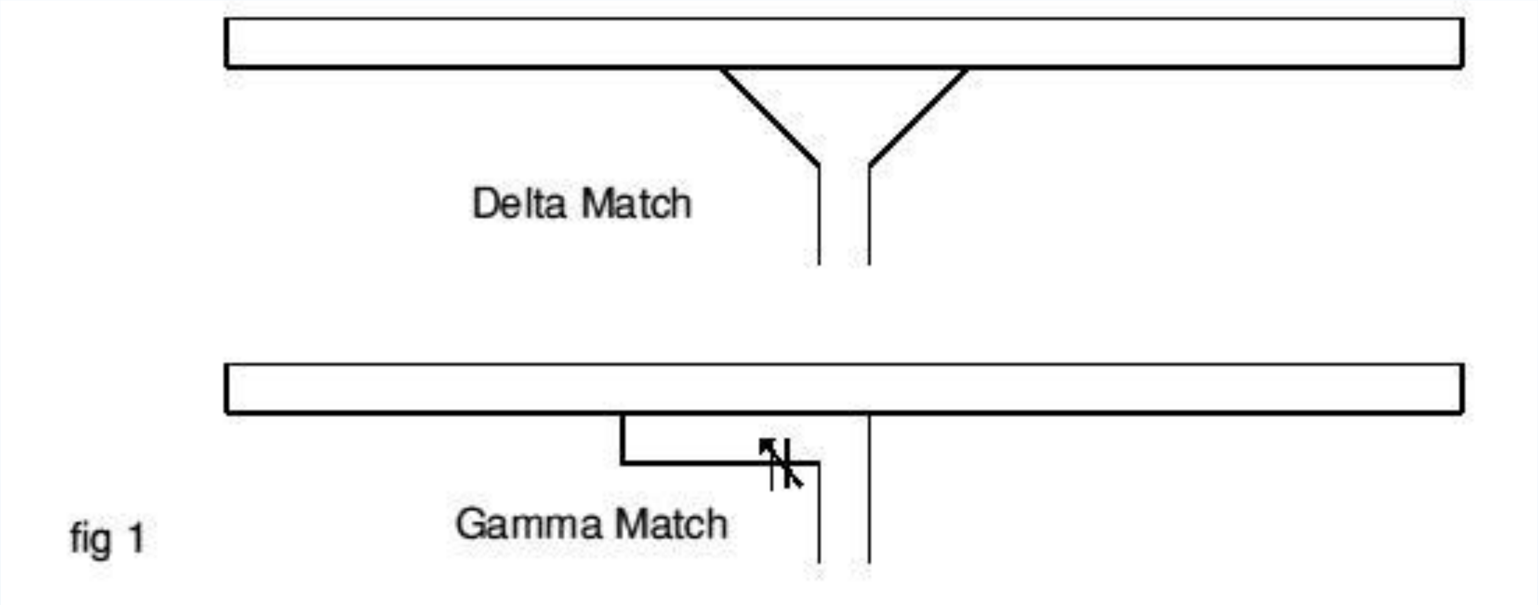
Ω

- L-Network to match low impedance antennas



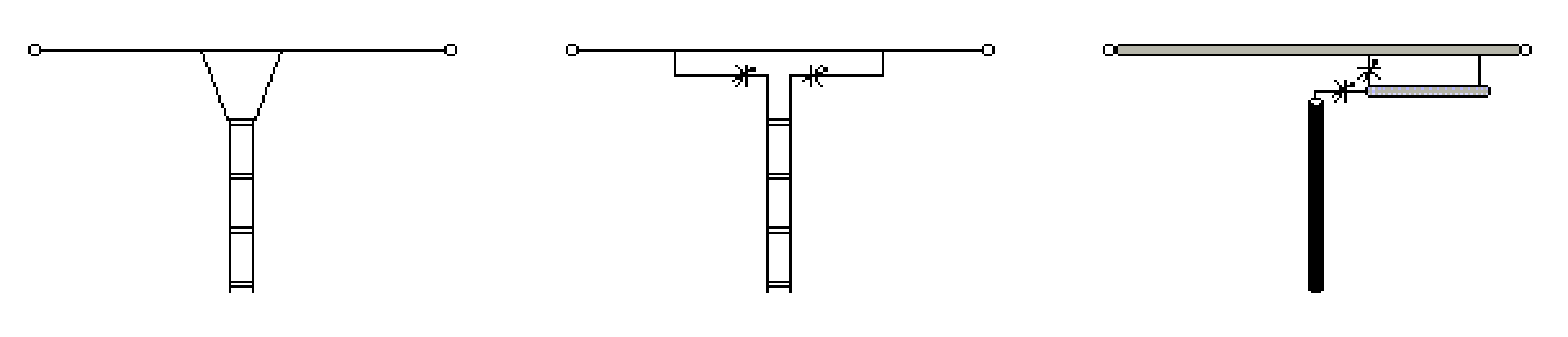
https://www.w8ji.com/omega_and_gama_matching.htm

Comparison



http://www.qsl.net/pa3hbb/6m3e1.htm

Comparison



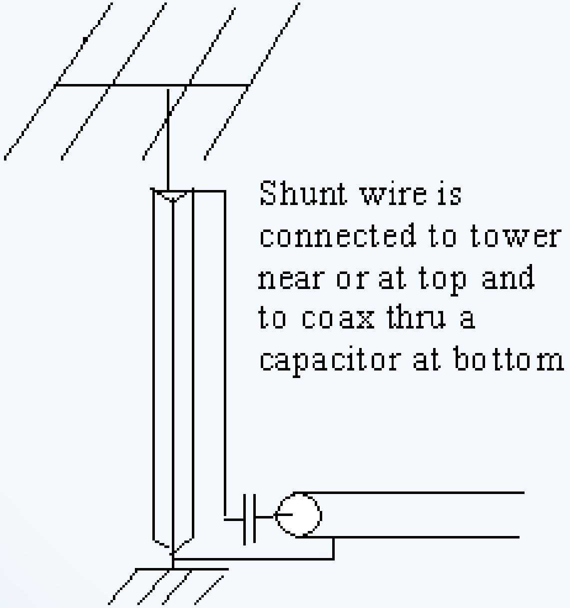
Delta

T

Omega

http://www.astrosurf.com/luxorion/qsl-transmission-line4.htm

Gamma Match Your Tower



Use your Tower as an antenna

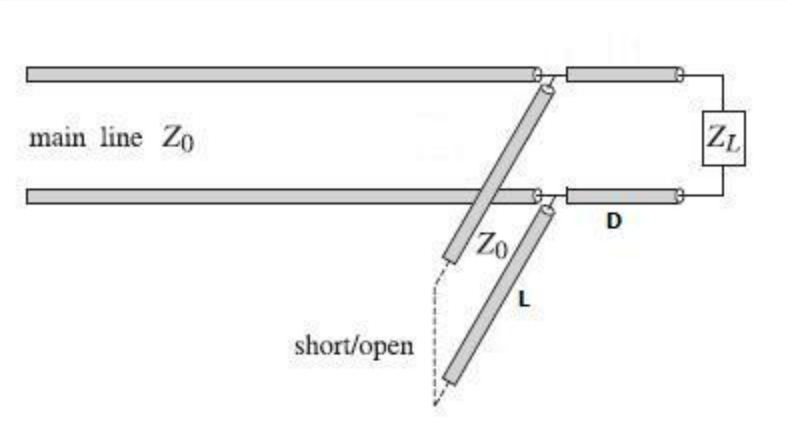
Good for the Low Bands (160 & 80)

AKA Shunt Feeding a Tower

http://www.qsl.net/w9rb/webdoc9.htm

Stub Matching

- Open or Shorted Transmission line added at a point along the Main Transmission Line
- Perfect Match at one frequency



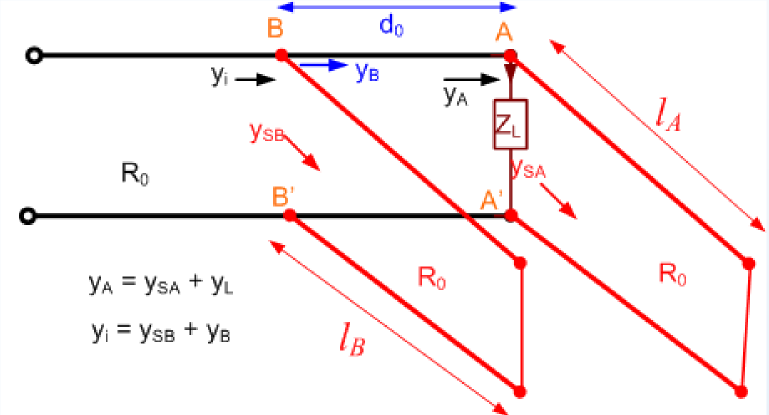


Fig : Impedance matching with double-stub method

http://www.arcticpeak.com/antennapages/single_stub_match.html

http://www.iitk.ac.in/mimt_lab/vlab/index.php?pg=im/theory1&usr=dimple&enc=b13354c54cb58678e7f417cc4974469b

Universal Stub Matching

- Practical for VHF & UHF due to manageable Stub Size

Figure 9.28
Page 9-30

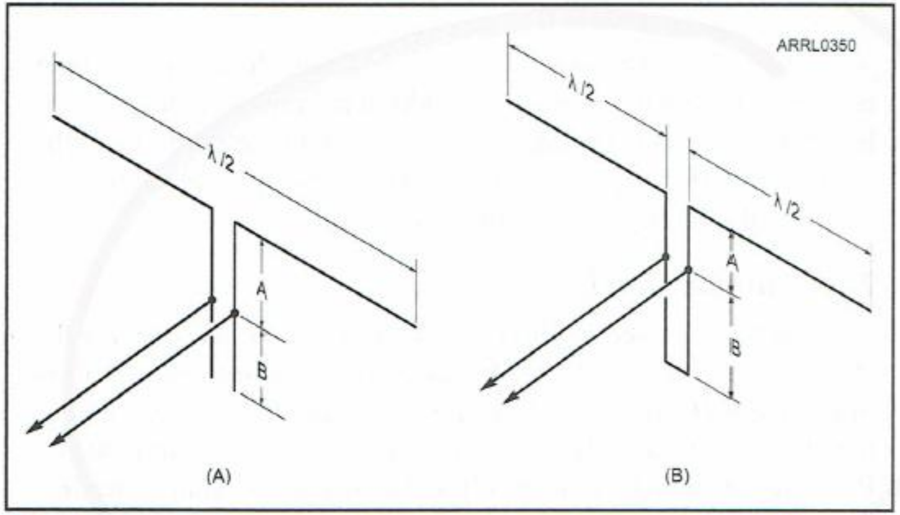
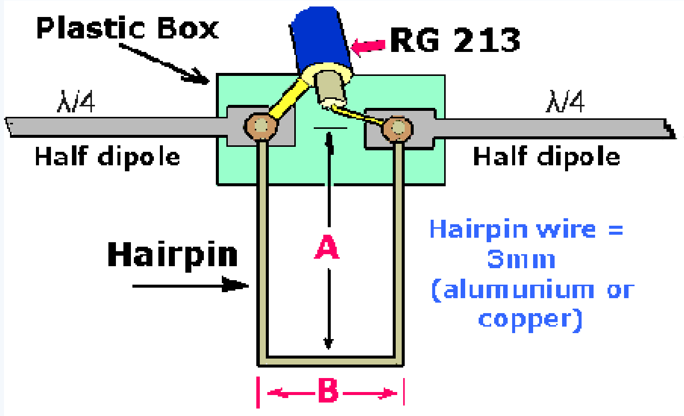


Figure 9.28 — The stub matching system uses a short perpendicular section of transmission line connected to the feed line near the antenna. Dimensions A and B are adjusted to provide a match to the transmitter and feed line.

Hairpin Match

- Driven Element is purposely made short (capacitive)
- Hairpin adds Inductance in Parallel (Shunt)



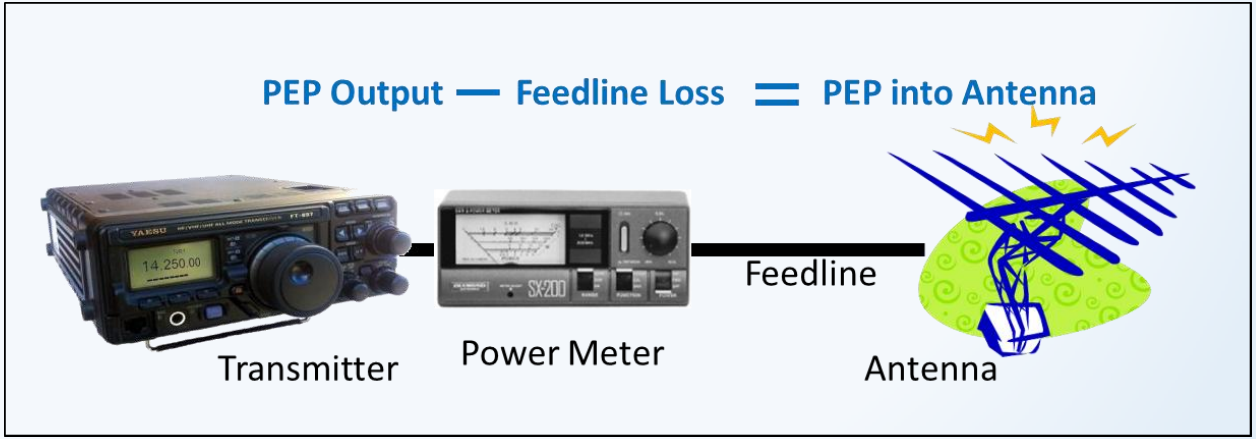
http://www.i1wqrlinkradio.com/antype/ch17/chiave1562.htm

http://www.qsl.net/sv1bsx/3EL-VHF/3EL_VHF.html

Transmission System Losses and Gains

- TX Power Output
- Less Feedline Loss
- Plus Antenna Gain
- Gives the ERP

ERP = Effective Radiated Power



http://www.hamradioschool.com/rf-exposure-evaluating-your-station/

Sample Problem

- E9A16. What is the effective radiated power relative to a dipole of a repeater station with 200 watts transmitter power output, 4 dB feed line loss, 3.2 dB duplexer loss, 0.8 dB circulator loss, and 10 dBd antenna gain?

-4 dB
-3.2 dB
-0.8 dB
+10 dB

Sum =
+2 dB

ERP =
More than 200
Less than 400

POWER 10 log P1/P2 = dB

VOLTAGE 20 log V1/V2 = dB

DB RULES OF THUMB				
Multiply Current / Voltage By		.	Multiply Power By:	
if +dB	if -dB	dB	if +dB	if -dB
1	1	0	1	1
1.12	0.89	1	1.26	0.8
1.26	0.79	2	1.58	0.63
1.4	0.707	3	2	0.5
2.0	0.5	6	4	0.25
2.8	0.35	9	8	0.125

VOLTAGE

POWER

http://www.rfcafe.com/references/electrical/ew-radar-handbook/decibel.htm

Answer

200 Watts x 1.58 = 316 Watts ERP

(Taken from the preceding chart)

Questions

Section 9.3

E9A03. Why would one need to know the feed point impedance of an antenna?

A. To match impedances in order to minimize standing wave ratio on the transmission line

B. To measure the near-field radiation density from a transmitting antenna

C. To calculate the front-to-side ratio of the antenna

D. To calculate the front-to-back ratio of the antenna

E9A03. Why would one need to know the feed point impedance of an antenna?

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B. To measure the near-field radiation density from a transmitting antenna

C. To calculate the front-to-side ratio of the antenna

D. To calculate the front-to-back ratio of the antenna

E9A15. What is the effective radiated power relative to a dipole of a repeater station with 150 watts transmitter power output, 2 dB feed line loss, 2.2 dB duplexer loss, and 7 dBd antenna gain?

A. 1977 watts

B. 78.7 watts

C. 420 watts

D. 286 watts

E9A15. What is the effective radiated power relative to a dipole of a repeater station with 150 watts transmitter power output, 2 dB feed line loss, 2.2 dB duplexer loss, and 7 dBd antenna gain?

- **A.** 1977 watts
- **B.** 78.7 watts
- **C.** 420 watts
- **D.** 286 watts

E9A16. What is the effective radiated power relative to a dipole of a repeater station with 200 watts transmitter power output, 4 dB feed line loss, 3.2 dB duplexer loss, 0.8 dB circulator loss, and 10 dBd antenna gain?

- **A.** 317 watts
- **B.** 2000 watts
- **C.** 126 watts
- **D.** 300 watts

E9A16. What is the effective radiated power relative to a dipole of a repeater station with 200 watts transmitter power output, 4 dB feed line loss, 3.2 dB duplexer loss, 0.8 dB circulator loss, and 10 dBd antenna gain?

- **A.** 317 watts
- **B.** 2000 watts
- **C.** 126 watts
- **D.** 300 watts

E9A17. What is the effective isotropic radiated power of a repeater station with 200 watts transmitter power output, 2 dB feed line loss, 2.8 dB duplexer loss, 1.2 dB circulator loss and 7 dBi antenna gain?

A. 159 watts

B. 252 watts

C. 632 watts

D. 63.2 watts

E9A17. What is the effective isotropic radiated power of a repeater station with 200 watts transmitter power output, 2 dB feed line loss, 2.8 dB duplexer loss, 1.2 dB circulator loss and 7 dBi antenna gain?

A. 159 watts

B. 252 watts

C. 632 watts

D. 63.2 watts

E9A18. What term describes station output, taking into account all gains and losses?

- **A.** Power factor
- **B.** Half-power bandwidth
- **C.** Effective radiated power
- **D.** Apparent power

E9A18. What term describes station output, taking into account all gains and losses?

A. Power factor

B. Half-power bandwidth

C. Effective radiated power

D. Apparent power

E9E01. What system matches a higher impedance transmission line to a lower impedance antenna by connecting the line to the driven element in two places spaced a fraction of a wavelength each side of element center?

A. The gamma matching system

B. The delta matching system

C. The omega matching system

D. The stub matching system

E9E01. What system matches a higher impedance transmission line to a lower impedance antenna by connecting the line to the driven element in two places spaced a fraction of a wavelength each side of element center?

A. The gamma matching system

B. The delta matching system

C. The omega matching system

D. The stub matching system

E9E02. What is the name of an antenna matching system that matches an unbalanced feed line to an antenna by feeding the driven element both at the center of the element and at a fraction of a wavelength to one side of center?

A. The gamma match

B. The delta match

C. The epsilon match

D. The stub match

E9E02. What is the name of an antenna matching system that matches an unbalanced feed line to an antenna by feeding the driven element both at the center of the element and at a fraction of a wavelength to one side of center?

A. The gamma match

B. The delta match

C. The epsilon match

D. The stub match

E9E03. What is the name of the matching system that uses a section of transmission line connected in parallel with the feed line at or near the feed point?

A. The gamma match

B. The delta match

C. The omega match

D. The stub match

E9E03. What is the name of the matching system that uses a section of transmission line connected in parallel with the feed line at or near the feed point?

- **A.** The gamma match
- **B.** The delta match
- **C.** The omega match
- **D.** The stub match

E9E04. What is the purpose of the series capacitor in a gamma-type antenna matching network?

- **A.** To provide DC isolation between the feed line and the antenna
- **B.** To cancel the inductive reactance of the matching network
- **C.** To provide a rejection notch to prevent the radiation of harmonics
- **D.** To transform the antenna impedance to a higher value

E9E04. What is the purpose of the series capacitor in a gamma-type antenna matching network?

- **A.** To provide DC isolation between the feed line and the antenna
- **B.** To cancel the inductive reactance of the matching network
- **C.** To provide a rejection notch to prevent the radiation of harmonics
- **D.** To transform the antenna impedance to a higher value

E9E05. How must the driven element in a 3-element Yagi be tuned to use a hairpin matching system?

- **A.** The driven element reactance must be capacitive
- **B.** The driven element reactance must be inductive
- **C.** The driven element resonance must be lower than the operating frequency
- **D.** The driven element radiation resistance must be higher than the characteristic impedance of the transmission line

E9E05. How must the driven element in a 3-element Yagi be tuned to use a hairpin matching system?

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B. The driven element reactance must be inductive

C. The driven element resonance must be lower than the operating frequency

D. The driven element radiation resistance must be higher than the characteristic impedance of the transmission line

E9E06. What is the equivalent lumped-constant network for a hairpin matching system of a 3-element Yagi?

A. Pi-network

B. Pi-L-network

C. A shunt inductor

D. A series capacitor

E9E06. What is the equivalent lumped-constant network for a hairpin matching system of a 3-element Yagi?

A. Pi-network

B. Pi-L-network

C. A shunt inductor

D. A series capacitor

E9E09. Which of these matching systems is an effective method of connecting a 50 ohm coaxial cable feed line to a grounded tower so it can be used as a vertical antenna?

A. Double-bazooka match

B. Hairpin match

C. Gamma match

D. All of these choices are correct

E9E09. Which of these matching systems is an effective method of connecting a 50 ohm coaxial cable feed line to a grounded tower so it can be used as a vertical antenna?

A. Double-bazooka match

B. Hairpin match

C. Gamma match

D. All of these choices are correct

E9E11. What is an effective way of matching a feed line to a VHF or UHF antenna when the impedances of both the antenna and feed line are unknown?

A. Use a 50-ohm 1:1 balun between the antenna and feed line

B. Use the universal stub matching technique

C. Connect a series-resonant LC network across the antenna feed terminals

D. Connect a parallel-resonant LC network across the antenna feed terminals

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B. Use the universal stub matching technique

C. Connect a series-resonant LC network across the antenna feed terminals

D. Connect a parallel-resonant LC network across the antenna feed terminals

Section 9.4

Transmission Lines

Antenna Analyzers

- **Built in RF Source**
- Single Frequency Measurement
- Swept Frequency Measurement
- PC Interface
- Plot to Graph or Smith Chart
- Direct readout of R + jX
- Portable (Can use up on a tower)

https://www.dxengineering.com/parts/reu-aa-30?seid=dxese1&cm_mmc=pla-google-_-shopping-_-dxese1-_-rigexpert&gclid=Cj0KEQjwioHIBRCes6nP56Ti1IsBEiQAxxb5G2Q6pcW5O0IfWYVXt9xb4YkdPb6GAYIhCEr7rVGI_FUaAmrd8P8HAQ

Directional Power Meter

- Has “Slugs” that are inserted in the Front
- Slugs for different frequencies and power levels
- Read power in the direction of the arrow
- Rotate the slug and read power in the opposite direction
- Knowing Forward and Reflected Power, SWR can be calculated (may be a chart on the back of the meter)

http://dmcitarsi.com/thruline-power-meter/

Hook Up

https://www.youtube.com/watch?v=fbj_r6QfN4I

https://en.wikipedia.org/wiki/Antenna_analyzer

Network Analyzers

http://www.madmadscientist.com/html/materials.html

Vector Network Analyzers

- DG8SAQ VNWA -3
- More affordable for hams
- Characterize components to 1.3 GHz
- Uses PC Software
- Internal RF Generator & Internal low noise spectrum analyzer
- Measures S-Parameters
- VSWR Plots
- Smith Chart Display

http://sdr-kits.net/VNWA3_Description.html

VNA Calibration

- Use an Open, Short, and 50 Ohm Load

S Parameters

- Scattering Parameters
- Characterize Gain, Return Loss, VSWR, refection coefficient and stability.
- DUT (Device Under Test) treated as a "black box"
- **Indicate the Ports** are where signal can enter or leave a DUT (**indicated by the subscripts**

The 2-port S-parameters have the following generic descriptions:

S_{11} is the input port voltage reflection coefficient

S_{12} is the reverse voltage gain

S_{21} is the forward voltage gain

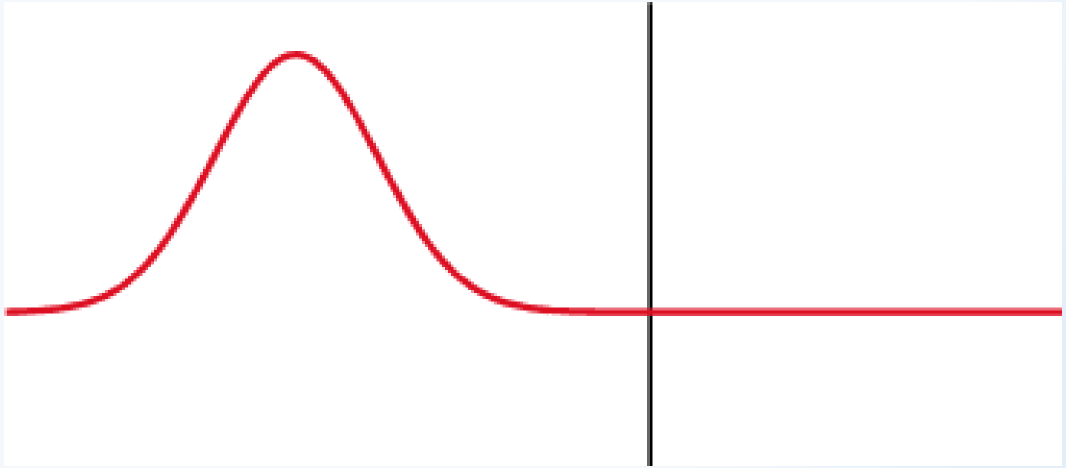
S_{22} is the output port voltage reflection coefficient.

https://en.wikipedia.org/wiki/Scattering_parameters

Reflection Coefficient

- How much of a wave is reflected?
- Can be derived from the SWR

$$\frac{SWR-1}{SWR+1}$$



https://en.wikipedia.org/wiki/Reflection_coefficient

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- S_{11} is the input port voltage reflection coefficient
- S_{12} is the reverse voltage gain
- S_{21} is the forward voltage gain
- S_{22} is the output port voltage reflection coefficient.

- **S21 = Forward Gain**

https://en.wikipedia.org/wiki/Scattering_parameters

https://en.wikipedia.org/wiki/Scattering_parameters

The 2-port S-parameters have the following generic descriptions:

- S_{11} is the input port voltage reflection coefficient
- S_{12} is the reverse voltage gain
- S_{21} is the forward voltage gain
- S_{22} is the output port voltage reflection coefficient.

www.pinterest.com

- **S11 = Return Loss (Reflection Coefficient)**

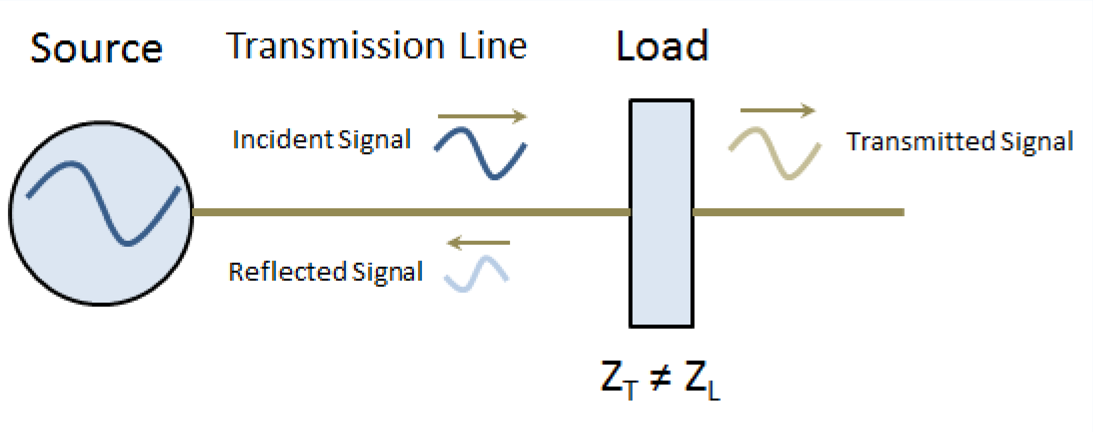
RF Ammeter

- Directly Measures RF current
- AM Broadcast TX output may be spec'd in amps.

https://www.surplussales.com/Meters/MtrRF-amps.html

http://www.mfjenterprises.com/Product.php?productid=MFJ-854

Mismatched Transmission Line

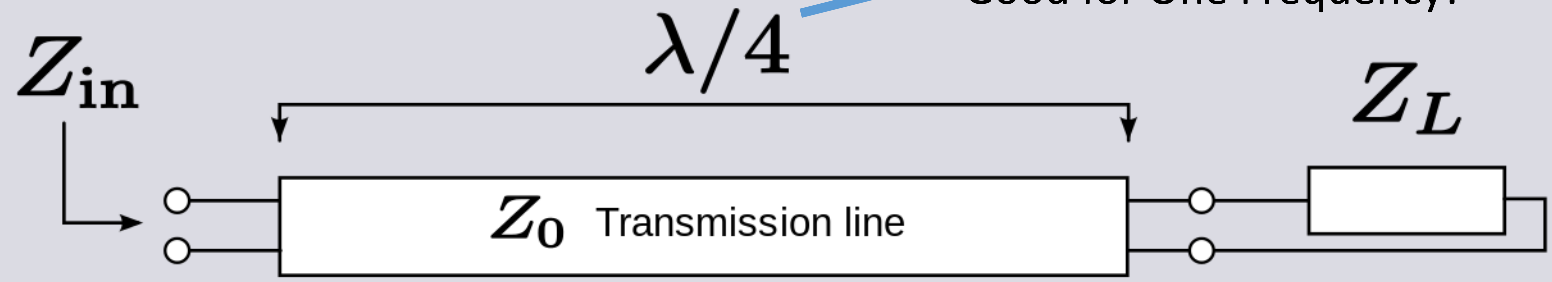


- Forward Wave
- Reflected Wave
- SWR > 1:1

https://thinkincredible.intraway.com/white-paper/the-effect-of-multiple-impedance-mismatches-on-tdr-fault-localization/

Transmission Line Transformer

Good for One Frequency!



75 Ohms

50 Ohms

100 Ohms

https://en.wikipedia.org/wiki/Quarter-wave_impedance_transformer

Velocity Factor

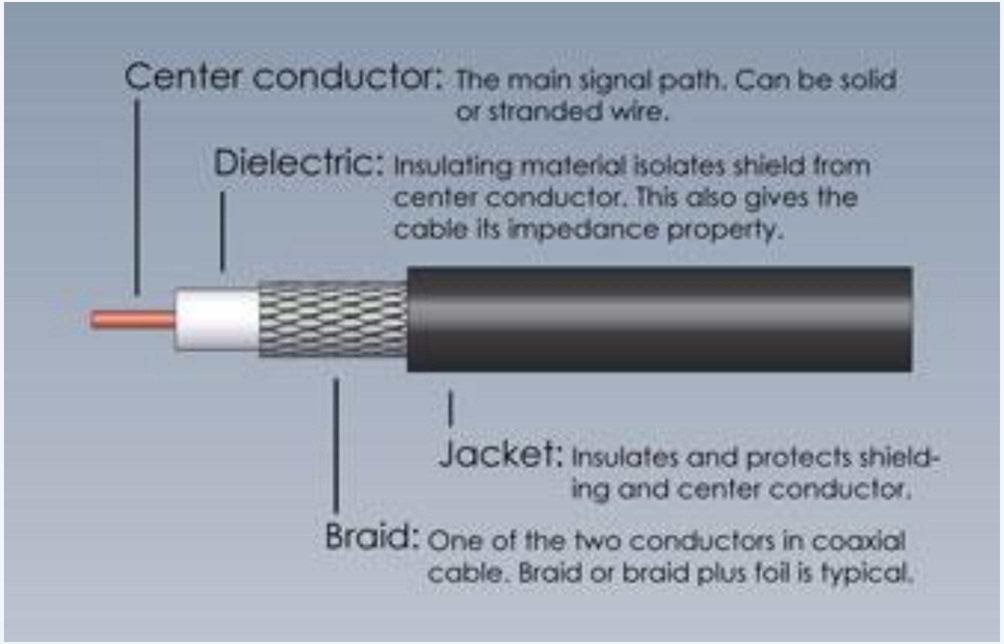
- Radio travels at the Speed of Light in a Vacuum
- Travels through bare wire nearly as fast
- Slowed down using Insulated wire (!)
- Coaxial cable dielectric slows it even more

Velocity Factor

- How fast is a radio wave traveling compared to the speed of light
- It is expressed as the velocity of the wave in the transmission line divided by the velocity of light in a vacuum
- Determined by the dielectric materials used in the cable

Cables make Waves Slow

Solid vs Foam Dielectric Coax



http://www.rfcables.com/Technical_wp-RFCableAssembly.htm

Foam Dielectric

- Foam dielectric has lower safe operating voltage limits
- Foam dielectric has lower loss per unit of length
- Foam dielectric has higher velocity factor

Cable Velocity Factor and Loss Data (per 100 feet)

Also See
Table 9-1
Page 9-33

Open Wire Line
= 0.95 to 0.99

Solid PE = 0.66

TYPE	VF	LOSS @ 10 MHz	LOSS @ 50 MHz	LOSS @ 100 MHz	LOSS @ 400 MHz	LOSS @ 700 MHz
RG-6/U PE (Belden 8215)	66.0	0.8	1.9	2.7	5.9	8.1
RG-6/U Foam (Belden 9290)	81.0	0.7	1.7	2.5	5.3	7.2
RG-8/U (PE (Belden 8237)	66.0	0.6	1.3	1.9	4.2	5.9
RG-8/U Foam (Belden 8214)	78.0	0.5	1.2	1.7	3.9	5.6
RG-8/U (Belden 9913)	84.0	0.5	1.0	1.4	3.4	5.0
RG-8X (Belden 9258)	82.0	0.9	2.1	3.1	6.6	9.1
RG-11/U Foam HDPE (Beld. 9292)	84.0	0.5	0.9	1.3	2.3	3.3
RG-58/U PE (Belden 9201)	66.0	1.1	2.5	3.8	8.4	11.7
RG-58A/U Foam (Belden 8219)	73.0	1.3	3.1	4.5	10.0	14.2
RG-59A/U PE (Belden 8241)	66.0	1.1	2.4	3.4	7.0	9.7
RG-59A/U Foam (Belden 8241F)	78.0	0.9	2.1	3.0	6.6	8.9
RG-174 PE (Belden 8216)	66.0	3.3	5.8	8.4	19	27
RG-174 Foam (Belden 7805R)	73.5		4.6		14.0 (450)	20.9 (900)

http://www.febo.com/reference/cable_data.html

Practical Problem

- E9F05. What is the approximate physical length of a solid polyethylene dielectric coaxial transmission line that is electrically one-quarter wavelength long at 14.1 MHz?

- How do you solve this? Let’s do it!

E9F05

- 14.1 MHz
- Wavelength in Meters = ?
- ¼ Wavelength = ?
- Velocity Factor of PE Coax = ?
- VF x ¼ Wavelength = ?

Standing Up for Standing Waves

https://www.youtube.com/watch?v=oejsHzurzv4

Impedance of Shorted or Open Transmission Line (Figure 9.33 Page 9-40, 9.34 Page 9-41)

Two General Rules:

- **A ½ Wavelength line is an Impedance Repeater**

  ½ Wave Open line appears open (Parallel Resonance)

  ½ Wave Shorted line appears shorted (Series Resonance)

- **A ¼ Wavelength line is an Impedance Inverter**

  ¼ Wave Open line appears shorted (Series Resonance)

  ¼ Wave Shorted line appears open (Parallel Resonance)

Table 9.33
Page 9-40

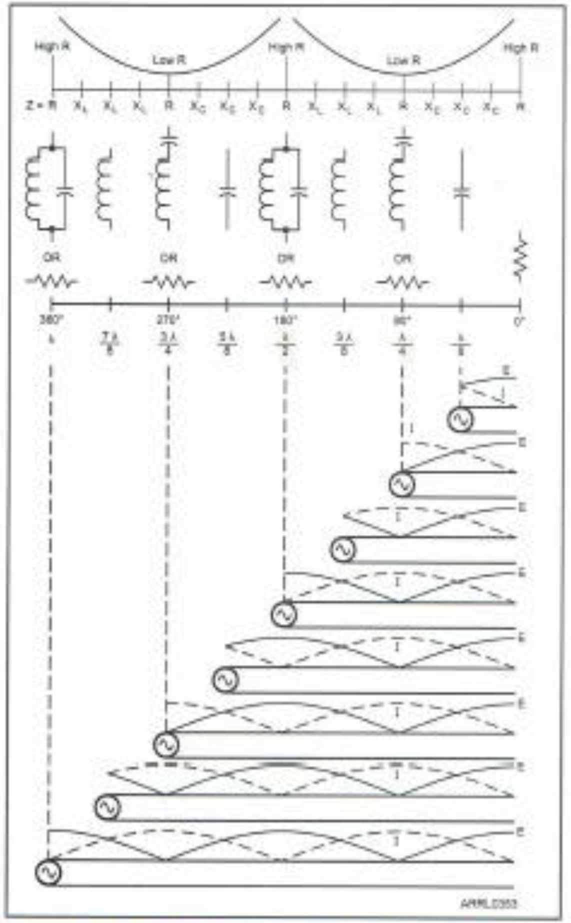


Figure 9.33 — This diagram summarizes the characteristics of open-circuited transmission lines. Voltage standing waves are shown as solid lines above each length of cable, and current standing waves are shown as dashed lines.

Open Lines

Table 9.34
Page 9-41

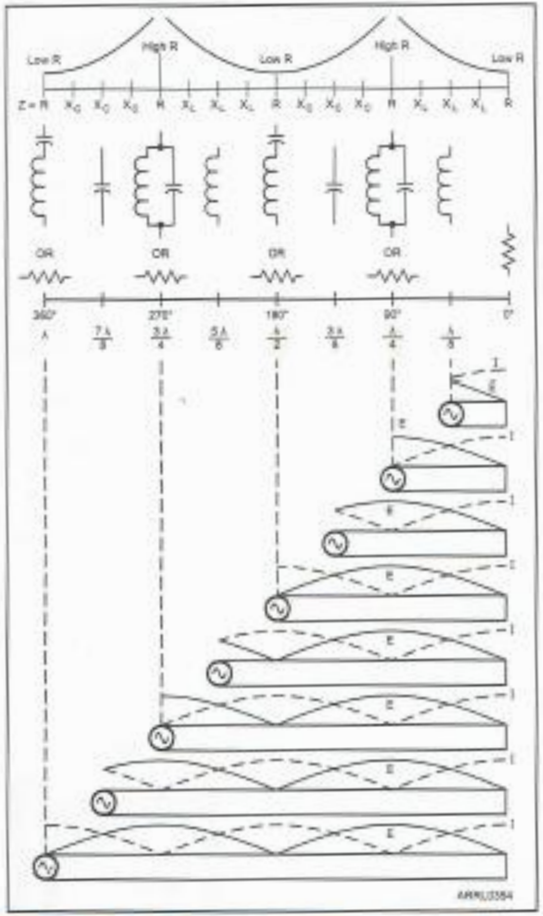


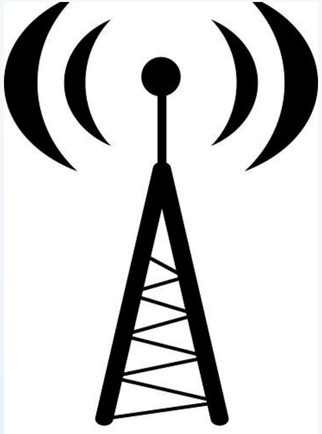
Figure 9.34 — This diagram summarizes the characteristics of short-circuited transmission lines. Voltage standing waves are shown as solid lines above each length of cable, and current standing waves are shown as dashed lines.

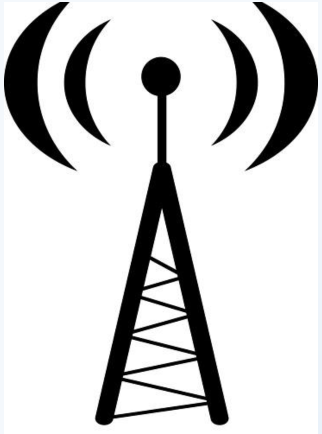
Shorted Lines

- A 1/8 Wave Open line appears as a Capacitance
- A 1/8 Wave Shorted line appears as an Inductor

- A 3/8 Wave Open line appears as an Inductance
- A 3/8 Wave Shorted line appears as a Capacitance

Prepare Yourself!





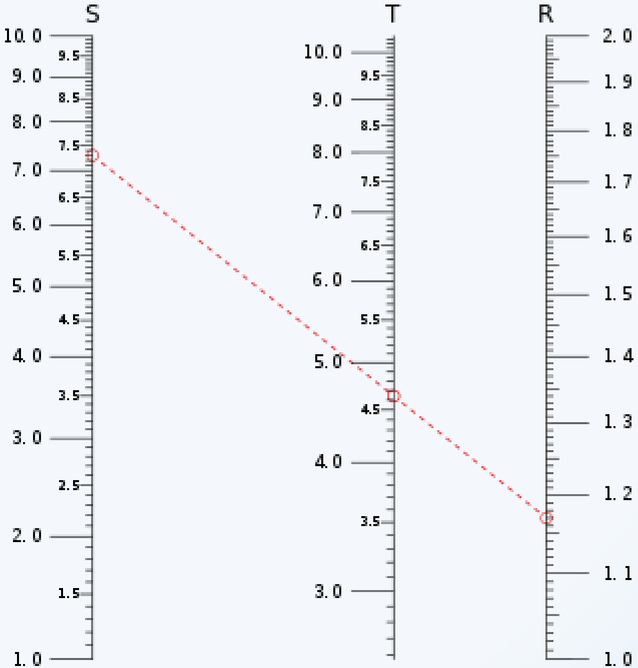
http://jewel925.com/secret-society/

https://commons.wikimedia.org/wiki/File:RadioTower.jpg

https://www.pinterest.com/pin/302093087478585326/

Nomogram

- Aka Alignment Chart
- Can be used to find an unknown value

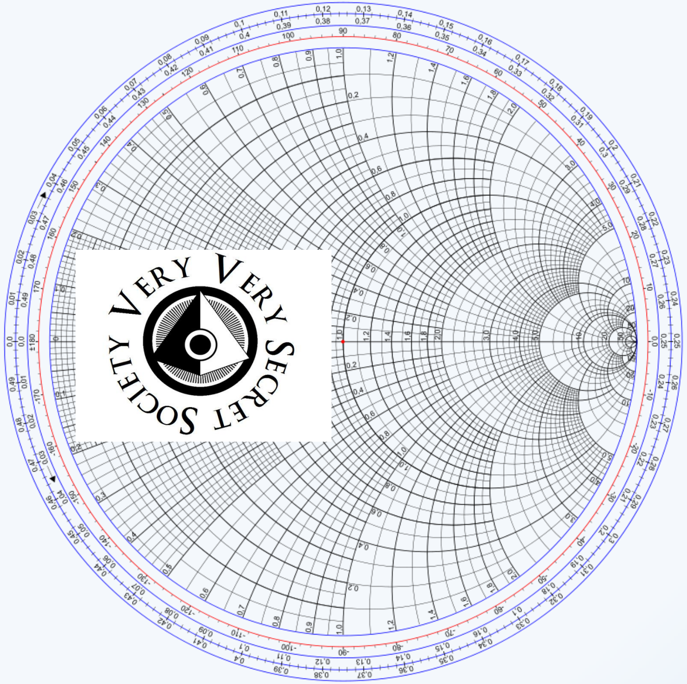


$$T = (1.84S + 4.66)^{0.37} (1.21R)^{4/3}$$

https://en.wikipedia.org/wiki/Nomogram

The Mother of All Nomograms!

Phillip Hagar Smith



https://en.wikipedia.org/wiki/Phillip_Hagar_Smith

"From the time I could operate a slide rule, I've been interested in graphical representations of mathematical relationships."

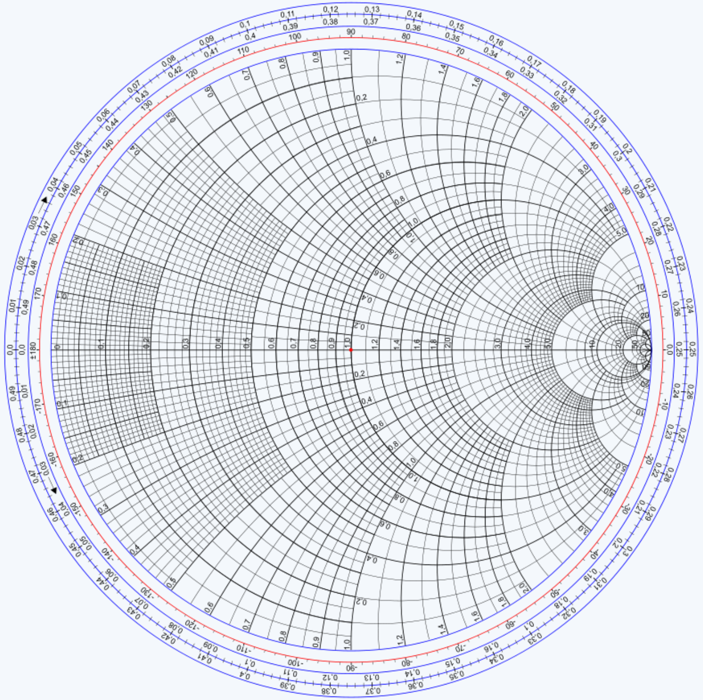
https://en.wikipedia.org/wiki/Phillip_Hagar_Smith

Smith Chart

Constant **Resistance Circles**

Constant **Reactance Arcs**

Fractions of
Transmission Line
Electrical Wavelength
around the edge



"All About Impedance and SWR"

Starts on Page 9-36

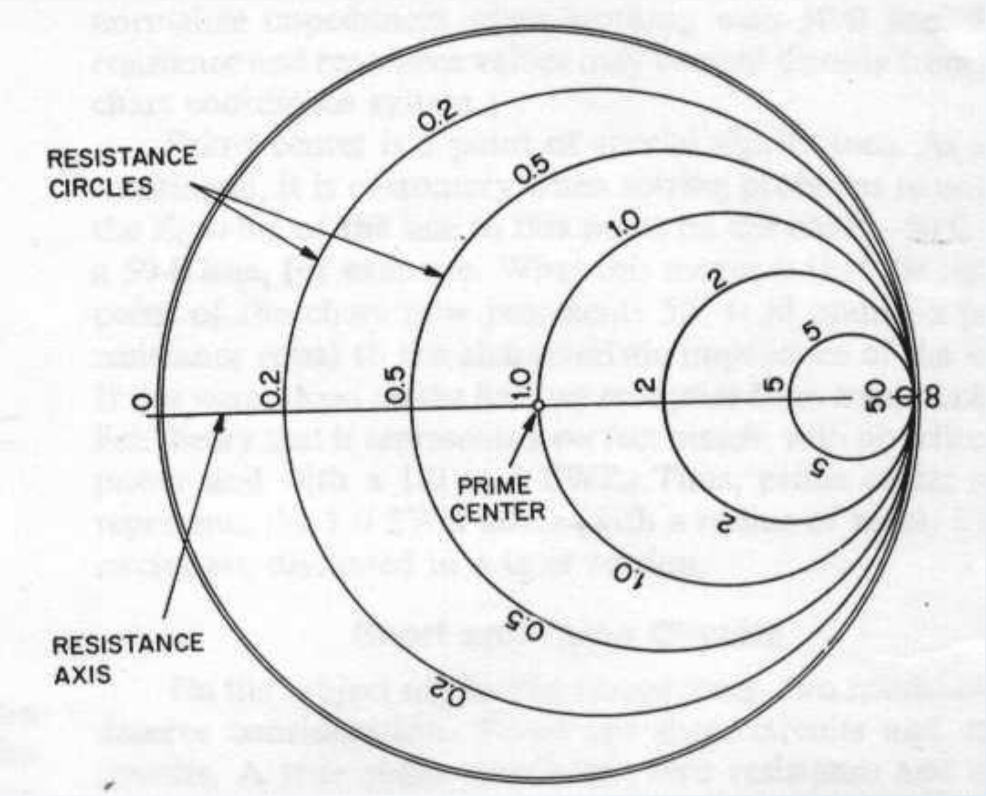
Chart on Page 9-38

https://en.wikipedia.org/wiki/Smith_chart

Resistance Circles

Short Circuit at left on R Axis

Open Circuit at Right on R Axis

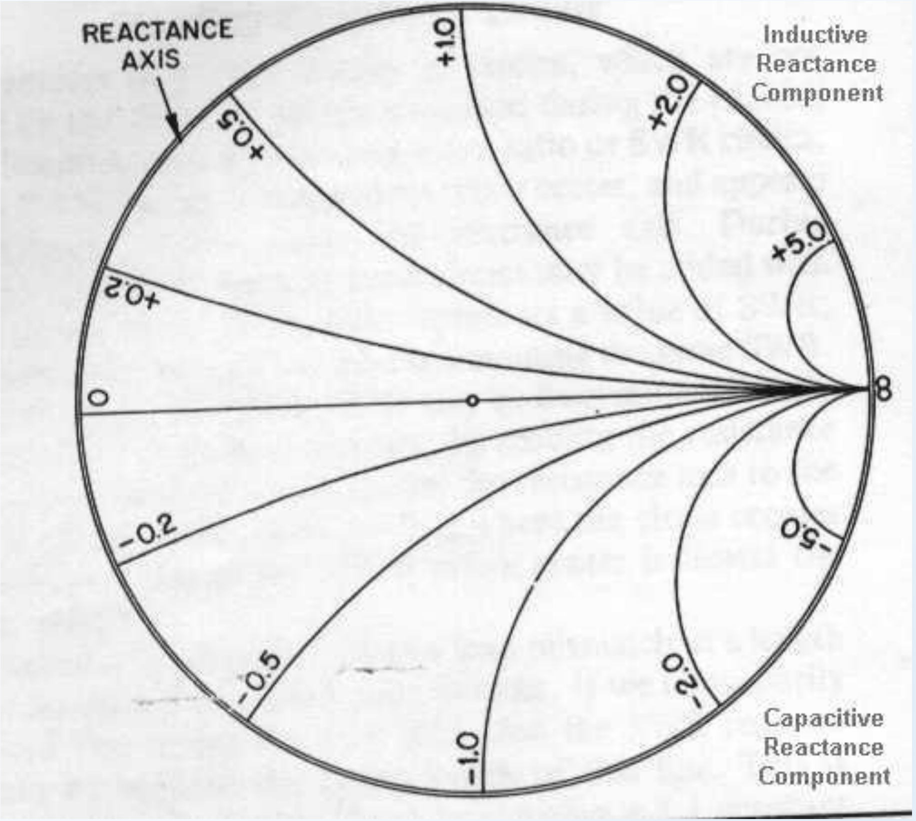


http://www.qsl.net/va3iul/Smith%20Chart/smith.html

Reactance Arcs

Inductive Reactance above the R Line

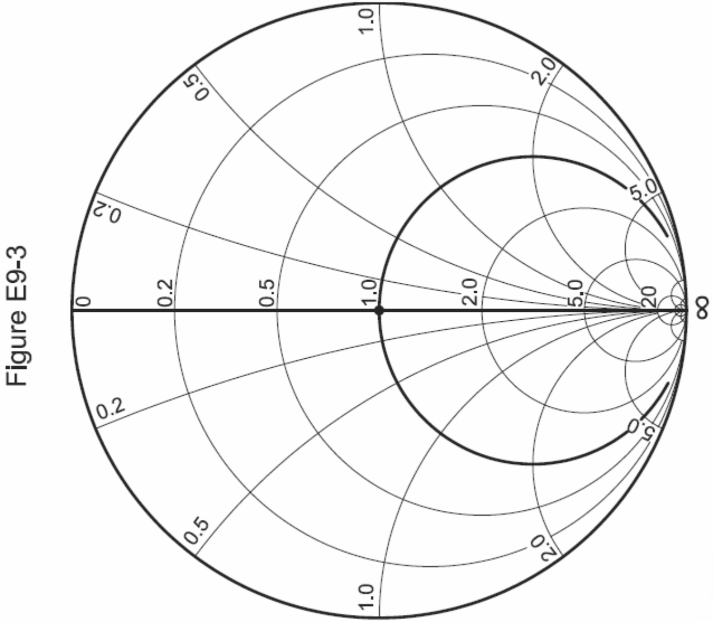
Capacitive Reactance below the R Line



http://www.qsl.net/va3iul/Smith%20Chart/smith.html

Smith Chart

Outer Circle is the **Reactance Axis**

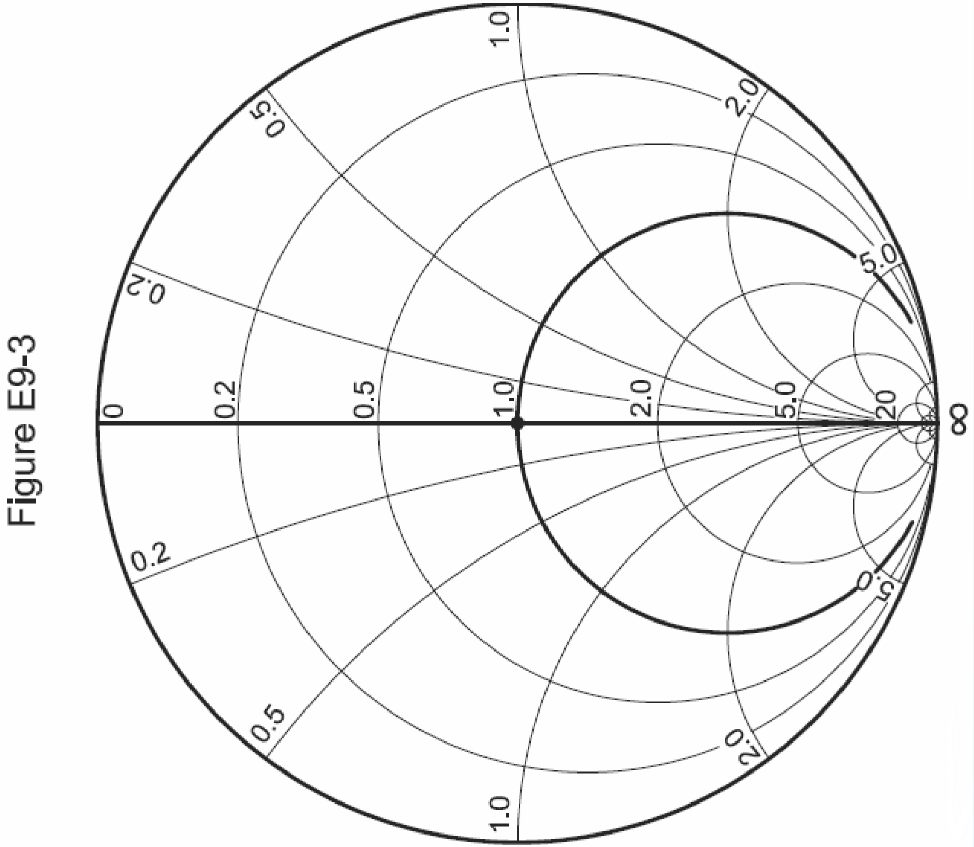


The Straight Line is the **Resistance Axis**

Point 1.0 is called the **Prime Center**

Normalizing means assigning a value to the Prime Center

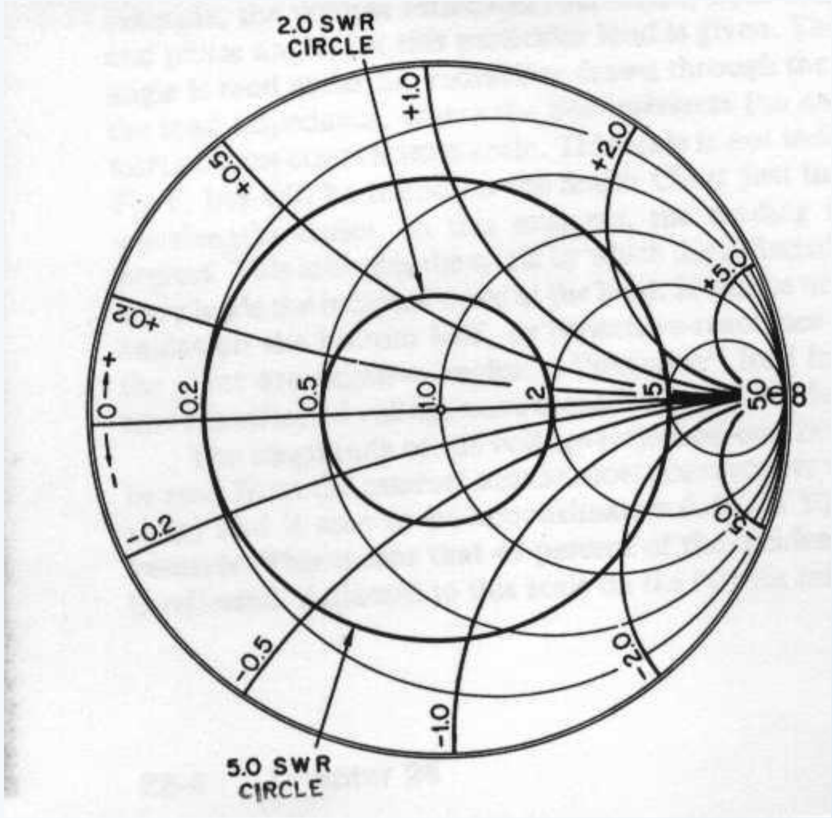
Other points are multiplied in the same way to give actual values of Resistance or Reactance at that point.



SWR Circles

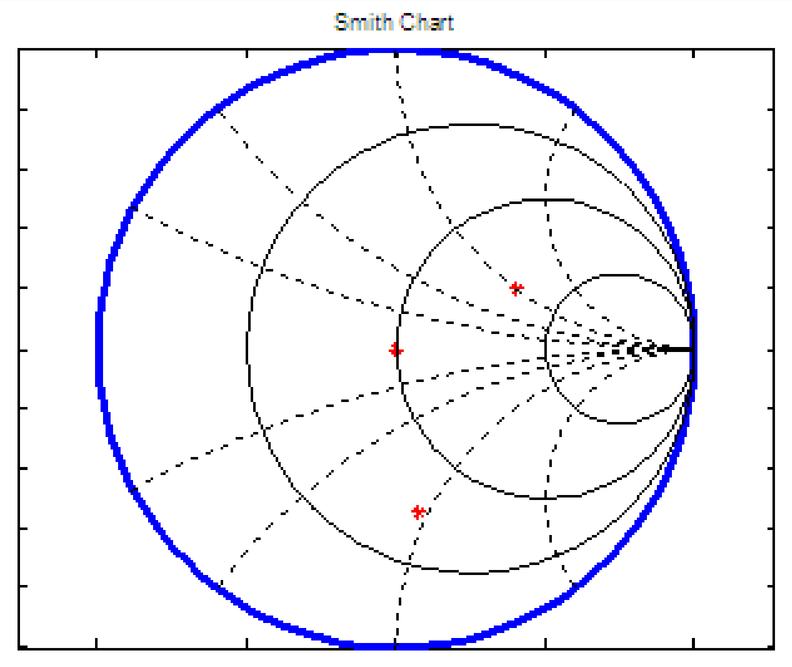
SWR is the same anywhere along the Circle

http://www.qsl.net/va3iul/Smith%20Chart/smith.html



Look at the Outer Ring – What does it say?

See Page 9-38



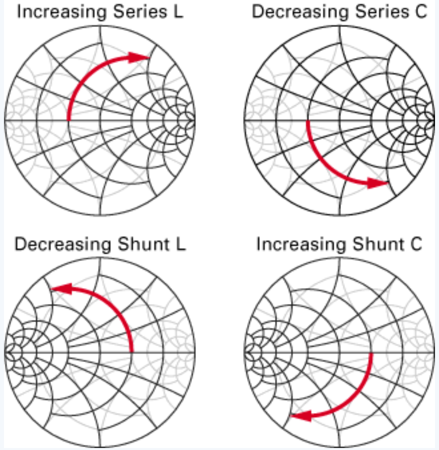
http://www.matrixlab-examples.com/smith-chart.html

Useful to calculate the Impedance along a Transmission Line.

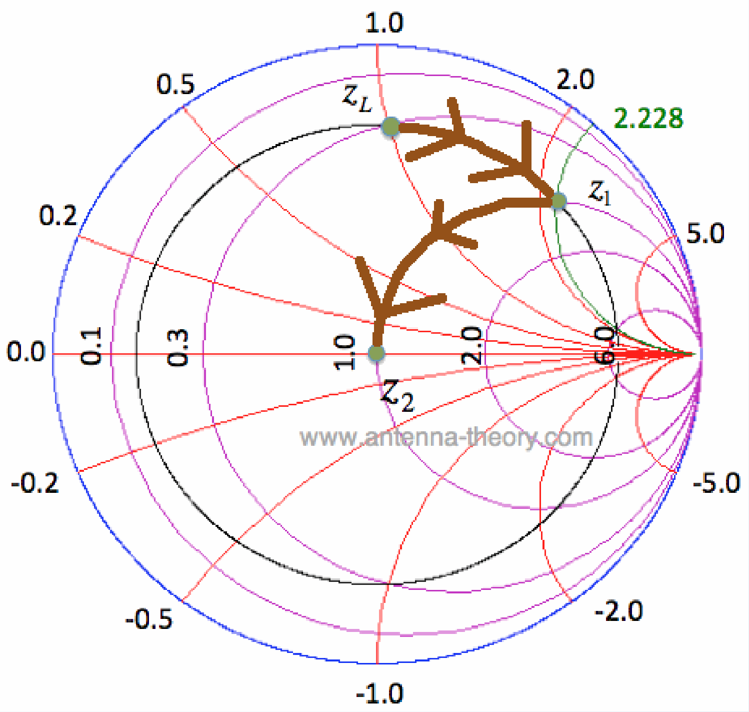
"Wavelengths toward the Load or toward the Generator"

Why the Smith Chart?

- Impedance Matching!



http://www.qsl.net/yo4hfu/Matching_Impendance.html

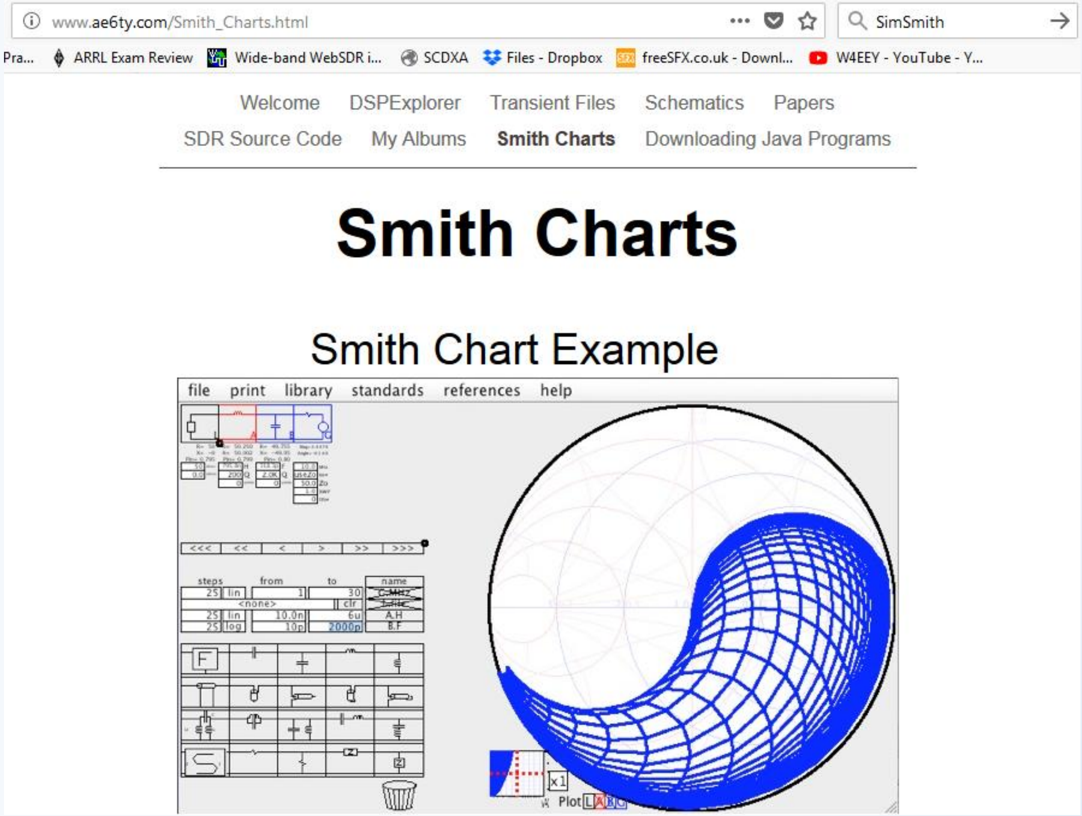


http://www.antenna-theory.com/tutorial/smith/smithchart6.php

Prefer Computers to Paper?

SIM Smith

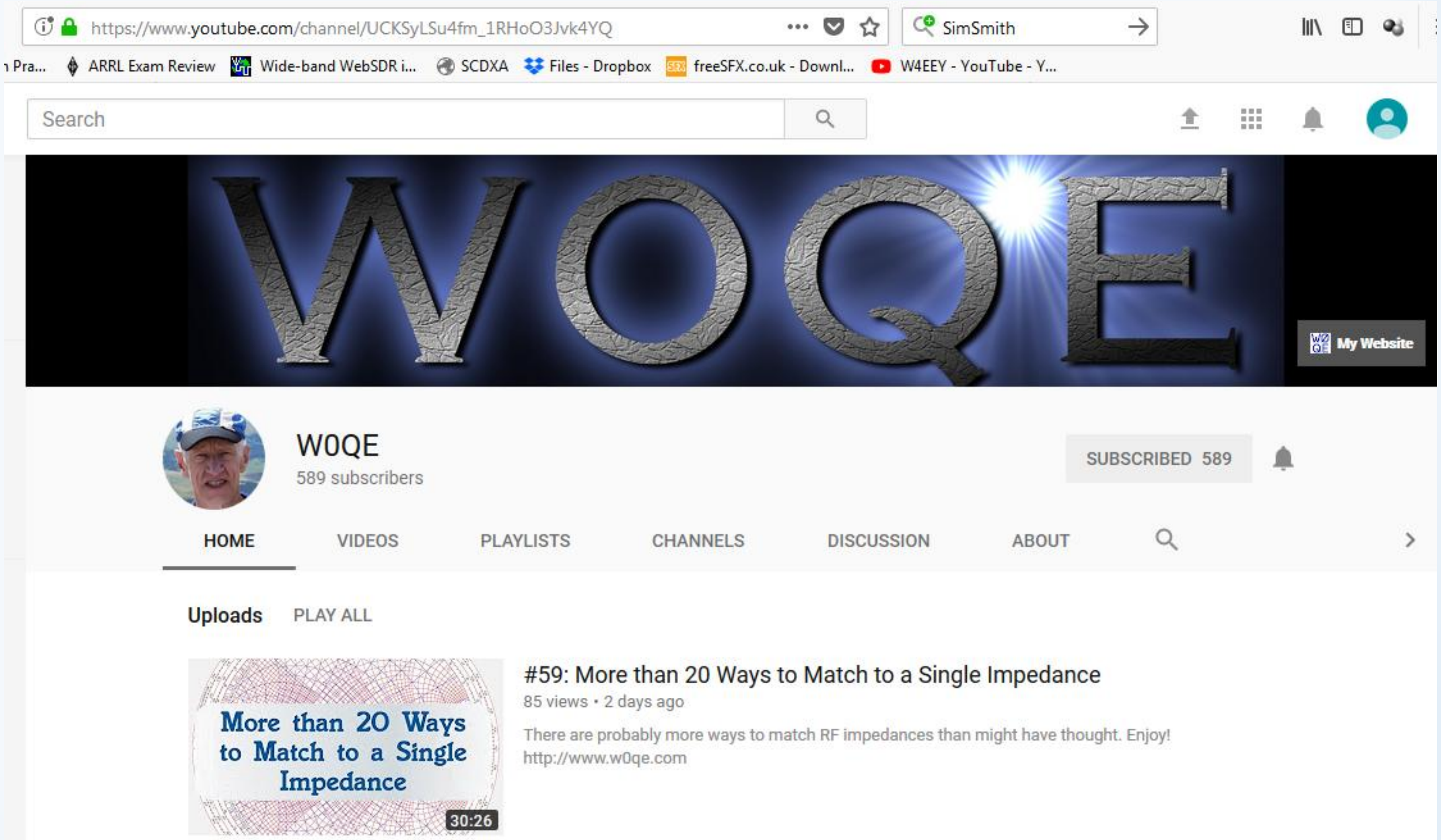
Free Windows Software



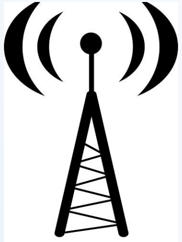
Written by:
Ward Harriman, AE6TY

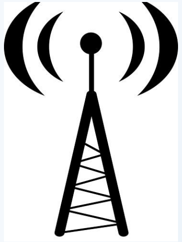
http://www.ae6ty.com/Smith_Charts.html

Larry Benko
W0QE



https://www.youtube.com/channel/UCKSyLSu4fm_1RHoO3Jvk4YQ





http://inspirationfeed.com/10-free-secret-society-badges/

https://www.flickr.com/photos/maraid/2285014955

Questions

Section 9.4

E4A07. Which of the following is an advantage of using an antenna analyzer compared to an SWR bridge to measure antenna SWR?

- **A.** Antenna analyzers automatically tune your antenna for resonance
- **B.** Antenna analyzers do not need an external RF source
- **C.** Antenna analyzers display a time-varying representation of the modulation envelope
- **D.** All of these choices are correct

E4A07. Which of the following is an advantage of using an antenna analyzer compared to an SWR bridge to measure antenna SWR?

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- **D.** All of these choices are correct

E4A08. Which of the following instruments would be best for measuring the SWR of a beam antenna?

A. A spectrum analyzer

B. A Q meter

C. An ohmmeter

D. An antenna analyzer

E4A08. Which of the following instruments would be best for measuring the SWR of a beam antenna?

A. A spectrum analyzer

B. A Q meter

C. An ohmmeter

D. An antenna analyzer

E4B06. How much power is being absorbed by the load when a directional power meter connected between a transmitter and a terminating load reads 100 watts forward power and 25 watts reflected power?

A. 100 watts

B. 125 watts

C. 25 watts

D. 75 watts

E4B06. How much power is being absorbed by the load when a directional power meter connected between a transmitter and a terminating load reads 100 watts forward power and 25 watts reflected power?

A. 100 watts

B. 125 watts

C. 25 watts

D. 75 watts

E4B07. What do the subscripts of S parameters represent?

- **A.** The port or ports at which measurements are made
- **B.** The relative time between measurements
- **C.** Relative quality of the data
- **D.** Frequency order of the measurements

E4B07. What do the subscripts of S parameters represent?

A. The port or ports at which measurements are made

B. The relative time between measurements

C. Relative quality of the data

D. Frequency order of the measurements

E4B09. What is indicated if the current reading on an RF ammeter placed in series with the antenna feed line of a transmitter increases as the transmitter is tuned to resonance?

- **A.** There is possibly a short to ground in the feed line
- **B.** The transmitter is not properly neutralized
- **C.** There is an impedance mismatch between the antenna and feed line
- **D.** There is more power going into the antenna

E4B09. What is indicated if the current reading on an RF ammeter placed in series with the antenna feed line of a transmitter increases as the transmitter is tuned to resonance?

A. There is possibly a short to ground in the feed line

B. The transmitter is not properly neutralized

C. There is an impedance mismatch between the antenna and feed line

D. There is more power going into the antenna

E4B11. How should an antenna analyzer be connected when measuring antenna resonance and feed point impedance?

A. Loosely couple the analyzer near the antenna base

B. Connect the analyzer via a high-impedance transformer to the antenna

C. Loosely couple the antenna and a dummy load to the analyzer

D. Connect the antenna feed line directly to the analyzer's connector

E4B11. How should an antenna analyzer be connected when measuring antenna resonance and feed point impedance?

- **A.** Loosely couple the analyzer near the antenna base
- **B.** Connect the analyzer via a high-impedance transformer to the antenna
- **C.** Loosely couple the antenna and a dummy load to the analyzer
- **D.** Connect the antenna feed line directly to the analyzer's connector

E4B13. Which S parameter is equivalent to forward gain?

A. S11

B. S12

C. S21

D. S22

E4B13. Which S parameter is equivalent to forward gain?

A. S11

B. S12

C. S21

D. S22

E4B16. Which S parameter represents return loss or SWR?

A. S11

B. S12

C. S21

D. S22

E4B16. Which S parameter represents return loss or SWR?

- **A.** S11
- **B.** S12
- **C.** S21
- **D.** S22

E4B17. What three test loads are used to calibrate a standard RF vector network analyzer?

- **A.** 50 ohms, 75 ohms, and 90 ohms
- **B.** Short circuit, open circuit, and 50 ohms
- **C.** Short circuit, open circuit, and resonant circuit
- **D.** 50 ohms through 1/8 wavelength, 1/4 wavelength, and 1/2 wavelength of coaxial cable

E4B17. What three test loads are used to calibrate a standard RF vector network analyzer?

A. 50 ohms, 75 ohms, and 90 ohms

B. Short circuit, open circuit, and 50 ohms

C. Short circuit, open circuit, and resonant circuit

D. 50 ohms through 1/8 wavelength, 1/4 wavelength, and 1/2 wavelength of coaxial cable

E9E07. What term best describes the interactions at the load end of a mismatched transmission line?

- **A.** Characteristic impedance
- **B.** Reflection coefficient
- **C.** Velocity factor
- **D.** Dielectric constant

E9E07. What term best describes the interactions at the load end of a mismatched transmission line?

A. Characteristic impedance

B. Reflection coefficient

C. Velocity factor

D. Dielectric constant

E9E08. Which of the following measurements is characteristic of a mismatched transmission line?

- **A.** An SWR less than 1:1
- **B.** A reflection coefficient greater than 1
- **C.** A dielectric constant greater than 1
- **D.** An SWR greater than 1:1

E9E08. Which of the following measurements is characteristic of a mismatched transmission line?

A. An SWR less than 1:1

B. A reflection coefficient greater than 1

C. A dielectric constant greater than 1

D. An SWR greater than 1:1

E9E10. Which of these choices is an effective way to match an antenna with a 100 ohm feed point impedance to a 50 ohm coaxial cable feed line?

A. Connect a 1/4 wavelength open stub of 300 ohm twin-lead in parallel with the coaxial feed line where it connects to the antenna

B. Insert a 1/2 wavelength piece of 300 ohm twin-lead in series between the antenna terminals and the 50 ohm feed cable

C. Insert a 1/4 wavelength piece of 75 ohm coaxial cable transmission line in series between the antenna terminals and the 50 ohm feed cable

D. Connect a 1/2 wavelength shorted stub of 75 ohm cable in parallel with the 50 ohm cable where it attaches to the antenna

E9E10. Which of these choices is an effective way to match an antenna with a 100 ohm feed point impedance to a 50 ohm coaxial cable feed line?

A. Connect a 1/4 wavelength open stub of 300 ohm twin-lead in parallel with the coaxial feed line where it connects to the antenna

B. Insert a 1/2 wavelength piece of 300 ohm twin-lead in series between the antenna terminals and the 50 ohm feed cable

C. Insert a 1/4 wavelength piece of 75 ohm coaxial cable transmission line in series between the antenna terminals and the 50 ohm feed cable

D. Connect a 1/2 wavelength shorted stub of 75 ohm cable in parallel with the 50 ohm cable where it attaches to the antenna

E9F01. What is the velocity factor of a transmission line?

A. The ratio of the characteristic impedance of the line to the terminating impedance

B. The index of shielding for coaxial cable

C. The velocity of the wave in the transmission line multiplied by the velocity of light in a vacuum

D. The velocity of the wave in the transmission line divided by the velocity of light in a vacuum

E9F01. What is the velocity factor of a transmission line?

A. The ratio of the characteristic impedance of the line to the terminating impedance

B. The index of shielding for coaxial cable

C. The velocity of the wave in the transmission line multiplied by the velocity of light in a vacuum

D. The velocity of the wave in the transmission line divided by the velocity of light in a vacuum

E9F02. Which of the following determines the velocity factor of a transmission line?

A. The termination impedance

B. The line length

C. Dielectric materials used in the line

D. The center conductor resistivity

E9F02. Which of the following determines the velocity factor of a transmission line?

- **A.** The termination impedance
- **B.** The line length
- **C.** Dielectric materials used in the line
- **D.** The center conductor resistivity

E9F03. Why is the physical length of a coaxial cable transmission line shorter than its electrical length?

- **A.** Skin effect is less pronounced in the coaxial cable
- **B.** The characteristic impedance is higher in a parallel feed line
- **C.** The surge impedance is higher in a parallel feed line
- **D.** Electrical signals move more slowly in a coaxial cable than in air

E9F03. Why is the physical length of a coaxial cable transmission line shorter than its electrical length?

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B. The characteristic impedance is higher in a parallel feed line

C. The surge impedance is higher in a parallel feed line

D. Electrical signals move more slowly in a coaxial cable than in air

E9F04. What is the typical velocity factor for a coaxial cable with solid polyethylene dielectric?

- **A.** 2.70
- **B.** 0.66
- **C.** 0.30
- **D.** 0.10

E9F04. What is the typical velocity factor for a coaxial cable with solid polyethylene dielectric?

- **A.** 2.70
- **B.** 0.66
- **C.** 0.30
- **D.** 0.10

E9F05. What is the approximate physical length of a solid polyethylene dielectric coaxial transmission line that is electrically one-quarter wavelength long at 14.1 MHz?

A. 20 meters

B. 2.3 meters

C. 3.5 meters

D. 0.2 meters

E9F05. What is the approximate physical length of a solid polyethylene dielectric coaxial transmission line that is electrically one-quarter wavelength long at 14.1 MHz?

- **A.** 20 meters
- **B.** 2.3 meters
- **C.** 3.5 meters
- **D.** 0.2 meters

E9F06. What is the approximate physical length of an air-insulated, parallel conductor transmission line that is electrically one-half wavelength long at 14.10 MHz?

- **A.** 15 meters
- **B.** 20 meters
- **C.** 10 meters
- **D.** 71 meters

E9F06. What is the approximate physical length of an air-insulated, parallel conductor transmission line that is electrically one-half wavelength long at 14.10 MHz?

A. 15 meters

B. 20 meters

C. 10 meters

D. 71 meters

E9F07. How does ladder line compare to small-diameter coaxial cable such as RG-58 at 50 MHz?

A. Lower loss

B. Higher SWR

C. Smaller reflection coefficient

D. Lower velocity factor

E9F07. How does ladder line compare to small-diameter coaxial cable such as RG-58 at 50 MHz?

- **A.** Lower loss
- **B.** Higher SWR
- **C.** Smaller reflection coefficient
- **D.** Lower velocity factor

E9F08. What is the term for the ratio of the actual speed at which a signal travels through a transmission line to the speed of light in a vacuum?

A. Velocity factor

B. Characteristic impedance

C. Surge impedance

D. Standing wave ratio

E9F08. What is the term for the ratio of the actual speed at which a signal travels through a transmission line to the speed of light in a vacuum?

- **A.** Velocity factor
- **B.** Characteristic impedance
- **C.** Surge impedance
- **D.** Standing wave ratio

E9F09. What is the approximate physical length of a solid polyethylene dielectric coaxial transmission line that is electrically one-quarter wavelength long at 7.2 MHz?

A. 10 meters

B. 6.9 meters

C. 24 meters

D. 50 meters

E9F09. What is the approximate physical length of a solid polyethylene dielectric coaxial transmission line that is electrically one-quarter wavelength long at 7.2 MHz?

A. 10 meters

B. 6.9 meters

C. 24 meters

D. 50 meters

E9F10. What impedance does a 1/8 wavelength transmission line present to a generator when the line is shorted at the far end?

- **A.** A capacitive reactance
- **B.** The same as the characteristic impedance of the line
- **C.** An inductive reactance
- **D.** The same as the input impedance to the final generator stage

E9F10. What impedance does a 1/8 wavelength transmission line present to a generator when the line is shorted at the far end?

- **A.** A capacitive reactance
- **B.** The same as the characteristic impedance of the line
- **C.** An inductive reactance
- **D.** The same as the input impedance to the final generator stage

E9F11. What impedance does a 1/8 wavelength transmission line present to a generator when the line is open at the far end?

A. The same as the characteristic impedance of the line

B. An inductive reactance

C. A capacitive reactance

D. The same as the input impedance of the final generator stage

E9F11. What impedance does a 1/8 wavelength transmission line present to a generator when the line is open at the far end?

- **A.** The same as the characteristic impedance of the line
- **B.** An inductive reactance
- **C.** A capacitive reactance
- **D.** The same as the input impedance of the final generator stage

E9F12. What impedance does a 1/4 wavelength transmission line present to a generator when the line is open at the far end?

A. The same as the characteristic impedance of the line

B. The same as the input impedance to the generator

C. Very high impedance

D. Very low impedance

E9F12. What impedance does a 1/4 wavelength transmission line present to a generator when the line is open at the far end?

- **A.** The same as the characteristic impedance of the line
- **B.** The same as the input impedance to the generator
- **C.** Very high impedance
- **D.** Very low impedance

E9F13. What impedance does a 1/4 wavelength transmission line present to a generator when the line is shorted at the far end?

- **A.** Very high impedance
- **B.** Very low impedance
- **C.** The same as the characteristic impedance of the transmission line
- **D.** The same as the generator output impedance

E9F13. What impedance does a 1/4 wavelength transmission line present to a generator when the line is shorted at the far end?

- **A.** Very high impedance
- **B.** Very low impedance
- **C.** The same as the characteristic impedance of the transmission line
- **D.** The same as the generator output impedance

E9F14. What impedance does a 1/2 wavelength transmission line present to a generator when the line is shorted at the far end?

A. Very high impedance

B. Very low impedance

C. The same as the characteristic impedance of the line

D. The same as the output impedance of the generator

E9F14. What impedance does a 1/2 wavelength transmission line present to a generator when the line is shorted at the far end?

- **A.** Very high impedance
- **B.** Very low impedance
- **C.** The same as the characteristic impedance of the line
- **D.** The same as the output impedance of the generator

E9F15. What impedance does a 1/2 wavelength transmission line present to a generator when the line is open at the far end?

A. Very high impedance

B. Very low impedance

C. The same as the characteristic impedance of the line

D. The same as the output impedance of the generator

E9F15. What impedance does a 1/2 wavelength transmission line present to a generator when the line is open at the far end?

- **A.** Very high impedance
- **B.** Very low impedance
- **C.** The same as the characteristic impedance of the line
- **D.** The same as the output impedance of the generator

E9F16. Which of the following is a significant difference between foam dielectric coaxial cable and solid dielectric cable, assuming all other parameters are the same?

A. Foam dielectric has lower safe operating voltage limits

B. Foam dielectric has lower loss per unit of length

C. Foam dielectric has higher velocity factor

D. All of these choices are correct

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D. All of these choices are correct

E9G01. Which of the following can be calculated using a Smith chart?

- **A.** Impedance along transmission lines
- **B.** Radiation resistance
- **C.** Antenna radiation pattern
- **D.** Radio propagation

E9G01. Which of the following can be calculated using a Smith chart?

A. Impedance along transmission lines

B. Radiation resistance

C. Antenna radiation pattern

D. Radio propagation

E9G02. What type of coordinate system is used in a Smith chart?

- **A.** Voltage circles and current arcs
- **B.** Resistance circles and reactance arcs
- **C.** Voltage lines and current chords
- **D.** Resistance lines and reactance chords

E9G02. What type of coordinate system is used in a Smith chart?

- **A.** Voltage circles and current arcs
- **B.** Resistance circles and reactance arcs
- **C.** Voltage lines and current chords
- **D.** Resistance lines and reactance chords

E9G03. Which of the following is often determined using a Smith chart?

A. Beam headings and radiation patterns

B. Satellite azimuth and elevation bearings

C. Impedance and SWR values in transmission lines

D. Trigonometric functions

E9G03. Which of the following is often determined using a Smith chart?

A. Beam headings and radiation patterns

B. Satellite azimuth and elevation bearings

C. Impedance and SWR values in transmission lines

D. Trigonometric functions

E9G04. What are the two families of circles and arcs that make up a Smith chart?

A. Resistance and voltage

B. Reactance and voltage

C. Resistance and reactance

D. Voltage and impedance

E9G04. What are the two families of circles and arcs that make up a Smith chart?

A. Resistance and voltage

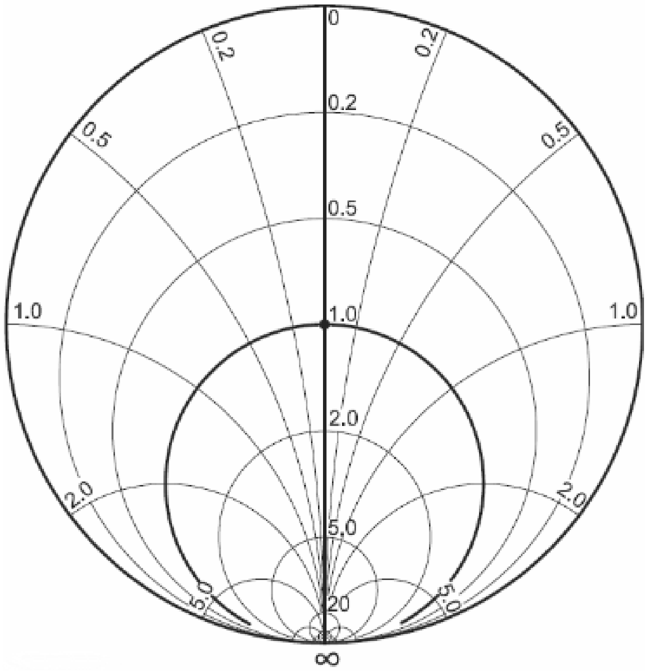
B. Reactance and voltage

C. Resistance and reactance

D. Voltage and impedance

E9G05. What type of chart is shown in Figure E9-3?

Figure E9-3



A. Smith chart

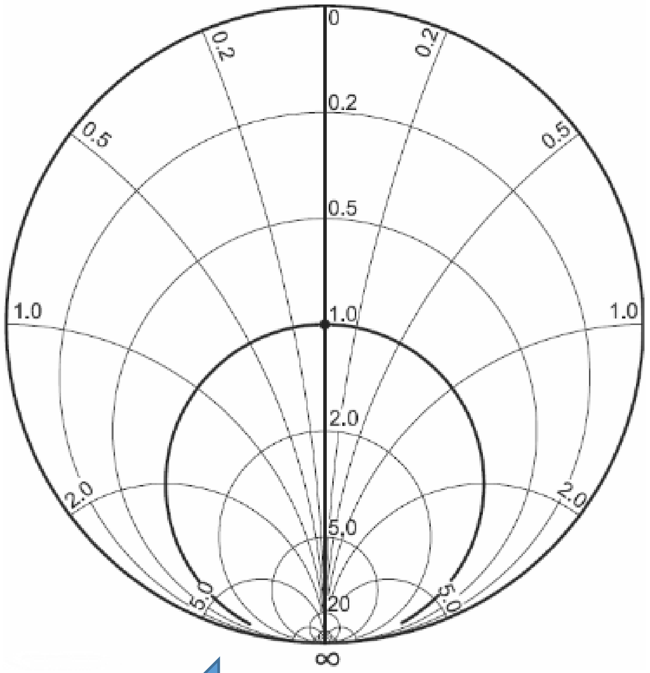
B. Free space radiation directivity chart

C. Elevation angle radiation pattern chart

D. Azimuth angle radiation pattern chart

E9G05. What type of chart is shown in Figure E9-3?

Figure E9-3



A. Smith chart

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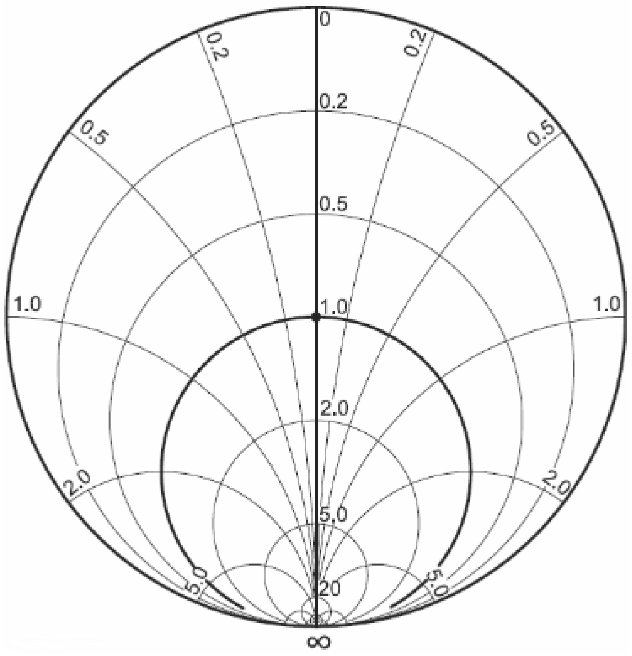
E9G06. On the Smith chart shown in Figure E9-3, what is the name for the large outer circle on which the reactance arcs terminate?

Figure E9-3



A. Prime axis

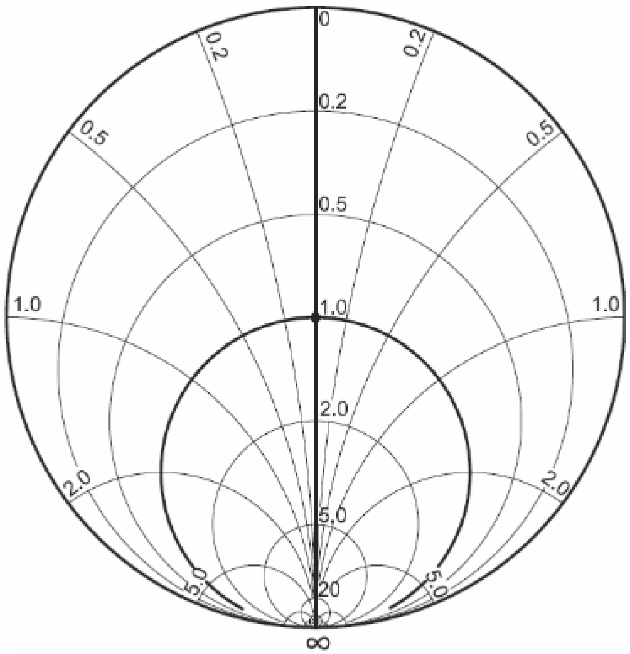
B. Reactance axis

C. Impedance axis

D. Polar axis

E9G06. On the Smith chart shown in Figure E9-3, what is the name for the large outer circle on which the reactance arcs terminate?

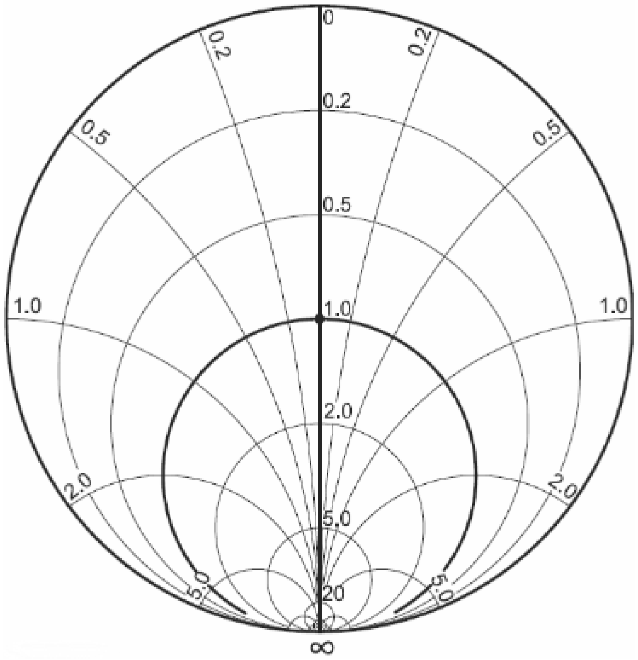
Figure E9-3



- **A.** Prime axis
- **B.** Reactance axis
- **C.** Impedance axis
- **D.** Polar axis

E9G07. On the Smith chart shown in Figure E9-3, what is the only straight line shown?

Figure E9-3



A. The reactance axis

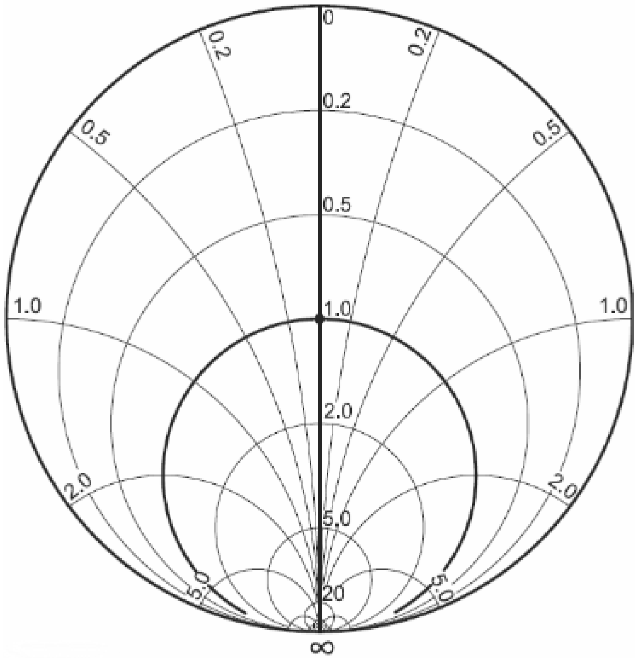
B. The current axis

C. The voltage axis

D. The resistance axis

E9G07. On the Smith chart shown in Figure E9-3, what is the only straight line shown?

Figure E9-3



A. The reactance axis

B. The current axis

C. The voltage axis

D. The resistance axis

E9G08. What is the process of normalization with regard to a Smith chart?

- **A.** Reassigning resistance values with regard to the reactance axis
- **B.** Reassigning reactance values with regard to the resistance axis
- **C.** Reassigning impedance values with regard to the prime center
- **D.** Reassigning prime center with regard to the reactance axis

E9G08. What is the process of normalization with regard to a Smith chart?

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- **B.** Reassigning reactance values with regard to the resistance axis
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E9G09. What third family of circles is often added to a Smith chart during the process of solving problems?

- **A.** Standing wave ratio circles
- **B.** Antenna-length circles
- **C.** Coaxial-length circles
- **D.** Radiation-pattern circles

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E9G10. What do the arcs on a Smith chart represent?

- **A.** Frequency
- **B.** SWR
- **C.** Points with constant resistance
- **D.** Points with constant reactance

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E9G11. How are the wavelength scales on a Smith chart calibrated?

- **A.** In fractions of transmission line electrical frequency
- **B.** In fractions of transmission line electrical wavelength
- **C.** In fractions of antenna electrical wavelength
- **D.** In fractions of antenna electrical frequency

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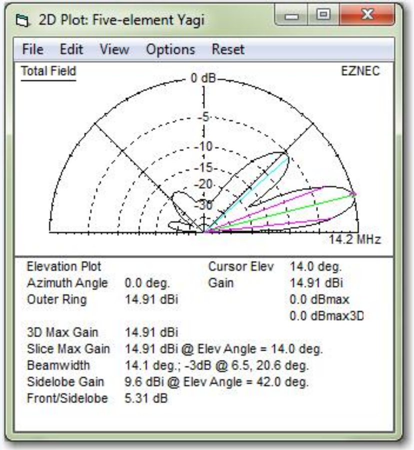
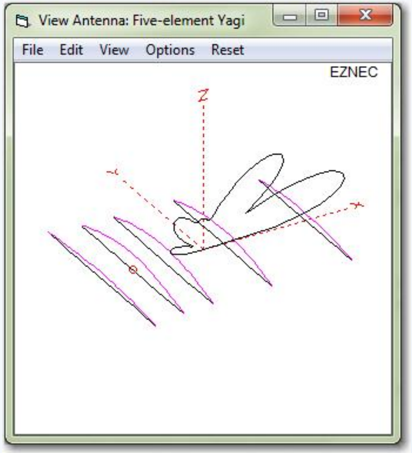
Section 9.5

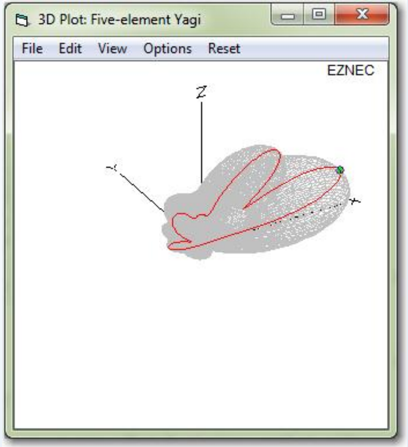
Antenna Design

Antenna Modeling

- Goal – To predict an antenna's performance before you actually build it.
- Try different options and see what happens on the computer







Software

- Based on the Numerical Electromagnetics Code (NEC)
- EZNEC by W7EL is one software program
- Uses "**Methods of Moments**" analysis
- **Uniform Currents in an individual antenna or wire "segments" are modeled**

MOM

- Generalized **Methods of Moments** is a method of estimating parameters of a probability distribution (such as mean and standard deviation in the case of normal distribution), by checking what possible values of distribution parameters lead to the best fitting moments of the sample drawn from the distribution.

  Moments are some measures describing the shape of the distribution. In case of the normal distribution, the four first moments are:

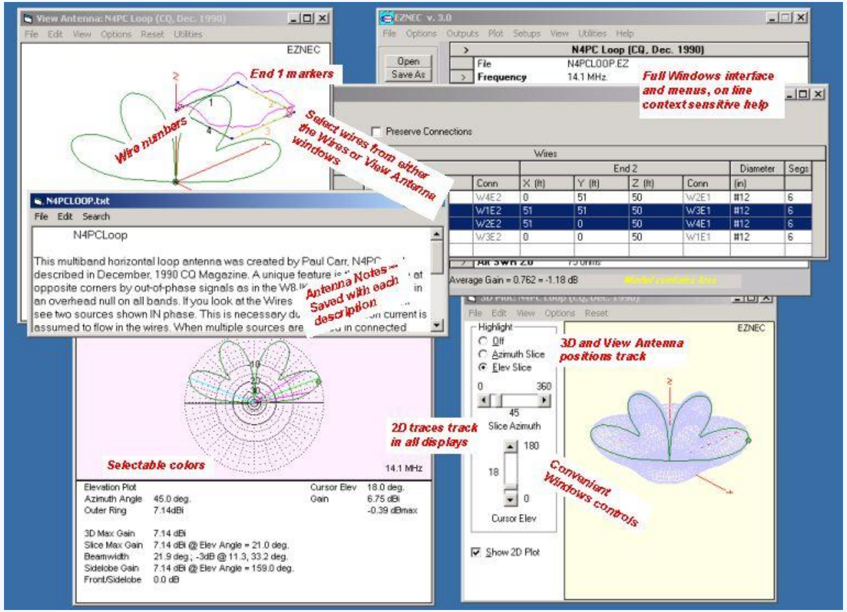
  1. mean
  2. variance -> standard deviation
  3. skewness
  4. kurtosis

https://www.pinterest.com/pin/467952217507678576/?lp=true

http://www.reakkt.com/2012/08/for-dummies-intro-to-generalized-method.html

EZNEC

$ 100 and up Price



https://www.eznec.com/

MMANA-GAL

- Free Antenna Modeling Software

http://hamsoft.ca/pages/mmana-gal.php

Software Quirks

- **Antenna Gain** may vary outside the modeled frequency range.
- Using less than the recommended ten segments modeled per ½ wavelength may give the **wrong feedpoint impedance**

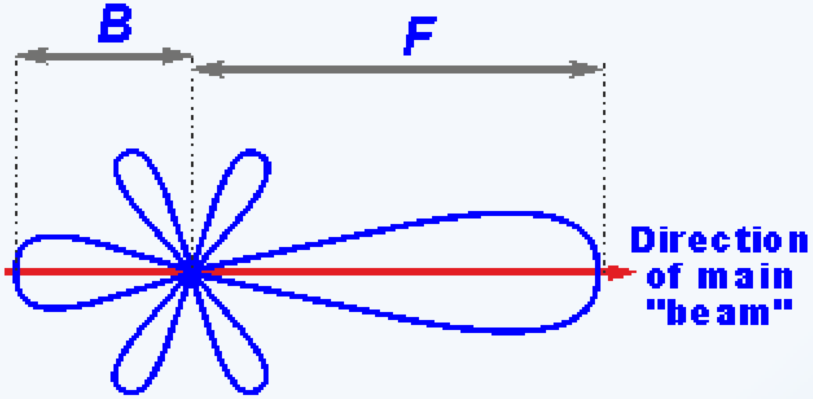
What can you learn?

Antenna Modeling can give:

- **SWR vs. frequency charts**
- **Polar plots of the far-field elevation and azimuth patterns**
- **Estimated Antenna gain, F-B**

Yagi Example

- If you Optimize for Max Gain you lose the Front to Back Ratio



http://www.radio-electronics.com/info/antennas/yagi/yagi-antenna-gain.php

Questions

Section 9.5

E9B04. What may occur when a directional antenna is operated at different frequencies within the band for which it was designed?

- **A.** Feed point impedance may become negative
- **B.** The E-field and H-field patterns may reverse
- **C.** Element spacing limits could be exceeded
- **D.** The gain may change depending on frequency

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E9B09. What type of computer program technique is commonly used for modeling antennas?

- **A.** Graphical analysis
- **B.** Method of Moments
- **C.** Mutual impedance analysis
- **D.** Calculus differentiation with respect to physical properties

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E9B10. What is the principle of a Method of Moments analysis?

- **A.** A wire is modeled as a series of segments, each having a uniform value of current
- **B.** A wire is modeled as a single sine-wave current generator
- **C.** A wire is modeled as a series of points, each having a distinct location in space
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E9B11. What is a disadvantage of decreasing the number of wire segments in an antenna model below the guideline of 10 segments per half-wavelength?

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- **B.** The resulting design will favor radiation of harmonic energy
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E9B13. What does the abbreviation NEC stand for when applied to antenna modeling programs?

- **A.** Next Element Comparison
- **B.** Numerical Electromagnetics Code
- **C.** National Electrical Code
- **D.** Numeric Electrical Computation

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E9B14. What type of information can be obtained by submitting the details of a proposed new antenna to a modeling program?

- **A.** SWR vs. frequency charts
- **B.** Polar plots of the far-field elevation and azimuth patterns
- **C.** Antenna gain
- **D.** All of these choices are correct

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End of Chapter 9