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9.4 TRANSMISSION LINES (page 9-31)

WAVELENGTH IN A FEED LINE (page 9-31)

VELOCITY OF PROPAGATION (page 9-32)

$$VF = \text{Velocity Factor} = \frac{\text{Speed of Wave in a Transmission Line}}{\text{Speed of Light in a Vacuum}}$$

Question E9F01: What is the velocity factor of a transmission line?
Answer: The velocity of the wave in the transmission line divided by the velocity of light in a vacuum.

Question E9F02: Which of the following determines the velocity factor of a transmission line?
Answer: Dielectric materials used in the line.

Question 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?
Answer: Velocity factor.

See Table 9.1 on page 9-33. VF of solid polyethylene = 66% = 0.66

Question E9F04: What is the typical velocity factor for a coaxial cable with solid polyethylene dielectric?
Answer: 0.66.

ELECTRICAL LENGTH (OF A TRANSMISSION LINE) (page 9-32)

Measured in wavelengths, the physical length of a transmission line is shorter than its electrical length.

LENGTH IN METERS = VF * WAVELENGTH
(in a transmission line) (in free space)

Question E9F03: Why is the physical length of a coaxial cable transmission line shorter than its electrical length?
Answer: Electrical signals move more slowly in a coaxial cable than in air.

Given: coax is RG-8 the VF is 0.66, 14.1 MHz, 1/4 Wavelength

Coax Length = VF * (300/frequency) * ¼ = 0.66 * (300/14.1) * ¼ = 3.52 meters

Question 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?
Answer: 3.5 meters.

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Given: coax is RG-8 the VF is 0.66, 7.2 MHz, 1/.4 Wavelength

Coax Length = VF * (300/frequency) * ¼ = 0.66 * (300/7.2) * ¼ = 6.9 meters

Question 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?
Answer: 6.9 meters.

Table 9.1 on page 9-33. VF of Open Wire Transmission Line = 95% = 0.95

Given: transmission line is Parallel Conductors the VF is 0.95, 14.1 MHz, 1/.2 Wavelength

Coax Length = VF * (300/frequency) * ½ = 0.95 * (300/14.1) * ½ = 10 meters

Question 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?
Answer: 10 meters.

FEED LINE LOSS (page 9-34)

Table 9.1 on page 9-33. Shows loss in dB per 100 feet at 100 MHz.

Ladder line has less loss at any frequency.

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

Question 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?
Answer: Foam dielectric has lower safe operating voltage limits, Foam dielectric has lower loss per unit of length, Foam dielectric has higher velocity factor.

REFLECTION COEFFICIENT AND SWR (page 9-34)

$$\text{Voltage Reflection Coefficient} = \frac{\text{Reflected Voltage}}{\text{Incident Voltage}} \text{ or } \frac{\text{Reflected Current}}{\text{Incident Current}}$$

The reflection coefficient is a good parameter to describe the interactions at the load end of a mismatched transmission line.

Question E9E07: What term best describes the interactions at the load end of a mismatched transmission line?
Answer: Reflection coefficient.

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(SWR) (page 9-34)

Question E9E08: Which of the following measurements is characteristic of a mismatched transmission line?
Answer: An SWR greater than 1:1.

POWER MEASUREMENT (page 9-35)

Question 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?
Answer: 75 Watts.

Questions 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?
Answer: There is more power going into the antenna.

SMITH CHART (page 9-36)

SMITH CHART CONSTRUCTION (page 9-36)

Question E9G01: Which of the following can be calculated using a Smith chart?
Answer: Impedance along transmission lines.

Question E9G02: What type of coordinate system is used in a Smith chart?
Answer: Resistance circles and reactance arcs.

Question E9G03: Which of the following is often determined using a Smith chart?
Answer: Impedance and SWR values in transmission lines.

Question E9G04: are the two families of circles and arcs that make up a Smith chart?
Answer: Resistance and reactance.

Question E9G05: What type of chart is shown in Figure E9-3?
Answer: Smith chart.

Question 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?
Answer: Reactance axis.

Question E9G07: On the Smith chart shown in Figure E9-3, what is the only straight line shown?
Answer: The resistance axis.

Question E9G10: What do the arcs on a Smith chart represent?
Answer: Points with constant reactance.

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NORMALIZATION (page 9-37)

Question E9G08: What is the process of normalization with regard to a Smith chart?
Answer: Reassigning impedance values with regard to the prime center.

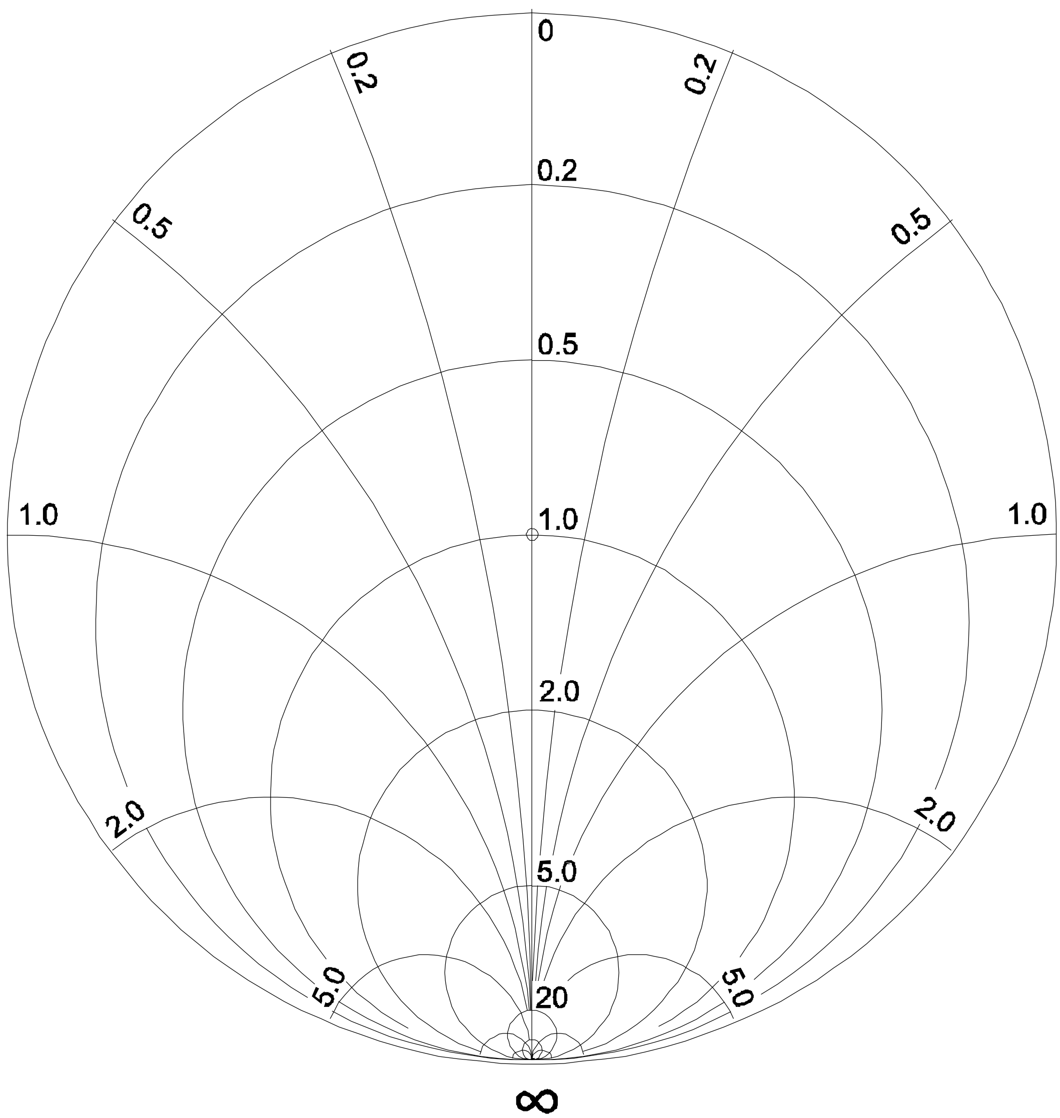
CONSTANT-SWR CIRCLES (page 9-37)

Question E9G09: What third family of circles is often added to a Smith chart during the process of solving problems?
Answer: Standing wave ratio circles.

WAVELENGTH SCALES (page 9-39)

Question E9G11: How are the wavelength scales on a Smith chart calibrated?
Answer: In fractions of transmission line electrical wavelength.

Figure E9-3



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TRANSMISSION LINE STUBS AND TRANSFORMERS (page 9-39)

(TRANSMISSION LINE STUBS) (page 9-39)

Rule 1: Every 1/2 wavelength (1/2. 1. 1-1/2, 2) along the transmission line the impedance repeats.

Rule 2: When a transmission line is odd 1/4 wavelengths long (1/4, 3/4, 1-1/4, 1-3/4, etc) the impedance at one end is inverted from that at the other end.

Rule 3: A very short open circuit transmission line appears as an open circuit.

Rule 4: A 1/8 wavelength open circuit transmission line appears as a ***capacitor*** (capacitive reactance) because of the two parallel wires.

Rule 5: A very short shorted circuit transmission line appears as short-circuit.

Rule 6: A 1/8 wavelength shorted circuit transmission line appears as an ***inductor*** inductive reactance) because of the continuous wires.

Question E9F10: What impedance does a 1/8 wavelength transmission line present to a generator when the line is ***shorted*** at the far end?
Answer: It appears as an inductive reactance – see rule 6.

Question E9F11: What impedance does a 1/8 wavelength transmission line present to a generator when the line is ***open (not shorted)*** at the far end?
Answer: It appears as a capacitive reactance – see rule 4.

Question E9F12: What impedance does a 1/4 wavelength transmission line present to a generator when the line is ***open (not shorted)*** at the far end?
Answer: It appears as a very low impedance (shorted, not open) – see rule 2.

Question E9F13: What impedance does a 1/4 wavelength transmission line present to a generator when the line is ***shorted*** at the far end?
Answer: It appears as a very high impedance (not shorted, open) – see rule 2.

Question E9F14: What impedance does a 1/2 wavelength transmission line present to a generator when the line is ***shorted*** at the far end?
Answer: It appears as a very low impedance (shorted, not open) – see rule 1.

Question E9F15: What impedance does a 1/4 wavelength transmission line present to a generator when the line is ***open (not shorted)*** at the far end?
Answer: It appears as a very high impedance (not shorted, open) – see rule 1.

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SYNCHRONOUS TRANSFORMERS (page 9-40)

You match the impedance between an antenna and a transmission line by placing a different transmission line, of 1/4 wavelength, of a different impedance, in series between the antenna and the primary transmission line.

The book says:

$$Z_1 = \text{square root of } (Z_0 \times Z_{load})$$

The book means:

$$Z_{\text{Characteristic Impedance}} = \text{square root of } (Z_{\text{Line Impedance}} \times Z_{\text{Load Impedance}})$$

Question 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?

Answer: 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.

$$Z_1 = \text{square root of } (Z_0 \times Z_{load}) = \text{square root of } (50 \times 100) = \text{square root of } (5000) = 70.71$$

(75 ohm cable is the closest match to 71 ohms)

SCATTERING (S) PARAMETERS (pages 9-94)

I really do not know anything about this stuff. I know that if you have an electrical circuit, either simple or complex, it can have ports: one port, two ports, three ports, etc. Here we are discussing two port systems like a transmission line with a port going out (responding port) and a port going in (incident port.) Each port has an input called "a" and an output called "b". The "S" parameter is defined as $S_{(Output)(Input)}$.or $S_{(Responding)(Incident)}$. Thus S_{11} refers to the ratio of the amplitude of the signal that reflects from port one to the amplitude of the signal incident on port one. When both numbers are the same the "S" values are referred to as reflection coefficients because they only refer to what happens at a single port. These reflection coefficients can be plotted on a Smith Chart. While for different numbers "S" values are referred to as transmission coefficients, because they refer to what happens at one port when it is excited by a signal incident at another port. The "S" values may be complex numbers.

Let's just simply look at the definitions.

Rule 1: S11 = b1/a1 = is the input port voltage reflection coefficient.

Rule 2: S12 = b1/a2 = is the reverse voltage gain.

Rule 3: S21 = b2/a1 = is the forward voltage gain.

Rule 4: S22 = b2/a2 = is the output voltage reflection coefficient.

Question E4B07: What do the subscripts of S parameters represent?

Answer: The port or ports at which measurements are made.

Question E4B13: Which S parameter is equivalent to forward gain?

Answer S21 – rule 3.

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ANTENNA AND NETWORK ANALYZERS (page 9-42)

I assume that everyone is familiar with antenna analyzers like the very portable hand held Rig Expert analyzer. They provide their own RF energy and are connected directly to the device being tested.

If you are lucky you have access to a Network Analyzer. To calibrate on you need to connect across the test port an short, a open and 50 ohms.

Question E4A08: Which of the following instruments would be best for measuring the SWR of a beam antenna?
Answer: An antenna analyzer.

Question E4B11: How should an antenna analyzer be connected when measuring antenna resonance and feed point impedance?
Answer: Connect the antenna feed line directly to the analyzer's connector.

Question E4A07: Which of the following is an advantage of using an antenna analyzer compared to an SWR bridge to measure antenna SWR?
Answer: Antenna analyzers do not need an external RF source.

Question: E4B17: What three test loads are used to calibrate a standard RF vector network analyzer?
Answer: Short circuit, open circuit, and 50 ohms.