Practical Antenna Systems: Dipoles

- Simplest type of antenna
- Dipole means “two electrical parts”
- Made from a straight conductor of wire one-half wavelength (1⁄2 λ) long with a feed point somewhere along the antenna
- Most are oriented horizontally, particularly on the lower frequency bands, and radiate a horizontally polarized signal
  - Can also be installed vertically, sloping or even drooping from a single support in the middle (inverted-V)
- The radiation pattern isolated in space looks like a donut

Ground Plane Antennas

- Most common type is one-quarter wavelength long (1⁄4 λ) with the feed point at the base
- Acts like one-half of a dipole with the missing portion made up by the electrical mirror formed by the ground plane
- Made from sheet metal or a screen of wires called radials that extend out from the base
- Extended length of a 5⁄8-λ ground-plane focuses more energy toward the horizon (better range)
- To reduce the physical size of the antenna, it is often constructed with some of the radiating conductor wound into a coil or a separate inductor inserted in the antenna … called is called *inductive loading*

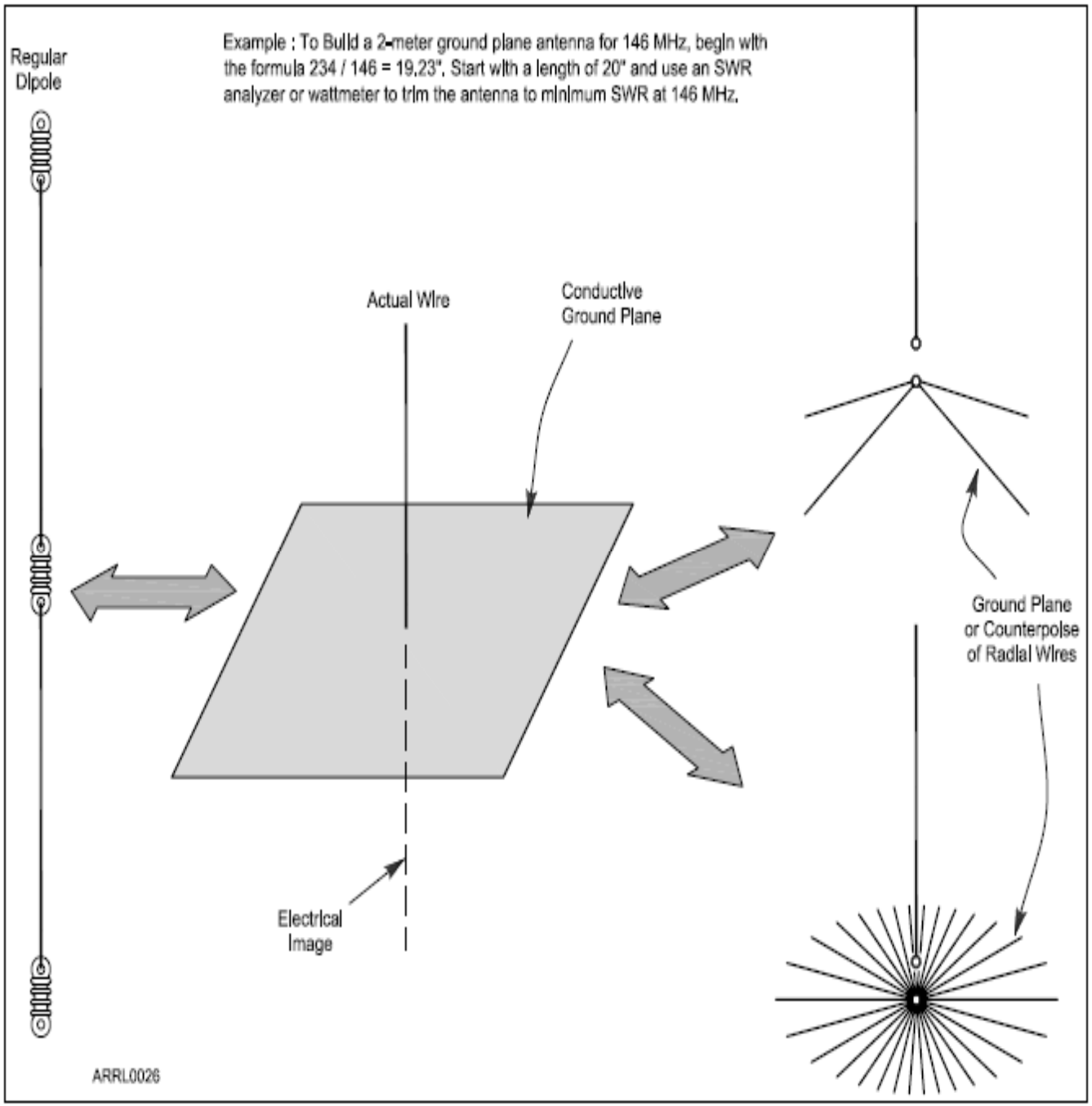

Figure 4.10 — A *ground-plane* makes up an electrical mirror that creates an image of the missing half of a ground-plane antenna. The result is an antenna that acts very much like a dipole. The ground plane can be made up of a screen of wires (often used at HF) or a metal surface at VHF and UHF. For VHF and UHF

Antennas for Handheld Radios

- The flexible antenna used with most handheld radios is called a *rubber duck* (ground-plane antenna shortened by coiling the conductor inside a plastic coating)
  - Doesn't transmit or receive as well as a full-sized ground-plane antenna
  - For best performance, hold the transceiver so that the antenna is vertical
  - Not very effective inside vehicles … up to 20 time less effective than an external mobile antenna
- Easy to connect handhelds to full-sized antennas … uses standard RF connectors … a 5-watt handheld can easily reach 10 miles with a "good" antenna

Calculating Antenna Length (dipole)

- To calculate length of a resonant dipole 1⁄2-λ long …

  Length (in feet) = 468 / frequency (in MHz) … or

  Length = 468 / f

  Example: At 50.1 MHz (in the 6 meter band), dipole length is calculated as 468 / 50.1 = 9.33 feet = 112 inches long

NOTE: The value of the constant used in the formula accounts for effects that cause an antenna to act like it is a little longer electrically than it is physically. The actual resonant length is affected by height above ground, its electrical properties, and nearby conductive objects. So…

Make the dipole a few percent longer at first (use 490 instead of 468), then use an SWR meter or antenna analyzer to determine the resonant frequency. Assuming the resonant frequency is too low because the dipole is too long, shorten it until the dipole is resonant at the desired

Calculating Ground Plane Length

- The length of a ground-plane antenna is half that of a dipole and is often estimated as: length (in feet) = 234 / frequency (in MHz)
- Example: At 146 MHz, a λ/4 ground-plane is 234 / 146 = 1.6 feet = 19 ¼ inches long
- Length adjustments also apply (similar to previous note about dipoles)

Directional Antennas

- Simple dipoles, ground-planes, and loops work well, but they have little gain (radiation patterns don't have strongly preferred directions)
- Use a *directional beam antenna* get the best reception in one direction
- On VHF and UHF, if a direct signal path is blocked, a beam antenna can be used to aim the signal at a reflecting surface to bypass the obstruction
- Most widely used type of beam antennas are *Yagis*
- Yagi beam antennas have much more *gain* than omni-directionals in their preferred direction

Yag

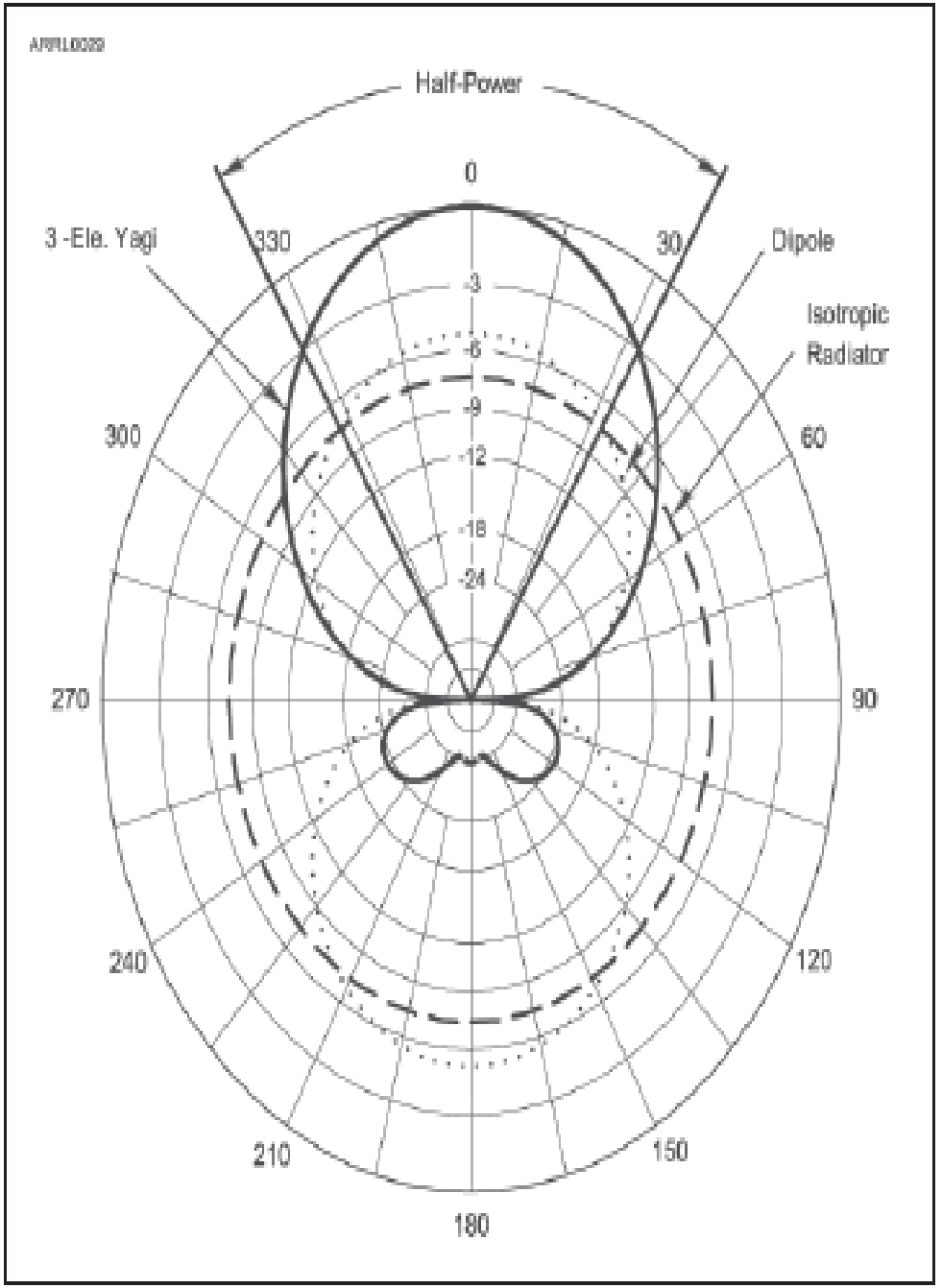

Figure 4.13 — The radiation pattern of a typical, three-element Yagi antenna with a driven element, reflector, and director shows that most of the *antenna's energy is focused in one direction along the boom* of the antenna (along the 0-180 axis of the graph.) Smaller amounts are radiated toward the side and back. This antenna also rejects noise and interference from the side and back. The round pattern of the isotropic

Yagis (cont.)

- Horizontally polarized Yagis are usually used for long-distance communications (results in lower ground losses when the wave reflects from or travels along the ground)
- As frequency increases and the

Figure 4.14 — N7CFO's dish antenna operates on 10 GHz and is portable enough to be taken on contest outings.

PRACTICE QUESTIONS

Which of the following describes a type of antenna loading?

A. Electrically lengthening by inserting inductors in radiating elements
B. Inserting a resistor in the radiating portion of the antenna to make it resonant
C. Installing a spring in the base of a mobile vertical antenna to make it more flexible
D. Strengthening the radiating elements of a beam antenna to better resist wind damage

T9A02 A 4-12

Which of the following describes a simple dipole oriented parallel to Earth's surface?

A. A ground-wave antenna
B. A horizontally polarized antenna
C. A travelling-wave antenna
D. A vertically polarized antenna

T9A03 B 4-12

What is a disadvantage of the short, flexible antenna supplied with most handheld radio transceivers, compared to a full-sized quarter-wave antenna?

A. It has low efficiency
B. It transmits only circularly polarized signals
C. It is mechanically fragile
D. All these choices are correct

T9A04 A 4-12

Which of the following increases the resonant frequency of a dipole antenna?

A. Lengthening it
B. Inserting coils in series with radiating wires
C. Shortening it
D. Adding capacitive loading to the ends of the radiating wires

T9A05 C 4-12

What is a disadvantage of using a handheld VHF transceiver with a flexible antenna inside a vehicle?

A. Signal strength is reduced due to the shielding effect of the vehicle

B. The bandwidth of the antenna will decrease, increasing SWR

C. The SWR might decrease, decreasing the signal strength

D. All these choices are correct

T9A07 A 4-12

What is the approximate length, in inches, of a quarter-wavelength vertical antenna for 146 MHz?

A. 112

B. 50

C. 19

D. 12

T9A08 C 4-12

What is the approximate length, in inches, of a half-wavelength 6 meter dipole antenna?

A. 6

B. 50

C. 112

D. 236

T9A09 C 4-12

In which direction does a half-wave dipole antenna radiate the strongest signal?

A. Equally in all directions
B. Off the ends of the antenna
C. In the direction of the feed line
D. Broadside to the antenna

T9A10 D 4-12

What is an advantage of a 5/8 wavelength whip antenna for VHF or UHF mobile service?

A. It has more gain than a 1/4-wavelength antenna
B. It radiates at a very high angle
C. It eliminates distortion caused by reflected signals
D. It has 10 times the power gain of a 1/4 wavelength whip

T9A12 A 4-12

What antenna polarization is normally used for long-distance CW and SSB contacts on the VHF and UHF bands?

A. Right-hand circular
B. Left-hand circular
C. Horizontal
D. Vertical

T3A03 C 4-15

When using a directional antenna, how might your station be able to communicate with a distant repeater if buildings or obstructions are blocking the direct line of sight path?

A. Change from vertical to horizontal polarization
B. Try to find a path that reflects signals to the repeater
C. Try the long path
D. Increase the antenna SWR

T3A05 B 4-15

What is a beam antenna?

A. An antenna built from aluminum I-beams
B. An omnidirectional antenna invented by Clarence Beam
C. An antenna that concentrates signals in one direction
D. An antenna that reverses the phase of received signals

T9A01 C 4-15

Which of the following types of antenna offers the greatest gain?

A. 5/8 wave vertical
B. Isotropic
C. J pole
D. Yagi

T9A06 D 4-15

Practical Feed Lines & Associated Equipment

Table 4.1: Common Types of Coaxial Cable

Loss in d

TYPE	IMPEDANCE	Loss Per 100' @ 30 MHz	Loss Per 100' @ 150 MHz
RG-6	75	1.4	33
RG-8	50	1.1	2.5
RG-8X	50	2.0	4.5
RG-58	50	2.5	5.6
RG-59	75	1.8	4.1
RG-174	50	4.6	10.3
RG-213	50	1.1	2.5
LMR-400	50	0.7	1.5

Online calculator:

www.timesmicrowave.com/calculator

Coaxial Cable (called COAX)

- See Table 4.1
- Performance of coaxial cable depends on the integrity of its outer jacket
- Moisture contamination is the most common cause of coax failure
- Prolonged exposure to the ultraviolet (UV) in sunlight will also cause the plastic in the jacket to degrade … then cracks … then moisture
  - Some coax jackets use a pigment to absorb & block UV

Coaxial Feed Line Connectors

- Type of connector to use depends on signal frequency
- UHF* series of connectors (PL-259 plugs and SO-239 receptacles) are the most widely-used for HF equipment
- Above 400 MHz, the Type N connectors are used
- Water in coaxial cable degrades the

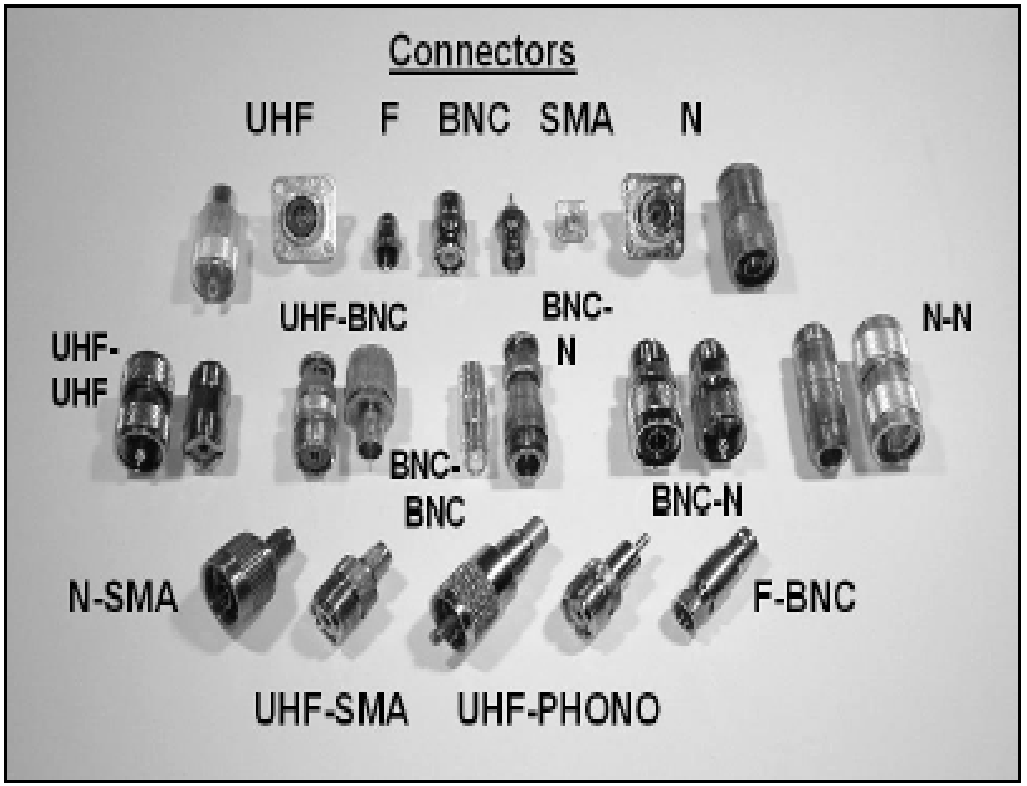

Figure 4.15 — The photo shows a variety of common coaxial connectors that hams use. The larger connectors are used for higher power transmitters and antennas. The most common are the UHF and N styles. Special adapters are used to make connections between cables and equipment that have

* UHF in this case is NOT Ultra High

SWR Meters and Wattmeters

- SWR Meters measure SWR by placing them in series with the feed line, usually right at the output of the radio
  - Many radios include a built-in SWR meter
- Alternatively, a *directional*

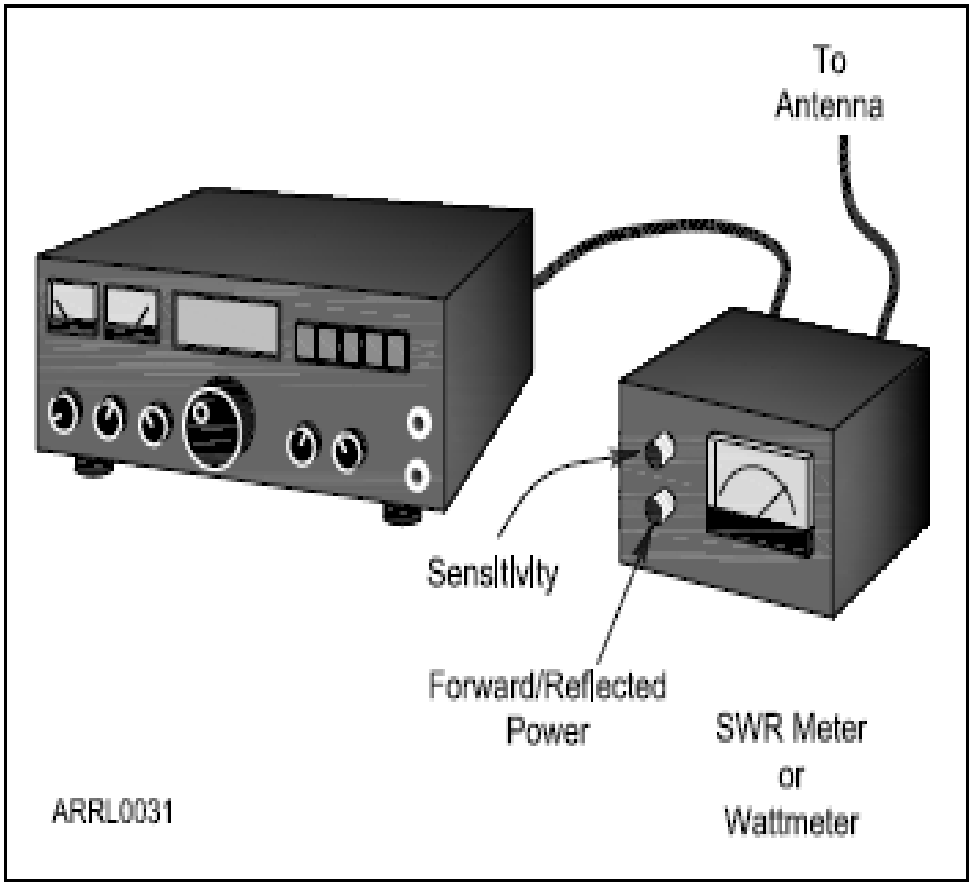

Figure 4.16 — The SWR meter measures power flowing toward the antenna (forward) and toward the transmitter (reflected or reverse).

Antenna Tuners

- *Impedance matchers* or *transmatches* or *antenna tuners* are used If the SWR at the end of the feed line is too high for the radio to operate properly
  - Connected at the output of the transmitter
  - Adjusted until the SWR measured at the transmitter output is acceptably close to 1:1 (antenna system's impedance has been matched to that of the transmitter output)
- Most tuners combine the functions of impedance matcher, directional wattmeter and antenna switch

Antenna Analyzers

- Used to measure an antenna system without using a transmitter whose signal might cause interference

Figure 4.13 – The popular MFJ series of antenna analyzers are used to adjust and troubleshoot antenna systems. The instrument contains a low-power signal source with an adjustable frequency and an SWR meter. The LCD display shows the operating frequency and information about the antenna impedance. The

PRACTICE QUESTIONS

Which of the following causes failure of coaxial cables?

A. Moisture contamination
B. Solder flux contamination
C. Rapid fluctuation in transmitter output power
D. Operation at 100% duty cycle for an extended period

T7C09 A 4-17

Why should the outer jacket of coaxial cable be resistant to ultraviolet light?

A. Ultraviolet resistant jackets prevent harmonic radiation
B. Ultraviolet light can increase losses in the cable's jacket
C. Ultraviolet and RF signals can mix, causing interference
D. Ultraviolet light can damage the jacket and allow water to enter the cable

T7C10 D 4-17

What is a disadvantage of air core coaxial cable when compared to foam or solid dielectric types?

A. It has more loss per foot
B. It cannot be used for VHF or UHF antennas
C. It requires special techniques to prevent moisture in the cable
D. It cannot be used at below freezing temperatures

T7C11 C 4-17

Which of the following types of solder should not be used for radio and electronic applications?

A. Acid-core solder
B. Lead-tin solder
C. Rosin-core solder
D. Tin-copper solder

T7D08 A 4-17

What is the characteristic appearance of a cold tin-lead solder joint?

A. Dark black spots
B. A bright or shiny surface
C. A rough or lumpy surface
D. Excessive solder

T7D09 C 4-17

Which of the following RF connector types is most suitable for frequencies above 400 MHz?

A. UHF (PL-259/SO-239)
B. Type N
C. RS-213
D. DB-25

T9B06 B 4-17

Which of the following is true of PL-259 type coax connectors?

A. They are preferred for microwave operation
B. They are watertight
C. They are commonly used at HF and VHF frequencies
D. They are a bayonet-type connector

T9B07 C 4-17

Which of the following is a source of loss in coaxial feed line?

A. Water intrusion into coaxial connectors
B. High SWR
C. Multiple connectors in the line
D. All these choices are correct

T9B08 D 4-17

What is the electrical difference between RG-58 and RG-213 coaxial cable?

A. There is no significant difference between the two types
B. RG-58 cable has two shields
C. RG-213 cable has less loss at a given frequency
D. RG-58 cable can handle higher power levels

T9B10 C 4-17

Where should an RF power meter be installed?

A. In the feed line, between the transmitter and antenna
B. At the power supply output
C. In parallel with the push-to-talk line and the antenna
D. In the power supply cable, as close as possible to the radio

T4A05 A 4-18

Which of the following is used to determine if an antenna is resonant at the desired operating frequency?

A. A VTVM
B. An antenna analyzer
C. A Q meter
D. A frequency counter

T7C02 B 4-18

Which instrument can be used to determine SWR?

A. Voltmeter
B. Ohmmeter
C. Iambic pentameter
D. Directional wattmeter

T7C08 D 4-18

What is the major function of an antenna tuner (antenna coupler)?

A. It matches the antenna system impedance to the transceiver's output impedance
B. It helps a receiver automatically tune in weak stations
C. It allows an antenna to be used on both transmit and receive
D. It automatically selects the proper antenna for the frequency band being used

T9B04 A 4-18

END OF MODULE 4

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