14-2: Common Antenna Types

The Dipole Antenna

- One of the most widely used antenna types is the **half-wave dipole**.
- The half-wave dipole, also called a **doublet**, is formally known as the **Hertz antenna**.
- A dipole antenna is two pieces of wire, rod, or tubing that are one-quarter wavelength long at the operating resonant frequency.
- Wire dipoles are supported with glass, ceramic, or plastic insulators at the ends and middle.

14-2: Common Antenna Types

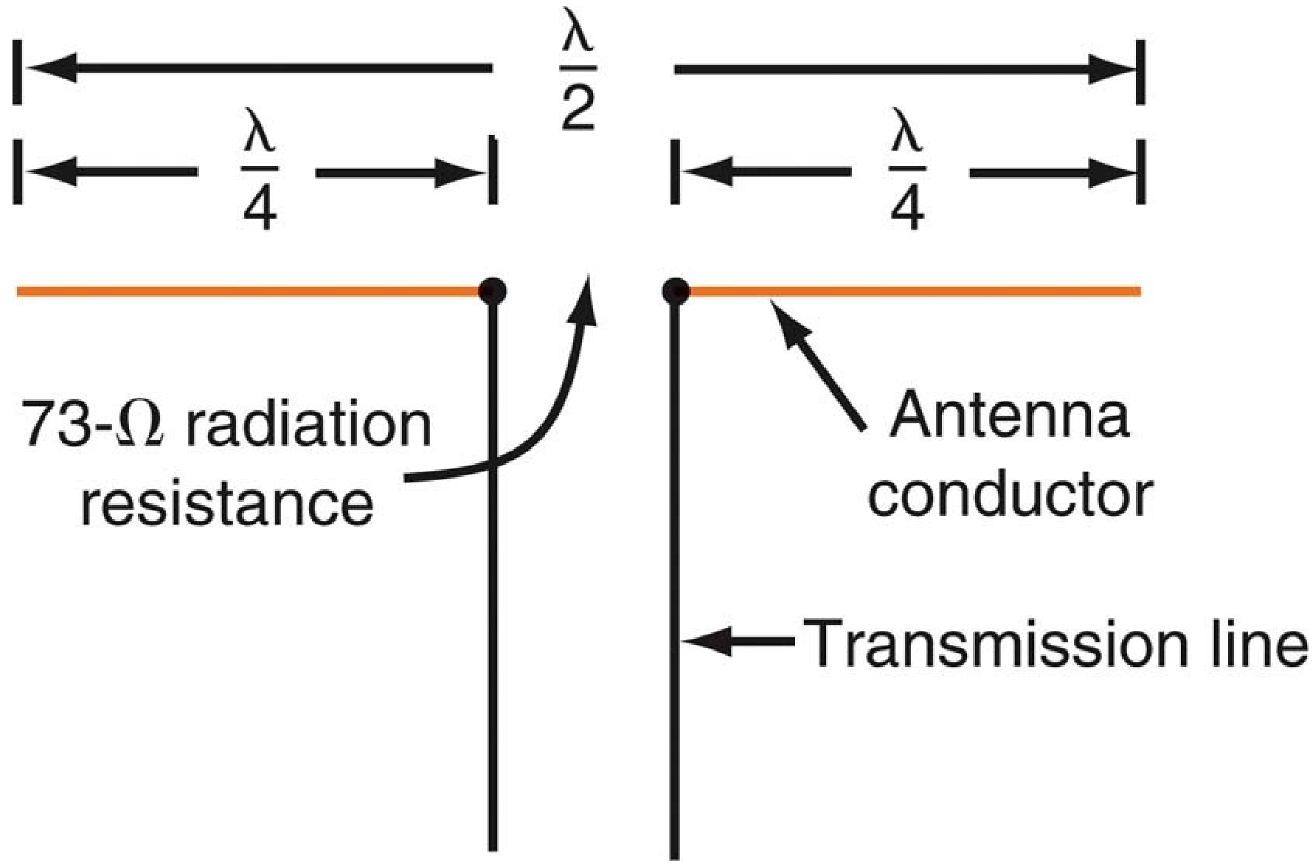

Figure 14-10: The dipole antenna.

14-2: Common Antenna Types

The Dipole Antenna

- The dipole has an impedance of 73 Ω at its center, which is the radiation resistance.
- An antenna is a frequency-sensitive device.
- To get the dipole to resonate at the frequency of operation, the physical length must be shorter than the one-half wavelength computed by $\lambda = 492/f$.
- Actual length is related to the ratio of length to diameter, conductor shape, *Q*, the dielectric (when the material is other than air), and a condition known as **end effect**.

14-2: Common Antenna Types

The Dipole Antenna

- **End effect** is a phenomenon caused by any support insulators used at the ends of the wire antenna and has the effect of adding capacitance to the end of each wire.
- The actual antenna length is only about 95 percent of the computed length.
- If a dipole is used at a frequency different from its design frequency, the SWR rises and power is lost.

14-2: Common Antenna Types

The Dipole Antenna: Antenna *Q* and Bandwidth

- The bandwidth of an antenna is determined by the frequency of operation and the *Q* of the antenna according to the relationship BW = f_r/Q.
- The higher the *Q*, the narrower the bandwidth.
- For an antenna, low *Q* and wider bandwidth are desirable so that the antenna can operate over a wider range of frequencies with reasonable SWR.
- In general, any SWR below 2:1 is considered good in practical antenna work.

14-2: Common Antenna Types

The Dipole Antenna: Antenna *Q* and Bandwidth

- The *Q* and thus the bandwidth of an antenna are determined by the ratio of the length of the conductor to the diameter of the conductor.
- Bandwidth is sometimes expressed as a percentage of the resonant frequency of the antenna.
- A small percentage means a higher *Q*, and a narrower bandwidth means a lower percentage.

14-2: Common Antenna Types

The Dipole Antenna: Conical Antennas

- A common way to increase bandwidth is to use a version of the dipole antenna known as the **conical antenna.**
- The center radiation resistance of a conical antenna is much higher than the 73 Ω usually found when straight-wire or tubing conductors are used.
- The primary advantage of conical antennas is their tremendous bandwidth.
- They can maintain a constant impedance and gain over a 4:1 frequency range.

14-2: Common Antenna Types

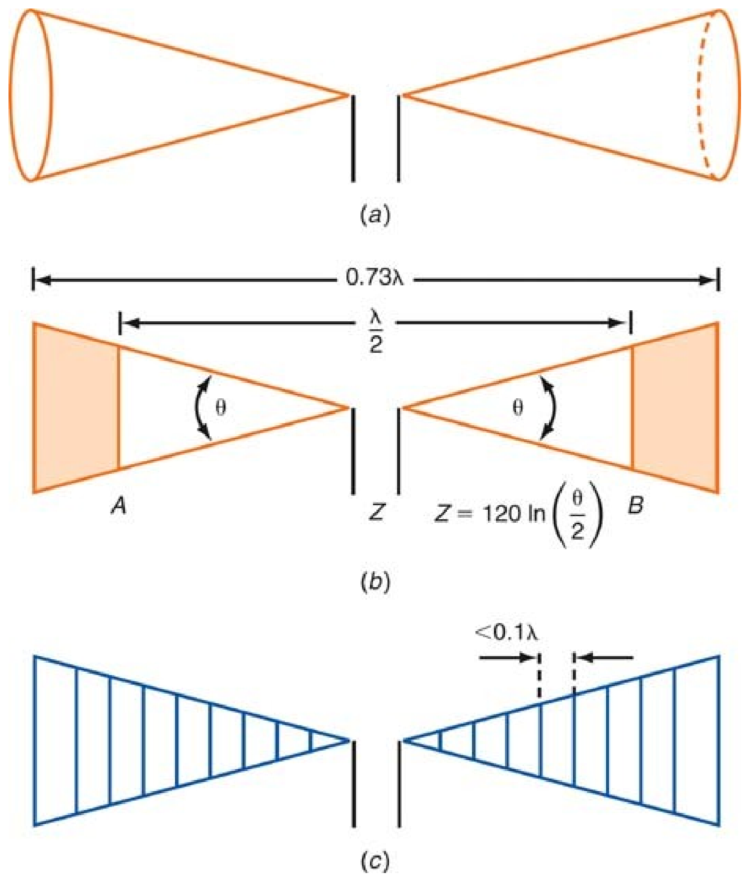

Figure 14-14: The conical dipole and its variation. (*a*) Conical antenna. (*b*) Broadside view of conical dipole antenna (bow tie antenna) showing dimensions. (*c*) Open-grill bow tie antenna.

14-2: Common Antenna Types

The Dipole Antenna: Dipole Polarization

- Most half-wave dipole antennas are mounted horizontally to the earth.
- This makes the electric field horizontal to the earth and the antenna is horizontally polarized.
- Horizontal mounting is preferred at the lower frequencies because the physical construction, mounting, and support are easier.
- This mounting makes it easier to attach the transmission line and route it to the transmitter or receiver.

14-2: Common Antenna Types

The Dipole Antenna: Radiation Pattern and Directivity

- The **radiation pattern** of any antenna is the shape of the electromagnetic energy radiated from or received by that antenna.
- Most antennas have directional characteristics that cause them to radiate or receive energy in a specific direction.
- The radiation is concentrated in a pattern that has a recognizable geometric shape.
- The measure of an antenna's directivity is **beam width**, the angle of the radiation pattern over which a transmitter's energy is directed or received.

14-2: Common Antenna Types

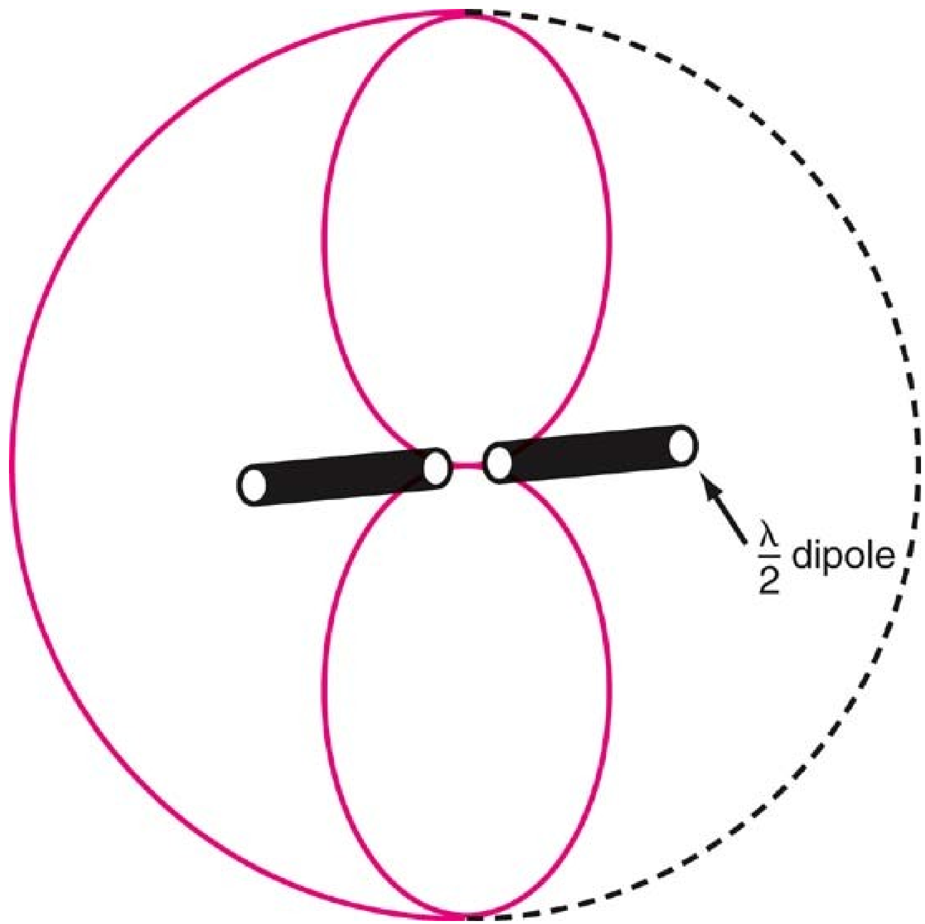

Figure 14-15: Three-dimensional pattern of a half-wave dipole.

14-2: Common Antenna Types

The Dipole Antenna: Antenna Gain

- A directional antenna can radiate more power in a given direction than a nondirectional antenna. In this “favored” direction, it acts as if it had gain.
- Antenna gain of this type is expressed as the ratio of the effective radiated output power P_{out} to the input power P_{in}.

14-2: Common Antenna Types

The Dipole Antenna: Antenna Gain

- Effective radiated power is the actual power that would have to be radiated by a reference antenna (usually a nondirectional or dipole antenna) to produce the same signal strength at the receiver as the actual antenna produces.
- The power radiated by an antenna with directivity and therefore gain is called the **effective radiated power (ERP).**

$$\text{ERP} = A_p P_t$$

14-2: Common Antenna Types

The Dipole Antenna: Folded Dipole

- A popular variation of the half-wave dipole is the **folded dipole.**
- The folded dipole is also one-half wavelength long.
- It consists of two parallel conductors connected at the ends with one side open at the center for connection to the transmission line.
- The impedance of this antenna is 300 Ω.
- Folded dipoles usually offer greater bandwidth than standard dipoles.
- The folded dipole is an effective, low-cost antenna that can be used for transmitting and receiving.

14-2: Common Antenna Types

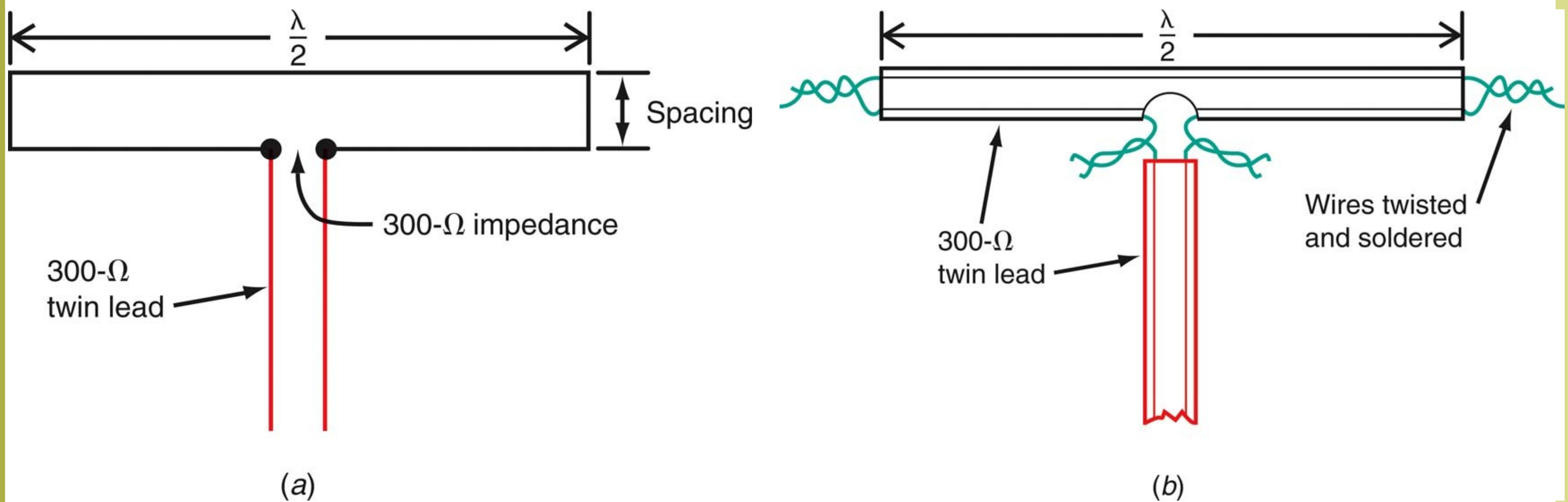

Figure 14-18: Folded dipole. (a) Basic configuration. (b) Construction with twin lead.

14-2: Common Antenna Types

Marconi or Ground-Plane Vertical Antenna

- The **one-quarter wavelength vertical antenna**, also called a **Marconi antenna,** is widely used.
- It is similar in operation to a vertically mounted dipole antenna.
- The Marconi antenna offers major advantages because it is half the length of a dipole antenna.

14-2: Common Antenna Types

Marconi or Ground-Plane Vertical Antenna: Radiation Pattern

- Vertical polarization and **omnidirectional** characteristics can be achieved using a one-quarter wavelength vertical radiator. This antenna is called a Marconi or **ground-plane antenna.**
- It is usually fed with coaxial cable; the center conductor is connected to the vertical radiator and the shield is connected to earth ground.
- The earth then acts as a type of electrical “mirror,” providing the other one-quarter wavelength making it equivalent to a vertical dipole.

14-2: Common Antenna Types

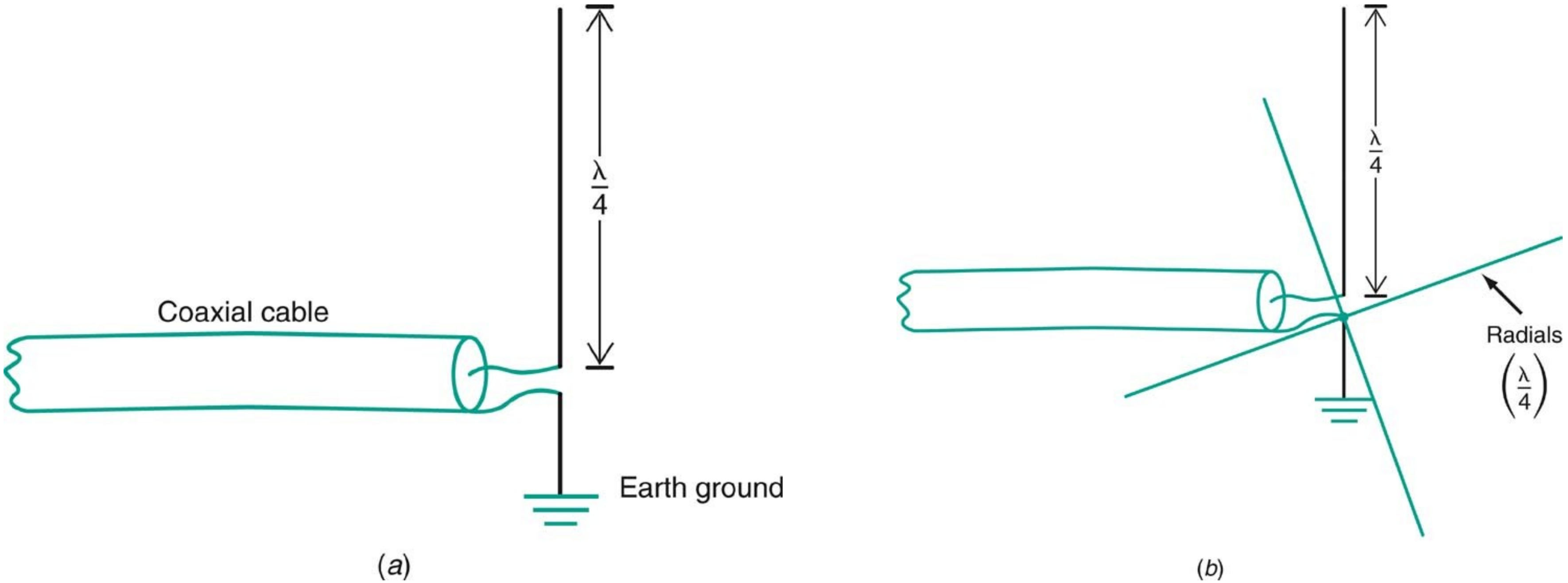

Figure 14-20: Ground-plane antenna. (*a*) One-quarter wavelength vertical antenna. (*b*) Using radials as a ground plane.

14-2: Common Antenna Types

Marconi or Ground-Plane Vertical Antenna: Ground Plane, Radials, and Counterpoise

- When a good electrical connection to the earth has been made, the earth becomes what is known as a **ground plane.**
- If a ground plane cannot be made to earth, an artificial ground can be constructed of several one-quarter wavelength wires laid horizontally on the ground or buried in the earth.
- These horizontal wires at the base of the antenna are called **radials,** and the collection of radials is called a **counterpoise.**

14-2: Common Antenna Types

Marconi or Ground-Plane Vertical Antenna: Antenna Length

- For many applications, e.g., with portable or mobile equipment, it is not possible to make the antenna a full one-quarter wavelength long.
- To overcome this problem, shorter antennas are used, and lumped electrical components are added to compensate for the shortening.

14-2: Common Antenna Types

Marconi or Ground-Plane Vertical Antenna: Antenna Length

- The practical effect of this design is a decreased inductance. The antenna no longer resonates at the desired operating frequency, but at a higher frequency.
- To compensate for this, a series inductor, called a **loading coil,** is connected in series with the antenna coil.
- The loading coil brings the antenna back into resonance at the desired frequency.