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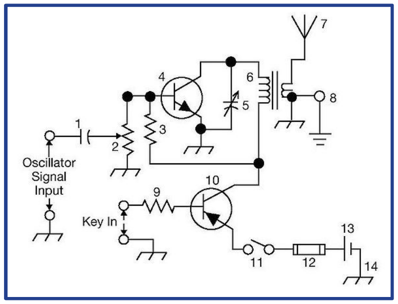

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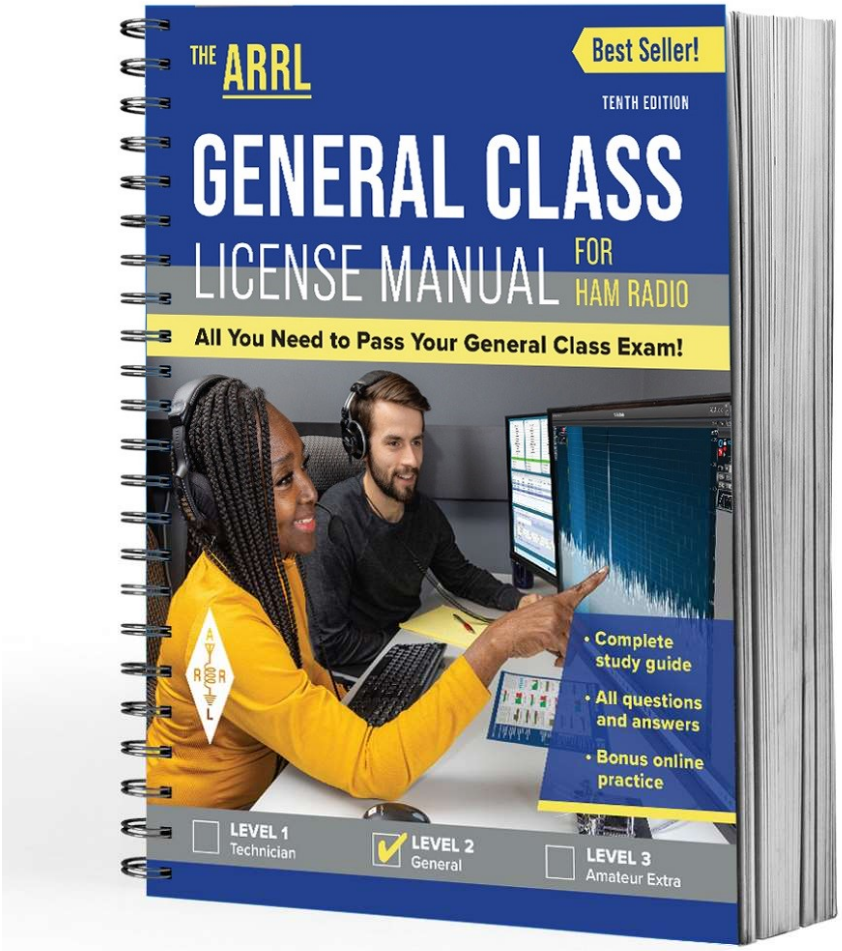


Chapter 7 Part 2 of 2

ARRL General Class
Antennas
Sections 7.3, 7.4, 7.5

Loop Antennas, Specialized Antennas, Feed Lines

Section 7.3
Loop Antennas

- Can be circular, square, triangular or any simple open shape that is not too narrow
- Feed line can be attached at a break in the loop or a smaller loop can be used to couple RF energy to the main loop
- A square loop with each leg 1⁄4 wavelength long is a *quad loop*
- Triangular or *delta loops* are usually symmetrical, each leg 1⁄3 wavelength long
- A one-wavelength loop acts electrically like two dipoles connected end-to-end with the open ends brought together
  - Circumference much larger than 1 λ, current patterns around loop have more than 2 peaks and nulls … result is an essentially omnidirectional pattern with the peak angle of radiation somewhat lower than a dipole at the same height

Quad and Delta Loop Beams

- Popular variation of the Yagi beam uses quad loops for elements (*quad*)
  - Has two or more full-sized loops mounted on a boom
- Quad or delta loop beam driven elements are approximately 1 λ in circumference and operate on the same principles of re-radiation and phase shift as does the Yagi
- The driven element of a quad is about 1⁄4 λ per side and of a symmetrical delta loop about 1⁄3 λ per side
- Quad and delta loop reflectors are about 5% longer in circumference than the driven element, and the directors about 5% shorter
- Front-to-back ratio is generally better for the Yagi

Fig. 7.10

1-Wavelength Loop Antenna

Direction of maximum signal is broadside to the plane of the loop, whether round, quad or delta. Orienting the loop vertically aims the maximum signal toward the horizon (*good for DX*).

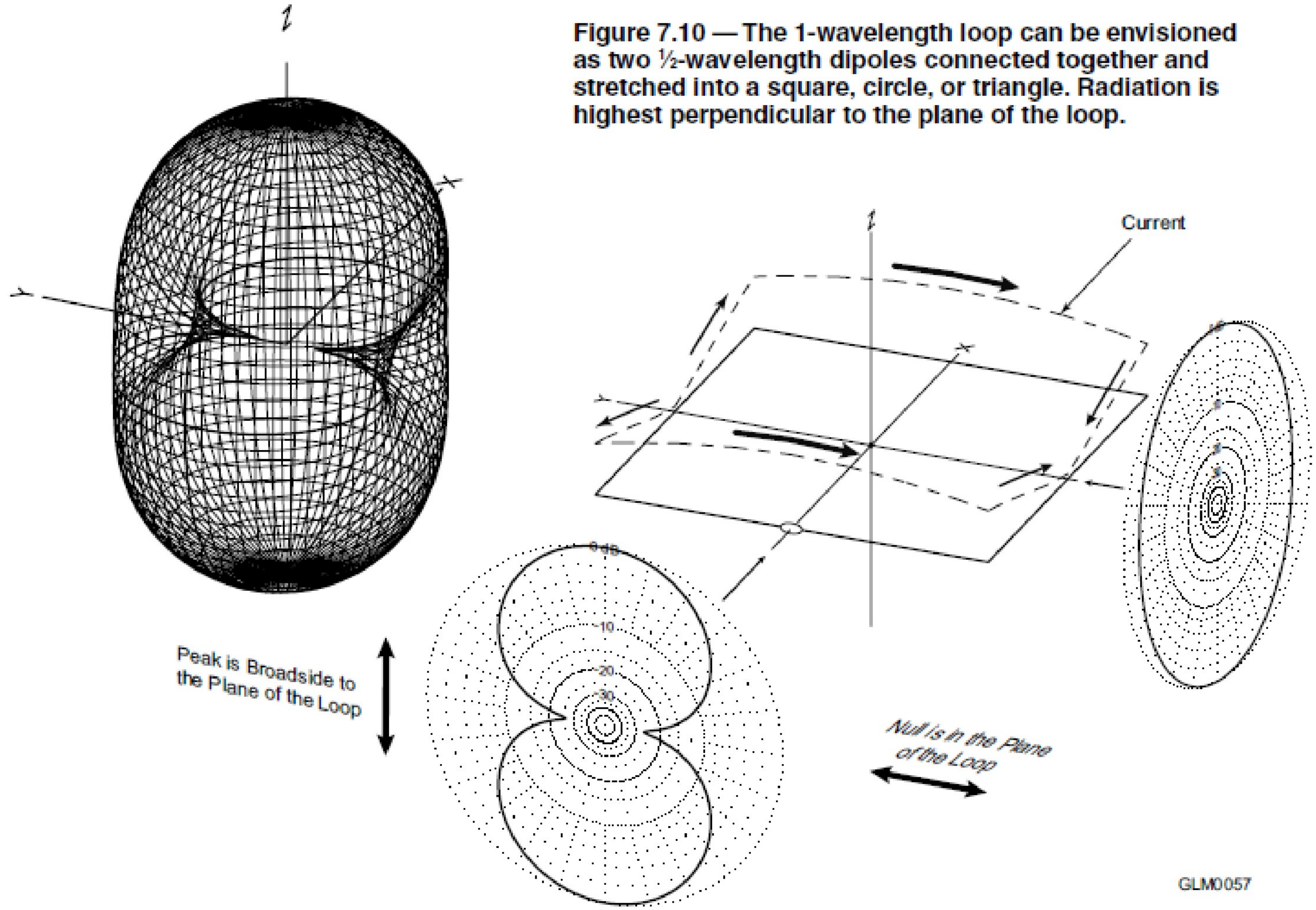


Figure 7.10 — The 1-wavelength loop can be envisioned as two ½-wavelength dipoles connected together and stretched into a square, circle, or triangle. Radiation is highest perpendicular to the plane of the loop.

Small Loops

- When the circumference of the loop becomes less than 1⁄3 λ, the current in the loop becomes relatively uniform all the way around the loop
  - Image in Fig. 7-10 a small loop rotated 90 degrees from the loop in the figure
- Causes radiation pattern to develop sharp nulls broadside to the plane of the loop
- In wide use as receiving antennas and portable or low-profile transmitting antennas
- The sharp null broadside to the loop makes them effective for direction-finding

Typical small loop portable HF antenna

Halo Antennas

- Dipole bent into a circle or square (the "squalo") with the ends separated by a small gap
- Not a continuous loop, but often viewed as a 1⁄2 λ loop
- Usually mounted horizontally so they produce an omnidirectional pattern with the horizontal polarization preferred for VHF weak-signal operation
- Halos for 6 and 2 meters can be mounted on a vehicle for mobile operation

PRACTICE QUESTIONS

In which direction is the maximum radiation from a VHF/UHF “halo” antenna?

A. Broadside to the plane of the halo
B. Opposite the feed point
C. Omnidirectional in the plane of the halo
D. On the same side as the feed point

G9D03 (C) Page 7-16

In which direction or directions does an electrically small loop (less than 1⁄10 wavelength in circumference) have nulls in its radiation pattern?

A. In the plane of the loop
B. Broadside to the loop
C. Broadside and in the plane of the loop
D. Electrically small loops are omnidirectional

Section 7.4: Specialized Antennas

Random Wire Antennas

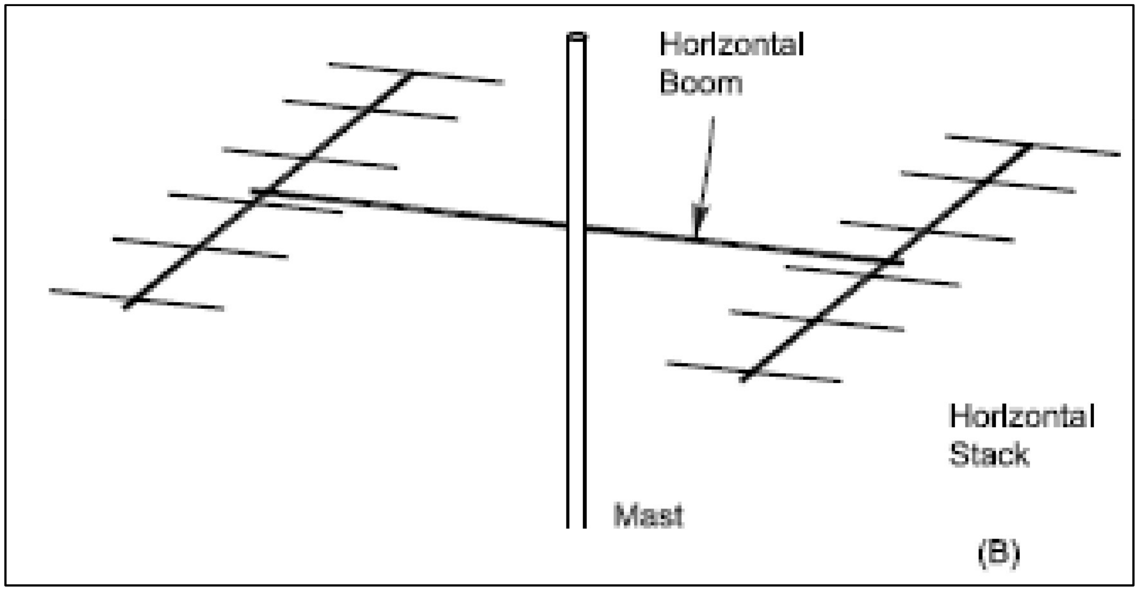
- Not always practical to have a 1⁄2 or 1⁄4 λ long resonant antenna (portable)
  - A random wire antenna can be used
- Connected directly to the output of the transmitter (or tuner) without a feed line
- *May result in significant RF currents and voltages on the station equipment (RF burns)*
- Can give excellent results on any band for which the transmitter or tuner can accept the feed point impedance

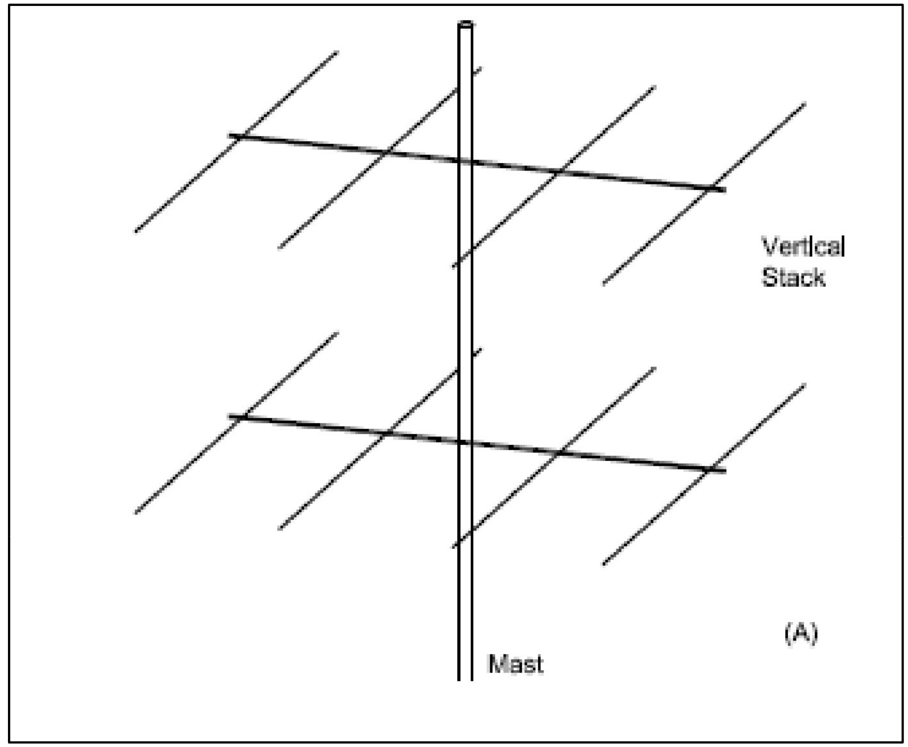
Stacked Antennas

- Stacking antennas (vertically or horizontally) results in more gain (see Fig 7.14)
- As more and more directors are added, the *beamwidth* of the main lobe (angle between points on the main lobe at which gain is 3 dB less than maximum) narrows
- Vertically stacking antennas increases gain and narrows the elevation beamwidth
- Most vertical stacks, with the antennas directly above each other, space the antennas about λ/2 apart. Spaced λ/2 apart, the additional gain for a vertical stack of two horizontally-polarized beams is about 3 dB.

Fig. 7.14: Stacked Antennas

Stacking antennas produces more gain in a main lobe that is carefully controlled. At **A**, two Yagis are stacked vertically on the same mast.



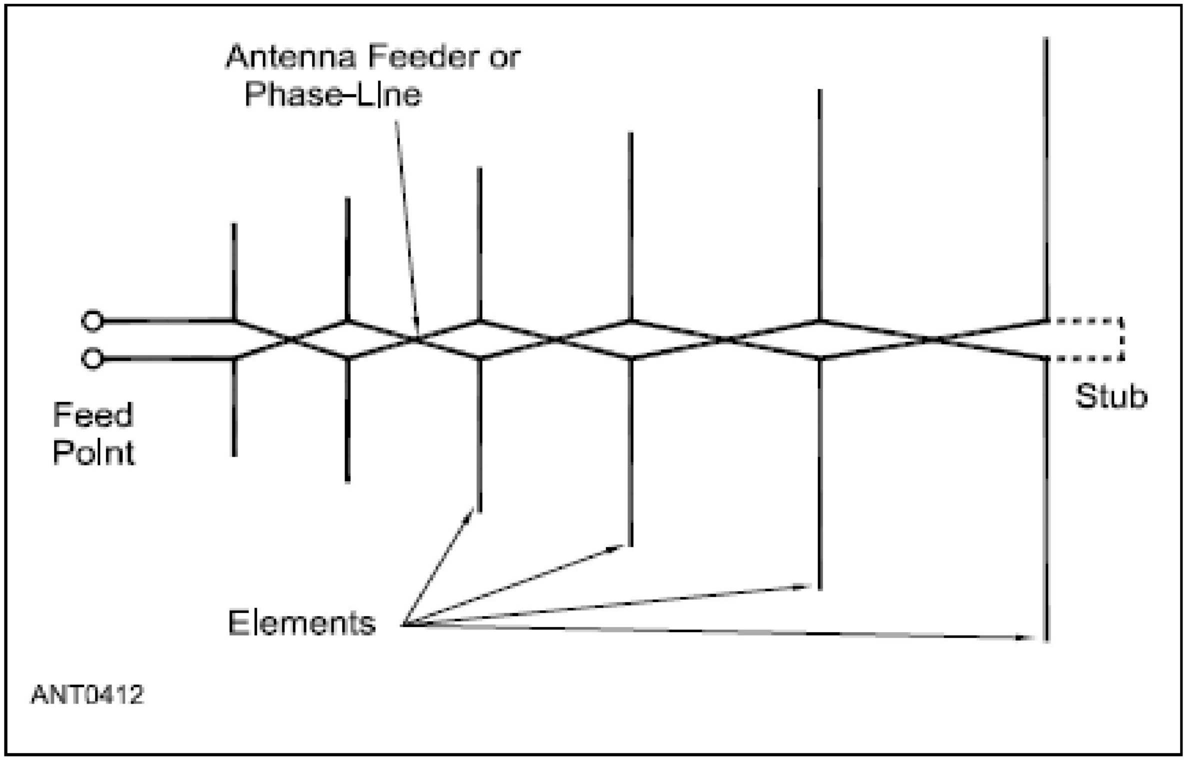


Log Periodic Antennas (or *Logs*) … See Fig. 7.15

- TV antennas are often *log periodics*
- "Log" refers to *logarithmic* & *periodic* means the spacing of the elements along the boom
- The length and the spacing of the elements increases logarithmically from one end to the other
- Designed to have a consistent radiation pattern and low SWR over a wide frequency bandwidth (as much as 10:1)
  - Meaning the log periodic can be used over several bands
- Not as much gain or front-to-back ratio as a Yagi antenna

Fig. 7.15: Log Periodic Antenna

The log periodic dipole array (LPDA) consists of dipoles fed by a common feed line that alternates polarity between elements. Traditional TV antennas sweep the elements slightly forward.

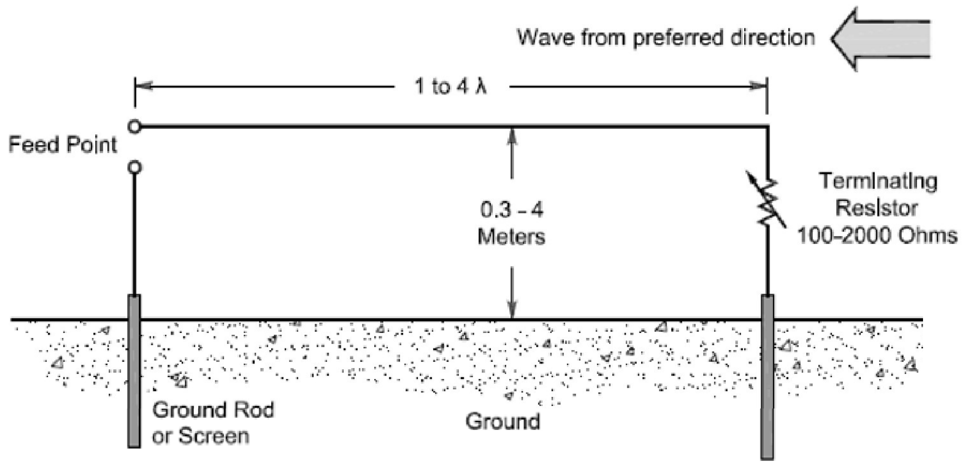


Beverage Antennas

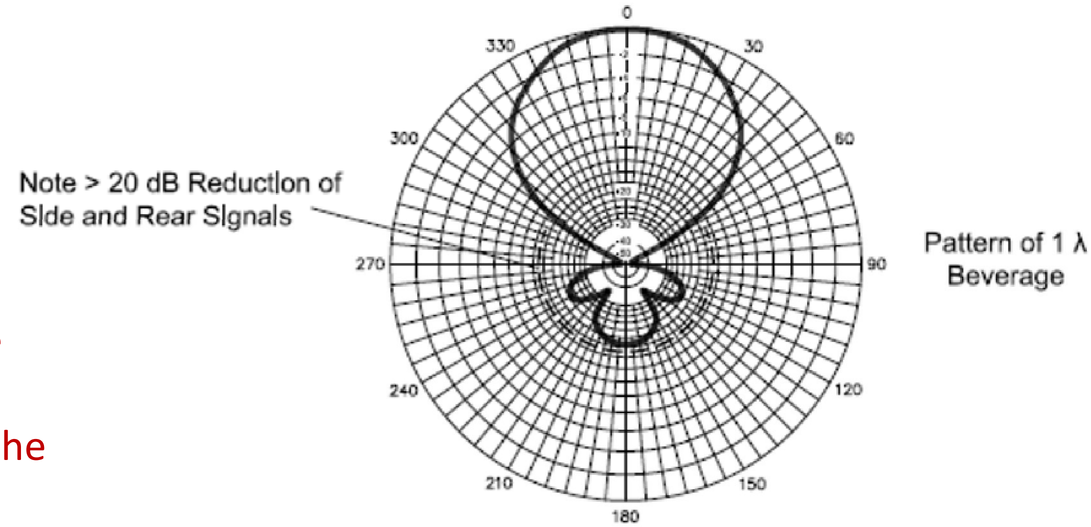
- Invented by Harold Beverage (see Fig 7.16)
- Designed not to have high gain, but to reject noise and interfering signals that are not from the desired direction
  - Result is lower signal strength but a better signal-to-noise ratio
- Referred to as a *traveling wave antenna*
- Consists of a long, low wire (usually less than 20 feet high) aligned with the preferred signal direction
- Used *exclusively for directional receiving* on MF and lower HF bands (40 meters and longer wavelengths)
  - Has high ground losses and is *too inefficient for use as a transmitting antenna*

Fig. 7.16: Beverage Antenna

Antenna Design



Radiation Pattern



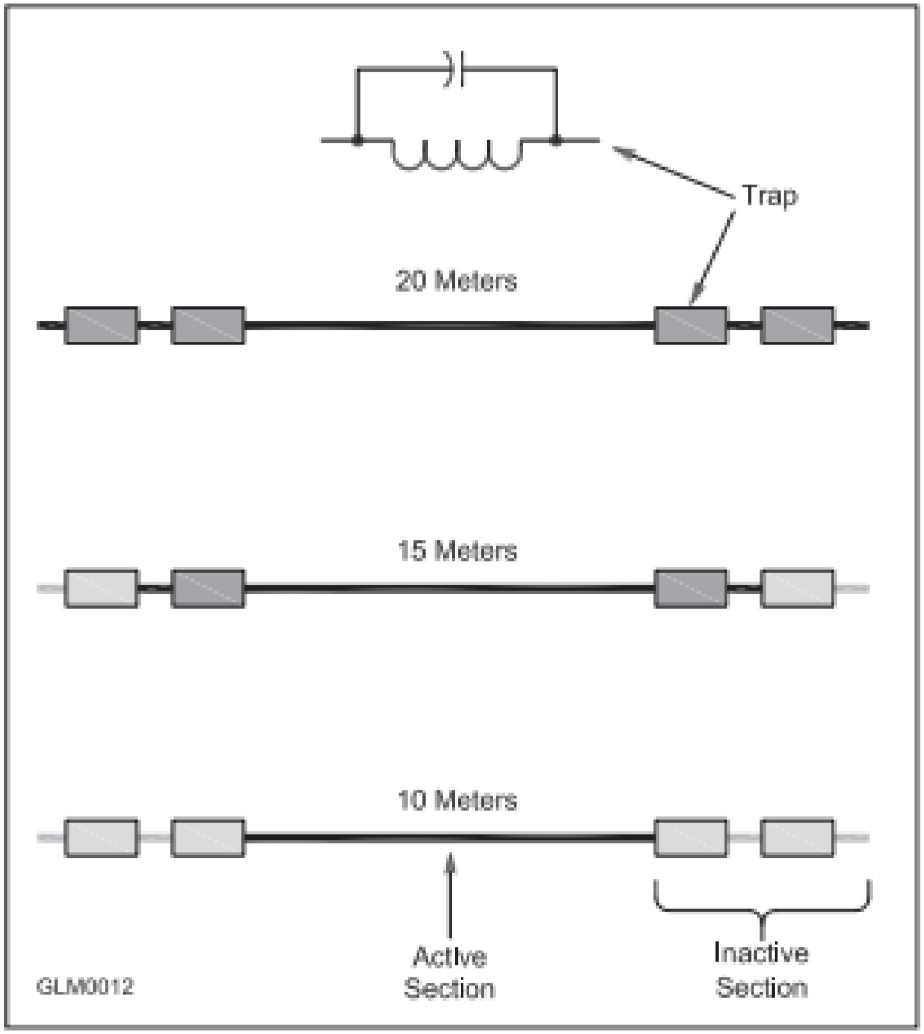
Signals arriving from the direction of the terminating resistor induce a traveling voltage wave along the wire transferred to the feed line at the feed point. Signals arriving from other directions are either absorbed by the terminating resistor or do not induce voltage waves in the antenna.

Multiband Antennas

- What hams generally mean by multiband antenna is a design that reconfigures itself electrically for each band of operation
- Most basic multiband antenna … *trap dipole* (See Fig 7.17)
  - Each trap is a parallel ***LC*** circuit
  - At resonance acts like an open circuit, below resonance like an inductor, and above resonance like a capacitor
  - At lower frequencies, the traps add inductance to the antenna, making the antenna look electrically longer
  - At higher frequencies, the capacitance electrically shortens the antenna

Fig 7.17: Traps

Traps are parallel LC circuits. They may be made from discrete inductors and capacitors or may use coaxial cable or metal sleeves. The traps act like open circuits at their resonant frequency, causing different sections of the antenna to be active on different bands. This drawing shows a trap antenna that works on 10, 15, and 20 meters.



Trap Dipoles (cont.)

- The lowest frequency of operation the antenna acts like a regular dipole, shortened by the inductance of the trap
- Yagis can also use traps to work on several bands
  - 3-element tribander Yagi with traps in the elements works well on 20, 15 & 10 meters
- Trap drawbacks
  - Because it works on multiple bands, it radiates harmonics and spurious signals (transmitter operator’s responsibility to be sure those signals are not generated)
  - Trap losses reduce the efficiency of the antenna
  - Will not radiate as well as a full-sized antenna

PRACTICE QUESTIONS

What is a characteristic of a random-wire HF antenna connected directly to the transmitter?

A. It must be longer than 1 wavelength
B. Station equipment may carry significant RF current
C. It produces only vertically polarized radiation
D. It is more effective on the lower HF bands than on the higher bands

In free space, how does the gain of two three-element, horizontally polarized Yagi antennas spaced vertically 1⁄2 wavelength apart typically compare to the gain of a single three-element Yagi?

A. Approximately 1.5 dB higher
B. Approximately 3 dB higher
C. Approximately 6 dB higher
D. Approximately 9 dB higher

G9C09 (B) Page 7-17

What is the primary function of antenna traps?

A. To enable multiband operation
B. To notch spurious frequencies
C. To provide balanced feed point impedance
D. To prevent out-of-band operation

G9D04 (A) Page 7-19

What is an advantage of vertical stacking of horizontally polarized Yagi antennas?

A. It allows quick selection of vertical or horizontal polarization
B. It allows simultaneous vertical and horizontal polarization
C. It narrows the main lobe in azimuth
D. It narrows the main lobe in elevation

Which of the following is an advantage of a log periodic antenna?

A. Wide bandwidth
B. Higher gain per element than a Yagi antenna
C. Harmonic suppression
D. Polarization diversity

G9D06 (A) Page 7-17

Which of the following describes a log-periodic antenna?

A. Element length and spacing vary logarithmically along the boom
B. Impedance varies periodically as a function of frequency
C. Gain varies logarithmically as a function of frequency
D. SWR varies periodically as a function of boom length

G9D07 (A) Page 7-17

What is the primary use of a Beverage antenna?

A. Directional receiving for low HF bands
B. Directional transmitting for low HF bands
C. Portable direction finding at higher HF frequencies
D. Portable direction finding at lower HF frequencies

G9D09 (A) Page 7-19

Which of the following is a disadvantage of multiband antennas?

A. They present low impedance on all design frequencies
B. They must be used with an antenna tuner
C. They must be fed with open wire line
D. They have poor harmonic rejection

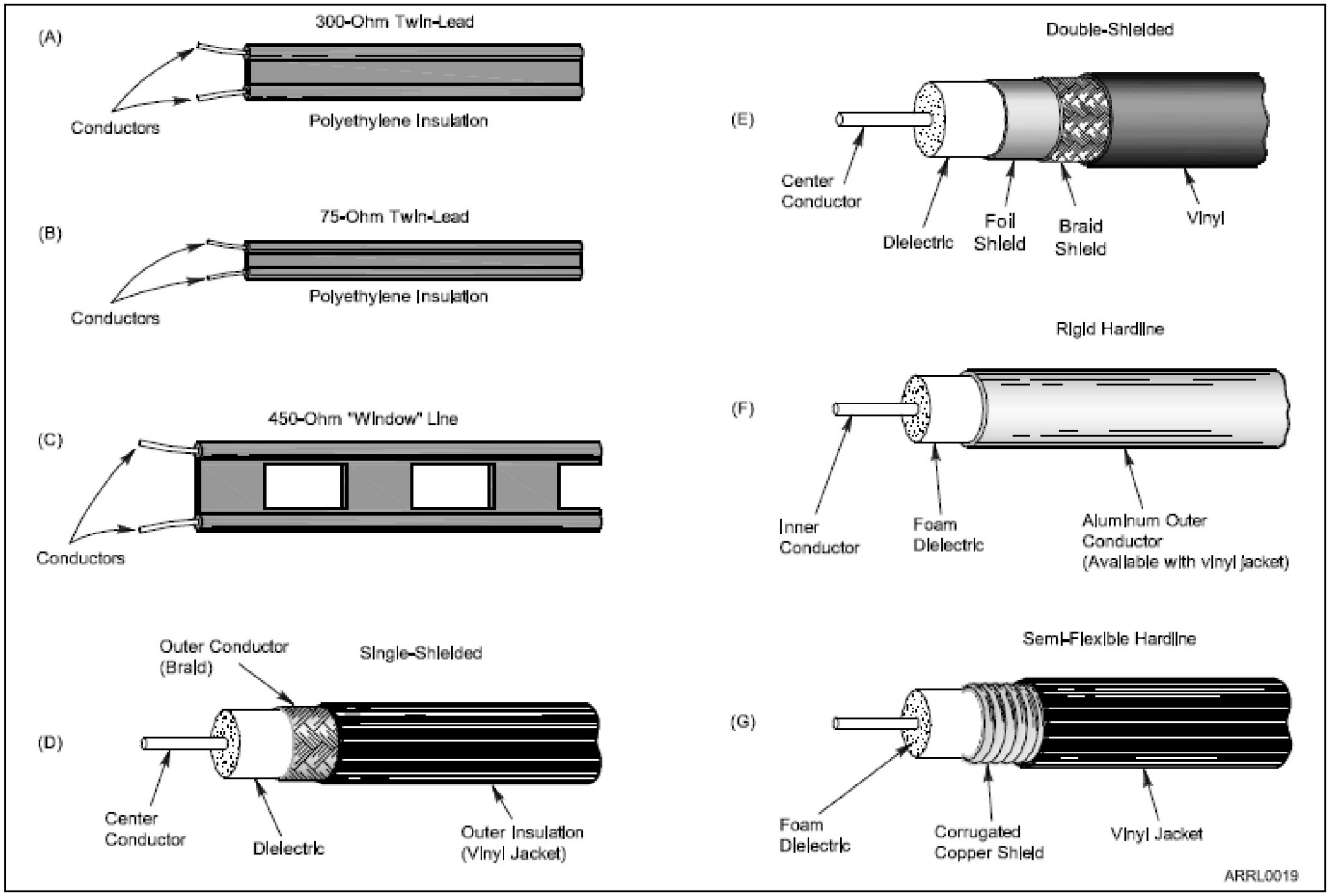
Section 7.5

Feed Lines / Characteristic Impedance

- *Balanced feed lines* consist of two parallel conductors separated by insulating material in the form of strips or spacers
- Have different characteristic impedances (Z_0) that characterize how electromagnetic energy is carried by the feed line (different from resistance)
- For parallel-conductor feed lines, the radius of the conductors and the distance between them determine Z_0
- Most common type is *window line*
- Typical impedance for window line is 450 Ω (some as low as 400 Ω)
- Most common characteristic impedances for *coaxial feed lines* used by amateurs are 50 Ω and 75 Ω

Fig 7.18

Some common types feed lines used by amateurs. Parallel conductor line (A, B, C) has two parallel conductors separated by insulation (dielectric). Coaxial cable (D, E, F, G) or “coax” has a center conductor surrounded by insulation. The center conductor may be made from stranded or solid wire. The second conductor, called the shield, covers the insulation and is in turn covered by the plastic outer jacket. The shield may be made from braid, or from solid aluminum or copper.



Forward & Reflected Power & SWR

- A feed line transfers all of its power to an antenna when the antenna and feed line impedances are *matched*
  - If impedances don’t match, some of the power is *reflected* by antenna
    - *Forward power*: power traveling *toward* the antenna
    - *Reflected power*: power reflected *by* the antenna
- Power in a feed line is reflected at any point at which the impedance of the feed line changes
  - Can be at an antenna, connector, or from a different type of feed line

SWR

- The waves carrying forward power and reflected power form stationary patterns inside the feed line. These are called *STANDING* waves.
- The ratio of the peak voltage in the standing wave to the minimum voltage is called the *standing wave ratio* (SWR)
  - Measures how well antenna and feed line impedances are matched
  - 1:1 is a perfect match … none of the power is reflected
  - SWR = infinity (∞) indicates that all the power was reflected
- SWR is always greater than 1:1 (for example, 3:1 and not 1:3)

Calculating SWR

SWR is equal to the ratio of the higher of antenna feed point impedance or feed line characteristic impedance to the lower.

Example: What is the SWR in a 50-Ω feed line connected to a 200-Ω load?

Example: What is the SWR in a 50-Ω feed line connected to a 10-Ω load?

SWR (cont.)

- Can be measured anywhere along feed line
  - Most commonly measured at connection to transmitter
- SWR is measured by an SWR Meter (also called *Bridge*)
- Transmitting equipment is designed to work at full power with an SWR at the input to the feed line of 2:1 or lower
- Antennas that are much too short or too long will not work well and will have extreme feed point impedances, causing high SWR

Impedance Matching

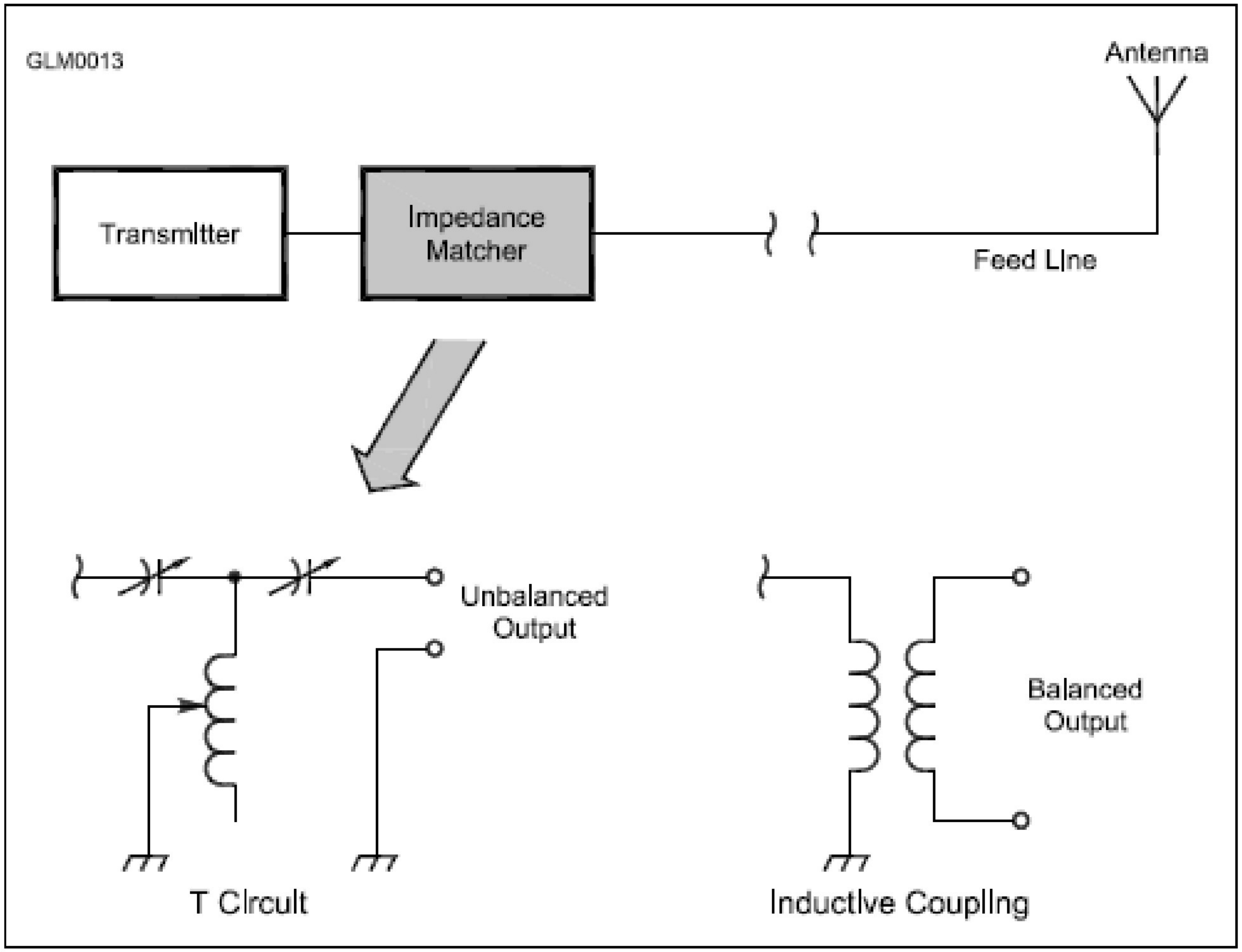
- Matching feed line and load (antenna) impedances eliminates standing waves from reflected power and maximizes power delivered to the load (*but, not always practical … the impedance matching is more often done at the transmitter end of the feed line*)
- Devices used to reduce SWR are called: impedance matcher, transmatch, antenna coupler, and antenna tuner
  - Tuners do NOT tune the antenna at all — only changes impedance of the antenna system at end of feed line to match that of transmitter
  - In other words, an antenna tuner increases the power transfer from the transmitter to the feed line

Impedance Matching (cont.)

- Devices constructed from inductors and capacitors that are adjustable by the operator
- T circuit can match a wide range of impedances at the feed line connection to 50 Ω that matches transmitter output impedance
- *It is important to remember that the SWR in the feed line between the impedance matching device and the antenna does not change … the device just changes the load going to the transmitter … SWR in feed line stays the same*

Fig. 7.19: T Network

Installed at the transmitter end of the feed line, a T network is designed to be used with unbalanced, coaxial feed lines. This circuit uses two variable capacitors and one variable inductor. To use balanced feed lines, such as window line, the output of a T network can be inductively coupled to the output so that neither of the feed line conductors is connected to ground.



Feed Line Loss

- Feed lines dissipate a little of the energy they carry as heat (called *attenuation* or *loss*)
- Loss is measured in dB per unit of length, usually dB/100 feet
- Loss increases with frequency for all types of feed lines
- The smaller the cable diameter, the higher the loss
- Increasing SWR in a feed line also increases the total loss
- The higher the feed line loss, the lower the measured SWR will be at the input to the line

PRACTICE QUESTIONS

What is the purpose of an antenna tuner?

A. Reduce the SWR in the feed line to the antenna
B. Reduce the power dissipation in the feedline to the antenna
C. Increase power transfer from the transmitter to the feed line
D. All these choices are correct

G4A06 (C) Page 7-22

Which of the following factors determine the characteristic impedance of a parallel conductor feed line?

A. The distance between the centers of the conductors and the radius of the conductors
B. The distance between the centers of the conductors and the length of the line
C. The radius of the conductors and the frequency of the signal
D. The frequency of the signal and the length of the line

G9A01 (A) Page 7-20

What is the relationship between high standing wave ratio (SWR) and transmission line loss?

A. There is no relationship between transmission line loss and SWR
B. High SWR increases loss in a lossy transmission line
C. High SWR makes it difficult to measure transmission line loss
D. High SWR reduces the relative effect of transmission line loss

G9A02 (B) Page 7-23

What is the nominal characteristic impedance of “window line” transmission line?

A. 50 ohms
B. 75 ohms
C. 100 ohms
D. 450 ohms

G9A03 (D) Page 7-21

What causes reflected power at an antenna's feed point?

A. Operating an antenna at its resonant frequency
B. Using more transmitter power than the antenna can handle
C. A difference between feed-line impedance and antenna feed-point impedance
D. Feeding the antenna with unbalanced feed line

How does the attenuation of coaxial cable change with increasing frequency?

A. Attenuation is independent of frequency
B. Attenuation increases
C. Attenuation decreases
D. Attenuation follows Marconi’s Law of Attenuation

In what units is RF feed line loss usually expressed?

A. Ohms per 1,000 feet
B. Decibels per 1,000 feet
C. Ohms per 100 feet
D. Decibels per 100 feet

What must be done to prevent standing waves on a feed line connected to an antenna?

A. The antenna feed point must be at DC ground potential

B. The feed line must be an odd number of electrical quarter wavelengths long

C. The feed line must be an even number of physical half wavelengths long

D. The antenna feed point impedance must be matched to the characteristic impedance of the feed line

G9A07 (D) Page 7-22

If the SWR on an antenna feed line is 5:1, and a matching network at the transmitter end of the feed line is adjusted to present a 1:1 SWR to the transmitter, what is the resulting SWR on the feed line?

A. 1 to 1
B. 5 to 1
C. Between 1 to 1 and 5 to 1 depending on the characteristic impedance of the line
D. Between 1 to 1 and 5 to 1 depending on the reflected power at the transmitter

What standing wave ratio results from connecting a 50-ohm feed line to a 200-ohm resistive load?

A. 4:1
B. 1:4
C. 2:1
D. 1:2

What standing wave ratio results from connecting a 50-ohm feed line to a 10-ohm resistive load?

A. 2:1
B. 1:2
C. 1:5
D. 5:1

END OF CHAPTER 7 PART 2 OF 2

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Feel free to contact me if you find errors or have suggestions for improvement.