

Technician License Course Chapter 4

Lesson Plan Module 9 – Antenna Fundamentals, Feed Lines & SWR



The Antenna System

- **Antenna:** Transforms current into radio waves (transmit) and vice versa (receive).
- **Feed line:** Connects your station to the antenna.
- **Test and matching equipment:** Allows you to monitor and optimize antenna system performance.



2014 Technician License Course

The Antenna (Some Vocabulary)

- **Element:** The conducting part or parts of an antenna designed to radiate or receive radio waves.
- **Driven element:** The element supplied directly with power from the transmitter.
- **Array:** An antenna with more than one element.



2014 Technician License Course

The Antenna (Some Vocabulary)

- **Parasitic element:** Elements not connected directly to a feed line.
- **Resonant:** An antenna is resonant when its feed point impedance has zero reactance.
- **Feed point:** Where the transmitted energy enters the antenna.
- **Radiation:** *NOT* radioactivity! An antenna emitting electromagnetic waves.



2014 Technician License Course

Electromagnetic Waves

- Radio waves are electromagnetic waves
 - Electric and magnetic fields are at right angles to each other, oscillating at the wave's frequency
 - Spread out into space from the antenna
 - Are created by ac current
 - Wave and current have the same frequency



2014 Technician License Course

Wave Polarization

- Orientation of the wave's electric field component with respect to the surface of the Earth
 - *Vertical* or *horizontal* – determined by elements
 - Can be *circular* if the orientation twists as the wave spreads through space
 - Combinations of polarization are called *elliptical* polarization



2014 Technician License Course

Cross-Polarization

- Antenna and wave polarization must match for maximum reception.
 - **Cross-polarized:** antenna elements and the wave's electric field are at right angles
 - Can reduce reception by a factor of 100
- For elliptically polarized waves (such as HF sky-wave) any antenna will respond at least partially.



2014 Technician License Course

The Decibel (dB)

- A ratio expressed as a power of 10 to make large numbers easier to work with.
 - $\text{dB} = 10 \log (\text{power ratio})$
 - $\text{dB} = 20 \log (\text{voltage ratio})$
- Positive values in dB indicate ratios > 1 and negative values of dB are for ratios < 1 .
- Antenna gain is discussed in terms of dB.



2014 Technician License Course

The Antenna (Some Vocabulary)

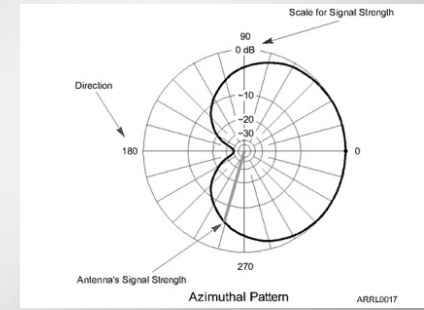
- **Gain:** Apparent increase in power in a particular direction by focusing radiation in that direction. Measured in decibels (dB).
- **Isotropic:** Equal radiation in all directions.
- **Omnidirectional:** No preferred horizontal direction.
- **Directional:** Antenna that focuses radiation in specific directions.



2014 Technician License Course

Antenna Radiation Patterns

- Radiation patterns are a way of visualizing antenna performance.
- The further the line is from the center of the graph, the stronger the signal at that point.
- Graph calibrated in dB.



2014 Technician License Course

Radiation Pattern Vocabulary

- **Nulls:** Directions of minimum gain
- **Lobes:** Regions between nulls
- **Main lobe:** Lobe with highest gain
- **Side lobe:** Any lobe other than the main lobe
- **Forward gain:** Gain in the direction assigned as forward



2014 Technician License Course

Radiation Pattern Vocabulary

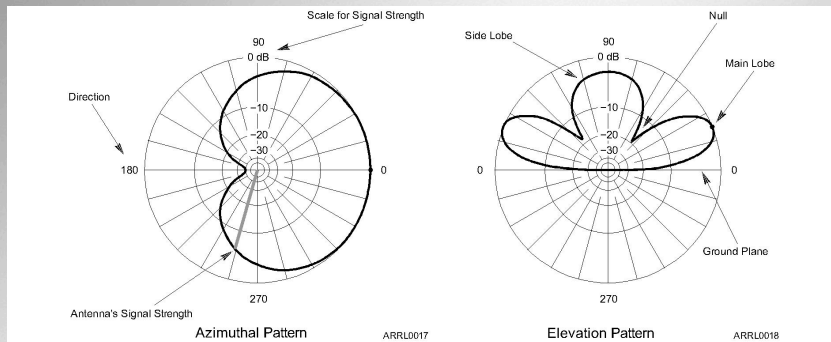
- **Azimuth pattern:** Radiation pattern showing gain in all horizontal directions around the antenna.
- **Elevation pattern:** Radiation pattern showing gain at all vertical angles from the antenna.
 - Often restricted to angles above horizontal



2014 Technician License Course

Azimuth Pattern

Elevation Pattern



Radiation Pattern Vocabulary

- **Front-to-back ratio:** Ratio of forward gain to gain in the opposite direction.
- **Front-to-side ratio:** Ratio of forward gain to gain at right angles to the forward direction.

Feed Lines

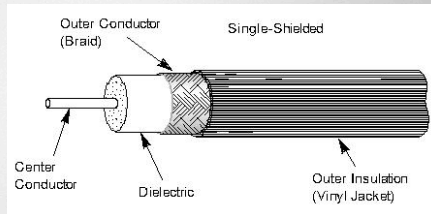
- The purpose of the feed line is to get RF power from your station to the antenna.
- Basic feed line types
 - *Coaxial cable* (coax)
 - *Open-wire line* (OWL) also called ladder line or window line
- Power lost as heat in the feed line is called *loss* and it increases with frequency.

Feed Line Vocabulary

- **Center conductor:** Central wire
- **Dielectric:** Insulation surrounding center conductor
- **Shield:** Braid or foil surrounding dielectric
- **Jacket:** Protective outer plastic coating
- **Forward (reflected) power:** RF power traveling toward (away from) a load such as an antenna

Coaxial Cable

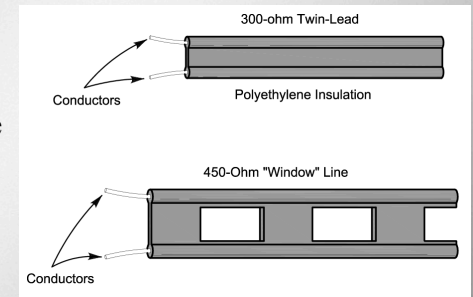
- Most common feed line
- Easy to use
- Not affected by nearby materials
- Has higher loss than open-wire line at most frequencies
- Air-insulated “hard line” has lowest loss



2014 Technician License Course

Open-Wire Line

- Lighter and less expensive than coax
- Has lower loss than coax at most frequencies
- More difficult to use since it is affected by nearby materials
- Requires impedance matching equipment to use with most transceivers



2014 Technician License Course

Characteristic Impedance

- The impedance presented to a wave traveling through a feed line
- Given in ohms (Ω), symbolized as Z_0
- Depends on how the feed line is constructed and what materials are used
 - Coax: 50 and 75 Ω
 - OWL: 300, 450, and 600 Ω



2014 Technician License Course

Standing Wave Ratio (SWR)

- If the antenna feed point and feed line impedances are not identical, some RF power is reflected back toward the transmitter.
 - Called a *mismatch*
 - Forward and reflected waves create a pattern of *standing waves* of voltage and current in the line
 - SWR is the ratio of standing wave max to min
- Measured with an *SWR meter* or *SWR bridge*.



2014 Technician License Course

Standing Wave Ratio (SWR)

- Reflected power is re-reflected at the transmitter and bounces back and forth.
 - Some RF power is lost as heat on each trip back and forth through the feed line
 - All RF power is eventually lost as heat or transferred to the antenna or load
- High SWR means more reflections and more loss of RF power (less transferred to the antenna or load).



2014 Technician License Course

Nothing Is Perfect

- SWR equals the ratio of feed point (or *load*) and feed line impedance, whichever is greater than 1 (SWR always greater than 1:1).
- What is an acceptable SWR?
 - 1:1 SWR is perfect – no power reflected
 - Up to 2:1 SWR is normal
 - Modern radios lower transmitter output power for protection when SWR is above 2:1



2014 Technician License Course

Nothing Is Perfect

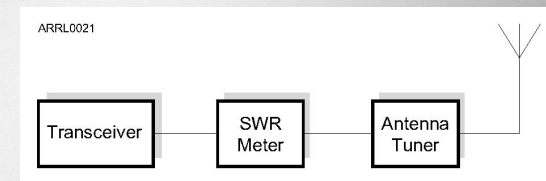
- SWR above 3:1 is considered high in most cases.
- Erratic SWR readings may indicate a faulty feed line, faulty feed line connectors, or a faulty antenna.
- High SWR can be corrected by
 - Tuning or adjusting the antenna or
 - With impedance matching equipment at the transmitter
 - Called an *antenna tuner* or *transmatch*
 - Does not change SWR in the feed line



2014 Technician License Course

Adjusting SWR

- An SWR meter is inserted in the feed line and indicates the mismatch at that point.
- Either adjust the antenna to minimize the reflected power or adjust the antenna tuner for minimum SWR at the transceiver.



2014 Technician License Course

Dummy Loads

- A dummy load is a resistor and a heat sink
 - Used to replace an antenna or other piece of equipment during testing.
- Dummy loads dissipate signals in the feed line as heat
 - Allows transmitter testing without sending a signal over the air
 - Helpful in troubleshooting an antenna system

