Technician License Course
Chapter 4

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

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The Antenna System

Antenna: An electrical conductor carrying Radio Frequency (RF) currents.

Feed line: An electrical cable to connect the transmitter to the antenna.

Matching equipment: Tuned circuits to help get maximum power to the antenna.

Test equipment: Meters for monitoring or testing antenna performance.

Antenna Vocabulary

Element: A conducting part of an antenna designed to radiate or receive radio waves.

Driven element: The element supplied directly with power from the transmitter

Parasitic Element: An element not driven directly which reflects or directs radiated signal.

Feed point: Where the transmitted energy enters the antenna.

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Antenna Vocabulary

Omni-directional – radiates in all directions.

Beam – An antenna which radiates better in one or more directions.

Gain – apparent increase in power in a particular direction compared to some other direction or compared to another antenna.

Antenna and Signal Polarization

Polarization: The direction of the **Electric Field** relative to the surface of the earth. Electric Field is usually parallel to radiating element.

- Vertical – E-Field is Perpendicular to earth
- Horizontal – E-Field is Parallel to earth
- Circular – Rotating
- Polarization is changed by ionospheric reflections.
- Incorrect polarization causes weak signal.

Decibels and Gain

Decibel – a unit for expressing and comparing gain. DB, dB, db, dbi, dbd, dbv. Based on the logarithm of a power ratio

Db = 10 X log(Pout/Pin)

Remember: 3dB ⇔ 2X; 6 dB ⇔ 4X; 10dB ⇔ 10X

DB gains are added. Numeric gains are multiplied.

Positive db is a gain. Negative db is a loss.

When gain is given in db, you need to know the reference. A 10dB antenna might not have gain compared to a different 6dB antenna.

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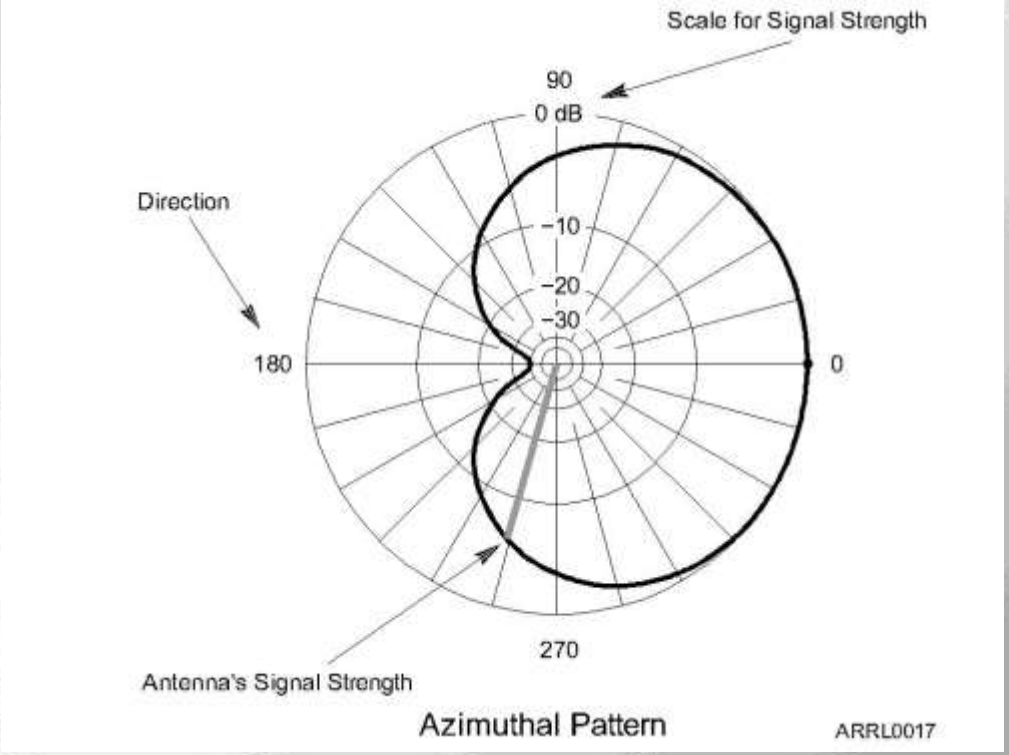
Antenna Radiation Patterns

Radiation patterns are a way of visualizing antenna performance at angles around the antenna.

The further the line is away from the center of the graph, the stronger the signal at that angle.



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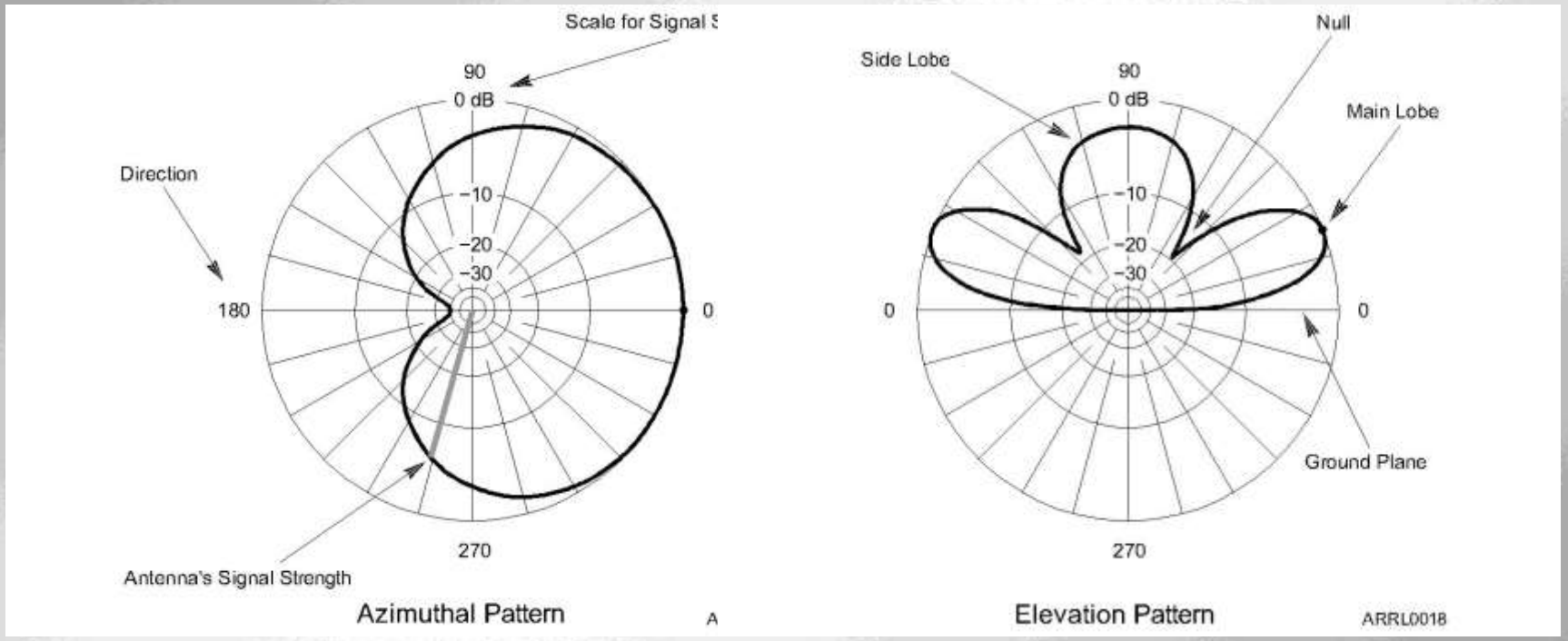

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Effects of Propagation

Radio waves consist of Electric Field and Magnetic Field at right angles to each other.

Ionosphere reflections may rotate the orientation of the E and M fields.

Frequencies in the radio wave are not changed but sidebands can have differing polarizations, which may cause distortion. This is called “Selective Fading”.

Received signal may flutter or fade as polarization shifts due to polarization of the receiving antenna.

Antenna versus Feed Line

Antennas have a feedpoint impedance. Feedlines have a characteristic impedance. Transceivers are designed for a specific load impedance.

For efficient transfer of energy from the transmitter to the feed line and from the feed line to the antenna, the various impedances need to match.

When there is a severe mismatch of impedances, things may still work, but not as effectively as they could.

Feed Line types

The purpose of the feed line is to get energy from your station to the antenna. Basic feed line types:

- Coaxial cable (coax).
- Open-wire or ladder line.
- Waveguide.
- Single wire.

Each has a characteristic impedance – each has its suitable applications.

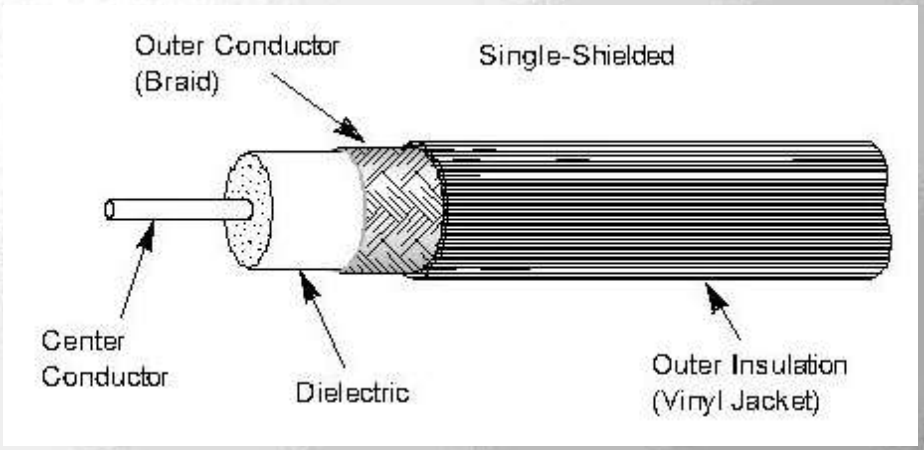
Coax

Coaxial cable is the most common feed line because it is easy to use.

Matches impedance of modern radio equipment (50 ohms).

Some loss of signal depending on coax quality (cost).

Needs protection from weather. Braid corrodes if water intrudes.



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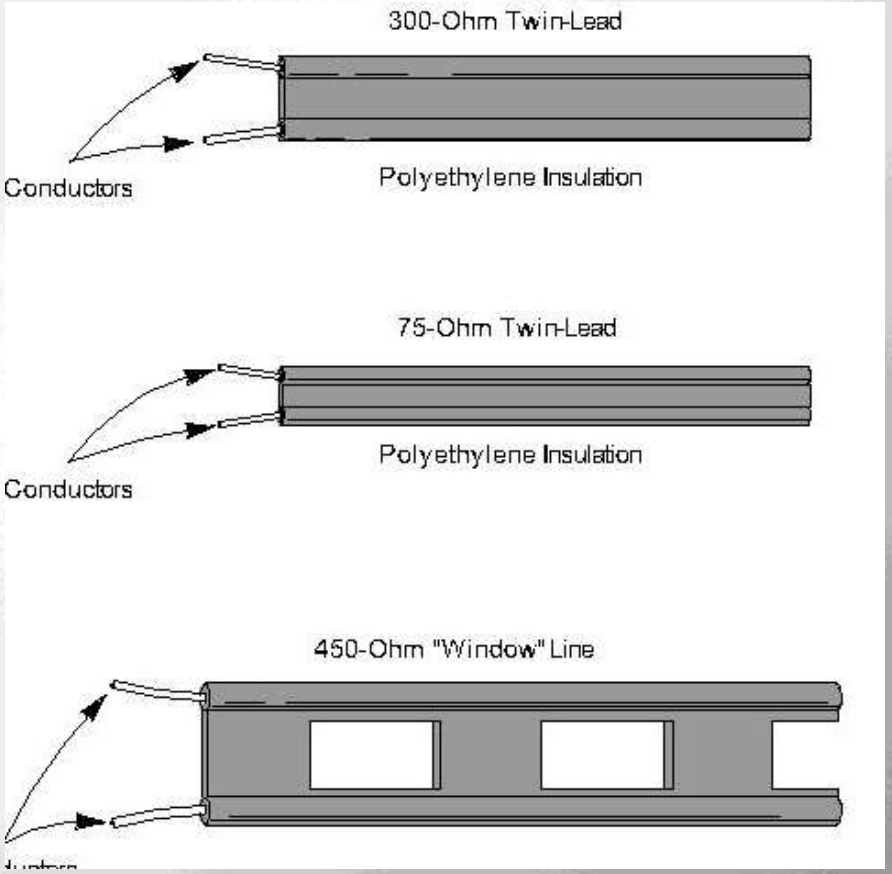
Twin Lead and Ladder Line

Not common today except in special applications.

Can be difficult to use.

May need an antenna tuner to make impedance match – but this allows a lot of flexibility.

Usually very low loss. But loss increases in wet weather.



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Antenna Impedance

Antennas have a feedpoint impedance expressed in ohms .

Usually 50 ohms for manufactured antennas.

Feedpoint impedance may depend on:

- Antenna design
- Height above the ground
- Distance from surrounding conductors
- Frequency of operation
- Environmental factors

Impedance – AC Resistance

Antennas include characteristics of a series circuit consisting of a capacitor, an inductor, and a resistor.

The combined response of these component parts to RF currents is called **Impedance.**

Sometimes expressed as R + jX (X means reactance)

- The “j” just means that the reactive voltage or current is out of phase with the resistive voltage.
- 50 + j10 (Inductive); May be too long
- 55 – j20 (Capacitive); May be too short
- In a “resonant” antenna, the reactance is zero at the operating frequency.

Standing Wave Ratio (SWR)

If the antenna and feed line impedances are not matched, some RF voltage is returned (reflected) back to the source.

Reflected voltage may make the feedline look like a mismatched load to the transmitter.

A mismatched load may cause the transmitter to:

- overheat. Too much current.
- have a voltage breakdown. Too much voltage.

SWR indicates how much mismatch. SWR is the ratio of load impedance to cable impedance (or cable to load, whichever is > 1).

An SWR value of 1:1 is a “perfect” match.

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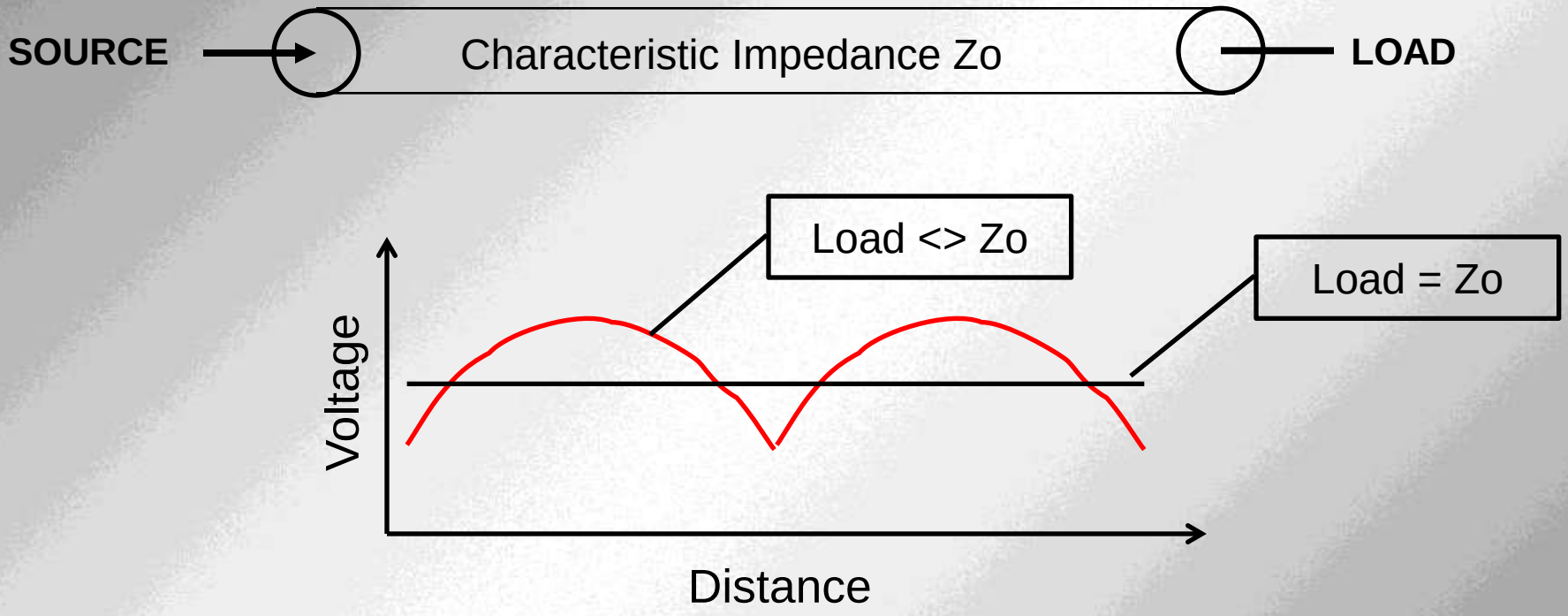
Voltages along the Feedline



The curve is a Voltage Standing Wave. VSWR is the ratio of the maximum and minimum voltages: Vmax / Vmin.

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Nothing is Perfect

Hams sometimes overstress about SWR. The goal should be to get maximum power from the transmitter into the antenna. Modern radios will start lowering transmitter output power automatically when SWR is above 2:1.

What is an acceptable level of SWR?

- 1:1 is perfect – As low as it can get.
- 1.5:1 is usually just as good as 1:1.
- 2:1 should be the max you accept (as a general rule). Greater than 2:1 is when you need to do something to reduce SWR.

If the SWR has increased over time, there might be a failure. Try a different feedline or antenna. Check connectors.