Introduction to Antenna Basics

Week 2: Intro to Antenna Testing

Karen Rucker

Housekeeping

Isotropic antennas have 0 dB gain (1 linear value - not 1 dB)

Class communication

Certificate of Completion available for this course - final quiz

Recap from last class

Antenna: transducer that converts energy from one domain into another domain

Antenna Gain is based on power at the antenna terminals and accounts for antenna (ohmic) losses

Polarization characterizes the direction of the Electric Field, E-field

Impedance matching:

1. maximizes the power transfer
2. minimizes signal reflection from the load

RF power is measured in decibels, or dB

$$dB = 10 \log (Pout/Pin)$$

Week 2 Class Outline

Radiating Responsibly

Near Field vs Far Field

Range Testing

Scattering Parameters (S-parameters)

Smith Charts

Network Analyzers

Calibrating a VNA

VSWR vs Return Loss

Attenuators

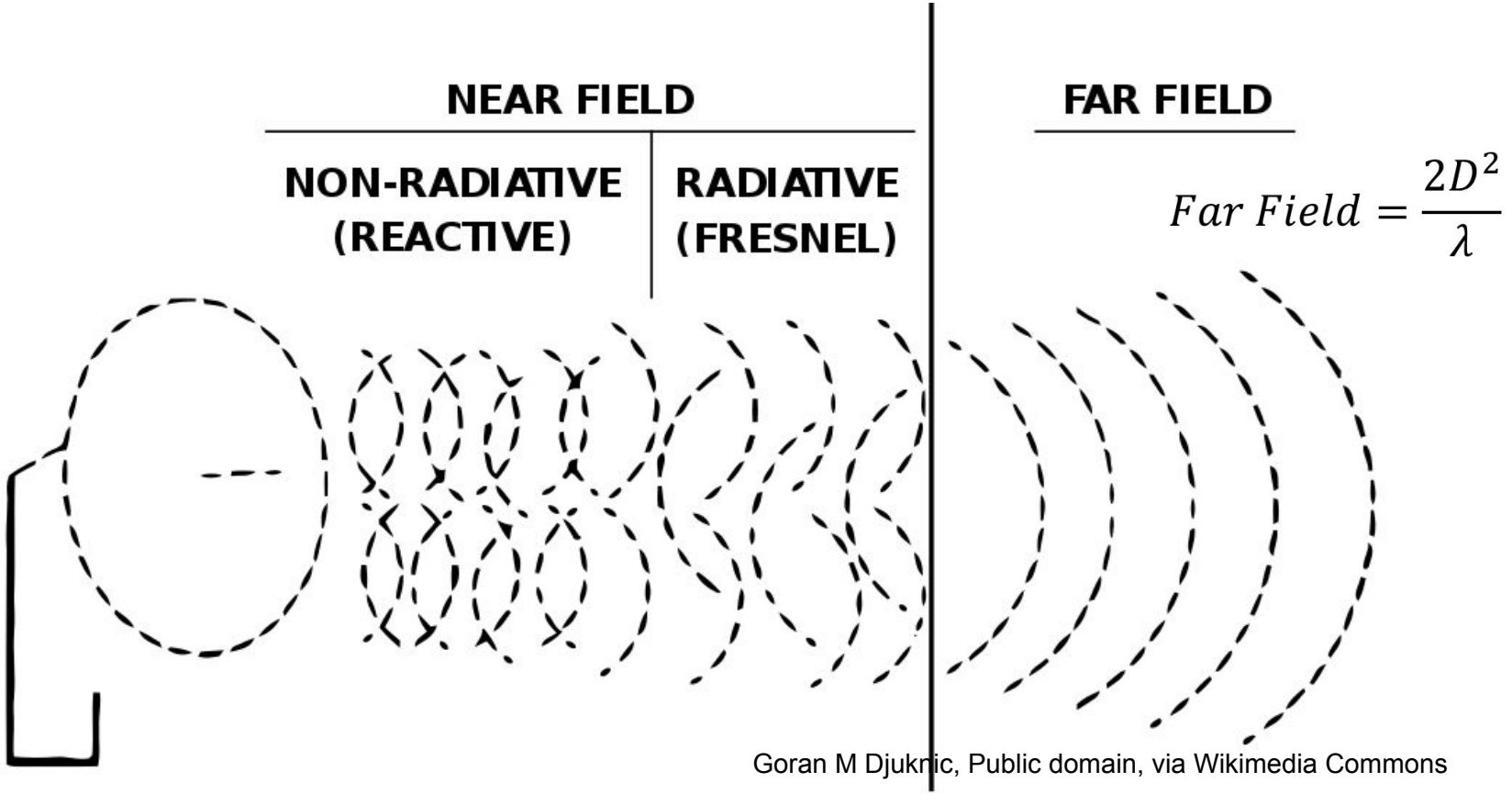
Dummy loads

Note on Radiating Responsibly

- Amateur radio license
- ISM radio bands - reserved internationally for industrial, scientific and medical (ISM) purposes
- Anechoic chamber
- Dummy loads

Image: K. Rucker

Near Field vs Far Field



Goran M Djukric, Public domain, via Wikimedia Commons

Range Testing

Indoor Far-field Range

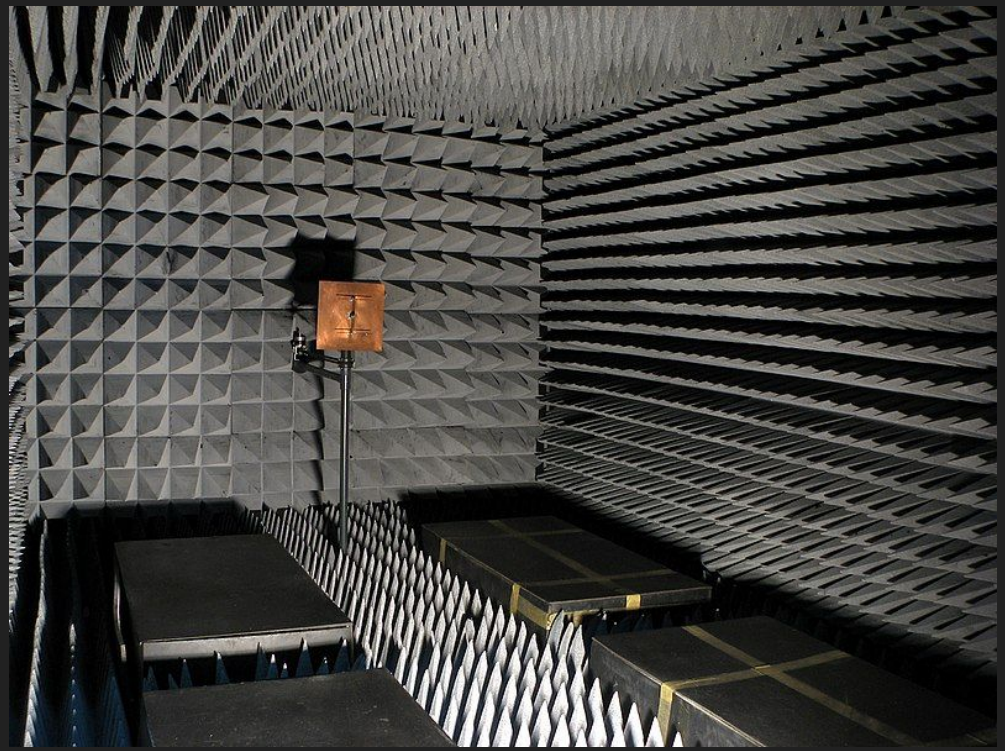
Outdoor Far-field Range

Reflector Compact Range

Planar Near-field Range

Gain Cuts

Coordinate Systems



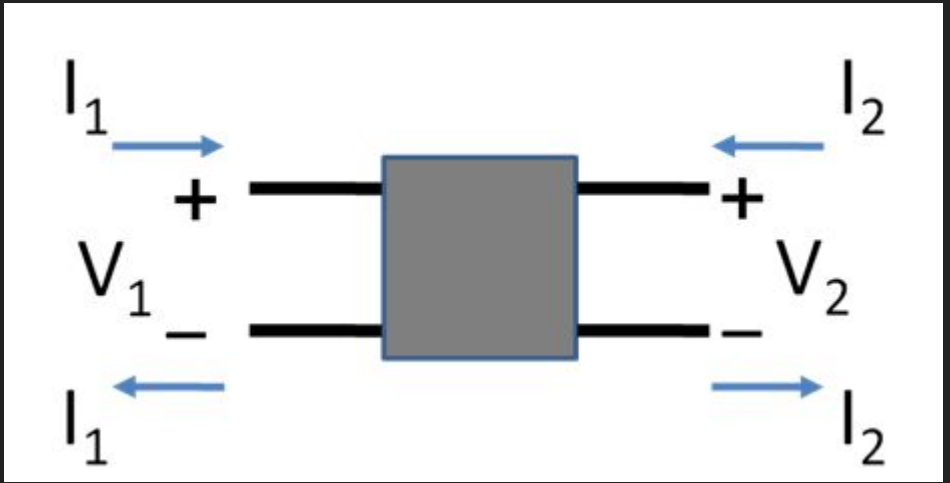
Scattering Parameters (S-parameters)

In the context of S-parameters, scattering refers to the way in which the traveling currents and voltages in a transmission line are affected when they meet a discontinuity caused by the insertion of a network into the transmission line.

2 port network

S11: reflection coefficient, return loss (RL)

S21: transmission coefficient, insertion loss (IL)

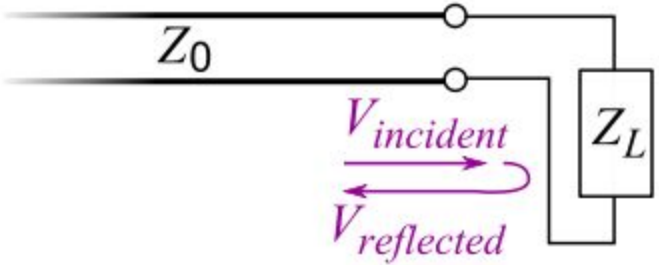


Return Loss vs Insertion Loss

$$\text{Return Loss} = \frac{\text{reflected power}}{\text{incident power}}$$

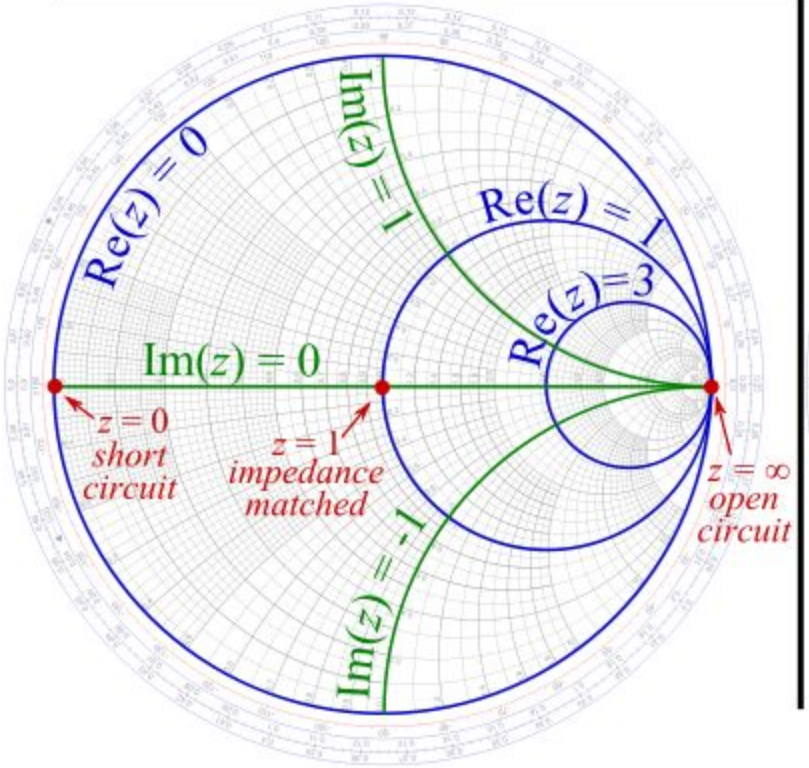
$$\text{Insertion Loss} = \frac{\text{incident power}}{\text{transmitted power}}$$

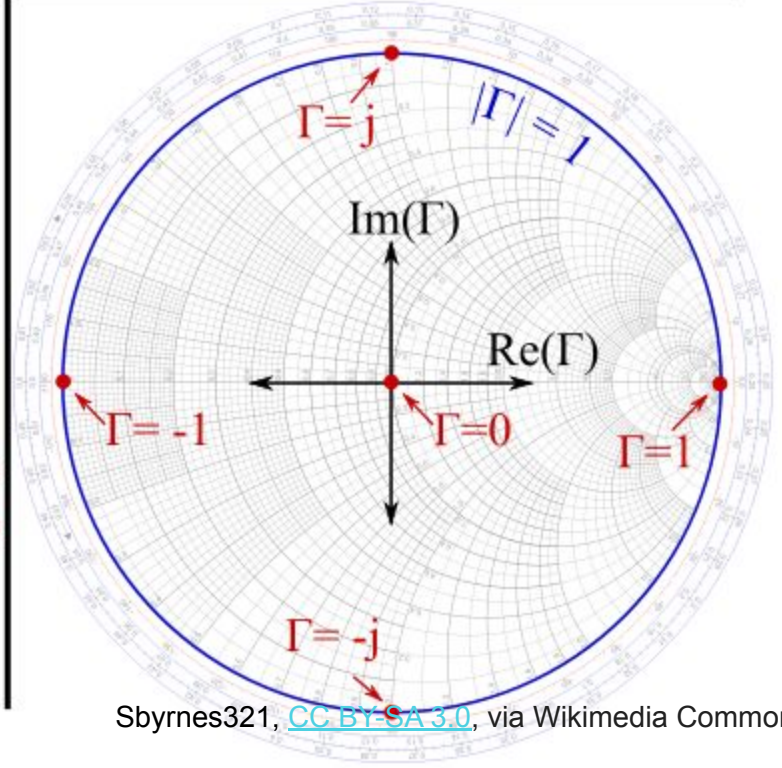
Image: K. Rucker



$$z = \frac{Z_L}{Z_0}$$

$$\Gamma = \frac{V_{reflected}}{V_{incident}}$$





Network Analyzers

injects a known frequency and amplitude source signal into a RF port

measures the relative amplitude and phase of this signal when received back into the VNA

Note about ESD protection

Calibrating a VNA

Specific to connector type

ALWAYS DOUBLE-CHECK YOUR CAL

Set frequency range first!

SMA-type cal procedures:

- 2-port: short-circuit, open, 50 Ω, thru (SOLT)
- 1-port: short-circuit, open, 50 Ω (SOL)

Image: K. Rucker

Double-checking a cal example

Save cal

Go through the standards again:

Short

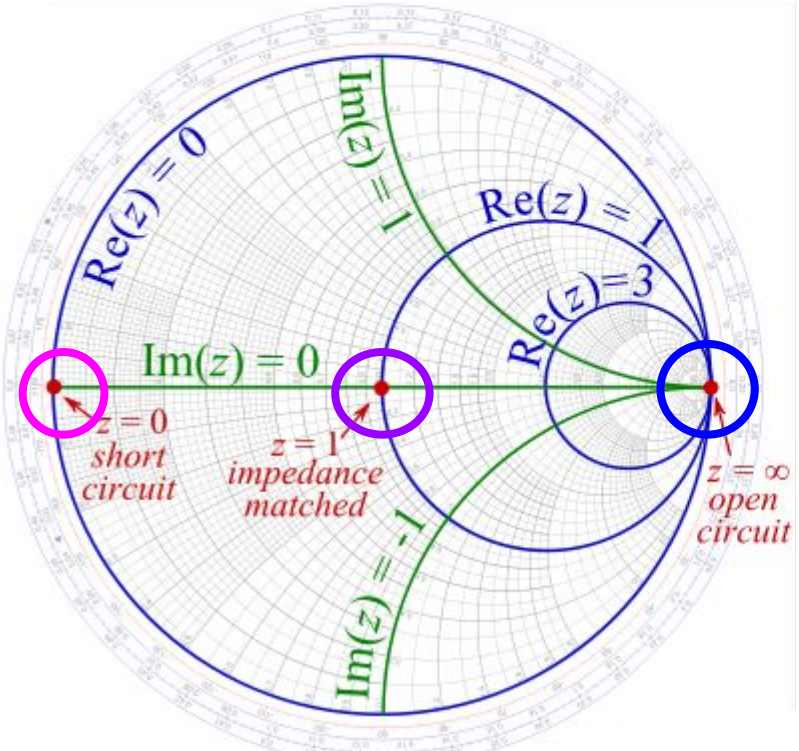
(LOGMAG plot should read close to 0dB)

Open

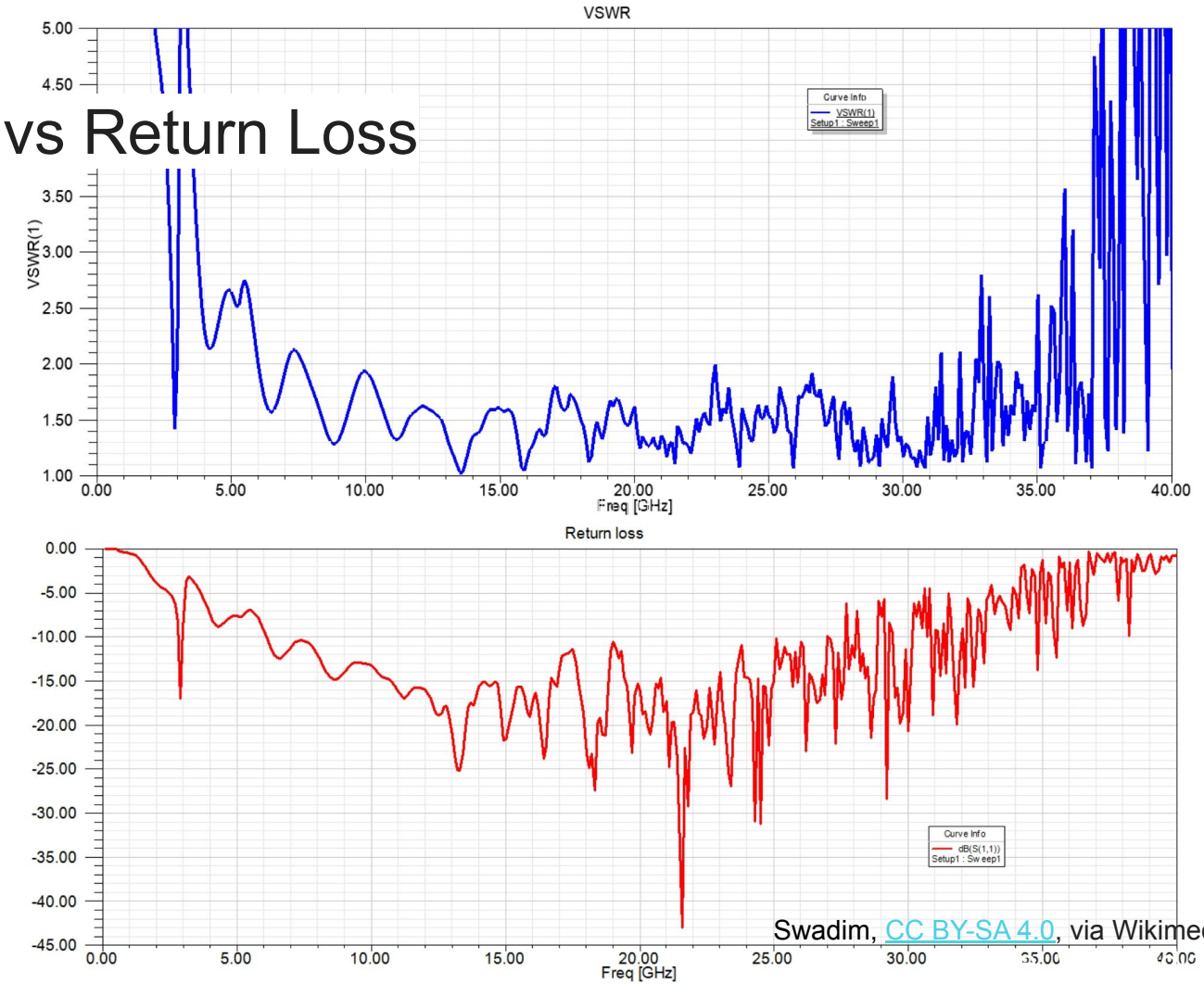
LOGMAG plot should read close to 0dB

Load 50 Ω

[LOGMAG Plot should be showing a low number (-50dB or below)]



VSWR vs Return Loss



Attenuation

Reduce signal level: high power RF signals, e.g. in transmitters where the signal level needs to be reduced before it can be applied to an item of test equipment.

Image: K. Rucker

Dummy Load

electrically simulates an antenna, to allow the transmitter to be adjusted and tested without radiating radio waves.

Additional Resources

Open source antenna modelling and simulation design tool

NanoVNA Saver code

How to Choose an Antenna Range Configuration paper

Insertion Loss vs Return Loss

So You Bought a VNA, Now What?

DIY Cal Standards Project by James Wilson

Smith Chart Basics + VNA Paperclip Test

Coming up next class

Introduction to wire antenna design. Topics covered will be, but are not limited to: dipoles, helixes, and yagis.

Questions?