RF Communication Link

Western Colorado Amateur Radio Club
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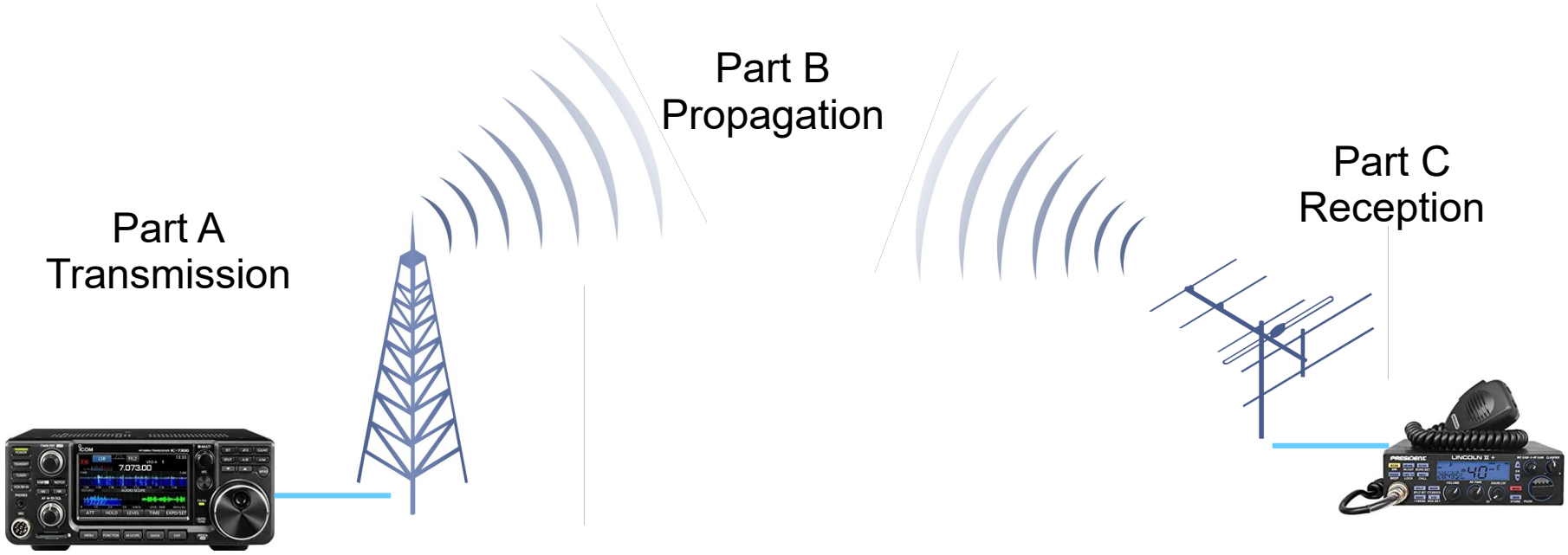
Communication Link

- Communication Link is broken into 3 parts
  - Transmission, Propagation, Reception
- Transmission is where damage to equipment is done



Contents

- Transmission
  - Intro
  - dB
  - VSWR/RL
  - Tuning
  - Example
- Propagation
  - Link
  - Antennas
  - Bouncing
  - Polarization
- Reception
  - SOI
  - Noise
  - Sensitivity

Communication Link

- RF Communication Link
  - Relates to all OTA (Over The Air) electro-magnetic based communications
- This presentation is broken into three sections
  - Transmission
  - Path
  - Reception
- Objective of Presentation
  - Sensitize audience to communication theory to enhance use of equipment (practical use)

Part A - RF Transmission Basics

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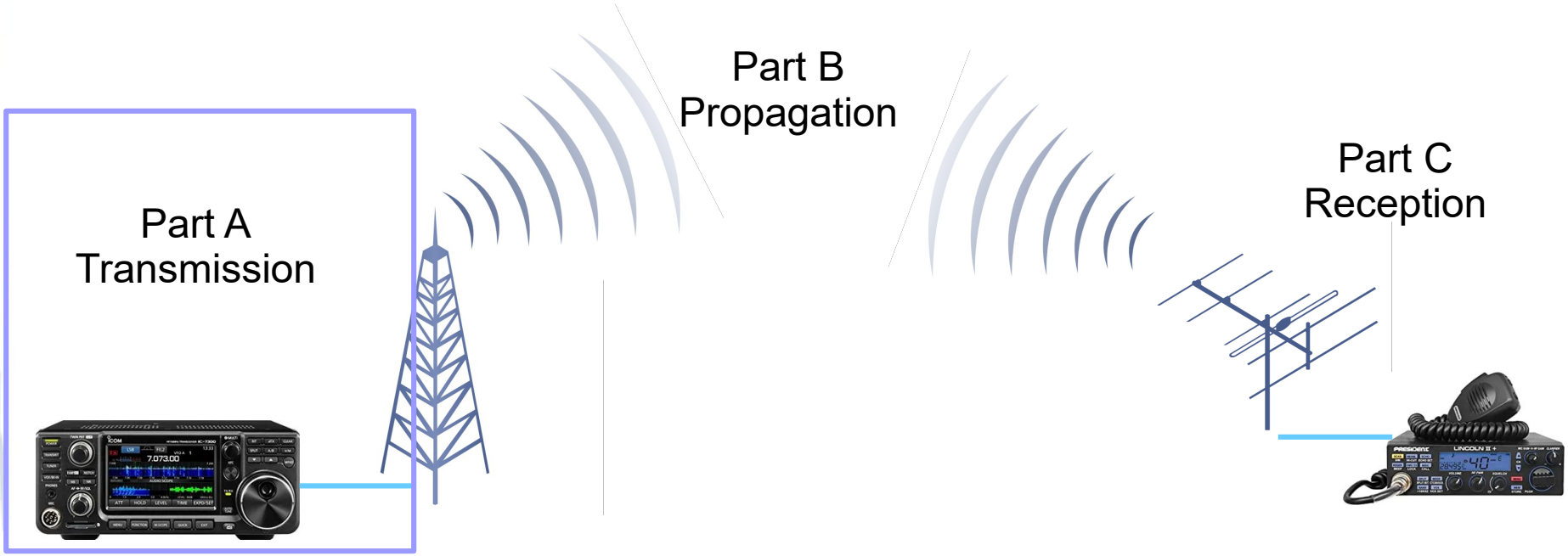

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Housekeeping - Decibels

- Logarithmic measurements – tough
  - Found very commonly in nature, makes life easier?
- dB – is a radio (unit-less) unless it has a followup letter (dBm, dBv, dBi, etc), then a measurement

- -10dB = 1/10
- -6 dB = 1/4
- -3 dB = 1/2
- 3 dB = 2X
- 6 dB = 4X
- 10 dB = 10X
- 20 dB = 100X

- -10dBm = 1/10 of 1mW = 0.1 mW
- -6 dBm = 1/4 = 0.25 mW
- -3 dBm = 1/2 = 0.5 mW
- 3 dBm = 2X =2 mW
- 6 dBm = 4X =4 mW
- 10 dBm = 10X =10 mW
- 20 dBm = 100X =100 mW

Ref to 0dBm = 1mW

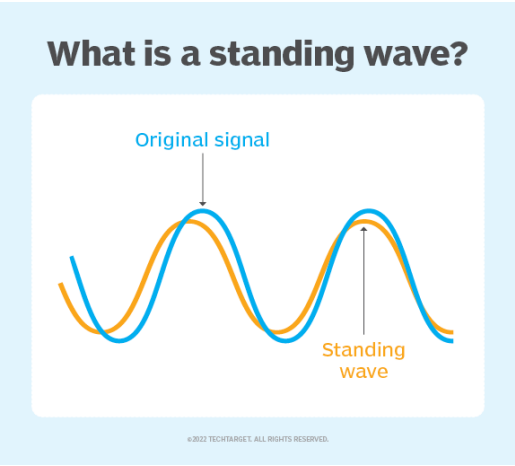
dB made easy

- 3dB is double/half
  - 0dBm=1mW, 3dBm=2mW, 6dBm=4mW, 9dBm=8mW
  - 0dBm=1mW, -3dBm=1/2mW, -6dBm=1/4mW, -9dBm=1/8mW
- 10dB is 10X or 1/10
  - 0dBm=1mW, 10dBm=10mW, 20dBm=100mW, 30dBm=1000mW (1W)
  - 0dBm=1mw, -10dBm=0.1mW, -20dBm=0.01mW, -30dBm=0.001mW (1uW)

It is not uncommon to have
RX signal strengths of -110dBm (10 nW or $1X10^{-8}$ W)
TX signal strengths of +60 dBm (1KW or $1X10^{3}$ W)

Importance of VSWR

- Getting energy through cables and into a antenna efficiently
- Nothing is perfect, thus discontinuities reflect energy
- Voltage Standing Wave Ratio is a measure of destructive forces of a wave upon itself due to its own reflected energy

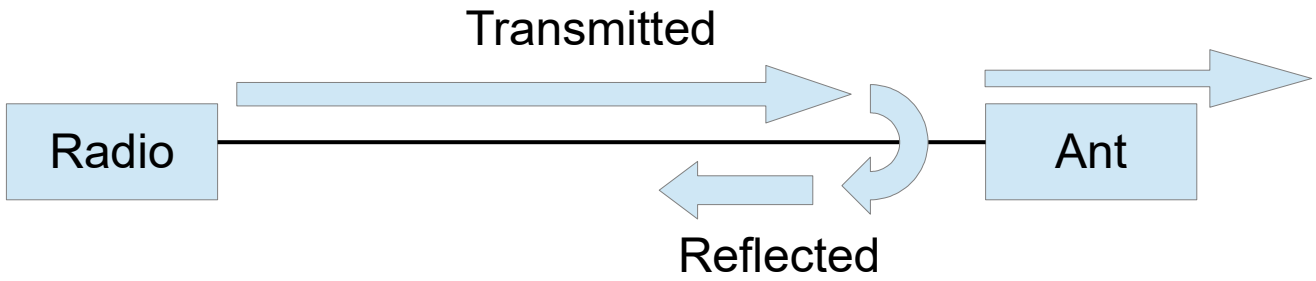


- Objective – get as much energy into the Air
- The amount of energy getting from your radio into the air is reduced by an imperfect VSWR
- Cheapest/Easiest way to extend communications is to ensure a good VSWR match (TX almost all energy provided by Radio, into the air)

What VSWR Means in Practical Terms

Return Loss & VSWR Table		
Return Loss (dB)	**What It Means**	**VSWR Number**
0 dB	100% reflection, no power into the antenna, all reflected back	Infinite
1 dB	80% reflection, 20% power into the antenna	17
2 dB	63% reflection, 37% power into the antenna	9
3 dB	50% reflection, 50% power into the antenna	6
5 dB	32% reflection, 68% power into the antenna	3.5
6 dB	25% reflection, 75% power into the antenna	3
8 dB	16% reflection, 84% power into the antenna	2.3
10 dB	10% reflection, 90% power into the antenna	2
15 dB	3% reflection, 97% power into the antenna	1.4
20 dB	1% reflection, 99% power into the antenna	1.2

VSWR (linear) and Return Loss (dB)



- Maximum Energy transferred when Radio and Ant are matched (complex conjugate)

Good Watch: https://www.youtube.com/watch?v=BijMGKbT0Wk

VSWR (linear) and Return Loss (dB)

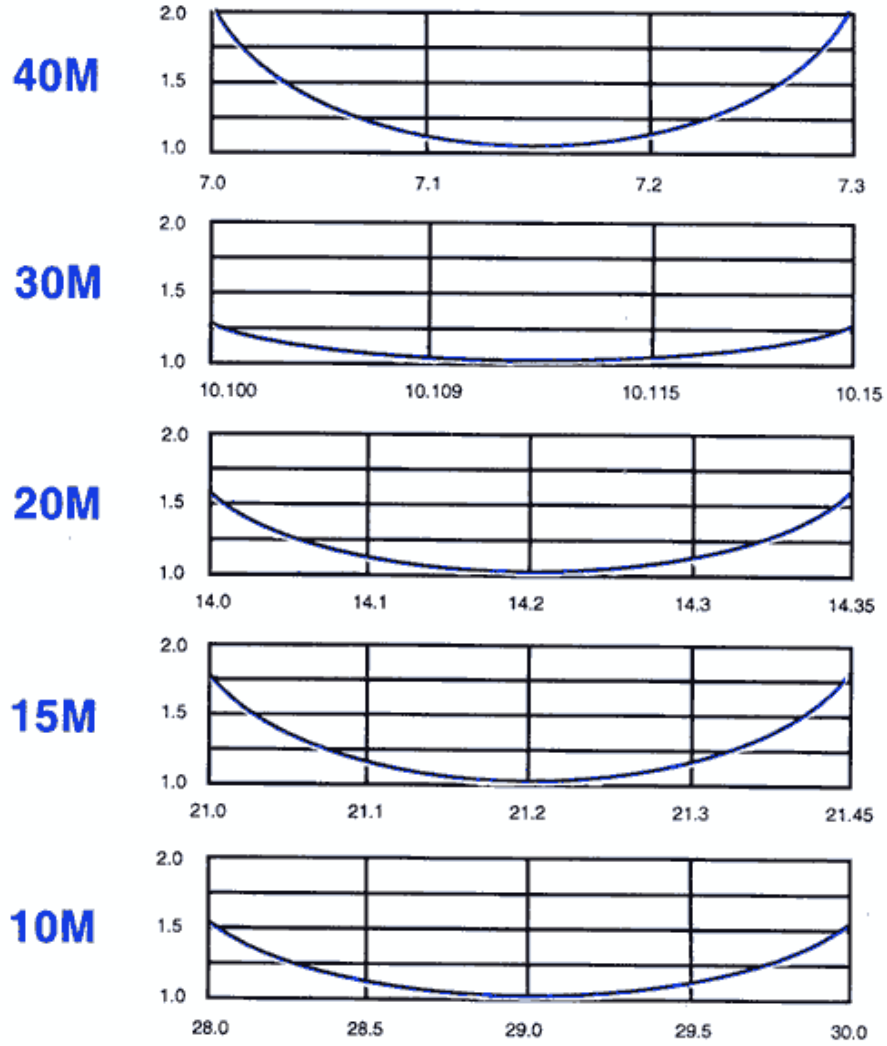
- Potential Radio Damage when poorly matched or transmitting when Antenna not connected (open)
- Built in Tuners (Automatic) usually handle 3:1 max
- Built in Tuners need to be initiated (after every frequency change)
- External tuners allow for greater matching >3:1

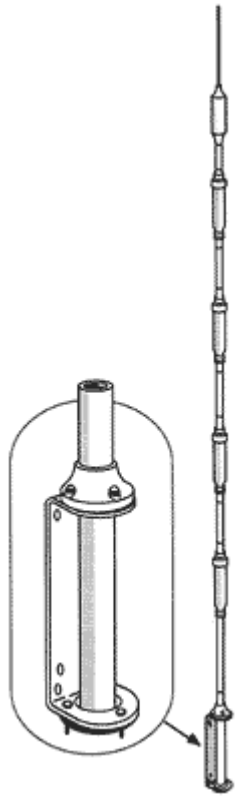
Good Watch: https://www.youtube.com/watch?v=BijMGKbT0Wk

VSWR for Antenna Tuning

- Antenna Specifications
  - Need to match an antenna to the frequency of interest
- Radio internal Tuner
  - Automatic internal tuners are not automatic, they need to be initiated after any frequency change.
- External Antenna Tuner

Example - Antenna Specifications





Examples – Radio Internal Tuner

- TX_2:1 Shows a transmission with VSWR at 2:1
- TX_Tuning shows the Radio Internal Tuner switching though internal matching circuits to select the best one
- TX_1:1 Shows the transmission after a matching network has been selected

TX_2:1

TX_Tuning

TX_1:1

Examples – External Tuner

- Ext_Tuning Close up shows the Forward power meter and Reference power meter over each other – resultant is the VSWR ratio
- Ext_Tuning Wideview shows the movement of a variable circuit and the resulting effect on VSWR

Ext_Tune Close up

Ext_Tuning Wideview

RF Transmission Basics

Questions?