{TESS+} VHF Training

Module 1:
Basic RF theory

Read more about {TESS+}: www.wfp.org/telecommunications-security-standards
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Session objectives

- Describe the components of a radio system
- Radio basics (frequency, wavelength, propagation)
- Describe antenna characteristics
- Describe SWR

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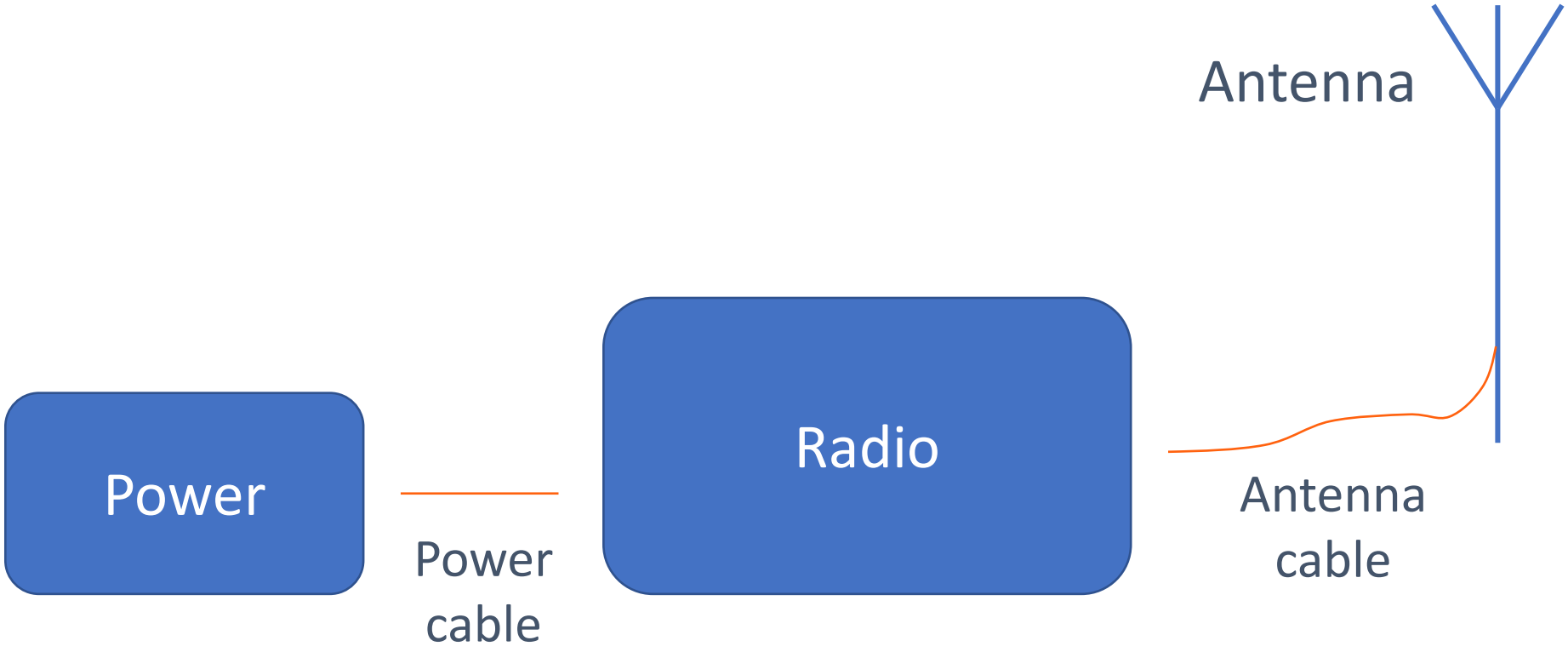
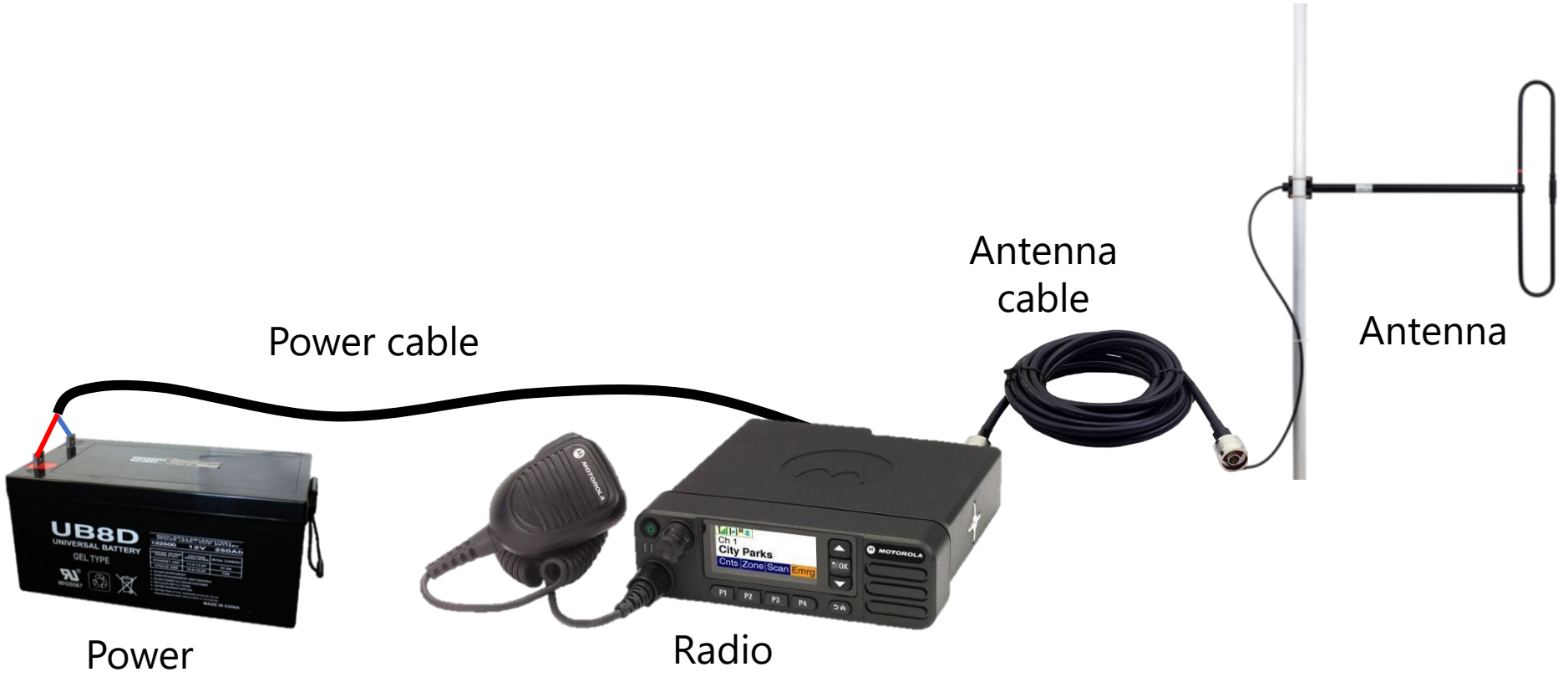
Basic components of a radio system

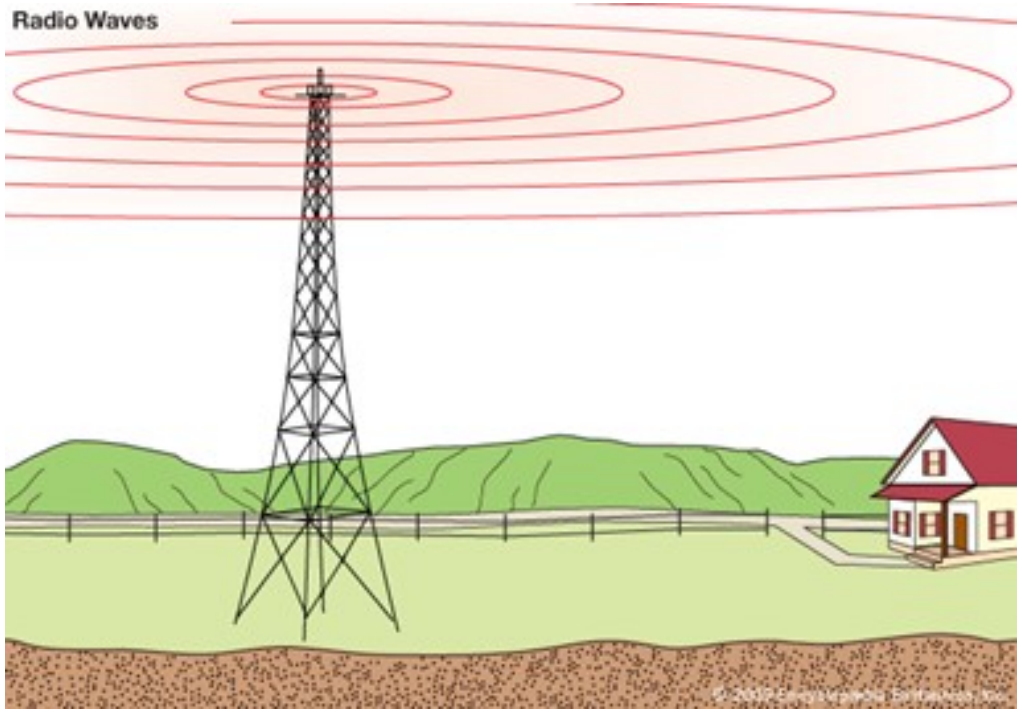


Basic components of a radio system



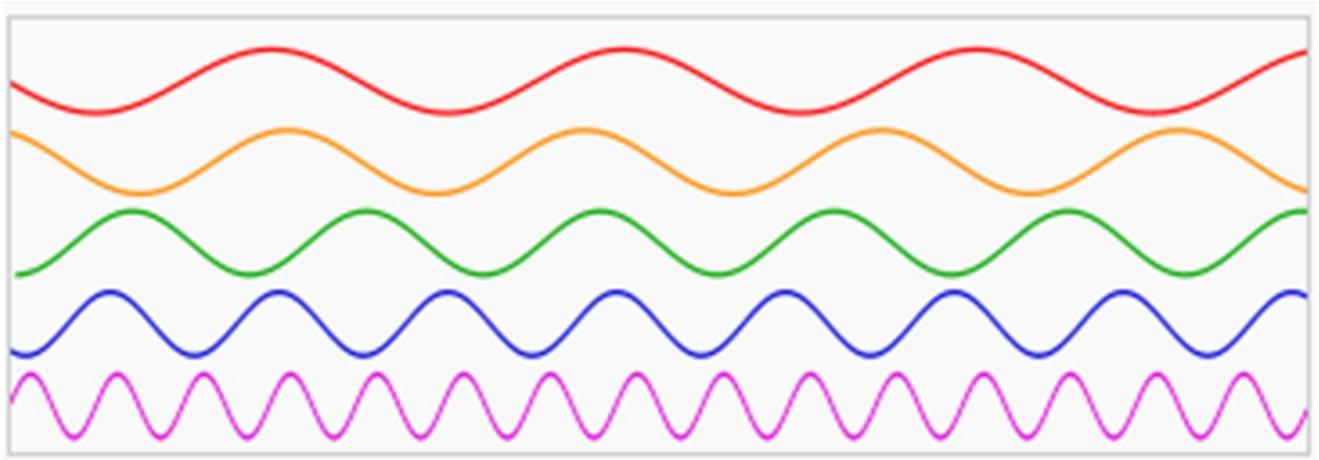
Radio basics

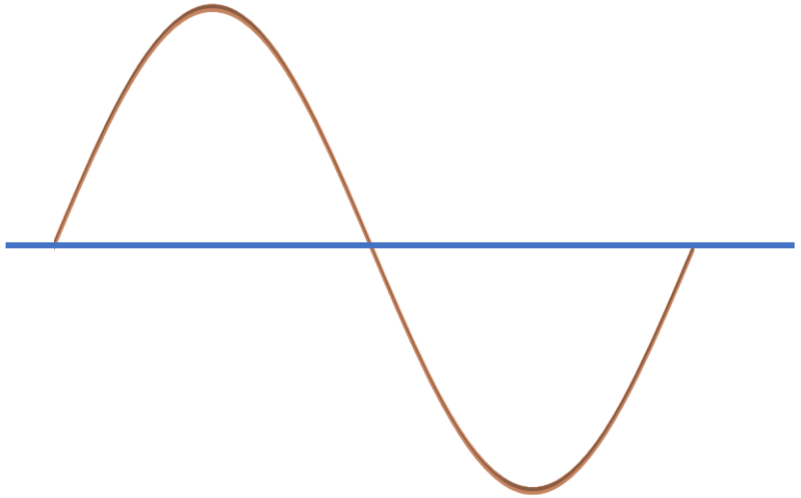
- Radio is the technology of using **waves** to **carry** information (such as sounds or pictures) by systematically changing the properties of the wave that carries the information into **electromagnetic** energy and transmitting it to be received through space.



Radio basics - frequency (f)

- Electromagnetic field (EMF) is a combination of electrical energy and magnetic energy that travel in a straight line
- Frequency: is the number of occurrences of repeating waves per unit of time, measured in Hertz (Hz).





1 oscillation = 1 Hertz (Hz)

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Radio basics - frequency (f)

Name	Symbol	Frequency
Extremely low frequency	ELF	3–30 Hz
Super low frequency	SLF	30–300 Hz
Ultra low frequency	ULF	300–3000 Hz
Very low frequency	VLF	3–30 kHz
Low frequency	LF	30–300 kHz
Medium frequency	MF	300–3000 kHz
High frequency	HF	3–30 MHz
Very high frequency	VHF	30–300 MHz
Ultra high frequency	UHF	300–3000 MHz
Super high frequency	SHF	3–30 GHz
Extremely high frequency	EHF	30–300 GHz

- *Frequencies above 1000 MHz are generally referred to as microwave.*
- *Names are assigned to various frequency ranges, e.g. L-Band, X-Band.*

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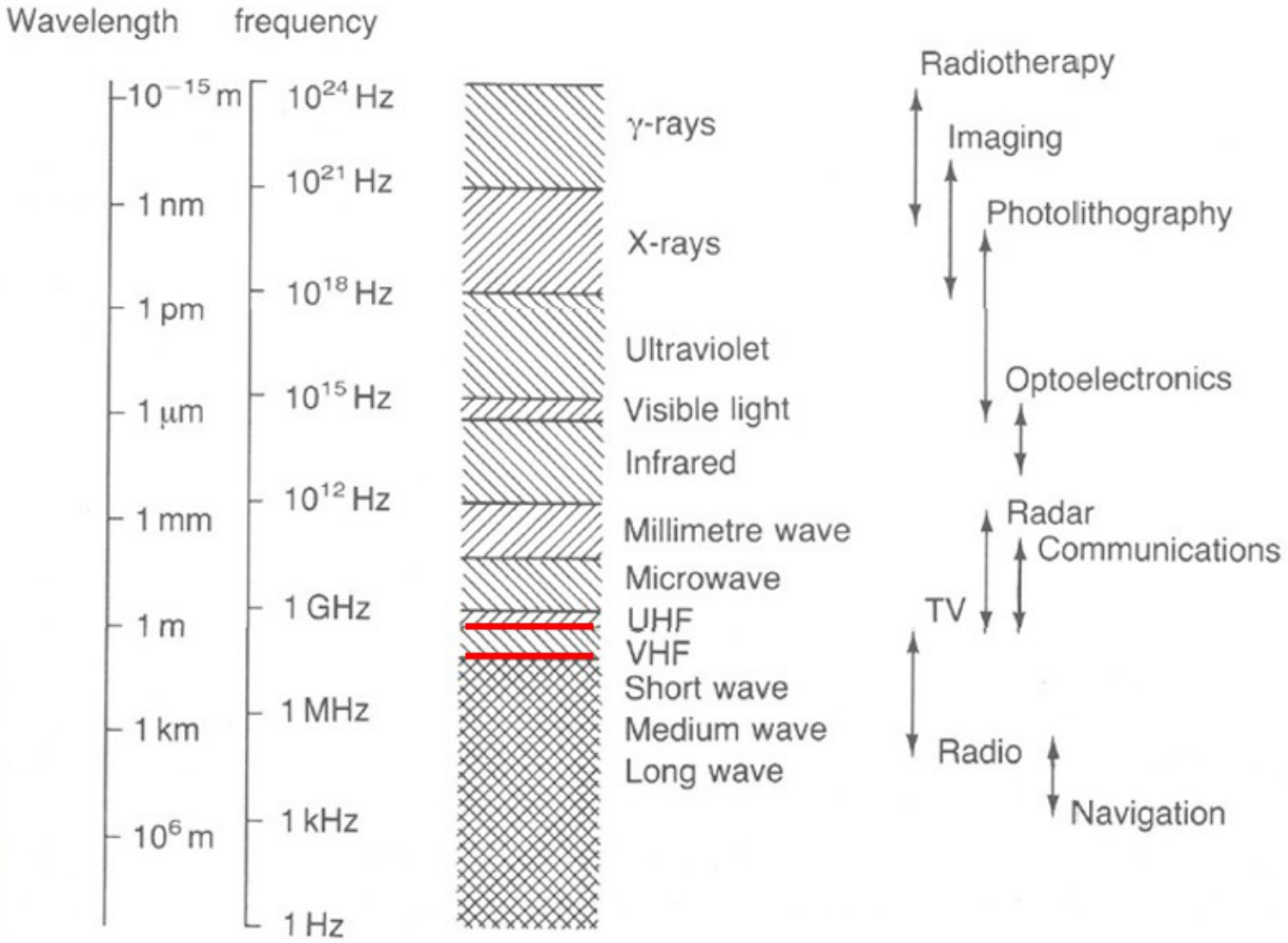
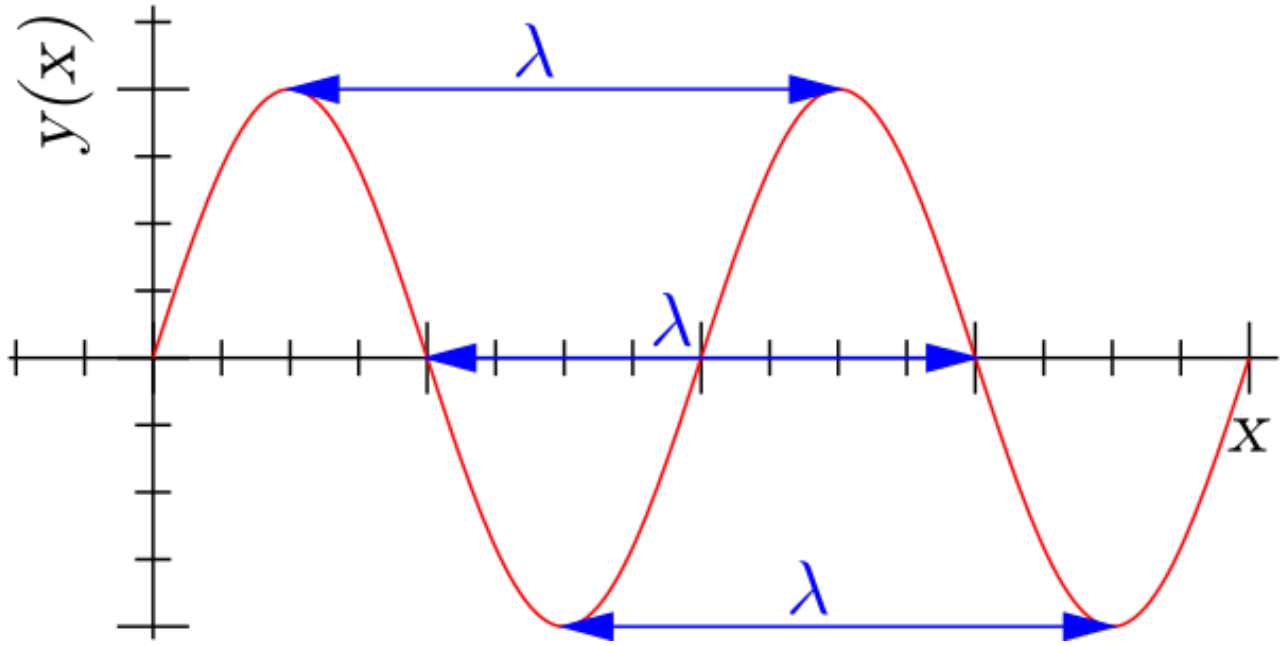
Radio basics - frequency (f)



Radio basics - wavelength (λ)

- Wavelength: is the distance between two successive crests or troughs of a wave, measured in metre (m). It is measured in the direction of the wave.



Radio basics - wavelength (λ)

- Electro-magnetic waves travel at the speed of light (appx. $3x10^8$ m/s) so the formula is:

Frequency => $f = 3x10^8 / \lambda$

Wavelength => $\lambda = 3x10^8 / f$

- Examples: Calculate the wavelength of EM waves travelling with the following frequencies:
  - 15 MHz => **20m**
  - 150 MHz => **2m**
  - 300 Mhz => **1m**
  - 3 GHz => **0.1m / 10cm**

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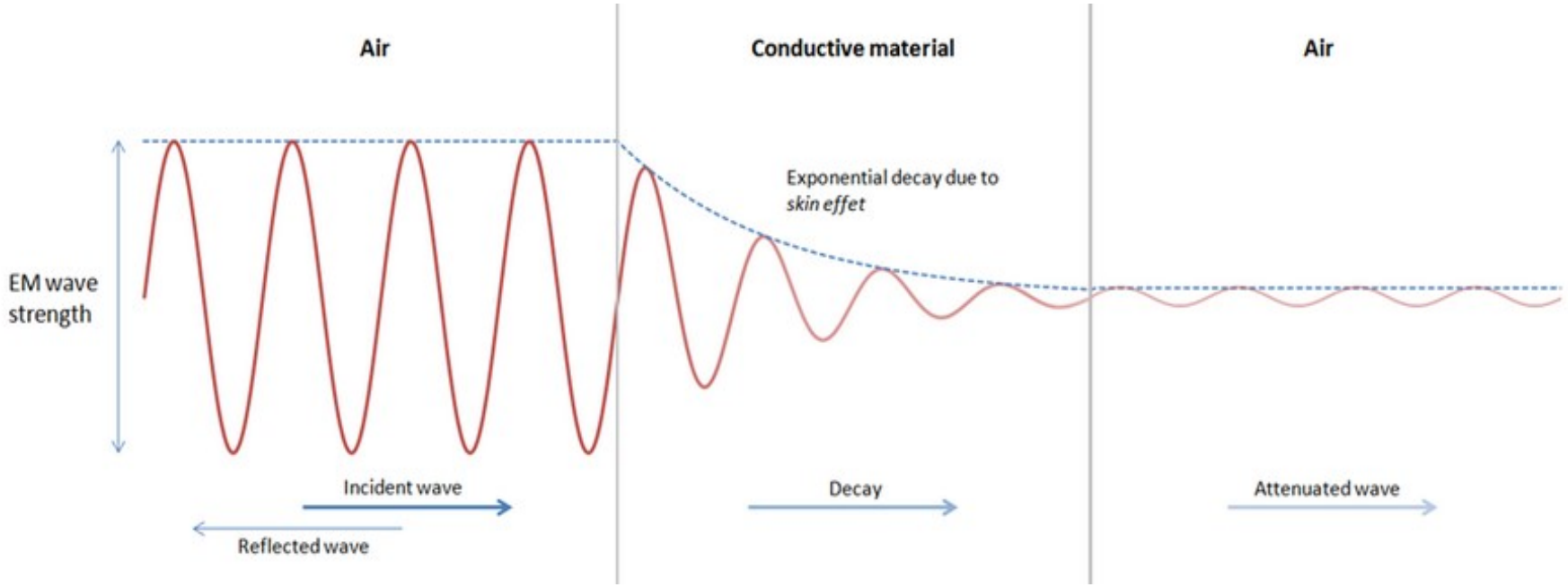
Radio basics - propagation

- Radio waves are affected by many factors including the medium and obstacles in its path. Radio waves are mainly affected by:
  - Attenuation, gradual loss of strength, reflection, diffraction.

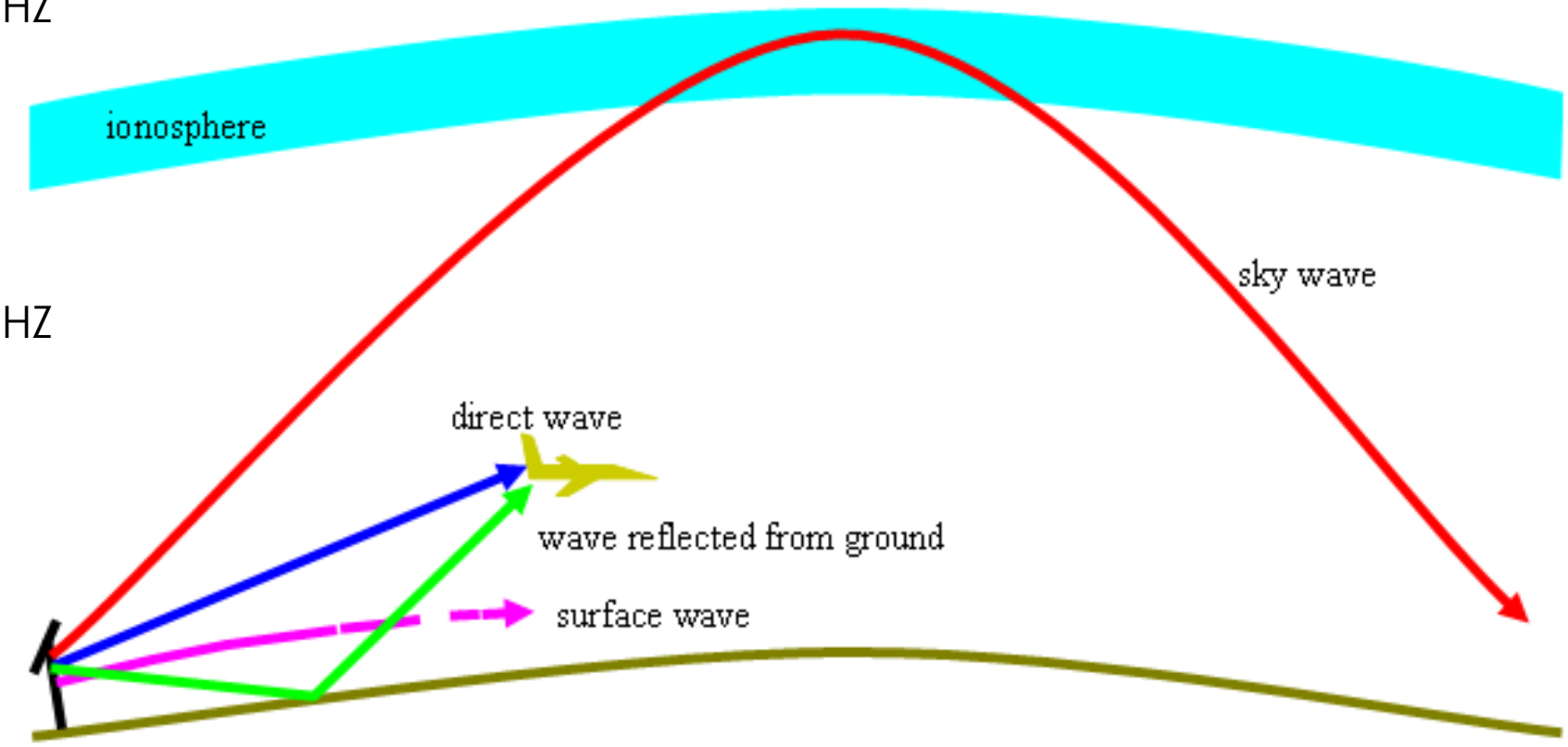


Radio basics - propagation

- Line of sight waves **vs** ground waves **vs** sky waves

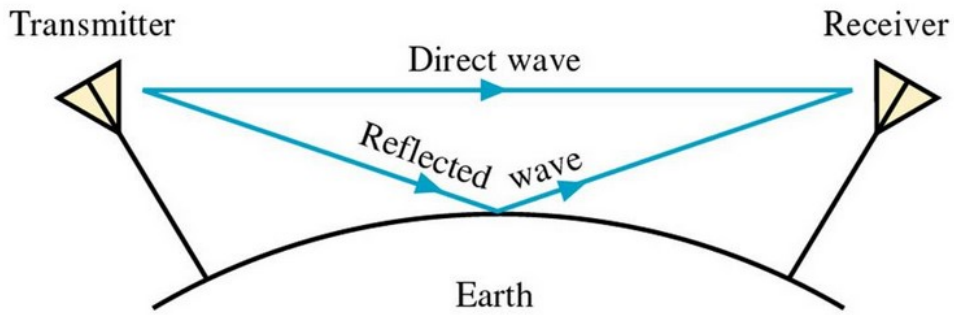
> 30 MHZ

< 30 MHZ



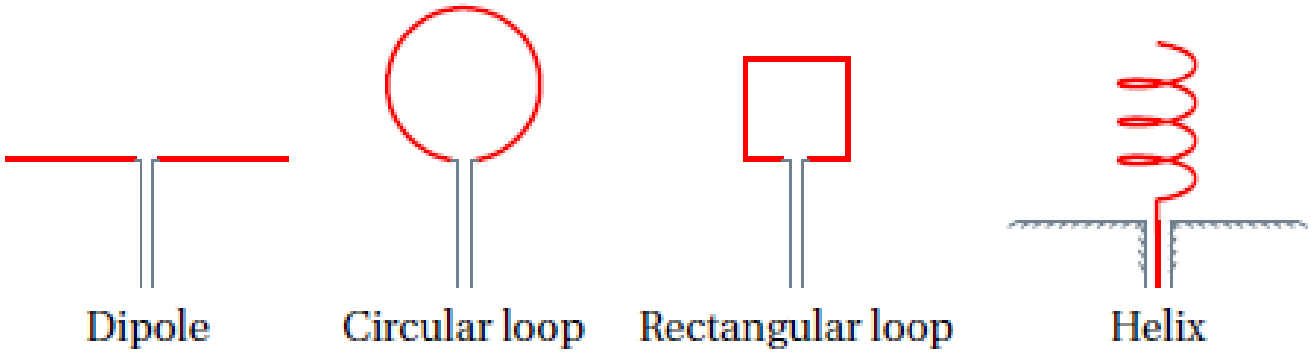
Radio basics - propagation

- VHF (30-300 MHz) signals only follow line-of-sight (LoS) meaning it is a direct wave.
- HF (3-30 MHz) signals are either ground waves or sky waves.
- Keeping other conditions constant, the distance the wave can travel depends on the height of the two antennas and the output power.

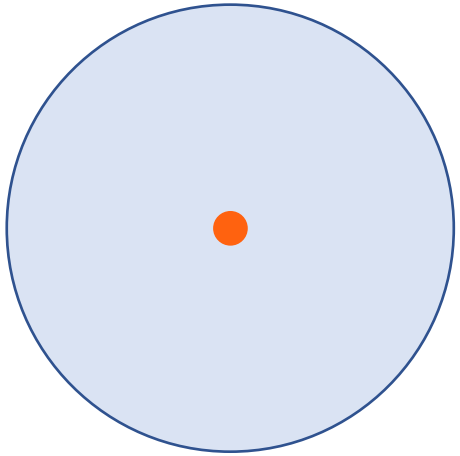


Radio basics - antennas

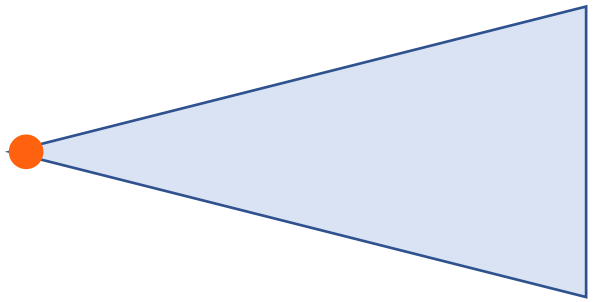
- Antenna: a metallic structure that captures and/or transmits radio electromagnetic waves.
- Antennas come in all shapes and sizes - some examples are shown below.



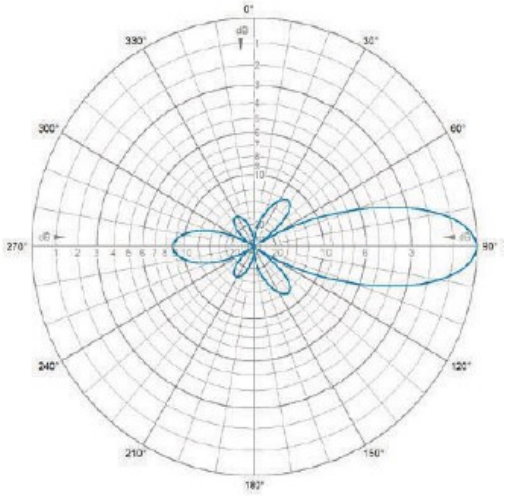
Radio basics - antennas (directivity and patterns)



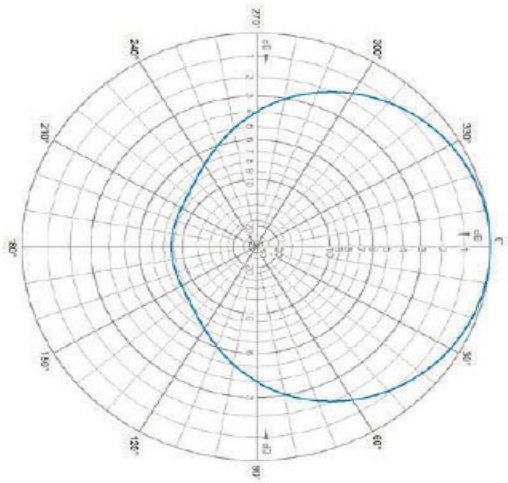
Omni-directional



Directional



E-plane (160 MHz)



H-plane (160 MHz)

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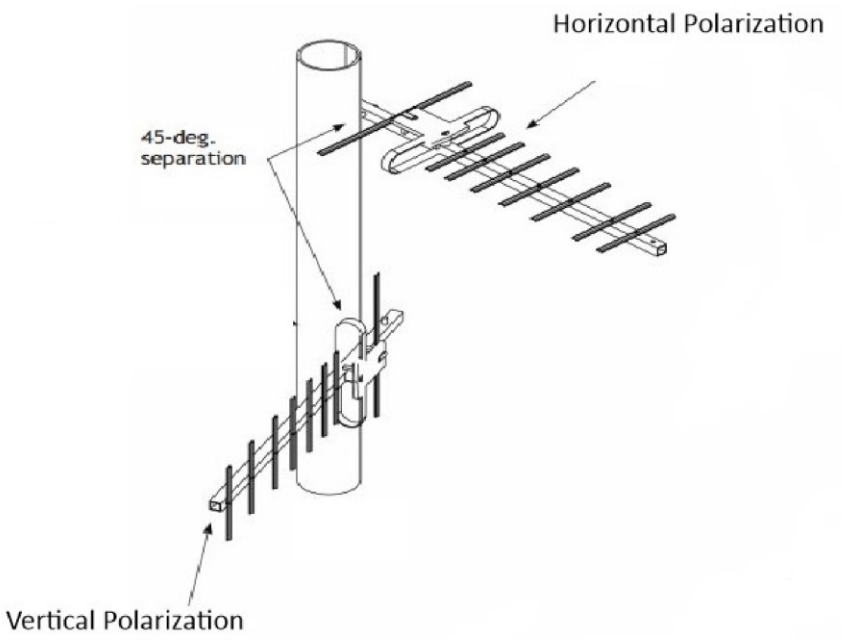
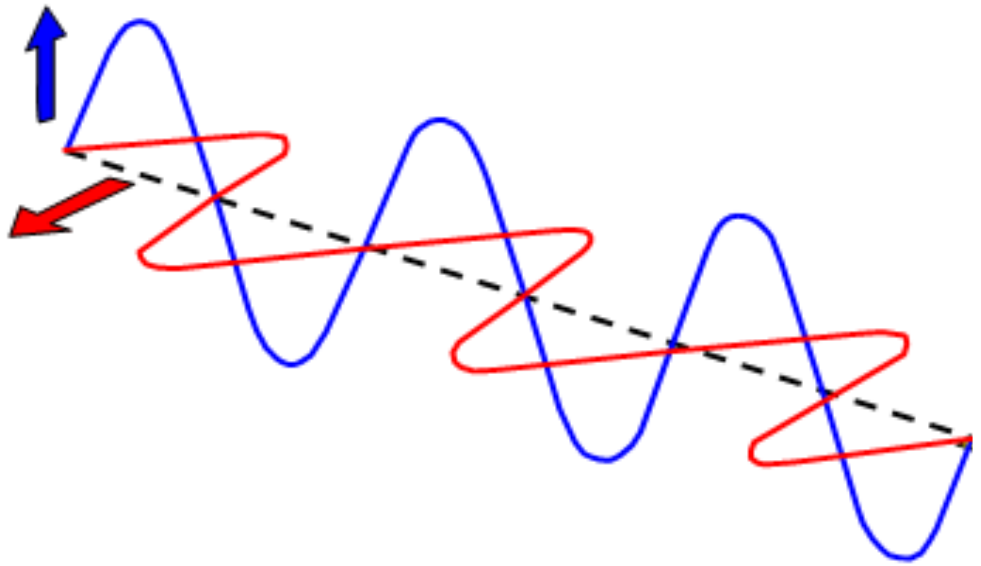
Radio basics - antennas (polarization)





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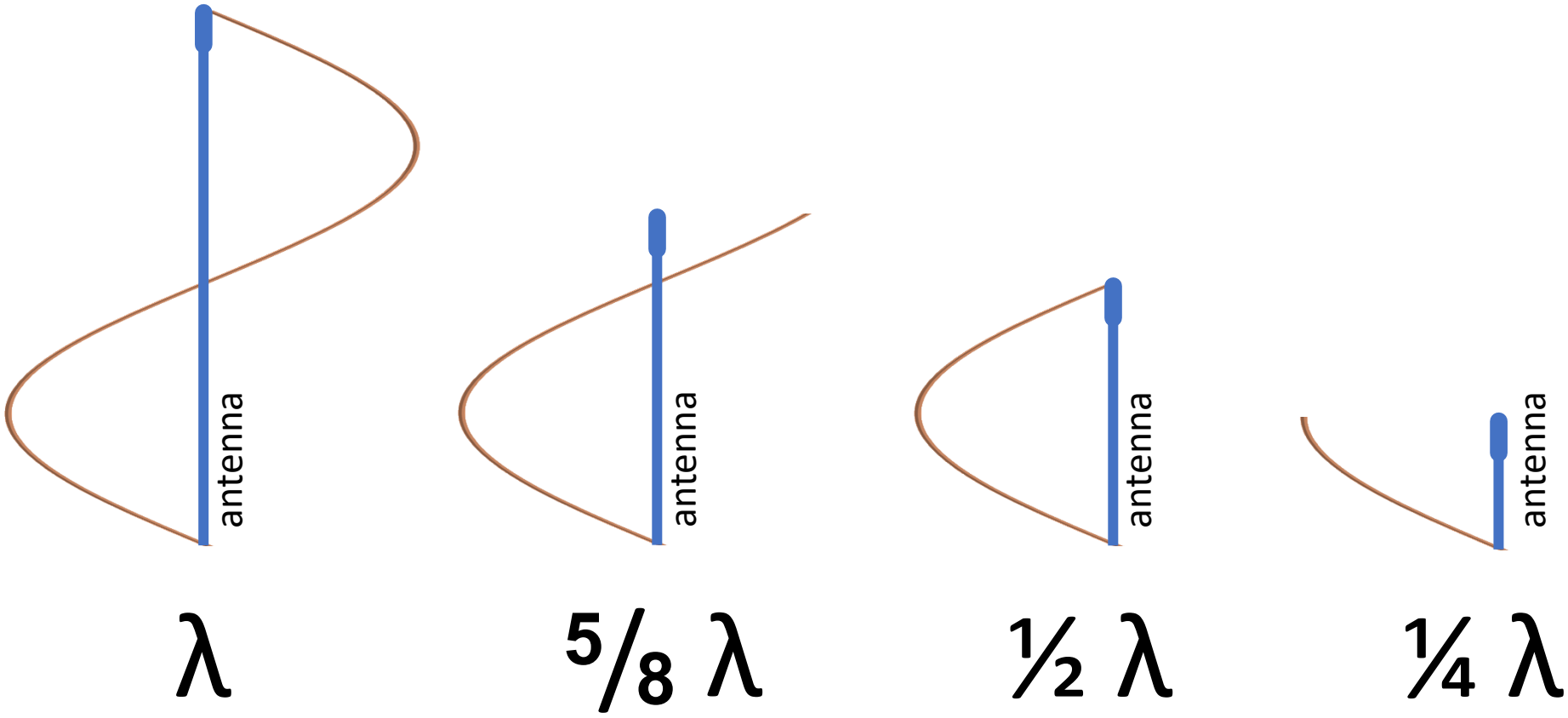
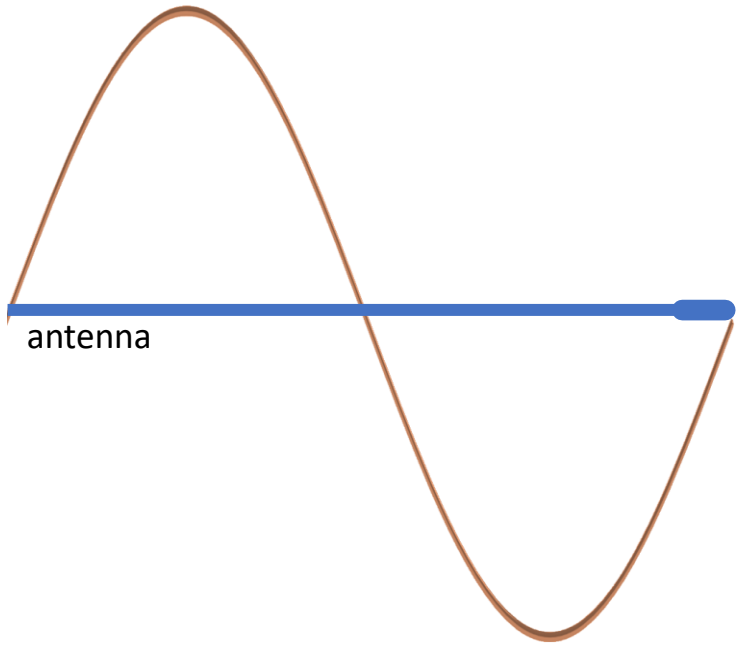
Radio basics - antennas (design)

- Wavelength **vs** antenna length



Radio basics - using the wrong antenna

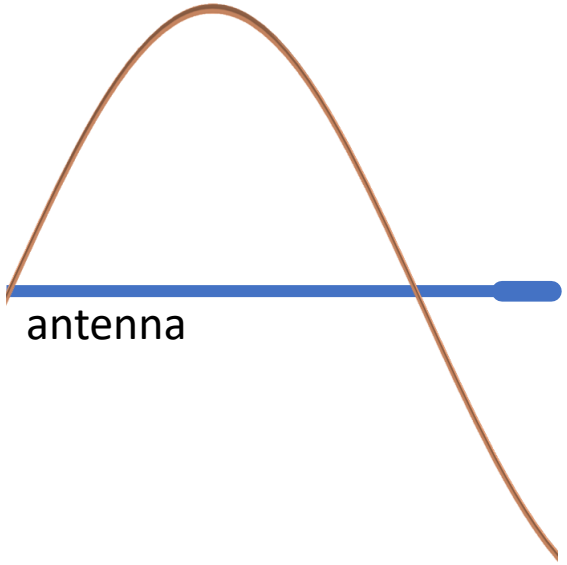
proper antenna



Transmitted power

wrong antenna

Reflected power



Transmitted power

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Radio basics - losses

- Every component between a transmitter and an antenna introduces a loss in transmission power.

Component	Loss (144 MHz @ 100m)
RG213 cable	9.2 dB
LMR600 cable	4.9 dB
N-connector	0.15 dB
Lightning arrestor	0.1 dB

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Radio basics – SWR (standing wave ratio)

- SWR: **s**tanding **w**ave **r**atio
- SWR measures transmitter output power and reflected power from the antenna system.
- SWR is a ratio – it measures how well the load is matched to the transmitter.
- An SWR meter is the testing device used to measure the strength and quality of transmission. It looks like this:

- The SWR meter should be installed between the antenna and the radio.

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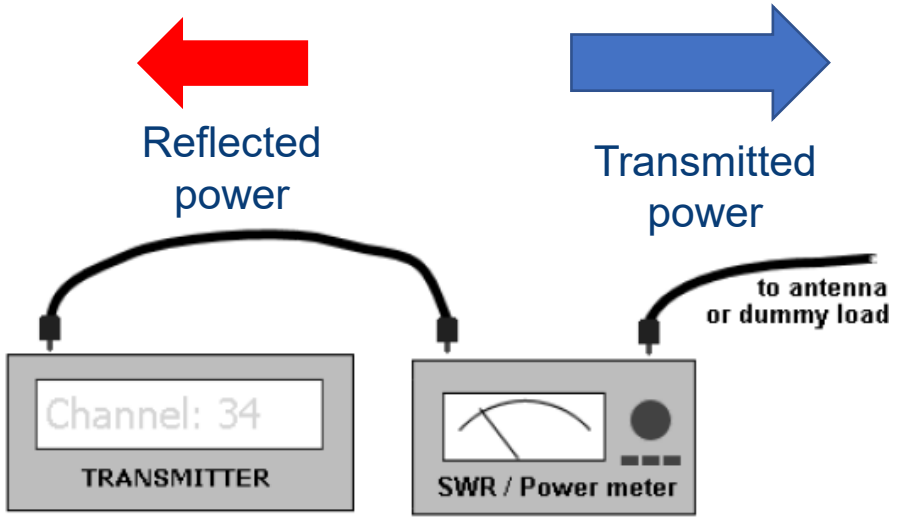
Radio basics - SWR

- When a signal is transmitted from a transmitter to the antenna, not all of the signal may be transmitted by the antenna due to various reasons, such as:
  - Antenna is not of the correct frequency
  - Open or short circuit in the cable
  - Impedance mismatch between transmitter, cable & antenna



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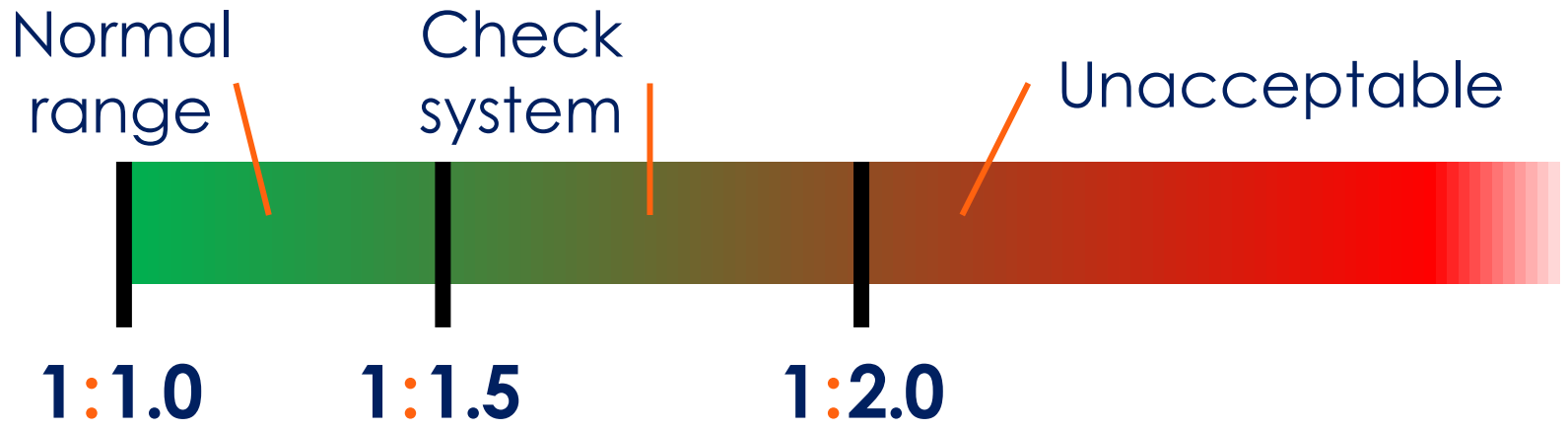
Radio basics - SWR

- SWR reading:
  - When the ratio of the forward signal is in phase with the reflected signal, the ratio is 1:1 (ie. perfect reading)
  - When the forward signal is not directly in phase and is slightly out of tune, the ratio is between 1:1.5 and 1:2.0 The antenna can still work with this SWR.
  - Anything beyond this is out of tune and should be rectified before adding a load.



- A high SWR can seriously damage the radio equipment!

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Radio basics - SWR

- High SWR values mean the transmitter sees a different load leading to damage of the transmitter, this could be related to:
  - Loss of power to antenna
  - Radio interference
  - Loose connector
  - Cable cut

Questions and remarks