Ferrite

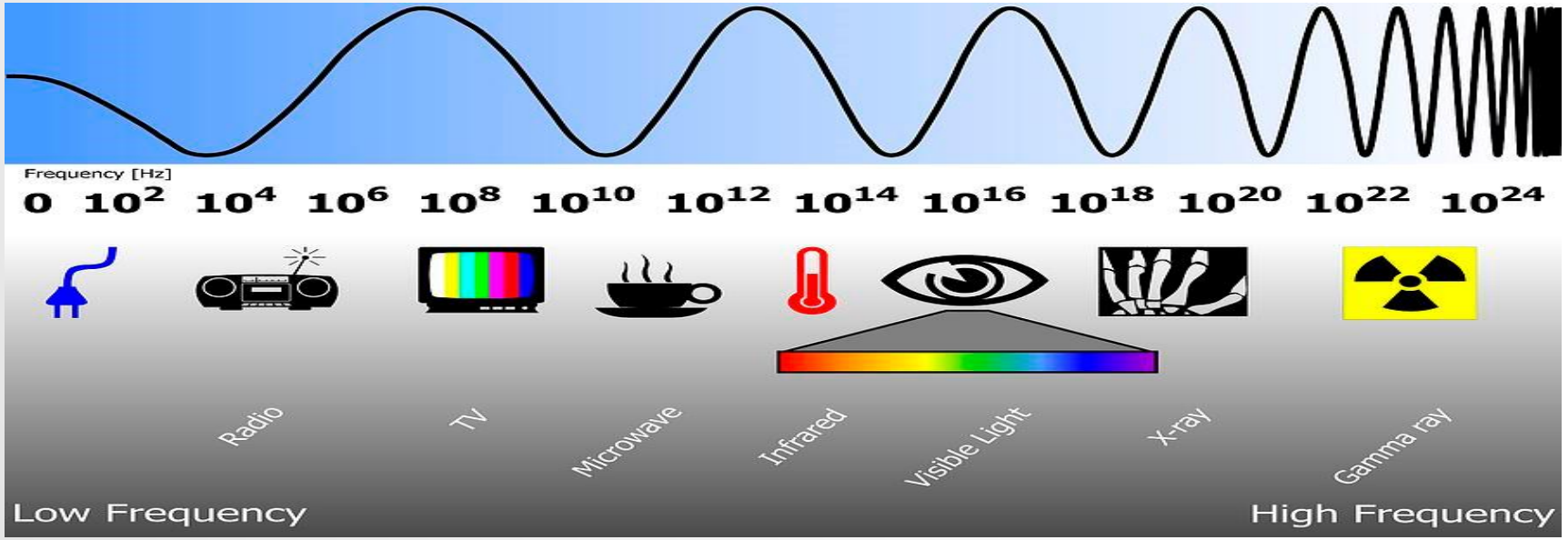
Microwave Technologies

UNDERSTANDING MICROWAVES & MICROWAVE DEVICES

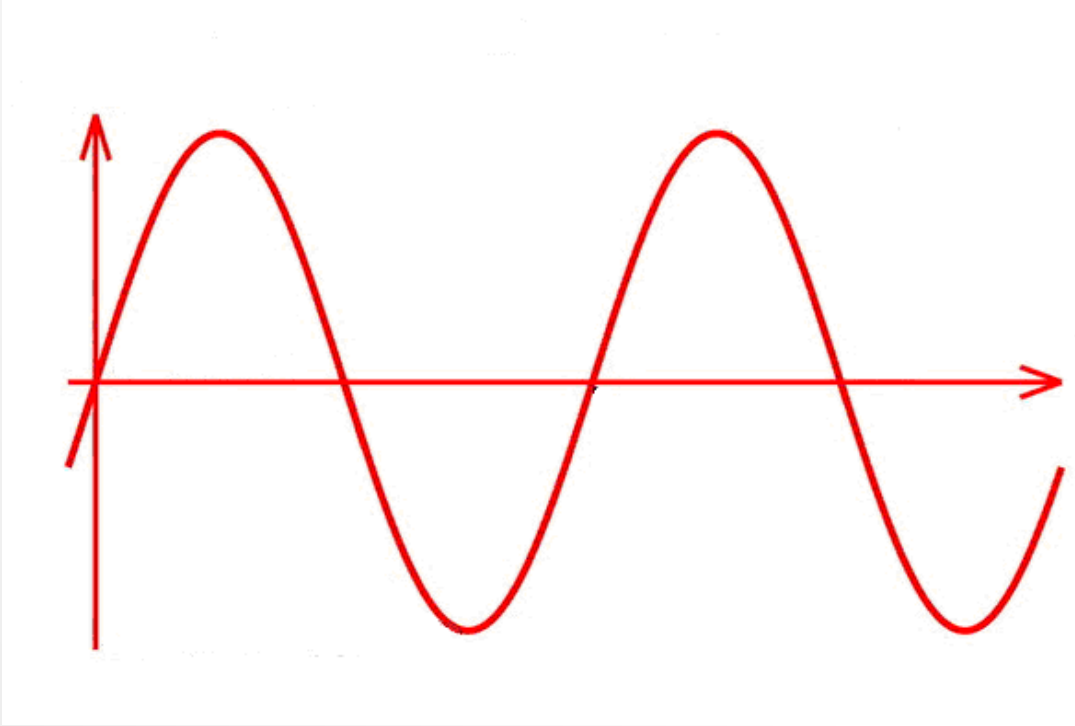
2017

WHAT ARE MICROWAVES?

- Not just a kind of oven!
- Microwaves are a form of energy in the electromagnetic (EM) spectrum.
- The EM spectrum runs from DC voltage to light and beyond.



EM WAVES



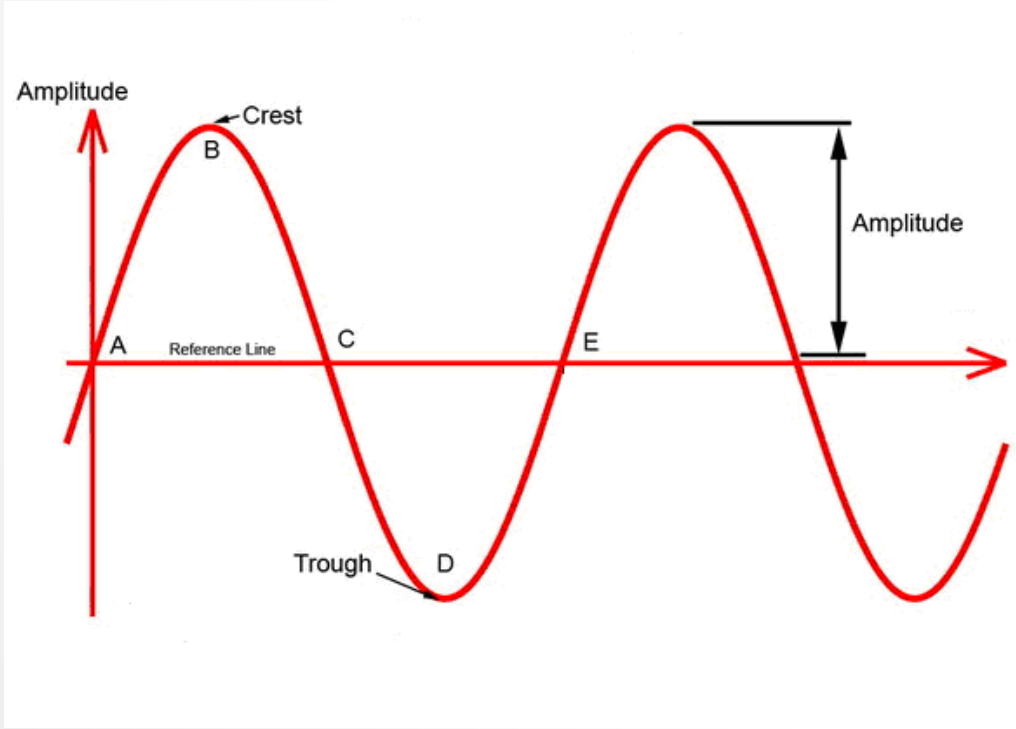
- The energy travels as transverse wave
- Transverse waves look like sine waves.

PROPERTIES OF WAVES

Waves have several components. The different parts of a transverse wave are:

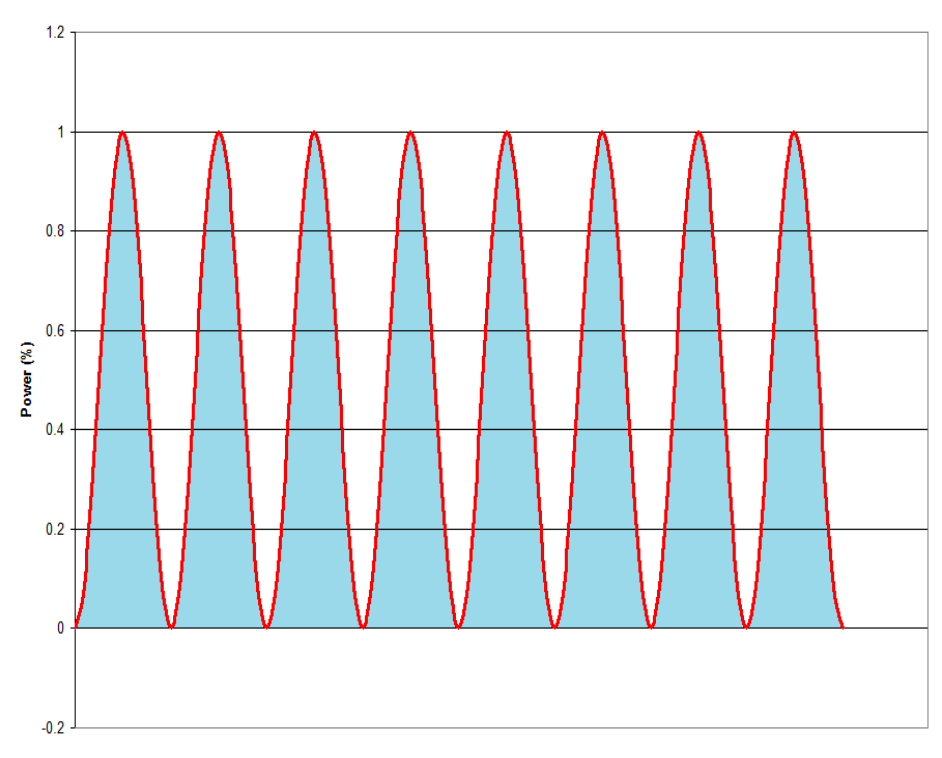
- Amplitude
  - Power
- Wavelength
- Frequency

AMPLITUDE



- Amplitude is the distance from the reference line to the highest point (crest) or lowest point (trough) on the wave.
- Amplitude is directly related to the amount of energy in the wave.

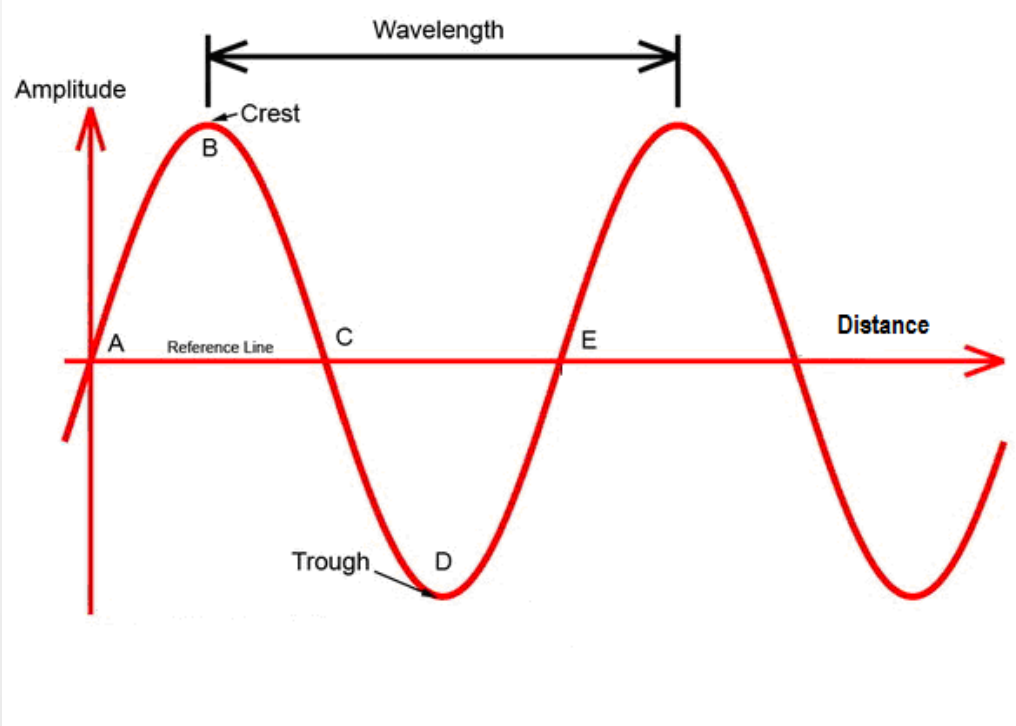
WATT ABOUT POWER?



- The amount of power in the wave is the amount of energy contained under each pulse.
- Power is measured in Watts (W).
- 1 kilowatt (kW) = 1,000 W
- 1 megawatt (MW) = 1,000,000 W

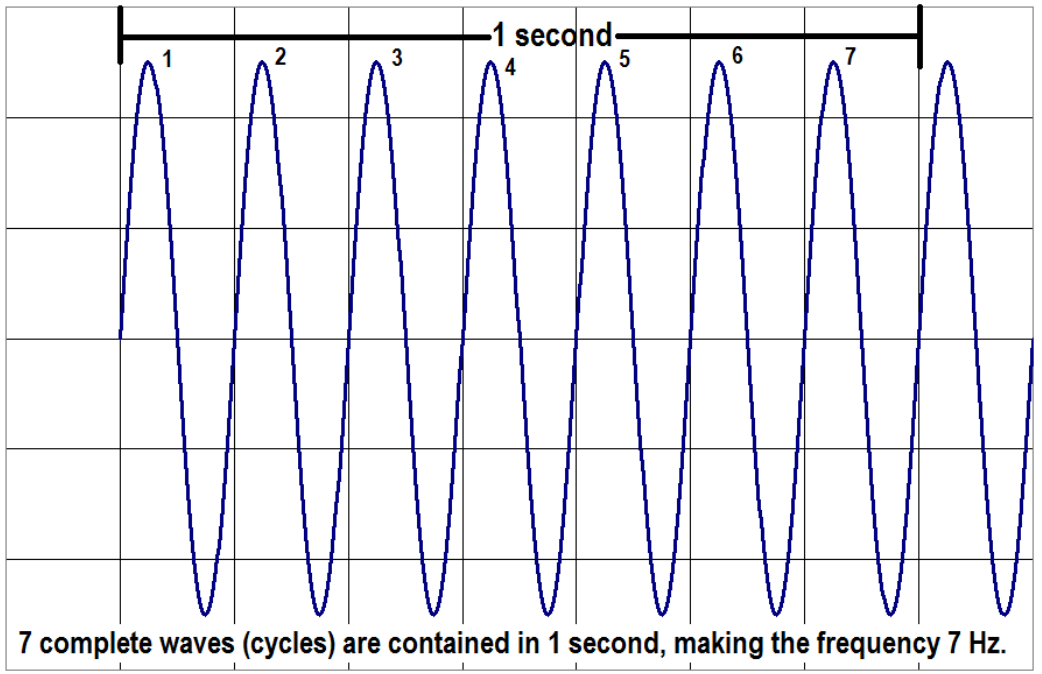
WAVELENGTH

- Wavelength is the distance between two identical spots on the wave.
- Can be measured from crest to crest or trough to trough.



FREQUENCY

- The frequency of the wave is the number of complete cycles that pass a set point in 1 second.
- Units of frequency are Hertz (Hz) or cycles per second.



HERTZ AND MORE

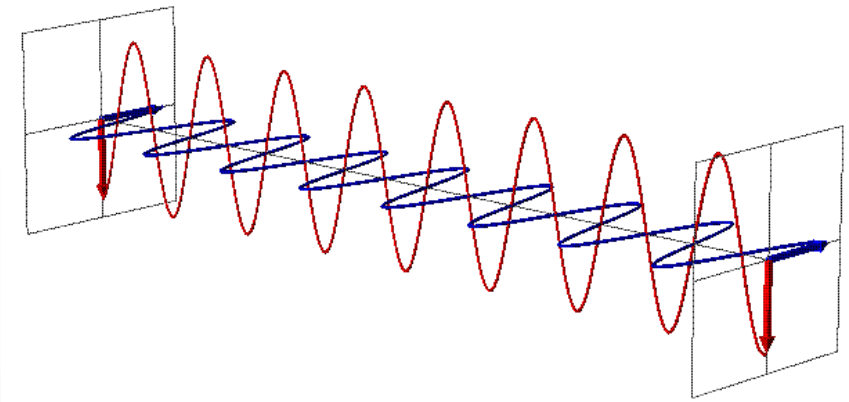
- The unit of frequency is the Hertz (Hz) and is equal to 1 cycle per second.
- Microwaves are usually in the megahertz or gigahertz ranges.
- 1 Megahertz (MHz) = 1,000,000 Hz
- 1 Gigahertz (GHz) = 1,000,000,000 Hz
- Visible light starts at a frequency of 400 terahertz or 400,000,000,000,000 Hz!

COMMON FREQUENCY RANGES AND USES

Name	Frequency range	Name Origin	Common uses
VHF	30 to 300 MHz	Very High Frequency	FM radio, television broadcasts
UHF	300 to 3000 MHz	Ultra High Frequency	Television broadcasts, Microwave oven, Microwave devices and communications, radio astronomy, mobile phones, wireless LAN, Bluetooth.
L Band	1 to 2 GHz	Long	Military telemetry, GPS, ATC radar
S Band	2 to 4 GHz	Short	Weather radar, surface ship radar, microwave ovens, microwave devices/communications.
C Band	4 to 8 GHz	Compromise (between S and X)	Long-distance radio telecommunications
X Band	8 to 12 GHz	X for crosshair (used in WW2 for fire control radar)	Satellite communications, radar, terrestrial broadband, space communications,
Ku Band	12 to 18 GHz	Kurtz Under	Satellite communications
K Band	18 to 26.5 GHz	Kurtz (German for short)	Radar, satellite communications, astronomical observations, automotive radar
Ka Band	26.5 to 40 GHz	Kurtz Above	Satellite communications

WHY "ELECTROMAGNETIC"?

- EM waves have two components: the electrical (red) and the magnetic (blue).
- The two components travel perpendicular to each other.
- The magnetic component allows us to use magnets and ferrite materials to affect wave behavior.



A QUICK WORD ON "FERRITE MATERIAL"

- Ferrite is a type of ceramic material which responds in predictable ways to the presence of a magnetic field.
- Used as the basis for many different microwave devices.
- Allow engineers to use magnets to control the behavior of the EM wave.

TRANSMISSION METHODS

- Move signals to a desired location in a controlled manner
- Types of transmission lines/methods:
  - Microstrip/Stripline
  - Coaxial Cable
  - Waveguide

STRIPLINE/MICROSTRIP

- Strips of copper between dielectric materials
- Good at many different frequencies.
- Limited to low power levels (~100W)

STRIPLINE/MICROSTRIP

Common Uses:

- Cell phones
- Bluetooth devices
- GPS
- EZPass transponders
- RFID tags
- Other small electronics

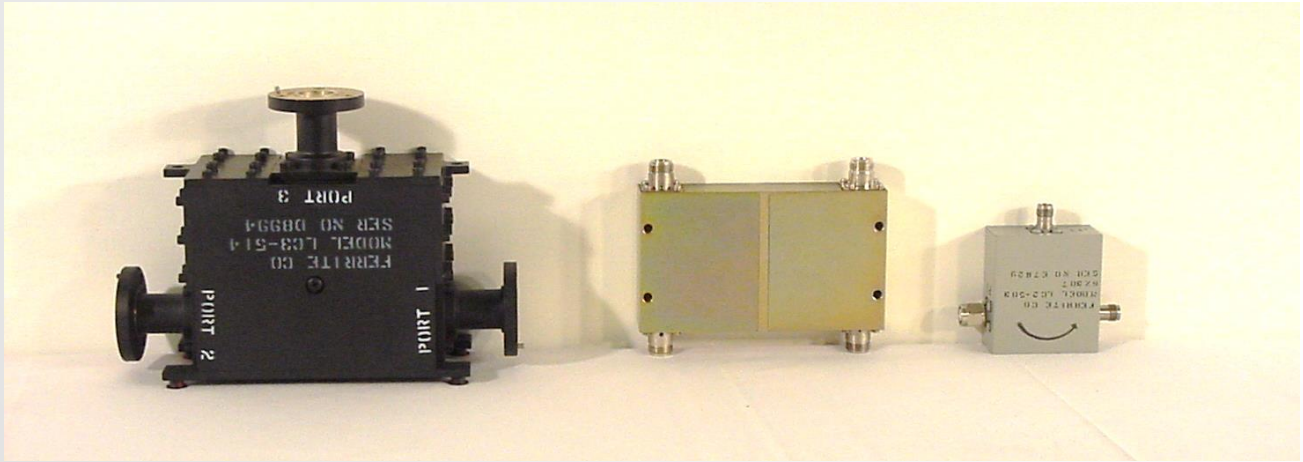
COAXIAL CABLE

- Center conductor surrounded by an insulator and another conductor.
- Good at many different frequencies.
- Most common types are limited to med-low power levels (~1000W)

COAXIAL CABLE

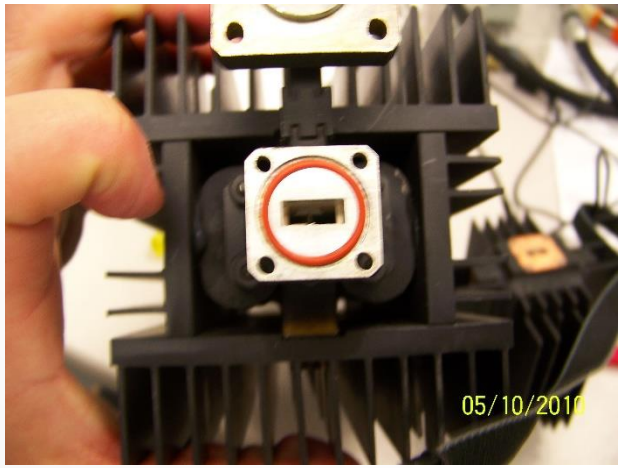
Common Uses:

- Television
- Internet
- Audio/Visual
- Other communication applications



WAVEGUIDE

- Most commonly rectangular metal tubing.
- Narrow frequency bands
- Wide variety of sizes depending on frequency
- Lower frequency = larger size
- Very high power (1MW+)



WAVEGUIDE

Common Uses

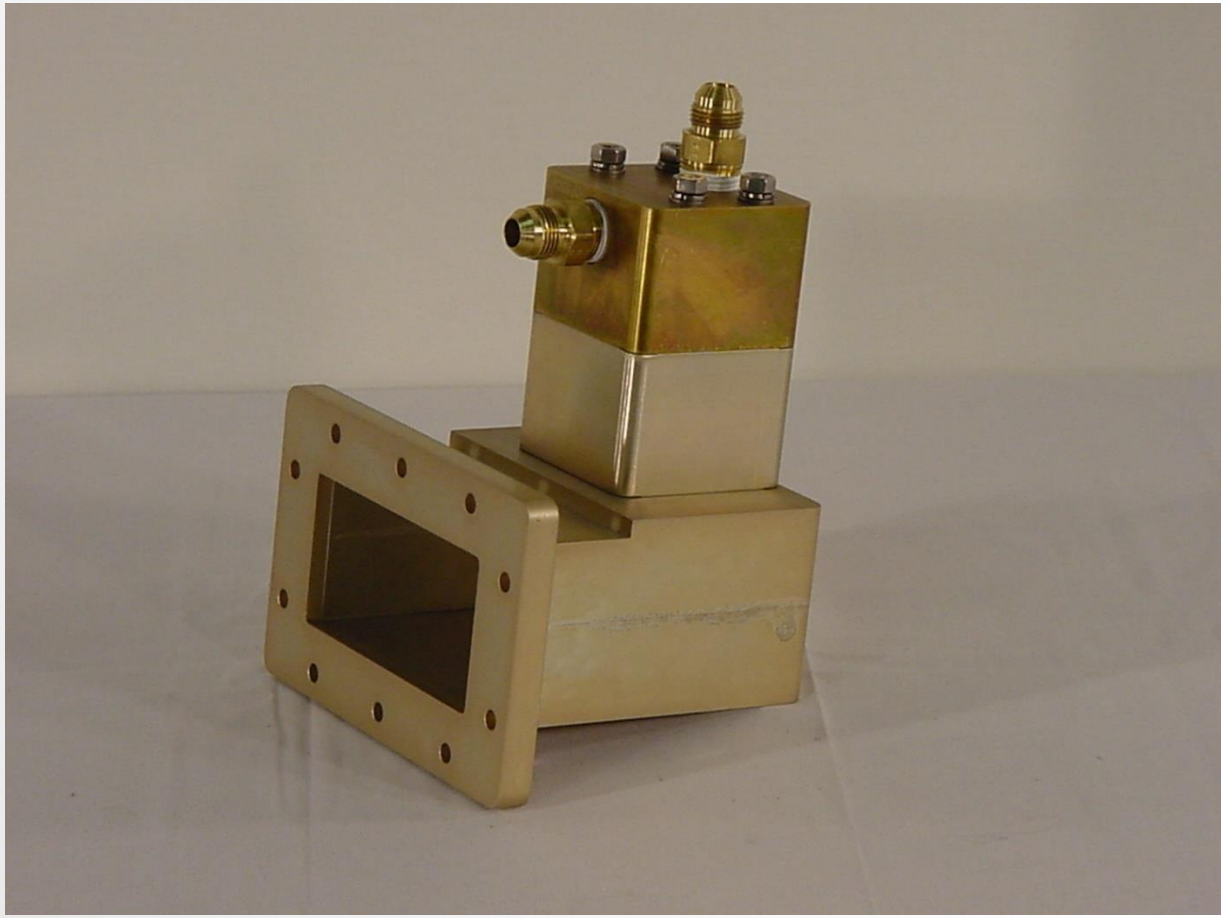
- Radar (commercial and military)
- Satellite communication (base station)
- CLINAC systems (medical)
- Industrial ovens and heating

COMMON TYPES OF MICROWAVE DEVICES

LOADS

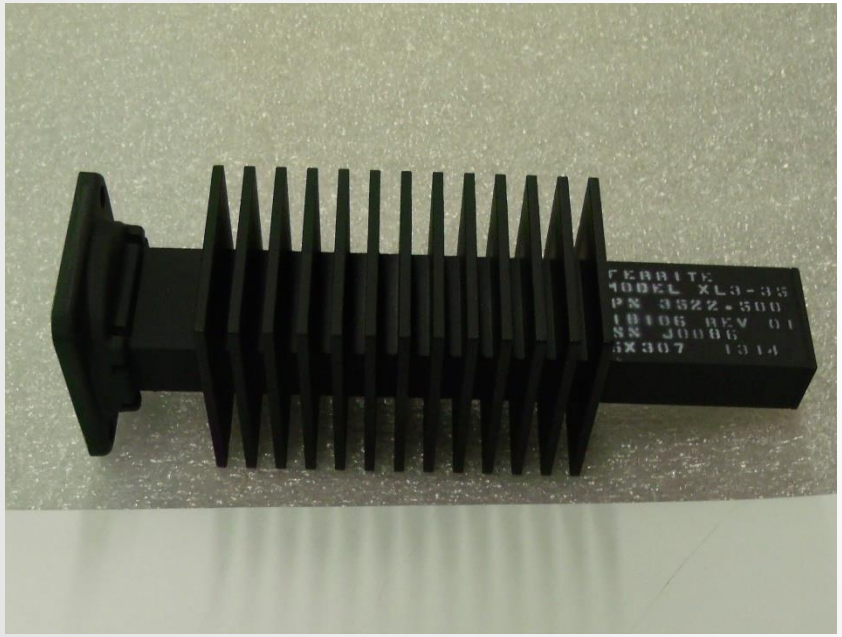
- Absorb power and convert it to heat
- Also called “dummy loads”
- Can be air cooled or water cooled
- Use different materials to absorb the power, such as:
  - Water
  - Ethylene or Propylene Glycol mixture
  - Silicon Carbide
  - Lossy ferrite material

WATER LOAD

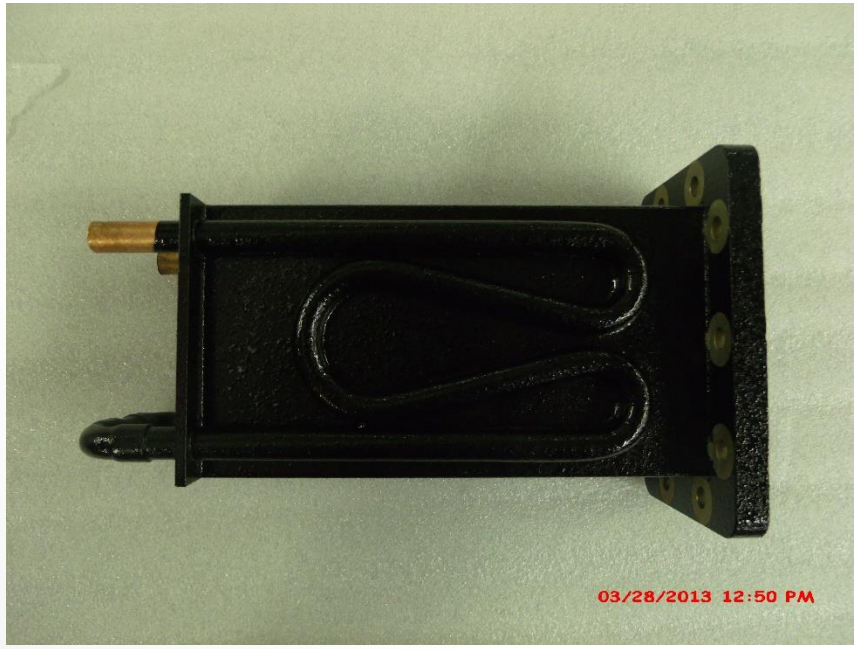


DRY LOAD

Air Cooled



Water Cooled



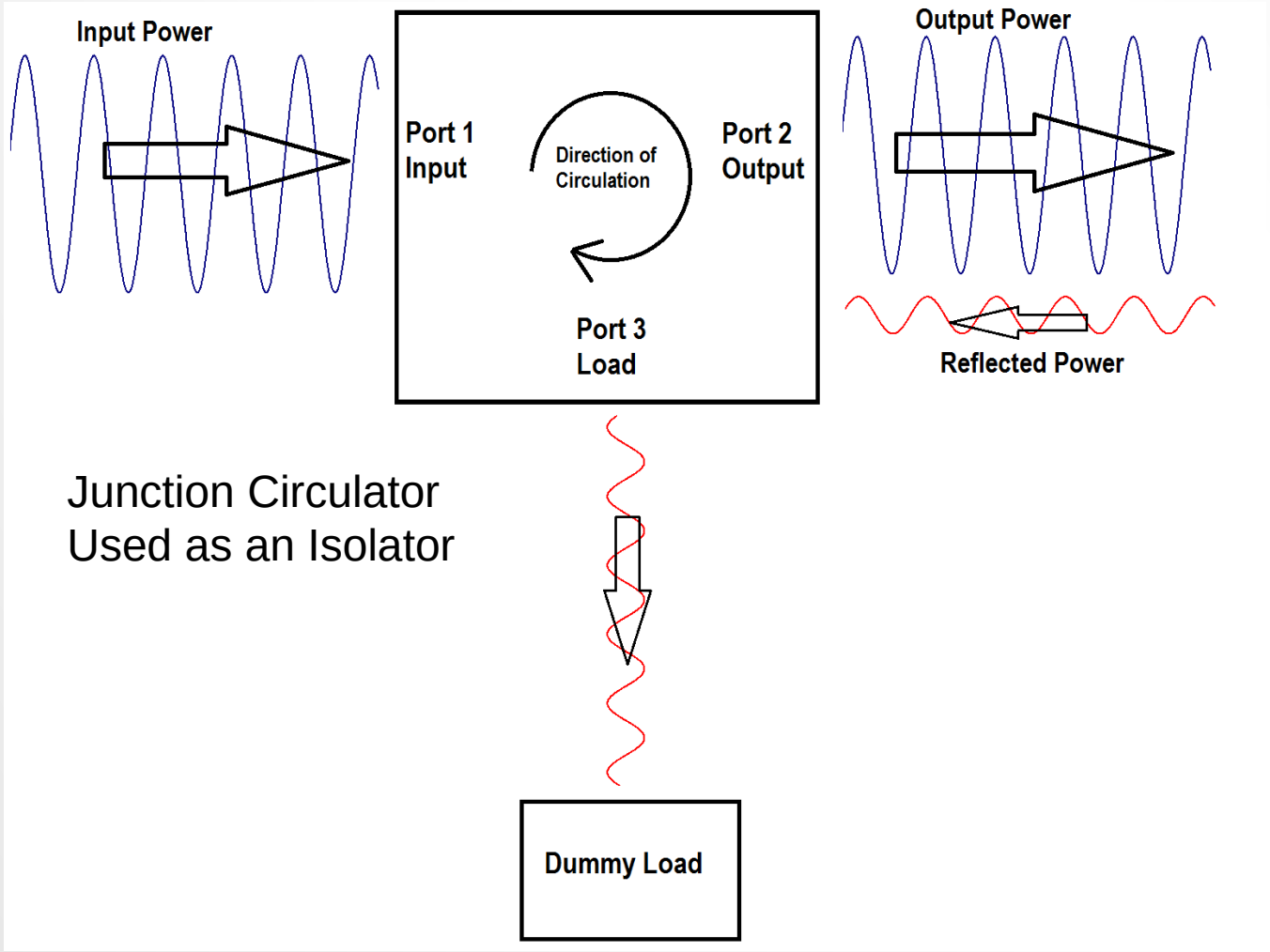
CIRCULATORS

- Often used as isolators or duplexers.
- Use magnetic fields to influence how the energy moves in the system.
- Typically 3 or 4 port devices
  - 3 Port – Junction Circulator
  - 4 Port – Differential Phase Shift Circulator

ISOLATORS

- Act as one way valves for energy
- Protect RF power sources from reflected power.
- Direct reflections away from the power source, usually into a dummy load.

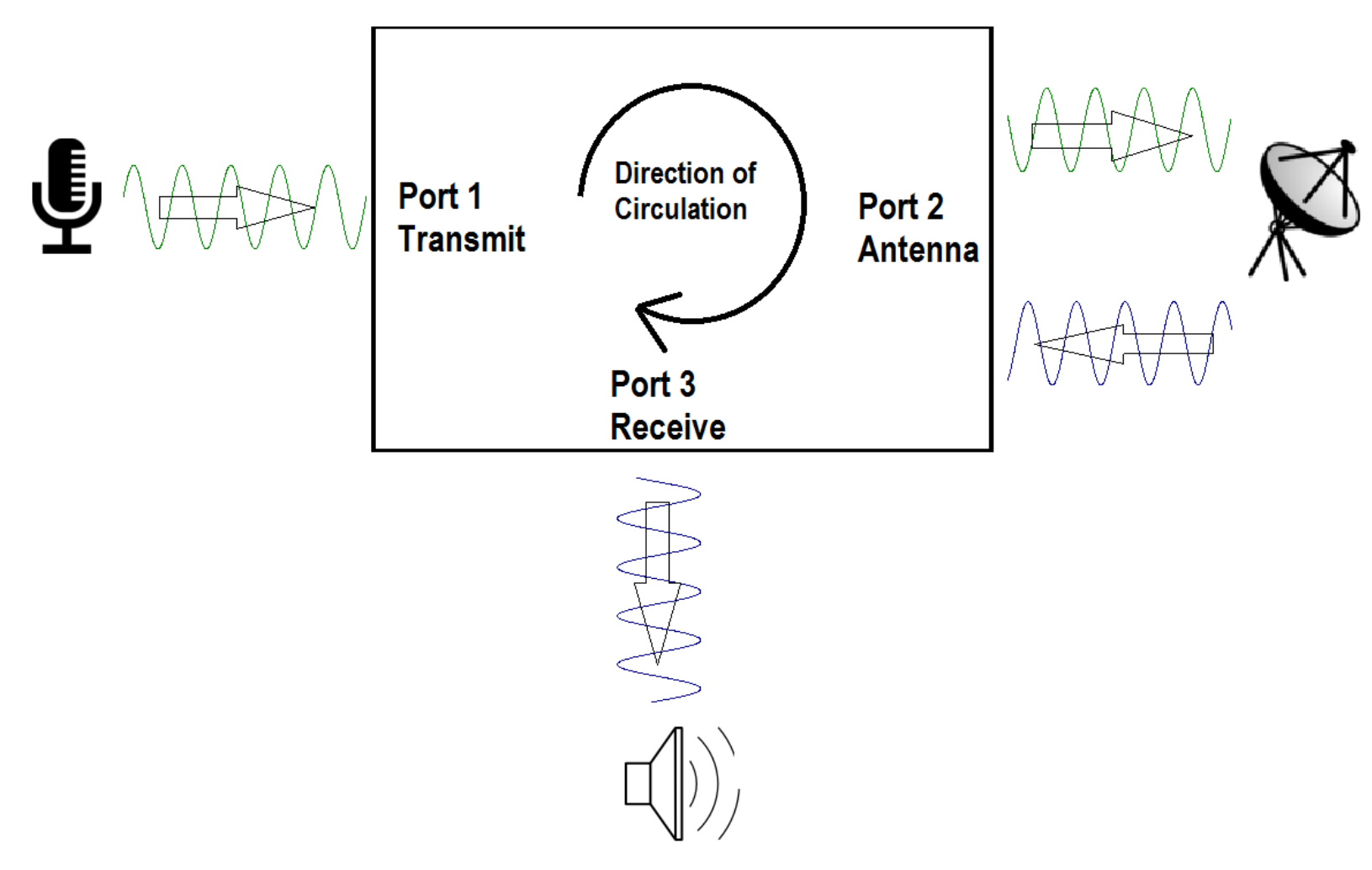
ISOLATOR



DUPLEXERS

- Allows systems to direct RF signals to different places using the same set of transmission lines (waveguide, coax, etc.)

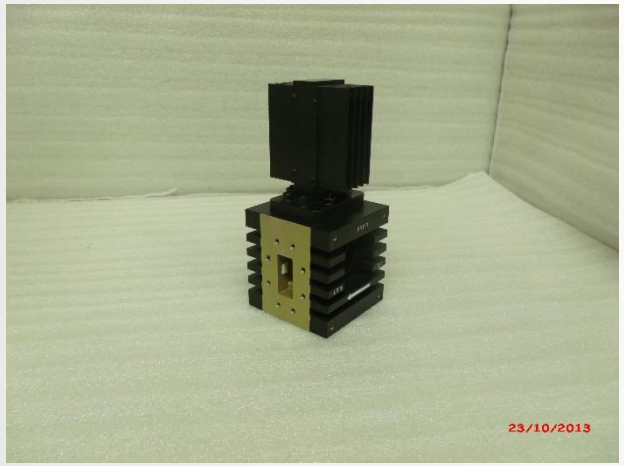
DUPLEXER

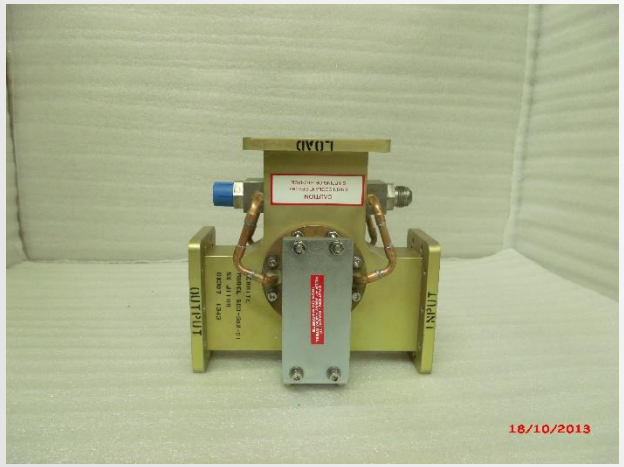


JUNCTION CIRCULATORS

- 3 Port Devices
- Lower power handling capability
- More sensitive to temperature variations
- Smaller footprint
- Lower Cost

JUNCTION CIRCULATORS





DIFFERENTIAL PHASE SHIFT CIRCULATORS

- 4 Port Devices
- Higher power handling capabilities
- Less sensitive to temperature variations
- Larger footprint
- More expensive

DIFFERENTIAL PHASE SHIFT CIRCULATORS

We thank you for your time and interest!

Please send any questions and comments to:

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