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.
• 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

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

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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

Junction Circulator
Used as an Isolator

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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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