



Technician License Course
Chapter 2
Radio and Signals Fundamentals



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Handling Large and Small Numbers

Electronics and Radio use a large range of sizes, i.e., 0.00000000000001 to 100000000000000.

Scientific Notation – using Powers of 10 – simplifies numbers, i.e., 3,000,000Hz = 3×10^6 Hz = 3 MHz.

Powers of 10 are indicated by using prefixes like:

- Kilo, Mega, Giga, Terra for large sizes.
 - Examples: KiloHertz, MegOhms, GigaByte
- pico, nano, micro, milli for small sizes.
 - Examples: picofarad, microhenry, millimeter

Abbreviations: pF (picoFarad), mH (milliHenry), KHz (KiloHertz), MHz (MegaHertz), GHz (GigaHertz)



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Some Metric System Prefixes

Prefix	Abbreviation	Factor	Power of 10
pico	p	0.000000000001	10 E-12
nano	n	0.000000001	10 E-9
micro	u	0.000001	10 E-6
milli	m	0.001	10 E-3
Kilo	K	1000	10 E3
Mega	M	1,000,000	10 E6
Giga	G	1,000,000,000	10 E9
Terra	T	1,000,000,000,000	10 E12

Note: lower case prefix for values less than 1



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Move the decimal point to convert

To From	pico p	micro u	milli m	Unit	Kilo K	Mega M	Giga G
pico p		← 6	← 9	← 12	← 15	← 18	← 21
micro u	→ 6		← 3	← 6	← 9	← 12	← 15
milli m	→ 9	→		← 3	← 6	← 9	← 12
Unit	→ 12	→ 6	→ 3		← 3	← 6	← 9
Kilo K	→ 15	→ 9	→ 6	→ 3		← 3	← 6
Mega M	→ 18	→ 12	→ 9	→ 6	→ 3		← 3
Giga G	→ 21	→ 18	→ 12	→ 9	→ 6	→ 3	



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Electromagnetic Waves

Radio is Energy in ElectroMagnetic (EM) waves.

- The Radio Frequency voltage on an Antenna creates an oscillating Electric Field.
- The Radio Frequency current in an Antenna creates an oscillating Magnetic Field.
- At a short distance from the antenna, the Electric Field and Magnetic Field combine into an ElectroMagnetic Wave which expands through space.



Fundamentals of EM (Radio) Waves

The Electric and Magnetic fields travelling at right angles to each other make up a Radio Wave.

- Energy in the wave moves at the velocity of light
 - 300,000,000 meters per second
 - 186,000 miles per second
- Energy spreads in all directions.
- Energy propagates in straight lines.
- Energy is absorbed by poor conductors.
- Energy is reflected by good conductors.



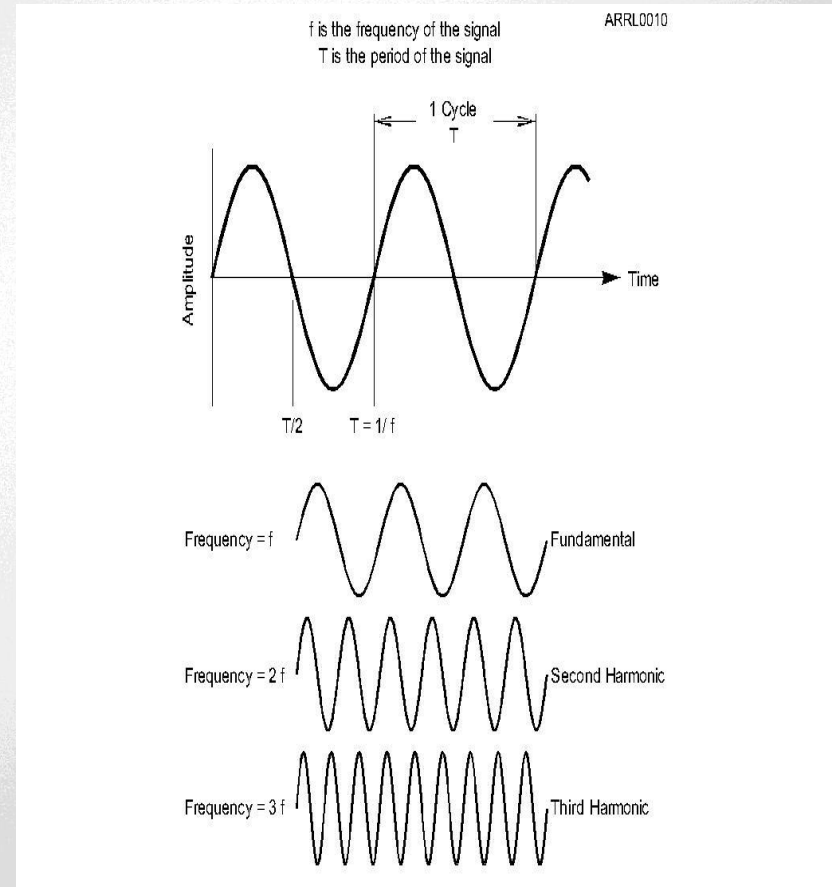
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Wave Vocabulary

Properties of Waves:

- Cycle: (Repetition of values)
- Waveform
 - Sine, Cosine
 - Pulse, Square, Rectangle
 - Triangle, Trapezoid
 - Voice
- Amplitude (Volts, Power)
 - Peak Value
 - Effective Value
- Frequency (Cycles/Sec., Hz)
 - Fundamental
 - Harmonics
- Period (Time for one cycle)



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Wavelength

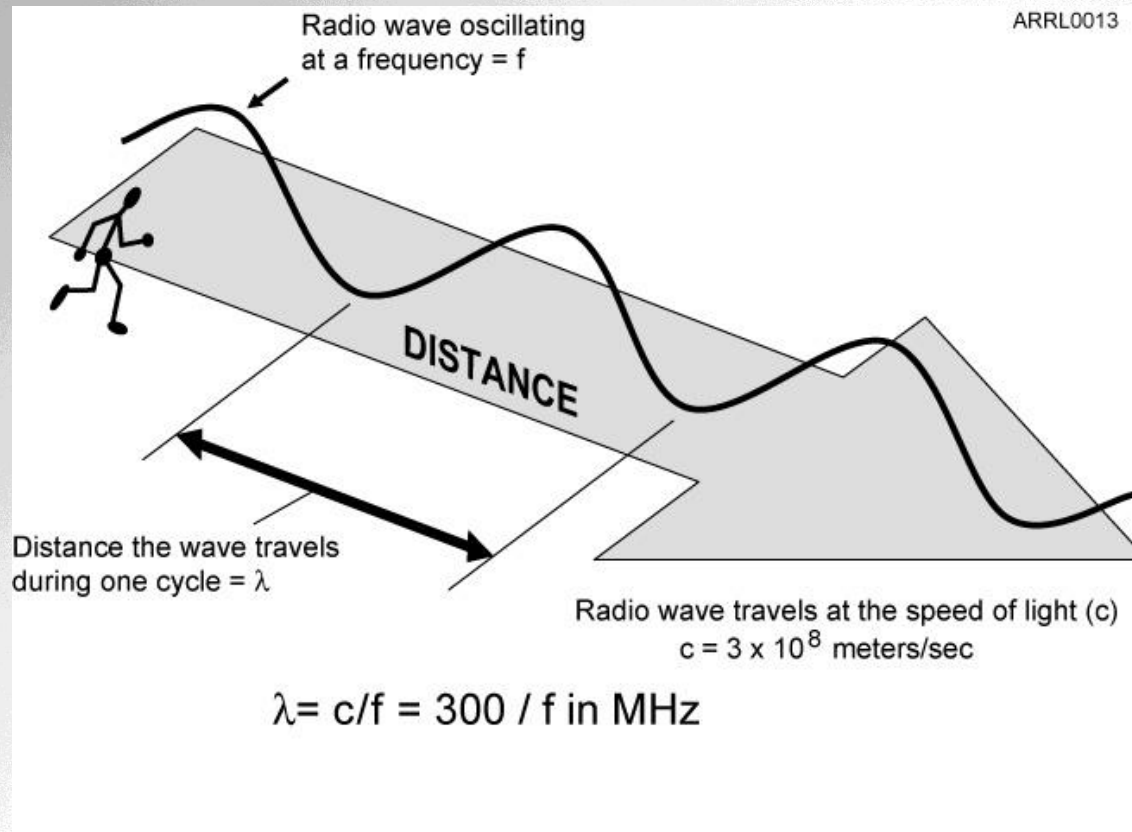
Wavelength is the distance the energy travels during one cycle of the magnetic or electric fields.

Wavelength (Meters) is Velocity of light divided by Frequency (Hertz)

- $300,000,000 / \text{Frequency in Hertz (Hz)}$.
- $300 / \text{Frequency in MegaHertz (MHz)}$.
- Higher Frequency \Leftrightarrow Shorter Wavelength.
- Lower Frequency \Leftrightarrow Longer Wavelength.



Wavelength



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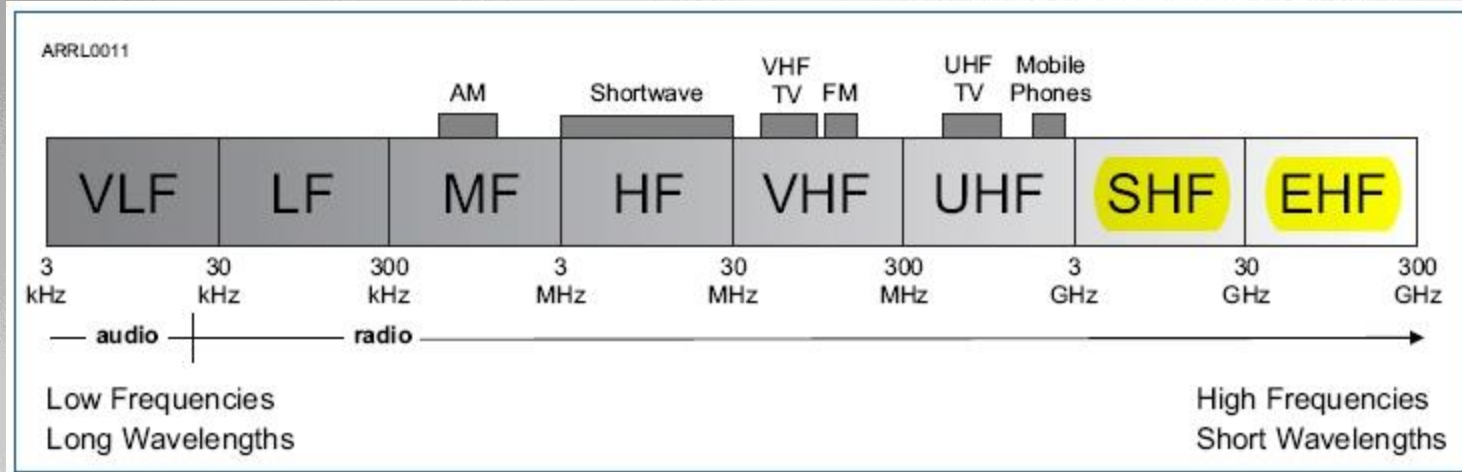
Radio Frequency (RF) Spectrum

A **Spectrum** is a range of frequencies.

- The light spectrum in a rainbow can be seen as colors. Colors are radio frequencies with wavelengths that human eyes can detect.
- Radios detect spectrums that are invisible.
- The Radio Spectrum (RF) is the range of frequencies which can exist in space.
- The RF spectrum is divided into ranges that have similar behaviors.



Radio Frequency (RF) Spectrum



VLF – Very Low Frequency, **LF** – Low Frequency, **MF** – Medium Frequency, **HF** – High Frequency, **VHF** – Very High Frequency, **UHF** – Ultra High Frequency, **SHF** – Super High Frequency, **EHF** – Extremely High Frequency



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What are the Amateur Radio Bands?

Amateurs are allowed to transmit within bands of frequencies. Bands are allocated in MF, HF, VHF, UHF, and SHF spectrum, (1.8 MHz and higher).

- Bands may be named for frequency or wavelength.
- Bands are divided into sub bands for different modes. On HF, voice at high end, digital lower than voice, and CW exclusively at low end.
- There are too many bands to list on one slide. Use the ARRL chart to study.



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US Amateur Radio Bands

US AMATEUR POWER LIMITS

FCC 97.313 An amateur station must use the minimum transmitter power necessary to carry out the desired communications. (b) No station may transmit with a transmitter power exceeding 1.5 kW PEP.

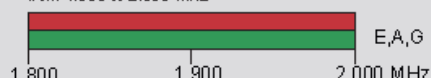
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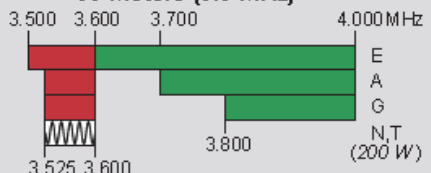


160 Meters (1.8 MHz)

Avoid interference to radiolocation operations from 1.900 to 2.000 MHz



80 Meters (3.5 MHz)

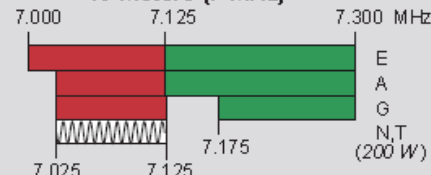


60 Meters (5.3 MHz)



General, Advanced, and Amateur Extra licensees may operate on these five channels on a secondary basis with a maximum effective radiated output of 100 W PEP. Permitted operating modes include upper sideband voice (USB), CW, RTTY, PSK31 and other digital modes such as PACTOR III as defined by the FCC Report and Order of November 18, 2011. USB is limited to 2.8 kHz centered on 5332, 5348, 5358.5, 5373 and 5405 kHz. CW and digital emissions must be centered 1.5 kHz above the channel frequencies indicated above. Only one signal at a time is permitted on any channel.

40 Meters (7 MHz)



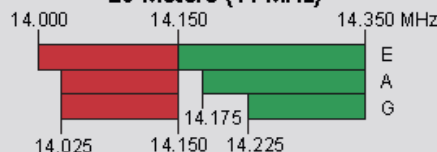
Phone and Image modes are permitted between 7.075 and 7.100 MHz for FCC licensed stations in ITU Regions 1 and 3 and by FCC licensed stations in ITU Region 2 West of 130 degrees West longitude or South of 20 degrees North latitude. See Sections 97.305(c) and 97.307(f)(11). Novice and Technician licensees outside ITU Region 2 may use CW only between 7.025 and 7.075 MHz and between 7.100 and 7.125 MHz. 7.200 to 7.300 MHz is not available outside ITU Region 2. See Section 97.301(e). These exemptions do not apply to stations in the continental US.

30 Meters (10.1 MHz)

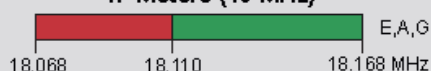
Avoid interference to fixed services outside the US.



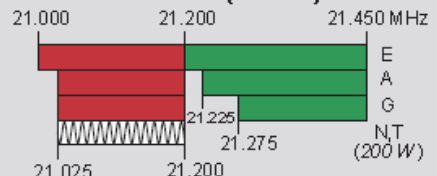
20 Meters (14 MHz)



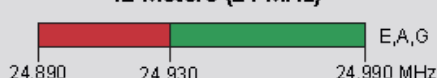
17 Meters (18 MHz)



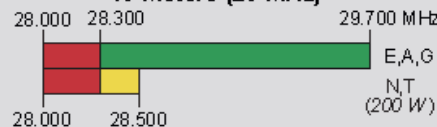
15 Meters (21 MHz)



12 Meters (24 MHz)



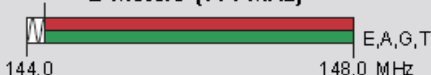
10 Meters (28 MHz)



6 Meters (50 MHz)



2 Meters (144 MHz)



1.25 Meters (222 MHz)



* Geographical and power restrictions may apply to all bands above 420 MHz. See *The ARRL Operating Manual* for information about your area.

70 cm (420 MHz)*



33 cm (902 MHz)*



23 cm (1240 MHz)*



All licensees except Novices are authorized all modes on the following frequencies:

2300-2310 MHz	10.0-10.5 GHz*	122.25-123.0 GHz
2390-2460 MHz	24.0-24.25 GHz	134-141 GHz
3300-3500 MHz	47.0-47.2 GHz	241-250 GHz
5650-5925 MHz	76.0-81.0 GHz	All above 275 GHz

* No pulse emissions

KEY

Note

CW operation is permitted throughout all amateur bands.

M CW is authorized above 50.1 MHz, except for 144.0-144.1 and 219-220 MHz.

Test transmissions are authorized above 5.1 MHz, except for 219-220 MHz

- = RTTY and data
- = phone and image
- = CW only
- = SSB phone
- = USB phone, CW, RTTY, and data
- = Fixed digital message forwarding systems only

- E = Amateur Extra
- A = Advanced
- G = General
- T = Technician
- N = Novice

See *ARRLWeb* at www.arrl.org for detailed band plans.

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Bands and Frequencies

There are three ways to tell someone where to meet you on the radio dial.

- Frequency – a distinct frequency point. Specified in KiloHertz (KHz), MegaHertz (MHz), or GigaHertz (GHz)
- Wavelength – The wavelength in Meters or centimeters. $(300 / F_{\text{MHz}})$
- Band – a group of adjacent frequencies between a low frequency and a high frequency.



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Frequency vs. Band Examples

Bands are often named for the wavelength of a frequency in the band.

Wavelength in Meters = (300 divided by Frequency in MHz).

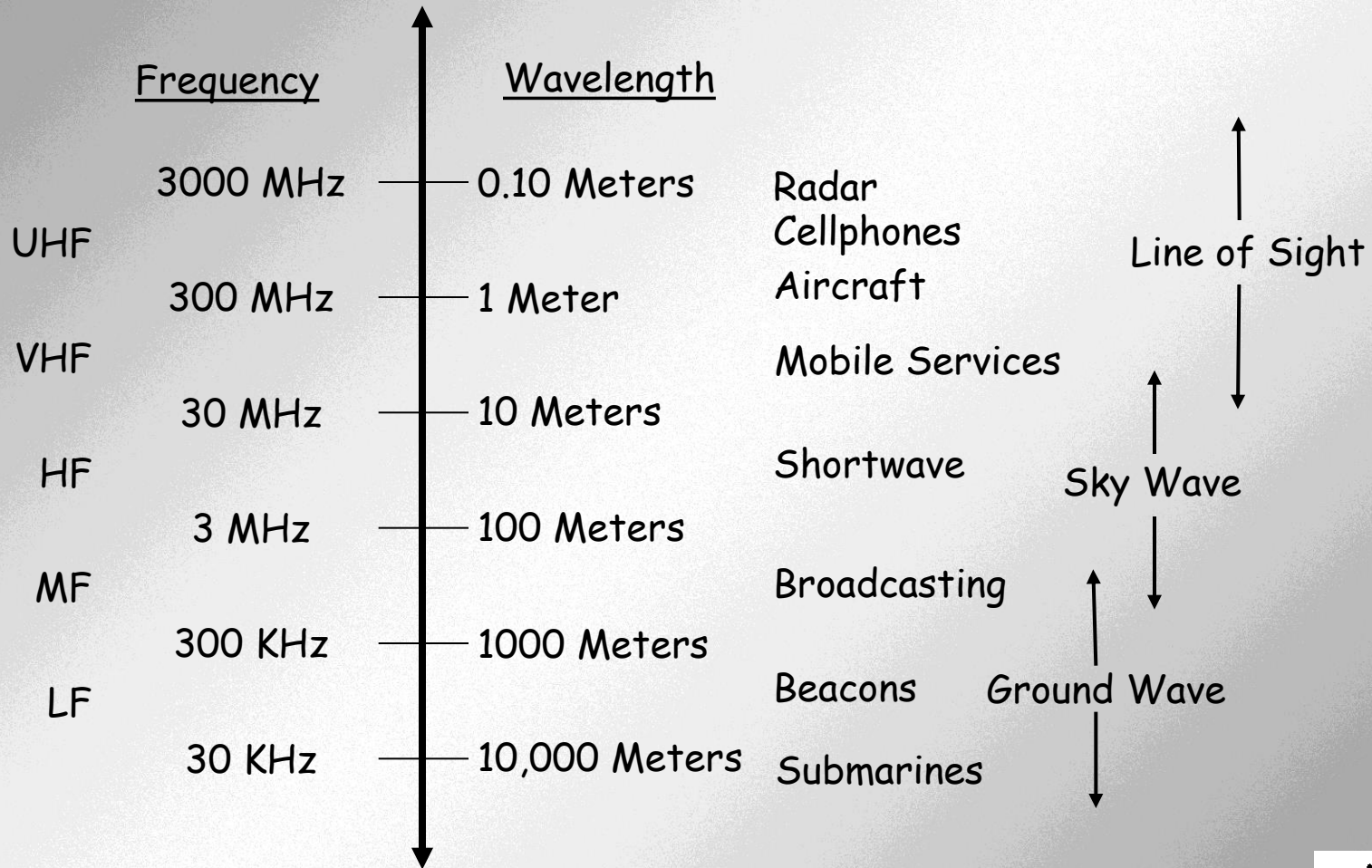
- $300/146 \text{ MHz} = 2.05 \text{ Meters}$
- $144\text{MHz} - 148\text{MHz} \Leftrightarrow 2 \text{ Meters}$

Frequency in MHz = (300 divided by Wavelength in Meters)

- $300 / 6 \text{ Meters} = 50 \text{ MHz}$
- $6 \text{ Meters} \Leftrightarrow 50\text{MHz} - 54\text{MHz}$



Frequency Versus Uses



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