Technician License Course
Chapter 2

Radio and Signals Fundamentals

Radio Waves

ARRL The national association for AMATEUR RADIO

Handling Large and Small Numbers

ARRL The national association for AMATEUR RADIO

Handling Large and Small Numbers

Electronics and Radio use the metric system because the numbers involved cover a wide range of sizes – billionths to billions. Powers of 10 – called Scientific Notation – lets us use small numbers for calculating by using prefixes like

ARRL The national association for AMATEUR RADIO

Handling Large and Small Numbers

Electronics and Radio use the metric system because the numbers involved cover a wide range of sizes – billionths to billions. Powers of 10 – called Scientific Notation – lets us use small numbers for calculating by using prefixes like

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

ARRL The national association for AMATEUR RADIO

Handling Large and Small Numbers

Electronics and Radio use the metric system because the numbers involved cover a wide range of sizes – billionths to billions. Powers of 10 – called Scientific Notation – lets us use small numbers for calculating by using prefixes like

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

Abbreviations like: pf (picoFarad), mH (milliHenry), KHz (KiloHertz), MHz (MegaHertz), GB (GigaByte)

ARRL The national association for AMATEUR RADIO

Some Metric System Prefixes

Prefix	Abbreviation	Factor	Power of 10
Pico	p	0.000000000001	10^{-12}
Nano	n	0.000000001	10^{-9}
Micro	u	0.000001	10^{-6}
Milli	m	.001	10^{-3}
Kilo	K	1000	10^{3}
Mega	M	1,000,000	10^{6}
Giga	G	1,000,000,000	10^{9}
Terra	T	1,000,000,000,000	10^{12}

Note: Use lower case prefix letters for less than 1

ARRL The national association for AMATEUR RADIO

Move the decimal point to convert

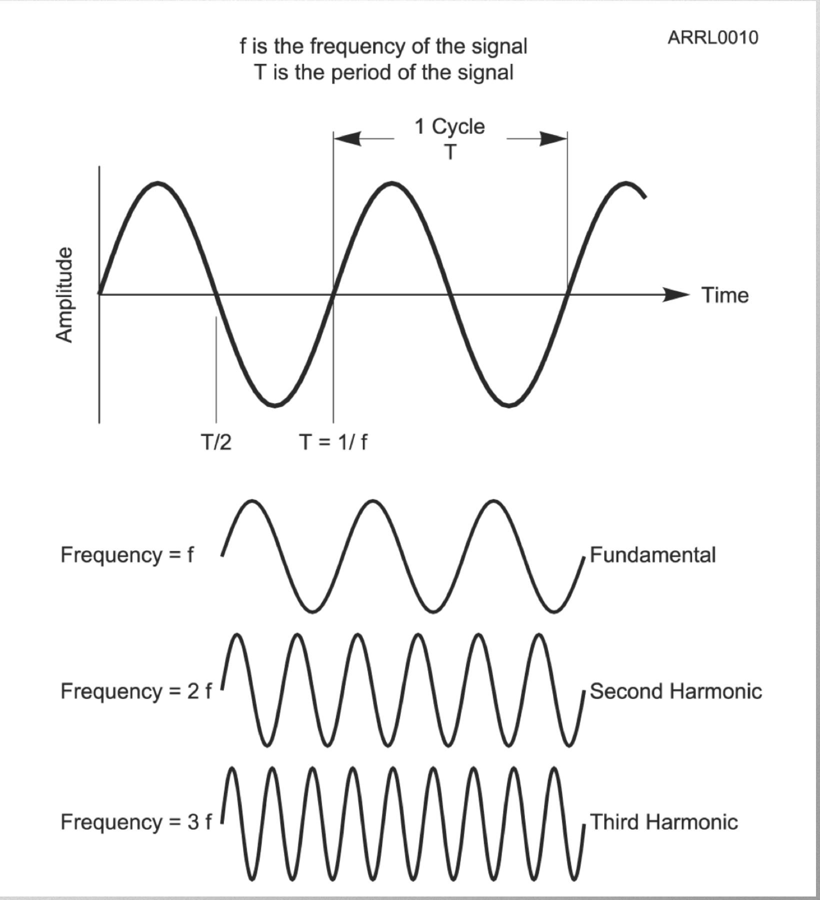
To From	Pico p	Micro u	Milli m	Unit	Kilo K	Mega M	Giga G
Pico p		< 6	< 9	< 12	< 15	< 18	< 21
Micro u	> 6		< 3	< 6	< 9	< 12	< 15
Milli m	> 9	> 3		< 3	< 6	< 9	< 12
Unit	> 12	> 6	> 3		< 3	< 6	< 9
Kilo K	> 15	> 9	> 6	> 3		< 3	< 6
Mega M	> 18	> 12	> 9	> 6	> 3		< 3
Giga G	> 21	> 18	> 12	> 9	> 6	> 3	

What we will talk about?

- What is a Radio Wave?
- What does a Radio Wave look like?
- What are Wavelengths?
- What is Electromagnetic Waves?
- What is the Radio Spectrum?
- What are Radio Bands?
- What is a radio signal?
- What is a repeater?

Wave Vocabulary

- Before we study radio, we need to learn some wave vocabulary.
  - *Waveform (sinewave)*
  - *Amplitude*
  - *Frequency (hertz, Hz)*
  - *Period (seconds, s)*
  - *Fundamental*
  - *Harmonics (1st, 2nd, 3rd, 4th, etc.)*
  - *Wavelength (Meters)*



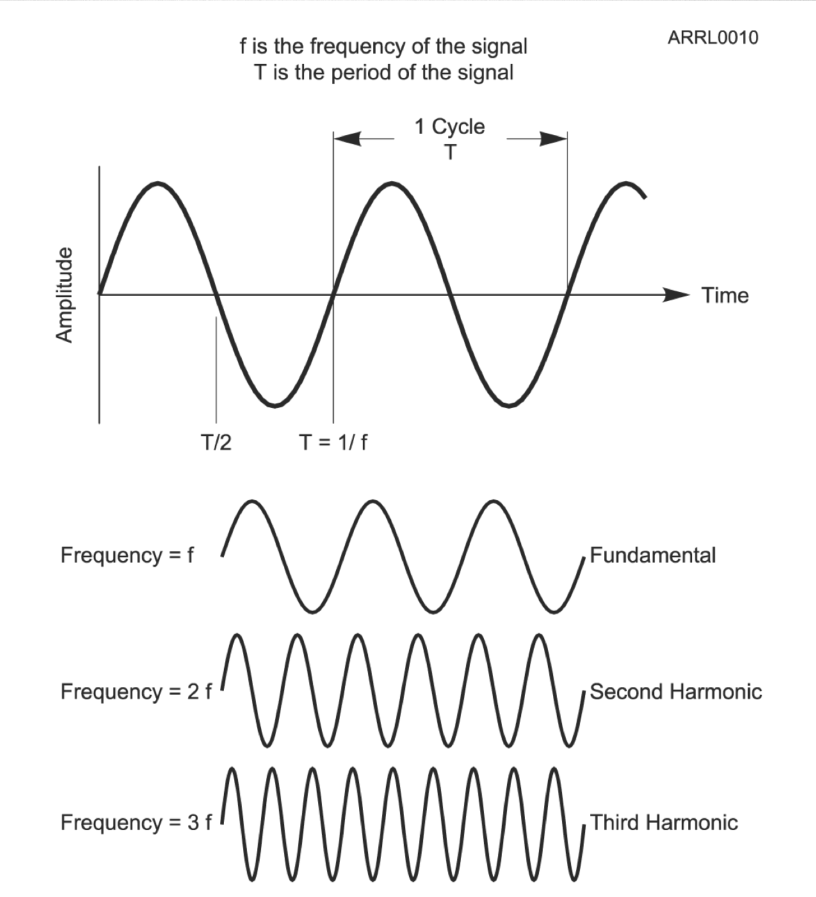
ARRL The national association for AMATEUR RADIO

Wave Vocabulary

– *Waveform (sinewave)*

Defined as

The amplitude of an ac signal over time



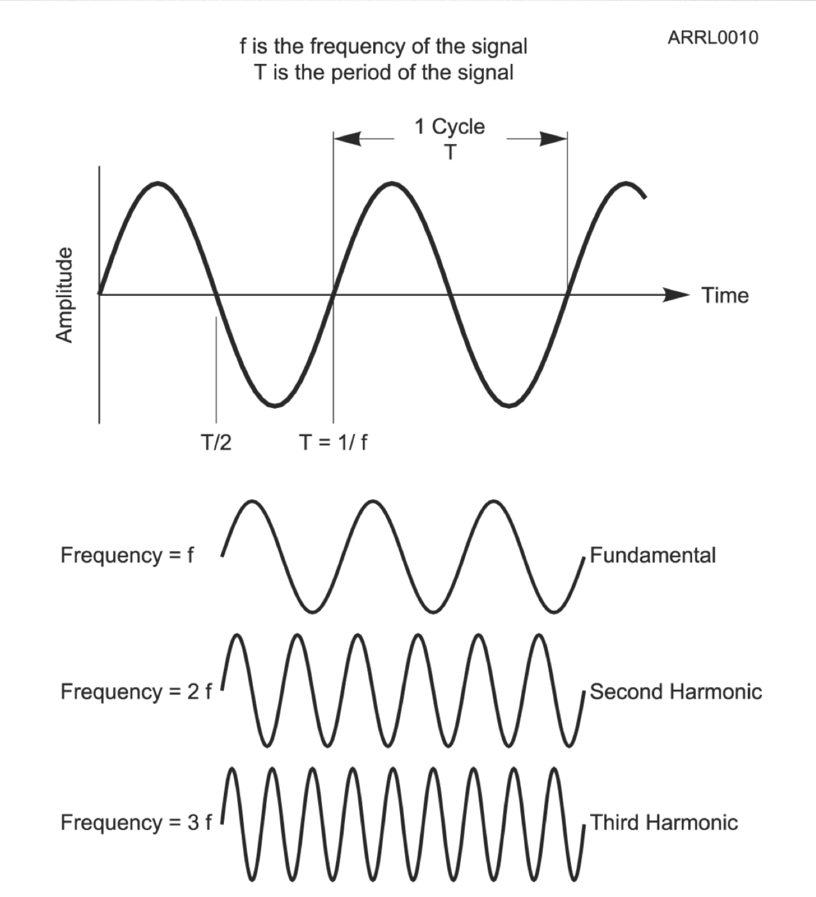
ARRL The national association for AMATEUR RADIO

Wave Vocabulary

– *Amplitude*

Defined as

The strength or magnitude of a signal



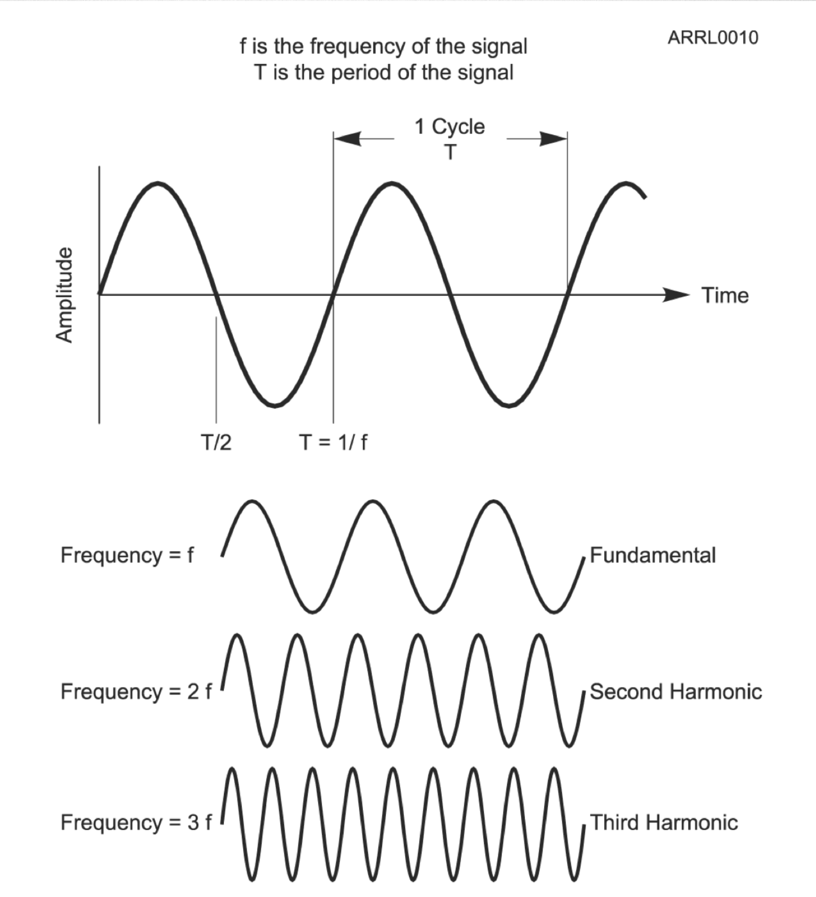
ARRL The national association for AMATEUR RADIO

Wave Vocabulary

– *Frequency (hertz, Hz)*

Defined as

The number of complete cycles per second of an ac current or ac voltage

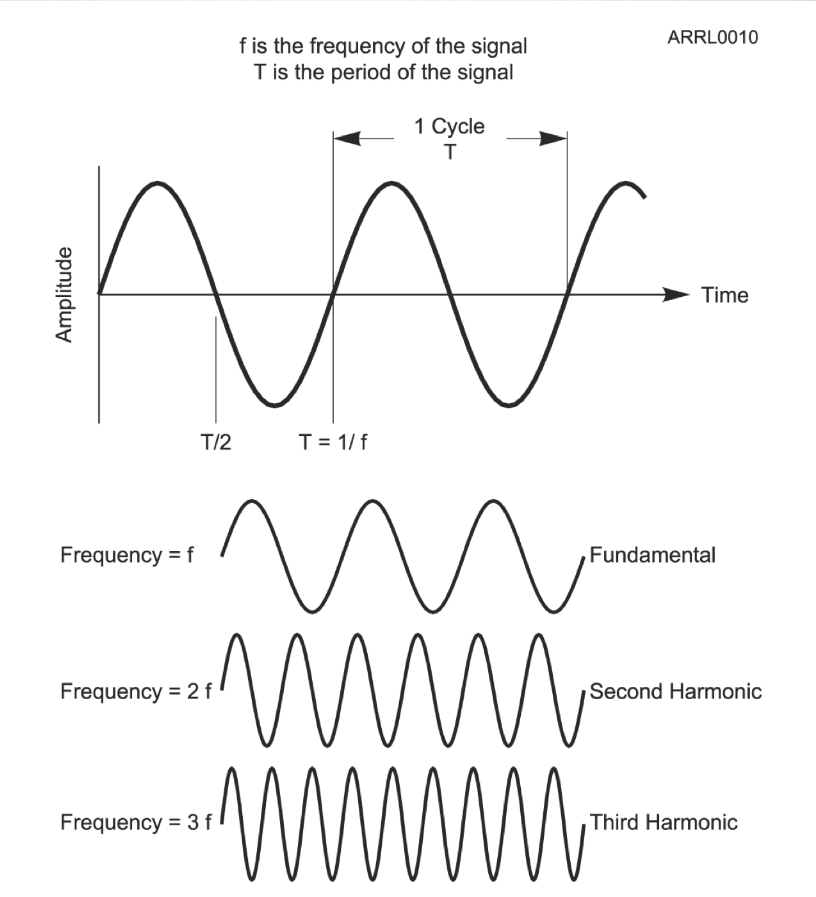


Wave Vocabulary

– *Period (seconds, s)*

Defined as

The time it takes for one complete cycle of a repeating waveform. The reciprocal of frequency.



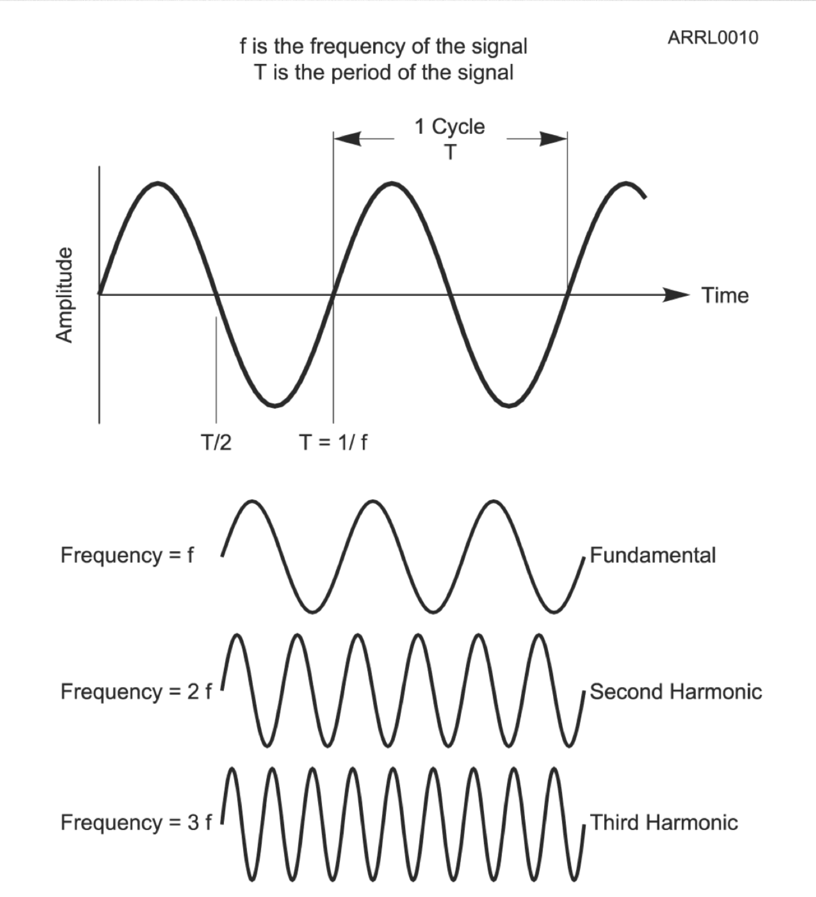
ARRL The national association for AMATEUR RADIO

Wave Vocabulary

– *Fundamental*

Defined as

The frequency of which all harmonics are integer multiples.



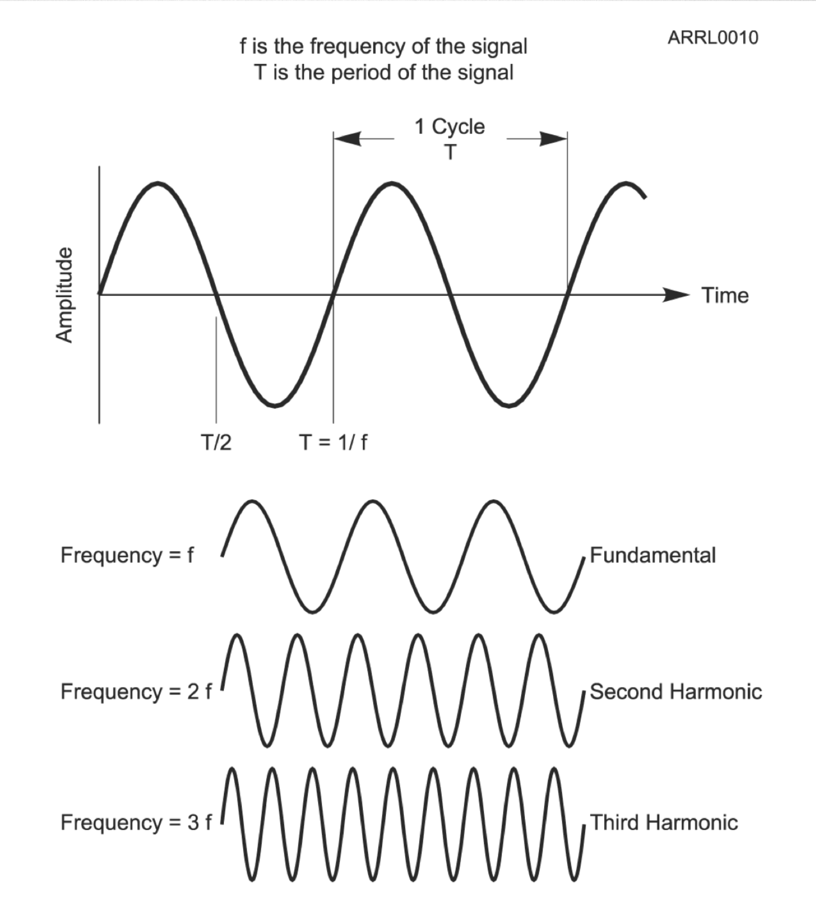
ARRL The national association for AMATEUR RADIO

Wave Vocabulary

– *Harmonics (1st, 2nd, 3rd, 4th, etc.)*

Defined as

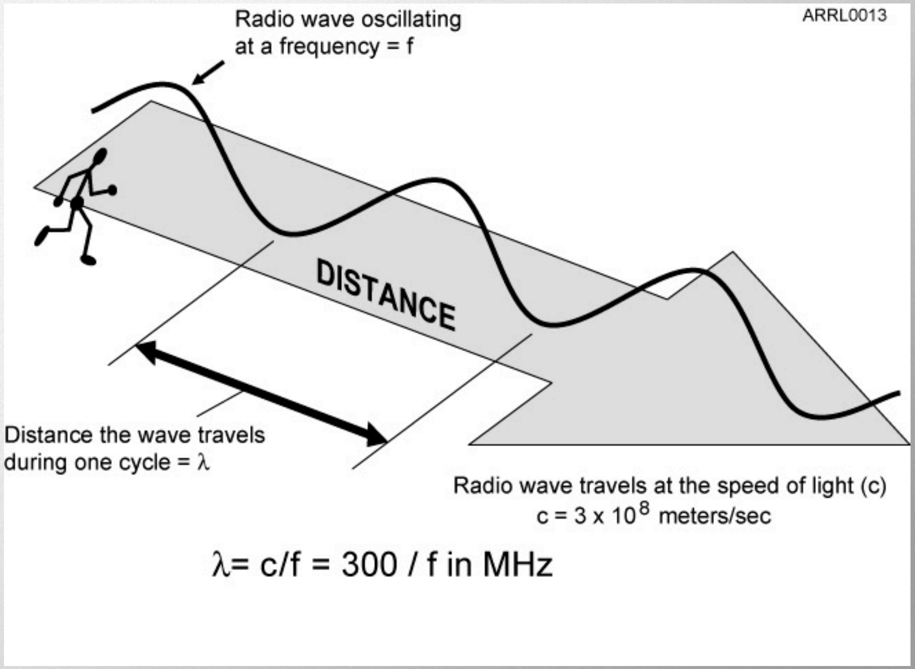
A signal that is an integer multiple of a fundamental frequency



The national association for AMATEUR RADIO

Wavelength

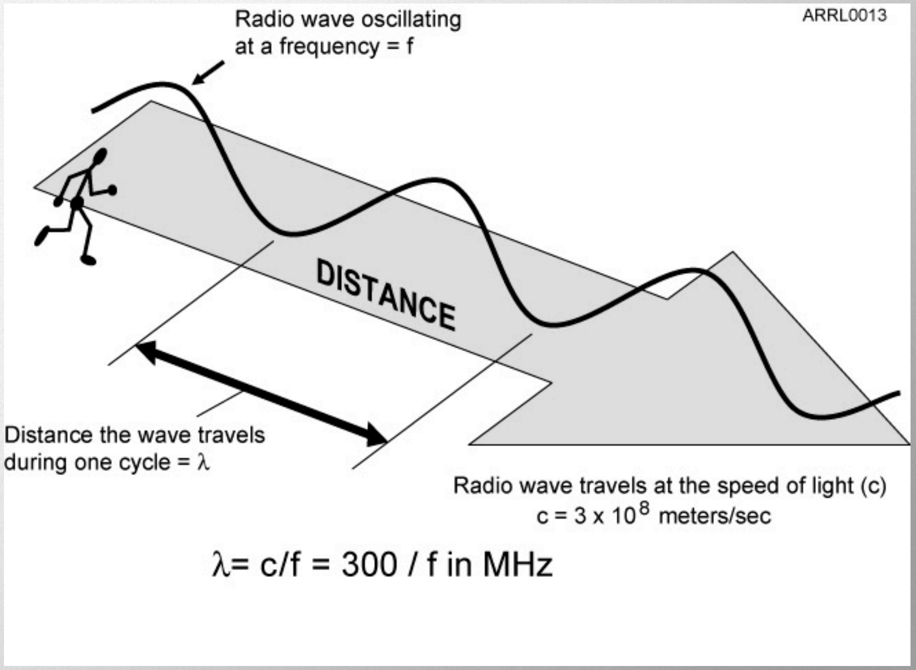
- *Wavelength* is the distance a radio wave travels during one cycle of the wave's electric and magnetic fields.



The national association for AMATEUR RADIO

Wavelength

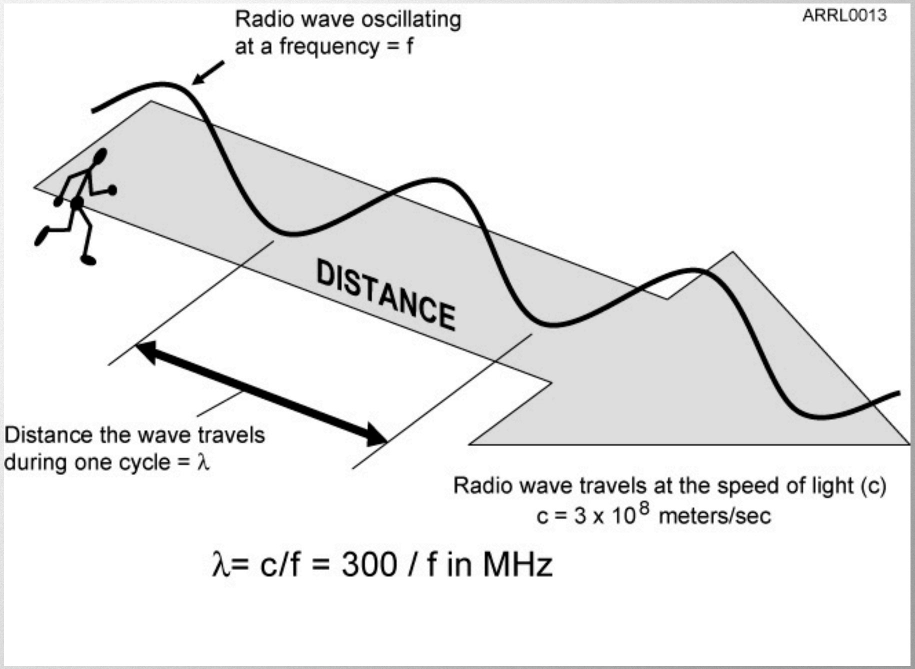
- *Wavelength* is the distance a radio wave travels during one cycle of the wave's electric and magnetic fields.
  - λ (lambda) is the symbol for wavelength



ARRL The national association for AMATEUR RADIO

Wavelength

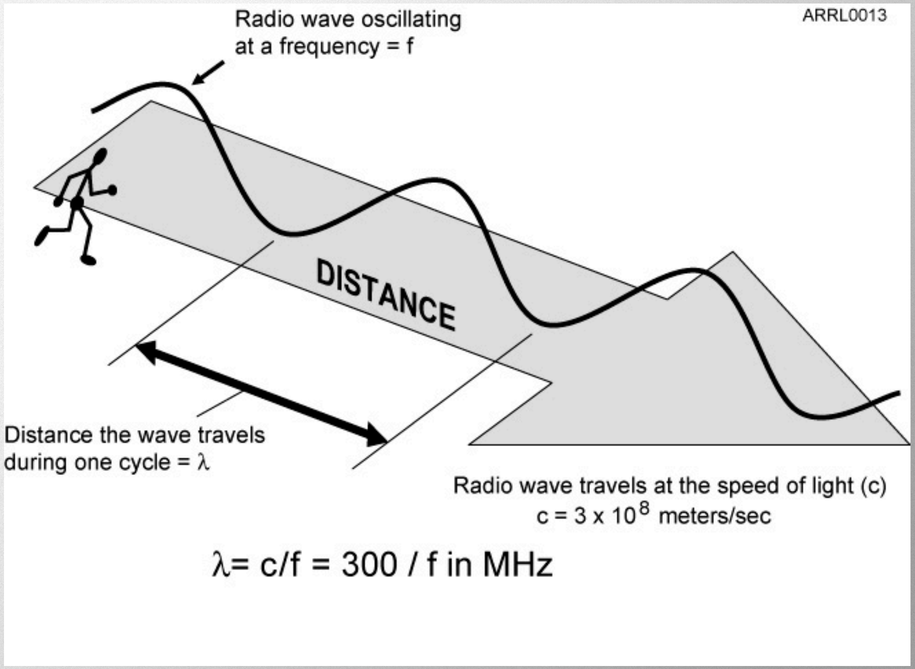
- *Wavelength* is the distance a radio wave travels during one cycle of the wave's electric and magnetic fields.
  - λ (lambda) is the symbol for wavelength
  - Waves travel at the speed of light, *c*.



ARRL The national association for AMATEUR RADIO

Wavelength

- *Wavelength* is the distance a radio wave travels during one cycle of the wave's electric and magnetic fields.
  - λ (lambda) is the symbol for wavelength
  - Waves travel at the speed of light, *c*.
  - Hams can refer to bands by frequency (50 MHz) or by wave-length (6 meters)



ARRL The national association for AMATEUR RADIO

Wavelength

How do we calculate the Wavelength of a Wave?

Wavelength

How do we calculate the Wavelength of a Wave?

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

- 300,000,000 / Frequency in Hz
- 300 / Frequency in MegaHertz
- Higher Frequency ⟺ Shorter Wavelength
- Lower Frequency ⟺ Longer Wavelength

ARRL The national association for AMATEUR RADIO

Electromagnetic Waves

- *Electromagnetic waves* are made up of electric and magnetic energy (*fields*).

ARRL The national association for AMATEUR RADIO

Electromagnetic Waves

- *Electromagnetic waves* are made up of electric and magnetic energy (*fields*).
- The electric and magnetic fields vary in the pattern of a sine wave.

ARRL The national association for AMATEUR RADIO

Electromagnetic Waves

- *Electromagnetic waves* are made up of electric and magnetic energy (*fields*).
- The electric and magnetic fields vary in the pattern of a sine wave.
- Electromagnetic waves travel at the speed of light.

Electromagnetic Waves

- Moving electrons in an antenna takes the place of the moving magnet.

Electromagnetic Waves

- Moving electrons in an antenna takes the place of the moving magnet.
- A Signal from a transmitter can make the electrons in an antenna move, transferring energy from the signal to electromagnetic waves.

Electromagnetic Waves

- The same process works “backwards” too.
- Electromagnetic waves encountering an antenna make electrons move in sync with the wave.
- Electromagnetic energy is transferred from the wave to the electrons.
- The moving electrons create a signal that can be detected by the receiver.

ARRL The national association for AMATEUR RADIO

Electromagnetic Waves

Radio is the use of Electromagnetic waves to carry the information you want to send.

Electromagnetic Waves

Radio is the use of Electromagnetic waves to carry the information you want to send.

- The Radio Frequency voltage on the Antenna creates an alternating Electric Field.

ARRL The national association for AMATEUR RADIO

Electromagnetic Waves

Radio is the use of Electromagnetic waves to carry the information you want to send.

- The Radio Frequency voltage on the Antenna creates an alternating Electric Field.
- The Radio Frequency current in an Antenna creates an alternating Magnetic Field.

Electromagnetic Waves

Radio is the use of Electromagnetic waves to carry the information you want to send.

- The Radio Frequency voltage on the Antenna creates an alternating Electric Field.
- The Radio Frequency current in an Antenna creates an alternating Magnetic Field.
- At some small distance from the antenna, the Electric and Magnetic fields combine into an Electromagnetic Wave which spreads through space.

ARRL The national association for AMATEUR RADIO

Fundamentals of EM (Radio) Waves

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

ARRL The national association for AMATEUR RADIO

Fundamentals of EM (Radio) Waves

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

- Energy in the wave travels at the velocity of light 300,000,000 meters per second (186,000 miles per second).

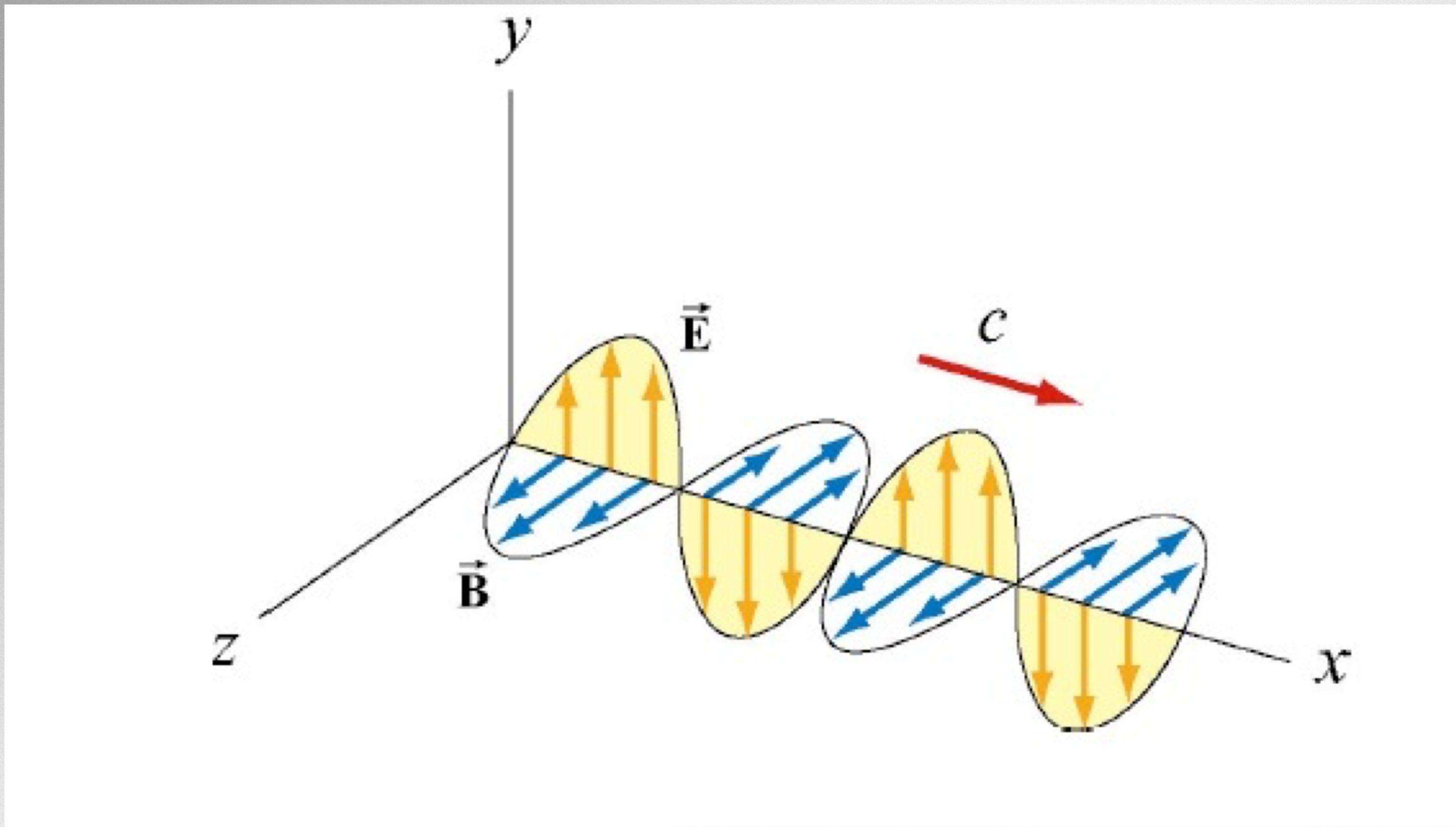
ARRL The national association for AMATEUR RADIO

Fundamentals of EM (Radio) Waves

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

- Energy in the wave travels 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.

ARRL The national association for AMATEUR RADIO


y
E
c
B
z
x

Electromagnetic Spectrum
Radio Frequency (RF) Spectrum

ARRL The national association for AMATEUR RADIO

Electromagnetic Spectrum Radio Frequency (RF) Spectrum

- The electromagnetic *spectrum* is divided into ranges of frequencies in which electromagnetic waves behave similarly.

ARRL The national association for AMATEUR RADIO

Electromagnetic Spectrum Radio Frequency (RF) Spectrum

- The electromagnetic *spectrum* is divided into ranges of frequencies in which electromagnetic waves behave similarly.
- Each range or segment has a different name.

Electromagnetic Spectrum Radio Frequency (RF) Spectrum

- The electromagnetic *spectrum* is divided into ranges of frequencies in which electromagnetic waves behave similarly.
- Each range or segment has a different name.
- Waves with a certain range of frequencies that can be used for communication are called *radio waves*.

ARRL The national association for AMATEUR RADIO

Radio Spectrum

The national association for
AMATEUR RADIO

Radio Spectrum

- Parts of the spectrum allocated for a common purpose are called a *band*, such as the "AM band" or "CB band."

ARRL The national association for AMATEUR RADIO

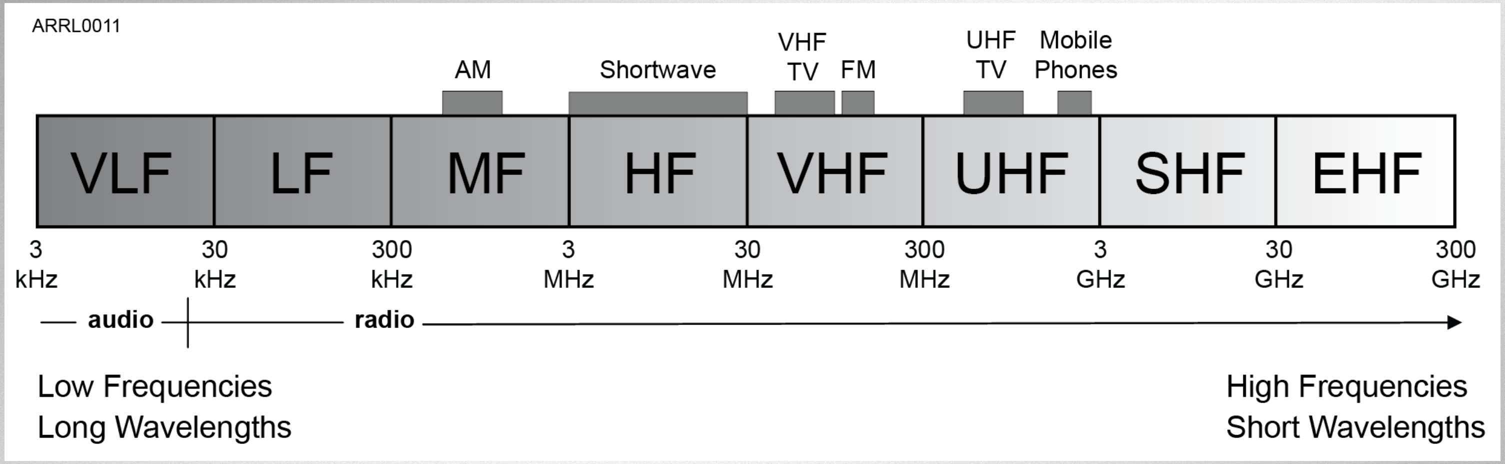
Radio Spectrum

- Parts of the spectrum allocated for a common purpose are called a *band*, such as the “AM band” or “CB band.”
- Signals in these bands are usually of the same type for commercial services

Radio Spectrum

- Parts of the spectrum allocated for a common purpose are called a *band*, such as the "AM band" or "CB band."
- Signals in these bands are usually of the same type for commercial services
- Hams share the band across many signals of different types

Radio Spectrum



- The part of the electromagnetic spectrum composed of radio waves is called the *radio frequency* or *RF* spectrum.

ARRL The national association for AMATEUR RADIO

What are the Amateur Radio Bands?

Amateurs are allowed to transmit inside bands of frequencies. There are too many bands to list on one slide. Use the ARRL chart to study.

What are the Amateur Radio Bands?

Amateurs are allowed to transmit inside bands of frequencies. There are too many bands to list on one slide. Use the ARRL chart to study.

- Bands are allocated in MF, HF, VHF, UHF, and SHF spectrum, (1.8 MHz and higher)

ARRL The national association for AMATEUR RADIO

What are the Amateur Radio Bands?

Amateurs are allowed to transmit inside bands of frequencies. There are too many bands to list on one slide. Use the ARRL chart to study.

- Bands are allocated in MF, HF, VHF, UHF, and SHF spectrum, (1.8 MHz and higher)
- Bands are named by frequency or wavelength.

ARRL The national association for AMATEUR RADIO

What are the Amateur Radio Bands?

Amateurs are allowed to transmit inside bands of frequencies. There are too many bands to list on one slide. Use the ARRL chart to study.

- Bands are allocated in MF, HF, VHF, UHF, and SHF spectrum, (1.8 MHz and higher)
- Bands are named by frequency or wavelength.
- Bands are divided into segments for different modes. On HF, voice at high end, digital lower than voice, and CW exclusively at low end.

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.

ARRL The national association for AMATEUR RADIO®

Amateurs wishing to operate on either 2,200 or 630 meters must first register with the Utilities Technology Council online at **https://utc.org/plc-database-amateur-notification-process/.** You need only register once for each band.

2,200 Meters (135 kHz)

E,A,G

135.7 kHz 1 W EIRP maximum **137.8 kHz**

630 Meters (472 kHz)

5 W EIRP maximum, except in Alaska within 496 miles of Russia where the power limit is 1 W EIRP.

E,A,G

472 kHz **479 kHz**

160 Meters (1.8 MHz)

Avoid interference to radiolocation operations from 1.900 to 2.000 MHz

E,A,G

1.800 1.900 2.000 MHz

80 Meters (3.5 MHz)

3.500 3.600 3.700 4.000 MHz

E
A
G
N,T (*200 W*)

3.800

3.525 3.600

60 Meters (5.3 MHz)

CW, Dig 5332 5348 5358.5 5373 5405 kHz

2.8 kHz

E,A,G (*100 W*)

USB 5330.5 5346.5 5357.0 5371.5 5403.5 kHz

General, Advanced, and Amateur Extra licensees may operate on these five channels on a secondary basis with a maximum effective radiated power (ERP) of 100 W PEP relative to a half-wave dipole. Permitted operating modes include upper sideband voice (USB), CW, RTTY, PSK31 and other digital modes such as PACTOR III. Only one signal at a time is permitted on any channel.

40 Meters (7 MHz)

7.000 7.075 7.100 7.300 MHz

ITU 1,3 and FCC region 2 west of 130° west or below 20° north

E
A
G
N,T (*200 W*)

7.175

N,T *outside region 2*

7.025 7.125

See Sections 97.305(c), 97.307(f)(11) and 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.

200 Watts PEP E,A,G

10.100 10.150 MHz

20 Meters (14 MHz)

14.000 14.150 14.350 MHz

E
A
G

14.175

14.025 14.150 14.225

17 Meters (18 MHz)

E,A,G

18.068 18.110 18.168 MHz

15 Meters (21 MHz)

21.000 21.200 21.450 MHz

E
A
G
N,T (*200 W*)

21.225

21.275

21.025 21.200

12 Meters (24 MHz)

E,A,G

24.890 24.930 24.990 MHz

10 Meters (28 MHz)

28.000 28.300 29.700 MHz

E,A,G

N,T (*200 W*)

28.000 28.500

6 Meters (50 MHz)

50.1

E,A,G,T

50.0 54.0 MHz

2 Meters (144 MHz)

144.1

E,A,G,T

144.0 148.0 MHz

1.25 Meters (222 MHz)

E,A,G,T
N (*25 W*)

219.0 220.0 222.0 225.0 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)*

E,A,G,T

420.0 450.0 MHz

33 cm (902 MHz)*

E,A,G,T

902.0 928.0 MHz

23 cm (1240 MHz)*

1240 1300 MHz

E,A,G,T
N (*5 W*)

1270 1295

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
2390-2450 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.
MCW is authorized above 50.1 MHz, except for 144.0-144.1 and 219-220 MHz.
Test transmissions are authorized above 51 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.

ARRL
We're At Your Service

ARRL Headquarters:
860-594-0200 (Fax 860-594-0259)
email: hq@arrl.org

Publication Orders:
www.arrl.org/shop
Toll-Free 1-888-277-5289 (860-594-0355)
email: orders@arrl.org

Membership/Circulation Desk:
www.arrl.org/membership
Toll-Free 1-888-277-5289 (860-594-0338)
email: membership@arrl.org

Getting Started in Amateur Radio:
Toll-Free 1-800-326-3942 (860-594-0355)
email: newham@arrl.org

Exams: 860-594-0300 email: vec@arrl.org

Bands and Frequencies

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

Bands and Frequencies

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

- Frequency – a distinct frequency point. Specified in KiloHertz (KHz), MegaHertz (MHz), or GigaHertz (GHz)

Bands and Frequencies

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

- Frequency – a distinct frequency point.
  Specified in KiloHertz (KHz), MegaHertz (MHz), or GigaHertz (GHz)
- Wavelength – The wavelength in Meters or centimeters ($300 / F_{MHz}$).

ARRL The national association for AMATEUR RADIO

Bands and Frequencies

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

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

ARRL The national association for AMATEUR RADIO

Frequency vs. Band Examples

Amateurs are allocated bands of frequencies.
Bands are often named for the wavelength of o
frequency in the band.

Frequency vs. Band Examples

Amateurs are allocated bands of frequencies. Bands are often named for the wavelength of o frequency in the band.

Wavelength in Meters. L=(300 / F $_{MHZ}$)

- 300/146 MHz = 2.05 Meters

ARRL The national association for AMATEUR RADIO

Frequency vs. Band Examples

Amateurs are allocated bands of frequencies. Bands are often named for the wavelength of o frequency in the band.

Wavelength in Meters. $L=(300 / F_{MHZ})$

- 300/146 MHz = 2.05 Meters
- 144 MHz – 148 MHz ⇔ 2 Meters

Frequency in MHz. $F_{MHz} = (300 / L)$

ARRL The national association for AMATEUR RADIO

Frequency vs. Band Examples

Amateurs are allocated bands of frequencies. Bands are often named for the wavelength of o frequency in the band.

Wavelength in Meters. $L=(300 / F_{MHZ})$

- 300/146 MHz = 2.05 Meters
- 144 MHz – 148 MHz ⇔ 2 Meters

Frequency in MHz. $F_{MHz} = (300 / L)$

- 300 / 6 Meters = 50 MHz

ARRL The national association for AMATEUR RADIO

Frequency vs. Band Examples

Amateurs are allocated bands of frequencies. Bands are often named for the wavelength of o frequency in the band.

Wavelength in Meters. $L=(300 / F_{MHZ})$

- 300/146 MHz = 2.05 Meters
- 144 MHz – 148 MHz ⇔ 2 Meters

Frequency in MHz. $F_{MHz} = (300 / L)$

- 300 / 6 Meters = 50 MHz
- 6 Meters ⇔ 50 MHz – 54MHz

ARRL The national association for AMATEUR RADIO

Station Effects of Wavelength

For the station antenna to efficiently send the radio wave out into space, the antenna must be designed for the specific operating frequency.

Station Effects of Wavelength

For the station antenna to efficiently send the radio wave out into space, the antenna must be designed for the specific operating frequency.

- Antennas with the wavelengths greater than one fourth of a wavelength can be very efficient.

ARRL The national association for AMATEUR RADIO

Propagation Effects of Wavelength

Radio signals propagate through space and in the atmosphere. Expected propagation distances depend on the signal wavelength.

- Long and Medium wavelengths are best for waves along the ground of water. (LF, MF)
- Short wavelengths are best for reflection by the Ionospheric layers. (HF)

ARRL The national association for AMATEUR RADIO

Propagation Effects of Wavelength

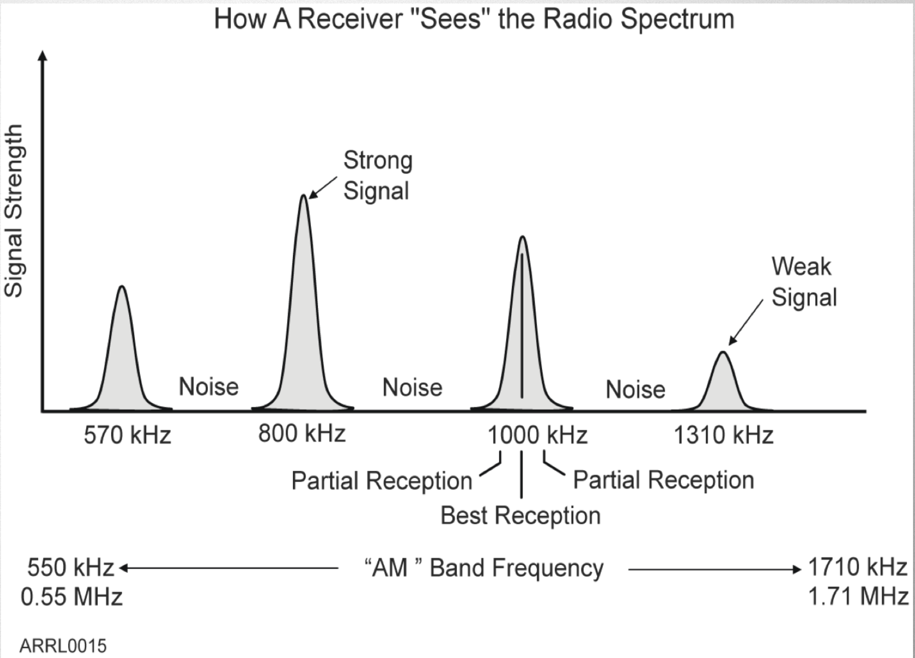
Radio signals propagate through space and in the atmosphere. Expected propagation distances depend on the signal wavelength.

- Long and Medium wavelengths are best for waves along the ground of water. (LF, MF)
- Short wavelengths are best for reflection by the Ionospheric layers. (HF)
- Very Short wavelengths are only reliable for line-of-sight propagation. (VHF, UHF, EHF)

ARRL The national association for AMATEUR RADIO

Radio Signals

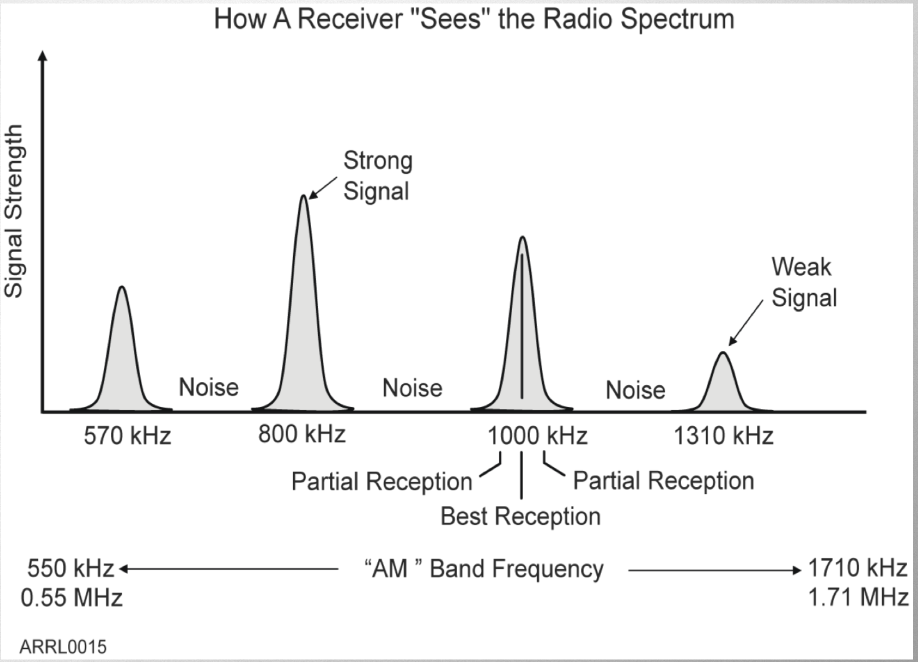
- A radio wave carrying information is a *radio signal*.



ARRL The national association for AMATEUR RADIO

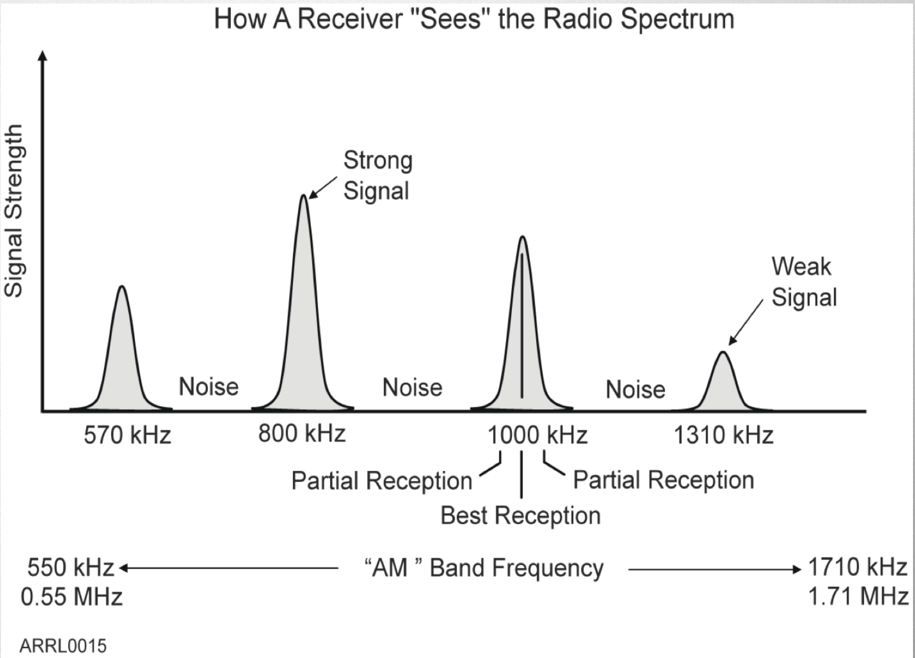
Radio Signals

- A radio wave carrying information is a *radio signal*.
- Each signal occupies a range of frequencies.



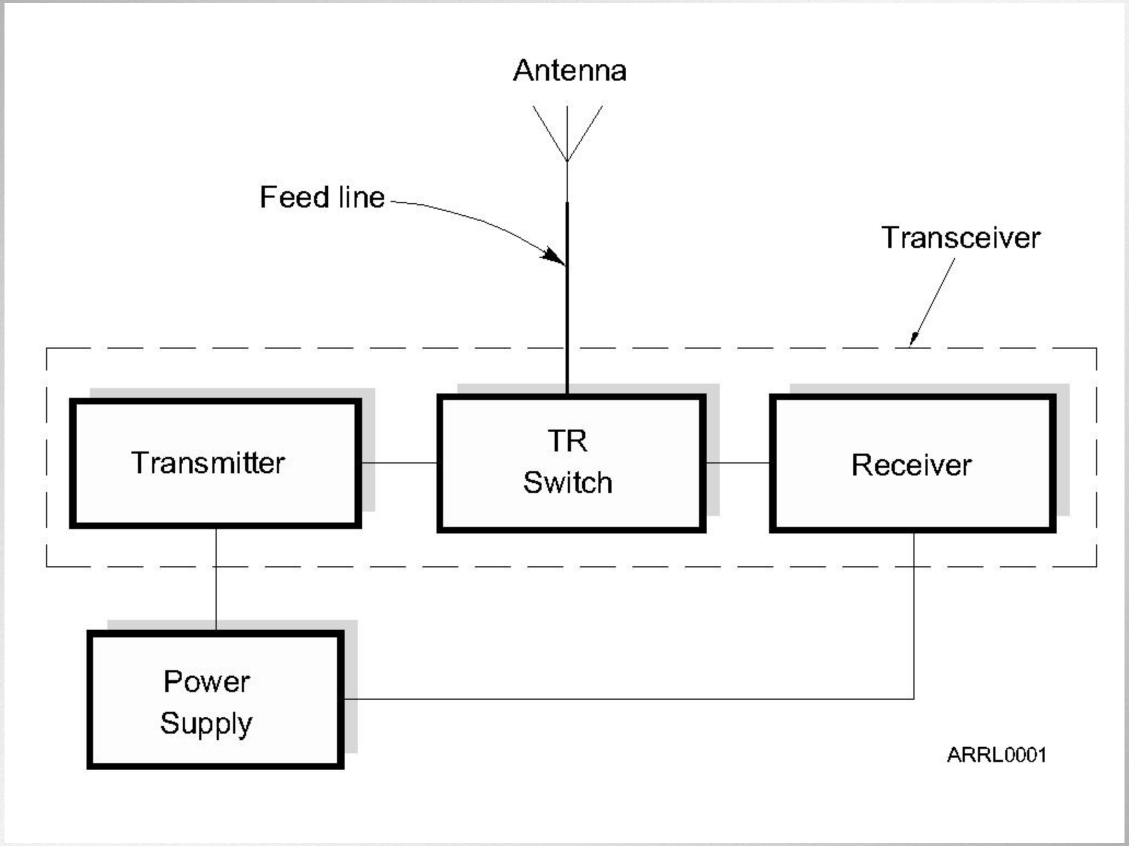
Radio Signals

- A radio wave carrying information is a *radio signal*.
- Each signal occupies a range of frequencies.
- Receivers “tune in” a signal by listening at the signal’s frequency.



ARRL The national association for AMATEUR RADIO

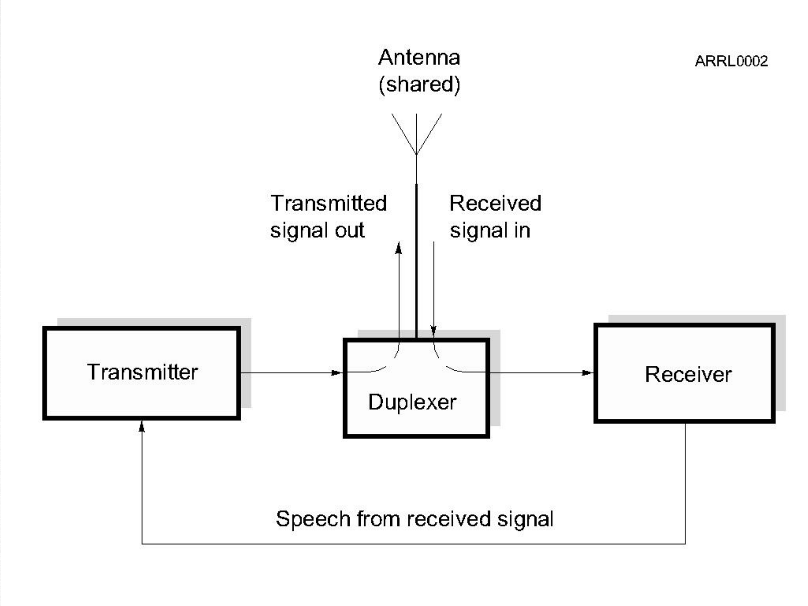
The Basic Radio Station



ARRL The national association for AMATEUR RADIO

Repeaters

- Repeaters consist of a receiver and transmitter that re-transmit the information from a received signal simultaneously on another frequency or channel.



The national association for AMATEUR RADIO

Technician License Course
Chapter 5.1

Modulation and Bandwidth

ARRL The national association for AMATEUR RADIO

What we will talk about

- What happens during radio communications
- How is information added to a Radio Signal?
- What does the Radio term phase refer to?
- What is Amplitude modulation?
- What is bandwidth?
- What is Single sideband modulation?
- What is FM / Phase modulation?

What Happens During Radio Communication?

- Transmitting (sending a signal):
  - Information (voice, data, video, commands, etc.) is converted to electronic form.
  - The information in electronic form is added to a radio wave.
  - The radio wave carrying the information is sent from the station antenna into space.

ARRL The national association for AMATEUR RADIO

What Happens During Radio Communication?

- Receiving:
  - The radio wave carrying the information is intercepted by the receiving station's antenna.
  - The receiver extracts the information from the received wave.
  - The information is then presented to the user in a format that can be understood (sound, picture, words on a computer screen, response to a command, etc.).

ARRL The national association for AMATEUR RADIO

What Happens During Radio Communication?

- Adding and extracting the information can be simple or complex.
- This makes ham radio fun…learning all about how radios work.
- Don't be intimidated. You will be required to only know the basics, but you can learn as much about the "art and science" of radio as you want.

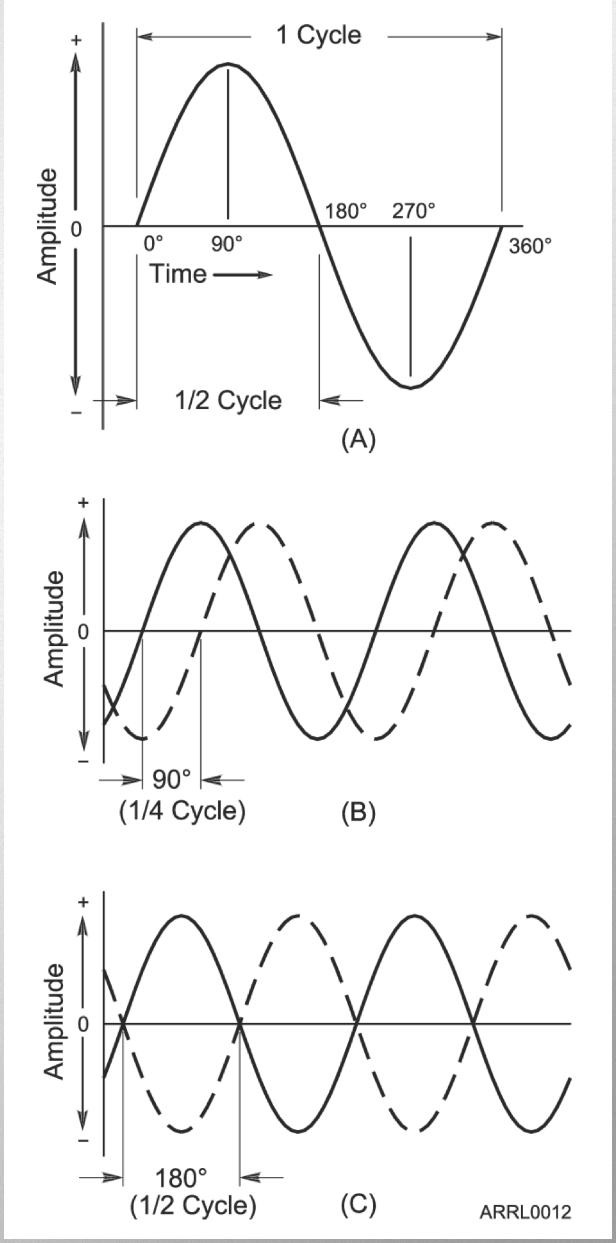
Adding Information – Modulation

- When we add some information to the radio wave, (the *carrier*) we *modulate* the wave.
  - Turn the wave on and off (Morse code)
  - Speech or music
  - Data
- Different modulation techniques vary different properties of the wave to add the information:
  - Amplitude, frequency, or phase

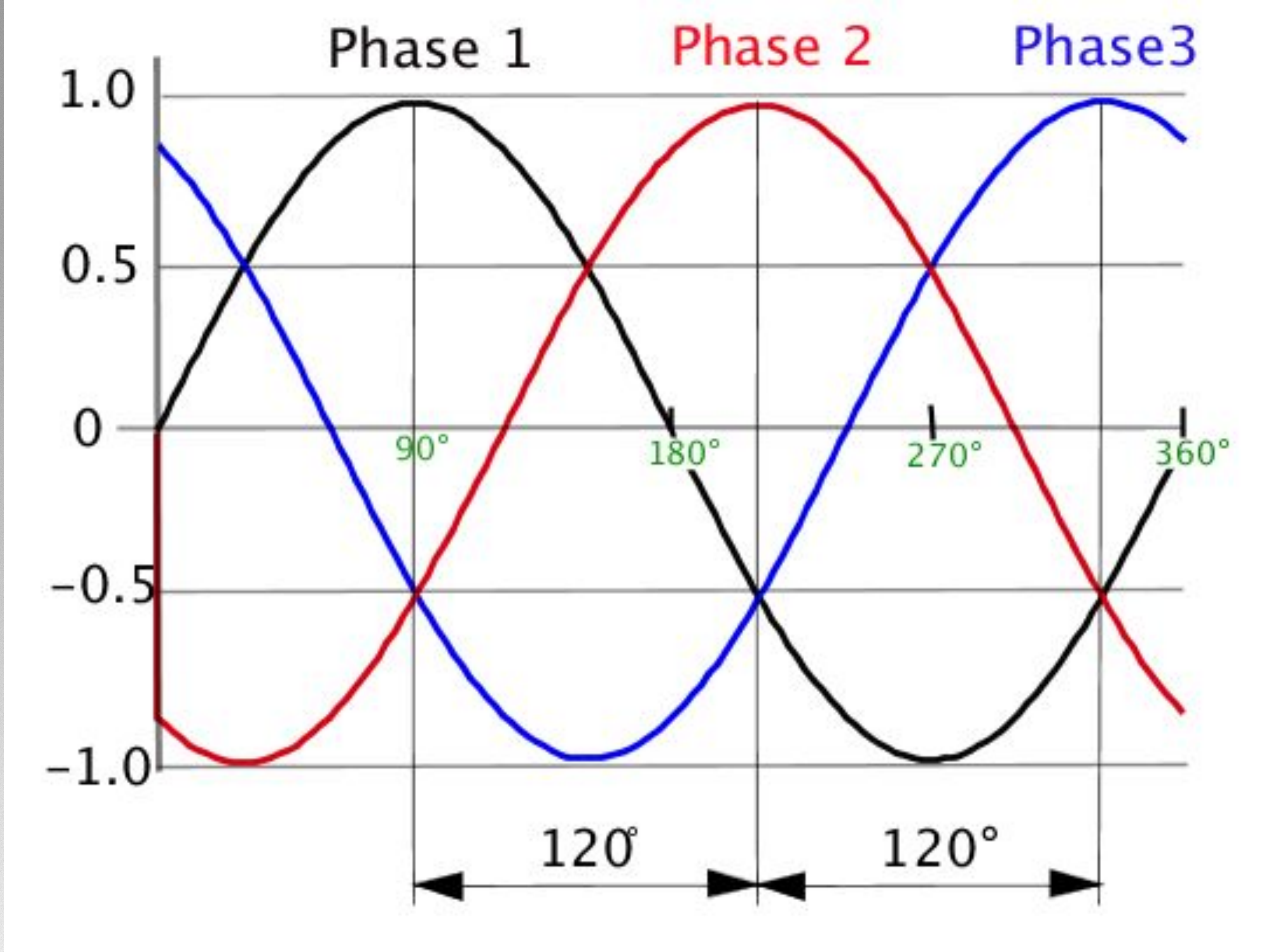
ARRL The national association for AMATEUR RADIO

Phase

- Along with frequency and period, another important property of waves is *phase*.
- Phase is a position within a cycle.
- Phase is also a relative position between two waves.

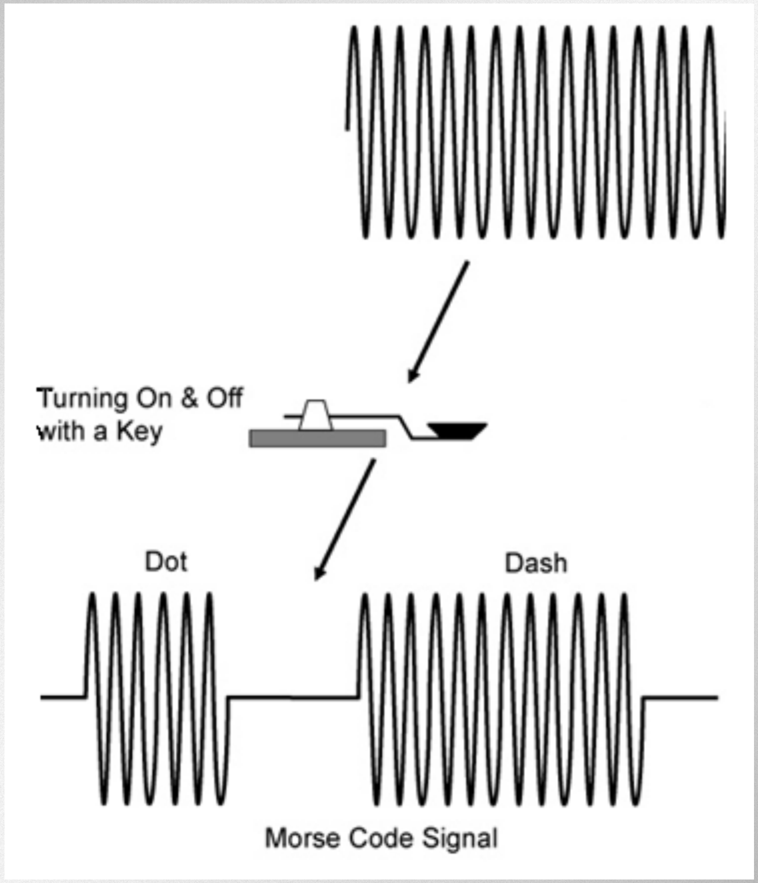


The national association for AMATEUR RADIO



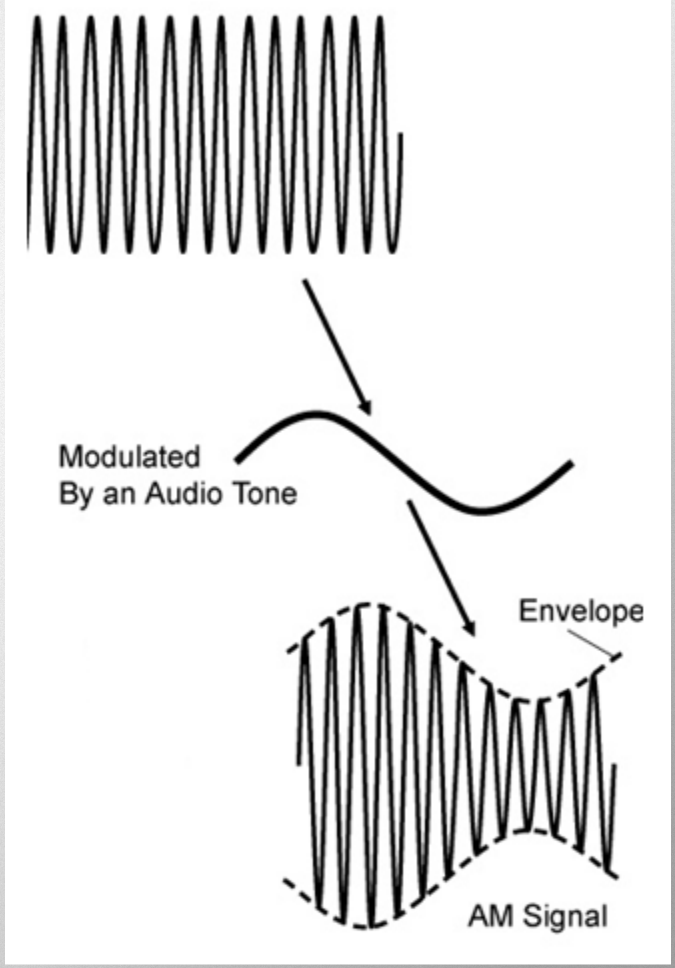
The national association for AMATEUR RADIO

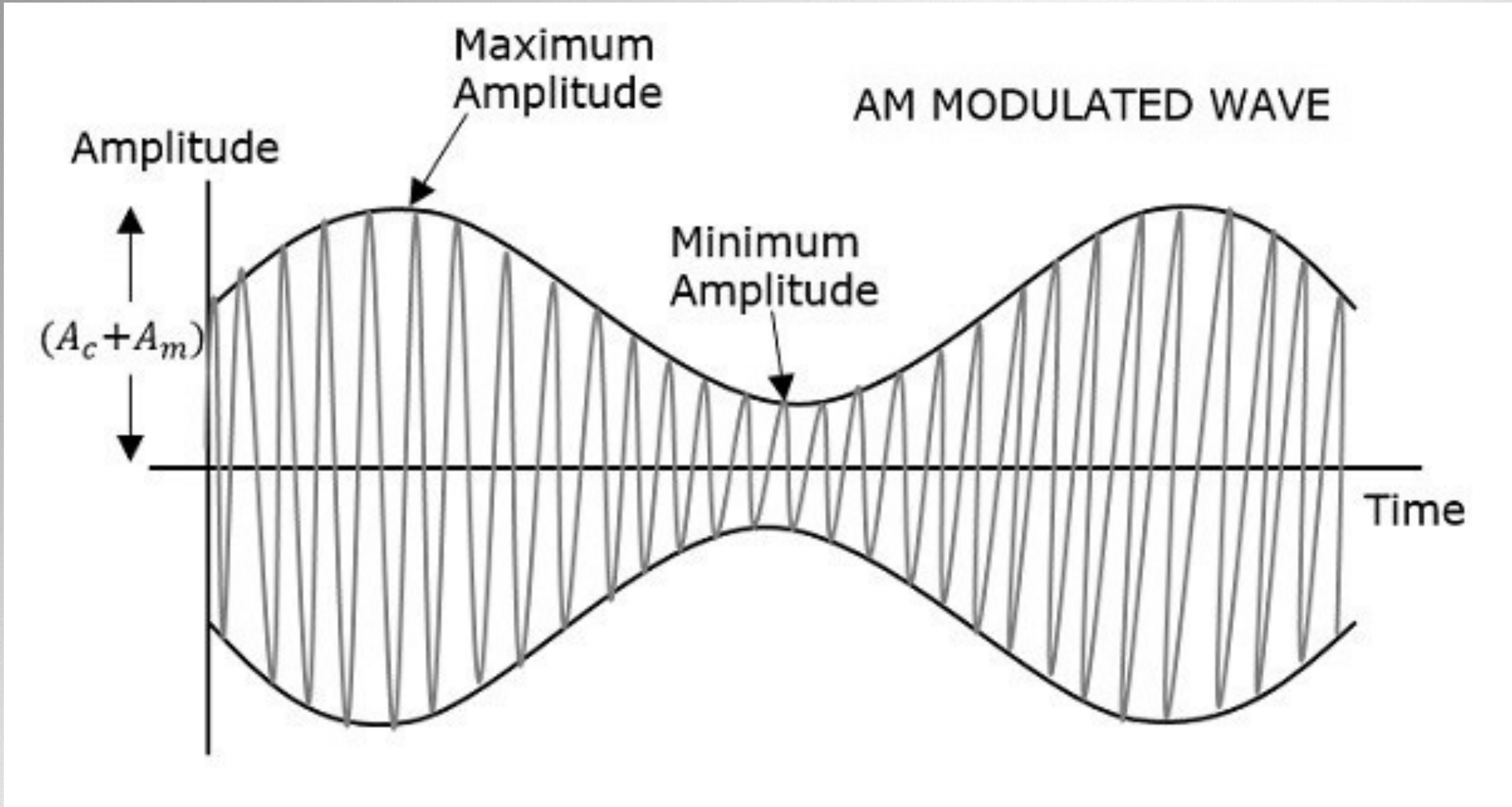
CW - Morse Code – On and Off



Amplitude Modulation (AM)

- In AM, the amplitude of the carrier wave is modified in step with the waveform of the information (the tone shown here).



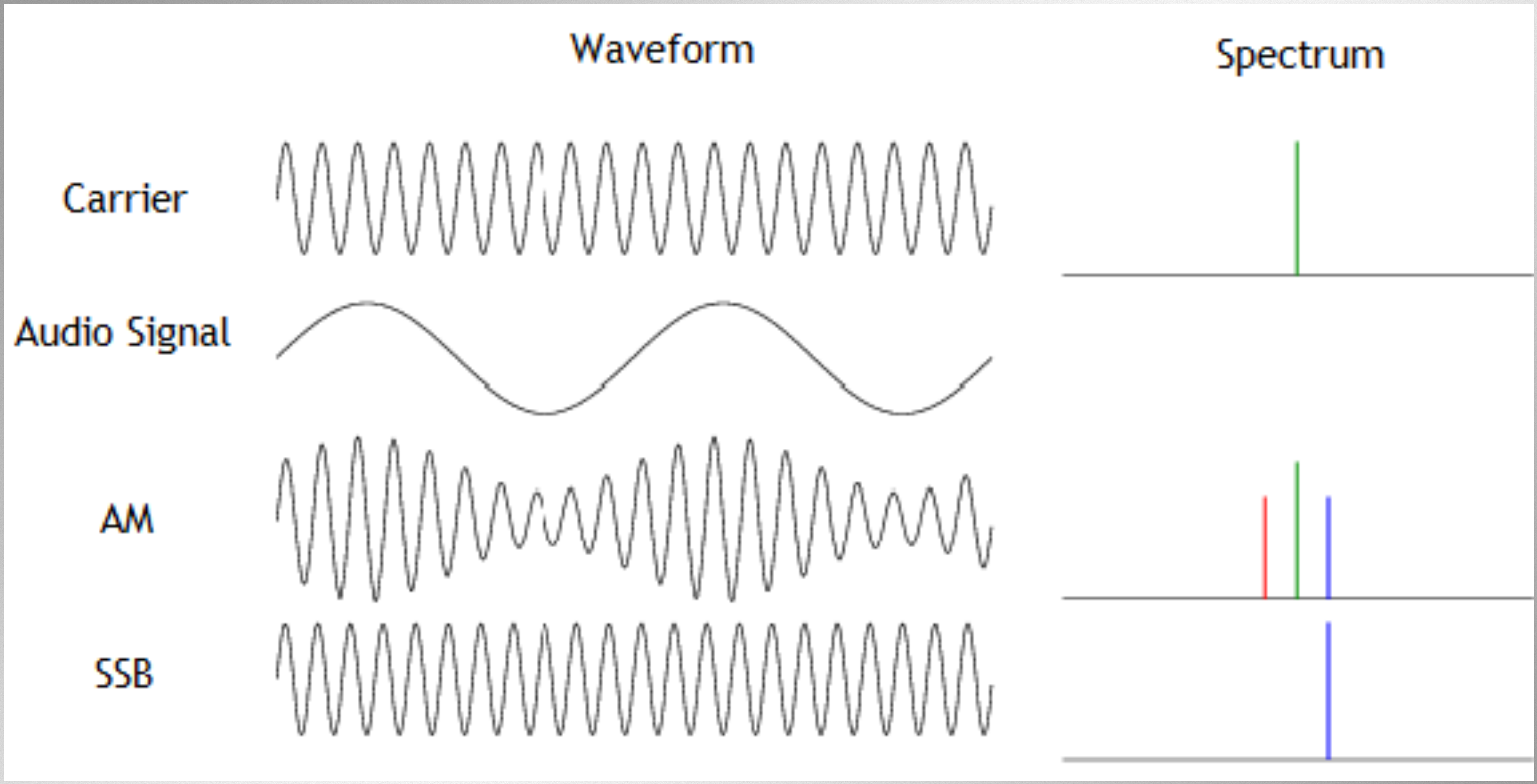


ARRL The national association for AMATEUR RADIO

Composite Signals

- The process of adding information to an unmodulated radio wave creates additional signals called *sidebands*.
- The sidebands and carrier work together to carry the information.
- The combination of carrier and sidebands creates a *composite signal*.

ARRL The national association for AMATEUR RADIO


Waveform
Spectrum
Carrier
Audio Signal
AM
SSB

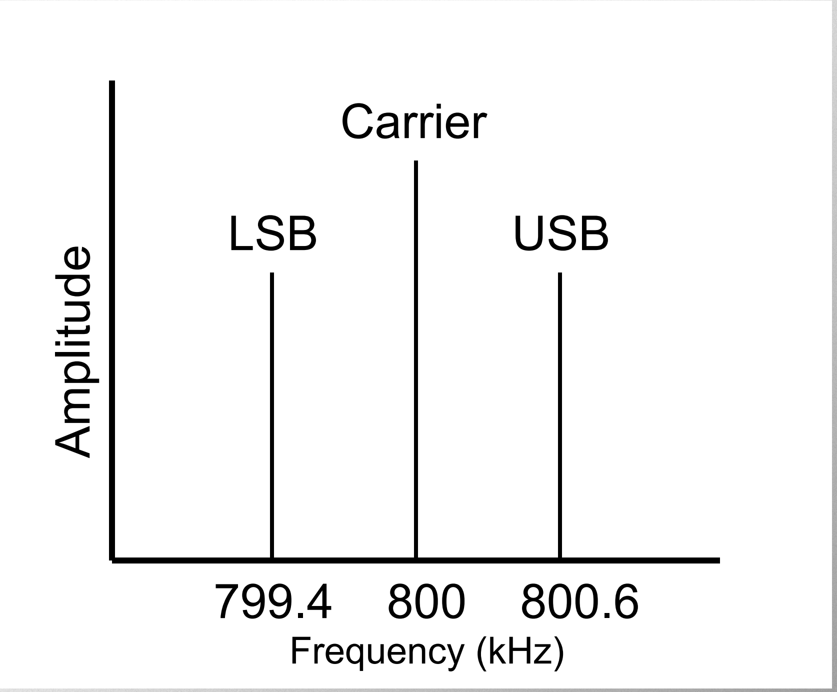
Bandwidth

- The carrier and sidebands have different frequencies, occupying a range of spectrum space.
- The occupied range is the composite signal's *bandwidth*.
- Different types of modulation and information result in different signal bandwidths.

ARRL The national association for AMATEUR RADIO

Characteristics of Voice AM

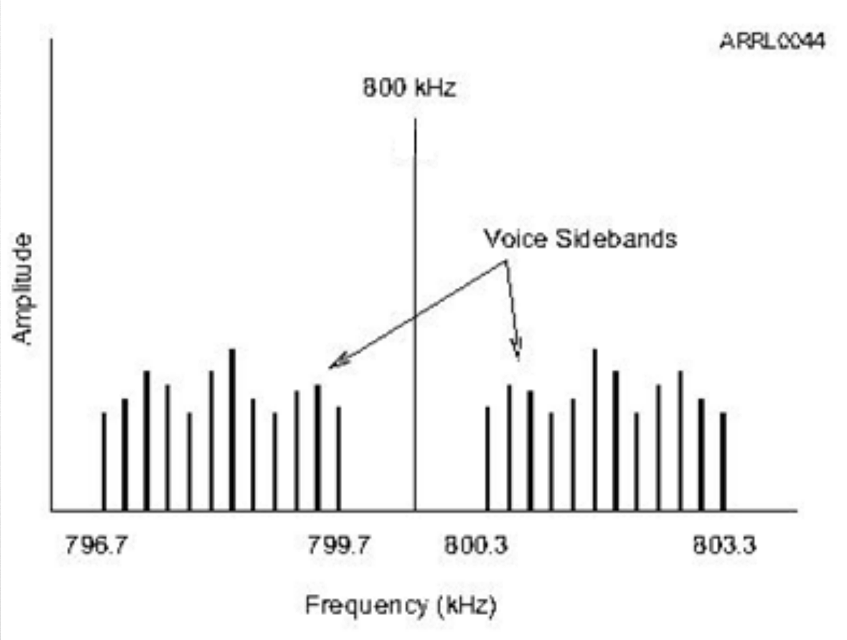
AM signals consist of three components:
  - Carrier
  - Lower sideband (LSB)
  - Upper sideband (USB)
- AM bandwidth is twice the information bandwidth.



AM signal being modulated by a 600 Hz tone

Characteristics of Voice Information

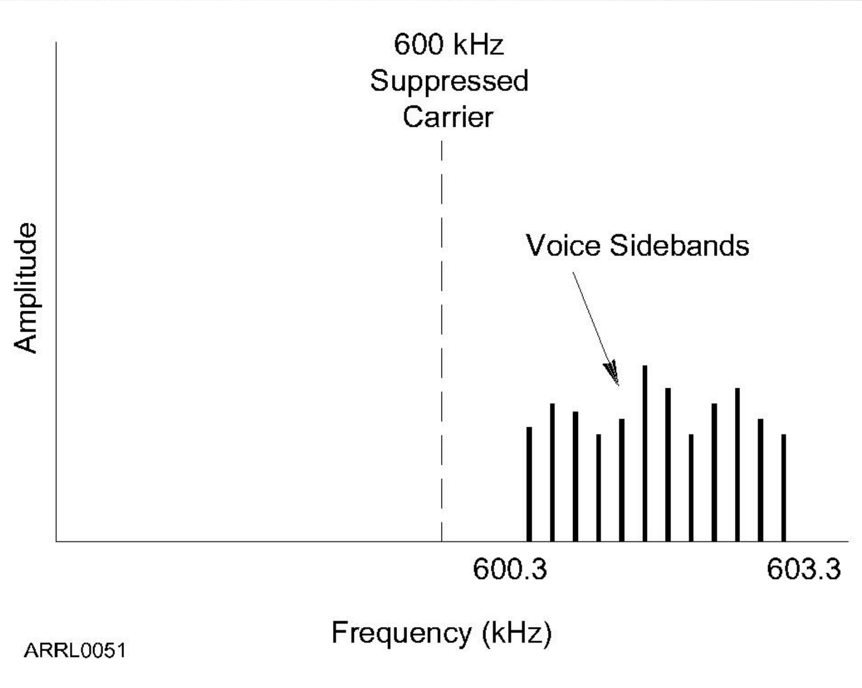
- Sounds that make up voice are a complex mixture of multiple frequencies from 300–3000 Hz
- Two mirror-image sets of sidebands are created, each up to 3000 Hz wide.
- AM voice signal bandwidth 2 x 3000 Hz = 6000 Hz



ARRL The national association for AMATEUR RADIO

Single Sideband Modulation (SSB)

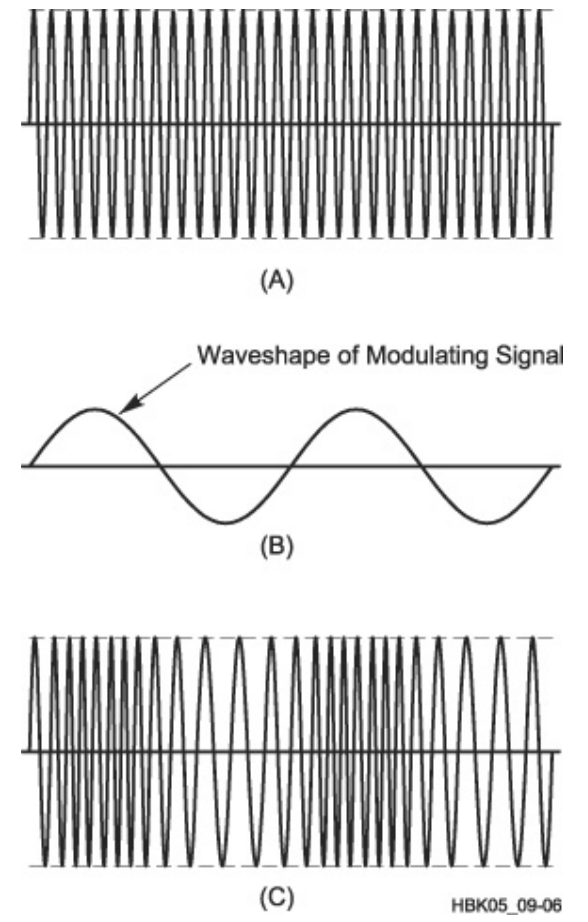
- The two sets of voice sidebands carry duplicate information.
- We can improve efficiency by transmitting only one sideband and reconstructing the missing carrier in the receiver.
- SSB bandwidth is only 3000 Hz for voice signals.



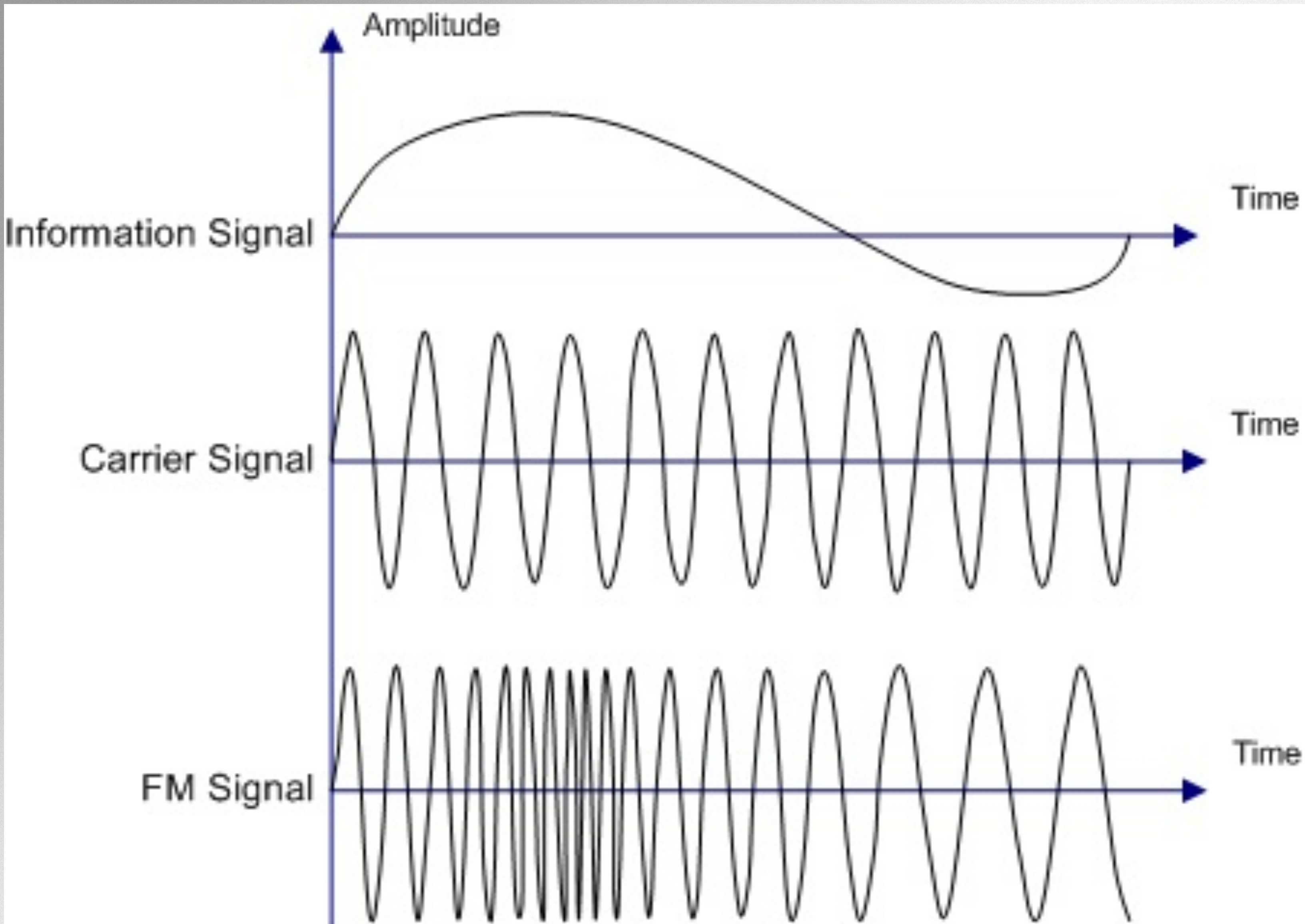
The national association for AMATEUR RADIO

Frequency and Phase Modulation (FM and PM)

- Instead of varying amplitude, if we use the information to vary the carrier's frequency, *frequency modulation (FM)* is produced.
- FM bandwidth (for voice) is between 10 and 15 kHz.
- We can also shift the signal's phase back and forth, creating *phase modulation (PM)* that is very similar to FM.



ARRL The national association for AMATEUR RADIO



The national association for AMATEUR RADIO

Typical Signal Bandwidths

Type of Signal	Typical Bandwidth
AM voice	6 kHz
AM broadcast	10 kHz
Commercial video broadcast	6 MHz
SSB voice	2 to 3 kHz
SSB digital	500 to 3000 Hz (0.5 to 3 kHz)
CW	150 Hz (0.15 kHz)
FM voice	10 to 15 kHz
FM broadcast	150 kHz

Keeping your signal in the Band

Amateur stations may use any frequency in their authorized bands but all frequencies of the signal must be inside the band limits.

- Never operate with the transmitter dial set at the band limit.
  - Inaccurate Dial Calibration
  - Frequency drift
- Set the transmitter dial far enough away from the limit to keep modulation frequencies inside the band.