

Intro to Radio

Hacksburg

Agenda

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 - ▶ Amplitude
 - ▶ Frequency
 - ▶ Bandwidth
 - ▶ Decibel Notion
- ▶ Modulation
 - ▶ Amplitude
 - ▶ Frequency
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- ▶ Rules and Regulations
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- ▶ Building Radios!

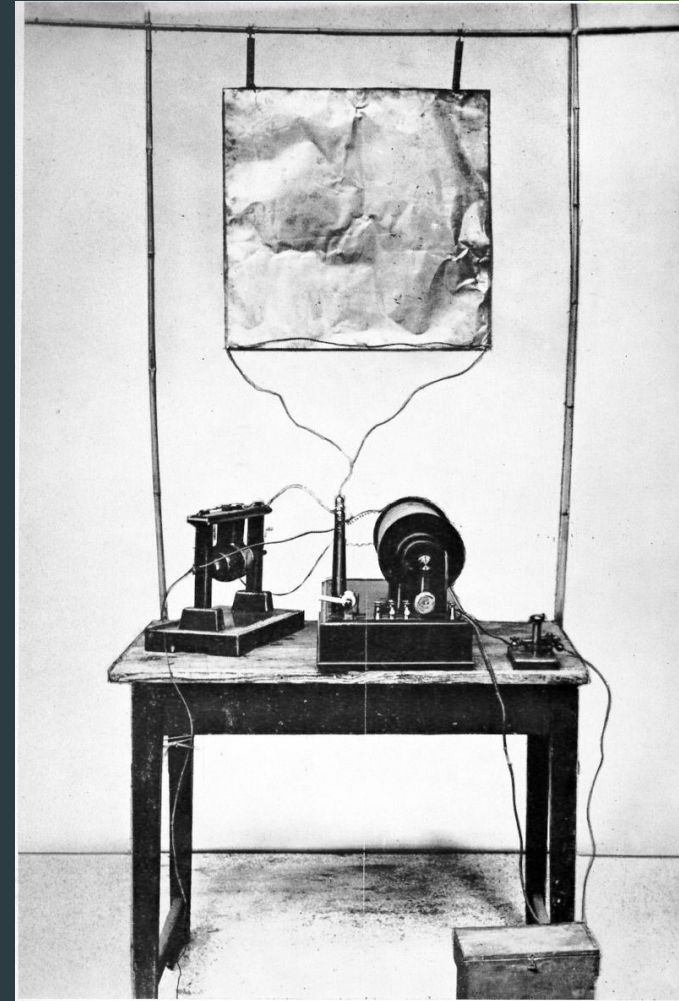
What is Radio

- ▶ Signaling and communicating using electromagnetic waves of frequency between 30 hertz (Hz) and 300 gigahertz (GHz)
- ▶ A transmitter is connected to an antenna which radiates the waves, and received by another antenna connected to a receiver
- ▶ Widely used in communication, radar, navigation, remote control, remote sensing, and many other applications



History

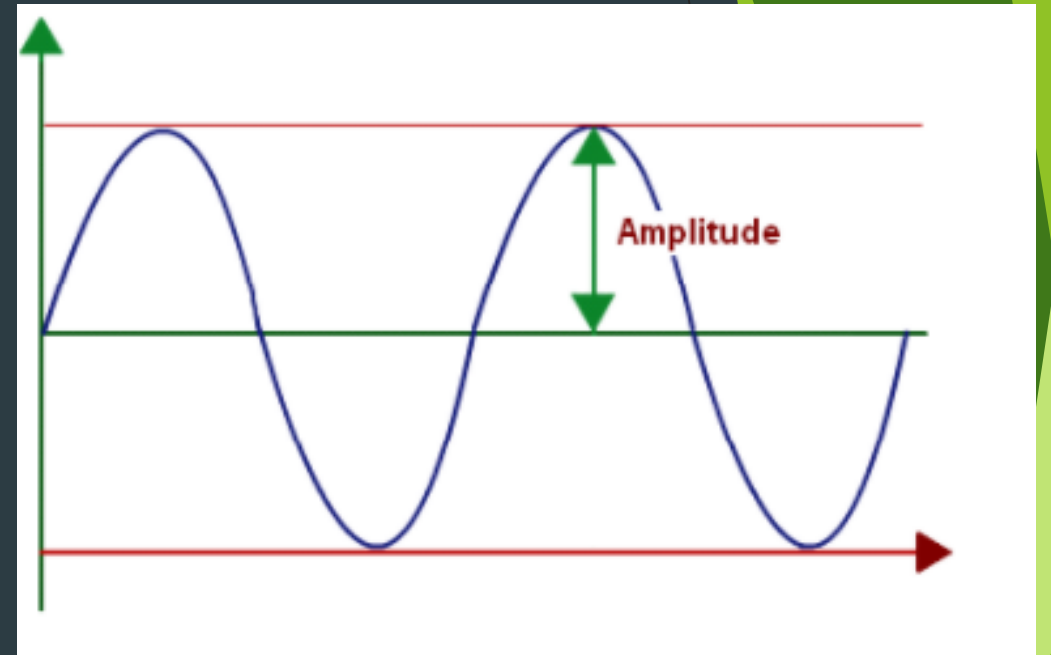
- ▶ Existence of radio waves proven by German physicist Heinrich Hertz in 1886
- ▶ Guglielmo Marconi sent a wireless Morse Code in 1895 and the first transatlantic signal on in 1901
- ▶ First commercial radio broadcast was transmitted in 1920



Marconi's first radio transmitter

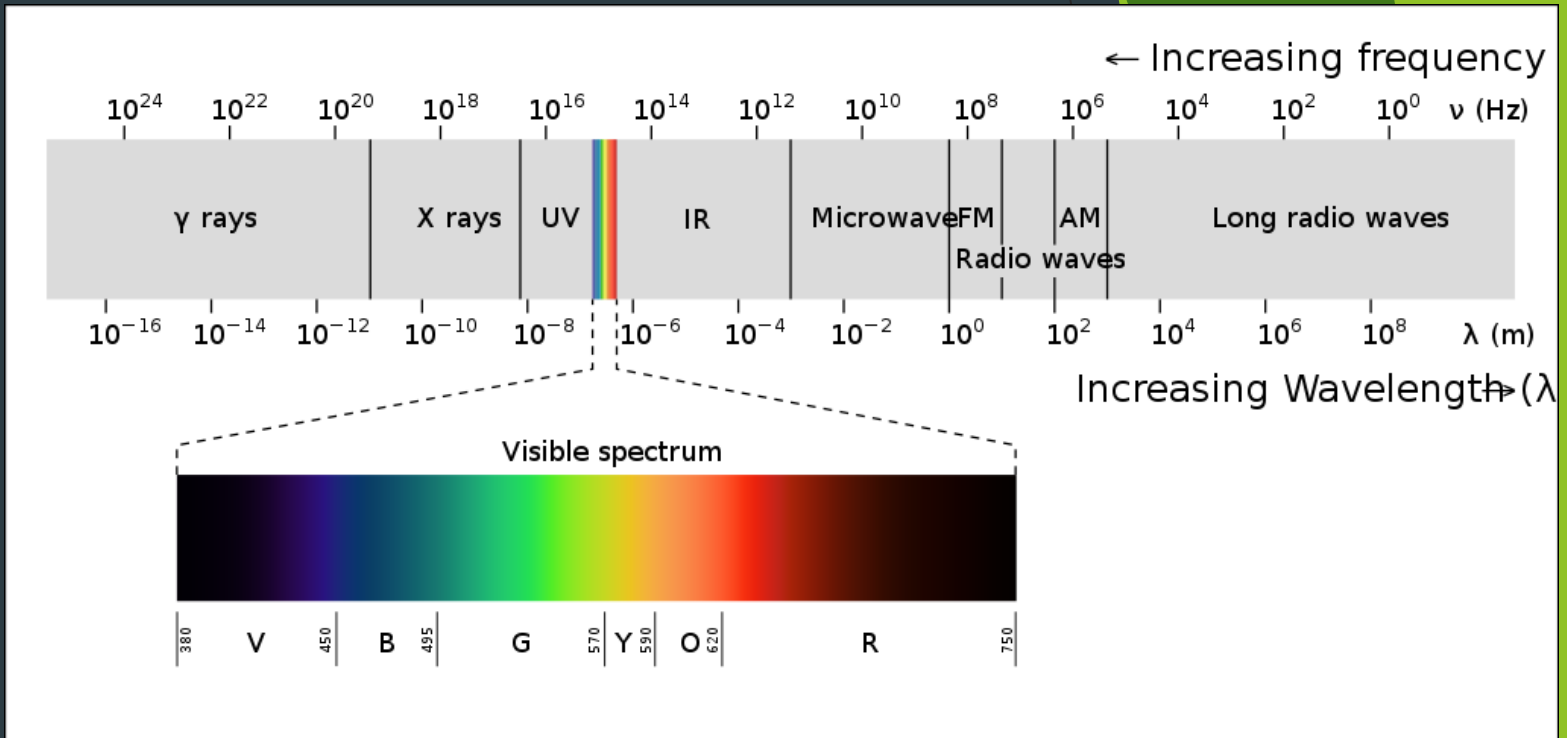
Amplitude

- ▶ The distance between the middle line of a wave and its peak
- ▶ Usually related to emitted power and antenna effectiveness
- ▶ The more amplitude a radio signal starts with the farther it can travel and the more it can penetrate other objects like walls or trees



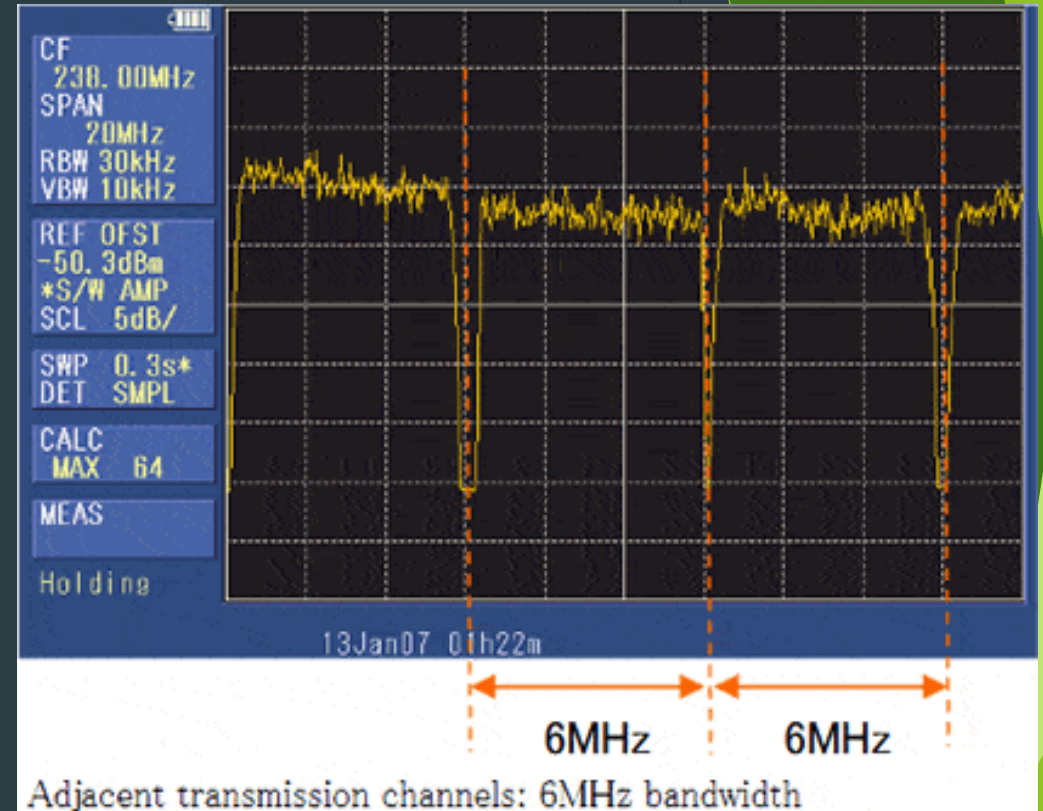
Frequency

- ▶ The number of times the electromagnetic wave oscillates per second
- ▶ Units of Hertz (Hz)
- ▶ Common frequency ranges
 - ▶ AM Radio: 540-1700 kHz
 - ▶ FM: Radio: 87-108 MHz
 - ▶ Amateur radio: 144-148 MHz\
 - ▶ 2m band
 - ▶ Television: 54-216 MHz and the 470-700 MHz.
 - ▶ WiFi: 2.4 and 5.0 GHz
- ▶ Higher frequencies can transmit more data



Bandwidth

- ▶ The range of frequencies a signal is transmitted over
- ▶ Bandwidth ranges are assigned so that signals do not interfere
- ▶ Common bandwidth:
 - ▶ FM Radio: 200 kHz
 - ▶ WiFi (2.4 GHz): 20 or 40 MHz
- ▶ A wider bandwidth is correlated with the ability to transmit more data



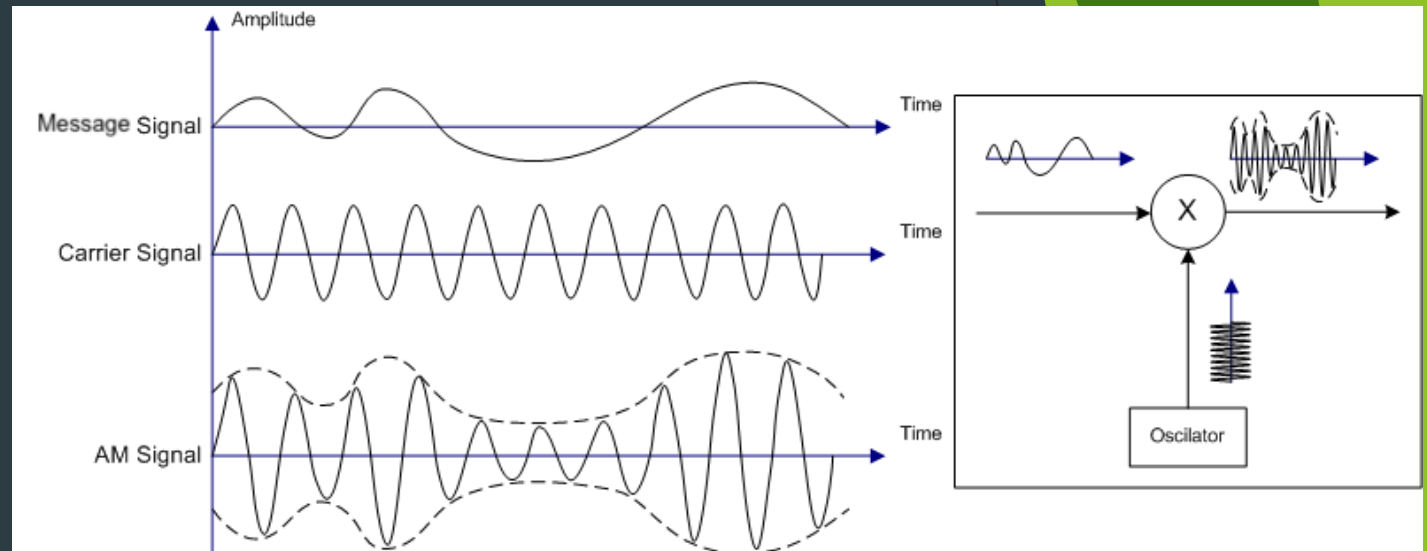
Decibel Notation

- ▶ A relative unit of measurement which expresses the ratio of two values on a logarithmic scale
- ▶ An increase of 3 dB represents a doubling of power
- ▶ The total decibel gain of a series of components (amplifiers, antennas, etc.) can be calculated simply by adding the decibel gains of the individual components
- ▶ In radio, dBm is commonly used to represent power relative to 1 milliwatt, usually referenced to a 50 Ω load



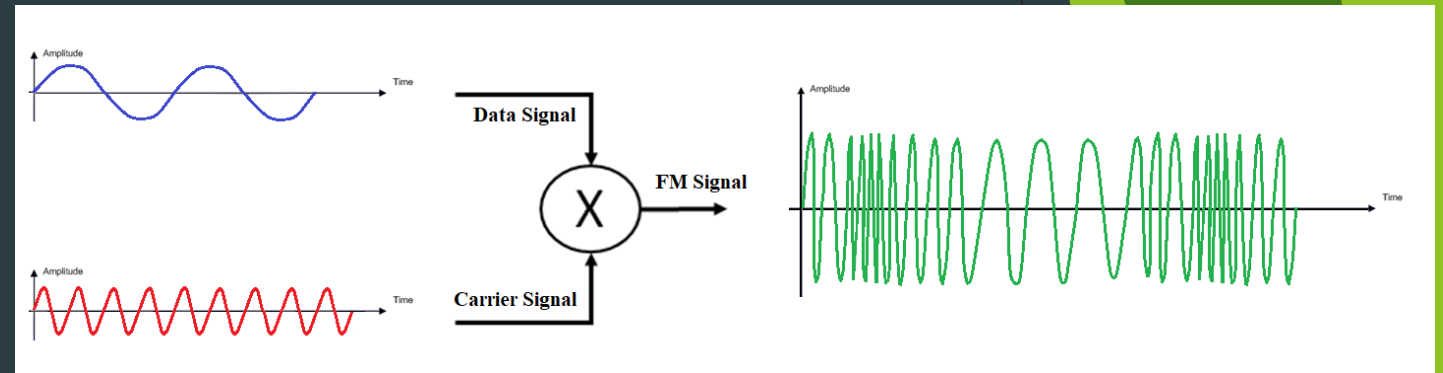
Amplitude Modulation (AM)

- ▶ The amplitude of the wave is varied in proportion to the message signal
- ▶ The earliest and simplest modulation method used for transmitting audio
- ▶ Analog telephone systems used amplitude modulation
 - ▶ Multiple signals could be transmitted on the same line by transmitting on separate frequencies
- ▶ More susceptible to interference than other modulation methods



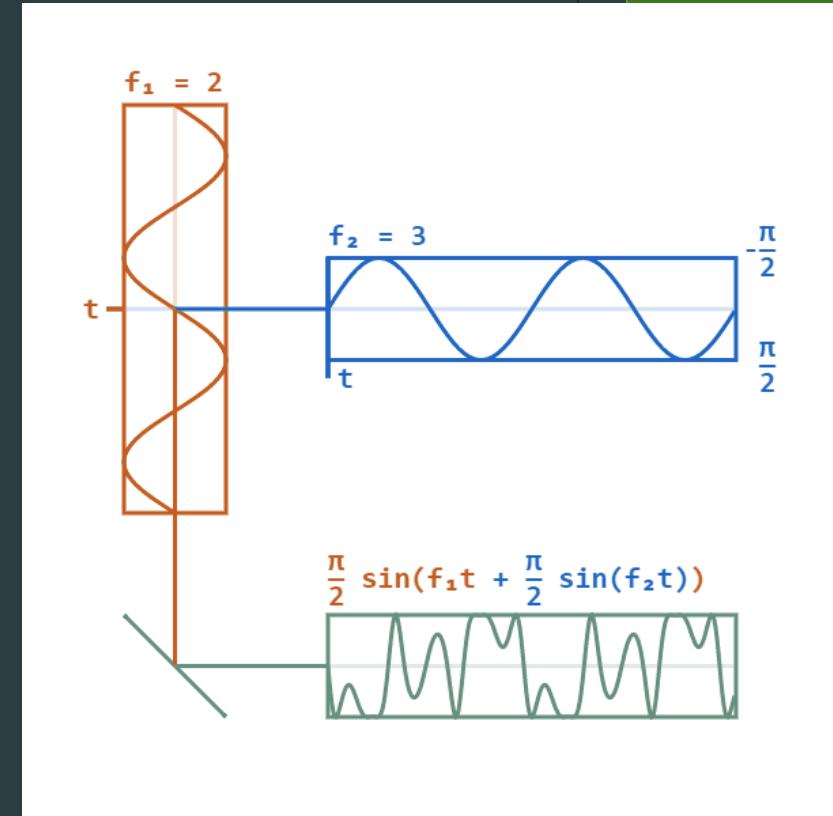
Frequency Modulation (FM)

- ▶ The frequency of the wave is varied in proportion to the message signal
- ▶ In analog frequency modulation of an audio signal, the instantaneous difference between the frequency of the carrier and the FM signal, is a function of the modulating signal
- ▶ FM provides improved signal-to-noise ratio compared to AM



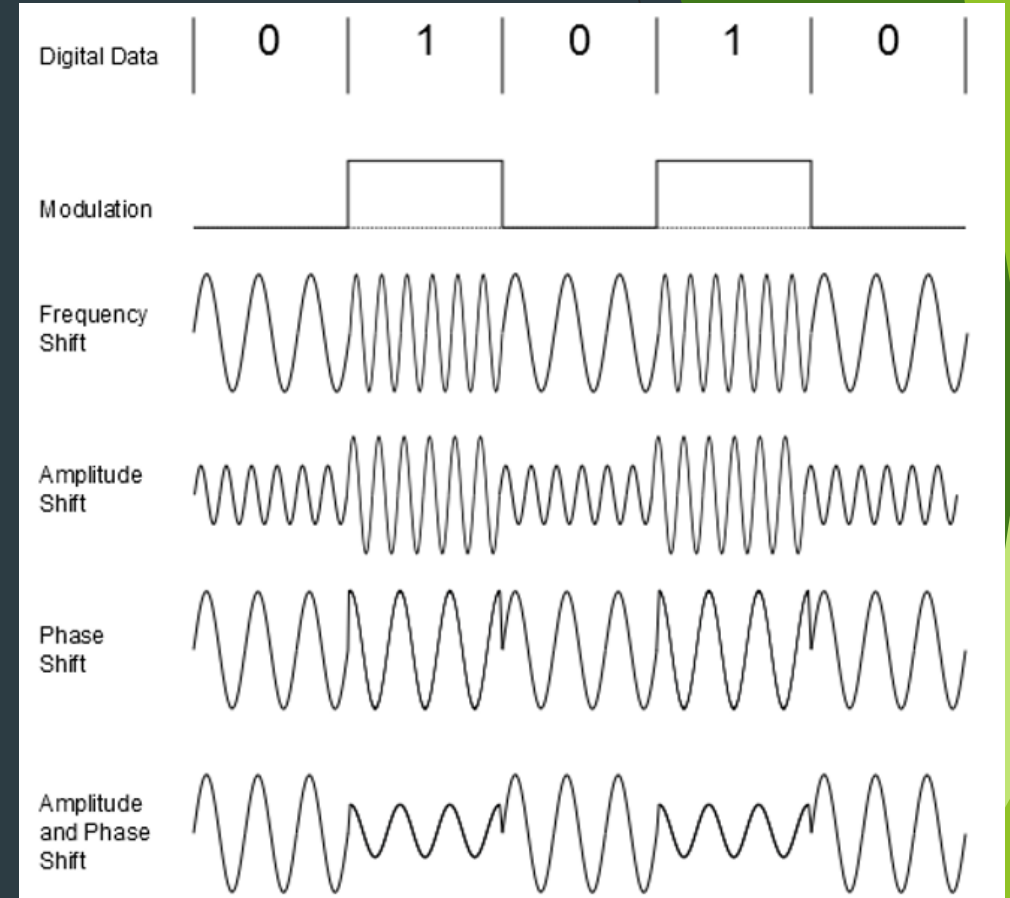
Phase Modulation

- ▶ Encodes a message signal as variations in the instantaneous phase of a carrier wave
- ▶ Used for many digital transmission technologies like Wi-Fi, GSM (cell phone), and satellite television
- ▶ Requires more complex hardware, but is more energy efficient and faster than other modulation techniques



Digital Modulation

- ▶ An analog carrier signal is modulated by a discrete signal (a set number of modulation symbols)
 - ▶ PSK (phase-shift keying): a finite number of phases are used.
 - ▶ FSK (frequency-shift keying): a finite number of frequencies are used.
 - ▶ ASK (amplitude-shift keying): a finite number of amplitudes are used.
 - ▶ QAM (quadrature amplitude modulation): a finite number of at least two phases and at least two amplitudes are used.
- ▶ Each phase, frequency, or amplitude is assigned a unique pattern of binary bits

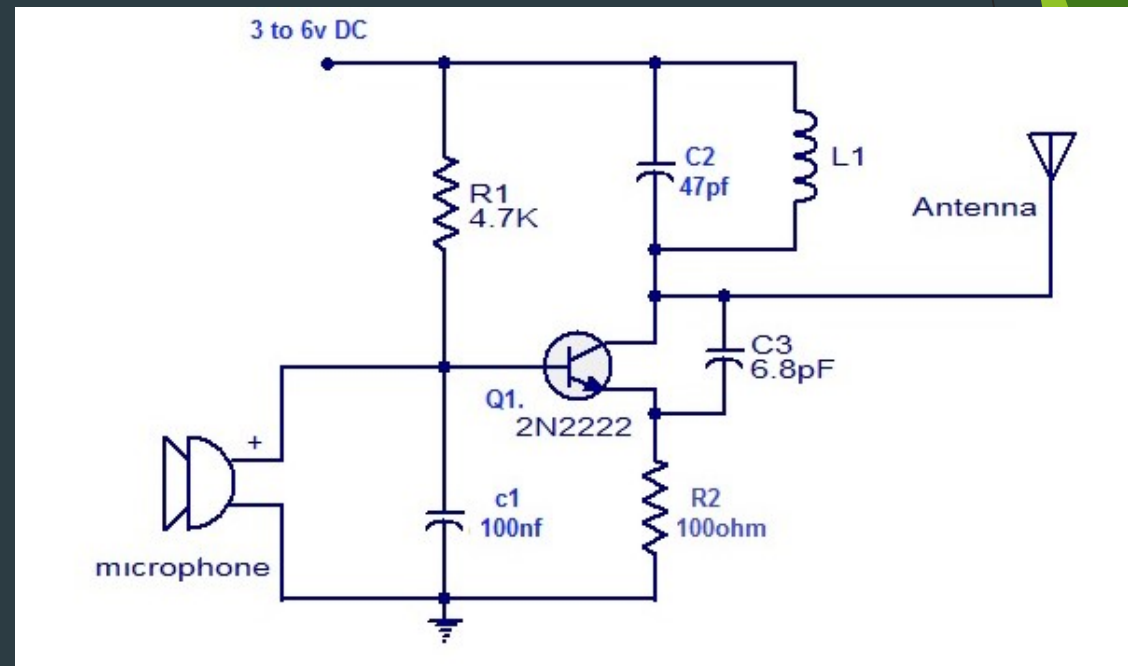


Rules and Regulations

- ▶ In the United States, the Federal Communications Commission (FCC) regulates communications by radio
- ▶ They assign frequency bands for all of the radio spectrum and maintain appropriate buffers
- ▶ Some spectrum bands are open for unlicensed operations, typically low power, short-range applications
 - ▶ wireless garage door openers, cordless phones, baby monitors, Wi-Fi, Bluetooth, etc
- ▶ Maintain standards for testing and authorizing wireless devices for sale
 - ▶ “This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.”
- ▶ Controls the testing standards for amateur radio operators

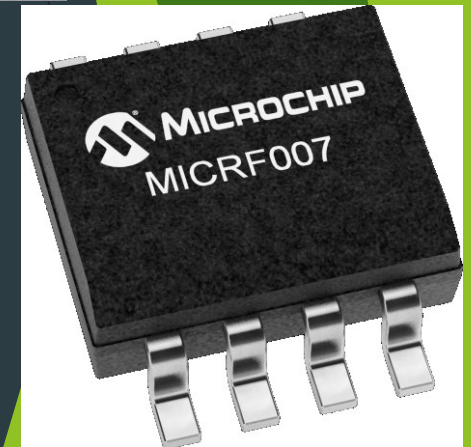
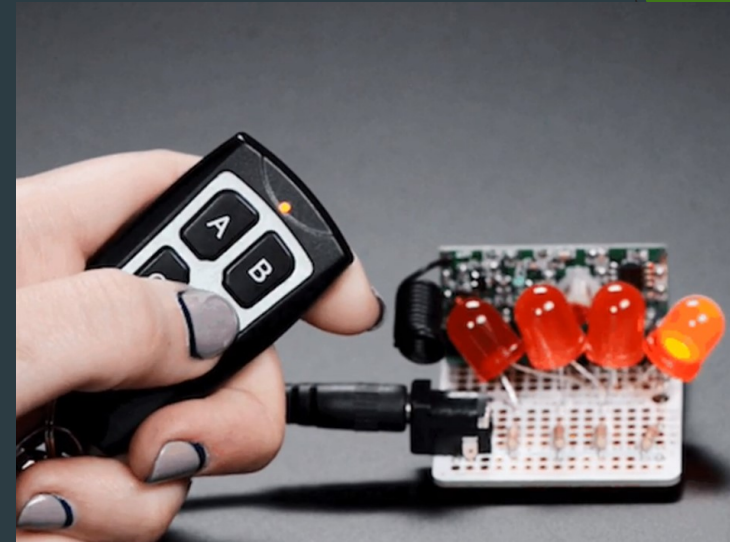
Simple FM Circuit

- ▶ The microphone converts sound into an electrical signal (left)
- ▶ A carrier wave is generated using an inductor-capacitor (LC) circuit (top right)
 - ▶ The measurements of the inductor/capacitor set the transmission frequency by setting the charge/discharge rate
- ▶ The microphone signal modulates the carrier wave through the transistor (center)
 - ▶ When the transistor is turned on by the microphone signal it alters the charge/discharge rate of the LC circuit, modulating the frequency
- ▶ The modulated wave is then transmitted through the antenna (far right)



Using radio as a hobbyist

- ▶ There are several options available if you want to add radio to a project
- ▶ Simple RF Receiver/Transmitter
 - ▶ Transmit or receive very simple signals such as keyfob button presses
- ▶ Single-chip integrated circuit (IC)
 - ▶ Requires a minimal number of extra components to set frequency
 - ▶ ICs often contain more advanced circuits and features than the simple transistor design
- ▶ Radio module/breakout board
 - ▶ Includes all radio circuitry on a board that can be communicated with using digital signals
 - ▶ Simple way to add radio to a microcontroller or computer without any additional circuitry





Questions?



Lets build radios!