

RF Communication

Team 8

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Discussion Topics

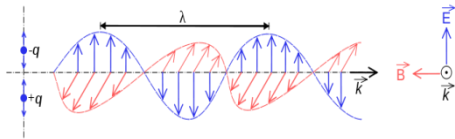
- Electromagnetic Spectrum
- Hardware
- Modulation/Demodulation
- Noise
- Bluetooth

Introduction

- What is RF Communication?
- Why is it important?

Electromagnetic Spectrum

- the range of all possible frequencies of [electromagnetic radiation](#)
 - photon particles traveling through space, carrying [radiant energy](#)
 - has both electric and magnetic field components

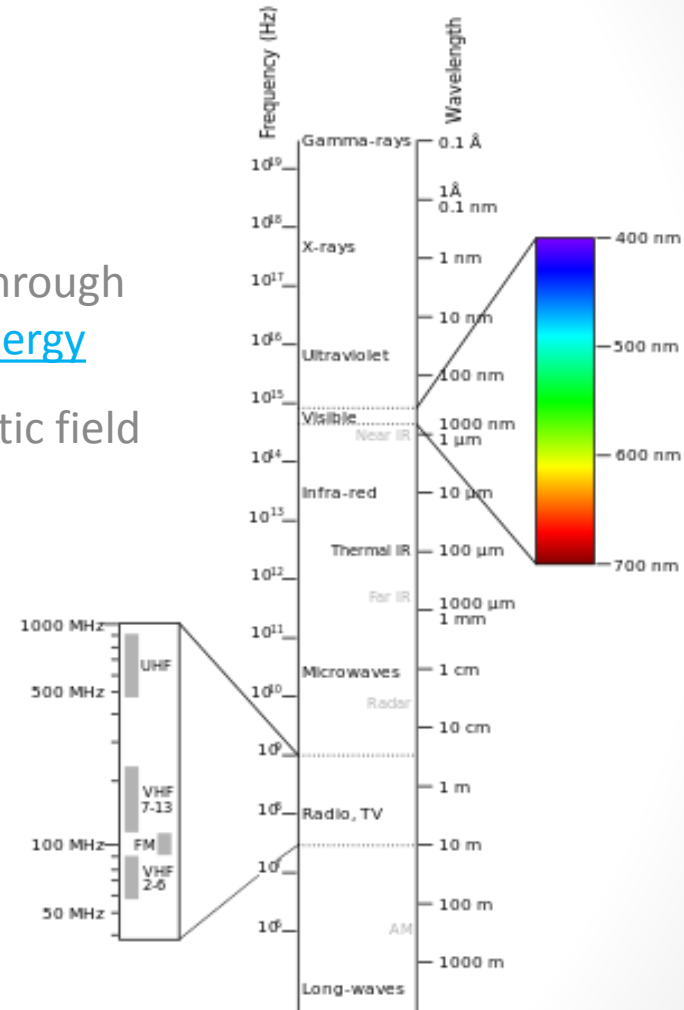


- Electromagnetic waves are typically described by any of the following three physical properties:

[frequency](#) f

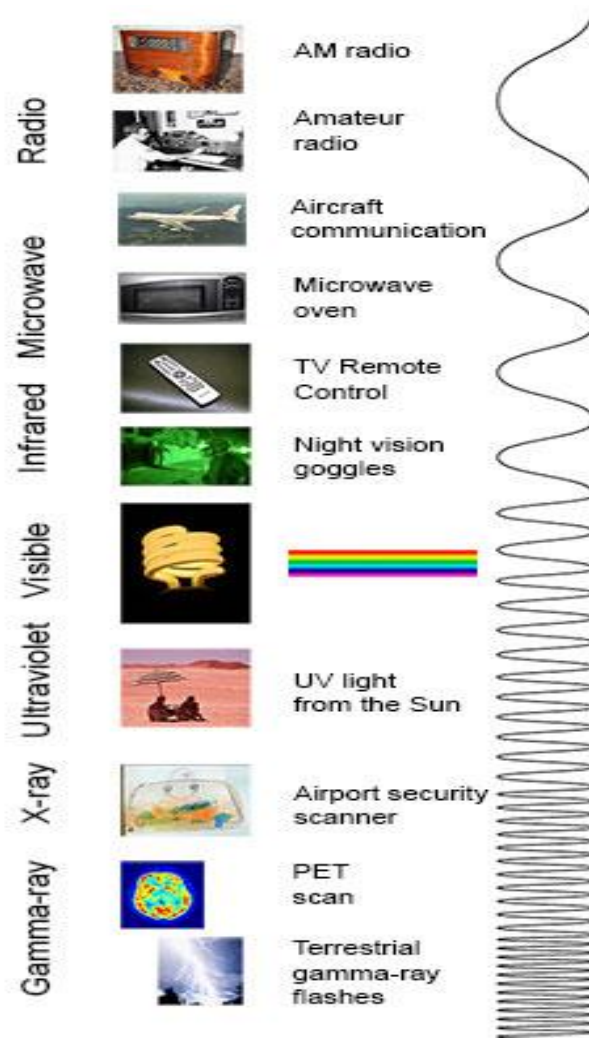
[wavelength](#) λ

[photon energy](#) E

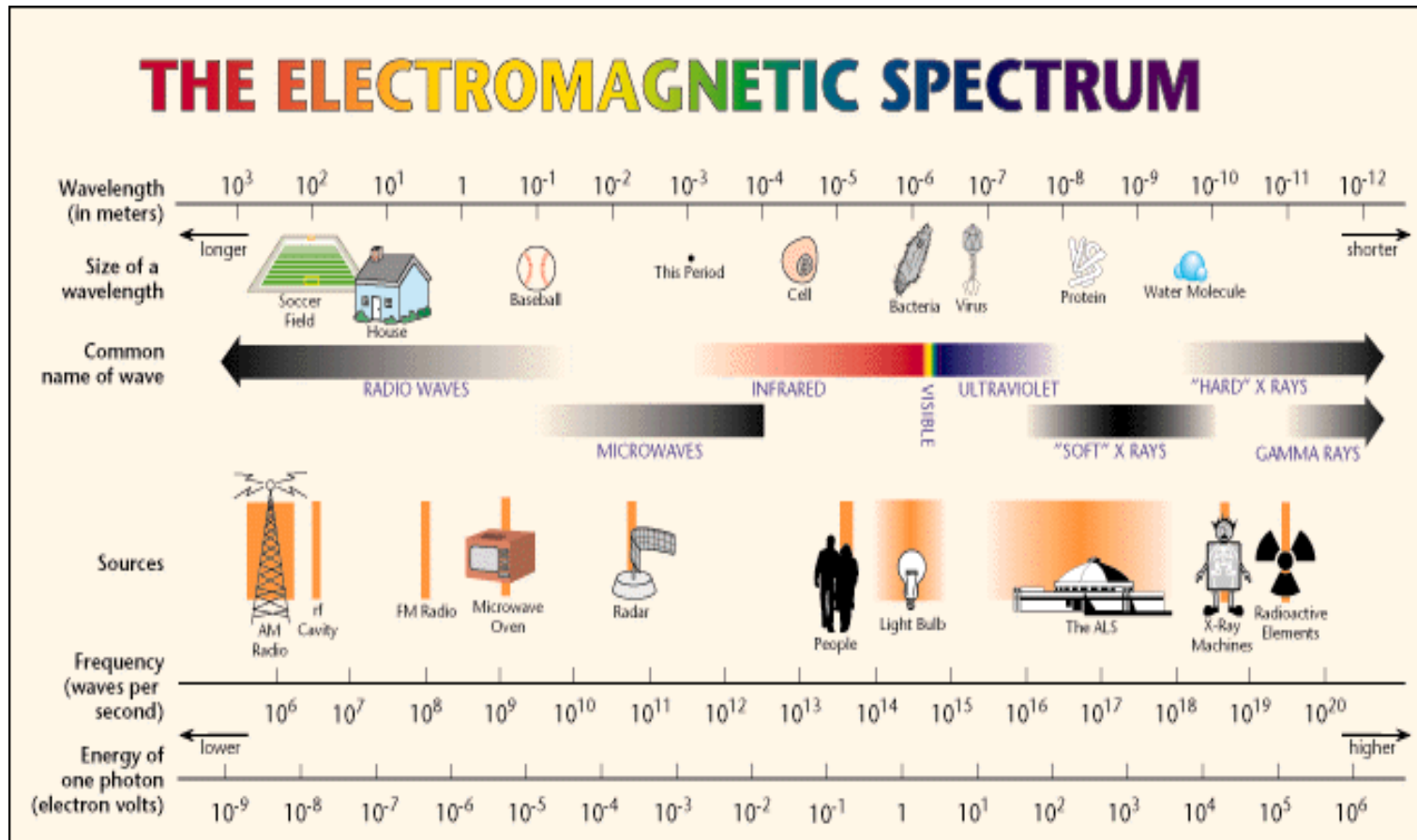


Electromagnetic Spectrum

Rabbits
Mate
In
Very
Unusual
eXpensive
Gardens



Electromagnetic Spectrum



UNITED STATES FREQUENCY ALLOCATIONS



U.S. DEPARTMENT OF COMMERCE
National Telecommunications and Information Administration
Office of Spectrum Management
October 2003

- Broadcasting
- Maritime
- Space Research
- Radio Navigation

Radio Spectrum

- Garage door openers, alarm systems: Around 40 MHz
- Standard cordless phones: Bands from 40 to 50 MHz



- Baby monitors: 49 MHz



- Radio controlled cars: Around 75 MHz

- MIR space station: 145 MHz and 437 MHz

- Cell phones: 824 to 849 MHz



- Air traffic control radar: 960 to 1,215 MHz

- Global Positioning System: 1,227 and 1,575 MHz

- Deep space radio communications: 2290 to 2300 MHz

- ISM – Industrial, Scientific, and Medical Radio Band: 2400 to 2480 MHz

Table of ITU Radio Bands

Band Number	Symbols	Frequency Range	Wavelength Range†
4	VLF	3 to 30 kHz	10 to 100 km
5	LF	30 to 300 kHz	1 to 10 km
6	MF	300 to 3000 kHz	100 to 1000 m
7	HF	3 to 30 MHz	10 to 100 m
8	VHF	30 to 300 MHz	1 to 10 m
9	UHF	300 to 3000 MHz	10 to 100 cm
10	SHF	3 to 30 GHz	1 to 10 cm
11	EHF	30 to 300 GHz	1 to 10 mm
12	THF	300 to 3000 GHz	0.1 to 1 mm



ISM Band - Bluetooth

- Radio bands reserved internationally for the use of RF energy for industrial, scientific and medical purposes other than telecommunications



Spread-spectrum frequency hopping

- 2.402 GHz and 2.480 GHz
- 79 individual, randomly chosen frequencies
- The transmitters change frequencies 1,600 times every second



RF Electronics

- Hardware Purposes:
 - Generate signals from system
 - Receive signal from other communication electronics
 - Create an antenna or transmission system
- Typical Hardware Components:
 - Antennas
 - Transmitters
 - Receivers
 - Amplifiers
 - Modulators
 - Oscillators
 - Filters

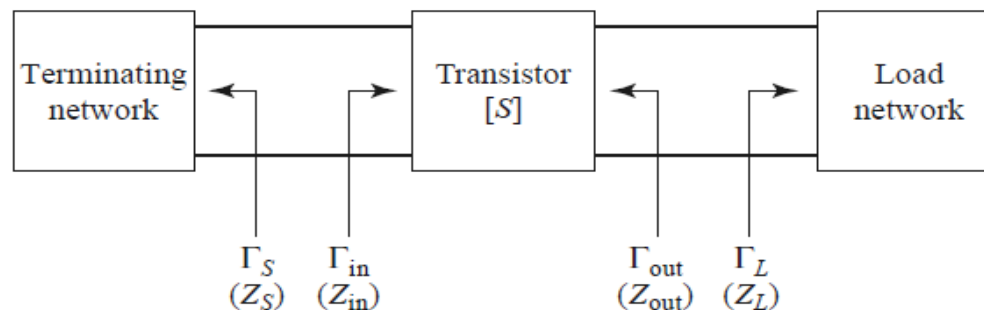
Transmitters

- Electronic circuit used to transmit signals
- Consists of:
 - Power Supply
 - RF Oscillator
 - Modulator Circuit
 - RF Power Amplifier
 - Antenna



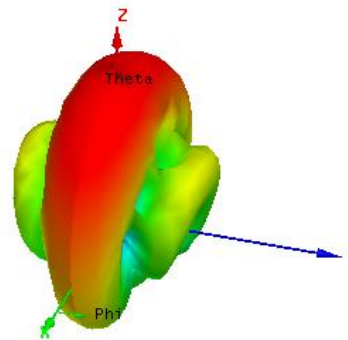
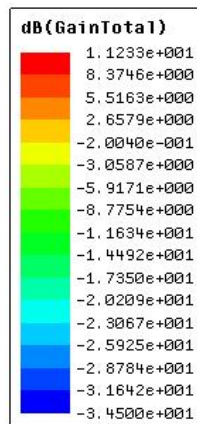
RF Oscillators

- Convert DC to carrier wave RF signal
- Negative Resistance Oscillator
 - Utilize stripline technology
 - DC bias voltage applied to supply energy
 - S-Parameters determine stability at desired frequency
 - $R_s = -\frac{R_{in}}{3}$; $X_s = -X_{in}$



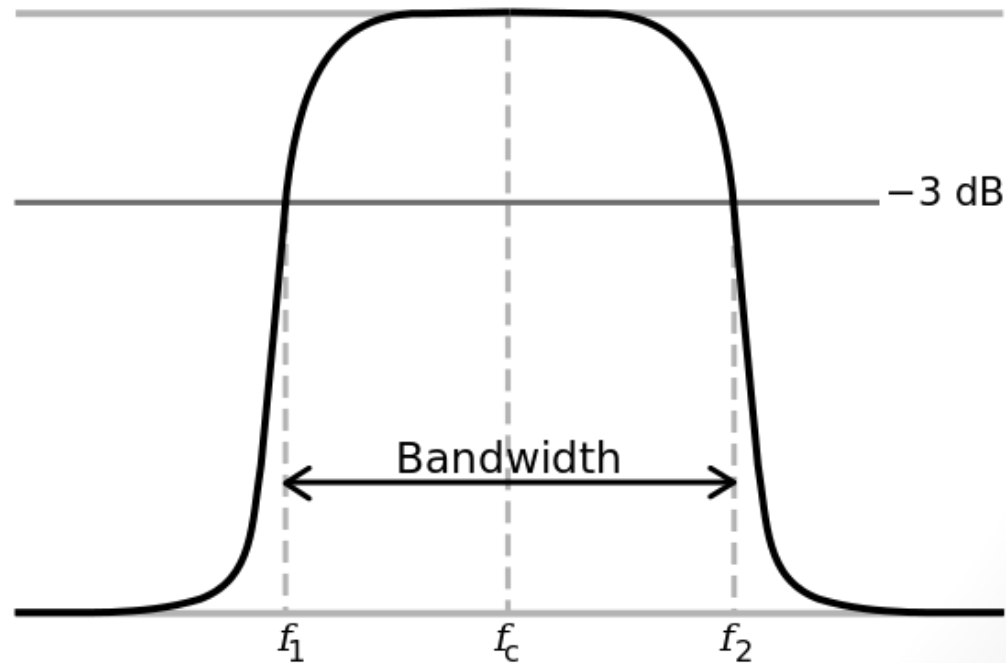
Antennas

- Matched to transmitter or receiver to deliver maximum power
- Converts electrical power into RF waves
- Radiation Pattern:
 - Reactive Near Field, Radiating Near Field, Far Field
 - Omnidirectional: Dipole Antenna, Slot Antenna
 - Directional: Dish Antenna, Slotted Waveguide Antenna



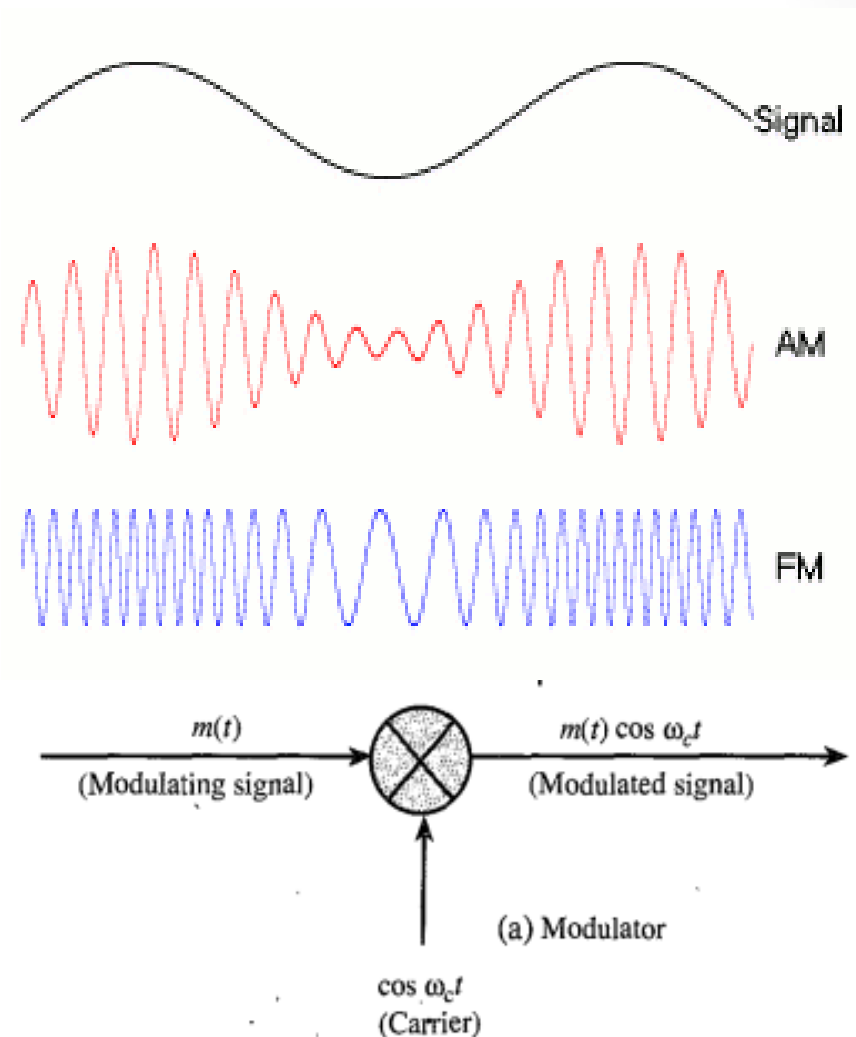
Antennas

- Directivity measures power density in direction of strongest emission versus isotropic antenna power density
- Antenna Efficiency: $\mathcal{E}_R = P_{\text{radiated}} / P_{\text{input}}$
- Gain
 - $G = \mathcal{E}_R \cdot D$
- Quality Factor
 - $Q = \frac{f_c}{f_2 - f_1}$



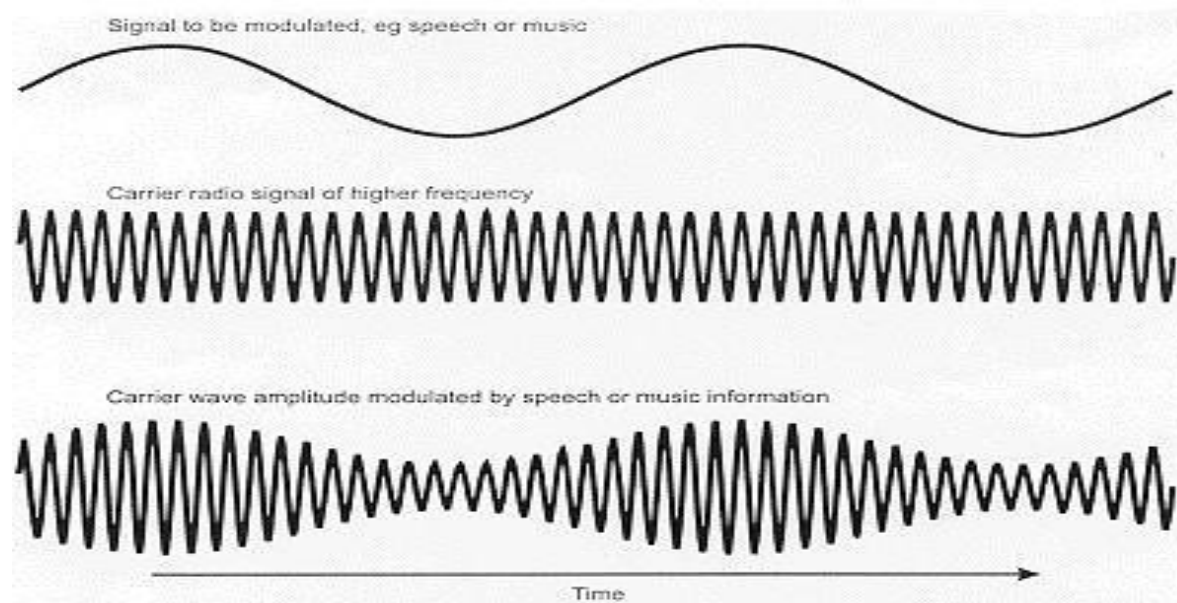
Modulation

- Modulation is a process that causes a shift in the range of frequencies in a signal
- Carrier communication
- Three types discussed: Amplitude Modulation, Frequency Modulation, Phase Modulation



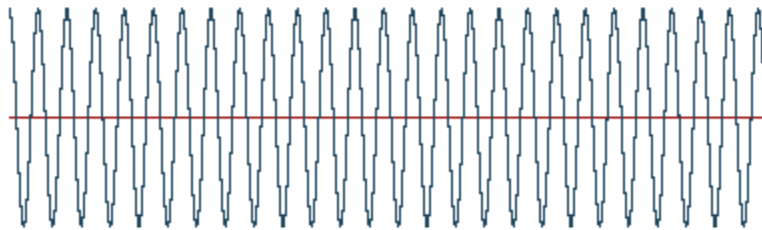
Amplitude Modulation

- Primary form of modulation until FM was adopted
- Power inefficient
- Noise
- Simple transmitter and receiver, but not when synchronization is needed
- Long distance transmission

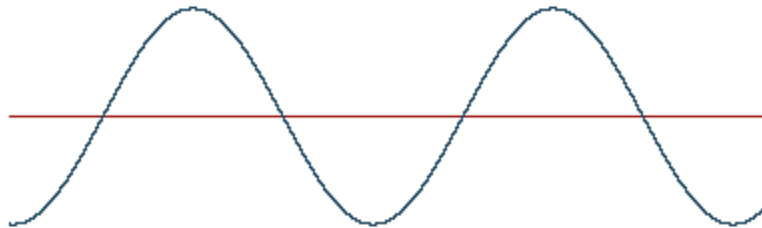


Frequency Modulation

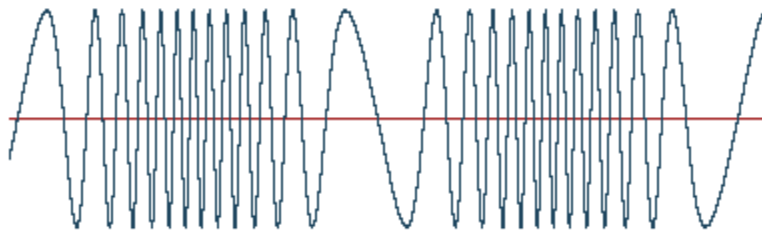
Carrier



Modulating Wave



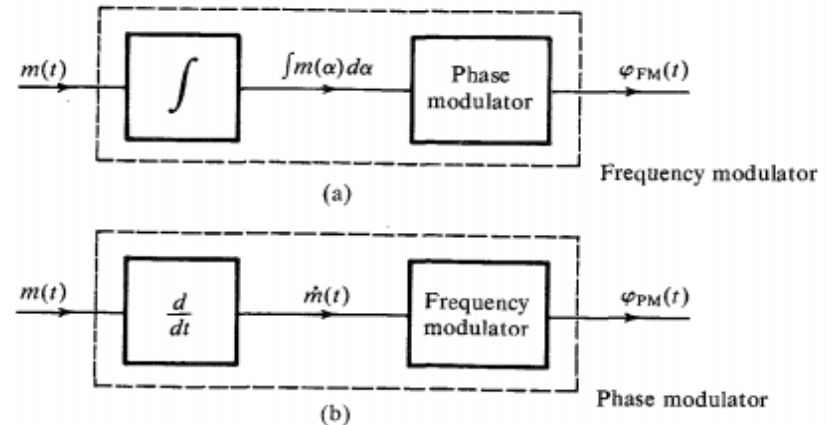
Modulated Result



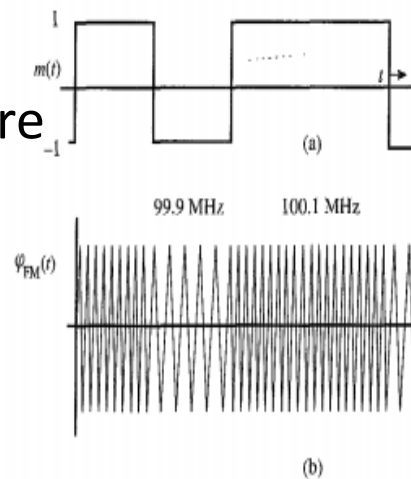
- Carrier Frequency varied in proportion to the message
- Most common modulation
- Power efficient
- Better Sound Quality
- Larger bandwidth
- Impacted by physical barriers

Phase Modulation

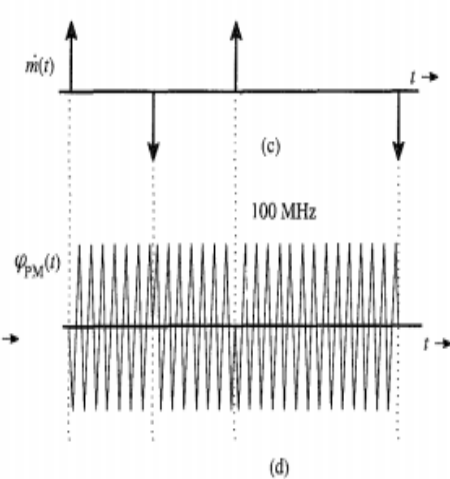
- Inseparable to FM; related by a derivative/integral relationship
- Jump discontinuities
- Frequency Shift Keying (FSK)
- Phase Shift Keying (PSK)
- Complex receiving hardware



FM Waves for Digital Modulation



PM Waves for Digital Modulation



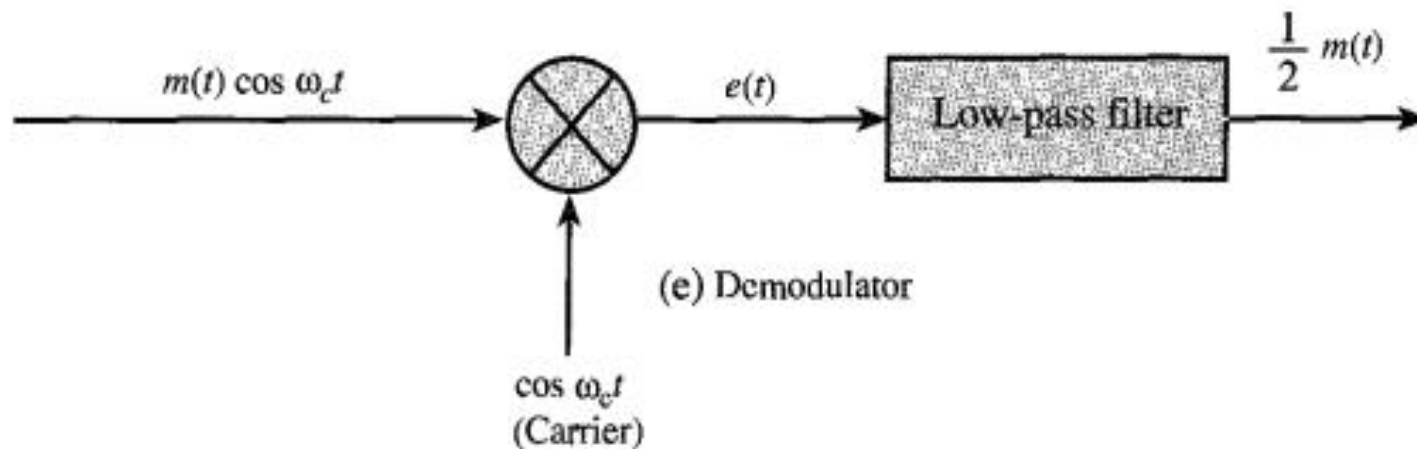
Modulation

- Comparing Modulation Types

Modulation	AM	FM
Power Efficiency	Poor	Excellent
Quality	Low	High
Bandwidth	Low	High
Noise	Susceptible	Less Susceptible
Complexity	Simple	Complex

Demodulation

- Demodulation is the process of recovering the signal from the modulated signal
- Envelope Detector (AM)
- Phase Locked Loop (FM)

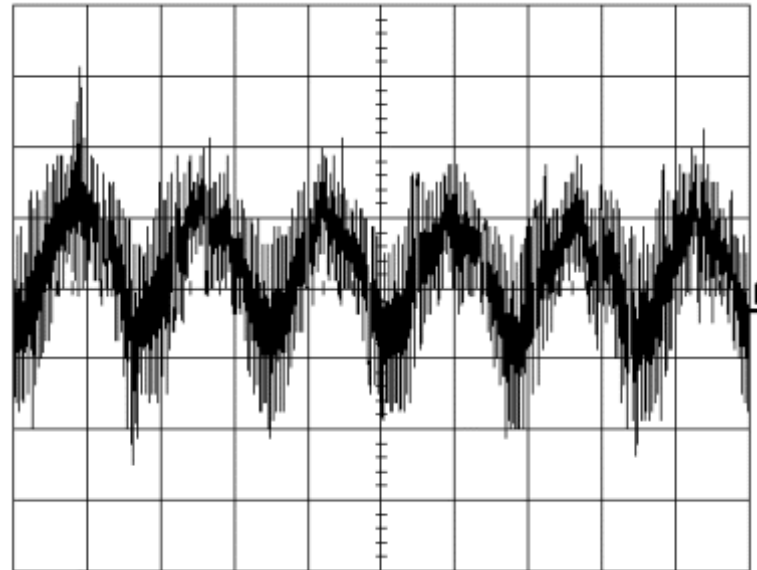


Demonstration



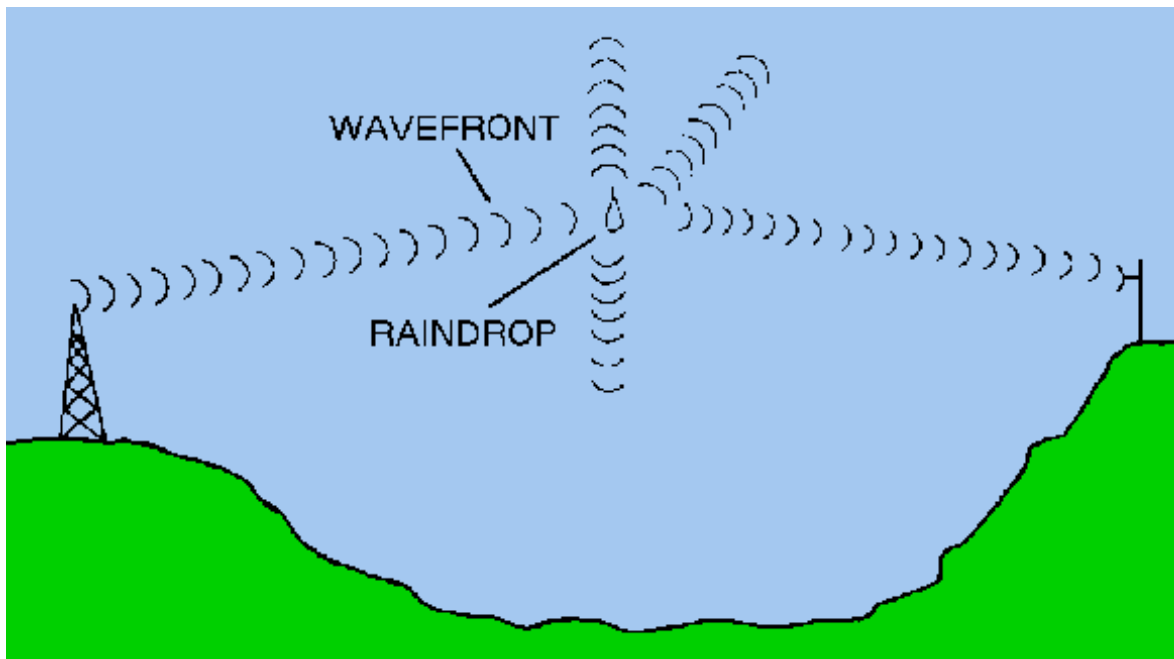
Noise

- Noise is the random changes in an electrical signal
- Noise can be present in the channel or in the internal circuitry of the transmitter/receiver



Noise in the channel

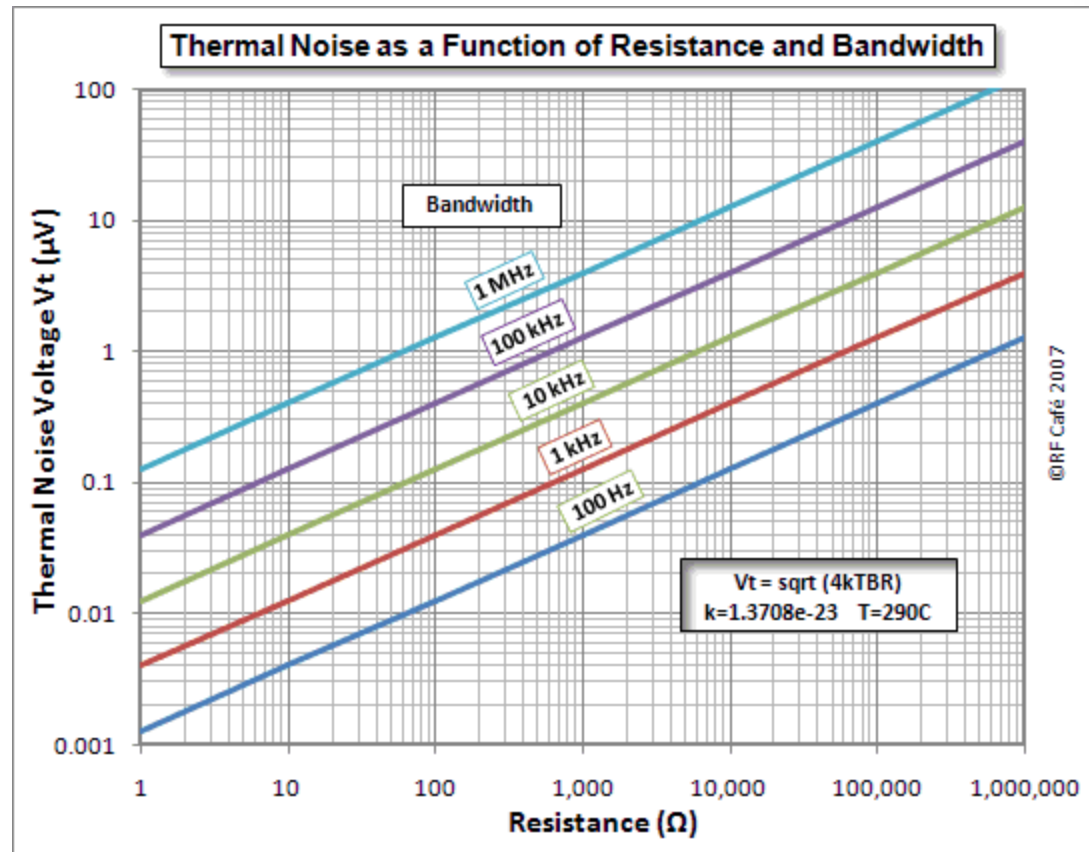
- For long range RF communication channel noise is an issue
- Channel noise is dependent on other sources in particular
 - Other broadcasts
 - Motors
- Signal arriving at several times with different delays



Noise in the circuitry

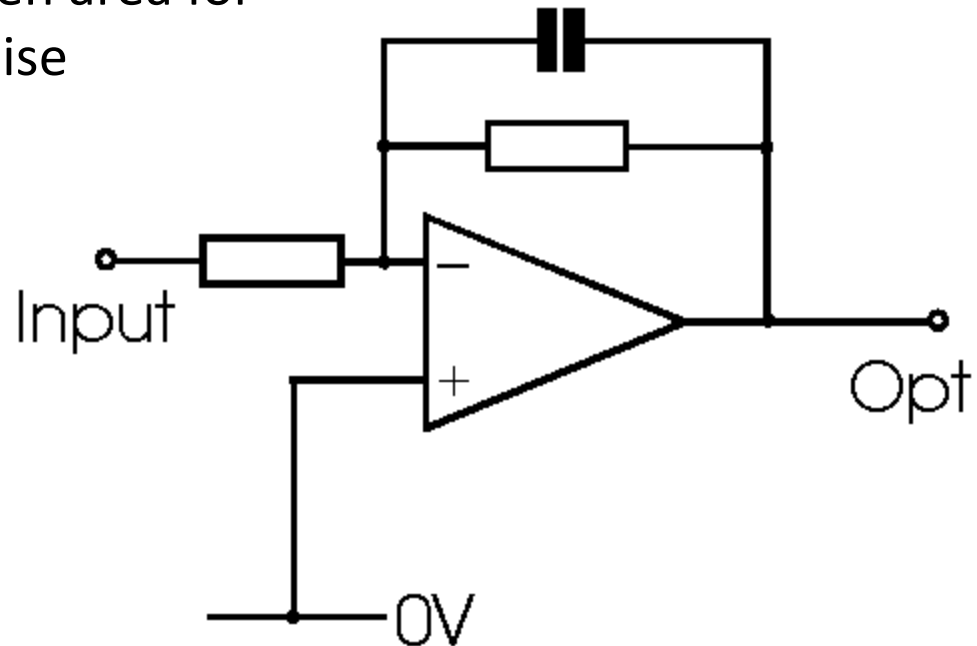
- Shot noise – caused by non constant motion of charge

- Thermal noise – generated by thermal motion of electrons. Increases with resistance.



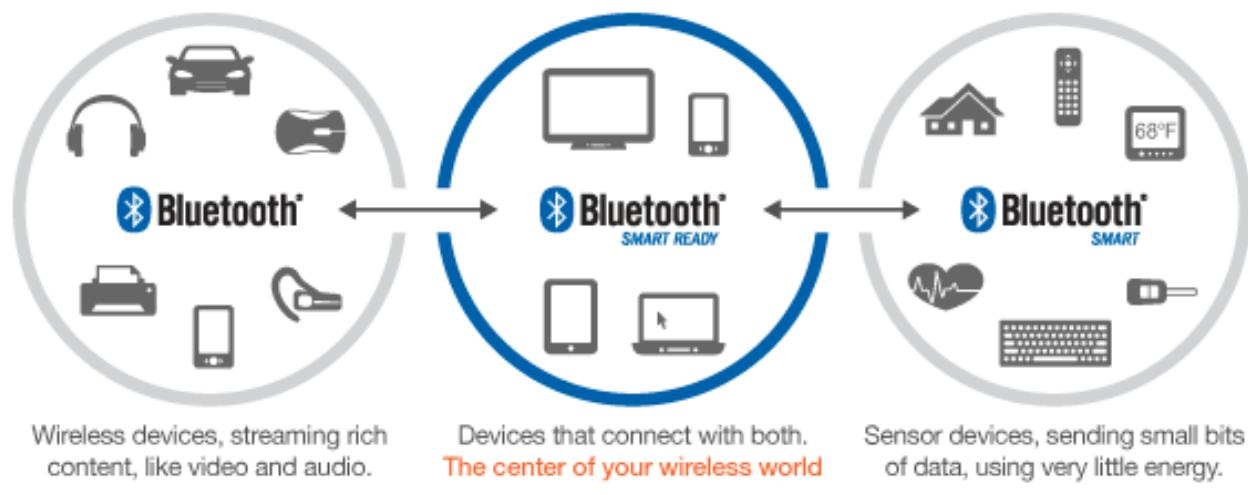
Reducing Noise

- Reducing resistor sizes reduces the thermal noise of the circuit
- Limiting bandwidth reduces the overall noise
- Using a smaller more open area for your channel reduces noise



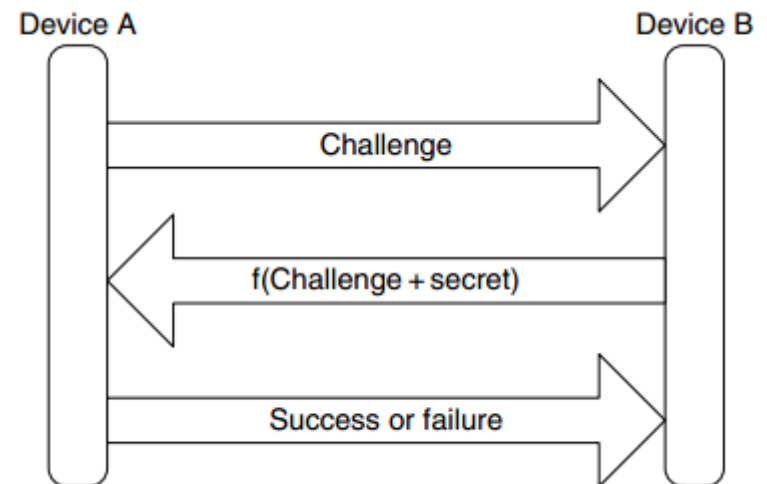
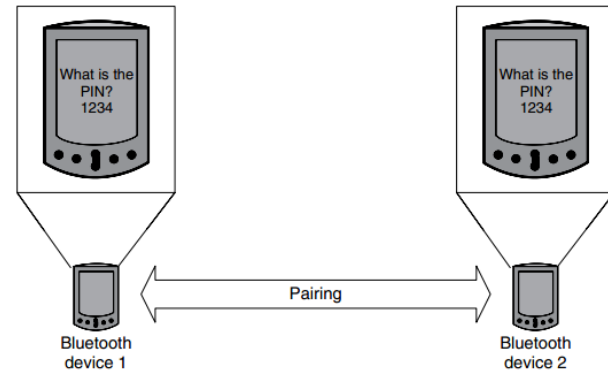
Bluetooth

- Uses radio frequency to connect devices
- Communication is based on Master-Slave principle
- Low Power Consumption
- Self-contained
- Supports multiple applications



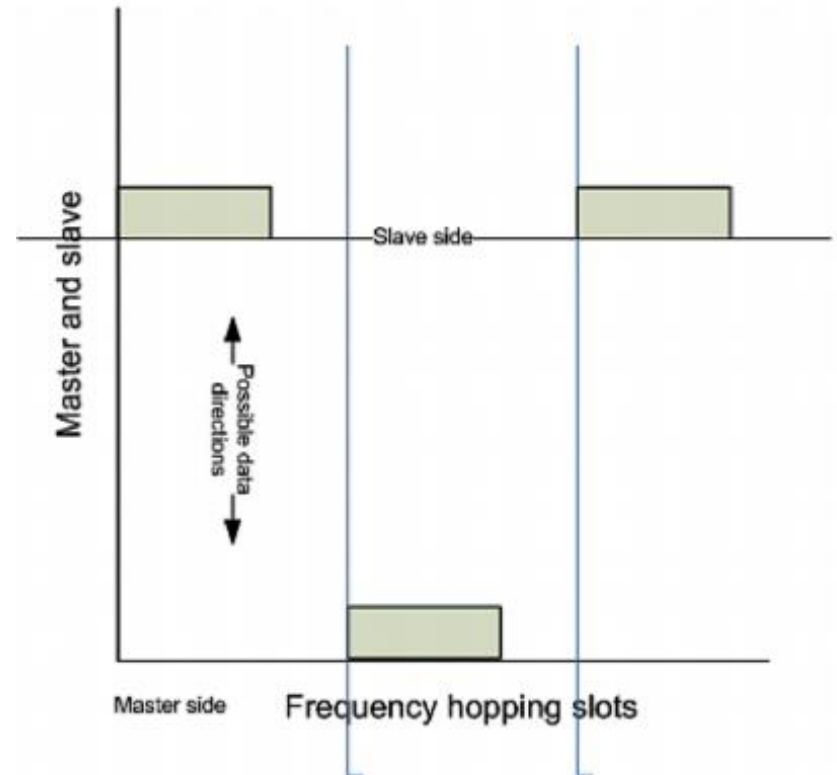
Pairing

- Uses Service Discovery Protocol (SDP)
 - Determines device address and parameters
- Only time slave devices can communicate directly with other slave devices
- Up to seven devices can be connected to a central master device



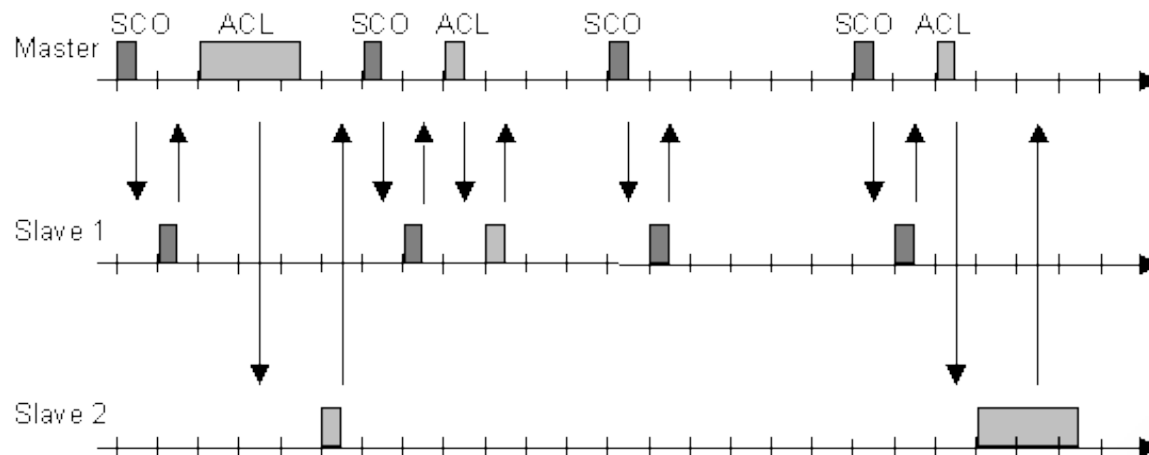
Frequency-Hopping Spread Spectrum

- Bluetooth operates in the 2.4 GHz band
 - Wi-Fi, Microwave Ovens, other BT networks
- Master establishes pseudorandom channel sequence
- Typically master and slaves alternate transmissions on consecutive time slots



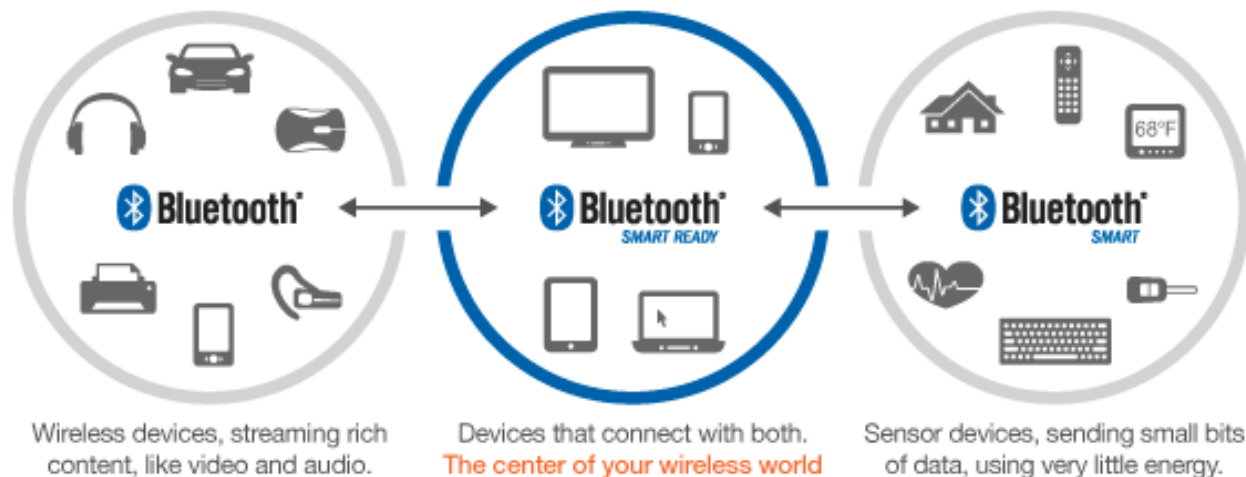
Link Types

- Synchronous Connection Oriented (SCO)
 - Symmetric point to point link
 - Used for Voice Communications
- Asynchronous Connection-Less (ACL)
 - Data Communication
 - Discovery



Profiles

- More than 30 Bluetooth Profiles
- Each is designed for a specific application
- A device's profile capabilities determines how it uses Bluetooth



Questions?

