EC 551
Telecommunication System Engineering

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Grades

Load	Percentage	Date
7th Week Exam	20%	Week of 22 March 2009
12th Week Exam	15%	Week of 26 April 2009
Final Exam	40%	
Participation	10%	
Reports	15%	

Textbook and website

- Textbook: No Textbook, only notes and papers

- Website: http://webmail.aast.edu/~khedr

Syllabus

- Tentatively

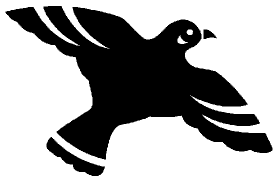
Week 1	Overview of digital, wireless communication systems
Week 2	Wireless Channel characteristics I
Week 3	Wireless Channel characteristics II
Week 4	Cellular concept and radio planning
Week 5	GSM System
Week 6	GPRS, EDGE,UMTS
Week 7	Multiple access techniques, OFDM
Week 8	WLAN Physical Layer
Week 9	WLAN MAC Layer
Week 10	WiMAX I
Week 11	WiMaX II
Week 12	IP and Mobile IP
Week 13	SIP
Week 14	VOIP
Week 15	Optical Networking

Pre-History of Wireless Communications:
Smoke Signals, Fires, Semaphore

- Relaying : Multi-hop routes (store-and-forward)

Pre-History of Wireless Communications: Homing Pigeons

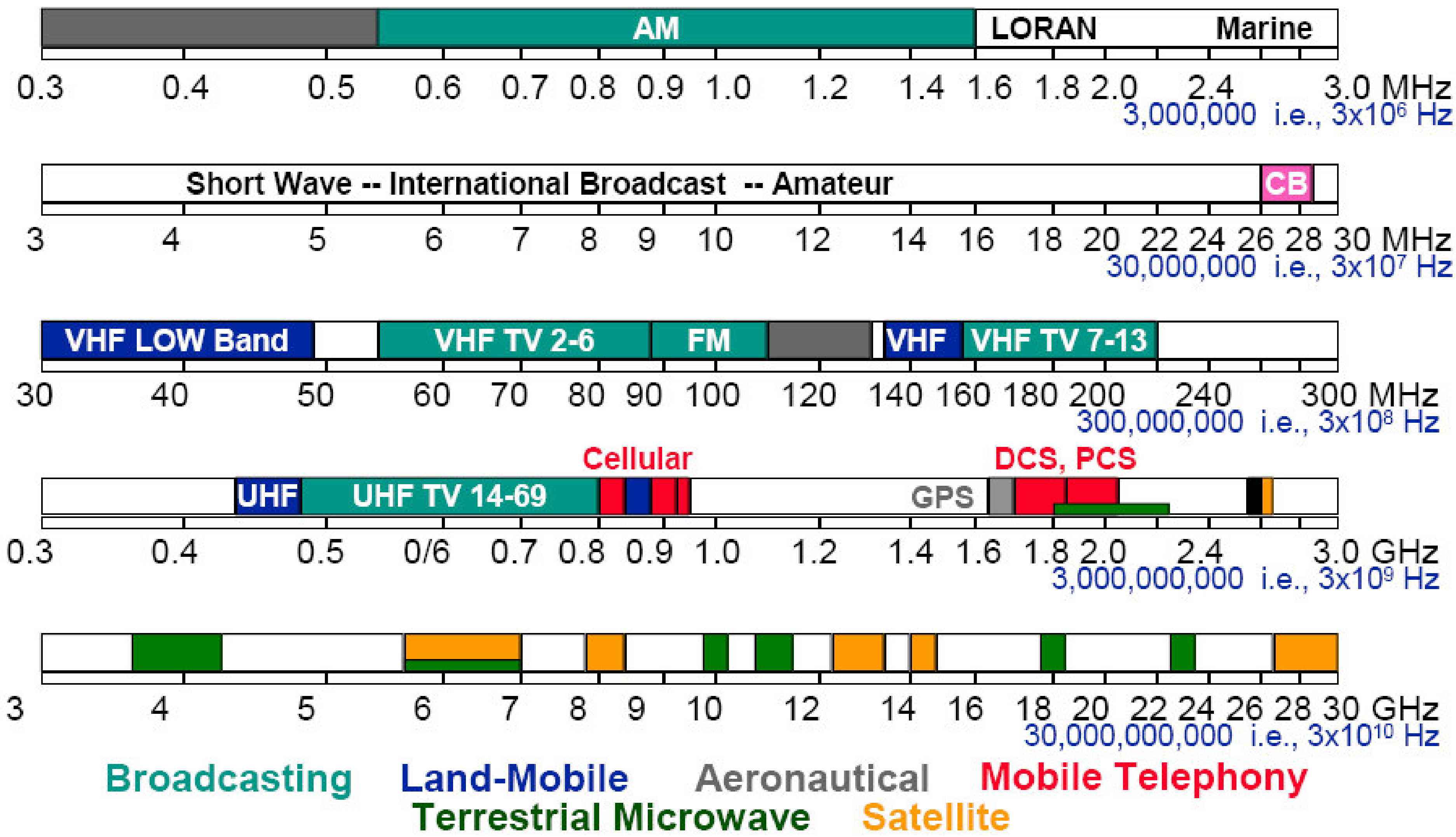
- Exploiting mobility

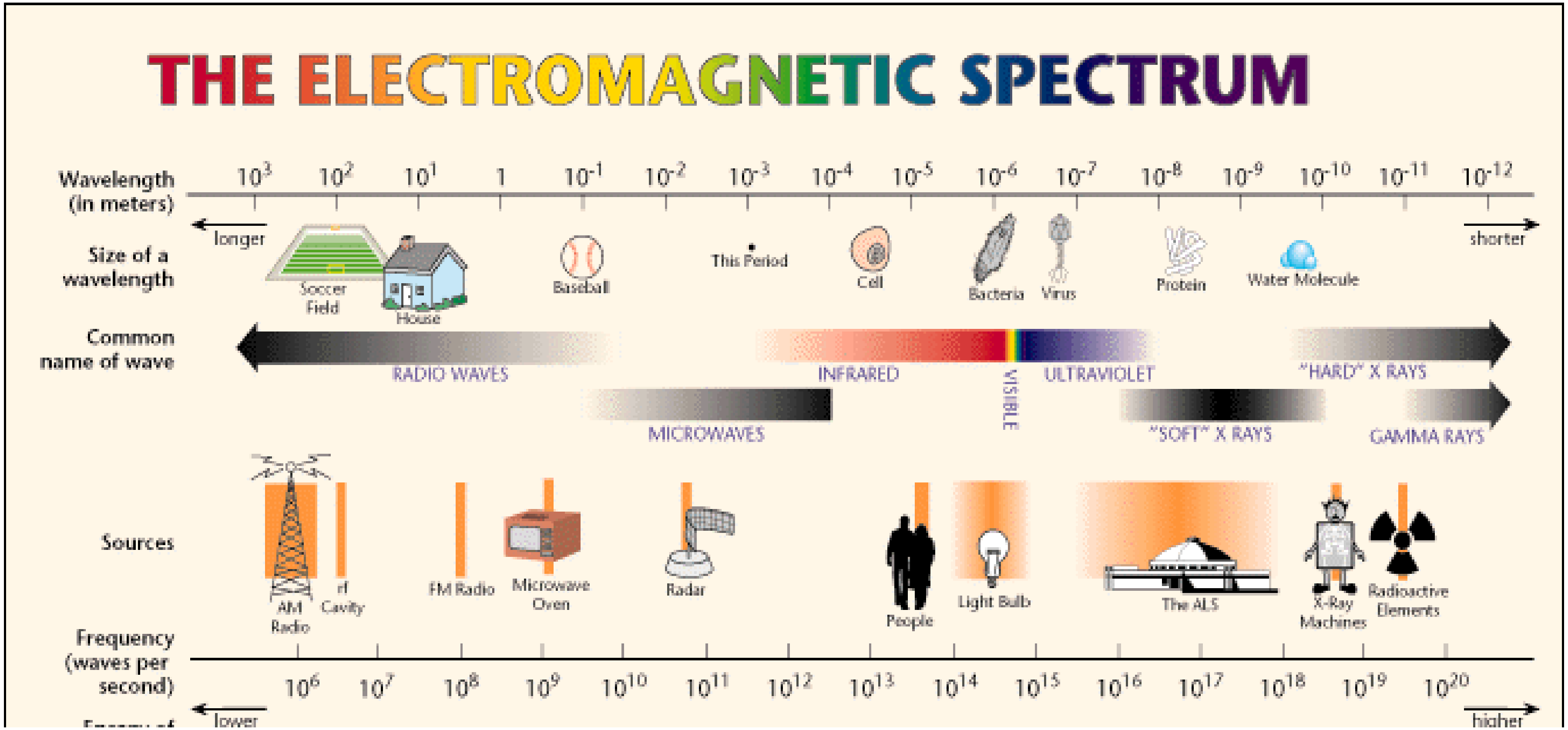


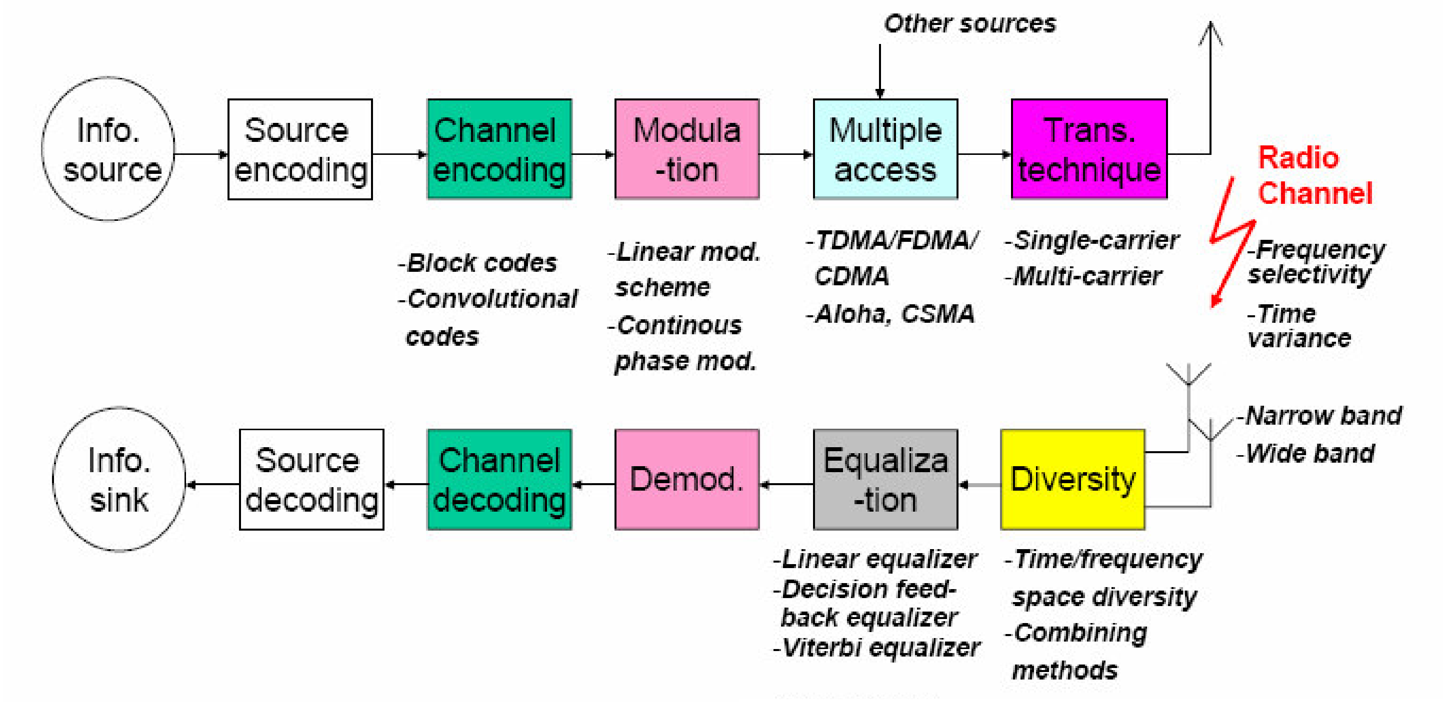
Pre-History of Wireless Communications: Perimeter Guards

- Aggregating knowledge

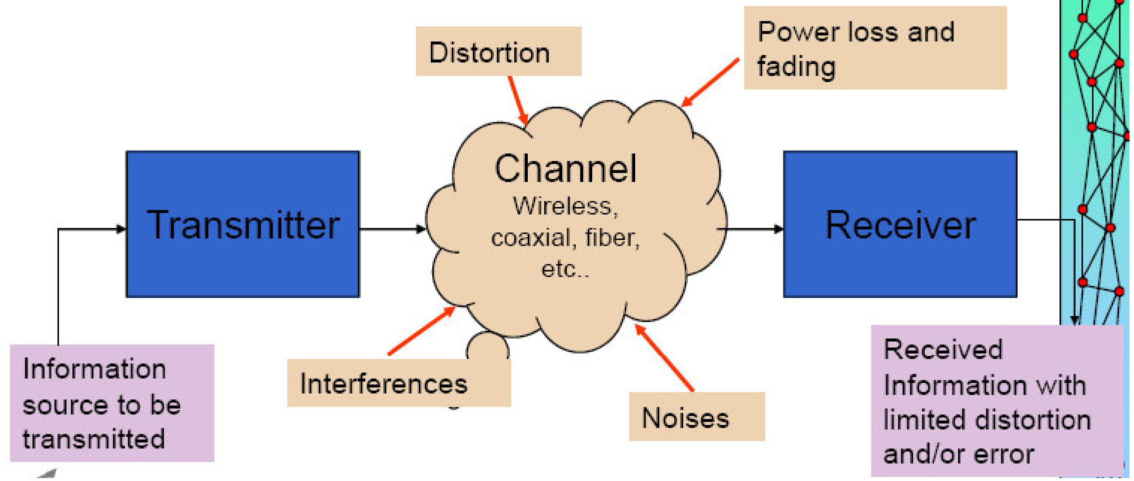
Frequencies Used by Wireless Systems
Overview of the Radio Spectrum




THE ELECTROMAGNETIC SPECTRUM
Wavelength (in meters)
10^{3} 10^{2} 10^{1} 1 10^{-1} 10^{-2} 10^{-3} 10^{-4} 10^{-5} 10^{-6} 10^{-7} 10^{-8} 10^{-9} 10^{-10} 10^{-11} 10^{-12}
longer
shorter
Size of a wavelength
Soccer Field
House
Baseball
This Period
Cell
Bacteria
Virus
Protein
Water Molecule
Common name of wave
RADIO WAVES
INFRARED
VISIBLE
ULTRAVIOLET
"HARD" X RAYS
MICROWAVES
"SOFT" X RAYS
GAMMA RAYS
Sources
AM Radio
rf Cavity
FM Radio
Microwave Oven
Radar
People
Light Bulb
The ALS
X-Ray Machines
Radioactive Elements
Frequency (waves per second)
10^{6} 10^{7} 10^{8} 10^{9} 10^{10} 10^{11} 10^{12} 10^{13} 10^{14} 10^{15} 10^{16} 10^{17} 10^{18} 10^{19} 10^{20}
lower
higher



- The following figure shows the basic block diagram of a communication system.



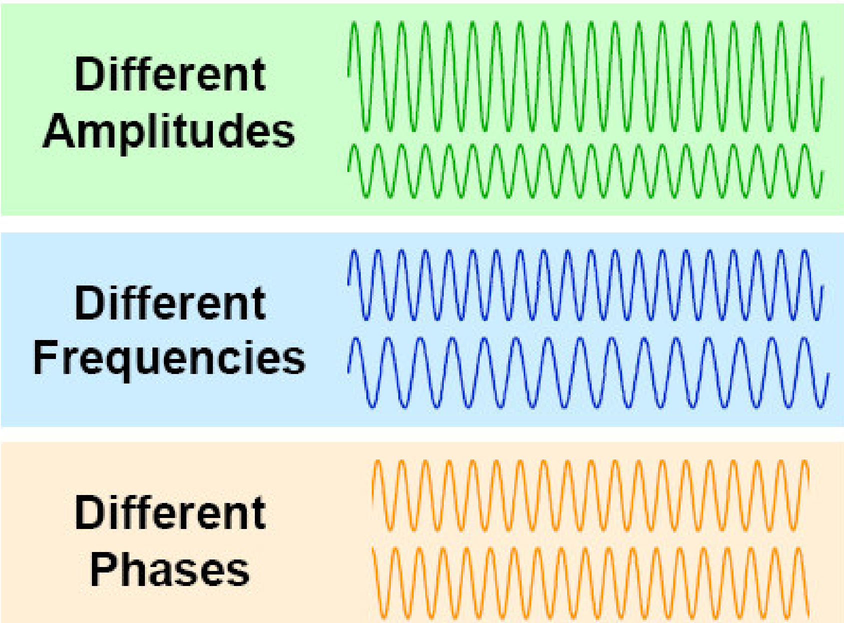
Characteristics of a Radio Signal

SIGNAL CHARACTERISTICS

$$S(t) = A \cos [\omega_c t + \varphi]$$

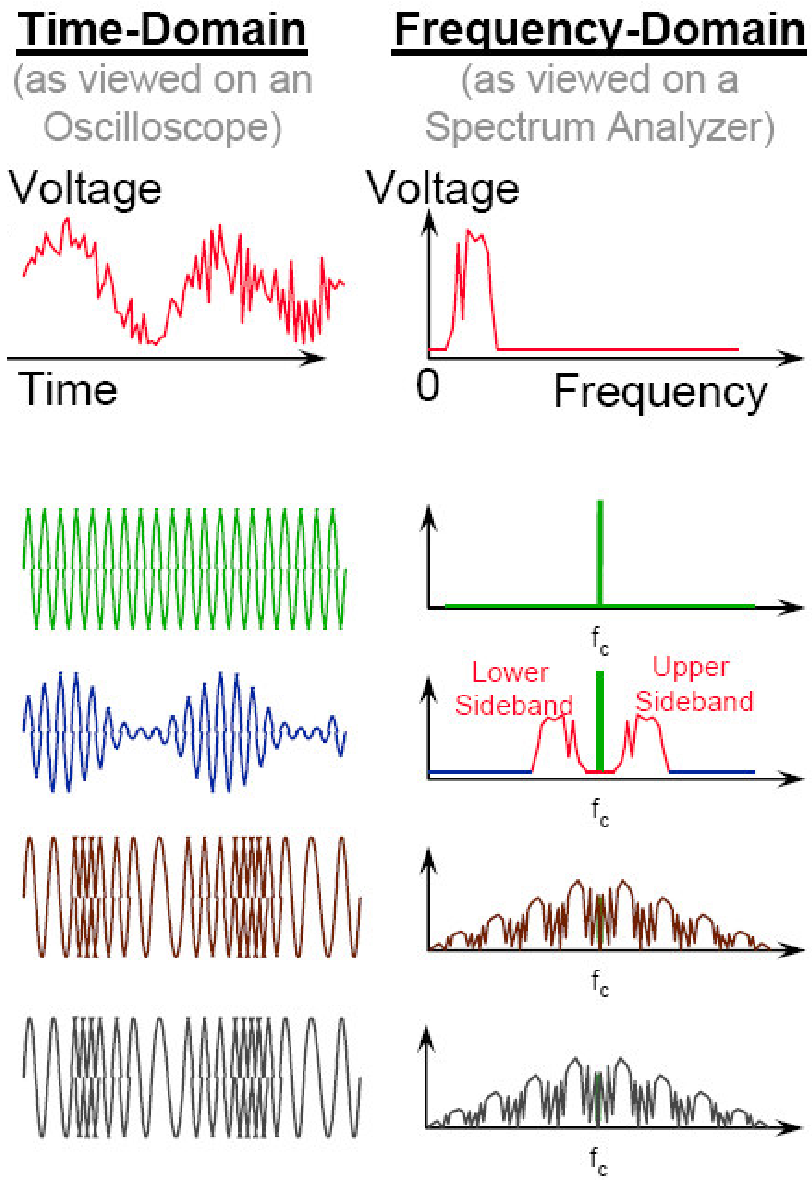
- $S(t)$: The complete, time-varying radio **signal**
- ω_c: Natural **Frequency** of the signal
- A: **Amplitude** (strength) of the signal
- φ: **Phase** of the signal

Compare these Signals:



- The purpose of telecommunications is to send information from one place to another
- Our civilization exploits the transmissible nature of radio signals, using them in a sense as our “carrier pigeons”
- To convey information, some characteristic of the radio signal must be altered (I.e., ‘modulated’) to represent the information
- The sender and receiver must have a consistent understanding of what the variations mean to each other
  - “one if by land, two if by sea”
- Three commonly-used RF signal characteristics which can be varied for information transmission:
  - Amplitude
  - Frequency
  - Phase

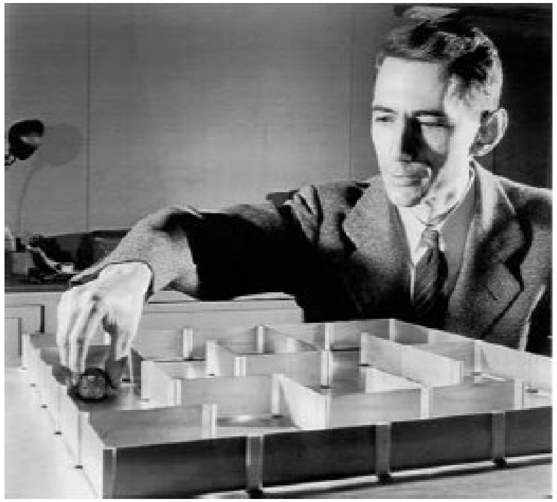
How Much Bandwidth do Signals Occupy?

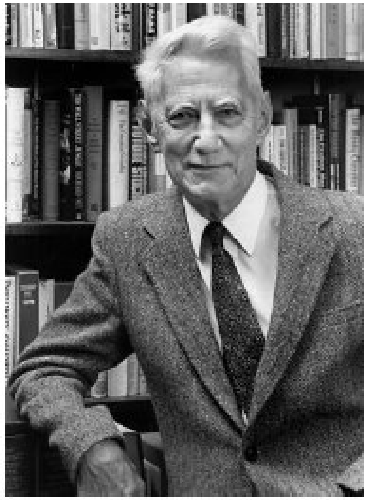


- **The bandwidth occupied by a signal depends on:**
  - **input information bandwidth**
  - **modulation method**
- **Information to be transmitted, called "input" or "baseband"**
  - bandwidth usually is small, much lower than frequency of carrier
- **Unmodulated carrier**
  - the carrier itself has **Zero** bandwidth!!
- **AM-modulated carrier**
  - Notice the upper & lower sidebands
  - total bandwidth = 2 x baseband
- **FM-modulated carrier**
  - Many sidebands! bandwidth is a complex Bessel function
  - Carson's Rule approximation 2(F+D)
- **PM-modulated carrier**
  - Many sidebands! bandwidth is a complex Bessel function

Claude Shannon:
The Einstein of Information Theory

- The core idea that makes CDMA possible was first explained by Claude Shannon, a Bell Labs research mathematician
- Shannon's work relates amount of information carried, channel bandwidth, signal-to-noise-ratio, and detection error probability
  - It shows the theoretical upper limit attainable





n 1948 **Claude Shannon** published his landmark aper on information theory, ***A Mathematical Theory of Communication***. He observed that the fundamental problem of communication is hat of reproducing at one point either exactly or pproximately a message selected at another oint." His paper so clearly established the oundations of information theory that his ramework and terminology are standard today. Shannon died Feb. 24, 2001, at age 84.

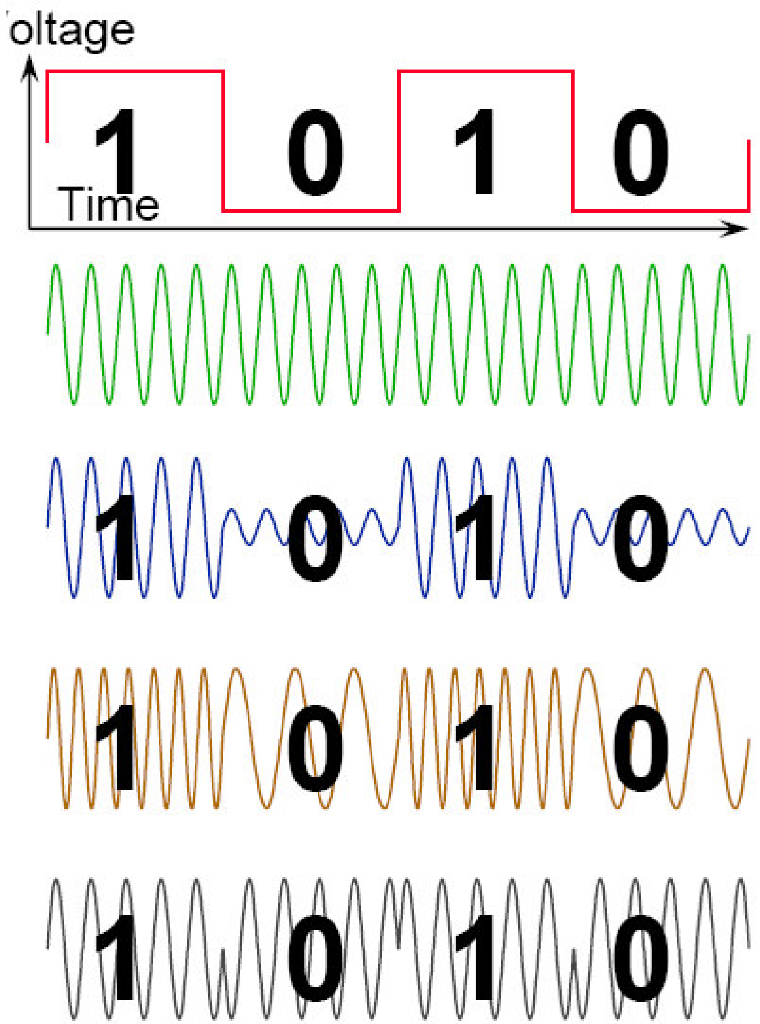
SHANNON'S CAPACITY EQUATION

$$C = B_\omega \log_2 \left[1 + \frac{S}{N} \right]$$

B_ω = bandwidth in Hertz
C = channel capacity in bits/second
S = signal power
N = noise power

Modulation by Digital Inputs

Our previous modulation examples used continuously-variable analog inputs. If we quantize the inputs, restricting them to digital values, we will produce digital modulation.



- For example, modulate a signal with this **digital** waveform. No more continuous analog variations, now we're "shifting" between discrete levels. We call this "shift keying".
  - The user gets to decide what levels mean "0" and "1" -- there are no inherent values
- Steady **Carrier** without modulation
- **Amplitude Shift Keying**
  ASK applications: digital microwave
- **Frequency Shift Keying**
  FSK applications: control messages in AMPS cellular; TDMA cellular
- **Phase Shift Keying**
  PSK applications: TDMA cellular, GSM & PCS-1900

Digital Modulation Schemes

- There are many different schemes for digital modulation, each a compromise between complexity, immunity to errors in transmission, required channel bandwidth, and possible requirement for linear amplifie
- Linear Modulation Techniques
  - BPSK Binary Phase Shift Keying
  - DPSK Differential Phase Shift Keying
  - **QPSK** Quadrature Phase Shift Keying ***IS-95 CDMA forward link***
    - Offset QPSK ***IS-95 CDMA reverse link***
    - Pi/4 DQPSK ***IS-54, IS-136 control and traffic channels***
- Constant Envelope Modulation Schemes
  - BFSK Binary Frequency Shift Keying ***AMPS control channels***
  - MSK Minimum Shift Keying
  - GMSK Gaussian Minimum Shift Keying ***GSM systems, CDPD***
- Hybrid Combinations of Linear and Constant Envelope Modulation
  - MPSK M-ary Phase Shift Keying
  - QAM M-ary Quadrature Amplitude Modulation
  - MFSK M-ary Frequency Shift Keying ***FLEX paging protocol***
- Spread Spectrum Multiple Access Techniques
  - DSSS Direct-Sequence Spread Spectrum ***IS-95 CDMA***
  - FHSS Frequency-Hopping Spread Spectrum

Thank you