

# ELG3175: Introduction to Communication Systems (online)

- **Instructor:** Dr. Sergey Loyka (CBY A608).
- **Course Web page:** <http://www.site.uottawa.ca/~sloyka/> . Some info and course material (lecture slides, lab guidelines, references etc.) will be posted there.
- **Lectures:** Wed. 16:00 - 17:20, Fri. 14:30 – 15:50, via MS Teams (“ELG3175 Lectures” team). 1st Lecture: Wed. Jan. 12, 16:00.
- **Tutorial:** Begin on Jan. 19 (no tutorial 1st week); via MS Teams (“ELG3175 Tutorial” team). Wed. 13:00 - 14:20, Thu. 17:30 - 18:50.
- **Labs:** Begin on Jan. 24 (no labs 1st 2 weeks); via MS Teams (“ELG3175 Lab” team) ; Monday 08:30 - 11:20, Tuesday 11:30-14:20.

- **Office hours:** You are encouraged to ask questions during lectures.
- **Assignments & quizzes:** about 8.
- **Midterm exam:** Fri. Feb. 18, 14:30-15:50 (regular lecture time)
  - Includes everything covered in the class before the midterm; open book.
  - Individual (no collaboration is allowed).
  - The regular plagiarism policies apply.
  - Marked exam papers will be returned within 2-3 weeks.
- **Final exam:**
  - Includes everything covered in the class (lectures, labs, tutorials, assignments); open book.
  - Individual (no collaboration is allowed).
  - The regular plagiarism policies apply.
  - It is for evaluation purposes only and will not be returned to the students.
  - Marks are final and will not be negotiated.

# On-line course delivery

- **Lectures:**

- via MS Teams on the regular schedule; “ELG3175 Lectures” team has already been set up, you should have access to it (via your uottawa account) if you are registered for the course. If you are registered but cannot access it, please contact our undergrad. office for assistance with registration/uottawa account.
- Please familiarize yourself with MS Teams and practice using it beforehand.

- **Tutorials:**

- via MS Teams on the regular schedule; “ELG3175 Tutorial” team has been already set up.

- **Labs:**

- via MS Teams the regular schedule, “ELG3175 Lab” team, + Matlab access to perform experiments (remotely using your uottawa account, consult our IT support if you have a problem).

- **Midterm and Final exams:**

- via Brightspace (use your uottawa account). A brief personal interview (via Teams or otherwise) will be used to validate the exam results.

# On-line course delivery

- Announcements, lecture slides, lab guidelines and other information will be available on the course web page, found at <http://www.site.uottawa.ca/~sloyka/>
- If you send me an email and expect an answer, include “ELG3175” in the subject line (no answer otherwise).
- You are encouraged to ask questions during lectures.
- All assignment and lab questions – to the respective TA.

- **Marking Scheme:**
  - Assignments + quizzes            20%
  - Labs                                    20%
  - Midterm Examination            20%
  - Final Examination                40%
  - Bonus points to everybody who takes active part in the course.
- **Note that:**
  - All the course components (lectures, tutorials, labs, assignments) are mandatory. Miss at your own risk.
  - Marking scheme is final and will not be changed.
  - Marks are determined by academic performance only (not by bargaining abilities).
  - Marks will not be negotiated.
  - All questions are to be answered during the semester (no guarantee afterwards).
- **Absence:** for medical reasons only, valid if medical certificate.

- **Required textbook (must have):**
  - L.W. Couch II, Digital and Analog Communication Systems, 8<sup>th</sup> Edition, Prentice Hall, 2013 (2007 is OK, but watch for section/problem #s).
- **Additional texts:**
  - W.M. Siebert, Circuits, Signals, and Systems, The MIT Press, 1986.
    - very good book, with intuitive engineering discussions/examples
  - A.V. Oppenheim, A.S. Willsky, Signals and Systems, Prentice Hall, 1997.
    - the standard textbook on signals & systems (ELG3125)
  - H.P. Hsu, Analog and Digital Communications, McGraw Hill, 1993 or 2002.
    - tons of examples
- **Alternative textbooks:**
  - R.E. Ziemer, W.H. Tranter, Principles of Communications, Wiley, New York, 2009.
  - B.P.Lathi, Modern Digital and Analog Communication Systems, Oxford University Press, 1998.
  - A.B. Carlson, P.B. Crilly, J.C. Rutledge, Communication Systems, McGraw Hill, 2002.
  - J.G. Proakis, M.Salehi, Fundamentals of Communications Systems, Prentice Hall, 2005.

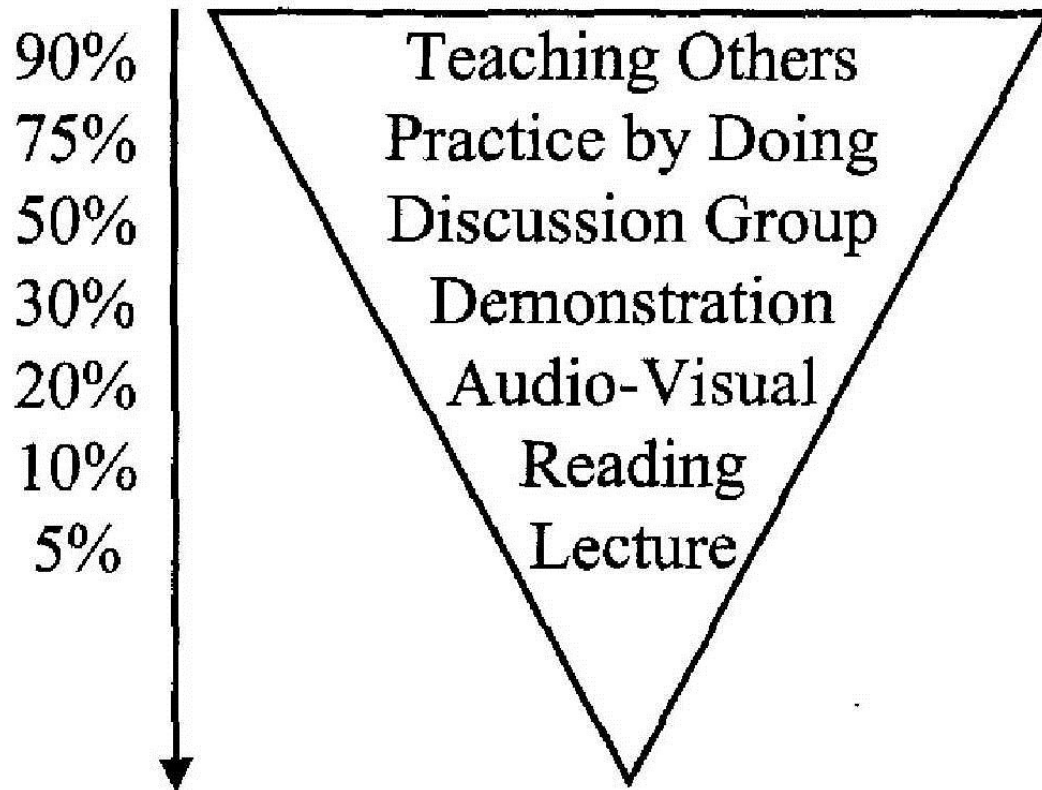
- **Prerequisite:** ELG3125 (very important)
  - Complex numbers/functions
  - Linear systems and signals (impulse/frequency response etc.)
  - Fourier analysis (continuous/ discrete time, spectra etc.)
  
- **Co-requisite:** ELG3126 (basic probability theory)

- **Plagiarism**: copying solutions to assignments, quizzes, exams and lab reports from anywhere is a serious academic crime that carries significant penalty. Plagiarism is absolutely not acceptable.
- While working in groups on assignments is not a plagiarism, submitting identical or nearly identical solutions is and will be severely penalized. Every student is expected to submit his own **individual solutions**.
- If two (or more) identical or almost identical sets of solutions are found, each student involved receives 0 (zero) for that particular assignment. If this happens twice, the students involved receive 0 (zero) for the entire assignment component of the course in the marking scheme and the case will be send to the Dean's office for further investigation.
- From the past experience, the students who copy assignments/labs, do **poorly in exams**.

# ELG3175: Introduction to Communication Systems

- **Purpose:** to introduce basic principles and techniques for the analysis and design of modern communication systems.
- **Contents:**
  - Introduction.
  - Review of Fourier analysis, linear systems & sampling theorem. Bandpass signals & Hilbert transform.
  - Linear modulation schemes: DSB AM, DSB-SC AM, SSB AM & vestigial AM. Detection of AM, superheterodyne receiver.
  - Angle modulation: phase & frequency. Detection of FM & PM.
  - Basic digital modulation techniques: ASK, PSK, FSK. Bandwidth requirements of PAM. PCM & companding.
  - Introduction to information theory and error control coding.

# How to Study: Learning Efficiency Pyramid



“Tell me and I’ll forget;  
show me and I may  
remember; involve me  
and I’ll understand.” –  
old Chinese proverb.

“No pain, no gain”  
– common wisdom.

**Figure 1. The Learning Pyramid, adapted from David Sousa, *How the Brain Learns*, Reston, VA, The National Association of Secondary School Principals, 1995, ISBN 0-88210-301-6.**

# How to Study ?

*“Education is the accumulation of understanding, not just an accumulation of facts” [D. Pozar]*

- Learning efficiency pyramid is a good guideline
- Reading is necessary, but taken alone is not efficient
- Solving problems (“practice by doing”)
  - is much more efficient
  - examples, assignments, end-of-chapter problems
- Group discussions
  - help provided you contribute something
- Systematic study during the semester
  - is a key to a success.
  - do not leave everything to the last day/night before exams!
- Lectures
  - should be supplemented by the items above

# Introduction to Communication Systems

- What is a communication system? Any means for transmission of information.
- Types of communication systems: wireline & wireless, digital & analog, point-to-point & broadcasting, low frequency/high frequency etc.
- Examples:
  - cell phone, landline
  - WiFi
  - Internet, optical fiber systems
  - TV, radio
  - remote control, wireless key
  - hard disk, USB memory stick

# Historical Review

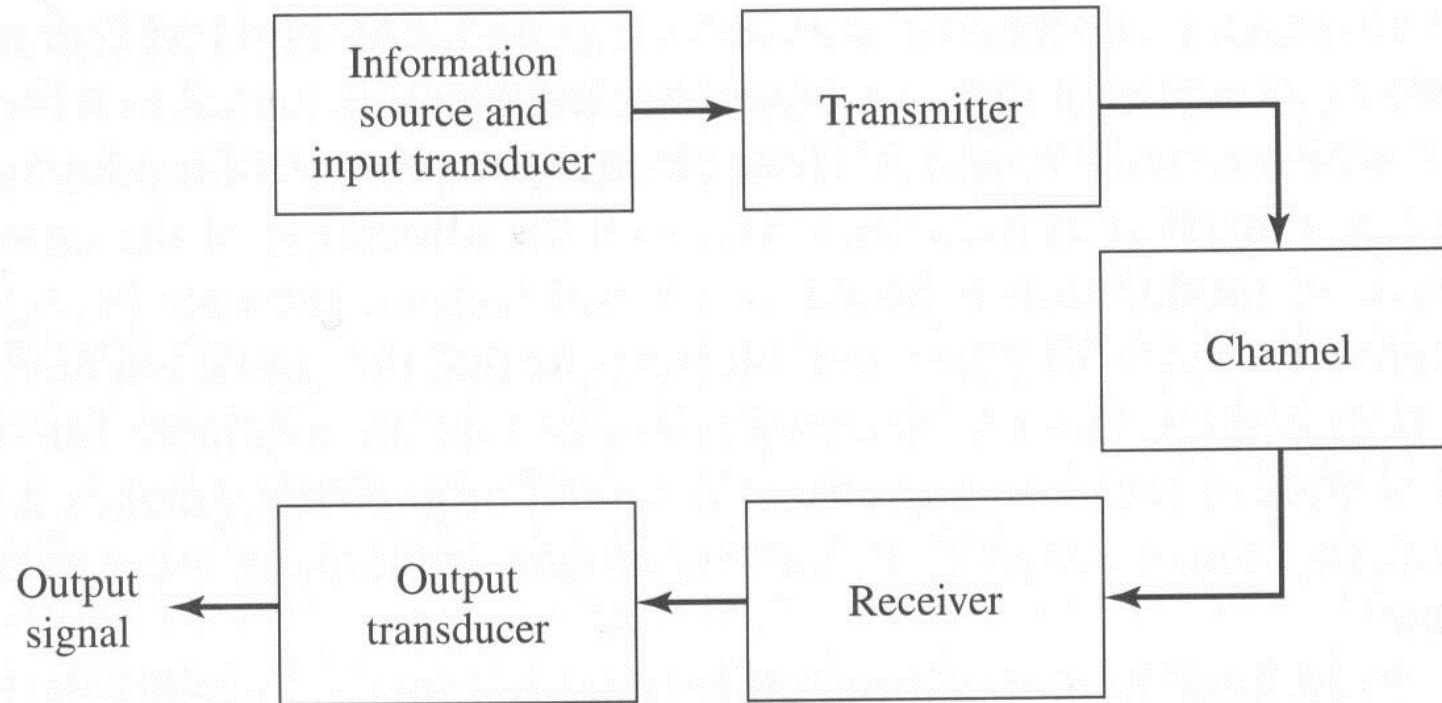
- telegraph by Morse, 1837 (operational in 1844).
- telephone by Bell, 1876 (Bell Telephone Company in 1877).
- radio (wireless) by A. Popov in 1895 & G. Marconi in 1896.
- first transcontinental wireless transmission in 1901 by Marconi
- vacuum diode by Fleming (1904) & vacuum triode by De Foster (1906)
- Superheterodyne receiver by Armstrong (during WWI)
- transcontinental telephone transmission in 1915 (operational)
- AM broadcast, 1920
- first TV system by Zworykin, 1929 (broadcasting in London, 1936)
- first FM communication system by Armstrong, 1933

# Historical Review

- 1st digital computer ENIAC at the University of Penn., 1945
- invention of transistor by Brattain, Bardeen & Shockley, 1947
- fundamental work of Shannon & birth of information theory, 1948
- transatlantic cable & telephone service between Europe and USA, 1953
- 1st Earth satellite is launched by USSR, 1957
- invention of IC by Kilby, 1958
- 1st commercial communication satellite, 1965
- single-chip microprocessor by Intel, 1971
- 1st cellular phone by Motorola, 1972
- personal computers, 1976
- Internet, 1990s
- Smartphone, 1993
- Google (?), Youtube, Facebook, Twitter

# Elements of Communication System

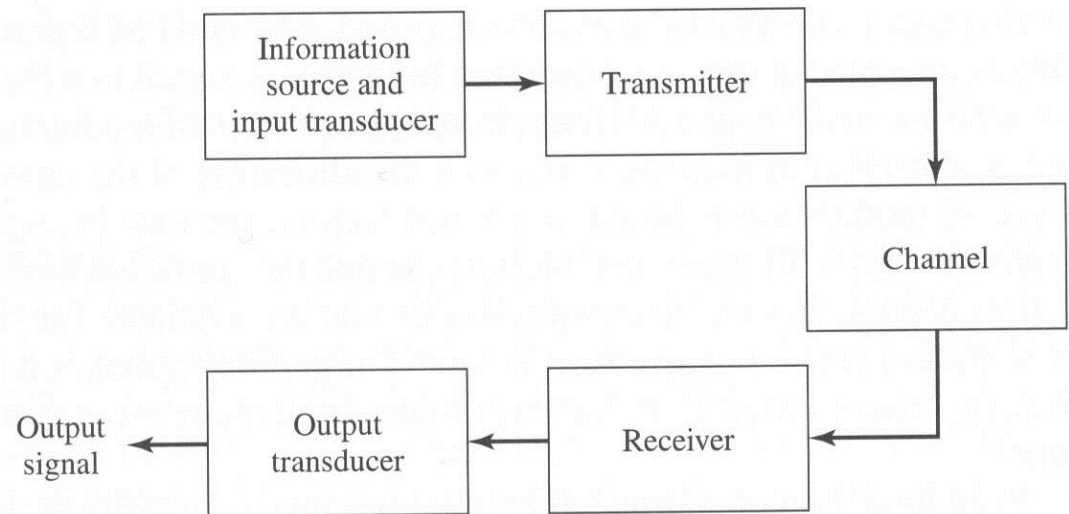
high-level block diagram



J.Proakis, M.Salehi, Communications Systems Engineering, Prentice Hall, 2002

# Elements of Communication System

- source – generates information (speech, video, text, data etc.)
- transducer – transforms source output into electrical signal (e.g. a microphone) and back (at Rx end)
- three major parts:
  - transmitter (Tx)
  - channel
  - receiver (Rx)



J.Proakis, M.Salehi, Communications Systems Engineering, Prentice Hall, 2002

# Transmitter

- Converts electrical signal into a form suitable for transmission through the channel (physical medium)
- Need to do this because the transducer output signal cannot, in most cases, be transmitted directly (doesn't match the channel)
- Conversion is made through modulation: amplitude (AM), frequency (FM) & phase (PM). Examples: AM & FM radio broadcast
- Other functions: filtering, amplification, radiation

# Channel

- This is the physical medium between the transmitter and the receiver
- Can be wired (telephone line) or wireless (radio)
- Whatever the medium, the signal is corrupted by noise and interference
- Examples: thermal noise, lightning discharge, automobile ignition noise, interference from other users etc.
- Channel may be highly non-stationary (i.e., fading)
- Significant signal attenuation may be introduced (100-200dB)
- Other types of signal distortions (i.e., spectrum distortion)

# Receiver

- Main function: to recover the message from the received signal
- Somewhat inverse of the transmitter function
- Demodulation: inverse of the modulation
- Operates in the presence of noise & interference. Hence, some distortions are unavoidable.
- Some other functions: filtering, suppression of noise & interference

# Characteristics of Communication Channels

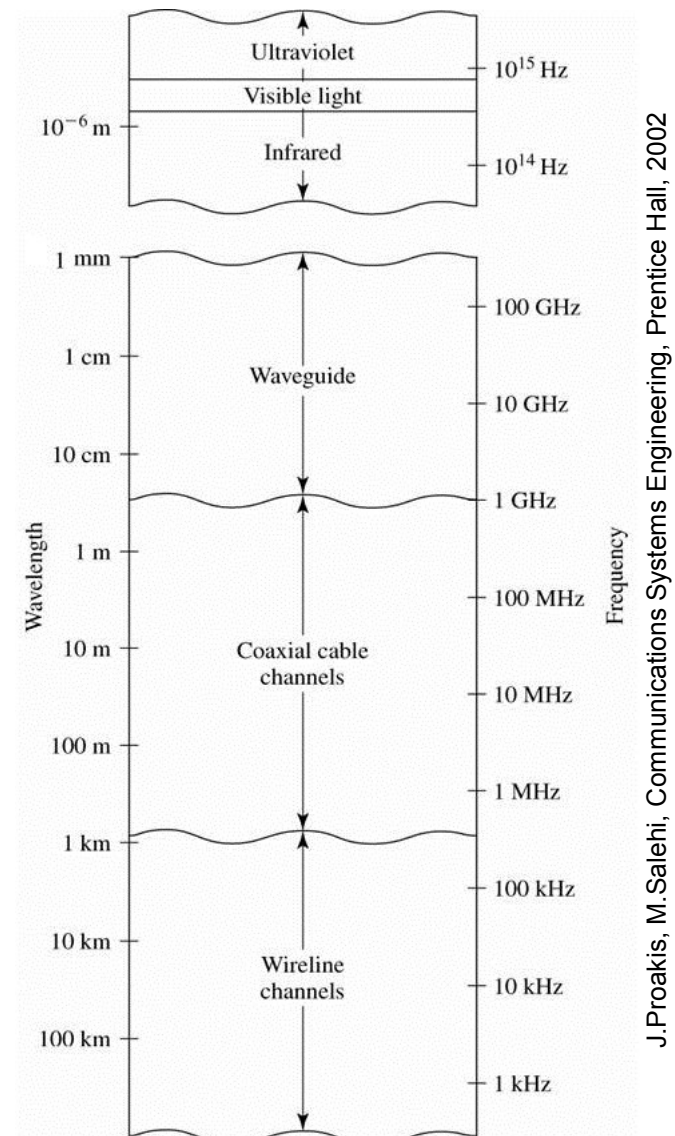
## Wireline channels:

- twisted-wire pair
- coaxial cable
- waveguides
- optic fiber

Signals are distorted in amplitude and phase. Some measures are required to reduce the effect of distortions.

Bandwidth of (up to)

- twisted pair: 10s kHz to 1s MHz
- coax cable: 10s GHz
- wave guide: 100s GHz
- optical fiber: 10 THz

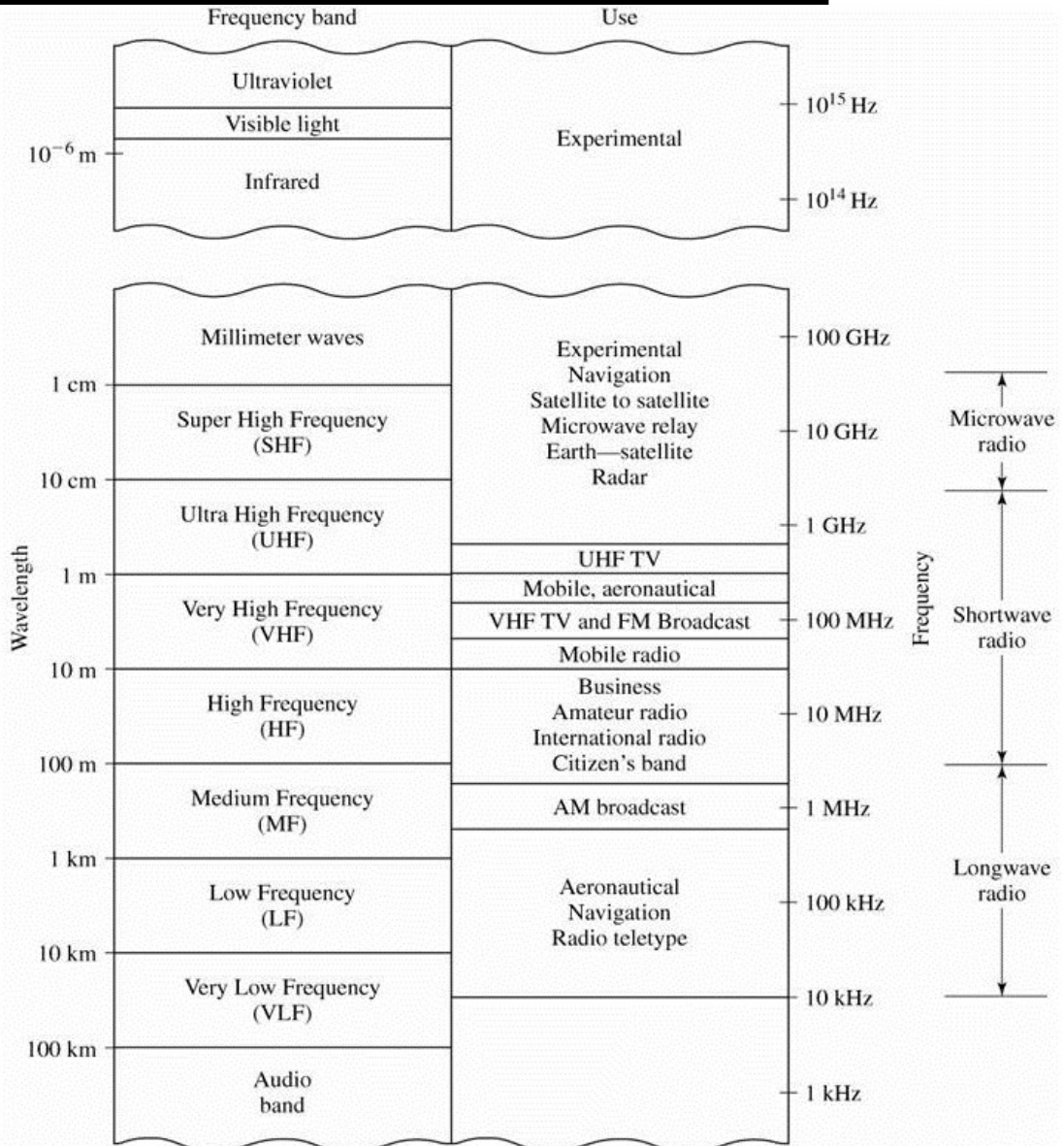


J.Proakis, M.Salehi, Communications Systems Engineering, Prentice Hall, 2002

# Radio Communication Channels

(wireless)

- Unguided electromagnetic wave, radiated by the Tx antenna, is a carrier of the signal
- Strong signal attenuation (up to 200 dB). Hence, high Tx power is required
- Susceptible to external interference
- Antennas are required. Size of antenna: comparable with wavelength

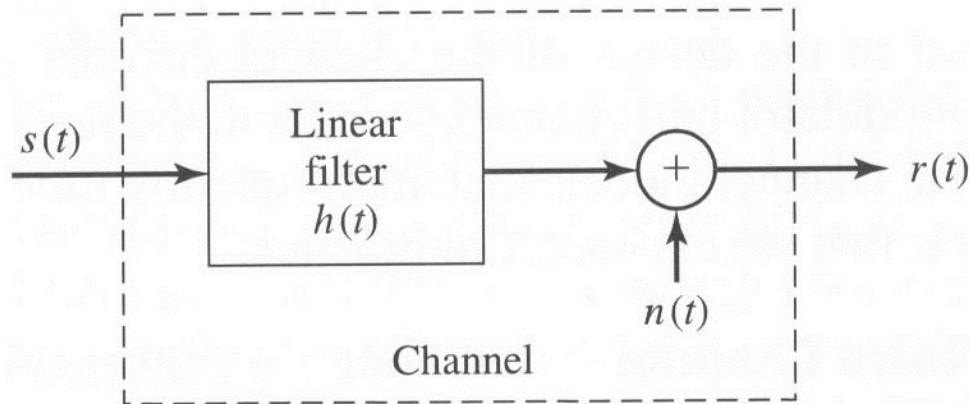


# Typical Frequencies

- Cell phone: 1-2 GHz
- Cordless phone: 43-50 MHz, 900 MHz, 2.4 and 5.8 GHz.
- Cable phone: 300-3400 Hz
- WiFi: 2.5, 5 GHz
- DSL Internet (over the phone cable): 30 kHz-1.5MHz
- TV (satellite): 10-12 GHz
- TV (cable/broadcast): 50-950 MHz
- AM broadcast: 300kHz – 1.5 MHz
- FM broadcast: 80-110 MHz
- Optical: 100s THz

# Mathematical Models of Channels

System-level model: linear time-invariant system



J.Proakis, M.Salehi, Communications Systems Engineering, Prentice Hall, 2002

$$\begin{aligned} r(t) &= s(t) * h(t) + n(t) = \\ &= \int_{-\infty}^{+\infty} h(\tau) s(t - \tau) d\tau + n(t) \end{aligned}$$

Detailed model: based on electromagnetics (i.e., radio wave propagation)

# Summary

- Definition of communication systems and their types. Examples.
- Historical review
- Block diagram and its elements.
- Main elements: transmitter, channel and receiver