

Department of Electrical and Computer Engineering

College of Engineering and Applied Sciences

WESTERN MICHIGAN UNIVERSITY



ECE 4600/5950

Communication Systems

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Course/Lecture Overview

- Syllabus
 - Personal Intro.
 - Textbook/Materials Used
 - Additional Reading
 - ID and Acknowledgment of Policies
-
- Textbooks
 - Chapter 1

Syllabus

- Everything useful for this class can be found on Dr. Bazuin's web site!
 - <http://homepages.wmich.edu/~bazuinb/>
- The class web site is at
 - http://homepages.wmich.edu/~bazuinb/ECE4600/ECE4600_Fa09.htm
- The syllabus ...
 - http://homepages.wmich.edu/~bazuinb/ECE4600/Syl_4600_ABET.pdf
 - http://homepages.wmich.edu/~bazuinb/ECE4600/Syl_4600.pdf
 - http://homepages.wmich.edu/~bazuinb/ECE4600/Syl_5950.pdf

Who am I?

- **Dr. Bradley J. Bazuin**

- Born and raised in Grand Rapids Michigan, Forest Hills School District
- Education
 - BS in Engineering and Applied Sciences, Extensive Electrical Engineering from Yale University in 1980
 - Graduate MS and PhD in Electrical Engineering from Stanford University in 1982 and 1989, respectively.
- Industry
 - Part-time ARGOSystems, Inc. (purchased by Boeing) 1981-1989
 - Full-time ARGOSystems, Inc. 1989-1991
 - Full-time Radix Technologies 1991-2000
- Academia
 - Term-appointed Faculty, WMU ECE Dept. 2000-2001
 - Tenure track Assistant Professor, WMU ECE Dept. 2001-2007
 - Tenured Associate Professor, WMU ECE Dept. 2007-
- Research
 - Wireless communications, RF signal physical layer signal processing
 - CAViDS condition based maintenance – sensors electronics and embedded microcontroller
 - Roll-to-roll Printed Electronics - organic and polymer semiconductors and functional materials used to form basic electronic devices and circuits
 - Sunseeker Electronics – CAN bus, CAN custom PCBs, battery protection system

Required Textbook/Materials

- A. Bruce Carlson, P.B. Crilly, *Communication Systems*, 5th ed., McGraw-Hill, 2010. ISBN: 978-0-07-338040-7
- MATLAB, Student Edition
- MATLAB Signal Processing Toolbox
 - The MATH Works,
MATLAB (\$99) and Signal Processing Toolbox (\$29)
<http://www.mathworks.com/>
- LTSpice IV – [Linear Technology](http://www.linear.com/designtools/software/index.jsp)
<http://www.linear.com/designtools/software/index.jsp>

Supplemental Books and Materials

- Leon W. Couch II, Digital and Analog Communication Systems, 7th ed. Prentice Hall, 2007.
ISBN: 0-13-142492-0.
- John G. Proakis and Masoud Salehi, Communication Systems Engineering, 2nd ed. Prentice Hall, 2002.
ISBN: 0-13-061793-8.
- B.P Lathi, Zhi Ding, Modern Digital and Analog Communication Systems, Oxford Univ. Press, 2009.
ISBN: 978-0-19-533145-5.

Identification and Acknowledgement

- Identification for Grade Posting, Course and University Policies, and Acknowledgement
- Please read, provide unique identification, sign and date, and return to Dr. Bazuin.

Course/Text Overview

Chapter 1: Introduction (1 Lecture)

Chapter 2: Signals and Spectra (2 Lectures)

Chapter 3: Signal Transmission and Filtering (4 Lectures)

Chapter 4: Linear CW Modulation (3 Lectures)

Exam #1

Chapter 5: Exponential CW Modulation (4 Lectures)

Chapter 6: Sampling and Pulse Modulation (2 Lectures)

Chapter 7: Analog Communication Systems (4 Lectures)

Exam #2

Course/Text Overview

Chapter 8: Probability and Random Variables (1 Lecture)

Chapter 9: Random Signals and Noise (1 Lecture)

Chapter 10: Noise in Analog Modulation Systems (3 Lectures)

Chapter 11: Baseband Digital Transmission (3 Lectures)

Chapter 14: Bandpass Digital Transmission (4 Lectures)

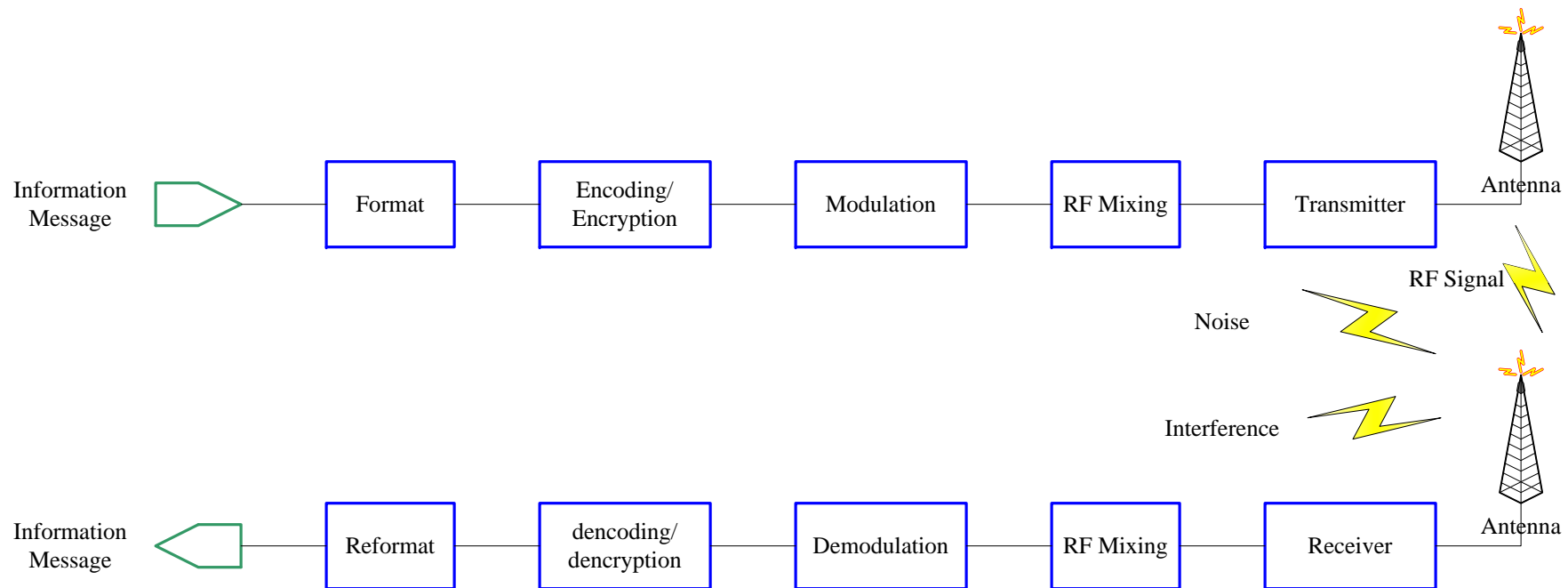
Chapter 15: Spread Spectrum Systems (1 Lectures, as time permits)

Final Exam

Chapter 1: Introduction

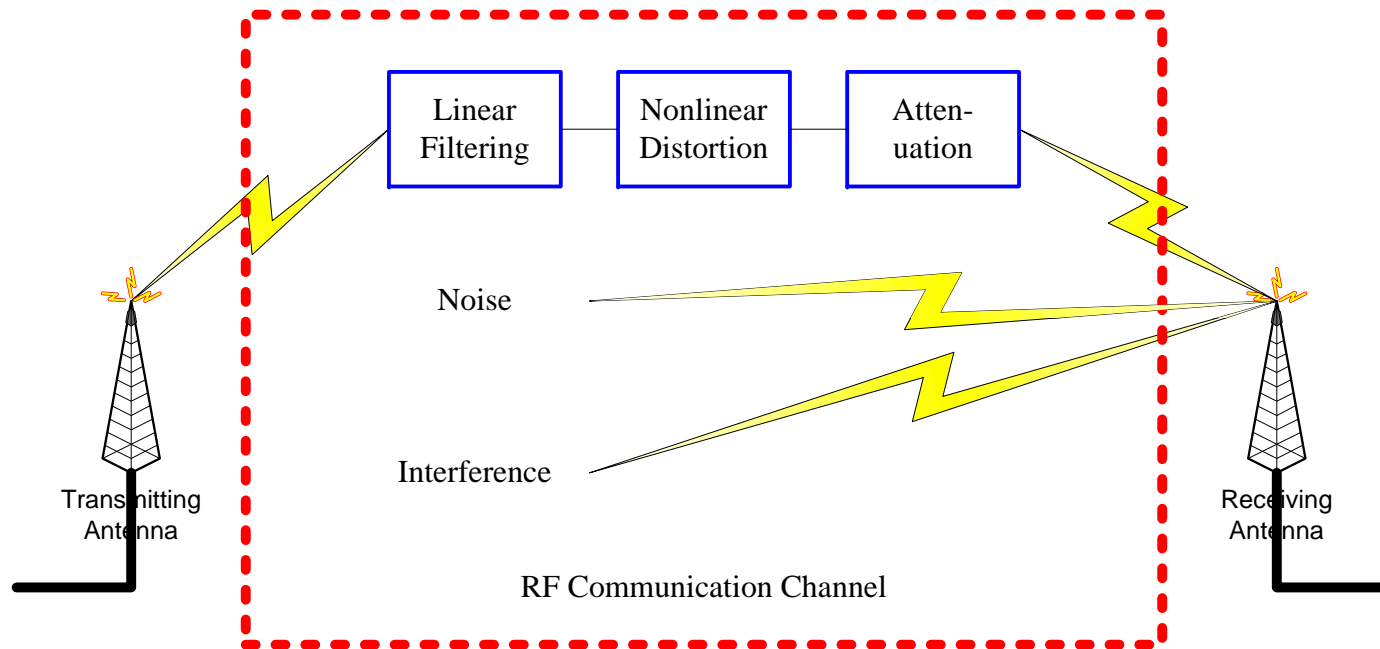
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Communications System



- Analog or Digital Communications
 - Information Message Type (Analog or Digital)
 - Modulation Type (Discrete or Continuous)
- Terminology
 - Message, Symbol, Signal, Noise

Communication Channel



- The channel greatly effects received RF signals
 - Frequency, Bandwidth, Transmitted Signal Power, RF Propagation
 - Attenuation, Nonlinear Distortion, Multipath, Range, Direction
 - Signal-to-Noise Ratio (SNR) and Signal-to-Interference Ratio (SIR)

Sinusoidal Signal Modulation

$$s(t) = A \cdot [1 + \mu \cdot m_1(t)] \cdot \cos \left\{ 2\pi \cdot f_0 \cdot t + \theta + \phi_p \cdot m_2(t) + 2\pi \cdot \Delta_f \cdot \int^t m_3(\lambda) \cdot d\lambda \right\}$$

- Message 1: Amplitude Modulation (AM)
- Message 2: Phase Modulation (PM)
- Message 3: Frequency Modulation (FM)

“Carrier” waveforms besides a sinusoid may be used

- Pulse Train, Pulse Position, Chaos, etc.

Complex Modulation

$$s(t) = A \cdot [1 + \mu \cdot m_1(t)] \cdot \exp \left\{ j \cdot 2\pi \cdot f_0 \cdot t + j \cdot \theta + j \cdot \phi_p \cdot m_2(t) + j \cdot 2\pi \cdot \Delta_f \cdot \int^t m_3(\lambda) \cdot d\lambda \right\}$$

- Using a complex phasor instead of a real sin or cos.
 - Perform signal processing in the complex domain (real and imaginary or in-phase and quadrature-phase).

Note: Both real and complex signals and signal notations exist and will be used in this class!

Received Signal

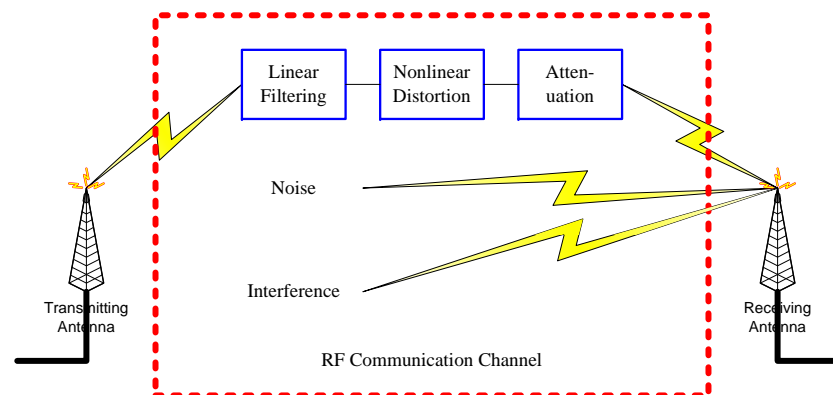
$$r(t) = s(t) * g(t) + \{s_2(t) * g_2(t) + \dots + s_N(t) * g_N(t)\} + n(t)$$

Signal of interest

Interference or
other signals

Noise

- The receiver must extract the original message as best possible!
- The RF channel(s) must be allocated and efficiently utilized.
 - Frequency band assignments and regulations (power, direction, etc.)
 - Signal modulation structures have different characteristics



Simple History of Communications

- **Telegraph – Samuel Morse**
- **Telephony – Alexander Graham Bell**
- **Wireless Telegraphy – Marconi and Popov**
- **Commercial Wireless Services**
 - **Point-to-point and ship-to-shore radios**
- **Transcontinental Telephone – The Bell System**
- **Television**
- **Teletypewriter**
- **FM Radio**
- **Sonar/Radar**
- **Color Television**
- **Transoceanic Telephone**
- **Satellite Communication**
- **Electronic Telephone Switching System**
- **Cable TV**
- **ARPANET**
- **Satellite TV Broadcasting**
- **Cellular Telephones**
- **Fax Machines**
- **High Definition Television (HDTV)**
- **Global Positioning System (GPS)**
- **Wireless Computer Networks (WiFi)**
- **Software Radios**
- **3G Connected Devices – 4G coming**

Societal Impact

- What would life be like without communication devices?
- What is your vision of future communications devices ...
 - Audio
 - Video
 - Computer Networks
 - New methods for transferring information
- Careers related to communications ...
 - In the near future, possibly all jobs will require some knowledge of communications devices and methods.
 - Engineers are the designers and developers, all others are the users.