Chapter 0

Course Introduction/Overview

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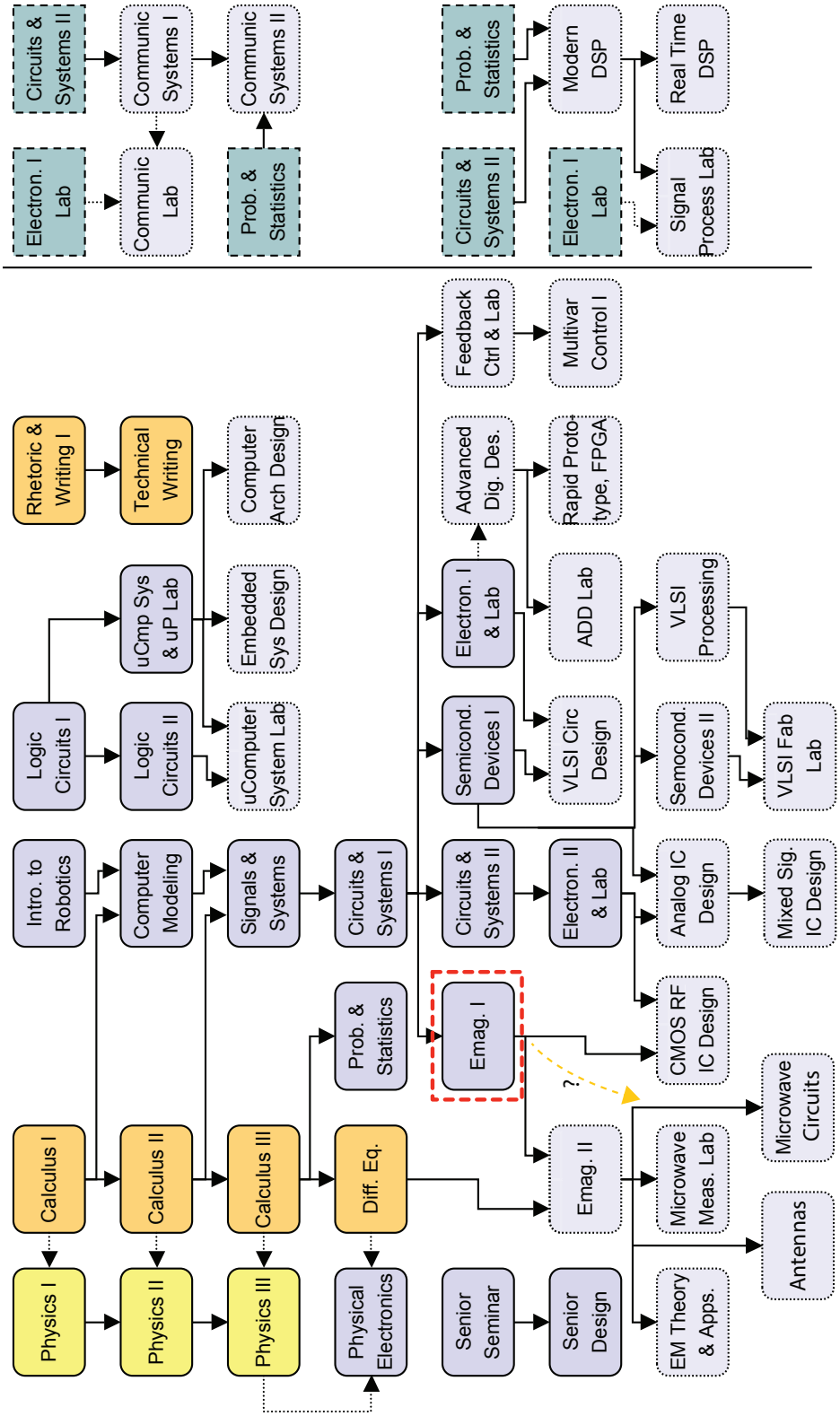
0.1 Introduction

- Course description
- Where are we in the undergraduate curriculum?
- Course syllabus main points
- Instructor policies
- The use of software tools
- The EM I/EM II course sequence (3110/3120) and Microwave Measurements Lab (ECE 4115)
- Other EM courses for senior elective and graduate students
- EM in the *Classical Era*
- EM in the *Modern Era*
- Dr Wickert's EM interests

0.2 Where are we in the Curriculum?



0.3 Syllabus Overview

ECE 3110 Electromagnetic Fields I Spring 2016

Class Time: Mon/Wed 12:15 ~ 1:30 PM
Classroom: Columbine Hall 216
Office Hours: Mon/Wed 11:00 ~ 12:00 PM, Tues 2:00 ~ 2:45 PM
Other times by appointment (walk in if available)
Web Site: http://www.eas.uccs.edu/wickert/ece3001/

Instructor

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EN 292
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Text

Fawwaz T. Ulaby, *Fundamentals of Applied Electromagnetics*, 7th. ed., Prentice Hall, 2015.

Course Description

Static electric and magnetic field analysis, Poisson's and Laplace's equations, steady electric current, fields of steady electric currents, ferromagnetic materials, boundary-value problems for static fields, time-varying electric and magnetic fields, and Maxwell's equations and wave equations. Relationship between field and circuit theory

Course Objectives

- Provide students with methods to analyze and understand electromagnetic field problems that arise in various branches of engineering
- Provide student with a comprehensive introduction to electromagnetic fields and its applications.
- Expose the students to the fundamental concept and techniques of electromagnetics.

Topics

- Waves and Phasors (Chapter 1)
- Transmission Lines (Chapter 2)
- Vector Analysis (Chapter 3)
- Electrostatics (Chapter 4)
- Magnetostatics (Chapter 5)

Homework

Assigned every Wednesday weekly. Assignments will be posted on the course Web Site http://www.uccs.edu/wickert/ece3110/. Papers are due at the start of class. Please make your work neat, logical, and on time. Late homework not accepted.

Exams

In-class quizzes: every Wednesday in class
Mid-term: March 16th, 2016
Final Exam: Wednesday May 18th, 2016 (10:20 AM – 12:20 PM)

Grading

Homework 10%
Quizzes + 1 (maybe two) Team Projects 50%
Mid-term exam 20%
Final exam 20%

0.4 Instructor Policies

- Homework papers are due at the start of class
- If business travel or similar activities prevent you from attending class and turning in your homework, please inform me beforehand to see if we can work something out
- Grading is done on a straight 90, 80, 70, ... scale with curving below these thresholds if needed
- Homework solutions will be placed on the course Web site in PDF format with security password required; hints pages may also be provided

0.5 The Use of Software Tools

- Computer analysis and simulation tools play a vital role in all engineering courses
- Analysis aids from low level to high level include:
  - Calculator, e.g., TI89 (good practice for exams)
  - Excel or similar spreadsheet program for calculations and plotting (more powerful than you might think)
  - Mathematica (free for UCCS students on your own machine) for symbolic and numerical calculations (there is a learning curve, but you may have used in the past)
  - Python/PyLab (Jupyter (was IPython) Notebook or QT command line interface) with NumPy and matplotlib (PyLab), and SciPy very powerful, and **free**; (command line interface similar to MATLAB); notebook will be used in class demos and a personal favorite since *open source*
  - MATLAB (now free for UCCS students on your own machine)
  - LTspice for transmission line simulation + lumped elements + generators, transient and AC frequency sweep; will use in Chapter 2
  - ADS (advanced design system), a very powerful microwave centric design tool from Keysight (formerly Agilent); not planning on using for this course
  - HFSS (high frequency structure simulator) a powerful electromagnetic fields and waves simulator; not planning on using for this course

0.6 The EM I/EM II course sequence and Microwave Measurements Lab

- Traditionally the two semesters of EM were static fields in semester one and dynamic or time varying fields in semester two
- Here at UCCS the text has been chosen to take a significant time-varying fields topic and move it into the first semester; what could that be? transmission lines
- That leaves a lot of other *fun* and *important* topics for EM II such as
  - The full form of Maxwell's equations
  - Plane-wave propagation
  - Wave reflection and transmission
  - Radiation and antennas
  - Satellite communication systems (in EM?) and Radar sensors
- The microwave measurements lab is a natural companion to EM II, as with time-varying fields in full swing, measurements using tools such as an RF/microwave signal generator, spectrum analyzer, power meter, and network analyzer fit into place
- Furthermore the use of an *anechoic chamber* makes sense too (want a free-space like environment to compare theory with measured), likewise a screen/shielded room that is relatively free of external RF/microwave sources (signals)

0.7 EM in the Classical Era

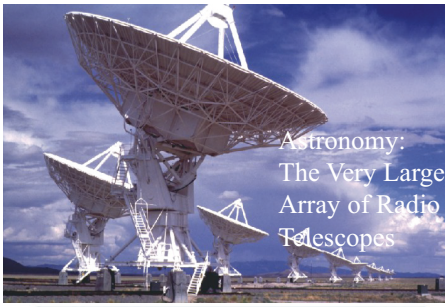
The topic of *engineering* electromagnetics (EM) is rooted in both physics and mathematics. The majority of what goes on in this course plays into your knowledge of these subjects. Circuit theory is also critical to the understanding of the course.

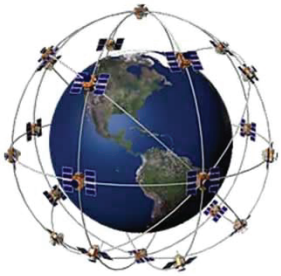
The authors divide the history of EM into the *classical era* and *modern era* (last 100 years). Well known names include:

- Coloumb: Electrical force between two charges
- Volta: Electric battery
- Ampère: Parallel currents in wires make then attract
- Biot & Savart: Relate magnetic field induced by wire segments to the current flowing through it
- Ohm: Relates electric potential to current and resistance
- Henry: Introduces concept of inductance
- Faraday: Changing magnetic flux and *electromotive force*
- Gauss: Relates electric flux through an enclosed surface to enclosed electric charge
- Maxwell: Four equations that are the foundation of classical electromagnetic theory
- Hertz: Electromagnetic radio waves

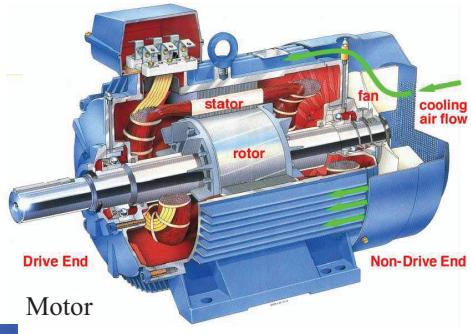
0.8 EM in the Modern Era

EM plays a role in all electronic devices. A very long list, spread over two time lines (communications and computers), are provided in the text. What can you add?

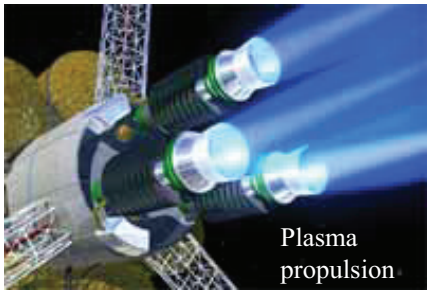


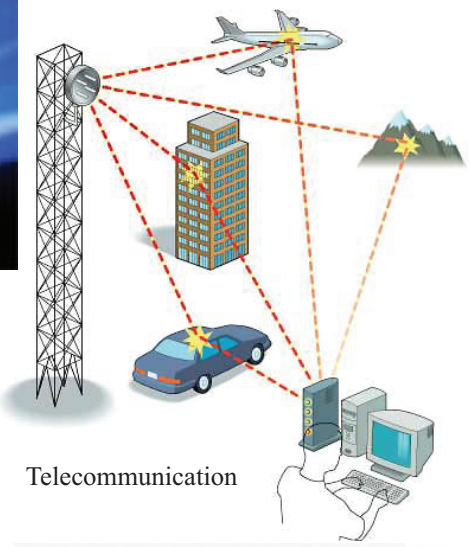


Global Positioning System (GPS)

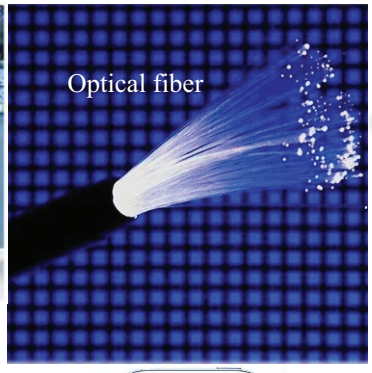


Motor



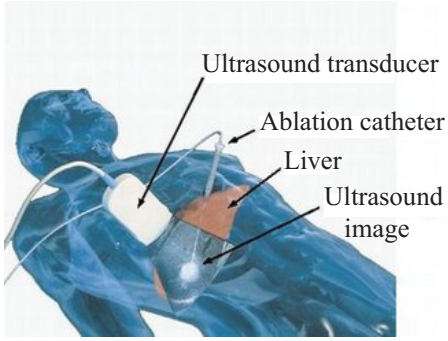


Telecommunication



Electromagnetic sensors

Cell
phone



Microwave ablation for
liver cancer treatment

Figure 1: Electromagnetics and Technology Today.

0.9 Dr Wickert's Interets

- Communications (wireless)
  - The RF/microwave portion of radio transmitters and receivers is also included here
  - I developed the microwave circuits course ECE 4250/5250 (see course Web site)
- Signal processing
  - Digital signal processing is my main focus
  - Analog signal processing is also of great interest
  - Early in my career I was involved with the electronics behind a 1 Gbps free-space optical communications system; wideband microwave circuit design played a critical role

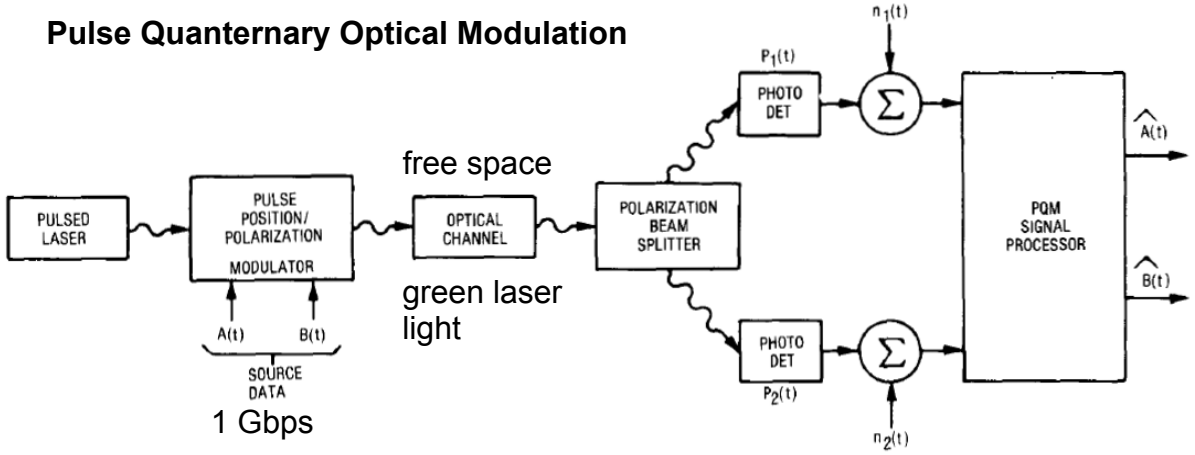
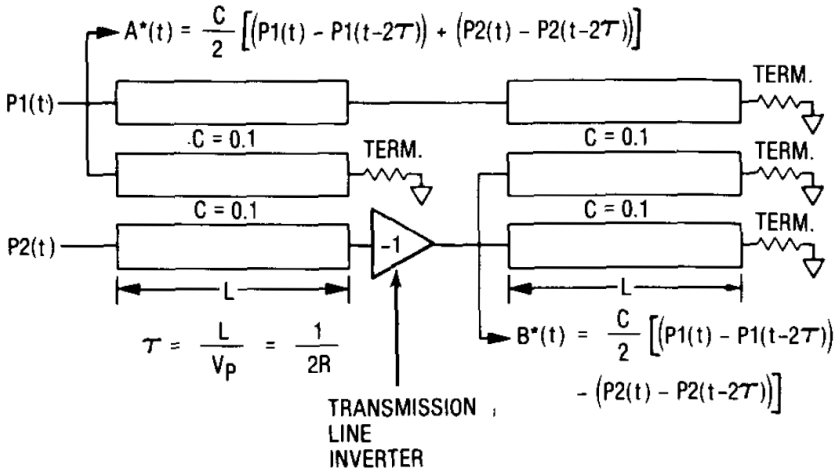


Figure 2: Pulse quanternary modulation (PQM) optical transceiver block diagram

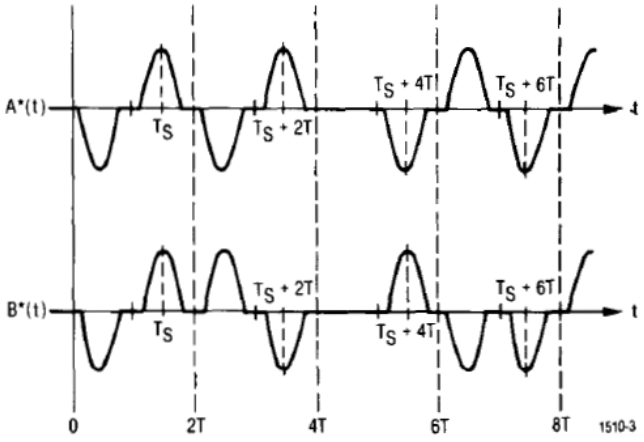
A three line directional coupler (stripline) provides an important part of the receiver

Two of the three line couplers plus one transmission line inverter complete the design



The output waveforms from the dual stripline combiner

Bit decisions on the $A(t)$ and $B(t)$ signal paths are made every T_S seconds (2 ns) or at a 500 MHz rate



Additional performance improvement is obtained by including the Costas Loop pulse demutliplexers

Here performance improvement is lower probability of bit error

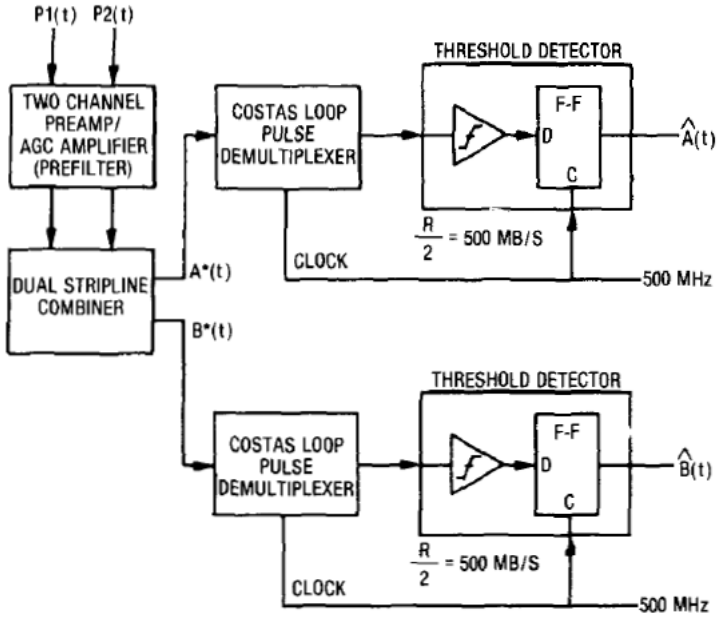


Figure 3: Details of the PQM receiver and the stripline coupler.