ECET 251
Digital Communications
Winter 2020

COURSE OUTLINE

The calendar description is available on the web @	http://camosun.ca/learn/calendar/current/web/ecet.html#ECET251

Ω *Please note: This outline will not be kept indefinitely. It is recommended students keep this outline for their records, especially to assist in transfer credit to post-secondary institutions.*

1. Instructor Information

(a) Instructor	Phil Vreugdenhil		
(b) Office hours			
(c) Location	CBA – 122A		
(d) Phone	250-370-4622	**Alternative:**	
(e) E-mail	VreugdenhilP@camosun.bc.ca		
(f) Website			

2. Intended Learning Outcomes

Upon successful completion of this course a student will be able to:

- demonstrate the use of Smith charts for communication designs;
- explain the operation of digital modulation techniques in time and frequency domains;
- explain the features of digital radio transmitters and receivers;
- describe the effects of noise in digital communication systems;
- demonstrate error detection and correction techniques;
- explain characteristics of spread spectrum schemes;
- describe radio standards and regulations;
- measure electromagnetic compatibility and interference characteristics;
- perform power density and range calculations;
- demonstrate the implementation of a software-defined radio

3. Required Materials – kit from TEC 228, compass set, rest available on the D2L site.

4. Course Content and Schedule

1.   Smith charts   **6 hours**
    1.1   Plotting points
    1.2   Matching with L or C
    1.3   Quarter-wave (λ/4) transformer design
    1.4   Matching stub design
    1.5   Micro strip examples

2.   Digital radio   **4 hours**
    2.1   Why use digital radio?
    2.2   What is digital radio?
    2.3   Keying (OOK, PSK, MPSK)
    2.4   I-Q modulator and demodulator
    2.5   Constellation diagrams
    2.6   Eye pattern
    2.7   Bit rate and symbol rate
    2.8   Encoding
        2.8.1   Balanced code
        2.8.2   Average DC voltage
        2.8.3   Multilevel codes
        2.8.4   Manchester encoding
        2.8.5   Return-to-zero (RZ) and Non-return-to-zero (NRZ)
        2.8.6   Unipolar and bipolar waveforms
    2.9   Bandwidth of digital signals
        2.9.1   Nyquist bandwidth
        2.9.2   Practical bandwidth
        2.9.3   Occupied bandwidth measurements

3.   Digital radio transmitter and receiver   **2 hours**
    3.1   PLL detectors
    3.2   Data slicer
    3.3   Filters
    3.4   Start and stop sequences
    3.5   Data synchronization

4.   Noise in digital radio   **1 hour**
    4.1   Effect on constellation diagram
    4.2   Eye pattern
    4.3   Bit error rate (BER)
    4.4   Coding gain
    4.5   Distance between points

5.   Errors
    5.1   Probability of errors   **2 hours**
        5.1.1   Shannon-Hartley law
        5.1.2 E_b/N_0 ratio
        5.1.3   Probability of error (POE) calculation with waterfall diagram
    5.2   Error handling   **1.5 hours**
        5.2.1   Error detection vs error correction
        5.2.2   Parity bit
        5.2.3   Redundancy and error determination
        5.2.4   Majority bit correction
        5.2.5   Hamming code
        5.2.6   Cyclic redundancy check (CRC) calculation

6.   Channel sharing   **0.5 hours**
    6.1   Time division multiple access (TDMA)

6.2	Frequency division multiple access (FDMA)	
6.3	Code division multiple access (CDMA)	

7.   **Software-defined radio**   **2 hours**

8.   **Spread spectrum (SS) modulation**   **2 hours**
- 8.1   Advantages and disadvantages of SS
- 8.2   Wideband vs narrowband
- 8.3   Direct-sequence SS (DSSS)
- 8.4   Pseudo-noise (PN) codes
- 8.5   Frequency-hopping SS (FHSS)
- 8.6   Noise in spread spectrum
- 8.7   Near-far problem
- 8.8   SS on the spectrum analyzer

9.   **Digital systems overview**   **3 hours**
- 9.1   Bluetooth
- 9.2   Zigbee
- 9.3   Cell phone systems
- 9.4   IEEE 802 WiFi radio standards

10.   **Radio regulations**   **1 hour**
- 10.1   International agreements
- 10.2   Part 15 regulation
- 10.3   Radio Canada and FCC
- 10.4   Unlicensed bands and ISM
- 10.5   Intentional and unintentional radiators
- 10.6   Overview of regulations for various bands
- 10.7   Certification
- 10.8   Signal strength regulations
- 10.9   Bandwidth regulations
- 10.10   Antenna and connector regulations
- 10.11   Responsibility of the designer or installer
- 10.12   Periodic and non-periodic operation

11.   **Introduction to electromagnetic propagation**   **1 hour**
- 11.1   Electric field strength
- 11.2   Magnetic field strength
- 11.3   Power density and the isotropic antenna
- 11.4   Polarization

12.   **Range calculations**   **2 hours**
- 12.1   Antenna effective area
- 12.2   Power received
- 12.3   Range equation

13.   **Wireless propagation in obstructed space**   **2 hours**
- 13.1   Review of refraction, reflection and scattering
- 13.2   Multipath propagation
- 13.3   Intersymbol interference (ISI) and bit spreading
- 13.4   Large-scale and small-scale path loss
- 13.5   Friis free space equation
- 13.6   Path loss in free space and obstructed space
- 13.7   Doppler effect
- 13.8   Strategies for propagation loss reduction

14.   **Electromagnetism (EM)**
- 14.1   EM theory   **3 hours**
  - 14.1.1   Importance of EM

	14.1.2	Electric field theory
	14.1.3	Magnetic field theory
	14.1.4	Near field and far field
	14.1.5	Introduction to Maxwell's equations

14.2   EM measurement   **2 hours**
      14.2.1   EM measurement techniques
      14.2.2   Antennas for EM measurement
      14.2.3   dBμV and dBμV/m
      14.2.4   EIRP

Tests, Quizzes, Other In-Class Assessments, and Review   **7 hours**

                                                           Total: **42 hours**

Labs:
1. Project Overview & Transmission Lines Basics & Intro to RF Gen Set & Spec An
2. Quarter-wave (λ/4) Transformer Match & Simulations
3. Matched Stubs
4. BPSK SPICE Simulation
5. QPSK SPICE Simulation
6, 8–9. Software-Defined Radio Labs 1, 2, 3   * No Lab in week #7 – Reading week
10-12. Wireless Link Project (Parts #1, 2, 3)
13. EM measurement
14. Wireless Link Project (Part #4 & Demo)

5. Basis of Student Assessment (Weighting)
(Should be directly linked to learning outcomes.)

Type	Weighting	Criteria
Labs	20%	Attendance, Use of Equipment, Quality of Data/Analysis
Smith Chart Test	10%	Impedance at a point, Stub & λ/4 Transformer Matching
Wireless Project & Report	10%	Functionality, Features, Analysis
Assignments	10%	Quality of Answers to Take-Home Questions
Mid Term Exam(s)	20%	Topics: Digital Radio, Tx/Rx, Errors, Channel Sharing
Final Exam	30%	Topics: Cumulative (but w/ no Smith Charts)
Total	100%	

6. Grading System
(If any changes are made to this part, then the Approved Course description must also be changed and sent through the approval process.)
(Mark with "X" in box below to show appropriate approved grading system – see last page of this template.)

[x]   Standard Grading System (GPA)

[   ]   Competency Based Grading System

7. Recommended Materials to Assist Students to Succeed Throughout the Course
Consult D2L, instructor, library, internet, etc for more information on any topic.

8. College Supports, Services and Policies

Immediate, Urgent, or Emergency Support
If you or someone you know requires immediate, urgent, or emergency support (e.g. illness, injury, thoughts of suicide, sexual assault, etc.), **SEEK HELP**. Resource contacts @ http://camosun.ca/about/mental-health/emergency.html or http://camosun.ca/services/sexual-violence/get-support.html#urgent

College Services
Camosun offers a variety of health and academic support services, including counselling, dental, disability resource centre, help centre, learning skills, sexual violence support & education, library, and writing centre. For more information on each of these services, visit the **STUDENT SERVICES** link on the College website at http://camosun.ca/

College Policies
Camosun strives to provide clear, transparent, and easily accessible policies that exemplify the college's commitment to life-changing learning. It is the student's responsibility to become familiar with the content of College policies. Policies are available on the College website at http://camosun.ca/about/policies/. Education and academic policies include, but are not limited to, Academic Progress, Admission, Course Withdrawals, Standards for Awarding Credentials, Involuntary Health and Safety Leave of Absence, Prior Learning Assessment, Medical/Compassionate Withdrawal, Sexual Violence and Misconduct, Student Ancillary Fees, Student Appeals, Student Conduct, and Student Penalties and Fines.

A. GRADING SYSTEMS *http://www.camosun.bc.ca/policies/policies.php*

The following two grading systems are used at Camosun College:

1. Standard Grading System (GPA)

Percentage	Grade	Description	Grade Point Equivalency
90-100	A+		9
85-89	A		8
80-84	A-		7
77-79	B+		6
73-76	B		5
70-72	B-		4
65-69	C+		3
60-64	C		2
50-59	D		1
0-49	F	Minimum level has not been achieved.	0

2. Competency Based Grading System (Non GPA)

This grading system is based on satisfactory acquisition of defined skills or successful completion of the course learning outcomes

Grade	Description

COM	The student has met the goals, criteria, or competencies established for this course, practicum or field placement.
DST	The student has met and exceeded, above and beyond expectation, the goals, criteria, or competencies established for this course, practicum or field placement.
NC	The student has not met the goals, criteria or competencies established for this course, practicum or field placement.

B. Temporary Grades

Temporary grades are assigned for specific circumstances and will convert to a final grade according to the grading scheme being used in the course. See Grading Policy at http://www.camosun.bc.ca/policies/E-1.5.pdf for information on conversion to final grades, and for additional information on student record and transcript notations.

Temporary Grade	Description
I	*Incomplete*: A temporary grade assigned when the requirements of a course have not yet been completed due to hardship or extenuating circumstances, such as illness or death in the family.
IP	*In progress*: A temporary grade assigned for courses that are designed to have an anticipated enrollment that extends beyond one term. No more than two IP grades will be assigned for the same course.
CW	*Compulsory Withdrawal*: A temporary grade assigned by a Dean when an instructor, after documenting the prescriptive strategies applied and consulting with peers, deems that a student is unsafe to self or others and must be removed from the lab, practicum, worksite, or field placement.