Course Syllabus EE 397K Microwaves Devices; Unique Number 15260
Spring, 1999; M-W 11:00-12:30, ENS 634A
Instructor: Dean P. Neikirk, office: ENS 635, phone 471-4669; MER 1.606F, 1-8549
e-mail: neikirk@mail.utexas.edu
Office Hours: M-W-F 9-10; afternoons by appointment
Class Web Page: http://weewave.mer.utexas.edu/DPN_files/courses/MicroWave_Devices/MicroWave_Dev.html
Prerequisites: EE 325; EE 325K, EE 339, and EE 363M won't hurt, but are not required

Objectives: The intrinsic speed/frequency performance of semiconductor devices has increased dramatically in the last decade and a half. For instance, today you can buy a MMIC (monolithic millimeter / microwave integrated circuit) amp with performance that ten years ago would probably have cost at least ten times more. Due to the extremely rapid growth of the Personal Communications Services (PCS) industry, the demand for knowledge about rf circuits and microwave wireless systems has also increased dramatically. Finally, as digital systems strive for speeds that require GHz effective bandwidths, microwave issues may begin to influence even microprocessor design!

Course Outline:

i) Review of network formulations: Z, Y, S, H, ABCD parameters
   - matching networks
   - microwave measurement techniques

i) Basic physical processes that determine ultimate speed/frequency limitations in semiconductor devices; "classical" microwave devices that clearly illustrate these phenomena:
   a. Transferred electron devices (TEDs)
   b. transit time effects

ii) "Extrinsic" effects which often produce more severe limits than the "intrinsic" device physics.
   a. contact resistance, space charge resistance
   b. impact of finite conductivity; skin resistance
   c. causality and propagation delays

iii) Basic rf models and properties of MISFETs and MESFETs.

As a class goal, we will try to prove or disprove the following conjecture:

The physical world is fundamentally unfriendly towards complex (read: *generally useful*) electronic systems which operate at frequencies in excess of 100 GHz or speeds faster than 10 psec.

I first proposed this in class six years ago, and I've seen little since then to suggest we change this goal....

Class Projects: You must complete a class project, which will count for 30% of your grade. The project will consist of the identification of **a state-of-the art high frequency/speed SYSTEM**, and a detailed, critical examination of relevant literature to identify what components limit the performance of this system. You will then prepare a written discussion of your findings, as well as presenting a DETAILED, BUT SHORT, **oral explanation** to the class. You will be expected to explain your findings in language we can all understand; I will not accept "conventional" explanations which consist primarily of fancy jargon. Before making your class presentation expect to spend at least two hours with me, with a return visit to clarify any problems (and I guarantee I will find something to object to) identified in your first meeting with me. Class presentations will begin in mid-April.

Reference texts: P. Ladbrooke, *MMIC Design: GaAs FETs and HEMTs*. Norwood, MA: Artech House, Inc., 1989 (ISBN 0-89006-314-1); Microwave Semiconductor Devices, by Sigfrid Yngvesson, Kluwer Academic Publishers, 1991 (ISBN 0-7923-9156-X); S. M. Sze, "High-Speed Semiconductor Devices," . New York: John Wiley & Sons, Inc., 1990 (ISBN 0-471-62307-5).

Other useful texts: G. Gonzalez, *Microwave Transistor Amplifiers: Analysis and Design*, second ed. Upper Saddle River, NJ: Prentice-Hall, Inc., 1997 (ISBN 0-13-254335-4); **Physics of Semiconductor Devices** editor S. M. Sze; Microwave Engineering, by D. Pozar, Addison-Wesley Publishing Co. (1990); Fields and Waves in Communication Electronics by S. Ramo, J. R. Whinnery, and T. Van Duzer.

Grades

Your grades will be based upon performance on homework, exams, and the class project. Homework will be assigned approximately weekly; credit for late homework will be reduced at a rate of 10% per class the work is late.
The weighting for different areas is:

Homework	15%
Mid term exam	25%
Class project	30%
Final	30%
	100%

The worst-case grades will be based on:

A	100-90% of total points available
B	80-89%
C	70-79%
D	55-70%
F	0-55%

THE UNIVERSITY OF TEXAS AT AUSTIN PROVIDES UPON REQUEST APPROPRIATE ACADEMIC ADJUSTMENTS FOR QUALIFIED STUDENTS WITH DISABILITIES. FOR MORE INFORMATION, CONTACT THE OFFICE OF THE DEAN OF STUDENTS AT 471-6259, 471-4241 TDD OR THE COLLEGE OF ENGINEERING DIRECTOR OF STUDENTS WITH DISABILITIES AT 471-4382.

OFFICIAL UNIVERSITY CALENDAR AVAILABLE AT: http://www.utexas.edu/student/registrar/98-99long.html

LAST DAY TO DROP: 4TH DAY OF CLASSES (Jan. 22); BETWEEN THEN AND Feb. 15 MUST GO TO DEAN'S OFFICE; AFTER Feb. 15 THERE MAY BE AN ACADEMIC PENALTY; after March 29 drops allowed by UT only for extreme non-academic reasons. Feb. 8: Last day a student may submit notice of planned absences in the spring semester for the observance of religious holy days. (See General Information, chapter 4, for requirements.)

Course Evaluation: University and optional in-house survey during last week of class.

Policy on CHEATING:

You are expected to do your own work at ALL times. I expect you will often discuss assignments, but you MUST do your own ORIGINAL written work. Any evidence of cheating or plagiarism* will be treated as grounds for FAILURE in the class.

The following is extracted from the document "On Being A Scientist: Responsible Conduct In Research" by the COMMITTEE ON SCIENCE, ENG, NATIONAL ACADEMY OF ENGINEERING, INSTITUTE OF MEDICINE, NATIONAL ACADEMY PRESS, Washington, D.C. 1995.

*"A CASE OF PLAGIARISM

"May is a second-year graduate student preparing the written portion of her qualifying exam. She incorporates whole sentences and paragraphs verbatim from several published papers. She does not use quotation marks, but the sources are suggested by statements like '(see . . . for more details).' The faculty on the qualifying exam committee note inconsistencies in the writing styles of different paragraphs of the text and check the sources, uncovering May's plagiarism.

"After discussion with the faculty, May's plagiarism is brought to the attention of the dean of the graduate school, whose responsibility it is to review such incidents. The graduate school regulations state that 'plagiarism, that is, the failure in a dissertation, essay, or other written exercise to acknowledge ideas, research or language taken from others' is specifically prohibited. The dean expels May from the program with the stipulation that she can reapply for the next academic year." [URL: http://www.nap.edu/readingroom/books/obas/contents/misconduct.html#Plagiarism]

"A broad spectrum of misconduct falls into the category of plagiarism, ranging from obvious theft to uncredited paraphrasing that some might not consider dishonest at all. In a lifetime of reading, theorizing, and experimenting, a person's work will inevitably incorporate and overlap with that of others. However, occasional overlap is one thing; systematic use of the techniques, data, words, or ideas of others without appropriate acknowledgment is another." [URL: http://www.nap.edu/readingroom/books/obas/contents/appendix.html#Plagiarism]

Policy on use of class news group:

We have a newsgroup set up on the net for this class at utexas.class.ee397k. This newsgroup is for **class business ONLY**. Homework or questions from lecture are appropriate topics for discussion. THE NORMAL RULES OF CIVIL DISCOURSE SHOULD BE FOLLOWED AT ALL TIMES. I will read the postings regularly, and enter into discussions as appropriate.

THIS SCHEDULE IS **WILL BE MODIFIED ONCE I SURVEY THE INTERESTS OF THE CLASS!**

Lecture	Date	Date	Reading from			
			Yng-vesson	Sze, Physics of Semi.	Sze, High-Speed Semi.	Ladbrooke
1	1/20	Introduction, Review: Semiconductors, bands, effective masses	Ch 1	Ch 1	Ch 1, 2	
2	1/25	Parasitic lead example, T-lines; Gunn effect				
3	1/27	Classical microwave devices: TEDs; negative differential conductivity; single temp., two-valley v-E model	Ch 2	Ch 11		
4	2/1	small signal Gunn diode analysis				
5	2/3	domain prop. velocity and equal area rule				
6	2/8	dc to rf efficiency, Gunn diode power/frequency limits				
7	2/10	Current-voltage waveforms and efficiency	Ch 4	Ch 9	Ch 4	
8	2/15	charged sheet drift: Ramo-Shockley theorem; space charge resistance and velocity-saturated effects; “transit/drift” region small signal impedance	Ch 3	Ch 10	Ch 3	
9	2/17	IMPATT injector models; small signal analysis				
10	2/22	IMPATT diodes continued				
11	2/24					
12	3/1	high frequency IMPATT power; tunnel diodes				
13	3/3	T-line model for resonant tunneling				
14	3/8	QWITTs				
15	3/10	QWITTs				
	3/15-3/20	SPRING BREAK				
16	3/22	Power, frequency limitations				
17	3/24	Parasitics: contact resistance				
18	3/29	contact resistance				
19	3/31	spreading resistance	Ch 5		Ch 5	
20	4/5	impact of epi resistance: "C"-V effects				
21	4/7	T-line models for resistance calculations	Ch 9		Ch 9	
22	4/12	T-line models for resistance calculations				
23	4/14	MISFETS and MESFETS				
24	4/19					
25	4/21					
26	4/26					
27	4/28					
28	5/3	I'll never be on schedule by this time anyway so I won't try to put anything here!				
29	5/5	Last Class				

FINAL: WEDS, May 12, 9:00-12:00