University of Maryland
Department of Physics
College Park, Maryland

Physics 485/685
Fall 2003

GENERAL INFORMATION

Instructor

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Course Emphasis

Physics 485/685 are survey courses in the basic methods of modern electronics with equal emphasis on laboratory work and lecture material.

Lecture meets once weekly Monday 2-3:50 p.m. in Room PHYS 4220.

There will be two laboratory sections on Wednesdays and Thursdays in Room PHYS 3211 from 1-5 p.m.

Textbooks/Manuals

Required

Introduction to electronic Circuit Design, R. R. Spencer and M. S. Ghausi, Prentice Hall, 2001.

Physics 485/685 Laboratory Manual, Department of Physics, University of Maryland at College Park, 2002/2003 Edition.

Recommended

Digital Design, Third Edition, M. Mano, Prentice Hall.

MicroElectronics, Second Edition, Millman and Grabel, McGraw Hill, 1987.

The Art of Electronics, Second Edition, P. Horowitz and W. Hill, Cambridge, 1989.
Building Scientific Apparatus, Third Edition, J. H. Moore, C. E. Davis, M. A. Coplan, Addison Wesley, Third Edition, 2003, Chapt. 6.

Designing with TTL Integrated Circuits, Texas Instruments Electronics Series, McGraw Hill.

TTL Cookbook, D. Lancaster, Howard W. Sams and Co., 1980

CMOS Cookbook, D. Lancaster, Howard W. Sams and Co., 1997

Lancaster's Active Filter Cookbook, D. Lancaster, Butterworth-Heinemann, 1996.

IC Op-Amp Cookbook, W. G. Jung, McMillan Computer Publications, 1986.

A Practical Introduction to Electronic Circuits, Second Edition, M. H. Jones, Cambridge, 1985.

Reading Assignments

The text (Spencer and Ghausi) will be used principally as a reference. There will be reading assignments and some problem assignments from Spencer and Ghausi. Additional materials will be distributed in class. These materials are intended to supplement the lectures. There will also be reading assignments from the Laboratory Manual in preparation for the laboratory work and lectures.

Homework

Homework will be assigned at approximately two week intervals and will be due approximately two weeks from date assigned.

There will be approximately 7, 20 minute quizzes during the semester. They will be given at regular intervals during the regular Monday class. There will be a final exam at the end of the semester.

Laboratory Work

During the laboratory period there will sometimes be discussions of the theory and design of the circuits under study. Everyone is expected to participate. Each student should obtain a bound laboratory notebook in which all data and descriptive information about each experiment is to be recorded. Notes and calculations on separate pieces of paper are not permitted. The laboratory notebook must have a table of contents in the beginning to aid in locating the different experiments. The notebooks will be periodically collected and checked. It should be possible to reconstruct the experiment from the information in the laboratory notebook. All entries in the notebook are to be made with pen, not pencil. Errors should be crossed out with a single line rather than erased or obliterated. Often, an incorrect calculation or circuit will contain information that is useful later on. Because laboratory experiments will often be discussed in class on Mondays, it is recommended that the laboratory notebook be brought to lecture.

There are seven experiments during the semester including a 4 to 5 week individual project at the end of the semester. The laboratory experiments are flexible by design allowing students latitude in pursuing individual interests. Descriptions of the experiments are given in the laboratory manual along with data sheets for the devices used in the experiments. Operation manuals for all the laboratory equipment are available in the laboratory.

Laboratory Reports

Separate written laboratory reports for each experiment will be due at the lecture period (Monday) 1 week + 5 days after the last scheduled laboratory session for that experiment. These reports should contain a description of procedures, tables and graphs showing results, and a discussion explaining the results. Unless prior arrangements are made with the staff, late reports will be subject to a penalty of 1/2 point (out of a maximum grade of 10 points) per day late. The laboratory reports should consist of four sections; Introduction, Experimental Procedure, Results, and Discussion and Conclusions.

The Introduction should contain a clear statement of the purpose of the experiment. Relevant circuit theory should be included in this section. Detailed derivations are not necessary.

The Experimental Procedure should contain all the information required to reproduce the experiment as it was done in the laboratory. A list of components and equipment along with schematic circuit diagrams should be part of this section. The measurement procedures should be clearly described in this section.

The experimental data form the Results section. Effective presentation of data is an important experimental skill. The usual ways of presenting data are in tables and graphs. When tables are used, columns should be clearly labeled with units. Graphs should have both axes clearly labeled. All experimental data should be presented with estimates of errors or uncertainties. The errors can be systematic as well as random and can be due to limitations of the measuring instruments as well as uncertainties in the values of the circuit components. For active devices, such as diodes and transistors, temperature effects can cause the results to deviate from the expected values. A discussion of the errors should accompany the data. It is not necessary to include component specification sheets, but reference to them should be given where appropriate.

The Discussion and Conclusions section should contain comparisons between the predicted and measured properties of the circuits. Suggestions for improving the experiment can be included in this section. Conclusions should be based on the data and comparisons with calculations based on the theory of the operation of the circuit. Applications of the results of the experiment should also be included here. Clarity rather than length or complexity is the goal of the reports. It should be possible to reproduce your results from the information in the report.

Grading

The semester grade for the course will be determined approximately in the following way:

Average laboratory grade	40%
Quizes	20%
Homework	15%
Final exam	25%

LECTURE SCHEDULE

Week	Lecture Topic
2	RC Circuit Analysis
3	Properties of Diodes, Laplace Transforms
4	Bipolar Transistors, Amplifiers, Equivalent Circuits
5	Frequency Response, Stability
6	JFET Properties, Amplifiers, Equivalent Circuits
7	Feedback and Differential Amplifiers
8	Operational Amplifiers - Ideal and Real
9	Active Filters, Non-Linear Operational Amplifier Circuits
10	Introduction to Digital Circuits
11	Logic Gates, Binary Arithmetic
12	Flip/Flops, Counters, Shift Registers
13	Digital Systems, D/A and A/D Conversion
14	Transducers and Special Devices, Microcomputer Architecture
15	Extraction of Signals from Noise

Components

1. Assorted 1/4 Watt resistors

2. Assorted capacitors (l0 pF to l0 μF)

3. Potentiometers lK, 2.5K, l0K

4. Diodes
   lN914 silicon small signal
   lN751A zener

5. Transistors
   2N2222 npn silicon switching and amplifier
   2N5458 n-channel JFET

6. Linear IC's
   741 general purpose operational amplifier
   NE555, NE556 timers
   LM311 comparitor

7. Digital IC's (LS/TTL and CMOS)
   7400 NAND
   7402 NOR
   7404 NOT
   7408 Adder
   7480 BCD to 1 of 10 Decoder
   7442 Decade Counter
   7495 Shift Register
   7476 JK-M/S-F/F

8. Display/Driver
   LN513RK single digit common cathode 7-segment red LED numeric display
   CD4543B BCDto-7-segment latch/decoder/driver

Notes on Operation Procedures for
Laboratory Work in Electronics

The emphasis in Physics 485/685 is on a working knowledge of the basic principles and devices of modern semiconductor electronics. We will construct practical circuits from discrete components as well as integrated circuits. For the circuits to function properly there are certain procedures that must be followed. Adherence to these procedures will insure success.

1. Be sure you understand the theory of your circuit before beginning construction. The values of all the components in the circuit must be calculated before construction can begin. This must be done before the beginning of the laboratory period.

2. Do not exceed the ratings of any of the components in the circuit. Check the power dissipation of all resistors, transistors and diodes used in the circuits.

3. Verify that the active components in your circuit are in working order. Transistors can be checked with a transistor checker or VOM. Diodes can be checked with a VOM. Do not abuse the components. Leads can only be bent so far and so often before breaking.

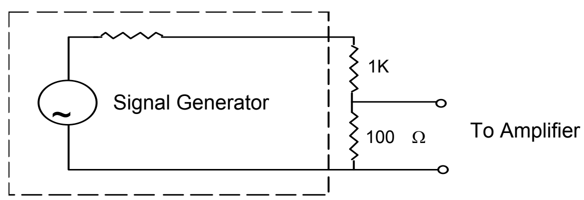
4. Take time to plan the physical layout of the circuit to avoid tangled wires and long leads that make trouble-shooting difficult and invite the pickup of unwanted signals from other parts of the circuit. Verify that all electrical connections are well made and that there is no possibility of shorts or open circuits.

5. Make sure that all circuit commons are correctly made. The variable d.c. power supplies <u>must</u> have either the positive or negative terminal at ground potential. They will not operate floating. The 5 volt d.c. and ±15 volt d.c. supplies must also have the common terminal at ground potential. For low level amplifier circuits where voltages do not exceed a few volts, the resistors have values from a few KΩ to a few 10s of KΩ. Bypass capacitors are in the range 0.1 to 10 μF. Electrolytic capacitors are used for values of capacitance from 1 to 100 μF and are polarized.

6. Be aware of loading errors. The Tektronix 60 MHz digital oscilloscope has an input impedance of approximately 1 MΩ in parallel with 30 pF and can be used for measuring voltages developed in high impedance circuits (up to 100 KΩ). The internal resistance of the VOM depends on the range on which it is used. The Keithly digital multimeter (DMM) has a constant input impedance of 10

megohms on all d.c. voltage ranges. In general, for the measurement of voltage the input impedance, Z_i, of the voltmeter should be large compared to the output impedance, Z_o, of the circuit under test. For current measurements, Z_i of the ammeter should be small compared to the impedance of the circuit in which it is inserted Operation manuals for all the equipment are available in the laboratory.

7. When operating a high gain amplifier, the input signal must be maintained at a fairly low level to maintain linear operation. To obtain a stable controllable low level signal from the oscillator a voltage divider as shown below can be used:



8. The measurement of the a.c. gain of a circuit implies that the output is a linear function of the input. Normally this is the case if the circuit under test is not overloaded to the point where the output signal is distorted. Gain measurements are best made with an oscilloscope where the input and output waveforms can be observed simultaneously.

9. The terms "blocking" and "by pass" are common. A blocking capacitor is used to couple a.c. signals from the output of one device to the input of a second device. The capacitor "blocks" any d.c. voltages from the first device. If the blocking capacitor is not sufficiently large it can limit the low frequency response of the circuit. A bypass capacitor is used to shunt a.c. signals around circuit components. A common application is in d.c. power supplies where undesirable a.c. ripple is shunted to ground through a large bypass capacitor across the output terminals of the supply.

10. In designing TTL circuits observe the following: a). Connect spare inputs to used inputs if the fan-out permits, otherwise connect them to V_{cc} via a resistor of 1 KΩ or greater. b). Decouple every 10 gates from V_{cc} with a 0.01 to 0.1 μF capacitor. c). Keep leads short.