COURSE TITLE: Electronic Circuit Analysis  COURSE NO: 662-124  CREDITS: 3 (Lec:2, Lab:2)

COURSE DESCRIPTION:
This course covers advanced topics associated with the analysis of electronic devices and circuits. Students are introduced to using frequency as a variable when analyzing electronic circuits. Bode plots will be used to describe circuit characteristics, and the analysis of resonant circuits will be covered in detail. Small signal analysis of transistor amplifiers will be emphasized to reinforce theoretical analyses. Students will perform laboratory experiments and prepare technical reports.

TEXT BOOK:  

LABORATORY:  

PROJECT:  
Each student will hand in a course notebook at the end of the 15th week. See detailed information in Appendix A

REFERENCE:  
Various other textbooks are available at the GTC and the Public Libraries regarding this subject. It will be to your advantage to consult these books. Reading from another perspective often can help with the many questions that surely will arise throughout the semester.

SECTION:  
662-124

STARTING DATE:  
January 14, 2004

MEETING TIME:  
M, W 7:00 pm - 9:00 pm

LOCATION:  
T-410

ENDING DATE:  
May 17, 2004

ASSIGNMENT & TEST:  
See the Course Plan in Appendix B

INSTRUCTOR:  
Patrick E. Hoppe
OFFICE: T414, PHONE: 262.619.6462, FAX: 262.7169
EMAIL: hoppep@gateway.tec.wi.us

OFFICE HOURS: See Appendix E

SPECIAL NEEDS STUDENT If you have any special education needs or concerns, please contact your class-room instructor or Special Needs Instructor on campus (Linda Mahoney, or Peggy Jude @ 262-619-6228).

ATTENDANCE Attendance is required. You are responsible for attending and completing all course requirements. If you miss a class, it is your responsibility to contact me, in advance if possible, and obtain the necessary information for any assignments. Remember, each classroom hour requires at least two additional hours of student preparation.

LAB REPORT The report must be entered in to the Engineering Log book and follow the format in Appendix D. The report is to be shown to the instructor prior to starting the next laboratory assignment (unless otherwise noted by the instructor).

GRADING All assignments, laboratory reports, quizzes, tests must show all work leading to the answer(s). They are graded from 0 to 100 points each.

All Homework for the chapters on the exam, must be turned in at the time of the exam. Late homework will not be accepted. Each student must turn in his or her own work.

<table>
<thead>
<tr>
<th>Point Value</th>
<th>EXAMS..................50%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ENG. LOG ................40%</td>
</tr>
<tr>
<td></td>
<td>(2 Formal Lab reports are 20% each of the Eng. Log grade)</td>
</tr>
<tr>
<td></td>
<td>HOMEWORK...........10%</td>
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<tr>
<td></td>
<td>(Course Book grade is 10% of the Homework grade)</td>
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</table>

<table>
<thead>
<tr>
<th>Letter Grade</th>
<th>A  93% to 100%</th>
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<tr>
<td></td>
<td>A- 91% to 92%</td>
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<td></td>
<td>B+ 89% to 90%</td>
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<td>B  85% to 88%</td>
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<td>B- 83% to 84%</td>
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<td>C+ 81% to 82%</td>
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<td>C  77% to 80%</td>
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<td></td>
<td>C- 75% to 76%</td>
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<td></td>
<td>D+ 73% to 74%</td>
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<td></td>
<td>D  70% to 72%</td>
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<td></td>
<td>D- 68% to 69%</td>
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<tr>
<td></td>
<td>F below 68%</td>
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</tbody>
</table>

SUPPLIES - A Texas Instruments Engineering calculator (TI-86) is required.
- A Scientific Notebook, available in the bookstore is required.
BROAD COMPETENCY

1. Analyze an AC circuit with frequency as a variable using standard AC circuit analysis techniques
2. Incorporate computer simulation into the AC circuit Analysis.
3. Determine the gain, the input impedance, and the output impedance of various single stage transistor amplifier configurations.
4. Demonstrate the development of electrical measurement capabilities form the laboratory work.
5. Write Technical reports from the information gathered in the laboratory work.

CORE ABILITIES

Gateway believes students need both technical knowledge and skills and core abilities in order to succeed in a career and in life. The following nine core abilities are the general attitudes and skills promoted and assessed in all Gateway programs; those followed by an asterisk are promoted and assessed in this course.

1. Act responsibly  *
2. Communicate clearly and effectively  *
3. Demonstrate essential computer skills  *
4. Demonstrate essential mathematical skills  *
5. Develop job-seeking skills  *
6. Respect self and others as members of a diverse society  *
7. Think critically and creatively  *
8. Work cooperatively  *
9. Value learning  *
Appendix A - Course-Book

The course-book will contain ALL handouts, class notes, quizzes, tests, and lab reports. The information will be divided into appropriate chapters of your book. Upon completion of this class, you will have a complete guide from which you may study from for future courses.

The course-book will contain a cover sheet with the following information:
- Course Name
- Course Number
- Your Name
- Date

The course-book will contain a Table of Contents with the following headings:
- Class Notes
- Quizzes
- Tests
- Lab Data
- Class Handouts

The course-book will be graded on its completeness and organization. Remember, you are creating this book for use as a reference for other classes, so you will benefit far beyond just the grade you receive for it. A three ring binder is recommended, 2" - 3" variety. **Please put your name & course name on the spline of the binder.**

**Learning Objects**

Learning Objects are included in the assignment schedule. It is your responsibility to complete them. They are not graded, nor does the instructor know if you viewed them. However, successful completion of the Learning Objects will most certainly improve your exam scores and more importantly, your overall understanding of the material. The Learning Objects were developed solely to aid you in your understanding of the material, please take advantage of them.

Learning Object Web Site:

http://cws.gateway.tec.wi.us/programs/engtech/Electronics.htm
<table>
<thead>
<tr>
<th>Week</th>
<th>Topic(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Introduction and review of the ideal transformer. Introduction to frequency as a variable in AC circuit analysis</td>
</tr>
<tr>
<td>2</td>
<td>RL and RC variable frequency circuit analysis and the derivation of the AC sinusoidal steady-state transfer function</td>
</tr>
<tr>
<td>3</td>
<td>Frequency Response and Bode plots of RL and RC circuits, the highpass and lowpass filter</td>
</tr>
<tr>
<td>4</td>
<td>Review &amp; Test #1</td>
</tr>
<tr>
<td>5</td>
<td>Review of resonance, resonant frequency, and series and parallel resonance. Review of Quality Factor (Q), half power bandwidth (BW), and 3 dB frequencies</td>
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<tr>
<td>6</td>
<td>Series-parallel resonant circuit analysis. Review of diodes, diode models and DC diode circuits</td>
</tr>
<tr>
<td>7</td>
<td>Review of large signal analysis applied to diode circuits. Small signal analysis applied to diode circuits.</td>
</tr>
<tr>
<td>8</td>
<td>Review of semiconductor transistor structures and operation of bipolar junction transistors (BJT) and FET’s; review of I-V characteristics.</td>
</tr>
<tr>
<td>9</td>
<td>Review &amp; Test #2</td>
</tr>
<tr>
<td>10</td>
<td>Review of BJT DC bias circuits and circuit analysis techniques. Review of JFET and MOSFET DC bias circuits and circuit analysis techniques</td>
</tr>
<tr>
<td>11</td>
<td>Introduction of the hybrid-p BJT AC model and the concept of dependent source; BJT h-parameters and their graphical determination specifically, $h_{ie}$, $h_{re}$, and $h_{re}$. AC analysis of CE, CB and CC amplifiers; derivation of input and output impedances and voltage and current gains; Q-point</td>
</tr>
<tr>
<td>12</td>
<td>AC analysis continued</td>
</tr>
<tr>
<td>13</td>
<td>Definition of and graphical determination for the FET two-port parameter $g_{m}$; simplified FET AC model</td>
</tr>
<tr>
<td>14</td>
<td>Review &amp; Test #3</td>
</tr>
<tr>
<td>15</td>
<td>AC analysis of CS, CG, and CC amplifiers; derivation of input and output impedances and voltage and current gains</td>
</tr>
<tr>
<td>16</td>
<td>Simplified frequency response analysis of BJT and FET amplifier circuits using the approximate cutoff frequencies and the Bode Plot</td>
</tr>
<tr>
<td>17</td>
<td>Review &amp; Test #4</td>
</tr>
</tbody>
</table>
### Appendix C - Assignment Schedule

<table>
<thead>
<tr>
<th>Unit</th>
<th>Reading</th>
<th>Lab Exercise</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Strangeway, Ch 13 &amp; 15.1 &amp; 15.2</td>
<td>None - Safety Review</td>
</tr>
<tr>
<td>2</td>
<td>Strangeway, Ch 15</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Strangeway, Ch 15</td>
<td>Ex. 31, Freq Response of RC &amp; RL circuits</td>
</tr>
<tr>
<td>4</td>
<td>Strangeway, Ch 15</td>
<td>Ex. 32, Another RC Transfer Function</td>
</tr>
<tr>
<td>5</td>
<td>Strangeway, Ch 16</td>
<td>Ex 33, Another RL Transfer Function (Formal Lab)</td>
</tr>
<tr>
<td>6</td>
<td>To be announced</td>
<td>none, make up lab</td>
</tr>
<tr>
<td>7</td>
<td>To be announced</td>
<td>Ex 34, Series Resonant</td>
</tr>
<tr>
<td>8</td>
<td>To be announced</td>
<td>Ex 35, Series - Parallel Resonant</td>
</tr>
<tr>
<td>9</td>
<td>To be announced</td>
<td>Diode I-V Characterisitic and Diode Small Signal resistance</td>
</tr>
<tr>
<td>10</td>
<td>To be announced</td>
<td>Diode Circuit Applications</td>
</tr>
<tr>
<td>11</td>
<td>To be announced</td>
<td>Transistor Biasing Circuit</td>
</tr>
<tr>
<td>12</td>
<td>To be announced</td>
<td>A Common Emitter BJT Amplifier and Amplifier loading</td>
</tr>
<tr>
<td>13</td>
<td>To be announced</td>
<td>A Common Source JFET Amplifier, Two-Port Parameters and Freq Response (Formal Lab)</td>
</tr>
<tr>
<td>14</td>
<td>To be announced</td>
<td>Lab Make up</td>
</tr>
<tr>
<td>15</td>
<td>Review</td>
<td>Lab Make up</td>
</tr>
<tr>
<td>16</td>
<td>Exam</td>
<td>Lab Make up</td>
</tr>
</tbody>
</table>

**Formal Labs**

1st Formal lab is due March 10, 2004
2nd Formal lab is due May 12, 2004

Homework will be assigned throughout the semester.
Appendix D - Lab Report in Engineering Log Book

Each lab report will be set up in the same fashion. It will contain the same sections, with only the information differing between reports. By creating a lab report in this manner, no important material will be overlooked nor will it be difficult to follow. Since you will be utilizing your labs as study material for future classes, organization and completeness will benefit you in the future.

1. Use a Bound (stitched binding) notebook. DO NOT use a loose leaf or Spiral bound notebook! **No Pages may be removed or added. The grade for that lab will be a 0 if a page is removed or added!**
2. Entries **MUST** be in Permanent Ink--Not Pencil. Entries to be make in single stroke block lettering.
3. The Title, Project Number, and Book Number should be accurately recorded when starting a New Page. Each page must be numbered.
4. All data is to be recorded directly into the notebook. The inclusion of all elaborate details is preferable. Notes and calculations should be done in the notebook, NOT on loose paper. In the case of an error, draw a single line through the incorrect data, date and initial. Do Not Erase or use correction fluid. All corrections should be initialed and dated.
5. After entering your data, sign and date all entries. Witness or witnesses should sign and date each entry. The witness must observe the work that is done, and have sufficient knowledge to understand what they read. Names of all who were present during any demonstration should also be recorded.
6. Use both sides of a Page. Never leave any White Space: "X" out or Crosshatch all unused space, and don’t forget to initial & date same.
7. When pasting graphs or other information in the notebook, sign over the edge to show who placed the information in the book.
ENTRY FORMAT FOR NOTEBOOK DATA

1. Title of Experiment *
2. Introduction *
3. Theoretical Solution
   a. Manual theoretical calculations *
   b. Theoretical simulation solutions including circuit diagrams *
4. Results
   a. Spreadsheet tables *
   b. Procedure*
   c. Simulation solutions using actual component values including circuit diagrams
   d. Any other illustrations of results such as graphs
5. Analysis of Results
   a. Discussion of results
   b. Error analysis
   c. Any other analysis
6. Conclusions

* Student must complete these items before the scheduled laboratory session

Lab Preparation

Prior to the lab session, read the assigned lab. Write a brief lab purpose statement and write the procedures you will be following in the Lab Notebook. It is best to construct the data tables at this time. Complete the Pre-lab requirements.

Performing the Lab

Complete the lab and enter the data in the lab Notebook.

After Lab
Write a brief conclusion and answer any questions in the lab manual.

The due date for engineering notebooks will be announced one week prior
FORMAL LABORATORY WRITE-UPS

Introduction

Good report writing is a fundamental part of engineering. As you proceed in school and industry, you will develop many ideas and perform many experiments that must be written so that others can understand. In many cases, these reports are submitted to superiors who have not been actively engaged in the test; hence, the report must be clear and concise enough to leave no doubt concerning the method of test and the interpretation of the results.

Proficiency at writing laboratory reports comes with practice. The report requirements will be as follows:

Report Outline: These report sections MUST be used in this order.

1. Title Page
2. Table of Contents
3. I. Introduction (do BEFORE lab)
4. II. Theoretical Solution (do BEFORE lab)
5. III. Results
6. IV. Analysis of Results
7. V. Conclusion

All report sections must be typed. Use the equation writer in the word processing software to type equations into the report.

Discussion of Report Outline Sections

See the sample laboratory report for an example of each Report Outline item.

1. Title Page

The title page serves the purpose as a cover for the report. The information on the title page is:

a. Company/college identification
b. Name of Experiment or Report
c. Identification Format: Submitted to:

Submitted by:
Date:
Lab Partners:

The guiding principle for the title page is neatness. The name of the report should be printed about three inches from the top of the page and centered in the horizontal direction. The identification should be started about three inches from the bottom of the page and in the center of the page to allow room for names.

2. Table of Contents

This is to identify various sections of the report and to state their location by page number. The five sections listed in the Report Outline MUST be used in the order given. The Introduction page is always page 1, but actual page numbering begins on page 2.

3. Introduction

This section leads to a statement of the problem investigated. It may be necessary to start with a general picture. A discussion of the history of what has been done in this area, who has done this work, and the conclusions drawn up to the time of the report is helpful. Many times this will set the spirit of the report so that interest is generated immediately. As the picture is narrowed, certain assumptions will be made. These assumptions should be justified as well as possible. The final statement in this section should be concise, setting forth the aim and scope of the investigation and contents of the report. The reader should have no doubt on the purpose of this experiment.
For this class, you must determine the purpose from reading the experiment. The Introduction should be written BEFORE the laboratory session. The Introduction should be limited in length to about two paragraphs.

4. Theoretical Solution

The Theoretical Solution is a prediction of what ought to happen in the experiment. This is preferably a mathematical analysis which is idealized with the assumptions made in the introduction. The proper equations must be developed and the desired information extracted from them.

One complete set of numerical calculations should be shown for the theoretical (predicted) results. If the same calculation is repeated several times, only show it once.

If the information will be represented in graphical form, certain rules are to be followed when drawing a graph, and they are discussed later in this article.

Be sure to state where all theoretical results are reported, usually in the Results table in the Results section.

For this class, the theoretical solution should be done BEFORE the laboratory session. It is recommended that you work on it well in advance so that you have sufficient time to ask questions if you need to.

5. Results

The following should be included in the Results section:

a. Procedure.

This section should give the reader a clear idea of the manner in which the investigation will be accomplished. It should cover:

1) A statement of the problem and the method which will be used in its solution.

2) An explanation of the apparatus to be used and the measurements which will be made, showing how and why the apparatus will produce the information desired. Any special apparatus used should be described sufficiently to acquaint the reader with its nature. Explanatory diagrams and drawings may be used.

3) An explanation of the application of formulas used in the calculations. Fundamentals and basic theory may be assumed, but special formulas unique to the investigation should be explained and their derivation shown. All symbols used in any equations should be defined and their units stated.

b. Data = Measured Results

Theoretical and Measured Results. All theoretical and measured results should be tabulated when possible. All related results, whether theoretical or measured, should be included in a single table. If the table is too large, break it up into multiple tables, but keep theoretical and measured results side-by-side.

c. Sample Calculations

This section should consist of a complete sample of each type of calculation involved in the determination of measured results. These sample calculations should first be shown in symbol form, each symbol being properly identified. Each set of sample calculations should be correlated with the table to which it applies.
d. Graphs

All graphs drawn should conform to the specifications mentioned later in this article.

6. Analysis of Results

This discussion is one of the most important sections of the entire report. As the name implies, it should be a complete analysis of the results obtained. The following topics should be included:

a. A discussion of the accuracy or reliability of the results: It is suggested that this section, when applicable, consist of a careful treatment of the effect upon the results of the following:

1) Errors resulting from assumptions and idealizations because of physical limitations in the performance of the test. Significant differences between measured data and theoretical analysis MUST be resolved. Do not attribute it to experimental error.

2) Errors in manipulation,

3) Errors in observation, and

4) Equipment limitations or failures.

Steps taken to minimize such errors should be emphasized.

b. A comparison of the measured results obtained with those which were expected from the theoretical analysis. Whenever the theory is apparently contradicted, probable reasons should be discussed. Experimental error is not an acceptable reason. Measurement errors must be corrected through re-measurement. Trends in the results should be stated.

c. When results are given in graphical form, the shape of each curve should be carefully explained. An explanation should state the causes for the particular shape the curve may have. If the slope is not constant, the nonlinearity should be discussed. If the area under the curve has meaning, or if the rate of change of the curve has meaning, it should be fully discussed.

d. Any original conclusions drawn as a consequence of the laboratory procedure and a study of the results obtained should be fully discussed.

7. Conclusion

This section is to include a concise conclusion of what was proven, shown, discovered, etc., during the laboratory. Review the laboratory objectives stated in the Introduction. Determine if the objectives were met and what they proved. Any critical results should be stated here along with its significance.

8. Recommendations (as needed)

Criticism and statements to improve either the theoretical solution or laboratory investigations are necessary. The experiment does not have to be original to improve on it. Criticism for the sake of merely improving the experiment need not concern the cost of equipment. In industry, however, this is important, and recommendations for improvement must bear in mind the cost which is related to the degree of accuracy desired.

9. Appendix (as needed)

If the development of equations is long and only the result is of importance, the development may be placed in this section and the result carried in the section desired.
10. Bibliography (as needed)

   This section consists of a list of sources of information consulted. Complete identification of the magazine or book by author, title, publisher, edition, and pages referred to is required.

Rules for Report Writing

1. Use unlined 8-1/2” x 11” white paper, one side only.
2. Leave a one-inch margin on all sides.
3. All report section titles must be capitalized, underlined or bolded, and centered on the page.
4. Do not repeat procedures when writing the Analysis of Results.
5. Make definite statements. Avoid statements which contain no information. Avoid trite expressions. For example, consider the statement: "The experiment was quite accurate." Quite is first of all a trite expression and secondly, it carries no hint of a number. It would be much better to say, "The experiment was 85 percent accurate."
6. Write in the third person and past tense except the introduction, which is in the present or future tense. Try to avoid using, too often, the introductory phrases: It was found...; It was seen...; it was thought...; etc.
7. Reports are not graded by weight, so do not make them longer than necessary. In fact, there are fewer chances to make spelling and grammatical errors in a shorter report!
8. Number all important equations so they can be easily identified and found.
9. Number all pages except page 1. Keep page numbers within the one inch margins. The Introduction begins on page 1.
10. The symbol "%" is not to be used--the word is spelled percent.
11. Numbers between one and ten are to be spelled out. Numbers above ten should be shown as a number.
12. Always refer to all tables and graphs. If a table or graph is not referred to, it is not important and therefore should not be in the report.
13. Standard engineering abbreviations may be used.

Rules for Drawing Tables

1. The table must have a title and label (table number) placed at the top left or center of the table.
2. Draw as many blocks as there are columns and rows of information. It must be rectangular.
3. The independent variable should be the first column on the left.
4. Every column must have a heading. Include units if appropriate.
5. If other columns are to be made from calculations or other results, the equations used to obtain this information and a sample calculation must be shown following the table.
6. The paper can be turned ninety degrees clockwise (landscape) to draw the table, if necessary.
Electronic Circuit Analysis

7. Decimal points are placed in a vertical line.
8. Explain each symbol used in a column heading. Give the dimensions or units of the symbols.
9. Any column position left blank must be explained.
10. When numbers in a column are repeated, do not indicate them with dashes or straight lines. Write out all numbers.
11. Leave at least a one-inch margin on all sides. The page number must be within the one-inch margin, too.

[See an example of a report table in the sample report later.]

Rules for Drawing Graphs

1. Every graph must have a title. It is usually placed in the top center position of the graph. The figure number and caption for the graph are placed below the graph.
2. The abscissa is the independent variable (drawn horizontally), and the ordinate is the dependent variable (drawn vertically).
3. Label the ordinate and abscissa correctly with the proper title and units. The ordinate should always be on the left.
4. Do not run graphs into the margins.
5. Choose scales that are easy to read and use most of the graph paper.
6. Curves can be plotted with the graph in the vertical or horizontal position. If the curves are drawn with the paper long side horizontal, the curve should be plotted so that the page is turned ninety degrees clockwise from the normal position to read it. The ordinate must still be on the left.
7. When plotting a curve from the exact equation, do not show any points. State the equation of the curve on the graph.
8. When plotting data points from an experiment, show all points. Do not draw a point-to-point curve. Plot an average smooth curve. The curve need not pass through any of the points.
9. If more than one curve is plotted on the same piece of paper, code the data points for each particular curve so they can be easily identified with that curve. The coding may be symbols such as: O ⊗ ⊙

If there is the possibility of confusion, put a legend on the curve to identify the proper symbol with the proper curve.
10. More than one ordinate may be used so that several curves can be plotted on the same paper. Each ordinate must have its own scaling and description. When more than one ordinate is used, the curves must be identified with the proper ordinate. Letters may be used for identification.
11. When a family of curves is plotted, each curve must be identified for the particular parameter that is being varied.
GRADING OF LABORATORIES:

1.) Labs are due one (1) week after being performed.
   a.) The penalty for late work is shown in the syllabus.

2.) Weight of each section in percentage
   a.) Title Page 5%
   b.) Table of Contents 5%
   c.) Introduction (do BEFORE lab) 10%
   d.) Theoretical Solution (do BEFORE lab) 20%
   e.) Results 10%
   f.) Analysis of Results 15%
   g.) Conclusion 15%
   h.) Answers to questions 10%
   i.) General report requirements 10%
My Office Hours are posted outside my office door.

If my office hours do not fit into your schedule, please contact me and we will find a mutually convenient time to meet.