Learning Guide

Faculty of Engineering and Information Technology

Electrical Engineering

48581 Digital Electronics

Autumn 2015
SUBJECT GUIDE

Welcome

Digital Electronics is a subject in the Engineering Degree course for students who major in Electrical Engineering.

This subject focuses on developing a set of field of practice skills and knowledge:

• It develops an applied base for your field of practice knowledge.

• It develops competence in the use of laboratory equipment through laboratory-based project work and problem-based learning.

• It lets you apply core skills and knowledge to a field of practice.

Digital Electronics is a subject in the last year of the course – it assumes that you have developed a proficiency in academic and information literacy skills, and provides specialised knowledge for a part of your field-of-practice. It also helps you to apply that specialist knowledge to practical, real-world problems in a laboratory setting and prepares you for the graduate workplace.

You will be expected to take on a significant responsibility for your own learning. While self-managed learning offers you choices about how and when you study, we also understand that you will learn best if there are convenient opportunities for you to interact with fellow students and course staff.

Therefore, the subject provides a balance between the convenience of independent learning and the stimulation of academic life. We hope you enjoy the content, learning experiences and assessment tasks that make up this subject as well as the benefits of managing your own learning.

Your Subject Coordinator

Dr Peter McLean is a Senior Lecturer at UTS in the School of Electrical, Mechanical and Mechatronic Systems within the Faculty of Engineering and Information Technology. Subjects taught include Electronics and Circuits, Circuit Analysis, Introductory Digital Systems, Signals and Systems, Data Acquisition and Distribution, Digital Electronics, Analog Electronics, Signal Processing, Power Circuit Theory, Embedded Software and Fundamentals of Electrical Engineering. He has undertaken numerous research projects in collaboration with industry that normally involve the development of embedded systems hardware and software. These include microcontroller-based power system protection devices, DSP-based power-line carrier systems and a broadband Internet distribution system for the home.
Where this subject fits into the course

This subject is a Stage 9 field-of-practice subject in the Electronics thread which is a part of the Electrical Major within various Bachelor of Engineering Degrees.

The need for this subject

It is assumed that you have already been introduced to and attained competence with basic electronics and circuits, digital logic design fundamentals, and learnt to design simple sequential programs in the C language. In this subject you will gain experience in the design of hardware of a digital system. It will be seen that the design of a digital system draws on many fields of engineering expertise, and that techniques of synthesis are highly dependent on system specifications.

The subject lays the foundation for many areas of further interest to the engineer – electronics design and fabrication, embedded software, real-time systems, signal processing and numerical methods.

Subject aims and objectives

The objective of this subject is for students to design, build and test hardware for an embedded application that utilises a modern digital integrated circuit, such as a field programmable gate array (FPGA), a microcontroller or a digital signal processor (DSP). It draws together many elements of engineering – system specification, design, implementation, testing, documentation and management – all in the context of a modern digital electronic system.

The technical content of the subject aims to develop the basic structure, operation and design of digital systems with an in-depth treatment of modern hardware components and design methodologies. The integrated circuits introduced will be field programmable gate arrays, microcontrollers, digital signal processors; memory subsystems; I/O subsystems; serial I/O subsystems; and power subsystems. Modern computer-aided hardware design software will be used extensively. Topics such as PCB manufacturing, surface-mount technology and EMC compliance will also be treated in depth.

The technical content is contextualised in a project in which individual students analyse the requirements of an embedded system and design the hardware to meet those requirements. A PCB will be designed, built and tested. Skills in debugging hardware will also be developed through the practice-based nature of the subject.

Three engineering themes permeate the subject. The first theme is the need for a systems perspective in engineering – students will need to analyse and dissect (through a requirements specification) and eventually synthesise in a hierarchical manner (through hardware and software design). The second theme is that students will be expected to draw knowledge from a wide variety of sources – previous subjects, industrial experience, industry publications and

"The artist is nothing without the gift, but the gift is nothing without work."
- Emile Zola
(1840-1902)
the Internet. The third theme is that of the need for engineers to take responsibility for their own professional development. You will produce professional documentation in the form of a project logbook that details requirements specifications, mathematical modelling, electronic and software design and testing as well as project management. A practical demonstration and oral presentation at the end of the project also gives students experience in communicating technical ideas.

Finally, the subject will prepare you for more advanced topics on hardware and software systems which you may encounter in professional practice and in further subjects.

Content

The content covered is divided into the following sections:

1. Passive Components
2. Switched-Mode Power Supplies
3. Digital Logic Families and IC Packaging
4. Crystal Oscillators
5. Electromagnetic Compatibility (EMC)
6. Printed Circuit Boards
7. Thermal Design
8. Digital Measurement Techniques
9. Design Project

Below is a brief summary of the content that is later covered in detail in the lecture notes.

Prerequisite knowledge

You are expected to have successfully completed subjects related to introductory electronics, circuit analysis and data acquisition and distribution systems.

Section 1 – Passive Components

The characteristics of passive components are given in detail, together with selection guides and application areas.

Section 2 – Switched-Mode Power Supplies

Types of switched-mode power supplies are examined for digital logic circuits, as well as some of their design considerations.

"In theory, there is no difference between theory and practice. But, in practice, there is."
- Jan L.A. van de Snepscheut
Section 3 – Digital Logic Families and IC Packaging

On overview of logic families and their history is given. Logic levels are discussed. Modern CMOS families are reviewed. SMT IC packaging is reviewed.

Section 4 – Crystal Oscillators

Feedback oscillator topologies are examined and the electrical characteristics of crystals are modelled. A brief overview of oscillator design considerations is given.

Section 5 – Electromagnetic Compatibility (EMC)

Principles of EMC are given, including types of sources, coupling and combating EMI. Regulatory standards are also introduced.

Section 6 – Printed Circuit Boards

An overview is given on PCB manufacture.

Section 7 – Thermal Design

The principles of thermal design, such as heat transfer theory, conduction, convection, heat sinks, radiation and modelling, are introduced.

Section 8 – Digital Measurement Techniques

An overview is given on using a DSO to measure digital signals, as well as some of the pitfalls of designing and probing PCBs.

Section 9 – Design Project

The project allows you to gain experience in putting a variety of ideas into practice, and requires the design of an embedded system. You will be required to interpret specifications and come up with sound engineering designs using a variety of methods. A PCB will be produced, populated and tested. Programming of software into the digital chips will be performed. The designs will be implemented and experimentally verified.
Other subject information

The following information takes precedence over the default policies outlined in section 3.3.1 of the Faculty’s Student Guide.

Internet

The subject has a web site which contains the subject documentation and links to important learning aids. The URL is:

http://services.eng.uts.edu.au/pmcl/

You should regularly visit and explore the web site to keep informed of any important announcements such as timetable or assessment changes.

Lectures

Class time is used for lectures and self-directed study sessions. Lectures will introduce new material in a modular fashion that can then be applied to the design of a real embedded system. Towards the end of semester, students will undertake an individual project in which the class time will serve as valuable resource / design / discussion sessions. During the lectures you will have the opportunity to meet with fellow students and with your subject coordinator who will answer questions and highlight selected topics.

Laboratories

The laboratories are unstructured sessions that give you access to specialised equipment. The laboratory work will be project-based and can be complemented with computer simulations and design exercises.

Twenty-four hour access to the Embedded Projects Laboratory will be given to students during the semester.
Assessment

Assessment for this subject is criterion-referenced. This means that your performance is measured against a set of criteria, not against the performance of other students.

The assessment criteria for this subject

In assessing your performance we will be looking for evidence that:

- You are able to efficiently carry out an accurate analysis of the requirements of a digital system, and are able to implement it with suitable modern electronic components.
- You have understood the concepts used in Electronics Design Automation and are able to apply them to the design of a practical digital system.
- You have understood the methods of project management and are able to apply them to a practical project by keeping a project logbook and communicating your design in both written and verbal form.

Assessment tasks

The assessment tasks and their weighting are given in the Subject Outline.

Assessment dates

All assessment dates are shown in the Study Guide and Subject Outline. Laboratory assessment is carried out by a practical exam.

Enrolment

Ensure that you are enrolled in the subject before the HECS census date.

https://onestopadmin.uts.edu.au/estudent/

Please remember

- Check the subject web site regularly each week to make sure you don’t miss any important announcements about assessment items.
- Submit all assessment tasks on the date due as extensions are very difficult to arrange.
- Keep a copy of all assessment tasks you submit.
STUDY GUIDE

There are two components to completing your study of Digital Electronics. They are:

- reading the lecture notes and associated “readings”
- completing the project satisfactorily

To guide you through these tasks there is a Timetable.

Structure of the Timetable

The Timetable will help you manage your learning in Digital Electronics. It does so through the following design features:

- It is organised in logical, linked and digestible steps, so that where your learning is headed remains clear. Each session of the Timetable refers to:
  - A lecture in the Lecture Notes. Each lecture may have associated readings that should be perused in that session.
  - Assessment tasks that should be started, or are due.

- The Timetable asks you, therefore, to be an active learner; not a passive reader. You should keep in mind that to achieve the necessary competence to pass this subject it is not sufficient to just read the pages of the lecture notes and readings a few weeks before assessment items are due. Apart from understanding the concepts given in the lecture notes, you also need to put them into practice and allow yourself sufficient time to reflect on what you have learnt.

- You can see what the learning tasks will be for each session of the Timetable before you begin. This enables you to mentally prepare for the learning tasks while you work through the session topic. In this way your learning stays focused on the main areas of the session; you don’t lose your way in the details.
The Lecture Notes

The lecture notes should be read before each session so that lectures can concentrate on particular topics of interest rather than trying to cover all the material.

Structure of the Lecture Notes

The Lecture Notes are an on-going development through a process of continual feedback from students attempting to learn the topics as well as a continual updating of the content as technology changes. Difficult or hard-to-grasp topics are expanded; or are presented in a different manner to the readings; or highlight the real-world application of the topic. Prerequisite material is often recapped. The Lecture Notes focus on topics needed for the project, so those topics that are important to this goal are treated fairly thoroughly. The Lecture Notes are therefore a complement to the readings, as well as a summary of the important topics.

Skim through first

If you are already familiar with the material in any section or if you want to get an overall feel for what it contains, you may like to skim through it first, looking at the headings and margin notes.

Textbooks

Textbooks are where you find the detail of the topics covered in this subject.

Prescribed textbook

There is no prescribed textbook for this subject.

Reference textbooks

The following is a list of reference textbooks that delve deeper into the topics of this subject. They may be used for alternative explanations or you may consider purchasing them if they relate to your chosen field:


The Assessment Tasks

The Project is published in documents separate to the Lecture Notes. It is up to you to submit each assessment item on time. The due dates for assessment items are given in the Timetable and Subject Outline.

Learning in partnership

Using a fellow student as a learning partner has been found repeatedly to be an important learning support. The idea is that you contact a fellow student, by whatever means is most convenient, to discuss your interpretation of a learning task, to check if your approaches are the same and to generally clear up any confusions which may have arisen. It has been found that well over half of the concerns students experience about their learning are to do with simply checking that they are 'on the right track' and can be solved using this method. If, however, the concern or uncertainty remains, it is then recommended that you contact your subject coordinator.

Your learning plan

Your time

Organising your time is a major challenge in learning. Leaving recommended readings and assignments to the last minute is a common problem. To assist you with this challenge you may find it useful to plan your study time before you start work on this subject. First decide on the best place and time each week to study without distractions and then make sure to adhere to your own plan.

It is estimated that over a period of 14 semester weeks you should set aside a total of approximately 9 hours of study time each week. It is recommended that you break up those hours into at least two study sessions each on a different day of the week. This is a rough guide only, as people learn at different rates and from different levels of experience.
## Timetable

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<thead>
<tr>
<th>DATE</th>
<th>LECTURE</th>
<th>READINGS</th>
<th>ASSESSMENT</th>
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| 1    | **L1: Passive Components**  
Resistor characteristics. Resistor types.  
Choosing resistors. Capacitor characteristics.  
Module 2: Help and DXP system menu  
Module 3: Schematic Editor Basics  
Module 4: Schematic Capture | |
| 2    | **L2: Switched-Mode Power Supplies**  
Pulse-width modulation. Buck regulator.  
Selection of components. Output filters. | Module 5: Multi-Sheet Design  
Module 6: Building the Project  
Module 7: Setting Up for Transfer to PCB and Importing Data  
Module 8: PCB Editor Basics | |
| 3    | **L3: Digital Logic Families and IC Packaging**  
Levels of integration. Voltage and current parameters. TTL logic and evolution. ECL. CMOS logic and evolution. Logic families. CMOS voltages. IC packaging. | [Surface Mount Soldering Exercise]  
Module 9: Setting Up The PCB  
Module 10: Global Editing  
Module 11: PCB Design Flow, Transferring a Design and Navigation  
Module 12: Design Rules | |
| 4    | **L4: Crystal Oscillators**  
Module 14: Placement and Re-annotation  
Module 15: Schematic Library Editor  
Module 16: PCB Library Editor | |
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<th>DATE</th>
<th>LECTURE</th>
<th>READINGS</th>
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<tbody>
<tr>
<td>5 Mar</td>
<td><strong>Schematic Review</strong></td>
<td><strong>Module 17: Linking Models, Parameters, Library Package &amp; Updates</strong></td>
<td>Schematic Review</td>
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<td></td>
<td>Schematics are reviewed before PCB design.</td>
<td><strong>Module 18: Routing and Polygons</strong></td>
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<td><strong>Module 19: Output Generation and CAM File Editing</strong></td>
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<td><strong>Module 20: 3D Mechanical CAD</strong></td>
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<td>6 Apr</td>
<td><strong>Public Holiday</strong></td>
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<td>7 Apr</td>
<td><strong>L5: Electromagnetic Compatibility (EMC)</strong></td>
<td><strong><a href="http://www.ti.com/lit/an/szza009/szza009.pdf">www.ti.com/lit/an/szza009/szza009.pdf</a></strong></td>
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<td>8 Apr</td>
<td><strong>Tutorial Week</strong></td>
<td></td>
<td>Log Book Section 1</td>
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<td>VC</td>
<td><strong>Vice-Chancellor’s Week</strong></td>
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<td></td>
<td>PCB manufacturing.</td>
<td><a href="http://www.youtube.com/watch?feature=player_detailpage&amp;v=2qk5vxWY46A">http://www.youtube.com/watch?feature=player_detailpage&amp;v=2qk5vxWY46A</a></td>
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<td>10 May</td>
<td><strong>PCB Review</strong></td>
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<td>PCB Review</td>
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<td>PCBs are reviewed before manufacture.</td>
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<td>11</td>
<td><strong>L7: Thermal Design</strong></td>
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<td>22 May</td>
<td>DSOs and bandwidth. Probes and loop inductances. Wires as transmission lines.</td>
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<td>13</td>
<td><strong>Project</strong></td>
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<td>29 May</td>
<td>Project work.</td>
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<td>14</td>
<td><strong>Project Assessment</strong></td>
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<td>Lab Test</td>
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<td>5 Jun</td>
<td>Lab testing.</td>
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<td>15</td>
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<td>Log Book</td>
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<td>12 Jun</td>
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<td>Section 2</td>
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<td>16</td>
<td><strong>Project Assessment</strong></td>
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<td>19 Jun</td>
<td>Oral presentation.</td>
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<td>Presentation</td>
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<td>26 Jun</td>
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