Sindh Madressatul Islam University, Karachi

DIGITAL LOGIC AND DESIGN

Course Supervised

by

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Lecture No#01

Department Computer Science faculty of Information Technology

COURSE SUPERVISOR

By

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Ph.D (Computer Science)

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COURSE INFORMATION

Course Code

CEN 201

Course Title

Digital Logic and Design

Credit Hours

4 (3+1)

Prerequisites

CEN101

COURSE OBJECTIVES

This course is designed to teach students the basic concepts of digital circuits.

This course that provides Computer Science students with material fundamental to the design and analysis of digital circuits.

This course introduces the logic operators and gates to lay the framework for strengthening the understanding of computer building blocks.

Combinational and sequential circuits are studied along with their constituent elements comprising adders, encoders and multiplexers as well as flip-flops, latches and registers etc.

The course provides necessary information to the students for future study of computer Architecture, Organization and Embedded Systems.

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COURSE DESCRIPTION

This course is designed to teach students, An overview & number systems, Number systems & codes, Logic gates, Digital circuits and operational characteristics, Boolean algebra and logic simplification, Karnaugh map & Boolean expression simplification, Comparator, Odd-Prime Number detector, Implementation of an odd-parity generator circuit, BCD adder, 16-bit ALU, the 74xx138 3-to-8 decoder, 2-input 4-bit multiplexer, Demultiplexer, Implementing constant 0s and 1s, the gal16v8, Abel input file of a quad 1-of-4 MUX, Application of S-R Latch, Flip-Flops, the 555 Timer, Up-Down counter, Digital Clock, Shift Registers, Memory, Analog to Digital Converters

COURSE LEARNING OUTCOMES

By the end of this course students able to:

1. Identify and describe digital circuits .
2. Know about how to design the digital logic circuits
3. How to analyze digital logic circuits
4. Demonstrate how logical gates are used to design a circuit.
5. Differentiate and distinguished between the Combinational Circuits and Sequential Circuits
6. Illustrate how to design and implement the digital logic circuit and to know its applications.

COURSE CONTENTS

Week	Cr. Hours	TOPICS
01	2	Introduction of course outline, Introduction of Digital Logic Design
	1	**Lab-1**
02	2	Number systems & codes
	1	**Lab-2**
03	2	Behavioral Models of Gates: Truth Table and Logical Expressions, Logic gates
	1	**Lab-3**
04	2	Boolean Algebra, logic simplification, Boolean Functions. Canonical and Standard Forms
	1	**Lab-4**
05	2	Karnaugh map & Boolean expression simplification
	1	**Lab-5**
06	2	Comparator, Odd-Prime Number detector
	1	**Lab-6**
07	2	Implementation of an odd-parity generator circuit, BCD adder
		Review
	1	**Lab-7**
8.		**MID TERM EXAMINATION**

COURSE CONTENTS

Week	Cr. Hours	TOPICS
09	2	Combinational-circuit Building Blocks, Signals, Decoders, Multiplexers (MUX) Encoders
	1	**Lab-8**
10	2	Programmable Logic Device, (PLAs), Programmable Array Logics (PALs)
	1	**Lab-9**
11	2	Flip-Flop , Types of Flip-Flop, Latch Flip-Flop, D Flip Flops, JK Flip-flops , SR Latches
	1	**Lab-10**
12	2	Register and Types of the registers
	1	**Lab-11**
13	2	555 Timer, Up-Down counter, Digital Clock, Memory
	1	**Lab-12**
14	2	Analog to Digital Converters
		Project Assignment Presentations
	1	**Lab-13**
15	2	Project Assignment Presentations
	1	Review
		Lab-14
16		**FINAL TERM EXAMINATION**

COURSE TEXT BOOKS

Text Book:

1. Introduction to Logic and Computer Design By Markowitz Alan B McGraw Hill.
2. Logic and Computer Design Fundamentals Second Edition Updated M.Morris Mano, Charles R Kime
3. R. H. Katz, Contemporary Logic Design, Prentice-Hall

Reference Book

1. Hayes, Introduction to Digital Logic Design, Addison-Wesley.
2. M. Mano, Digital Design, 2nd Ed., Prentice-Hall.
3. C. H. Roth, Jr., Fundamentals of Logic Design, 3rd Ed.
4. Digital Fundamentals (Eighth Edition), by Floyd.
5. Digital Systems: Principles and Applications (Seventh Edition) by Tocci. Widmer

COURSE GOALS

Students by the end of this course should have the knowledge about the basics of digital logic concepts and digital devices/circuits logic design.

They should know about the best practices of digital devices and digital devices operations.

LEARNING STRATEGIES

Active learning strategies are employed in this course to encourage students' participation in class and to foster their abilities to gather information and data from its sources and analyze it.

Active learning strategies will focus on Theory, Problem Analysis, Design and/or Solution and Social Ethical Issues related to Computer Science in general and course in particular.

Active learning strategies include assignments/projects where students work in individual and in teams to solve certain problems and do projects on their own. Readings may include many Internet sites.

COURSE GRADING SCALE

Numerical Grade (NG)	Alphabetical Grade (AG)	Grade Point Average (GPA)
91% and above	A	4.00
80% - 90%	A-	3.66
75% - 79%	B+	3.33
71% - 74%	B	3.00
68% - 70%	B-	2.66
64% - 67%	C+	2.33
61% - 63%	C	2.00
58% - 60%	C-	1.66
54% - 57%	D+	1.33
50% - 53%	D	1.00
Below 50%	F	0
-	I	Incomplete
-	W	Withdrawn

STUDENT EVALUATION

Following is the across assessment tools of 100 Marks distribution

Course work Evaluation Distribution	**Marks Distribution**
Quizzes	10
Mid Term Exam	20
Assignments	10
Class Participation	05
Projects /Practical work	15
Final Term Exam	40
Total	**100**

ATTENDANCE POLICY

Students are expected to attend their classes. Absence never exempts a student from the work required for satisfactory completion of the courses. Excessive absences of any course will result in:

First warning for absence of 10% of the class hours

Second warning for absence of 20% of the class hours

A failing grade in the course for an absence of 25% of the class hours **(as per HEC guidelines)**

Exception to (3) may be made in the case of serious illness or death to an immediate family member if approved by the dean of the college. In such case, the student will receive a W grade in the course

PLAGIARISM

It is use of someone else's idea, words, projects, artwork, phrasing, sentence structure, or other work without properly acknowledging the ownership (source) of the property.

Plagiarism is dishonest because it misrepresents the work of someone else as ones own.

Students who are suspected of plagiarism will answer to an investigation.

Those found guilty will face a disciplinary action as per the university rules.

DIGITAL LOGIC AND DESIGN

Digital logic is the representation of signals and sequences of a digital circuit through numbers. It is the basis for digital computing and provides a fundamental understanding on how circuits and hardware communicate within a computer.

A logic gate is an elementary building block of a digital circuit. Most logic gates have two inputs and one output.

Digital logic design is a system in electrical and computer engineering that uses simple number values to produce input and output operations. As a digital design engineer, you may assist in developing cell phones, computers, and related personal electronic devices.

DIGITAL LOGIC AND DESIGN

Digital logic design is the basis of electronic systems, such as computers and cell phones.

Digital logic is rooted in binary code, which renders information through zeroes and ones, giving each number in the binary code an opposite value.

This system facilitates the design of electronic circuits that convey information, including logic gates with functions that include AND, OR, and NOT commands.

The value system translates input signals into specific output. These functions facilitate computing, robotics, and other electronic applications.

DIGITAL LOGIC APPLICATIONS

Digital logic design forms the foundation of electrical engineering and computer engineering.

Digital logic designers build complex electronic components that use both electrical and computational characteristics such as power, current, logical function, protocol, and user input.

Digital logic design is used to develop hardware, such as circuit boards and microchip processors.

This hardware processes user input, system protocol, and other data in navigational systems, cell phones, or other high-tech systems

DIGITAL HARDWARE

Logic circuits are used to build computer hardware as well as other products (digital hardware).

Late 1960’s and early 1970’s saw a revolution in digital capability

- ✓Smaller transistors
- ✓Larger chip size

More transistors/chip gives greater functionality, but requires more complexity in the design process

DIGITAL HARDWARE

Integrated circuits are fabricated on silicon wafers. Wafers are cut & packed to form individual chips. Chips have from tens to millions of transistors.

Complexity can, and generally does, exceed human capability:

– 10-100 million transistors/cm2 now
– 100-1000 million transistors/cm2 in 10 years (?)
– http://en.wikipedia.org/wiki/Transistor_count

Provides motivation for computer-based design techniques
Most engineering work is done with CAD packages

TWO DESIGN APPROACHES

Traditional

- ✓ Relies on mathematical models
- ✓ Analytical approaches
- ✓ Provides insight and understanding of problem
- ✓ Useful for small problems
- ✓ Inadequate for large (real) problems

Traditional approach of logic design employing SSI and MSI circuits have been strongly challenged in recent years as a result of advances in technology.

TWO DESIGN APPROACHES

CAD

- ✓Software relies on mathematical model
- ✓Analytical approach
- ✓Transparent to user
- ✓Many details are abstracted
- ✓Useful/required for real problems

Computer aided design employing the LSI programmable logic devices (PLD'S). The programmable logic devices currently available to logic designers and classified as ROMs, PLAs and FPGA

Why we study Digital Logic

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Knowing digital logic design is necessary when one designs new CPUs, Programs FPGAs, (Field Programmable Gate Array) and connects those components to other digital chips.

Sometimes it comes in handy for some kinds of computer programming.

That's why it is necessary to study the "digital logic design" to understand the digital circuits and its functionality.

DIGITAL ELECTRONIC CIRCUITS

Digital electronics or digital (electronic) circuits are electronics that handle digital signals- discrete bands of analog levels, rather than by continuous ranges (as used in analogue electronics).

All levels within a band of values represent the same numeric value.

The number of these states is two, and they are represented by two voltage bands.

These correspond to the "false" ("0") and "true" ("1") values.

A digital signal has two or more distinguishable waveforms, For example, high voltage and low voltages, each of which can be mapped onto a digit. 0,1.

DIGITAL ELECTRONIC CIRCUITS

Digital electronic circuits are usually made from large assemblies of logic gates

There are seven Logic gates.

- ✓AND gate (7408)
- ✓OR gate (7432)
- ✓NOT gate (7404)
- ✓NAND gate (7400)
- ✓NOR gate (7402)
- ✓Exclusive OR gate (7486)
- ✓Exclusive NOR gate (74266)

These gates we will study in third lecture in detail.

ADVANTAGE OF DIGITAL CIRCUITS

when compared to analog circuits is that signals represented digitally can be transmitted without degradation due to noise

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For example, a continuous audio signal transmitted as a sequence of 1s and 0s, can be reconstructed without error.

Information storage can be easier in digital systems than in analog ones

Digital fragility can be reduced by designing a digital system for robustness

DESIGN ISSUES IN DIGITAL CIRCUITS

Digital circuits are made from analog components.

The design must assure that the analog nature of the components doesn't dominate the desired digital behavior.

Digital systems must manage noise and timing margins, parasitic inductances and capacitances, and filter power connections.

Since digital circuits are made from analog components, digital circuits calculate more slowly than low-precision analog circuits that use a similar amount of space and power.

DESIGN ISSUES IN DIGITAL CIRCUITS

However, the digital circuit will calculate more repeatable, because of its high noise immunity.

On the other hand, in the high-precision domain (for example, where 14 or more bits of precision are needed), analog circuits require much more power and area than digital equivalents.

DIGITAL CIRCUITS CONSTRUCTION

A digital circuit is often constructed from small electronic circuits called logic gates that can be used to create combinational logic.

Each logic gate represents a function of boolean logic. A logic gate is an arrangement of electrically controlled switches, better known as transistors.

Each logic symbol is represented by a different shape. The actual set of shapes was introduced in 1984 under IEEE/ANSI standard 91-1984.

"The logic symbol given under this standard are being increasingly used now and have even started appearing in the literature published by manufacturers of digital integrated circuits.”

DIGITAL CIRCUITS CONSTRUCTION

The output of a logic gate is an electrical flow or voltage, that can, in turn, control more logic gates.

Logic gates often use the fewest number of transistors in order to reduce their size, power consumption and cost, and increase their reliability.

Integrated circuits are the least expensive way to make logic gates in large volumes. Integrated circuits are usually designed by engineers using electronic design automation software (see below for more information).

Another form of digital circuit is constructed from lookup tables, (many sold as "programmable logic devices", though other kinds of PLDs exist).

Lookup tables can perform the same functions as machines based on logic gates, but can be easily reprogrammed without changing the wiring.

DIGITAL CIRCUITS CONSTRUCTION

Therefore, in small volume products, programmable logic devices are often the preferred solution. They are usually designed by engineers using electronic design automation software.

When the volumes are medium to large, and the logic can be slow, or involves complex algorithms or sequences, often a small microcontroller is programmed to make an embedded system. These are usually programmed by software engineers.

When only one digital circuit is needed, and its design is totally customized, as for a factory production line controller, the conventional solution is a programmable logic controller, or PLC. These are usually programmed by electricians, using ladder logic.

STRUCTURE OF DIGITAL SYSTEMS

Engineers use many methods to minimize logic functions, in order to reduce the circuit's complexity.

When the complexity is less, the circuit also has fewer errors and less electronics, and is therefore less expensive.

The most widely used simplification is a minimization algorithm like the Espresso heuristic logic minimizer within a CAD system, although historically, binary decision diagrams, an automated Quine–McCluskey algorithm, truth tables, Karnaugh maps, and Boolean algebra have been used.