KING FAHD UNIVERSITY OF PETROLEUM & MINERALS  
*COMPUTER ENGINEERING DEPARTMENT*

COE 405 Design and Modeling of Digital Systems

Term 122 Lecture Breakdown

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| **Lec#** | **Date** | **Topics** | **Ref.** |
| 1 | S 26/1 | Syllabus & Course Introduction. Introduction to Digital Design Methodology. | Chapter 1 |
| 2 | M 28/1 | Digital System Design Cycle, Architecture Design Example, Design Space and Evaluation Space, Digital System Complexity. | Chapter 1 |
| 3 | W 30/1 | Dealing with Design Complexity, Design Hierarchy, Abstractions, Design Domains & Levels of Abstraction, Design Methods, Design vs. Synthesis, Synthesis Process, Circuit Synthesis, Hardware Description Languages, Design Automation & CAD Tools, Design Flow in Verilog. | Chapter 1 |
| 4 | S 2/2 | Definitions: implicant, Prime Implicant, Essential Prime Implicant, Minimum cover, Minimal cover or irredundant cover. Shannon's Expansion, Boolean Expansion Based on Orthonormal Basis. | Chapter 2 |
| 5 | M 4/2 | Sum of Product (SOP) Simplification Procedure, Don’t Care Conditions, SOP Simplification Procedure using Don’t Cares, Product of Sum (POS) Simplification, Combinational Circuits Design Procedure. | Chapter 2 |
| 6 | W 6/2 | Combinational Circuits Design Procedure, Iterative Design, Decoders, Implementing Functions using Decoders. | Chapter 2 |
| 7 | S 9/2 | Multiplexers, Implementing Functions using Multiplexers. Sequential Circuit Model, Timing of Sequential Circuits, Latches and Flip-Flops, Sequential Circuit Design Procedure. | Chapter 2 & 3 |
| 8 | M 11/2 | Sequential Circuit Design Examples. | Chapter 3 |
| 9 | W 13/2 | Sequential Circuit Design Examples. | Chapter 3 |
| 10 | S 16/2 | State Minimization. | Chapter 3 |
| 11 | M 18/2 | State Minimization. **(Quiz#1)** | Chapter 3 |
| 12 | W 20/2 | Data Path & Control Unit Partitioning, Data Path Design, Registers, Shift Registers, Modulo N (i.e. divide by N) Counters. |  |
| 13 | S 23/2 | Three-State Devices, A Register Bank with a 4-bit Data Bus, Design Steps, Example: Traffic Light Controller. |  |
| 14 | M 25/2 | Communication between DP and CU: timing issues, Algorithmic State Machine (ASM) Chart, Timing in ASM Charts | 5.14 |
| 15 | W 27/2 | ASM Chart => Controller, ASM Chart => Architecture/Data Processor, Implementing Controller, Algorithmic State Machine and DataPath (ASMD) Chart, ASMD Chart for 4-bit Counter. | 5.14-5.15 |
| 16 | S 2/3 | 2:1 Decimator, One’s Count Circuit. Introduction, Why use HDL ?, Definition of a Module. | 5.14-5.15, 4.1 |
| 17 | M 4/3 | Gate-level modeling, Verilog primitives, Verilog Syntax, Verilog Data Types, Module instantiation, Organization of a Testbench for Verifying a Unit Under Test (UUT). | 4.1-4.2 |
| 18 | W 6/3 | Testbench Template, Propagation Delay, Inertial Delay, Transport Delay, Truth Table Models of Combinational and Sequential Logic with Verilog, Data Types for Behavioral Modeling. | 4.2-4.4, 5.1-5.2 |
|  | W 6/3 | **Last Day for Dropping with W** |  |
| 19 | S 9/3 | Boolean Equation-Based Behavioral Models of Combinational Logic, Assign Statement, Verilog Operators. | 5.3 |
| 20 | M 11/3 | **(Quiz#2)** |  |
| 21 | W 13/3 | Propagation Delay & Continuous Assignment, Latches & Level-Sensitive Circuits, Always Block, Procedural Assignment | 5.4-5.5 |
| 22 | S 16/3 | Wire vs. Reg, Algorithm-Based Models, if statement, case statement, D Latch, D Flip-flop (synchronous & asynchronous reset), Data Flow/ RTL Models: Shifter | 5.6-5.8 |
| 23 | M 18/3 | Behavioral Models of Multiplexor, Encoder, Decoder, Seven Segment Display Decoder, Linear Feedback Shift Register (LFSR) | 5.9-5.10 |
|  | T 19/3  (Makeup) | FPGA Tutorial |  |
| 24 | W 20/3 | No Class |  |
|  | **23-27/3** | **Midterm Vacation** |  |
| 25 | S 30/3 | LFSR Modeling, Repetitive Algorithms: for loop, repeat loop, while loop, disable, forever. Machines with Multicycle Operations. Tasks and Functions. | 5.11-5.13 |
| 26 | M 1/4 | Tasks and Functions, Behavioral Modeling of Control Unit, Behavioral Models of Counters, Behavioral Models of Shift Registers. | 5.14-5.16 |
| 27 | W 3/4 |  |  |
|  | Th. 4/4 | Midterm Exam |  |
| 28 | S 6/4 | Barrel Shifter, Universal Shift Register, Register Files. Circuit Synthesis, Multilevel logic synthesis. Solution of Midterm Exam. | 5.16 & 6.1 |
| 29 | M 8/4 | Multilevel Logic Synthesis, Logic Network modeling, Network Optimization, Area and Delay estimation, Multilevel Logic Transformations: Elimination, Decomposition, Factoring, Extraction, Simplification, Substitution. | 6.1 |
| 30 | W 10/4 | Timing Issues in Multiple-Level Logic Optimization: Network Delay Modeling, topological critical path, false path, Algorithms for Delay Minimization, Behavioral or High-Level Synthesis: CDFG, scheduling, allocation. | 6.1 |
|  | W 10/4 | **Last Day for Dropping all Courses with W** |  |
| 31 | S 13/4 | Synthesis of Combinational Logic, Synthesis of Priority Structures. Exploiting Logical Don’t Care Conditions, Resource Sharing, Synthesis of Sequential Logic with Latches, Synthesis of Three-State Devices and Bus Interfaces, Synthesis of Sequential Logic with Flip-Flops. | 6.2-6.6 |
| 32 | M 15/4 | **(Quiz#3)** |  |
| 33 | W 17/4 | Synthesis of Explicit State Machine | 6.7 |
| 34 | S 20/4 | FPGA Tutorial#2 (LCD, Audio, ROM) |  |
| 35 | M 22/4 | Synthesis of Gated Clocks and Clock Enable, Operator Grouping, Expression Substitution, Synthesis of loops. Design and Synthesis of RISC Stored Program Machine (SPM). | 6.11-6.13 & 7.3 |
| 36 | W 24/4 | Controller ASM Charts, RISC SPM Module, Processing Unit Module. | 7.3 |
| 37 | S 27/4 | Processing Unit Module, Memory Module, Control Unit Module, RISC SPM Test Bench. | 7.3 |
| 38 | M 29/4 | **(Quiz#4)** |  |
| 39 | W 1/5 | FPGA Tutorial#3: using Xilinx Core Generator. |  |
| 40 | S 4/5 | Universal Asynchronous Receiver Transmitter (UART), Block Diagram of a UART, UART Transmitter, UART Transmitter ASMD Chart, UART Transmitter Operation. | 7.4 |
| 41 | M 6/5 | UART Transmitter Module, UART Transmitter ASMD Chart, UART Receiver, UART Receiver ASMD Chart, UART Receiver Module. | 7.4 |
| 42 | W 8/5 | Programmable Logic and Storage Devices: History of Computational Fabrics, ASIC vs. FPGA, FPGA Advantages, Reconfigurable Logic, Anti-Fuse-Based Approach, RAM Based Field Programmable Logic, Xilinx FPGA Families, The Xilinx 4000 CLB. | Chapter 8 |
|  | W 8/5 | **Dropping all Courses with WP/WF** |  |
| 43 | S 11/5 | LUT Mapping, Configuring the CLB as a RAM, FPGA Interconnect, Basic I/O Block Structure, CLB Structure, 5-Input Functions, Distributed RAM, Shift Register, Carry & Control Logic, Adder Implementation, Carry Chain, 18 x 18 Embedded Multiplier. | Chapter 8 |
| 44 | M 13/5 | FPGA Design Flow – Mapping, Placement & Route, Memory Types, FPGA Memory Implementation, LUT-Based RAMS, Block RAM. | Chapter 8 |
| 45 | W 15/5 | Block RAM Logic Diagram, Block RAM Data Combinations and ADDR Locations, Read & Write Operations, Write Modes, Conflict Avoidance, Using Core Generator. | Chapter 8 |