

Contents

<i>Preface</i>	<i>vii</i>
<i>List of Abbreviations</i>	<i>xvii</i>

CHAPTER 1: Combinational logic	1.1–1.196
1.1 Introduction to Combinational Circuits	1.1
1.1.1 Problem Formulation and Design of Combinational Circuits	1.2
1.2 Boolean Algebra	1.2
1.2.1 Duality	1.4
1.2.2 Postulates of Boolean Algebra	1.4
1.2.3 Boolean Theorems	1.6
1.3 Binary Logic	1.9
1.4 Logic Gates	1.10
1.4.1 Universal Gates	1.14
1.4.2 Positive and Negative Logic Gates	1.17
1.5 Boolean Functions	1.19
1.5.1 Implementation of Boolean Functions by Logic Gates	1.22
1.5.2 Minterms	1.22
1.5.3 Maxterms	1.24
1.5.4 Standard Forms	1.25
1.5.5 Sum-of-Products and Product-of-Sums Simplification	1.25
1.5.6 Canonical Form	1.26
1.5.7 Complement of a Function	1.27
1.5.8 Implementation of Boolean Functions Using Universal Gates	1.28
1.5.9 Simplification of Boolean Expressions or Functions	1.36
1.6 Karnaugh Map (or K-map) Minimization	1.37
1.6.1 Analysis and Design Procedures of Combinational Circuits using K-map	1.37
1.6.2 Two-Variable K-map	1.38
1.6.3 Three-Variable K-map	1.40
1.6.4 Four-Variable K-map	1.43
1.6.5 Five-Variable K-map	1.46
1.6.6 Realization of Product-of-Sums Form using K-map	1.56
1.6.7 Completely and Incompletely Specified Functions (K-map with Don't-Care Conditions)	1.57
1.7 Binary Arithmetic	1.71
1.7.1 Binary Addition	1.71
1.7.2 Binary Subtraction	1.71
1.7.3 One's and Two's Complement Addition	1.72

1.7.4 One's and Two's Complement Subtraction	1.75
1.7.5 Adders	1.77
1.7.6 Half Adder	1.77
1.7.7 Full Adder	1.78
1.7.8 Binary Parallel Adder	1.82
1.7.9 BCD Adder (Decimal Adder)	1.85
1.7.10 Subtractors	1.88
1.7.11 Half Subtractor	1.88
1.7.12 Full Subtractor	1.89
1.7.13 Binary Parallel Adder/Subtractor	1.92
1.8 Magnitude Comparator	1.94
1.8.1 4-bit Magnitude Comparator	1.94
1.8.2 3-bit Magnitude Comparator	1.100
1.8.3 2-bit Magnitude Comparator	1.101
1.9 Decoders	1.102
1.9.1 Logic High 2-to-4 Decoder	1.103
1.9.2 Logic Low 2-to-4 Decoder	1.104
1.9.3 Logic High 2-to-4 Decoder with Logic Low Enable	1.106
1.9.4 Logic High 3-to-8 Decoder	1.108
1.9.5 Logic Low 3-to-8 Decoder	1.111
1.9.6 Combinational Circuit Design Using Decoder	1.117
1.10 Encoders	1.122
1.10.1 Logic High 4-to-2 Encoder	1.122
1.10.2 Logic High 8-to-3 Encoder	1.124
1.11 Priority Encoders	1.125
1.11.1 Logic High 4-to-2 Priority Encoder	1.126
1.11.2 Logic High 4-to-2 Priority Encoder Design using K-maps	1.128
1.11.3 Logic High 8-to-3 Priority Encoder	1.129
1.12 Multiplexer	1.135
1.12.1 Combinational Circuit Design using Multiplexer	1.142
1.13 Demultiplexer	1.152
1.13.1 Demultiplexers and Decoders	1.158
1.14 Summary of Important Concepts	1.158
1.15 Short-Answer Questions	1.160
1.16 Exercises	1.172

CHAPTER 2: SYNCHRONOUS SEQUENTIAL LOGIC**2.1–2.176**

2.1 Introduction to Sequential Circuits	2.1
2.2 Bistable Element and Latches	2.2
2.2.1 SR Latch	2.2
2.2.2 Analysis of SR Latch using NOR Gates	2.3
2.2.3 Analysis of SR Latch using NAND Gates	2.5
2.3 Flip-Flops	2.8
2.3.1 Clock and Triggering of Flip-flops	2.9

2.3.2 SR Flip-Flop	2.10
2.3.3 JK Flip-Flop	2.15
2.3.4 T Flip-Flop (Toggle Flip-Flop)	2.21
2.3.5 D Flip-Flop (Data Flip-Flop)	2.22
2.3.6 Flip-Flop with Preset and Reset Facility	2.23
2.4 Master-Slave Flip-Flop	2.25
2.5 Excitation Table and Characteristic Equation of Flip-Flops	2.25
2.5.1 Excitation Table of D Flip-Flop	2.25
2.5.2 Excitation Table of JK Flip-Flop	2.27
2.5.3 Excitation Table of T Flip-Flop	2.29
2.5.4 Excitation Table of SR Flip-Flop	2.30
2.6 Analysis and Design of Synchronous (or Clocked) Sequential Circuits	2.32
2.6.1 Design of Mealy and Moore Models	2.33
2.7 State and State Equations	2.34
2.7.1 State Table and State Diagram	2.35
2.7.2 State Reduction	2.35
2.7.3 State Assignment	2.36
2.7.4 Lock-out Condition Circuit Implementation	2.37
2.8 Register	2.79
2.9 Shift Register	2.81
2.9.1 Serial-in Serial-out Shift Register	2.81
2.9.2 Serial-in Parallel-out Shift Register	2.84
2.9.3 Parallel-in Serial-out Shift Register	2.84
2.9.4 Parallel-in Parallel-out Shift Register	2.85
2.9.5 Universal Shift Register	2.85
2.9.6 Application of Shift Register	2.89
2.10 Design of Counters	2.89
2.11 Asynchronous or Ripple Counter	2.90
2.11.1 Up Counter	2.90
2.11.2 Down Counter	2.93
2.11.3 Up/Down Counter using T Flip-Flop	2.94
2.11.4 Down Counter with Positive Clock	2.95
2.11.5 BCD Counter	2.96
2.11.6 MOD Counter	2.99
2.12 Synchronous Counter	2.103
2.12.1 Synchronous Binary Up Counter	2.104
2.12.2 Synchronous Binary Down Counter	2.107
2.12.3 Synchronous Up/Down Counter	2.109
2.12.4 Synchronous BCD Counter	2.110
2.12.5 Ring Counter	2.114
2.12.6 Johnson Counter	2.115
2.12.7 Application of Counter	2.153
2.13 Summary of Important Concepts	2.153
2.14 Short-Answer Questions	2.155
2.15 Exercises	2.159

CHAPTER 3: Computer Fundamentals	3.1–3.46
3.1 Introduction	3.1
3.1.1 Computer Generations	3.1
3.1.2 Computer Classification based on Current Market Requirements	3.3
3.2 Functional Units of a Digital Computer	3.3
3.2.1 Computer Architecture and Organization	3.4
3.2.2 Instruction Set Architecture (ISA)	3.4
3.2.3 RISC and CISC Instruction Set Architecture	3.4
3.3 Basic Organization of a Computer	3.5
3.4 Basic Architecture	3.6
3.4.1 Von Neumann Architecture	3.6
3.4.2 Harvard Architecture	3.7
3.4.3 Modified Harvard Architecture	3.7
3.5 Operation and Operands of Computer Hardware Instruction	3.8
3.5.1 Types of Instructions	3.9
3.5.2 Types of Operands	3.9
3.5.3 Classification of Instructions based on Operand Address	3.10
3.6 Interaction between Assembly and High Level Language	3.11
3.6.1 Machine Level Programming	3.11
3.6.2 Assembly Level Programming	3.12
3.6.3 High Level Programming	3.12
3.7 Instruction and Instruction Sequencing	3.12
3.7.1 Instruction Sequencing	3.15
3.8 Encoding of Machine Language Instructions	3.16
3.8.1 Format of 8086/8088 Instructions	3.16
3.8.2 Encoding of 8086/8088 Instructions	3.19
3.8.3 ARM7TDMI Instruction Set	3.21
3.8.4 Encoding of ARM Instruction	3.21
3.8.5 Encoding of THUMB Instruction	3.21
3.9 Memory Location, Address and Operation	3.25
3.9.1 Memory Locations and Addresses	3.26
3.9.2 Memory Operations	3.28
3.9.3 Stack Memory	3.28
3.10 Addressing Modes	3.29
3.10.1 Addressing Modes of 8086/8088 Processor	3.29
3.10.2 Addressing Modes of ARM Processor	3.35
3.11 Summary of Important Concepts	3.38
3.12 Short-Answer Questions	3.39
3.13 Exercises	3.44
CHAPTER 4: Processor	4.1–4.38
4.1 Introduction	4.1
4.1.1 Introduction to ARM	4.1
4.1.2 Functional Building Blocks of a Processor (Microprocessor)	4.2

4.2 Processor Internal Buses	4.3
4.2.1 One-Bus Organization	4.3
4.2.2 Two-Bus Organization	4.4
4.2.3 Three-Bus Organization	4.5
4.3 Architecture of Intel x86 and ARM Processor	4.5
4.3.1 Architecture of Intel 8086/8088 Processor	4.6
4.3.2 Architecture of ARM7TDMI Processor	4.9
4.4 Instruction Execution	4.14
4.4.1 Instruction Cycle	4.14
4.5 Building a Data Path	4.16
4.6 Designing a Control Unit	4.20
4.6.1 Hardwired Control	4.20
4.6.2 Microprogrammed Control	4.21
4.7 Pipelining	4.27
4.7.1 Pipeline Hazards	4.27
4.7.2 Data Hazard	4.28
4.7.3 Control Hazard	4.28
4.7.4 Structural Hazard	4.28
4.7.5 Instruction Pipeline	4.29
4.8 Summary of Important Concepts	4.32
4.9 Short-Answer Questions	4.33
4.10 Exercises	4.36

CHAPTER 5: Memory and IO**5.1–5.46**

5.1 Memory Concepts	5.1
5.1.1 Types of Semiconductor Memories	5.2
5.1.2 Main Memory of Desktop/Laptop Computers	5.3
5.2 Memory Hierarchy	5.3
5.3 Memory Management	5.5
5.4 Virtual Memory	5.6
5.4.1 Paging	5.8
5.4.2 Address Translation in Paging	5.8
5.4.3 Translation Lookaside Buffer (TLB)	5.10
5.5 Cache Memories	5.15
5.5.1 Organization of Cache Memory	5.15
5.5.2 Cache Memory Access for Read Operation	5.16
5.5.3 Cache Replacement Technique	5.17
5.5.4 Write Policy in Cache Memory	5.17
5.5.5 Some Important Terms in Cache Memory	5.18
5.6 Cache Memory Mapping Techniques	5.19
5.6.1 Direct Mapping	5.19
5.6.2 Associative Mapping	5.22
5.6.3 Set Associative Mapping	5.24

5.7 DMA (Direct Memory Access)	5.27
5.7.1 A Computer System with a DMA Controller	5.27
5.8 Accessing IO: Parallel and Serial Interface	5.29
5.8.1 Parallel Interface	5.29
5.8.2 Paralle Data Transfer Schemes	5.31
5.8.3 Interrupt Driven Data Transfer Scheme	5.33
5.8.4 Interrupt IO	5.33
5.8.5 Serial Data Transfer	5.34
5.8.6 Serial Interface	5.35
5.9 Interconnection Standards (IO Interconnection Standards)	5.36
5.9.1 USB (Universal Serial Bus)	5.36
5.9.2 SATA (Serial Advanced Technology Attachment)	5.38
5.10 Summary of Important Concepts	5.38
5.11 Short-Answer Questions	5.40
5.12 Exercises	5.44

Appendices**A.1–A.70**

Appendix 1: List of Some Standard IC's	A.1
Appendix 2: Pin Configuration of Some Standard IC's	A.2
Appendix 3: Boolean Theorems	A.12
Appendix 4: Two Variable Boolean Function	A.13
Appendix 5: Summary of Flip-Flop Tables	A.14
Appendix 6: Number Systems	A.15
Appendix 7: Unsigned and Signed Binary Integer Number Systems	A.21
Appendix 8: Fixed and Floating Point Representation	A.27
Appendix 9: BCD	A.35
Appendix 10: ASCII Codes	A.36
Appendix 11: List of Processors Released by Intel	A.41
Appendix 12: Formats of 8086/8088 Instructions	A.43
Appendix 13: ARM Instruction Set Summary	A.57
Appendix 14: THUMB Instruction Set Summary	A.64

UNIVERSITY QUESTION PAPERS**Q.1–Q.8****Index****I.1–I.4**

List of Abbreviations

AC	Accumulator
AF	Auxiliary carry Flag
ALU	Arithmetic and Logic Unit
ARM	Advanced RISC Machine
AR	Address Register
ASCII	American Standard Code for Information Interchange
AT	Advanced Technology
ATA	Advanced Technology Attachment
BA	Base Address
BCD	Binary Coded Decimal
BEQ	Branch if Equal
BIU	Bus Interface Unit
BR	Branch
CAR	Control Address Register
cd	Compact Disc/Condition
CF	Carry Flag
CS	Code Segment
CMOS	Complementary Metal Oxide Semiconductor
CISC	Complex Instruction Set Computing/Computer
CPU	Central Processing Unit
CPSR	Current Program Status Register
CRT	Cathode Ray Tube
DDR	Double Data Rate
DF	Direction Flag
DIMM	Dual Inline Memory Module
DMA	Direct Memory Access
DRAM	Dynamic Random Access Memory
DR	Data Register
DS	Data Segment
EA	Effective Address
EEPROM	Electrically Erasable-Programmable Read Only Memory
ENIAC	Electronic Numerical Integrator and Computer

EPROM	Erasable-Programmable Read Only Memory
EU	Execution Unit
EX	Extra Segment
FIFO	First-In-First-Out
IBM	International Business Machine
ICs	Integrated Circuits
IF	Interrupt Flag
IO	Input-Output
ILP	Instruction-level parallelism
IP	Instruction Pointer / Intellectual Property
IRA	International Reference Alphabet
IR	Instruction Register
ISA	Instruction Set Architecture
LFU	Least Frequently Used
LIFO	Last-In-First-Out
LRU	Least Recently Used
LSI	Large Scale Integration
MA	Memory Address
MAR	Memory Address Register
MDR	Memory Data Register
MMU	Memory Management Unit
MSI	Medium Scale Integration
NOP	No Operation
OF	Overflow Flag
PAAT	Parallel Advanced Technology Attachment
PC	Personal Computer
PDP	Personal Data Processor
PF	Parity Flag
PMD	Personal Mobile Devices
RAM	Random Access Memory
ROM	Read Only Memory
RWM	Read/Write Memory
RISC	Reduced Instruction Set Computing/Computer
SATA	Serial Advanced Technology Attachment
SBR	Subroutine Register
SDD	Solid State Drives
SF	Sign Flag
SIMM	Single Inline Memory Module
SP	Stack Pointer

SPSR	Saved Program Status Register
SRAM	Static Random Access Memory
SSI	Small Scale Integration
SS	Stack Segment
TDMI	THUMB, Debug and Multiplier Integration
TF	Trace Flag
TLB	Translation Lookaside Buffer
ULSI	Ultra Very Large Scale Integration
USB	Universal Serial Bus
UV	Ultra Violet
VLSI	Very Large Scale Integration
WSC	Warehouse Scale Computers
ZF	Zero Flag