DIGITAL LOGIC DESIGN

Ricardo B. San Agustin, EE, MIT
Gaudencio Jeffrey G. Romano, MSCS, MACoED
Arfel V. Aguilar, MIT
Sonny C. Roque, MIT
Alneslyn C. Bucud, MIT(c)

Raymond S. Macatangga, DIT
Consultant and Editor

DIGITAL LOGIC DESIGN

Ricardo B. San Agustin, EE, MIT
Gaudencio Jeffrey G. Romano, MSCS, MACoED
Arfel V. Aguilar, MIT
Sonny C. Roque, MIT
Alneslyn C. Bucud, MIT(c)

Raymond S. Macatangga, DIT
Consultant and Editor

DIGITAL LOGIC DESIGN

Copyright 2018
By Authors:

Ricardo B. San Agustin, EE, MIT
Gaudencio Jeffrey G. Romano, MSCS, MACoED
Arfel V. Aguilar, MIT
Sonny C. Roque, MIT
Alneslyn C. Bucud, MIT(c)

Raymond S. Macatangga, DIT
Consultant and Editor

and

Jimczyville Publications

ALL RIGHTS RESERVED. No part of this module may be used or reproduced in any form by any means graphic, electronic, or mechanical, including photocopying, or information storage without the prior permission from the authors and publisher.

Published by:
Jimczyville Publications
#16 Concha St., Tinajeros, Malabon City
jimczyvillepublication@yahoo.com
jimczyville.publications2004@gmail.com
Tel. nos.: (02) 285-30-55

Layout Artist: Romer C. Villestas

Cover Design: Gaudencio Jeffrey G. Romano, MSCS, MACoED

ISBN: 978-621-8122-16-1

Table of Contents

	Page
Preface	i
Acknowledgement	ii
Table of Contents	iii
UNIT 1. INTRODUCTION TO DIGITAL LOGIC	
Lesson 1. Digital Logic	
1.1 Analog	1
1.2 Digital	2
1.3 Advantages and Disadvantages of Digital	3
Lesson 2. Brief History of Number System	
2.1 Brief History of Number System	5
2.1.1 Unary System	6
2.1.2 Roman Numeral	7
2.1.3 Decimal System	7
2.1.4 Rounding off-number	8
2.1.5 Engineering Notation	9
2.1.6 Scientific Notation	10
2.2 A Brief History of Binary Number System	10
2.2.1 Understanding Binary Numbers	11
2.2.2 Applications of Number System	11
2.2.3 Advantages of the Binary Number System	12
2.3 Generation of Computer	12
2.3.1 First Generation Computer	13
2.3.2 Second Generation Computer	14
2.3.3 Third Generation Computer	16
2.3.3.1 Moore's Law	18
2.3.4 Fourth Generation Computer	20
2.3.5 Fifth Generation of Computer	22
Lesson 3. Number System Conversion	
3.1 Four Types of Number Systems	23
3.2 Binary Number System Conversions	24
3.2.1 Binary to Decimal Conversion	24

3.2.2 Decimal to Binary Conversion 25
3.2.3 Binary to Octal Conversion 26
3.2.4 Octal to Binary Conversion 28
3.2.5 Decimal to Octal Conversion 29
3.2.6 Octal to Decimal Conversion 30
3.2.7 Binary to Hexadecimal Conversion 31
3.2.8 Hexadecimal to Binary Conversion 32
3.2.9 Decimal to Hexadecimal Conversion 33
3.2.10 Hexadecimal to Decimal Conversion 34

Lesson 4. Arithmetic Number System
4.1 Binary Arithmetic 37
4.1.1 Binary Addition 37
4.1.2 Binary Subtraction 38
4.1.3 Binary Multiplication 39
4.1.4 Binary Division 39
4.2 Octal Arithmetic 41
4.2.1 Octal Addition 41
4.2.2 Octal Subtraction 42
4.2.3 Octal Multiplication 43
4.2.4 Octal Division 45
4.3 Hexadecimal Arithmetic 46
4.3.1 Hexadecimal Addition 46
4.3.2 Hexadecimal Subtraction 47
4.3.3 Hexadecimal Multiplication 49
4.3.4 Hexadecimal Division 51

Lesson 5. Basic Logic Gates
5.1 Basic Logic Gates 53
5.2 AND gate 53
5.3 OR gate 54
5.4 NOT gate of Inverter 55
5.5 NAND gate 56
5.6 NOR gate 56
5.7 XOR gate 57
5.8 XNOR gate 58

Lesson 6. Introduction to Boolean Algebra
6.1 Brief History of Boolean Algebra 61
6.2 Law of Boolean Algebra 63
6.2.1 Identity Law 63
6.2.2 Commutative Law 64
6.2.3 Associative Law 65
6.2.4 Idempotent Law 65
6.2.5 Double Negative or Double Negation 66
6.2.6 Complementary Law 66
6.2.7 Law of Intersection 67
6.2.8 Union 68
6.2.9 Distributive Law 68
6.2.10 Absorption 69
6.2.11 Common Identities 70
6.2.12 De Morgan's Theorem 71
6.3 Boolean Algebra Simplification 71
6.4 Logic Circuit Simplification 75
6.5 Designing a Logic Circuit 80

Lesson 7. Introduction to Karnaugh Mapping
7.1 Brief History of Karnaugh Map 87
7.2 The Concept of K-maps 88
7.3 K-maps Implementation in Two Variables 89
7.4 K-maps Implementation in Three Variables 91
7.5 K-maps Implementation in Four Variables 93
7.6 K-maps Don't Care Condition 96

UNIT 2- DITAL LOGIC FAMILIES

Lesson 8. Digital Logic Families
8.1 Introduction to Digital Logic 101
8.2 Digital Logic Families 102
8.2.1 Diode Logic 103
8.2.2 Resistor-Transistor Logic (RTL) 104
8.2.3 Diode-Transistor Logic (DTL) 105
8.2.4 Emitter-Coupled Logic (ECL) 106

8.2.5 Transistor-Transistor Logic (TTL) 108
8.2.6 Complementary Metal-Oxide Semiconductor (CMOS) 109
8.3 Character of a Digital Circuits 110
8.3.1 Fan-in 110
8.3.2 Fan-out 110
8.3.3 Power dissipation 110
8.3.4 Propagation Delay 110
8.3.5 Noise Margin 111

Lesson 9- Multivibrator and Flip-flops
9.1 Multivibrators 113
9.2 The Multivibrator's Primary Components 115
9.2.1 Flip-flops 115
9.3 Types of Flip-flops 116
9.3.1 SR Flip-flops 116
9.3.2 D Flip-flops 118
9.3.3 JK Flip-flops 119
9.3.4 T Flip-flops 120
9.4 Applications of Multivibrators and Flip-flops 121
9.4.1 Application of Multivibrator 121
9.4.2 Application of Flip-flops 122
9.5 Registers 122
9.6 Random Access Memory (RAM) 122

Lesson 10- Register
10.1 Central Processing Unit (CPU) Registers 123
10.2 Central Processing Unit (CPU) Architecture 124
10.2.1 Register 125
10.2.2 PC Program Counter 125
10.2.3 MAR- Memory Address Register 125
10.2.4 MDR-Memory Data Register 126
10.2.5 CIR- Current Instruction Register 126
10.2.6 Accumulator 127
10.3 RISC and CISC 127

Lesson 11- Counters
11.1 Counters 129
11.2 Types of Counters 130

11.2.1Asynchronous Counters 130
11.2.2 Synchronous Counters 130
11.2.3 Up-Down Counter or Bidirectional Counters 130
11.2.4 Decade Counters 131
11.2.5 Ring Counters 132
11.2.6 Johnson Counters 132
11.2.7 Modulus Counter's 133
11.3 Functions and Application of Counters 133
11.3.1 LM555 IC 135
11.3.2 Simple Blinking LED Circuit using a 555 IC 136

Lesson 12- Decoders BCD to Seven Segment
12.1 Common Cathode and Common Anode Format 144
12.2 Seven-Segment Display Format 144
12.3 Binary Coded Decimal 146
12.4 BCD to 7-Segment Display Decoders 146
12.5 BCD to 7-Segment Decoder 147
12.5.1 Display Decoder Example 147
12.5.2 Seven-Segment LED Display 148
12.5.3 Multiplexing the 7-segment LED Display 149
12.5.4 Two types of seven segment displays are in use 150
12.5.5 C Program code for Multiplexing seven segment display using PIC microcontroller 152

Lesson 13- Current Trends in Digital Design
13.1 Iot Platform 157
13.2 IoT Command and Control Software 158
13.3 Smart Machines 159
13.4 2-D Electronics 159
13.5 Organic Electronics 160
13.6 Memristor 161
13.7 Spintronics 162
13.8 Molecular Electronics 163

Assessment Tasks 165

References 241

ABOUT THE AUTHORS

ENGR. RICARDO B. SAN AGUSTIN, he attained BS Electronics Engineer at Technological Institute of the Philippines (Manila)on 2005 March and he also finished his Master in Information Technology (MIT) at Technological University of the Philippines (Manila) on March 14, 2018.

He is a CompTIA Certified, Microsoft Certified Educator (MCE), Microsoft Technology Associate (MTA), Microsoft Office Specialist (MOS), Trainers Methodology Certificate I, National Certificate II (Tesda NC II) and he also a member of Institute of Electronics Engineers of the Philippines Manila and Philippine Society of Information Technology Educators (PSITE-NCR). Engr. San Agustin is currently employed in Our Lady of Fatima University Valenzuela Campus as a faculty member of College of Computer Studies under the Information Technology Program.

MR. GAUDENCIO JEFFREY G. ROMANO is a graduate of Master of Science in Computer Science (MSCS) and Master of Arts in Computer Education (MACoEd) with a Bachelor's degree in Computer Science in AMA University, Quezon City Campus.

He taught in AMA University, Quezon City from 1998 to 2003 and currently employed as an Instructor IV in the College of Computer Studies under the Computer Science Program at Our Lady of Fatima University, Valenzuela City Campus. He is a Microsoft Certified Educator (MCE), Microsoft Technology Associate (MTA) and Microsoft Office Specialist.

MR. ARFEL V. AGUILAR, received his 1st Technical Vocational Diploma from the Associate in Electronics Technology Program at Philippine Science and Technology Center-Caloocan campus. He attained his Bachelor of Science in Computer Science Program at Asian College of Science and Technology and he also finished his Master's Degree in Information Technology at Technological Institute of the Philippines-Manila Campus.

He is a certified as MIE Trainer, MS Teacher Academy Office 365 and One Note, Microsoft Innovative Educator, Microsoft Education Contributor, Microsoft Education Influencer and he also passed the examination of being Microsoft Office Specialist and chosen as 1 of the 1000 Microsoft Education Ambassadors in the Philippines.

In terms of research, his study received the 1st Place in the National Conference held in Baguio which organized by Research and Educational Development Training Institute-Manila. Another research study was awarded as Top 1 Best Research of the Year in Annual Oral Research Exposition organized by Our Lady of Fatima University. Mr. Aguilar is currently the Information Technology Program Head at Our Lady of Fatima University, Quezon City campus. He is also the Committee Chair in the Instruction Area during accreditation of PACUCOA (Philippine Association of Colleges and Universities Commission on Accreditation).

Jimczyville Publications
#16 Concha St., Brgy. Tinajeros Malabon City
jimczyville.publications2004@gmail.com
jimczyvillepublication@yahoo.com
Tel.No: (02) 285-30-55

ISBN: 978-621-8122-16-1

"Aiming for Academic Excellence, Social Transformation and Fervent Faith in God thru relevant, Updated and Authoritative Books and Teaching Materials"