

INTERNATIONAL EDITION

Eighth Edition

DIGITAL FUNDAMENTALS

FLOYD

Contents

Introductory Digital Concepts 1

- 1-1 Digital and Analog Quantities 2
- 1-2 Binary Digits, Logic Levels, and Digital Waveforms 4
- 1-3 Introduction to Logic Operations 10
- 1-4 Overview of Logic Functions 12
- 1-5 Fixed-Function Integrated Circuits 17
- 1-6 Programmable Logic Devices (PLDs) 21
- 1-7 Introduction to Test Instruments 23
Digital System Application 30

Number Systems, Operations, and Codes 40

- 2-1 Decimal Numbers 42
- 2-2 Binary Numbers 44
- 2-3 Decimal-to-Binary Conversion 47
- 2-4 Binary Arithmetic 50
- 2-5 1's and 2's Complements of Binary Numbers 54
- 2-6 Signed Numbers 56
- 2-7 Arithmetic Operations with Signed Numbers 62
- 2-8 Hexadecimal Numbers 69
- 2-9 Octal Numbers 75
- 2-10 Binary Coded Decimal (BCD) 78
- 2-11 Digital Codes and Parity 81
Digital System Application 91

Logic Gates 104

- 3-1 The Inverter 106
- 3-2 The AND Gate 109
- 3-3 The OR Gate 116
- 3-4 The NAND Gate 121
- 3-5 The NOR Gate 126
- 3-6 The Exclusive-OR and Exclusive-NOR Gates 131
- 3-7 Fixed-Function Logic: IC Gates 135
- 3-8 Troubleshooting 146
- 3-9 Programmable Logic 152

Boolean Algebra and Logic Simplification 168

- 4-1 Boolean Operations and Expressions 170
- 4-2 Laws and Rules of Boolean Algebra 171
- 4-3 DeMorgan's Theorems 177
- 4-4 Boolean Analysis of Logic Circuits 180
- 4-5 Simplification Using Boolean Algebra 182
- 4-6 Standard Forms of Boolean Expressions 186
- 4-7 Boolean Expressions and Truth Tables 192
- 4-8 The Karnaugh Map 196
- 4-9 Karnaugh Map SOP Minimization 198
- 4-10 Karnaugh Map POS Minimization 207
- 4-11 Five-Variable Karnaugh Maps 211
- 4-12 Programmable Logic 214
Digital System Application 220

Combinational Logic 236

- 5-1 Basic Combinational Logic Circuits 238
- 5-2 Implementing Combinational Logic 243
- 5-3 The Universal Property of NAND and NOR Gates 249
- 5-4 Combinational Logic Using NAND and NOR Gates 251
- 5-5 Logic Circuit Operation with Pulse Waveforms 256
- 5-6 Troubleshooting 260
- 5-7 Programmable Logic 266
Digital System Application 270

Functions of Combinational Logic 288

- 6-1 Basic Adders 290
- 6-2 Parallel Binary Adders 293
- 6-3 Comparators 301
- 6-4 Decoders 304
- 6-5 Encoders 313
- 6-6 Code Converters 318

- 6-7 Multiplexers (Data Selectors) 320
- 6-8 Demultiplexers 329
- 6-9 Parity Generators/Checkers 330
- 6-10 Troubleshooting 334
- 6-11 Programmable Logic 336
 - Digital System Application 340

Combinational Logic Programming with ABEL 362

- 7-1 The GAL22V10 364
- 7-2 The GAL16V8 371
- 7-3 Introduction to ABEL 374
 - Digital System Application 384

Flip-Flops and Related Devices 392

- 8-1 Latches 394
- 8-2 Edge-Triggered Flip-Flops 400
- 8-3 Master-Slave Flip-Flops 412
- 8-4 Flip-Flop Operating Characteristics 414
- 8-5 Flip-Flop Applications 417
- 8-6 One-Shots 422
- 8-7 The 555 Timer 427
- 8-8 Troubleshooting 433
- 8-9 Programmable Logic 436
 - Digital System Application 439

Counters 458

- 9-1 Asynchronous Counter Operation 460
- 9-2 Synchronous Counter Operation 468
- 9-3 Up/Down Synchronous Counters 476
- 9-4 Design of Synchronous Counters 479
- 9-5 Cascaded Counters 489
- 9-6 Counter Decoding 493
- 9-7 Counter Applications 497
- 9-8 Troubleshooting 501
- 9-9 Logic Symbols with Dependency Notation 506
- 9-10 Programmable Logic 508
 - Digital System Application 512

Shift Registers 530

- 10-1 Basic Shift Register Functions 532
- 10-2 Serial In/Serial Out Shift Registers 533

- 10-3 Serial In/Parallel Out Shift Registers 537
- 10-4 Parallel In/Serial Out Shift Registers 540
- 10-5 Parallel In/Parallel Out Shift Registers 543
- 10-6 Bidirectional Shift Registers 545
- 10-7 Shift Register Counters 548
- 10-8 Shift Register Applications 552
- 10-9 Troubleshooting 559
- 10-10 Logic Symbols with Dependency Notation 561
- 10-11 Introduction to CPLDs 563
 - Digital System Application 567

Sequential Logic Programming with ABEL 582

- 11-1 Implementing Shift Registers with PLDs 584
- 11-2 Implementing Counters with PLDs 588
- 11-3 PLD System Implementation 596
 - Digital System Application 606

Memory and Storage 616

- 12-1 Basics of Semiconductor Memory 618
- 12-2 Random-Access Memories (RAMs) 621
- 12-3 Read-Only Memories (ROMs) 634
- 12-4 Programmable ROMs (PROMs and EPROMs) 639
- 12-5 Flash Memories 643
- 12-6 Memory Expansion 647
- 12-7 Special Types of Memories 654
- 12-8 Magnetic and Optical Storage 659
- 12-9 Testing and Troubleshooting 665
- 12-10 Introduction to FPGAs 669
 - Digital System Application 676

Introduction to Microprocessors, Computers, and Buses 692

- 13-1 The Microprocessor and the Computer 694
- 13-2 Historical Review of Microprocessor Families 699
- 13-3 The 8086/8088 Microprocessor and Software Model for the Pentium Processor 703
- 13-4 Microprocessor Programming 710
- 13-5 The Central Processing Unit (CPU) 718
- 13-6 The Memory 723
- 13-7 The Input/Output (I/O) Port 727
- 13-8 Interrupts 730

- 13-9 Direct Memory Access (DMA) 732
 - 13-10 Internal System Interfacing 734
 - 13-11 Standard Buses 738
- Introduction to Digital Signal Processing 756**

- 14-1 Digital Signal Processing Basics 758
- 14-2 Converting Analog Signals to Digital 759
- 14-3 Analog-to-Digital Conversion Methods 765
- 14-4 The Digital Signal Processor (DSP) 776
- 14-5 Digital-to-Analog Conversion Methods 782

Integrated Circuit Technologies 798

- 15-1 Basic Operational Characteristics and Parameters 800
- 15-2 CMOS Circuits 808

- 15-3 TTL Circuits 813
- 15-4 Practical Considerations in the Use of TTL 818
- 15-5 Comparison of CMOS and TTL Performance 825
- 15-6 Emitter-Coupled Logic (ECL) Circuits 826
- 15-7 PMOS, NMOS, and E²CMOS 827

APPENDICES

- A Data Sheets 838**
- B Error Detection and Correction Codes 884**
- C Conversions 890**
- Answers to Odd-Numbered Problems 892**
- Glossary 926**
- Index 937**