
contents

Preface xiii

1 Numbering Systems or Codes 1

- 1-1 Introduction 1
- 1-2 Code Conversion 6
- 1-3 Code Conversion with Fractional Components 9
- 1-4 Binary Coded Decimal 15
- 1-5 The Gray Code 16
- 1-6 A General Method for Conversion to Any Base 20
- 1-7 Fractional Conversion 23
- 1-8 Short Form Conversion from Decimal to Any Base 25

2 Transistor Review and TTL Circuits 29

- 2-1 Transistor Review 29
- 2-2 TTL 41
- 2-3 A Typical TTL Inverter Circuit 43
- 2-4 The TTL NAND Gate 44
- 2-5 TTL Inputs 50
- 2-6 TTL Output Specifications and Fanout 51
- 2-7 Open Collector Output Circuit 53
- 2-8 Interpreting Specification Data Sheets 54
- 2-9 Rise Time, Fall Time, and Propagation Delay 58
- 2-10 Other TTL Series 60

3 Logic Elements 65

- 3-1 Introduction 65
- 3-2 The AND Circuit 65
- 3-3 The OR Gate 66
- 3-4 The NOT Function 67
- 3-5 The NAND Gate 67
- 3-6 The NOR Gate 68
- 3-7 The Exclusive OR Gate 68

3-8	The Exclusive NOR Gate	69
3-9	Logic Element Usage	70
3-10	Sum of Products from the Truth Table	73
3-11	Boolean Algebra	75
3-12	Boolean Derivations and Examples	77
3-13	De Morgan's Theorems	78
3-14	Algebraic Analysis of Existing Circuits	80
3-15	The Product of Sums	81
3-16	Other Theorems	82
3-17	Circuit Simplification	83
3-18	The Karnaugh Map	83
3-19	Complementing the Karnaugh Map	88
3-20	A Five-Variable Karnaugh Map	90
3-21	Practical Uses for the Karnaugh Map	92
3-22	The Universal NAND Gate	94
3-23	Summary	95
4	Flip Flops or Multivibrators	100
4-1	Introduction	100
4-2	The Bistable Multivibrator	100
4-3	The R/S Integrated Flip Flop	101
4-4	The NAND Gate Bistable	103
4-5	The Clocked R/S Flip Flop	104
4-6	The D Flip Flop	106
4-7	The J/K Flip Flop	107
4-8	The J/K Flip Flop with Preset & Clear	110
4-9	The Race Problem	113
4-10	The Master/Slave J/K Flip Flop	114
4-11	The Monostable Multivibrator	115
4-12	The Astable Multivibrator	118
4-13	The 555 Timer	119
4-14	The 555 as an Astable Multivibrator (A Clock)	123
4-15	The 74121 and 74123 Monostable Multivibrators	125
4-16	The Crystal Oscillator	127
4-17	The Schmitt Trigger	127
5	Counters and Latches	135
5-1	Introduction	135
5-2	The Ripple Counter	135
5-3	A Divide-by-Sixteen Ripple Counter	137
5-4	Feedback Counters for Nonstandard Moduli	139
5-5	The Ring Counter	141
5-6	The Johnson Counter	144
5-7	Illegal States	145

- 5-8 A Decade Shift Counter 148
- 5-9 Nonstandard Modulus Obtained by Feedback 149
- 5-10 Latches 150
- 5-11 The *D* Latch 151
- 5-12 Parallel-Loaded Latch 152
- 5-13 The 74192/74193 Counter 153
- 6 ECL and CMOS 164**
 - 6-1 Introduction 164
 - 6-2 Emitter-Coupled Logic 164
 - 6-3 Design Considerations for ECL 167
 - 6-4 TTL to ECL Logic Level Conversion 169
 - 6-5 The Two Families of ECL 170
 - 6-6 CMOS 170
 - 6-7 A CMOS NAND Gate 172
 - 6-8 CMOS Design Considerations 173
 - 6-9 CMOS to TTL Interfacing 175
 - 6-10 TTL to CMOS Interfacing 175
 - 6-11 ECL to CMOS Interfacing 176
- 7 Chip Survey and Applications 178**
 - 7-1 Introduction 178
 - 7-2 Data Sheets and Specifications 179
 - 7-3 Gates 184
 - 7-4 Buffers, Drivers, and Transceivers 184
 - 7-5 Decoders, Encoders, Selectors, and Multiplexors 188
 - 7-6 Arithmetic Circuits and Processor Elements 190
 - 7-7 Flip Flops, Registers, and Latches 193
 - 7-8 Counters 194
 - 7-9 Shift Registers 195
 - 7-10 Timing Chips 197
 - 7-11 Memories 199
 - 7-12 Hybrid Devices 201
 - 7-13 Comparators 204
 - 7-14 Optoelectronic Components 206
 - 7-15 Logic Arrays 207
- 8 Arithmetic 214**
 - 8-1 Introduction 214
 - 8-2 Addition 214
 - 8-3 The Accumulating Adder 220
 - 8-4 Subtraction by Complement Addition 221
 - 8-5 Multiplication 230
 - 8-6 Division 236

ing Point Operations	240
mal Arithmetic	246
l Arithmetic	254

~~the Digital Computer~~

9 Memory 265

9-1 Introduction	265
9-2 Memory Components	266
9-3 Memory Addressing and Data Line Interconnections	268
9-4 Memory Timing	279
9-5 Application Examples	283
9-6 Read-Only Memories	289
9-7 Dynamic Memories	295
9-8 Core Memories	297
9-9 Bubble Memory	300
9-10 Associative Memories	302
9-11 CCD Memory	303
Chapter 9 Appendix: Data Sheets	310

10 Synchronous Sequential Logic

10-1 Introduction	323
10-2 Flip Flop Excitation Tables	324
10-3 Synchronous Counters	326

11 Sequential Logic Continued 350

11-1 Introduction	350
11-2 State Diagrams	350
11-3 Sequential Analysis	353
11-4 Control Pulse Generation	357
11-5 Flip Flop Conversion	374

12 D/A and A/D Converters 380

12-1 Introduction	380
12-2 Bits and Weights	380
12-3 A Simple D/A Converter	381
12-4 The Iterative Binary Ladder	383
12-5 Binary Ladders with Switch Isolation	385
12-6 Voltage Division	386
12-7 A BCD D/A Converter	388
12-8 A Multiplying D/A Converter	389
12-9 A Dividing D/A Converter	392
12-10 Specifications	394
12-11 The A/D Converter	394
12-12 The Dual-Slope Integrating A/D Converter	395

12-13	The Counter-Type <i>A/D</i> Converter	396
12-14	The Successive Approximation <i>A/D</i> Converter	398
12-15	Sample and Hold Circuits	399
12-16	Flash Converters	400
12-17	Some Performance Considerations	405

13 An Introduction to Computers 409

13-1	Introduction	409
13-2	Essential Computer Blocks	411
13-3	The Bus	411
13-4	The Open Collector Gate as a Bus Driver	411
13-5	The Tristate Gate	414
13-6	I/O Ports	417
13-7	Standard Bus Structures	418
13-8	The Keyboard	421
13-9	The Single-Board Computer LED Display	423
13-10	A Single-Board Microcomputer	426
13-11	The CPU	427
13-12	Completing the System	429
13-13	Data Format and Instruction Set	430
13-14	A Simple Program	432

14 A Survey of Computer Peripherals 434

14-1	Introduction	434
14-2	The CRT Terminal	436
14-3	The Disk Drive	440
14-4	The Disk	441
14-5	The Head	444
14-6	Access Time	446
14-7	Data Recording	446
14-8	Disk Error Correction and Detection	
14-9	The Tape Transport	452
14-10	Tape Format	453
14-11	Data Recording	454
14-12	Data Transfer and Tape Speed	456
14-13	Tape Error Detection and Correction	456
14-14	The Modem	457
14-15	Transmission Codes	457
14-16	Printers	458

Appendix A: The Operational Amplifier

Appendix B: Cabling 479

Index 486