INDICE

Preface	xv
Chapter one **Digital logic circuits** 1-1Digital computers	1
1-2 Logic gates	4
1-3 Boolean algebra	7
Complement of a function	10
1-4 Map simplification	11
Product-of-sums simplification	14
Don't-care conditions	16
1-5 Combinational circuits	18
Half-adder	19
Full-adder	20
1-6 Flip-flops SR flip-flop	22
D flip-flop	23
JK flip-flop T flip-flop	24
Edge-triggered flip-flop	25
Excitation tables	27
1-7 sequential circuits Flip-flop input equations	28
State table	30
State diagram	31
Design example	32
Design procedure	36
Problems	37
References	39
Chapter two **Digital components** 2-1 Integrated circuits	41
2-2 Decoders	43
NAND gate decoder	45
Decoder expansion	46
Encoders	47
2-3 Multiplexers	48
2-4 Registers	50
Register with parallel load	51
2-5 Shift registers Bidirectional shift register with parallel load	53
2-6 Binary countries	56
Binary counter with parallel load 2-7 Memory unit	58
Random-access memory	60
Read-only memory	61
Types of ROMs	62
Problems	63

References	65
Chapter three **Data representation** 3-1 Data types	67
Number systems	68
Octal and hexadecimal numbers	69
Decimal representation	72
Alphanumeric representation	73
3-2 Complements	74
(r-1) s complement (r s) complement	75
Subtraction of unsigned numbers	76
3-3 Fixed-point representation	77
Integer representation	78
Arithmetic addition	79
Arithmetic subtraction Overflow	80
Decimal fixed-point representation	81
3-4 Floating-point representation	83
3-5 Other binary codes Gray code	84
Other decimal codes	85
Other alphanumeric codes	86
3.6 Error detection codes	87
Problems	89
References	91
Chapter four **Register transfer and microoperations** 4-1 Register transfer language	93
4-2 Register transfer	95
4-3 Bus and memory transfers	97
Three- state bus buffers	100
Memory transfer	101
4-4 Arithmetic microoperations	102
Binary adder	103
Binary adder-subtractor	104
Binary incrementer	105
Arithmetic circuit	
4-5 Logic microoperations	108
List of logic microoperations	109
Hardware implementation Some applications	111
4-6 Shift microoperations	114
Hardware implementation	115
4-7 Arithmetic logic shift unit	116
Problems	119
References	122
Chapter five **Basic computer organization and design**	123

5-1 Instruction codes	
Stored program organizations	125
Indirect address	126
5-2 Computer registers	127
Common bus system	129
5-3 Computer instructions	132
Instruction set completeness	134
5-4 Timing and control	135
5-5 Instruction cycle Fetch and decode	139
Determine the type of instruction	141
Register-reference instructions	143
5-6 Memory-reference instructions AND to AC	145
ADD to AC LDA: Load to AC	146
STA: store AC Bun: branch unconditionally BSA: branch and save return address	147
ISZ: increment and skip if zero Control flowchart	149
5-7 Input-output and interrupt	150
Input-output configuration	151
Input-output instructions	152
Program interrupt	153
Interrupt Cycle	156
5-8 Complete computer description 5-9 Design of basic computer	157
Control logic gates Control of registers and memory	160
Control of single flip-flops Control of common bus	162
5-10 design of accumulator logic	164
Control of AC register	165
Adder and logic circuit	166
Problems	167
References	171
Chapter six **Programming the basic computer** 6-1 Introduction	173
6-2 Machine language	174
6-3 Assembly language Rules of the language	179
An example	181
Translation to binary	182
6-4 The assembler	183
Representation of symbolic program in memory	184
First pass	185
Second pass	187

6-5 Program loops	190
6-6 Programming arithmetic and logic operations	192
Multiplication program	193
Double-precision addition	196
Logic operations Shift operations	197
6-7 Subroutines	198
Subroutines parameters and data linkage	200
6-8 Input-Output programming	203
Character manipulation	204
Program interrupt	205
Problems	208
References	211
Chapter seven **Microprogrammed control** 7-1 Control memory	213
7-2 address Sequencing	216
Conditional branching	217
Mapping of instruction	219
Subroutines 7-3 Microprogram example Computer configuration	220
Microinstruction format	222
Symbolic microinstructions	225
The fetch routine	226
Symbolic microprogram	227
Binary microprogram	229
7-4 Design of control unit	231
Microprogram sequencer	232
Problems	235
References	238
Chapter eight **Central processing unit** 8-1 Introduction	241
8-2 General register organization	242
Control world	244
Examples of microoperations	246
8-3 Stack Organization Register stack	247
Memory stack	249
Reverse polish notation	251
Evaluation of arithmetic expressions	253
8-4 Instructions formats	255
Three-address instructions Two- address instructions	258
One-address instructions Zero-Address instructions RISC instructions	259
8-5 Addressing modes	260

Numerical example	264
8-.6 Data transfer and manipulation	266
Data transfer instructions	267
Data manipulation instructions	268
Arithmetic instructions	269
Logical and bit manipulation instructions	270
Shift instructions	271
8-7 Program control	273
Status bit conditions	274
Conditional branch instructions	275
Subroutine call and return	278
Program interrupt	279
Types of interrupts	281
8-8 Reduced instruction set computer (RISC)	282
CISC characteristics	283
RISC characteristics	284
Overlapped register windows	285
Berkeley RISC I	288
Problems	291
References	297
Chapter nine **Pipeline and vector processing** 9-1 Parallel processing	299
9-2 Pipelining	302
General considerations	304
9-3 arithmetic Pipeline	307
9-4 Instruction pipeline	310
Example: four-segment instruction pipeline	311
Data dependency	313
Handling of branch instructions	314
9-5 RISC pipeline	315
Example: three-segment instruction pipeline	316
Delayed load	317
Delayed branch	318
9-6 Vector processing	319
Vector operations	321
Matrix multiplication	322
Memory interleaving	324
Supercomputers	325
9-7 Array processors Attached array processor	326
SIMD array processor	327
Problems	329
References	330
Chapter ten **Computer arithmetic** 10-1 Introduction	333
10-2 Addition and subtraction	334
Addition and subtraction with signed-magnitude	335

Hardware implementation	336
Hardware algorithm	337
Addition and subtraction with signed-2s Complement data	338
10-3 Multiplication algorithms	340
Hardware implementation for signed-magnitude data	341
Hardware algorithm	342
Booth multiplication algorithm	343
Array multiplier	346
10-4 Division algorithms	348
Hardware implementation for signed magnitude data	349
Divide overflow	351
Hardware algorithm	352
Other algorithms	353
10-5 Floating-point arithmetic operations Basic considerations	354
Register configuration	357
Addition and subtraction	358
Multiplication	360
Division	362
10-6 decimal arithmetic unit	363
BCD adder	365
BCD subtraction	368
10-7 Decimal arithmetic operations	369
Addition and subtraction Multiplication	371
Division	374
Floating-point operations	376
Problems	376
References	380
Chapter eleven **Input-output organization** 11-1 Peripheral devices	381
ASCII alphanumeric character	383
11-2 Input-output interface	385
I/O bus and interface modules	386
I/O versus memory bus	387
Isolated versus memory-mapped I/O	388
Example of I/O	389
11-3 Asynchronous data transfer Strobe control	391
Handshaking	393
Asynchronous serial transfer	396
Asynchronous Communication interface	398
First-in, first-out buffer	400
11-4 Modes of transfer	402
Example of programmed I/O	403
Interrupt-initiated406 I/O Software consideration	406

11.5 Priority interrupt	407
Daisy-Chaining priority	408
Parallel priority interrupt	409
Priority encoder	411
Interrupt cycle	412
Software routines	413
Initial and final operations	414
11-6 Direct memory access (DMA)	415
DMA controller	416
DMA transfer	418
11-7 Input-output processor (IOP)	420
CPU-IOP communication	422
IBM 370 I/O channel	423
Intel 8089 IOP	427
11-8 Serial communication	429
Character-oriented protocol	432
Transmission example	433
Data transparency	436
Bit-oriented protocol	437
Problems	439
References	442
Chapter twelve **Memory organization** 12-1 Memory hierarchy	445
12-2 Main memory	448
RAM and ROM chips	449
Memory address map	450
Memory connection to CPU 12-3 Auxiliary memory	452
Magnetic disks	454
MAGNETIC TAPE	455
12-4 Associative memory	456
Hardware organization	457
Match logic	459
Read operation	460
Write operation	461
12-5 Cache memory	462
Associative mapping	464
Direct mapping	465
Set-associative mapping	467
Writing into cache	468
Cache initialization 12-6 Virtual memory	469
Address space and memory space	470
Address mapping using pages	472
Associative memory page table	474
Page replacement	475
12-7 Memory management hardware	476
Segmented-page mapping	477

Numerical example	479
Memory protection	482
Problems	483
References	486
Chapter thirteen **Multiprocessors** 13-1 Characteristics of multiprocessor	489
13-2 Interconnection structures Time-shared common bus	491
Multiport memory	493
Crossbar switch	494
Multistage interconnection	498
13-3 Interprocessor arbitration System bus	500
Serial arbitration procedure	502
Parallel arbitration logic	503
Dynamic arbitration algorithms	505
13-4 Interprocessor communication and synchronization	506
Interprocessor synchronization	507
Mutual exclusion with a semaphore	508
13-5 Cache coherence Conditions for incoherence	509
Solutions to the cache coherence problem	510
Problems	512
References	514
Index	515