

CONTENTS

PREFACE	xi
1	
WHAT DOES THE CPU DO?	1
Computers Can Process Any Type of Information.....	11
The CPU Is the Core of Each Computer.....	14
The Five Components of a Modern Computer.....	16
ALUs: The CPU's Core.....	22
CPUs Process Operations and Make Decisions.....	25
What Is Information Anyway?.....	30
The Difference Between Analog and Digital Information.....	31
2	
DIGITAL OPERATIONS	35
The Computer's World Is Binary.....	36
The Reciprocal States of 1 and 0.....	37
Decimal vs. Binary Number Systems.....	38
Expressing Numbers in Binary.....	40
Fixed-Point and Floating-Point Fractions.....	42
Addition and Subtraction in Binary.....	44
What Are Logic Operations?.....	48
Integrated Circuits Contain Logic Gates.....	48
The Three Basic Logic Gates: AND, OR, and NOT.....	51
Truth Tables and Venn Diagrams.....	53
A Summary of the AND, OR, and NOT Gates.....	55
Other Basic Gates: NAND, NOR, and XOR.....	57
A Summary of the NAND, NOR, and XOR Gates.....	58
De Morgan's Laws.....	60
Circuits That Perform Arithmetic.....	62
The Addition Circuit.....	62
The Half Adder.....	64
The Full Adder and Ripple Carry Adder.....	66
The Carry Look-Ahead Adder.....	68
Circuits That Remember.....	70
Circuits with Memory Are a Necessity!.....	70
Flip-Flop: The Basics of Memory Circuits.....	74
The RS Flip-Flop.....	76
The D Flip-Flop and the Clock.....	78
The T Flip-Flop and Counters.....	81
Modern Circuit Design: CAD and FPGA.....	85

3

CPU ARCHITECTURE	87
All About Memory and the CPU	88
Memory Has Assigned Addresses	89
Data Passes Through the Bus	92
Bus Width and Bits	94
R/W Signals and I/O Signals	98
Instructions Are Made of Operands and Opcodes	101
Accumulators and Other Registers Are Used in Operations	103
CPU Instruction Processing	106
Classic CPU Architecture	106
The Instruction Cycle	107
The Instruction We Process Changes Depending on the Program Counter	112
All Kinds of Memory Devices	115
A Comparison Between HDD and Memory	116
RAM Space, ROM Space, and I/O Space	119
What Are Interrupts?	122
Interrupts Are Useful	122
The Stack and the Stack Pointer	126
Interrupt Priority	128
Memory Classifications	132
I/O Ports and the GPU	132
Clock Frequency and Degrees of Accuracy	133
Clock Generators	134
Timer Interrupts	135
Reset Signals	136
CPU Performance Is Measured in FLOPS	137

4

OPERATIONS	139
Types of Operations	140
There Are Many Types of Instructions	142
Instructions for Arithmetic and Logic Operations	144
What Are Bit Shifts?	145
The Sign Bit Lets Us Express Negative Binary Numbers	147
Logical Shifts and Arithmetic Shifts	149
Circular Shifts (Rotating Shifts)	152
Data Transfer Operations	153
Input/Output Instructions	154
Branch Instructions	155
Condition Evaluation and Status Flags	158
Putting Branches and Condition Evaluation Together	161
Operand Types	162
How Many Operands Do We Have?	162
Operands Take Many Forms	165
Immediate Value Processing	166
Address References	167

What Are Addressing Modes?	168
Addressing Mode Overview.	172
The Structure of Operations in the ALU	176
A Look Inside the ALU.	176
Basic Circuit Architecture of the 74S181	178
Serial Transmission and Parallel Transmission	185
An Overview of Some Basic Registers	186
An Overview of Some Basic Status Flags.	187
The SLEEP Instruction	188
5	
PROGRAMS	189
Assembly and High-Level Languages	190
What Are Assembly Languages?	192
The Characteristics of Assembly Languages and High-Level Languages.	194
The Difference Between Programs and Source Code	199
Program Basics.	200
What Can You Make Using Conditions and Jumps?	200
What Should We Make the Computer Do?	204
Where are Programs Stored?	208
What Happens Before a Program Is Executed?	208
6	
MICROCONTROLLERS	211
What Are Microcontrollers?	212
Microcontrollers Are in All Kinds of Products	213
The Function of a Microcontroller.	214
Architecture of a Microcontroller	219
What Are DSPs?	222
DSPs and Multiplier-Accumulate Operations.	224
Microcontrollers in Industrial Machines	224
EPILOGUE	227
AFTERWORD	239
INDEX	241