

***Microprocessors /
Microcomputers /
System Design***



TEXAS INSTRUMENTS ELECTRONIC SERIES

Microprocessors/ Microcomputers/ System Design

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TABLE OF CONTENTS

Chapter 1. Basic Decisions in System Design	1-1
Introduction	1-2
The Impact of Semiconductors	1-3
Applications of Programmable Semiconductors	1-11
Single-Chip Microcomputer Applications	1-12
Multi-Chip Microcomputer Applications	1-13
Building a Microprocessor Based System	1-15
Basic Hardware Components	1-15
Programming for Microcomputers	1-17
Which Microprocessor or Microcomputer to Use	1-20
Evolution of Memory-to-Memory Architecture	1-20
Getting up to Speed on Microprocessors	1-28
Bibliography	1-29
Books	1-29
Articles	1-30
List of Periodicals to be Monitored	1-30
 Chapter 2. Product Selection Guide	2-1
The 9900 Family — What Is It?	2-2
Family Overview	2-2
The Hardware Family	2-2
The Software and Development Systems Support	2-2
Typical Applications	2-8
Hardware Selection	2-9
The Component Route: CPU	2-10
CPU Selection	2-12
Flexible I/O	2-14
Family Members Fitted to the Application	2-14
Interrupt Flexibility	2-14
The Component Route: Peripherals	2-15
Interface Techniques	2-16
Serial I/O for Data Communications	2-16
Parallel I/O	2-16
Clock and Support Logic	2-19
Cost Effectiveness of NMOS LSI Peripherals	2-20
CRU Interface	2-21
The Component Route: Memory	2-21
The Component Route: Miscellaneous Components	2-23
The Modular Route: Microcomputer Modules	2-23
The Minicomputer Route	2-26

TABLE OF CONTENTS

9900 Family Software and Development Systems	2-28
Importance of Software	2-28
Software Development Systems	2-29
Support Software and Firmware	2-38

Chapter 3. A First Encounter:

Getting Your Hands on a 9900	3-1
Purpose	3-2
Where to Begin	3-2
What You Have	3-3
Getting It Together	3-5
Unpacking and Checking the Microcomputer (TM 990/100M-1)	3-13
Connecting the Microterminal TM 990/301	3-15
Operating the Microcomputer	3-15
Telling the Microcomputer What to Do	3-18
How Was It Done?	3-24
Back to Basics	3-25
Registers	3-26
Workspace	3-28
SBZ and SBO Instructions	3-30
I/O Selection	3-32
TB Instruction	3-34
Idea to Flowchart	3-35
Flow Charts	3-36
WAIT Subroutine	3-38
Subroutine Jump	3-39
A Loop Within the WAIT Subroutine	3-41
Loading a Register for the Time Delay	3-42
Where Does the Program Start?	3-43
Writing the Program	3-45
WAIT Subroutine Call	3-46
Return from WAIT Subroutine	3-47
Writing the Machine Code	3-52
Immediate Instructions	3-52
Instructions SBQ, SBZ	3-54
Instruction BL	3-55
Miscellaneous Instructions	3-55
Jump Instructions	3-56
Summary	3-59
Assembly Language Program: Table 3-2	3-60

Chapter 4. Hardware Design:

Architecture and Interfacing Techniques	4-1
Introduction	4-2
Architecture	4-5
Basic Microprocessor Chip	4-5
Microprocessor Registers	4-5
Memory-to-Memory Architecture	4-9
Context Switching	4-11

TABLE OF CONTENTS

Memory	4-12
Memory Organization	4-13
Memory Control Signals	4-15
Static Memory.	4-23
Dynamic Memory.	4-25
Buffered Memory.	4-28
Memory Parity	4-28
Memory Layout.	4-30
Instruction Execution	4-32
Timing	4-32
Cyclic Operation	4-35
Input/Output	4-42
Direct Memory Access.	4-42
Memory Mapped I/O	4-43
Communications Register Unit (CRU).	4-45
CRU Interface.	4-46
CRU Interface Logic.	4-46
Expanding CRU I/O.	4-47
CRU Machine Cycles	4-47
CRU Data Transfer.	4-51
CRU Paper Tape Reader Interface	4-54
Burroughs SELF-SCAN Display Interface	4-57
Interrupts	4-59
Reset	4-60
Load	4-61
Basic Machine Cycle	4-63
Maskable Interrupts	4-64
Interrupt Service	4-64
Interrupt Signals	4-66
Interrupt Masking	4-67
Interrupt Processing Example.	4-70
Electrical Requirements	4-71
Understanding the Electrical Specifications	4-71
Detailed Electrical Interface Specifications (TMS 9900)	4-75
TMS 9900 Clock Generation	4-75
TMS 9900 Signal Interfacing	4-78
TMS 9940 Microcomputer	4-82
Pin Assignments and Functional Control	4-83
Interrupts	4-83
Decrementer.	4-86
CRU Implementation.	4-86
Multiprocessor System Interface (MPSI)	4-87
Summary	4-88

TABLE OF CONTENTS

Complete Listing of Machine Cycles	4-89
Machine Cycles	4-89
9900 Machine Cycle Sequences	4-90
Terms and Definitions	4-90
Data Derivation Sequences	4-91
Workspace Register	4-91
Workspace Register Indirect	4-91
Workspace Register Indirect Auto-Increment (Byte Operand)	4-91
Workspace Register Indirect Auto-Increment (Word Operand)	4-91
Symbolic	4-92
Indexed	4-92
Instruction Execution Sequences	4-92
A, AB, C, CB, S, SB, SOC, SOCB, SZC, SZCB, MOV, MOVB, COC, CZC, XOR	4-92
MPY (multiply)	4-93
DIV (divide)	4-94
XOP	4-94
CLR, SETQ, INV, NEG, INC, INCT, DEC, DECT, SWPB	4-95
ABS	4-95
X	4-96
B	4-96
BL	4-96
BLWP	4-97
LDCR	4-97
STCR	4-98
SBZ, SBO	4-99
TB	4-99
JEQ, JGT, JH, JHE, JL, JLE, JLT, JMP, JNC, JNE, JNQ, JOC, JOP	4-99
SRA, SLA, SRL, SRC	4-100
AI, ANDI, ORI	4-100
CI	4-101
LI	4-101
LWPI	4-101
LIMI	4-101
STWP, STST	4-102
CKON, CKOF, LREX, RSET	4-102
IDLE	4-102
RTWP	4-103
Machine-Cycle Sequences in Response to External Stimuli	4-103
RESET	4-103
LOAD	4-104
Interrupts	4-105
Timing	4-105

TABLE OF CONTENTS

Chapter 5. Software Design:	
Programming Methods and Techniques	5-1
9900 Architecture	5-2
Instruction Register and Cycle	5-4
Program Counter (PC)	5-6
Status Register (ST)	5-7
Workspace Pointer (WP)	5-8
Program Environment or Context	5-9
Memory Organization	5-10
ROM/RAM Partitioning	5-11
Reserved Memory	5-11
Workspace Utilization	5-12
The Workspace Concept and Uses	5-12
Dedicated Areas of Workspaces	5-15
Workspace Location	5-17
Subroutine Techniques	5-19
Types of Subroutines	5-19
Parameter Passing	5-25
Multiple Level Shared Workspace Subroutines	5-28
Shared Workspace Mapping	5-28
Re-entrant Programming	5-30
Programming Tasks	5-33
Initialization	5-33
Masking and Testing	5-35
Arithmetic Operations	5-38
Input/Output	5-43
Memory Mapped Input/Output	5-43
CRU Input/Output	5-44
Input/Output Methods	5-45
 Chapter 6. Instruction Set	 6-1
Software Features of the 9900	6-2
Processor Registers and System Memory	6-2
Program Counter	6-3
Workspace	6-3
Status Register	6-4
Addressing Modes	6-6
Workspace Register Addressing	6-6
Workspace Register Indirect Addressing	6-6
Workspace Register Indirect Addressing with Autoincrement	6-6
Symbolic or Direct Addressing	6-7
Indexed Addressing	6-8
Special Addressing Modes	6-8
Assembly Language Programming Information	6-10
Assembly Language Formats	6-10
Terms and Symbols	6-11
Survey of the 9900 Instruction Set	6-13

TABLE OF CONTENTS

Instruction Descriptions	6-16
Data Transfer Instructions	6-18
LI Load Immediate	6-18
LIMI Load Interrupt Mask Immediate	6-18
LWPI Load Workspace Pointer Immediate	6-19
MOV Move Word	6-19
MOVB Move Byte	6-20
SWPB Swap Bytes	6-21
STST Store Status	6-21
STWP Store Workspace Pointer	6-22
Arithmetic Instructions	6-23
A Add Words	6-23
AB Add Bytes	6-24
AI Add Immediate	6-25
S Subtract Words	6-25
SB Subtract Bytes	6-26
INC Increment	6-27
INCT Increment by Two	6-27
DEC Decrement	6-28
DECT Decrement by Two	6-28
NEG Negate	6-29
ABS Absolute Value	6-29
MPY Multiply	6-30
DIV Divide	6-31
Comparison Instructions	6-32
C Compare Words	6-32
CB Compare Bytes	6-33
CI Compare Immediate	6-34
COC Compare Ones Corresponding	6-34
CZC Compare Zeroes Corresponding	6-35
Logic Instructions	6-36
ANDI AND Immediate	6-36
ORI OR Immediate	6-37
XOR Exclusive OR	6-38
INV Invert	6-38
CLR Clear	6-39
SETO Set to One	6-39
SOC Set Ones Corresponding	6-40
SOCB Set Ones Corresponding, Byte	6-40
SZC Set to Zeroes Corresponding	6-41
SZCB Set to Zeroes Corresponding, Bytes	6-42
Shift Instructions	6-43
SRA Shift Right Arithmetic	6-43
SLA Shift Left Arithmetic	6-44
SRL Shift Right Logical	6-45
SRC Shift Right Circular	6-45

TABLE OF CONTENTS

Unconditional Branch Instructions	6-46
B Branch	6-46
BL Branch and Link.	6-47
BLWP Branch and Load Workspace Pointer	6-48
XOP Extended Operation	6-49
RTWP Return with Workspace Pointer	6-50
JMP Unconditional Jump.	6-50
X Execute.	6-51
Conditional Jump Instructions.	6-52
JH, JL, JHE, JLE, JGT, JLT, JEQ, JNE,	
JOC, JNC, JNQ, JOP	6-52
CRU Instructions	6-53
SBO Set Bit to Logic One	6-53
SBZ Set Bit to Logic Zero	6-54
TB Test Bit	6-54
LDCR Load CRU	6-55
STCR Store CRU	6-57
Control Instructions	6-58
LREX, CKOF, CKON, RSET, IDLE,	6-58
Special Features of the 9940.	6-59
LIIM Load Immediate Interrupt Mask	6-59
XOP Extended Operation	6-60
DCA Decimal Correct Addition	6-61
DCS Decimal Correct Subtraction	6-62
Chapter 7. Program Development: Software Commands —	
 Descriptions and Formats	7-1
Introduction	7-2
Assembly Language Programming: Formats and Directives	7-3
Assembly Language Application	7-4
Assembly Language Formats	7-4
Terms and Symbols	7-6
Assembler Directives.	7-8
Program Linkable Directives	7-15
Assembler Output	7-15
9900 Reference Data	7-17
TM990/402 Line-by-Line Assembler User's Guide	7-25
General	7-26
Installation	7-26
Operation	7-27
Setup	7-27
Inputs to Assembler	7-27
Exiting to the Monitor	7-32
Pseudo-Instructions.	7-32
TIBUG Monitor	7-33
TM990/302 Software Development Board	7-37
TXDS Commands for FS990 Software Development System	7-43
AMPL Reference Data	7-50
POWER BASIC MP 307.	7-66
Cross Support	7-76

TABLE OF CONTENTS

Chapter 8. Applications	8-1
A Simulated Industrial Control Application (With TM990/100M Microcomputer and 5MT I/O Modules)	8-3
A Low Cost Data Terminal	8-75
TMS 9900 Floppy Disk Controller	8-89
Glossary	G-1
Appendix	A-1
Index	I-1

CHAPTER 1

Basic Decisions In System Design

INTRODUCTION

Texas Instruments has developed and is manufacturing a family of microprocessor products and systems based on the architecture of its 990 minicomputer. The purpose of this book is to present enough factual information about the 9900 and the family of devices and systems surrounding it to serve not only as a guide for deciding to use the 9900 in an application, but also as the primary reference for design and programming activities. The book is much more than a data book or a collection of application notes. It contains basic concepts, presents methods and techniques, and most important of all, shows how the architecture of the 9900, substantially superior to other microprocessor architectures, can be translated into cost effective applications.

The time investment you make in learning how to use the 9900 will inevitably produce substantial benefits because your designs will be advanced well beyond other microprocessor systems; they will be expandable, flexible, easily upgraded and will not be obsolescent. The capital investment in programming systems will bring powerful computing equipment and software tools to your design team that will have them outdistancing the competition in a very short time.

In reading this book, you will see the 9900 product as more than a single microprocessor. You will find a family of processors, peripherals, boards, minicomputers and systems all based on a single architectural concept called *memory-to-memory architecture*. It is this basic principle which, when fully understood at the fundamental level, will help you understand why and how the 9900 can be used to implement outstanding products. In addition, you will see why Texas Instruments has made the commitment to the continued support of the 9900 family in both hardware and software. New microprocessors and peripheral devices will retain and complement the basic architectural features—the 16-bit word length, the instruction set, the I/O techniques, etc. Texas Instruments software support goes beyond the standard assembler, editor, linker and PROM programmer software. New design tools such as POWER BASIC and PASCAL are now available. These powerful software products bring structured programming disciplines into focus and help you to attain an advanced programming capability.

All in all, the book is a collection of useful factual material which should be of substantial benefit to anyone considering designing with microprocessors. For those who have very limited exposure to designing with semiconductor products, the next few sections will be helpful because the theme of “more functions at lower cost” is demonstrated. These ideas lead to the basic philosophy that designing with *standard hardware* — semiconductor LSI products which are *programmable* — is the most economical procedure, and should be carefully considered for *every* new electronic product.

THE IMPACT OF SEMICONDUCTORS

In the short thirty years since the invention of the transistor (the first semiconductor device to exhibit amplification), there have been more inventions and more scientific and engineering accomplishments than in all time previous. The field of digital electronics (especially computers) has been the greatest contributor of new products for these accomplishments and, therefore, has become one of the most rapidly growing industries. Manufacturers of semiconductor components (transistors, integrated circuits, microprocessors and memories) have been providing the building blocks, and the equipment manufacturers have been taking advantage of the opportunity by developing the most sophisticated systems that are economically feasible.

In his keynote address to the 1977 National Computer Conference, Mark Shepherd, Chairman of the Board of Texas Instruments, made the following points:

“Until 1971, the semiconductor industry was in the circuits business.

Semiconductor circuits, complex though they were, constituted only a fraction of an entire system. The one-chip calculator developed in 1971 was the first significant complete system. Since then many calculators and watches have been developed where the entire system function is accomplished by one or a few semiconductor chips. These were custom chips because the technology did not allow any reserve computing power for other applications.

“The semiconductor industry has now entered an era where the entire system function of an end product can be accomplished by a few semiconductor chips, or a single chip, with enough versatility to permit adaptation to many different applications through the programming.

“This change carries enormous implications for the system designer. 1) The lead time for system implementation is shortened because no special chip development is required. 2) The development cost will be low because it will be limited to software (which may be executed in hardware). 3) The required degree of electronic sophistication on the part of the user is much less. To achieve these advantages the system designer must be prepared to use standard products produced in large volume rather than custom devices.

“The functional equivalent of a medium-scale computer (*Figure 1-1*) cost \$30,000 in the early 1960s. Its cost equivalent has now dropped to \$4,000 and is projected to be at less than \$100 by 1985, penetrating the personal cost threshold. As this is accomplished, greater challenges will be encountered in the cost of sales, service, and maintenance, requiring that we learn to incorporate self-diagnostic and self-repair functions into our systems.”

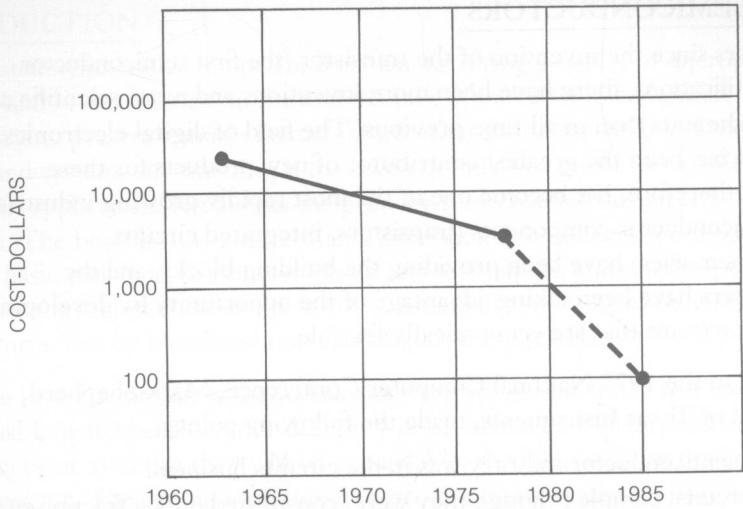


Figure 1-1. Cost of Medium Scale Computer
(M. Shepherd, 1977 NCC)

The cost of the hardware components for a typical digital system has been decreasing with time because new and more powerful semiconductor devices have been developed. Equally important is the fact that the development cost for the typical digital system hardware has also been decreasing. *Figure 1-2* illustrates how impressive this cost reduction has been. Contrast the figures of 7-8 *million* dollars in the early fifties with 8-9 *thousand* dollars in the late seventies; digital system development cost has been reduced by a factor of *one thousand* in a period of 25 years! An extension of this trend indicates that typical system hardware development cost will be approximately \$1,000 by 1985.

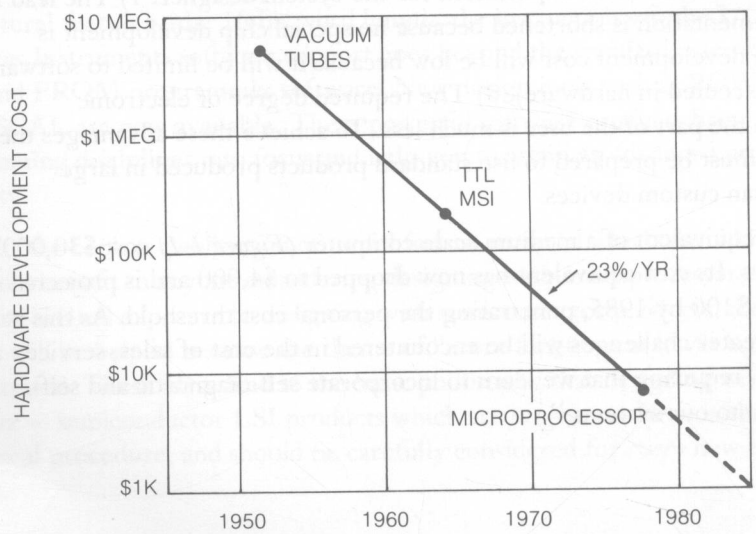


Figure 1-2. Typical Digital System Hardware Development Cost at OEM Manufacturer