PREFACE TO THE FOURTH EDITION

The tremendous power and usefulness of digital techniques and systems can be seen from the wide variety of industrial machinery, computers, microprocessors, household appliances (e.g., washing machines, refrigerators, digital TVs), medical equipment, internet, e-banking, e-business, e-governance, etc. which are based on the principles of digital electronics. The areas of applications of digital electronics have been increasing day by day, resulting in an unprecedented interest in the subject. In fact, digital systems have invaded all walks of life creating a digital revolution.

One of the important reasons for the unprecedented growth of digital electronics is the advent of integrated circuits (ICs). Developments in the IC technology have made it possible to fabricate complex digital circuits, such as microprocessors, memories, complex programmable logic devices (CPLDs) and field programmable gate arrays (FPGAs).

The wonderchip **microprocessor** has been the most fantastic development of the recent years. No other single development has affected our lives as much as the microprocessor in such a short time. Its ever-increasing applications have resulted in developments which were simply unheard of till a few years ago. The emergence of various programmable logic devices have resulted in significant changes in the design methodologies of digital systems. The designers of modern digital systems in industry rarely use conventional manual techniques. Instead, computer aided design (CAD) tools are used. But this has not made the basic concepts and the manual techiques of digital theory and practice obsolete. Rather, the manual techniques are the foundation of CAD tools and they provide a clear insight into the CAD tools. Therefore, it is very essential to have a strong foundation of the basic digital techniques for making effective use of automation in design.

This has made it imperative for all those who aspire to design, develop, test, and maintain various electronic systems to learn the principles of modern digital devices and systems.

The rate of developments in this field has been extremely high leading to the fast obsolescence of devices and systems. It has always been impossible to keep pace with the latest developments in any textbook. However, a sincere effort has been made to cover the developments in this field, in the last twenty five years, through the three editions of this book which have been highly successful. The fourth edition is another step in this direction. Some of the topics covered in this edition have appeared for the first time in any textbook.

The developments in the CMOS technology, in the last few years, have led to a number of new IC devices which are smaller, faster, low-power consuming, low-voltage, very high number of components on a chip, and perform highly complex functions requiring microprocessors, peripherals, digital signal processors (DSPs), etc. Now, a single chip containing tens of millions of transistors can be programmed to create a system-on-a-chip. The emergence of these devices have made significant changes in the design and development of digital systems for performing various functions.

The availability of serial and parallel EEPROMs, first-in, first-out (FIFO) and bidirectional FIFO (BiFIFO) memories, FPGAs with built-in hard-core logic devices (Intellectual property) such as microprocessors, peripherals, DSPs are extremely useful for designing system-on-a-chip. The serial and parallel flash memories are being used as non-volatile RAMs (NVRAMs) and are expected to replace hard-disks in future. The in-system programmability feature has made it possible to make fast modifications in the system easily. On-chip design security eliminates any visual or electrical detection of configuration pattern which prevents any theft of circuits via readback or any accidental overwriting. To make the best advantage of these and other developments, the digital designers are expected to have good knowledge of these devices and their programming mechanisms using CAD tools.

The fourth edition of the book deals with the subject of digital techniques and systems from the basic circuits (gates) to small scale integrated circuits (SSI), medium scale integrated circuits (MSI), large scale integrated circuits (LSI), and very large scale integrated circuits (VLSI). Computer aided design concepts, CAD tools and hardware description language VHDL have been introduced to familiarise the readers with the CAD techniques.

This book is self contained and is suitable for a course in digital electronics and logic design for electrical, electronics, computer and other engineering disciplines and computer science programmes. Students of physics specialising in electronics will also find the book useful. For experimental work using SSI and MSI devices, the reader is advised to refer to Jain and Anand, Digital Electronics Practice Using Integrated Circuits, Tata McGraw Hill, 1983.

The book has been systematically organised and the presentation has been kept at a level suitable for a student with the basic knowledge of circuit theory and electronics.

Salient Features of the Fourth Edition

- Improved and enhanced coverage of VHDL.
- Design of a large number of various combinational and sequential circuits using VHDL included.
- Expanded and improved coverage of CMOS logic.
- Expanded and improved coverage of SPLDs, CPLDs, and FPGAs.
- Low-voltage CMOS, and BiCMOS logic families included.
- Coverage of TTL logic family improved, updated, and 74F (Fast TTL) family included.
- Expanded and reorganised coverage of semiconductor memories. Various memories covered are:
  - Asynchronous SRAM, synchronous SRAMs (Late Write, No Wait State, Double Data Rate (DDR), Quad, and Dual Port)
  - FPM, EDO, and BEDO Asynchronous DRAMs and synchronous DRAM (SDRAM), and DDRSDRAM
  - Serial and parallel EEPROMs
  - Serial and parallel flash Memories
  - Asynchronous and synchronous first-in, first-out (FIFO), Bidirectional FIFO (BiFIFO) Memories
- Improved coverage of error detecting and correcting codes.
- Hazards in combinational and sequential circuits and design of hazard free circuits included.

- Added a large number of Solved Examples, Review Questions with Answers, and Problems to help students understand and apply the topics discussed successfully.

Chapter 1 introduces the fundamental concepts of digital electronics, advantages of digital systems, and the basic digital circuits. Various number systems and commonly used codes in digitial systems and microprocessors have been discussed in **Chapter 2**. Error-detecting and error-correcting codes have also been discussed in data. **Chapter 3** reviews semiconductor devices from the point of view of their applications in digital circuits. Based on these devices, various digital circuits, referred to as logic families, have been discussed in **Chapter 4**.

CMOS logic has now almost replaced the earlier most commonly used TTL logic. However, because of its higher speed of operation and driving capabilities TTL logic is still preferred in many designs. Even a number of CMOS devices are available which are TTL compatible. The latest 74F (Fast TTL) series has also been included in this chapter. The CMOS logic has been discussed in detail and the advanced high speed CMOS logic family series 74AHC/74AHCT/74FCT, and low-voltage CMOS (LVCMOS) logic have also been included in this edition. The logic family using bipolar and unipolar logic BiCMOS has also been introduced in this edition. This chapter also deals in detail the interfacing problems between ICs of the same logic family and between those of different logic families to obtain maximum benefits in the design of digital systems.

Chapter 5 deals with the conventional methods of combinational circuits design such as algebraic method, K-map simplification and Quine-Mcluskey method. Hazards in combinational digital circuits and design of hazard-free circuits have also been included in this edition.

Combinational logic design using MSI circuits is covered in **Chapter 6**, which is important for the design of digital systems considering the simplicity in design, cost, space, power requirement, speed and other factors.

Chapter 7 introduces the basic building block of a sequential circuit—the FLIP-FLOP. All types of FLIP-FLOPs with their excitation tables and triggering methods have been discussed in detail. Sequential logic design has been discussed in Chapter 8. Here again, both the approaches, namely conventional design using FLIP-FLOPs and the modern approach using available MSI circuits, have been discussed. Design of synchronous sequential as well as asynchronous sequential circuits have been discussed in detail. Synchronous counters design using D-type FLIP-FLOPs have been added since D-type FLIP-FLOPs are most commonly used in modern programmable logic devices. Hazards in sequential circuits have also been dealt with in this chapter.

Chapter 9 deals with timing circuits and their applications which are essential to a digital system.

The analog-to-digital (A/D) and digital-to-analog (D/A) converters form an important part of many digital systems and the commonly used techniques for such conversions have been discussed in **Chapter 10**.

Chapter 11 deals with semiconductor memories which have assumed an important role in present-day digital systems. This chapter has thoroughly been revised to include various semiconductor memory devices which are being used currently. Serial and parallel EEPROMs, serial and parallel flash memories, first-in, first-out (FIFO) memories, bidirectional FIFO (BiFIFO) memory, asynchronous and synchronous SRAMs, asynchronous and synchronous DRAMs have been discussed in detail.

Programming techniques used for programmable ROMs and erasing techniques used for erasable programmable ROMs have also been discussed.

Chapter 12 presents various programmable logic devices (PLDs), such as programmable logic array (PLA), programmable array logic (PAL), electrically erasable PLD (EEPLD), generic array logic (GAL), complex programmable logic devices (CPLDs), and field programmable gate array (FPGA) devices. Xilinx Cool Runner-II CPLD family, Virtex FPGA family, and Altera Stratix FPGA family devices have been discussed in detail.

The microprocessors have been introduced in **Chapter 13**. The fundamentals of microprocessors have been presented in a manner that even a novice would understand this highly sophisticated device. The most widely used Intel's 8085A 8-bit microprocessor has been chosen for discussion. Its organisation, operation and programming have been discussed in detail, which will help the students learn the use of microprocessors. The Intel's 16-bit microprocessor 8086 has also been introduced briefly.

Chapter 14 introduces computer aided design (CAD) approach to digital system design. CAD tools needed for this purpose have been discussed. The VHDL, a hardware description language has been introduced, which is the basic requirement of designing using CAD tools.

Combinational logic circuits: truth table, arithmetic circuits, decoders, multiplexers, priority encoder, digital comparators, BCD-to-7-segment decoder, tristate buffer, and Sequential logic circuits: FLIP-FLOPs, latches, shift registers, registers, and counters have been described using VHDL.

Glossary of the important terms used in the book and Review Questions with answers for each chapter have been included to enhance the understanding of the users.

Online Learning Centre

This book is accompanied by an exhaustive online learning centre http://www.mhhe.com/jain/mde4e which provides useful resources for students and instructors. Students can access simulation software, sample chapters, additional MCQs, web links and university questions along with answers. Instructors can avail PowerPoint Slides (chapter-wise), solution manual, university questions along with answers and class tests. Suggestions for further improvement of the book can be sent at the following email id—tmh.cse feedback@gmail.com (*kindly mention the title and author name in the subject line*).

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