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# Microprocessors and Microcontrollers

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CD INSIDE

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and education by publishing worldwide. Oxford is a registered trademark of
Oxford University Press in the UK and in certain other countries

Published in India by
Oxford University Press
YMCA Library Building, 1 Jai Singh Road, New Delhi 110001, India



First Edition published in 2010
Ninth impression 2013



ISBN-13: 978-0-19-806647-7
ISBN-10: 0-19-806647-3

Typeset in Times New Roman
by Trinity Designers & Typesetters, Chennai
Printed in India by Raj Kamal Electric Press, Kundli

*To*
*our parents, teachers*
*and*
*to our institutions*

N. SENTHIL KUMAR
M. SARAVANAN

*I dedicate this work*
*to my father Late Mr S. Seenithangam.*

S. JEEVANANTHAN

# PREFACE

A microprocessor is technically a miniaturized central processing unit (CPU) of a computer. While it plays a pivotal role in the functioning of a computer, it requires the support of external components, such as memory and I/O devices, to perform meaningful tasks. Microprocessors are general-purpose devices that can be programmed and reprogrammed to perform different sets of tasks. Conversely, a microcontroller is a chip that not only performs the desired tasks but also has integrated components, such as memory and I/O ports, as part of its design. Since it acts as a tiny computer with all its integrated features, a microcontroller is also termed as 'computer-on-a-chip' or 'system-on-a-chip'. Microcontrollers are used in applications to perform specific tasks and hence do not require reprogramming.

Advancements in the semiconductor industry led to the introduction of very fast, high power, and miniaturized integrated circuits (ICs). It also paved way for the growth of advanced microprocessors and microcontrollers that serve to perform enviable tasks with unimaginable precision and accuracy. The evolution of these high speed entities fuelled the growth of many innovative applications, virtually in every sphere of our lives.

The first microprocessor, 4004, was introduced by Intel in 1971. This 4-bit microprocessor was developed to be used in a calculator. This first-generation microprocessor has developed over the years and seen about five generations within four decades. Technological advancement has taken place in terms of increase in the size of the data handled, speed of execution, amount of memory interfaced, and reduction in physical size. Today, there are several processors in the market, from which designers can select the one that best suits their requirements. It can be said that the number of personal computers in a developed country is greater than its human population. In addition, recent statistical reports point out that every house in a developed country has an average of about 30 processors working hidden in various domestic appliances.

Microprocessors and microcontrollers have facilitated the execution of complicated tasks such as automation, precision measurement, and control, in a simple and effective manner. They are popular today because of their unprecedented use in almost all areas. Applications of microprocessors and microcontrollers can be found equally in both complex industrial processes and simple domestic appliances.

## ABOUT THE BOOK

This book is the result of the author team's endeavour to bring forth a comprehensive learning resource to cater to this extremely important subject in the engineering curricula. The book covers the important features and applications of different microprocessors and microcontrollers. The book is written with a view to present to the readers the internal architecture, programming, system design, and select interfacing aspects of Intel's 8085 and 8086 microprocessors, and Intel's 8051 and 8096 microcontrollers in a student-friendly manner. Since almost all universities in India offer this subject as an introductory and interdisciplinary course, the contents of this book have been written in a simple way assuming that the students have no prior knowledge of this topic. The book would be useful to undergraduate engineering students of electrical and electronics, electronics and communication, instrumentation and control, information technology, and computer science and also to practising engineers.

The book addresses the basic architecture of the microprocessors and microcontrollers and explains the related hardware and software models of the selected chips. It covers the programming of Intel microprocessors (8085 and 8086) and microcontrollers (8051 and 8096) and then proceeds to the interfacing of specific devices with selected processors. The strength of the book lies in the discussion of a large number of examples on programming and interfacing, which would offer a vivid understanding of the applications of these chips.

## KEY FEATURES

- One-text resource covering the 8085, 8086, and 8051 and an introduction to the 8096 processors
- Exhaustive programming examples (assembly language codes), which would not only help students hone their programming skills but also allow faculty members to use select portions for their laboratory
- A section on C programming applied to the 8051 processor
- Application examples (case studies) on traffic light control, thermometer, elevator control, and washing machine control to appreciate the general design process
- Simple theoretical questions, programming questions, and application sets ('Think and answer' type questions) at the end of all the relevant chapters
- Extensive coverage of advanced Intel processors including the Pentium processors, PowerPC, and PIC16F877 microcontroller
- Accompanied by a CD containing ALP codes and simulation-based learning for select examples discussed in the book

## CONTENT AND ORGANIZATION

This book consists of six parts. After a general introduction to microprocessors, the first part of the book covers the basic hardware details of the 8085 processor with the related signals and their implications. The second part details the instruction set

and programming of the 8085. The third part explains the hardware and software details of Intel's 8-bit 8051 microcontroller series. The hardware and software details of Intel's 16-bit microprocessor, the 8086, form the fourth part. The fifth part includes the details of Intel's 16-bit microcontroller, the 8096. The last part covers the recent developments in microprocessor-based systems, other advanced microprocessors, and the PIC16F877 microcontroller.

Chapter 1 of the book contains an introduction to microprocessors, a list of various terms related to microprocessor technology, and the evolution of microprocessors.

Chapter 2 introduces and explains the details of Intel's 8085 microprocessor, along with its basic architecture and pin details.

Chapter 3 details the complete instruction set of the 8085 processor and the related instruction format, addressing modes, and classification.

Chapter 4 discusses numerous 8085 example programs.

Chapter 5 explains the basic data transfer mechanism between the processor and the peripheral, along with the interrupt structure of the 8085 processor.

Chapter 6 covers the methods of interfacing the memory and input/output devices with the 8085 processor.

Chapter 7 handles the interfacing of some of the programmable peripheral devices manufactured by Intel with the 8085 processor.

Chapter 8 gives an overview of a complete 8085-based system, including the address map, a general microcomputer system, and other supporting devices.

Chapter 9 introduces Intel's 8-bit microcontroller, the 8051, with details of its internal architecture and memory organization.

Chapters 10 and 11 cover the software and internal hardware details of the 8051 microcontroller.

Chapter 12 explains the interfacing of the 8051 with a few basic peripherals and includes numerous solved examples. This chapter also covers RTC interfacing using the $I^2C$ standard.

Chapter 13 introduces the architecture, memory locations, and pin details of Intel's 16-bit processor, the 8086.

Chapter 14 discusses the addressing modes, instruction set, and programming of the 8086.

Chapters 15 and 16 cover the interrupt structure of the 8086 and memory and I/O interfacing (inclusive of printer and CRT terminal) with the 8086.

Chapters 17 deals with multiprocessor configuration, its advantages, need, bus arbitration, and interconnection topologies.

Chapter 18 describes complete 8086-based systems.

Chapter 19 presents the basic features of Intel's 16-bit 8096 microcontroller series.

Chapter 20 addresses the programming of the 8096 microcontroller.

Chapter 21 details the internal hardware of the 8096.

Chapter 22 discusses the recent trends and developments in microprocessor technology and the use of high-level language programming with the 8051 microcontroller, along with a few examples in C language.

Chapter 23 offers a preview of Intel's advanced processors (80186, 80286 80386, 80486, and Pentium), PowerPC, and the features, architecture, and programming of the PIC16F877 microcontroller.

Appendices A–E contain the instruction sets of the 8085, 8051, 8086, and 8096 processors, for ready reference. They also contain case studies on washing machine and elevator control.

## IN THE CD

- Simulator for the 8085 processor, from http://gnusim8085.org. Students can execute in this simulator the 8085 assembly language codes given in the book. They can execute each instruction and see how it affects the various registers, the memory, and the flags. This will help in understanding the instruction set and algorithms used in the programming examples.
- Assembly language codes for 8085 from Chapter 4, which can be readily executed in the simulator
- Assembly language codes for 8051 and 8086, from Chapters 10 and 14 respectively, which can be run in any executable environment

Students and faculty members are requested to go through the readme.mht file (autorun enabled), which provides guidelines for installation and utilization of the simulator.

## ACKNOWLEDGEMENTS

The authors acknowledge the authorities of their respective institutions for having permitted them to embark on this mission and also for providing the necessary support. Special thanks to Mr Sridhar Ratnakumar, Activestate Software Inc, Canada, for having permitted us to use the 8085 simulator developed by him in the CD accompanying the book. During the course of development of this book we were hardly able to spare any time for our families. Their support has made this book possible. The support rendered by the editorial team of Oxford University Press is gratefully acknowledged. We would also like to thank all the reviewers who gave their valuable comments on the manuscript at its draft stage. It is with devotion that we recall the blessings of the Almighty for having been with us in our efforts to come out with this book.

While we have tried our best to make the book error-free, readers are encouraged to write to us with feedback, suggestions, and comments for improving the content of the book.

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**S. Jeevananthan**

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