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Embedded Microcontroller Interfacing

Designing Integrated Projects

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Preface

Mixed-Signal Embedded Microcontrollers are commonly used in integrating analog components needed to control non-digital electronic systems. They are used in automatically controlled devices and products, such as automobile engine control systems, wireless remote controllers, office machines, home appliances, power tools, and toys. Microcontrollers make it economical to digitally control even more devices and processes by reducing the size and cost, compared to a design that uses a separate microprocessor, memory, and input/output devices. In many undergraduate and post-graduate courses, teaching of mixed-signal microcontrollers and their use for project work has become compulsory.

Students face a lot of difficulties when they have to interface a microcontroller with the electronics they deal with. This book addresses some issues of interfacing the microcontrollers and describes some project implementations with the Silicon Lab C8051F020 mixed–signal microcontroller. The intended readers are college and university students specializing in electronics, computer systems engineering, electrical and electronics engineering; researchers involved with electronics based system, practitioners, technicians and in general anybody interested in microcontrollers based projects.

The complete book is divided into ten chapters. It is our view that expertise in microcontrollers is achieved by using it in different applications. Most of the book is dedicated to describe a few project implementations. Six different successful projects have been detailed.

Chapter 1 describes the fundamentals of electronics and analog processing circuits. The input signal is almost always passed through some analog processing circuits before it is interfaced to a microcontroller. For signal processing, the basic knowledge of this chapter is very important.

Chapter 2 gives an overview of the SiLab C8051F020 micro-controller. On-chip peripherals such as ADC and DAC, and other features like the digital crossbar and the voltage reference generator are briefly introduced. While programming using a high level language, such as C, makes it less important to know the intricacies of the hardware architecture of the microcontroller, it is still beneficial to have some knowledge of the memory organization and the special function registers.

Chapter 3 introduces the Keil™ C compiler for the SiLab C8051F020 microcontroller. The high level language C, in combination with some standard codes, is used to develop the software program. The differences in programming the C8051F020 in C, compared to a standard C program, are almost all related to architectural issues which are highlighted in this chapter.

Chapter 4 describes some of the important design issues of interfacing a microcontroller to common electronic circuits. Open collector configuration, loading problems, microcontroller cross-bar definition, driving output load etc. have been discussed.

In chapter 5 we have detailed the development of a DC motor control project using Silabs 8051F020. It has been taken directly off our teaching program. A problem based learning and teaching approach was taken and our main focus in this chapter is to describe in detail the laboratory exercise in which the students work in groups for a complete semester. The software part of the project involves the development of the software to control the speed of the DC motor. The hardware part of the project is the design and development of over-current protection circuit and the associated expansion board.

In chapter 6 we have described the design, fabrication and implementation of a switched mode power supply based on both discrete circuit and embedded microcontroller. Even though an integrated circuit (IC) with a complete switched mode power supply is now available, from a student's learning perspective still a lot of things can be learnt while doing this project.

Chapter 7 details the implementation of an embedded microcontroller based control system for magnetic levitation.

Chapter 8 describes the hardware implementation of a microcontroller based remote firing module to detonate fireworks and the software to control this remote module. Traditional systems for fireworks detonation usually use very long runs of cable, up to several hundred meters, for each firework connected. This increases the setup time and cost significantly. To reduce the amount of wiring, short lengths of cable are often used; this however places the technicians at risk because of the close proximity to the firework shells. The proposed wireless system overcomes these shortcomings.

Chapter 9 describes an embedded microcontroller based sensing system for seafood inspection. Interdigital sensors have been used for non-destructive and non-invasive inspection of the material properties. There are many applications of interdigital sensors based systems.

We are indebted to many of our students and colleagues who were involved with the various projects over several years and some of their works have been used in this book. In particular we would like to acknowledge the contribution of our past and present students Dan Paolo Salvador, Elijah Sheppard, Jamses Tingsley, Chinthaka Gooneratne, Anuroop Gaddam, Adam Bullen, Mohd. Syaifudin Abdul Rahman, Vishnu Kasturi, Karan Singh Malhi, Michelle Cho and Matthew Finnie. Chapters 2 and 3 are, in parts, reproduced by kind permission from Silicon Laboratories, USA, from the book "Embedded Programming with Field-Programmable Mixed-Signal Microcontrollers", Second Edition, 2008 (ISBN: 978-0-9800541-0-1) and we would like to thank Chew Moi Tin and Prof. Chris Messom who had contributed to it. Over the years we have received invaluable technical support for our projects from Ken Mercer and we thank him profusely.

We would also like to express our sincere thanks to our family members for their continuous support and patience.

We hope you find this book useful.

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