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Atmel AVR Microcontroller Primer

Programming and Interfacing

Steven F. Barrett
Daniel J. Pack

***SYNTHESIS LECTURES ON
DIGITAL CIRCUITS AND SYSTEMS***

Mitchell Thornton, Series Editor

Atmel AVR Microcontroller Primer: Programming and Interfacing

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ABSTRACT

This textbook provides practicing scientists and engineers a primer on the Atmel AVR microcontroller. Our approach is to provide the fundamental skills to quickly get up and operating with this internationally popular microcontroller. The Atmel ATmega16 is used as a representative sample of the AVR line. The knowledge you gain on the ATmega16 can be easily translated to every other microcontroller in the AVR line. We cover the main subsystems aboard the ATmega16, providing a short theory section followed by a description of the related microcontroller subsystem with accompanying hardware and software to exercise the subsystem. In all examples, we use the C programming language. We conclude with a detailed chapter describing how to interface the microcontroller to a wide variety of input and output devices.

KEYWORDS

Atmel microcontroller, microcontroller, ATmega16, Atmel AVR, microcontroller interfacing

Preface

In 2006, Morgan & Claypool Publishers (M&C) released our textbook *Microcontrollers Fundamentals for Engineers and Scientists*. The purpose of this textbook was to provide practicing scientists and engineers a tutorial on the fundamental concepts and the use of microcontrollers. The textbook presented the fundamental concepts common to all microcontrollers. Our goals for writing this follow-on book are to present details on a specific microcontroller family—the Atmel AVR Microcontroller.

Why Atmel? There are many excellent international companies that produce microcontrollers. As Atmel states, “Atmel Corporation is an industry leader in the design and manufacture of advanced semiconductors, with focus on microcontrollers, nonvolatile memory, logic, radio frequency components and sensors.” Some of the highlights of the Atmel AVR line include

- high performance coupled with low power consumption,
- outstanding flash memory technology,
- reduced instruction set computer Harvard Architecture,
- single-cycle instruction execution,
- wide variety of operating voltages (1.8–5.5 VDC),
- architecture designed for the C language,
- one set of development tools for the entire AVR line, and
- in-system programming, debugging, and verification capability.

Although all of these features are extremely important, we have chosen to focus on the Atmel AVR line of microcontrollers for this primer for a number of other related reasons:

- The learning curve for Atmel microcontrollers is gentle. If this is your first exposure to microcontrollers, you will quickly come up to speed on microcontroller programming and interfacing. If you already know another line of processors, you can quickly apply your knowledge to this powerful line of 8-bit processors.
- It is relatively inexpensive to get started with the Atmel AVR microcontroller line. The microcontrollers themselves are inexpensive, and the compilers and programming hardware and software are relatively inexpensive.

- The AVR line provides a full range of processing power, from small 8-pin processors to complex 100-pin processors. The same compiler and programming hardware may be used with a wide variety of microcontrollers.
- Many of the AVR microcontrollers are available in dual inline package, which makes them readily useable on a printed circuit board prototype (e.g., senior design projects).
- Many of the microcontrollers in the AVR line are pin-for-pin compatible with one another. This allows you to easily move up and down the AVR line as your project becomes better defined.
- Atmel has documentation available for every microcontroller at your fingertips. Simply visit www.atmel.com. Furthermore, Atmel customer support is good and responsive.
- There is worldwide interest in the AVR microcontroller line. We would be remiss to not mention AVR Freaks. This is a dedicated, international group of AVR experts who share their expertise online with other high-power users and novices alike.

Approach of the book

If this is your first exposure to microcontrollers, we highly recommend that you read first our other M&C textbook, *Microcontrollers Fundamentals for Engineers and Scientists*. It will provide you the background information necessary to fully appreciate the contents of this textbook. This textbook picks up where the first one left off. We have received permission from M&C to include some of the background material from the first textbook in this text to allow for a complete stand-alone product.

Our approach in this textbook is to provide you the fundamental skills to quickly get up and operating with an Atmel microcontroller. We have chosen to use the AVR ATmega16 as a representative sample of the AVR line (more on this processor later). The knowledge you gain on the ATmega16 can be easily translated to every other microcontroller in the AVR line.

We will use an ongoing testbench example throughout the textbook. We will start by having you get a simple microcontroller circuit operating with a simple menu program that interacts with external devices. As we move through various microcontroller subsystems, we will continue to add features to the testbench. By the end of the textbook, you will have a complete hardware/software system that demonstrates the features of the ATmega16. You can then use this testbench to adapt to other applications.

The M&C textbooks are designed to be short tutorials on a given topic. Therefore, our treatment of each topic will provide a short theory section followed by a description of the related microcontroller subsystem with accompanying hardware and software to exercise the subsystem. In all examples, we will use the C programming language. There are many excellent C compilers available for the Atmel AVR line. We have chosen the ImageCraft ICC AVR compiler for its short learning curve and ease of use.

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Laramie and Colorado Springs, November 2007

Steve Barrett and Daniel Pack

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