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Embedded Systems: Real-Time Operating Systems for Arm Cortex M Microcontrollers

Jonathan Valvano

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Embedded systems are a ubiquitous component of our everyday lives. We interact with hundreds of tiny computers every day that are embedded into our houses, our cars, our toys, and our work. As our world has become more complex, so have the capabilities of the microcontrollers embedded into our devices. The ARM® Cortex™-M family represents the new class of microcontroller much more powerful than the devices available ten years ago. The purpose of this book is to present the design methodology to train young engineers to understand the basic building blocks that comprise devices like a cell phone, an MP3 player, a pacemaker, antilock brakes, and an engine controller. This book, now in its third edition (September 2014), is the third in a series of three books that teach the fundamentals of embedded systems as applied to ARM® Cortex™-M microcontrollers. This third volume is primarily written for senior undergraduate or first-year graduate electrical and computer engineering students. It could also be used for professionals wishing to design or deploy a real-time operating system onto an ARM platform. The first book Embedded Systems: Introduction to the ARM Cortex-M Microcontroller is an introduction to computers and interfacing focusing on assembly language and C programming. The second book Embedded Systems: Real-Time Interfacing to ARM Cortex-M Microcontroller focuses on interfacing and the design of embedded systems. This third book is an advanced book focusing on operating systems, high-speed interfacing, control systems, robotics, and the Internet of Things (IoT). Rather than buying and deploying an existing OS, the focus is on fundamental principles, so readers can write their-own OS. An embedded system is a system that performs a specific task and has a computer embedded inside. A system is comprised of components and interfaces connected together for a common purpose. Specific topics include microcontrollers, design, verification, hardware/software synchronization, interfacing devices to the computer, real-time operating systems, data collection and processing, motor control, analog filters, digital filters, and real-time signal processing. This book employs many approaches to learning. It will not include an exhaustive recapitulation of the information in data sheets. First, it begins with basic fundamentals, which allows the reader to solve new problems with new technology. Second, the book presents many detailed design examples. These examples illustrate the process of design. There are multiple structural components that assist learning. Checkpoints, with answers in the back, are short easy to answer questions providing immediate feedback while reading. Simple homework questions provide more detailed learning opportunities. The book includes an index and a glossary so that information can be searched. The most important learning experiences in a class like this are of course the laboratories. Each chapter has suggested lab assignments. More detailed lab descriptions are available on the web. Specifically for Volume 1, look at the lab assignments for EE319K. For Volume 2 refer to the EE445L labs, and for this volume, look at the lab assignments for EE445M/EE380L.6. There is a web site accompanying this book http://users.ece.utexas.edu/~valvano/arm. Posted here are Keil uVision projects for each the example programs in the book. You will also find data sheets and Excel spreadsheets relevant to the material in this book. The book will cover embedded systems for the ARM® Cortex™-M with specific details on the LM3S8962, TM4C123, and TM4C1294. Most of the topics can be run on either of the TM4C123 or TM4C1294 LaunchPads. Ethernet examples can be run on the LM3S8962 or TM4C1294. Although the solutions are specific for the LM3S/TM4C family, it will be possible to use this book for other ARM derivatives.

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