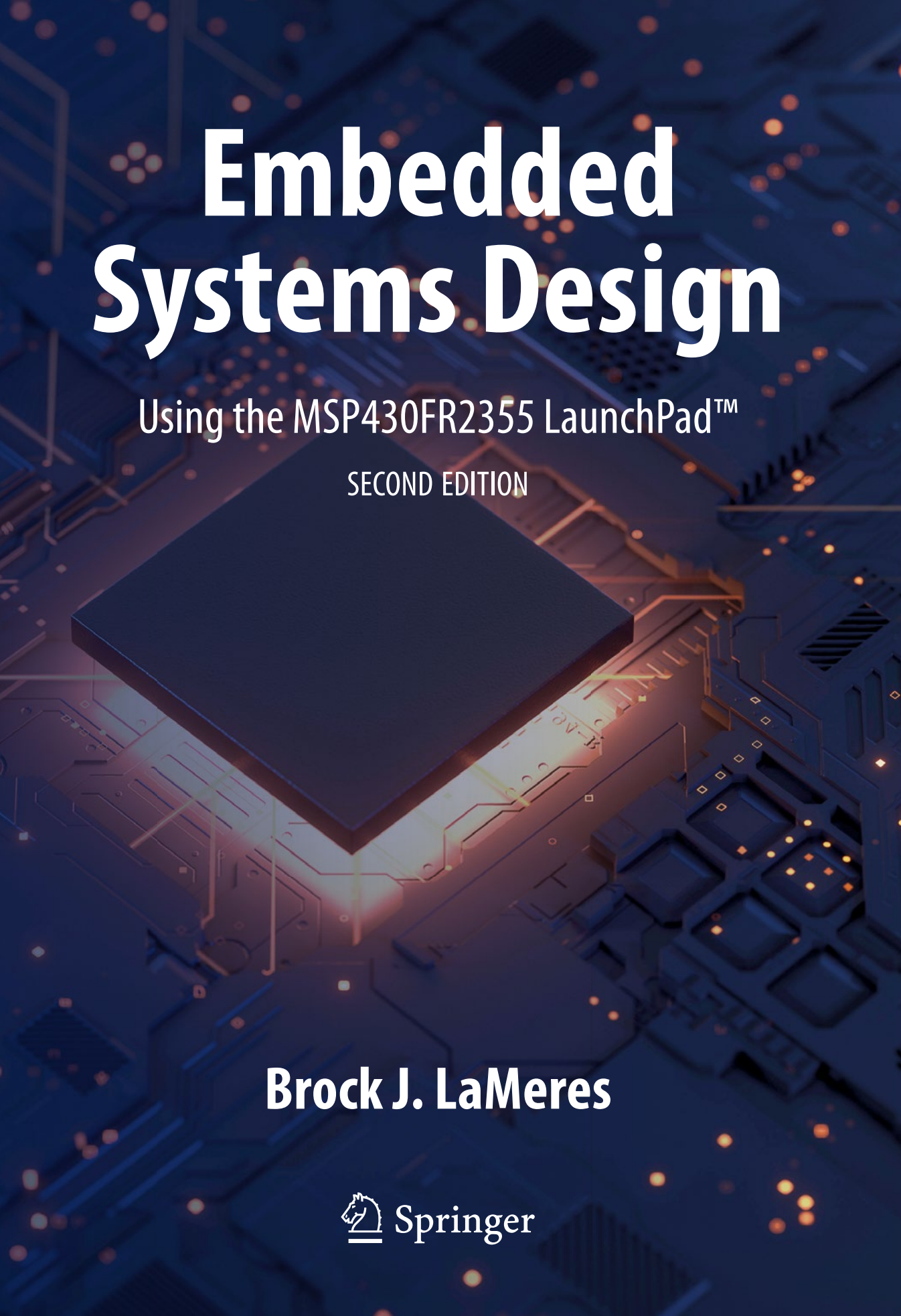
Embedded
Systems Design
Using the MSP430FR2355 LaunchPad™
SECOND EDITION
Brock J. LaMeres
Springer

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2nd Edition

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Preface

Why Another Book on Embedded Systems?

Embedded computers represent one of the most pervasive technologies of our time. When most people think of computers, they think of their laptops and workstations, or even the servers that are the backbone of the Internet; however, when one begins to contemplate how many technologies around them use small, inexpensive computers embedded as their "brains," one begins to more fully understand the magnitude of how many embedded computers exist in our society. If you look around any room you will see technology that is so commonplace, you may not even realize that most of it is run by an internal computer. Technologies such as appliances, thermostats, handheld devices, projectors, televisions, personal assistants, and radios all have small computers within them that control their operation. As one starts to notice all of the embedded computers around them, they will quickly notice that there are orders of magnitude more embedded computers than the standard general-purpose computers that run Windows® or iOS™. As these technologies become *smarter* and are Wi-Fi connected, we move into era called the *Internet of Things*. This next technological paradigm shift will turn all of the embedded computers into a collaborative network in an attempt to make our lives better by automating taking mundane tasks.

Simultaneous to the exponential increase in embedded computers in our society is the need for engineers and software developers that can build and program these systems. Due to the high popularity of embedded computers, there is also a wide range of embedded computer platforms. As such, the textbooks that exist to aid in the education of embedded computers are somewhat fragmented. Textbooks for embedded computers aren't able to be written at only the theoretical level such as circuits and electronics textbooks. Instead, they must identify a computer platform and focus the content on that specific embedded computer technology. This leads to a large number of embedded systems books to support the large number of embedded platforms. This also leads to books becoming obsolete much faster than traditional engineering textbooks.

One reason for a new book in this area is creating comprehensive content around a widely popular embedded computer, the Texas Instruments MSP430. The MSP430 is a modern computer platform that is mature in the market and has a great deal of technical and educational support behind it. This means that this platform will be relevant and supported for at least the next 10–15 years.

A second reason for a new book in this area is to provide content the way people actual learn (i.e., by doing). Current embedded systems books, even those targeting the MSP430, tend to only provide small code segments that can't be directly run on a target platform. This new book approaches content delivery around the model that the reader is sitting at a computer with an MSP430 plugged in and running each of the examples as they move through the book. This *learn-a-little*, *do-a-little* is a proven pedagogical strategy. It also supports both active learning within the classroom and self-regulated learning for individual readers.

A third reason for a new book in this area is to provide a seamless delivery of both assembly language and C language programming of the MSP430. Most embedded systems books are structured in one of three ways: (1) they only cover assembly; (2) they only cover C; (3) they attempt to cover both but don't provide sufficient details of either. This new book will begin in assembly language as a means to show the lower-level operation of the computer hardware. It will then move into C to implement more complex systems that require abstracting the lower-level hardware. With the design of the book consisting of examples in both languages that can be directly coded and run, there will not be a void between the examples and real implementation of the concepts as seen in other books.

The three guiding principles for the design of this book are:

Learn by example This book is designed to teach the material the way it is learned, through example. Every concept that is covered in this book is supported by numerous programming examples that provide the reader with a step-by-step explanation for how and why the computer is doing what it is doing.

Learn by doing This book targets the Texas Instruments MSP430 microcontroller. This platform is a widely popular, low-cost embedded system that is used to illustrate each concept in the book. The book is designed for a reader who is at their computer with the MSP430 plugged in so that each example can be coded and run as they learn.

Build a foundational understanding first, then move into abstraction This book teaches the basic operation of an embedded computer using assembly language first so that the computer operation can be explored at a lower level. Once complicated systems are introduced (i.e., serial communication and analog-to-digital converters), the book moves into the C programming language. Moving to C allows the learner to abstract the operation of the lower-level hardware and focus on understanding how to "make things work." By spending time in assembly to understand the underlying hardware, the transition to C can happen more rapidly while still leaving the reader with a foundational understanding of the underlying hardware.

If this learning model is followed, the reader will come away with much more than knowledge of facts and figures; they will have a skillset and experience with embedded systems that will be both marketable and of key importance to our society.

This second edition adds two highly requested chapters: Chaps. 16 and 17. Both chapters provide example programs on how to configure these systems and observe their operation.

How to Use This Book

This book is most effective when the reader has the *Texas Instruments Inc. MSP430FR2355 LaunchPad™ Development Kit* and codes along with the material. All examples can be directly run on the LaunchPad™ board. All programs were created and compiled using the *Texas Instruments Inc. Code Composer Studio (CCS)*. This development environment is free from Texas Instruments and can be run on multiple operating systems. Each of the examples noted with a keyboard are ones that are intended to be coded in CCS and run on the LaunchPad™ board.

There are three supporting documents that should also be downloaded from Texas Instruments to provide background for the material in this book. The first is the *MSP430FR4xx and MSP430FR2xx Family User's Guide*[1]. This document gives the general concept of operation for the MSP430 architecture that is used on the specific microcontroller targeted in this book. Throughout this book, this document is referred to as the "MSP430 User's Guide." The second document that should be retrieved is the *MSP430FR235x, MSP430FR215x Mixed-Signal Microcontrollers Device-Specific Data Sheet*[2]. This second document provides the specific details of the MSP430FR2355 microcontroller device that is used in each example. Throughout this book, this document is referred to as the" Device-Specific Data Sheet." The final document that should be retrieved is the *MSP430FR235x LaunchPad™ Development Kit User's Guide*[3]. This document describes the circuitry implemented on the LaunchPad™ board. This document is critical to understanding the types of input/output and programming capability available on the LaunchPad™ board.

Additional Resources

Supporting videos will be posted to the author's YouTube channel, which can be found at https://www.youtube.com/c/DigitalLogicProgramming_LaMeres. This channel contains many other videos beyond embedded systems to help people learn digital logic, basic programming, and robotics. Subscribe to this channel in order to be notified when new videos for this book are posted.

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Contents