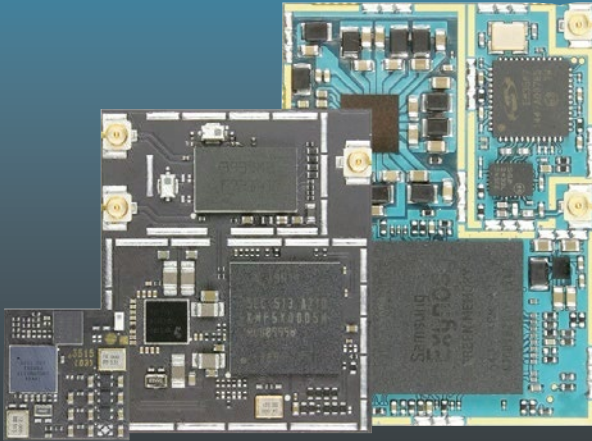


TECHNOLOGY IN ACTION™



Beginning Samsung ARTIK



A Guide for Developers

—

Cliff Wootton

EXTRAS ONLINE

apress®

Beginning Samsung ARTIK

A Guide for Developers



Cliff Wootton

Apress®

Beginning Samsung ARTIK

Cliff Wootton
Crowborough, East Sussex, United Kingdom

ISBN-13 (pbk): 978-1-4842-1951-5
DOI 10.1007/978-1-4842-1952-2

ISBN-13 (electronic): 978-1-4842-1952-2

Library of Congress Control Number: 2016940104

Copyright © 2016 by Cliff Wootton

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed. Exempted from this legal reservation are brief excerpts in connection with reviews or scholarly analysis or material supplied specifically for the purpose of being entered and executed on a computer system, for exclusive use by the purchaser of the work. Duplication of this publication or parts thereof is permitted only under the provisions of the Copyright Law of the Publisher's location, in its current version, and permission for use must always be obtained from Springer. Permissions for use may be obtained through RightsLink at the Copyright Clearance Center. Violations are liable to prosecution under the respective Copyright Law.

Trademarked names, logos, and images may appear in this book. Rather than use a trademark symbol with every occurrence of a trademarked name, logo, or image we use the names, logos, and images only in an editorial fashion and to the benefit of the trademark owner, with no intention of infringement of the trademark.

The use in this publication of trade names, trademarks, service marks, and similar terms, even if they are not identified as such, is not to be taken as an expression of opinion as to whether or not they are subject to proprietary rights.

While the advice and information in this book are believed to be true and accurate at the date of publication, neither the authors nor the editors nor the publisher can accept any legal responsibility for any errors or omissions that may be made. The publisher makes no warranty, express or implied, with respect to the material contained herein.

Managing Director: Welmoed Spahr

Lead Editor: Jeffrey Pepper

Editorial Board: Steve Anglin, Gary Cornell, Louise Corrigan, James T. DeWolf,
Jonathan Gennick, Robert Hutchinson, James Markham, Matthew Moodie,
Susan McDermott, Jeffrey Pepper, Douglas Pundick, Dominic Shakeshaft,
Gwenan Spearing, Matt Wade, Steve Weiss

Coordinating Editor: Melissa Maldonado

Copy Editor: April Rondeau

Compositor: SPi Global

Indexer: SPi Global

Artist: SPi Global

Distributed to the book trade worldwide by Springer Science+Business Media New York, 233 Spring Street, 6th Floor, New York, NY 10013. Phone 1-800-SPRINGER, fax (201) 348-4505, e-mail orders-ny@springer-sbm.com, or visit www.springer.com. Apress Media, LLC is a California LLC and the sole member (owner) is Springer Science + Business Media Finance Inc (SSBM Finance Inc). SSBM Finance Inc is a **Delaware** corporation.

For information on translations, please e-mail rights@apress.com, or visit www.apress.com.

Apress and friends of ED books may be purchased in bulk for academic, corporate, or promotional use. eBook versions and licenses are also available for most titles. For more information, reference our Special Bulk Sales–eBook Licensing web page at www.apress.com/bulk-sales.

Any source code or other supplementary materials referenced by the author in this text is available to readers at www.apress.com. For detailed information about how to locate your book's source code, go to www.apress.com/source-code/.

Printed on acid-free paper

To my longtime buddy, Pete Willis.

Contents at a Glance

About the Author	xxvii
Acknowledgments	xxix
Trademarks.....	xxxii
Foreword	xxxiii
Introduction	xxxv
■ Chapter 1: Getting Started	1
■ Chapter 2: Welcome to the Internet of Things	9
■ Chapter 3: Hello, ARTIK.....	15
■ Chapter 4: Understanding Security	41
■ Chapter 5: Your Development Kit.....	47
■ Chapter 6: Getting Your Hardware Together	59
■ Chapter 7: Setting Up a Terminal Emulator	81
■ Chapter 8: Talking to Your ARTIK.....	99
■ Chapter 9: Network Configuration	109
■ Chapter 10: Configuring and Upgrading	143
■ Chapter 11: Programming Your ARTIK.....	159
■ Chapter 12: Using Eclipse IDE	175
■ Chapter 13: Using Arduino IDE	195
■ Chapter 14: Using the Command Line	219

■ Chapter 15: Programming in C Language.....	239
■ Chapter 16: Programming with Node.js	257
■ Chapter 17: Programming with Python	267
■ Chapter 18: Integrating with SAMI	273
■ Chapter 19: Integrating with Temboo	301
■ Chapter 20: Debugging Your Application.....	325
■ Chapter 21: Deploying Your Application	333
■ Chapter 22: Next Steps	341
Index.....	347

Contents

About the Authorxxvii

Acknowledgmentsxxix

Trademarks.....xxxi

Forewordxxxiii

Introductionxxxv

■ Chapter 1: Getting Started 1

 Introducing the ARTIK Family 1

 Reinventing the Engineering Process..... 1

 About This Book 2

 Finding Out About ARTIK..... 2

 Provenance..... 3

 Experience Helps..... 4

 Your Journey Through the Book 4

 Do You Use Windows, Linux, or Mac OS X? 4

 Get Your Samsung Account 5

 Buy an ARTIK Development System Now 5

 Would You Like to Know More? 5

 What to Read Next..... 6

 Quick Start..... 6

■ Chapter 2: Welcome to the Internet of Things	9
What Is the Internet of Things?	9
Concept Map.....	9
An Example You Can Build Today.....	10
The Internet Is Changing—Rapidly	10
Disruptive Changes.....	11
Network Architecture and Design.....	11
Sensors.....	11
Lifestyle Changes	12
A Revolution in Medicine and the Care Community.....	12
Industrial Internet of Things	13
Revenue-generating Opportunities.....	13
■ Chapter 3: Hello, ARTIK.....	15
What Is an ARTIK Module?.....	15
What Is an Ecosystem?	15
The ARTIK Modules.....	16
Software Support	17
The ARTIK Community	17
Security and Privacy Are Core Needs	18
The Connected Cloud Service	19
Sensory Capabilities.....	19
Communications Challenges.....	19
Integration with Other Platforms	20
Benefits to Consumers	21
Introducing the ARTIK 1	21
Functional Organization.....	22
Operating System	22

Wireless Communications	22
Spatial Sensors.....	23
Computing Capacity.....	23
Memory Storage	23
Video Display Output	23
Introducing the ARTIK 5.....	24
Functional Organization.....	25
Operating System	25
Wireless Communications	25
Networking Protocol Support	26
Computing Capacity.....	26
Graphics Processing Unit (GPU).....	26
Memory Storage	27
Hardware Video Codec Support	27
Introducing the ARTIK 10.....	28
Functional Organization.....	29
Operating System	30
Wireless Communications	30
Networking Protocol Support	31
Computing Capacity.....	31
Graphics Processing Unit (GPU).....	31
Memory Storage	32
Audio Codec Support	32
Hardware Video Codec Support	33
Comparing the ARTIK Modules	33
Power Management Integrated Circuit (PMIC)	33
Security Management	34
Support for Audio Coding.....	34

Support for Video Coding	34
Physical Connections.....	35
About the ARTIK Operating Systems	35
Nucleus RTOS	35
Linux: Fedora OS.....	36
But What Is Yocto?	37
Other Operating Systems.....	38
Summary	39
■ Chapter 4: Understanding Security	41
Risk Factors and Dystopian Futures.....	41
Security Ecosystem.....	42
SAMI	42
OAuth2.....	42
Cloud-based Services	43
Open Technologies for Sharing.....	43
Keeping Your Data Safe and Secure.....	43
Secure Operating System.....	43
Firmware Security.....	44
Device Authentication.....	44
Data Encryption	44
Get Your Samsung Account Now	44
Embedded Secure Element	45
Hardware Crypto Engine	45
Segregated Trust Zone	46
Current Status	46
Summary	46

■ Chapter 5: Your Development Kit.....	47
The Developer Reference Board.....	47
About the Developer Reference Boards.....	47
What Is in the Box?	48
The Type 1 Developer Reference Board.....	50
The Type 5 & 10 Developer Reference Boards (Beta).....	51
Early Production Models.....	53
Type 5 and 10 Developer Reference Board Connectors	53
Type 5 and 10 Developer Reference Board Switches.....	55
Type 5 and 10 Developer Reference Board LED Indicators	55
Type 5 and 10 Developer Reference Board Jumpers	56
Connecting External Devices.....	56
Summary.....	57
■ Chapter 6: Getting Your Hardware Together	59
Your Workbench	59
Setting Up a Hardware Workbench	59
Wiring Up Your Circuits	60
Test Equipment.....	61
Setting Up a Software Workbench.....	62
Risk Managing Your Software Development.....	63
Configuring the Developer Reference Board	63
Communicating with Your ARTIK	65
Connecting the ARTIK Development System	66
USB Serial Interfaces	67
Hooking Up the Serial Interface.....	68
Setting Up a USB Serial Interface Driver on Windows	68
Setting Up a USB Serial Interface Driver on Mac OS X	69

Setting Up a USB Serial Interface Driver on Ubuntu Linux.....	75
Setting Up a USB Serial Interface on Android Devices	77
USB Vendor IDs.....	78
Summary.....	79
■ Chapter 7: Setting Up a Terminal Emulator	81
Serial Connections with a Terminal Emulator.....	81
Installing Your Terminal Emulator	82
Adding a Terminal Emulator to Windows.....	82
Install PuTTY on Windows.....	82
Connecting to the ARTIK Development System from PuTTY	84
Closing the Connection.....	84
Logging the Output to a File	85
PuTTY Log File Naming.....	85
Using the Default Terminal Application on Mac OS X	86
Closing the Connection.....	87
Recovering from a Bad Screen Exit	88
Other Useful Screen Commands.....	89
Logging the Output to a File	89
Log Capture Example 1 (Clipboard Cut and Paste)	90
Log Capture Example 2 (Screen Command Logging)	90
Log Capture Example 3 (Output Redirection).....	91
Log Capture Example 4 (Stream Duplexing).....	91
Log Capture Example 5 (Script Command Logging)	92
Alternatives to the Mac OS X Terminal App	92
Using the Minicom Terminal Application on Linux.....	92
Installing Minicom with yum	93
Installing Minicom with apt-get.....	93
Building Minicom from the Source Code Files.....	93

Configure Minicom to Talk to the ARTIK Developer Reference Board	94
Connecting to the ARTIK Development System from Minicom	95
Closing the Connection	96
Logging the Output to a File	96
Pausing the Screen Output	97
Using Minicom Inside Your ARTIK	97
Summary	97
■ Chapter 8: Talking to Your ARTIK	99
Starting Up the ARTIK	99
The System Administrator Console	99
U-boot Universal Boot Loader Messages	99
Booting the Kernel	100
OS Kernel Startup	101
Setting the Boot Mode Switches	103
Booting Up Your ARTIK Development System	104
Login Credentials	105
Shutdown Commands	106
Shutdown Warnings	107
Shutdown Console Logging Messages	108
Summary	108
■ Chapter 9: Network Configuration	109
Networking Your ARTIK	109
Networking Protocol Support	109
Choosing the Best Networking Strategy	110
Wireless Networking	110
Dynamic Name Auto-discovery Support	111
Protocol Support	112

OMA Lightweight M2M Protocol (LW M2M)	112
Constrained Application Protocol (CoAP).....	113
Message Queue Telemetry Transport Protocol (MQTT).....	113
6LoWPAN Protocol.....	114
Using ZigBee and Thread Protocols.....	114
OpenHAB Support in ARTIK 10 Modules	115
OpenStack (Swift) Framework	116
Configuring Your Ethernet Connection	117
How It Works	117
IPv4 Addressing Notation	118
IPv6 Addressing Notation	120
Port Numbers	121
The Switchover.....	122
IP Address Configuration in Your ARTIK	122
Inspecting the IP Addresses	122
Setting a Temporary IP Address on the Ethernet Interface.....	123
Setting a Default Persistent Static IP Address.....	123
Configuring Your ARTIK for IPv6 Operation	125
DNS Configurations	126
Introducing systemd.....	126
The Impact of systemd on DNS Configuration.....	126
Statically Configuring Your DNS Servers	127
Getting State of Your IP Links	128
Configure the Wi-Fi Networking	130
Setting Up Wi-Fi Communications.....	130
Another Way to Configure Your Wi-Fi.....	133

Troubleshooting FAQ	135
Advanced Wi-Fi Configuration	136
Automatically Reconnect Your Wi-Fi after Each Reboot	136
Connecting with Telnet via SSH.....	138
Configuring Your Bluetooth Wireless Interface	139
Setting Up Bluetooth for an ARTIK 5 or 10	139
Summary	141
■ Chapter 10: Configuring and Upgrading	143
Updating Your Operating System.....	143
Writing Downloaded Images to an SD Card	143
Writing Micro SD Card Images on Windows	143
Writing Micro SD Card Images on Linux	144
Writing Micro SD Card Images on Mac OS X	146
Updating Your ARTIK 5 or 10.....	152
Known Firmware Versions.....	155
Installing Software on Your ARTIK	156
Summary	157
■ Chapter 11: Programming Your ARTIK.....	159
Everything Is the Same but Different	159
Programming Your ARTIK.....	159
Setting Up Your Software Development Environment	160
Code-Editing Tools.....	160
Folders vs. Directories.....	161
File-System Path: Folder Separator Characters	161
Spaces in File Names and Paths	162
Upper- and Lowercase Issues	162

Of Camels and Underscores	164
Let the Environment Do the Heavy Lifting	164
Links vs. Aliases	164
Mac OS Resource Forks	165
New-Line Characters.....	165
Typographers Quotes.....	166
Being in Two Places at Once	166
Developing Your Code.....	169
What Is Cross-Compiling?	169
Building Code for the Correct Target CPU	170
Debug vs. Release.....	170
Managing Your Code.....	171
Why Do You Need Java?	172
Checking the Java Version on Windows	172
Checking the Java Version on Mac OS X	172
Checking the Java Version on Linux	173
Installing Java.....	173
Do You Need Java on Your ARTIK?	174
Summary	174
■ Chapter 12: Using Eclipse IDE	175
Installing, Configuring, and Using Eclipse IDE	175
Before You Install Eclipse IDE	175
Getting Help.....	175
Installing Eclipse IDE	176
Eclipse on Mac OS X.....	176
Workspace Preferences	178
Adding New Tools to Your Eclipse IDE	179

What Is a Toolchain?.....	180
Installing Support for ARTIK Development.....	180
Why Build Tools Are Needed	181
Installing the GNU ARM Eclipse Plugin on Mac OS X.....	181
Installing an ARM Toolchain on Mac OS	182
Configuring Your IDE for Remote Exploring	185
Setting Up a Default Toolchain	188
Semi-hosting Stubs.....	189
Support for the MIPS Architecture.....	190
Support for Eclipse Smart Home	190
Making a New ARM Project.....	190
Deploy the Binary to Your ARTIK.....	194
Summary	194
■ Chapter 13: Using Arduino IDE	195
Installing, Configuring, and Using Arduino IDE	195
Before You Install Arduino IDE	195
How To.....	195
Recommended Settings for Your Arduino IDE	197
Installing and Configuring libArduino	199
Configuring Your ARTIK for Uploads (Board Setup).....	201
Uploading a Sketch to Your ARTIK with Arduino IDE	202
Network Upload Method	202
Serial Upload Method	203
Native Sketch Compilation	203
Recommended Update Cycle	204
Developing with libArduino SDK.....	204

Arduino Pins: Type 1 Developer Reference Board	204
Arduino Pins: Type 5 and Type 10 Developer Reference Boards.....	206
System Commands	208
Detecting the Board Version.....	208
The Serial Object.....	209
The Serial1 Object.....	209
The DebugSerial Object.....	210
Pin Modes.....	210
Reading Digital Input Pin Values.....	211
Setting Digital Output Pin Values.....	211
Setting Analog Output Pin Values	212
Reading the Analog Inputs	213
Serial Peripheral Interface (SPI)	214
Detecting Interrupts	214
Pausing for Breath.....	214
Powersaving Mode	215
Compiling and Running Sketches Natively.....	215
Where to Find Out More	216
Troubleshooting.....	217
Managing the Type 5 vs. Type 10 Pin-Number Differences	217
CPU Utilization at 100 Percent.....	217
Digital Read Only Ever Reports a 1 Value	217
Porting Projects from Other Architectures.....	218
Logic Levels.....	218
Summary	218

■ Chapter 14: Using the Command Line	219
Command-Line ARM Toolchains	219
Ubuntu Linux	219
Debian Linux.....	220
Mac OS X.....	220
Adding a UNIX Command Line to Windows	221
UNIX I/O Streams and Redirection.....	221
What's Where?	222
File System Mapped Properties Inside the ARTIK.....	223
What CPU Is Available?	223
Detecting Current Processor Speed	224
Connecting to Remote Web Servers.....	224
Examples with curl	225
Useful UNIX Commands Inside Your ARTIK.....	226
Quitting and Aborting Processes	226
Inhibiting the Debugging Messages	227
Setting the Correct Date	228
Checking Your Memory Usage	228
The vi Editor (Why vi?).....	228
How to Use vi.....	229
Open a File for Editing or Create a New One	229
Inside the vi Editor	229
Saving and Exiting	229
Command Mode	230
The GCC Compiler.....	232
Language Support	233
Supporting Libraries	233
GCC ARM Compiler Support.....	234

Getting GCC Up and Running	234
Writing a Simple Program (Hello World)	235
Compiler Warnings	236
Next Steps	236
SCP: Secure Copy	236
File Upload to ARTIK Module.....	237
File Download from ARTIK Module	237
Summary	237
■ Chapter 15: Programming in C Language.....	239
Programming Your ARTIK Natively in C.....	239
Coding Strategies	239
Creating a Simple Application	240
Looking Deeper Inside Your ARTIK.....	241
About the /sys Virtual File System.....	242
GPIO Pins	243
GPIO: Pin Mapping	243
GPIO: Pin Export to the User Domain	245
GPIO: Pin Direction Setting	246
GPIO: Digital Value Setting	247
GPIO: Digital Value Reading	247
GPIO: Edge Detecting	248
Reading Analog Input Values	249
Analog Read Differences Between ARTIK 5 and 10	250
Library Function Toolkit.....	250
An Example	254
Accessing Remote Systems with libCurl.....	254
Summary	256

■ Chapter 16: Programming with Node.js	257
Developing with Node.js.....	257
The Architectural Design	258
Compiled Binary Code	259
Checking the Version of Your Node.js Installation	259
Extending Node.js.....	260
Installing NPM	260
Node Packages and Modules	261
Installing the WebSocket Module	262
Let's Write Some Node.js Code	262
Reading a Pin Voltage with Node.js.....	262
Sending Data to SAMI with Node.js.....	264
Summary	266
■ Chapter 17: Programming with Python	267
Developing with Python.....	267
Checking Your Python Interpreter.....	268
Installing the Python Package Manager	268
Installing Python Packages	269
Run a Simple Python Test.....	269
Reading a Pin Voltage with Python.....	270
Summary	271
■ Chapter 18: Integrating with SAMI	273
About SAMI.....	273
What Is SAMI?	274
Interacting with SAMI	275
How SAMI Works	275

SAMI Developer Documentation..... 276

Security 276

Authentication 277

Messages 277

User 278

User ID 278

Devices..... 279

Device Type 279

Device ID 280

Applications..... 280

Application ID 280

OAuth2 Access Tokens 280

Manifest 280

Raw Data..... 282

Normalized Data..... 282

The SAMI API 282

Developer SDK Libraries..... 283

SAMI Tools 284

 The Developer Portal 284

 The User Portal 285

 API Console..... 286

 Device Simulator 286

 Manifest Validator..... 286

User Portal: Managing Devices 286

 Device Details..... 288

User Portal: Managing Rules	289
Rule-based Actions.....	290
Adding New Rules	290
User Portal: Displaying Charts.....	292
User Portal: Viewing Data Logs	293
User Portal: Exporting Data	294
Developer Portal: Managing Device Types.....	294
Developer Portal: Managing Applications.....	295
Connecting to SAMI from Your Applications	295
Acquiring an Access Token for Your Application.....	296
Getting Data from SAMI for Your Application.....	296
Sending Data to SAMI from Your Device	297
Try Out More Examples	298
Want to Know More?	298
Summary	299
■ Chapter 19: Integrating with Temboo	301
Hello Temboo	301
Developing with Temboo	302
Registering Your Temboo Account	302
Your Temboo Account Dashboard	303
Monitoring Your Activity.....	304
Your Choreo Library Dashboard.....	306
Supported Platforms	307
Supported Connectivity	308

Online Data Storage	308
Choreographies	308
Condition Handling	310
Remote Storage in Profiles.....	311
Output Filters.....	311
Data Streaming	311
Machine-to-Machine (M2M) with Temboo.....	312
Temboo and ARTIK.....	312
Temboo and ARTIK 5.....	313
Getting Ready to Tango with Temboo	313
An Example of Code Generated by Temboo	315
Shared Login Credentials	320
Missing cdefs.h Message.....	321
Using CURL via a REST API Instead of C.....	321
Using Temboo with Node.js	322
Sample Code to Experiment With.....	322
Summary	324
■ Chapter 20: Debugging Your Application.....	325
Debugging Your App	325
Software Debugging with GDB	325
Onboard Native Debugging with GDB	326
Remote Debugging with GDB	327
IDE Support for Debugging.....	328
Emulating Your Hardware with QEMU	329
Using the JTAG Connectors	329

Hardware Debugging with SEGGER J-Link.....	329
Hardware Debugging with OpenOCD.....	331
Cleaning Up after Debugging	331
Summary	331
■ Chapter 21: Deploying Your Application	333
Getting Ready	333
Deploy Files to ARTIK with scp	333
Deploy Files across the Network.....	334
Deploy Files to Your ARTIK with a Micro SD Card	334
Deploy Files to Your ARTIK with a USB Flash Drive	337
Prototypes vs. Production	338
Integrating the ARTIK into your Products	338
Summary	339
■ Chapter 22: Next Steps.....	341
What Do You Want to Make?.....	341
Finding Out about More Project Ideas	343
Becoming a Partner Organization.....	344
Going Deeper into ARTIK Development.....	344
My Challenge to You	345
Index.....	347

About the Author



Cliff Wootton is a Royal Television Society (2002) Innovation award-winning former interactive TV systems architect at the BBC, specializing in content management systems and digital video. He was a guest speaker on pre-processing for video compression at the Apple WWDC 2007 developer conference and presented a technical paper on interactive TV systems at the NAB 2003 conference. He has taught IoT, real-world computing with Arduino, multimedia, video compression, metadata, and how to build multimedia art installations at the master's level at the University of the Arts, London. Cliff now concentrates on research and development projects, building digital media tools for creating audiovisual content, multimedia, electronic book publishing, writing, teaching, and playing the bass guitar.

Acknowledgments

Huge thanks are due to these people who created resources online and contributed ideas and practical help while I was writing this book. Their assistance was truly invaluable and is gratefully acknowledged.

- **Steve Weiss, Melissa Maldonado, Jeff Pepper, and Jonathan Gennick** at Apress—it has been great to work with you guys again
- **Glenn Cameron** at Samsung, who kindly provided prototype hardware and technical resources
- **Curtis Sasaki** for generously contributing the foreword
- **Fred Patton** at Samsung for his excellent photographic contributions and technical support
- **Martin Kronberg** for putting some helpful projects online in the Hackster.io blog
- **Simon Tatham**, who wrote and maintains the PuTTY application
- The minicom project team
- The Temboo team for their generosity in sharing insights into deeply technical interface code through their code-publishing mechanisms
- **Kevin Sharp** for his helpful contributions to the ARTIK blog
- All the `artik.io` forum posters whose questions inspired me to cover interesting topics
- **Gaynor Bromley** at Panasonic Electric Works UK Ltd for the AXT connector images
- **Joe Geoghegan** and **Bhavin Naik** at Mentor Graphics for technical white papers about Nucleus OS
- **Paul Stoffregen** for developing the `Bridge.h` library used in the Arduino IDE
- **Tevon Jordaan** for introducing me to Scrivener (an extraordinarily good book-writing tool).
- The Scrivener application developer team (see <http://www.literatureandlatte.com>)