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**DENNIS E.  
BROWN**

President,  
RFID Runner





# RFID Implementation

Dennis E. Brown



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### **RFID Implementation**

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# DEDICATION

This book is dedicated to Resa, my wife and my life for nearly 30 years.

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# INTRODUCTION

RFID stands for *Radio-Frequency Identification*. It is the name given to systems that put “tags” on objects (items bought and sold commercially, documents, people, animals, vehicles, containers, and so on) so they can be identified, tracked, and managed automatically utilizing radio frequency equipment and supporting computer systems. Tags are very small radio transmitter/responders (also called “transponders”) that store and broadcast data. There are a variety of types of tags, and they come in various shapes, sizes, and capabilities. The data in the tag may be a simple identification number that identifies the object, or it may fully describe it. It may give its history or contain relevant information such as warnings or instructions. The tag most often contains just a number, similar to a license plate on a car. The number serves as a key to a record in a database on a “host computer,” which stores the actual data. The format of the number is an important consideration, as it must be read by a variety of systems, not all of which may be known at the time the system is designed. When the tags are in the vicinity of a reader, they broadcast their contents. The reader captures this information and sends it to a host computer. The host uses the data in an application program, such as a warehouse management system, inventory system, database or Enterprise Resource Planning (ERP) system. The data may also be stored in a data warehouse where analysts can use it to study, evaluate, and improve the movement of goods; reduce the time involved; and uncover various hidden dependencies and correlations.

RFID is one of many tools that perform automatic collection of data. Similar tools you may be familiar with are bar codes and credit cards with magnetic stripes on them. RFID differs from these in that it is more automatic, and it is capable of higher speeds of operation. Thus, RFID can automatically gather data that might not be collected otherwise. Having collected the data, you can then use it to improve your operations and solve several very complex and time-sensitive problems. In 2004, Wal-Mart and the Department of Defense decided they wanted to solve those problems. They announced a schedule by which their suppliers needed to attach RFID tags on the pallets and cases of goods they shipped to particular distribution centers. Best Buy, Target, Albertson’s, and Metro Group in Europe all quickly made similar demands. These demands have been called “mandates” in the press. As people began to understand the scope of the mandates, RFID went from obscurity to celebrity very quickly.

The excitement around RFID centers on its “new” applicability to supply chain management, but RFID is in widespread use in other applications as well. As Chapter 5 describes, RFID technology has applicability for baggage handling, security, asset management, and a host of other uses. These applications, less dramatic in many cases than those in the supply chain, are nonetheless profitable uses of the technology. They benefit from the falling costs of tags and readers and the increased number of persons familiar with the techniques that arise from the supply chain uptake.

## Background

RFID’s basic technology dates from World War II, where it was used to identify friendly ships and airplanes. Today, low-cost tags and equipment and sophisticated applications support a variety of new uses for the technology beyond aircraft identification.

In June 2003, it was apparent that the following developments were either fully available or would be available soon:

- Protocols were becoming standardized.
- The price of tags was coming down.
- Higher-frequency technology was becoming available.
- The ability to send and receive data at faster data rates was being developed.
- The ability to read multiple tags in the same read zone at the same time was demonstrated.
- Software was becoming available that would utilize the RFID-generated data.

In addition to these developments, the rise of the Internet as a critical part of most companies’ infrastructure means that connectivity is always on and always available. Tags anyplace in the world can communicate with a nearby reader and thus signal their location and telemetry (temperature, moisture, pedigree, radiation) to listening applications.

The United States Department of Defense (DoD) and Wal-Mart and other retailers felt they could justify requiring their vendors to tag pallets and cases being shipped to them. In July 2005, tags containing integrated circuit chips were commercially available for about 25–30 cents each in large quantities. By September, one firm announced they had reduced



their tag prices to 15 cents each. It is widely believed that when tags reach a price of 5 cents or less each, retailers will require that they be used on individual low-cost items, not just the cases, pallets, and containers. Experts now project that this will happen in the 2007–2008 time-frame.

RFID systems generate data that organizations can use to improve operations. RFID's proponents claim that these systems:

- Improve management of facilities, assets, and resources
- Reduce theft or misplacement of goods, tools, equipment, files, prisoners, or small children
- Keep detailed records of the history of each item in trade
- Increase the speed and accuracy of nearly all business transactions
- Enable suppliers to comply with customer mandates

Accomplishing these goals requires that you keep data that is current, complete, and error free. This perfecting of the data in databases is an often-overlooked prerequisite to utilizing the collected data for decision making. But RFID is unique because other currently available methods of data collection are costly, cumbersome and, in some cases, unreliable and too slow to provide high quality, synchronized data. The payoff for an RFID project comes from the utilization of the data to drive down errors, theft, cost, and inefficiency and to increase the speed of a company's activities and transactions.

## Major Vendor Support for RFID

RFID has attracted the attention of the most sophisticated companies in the technology sector. IBM, Accenture, Sun, HP, Microsoft, and Intel have all announced major investments in RFID products and services. Oracle and SAP have RFID initiatives. And companies such as Symbol and Intermec, RFID industry leaders, are seeing substantial growth. Many large consumer goods companies are conducting pilots, and several have begun large-scale deployments.

RFID today delivers value for companies, with the ability to provide real-time error-free information that they can use to solve complex business problems. As the cost of tags continues to come down, companies will find new and innovative uses for the technology. As new global

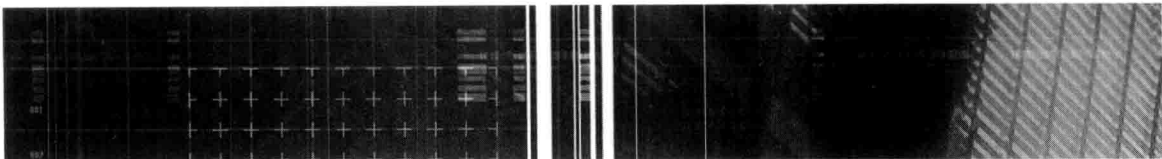
standards are announced and embodied in available products, the barriers to adoption are reduced. With leading companies demanding RFID tags on products and shipping containers, the technology will continue its rapid adoption throughout the total supply chain. Consumers will become better educated about the technology to allay their privacy fears. As with other disruptive technologies, companies that master RFID early will enjoy competitive advantages as compared with those that wait. Companies around the world are starting pilot projects and learning how to work with this exciting technology.

# CONTENTS

	About the Author	viii
	Acknowledgments	ix
	Introduction	x
<b>PART I</b>	<b>The Basics</b>	<b>1</b>
<b>Chapter 1</b>	<b>RFID Physics, Standards, and Regulations</b>	<b>3</b>
	1.1 RFID Physics	4
	1.2 Deciding on Your Frequency	15
	1.3 RFID Standards Bodies and Organizations	18
	1.4 United States Federal Communications Commission (FCC)	27
	1.5 Singapore	28
	1.6 European Telecommunications Standards Institute (ETSI)	28
	1.7 Japan	29
	1.8 China	29
	1.9 Chapter Summary	30
<b>Chapter 2</b>	<b>The EPCglobal Network</b>	<b>31</b>
	2.1 Electronic Product Code (EPC)	33
	2.2 EPC Encoding Schemes	37
	2.3 EPC Gen-2 Identification System	49
	2.4 EPC Middleware	53
	2.5 EPCglobal Network Information Services Functionality	56
	2.6 Chapter Summary	60
<b>Chapter 3</b>	<b>Components of an RFID System</b>	<b>61</b>
	3.1 Data	63
	3.2 Tags	64
	3.3 Antennas	81
	3.4 Connectors	91
	3.5 Cables	92
	3.6 Readers	92
	3.7 Encoder/Printers for Smart Labels	103
	3.8 Controllers	106
	3.9 Software	107
	3.10 Chapter Summary	113
<b>Chapter 4</b>	<b>Bar Codes and RFID Tags</b>	<b>115</b>
	4.1 Bar Codes Introduced	116
	4.2 Bar Code Symbolologies	119
	4.3 Bar Code Advantages	125
	4.4 RFID Advantages over Bar Codes	128
	4.5 Chapter Summary	130

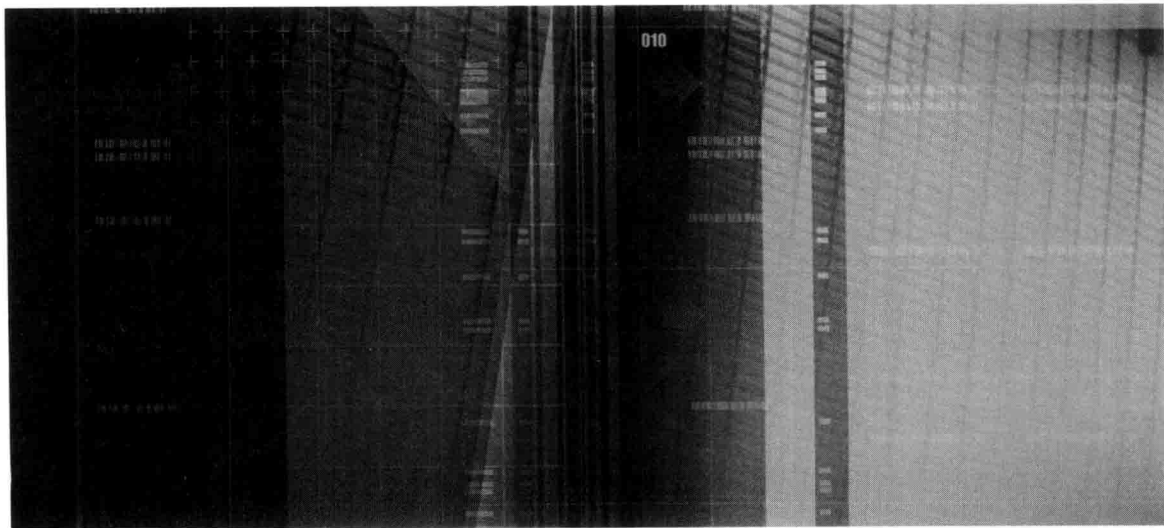
<b>PART II</b>	Applications	133
<b>Chapter 5</b>	RFID Applications	135
	5.1 Signature Applications	136
	5.2 RFID Application Types	149
	5.3 The Question of Return on Investment	170
	5.4 Chapter Summary	170
<b>Chapter 6</b>	RFID at the United States Department of Defense	173
	6.1 World War II Logistics	175
	6.2 Desert Storm Logistics	175
	6.3 Between the Wars	177
	6.4 Logistics in Afghanistan: Enduring Freedom (2001)	178
	6.5 Logistics in Iraq I: Iraqi Freedom	178
	6.6 The DoD RFID Mandate	181
	6.7 The Challenge	186
	6.8 Chapter Summary	186
<b>Chapter 7</b>	The Pharmaceutical Industry	187
	7.1 The Role of the U.S. Federal Drug Administration	188
	7.2 Regulatory Pressure by States	191
	7.3 Drug Counterfeiting	192
	7.4 Product Returns	192
	7.5 Inventory Management	192
	7.6 Patient Safety and Quality Control	192
	7.7 Product Recalls	193
	7.8 Chapter Summary	193
<b>Chapter 8</b>	RFID in the Supply Chain	195
	8.1 The Retailer in the Supply Chain	197
	8.2 Supply Chain Management (SCM)	207
	8.3 The Adaptive Network	219
	8.4 Chapter Summary	222
<b>PART III</b>	Your Project	223
<b>Chapter 9</b>	Business Justification for RFID	225
	9.1 Enumerate Potential Applications	228
	9.2 Build Business Cases	228
	9.3 Determine Priorities	245
	9.4 Create Milestones	246
	9.5 The Controversy Around ROI for RFID	247
	9.6 Chapter Summary	251
<b>Chapter 10</b>	Plan Your Project	253
	10.1 Phase 1: Preliminary Planning	257
	10.2 Phase 2: Step 1, Plan the Pilot	267

10.3 Phase 2: Step 2, Execute the Pilot	291
10.4 Phase 3: Step 1, Plan Your Technical Integration	296
10.5 Phase 3: Step 2, Execute Technical Integration	302
10.6 Phase 4: Step 1, Plan Your Rollout	306
10.7 Phase 4: Step 2, Execute the Rollout	314
10.8 Review and Evaluate the Project	316
10.9 Implementation Notes	316
10.10 Chapter Summary	322
<b>Chapter 11</b> Tag-and-Ship	323
11.1 Tag-and-Ship Is Controversial	324
11.2 Methods of Tag-and-Ship	325
11.3 Steps to Tag-and-Ship	326
11.4 Slap-and-Ship with Smart Labels	329
11.5 Tag-and-Ship with RFID Tags	330
11.6 Training and Onsite Documentation	331
11.7 Moving Beyond Tag-and-Ship	335
11.8 Chapter Summary	335
<b>Chapter 12</b> Engineering Tag Performance	337
12.1 Your Test Department	338
12.2 Site Analysis	347
12.3 Test Facilities	355
12.4 The Testing Protocols	357
12.5 Chapter Summary	375
<b>Chapter 13</b> Data Integrity and Data Synchronization	377
13.1 Data Quality Assessment	380
13.2 Data Management	385
13.3 Global Data Synchronization	389
13.4 Chapter Summary	395
<b>Chapter 14</b> Privacy	397
14.1 Privacy in Various Countries	399
14.2 Parsing the Problem	404
14.3 The Solution	407
14.4 EPC Privacy Guidelines	408
14.5 Fair Information Practices and the RFID Bill of Rights	410
14.6 The Role of the Implementer	411
14.7 Chapter Summary	413
<b>PART IV</b> References	415
Appendix A Typical Application Profiles	417
Appendix B Bibliography	419
Glossary	427
Index	443

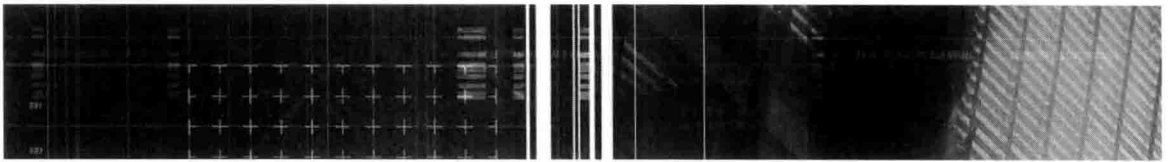


PART **I**

The Basics

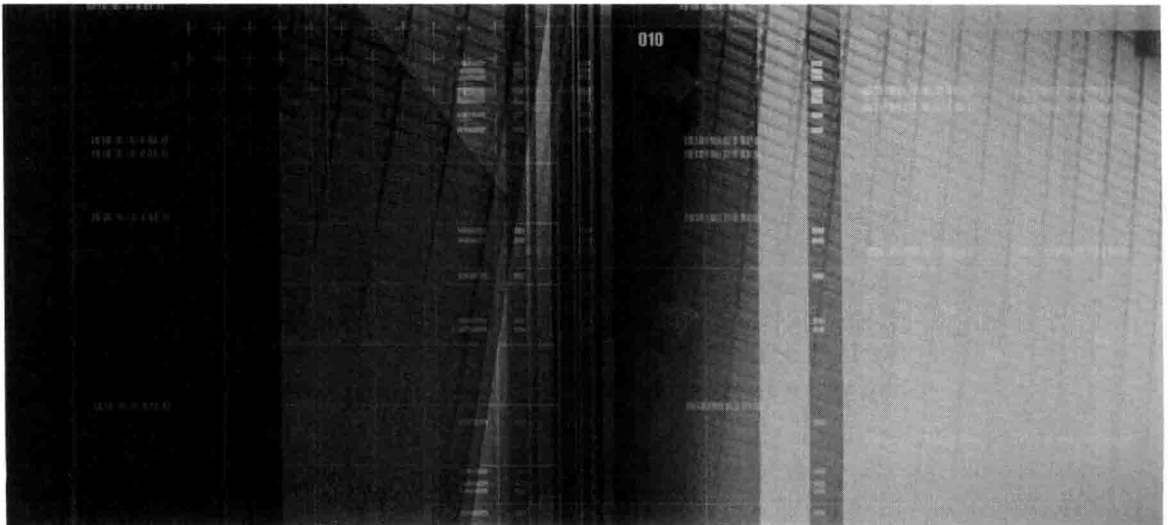






CHAPTER **1**

# RFID Physics, Standards, and Regulations





Too many RFID systems are installed based on “one-size-fits-all” starter kits and trial-and-error project methodologies. These two approaches ignore the physics and distinctive characteristics of the radio waves that govern how well the systems will work in practice. The result is predictable: tag-read rates are low and the systems perform ineffectually. This chapter describes the science behind your RFID system, the underlying mechanics on which all RFID systems are built. It then goes on to explain the standards and regulations that enable systems built by different manufacturers to work together.

## 1.1 RFID Physics

A wave is a disturbance that carries energy from one place to another. Radio waves are created when electrons are passed through a conductor, like an electrical wire. The current creates a magnetic field. Fluctuations in the current produce changes in the magnetic field, creating *waves* of electromagnetic energy. These are called electromagnetic (EM) waves.

There are many types of EM waves you encounter other than radio waves, such as microwaves, gamma waves, x-rays, and light. EM waves oscillate, or vibrate. *Radio waves* are low-frequency electromagnetic waves, which means they oscillate more slowly, and their wavelengths are longer than other types of EM waves. Radio waves share many characteristics with other EM waves, but they differ from light and microwaves in important ways.

Radio waves and light waves both pass readily through air. But unlike light, radio waves can pass through many other materials such as plastic, cardboard, wood, cloth, and so on. Radio waves are less efficient at passing through metal, graphite, sodium, and liquids. We call these *opaque materials*. See Section 1.1.1 for a discussion of this important topic. Different wave frequencies differ in their ability to penetrate opaque materials. We will return to this point often in this book, as it impacts many aspects of implementing your system. Frequency and wavelength are discussed in detail in Section 1.1.2.

You probably have experience with radio waves every day, as you make use of radio and television entertainment and cordless telephones. All of these use radio waves to deliver sound or pictures to your car or house (excluding alternate delivery mechanisms such as cable television). Every day, you make use of the ability of radio waves to carry data such as voice,