WAVES SERIES



Design Constraints for NFC Devices

Dominique Paret





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First published 2016 in Great Britain and the United States by ISTE Ltd and John Wiley & Sons, Inc.

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ISTE Ltd 27-37 St George's Road London SW19 4EU UK

www.iste.co.uk

John Wiley & Sons, Inc. 111 River Street Hoboken, NJ 07030 USA

www.wiley.com

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Library of Congress Control Number: 2016933848

British Library Cataloguing-in-Publication Data A CIP record for this book is available from the British Library ISBN 978-1-84821-884-0

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Acknowledgements

During my long career in three disciplines – firstly as a professional and industrialist at Philips/NXP Semi-Conductors, secondly and simultaneously as a teacher at numerous engineering schools and universities, and finally, for the past ten years, as founder of dp-Consulting (a firm of consultants and independent technical experts) – I have had the opportunity to meet many experts in this field. Therefore, it is extremely difficult to thank everyone individually to whom thanks are due – that could fill an entire book and more! In addition, as NFC (Near-Field Communication) has such a vast range of applications, it would be fallacious to try to write such a book as this on the subject alone, so my heartfelt thanks go to numerous colleagues and friends:

- from NXP Semiconductors in Graz (Austria), Hamburg (Germany), Monza (Italy), and Caen (France), with whom I have worked for many years;

- customers, partners, and competitors whom I frequently meet at working meetings of the ISO and "mirror" commissions at AFNOR (France's standardization body).

In addition, in the coming chapters, I shall occasionally address some specific acknowledgements to various friends for their help.

I also devote this book to the many, many readers who have followed me over the years, through series of publications and technical reports. I owe to you many of these words of gratitude, because it is thanks to you and for you that I have been able to take my courage in both hands to squeeze as much detail out of the subject as possible, with a view to presenting some of its mysteries in as didactic a fashion as possible! In any case, thanks again to one and all for your help and your assiduousness in reading my work. If these few words of thanks have encouraged you to persevere in learning the technique and given you a vocation as a trainer and pedagogue, I would be delighted.

Once again, my true thanks to all of you for your contributions and your faithful friendship.

Preface

Why and for Whom is this Book Written?

Why

Working in the field of NFC (*Near-Field Communication*) since its very beginnings (a little over 15 years now!), I have written a great deal about this subject in the past. Many advances have been made on the basis of the operational principles, and wonderful and highly varied applications (*software*) in NFC (particularly with mobile phones). However (there is always a but), there has been relatively little detailed literature produced on the specific functions and the mysteries of application-specific integrated circuits and antennas (*hardware*) involved in NFC, and less still about the physical layers – the air interface. It is my hope that this book will go a long way towards filling that void.

Therefore, I would rather clarify the situation immediately. It is not out of pure ideology that I wish to rectify this shortcoming, but instead because it is a day-to-day reality. Designers and users often graciously overlook certain constraints, thinking "It will work fine without it"! However, communicating through the air interface, networked antennae, the various form factors of different applications and physical environments, their problems are unfortunately truths that must be taken into account, and without which nothing constructive can be achieved.

For whom

Having been a technical consultant for many years to numerous companies in navigating these mysterious waters, and in view of the thriving NFC market, I have designed this book to serve engineers, technicians, students, and the growing number of new arrivals to this domain, to help them avoid certain pitfalls. At present, there is little information or basic technical and application training available on these subjects. Hence, today, I offer this book to give you an initiation in the field and a specific knowledge of the constraints of design devoted to NFC devices, and I have taken it upon myself to gather, compile, and collate a technical database made up of various generic industrial examples, concrete and highly-detailed examples of "designs for NFC devices and possibly more", with widespread involvement from my company "dp-Consulting".

The aim of this book is not to be a coverall in marketing, or a joyous ramble through the subject, but a technical reference offering an in-depth examination of all the technical details and all the functional and application issues pertaining to these technologies. As readers will discover over the course of the book, the field of applications and usages is enormously varied – ranging from the exchange of dematerialized data to secure payment, controlled by a pocket device (such as a mobile phone or a camera), which can also be used as a chip card or a reader, a television, in a car, etc. Thus, we have a multitude of "form factors", environments, etc., leading to a multitude of technical problems where antennas are concerned!

Additionally, so as not to hamper readers' understanding of the devices presented herein, I have done my utmost to make the book as clear and instructive as possible, so they can instantly see the point being made and the link between theory, technological aspects, financial factors, etc.

For now, I hope that readers will find this book enjoyable and illuminating. Above all, enjoy it, because it is for you (not for me) that I have written it! On that point, if any shadow of a doubt remains, readers are always welcome to contact me to put forward any comments, remarks, questions, etc. (provided they are constructive, of course) about the substance and the form of this book, via e-mail at dp-consulting@orange.fr.

IMPORTANT NOTES.- It must also be noted that this book is intended to complement many of my other works. Those works offer a more specific, even more detailed focus on the techniques used in contactless technology, in near fields in HF and NFC, and the implementation of those techniques. This further reading should also sate the technical curiosity of the vast majority of

users. Note, also, that I have borrowed and reproduced from those books¹ a number of sections written previously, because sometimes it is very difficult not to simply rewrite the same things on the same subjects, all the more so given that those writings on the physical fundaments of NFC date from the late 19th Century (Biot, Savart, Maxwell and Laplace). Given that this field is evolving rapidly, it will inevitably be necessary to update the content of these books in three or four years' time, but in any case, until then at least readers will have the fundamental principles in place!

Warning

This book is intended to serve as an introduction to, and a detailed, instructive presentation of, the principles and constraints of NFC, and also to give people coming into this field an overall conceptual and applicational view of it.

EXTREMELY IMPORTANT NOTE. – From the very start, I wish to draw readers' attention to the important fact that, in order to give adequate coverage of the field of NFC, this book describes a great many patented technical principles, subject to the holding of licences and their associated rights (bitcodes, communication techniques, etc.). They have already been published in official professional technical texts/communications, or at conferences/ public seminars, but above all, they must be used in accordance with the legislation in force.

Dominique PARET February 2016

¹ Numerous documents and articles previously written by Dominique Paret and prepared for other technical publications have been included and adapted:

[–] Applications en identification radiofréquence et cartes à puces sans contact, vol. 1, Dunod, Paris, 2003.

⁻ RFID and Contactless Smart Card Applications, Wiley, Hoboken, 2005.

[–] NFC (Near Field Communication). Principes et applications de la communication en champ proche, Dunod, Paris, 2012.

Introduction

This book is specifically devoted to the design (theoretical and practical) of antennas for "NFC devices", irrespective of their environments, sizes, and applications (readers, tags, mobile phones in card emulation mode, peer-to-peer (P2P) mode, tablets, communicating objects, TVs, photo frames, etc.).

Before going into detail about the content of the individual chapters, it is assumed that readers already have some degree of familiarity with the field of radiofrequency (RF) and know roughly what the term "NFC" covers. Therefore, after a brief recap of the basics of the technical constraints and the normative framework which must always be borne in mind, we shall carry out a detailed examination of the designs of 13.56 MHz antennas for NFC "*initiators*" and "*targets*", but also of all the problems of mutual interactions between initiators and targets which must always be taken into account in order to ensure the correct operation of an NFC setup.

Readers should take note right now that when reading this book, they should always be conscious of the problems that may be caused by the physical layer (the medium and its management). The challenge here, then, is to present this book in as appropriate and clear a way as possible to help in understanding all these issues. After much reflection and discussion, a choice had to be made in favor of an overarching, clearly-didactic presentation, so that readers can easily orientate themselves in the maze of all these laws of communication, which many of our readers will discover and employ in years to come. The division of the table of contents gives a very clear roadmap to follow in order to gain a helpful view of the concrete design of antennas for all sorts of "NFC devices", and of the state-of-the-art in the field.

And now, dear friends, to work!

Part 1

Introduction to – and Reminders About – NFC

Introduction to Part 1

The first part of this book is divided into three chapters. In Chapter 1, the aim is to recap the operational principles of near-field communication (NFC) succinctly.

Chapters 2 and 3 describe the rigid structure of normative and regulatory constraints which apply to NFC elements, and primarily the design of their radiofrequency stages, their antennas and the connective problems directly associated therewith.

Although this first part of the book is an introduction, it encapsulates numerous technical points which are important to know in order to appreciate the application problems of today's world and of these devices.

It is now for you, the readers, to discover all this for yourselves.