RFID AT ULTRA AND SUPER HIGH FREQUENCIES

Theory and application

Dominique Paret
Consultant – Senior Technical Expert, DP-Consulting

Translated by: Roderick Riesco, MA, Member of the Institute of Translation and Interpreting, UK
Part Two  Wave Propagation: Principles, Theories ... and the Reality  55

4  Some Essential Theory  57
   4.1 The Phenomenon of Propagation and Radiation  57
   4.2 The Hertzian Dipole  57
   4.3 Classification of Fields and Regions of Space  62
   4.4 RFID Applications Using UHF and SHF, i.e. Far Field Applications  66
   4.5 The Hertzian Dipole and a Dipole of any Length, $\lambda/n$ and $\lambda/2$  85
   4.6 List of the Main Formulae in this Chapter  92
   4.7 Appendix 1: Brief Notes on Maxwell's Equations  94
   4.8 Appendix 2: Brief Notes on Complex Numbers  96
   4.9 Appendix 3: Brief Notes on Powers Expressed as Complex Numbers  97
   4.10 Appendix 4: Brief Notes on Vectors  100

5  Wave Propagation in Free Space  103
   5.1 Isotropic and Anisotropic Antennas  103
   5.2 Antenna Gain  105
   5.3 Power Flux Density at One Point in Space  110
   5.4 Effective Radiated Power $P_{\text{ERP}}$  112

6  Power Recovery at the Terminals of the Tag Antenna  121
   6.1 Recovering the Transmitted Radiated Power (or Some of It)  121
   6.2 The Concept of Aperture or Surface  122
   6.3 Definition of the Main Parameters Required for an RFID Application  140

7  Reality Check: How to Manage Everyday Problems  163
   7.1 Effects of the Application Environment  164
   7.2 Tag Polarization Losses, $\theta_{\text{polarization}} = p$  177
   7.3 Antenna Load Mismatch Factor, $\theta_{\text{load matching}} = q$  183
   7.4 Voltage Standing Wave Ratio (VSWR)  187
   7.5 Losses Due to the Physical Design of the Antenna, $\theta_{\text{antenna}}$  195
   7.6 By Way of Conclusion  195
   7.7 Real-World Examples of RFID at UHF and 2.45 GHz  196
   7.8 Effects of the Mounting of the Integrated Circuit on the Tag Substrate  198
   7.9 By Way of Conclusion  199
   7.10 Example at UHF and SHF  199
   7.11 Appendix: Fact and Fantasy About UHF Tags and Water  202

8  Reflection and/or Reradiation of Waves and RFID Applications  207
   8.1 The Physical Phenomenon of Wave Scattering  207
   8.2 Scattering Modes  209
   8.3 Power Scattered/Reradiated/Reflected by the Tag, $P_s$  209
   8.4 Radar Cross-Section (RCS) of the Tag, $\sigma_s$  220
   8.5 Appendix  238
# Contents

## Part Four Standards and Regulations

15 Standards for RFID at UHF and SHF

15.1 The Purpose of the Standards

15.2 Users and Providers of Standards

15.3 The ISO/OSI Layer Models

15.4 ISO Standards for Contactless Technology

15.5 Appendix 1: Hierarchy and Structure of the EPC System

15.6 Appendix 2: Structure of the EPC Number

15.7 Appendix 3: Some Facts about the Everyday Performance of ISO 18000-6 mode C – EPC C1 G2

16 Regulations and Human Exposure

16.1 Survey of Standards and Regulations

16.2 Summary of Regulations in the USA, Europe, France and the Rest of the World Relating to RFID at UHF and SHF

16.3 Standards for Magnetic and Electrical Fields in a Human Environment: Human Exposure

16.4 Other Requirements to be Met

17 The Effects and Repercussions of Regulations on Performance

17.1 Frequency

17.2 Transmission Level

17.3 Summary

17.4 Comparison Between Europe and the USA

17.5 UHF or 13.56 MHz Around the World and in Europe

17.6 Appendix: The Main Standards and Regulations

## Part Five Components for Tags and Base Stations

18 RFID Tags

18.1 Some General Remarks

18.2 Summary of Operating Principles

18.3 The Technology of Tags

18.4 Antennas for Tags

19 The Base Station

19.1 Introduction

19.2 Examples of Base Station Hardware Architecture

19.3 Examples of Products

19.4 Antennas for Base Stations

19.5 Some Concluding Remarks

20 Conformity, Performance and Methods for Evaluating Tags and Systems

20.1 Official Measurement and Test Methods

20.2 Required Parameters