



THE COMMUNICATIONS HANDBOOK SECOND EDITION

Editor-in-Chief

Jerry D. Gibson

*Southern Methodist University
Dallas, Texas*



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Preface

The handbook series published by CRC Press represents a truly unique approach to disseminating technical information. Starting with the first edition of *The Electrical Engineering Handbook*, edited by Richard Dorf and published in 1993, this series is dedicated to the idea that a reader should be able to pull one of these handbooks off the shelf and, at least 80% of the time, find what he or she needs to know about a subject area. As handbooks, these books are also different in that they are more than just a dry listing of facts and data, filled mostly with tables. In fact, a hallmark of these handbooks is that the articles or chapters are designed to be relatively short, written as tutorials or overviews, so that once the reader locates the broader topic, it is easy to find an answer to a specific question.

Of course, the authors are the key to achieving the overall goal of the handbook, and, having read all of the chapters personally, the results are impressive. The chapters are authoritative, to-the-point, and enjoyable to read. Answers to frequently asked questions, facts, and figures are available almost at a glance. Since the authors are experts in their field, it is understandable that the content is excellent. Additionally, the authors were encouraged to put some of their own interpretations and insights into the chapters, which greatly enhances the readability. However, I am most impressed by the ability of the authors to condense so much information into so few pages. These chapters are unlike any ever written—they are not research journal articles, they are not textbooks, they are not long tutorial review articles for magazines. They really are a new format.

In reading drafts of the chapters, I applied two tests. If the chapter covered a topic with which I was familiar, I checked to see if it contained what I thought were the essential facts and ideas. If the chapter was in an area of communications less familiar to me, I looked for definitions of terms I had heard of or for a discussion that informed me why this area is important and what is happening in the field today. I was amazed at what I learned.

Using *The Communications Handbook* is simple. Look up your topic of interest either in the [Table of Contents](#) or the Index. Go directly to the relevant chapter. As you are reading the chosen chapter, you may wish to refer to other chapters in the same main heading. If you need some background information in the general communications field, you need only consult [Section I, Basic Principles](#). There is no need to read *The Communications Handbook* beginning-to-end, start-to-finish. Look up what you need right now, read it, and go back to the task at hand.

The pleasure of such a project as this is in working with the authors, and I am gratified to have had this opportunity and to be associated with each of them. The first edition of this handbook was well-received and served an important role in providing information on communications to technical and non-technical readers alike. I hope that this edition is found to be equally useful.

It is with great pleasure that I acknowledge the encouragement and patience of my editor at CRC Press, Nora Konopka, and the efforts of both Nora and Helena Redshaw in finally getting this edition in print.

Jerry D. Gibson
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Editor-in-Chief

Jerry D. Gibson currently serves as chairman of the Department of Electrical Engineering at Southern Methodist University in Dallas, Texas. From 1987 to 1997, he held the J. W. Runyon, Jr. Professorship in the Department of Electrical Engineering at Texas A&M University. He also has held positions at General Dynamics—Fort Worth, the University of Notre Dame, and the University of Nebraska—Lincoln, and during the fall of 1991, Dr. Gibson was on sabbatical with the Information Systems Laboratory and the Telecommunications Program in the Department of Electrical Engineering at Stanford University.

He is co-author of the books *Digital Compression for Multimedia* (Morgan–Kaufmann, 1998) and *Introduction to Nonparametric Detection with Applications* (Academic Press, 1975 and IEEE Press, 1995) and author of the textbook *Principles of Digital and Analog Communications* (Prentice-Hall, 2nd ed., 1993). He is editor-in-chief of *The Mobile Communications Handbook* (CRC Press, 2nd ed., 1999) and *The Communications Handbook* (CRC Press, 1996) and editor of the book *Multimedia Communications: Directions and Innovations* (Academic Press, 2000).

Dr. Gibson was associate editor for speech processing for the *IEEE Transactions on Communications* from 1981 to 1985 and associate editor for communications for the *IEEE Transactions on Information Theory* from 1988 to 1991. He has served as a member of the Speech Technical Committee of the IEEE Signal Processing Society (1992–1995), the IEEE Information Theory Society Board of Governors (1990–1998), and the Editorial Board for the *Proceedings of the IEEE*. He was president of the IEEE Information Theory Society in 1996. Dr. Gibson served as technical program chair of the 1999 IEEE Wireless Communications and Networking Conference, technical program chair of the 1997 Asilomar Conference on Signals, Systems, and Computers, finance chair of the 1994 IEEE International Conference on Image Processing, and general co-chair of the 1993 IEEE International Symposium on Information Theory. Currently, he serves on the steering committee for the Wireless Communications and Networking Conference.

In 1990, Dr. Gibson received The Fredrick Emmons Terman Award from the American Society for Engineering Education, and, in 1992, was elected fellow of the IEEE “for contributions to the theory and practice of adaptive prediction and speech waveform coding.” He was co-recipient of the 1993 IEEE Signal Processing Society Senior Paper Award for the field of speech processing.

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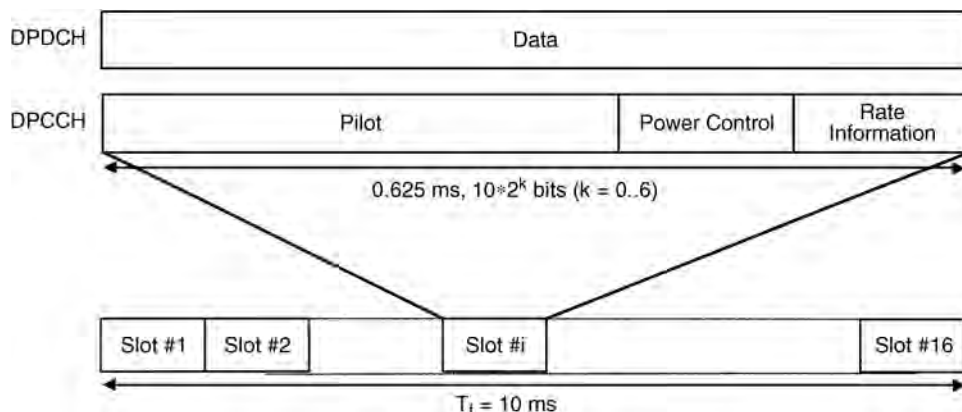


FIGURE 89.6 Reverse link dedicated channel structure in WCDMA.

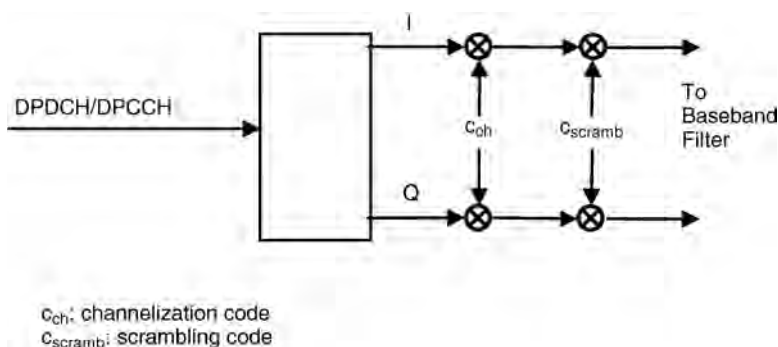


FIGURE 89.7 Forward link spreading of DPDCH and DPCCH.

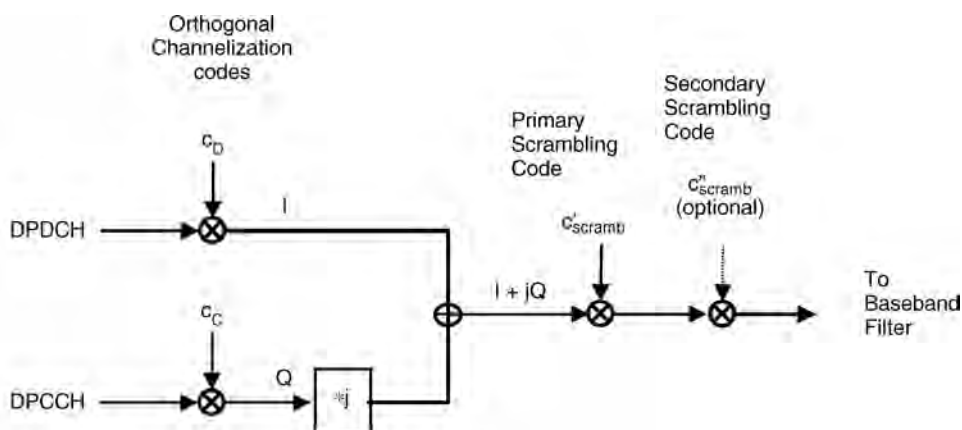


FIGURE 89.8 Reverse link spreading for the DPDCH and DPCCH.

reverse DPDCH channels have been convolutional encoded and interleaved prior to framing. The major difference between the forward and reverse links is that the reverse channel structure of the DPCCH is a separate code channel from the DPDCH.

After framing, the forward and reverse link channels are spread as shown in Figs. 89.7 and 89.8. On the forward link orthogonal, variable rate codes, c_{ch} , are used to separate channels and pseudo random

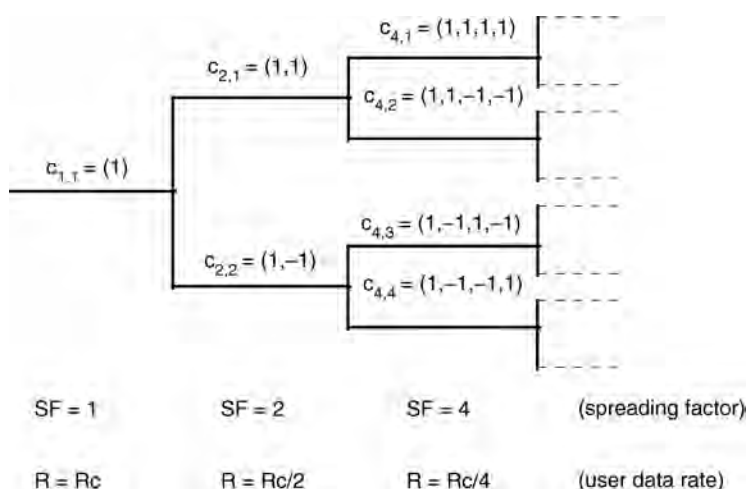


FIGURE 89.9 Construction of orthogonal spreading codes for different spreading factors.

scrambling sequences, c_{scramb} , are used to spread the signal evenly across the spectrum and separate different base stations. On the reverse link, the orthogonal channelization codes are used as in the forward link to separate CDMA channels. The scrambling codes, c'_{scramb} and c''_{scramb} , are used to identify mobile stations and to spread the signal evenly across the band. The optional scrambling code is used as a means to group mobiles under a common scrambling sequence.

Spreading Codes

WCDMA employs long spreading codes. Different spreading codes are used for cell separation in the forward link and user separation in the reverse link. In the forward link Gold codes of length 2^{18} are truncated to form cycles of 2^{16} times 10 ms frames. In order to minimize the cell search time, a special short code mask is used. The synchronization channel of WCDMA is masked with an orthogonal short Gold code of length 256 chips spanning one symbol. The mask symbols carry information about the BS long code group. Thus, the mobile station first acquires the short mask code and then searches the corresponding long code. A short VL-Kasami code has been proposed for the reverse link to ease the implementation of multiuser detection. In this case, code planning would also be negligible because the number of VL-Kasami sequences is more than one million. However, in certain cases, the use of short codes may lead to bad correlation properties, especially with very small spreading factors. If multiuser detection were not used, adaptive code allocation could be used to restore the cross-correlation properties. The use of short codes to ease the implementation of advanced detection techniques is more beneficial in the forward link since the cyclostationarity of the signal could be utilized for adaptive implementation of the receiver.

Orthogonality between the different spreading factors can be achieved by tree-structured orthogonal codes whose construction is illustrated in Fig. 89.9 [5]. The tree-structured codes are generated recursively according to the following equation,

$$c_{2n} = \begin{pmatrix} c_{2n,1} \\ c_{2n,2} \\ \vdots \\ c_{2n,2n} \end{pmatrix} = \begin{pmatrix} \begin{pmatrix} c_{n,1} & c_{n,1} \\ c_{n,1} & -c_{n,1} \end{pmatrix} \\ \vdots \\ \begin{pmatrix} c_{n,n} & c_{n,n} \\ c_{n,n} & -c_{n,n} \end{pmatrix} \end{pmatrix}$$