Digital Signal Processing for Measurement Systems

Theory and Applications

Information Technology: Transmission, Processing, and Storage

Series Editors: Robert Gallager
Massachusetts Institute of Technology
Cambridge, Massachusetts

Jack Keil Wolf
University of California at San Diego
La Jolla, California

The Multimedia Internet
Stephen Weinstein

Coded Modulation Systems
John B. Anderson and Arne Svensson

Communication System Design Using DSP Algorithms:
With Laboratory Experiments for the TMS320C6701 and TMS320C6711
Steven A. Tretter

Interference Avoidance Methods for Wireless Systems
Dimitrie C. Popescu and Christopher Rose

MIMO Signals and Systems
Horst J. Bessai

Multi-Carrier Digital Communications: Theory and Applications of OFDM
Ahmad R.S. Bahai, Burton R. Saltzberg and Mustafa Ergan

Performance Analysis and Modeling of Digital Transmission Systems
William Turin

Stochastic Image Processing
Chee Sun Won and Robert M. Gray

Wireless Communications Systems and Networks
Mohsen Guizani

A First Course in Information Theory
Raymond W. Yeung

Nonuniform Sampling: Theory and Practice
Edited by Farokh Marvasti

Principles of Digital Transmission: with Wireless Applications
Sergio Benedetto and Ezio Biglieri

Simulation of Communication Systems, Second Edition: Methodology,
Modeling, and Techniques
Micheal C. Jeruchim, Phillip Balaban and K. Sam Shanmugan

Wireless Networks
Multiuser Detection in Cross-Layer Design
Christina Comaniciu, Narayan B. Mandayam and H. Vincent Poor

Digital Signal Processing for Measurement Systems

Theory and Applications

Gabriele D'Antona
Dipartimento di Elettrotecnica – Politecnico di Milano
Milan, Italy

Alessandro Ferrero
Dipartimento di Elettrotecnica – Politecnico di Milano
Milan, Italy

Springer

Gabriele D'Antona
Alessandro Ferrero
Department of Electrical Engineering
Politechnic University of Milan
Milano 20133
Italy
gabriele.dantona@polimi.it
alessandro.ferrero@polimi.it

Library of Congress Control Number: 2005927075

ISBN-10: 0-387-24966-4 e-ISBN 0-387-28666-7
ISBN-13: 978-0387-24966-7

Printed on acid-free paper.

Printed in the United States of America. (SPI/EB)

9 8 7 6 5 4 3 2 1

springeronline.com

To our families

CONTENTS

CONTRIBUTORS

Prof. Gabriele D'Antona, Ph.D., is Associate Professor of Electrical and Electronic Measurements at the Electrical Engineering Department of the "Politecnico di Milano" University, Milano, Italy. Previously, since 1991 to 1996, he joined the JET-Joint European Torus Laboratory in Abingdon, UK. His current research interests are principally concerned with the study of advanced variational and probabilistic signal processing techniques for the state estimation and control of distributed complex systems. Applications have been developed in several national and international programs for thermonuclear fusion research and environmental monitoring.

He is co-chair of the Environmental Measurements Technical Committee of the IEEE Instrumentation and Measurement Society and Scientific Collaborator of the Italian Institute of Plasma Physics.

Prof. Alessandro Ferrero was born in Milano, Italy, in 1954. He received the M.S. degree in Electrical Engineering from the "Politecnico di Milano", Milano, in 1978. In 1983 he joined the Dipartimento di Elettrotecnica of the Politecnico di Milano as an Assistant Professor on Electrical Measurements. From 1987 to 1991 he was Associate Professor of "Measurements on Electrical Machines and Systems" at the University of Catania, Catania, Italy. From 1991 to 1994 he was Associate Professor of Electrical Measurements at the Dipartimento di Elettrotecnica of the "Politecnico di Milano" University, Milano, Italy. He is presently Full Professor of Electrical and Electronic Measurements at the same Department. His current research interests are concerned with the application of Digital Signal Processing to Electrical Measurements, measurements on electric power systems and the qualification of the measurement process. He is a Fellow member of IEEE, member of AEIT (the Italian Association of Electrical and Electronic Engineers), member of ANIPLA (the Italian Association on Industrial Automation). He's presently the Chairman of the Italian Association on Electrical and Electronic Measurements, member of the North Italy Chapter of the IEEE IM Society and member of the AdCom of the IEEE Instrumentation and Measurement Society. He is the recipient of the 2006 IEEE Joseph F. Heithley Award in Instrumentation and Management.

PREFACE

This book deals with the fundamentals of the Digital Signal Processing Theory, paying particular attention to its application to measurement issues. Therefore, the sampling theorem is thoroughfully analyzed under different points of view, in order to emphasise its impact on the measurement accuracy. Different methods are also explained for the mitigation of the measurement errors that may arise from a not totally correct sampling strategy.

The discrete systems are also considered and analyzed, in order to frame the digital filters into a strict mathematical approach. The FIR and IIR filters are then introduced, and the basic guidelines for their specification, design and use are given.

This book is therefore mainly devoted to graduated and post-graduated students of technical faculties, and to professionals that want to have a closer look to the Digital Signal Processing theory in order to apply it to the practical situations in the correct and most effective way.