

Simulation of MIMO Antenna Systems in Simulink and Embedded Matlab

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Abstract—Multi-Input Multi-Output (MIMO) has emerged as a hot topic in wireless communications during the last decade. This is due to possible dramatic increases in reliability and capacity as compared to single-antenna solutions. However, much of the existing theoretical results are based on very simplistic models of the antennas and transceiver circuitry. Within the Strategic Research Center on Antenna Systems Chormant at Chalmers, we are developing a systems simulator for making more realistic studies of MIMO systems. Models of different complexity can be used for the different components. For the linear components, S-parameters are used as the interface. These can come from theoretical models, electromagnetic field simulations, or directly from measurements. For the non-linear components, simple memoryless models can be used, as existing in the RF Toolbox. However, wideband applications demand more elaborate models. We have implemented a so-called memory polynomial model, which has been found to match measurements of non-linear wideband power amplifiers well. Since RF Toolbox cannot handle multi-port scattering matrices (y-*z*), the MIMO part is here computed in a Matlab function, and then implemented as a MIMO transfer function. The paper describes an implementation of a transceiver chain including mixers, filters, PA/LNA, matching network, MIMO antennas and channel models. The simulator can be used for a wide range of wireless communication applications.

I. INTRODUCTION

Today, hardly any hardware of some complexity is built without first performing extensive computer simulations. Communication and radar systems involving antennas is no exception. However, in almost all cases a communication (or radar) system is simulated with very crude models of the hardware and underlying physics. In contrast, the hardware (e.g. antennas) design is based on detailed electromagnetic simulation, but not taking the system aspects into account. The purpose of this paper is to describe some steps in bridging the gaps between system and hardware level simulation, based on Matlab and Simulink. The goal is to be able to directly see the effect of component design, or architecture, on system-level performance measures. The focus in this presentation is on a wireless communication system, and the performance measures are usually given in the form of bit-error rate (BER) or some other Quality-of-Service (QoS) measure. The ultimate goal of such a system-level simulator is to enable system-level optimization of components, such as material properties or

physical dimensions of antennas etc. However, in this presentation the focus is on simulation of the hardware models at radio frequency (RF). Some details regarding implementation of the signal processing part of a MIMO (Multiple Input Multiple Output) Wideband Code-Division Multiple Access (WCDMA) system, which is the 3G standard for mobile telephony, is given in the companion paper [1].

This paper is organized as follows: The next subsection gives a short introduction to MIMO communication systems, after which an overview of the architecture is given. Section II presents our implementation of the MIMO channel, whereas the antenna frontend is presented in III. This block consists of all parts of the transmitter (receiver) that are represented with physical scattering (S-parameter) models. This includes the antenna, matching network, receiver filters, and also the front-end of the amplifier. In IV, the implementation of amplifier non-linearities is discussed. Section V presents some preliminary simulation results, whereas Section VI concludes the paper.

A. MIMO in Wireless Communication

During the last 20 years or so there has been a tremendous growth in the wireless communication industry. In the beginning, the focus was only on speech, and the challenge was to allocate as many users as possible within a given bandwidth. Today, there is also an increasing demand in bitrate, to allow more advanced services such as video streaming and TV. Traditionally, the growing demand of capacity has been met by increasing the bandwidth and/or by inventing more spectrally efficient communication protocols. However, since the introduction at Bell Labs about 10 years ago (see e.g. [2]), the concept of MIMO (Multiple Input Multiple Output) has received an increasing attention. The main observation is that if both the transmitter and the receiver are equipped with n antennas, the capacity (bitrate) can be increased by up to a factor of n , depending on the richness of the wireless channel. In principle, one can form n parallel channels, which can transmit independently of one another. In general, this is not possible for line-of-sight (LOS) channels, since the multiple channels cannot be independent and will therefore interfere. However, in a rich scattering environment, the capacity can increase by a factor up to n [3]. The transmission of data in parallel streams is usually referred to as *spatial multiplexing*.

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El Oualkadi, Ahmed,Zbitou, Jamal



Simulation Of Mimo Antenna Systems In Simulink:

Problem-Based Learning in Communication Systems Using MATLAB and Simulink Kwonhue Choi, Huaping Liu, 2016-02-29 Designed to help teach and understand communication systems using a classroom tested active learning approach Discusses communication concepts and algorithms which are explained using simulation projects accompanied by MATLAB and Simulink Provides step by step code exercises and instructions to implement execution sequences Includes a companion website that has MATLAB and Simulink model samples and templates password matlab *Computational Modeling and Simulation of Advanced Wireless Communication Systems* Agbotiname Lucky Imoize, Webert Montlouis, Mohammad S. Obaidat, Segun I. Popoola, Mohammad Hammoudeh, 2024-11-29 The book covers the exploitation of computational models for effectively developing and managing large scale wireless communication systems The goal is to create and establish computational models for seamless human interaction and efficient decision making in beyond 5G wireless systems *Computational Modeling and Simulation of Advanced Wireless Communication Systems* looks to create and establish computational models for seamless human interaction and efficient decision making in the beyond 5G wireless systems This book presents the design and development of several computational modeling techniques and their applications in wireless communication systems It examines shortcomings and limitations of the existing computational models and offers solutions to revamp the traditional architecture toward addressing the vast network issues in wireless systems The book addresses the need to design efficient computational and simulation models to address several issues in wireless communication systems such as interference pathloss delay traffic outage and so forth It discusses how theoretical mathematical and experimental results are integrated for optimal system performance to enhance the quality of service for mobile subscribers Further the book is intended for industry and academic researchers scientists and engineers in the fields of wireless communications and ICTs It is structured to present a practical guide to wireless communication engineers IT practitioners researchers students and other professionals **Understanding LTE with MATLAB** Houman Zarrinkoub, 2014-01-28 An introduction to technical details related to the Physical Layer of the LTE standard with MATLAB The LTE Long Term Evolution and LTE Advanced are among the latest mobile communications standards designed to realize the dream of a truly global fast all IP based secure broadband mobile access technology This book examines the Physical Layer PHY of the LTE standards by incorporating three conceptual elements an overview of the theory behind key enabling technologies a concise discussion regarding standard specifications and the MATLAB algorithms needed to simulate the standard The use of MATLAB a widely used technical computing language is one of the distinguishing features of this book Through a series of MATLAB programs the author explores each of the enabling technologies pedagogically synthesizes an LTE PHY system model and evaluates system performance at each stage Following this step by step process readers will achieve deeper understanding of LTE concepts and specifications through simulations Key Features Accessible intuitive and

progressive one of the few books to focus primarily on the modeling simulation and implementation of the LTE PHY standard Includes case studies and testbenches in MATLAB which build knowledge gradually and incrementally until a functional specification for the LTE PHY is attained Accompanying Web site includes all MATLAB programs together with PowerPoint slides and other illustrative examples Dr Houman Zarrinkoub has served as a development manager and now as a senior product manager with MathWorks based in Massachusetts USA Within his 12 years at MathWorks he has been responsible for multiple signal processing and communications software tools Prior to MathWorks he was a research scientist in the Wireless Group at Nortel Networks where he contributed to multiple standardization projects for 3G mobile technologies He has been awarded multiple patents on topics related to computer simulations He holds a BSc degree in Electrical Engineering from McGill University and MSc and PhD degrees in Telecommunications from the Institut Nationale de la Recherche Scientifique in Canada <http://www.wiley.com/go/zarrinkoub>

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2005, 2005 Presents a major forum for engineers and researchers in Ireland on communications control and DSP This conference is one of the premier conferences held in Ireland addressing a number of aspects **IOT with Smart Systems** Tomonobu Senjyu, Parakshit Mahalle, Thinagaran Perumal, Amit Joshi, 2022-01-05 This book gathers papers addressing state of the art research in all areas of information and communication technologies and their applications in intelligent computing cloud storage data mining and software analysis It presents the outcomes of the Fifth International Conference on Information and Communication Technology for Intelligent Systems ICTIS 2021 held in Ahmedabad India The book is divided into two volumes It discusses the fundamentals of various data analysis techniques and algorithms making it a valuable resource for researchers and practitioners alike Engineering Vibration, Communication and Information Processing Kanad Ray, S. N. Sharan, Sanyog Rawat, S. K. Jain, Sumit Srivastava, Anirban Bandyopadhyay, 2018-10-30 This book discusses the revolution of cycles and rhythms that is expected to take place in different branches of science and engineering in the 21st century with a focus on communication and information processing It presents high quality papers in vibration sciences rhythms and oscillations neurosciences mathematical sciences and communication It includes major topics in engineering and structural mechanics computer sciences biophysics and biomathematics as well as other related fields Offering valuable insights it also inspires researchers to work in these fields The papers included in this book were presented at the 1st International Conference on Engineering Vibration Communication and Information Processing ICoEVCi 2018 India

Wireless Communication Signals Huseyin Arslan, 2021-04-06 WIRELESS COMMUNICATION SIGNALS A practical guide to wireless communication systems and concepts Wireless technologies and services have evolved significantly over the last couple of decades and Wireless Communication Signals offers an important guide to the most recent advances in wireless communication systems and concepts grounded in a practical and laboratory perspective Written by a noted expert on the topic the book provides the information needed to model simulate test and analyze wireless system and wireless circuits

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Wireless Communication Signals introduces wireless communication systems and concepts from both a practical and laboratory perspective *Antem 2005* ,2005 *Disruptive technologies in Computing and Communication Systems* K. Venkata Murali Mohan,M. Suresh Babu,2024-06-24 The 1st International Conference on Disruptive Technologies in Computing and Communication Systems ICDTCCS 2023 has received overwhelming response on call for papers and over 119 papers from all over globe were received We must appreciate the untiring contribution of the members of the organizing committee and Reviewers Board who worked hard to review the papers and finally a set of 69 technical papers were recommended for publication in the conference proceedings We are grateful to the Chief Guest Prof Atul Negi Dean Hyderabad Central University Guest of Honor Justice John S Spears Professor University of West Los Angeles CA and Keynote Speakers Prof A Govardhan Rector JNTU H Prof A V Ramana Registrar S K University Dr Tara Bedi Trinity College Dublin Prof C R Rao Professor University of Hyderabad Mr Peddigari Bala Chief Innovation Officer TCS for kindly accepting the invitation to deliver the valuable speech and keynote address in the same We would like to convey our gratitude to Prof D Asha Devi SNIST Dr B Deevena Raju ICFAI University Dr Nekuri Naveen HCU Dr A Mahesh Babu KLH Dr K Hari Priya Anurag University and Prof Kameswara Rao SRK Bhimavaram for giving consent as session Chair We are also thankful to our Chairman Sri Teegala Krishna Reddy Secretary Dr T Harinath Reddy and Sri T Amarnath Reddy for providing funds to organize the conference We are also thankful to the contributors whose active interest and participation to ICDTCCS 2023 has made the conference a glorious success Finally so many people have extended their helping hands in many ways for organizing the conference successfully We are especially thankful to them Computer Aided Constellation Management and Communication Satellites Daljeet Singh,Raghvendra Kumar Chaudhary,Krishna Dev Kumar,2023-03-01 This book comprises the select proceedings of the International Conference on Small Satellites and its Applications ICSS 2022 It aims to provide a comprehensive and broad spectrum picture of the state of the art research development and commercial perspective of various discoveries conducted in the real world smart small satellites applications and their services The contents of this book focus on efficient power management systems application based optimum payload designs telemetry and telecom and advanced navigation and RF systems flight and ground software structure mechanism and materials spacecraft autonomy quality testing and reliability for designing the small satellites through advanced computational

procedures for a variety of applications etc This book proves to be a valuable resource for those in academia and industry
dgdg Advanced Applications of Rapid Prototyping Technology in Modern Engineering Md Enamul Hoque,2011-09-22

Rapid prototyping RP technology has been widely known and appreciated due to its flexible and customized manufacturing capabilities The widely studied RP techniques include stereolithography apparatus SLA selective laser sintering SLS three dimensional printing 3DP fused deposition modeling FDM 3D plotting solid ground curing SGC multiphase jet solidification MJS laminated object manufacturing LOM Different techniques are associated with different materials and or processing principles and thus are devoted to specific applications RP technology has no longer been only for prototype building rather has been extended for real industrial manufacturing solutions Today the RP technology has contributed to almost all engineering areas that include mechanical materials industrial aerospace electrical and most recently biomedical engineering This book aims to present the advanced development of RP technologies in various engineering areas as the solutions to the real world engineering problems *Handbook of Research on Advanced Trends in Microwave and Communication Engineering* El Oualkadi, Ahmed,Zbitou, Jamal,2016-08-25 Wireless communications have become invaluable in the modern world The market is going through a revolutionary transformation as new technologies and standards endeavor to keep up with demand for integrated and low cost mobile and wireless devices Due to their ubiquity there is also a need for a simplification of the design of wireless systems and networks The Handbook of Research on Advanced Trends in Microwave and Communication Engineering showcases the current trends and approaches in the design and analysis of reconfigurable microwave devices antennas for wireless applications and wireless communication technologies Outlining both theoretical and experimental approaches this publication brings to light the unique design issues of this emerging research making it an ideal reference source for engineers researchers graduate students and IT professionals Advances in Measurement Systems Milind Sharma,2010-04-01 This book is a collection of 24 chapters concerning the developments within the Measurement Systems field of study The collection includes scholarly contributions by various authors and edited by a group of experts pertinent to Measurement Systems Each contribution comes as a separate chapter complete in itself but directly related to the book s topics and objectives The target audience comprises scholars and specialists in the field

MIMO Processing for 4G and Beyond Mário Marques da Silva,Francisco A. Monteiro,2016-04-19 MIMO Processing for 4G and Beyond Fundamentals and Evolution offers a cutting edge look at multiple input multiple output MIMO signal processing namely its detection in both time and frequency domains and precoding It examines its integration with OFDM UWB and CDMA along with the impact of these combinations at the system level Massive M **5G NETWORKS AND BEYOND: FUTURE OF COMMUNICATION** DR. SAJIDULLAH S. KHAN,PROF. BABASAHEB H.

PANSAMBAL,SRILAKSHMI.CH,NEELAM MOUNIKA,2025-08-08 5G is the next generation cellular standard following 4G It has been defined by multiple worldwide standards groups including the International Telecommunication Union ITU 3GPP

and ETSI The official ITU specification International Mobile Telecommunications 2020 calls for maximum downlink and uplink throughputs of 20 Gbps and 10 Gbps respectively latency of less than 5 ms from endpoint to RAN and huge scalability however early installations may be less ambitious The new system architecture incorporates core network slicing and edge computing 5G or fifth generation is the most recent iteration of cellular technology designed to significantly improve the speed and responsiveness of wireless networks With 5G data carried across wireless broadband connections might reach rates of up to 20 Gbps exceeding landline network speeds while also providing latency of 1 ms or less for applications that demand real time response Because of increased bandwidth and sophisticated antenna technology 5G will allow for a significant increase in the volume of data delivered across wireless systems

Advances in Smart Communication and Imaging Systems Rajeev Agrawal, Chandramani Kishore Singh, Ayush Goyal, 2021-04-13 This book presents select and peer reviewed proceedings of the International Conference on Smart Communication and Imaging Systems MedCom 2020 The contents explore the recent technological advances in the field of next generation communication systems and latest techniques for image processing analysis and their related applications The topics include design and development of smart secure and reliable future communication networks satellite radar and microwave techniques for intelligent communication The book also covers methods and applications of GIS and remote sensing medical image analysis and its applications in smart health This book can be useful for students researchers and professionals working in the field of communication systems and image processing

Technological Applications for Smart Sensors S. Kannadhasan, R. Nagarajan, Alagar Karthick, V. Kumar Chinnaiyan, 2025-09-15 This new volume presents a plethora of clever real time applications of smart sensor technology with examples from diverse areas The volume showcases novel applications of smart sensors such as for automatic dual axis solar tracking systems for wearable flexible electronic devices for effective security systems in banking and finance in healthcare for cancer detection and cardiac patient monitoring for chemical safety in laboratories for water quality monitoring systems for agricultural irrigation control for maintenance of industrial machines for fire detection safety systems to name a few of the many smart sensor innovations highlighted in this volume

5G Wireless Systems Yang Yang, Jing Xu, Guang Shi, Cheng-Xiang Wang, 2017-09-14 This book focuses on key simulation and evaluation technologies for 5G systems Based on the most recent research results from academia and industry it describes the evaluation methodologies in depth for network and physical layer technologies The evaluation methods are discussed in depth It also covers the analysis of the 5G candidate technologies and the testing challenges the evolution of the testing technologies fading channel measurement and modeling software simulations software hardware cosimulation field testing and other novel evaluation methods The fifth generation 5G mobile communications system targets highly improved network performances in terms of the network capacity and the number of connections Testing and evaluation technologies is widely recognized and plays important roles in the wireless technology developments along with the research on basic theory and key technologies The

investigation and developments on the multi level and comprehensive evaluations for 5G new technologies provides important performance references for the 5G technology filtering and future standardizations Students focused on telecommunications electronic engineering computer science or other related disciplines will find this book useful as a secondary text Researchers and professionals working within these related fields will also find this book useful as a reference

Recent Advances in Satellite Aeronautical Communications Modeling Grekhov, Andrii Mikhailovich,2019-03-15

Modern systems and means of aeronautical radio communication are continuously being improved but without the development of new technical means the aviation industry suffers The development of more innovative plans of aviation technology are needed in order to respond to the ever increasing standard of aviation technology Recent Advances in Satellite Aeronautical Communications Modeling is devoted to the modeling of satellite communication channels for aircraft and RPAS UAV using the Matlab Simulink and NetCracker software Featuring research on topics such as channel coding microwave emitters and array modeling this book is ideally designed for scientists engineers air traffic controllers managers researchers and academicians

Research Anthology on Reliability and Safety in Aviation Systems, Spacecraft, and Air Transport Management Association, Information Resources,2020-09-24 As with other transportation methods safety issues in aircraft can result in a total loss of life Recently the air transport industry has come under immense scrutiny after several deaths occurred due to aircraft design and airlines that allowed improperly inspected aircraft to fly Spacecraft too have found errors in system software that could lead to catastrophic failure It is imperative that the aviation and aerospace industries continue to revise and refine safety protocols from the construction and design of aircraft to secure and improve aviation systems and to test and inspect aircraft The Research Anthology on Reliability and Safety in Aviation Systems Spacecraft and Air Transport is a vital reference source that examines the latest scholarly material on the use of adaptive and assistive technologies in aviation to establish clear guidelines for the design and implementation of such technologies to better serve the needs of both military and civilian pilots It also covers new information technology use in aviation systems to streamline the cybersecurity decision making planning and design processes within the aviation industry Highlighting a range of topics such as air navigation systems computer simulation and airline operations this multi volume book is ideally designed for pilots scientists engineers aviation operators air traffic controllers air crash investigators teachers academicians researchers and students

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