

SMALL ANTENNA MEASUREMENTS IN SPHERICAL NEARFIELD SYSTEMS

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Abstract

Small antennas and other modern antenna applications are using increasingly higher frequencies while demanding very rapid development and testing cycles. A fast, reliable and accurate way to exhaustively determine antenna performance is based on spherical near field measurement techniques combined with probe array technology.

The StarLab spherical near field measurement system has recently evolved to cover the entire frequency band from 800MHz to 18GHz as discussed in [1, 2, 3]. The system is based on patented probe array technology and advanced modulated scattering technique, A-MST [4, 5]. The measurement system is mainly aimed at the characterization of wireless terminals for development, pre-qualification or pass/fail production purposes. It is flexible, with functionalities that can be easily extended depending on the needs of the user. The equipment can be interfaced with different RF measurement devices in order to perform either passive or active measurements.

This paper describes the innovative design aspects of the evolved measurement system and present results from the validation campaign. The use of diagnostic and analysis software modules for efficient antenna testing is also presented.

1 Introduction

The StarLab spherical near field measurement system is shown in Figure 1. The original probe array of 15 dual polarized probes covering the lower frequency range up to 6GHz band has been complemented with a second set of 16 probes covering the frequency range from 6-18GHz. The two arrays are interleaved and fully integrated in the original structure of the StarLab. The new system offers wider bandwidth, the speed advantages of a probe array while the mechanical rotation in elevation allows for unlimited angular resolution over the full 3D sphere. With integrated diagnostic software modules the antenna designer can rapidly determine sources of erroneous performance and provide corrective actions in real time [6, 7].



Figure 1: StarLab 18GHz spherical near field measurement system based on A-MST technology.

A key feature of the StarLab is its compactness allowing it to be used directly in laboratories or production centers without extra logistics. The mechanical structure is mounted on wheels and the compact dimensions allow it to go through a standard double door. If needed one of the two cylinders of absorbers can easily be removed in order to pass through a standard single door.

2 StarLab system description

Field sampling is performed by a wide band probe array composed of a number of evenly spaced elements along the circumference of the support structure. The Device Under Test (DUT) is located in the center of the system on top of a Rohacell® foam column. The full sphere measurement is performed by electronically scanning the probe array in elevation and rotating the DUT 180° in azimuth. As a consequence a full 3D measurement can be performed very rapidly compared to conventional single-probe systems.

The probe array structure can mechanically rotate around its center increasing the number of measurement points by an integer factor (over-sampling factor). This feature enables the user to perform measurements with a high number of sampling points as show in Figure 2.

Nearfield Antenna Measurements

Vincent Beaulé



Nearfield Antenna Measurements:

Near-field Antenna Measurements Dan Slater, 1991-01-01 This reference book shows the reader how to calculate antenna gain pattern and horn beam pointing with increased speed and efficiency It presents a technical overview of the theory and practice of antenna near field measurements and explains the basic concepts behind near field measurement theory from the viewpoints of Fourier optics Doppler beam forming and aperture synthesis This book is designed to be of interest to antenna design and test engineers radar engineers senior technicians and graduate students **Spherical**

Near-field Antenna Measurements Jesper E. Hansen, 1988 This book describes the aspects of antenna test ranges data processing schemes and measurement schemes *Principles of Planar Near-Field Antenna Measurements* Stuart Gregson, John McCormick, Clive Parini, 2007-12-31 This single volume provides a comprehensive introduction and explanation of both the theory and practice of Planar Near Field Antenna Measurement from its basic postulates and assumptions to the intricacies of its deployment in complex and demanding measurement scenarios To do this the book initially examines the properties of antennas that allow them to enhance the free space interaction of electronic systems and this leads into a full description of the theory of Planar Near Field Scanning **Near-Field Antenna Measurements** Vadim Serafimovich Kalashnikov, Maxim Yurievich Ponomarev, Oleg Yurievich Platonov, Victor Vasilievich Shubnikov, Mark Ilyich Rivkin, Artem Yurievich Shatrakov, Yury Grigorievich Shatrakov, Oleg Ivanovich Zavalishin, 2021-04-27 This book is useful both for those who want to get initial information on the measurement of the antenna parameters and for specialists directly involved in the experimental determination of the antenna parameters from the results of measuring the amplitude phase distribution in the near zone of the antennas Currently the near field method is the most common one for antenna measurements In most books an academic approach is given to the issue under consideration and it is difficult to use them for the direct organization of measurements In many others specific narrow issues are considered that are accessible to understanding only by highly qualified engineers readers The purpose of this book is to get rid of the above disadvantages by offering the reader a more accessible exposition and formulas by which appropriate computer programs can be written with minimal effort The contents of this book allow interested specialists to be not only users of the near field measuring facilities but also help in understanding the principles of their work This book is intended for engineers and specialists whose activities are related to experimental testing of radio characteristics of complex antenna systems especially near field measurements and is also useful as a textbook for senior students in the field of radioelectronics and radiophysics **Near-Field Antenna Measurements** Vadim Serafimovich Kalashnikov, Maxim Yurievich Ponomarev, Oleg Yurievich Platonov, Victor Vasilievich Shubnikov, Mark Ilyich Rivkin, Artem Yurievich Shatrakov, Yury Grigorievich Shatrakov, Oleg Ivanovich Zavalishin, 2021 This book is useful both for those who want to get initial information on the measurement of the antenna parameters and for specialists directly involved in the experimental determination of the antenna parameters from the results of measuring the

amplitude phase distribution in the near zone of the antennas Currently the near field method is the most common one for antenna measurements In most books an academic approach is given to the issue under consideration and it is difficult to use them for the direct organization of measurements In many others specific narrow issues are considered that are accessible to understanding only by highly qualified engineers readers The purpose of this book is to get rid of the above disadvantages by offering the reader a more accessible exposition and formulas by which appropriate computer programs can be written with minimal effort The contents of this book allow interested specialists to be not only users of the near field measuring facilities but also help in understanding the principles of their work This book is intended for engineers and specialists whose activities are related to experimental testing of radio characteristics of complex antenna systems especially near field measurements and is also useful as a textbook for senior students in the field of radioelectronics and radiophysics

Antenna Characterization Using Phaseless Near-field Antenna Measurements Trevor Brown, 2016 This thesis focuses on the application of electromagnetic inverse source techniques to characterize antennas using phaseless amplitude only near field NF measurement data Removing the need to measure phase reduces the overall cost of the measurement apparatus since simple power meters can be used instead of expensive vector network analyzers It has also been shown in the literature that a phaseless approach can improve the accuracy of the calculated far field FF pattern in the presence of probe positioning errors compared to the amplitude and phase approach A brief discussion on the state of the art methods for characterizing antennas using phaseless near field measurement data is presented Two general approaches used most often to perform near field to far field NF FF transformations namely modal expansion and source reconstruction are explained in detail for scenarios with and without phase information A phaseless source reconstruction method SRM is the primary focus of this work The SRM is an application of an electromagnetic inverse source technique and therefore the complexities of solving the associated ill posed inverse source problem are discussed The application of the SRM to spherical and planar measurement geometries are presented along with the concerns regarding regularization resulting from discretizing the ill posed system A multiplicative regularization MR scheme originally developed for inverse scattering is adapted to suit the nonlinear cost functional for the phaseless planar measurement case and the mathematical framework is derived in detail The resulting MR SRM is fully automated and incorporates adaptive regularization The developed algorithms are evaluated using several examples with synthetic phaseless NF data demonstrating the benefits and limitations of the source reconstruction method and the multiplicative regularization scheme The application of the SRM to antenna diagnostics using phaseless NF data is also shown Finally the developed planar algorithms are tested with experimentally collected phaseless measurement data to demonstrate their potential as suitable antenna characterization techniques that can be of interest to the antenna measurement community Near-field antenna measurements on a cylindrical surface Arthur D. Yaghjian, 1977

Theory and Practice of Modern Antenna Range Measurements, Volume 1 Clive Parini, Stuart Gregson, John

McCormick, Daniël Janse van Rensburg, Thomas Eibert, 2020-12-09 This greatly expanded co authored two volume text provides a comprehensive introduction and explanation of both the theory and practice of modern antenna measurements from their most basic postulates and assumptions to the intricate details of their applications in various demanding modern measurement scenarios *Probe Correction for Near-Field Antenna Measurements* A. D. Yaghjian, MITRE CORP BEDFORD MA., 1985 To quote Kummer and Gillespie Proc IEEE April 1978 The antenna measurements problem is now of equal difficulty with that of design now the antenna engineer often has to design the antenna as well as the method of measurement In addition they state that The near field technique may well become accepted as the most accurate technique for the measurement of power gain and of patterns for antennas that can be accommodated by the measuring apparatus However in order to accurately determine the far fields of antennas from near field measurements one has to correct in general for the nonideal response of the measurement probe In this paper we review planar cylindrical and spherical scanning and show how probe correction can be introduced as a simple modification to near field scanning with ideal dipole probes that measure the electric or magnetic field at a point Data sampling spacing efficient computational methods and experimental errors involved with near field measurements are also discussed Author Post-processing Techniques in Antenna Measurement Manuel Sierra Castañer, Lars J. Foged, 2019-09-06 This book summarises recent developments and enhancements in post processing techniques that increase the quality and effectiveness of modern antenna measurements Recent advances in near to far field transformation algorithms for enhancing measurement accuracy in the presence of different common error sources are explained in detail Developments in techniques for reducing the effect of echoes noise and leakage and to reduce acquisition time are also explored **Experimental Analysis of a Spherical Near Field to Far Field Transformation Algorithm**, 2016 Antennas are an indispensable part of any wireless system The wireless industry is evolving quickly in the modern age which requires more antenna specifications that are crucial to the over all system performance Therefore antenna development requires a new technique to facilitate the antenna measurements The objective of this research is to investigate and understand the process of the spherical near field to far field transformation This research will contribute as part of an effort for a project to build a spherical near field antenna test chamber in the Electrical and Computer Engineering Department at Oakland University In this study the theory behind the Algorithm that makes the near field antenna measurement valid was discussed also the inputs and parameters to control the transformation performance were identified Finally the algorithm was validated using three data sets from different sources First data set Oakland University Automotive Antenna Range and its nearfield transformation software Second antenna simulation software The third data set was collected from the Antenna Chamber that allows both far field and near field measurements All outcomes successfully matched the actual far field patterns Planar Near-field Antenna Measurements Allen C. Newell, National Institute of Standards and Technology, 1989* **Adaptive Acquisition Techniques for Spherical**

Near-Field Antenna Measurements Vincent Beaulé, 2013 This thesis presents a practical approach to reduce the overall testing time in a spherical near field SNF antenna measurement environment The premise of this work is that the acquisition time is mostly dominated by the mechanical movement and the processing electronic Moreover it is assumed that the transformation time to go from the near field domain to the far field domain NF FF transform is small compared to the acquisition time Thus this operation can be done repeatedly while the acquisition is on going without significantly affecting the overall test time This situation allows to continuously evaluate the far field FF of the antenna under test AUT so that certain decision functions based on the radiation pattern of the antenna can be monitored Such decision functions are based on the antenna specification such as the gain the side lobe level etc We do not proceed with a complete scan of the measurement sphere but effectively allow the probe to follow a directed path under control of an acquisition rule so that the sampled near field NF datapoints constitute an acquisition map on the sphere The acquisition can then be terminated based on decision function values allowing the smallest amount of data needed to ensure accurate determination of the AUT performance measures

Phase Retrieval in Near-field Antenna Measurements Ji Wu, Technical University of Denmark. Electromagnetics Institute, DTH., EMI., 1993 *IEEE Std 1720-2012*, 2012 *Probe-corrected Spherical Near-field Antenna Measurements* F. Holm Larsen, 1994 Near Field Antenna Measurement System Alan E. Holley, HUGHES AIRCRAFT CO FULLERTON CA., 1982 This report describes the development and evaluation of a fully automated self contained near field antenna measurement facility A description of the system and its normal operation is included The development of each major subsystem is described and the evaluation procedures and results are detailed Finally recommendations for further development are given In summary the system has shown the feasibility of performing complex antenna measurements in a highly time effective production mode while retaining accuracies comparable to typical far field ranges Author

Antenna Measurement Techniques Association, 1991 **IEEE Draft Recommended Practice for Near-Field Antenna Measurements**, 2012 *Near-Field Antenna Measurements on a Cylindrical Surface* Arthur D. Yaghjian, 2017-10-28 Excerpt from *Near Field Antenna Measurements on a Cylindrical Surface* A Source Scattering Matrix Formulation This work addresses the problem of measuring the radiating fields of a test antenna by scanning with a probe antenna on an imaginary cylinder surrounding the test antenna The problem of measuring the receiving characteristics of the test antenna is very closely related but for the sake of brevity it will be left as an exercise for the reader Of course most antennas are reciprocal so once the radiating or transmitting characteristics are determined the receiving properties follow immediately from the reciprocity relationship 15a As a first step in formulating the cylindrical scanning technique the EM fields outside an arbitrary test antenna radiating into free space will be expanded in a complete set of cylindrical waves eigenfunctions or modes The test antenna and its coordinate system fixed to the test antenna are shown schematically in figure 1 In cylindrical coordinates the point P is designated by p in spherical coordinates by r or ρ It has been shown 4 that in

cylindrical coordinates the e H fields in free space in this case outside the radius a of the smallest cylinder circumscribing the test antenna About the Publisher Forgotten Books publishes hundreds of thousands of rare and classic books Find more at www.forgottenbooks.com This book is a reproduction of an important historical work Forgotten Books uses state of the art technology to digitally reconstruct the work preserving the original format whilst repairing imperfections present in the aged copy In rare cases an imperfection in the original such as a blemish or missing page may be replicated in our edition We do however repair the vast majority of imperfections successfully any imperfections that remain are intentionally left to preserve the state of such historical works

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