



Bipolar Planar Near-Field Antenna Measurement and Diagnostic System at UCLA's Department of Electrical Engineering. Courtesy of Professor Yahya Rahmat-Samii.

ANNOUNCING A FOUR-DAY SHORT COURSE

Microwave Antenna Measurements

May 11-14, 2010 at UCLA

*With Doren W. Hess, Donald G. Bodnar, Dayel Garneski,
Per O. Iversen, Daniël Janse van Rensburg, Kefeng Liu,
Dean L. Mensa, Carl F. Stubenrauch, and Yahya Rahmat-Samii*

Microwave Antenna Measurements

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This course is an intensive study of all aspects of the measurement of microwave antenna characteristics. Techniques for the determination of antenna radiation patterns, directivity, gain, polarization, and impedance are presented. The design, use, and evaluation of all capabilities used for antenna measurements are addressed, including outdoor ranges, compact ranges, anechoic chambers, and all near-field scanning methods in current use. The concepts are illustrated by experimental results obtained from measured data. The course covers antenna measurements in the microwave and millimeter-wave frequency ranges and the instrumentation required for these measurements. Additional specialized topics include phased-array testing and alignment, antenna diagnostic methods, synthetic aperture techniques, measurements of wireless antennas, electromagnetic interference and compatibility issues, and radome testing. Participants also tour the UCLA Antenna Range and view an example of a near-field scanning facility covered in the course.

The course is intended for engineers, scientists, engineering managers, and practicing antenna measurement technicians who need to understand quickly and thoroughly the principles of state-of-the-art antenna measurement techniques.

The lecturers are recognized experts in antenna measurements who have made important contributions to the development of the modern antenna measurement techniques. The lectures are derived from their experience in industrial, academic, and government settings.

This is the 41st anniversary of the course, which had been presented for many years at California State University, Northridge, under the enduring leadership of the late Professor Edmond Gillespie.

UCLA Extension has presented this highly successful short course since 2006.

Prerequisite

BS in engineering or science, or equivalent experience.

Course Materials

Lecture notes are distributed on the first day of the course. These notes are for participants only and are not for sale. A CD of the notes also is provided to each participant.

Coordinator and Lecturer

Doren W. Hess, PhD, Senior Staff Engineer, MI Technologies, Suwanee, Georgia. Dr. Hess's work at MI Technologies focuses on near-field scanning and compact range applications. He was previously with Scientific-Atlanta, where his work centered on industrial applications of compact ranges and near-field scanning. He was responsible for final development of the first Scientific-Atlanta compact range product and the first commercial spherical near-field product offered by Scientific-Atlanta. Dr. Hess is a Member of the IEEE Antennas and Propagation Society, where he served as a member of the AdCom and as past editor of the measurements column of its magazine; and a past president of the Antenna Measurement Techniques Association, who honored him with its Distinguished Achievement Award in 1997.

Lecturers

Donald G. Bodnar, PhD, Vice President, MI Technologies, Atlanta, Georgia. Dr. Bodnar is responsible for the development of new business areas and products. He is an internationally known expert in the field of antenna design and analysis, especially scanning reflector antennas, and in the polarization characterization of antennas using both theoretical and experimental methods. He has performed antenna and RCS measurements using compact range, near-field, and far-field measurement techniques. Dr. Bodnar is President of the Antenna Measurement Techniques Association; a Fellow of IEEE; past president and vice president, IEEE Antennas and Propagation Society; past chairman, IEEE Antenna Standards Committee; and author or co-author of over 100 publications.

Dayel Garneski, MSEE, Engineering Fellow, Space and Airborne Systems, Raytheon Company, El Segundo, California. For the past 21 years, Mr. Garneski has participated in the design, testing, and calibration of numerous phased array antennas. His experience in near-field measurements includes the implementation of back-projection techniques for array calibration and diagnostics, active array calibration techniques, probe position error correction, volumetric power density mapping, diagnostic imaging of array scattering for radar cross section control, and specification of near-field measurement systems for phased array testing. He received the BSEE from the University of Southern California and the MSEE from UCLA.

Per O. Iversen, MSEE, Chief Executive Officer, ORBIT/FR Inc., Horsham, Pennsylvania. Mr. Iversen has nearly 20 years of experience in the area of applied electromagnetics and antennas. Prior to his current position, he was chief technology officer with SATIMO SA, Kennesaw, Georgia, where he contributed to the development of multiple probe antenna measurement systems for a wide range of applications. He also worked for several years at ESTEC, the Technology Centre of the European Space Agency, Noordwijk, Netherlands, where he managed antenna development programs for both terrestrial and spaceborne applications. Mr. Iversen is a Senior Member of the Antenna Measurement Techniques Association.

Daniël Janse van Rensburg, PhD, Senior Applications Engineer, Nearfield Systems, Inc., Torrance, California. Dr. Janse van Rensburg has been actively involved in the design and implementation of antenna test systems worldwide for the past 16 years and has published many technical papers on near-field and compact range systems. His field of interest is measurement error analysis and modeling. He regularly contributes as a short course lecturer on antenna testing and in 2005 was appointed Adjunct Professor, Electrical and Computer Engineering Department, University of Ottawa, Canada. He is a Senior Member of the IEEE, Member of the Antenna Measurement Techniques Association, and a Licensed Professional Engineer in Ontario, Canada.

Kefeng Liu, MS, Product Development Manager, ETS-Lindgren, Austin, Texas. Mr. Liu's industrial career has been dedicated to applying numerical electromagnetic computational methods to the analysis and design verification of RF absorbers and anechoic chambers, and to the evaluation of low observable RF absorber performance from 10 MHz to 110 GHz. He was involved in the design and verification of many multi-million dollar projects with compact ranges, tapered far-field ranges, and EMC chambers with cutting-edge performance, and was responsible for the development of the ETS-Lindgren's turnkey antenna and RCS measurement system solution packages. He is the inventor and/or co-inventor of three U.S. patents.

Dean L. Mensa, PhD, independent consultant in RCS measurements, Ventura, California. During his 37-year career at the Naval Air Warfare Center, Point Mugu, California, Dr. Mensa focused on the collection and application of radar signatures to establish the performance of airborne radar and missile systems, and directed the technical operations of the Radar Reflectivity Laboratory in conducting tests and analyses of radar signatures. He received the Navy Meritorious Civilian Service Award in 1994 and the Antenna Measurement Techniques Association Distinguished Achievement Award in 1995. Dr. Mensa has authored over 200 technical reports and 25 technical papers, conducted or participated in a number of short courses, and is a Senior Member of IEEE. He is known for his application of high-resolution inverse SAR imaging methods to RCS diagnostics and has written two texts on the subject.

Carl F. Stubenrauch, PhD, consultant in near-field antenna measurements, Boulder, Colorado. Dr. Stubenrauch is retired from the National Institute of Standards and Technology (NIST), Boulder, Colorado. During his 25-year career at NIST, his research was focused on near-field measurement of antenna parameters. He has lectured at a number of short courses in antenna measurements. He is a Registered Professional Engineer, Senior Member of the IEEE, and a Member of URSI Commission A and the Optical Society of America.

Lecturer and UCLA Faculty Representative

Yahya Rahmat-Samii, PhD, Distinguished Professor, holder of the Northrop-Grumman Chair in Electromagnetics, and past chairman, Department of Electrical Engineering, Henry Samueli School of Engineering and Applied Science, UCLA. Professor Rahmat-Samii is a member of the U.S. National Academy of Engineering (NAE) and the current Chairman of the U.S. National Committee of the International Union of Radio Science (USNC-URSI). He received the IEEE Third Millennium Medal and the AMTA Distinguished Achievement Award in 2000, the International Union of Radio Science (URSI) Booker Gold Medal in 2005, the Chen-To Tai Distinguished Educator Award of the IEEE Antennas and Propagation Society in 2007, and in 2009 the IEEE Antennas and Propagation Society's Distinguished Achievement Award, recognizing his outstanding career contributions. Professor Rahmat-Samii is a co-author of four books and over 800 journal and conference papers. His pioneering research contributions cover modern design analyses and measurements in antenna engineering. His original concepts have been used in NASA's space missions and in commercial personal communication systems.

Daily Schedule

TUE Introduction to Antennas (*Bodnar*)

Phasors and Time-Harmonic Fields, Cartesian and Spherical Coordinate Systems, Types of Antenna, Radiation Intensity and Gain, Power Flux Density and Effective Area, Directivity, Definition of Polarization, Antenna Patterns.

Introduction to Antenna Measurements (*Hess*)

The Far-Field Criterion, Antenna Pattern Measurement, Display of Antenna Data, Friis Transmission Formula, Range Power Budget, Antennas as Transducers, Basic Polarization Measurement, Types of Antenna Ranges.

Electromagnetic View of Antenna Measurements (*Rahmat-Samii*)

Historical Background, Fundamentals, Coordinate Systems and Wave Equation Solutions, Equivalence Theorem, Equivalent Sources, Huygen's Principle, Overview of Near-Field Measurements.

Measurement of Gain and Directivity (*Bodnar*)

Measurement of Gain by Comparison to Standards, Availability of Gain Standards, Numerical Calibration of Standard Gain Horns, Measurement Errors, Influence of Impedance Mismatch, Measurement of Directivity, Pattern Integration.

Scattering Matrix Description of Waveguide Junctions and Antennas

(*Stubenrauch*)

Basis Functions for Fields in a Waveguide; Impedance Parameters; Traveling Waves; The Scattering Matrix; One- and Two-Port Networks; Measurements of Scattering Parameters of Sources, Loads, and Antennas; Mismatch Correction—Antenna Gain Measurement Example; Scattering Matrix Description of Antennas.

Antenna Range Instrumentation (*Bodnar*)

Antenna Measurement Receivers, Transmitters, Positioners, Control Systems, and Recorders; Automated Systems; Data Acquisition, Analysis, and Display.

WED Planar Near-Field Measurements (*Stubenrauch*)

Planar Transmission Equation and Probe Correction; Scattering Parameters and Antenna Gain, Polarization, and Pattern; Practical Implementation of Planar Geometries; Range Power Budget; Setup and Initial Testing; Typical Results; Measurement Errors; Near-Field Measurement of EIRP and Saturating Flux Density.

Plane and Bipolar Near-Field Scanning (*Rahmat-Samii*)

Plane-Polar and Bipolar Near-Field Measurement Techniques; Concepts and Implementation; Data Processing Methods; Optimum Sampling Interpolation; Jacobi-Bessel, Fourier-Bessel; Holographic Image Formation; Examples; Phase Retrieval and Phaseless Measurement Techniques.

Phased Array Testing (*Gameski*)

Introduction to Phased Array Antennas, Discussion of Phased Array Testing on Planar Near-Field Ranges, Review of General Back-Projection Theory, Enhanced Back-Projection Using Array Formulation, Measurement Examples, Power Density Prediction from Planar Near-Field Measurements, Survey of Other Methods of Phased Array Calibration and Fault Detection.

Cylindrical Near-Field Scanning (*Stubenrauch*)

Application of Cylindrical Scanning, Typical Implementations, Development and Solution of Transmission Equation, Measurement Examples and Error Studies, Back-Transformation Issues.

Spherical Near-Field Scanning (*Hess*)

The SNF Transmission Equation, Choice of Sampling Intervals and Minimum Sphere, Near-Field and Far-Field Coverage Area, Modal Filtering, Spherical Coordinate Systems, Moving and Fixed Line-of-Sight Ranges, Examples of SNF Range Implementations, Transforms to Arbitrary Radii.

Optimal Sampling of Antenna Near-Field Data (*Rahmat-Samii*)

Review of Sampling in Fourier Signal Processing, Band-Limited Feature of Radiation Field, Interpolation with Cardinal Functions, Interpolation from Minimal Number of Samples, Interpolation with Non-Uniformly Spaced Samples, Construction of Optimum Sampling Function.

Calibration of Gain and Polarization Standards (*Stubenrauch*)

Three-Antenna Method, Extrapolation Technique for Gain Measurements, Swept-Frequency Measurements, Polarization Measurements of/for Linearly and Circularly Polarized Antennas, Calibration of Near-Field Probes.

THU Implementation of Near-Field Systems (*Janse van Rensburg*)

Overview of NF System Types; Examples of Typical Planar, Cylindrical, and Spherical Near-Field Test Systems; Mechanical Requirements; RF Subsystems Requirements; Software Requirements.

Error Analysis in Near-Field Scanning (*Janse van Rensburg*)

Methodology and Goal of Uncertainty Error Analysis; Types of Error Budgets; The NIST 18-Term Error Budget for PNF, CNF, and SNF Systems; Discussion of Specific Error Terms; Case Studies.

Multiple Probe Antenna Measurement Systems (*Iversen*)

Multiple Probe Antenna Measurements—Background, Probe Array Design Challenges, Probe Array Calibration Methods, Measurement Uncertainties Specific to Probe Arrays, Examples of Test Facilities and Applications.

Compact Ranges (*Hess*)

Point Source Compact Range Systems, Sub-Reflector Compact Ranges, Reflector Surface Accuracy Consideration, Reflector Edge Treatment Consideration, Test Zone Specifications and Evaluation of Test Zone Fields, Numerical Modeling of Compact Ranges, Compact Ranges for RCS Measurements, Feeds for Compact Range Systems.

Anechoic Chambers (*Liu*)

Understanding the RF Absorbers, Design and Evaluation Methods for Tapered and Rectangular Chambers, Anechoic Chamber Layouts, Anechoic Chamber Quiet Zone Evaluation Methods, Guidelines for Chamber Accessories.

Tour of the UCLA Antenna Range

FRI Wireless Testing (*Liu*)

Testing Electrically Small versus High-Gain Antennas, Cellular Telecommunication Internet Association (CTIA) Over-the-Air (OTA) Performance Testing, Active versus Passive Measurements, Future Applications, The Ideal System, Example Solutions.

EMI/EMC Testing (*Liu*)

Overview of Electromagnetic Compatibility, Commercial and Military EMC Testing, Radiated Emission Measurement, Radiated Immunity/Susceptibility Measurement, EMC Test Site Facility Requirements, Test Site Acceptance, Summary.

RCS Measurements and RCS of Installed Antennas (*Mensa*)

Measurement of RCS, Scattering from Antennas, Structural and Antenna Modes, Specular and Traveling-Wave Scattering, Test Bodies for RCS of Flush Antennas.

Radome Testing (*Hess*)

Relationships between Antennas and Radomes; Reflectivity, Transmission Efficiency; Pattern Distortion, Beam Deflection, Boresight Shift; Radome Positioners, Gimbal Positioners, Beam Straddlers, Null Seekers; Far-Field Ranges, Compact Ranges, Near-Field Scanning Ranges.

Synthetic Aperture Concepts (*Mensa*)

Imaging Notions; Beam-Forming Properties of Antennas; Real and Synthetic Apertures; Beam Resolution, Steering, and Focusing; Linear, Spotlight, and Inverse SAR; Sampling Requirements; Image Focusing; Two-Dimensional Image Examples.

Design and Evaluation of Far-Field Ranges (*Hess*)

Field Regions, Frequency Regimes, and Radiation Patterns; In-Situ Measurements and Model Measurements; Spherical Coordinate Antenna Ranges; Moveable and Fixed Line-of-Sight Ranges; Achieving Uniform Plane-Wave Illumination; Control of Unwanted Radiation; Design Equations for Ground Reflection and Elevated Ranges; Evaluation of Far-Field Ranges.

**For more information call the
Short Course Program Office at
(310) 825-3344;
fax (310) 206-2815.**



Enrollment Information

Dates	May 11-14 (Tuesday through Friday)
Time	8am-5pm (subject to adjustment after the first class meeting)
Location	Room G-33 West, UCLA Extension Building , 10995 Le Conte Avenue (adjacent to the UCLA campus), Los Angeles, California
Reg#	V5804
Course No.	Engineering 881.239
Units	2.4 CEU (24 hours of instruction)
Fee	\$2,495 , includes course materials

Enrollment

Fee includes course materials; it does not include parking, lodging, or meals. Enrollment is limited. *Early enrollment is recommended.*

Enroll online by visiting uclaextension.edu. Search for keyword V5804 and complete the online enrollment form for secure registration. **A tentative reservation may be made to hold space in the course.** (This reservation may be canceled at any time without penalty.) Call **(310) 825-3344** or email shortcourses@uclaextension.edu. Late and/or on-site enrollments are possible if space allows. Single-day attendance also is permitted upon approval.

Details regarding course location, parking, and housing accommodations will be mailed to everyone who enrolls or reserves a place in the course. For more information call **(310) 825-3344** or email shortcourses@uclaextension.edu.

UCLA Extension reserves the right to cancel or reschedule a short course, and to change instructors.

Refunds

The course fee (less a \$100 service charge) will be refunded only if cancellation of enrollment is postmarked by April 30, 2010. Notify the Short Course Program Office immediately by calling (310) 825-3344, followed by a written request for refund. A refund is not allowed after this date; however, you may apply the course fee (less the \$100 service charge) toward enrolling in another short course. A full refund is given if a course is canceled, discontinued, rescheduled, or participant is dissatisfied after attending the first day. UCLA Extension assumes no liability for travel or other expenses incurred by participants requesting a refund.

Course Fee Discounts

Team Advantage—Send three people from your organization as a group and receive one free enrollment for a colleague. Many past participants say that having three or more colleagues attend a short course together is highly beneficial. Multiple attendees are known to share knowledge and experiences, extend their networking chain, and return with new skills and ideas that can be applied more effectively throughout their team or organization. For this reason, we've created "Team Advantage." When you register three people as a group, we'll offer you one free additional enrollment (as approved by your organization) at no charge. It's a great way for you to invite a colleague, boss, supplier, client, or another vital member of your organizational team and get started on your path to success! *This offer is limited to one per organization.*

Academic—A limited number of 25 percent discounts are available to full-time faculty members and full-time graduate students (who do not work full time) from accredited universities. Submit a written request, including verification of academic status, to the Short Course Program Office at least three weeks prior to the course's start date. (Academic team discounts are not available.)

Multiple Course—Any paying participant of a short course qualifies for a 10% discount off the fees of additional short courses taken within one calendar year of the first course. (This discount cannot be combined with other course discounts.) Please request this discount when making your reservation and/or enrolling.

For more information about these discounts, call **(310) 825-3344**.

Continuing Education Unit (CEU)

One CEU is awarded for each 10 contact hours of satisfactory participation in an organized noncredit continuing education program.

Tax Credit

You may be eligible for a tax credit for fees paid at UCLA Extension. For details see the tax information in the general information section of the UCLA Extension quarterly catalog, or visit uclaextension.edu.

Further Information

Contact UCLA Extension, Short Course Program Office, 10995 Le Conte Avenue, Suite 542, Los Angeles, CA 90024-1333; **(310) 825-3344**; fax (310) 206-2815; email shortcourses@uclaextension.edu.

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