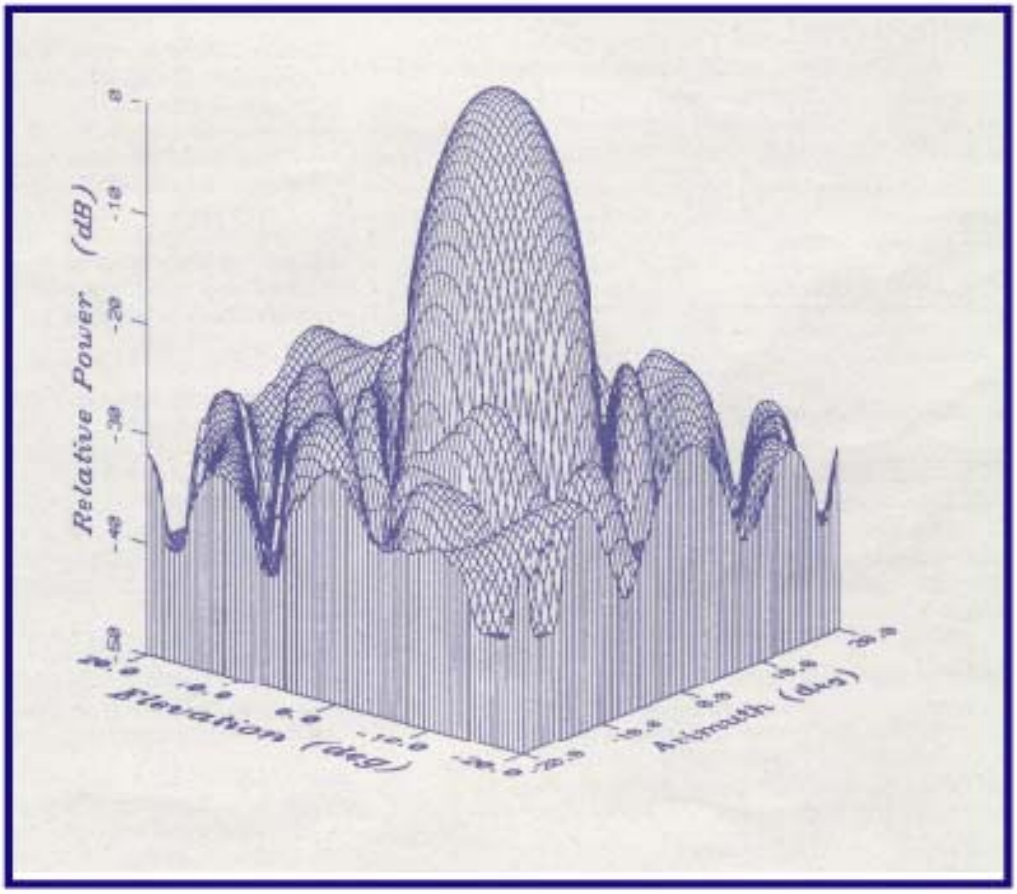
Microwave Antenna Measurements

Four Day Short Course
July 25–28, 2006
Los Angeles, CA



Includes a Tour of the
UCLA Antenna Laboratory

UCLA Extension

COURSE DESCRIPTION

The course is an intensive study covering 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 lectures address specialized topics of: phased-array testing and alignment, antenna diagnostic methods, synthetic aperture techniques, measurements of wireless antennas, and propagation of wireless signals.

FOR WHOM INTENDED

Engineers, scientists, engineering managers and practicing antenna measurement technicians who need to quickly and thoroughly understand the principles of state-of-the-art antenna measurement techniques.

COURSE MATERIAL

Lecture notes distributed on the first day of the course.

UCLA FACULTY REPRESENTATIVE

Yahya Rahmat-Samii, Distinguished Professor, and former Chairman of the UCLA Electrical Engineering Department (2000 – 2005).

ENROLLMENT INFORMATION

Dates	July 25- 28 (Tuesday through Friday)
Time	8am -5pm
Location	UCLA Extension Building, 10995 Le Conte Avenue (adjacent to UCLA campus), Los Angeles, California
Units	2.4 CEU
Fee	$1995

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

Also, see the Continuing Education Listing of Short Courses at: www.uclaextension.edu/shortcourses available after April 15.

The course includes a tour of the UCLA Antenna Range where participants will see an example of a near-field scanning facility covered in the course.

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

This is the 37th offering of the course which, for many years, has been presented at California State University, Northridge under the enduring leadership of Professor Edmund S. Gillespie.

COURSE PROGRAM

Tuesday July 25, 8 a.m.-5 p.m.

INTRODUCTION TO ANTENNA MEASUREMENTS
Antenna Parameters for Measurements ● Friis Transmission Formula ● Radar Range Equation ● Coordinate Systems in Antenna Measurements ● Positioners ● Radiation Pattern Display Formats

FAR-FIELD ANTENNA RANGES
In-Situ Measurements ● Modeling Techniques ● Elevated, Ground Reflection, Slant Range and Image Plane Ranges ● Phase and Amplitude Taper ● Reflections ● Mutual Coupling ● Instrumentation ● Power Budget ● Diffraction Fences ● Field Probes ● Pattern Comparison

FAR-FIELD AND DIRECTIVITY MEASUREMENTS
Pattern Integration ● Two-Antenna Method ● Three-Antenna Method ● Gain Transfer Measurements ● Image Plane Methods ● Errors in Gain Measurements

POLARIZATION MEASUREMENTS
Introduction ● Polarization of Waves ● Polarization of Antennas ● Representations of Polarization ● Polarization Matrices ● Polarization Pattern Measurements ● Two-Antenna Measurements ● Three-Antenna Measurements ● Multiple Amplitude Component Method ● Phase-Amplitude Methods ● Errors in Polarization Measurements

IMPEDANCE MEASUREMENTS
Basis Functions for Fields is a Waveguide ● Impedance Parameters ● Traveling Waves ● The Scattering Matrix ● One and Two Port Networks ● Mismatch Factor● Smith Chart ● Measurement of Scattering Parameters of Sources, Loads and Antennas ● Mismatch Correction in Antenna Gain Measurement

Wednesday, July 26, 8 a.m.-5 p.m.

ANECHOIC CHAMBERS
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

COMPACT RANGES
Basic Concept ● Prime Focus, Dual Reflector, Shaped Reflector and Sub-reflector Ranges ● Surface Smoothness ● Edge Treatment: Rolled and Serrated ● Reflector Focal Length ● Polarization Considerations ● Re-radiation Effects● RCS Measurement Concepts ● Evaluation Techniques

NEAR-FIELD SCANNING TECHNIQUES
Basic Geometries ● Probe Correction ● Advantages and Disadvantages
Scattering Matrix Description of Antenna Interactions ● Intuitive Development of the Planar Transmission Equation ● Relations between Scattering Parameters and Antenna Gain, Polarization and Pattern ● Typical Data and Calculated Results ● Near-field Measurement of EIRP and Saturating Flux Density

PLANAR NEAR-FIELD MEASUREMENTS

SPHERICAL NEAR-FIELD MEASUREMENTS

Thursday, July 27, 8.a.m-5 p.m.

CYLINDRICAL NEAR-FIELD MEASUREMENTS

PLANE POLAR AND BI-POLAR NEAR-FIELD MEASUREMENTS

DIAGNOSTIC METHODS AND PHASE-LESS TECHNIQUES
Microwave Antenna Imaging and Diagnostics ● Holographic Image Formation ● Measurement Examples ● Phase Retrieval and Phase-less Measurements and Diagnostics ● Various Algorithms ● Examples for Bi-polar Measurements

IMPLEMENTATION OF NEAR-FIELD SYSTEMS
Examples of Typical Planar, Cylindrical and Spherical Near-field Test Systems ● Error Analysis Concepts ● Practical Limitations During Realization ● Error Assessment and Impact on Actual Test Results

PHASED ARRAY TESTING USING NEAR-FIELD SCANNING
Back Projection ● Diagnostics ● Alignment Techniques ● Data Analysis Techniques

VISIT TO UCLA ANTENNA LABORATORY AND RECEPTION

Friday, July 28, 8 a.m.-3:45 p.m.

CALIBRATION OF ANTENNA GAIN AND POLARIZATION STANDARDS
Three Antenna Method ● Extrapolation Technique for Gain Measurements ● Swept-frequency Measurements ● Polarization Measurements for Linearly and Circularly Polarized Antennas

ANTENNA RANGE INSTRUMENTATION
Antenna Measurement Receivers, Transmitters, Positioners, Control Systems and Recorders ● Automated Systems ● Data Acquisition, Analysis and Display

SYNTHETIC APERTURE CONCEPTS
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

MEASUREMENTS OF WIRELESS ANTENNAS
Wireless Antenna Types ● Wireless Antenna Characteristics ● Outdoor vs Indoor Testing ● Far-Field vs Near-Field Testing ● Near-Field Scanner Designs ● Positioner Selection ● Anechoic Chamber Considerations ● Absorber Selection ● Software Considerations

PROPAGATION OF WIRELESS SIGNALS
EM Wave Interactions with Matter ● Definition, Importance, and Role of Free-space Propagation ● Propagation Examples ● Cell Propagation ● Propagation Models ● Propagation Measurements ● References

FACULTY

Donald G. Bodnar is the Vice President of MI Technologies responsible for development of new business areas and products. Prior to joining MI Technologies, he was with the United States Air Force as Chief Scientist, Sensors Directorate of the Air Force Research Laboratory and prior to that as Chief Scientist, Rome Laboratory. Before joining the Air Force, Dr. Bodnar was a member of the research faculty at the Georgia Institute of Technology (GTRI) where he was a Division Chief and later a Laboratory Director. Dr. Bodnar 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. He is a Fellow of the IEEE, a past President and a past Vice President of the IEEE Antennas and Propagation Society, past Chairman of the IEEE Antenna Standards Committee, and is the author or co-author of over 100 publications.

Dayel Garneski is with Raytheon Company, Space and Airborne Systems in El Segundo, California, where for the past eighteen years he 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, and diagnostic imaging of array scattering for radar cross section control. He received the BSEE from the University of Southern California and the MSEE from UCLA.

Doren W. Hess received his Bachelor of Science degree from Duke University in 1965 and his Ph.D. from The University of North Carolina at Chapel Hill in 1973. Following two years as a Postdoctoral Research Associate at Chapel Hill, he joined Scientific-Atlanta in 1974 where his work was 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 for the first commercial spherical near-field product offered by Scientific-Atlanta and was the senior technical member of a design team for Scientific-Atlanta's planar near-field system. He is the author of articles and conference presentations on spherical and planar near-field scanning, compact range measurements, and automatic antenna measurements. His professional interests include electromagnetic scattering and radar cross-section, radome and antenna measurements. Dr. Hess is a member of the IEEE Antenna and Propagation Society, where he has served as a member of the AdCom. He is a past editor of the Measurements Column of the AP-S Magazine and a past President of the Antenna Measurement Techniques Association. In 1997 the Antenna Measurement Techniques Association honored him with its Distinguished Achievement Award. In 1998, he joined Aeroflex Lintek Corporation in Powell, Ohio as Executive Vice President. In the Fall of 2000 he left Lintek to become a consultant for Microwave Instrumentation Technologies. In October 2001, he joined MI Technologies in Duluth, Georgia as a Senior Staff Engineer. His work there is focused on near-field scanning and compact range applications.

Daniël 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. He works for Nearfield Systems Inc in Torrance CA and his field of interest is measurement error analysis & modeling. He received the B.Eng, M.Eng and Ph.D. Degrees in Electrical Engineering from the University of Pretoria, South Africa in 1985, 1987 and 1991, respectively. He regularly contributes as a short course lecturer on antenna testing and was appointed Adjunct Professor in the Electrical & Computer Engineering Dept at the University of Ottawa, Canada in 2005. He is a Senior Member of the IEEE, Member of the Antenna Measurement Techniques Association (AMTA) and a Licensed Professional Engineer in Ontario, Canada.

Randy J. Jost received BSEE (1978), MSEE (1980) and PhD (1988) degrees from the University of Missouri-Columbia. He is currently a Senior Scientist for the Space Dynamics Laboratory at Utah State University in Logan, UT and an adjunct professor in the Departments of Electrical & Computer Engineering and Physics at USU. His areas of research interest include radar and microwave engineering, remote sensing, electromagnetic compatibility, computational electromagnetics, the calibration and characterization of electromagnetic ranges and the measurement of dielectric, magnetic and optical materials. After completing his graduate studies, he taught at the Air Force Institute of Technology (AFIT) from 1984-1988, in Dayton, Ohio, having received a commission as a Second Lieutenant in the US Air Force in 1982. Upon leaving AFIT, he worked for the Air Force Research Laboratory, at Wright-Patterson AFB until 1991. From 1991 to 1996, he worked as a Program Manager for SRI, International in Rosslyn, Virginia. During this period, he also served as an IPA for the Office of Secretary of the Air Force for two years. From 1996 to 2000 he was the Technical Director of Engineering for Johnson Controls, the operations and maintenance contractor at the National RCS Test Facility, located at White Sands Missile Range, New Mexico. He recently retired as a Lieutenant Colonel from the US Air Force Reserve, where his last assignment was with the Directed Energy Directorate of the Air Force Research Laboratory at Kirtland AFB, New Mexico. He holds both Amateur Extra and Commercial Radiotelephone Operator licenses, is a senior member of the IEEE, a member of ASEE, ACES and SPIE, and currently serves as the Vice President of the Antenna Measurement Techniques Association.

Kefeng Liu graduated from Xiamen University with BS degree and from the Electrical Engineering department of Ohio University with the MS degree. He was an RF engineer specializing in long-distance short-wave communication utilizing reflections from ionospheres at China Research Institute of Radio-wave Propagation from 1982 to 1985, a research associate specializing in numerical modeling and antenna measurements at Arizona State University from 1987 to 1992. From 1992 to the present, he worked for Ray Proof Shielding System Corporation, and subsequently ETS-Lindgren where he is the product development manager of ETS-Lindgren. His 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 ETS-Lindgren's turkey antenna and RCS measurement system solution packages. He was the designer of the ETS-Lindgren's curvilinear, FS-series, and PS-Series absorber product lines and the broadband dual-polarized ridged horn antenna and is the inventor and/or co-inventor of three US patents. He is a member of IEEE-APS/EMC and MTT societies, and AMTA.

Dean L. Mensa is an independent consultant in RCS measurements and a graduate of the University of California with BS, MS, and Ph.D. degrees. During his 37-year career at the Naval Air Warfare Center, Pt. Mugu, California, his focus was on the collection and application of radar signatures to establish the performance of airborne radar and missile systems. He directed 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. He has authored over 200 technical reports, 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.

Yahya Rahmat-Samii is a Distinguished Professor of the Electrical Engineering Department at the University of California, Los Angeles (UCLA). Before joining UCLA, he was a Senior Research Scientist at NASA Jet Propulsion Laboratory (JPL). He became a Fellow of IEEE in 1985, and was elected as the president of IEEE Antennas and Propagation Society (AP-S) in 1995. Rahmat-Samii has published over 650 journal and conference papers and over 20 books/book chapters in the areas of electromagnetics and antennas. He has had pioneering research contributions in diverse areas of electromagnetics, antennas, measurement and diagnostics techniques, numerical and asymptotic methods, satellite and personal communications, human/antenna interactions, frequency selective surfaces, electromagnetic band-gap structures, applications of the genetic algorithms and particle swarm optimization, etc., (visit http://www.ee.ucla.edu/antlab).In 1992 and 1995, he was the recipient of the Best Application Paper Prize Award (Wheeler Award) for papers published in IEEE AP-S Transactions. In 1999, he was the recipient of the University of Illinois ECE Distinguished Alumni Award. In 2000, Dr. Rahmat-Samii received the IEEE Third Millennium Medal and the AMTA Distinguished Achievement Award. In 2001, he received an Honorary Doctorate in physics from one of the oldest universities in Europe, the University of Santiago de Compostela, Spain. In 2001, he was elected as the Foreign Member of the Royal Academy of Belgium for Science and the Arts. In 2002, he received the Technical Excellence Award from JPL. He is the recipient of the 2005 International Union of Radio Science (URSI) Booker Gold Medal presented at the URSI General Assembly, New Delhi, India. Professor Rahmat-Samii is the designer of the IEEE AP-S logo.

Carl F. Stubenrauch is a consultant in near-field antenna measurements. He 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 received his BS and MS from the University of Illinois and Ph.D. from the University of Michigan, all in electrical engineering. He is a Registered Professional Engineer, a senior member of the IEEE, a member of URSI Commission A, and the Optical Society of America.