TeTech

Constantijn Huygensstraat 20
3601 SC Maarssen
the Netherlands
Tel: + 31 (0) 346 284004
Email: *info@tetech.nl*
Web: *www.tetech.nl*
CoC: 30169033
VAT: NL001961734B19

Antenna Properties and Antenna Measurement

Introduction

The use of wireless communication is still growing. More and more Electronic Engineers become involved with antennas and radio waves. Whether you design, buy or integrate antennas into your system, it is good to know how the antenna performs in your application. This is especially true in case of using antennas outside their normal operating envelope (for example close to sheet metal or bulky material). In many cases, it is not that difficult to measure.

With the advent of "pre-compliance" measuring equipment and cheap Vector Network Analysis equipment, more and more Engineers become involved in EMC and radio measurements. Many (product) standards, like EN55011 and EN55022 require Field Measurement. The "transducer" for converting radio waves to electrical quantities is the Antenna.

This course deals with Antenna Properties, EM field properties, Radio Wave Propagation for Antenna Measurement and how to actually measure Antenna Properties (like Gain, ERP, EIRP, polarization, etc). It will be shown (theoretically and practically) that measuring of antennas with size up to a few wavelengths can be done with relative simple means, often without an Anechoic Chamber.

This course is conducted for small groups only and has strong interaction. This almost guarantees good knowledge transfer and reduces foreign language related problems.

Who should attend?

This Course is for people (Equipment Manufacturers, System Integrators, Designers) that need to assess the performance of an Antenna or a complete system incorporating one or more Antennas. One can think of antennas or wireless systems for mobile and portable applications like: LPD ISM equipment with Internal or External Antennas, RF & UHF RFID, Wireless add-ons for PC/laptop, wireless networking, Antennas for Covert Operations and Intelligence, Cellular Systems, etc.

This course is also useful for people involved in EMC measurements and people involved with Fixed Services (HF or Microwave).

If you are into magnetic field generating or receiving antennas (Inductive EAS, MF & RF RFID, power transfer, magnetic field sensing), this course is not suited for you, as this course focuses on Radiation Fields / radio waves rather then Near Fields. TeTech can provide you a custom course for Near Field antennas and energy transfer.

If you want to study antennas on a strictly mathematical basis (differential vector calculus), this course is not suited for you.

If you are interested in antenna design, please take a look at the "Practical Design of small RF Antennas" course. The "Antenna Assessment and Antenna Measurement" course is a good preparation for the Antenna Design course.

What you will learn?

After course completion, attendees will:

- Know the Properties and Definitions used concerning spherical and plane EM fields (radio waves)
- Know Antenna Properties and definitions used within the Antenna Community
- Have good understanding of the relationship between: Radiation Pattern, Gain, Geometry of the antenna, Wavelength, etc
- Be able to assess the influence of reflections and Far/Transition Field Zone issues on the accuracy of an Antenna Test Range
- Be able to make/setup and verify a test setup
- Be able to determine Antenna Properties via measurements

Prerequisite

Attendees should have a Secondary Vocational or Polytechnic level in Telecommunications, Physics or Electronics. Attendees should be familiar with:

- Basic mathematics (linear and quadratic functions, goniometric functions, complex calculus [a+jb])
- Concept of: voltage, current, power and simple calculations on RLC networks
- Some idea of Standing wave and traveling waves (Transmission Line Basics)
- 3D imagination
- Basics of Telecommunication Systems when overall System Measurements (like Sensitivity) are of interest
- Average knowledge of English Language

Do you have doubts about your level? Don't hesitate to contact TeTech. Additional classes can be added to make sure you are best prepared to attend this course. For example, "Electromagnetism for Antennas and Electronics" can easily be added when your electromagnetism isn't up to date.

Course Content

Electromagnetic waves, energy approach

Energy propagation from point sources, Radiation intensity (U, W/sr), Power Flux Density (PFD, θ_P, S, W/m^2), 1/r^2 law, Spherical Coordinates, Equivalence with heat radiation from Sun, Introduction to "Effective Aperture" or "Capture Area" (m^2)

Electromagnetic waves, Field approach

Power in Electrical Systems, E- and H-field, Field pattern under parallel plate transmission line, (Average) Poyning Vector (S, W/m^2), Plain Wave Field Properties (E-, H-field, Z_0, field orientation, etc), Equivalence between Field properties of transmission line and free space radio waves, Field Polarization (Polarization ellipse, RHC, LHC, Tilt Angle, Polarization losses)

Antenna Properties (energy approach)

Concept of Directivity and Conservation of Energy, Antenna Gain (dBi, dBd), Gain of Isotropic Radiator and Dipole, ERP, EIRP, Radiation Efficiency, Relation between Gain and Directivity, Gain in case of Polarized EM Fields

Antenna Properties (Interference approach)

Half Power Beam width (HPBW, BW_{-3dB}), Diffraction limit, Relation between HPBW and size, Relation between HPBW and Gain, Radiation Patterns and measuring plane definitions (like H-field and E-field plane), Side lobes, F/B ratio, Effect of Distribution Taper on Side Lobes

Antennas from a receive perspective

Concept of Effective Aperture (A_e, m^2), Relation between Gain and Effective Aperture (or Capture Area), Effective Aperture for various Antennas, Aperture Efficiency, Antenna Factor (AFE), polarization, optional: antenna noise temperature

Antenna Transmission Calculations and Field Zones

Step by Step derivation of the Friis Transmission Formula, Limitations on Point Source Approach, Far-, Transition- and Reactive Field zone (based on interference and beam approach), Fresnel Zones, Loss of accuracy of Friis formula within Transition Field Zone, Practical use of the Friis formula (minimum distance criteria), Field Uniformity, Effect of Distribution Taper on field uniformity within Transition (Fresnel) Zone

Cable Reflection and VSWR

Reflection Coefficient, Standing Waves and VSWR, losses based on source with linear output, cable losses, effect of Equipment Mismatch (input and output VSWR) on Accuracy, Losses in case of non-linear outputs (Power Amplifiers), Common Mode issues (radiation from Antenna Feed and effect on Antenna Input Impedance)

Reflection in Free Space and effect on Accuracy of Antenna Range

Properties of various Media and definitions used, complex propagation constant, Fresnel Formulas (for reflection) and similarity with cable reflection, Image Theory (and limitations), Reflection from large and small objects (based on Fresnel diffraction), Surface Impedance, Reducing Reflections, RF absorbers, Two-Ray propagation model

Antenna Measurement

Required Hardware, Practical Antenna Measurement (Absolute and Gain Comparison methods, Far Field and Transition Field methods), Notes on the Antenna Fixture, Compensation for Cable losses, Measurement of EIRP or ERP, Measurement of Antenna Efficiency, Assessing the effect of Reflections and Transition Field issues on Accuracy, Measurement of VSWR

Antenna Ranges

Overview of Antenna Ranges (Reflection, Outdoor, Indoor, Transitional Field, Near Field/Transitional Field probing), Hardware Requirements for an Antenna Test Range, The Antenna Range for Low Gain Antennas (without RF absorbers)

Antenna Measurement with limited means (optional)

Signal Sources, design and use of microstrip or slotted line for impedance and VSWR measurements (inclusive Smith Chart), VSWR measurement with impedance bridge, Simple down converters, Diode detectors (properties, design, correction for non-linearity, and practical use), Making and verifying your own Gain Standard

Antennas and noise (optional)

Noise Sources related to Antennas (man-made, galactic, resistive, atmospheric, electronic), Noise Temperature and Fa (as used in ITU-R P.372), equivalent E-field noise floor of Antennas, noise measurement

All course material is presented in a mixture of theory, sound examples and exercises (both theoretical and practical). It is advised to do the practical part in the frequency range of interest and with the equipment that will be used during actual measurements. Antennas for popular frequency bands are available (400, 433, 850, 868, 900, 1500, 1800 MHz and 2.45 GHz). A Gain Standard and transmitting antenna for other frequencies can be prepared before or during the course.

Every course attendee receives a special prepared, easy to understand handout that consists of about 140 pages (70% text and 30% illustrations) and the examples that have been discussed during the course.

Would you like to discuss some special topics? Please don't hesitate to ask. It is very likely that your wishes can be incorporated into this Antenna Course.

This course can be completed with an examination (English or Dutch language).

Location, Schedule and Number of Attendees

This course is mostly given on-site, inside or outside the Netherlands and can be conducted within or outside office hours.

Depending on the agreed program, entry level and number of attendees, about 5 to 10 days is required (for the standard course).
It is recommended to conduct the course over a period of several weeks. This is to enable smooth assimilation of the material. It is also recommended to limit the number of attendees to 10 per session to maintain good interaction.

Price

The price will be determined based on the agreed course program. It is recommended to have maximum 6 hours/day, as this course is intensive. You will receive a quotation when all required information is collected. You can use the guidelines mentioned below for budgetary purpose.

The price can be broken down into

- A lump sum of € 600,-- (standard course preparation)
- A lump sum € 30,-- per attendee
- € 105,-- per course hour (€ 630/day based on 6 hours)
- Additional cost for special requests that are not covered by the standard course preparation
- Travel, lodging, Visa, etc

A 6 day course for 5 attendees would cost about € 1100.--/attendee. This is including 75 km travel distance around Utrecht and some reserve for special requests. All prices are exclusive VAT.

During the course we may conclude that the original plan needs to be updated. If so costs will be recalculated.

Interested?

If you are interested, please contact TeTech, free of any obligation. This Course can easily be adapted to your special needs. TeTech will be happy to discuss your needs and convert them into a course that will help you forward.

This course covers just a part of TeTech's Expertise. There are several other courses with a strong relation to this course.

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