



Fundamentals of RF and Microwave Measurements

2-Day Classroom Course

COURSE OVERVIEW

Updated for 2019, this popular 2-day classroom course provides a solid grounding in radio frequency (RF), wireless and microwave measurements from high-frequency (HF) to 40 GHz. The course introduces basic theory and high-frequency measurement concepts before addressing a range of common RF, wireless and microwave measurements used in research and development (R&D), manufacturing test and production environments.

The course is delivered in partnership with leading test and measurement equipment manufacturer Rohde & Schwarz at their UK office in Fleet. The course includes a series of practical measurement demonstrations to help reinforce concepts, performed using the latest RF and microwave test and measurement instruments.

Throughout the course, there will be plenty of opportunities to ask the instructor questions to help clarify understanding. There will also be opportunities for hands-on time with test equipment under expert guidance from the course instructor.

WHAT YOU WILL LEARN

- » Understand the essential principles of RF, wireless and microwave measurements
- » Describe key RF, wireless and microwave measurement parameters
- » Understand different RF connector types and how to correctly care for them
- » Understand how to use a range of RF, wireless and microwave measurement equipment
- » Reduce the risk of expensive test equipment damage, downtime and repair costs
- » Understand how to correctly perform a range of RF and microwave measurements
- » Develop improved problem solving capability due to better understanding of measurements
- » Better utilise test equipment features and functionality

TARGET AUDIENCE

- » Recent Graduates
- » New Starters
- » RF Design Engineers and Technicians
- » Microwave Engineers and Technicians

- » RF Test Engineers and Technicians
- » RF Applications Engineers
- » Technical Managers

This technical course is ideal for graduates and new entrants to the field of RF, wireless and microwave measurements. It is also suitable for those with industry experience but with knowledge gaps that need to be addressed.

Staff members taking the course typically include engineers and technicians involved in making RF, wireless and microwave measurements and working in R&D, manufacturing test and production environments in the RF, wireless and microwave communications industry.

The course is also suitable for recent graduates or experienced engineers moving into the RF, wireless and microwave field, who need to quickly get up-to-speed with high-frequency (HF) measurement techniques in order to become more productive. In addition, the course will be of interest to managers working in a test environment who wish to improve their understanding of HF measurements in order to better manage the test process.

COURSE CURRICULUM

- » Transmission Lines and S-parameters
- » Connectors and Cable Care
- » Vector Network Analysis
- » Calibration, Verification and Accuracy of Vector Network Analysers
- » Spectrum Analysis
- » Power Measurements
- » Noise Figure Measurements
- » Phase Noise Measurements
- » Digital Modulation Measurements
- » Antennas and EMC
- » Practical Measurement Demonstrations

PREREQUISITES

Although there are no formal prerequisites for this course, an ability to absorb and understand technical concepts is essential together with a desire to learn more about the topics covered. A technical background is desirable in order to derive maximum benefit from the course.

Those taking the course would normally be qualified to degree-level or have equivalent experience in an engineering, physics or mathematics-related subject. If you are unsure about the technical level of the course then either [click here](#) to complete the contact form or call our office on +44 (0)1962 920 123.

WHAT'S INCLUDED?

- » Class tuition by industry expert with 30+ years of experience
- » Full-colour printed course notes including all presentation slides

- » Morning and afternoon refreshments and buffet lunches
- » High-quality printed Certificate of Attendance

COURSE FEE

£1125 + £225 VAT = £1350 GBP per person

COURSE DATES

[Click here](#) to view the latest scheduled course dates.

COURSE LOCATION

The course will be held in a modern, well-equipped conference room at Rohde & Schwarz UK.
[Rohde & Schwarz UK, Ancells Business Park, Fleet, Hampshire, GU51 2UZ, UK](#)

ONSITE COURSE OPTION

If you have a group or team that requires training, then we can deliver this course onsite at your facility at most locations around the World. For further information, either [click here](#) to complete the contact form or call our office on +44 (0)1962 920 123.

COURSE CONTENT

Transmission Lines and S-Parameters

- » Units of power, dB and dBm
- » Watts and dBm
- » Power transfer efficiency
- » Transmission line fundamentals
- » Characteristic impedance
- » Reflection and transmission of pulses
- » Short, open and load transmission line terminations
- » High-frequency device characterisation
- » Transmission and reflection parameters
- » S-parameters and signal flow graphs
- » Introduction to the Smith Chart

Connectors and Cable Care

- » Coaxial connector categories
- » Precision connector frequency ranges
- » Common coax line sizes
- » Inner conductor concepts
- » Identifying a slotless connector
- » Slotted vs slotless connector interface
- » 3.5 mm connector (APC-3.5)
- » 7 mm connector (APC-7)
- » N-type connector (18 GHz)

- » SMA connector
- » Mechanically compatible connectors
- » Cleaning coaxial connectors
- » Use of connector savers and adaptors
- » Interface dimensions and gauging
- » Connector care demonstration*
- » Connector gauging and torquing demonstration*

Vector Network Analysis

- » Vector network analyser types
- » Reflection coefficient measurement
- » Two-port device measurement
- » Behaviour of ideal and actual couplers
- » Systematic measurement errors
- » Full two-port error model
- » Vector error correction
- » Calibration standards and cal types
- » Simple response calibration
- » Two-port calibration
- » Response vs two-part calibration
- » Calibration kits and care
- » Electronic calibration (ECal)
- » Thru-reflect-line (TRL) calibration
- » TRL & LRL calibrations
- » TRL calibration on microstrip
- » Semi-rigid coax calibration kit
- » S-Parameters for balanced devices
- » What are balanced devices?
- » Calculating balanced S-Parameters
- » Balanced SAW filter example
- » Group delay
- » Amplifier stability and measurements
- » Power sweep gain compression
- » TDR equipment
- » Time-domain reflectometer (TDR)
- » TDR characterisation
- » Time-domain and de-embedding
- » Time-domain gating

Calibration, Verification and Accuracy of Vector Network Analysers

- » Verification of error terms
- » Measurement of effective directivity at low and RF frequencies (<6 GHz)
- » Measurement of effective directivity at high frequencies

- » Calibrated network analyser with airline and fixed termination
- » Effective source match
- » Non-linearity, noise and isolation
- » Effective isolation, noise and load match
- » Transmission and reflection tracking
- » VNA calibration and verification demonstration*
- » S-parameter VNA measurement demonstration*

Spectrum Analysis

- » Spectrum analysis
- » Basic spectrum analyser block diagram
- » Microwave spectrum analyser
- » Harmonic mixer responses
- » Front-end filtering
- » Preselector response
- » Microwave and low-band architecture
- » Tracking generator architecture
- » Spectrum analyser controls
- » RF attenuator
- » Sweep time
- » Resolution bandwidth filters
- » Wide resolution bandwidth filter
- » Noise floor
- » Dynamic range of modulated signal measurements
- » Video signal processing
- » Video filter bandwidth
- » Detector sampling methods, types and properties
- » Key specifications
- » Dynamic range
- » Second and third-order distortion
- » Dynamic range and distortion vs noise
- » Inaccuracies due to VSWR
- » Spectrum analyser measurement demonstration*

Power Measurements

- » Direct digitising receiver
- » Receiver design objectives
- » Receiver impairments
- » Receiver sensitivity
- » Selectivity requirements
- » Effects of phase noise
- » Receiver blocking mechanisms
- » Frequency planning to avoid spurs

- » System planning to minimise noise and distortion
- » Prediction of performance of cascaded blocks
- » Cascaded receiver analysis example
- » Time division duplex (TDD) considerations
- » Frequency division duplex (FDD) considerations
- » TDD and FDD system
- » Problems with wideband sampling

Noise Figure Measurements

- » Noise figure
- » Cascaded noise figure
- » Why noise is measured
- » How noise is measured
- » Noise sources
- » Avalanche diode noise source
- » Noise figure measurement system
- » Typical noise figure meters
- » Noise waves
- » Effect of isolation

Phase Noise Measurements

- » Phase noise measurement methods
- » Definition of phase noise
- » Oscillator phase noise profile
- » Terms used to define stability and noise on a carrier
- » Effects of phase noise
- » Constellations with phase noise
- » Phase noise conversions
- » Basis of all phase noise measurement techniques
- » Measuring with a spectrum analyser
- » Spectrum analyser with external preselection
- » Quadrature method and calibration technique
- » Checking and correcting phase locked loop effects
- » Quadrature method test system
- » Delay line discriminator method
- » FM discriminator and performance
- » Sources of measurement uncertainty
- » Comparison of phase noise measurement methods

Digital Modulation Measurements

- » Transmitter modulation measurements
- » Power spectral density measurements
- » Why does linearity matter?

- » AM-AM and AM-PM nonlinearities
- » Spectral regrowth
- » Two-tone Intermodulation
- » Adjacent channel power
- » ACLR measurement
- » Harmonics and spurious signals
- » Power-time response
- » Error vector magnitude (EVM)
- » EVM measurement
- » Types of EVM measurement
- » EVM measurement examples
- » EVM specifications in practice
- » EVM combination mechanisms
- » EVM uncertainty guidelines
- » Receiver modulation measurements
- » Handset test setup
- » Bit error rate (BER) testing
- » Receiver sensitivity
- » Adjacent/alternate channel selectivity
- » Spurious response measurements
- » Receiver chain measurements

Antennas and EMC

- » Antennas
- » Radiation from conducted currents
- » EMC measurements
- » EMC measurement antennas
- » Anechoic chamber
- » Open area test site (OATS)
- » Antenna parameters and terms
- » Measuring antennas
- » Power radiation pattern
- » Wheeler Cap method
- » Three antenna method
- » Calculation of antenna factor
- » Standard antenna method
- » Typical antenna factor
- » Use of choke on coax outer
- » EIRP (effective isotropic radiated power)

Practical Measurement Demonstrations*

- » Connector care, gauging and torquing
- » RF and microwave power measurements

- » Network analyser calibration and verification
- » Network analyser measurements – insertion loss, return loss etc.
- » Network analyser measurements – amplifiers and filters
- » Spectrum analyser measurements – bandwidth, intermodulation and noise power etc.
- » Vector signal analyser measurements

* Demonstrated measurements may vary slightly depending on test equipment availability and installed feature sets. There will be opportunities during the course for hands-on time with test equipment under expert guidance from the course instructor.

Please note that minor changes may be made to course content based on delegate feedback, continuous improvement and technological developments.

ABOUT US

The Technology Academy was established in 2007 as a private UK company specialising in the development and delivery of instructor-led and online RF, wireless, digital TV and broadcast technology training courses to meet the continuing professional development needs of individuals and companies developing innovative technology products and services. All of our courses are taught by leading technical experts drawn from industry and academia with many years of experience in their specialist fields. Courses are delivered throughout the UK, Europe and Rest of the World. We are a training partner of Rohde & Schwarz UK, who support courses by providing the latest test and measurement equipment for practical demonstrations.

OUR INSTRUCTORS

As experts in their respective fields, our instructors and advisors are carefully selected from leading technology companies and universities for their comprehensive knowledge of the subject matter. In addition to expert subject knowledge, each instructor has demonstrated the ability to translate complex technical theory into practical, understandable and relevant concepts and teach to a professional audience in an effective, lively and enthusiastic manner. All instructors know the subject matter intimately and are able to expand on all course topics as and when required, emphasising key concepts with suitable analogies and practical examples.

TERMS & CONDITIONS

We encourage you to read our full [Terms and Conditions](#), which cover important issues like payment and cancellation policies.

ANY QUESTIONS?

Please [click here](#) and complete the contact form or call our office on +44 (0)1962 920 123.

Delivered in partnership with leading test equipment manufacturer [Rohde & Schwarz](#).



ROHDE & SCHWARZ

E&OE.