



## Practical RF and Microwave Measurements

Course Code: RF3-ON Duration: 3 Days Course Level: Intermediate

### Course Overview

This 3-day intermediate-level course provides a solid grounding in RF and microwave measurements by combining a series of lectures with practical hands-on sessions using a range of test equipment. The course covers the key measurements used to characterise RF and microwave components found in a wide range of wireless communications systems, including handsets, cellular basestations, femtocells, WiMAX and wireless LAN systems, GPS systems, communications satellites and DBS receivers.

### Who Will Benefit?

The course is aimed at technicians and engineers working in research and development, manufacturing test and production environments involved in making RF and microwave measurements. The course is also suitable for recent graduates or experienced engineers moving into the RF and microwave field, who must quickly get up-to-speed with measurement techniques. The course will also be of interest to managers working in a test environment, who wish to improve their understanding of RF and microwave measurements in order to better manage the test process.

### Learning Outcomes

Upon completion of this course, participants will be able to:

- ◆ Understand the important principles of RF and microwave measurements
- ◆ Describe key RF and microwave measurement parameters
- ◆ Understand the operation of RF and microwave measurement instruments
- ◆ Appreciate the significance of measurement uncertainty on measurements
- ◆ Correctly care for cables, connectors and calibration standards
- ◆ Understand how to correctly perform a range of RF and microwave measurements

### Business Benefits

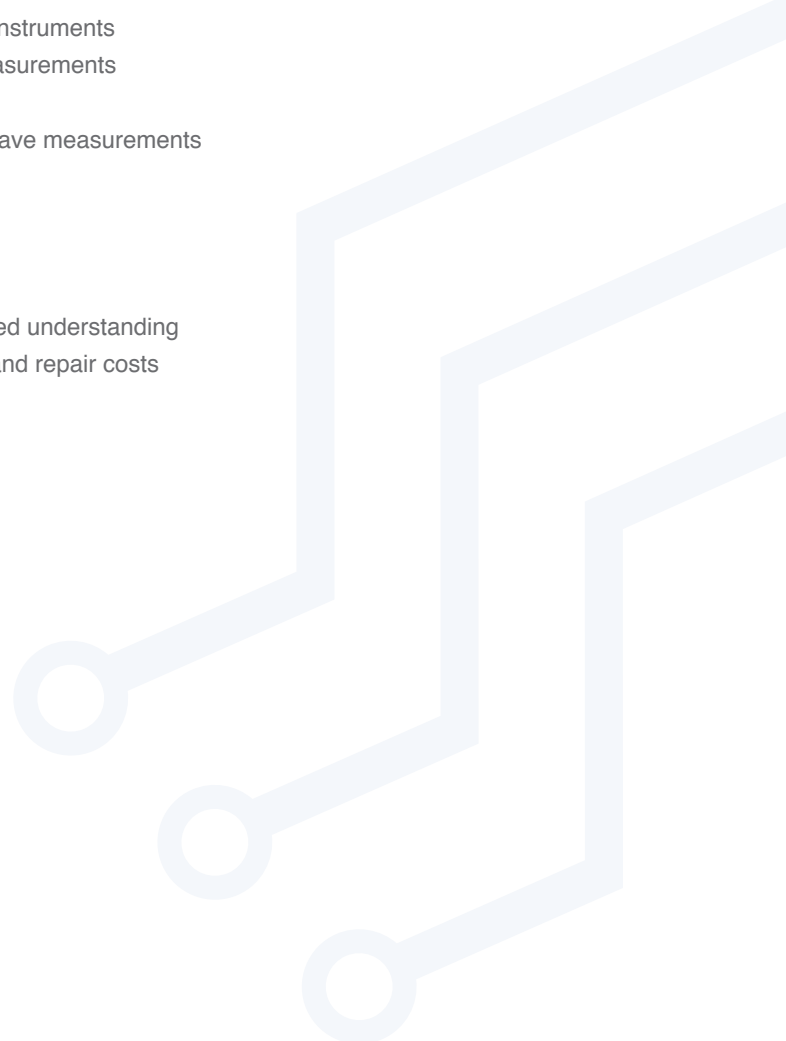
The course will deliver the following business benefits:

- ◆ Improved test and measurement efficiency
- ◆ Reduced test and measurement times and costs due to improved understanding
- ◆ Reduced risk of expensive test equipment damage, downtime and repair costs
- ◆ Better utilisation of test equipment features and functionality

### Course Programme

The course content covers:

- ◆ Transmission lines
- ◆ S-parameters
- ◆ Measurement uncertainty
- ◆ Connectors and cable care
- ◆ Signal generators and sources
- ◆ Vector network analysis and calibration
- ◆ Spectral analysis
- ◆ Power measurements
- ◆ Noise figure measurements
- ◆ Vector signal analysis
- ◆ Practical hands-on measurement sessions



## Practical RF and Microwave Measurements

### Instructor

Detailed information about the course instructor is available on request.

### Prerequisites

Participants would normally be qualified to degree level or equivalent in an electronic engineering, physics or mathematics-related subject. They should also have a basic understanding of electronics, RF and microwave technology.

### Course Level

Intermediate: Assumes the participant has general knowledge of the subject and professional experience of the specific areas covered.

### Course Venue

Delivered on-site either at customer premises or at any suitable venue throughout the UK, Europe and Rest of the World.

### Dates

Flexible according to your requirements.

### Course Fees

Please call us on +44 (0)1962 855 730 to request a quote.

### What's Included?

Course participants will each receive a set of high-quality bound course notes printed in full colour and a Certificate of Attendance.

### Customisation

For on-site courses, we do not force your organisation to adopt a standard, 'one-size-fits-all' training programme. The standard course programme can be adapted both in content and duration according to your exact requirements and specifications. Our technical experts will assist you in identifying these, even if they are uncertain or unclear. The course programme is then fitted to your exact requirements. Please call us on +44(0)1962 855 730 to discuss your requirements in more detail.

### Related Courses

Related courses include Antennas and Propagation for Wireless Communications Systems (RF2), Practical Design of Wireless Digital Communications Systems (RF4), PCB Design for RF and High-Speed Applications (RF5) and RF and Microwave Power Amplifier Design (RF6).

### Terms and Conditions

We encourage you to read our Terms and Conditions, which cover important issues like payment and cancellation policies. Our Terms and Conditions can be found on our website.

### Further Information

For further information about this course, please call us on +44 (0)1962 855 730.

## Practical RF and Microwave Measurements

### Detailed Course Content

#### RF and Microwave Measurement Fundamentals

- ◆ Transmission lines
- ◆ Characteristic impedance, reflection coefficient, VSWR and return loss
- ◆ Impedance matching
- ◆ S-parameters and definitions S11, S21, S12, S22
- ◆ De-embedding of S-parameters
- ◆ RF mismatch errors and measurement uncertainty
- ◆ Calibration
- ◆ Connector repeatability
- ◆ Different types of connector and adaptor
- ◆ Care of cables, connectors and calibration standards
- ◆ Connector cleaning methods

#### Signal Generators

- ◆ Fundamentals of signal generation
- ◆ Single and multi-tone signal generation
- ◆ How to set up and operate a signal generator

#### Vector Network Analysis

- ◆ Fundamentals of vector network analysis
- ◆ Sources of measurement error
- ◆ Calibration
- ◆ How to set up and operate a VNA

#### Spectral Analysis

- ◆ Fundamentals of spectral analysis
- ◆ Resolution, sensitivity and accuracy
- ◆ Frequency range
- ◆ Resolution bandwidth, sweep time
- ◆ Noise floor and dynamic range
- ◆ How to set up and operate a spectrum analyser

#### Power Measurements

- ◆ Fundamentals of power measurement
- ◆ Power measuring instruments
- ◆ Type of power sensor
- ◆ Signal types and measurement challenges
- ◆ Averaging power meters
- ◆ Sampling power meters
- ◆ Measurement reliability
- ◆ Power measurement standards, traceability and uncertainty

#### Noise Figure Measurements

- ◆ Basic theory including definition of noise figure
- ◆ Noise sources

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### Vector Signal Analysis

- ◆ Fundamentals of vector signal analysis

### Measurement Demonstrations

- ◆ Communications system overview
- ◆ System component specifications
- ◆ Receiver components
- ◆ Front-end filter (S-parameters, insertion & return loss etc.)
- ◆ Low noise amplifier (gain, power, phase, distortion, S-parameters etc.)
- ◆ Transmitter components
- ◆ Phase-locked oscillator (phase noise etc.)
- ◆ Power amplifier (gain, power, phase, harmonics and distortion etc.)
- ◆ Upconverter (conversion gain)
- ◆ Digital signal measurements
- ◆ Adjacent channel power
- ◆ Error vector magnitude
- ◆ Constellation diagrams
- ◆ Bit error rate