Course Description

Course name	**#026 - Essentials of Radio Communications Systems**
Duration	**3 days**
Format	**Public Classroom and Inhouse Event. Not suitable Online**

Overview
Dr. Richard G. Ranson, Consultant at Radio System Design, UK, is teaching this 3-day course in Radio Communications Systems.

The advent of 5G and the technology spin-offs along the way have re-invigorated developments in all radio systems. They have produced new levels of sophistication as well as RF ICs for complex functions which amalgamate analogue/digital circuit ideas as well as sophisticated signalling and protocol layers.

This comprehensive course, from an established expert and IEEE life fellow, gives a thorough view of all key elements of receivers and transmitters, from circuit blocks through the system level to network concepts.

Recommendation!
Continue the week by attending course **#025 – Hands-On Software Defined Radio** by the same instructor.

Technical Focus
Wireless connectivity is entering all corners of the applications space from phones and computers to everyday items like doorbells as well as a plethora of new ideas surrounding the internet of things. This comprehensive course is focused on understanding the essentials of RF communications from a system block diagram perspective and showing how key, block level, parameters can be related to the system specification to appreciate the radio systems as a whole.

The course builds some basic concepts to understanding the essentials of sophisticated systems such as WiFi and 5G. It is intended to give designers a thorough view of all key elements, from circuit blocks through the system level to network concepts. Also, having an emphasis on practical aspects helps participants relate to other requirements.

Course Content
The course explains essential system performance from base band to RF and back.
It explains the basics of system performance from constituent component block characteristics, block interaction and the relation to the top-level system specifications. Various tools are used to provide accurate initial estimates of performance while others show the relative contribution of different elements. Together they help isolate critical performance parameters, giving designers tools for cost effective solutions with an understanding of the interrelated aspects.

Who should attend?
This is intended for system designers, those interested in adding radio communications functions to existing products and component specialists wanting to understand more about how the whole system works. It is suitable for established radio technology companies as well as those with new applications wanting to understand the opportunities available.

Course Daily Schedule

Day 1 – Fundamental Limits
The essential feature of any RF communications system is successfully detecting a small signal against the background of noise whilst minimizing the interference from other signals and distortion. The first day introduces, or refreshes, standard concepts such as noise figure and intermodulation (IM), showing the sources and ways to evaluate these key concepts. It expands typical analyses with consideration of temperature, compression and the evaluation of ADC performance in modern digital receivers. These concepts are illustrated with practical examples and by developing a comprehensive, multi-stage spreadsheet to solidify the calculations and better understand how the performance of a cascade of system blocks is evaluated.

Day 2 – System Considerations
The second day describes issues associated with frequency translation, necessary to convert the base band signal to an RF carrier for transmission, reception and demodulation. The previous IM concepts are expanded to explain mixers with illustrations of radio architectures using an intermediate frequency (IF) as well important concepts associated with low IF, direct conversion and frequency translation as part of the ADC process. There is an introduction to the RF link budget to understand the key antenna and propagation concepts as well as channel impairments such as fading and delay spread that lead to substantial variability in radio propagation. Also, since filters are required at various parts of the signal chain, there is a discussion of standard terminology, fundamental principles and ways to estimate complexity from the just system requirements.

Day 3 – Examples of Implementation
In the final day, key concepts of modulation and access technologies are described with relative merits illustrated by reference to established wireless standards such as WCMDA, WiFi, LTE/5G and digital broadcast standards. Looking at these solutions helps to illustrate the strengths and weaknesses of various approaches from basic QPSK, through CDMA to the modern ideas using OFDM and MIMO. It shows how signals can be designed to combating channel impairments, as well as optimizing various resources such as frequency re-use, RF bandwidth and power. Other important design choices such as combining and sharing resources between many users and how concepts like MIMO are used to achieve network throughputs that actually challenge the traditional idea of the theoretical limits.

The course finishes with some perspective on the latest trends in radio communications with a view on how they might be best utilized. It covers key concepts relating to software defined radio (SDR) with a practical demonstration. As well as developments such as those in, 5G / New Radio, full duplex and ideas triggered from the incredible capabilities of the latest generation of RF ICs

Throughout the lectures, various practical tools including spreadsheets are used to illustrate key issues and to provide information for future analysis and design. A copy of all the Excel examples, many useful application notes, and alphabetic list of abbreviations and other material is provided to each student on a memory stick. This is made more accessible via an innovative wiki-based hypertext structure that allows easy access using a standard web browser.

Instructor Biography

Dr. Richard Ranson is the founder and Engineering Director of Radio System Design, a bespoke design and consultancy service specializing in microwave communications technology. He received his Ph.D. degree from the University of Leeds and has been in industry, actively involved in research and development of microwave components and systems for over 35 years.

He has been interested in radio from an early age. He obtained a Class A amateur radio license at the age of 14 and has been building and studying radios ever since. At university he specialized in microwave engineering obtaining a PhD on the now not so common topic of Transferred Electron Devices Amplifiers. His early work was on military systems, designing IFM and band translators for ECM equipment at MEL, then a part of Philips Electronics. He moved to the USA where he worked for AIL and Watkins Johnson Co. As well as various converter and customer specific products Dr. Ranson became a project leader on three major microwave receiver developments. One was the first upconverting, broadband microwave ELINT receiver employing an approximately 22 GHz first IF. The second was an innovative microwave impulse receiver where he was responsible for the key filter designs and the last was a very high dynamic range, triple conversion microwave to baseband processor for ADC signal processing.

In 1996 Dr. Ranson returned to the UK as Subsystems Engineering Director for Filtronic Comtek. There he grew the development team and expanded the company business and capabilities in integrated front-end products. After that he became Director of Wireless Research working with a team focused on high efficiency power amplifiers for base station applications. They were early adopters of the Doherty architecture, producing innovative designs for single and multi-carrier linear power amplifiers, employing large Filtronic GaAs pHEMTs and achieving state-of-the-art power added efficiencies. Later he became the Engineering Director of the Integrated Products Group of Filtronic plc responsible for engineering across the four business units in the group. This broad technology base ranged from semiconductor device and MMIC development, through integrated assemblies for point to point radios to advanced radar and ECM sub-systems.

From 2008, Dr Ranson founded and runs Radio System Design Ltd (RSD), a specialist RF and microwave consultancy. The work has 3 main threads, bespoke design, engineering consultancy and technical training. RSD has been profitable from inception achieving sales of over (GBP) 1 million in the first 3 years. It has successfully completed substantial engineering contracts, continuing consultancy support and technical training in the UK, Canada, USA and Europe.

Dr. Ranson is a Fellow of both the IEE now IET and the IEEE. Since 2006, he is a visiting Professor at Leeds University and has published technical articles, organized and presented in MTT workshops and presented numerous internal presentations and international seminars. He was the Digest Editor for the 1996 MTT Symposium in San Francisco, where he helped pioneer the publication on CD-ROM. He is a member of the MTT-S 2010 Technical Program Committee, the past Chairman of the MTT Technical Coordination Committee 20 on Wireless Communications. He has also been an Invited Editor for the Special Issue of the MTT Microwaves Letters focussed on European wireless communications technology. In 2006 he was the Technical Program Committee Chairman for European Microwave Week and the General Chair of the ECWT. Most recently, Dr Ranson served as UK member of the Board of Directors for the European Microwave Association (EuMA).

Dr. Ranson has been a member of the Continuing Education Institute-Europe faculty since 2004.