Essentials of Radio Communications Systems

Instructor

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Technology Focus

Wireless connectivity is entering all corners of the applications space from phones and computers to every day items like door bells as well as a plethora of new ideas surrounding the internet of things. This comprehensive course is focussed 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 from some basic concepts up 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.

Dr Ranson is a recognised expert in this field, running a successful consultancy for the last 15 years, with >40 years experience in the RF and microwave industry and a retired FIET and life fellow of the IEEE. He is an established lecturer to industry with more that 50 courses in Europe and North America and a past visiting professor at Leeds University.

Course Objectives and Who Should Attend

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.

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.

Day 1 – Fundamental Limits

The essential feature of any RF communications system is successfully detecting a small signal against the background of noise whilst minimising 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 illustrates 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 optimising 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 utilised. 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.