Course Description

Course name	**#025 - Hands On Software Defined Radio**
Duration	**2 days**
Format	**Public Classroom and Inhouse Event. Not suitable Online**

Overview
Dr. Richard G. Ranson, Consultant at Radio System Design, UK, is teaching this 2-day course in Radio Communications Systems.

Modern radio systems now rely on digital signal processing for more and more functions in both the transmitter and the receiver. This technology enables wireless interconnectivity for a diverse range of products and services from satellite communications to mobile phones and the internet of things.

Furthermore, this RF functionality has never been more accessible. This 2-day course uses supplied hardware and software to illustrate the key concepts and convert theory into practice. During the course students complete a QPSK radio link; digits to RF and back to understanding the core concepts of SDR.

Recommendation!
Begin the week by attending course **#026 - Essentials of Radio Communications Systems** by the same instructor.

Technical Focus
This hands-on course teaches the key concepts of digital radio technology via practical exercises using real hardware. Participants use their own laptop with all the required RF hardware and DSP software provided for use during the course.

The course demonstrates by example a complete digital radio link, covering sampling fundamentals and sampling rate changes, digital filtering, creating a transmit signal then receiving the signal with clock recovery and channel equalization. Each section of the course is split into 3 parts consisting of lectures on theory or implementation, then the actual 'hands on' part where the students follow prepared experiments that implement the section topic, reinforcing the material and enhancing their learning. This is then followed by a short discussion part to share findings and maybe add some additional theory to the topic. A complete set of lecture notes is provided as well as notes on the various experiments to assist and document the anticipated findings.

The course provides an ADALM Pluto SDR and an Ubuntu live USB memory stick, preloaded with all the required software and drivers for the course. Participants boot their computer (mac, pc or linux) using the memory stick provided and no software is installed on the participant's computer. The 'Ubuntu live' disk is a complete OS, self-contained, with all the software installed, tested and ready to go, essentially the computer just provides the keyboard, mouse, display and CPU to run and interact with SDR.

Course Content

Understand the basics of DSP using real hardware rather than abstract theory

- Understand the fundamentals of sampling and the discrete Fourier transform
- How and why to filter digitally
- Define common properties of finite impulse response filters and the basics of design
- Understand the basics of digital modulation and creating a transmitter
- Appreciate the need of interpolation and decimation
- Understand receiver synchronization and the role of signal shaping filters

Who should attend?

This is a course focusing on understanding and applying key principles of digital radio concepts. It is for product developers wanting to exploit new radio ideas as well as established engineers looking to better understand the interface between digital signals and analogue RF hardware. Using a low cost development platform and open-source software, the course demonstrates the now very low barrier to entry into this previously specialized area of technology.

Course Daily Schedule

Day 1

1) Hardware Introduction

Getting everyone to boot their computer and detect the hardware. Then use the Pluto device and IIO Oscilloscope application to generate a 2 -tone signal and observe that in the time and frequency domains.

2) Introduction to GNU Radio Companion (GRC)

Create a broadcast FM radio receiver from GRC blocks using the Pluto Rx. Illustrates some of the GRC visualization tools, setting the sampling rate, seeing why rate conversion is needed and matching data streams to the computer sound card for audio output.

3) Investigating Sampling

Understanding the tradeoff between sampling rate, number of bits, noise and bandwidth. Along the way observing alias signals, applying decimation and the need for filtering.

4) Digital FIR Filters

Basic design, calculating taps and applying them to the FIR hardware inside Pluto. Then use GRC for further investigations, creating realistic signals and observing the effect of filtering.

Day 2

1) Interpolation

Demonstrating how to increase the sample rate while restricting the bandwidth. Looking at RRC and other filtering approaches for digital modulation.

2) Transmitting
Generate digital data streams, mapping data to symbols and some basic digital modulation. Observing the potential bandwidth of raw digital data and the need for a smarter approach.

3) Creating a QPSK Data Link
Using Pluto to both transmit and, via an RF loop back cable, receive a digital data signal. Integrating that with GRC to observe the signal processing steps in both transmitter and receiver.

4) Receiver Synchronisation
Further investigate the QPSK link to understand details of the GRC blocks that perform timing recovery and channel adaptation.

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.