Hands on SDR Course

The hands on course teaches the key concepts of digital radio technology via practical exercises using real hardware. All the required RF hardware and DSP software is provided for 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 equalisation. 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.

What you will learn

- 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 synchronisation and the role of signal shaping filters

Day 1

1) Hardware Introduction
   Getting everyone to link their computer with the Raspberry Pi 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 visualisation 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 more 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 a 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 adaption.