Understanding Radio Communications

About this course

We all use digital wireless: Bluetooth, WiFi, 3G, 4G, 5G, LoRA, MESH, C6LoPAN….
But do we have any idea how it works? Students who study "Telecomms" courses learn about "RF" in depth, but what about everybody else? Computer Scientists and Programmers, Mechanical; Automotive; and Aerospace Engineers, would all benefit from knowing about this key technology. If you know a little about signals and signal processing, this course will enable you to understand RF Communications and bring these signals to life.

This course began as an optional course for Aerospace Students, who are active developers of "CubeSats", small satellites sending telemetry back to earth. Finding, capturing and demodulating signals from these satellites is a perfect example of today's needs from digital wireless.

Introduction

Software Defined Radio (SDR) has brought together two disciplines and fundamentally changed the way radio systems are implemented. It is a combination of radio electronics and computing. Computing is now at the heart of most engineering disciplines, so a practical appreciation of SDR is an ideal way to show that the radio spectrum is just as accessible as the visible light spectrum or indeed the audio spectrum. SDR is in effect the "camera" that enables you to "view" the radio spectrum!

SDRplay has sponsored Sapienza University of Rome, Department of Mechanical and Aerospace Engineering, to develop a practical course that will inspire Science, Technology and Engineering students to nurture their understanding of radio communications.

This 11-lecture course provides teaching materials and practical workshops that lead students from the first switch-on of an SDR through to signal reception, demodulation, and finally, successful communications with satellites. The course duration is about 12 hours.

The Authors

The course materials were developed by Lorenzo Frezza and Paolo Marzioli, PhD students at Department of Mechanical and Aerospace Engineering (DIMA), Sapienza University of Rome, Italy.

Pre-Requisites

The course is suitable for all students that have some basic knowledge of signal theory and signal processing. We have broadened and optimized the content to appeal to under-grads in Science, Technology, Engineering & Maths ("STEM"). Self-study is also possible using the videos as your teacher.

Hardware Required

(1) SDR Receiver: RSP1A ~$130, per workstation

https://uk.rs-online.com/web/p/communication-wireless-development-tools/1503954/

(2) "Basestation" in-Lab Satellite Simulator:

- Arduino Uno or Nano – $23 - https://store.arduino.cc/arduino-uno-rev3

- Transmitter. TI CC1101 Arduino compatible board ~10$

Examples: SMAKN   SIV   Neuftech   ICQUANZX

For Direct Satellite Reception, per Lab:

- Omnidirectional UHF antenna (435 MHz) < $35 Example Antenna

- Low-noise UHF amplifier, Bias-T. ~$15 to $30 Examples - NooElec Lana RTL-SDR LNA

Software Required (all free downloads):

(3) SDR Uno - https://www.sdrplay.com/sdruno/

(4) GNURadio for SDRplay - https://www.sdrplay.com/new-easy-sdrplay-set-up-for-gnu-radio-on-windows/

(5) Arduino IDE - https://www.arduino.cc/en/main/software

(6) Gpredict - http://gpredict.oz9aec.net/download.php

For Direct Satellite Reception & Decoding:

- UH7ZO Sound Modem - http://uz7.ho.ua/packetradio.htm

- VB-CABLE - https://vb-audio.com/Cable/

- AGW Online KISS - https://www.dk3wn.info/wp/digital/

Course Contents

Chapter	Lecture	Lab	Description
1. "Hello World"	✔	✔	SDR Basics
2. SDR Features	✔	✔	Main features of an SDR
3. Modulation	✔	✔	Basics of analog and digital modulation
4. GNURadio – Part 1		✔	Connecting the RSP1A to GNUradio and learning how to receive FM radio
5. GNURadio – Part 2		✔	
6. Packetization	✔	✔	How to divide data in packets
7. Receiving data from a dummy transmitter		✔	Using SDRs for data reception: how to build a GNUradio script that makes a telemetry station out of your RSP1A
8. Receiving data from a dummy transmitter (Part 2)		✔	
9. FEC + Scrambling	✔	✔	Optimising data reception
10. Nanosatellites and Ground Stations	✔	✔	Introducing nano satellites and setting up a satellite telemetry station
11. Receiving a satellite signal		✔	Receiving real satellite telemetry through your RSP

Videos

Our Authors at La Sapienza have produced videos that illustrate the set-up and running of the Lab exercises, you can view them here:
https://www.youtube.com/channel/UCsGfvgkoolsGJw-bnoA7MGg/

Support

We have a dedicated Forum for users of these materials, it can be found here: https://uni.sdrplay.com/forum/
It is our wish that this will build into a valuable Knowledge-Base for all your FAQs.

Please use this as the primary channel for any questions that you have about using these materials.

For specific technical questions about the RSP1A and the SDRuno software, there are links to several active forums here:
https://www.sdrplay.com/communitylinks/

Getting the Material

To receive these materials please submit an online request here:

https://www.sdrplay.com/UnderstandingRadio/

We will ask for some brief details about who and where you are, and what you plan to do with the materials. We usually reply within 3 working days.

Next Steps

In recognition of the creativity of our Authors in Rome, a translation into Italian will appear later this year.
We welcome your feedback about using the materials in your curriculum!

Supporting Academia

The Educators Programme has incentives to help set-up projects and labs. Details: https://www.sdrplay.com/Educators/
e-mail: uni@SDRplay.com