

Understanding Radio Communications

About this course

Bluetooth, WiFi, 3G, 4G, 5G, LoRA, MESH, C6LoPAN.... digital wireless communications are a fundamental part of modern electronic and computing systems.

25 years ago radio amateurs, hobbyists, and under-graduates in Electronics or Telecommunications, all studied the basics of RF and the fundamental modulation techniques such as CW, AM, FM, and SSB. Since then, this chapter of learning has disappeared. For most “digital RF” has become a “black box”.

This course provides an interesting and practical way to learn about digital wireless communications and to put the techniques to work receiving telemetry from the hundreds of “CubeSats” in orbit around the Earth. It is a fun way to learn important things!

Introduction

Software Defined Radio (SDR) has fundamentally changed the way radio communications systems are implemented. SDR technology bridges the traditional divide between 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” or the “microphone” to access 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 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 started life as a 12-hour optional course for third-year Bachelor's students in Aerospace Engineering and has been broadened to make it suitable for all students that have some basic knowledge of signal theory and signal processing.



Hardware Required: Windows PC plus.....

(1) SDR Receiver: [RSP1A](#) ~\$110, per workstation

<https://www.sdrplay.com/purchase/>

(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 a series of videos to illustrate the Lab exercises, you can view them here:

<https://www.youtube.com/channel/UCsGfvgkoolsGJw-bnoA7MGg/>



Support

We have set-up 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

We have plans for both Italian and Japanese translations of the materials. Please share 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

More about SDRplay at <https://www.sdrplay.com>

SDRPLAY