Project Télécom

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This is a Matlab simulator project which aims to make a hardware-in-loop transmission bench consisting of digital processing in Matlab and analog processing with real power amplifier in WebLab.

Students will work in groups of two or three for a project in 24 hours (6 sessions).
They can choose SDR project or Matlab simulator project.
For SDR project, documents are found in the page “SDR” on Moodle.

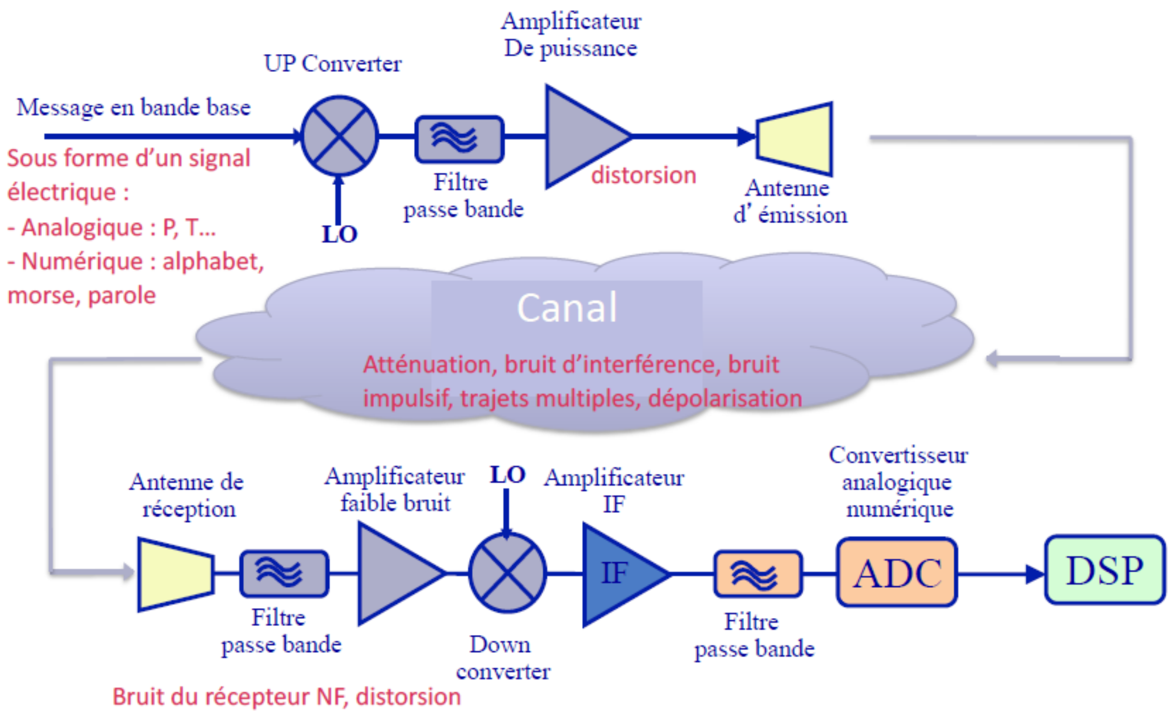
Project report and Fully commented Matlab file to be submitted before the midnight of January 5, 2026, to siqi.wang@sorbonne-universite.fr.
The files should be zipped to a folder named after [Telecom Rapport]Nom_Prenom.
The subject of email should be: [Telecom Rapport] Nom_Prenom

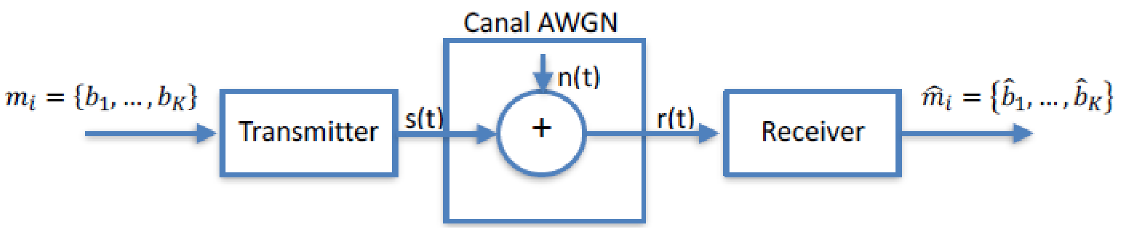
The report should be written using the template of IEEE provided in Moodel (in Word or Latex format). It can be written in English or French.

Expected content in the report:

- Report including:
    - Name, student number (put in author affiliation at the bottom of the first column)
    - Section of Introduction: the context and motivation of the telecommunication system developed in this project.
    - Section of system architecture: describe the overall of your work and system schematic diagram.
    - Section of obtained results (figures, tables to present the evolution of metrics under different tests)
    - Section of Analysis: Performance interpretation and explanation
    - An optional section if you have time: Critical reflection on possible improvements, for example, extension with PA linearization and discussion of its importance in modern communication systems
    - Conclusion: what you have learned from this work

Signal transmission and reception system





This project aims to help students understand the challenges in telecommunication systems from noise and device impairments. The students will first establish a transmission chain in Matlab. Then they will manually add different levels of noise to the chain and evaluate the impacts on the transmission quality. Furthermore, the students will test the signals on a real transmitter through WebLab Matlab client (https://dpdcompetition.com/rfweblab/measurement-setup/). An optional step is to utilize the DPD technique to compensate for the nonlinearities of this transmitter.

Task I – Build the TX/RX System in Matlab (Script or Simulink are both ok.)

Objective:
Construct a basic transmission chain (transmitter–receiver) simulation using Matlab.
Detailed steps:

1. **Define the global block diagram of the transmission chain:**
   - Binary data source (e.g., random bit generator, some words coded in ASCII, etc.)
   - Baseband modulator (BPSK, QPSK, 16QAM)
   - Transmission channel without noise (first step)
   - Corresponding demodulator
   - Receiver: recovery and visualization of received bits

2. **Implement the transmitter (TX):**
   - Digital signal generation: Modulation block (e.g., BPSK, QPSK, 16QAM)
   - Mixer/IQ modulator with carrier frequency.
   - Optional: transmit filter (e.g., Root Raised Cosine)
3. **Implement the receiver (RX):**
   - Demodulation block (corresponding to chosen modulation)
   - Bit error rate (BER) calculation by comparing transmitted and received bits
4. **End-to-end simulation:**
   - Verify correct operation in the absence of noise
   - Visualization of signals (constellations, time/frequency plots)

Task II – Add Noise and Apply Modulation Techniques for Robustness

Objective:

Test the robustness of the system against noise and improve performance with appropriate modulation schemes.

Detailed steps:

1. **Add random noise in the channel:**
   - AWGN (Additive White Gaussian Noise)
   - Optionally, other impairments (e.g., impulsive noise, fading)
2. **Measure performance:**
   - BER as a function of SNR (draw BER vs. SNR curves)
3. **Compare different modulations:**
   - Implement BPSK, QPSK, 16-QAM, etc.
   - Compare performance at the same SNR

Task III – Power Amplifier (PA) Modeling and Linearization

Objective:

Model the nonlinear effects of a real power amplifier in WebLab testbench from distance and apply linearization techniques to mitigate distortion.

More details of introduction on WebLab testbench can be seen in:

https://dpdcompetition.com/rfweblab/measurement-setup/

The signal fed to WebLab should be baseband signal (complex-valued). The IQ modulation and upconversion to RF is done automatically by WebLab.

The signal acquired from WebLab is also baseband signal.

Detailed steps:

1. **Run the testbench from Matlab interface:**
   - Download and unzip the Matlab source files from Moodle.
   - Run "main.m" and observe nonlinear distortion effects (AM/AM, AM/PM) on the transmitted signal.
   - Measure signal quality metrics: EVM (Error Vector Magnitude), ACPR (Adjacent Channel Power Ratio), input power, output power, supply voltage, and supply current. Compute the power efficiency of the PA.
   - Transmit modulated signals (QPSK or 16-QAM).
   - Visualize constellation degradation and spectral regrowth.
   - Compare BER performance with and without PA distortion.

- Change the power of input signal and redo the steps above. See the evolution of the EVM, ACPR, BER performance, and Power efficiency of the PA.

2. **Linearization via Digital Predistortion (DPD):**
   - Implement a predistorter before the PA using memory polynomial models.
   - Adapt coefficients using LS in indirect learning architecture.
   - Evaluate the effectiveness of linearization by measuring ACPR, EVM, and NMSE improvements.
   - Compute the BER after linearization with DPD.