FSK Wireless Communication between Two Personal Computers

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ABSTRACT

During the senior year of the engineering cycle of Polytech'Nice-Sophia, the students who follow the "Telecommunication and Networks" specialization are taught several Computer-Aided Design labs. One of them consists in designing the main elements of a 2.5 GHz Frequency Shift Keying wireless communicating network between two Personal Computers. This paper describes this teaching experience and more precisely this whole lab, which is largely inspired from a successful course developed at Utah State University, Logan and Brigham Young University, Provo [1].

1. SET-UP DESCRIPTION

The block diagram of the FSK Transmitter/Receiver (Tx/Rx) is depicted in Figure 1. The communication system operates in the following way. Through a Visual BASIC program, a text, when written on the Tx PC is converted into a -12V/+12V signal, which is available on the serial "COM" Port of the PC. A small electronic circuit board (EC Tx) is in charge of setting the magnitude levels of this Tx signal at respectively 8.3V and 11.8V. Then, this signal is sent into a Voltage Controlled Oscillator to respectively being changed in two 2.4 and 2.6 GHz frequency signals at its output. The modulated FSK signal feeds a patch antenna and is radiated in free space. At a certain distance, an identical antenna collects this signal which is sent to a lumped amplifier. The signal is then equally divided by a -3 dB microstrip divider. It is then filtered around 2.4 and 2.6 GHz through two coupled-lines microstrip bandpass filters. These two signals are rectified by diode detectors and are sent to the Rx electronic circuit board (EC Rx) which consists of a comparator designed to deliver a -12V/+12V signal. The signal is brought to the serial "COM" port of the Rx PC and the text is displayed almost in real time on the PC screen with the help of a Visual BASIC program. The received text must match the sent text to validate that the wireless communication was carried out without any errors.

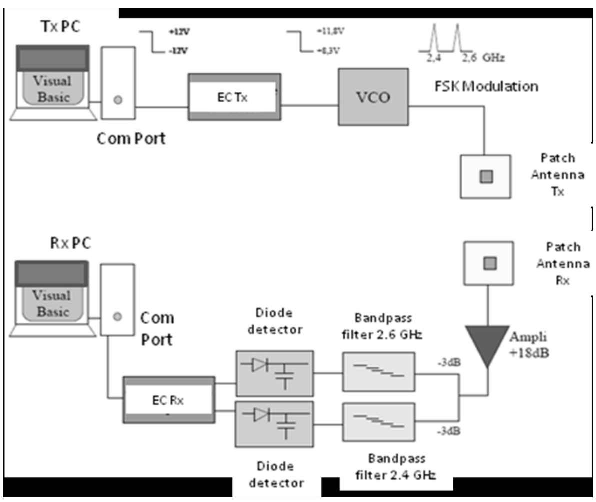

Figure 1 Block Diagram of the FSK wireless link between two PC's

2. STUDENTS DUTIES

The students are in charge of the design of all the blocks of the receiver except the amplifier. The whole course is divided in five Labs. At the beginning of the day-lab, the teacher presents the work to be carried out while insisting on the key points and the tricks. The students have then a schedule and some circuit goals. They must design and optimize the considered block until reaching a finalized layout ready for lithophotography.

3. DESCRIPTION OF THE LABS

A. Initiation to ADS-Momentum

The first meeting consists in presenting how operates the WLAN network and especially which elements will have to be designed. This short introduction is followed by a software initiation of the Agilent Momentum electromagnetic software.

B. Design of the patch antennas

The second lab consists in designing the antennas of the wireless network. The proposed design procedure is based on the transmission line method: it allows achieving an analytical first-order dimensioning of the patch at 2.4 GHz given a specific substrate (dielectric permittivity=3.2, height=1.524mm). The following stage consists in actually simulating this patch and readjusts its dimensions for a 2.4 GHz operation. We started with two juxtaposed patch antennas as only one is not able to fulfill the 200 MHz bandwidth necessary for the wireless link. Since this course is taught, the antenna is improved every year. We have today several antennas satisfying the return loss goal (-10 dB at 2.4 and 2.6 GHz). The fabricated antennas achieve a gain varying from 5 to 14 dBi according to the configuration (stacked patches or linear array of patches). Fig. 2 presents a side view and a top view of the stacked patches prototype. The simulated and measured input impedance are also presented in this curve.

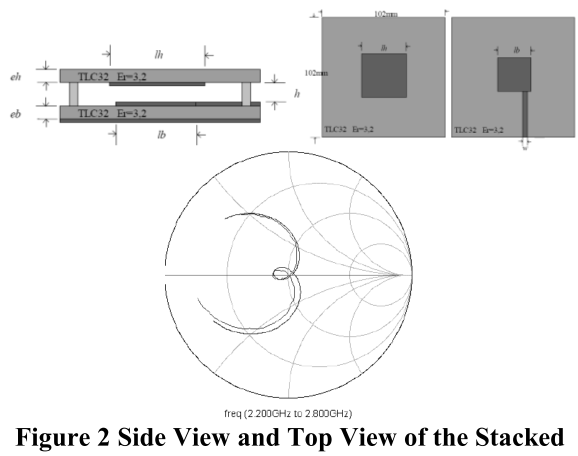

Figure 2 Side View and Top View of the Stacked Patches Antenna. Simulated and Measured Input Impedance on a Smith Chart

C. *Design of the 3dB divider*

The third lab relates to the microstrip divider to ensure a proper split of the signal which is amplified at the Rx side of the link (fig. 1). This stage does not present any particular difficulties. The simulated scattering parameters are presented at the left side of Figure 3 and measured ones at the right side.

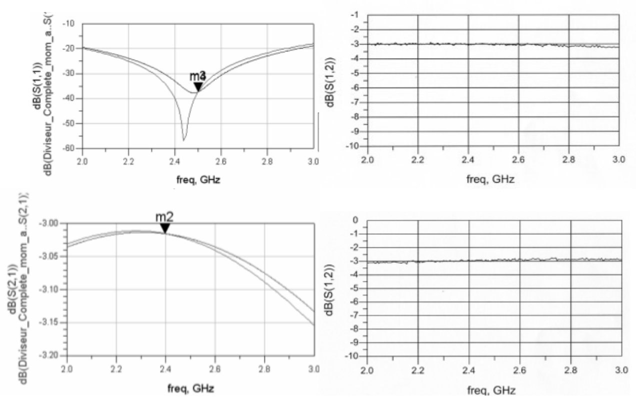

Figure 3 Simulated and Measured Scattering Parameters of the 3dB Microstrip Divider

D. *Design of the bandpass filters*

The fourth lab consists in designing the coupled lines bandpass filters in microstrip technology. They must separates the signal received in two others each one only containing the 2.4 GHz or the 2.6 GHz frequency (fig. 1). The maximum ripple in the bandwidth should not exceed 0.5 dB while the desired attenuation outside this bandwidth must reach 20 dB. Fig. 4 depicts the layout of the 2.4 GHz filter, a picture of the two manufactured filters and their measured performances. We can notice that the out-of-band performances in terms of rejection are satisfactory but insertion loss of both filters in the pass-band is about -3.5 dB. This is largely below that the -0.7 dB simulated value.

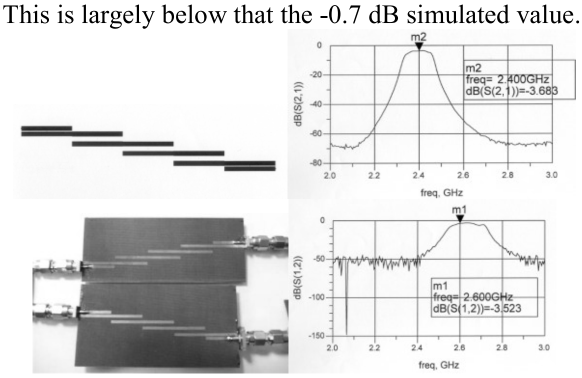

Figure 4 Layout, Picture and Measured S_{21} parameter of the two microstrip coupled line filters

E. *Design of the diode detectors*

The last lab consists in designing the two diode detectors, one operating at 2.4 and the other at 2.6 GHz. The selected diode (surface mount zero bias schottky detector diodes) is provided by the Agilent manufacturer: HSMS-2850. The students use the scattering parameters of the diode which are found in the Agilent DataSheet for the Harmonic Balance circuit simulation. The detector is fed with a 0 dBm power, the goal being to recover 1V at its output. The optimization consists in choosing the best capacitor for efficient envelope detection as well as the best parallel microstrip stub for maximizing power transfer through a correct input matching. Usually, these goals are almost achieved since we measure an output voltage of 0.8V.

4. TEST OF THE COMPLETE SYSTEM

This teaching experiment ends with a debriefing where the teacher compares the best designed circuits. This last part is particularly appreciated by the students because they have been, during one month, immersed in a competition for satisfying a fictitious customer (the teacher) who is now about to buy the best blocks. In parallel, a measurement of the whole system is performed with the elements manufactured by the teacher. Fig. 6 presents a view of the complete system where it can be distinguished all the previously described circuits. Particularly, the first fabricated antenna-prototype made with the juxtaposition of the two patches is revealed.

Figure 6 All Rx Blocks of the network (left side) and final test with the two PC's (right side)

The wireless network is very satisfactory for a few meters distance. Unfortunately, increasing the gain of the antennas did not make any significantly enhancement of the communicating distance. Our investigations revealed that the VCO does not deliver signals perfectly set at 2.4 and 2.6 GHz but rather at 2.45 and 2.55 GHz. Consequently, several degradations occur at the Rx chain. They are difficult to compensate: the delivered levels of the bandpass filters and the ones of the diode detectors. A more thorough study is necessary to avoid this VCO problem. Especially, a modification on the electronic board at the Tx chain would probably make it possible to deliver adequate voltage levels at the entry of the VCO. Possible improvements could be to achieve system (or Ptolemy) simulations of the whole RF chain under ADS. This would provide us a better performance indicator like the BER rather than a simple visual indication of the received message. In addition, owing to the fact that the network is conceived with blocks, the measurement side of these modules could also be developed on the passive elements and the active elements (1 dB compression point, IP3, ACPR etc...). Other types of digital modulations could also be considered. Finally with the exponential increase of WLAN networks at Polytech'Nice, we are currently experiencing more and more jamming. The new version of the WLAN network should be designed away from 2.4 GHz to avoid this electromagnetic pollution.

5. CONCLUSION

This course closely associates the simulated results obtained at the different design stages with those measured and observed on a functional system. It gives the opportunity for the students to evaluate their work and the efforts provided during the labs. This course is also one of the most appreciated because giving in real time the proof of the transmission without wires of a message by radio waves. Thus, it allows re-examining in a handling way many concepts taught and learned during previous years.

REFERENCES

[1] Furse C., Woodward, R.J, Jensen M.A., *"Laboratory Project in Wireless FSK Receiver Design"*, IEEE Transactions on Education, Volume 47, Issue 1, pp. 18-25, February 2004.