



1 Objective

Develop a system to measure the **human heartbeat** and **respiration rates**.

Learning outcomes

Successful completion of this activity will provide the students with practical knowledge on:

1. Hardware and software aspects of radar systems.
2. Generation, acquisition and processing of electromagnetic signals.
3. Development of a testbed and procedures for the validation of a radar system.

2 Design specifications

1. Spectrum usage according to applicable law [1, 2].
2. Measurement distance from subject: from 0 to 2 meters.
3. Real-time operation, heart rate and respiration rate display at most ten seconds after the positioning of the subject in front of the radar.
4. Indication of the presence/subject of a subject.
5. Maximum measurement error: 20% for both heart and respiratory rates.
6. False alarm rate of subject presence less than 20%.
7. Detection rate of subject presence $\geq 70\%$.

Grading

Evaluation will consider the following items (see below for details on format, contents and schedule):

1. (35%) Written project proposal
2. (35%) Written final report
3. (30%) Device demonstration and measurements: includes device aesthetics, robustness and performance

Deliverable documents

Documents must have the official format of the IEEE Transactions, there are templates available in L^AT_EX and MS-Word in this link (select “template for all Transactions”):

http://www.ieee.org/publications_standards/publications/authors/authors_journals.html

2.1 Project Proposal

The project proposal must include these sections:

1. Interest of the system developed, applications and previous works.
2. Problem statement and specifications.
3. List of activities and schedule for the project development, including a report on the partial advance achieved at the time.
4. Approximate budget including student time.
5. Validation testbed: proposal of a hardware device that simulates a person with representative size, and heart/respiration rates.
6. Detailed definition of the protocol followed to evaluate all the specifications.
7. Preliminary results: description of any design/simulation results obtained in the development of the project.
8. Description of the challenges foreseen for the completion of the project and how these will be faced.

Note that the project proposal is limited to an extent of four pages.

2.2 Final Report

The final report must include these sections:

1. Abstract: Describes the aim and scope of the work presented, the various steps followed in the process, and the results obtained. This is to be written in English and must have at most fifteen (15) lines.
2. Introduction, which includes these elements:
 - (a) Motivation of the work presented, interest and current and potential applications of the system developed.
 - (b) Complete list of the device specifications and metrics attained in each of these.
 - (c) High level description of the process followed to develop the device, justification of the various choices.
3. Antenna element:
 - (a) Antenna type, operation principle and specifications: impedance bandwidth, beam width in the main planes, realized gain.
 - (b) Dimensions and materials including a fully quoted drawing of the structure.
 - (c) Design/simulation results if applicable.
4. Transmitter and receiver, description and specifications: power, bandwidth, sensitivity.
5. Processing algorithms: principles, software environment, operation outline, full code (as an annex).
6. Prototype description: manufacturing and/or integration procedure and a photo of the final device.
7. Validation testbed: description of the system, specifications and photograph.
8. Experimental validation: detailed description of the test scenarios considered (at least two) and results (reference Vs. Measurement with your system) including assessment of the specification metrics.
9. Analysis of results:
 - (a) Critical evaluation of the results in terms of attainment of the specifications.
 - (b) Discussion of the limitations of your system in real applications and guidelines for future work.
 - (c) Analysis of the adherence of your system to the applicable regulation concerning spectrum use.
10. References (see the citation guidelines in the format assigned for this report).

Note that the final report is limited to an extent of six pages.

Schedule and products

The products of this project and delivery dates are:

Item	Specification	Date
Project proposal	PDF uploaded to the course website, size < 10MB	October 17
Final report	PDF report, commented scripts, ready-to-run simulation files	December 1
Device Prototype and testbed	Demo and Q&A.	December 1

** Please note that submissions not conforming to the above guidelines will not be considered.*

References

- [1] Agencia Nacional del Espectro (ANE), *Resolución No. 105 de 27 de marzo de 2020, "Por medio de la cual se actualiza el Cuadro Nacional de Atribución de Bandas de Frecuencias"*. República de Colombia, 2020.
- [2] International Commission on Non-Ionizing Radiation Protection (ICNIRP), "Guidelines for limiting exposure to electromagnetic fields (100 kHz to 300 GHz)," *Health Phys.*, vol. 118, no. 5, pp. 483–524, may 2020.
- [3] M. Skolnik, *RADAR Handbook*, 3rd ed. McGraw-Hill, 2008.
- [4] —, *Introduction to RADAR Systems*, 3rd ed. McGraw-Hill, 2001.
- [5] S. M. A. T. Hosseini and H. Amindavar, "A new ka-band doppler radar in robust and precise cardiopulmonary remote sensing," *IEEE Transactions on Instrumentation and Measurement*, vol. PP, no. 99, pp. 1–11, 2017.