Student Design Competition

IEEE IMS 2023 in San Diego, California 11-16 June 2023

SDC1 - Wearable Backscatter Radio Student Design Competition

Body-worn Ultra-High-Frequency RFID transponder

Detailed description and rules

Introduction

The participants will be asked to design and prototype an original low-cost and miniaturized wearable backscatter modulator (WBM) that is a fundamental block of Ultra-High-Frequency (UHF) RFID. In this system, the reader will transmit a continuous signal and the transponder (WBM) will reflect the signal and introduce a modulation to convey the information. The device under test (WBM) will consist of an antenna and a binary backscatter modulator (i.e., on binary amplitude shift keying, BASK, or binary phase shift keying (BPSK)) and should be optimized to operate at low-power level and maximum sensitivity in this scenario. The proposed system should work in the RFID UHF band and will be evaluated with a 915 MHz sinusoidal continuous wave signal. The wearable device should be made of cheap materials like cardboard, copper tapes cut with a traditional blade /or knife and other cheap electronic components for a low-budget project.

Design specifications and rules

The project should be the result of the students' effort. The judges will be asked to verify that during their evaluation. The specifications and rules are the following:

1. The setup (see Fig. 1):

   a. One **reader** and one **tag**.

   b. The reader will transmit a sinusoidal signal at a frequency of 915 MHz. The transmitted power will be P_{TX}=36 dBm (EIRP).

   c. Two linearly polarized antennas will be used as the reader: one for the downlink and one for the uplink (bistatic configuration). Both antennas are placed adjacently on the same table and aligned with the center spot of a $95\ cm \times 60\ cm \times 35\ cm$- phantom (representing the average size of a human torso). The phantom can be made of bags of saline water with 0.4 % wt of NaCl and 99.6% wt of DI water (%wt: percentage by weight), which approximates a medium of dielectric 81 (to mimic the human body). The transmitting antenna is connected to a signal generator and the receiving antenna, to a spectrum analyzer.

   d. The WBM (device under test, DUT) will be placed at 3 meters away from the reader for

evaluation.

e. The tag will consist of the device under test (WBM), a waveform generator to generate the modulation signal and a driver to interface the modulation signal to the backscatter modulator. The input signal of the driver is the output of the waveform generator, and the device under test has one port (wires) that allows it to be connected to the driver.

2. The students are free to use any readily available technology.

3. No internal batteries, nor energy harvesting circuits are allowed.

4. The prototype should be made of cheap and sustainable materials like cardboard, Styrofoam, copper tapes, aluminum foil, etc

5. The students are encouraged to use very easy manufacturing process like using a little knife or blade to cut copper tapes for example
6. The prototype will be inspected internally by the judges.
7. The dimensions of the whole device (substrates and soldered components) under test should not exceed $5\ cm \times 5\ cm \times 1\ cm$.
8. The thickness of the WDM (device) should not exceed 1 cm.
9. The maximum weight of the prototype should be 10 grams.
10. The device under test will be placed on the phantom (of dimensions $95\ cm \times 60\ cm \times 35\ cm$) located on a table at 3 meters from the reader. The device (WBM) can be mounted on the phantom using double sided adhesive tapes. The competing teams will be asked to place their prototypes at the marked positions for evaluation (see Fig 2).
11. The waveform generator will generate a square wave with a frequency f=1 MHz
12. The 0-to-peak voltage of the output of the drivers can be chosen by participants in the range [0.8-3.6] V. The driver that will be used for evaluation will be a signal buffer SN74AUP1G34 (single-ended square wave).
13. The overall power consumption (P) will be evaluated by measuring the power consumption of the driver ($P = V \times I$). The current consumption of the driver will be calculated as $c\ DD\ DD$ the average current consumption during a continuous modulation operation.
14. The initial testing can be performed at the students' home lab on a phantom (with the requirements listed above) and be reported on their poster presentation.
15. The students are encouraged to build more than one prototype in case one is defective during the judging process. Students who only have one prototype even it becomes defective during the judging process, will be asked to finish the testing experiment and the score will be given based on the corresponding performance.

Evaluation process

The performance of the device will be evaluated as a trade-off between the design geometry, the sensitivity, and the power consumption from the experimental setup described above. The leading criterion for the evaluation will be the figure-of-merit (FOM) detailed below. In addition, each competing team will be required to prepare a small poster (A3 size) to describe the step-by-step process used for design, fabrication, and initial testing of the device. This poster presentation should be at the level of the IEEE Microwave Magazine standards. The students are encouraged to detail every step that was taken to bring their project to the finished line. The FOM will be estimated as follows:

$$P_{total} = \frac{P_{RX1}(nW) + P_{RX2}(nW) + P_{RX3}(nW)}{P_{C1}(\mu W) + P_{C2}(\mu W) + P_{C3}(\mu W)}$$

$$FOM = P_{total} \times \frac{25}{D_1(cm) \times D_2(cm) \times D_3(cm)} \times \frac{10}{wieght\ (g)}$$

Where the $P\ RXi$ is the power associated with the first side-band signal measured by the spectrum analyzer (i.e., power at 916 MHz) and the PCi is the power consumption of the driver, corresponding to the transmitted power P_{TX} and the marked position i, and D1, D2, and D3 are the dimensions of the prototype (the brick circumscribing it).

Scoring

The judges will assign a total score according to the breakdown below:

Criteria	**Maximum Score**	**Weights**
$P\ total$	10 points	1
FOM	10 points	3
Grand Total		**40 points**

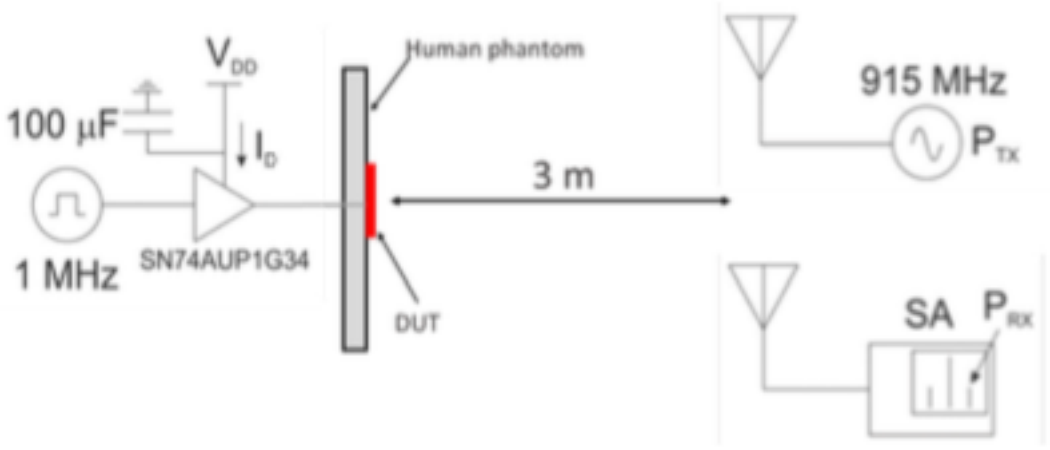

Figure 1:Measurement setup

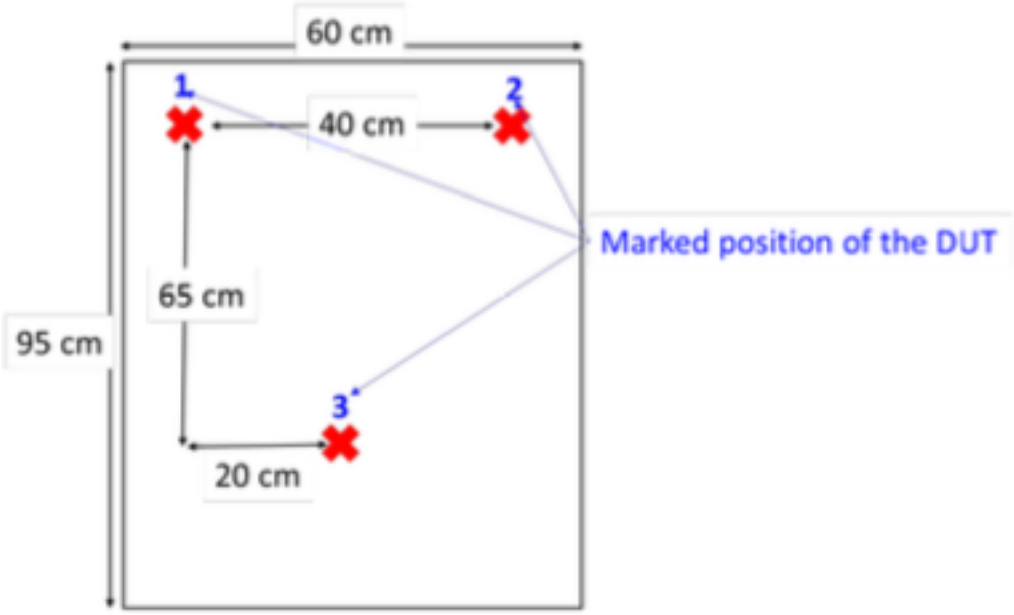

Figure 2: Illustration of the marked positions to mount the DUT on the phantom

How to participate

Competing teams will be required to submit the entry forms by 3 April 2023. Following the entry form submission will be an abstract detailing the proposed design, an estimate of the average power consumption of the circuit that should be submitted on 22 May 2023. The teams are encouraged to be inclusive (participation of women and other underrepresented minority groups).

supporting MTT-S Technical Committee

TC-26 (RFID, Wireless Sensor and IoT)

Contact information

- Dieff Vital, dvital@uic.edu
- Mahmoud Wagih, mahmoud.wagih@glagsow.ac.uk
- Hamed Rahmani, hamedrahmani@ibm.com
- Valentina Palazzi, valentina.palazzi@unipg.it
- John Kimionis, jkimionis@ieee.org
- Thomas Ußmüller, thomas.ussmueller@uibk.ac.at
- Spiros Daskalakis, daskalakispiros@gmail.com