Realization of RF and microwave energy harvesting system adapted to GSM-900 network for low power consumption sensors feeding

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Presentation summary

1) Introduction

The RF and microwave energy harvesting technology attracts more than more many researchers around earth, due to it simplicity and the high possibility to miniaturize this circuit according with the wave frequencies that this system is matched to.

This system gives a large possibility to realize the energy autonomous of many electronic devices such as (sensors, smart watches, etc.).

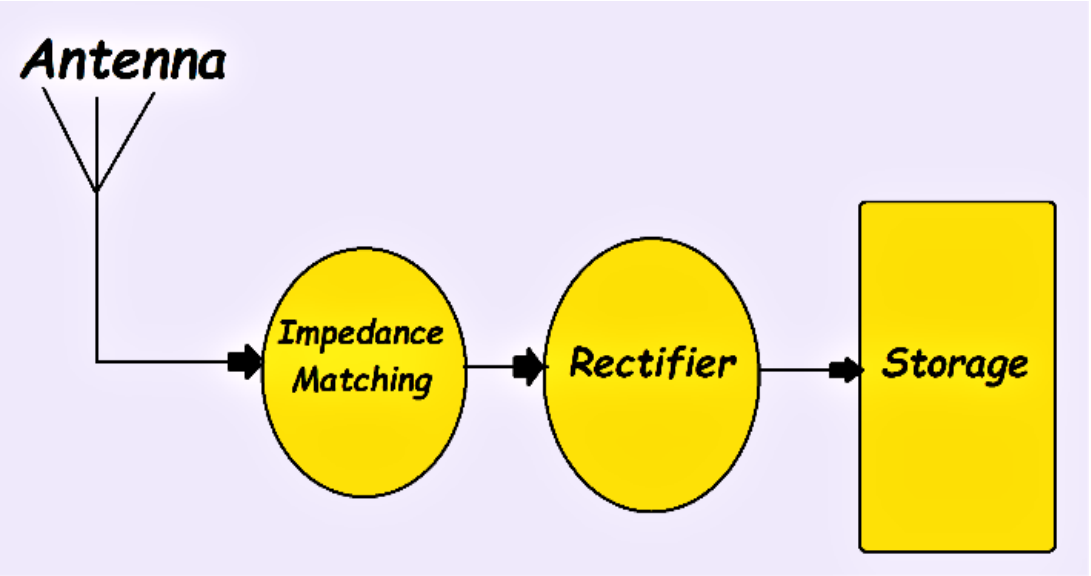


Figure 1. General RF energy harvesting system blocs

2) Proposed Antenna (simulation & measurement)

2-1) Antenna structure

This antenna structure is simulated on Teflon hybrid technology with a thickness of 0,67 mm.

The antenna feeding is in base of coplanar line.

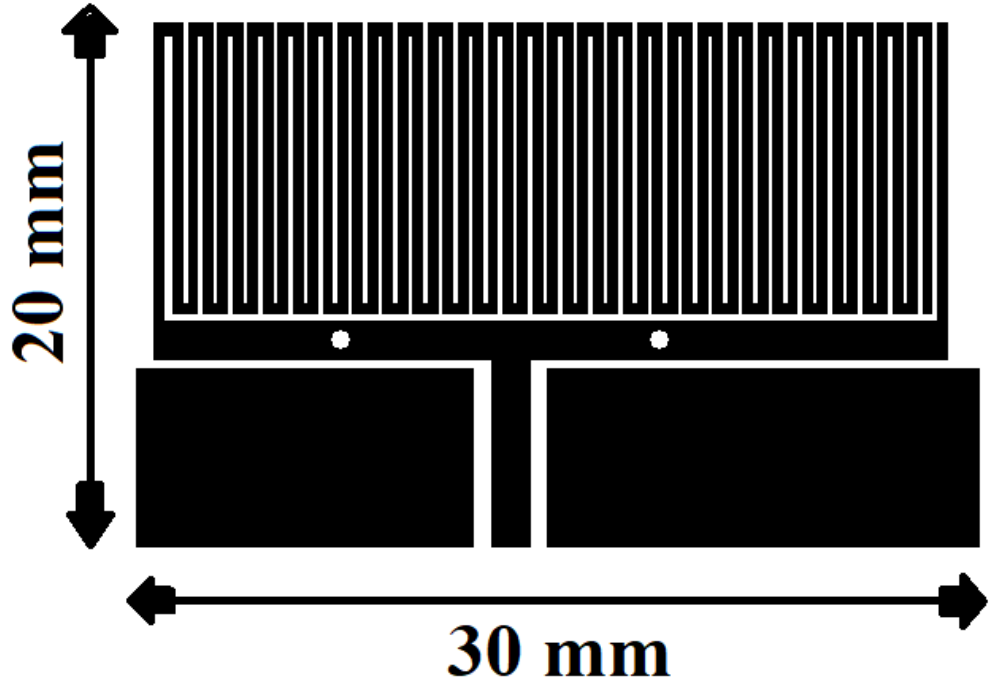


Figure 2. The proposed Antenna Structure

- Simulation results obtained by using CST Software

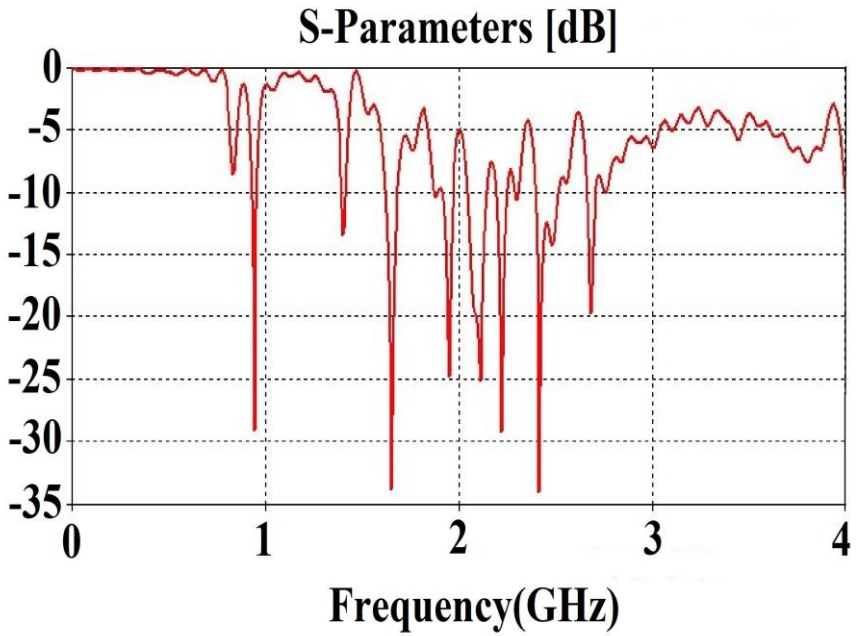


Figure 3. Simulated S_{11} antenna response

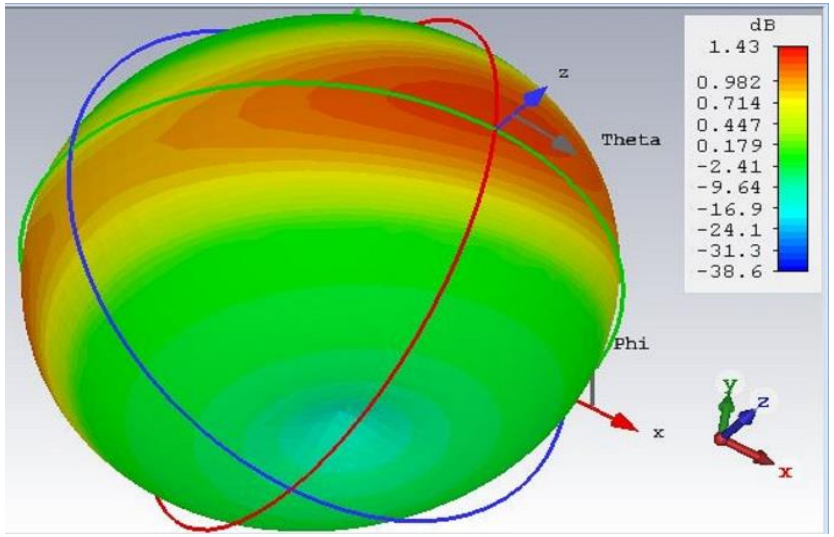
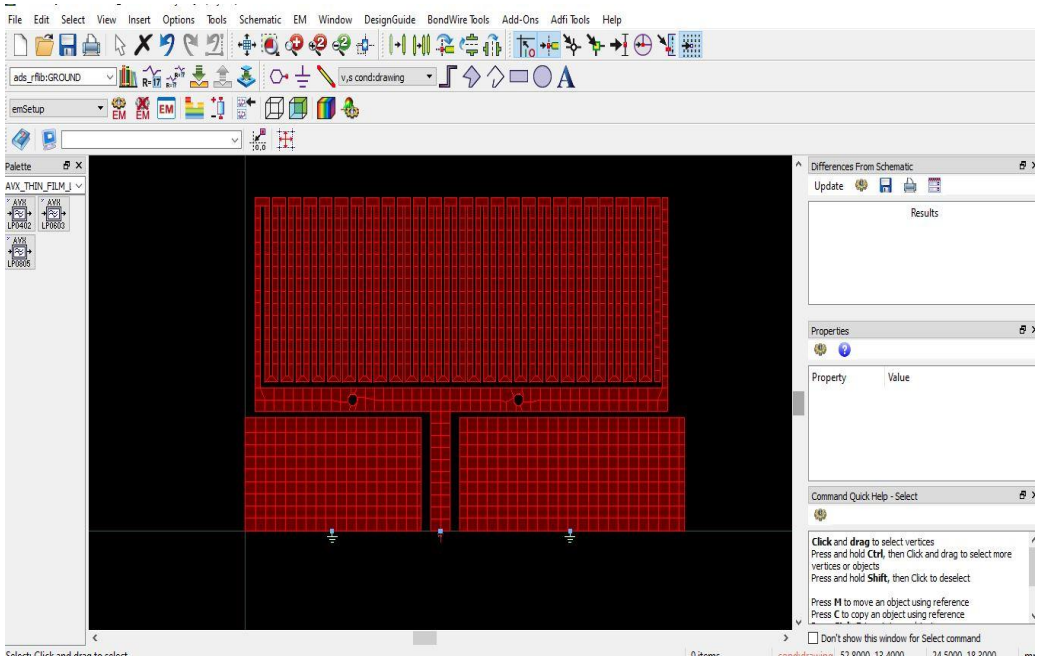


Figure 4. Radiation diagram at 948 MHz, 1.8 GHz, 1.96 GHz

- S11-Co-simulation result obtained by using ADS Software



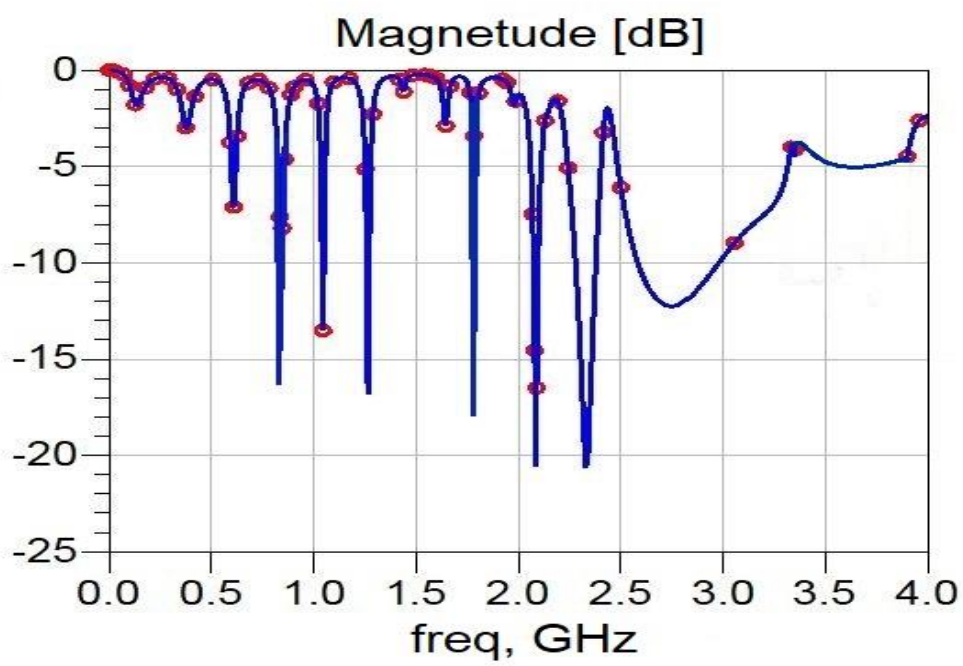


Figure 5. Representation and S11 Co-simulation Response on ADS Software

2-2) Electrical equivalent circuit model

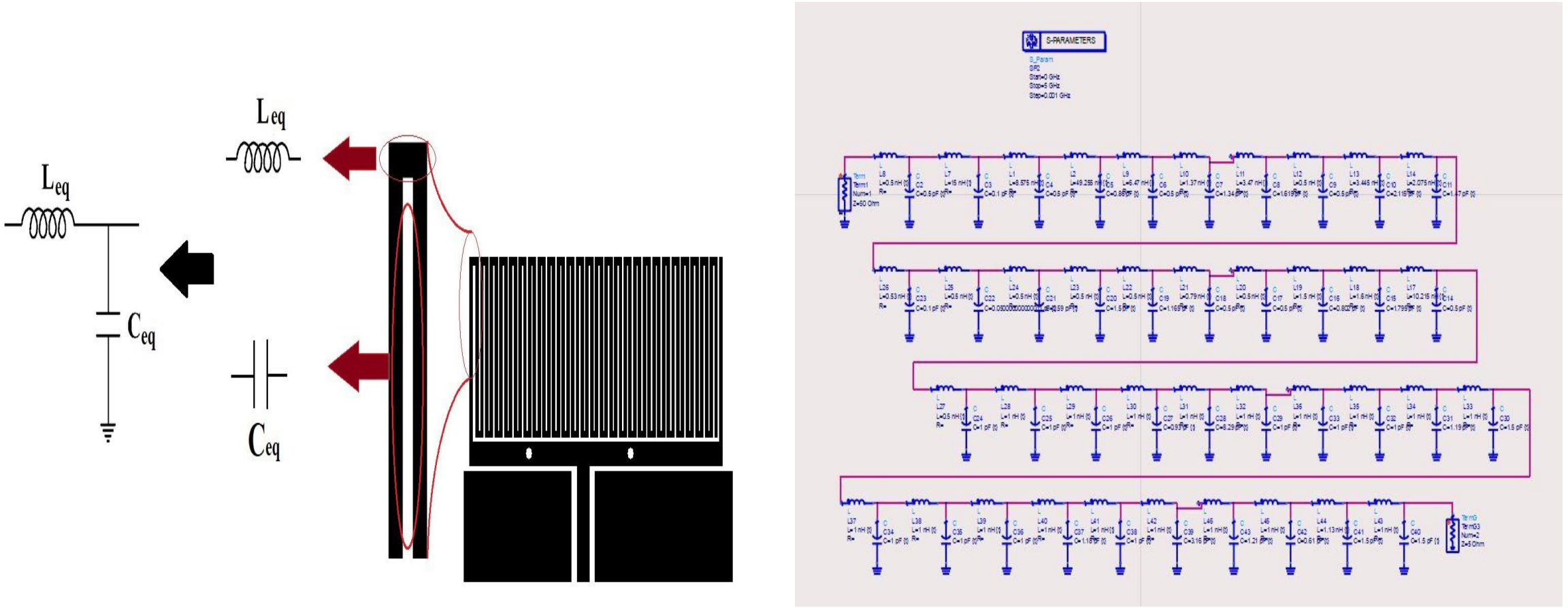


Figure 6. Antenna electrical equivalent circuit

- Simulation result obtained by using ADS Software

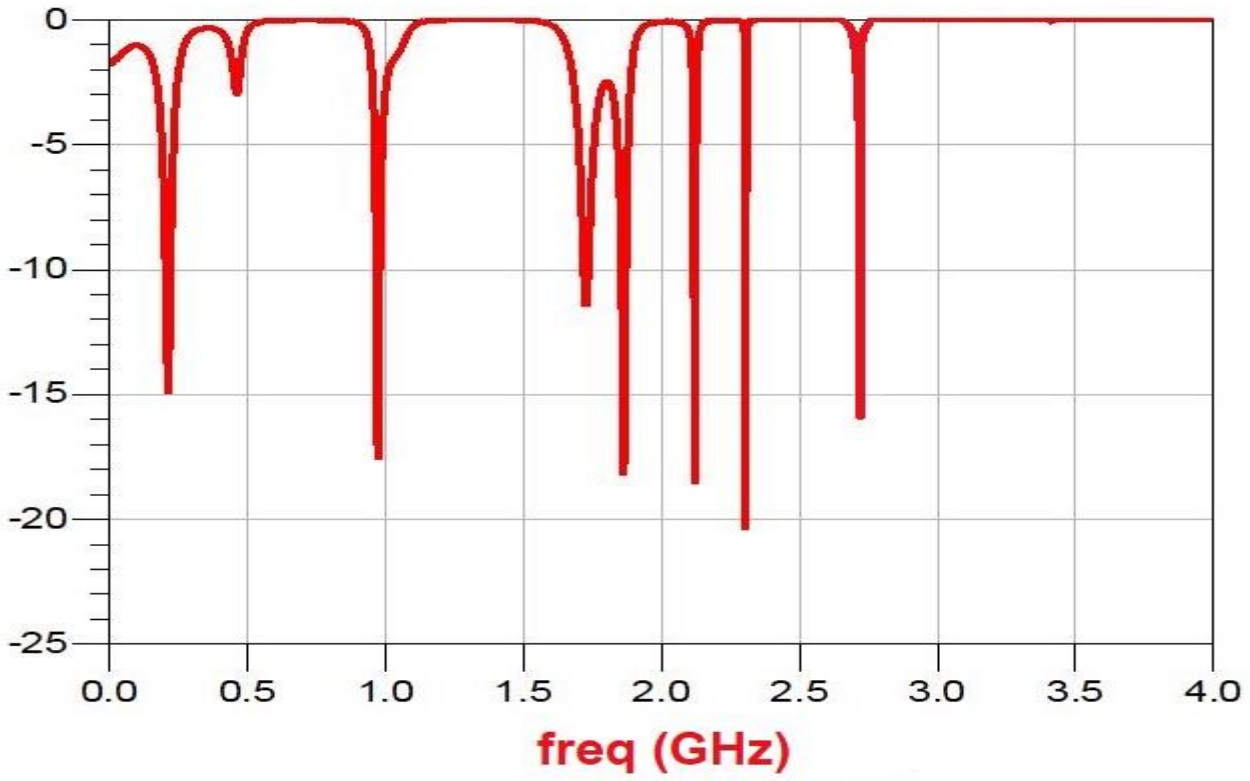


Figure 7. Antenna electrical equivalent circuit response

2-3) Realization and Measurements on Vector Network Analyzer

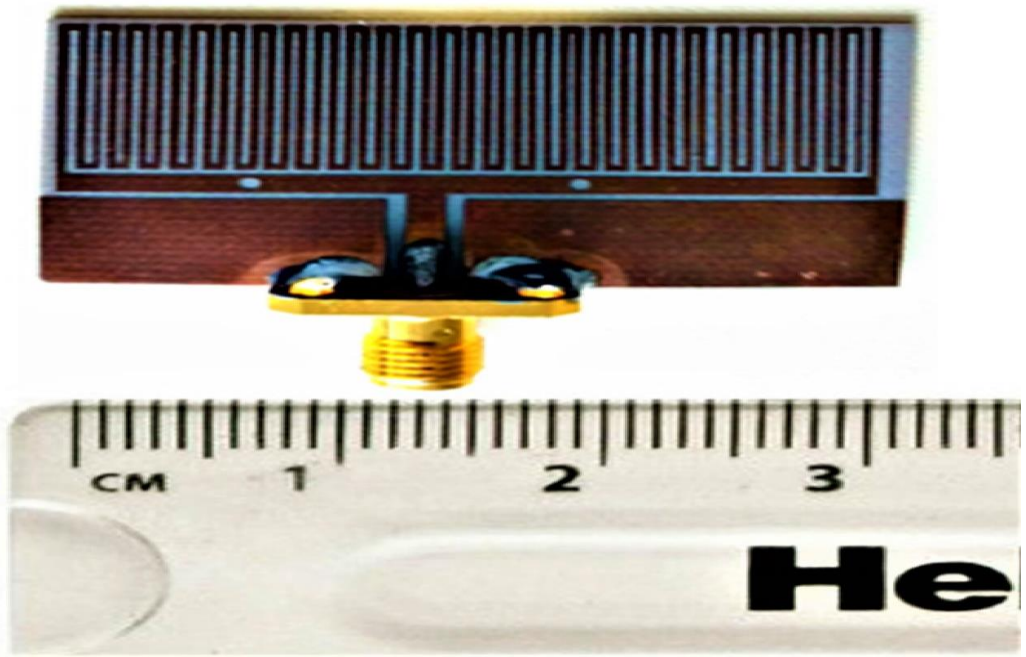


Figure 8. Realized antenna

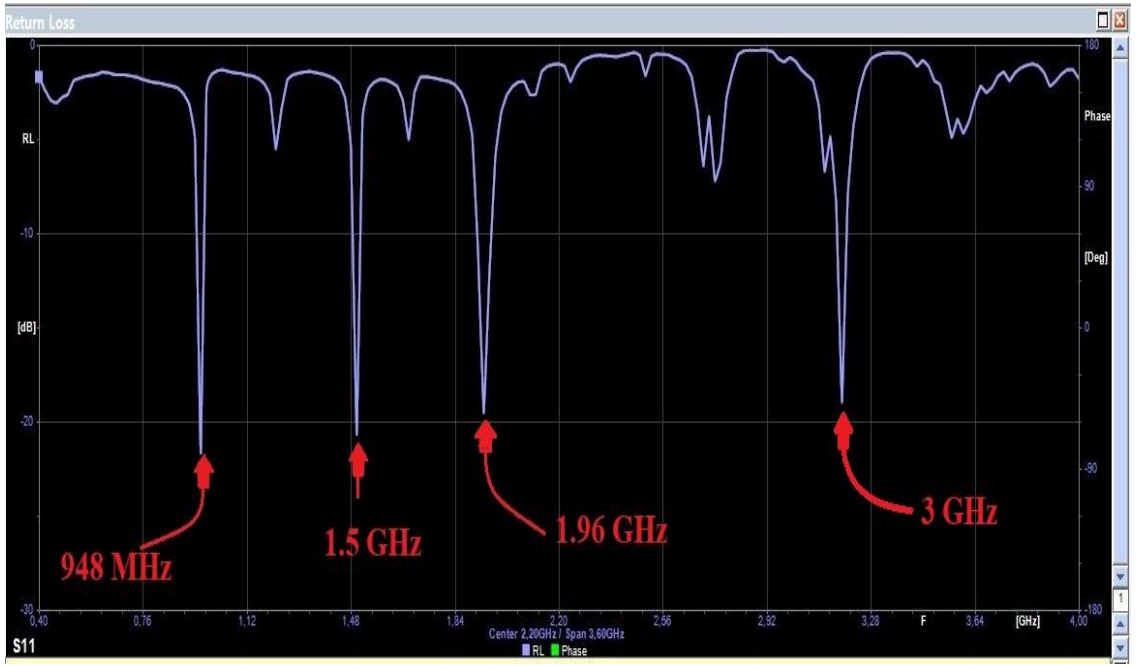


Figure 9. Measured Antenna response

3) Rectification Circuit

3-1) Rectifier Model

The rectifier has a function of transforming an AC signal to a DC one. the proposed circuit is based on two Schottky diodes and two parallel capacitors to ensure the voltage doubler function.

The simulation of the equivalent impedance of this circuit is indispensable to realized the adaptation between antenna and this circuit.

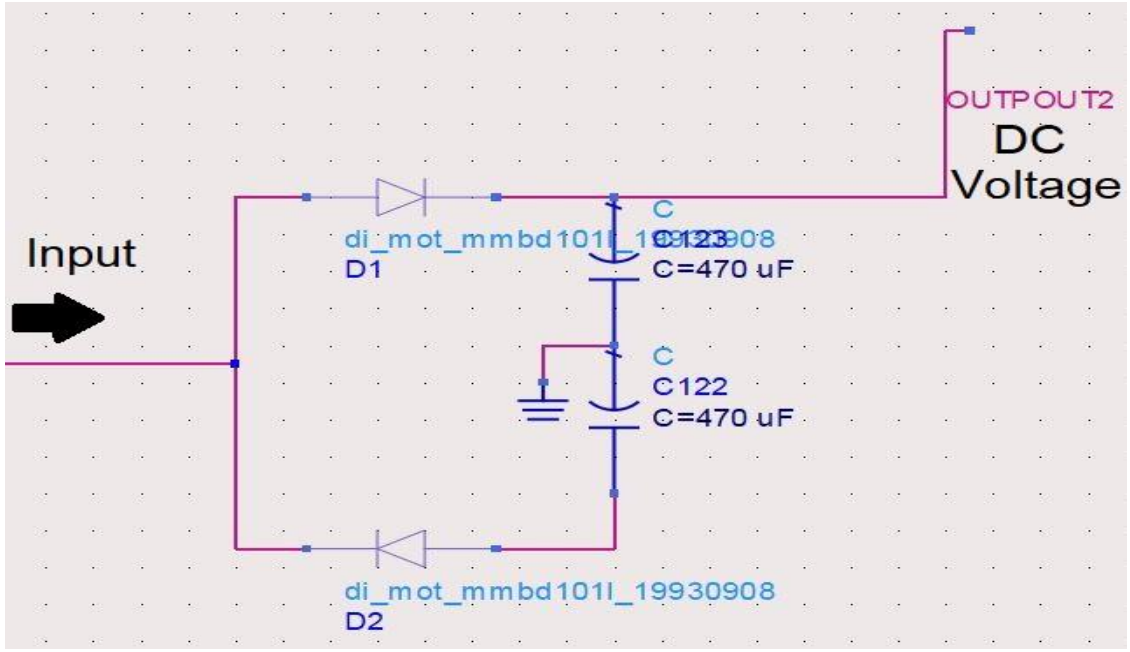


Figure 10. Rectifier circuit

3-2) Equivalent impedance of rectifier

By exploring smith chart on ADS software we can calculate the equivalent impedance of the rectifier, this parameter is too important to match this circuit to the antenna.

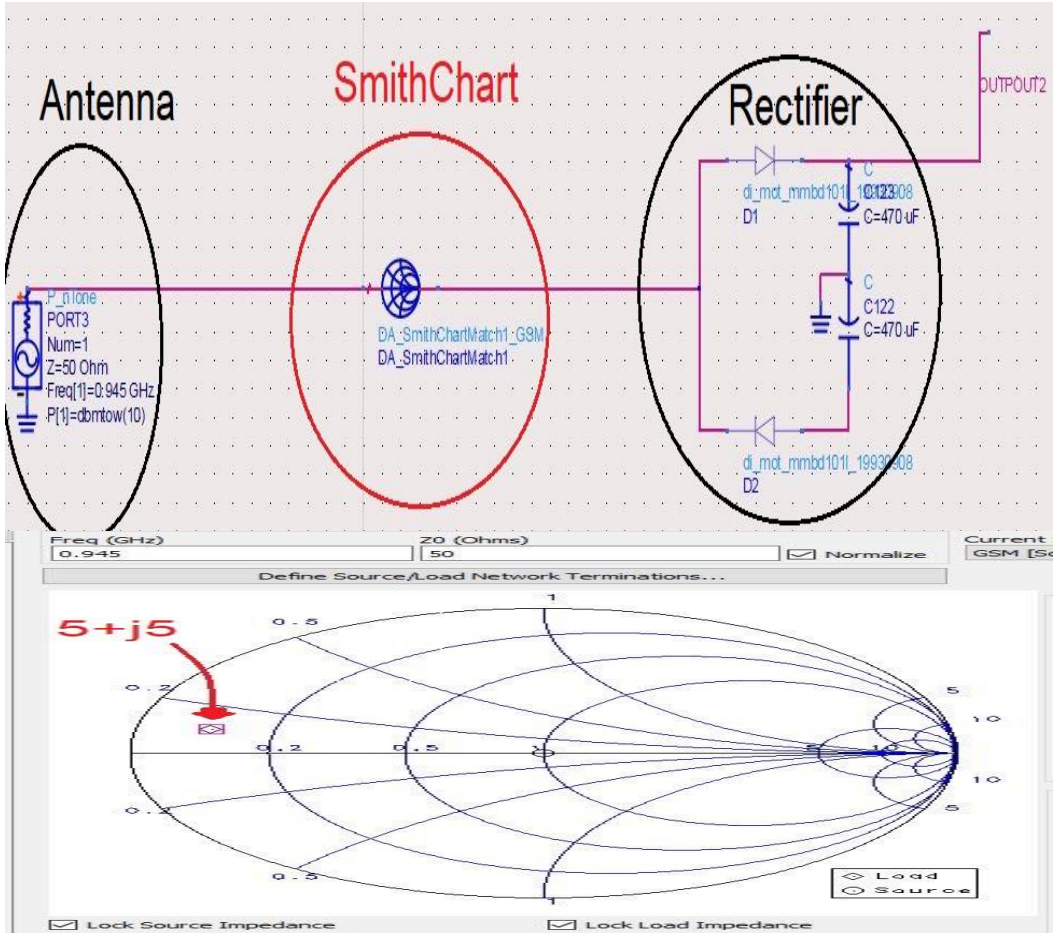


Figure 11. Equivalent impedance of the proposed rectifier on ADS

4) Impedance matching circuit

4-1) Smith chart adaptation

Until now, we know Bothe impedances (of the antenna and rectifier), with those values we can design the impedance matching circuit between antenna and rectifier for 945 MHz which is depicted in this figure.

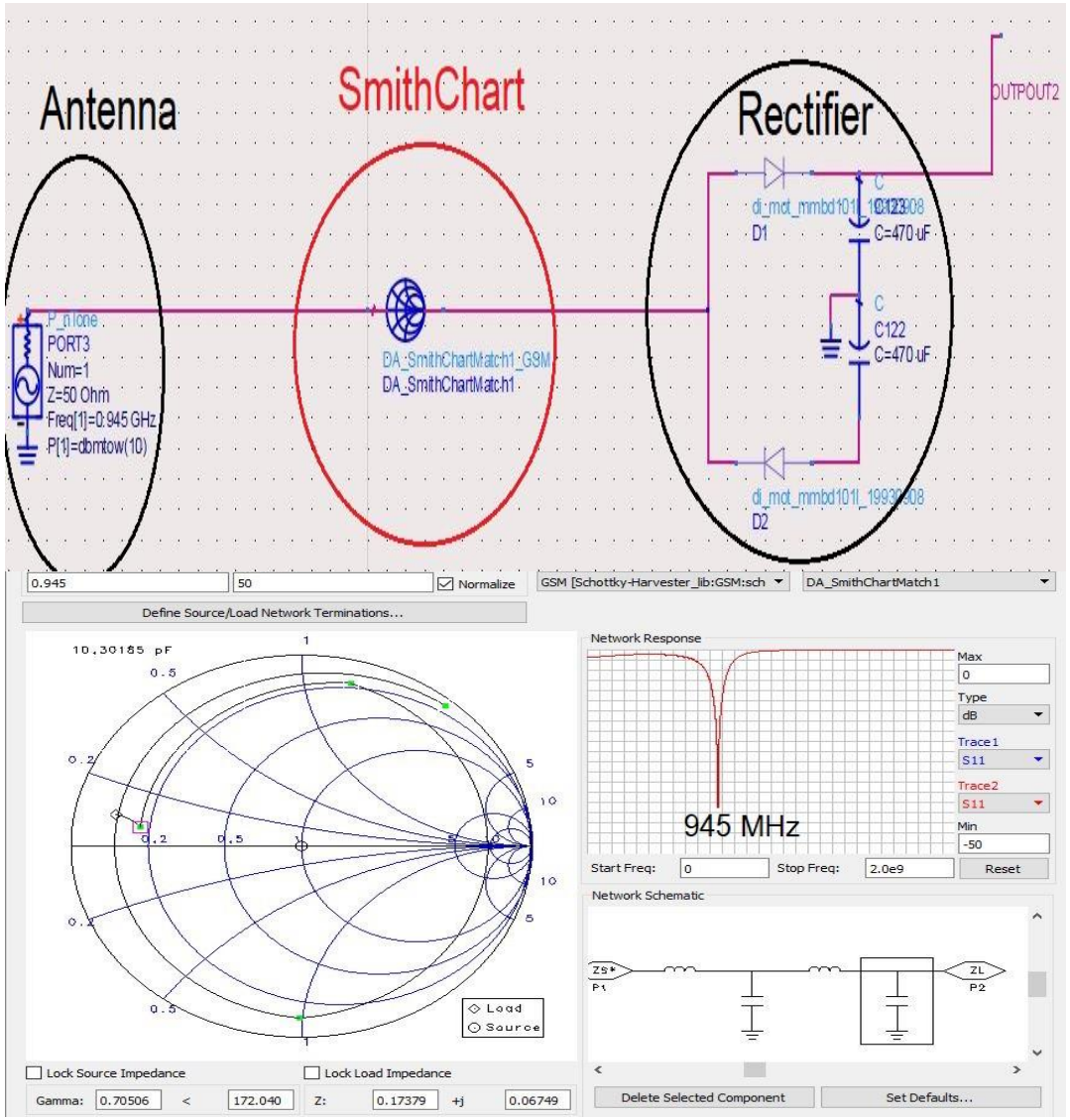


Figure 12. Impedance matching circuit design

4-2) Proposed model

This circuit is composed of a superposition of two LC resonators, which allow to ensure a maximum power transfer from the antenna to rectifier

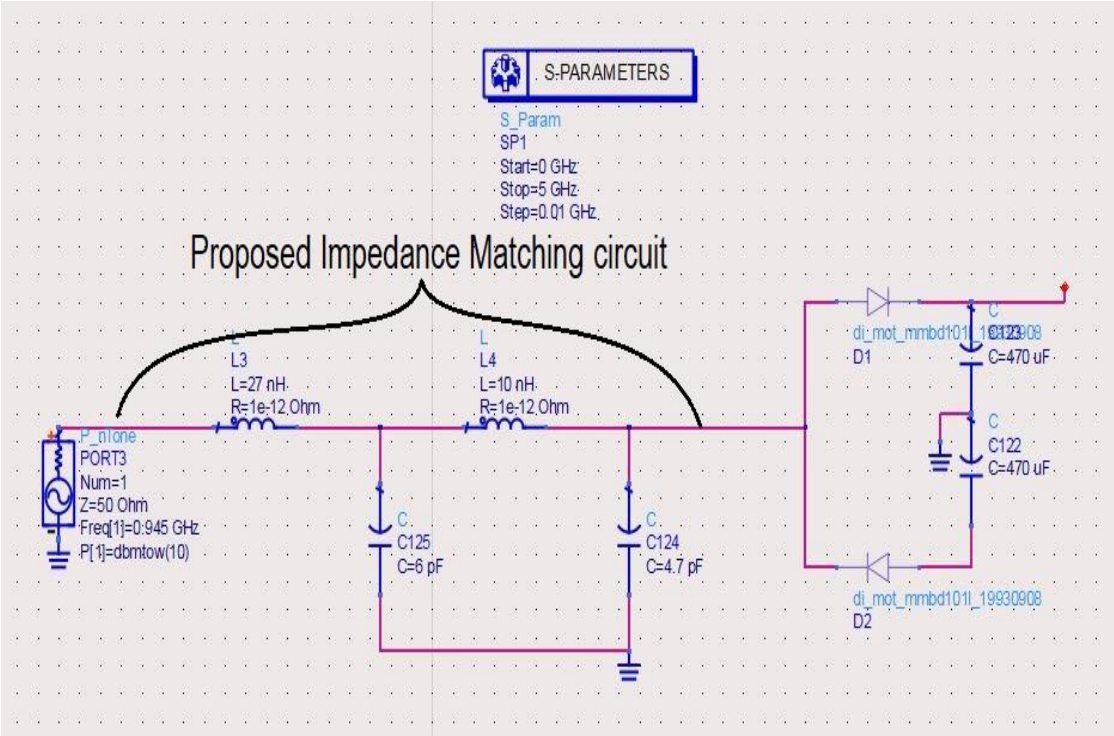


Figure 13. Impedance matching circuit

5) Proposed RF and microwave energy harvesting system

5-1) RF and microwave energy harvesting circuit

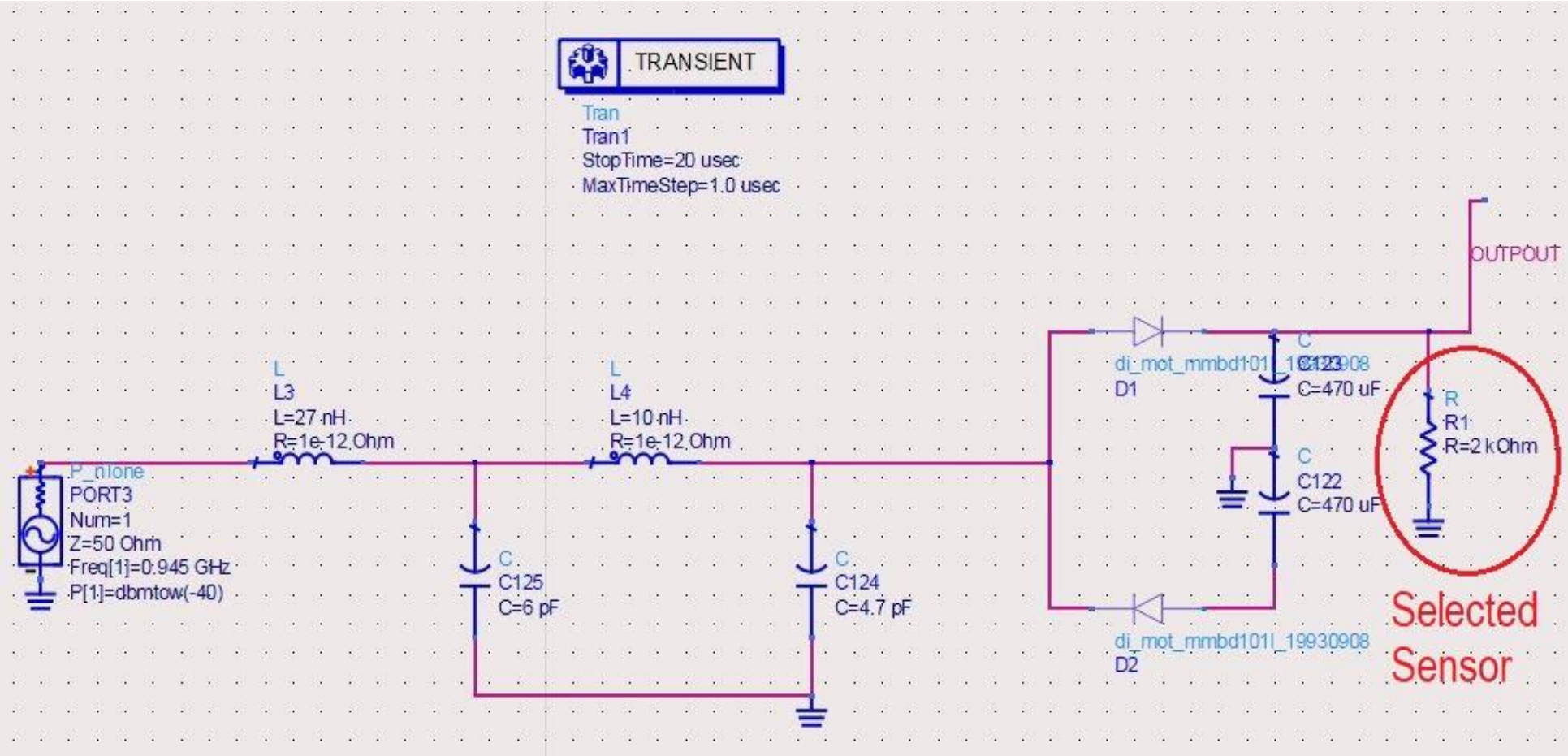


Figure 14. RF and microwave energy harvesting circuit

5-2) Simulation Results on ADS Software

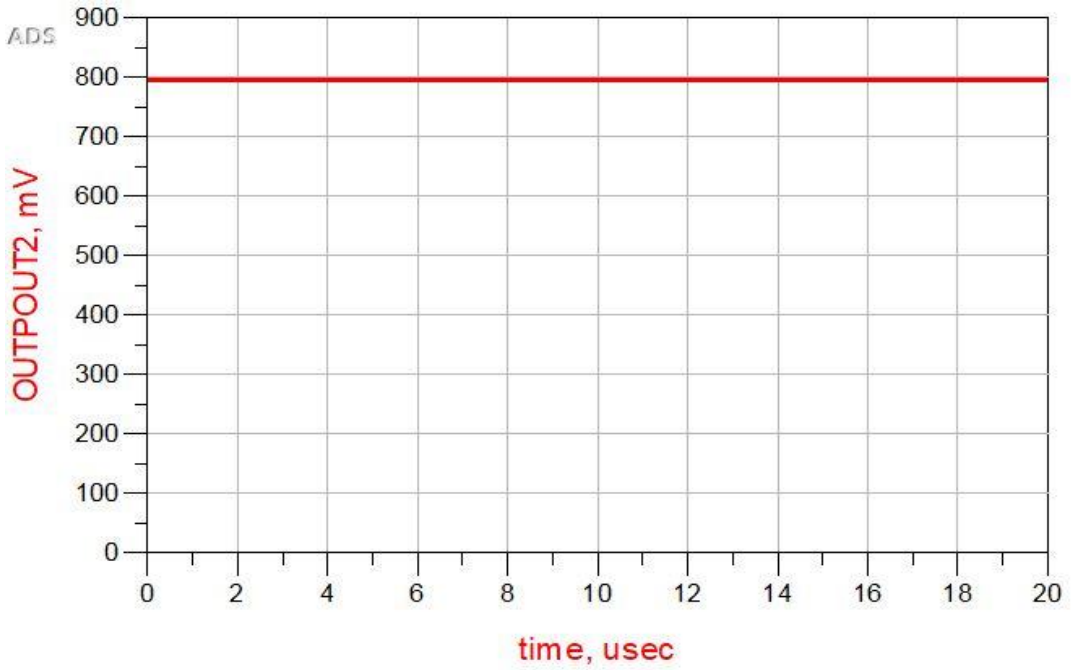


Figure 15. Response for open load

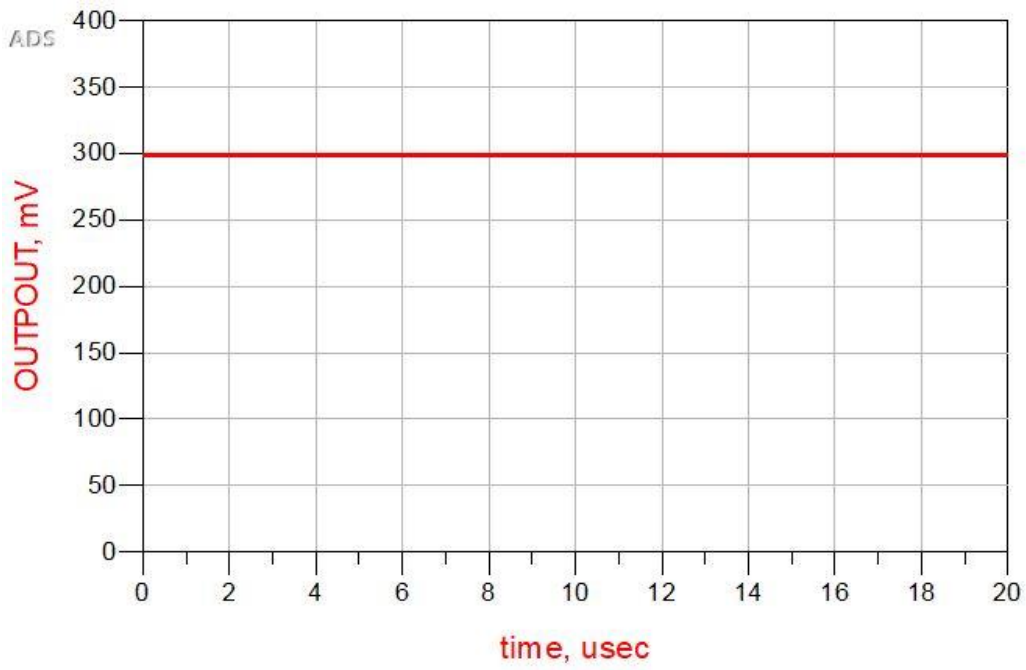
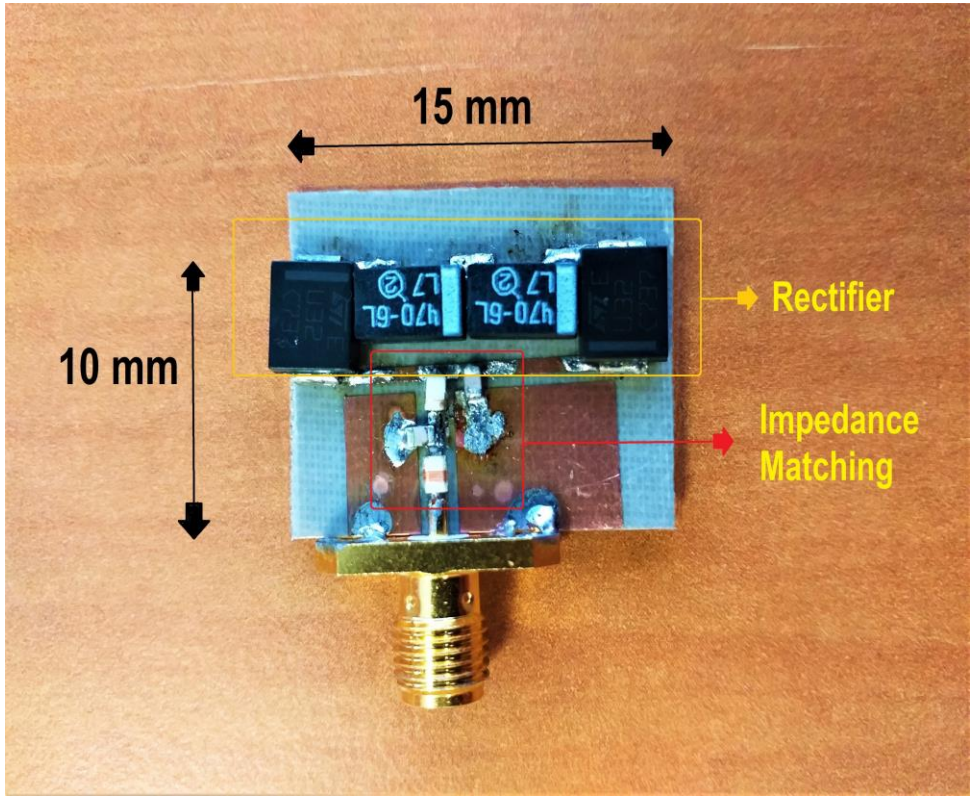


Figure 16. Response for 2 kΩ resistance load

5-3) Realization & Measurement



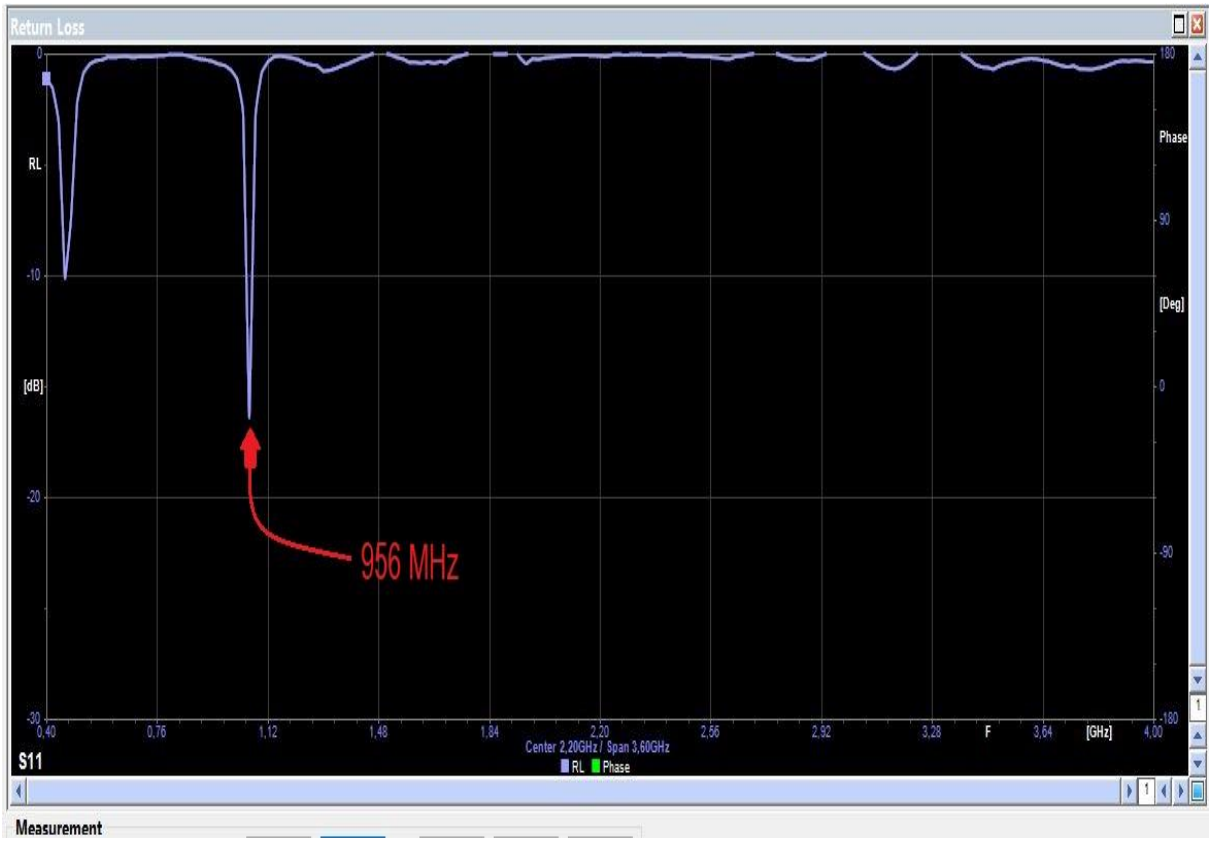
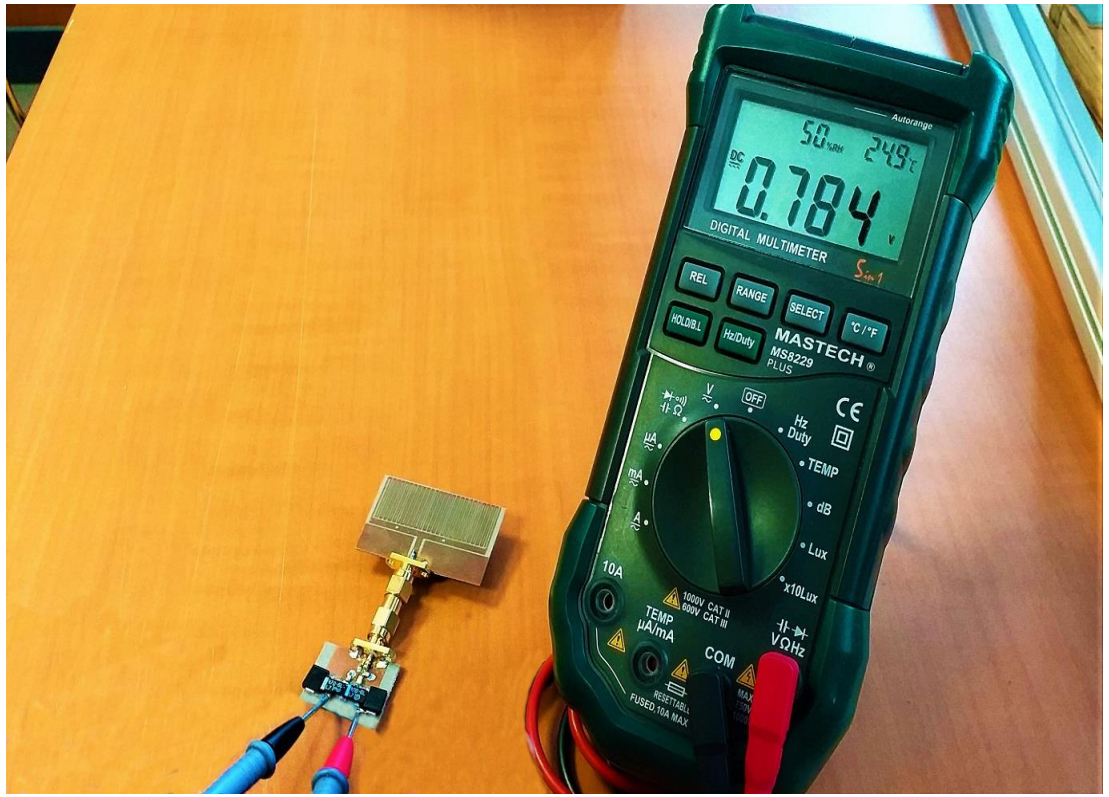


Figure 17. Measured return loss of the proposed system



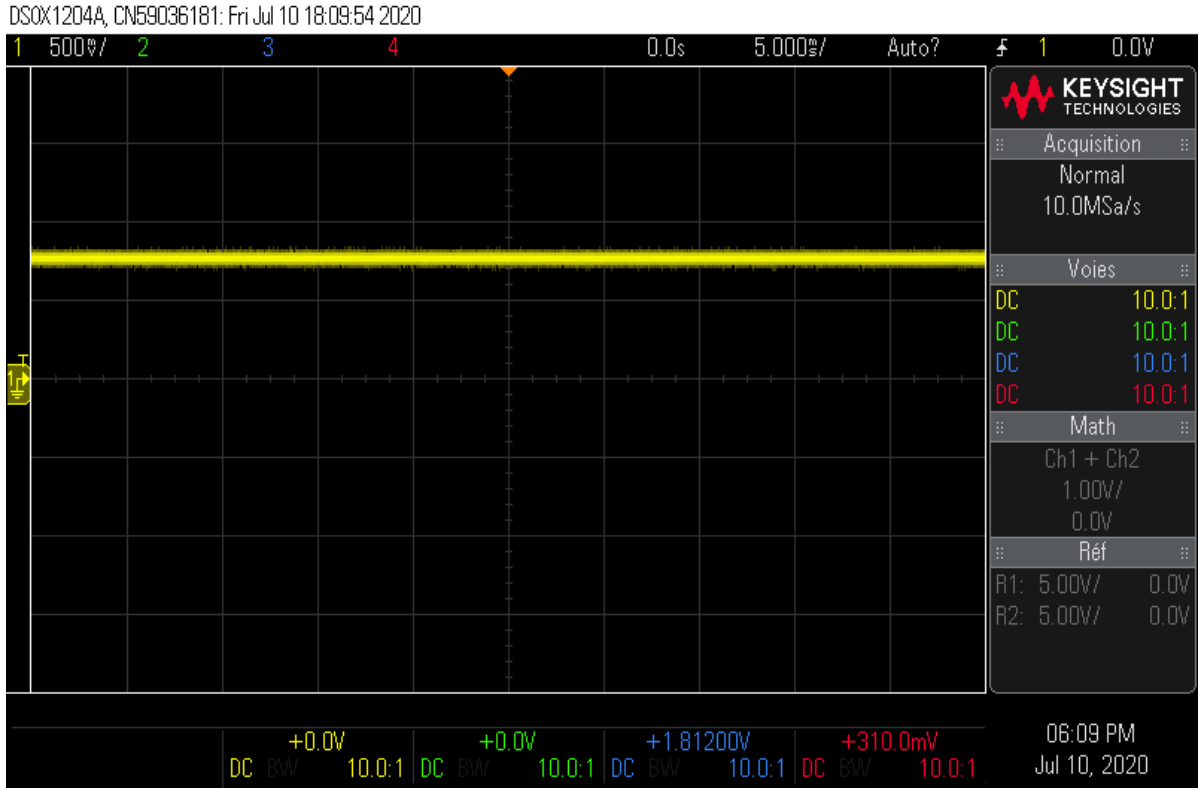


Figure 18. Measured DC output voltage for GSM-900 network

6) Conclusion & Perspective

from this work, we proved that is possible to feed low power consumption electronic devices (sensors, Radio-cognitive devices, smart watches, etc.) using RF and microwave energy harvesting systems, by exploring all mobile communication and wireless networks. A circuit adapted to GSM-900 network has been proposed to feed low power consumption sensors. By exploring more mobile communication networks more we increase the DC Output voltage. The realized antenna and RF and microwave energy harvesting circuit (impedance matching + rectifier) are too miniature with a dimension of 20x30x0.67 mm^3 and 10x15x0.67 mm^3 respectively. The harvested DC voltage from GSM-900 is 0.8 V for open load and 0.3 V for 2 kΩ resistance load.

Perspective :

- More miniaturization with keeping an acceptable efficiency level.
- Realize a system which could covers all mobile communication and wireless networks simultaneously.
- Use some amplification techniques to increase the harvested DC voltage.
- Apply this system to give a real feeding test.

Thank you for your attention