Prototyping and analysis of a textile loop antenna by an embroidery process for near field communication (NFC) applications

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EXTENDED ABSTRACT

Key words: Antennas, Connected, Communication, Smart, Textile

1. INTRODUCTION

The use of textile materials for wireless communication and energy harvesting is supposed to improve communications around human body and to interconnect users within new concept of Internet of Clothing (IoC). Nowadays, there is different ways to develop wearable antennas, as patches or prints [1], [2]. This concept is also under development throughout French ANR CONTEXT project funded by National Ministry of Research. The main objective focuses on body-centric communication and energy and data transfer. It aims also at development of power supply for textile structures embedded electronic components such as low consumption sensors, actuators and processing and communication electronic modules. Therefore, NFC 13.56MHz wireless communication will be used for energy transfer from smartphones to connected clothing and for data transfer from connected clothing to a smartphone [3]. Data collected could be sent to a cloud for further processing, analysis and if necessary decision making.

ANR CONTEXT project aims also to solve the problem of unreliable connections among sensors, actuators and processing and communication electronic modules, by using textile metamaterials as wave guides at ISM band (2.4GHz) for communications purposes [4].

Our project should have repercussions in the telemedicine field, security, sports and leisure etc [5].

2. MATERIAL AND METHOD

This study is dedicated to energy and data transfer using NFC protocol. First step of this study aims to design an RLC resonant circuit at 13.56MHz compatible with textile structures composed of textile flat loop coil on a fabric support made by embroidery and an adapted capacitor. Three designs of textile flat loop coil made by ZSK industrial machine have been realized: one turn and three yarns coil **1T3Y**, five turns and one yarn coil **5T1Y** and five turns and three yarns coil **5T3Y**.

From these data, the inductance is calculated to adapt the capacity value in order to create 13.56MHz resonant antennas. The use of textile conductive yarn, instead of classic conductive yarn, involves an increasing of the circuit resistance. In order to prevent power and transfer issues, two coils has been made by overlapping three textile conductive yarns “DataTrans” from TibTech Innovation company to reduce the total circuit resistance.
Then, two different methods have been used to characterize antennas in order to evaluate their functioning. As all electrical values were known a simulation using software LTspice has been carried out to verify antennas’ frequency. It also highlights the antenna bandwidth and quality factor. Second, electrical parameters measurements have been realized through a calibrated impedance meter Agilent 6490B

3. EXPERIMENTAL RESULTS AND DISCUSSION

First, the impedance analyzer carried out the measurements of the coils inductance in order to calculate the necessary capacity. The table 1. shows the inductance obtained results and values of corresponding capacity. Moreover, the table contains values of coil quality factors calculated by the following equation (1), where L is the inductance, ω_0 the resonant pulsation and R the resistance:

$$\mathbf{Q = \frac{L.\omega_0}{R}} \tag{1}$$

Table 1. Experimental inductances of the three coils and their corresonding capacity

Coil prototype	Experimental inductance (H)	Corresponding capacity (F)	Calculated quality factor Q
1T3Y	4.06E-07	3.40E-10	28.4
5T1Y	6.00E-06	2.30E-11	70
5T5Y	4.40E-06	3.13E-11	101.3

The quality factor of the coil will be the most influential parameter in the power transfer and the frequency range of the antennas. As expected the value of Q increase with the number of yarns and turns. Indeed, the number of yarns enables a decrease of the coil resistance and the number of turn enables an increase of inductance.
Second, Impedance analyzer obtained results show an annulation of the reactance around 13.56MHz, which highlight the presence of a resonance in the desired frequency range. The table 2. compiles experimental and simulated resonant frequencies of three antenna prototypes.

Table 2. Experimental and simulated resonant frequency of the three different antennas

Nom prototype	Experimental resonant frequency (MHz)	Simulation resonant frequency (MHz)
1T3Y	13,2 < f_0 < 13,75	13,54
5T1Y	13,2MHz < f_0 < 13,75	13,54
5T3Y	12,1 < f_0 < 12,65	13,59

4. CONCLUSION

Results obtained in this study were encouraging. First, values of inductance, resistance and quality factor highlight a good flexibility in the coils prototyping process. This flexibility enables to find a compromise between the necessary power transfer to feed low consumption sensor and the usable frequency range essential to the device stability and robustness.
Second, even if resonant frequencies are slightly shifted from 13.56MHz, they are in the bandwidth.
Finally, the next step of the ANR CONTEXT project is to measure and study the influent parameters such as coil geometries and substrate stress on the quality factor and the power transfer.

This work was supported by the French Agence Nationale de la Recherche and the French Direction Générale de l'Armement by means of the ANR CONTEXT project, ANR-17-CE24-0013.

5. REFERENCES

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