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Remote power supply for a medical patch by NFC technology

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Abstract – In this work, we present a medical patch used for medical monitoring able to be powered wirelessly by magnetic coupling. It contains a flexible coil to achieve this coupling with an external device which delivers magnetic field. After coil design by simulations, measurements are implemented to characterize the power recovered for the patch medical device.

Keywords: Medical patch, WPT, Coil, NFC, Energy harvesting.

I. INTRODUCTION

Medical devices such as patches are wearables systems placed on the body for monitoring or for diagnostic some diseases. They have become a big demand nowadays [1] and they are more present in our lives. Generally, medical devices contain electronic unit operating with a continuous power supply whose level depends on the application demand so, it can be low (0.1 mW) or high (>100 mW) [2].

In the first, patches were powered by rechargeable or replaceable batteries. This requires connectors or battery lids. These parts must be cleaned and sterilized with each use. This operation is difficult and it increases risk of infections [3]. Furthermore, this method of charging takes time and it is an inconvenient for urgent measurements.

Recently, wireless power transfer (WPT) principle was used to power these devices. It enables a power source unit to transmit electromagnetic energy to the electronic unit. This can be achieved with magnetic coupling between two coils. One placed on the patch and the other on the power source unit. The WPT allows the patches to be either battery-based or battery less. This increases the cycle life and makes it more convenient for the use. This method of powering was used in many medical devices such as in [4] where a wristband diagnostic device for patients is equipped with inductive charging system. In [5], the work proposes a resonance-based system to power wristband wearable devices.

One of the technologies that uses WPT is Near Field Communication (NFC). It operates at 13.56MHz [6]. Basically, NFC is used to achieved data transfer between two devices. In this paper, we use NFC technology to power a medical patch so, in addition to the ability of powering, NFC allows the device to communicate. The choice of NFC facilitates the use for the patient since the it is present in most smartphones.

The patch presented in this paper is a medical sensor which analyses biomarkers presents in sweat to detect bacteria [7]. It contains a coil to achieve the powering of low-power microcontrollers. In the first part, we present the coil design with its theoretical characteristics constraints. The simulated and measured characteristics will be presented later in the paper. The last part, presents the energy harvesting measurements using a NFC reader.

II. THE PATCH DESIGN

The patch has a commercial patch size, $5 \times 5 \text{ cm}^2$, and it contains a square $4 \times 4 \text{ cm}^2$ planar coil printed on a single side printed circuit board (PCB). To be easily wearable, the patch should be flexible so, the coil was printed on flexible FR-4 substrate whose thickness is $125 \mu\text{m}$.

To avoid the human tissues effects on the patch coil and possible magnetic interferences between the medical sensor and the coil, we used a shielding [8]. The shielding is a magnetic/conductive shielding, made up of $300 \mu\text{m}$ of ferrite thickness and $80 \mu\text{m}$ of copper thickness (Fig. 1) The ferrite used is MSLL12060-200 from Laird Technology [9].

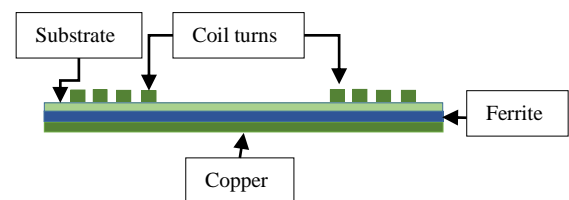


Fig. 1. The emplacement of the shielding materials

NFC technology requires the respect of certain conditions on the coil characteristics. The coil should operate at 13.56 MHz and its quality factor must be close to 40. This value of Q-factor allows to have the appropriate transmission bandwidth for the NFC data transfer [10]. To tune the patch coil at $f_0 = 13.56 \text{ MHz}$, its self-resonant frequency should be by far higher than the operating frequency. The coil is connected to a NFC chip to achieve energy harvesting. The one used here is the NXP NT3H chip. It contains a power management logic to recover the energy of the coil connected to it. Its output pin (V_{out}) delivers a continuous voltage when the coil is receiving magnetic field [11]. This pin is able to deliver up to 2.9 V.

The chip has a global parallel capacitor of 50 pF so, to operate at 13.56 MHz, the patch coil should have an inductance of

2.75 μH with its shielding. The design of the coil was done with CST Software and the measurements of its characteristics were done with Vector Network Analyzer (VNA) R&S ZNB8. The coil has 4 turns with track width of 0.33 mm and a spacing of 0.35 mm. Simulations of the coil characteristics at 13.56 MHz and measurements results are presented on the table I.

TABLE I. Coil characteristics at 13.56 MHz

| Coil characteristics | Values | |
|---|------------|--------------|
| | Simulation | Measurements |
| Inductance with shielding (μH) | 2.82 | 2.70 |
| Resistance with shielding (Ω) | 4.5 | 4.2 |
| Q-factor with shielding | 53 | 54 |
| Self-resonance frequency (MHz) | 35 | 44 |

Fig. 2 shows the coil design printed on the flexible substrate.



Fig. 2. Coil design

III. ENERGY HARVESTING MEASUREMENTS

To validate the capacity of this patch to recover power for its electronic unit by magnetic coupling, measurements of the power harvesting were done using NXP CLRC663 NFC reader as magnetic field source. The patch coil, connected to NXP NT3H chip, was placed face to the reader coil with a distance of 3mm between them which can simulate the thickness of clothes. The V_{out} pin were loaded with a variable resistance values. The electronic unit was simplified as resistive one. The measurement results of the recovered power and V_{out} voltage are shown in Fig. 3.

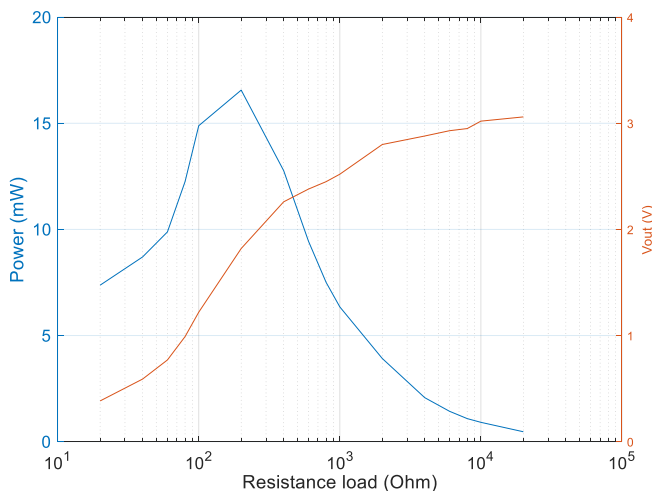


Fig. 3. Recovered power and V_{out} level as a function of resistance load

The patch is able to deliver 18 mw to its electronic unit with a voltage of 1.82V. This is the minimum voltage of low-power microcontrollers.

In the second measurement, we curved the patch with a radius measurement from 20 mm to 60 mm and we measured the power recovered from the patch. The patch was loaded with a resistance of 200 Ohm, the same one which gives the maximum power recovered.

This measurement were done to see the curvature influence on the energy harvesting. The Fig. 4 shows this influence.

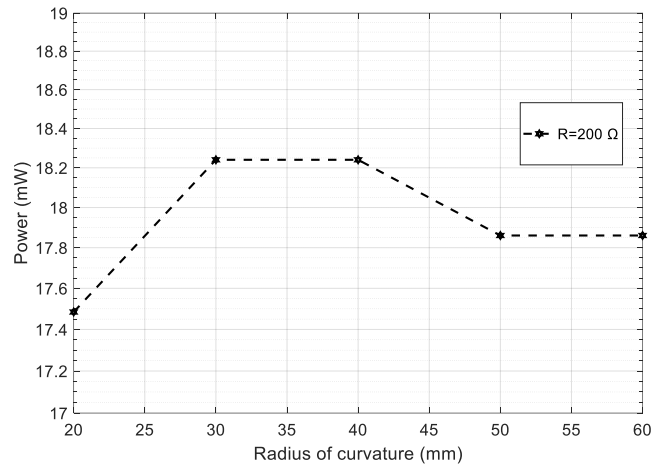


Fig. 4. The recovered power as a function on curvature radius

The recovered power is insensitive to the flexibility of the patch. On this range of radius curvature, we detect a difference of 4% only.

IV. CONCLUSION

In this paper, we presented a wearable patch used to medical monitoring purpose. The patch is able to be powered wirelessly using NFC technology. The coil patch design was done to respect the NFC constrains on the coil characteristics. The validation of the patch performance on the energy harvesting was done using a NFC reader. The measurement results show that the medical patch is able to recover up to 18mW.

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