Wireless Power Transfer for Wearable Applications

O. Vorobyov, V. Kopta, J. R. Farserotu

The proposed solution for Wireless Power Transfer provides a means of remote powering via guided propagation through a flexible, stretchable waveguide structure. The structure may be molded to conform to various different shapes (e.g., suited for wearable applications). In addition to low losses, the structure, without wires, also offers opportunities for improved reliability, lower production cost and ease of configuration.

Short distance wireless power transmission (WPT) is becoming increasingly popular as a means of remotely powering devices, towards batteryless operation. Potential applications include wearable devices, body area network (BAN) and consumer electronics applications, as well as, applications operating under constraints, or in environments, where conventional wired sources of power or batteries are either unsuitable or undesirable (e.g., extreme autonomy and miniaturization).

The proposed low loss, flexible waveguide (FWG) solution for WPT was developed in the course of the WiseSkin Nano-Tera project. WiseSkin targets the development of an artificial skin embedded with tactility sensors (pressure sensors) for restoration of a natural sense of touch in a prosthetics application. The proposed solution offers the following benefits:

- Batteryless operation – of nodes (e.g., sensor or actuator nodes) helps to reduce their footprint and lower their cost.
- Increased robustness / reliability – there are no wires or mechanical contacts (hard to implement and a first source of failure) to break, either for powering or communication.
- Easier to manufacture / lower cost – removal of the mechanical contacts eases manufacturing and reduces cost. Sensor and actuator devices may be placed anywhere within the FWG (not constrained by wires or connections).
- Ease of device placement – sensors and actuators can be placed almost anywhere within, as well as on, the structure.
- Scalability – to larger number of devices is readily possible as there are not contact or wires to connect.

An illustration of the concept for WPT [1,2] is shown in Figure 1.

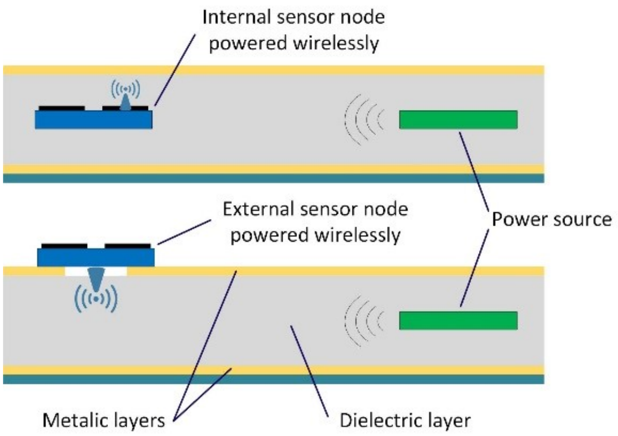
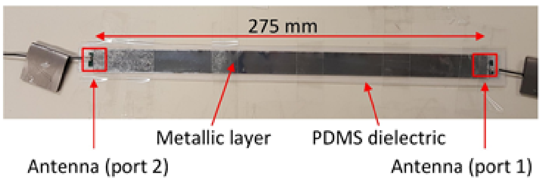


Figure 1: General concept of a sensor node remotely powered via RF energy harvested from a RF source and distributed via the FWG.

The sensor(s) or actuator(s) may be either inside or outside of the FWG structure. In this work, the antenna and the waveguide are optimized for operation in the 2.4 GHz ISM band. The use of other bands is also possible, in particular higher frequencies, which enable the antennas for the wireless sensor / actuator nodes to be further miniaturized.

In order to assess the performance of the proposed wireless power delivery system, several FWG prototypes were implemented. For the purpose of test and measurement, a compact capacitive loop antenna solution with top and bottom metallization was used (optimized for integration into the FWG at 2.4 GHz). The loop antenna is basically a rectifier-antenna combination (rectenna), i.e. without any integrated rectifier circuit. Antennas are inserted into both ends of the FWG (source and sink) and the received signal is measured and characterized in terms of S21-parameter of the waveguide.

The results are presented in Figure 2. The S21 parameter is equal to -4 dB at roughly 2.4 GHz, indicating that about 40% of the radiated power is available to power devices. The next step is to integrate ULP sensor nodes with the waveguide structure.



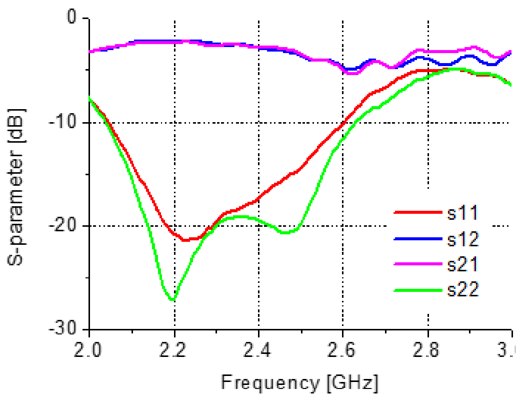


Figure 2: Sample of the waveguide under test (top) and its measured performance characteristics (bottom).

This work was partially funded by Nano-Tera national research program under SNF grant No. 20NA21-143070 [3]. We would like to thank the Nano-Tera program and the SNF for their support.

[1] V. Kopta, J. R. Farserotu, O. Vorobyov, “System and method for remote powering at least one sensor or actuator from a RF power source”, May 3, 2017, EP Patent App. EP20,150,192,228; US Patent App. 15/336,955.

[2] A. Vorobyov, *et al.*, "Efficient through-waveguide wireless power transfer for body area networks", BIOCAS IEEE Biomedical Circuits and Systems Conf. (2017).

[3] "WiseSkin" project: http://www.nano-tera.ch/projects/353.php