RF energy harvesting for LoRaWAN operation

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Recently, there has been an increased interest in Low-Power Wide-Area Network (LPWAN) for the Internet of Things (IoT) applications. To overcome the battery limitations associated with the long scale IoT deployment, there has been an increased research interest in collecting energy from the environment in order to provide unlimited lifetime for these devices. There are many forms of energy that can be harvested for the self-sustainable operation of LoRa devices, such as solar and thermal energy, to name a few [1]. Here, we focus on the energy coming from the existing radio transmissions, named as Radio Frequency (RF) energy harvesting. RF energy scavenging can collect the available RF energy from the surrounding environment and convert it to dc power. Despite the many benefits of this free and ubiquitous energy source for Long-Range Wide-Area Network (LoRaWAN) applications, the energy levels are low and time-varying.

This work studies the possibility of utilizing the available RF energy for LoRaWAN applications with the ultimate goal to overcome the problem of the batteries limited lifespan and their negative impact on the environment [2]. The feasibility study is based on measurements carried out in many countries over the last decade [3, 4]. An analytical LoRaWAN energy model is developed based on a Class A LoRa device (Figure 1a) to estimate the power requirements of the application. Due to the low RF energy levels in the environment, the potential of the self-sustainable operation of LoRa devices based on RF energy harvesting strongly depends on the surrounding environment and the performance of the individual components of the sensor node (Figure 1b). It is shown that the sleep current and the capacitor leakage current are significant limiting factors, while LoRa duty cycle and data rate (DR0-DR5) are subject to the available RF energy levels.

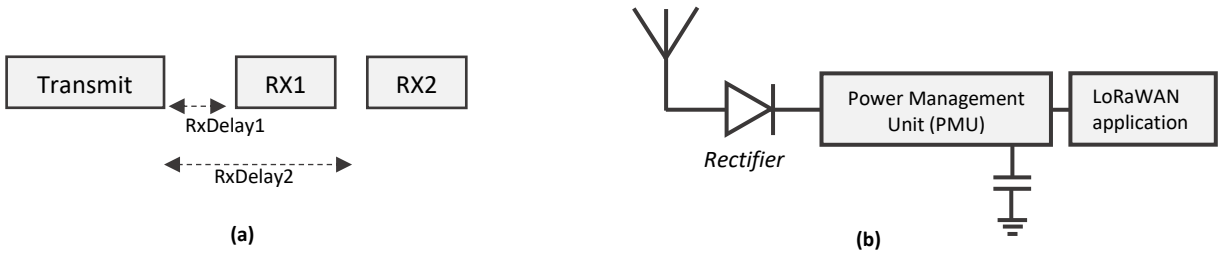

Figure 1. (a) Format of class A transmission and (b) structure of LoRaWAN sensor node powered from RF energy.

References

[1] Giacomo Peruzzi and Alessandro Pozzebon. A Review of Energy Harvesting Techniques for Low Power Wide Area Networks (LPWANs). Energies, 13(13), 2020.
[2] J. Finnegan, K. Niotaki and S. Brown, Exploring the Boundaries of Ambient RF Energy Harvesting with LoRaWAN, in IEEE Internet of Things Journal, doi: 10.1109/JIOT.2020.3030349.
[3] R. J. Vyas, B. B. Cook, Y. Kawahara, and M. M. Tentzeris. E-WEHP:A Batteryless Embedded Sensor-Platform Wirelessly Powered From Ambient Digital-TV Signals. IEEE Transactions on Microwave Theory and Techniques, 61(6):2491–2505, Jun 2013.
[4] A. Alex-Amor, A. Palomares-Caballero, J.M. Fern´andez, P Padilla, D. Marcos, M. Sierra-Castaner, and J. Esteban. RF Energy Harvesting System Based on an Archimedean Spiral Antenna for Low-Power Sensor Applications. Sensors, 19, Mar 2019.