Abstract PhD Thesis Russo Caterina

Wireless Sensors Networks (WSN) are expanding in all field of industry with the 4.0 revolution. The digitalization of the machinery and the increasing requirement of safety makes mandatory a real-time monitoring network. These networks are based on Internet of Things (IoT) sensors, designed to be robust, small and with a reliable wireless connection. These sensors are meant to be “Place and Forget” in order to have a continuous stream of data even in inaccessible places. To be smaller enough these sensors are mainly based on Micro Electrical Mechanical system (MEMS) technology and on the latest ultralow-power microcontroller. The main limitation on the spread of these technologies is related to their power supply, nowadays powered by wired or battery, but not sustainable anymore. So, to solve this issue and enhance the spread of the WSN the use of Energy harvester devices seems to be an optimal solution. The energy harvester devices scavenge energy from the ambient, which could be solar, vibrational, thermal, or even the radio-frequency energy, and convert it into useful electrical energy.

In this context, this thesis deals with the design of a vibrational energy harvester (VEH) to power supply a node of a WSN for the railway field. Firstly, the state of the art of these technologies and their application are studied in order to better understand how this work collocates. Then, the modeling of the vibrational energy harvester is explained, starting with the study with a linear one-degree-of-freedom mass-spring-damper system. Thereafter the model is complicated with the non-linearities, beginning with the stiffness and then with the damping and the electromagnetic coupling coefficient. To compute the stiffness a Maxwell simulation is performed. The model together with the previous experimental analysis developed on the previous VEH prototypes done by our research group was useful to find the parameter of optimization for the new one. In the end, the optimized prototype was realized in a modular way to test different configurations and of that was performed the experimental analysis shown in the fourth chapter.

Obtaining the optimal results of 34 mW in DC voltage if excited at 0,5 g at its resonant frequency and the highest value of FoM 7,13 $\%$ and NPD 19,4$\%$. In the last chapters, the importance of knowing the duty cycle of the application is explained together with the possible application of these types of the energy harvesters. Finally, the limitation of the one degree of freedom energy harvester is also explained and in the last chapter is shown the work developed to study a 2 dof system. With this type of energy harvester, two resonant frequencies are reached but the dimension of the device became important, but for the application in the railway field, when you have different load condition seem appropriate. In the end, the conclusion of this work is presented highlighting the pros and cons of the two devices studied.