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Perspectives and opportunities for vibration energy harvesting technologies in industrial applications

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I. INTRODUCTION

The growing global demand for sustainable technologies increased the focus on developing SMART, Industrial 4.0, and environmental applications with embedded autonomous monitoring and diagnostic units. The operation of modern sustainable systems requires complex monitoring tasks that employ IoT sensing and monitoring units [1]. Developed embedded IoT systems based on modern sensing materials and electronics could be used for long-term sensing to indicate wear, anomalies, or system degradation [2]. Monitoring applications of modern aircraft systems leads to an increase in the opportunity for the development of energy harvesting applications [3].
This contribution is focused on mechanical systems that operate under vibrations and provides a summary of potential physical principles of energy harvesting. The contribution addresses the critical challenges in mechanical energy harvesting technologies and provides an overview of the successful transfer of energy harvesting technology from laboratory specimens to industrial applications.

II. KINETIC ENERGY HARVESTING SYSTEMS

Energy harvesting technologies are characterized by converting waste and ambient mechanical vibration into useful electricity. This physical principle is shown in Fig. 1 in the form of a hybrid kinetic energy harvester [4]. Kinetic energy of vibration (green) is transferred into resonance operation, and consequently, this relative movement (red) is converted by electromagnetic (blue) or piezoelectric principle (orange) into electricity.

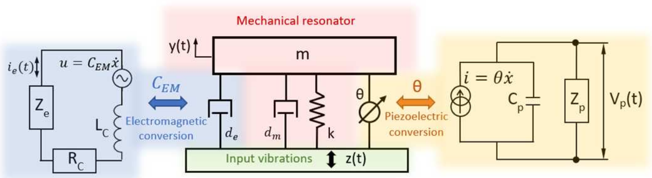

Fig. 1. Hybrid kinetic energy harvesting system; system of mechanical resonator (red), electro-magnetic (blue) and piezoelectric conversion system (orange)

The one degree of freedom mathematical model of mechanical resonator (1) could be used for both piezoelectric and electromagnetic converters, and the consumption of harvested energy is analysed. Both converters could be in different forms and designs, and provide a coupled electro-mechanical system. The model of the piezoelectric composite beam (2) is well understood and described in many papers, such as [5]. The example of a common electromagnetic system (3) is described in publication [6].

III. APPLICATIONS OF ENERGY HARVESTING DEVICES

Several thousand journal papers about kinetic energy harvesting systems provide analysis and solutions for energy harvesting devices in a lab environment. However, only a few technical applications with energy harvesting sources provide a fruitful solution for wireless sensor nodes.
Developing energy harvesting technologies provides a novel and autonomous energy source for IoT applications [7] in reporting, monitoring, and diagnostic purposes. Primarily vibration energy harvesting technology is developed for safe aircraft applications [3]. Significant demands are placed on energy sources for biomedical applications [8]. However the promising energy harvesting outputs are reported in operation on a railway infrastructure [9] and environmental sea monitoring [10].

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