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Energy Harvesting, an incredible solution for Structural Health Monitoring Systems of Bridge

Waheed Gul

Department of Mechanical Technology, University of Technology Nowshera, Nowshera, Pakistan

E-mail: waheed@uotnowshera.edu.pk

Abstract. Wireless Sensor network (WSN) has received immense public interest in recent years. Due to ease of installation, optimum size, prolonged life and low cost, Wireless sensors Network (WSN) are widely used for Bridge health monitoring system. The solitary concern of such sorts of systems is the inadequate life of batteries that deliver power to them. In order to overwhelm this problem, energy harvester is an enduring solution. Energy harvesting is essentially seizure free energy from external sources and converts it to useable electrical energy. This paper reviews the supreme topical development of the energy harvesters in the field of structural monitoring system based on vibrations. The PE-VEHs and EM-VEHs are characterized based on their power production capability, resonant frequency, size, power density, base excitation and internal resistance etc. The overall power production range for the developed bridge energy harvesters is from 0.000016 to 31500 μW, conversely, the resonant frequencies of these energy harvesters lying in the range of 1Hz to 13.9 kHz. The power rank produced by the reported PE-VEHs fall in the range of 0.038 to 7700μW and their resonant frequencies are in the varying from 1Hz to 13.9 kHz. The developed EM-VEHs have comparatively low resonant frequencies ranges from (1Hz to 348Hz) and presented the competence of generating power from 0.000016 μW to 31500 μW.

1. Introduction

A WSN as shown in fig.1 comprises numerous components [7], like micro sensors, signal processing unit, power management unit, microcontroller unit, and built-in memory, analog to digital converter (ADC), transmitter, and receiver. Sensor transforms the physical signal, such as pressure, temperature, humidity, or vibration, into a particular electrical signal. The transmitter and receiver are used for transmitting and receiving the information data flanked by WSN and the operator. Memory unit enables on-board data storage. Microcontroller controls the complete performance and process of various components present on board. Power management circuit distributes and manages the power to the WSN components. A battery or a super capacitor is used as the power source in the WSN [8]. Most of the commercial WSNs function on batteries; however, the limited life of batteries restricts the performance and application of WSNs. For a device with 100 μW power consumption, a lithium battery of 1 cm3 volume can be used solitary for one-year process [9 10]

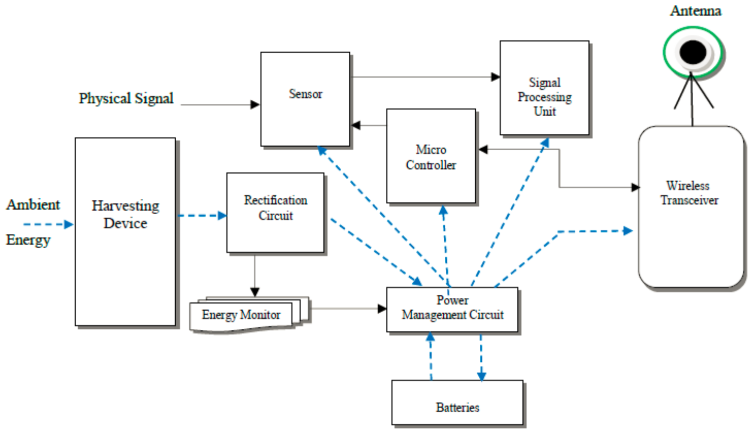

Figure 1. Architecture of an energy harvesting wireless sensor node

2. Bridges Vibrations

Table 1. Tilts The Vibration Data Of Numerous Bridges.

S. No	Bridge	Location	Frequency (Hz)	Acceleration (g)	Reference
1	New Carquinez	California	1–40	0.01–0.102	[11]
2	Komtur	Berlin	2–2.6	0–0.0061	[12]
3	Ypsilanti	Michigan	2–30	0.01–0.035	[13]
4	Golden Gate	San Francisco	0–1.5	0–0.061	[14]
5	RT11 bridge in Potsdam	New York	3.1	0.38	[15]
6	Box girder bridge	Austin	1–15	0.12	[16]
7	3rd Nongro Bridge	South Korea	4.1	0.025	[17]
8	Huanghe Bridge	China	1-2	0.015	[18]
9	Seohae Grand Bridge	South Korea	1	0.0125	[19]
10	IH-35N over Medina River	Texas,USA	3.1	0.15	[20]

3. Results

Figure 2 demonstrates the power produced by the developed bridge vibration energy harvester as a function of base excitation (Acceleration). The EM-VEHs are compared under lower acceleration ranks vary from (0.025 to 8 g), with PE-VEHs, which are exposed to (0.2 to1 g), acceleration levels. Low excitation level (0.02 to 0.29 g) harvesters are stated by [57, 58, 62, 63,65,67,69, 71 and 72]. The developed harvester [61] is characterized under medium acceleration (1 g).Though, the harvesters functioned under high acceleration levels (3 to 8 g) are developed in [70, 73]. The EM-VEH reported in [57] is functioned under the lowermost acceleration level of 0.02 g; still, among the energy harvesters, a PEVEH [70] is exposed to the high acceleration level of 8 g. reasonably, the harvesters [65] and [67] generate high power levels at medium acceleration levels of 0.29 and 0.21 correspondingly.

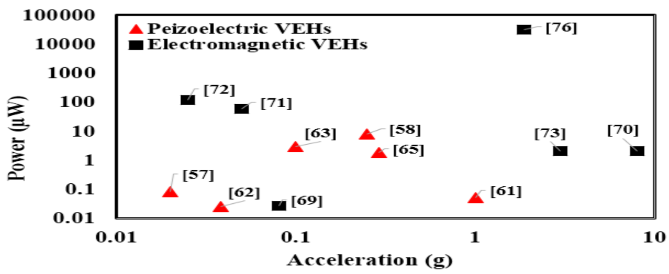

Figure 2. Power vs Acceleration characterization of PVEHs and EMVEHs of Bridges

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The power reported for the bridge vibration energy harvesters with respect to the harvester's dimension is presented in Figure 3. In all the reported bridge vibration energy harvesters, the PE-VEH [58] has the smallest size (1 cm^3) and produced a power of 375 μW. However, PE-VEH reported in [66] is of the largest size (12209 cm^3) and it can generate 83.5 μW. By equating the inclusive size, the EM-VEHs are comparatively smaller in size than PE-VEHs except reported in [58].

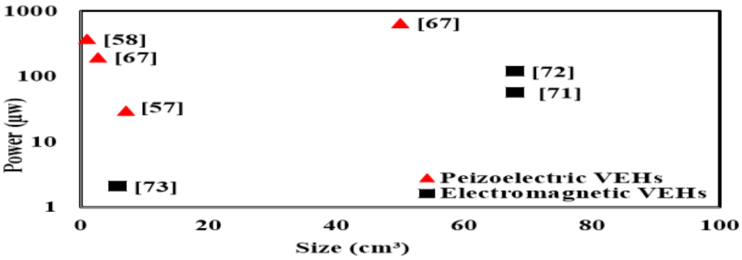

Figure 3. Power vs Size characterization of PVEHs and EMVEHs of Bridges

For the developed bridge vibration energy harvesters, the power density schemed against the harvester's resistance is presented in Figure 4.The resistance of the EM-VEHs is in the range of (3.6 to 457Ω), conversely, for the PE-VEHs the resistance is comparatively high and it ranges from 9.7 to 5200 kΩ.

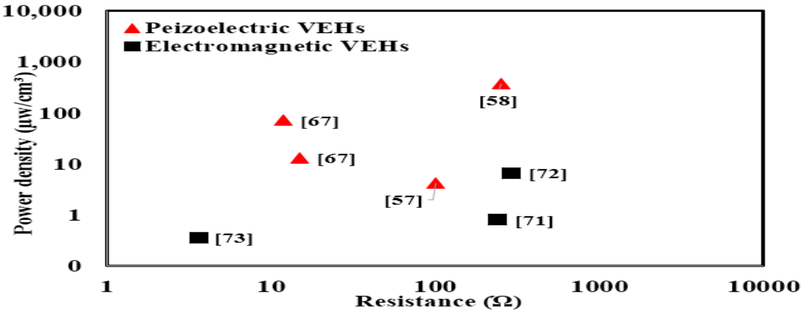

Figure 4. Power density vs Resistance characterization of PVEHs and EMVEHs of Bridges

All of the reported bridge vibration energy harvesters would produce peak power at resonance state. Though, at off-resonance action the power generation by the resonant energy harvesters is usually on the lower side. Furthermore, these energy harvesters have a slender bandwidth, which is also a subject of matter. Power plotted resonant frequency is shown in Fig. 5.

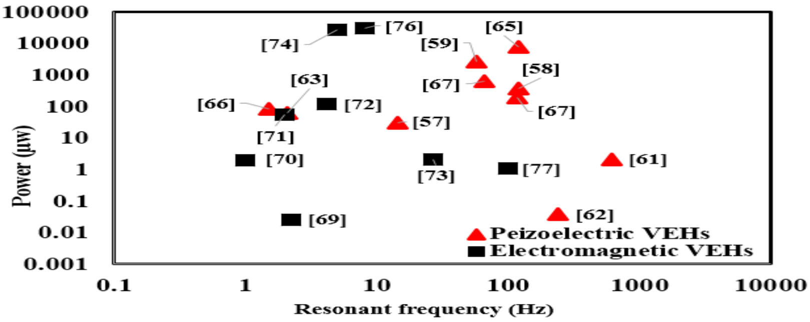

Figure 5. Power vs Resonant frequency characterization of PVEHs and EMVEHs of Bridges

4. Conclusions

The power producing capability of the developed bridge vibration energy harvesters is pretty enough to function maximum of the commercially accessible wireless sensor nodes conferred in the introduction. Furthermore, the resonant frequencies of most of the developed bridge energy harvesters placed in the narrowband which is quite suitable for vibrations available at bridge assemblies.

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