Energy Scanning for Designing Self-Generative Power Grid to Operate Wireless Sensors in Health Sensing Modules

Heonjun Yoon[1], Byeng D. Youn[2], Miso Kim[3], and Choon-Su Park[4]

[1,2]*Department of Mechanical and Aerospace Engineering, Seoul National University, Seoul, 08826, Republic of Korea*
heonjun@snu.ac.kr
bdyoun@snu.ac.kr

[3,4]*Center for Safety Measurement, Korea Research Institute of Standards and Science, Daejeon, 34113, Republic of Korea*
misokim@kriss.re.kr
choonsu.park@kriss.re.kr

ABSTRACT

The effectiveness of prognostics and health management (PHM) in operation reliability improvement and failure prevention strongly depends on health-relevant information conveyed by a sensory signal. The advances in wireless communications and low power electronics have allowed the deployment of wireless sensor network (WSN) for a health sensing module in the PHM. Energy harvesting (EH) has received much attention as a possible solution of a self-generative power grid to sustainably operate the wireless sensors. Piezoelectric vibration energy harvesting (PVEH) is a technology that converts ambient, otherwise wasted, vibration energy into electric power in response to the mechanical strain. Prior to selecting best sites for installation of the PVEH devices, it is of great importance to preliminary scan the amount of harvestable electric power in a cost-effective manner. This study thus aims at establishing an 'energy scanning' concept to provide a guideline on how to optimally design the location and the number of the PVEH devices for the self-generative power grid in the health sensing module. The backbone idea of the energy scanning is to implement the stochastic electroelastically-coupled analytical model using time-frequency analysis for quantifying the expected output electric power based on a non-stationary random vibration signal acquired from an engineered system. The three-fold steps are systematically organized with an aim to realize the energy scanning as: (1) analysis of ambient vibration sources induced by a target engineered system, (2) optimal design of the PVEH device, and (3) prediction of the expected output electric power in a statistical manner. Finally, the predictive capability of the energy scanning is validated with experimental observations. The main contribution of this study lies in that the energy scanning plays an essential role in scheduling the operation time interval of wireless sensors when the amount of harvestable electric power is larger than the threshold at which it is set to activate the operation

.