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MODEL VALIDITY OF BOND-GRAPH ELEMENTS FOR POWER ASSESSMENT

Abstract

In this paper, we devise bond-graph elements for electromechanical coupling systems such as an energy-harvester, and investigate their validity and usefulness for power evaluation. The bond-graph is a power-based analytical approach to the description of dynamic systems. It shows power flow in a graphical way, which helps us to easily grasp the dynamic behavior of complicated systems. The bond-graph is able to treat the bidirectional power flow well, while energy-harvesting is the conversion process from mechanical power to electrical one, and vice versa. The bond-graph is thus quite a suitable methodology to deal with sophisticated energy-harvesters. The most advantageous point of the bond-graph is adaptability to the systems that are subject to their components swap. The bond-graph method solves simultaneous sets of algebraic equations, instead of differential equations. On the other hand, common simulation methods, such as solving differential equations, are bothersome and difficult to change the number of their components because the common simulation should re-construct the simultaneous set of differential equations. To take advantage of the bond-graph methodology for analyzing an energy-harvester composed of piezoelectric transducers, it is necessary to create a piezoelectric model that is compatible with the bond-graph manner. So far, there are some proposals for describing piezoelectric models; however, most of which are not compatible with the bond-graph. We derive energy conservation of the electromechanical coupling system and assess the validity of the model. New bond-graph models for a diode-bridge and a control circuit need to be devised. From the above, whole bond-graph model of the smart energy-harvester is constructed by combing proposed bond-graph elements. We analyze the smart energy-harvester that is composed of a vibrating structure and complex circuits including the proposed bond-graph elements such as a diode-bridge and a control circuit. Numerical simulations show that the harvested power efficiency is seriously affected by the resistance of electric loads. In too small and large resistance cases, the power efficiency is low because the voltage of the storage capacitor cannot rise due to large consumption of electric loads. Since the electric charge is discontinuous, power waveforms of the energy-harvester also become discontinuous. Finally, bond-graph simulations demonstrate that the input power is discomposed to some powers and that total power equals input power. The bond-graph analysis reveals the power flow of electromechanical systems and it helps us to provide informative information in designing these system such as sophisticated energy-harvesters.