Characterization of piezoelectric MEMS vibration energy harvester with two-degree-of-freedom system under impulsive force

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[Introduction] Piezoelectric vibration energy harvesting (pVEH) has attracted a lot of attention as the power source for self-powered devices. To expand the application area of the pVEH, we are focusing on energy harvesting from random vibration. In previous work, we have investigated the electromechanical response of conventional MEMS pVEHs with single-degree-of-freedom (SDOF) system under impulsive force, a simplified form of random vibration. The results showed that the output power is almost independent of the resonance frequency of the pVEHs even with hundreds of mechanical Q factor.[1] Furthermore, we have reported that the output power can be enhanced using a dynamic magnifier (DM), known as two-degree-of-freedom (2DOF) system. The theoretical analysis suggests that DM with high Q factor is effective for the enhancement.[2] Thus, in this study, the electromechanical properties of pVEH with high Q-DM were investigated under impulsive forces.

[Results] DM with U-shape was fabricated by a stainless steel sheet. The mechanical Q factor of the DM was 73. The MEMS-pVEH fabricated using PZT films showed a resonance frequency of 186Hz, a mechanical Q factor of 400, and a generalized electromechanical coupling factor (K^2) of 0.7%. To consist 2DOF-pVEH, DM was set under the MEMS-pVEH. Fig.1 shows the frequency dependence of the output voltage under sinusoidal vibration. The peaks at 131 and 185Hz correspond to the resonance frequency of the DM and pVEH, respectively. Figure 2 shows an example of waveforms of the input impulsive force, the displacement of the DM, and output voltage. As can be seen, the DM is largely moved after applying the force then vibrated with its own resonance frequency. The output voltage showed the vibration of multiple harmonic vibrations. Output energy calculated for 0.2s after applying the impulsive force was 1.3nJ/g, which is higher than that in SDOF-pVEH. Further investigation and analysis will be presented.

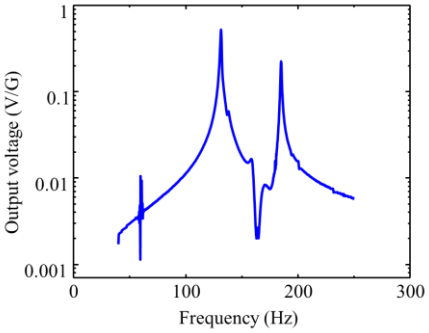

Fig.1: Dependence of output voltage and frequency of the 2DOF-pVEH

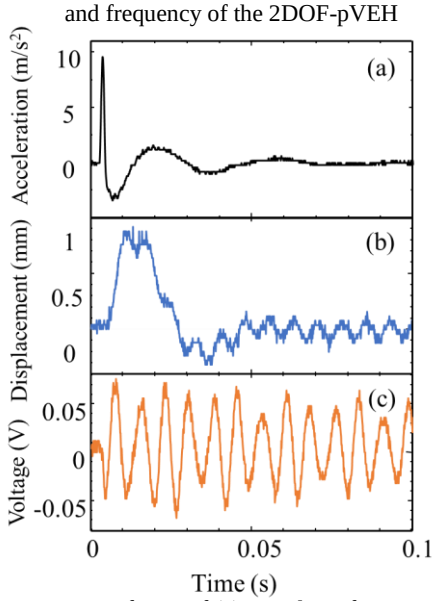

Fig.2: Waveforms of (a) Impulsive force, (b) Displacement of dynamic magnifier, (c) output voltage at load resistance of 100 kΩ.

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[References]

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