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Energy-Harvesting Dynamo Structure Using Both Swing and Rotation

振動と回転を利用するエネルギーハーベスト用発電機構の研究

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1. Introduction

Energy harvesting techniques have become very popular these days. There are a lot of similar technologies from large-scale energy recovery systems used in electric trains and hybrid vehicles to middle-scale systems such as HEMS (Home Energy Management Systems). Electric trains and hybrid vehicles use their motors as dynamos when reducing velocities or braking, which provides high total-energy performances. Besides such large- and middle-scale industrial and home energy saving trends, energy harvesting from our living environment has also been a remarkable movement in recent years. A lot of studies have been done about electric power generation from vibrations of objects in our living environment and temperature differences of human bodies or others. However today's power levels are not so high, that is those from 100 μW to several mW, which cannot be widely used in consumer products. On the other hand, unplugged battery charge for electric handy gadgets such as watches, cellular phones, digital cameras, etc. has become a realistic requirement nowadays.

In this paper, we study an energy harvesting device which might provide such high voltage that it can be used as power supply for electric handy gadgets. In our configuration, we exploit both swing (vibration) and rotation phenomena of a fan-shape weight whose center is fixed with bearing. Along the fringe of weight several small Neodym magnets are buried. Two sheets of polyimide multi-layer film where many coils are formed are used to generate electric power. Our proposed small dynamo can be mainly divided into three portions, top high magnetic-permeability (μ) steel plate, middle rotary fan-shape weight and also bottom high magnetic-permeability steel plate. One sheet of polyimide film is arranged between top steel pale and middle weight, while the other is between the weight and bottom steel. Voltage up-conversion method should also be investigated. We have studied new technique, which is in the other paper.

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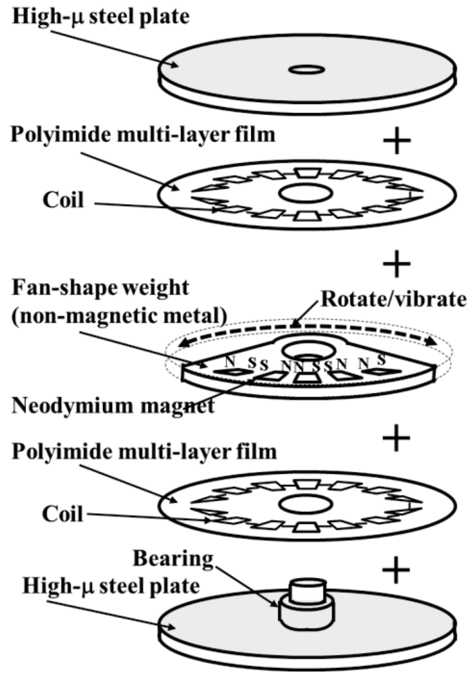


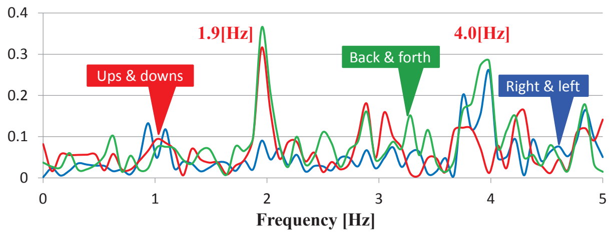
Fig. 1 Proposed energy-harvesting dynamo.

2. Dynamo configuration with swing and rotation

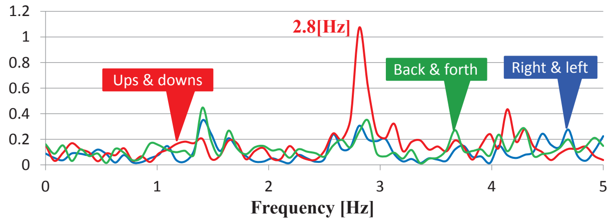
In general, power density of magnetic dynamos is larger than other generators using piezoelectric materials, such as PZT, PVDF, etc. However, generated voltages are low compared with other technologies. To pull as much energy as possible out of the dynamo, we have proposed the configuration shown in Fig. 1 which can use both swing and rotation to generate voltages.

3. Vibration amplitude and frequency of active human body

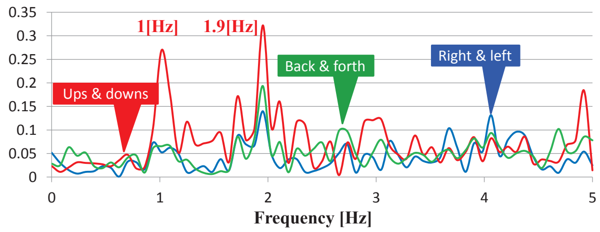
If the dynamo is installed in a cellular phone for example, it is usually used on a palm or stored in a handbag. In this case, vibration of a human body is very important to achieve synchronization between the fan-shape weight and the body. Measured amplitude and frequency of a body are shown in Figs. 2, which illustrate that vibration at 1-4 Hz should be considered to design the weight.



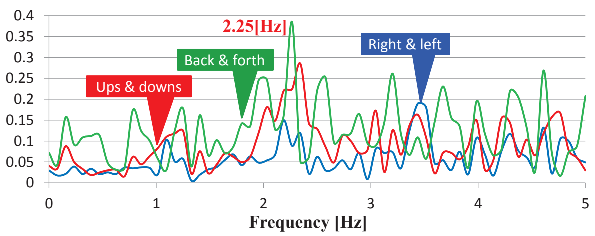
(a) Walking



(b) Running



(c) Going up stairs



(d) Going down stairs

Fig. 2 Vibration of human body when walking, running, going up stairs and going down stairs.

4. Fundamental experiment for dynamo with swing and rotation

A fundamental experiment to check our proposal was conducted. We made a large prototype dynamo to measure basic functions, because it is a little bit difficult to develop an actual sized dynamo, i.e. smaller sized dynamo. In order to achieve both swing and rotation, a stepping motor was introduced. As the photograph is shown in Fig. 3, using a control circuit and continuous swinging with arbitrary rotation angles for the dynamo was achieved. Generated voltage waveforms by swing and rotation are shown in Fig. 4(a) and (b) respectively. Generated voltages vs rotation speed are shown in Fig. 5.

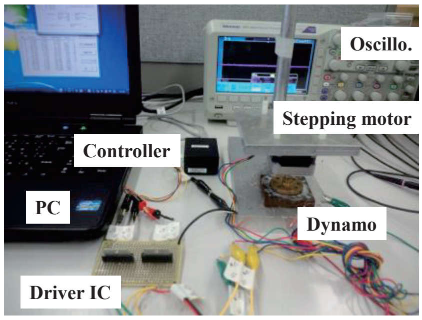
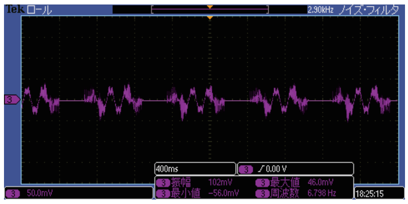
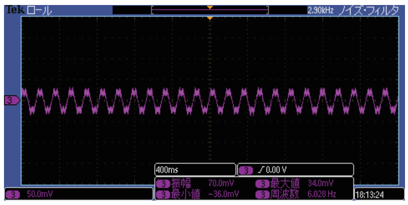


Fig. 3 Fundamental experimental set-up using large prototype dynamo with swing and rotation.



(a) Voltage wave form by swing



(b) Voltage wave form by rotation.

Fig. 4 Generated voltages from Fig. 3's dynamo.

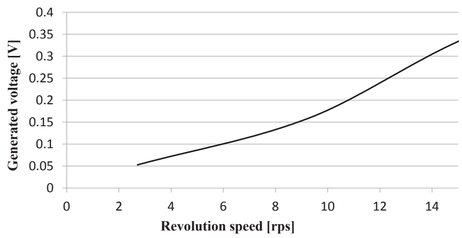


Fig. 5 Amplitude of generated voltages vs revolution speed of Fig. 3's dynamo.

5. Conclusion

A new energy harvesting device which uses a concept of magnetic dynamo aiming at handy electric gadgets has been proposed. A fundamental experiment to check basic features of our proposal shows that the structure can provide voltage generation by both swing and rotation. Up-converting the low voltage is another important problem, which will be treated in the other paper.

Reference

1. T. Haremaki and M. Hikita, in Proc. of Symp. on Ultrason. Electron. Vol.34, pp.129-130, 2013.