

# Improving the efficiency of vibration energy harvester using piezoelectric elements in different installation environments

Kobe high school Takumi Hiramatsu Yusei Maeba Runa Matsuo Ryoya Yamagishi

## ○ Research background

In these days, piezoelectric elements are getting people's attention as an environmentally friendly energy source. Piezoelectric elements generate electricity by using pressure differences. And "power generating floor" is known as a method of generating electricity using piezoelectric elements. In "power generating floor", we can generate electricity by stepping on a plate covered with piezoelectric elements. However, piezoelectric elements have some disadvantages. One of them is that the efficiency is very low. In JR's demonstration experiment, they installed "power generating floor" on some station ticket gates and measured the amount of power generated per day. However, it generated electricity which illuminates one light bulb for only 80 minutes. It can be said to be significantly less efficient than other generators. Against this background, in our research, we aimed to improve the efficiency of "power generating floor".

## ○ Purpose

To improve the efficiency of vibration energy harvester using piezoelectric elements in different installation environments.

## ○ Research plan

### ①Method

- Attach 20 piezoelectric elements to a wooden board of 20cm × 30cm.
- Connect all piezoelectric elements in series to make one circuit (do not connect both ends).
- In order to convert the alternating current generated from the piezoelectric elements to the direct current, make a rectifier circuit (bridge circuit) by connecting diodes to the lead line at both ends.
- Connect a capacitor to the end of the rectifier circuit, conduct control experiments and store the power generated from the device.
- Connect a capacitor that stored power to a resistor (2Ω) and a galvanometer.
- While shooting a video of the galvanometer, turn on the switch and shoot the deflection of the galvanometer.
- Check the video and plot the relationship between time and current in a table.
- Calculate approximate curve using python.
- Integrate the approximation curve, calculate the total current, and obtain the total power generation (electric power).

### ②control experiment

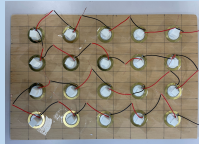
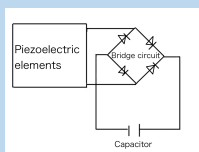
#### ( i )Weight difference

50kg 80bpm  
65kg 80bpm  
80kg 80bpm

#### ( ii )tempo difference

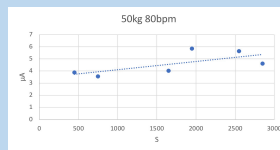
65kg 60bpm  
65kg 80bpm  
65kg 100bpm

$$I(t) = \frac{dQ}{dt} = -\frac{V_0}{R_2} e^{-\frac{1}{R_2C}t}$$

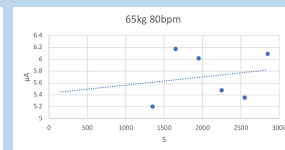


## ○ Result

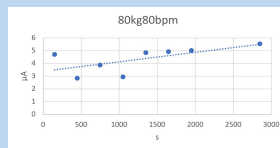
### ①weight difference



total energy : 380.88 μJ



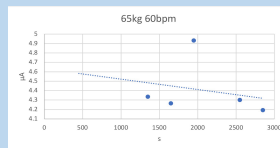
total energy : 591.68 μJ



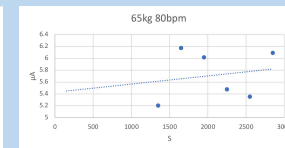
total energy : 338.00 μJ



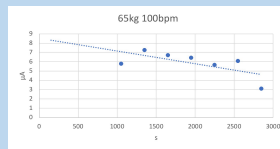
### ②tempo difference



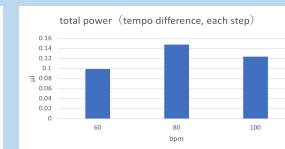
total energy : 297.68 μJ



total energy : 591.68 μJ



total energy : 619.52 μJ



## ○ Conclusion

From the difference in total power generation, it can be said that the middle weight of 65 kg and the fastest tempo of 100 bpm are the most efficient.

## ○ Consideration

- About the weight, our hypothesis was wrong because 80kg was heavy and the piezoelectric element was not durable enough to collect power.
- Also, the reason why the tempo didn't go according to the hypothesis was that the three bpm's (60, 80, and 100bpm) researched this time were slow overall, so 100bpm was neither too fast nor too slow.

## ○ Future Prospects and Reflections

- Only a small amount of power was generated in this experiment. We think the reason is that the capacitor was being connected even while we were not stepping on the piezoelectric elements. That caused outflow of generated power. We had to consider countermeasures for that.
- In this experiment, we considered only about the external factors of "power generation floor" (weight and tempo of people who step on the piezoelectric elements). We want to consider about internal factors next time.
- If we conduct demonstration experiments in places: with slopes, stairs, or entrances, the research could become more credible.

## ○References

- LEDを圧電素子で光らせる 大阪岸和田高等学校 松本知歩  
(<https://www.osaka-c.ed.jp/kishiwada/KeM/pdf/researchPaper2017-2.pdf>)
- 圧電素子で床発電を作ってみた  
(<https://youtu.be/L6xedW1CDk>)
- 高校物理の備忘録 コンデンサの充電・放電過程  
(<https://physnotes.jp/em/capacitor-charge-discharge/#-3>)

## ○ Hypothesis

Regarding the weight, we think that heavier pressure generate greater amount of power. So we think that the 80kg one will generate the greatest power.  
Regarding the tempo, we think that ones that are too fast or too slow will not generate much power. So we think that the 80bpm one will generate the greatest power.