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A1_2 A Powerful Paper

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Abstract

In this paper, we describe a theoretical keyboard that generates energy by converting individual key presses into an electrical current via electromagnetic induction, and calculate the amount of energy produced on average to be 6.4×10^{-7} J per special topics report typed with the keyboard. We then discuss the efficiency of such a device, along with suggesting potential improvements to the proposed design.

Introduction

The average character count for a paper in this journal (calculated by taking an average of all of the character counts of papers in Volume 17) is 5,730 characters including spaces.

This means, on average, there are 5,730 key presses in an average length report. The question we aim to answer in this paper is, if we could harness the energy used to press these keys via electromagnetic induction in a theoretical specialised keyboard, how much energy would it generate and would it be worthwhile to build?

Theory

The theoretical keyboard in question would have a magnet and a coil of 26 gauge copper wire underneath each key-cap as shown in Fig. 1. When a key is pressed down or released, the magnet would induce a current in the coil which would be passed through a diode, so that only a current flowing in one direction needs to be considered. The electrical energy would then be collected in a battery or other such power storage device.

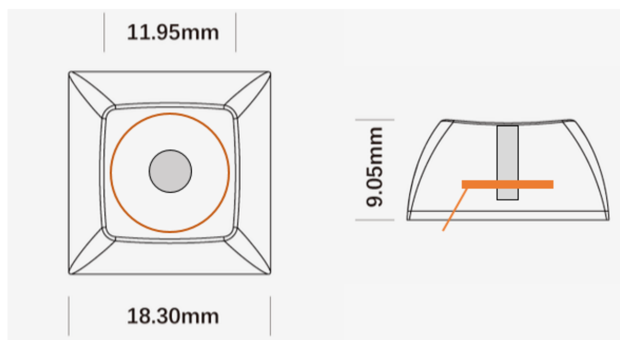

Figure 1: A visualisation of how an individual key on the theoretical keyboard would be constructed. The dimensions shown are for the key-cap, which would house the coil (shown in orange here). Base images of the key-cap can be found at [1].

The coil shown in Fig. 1 would be an 11 mm diameter coil of 5 thin turns of copper wire, thus allowing it to fit inside the key-cap with dimensions stated in figure 1. The strength of the magnet would be 0.001 T, which is the same as a standard fridge magnet [2]. This is because a stronger magnet could cause unwanted damage or interference in nearby computer hardware. We will also assume that the time taken to press a key down is equal to the time taken to release a key and have it return to its rest position, which we measured to be 0.05 s.

With these values defined, we calculated the amount of electrical energy generated by this system from a single key press. We start from a re-arrangement of Faraday's Law:

$$|V| = NA(\Delta B/\Delta t) \quad (1)$$

where A is the circular area enclosed by the coil from the top down view in Fig. 1, and the other symbols have their usual meanings. Using this, we calculated the voltage generated by a single key movement to be 9.5 μV.

To calculate the power that this voltage could supply through the copper wire, we first calculated the resistance of the copper wire using $R = \rho d_{wire}/a$. The resistivity (ρ) of copper is 1.9×10^{-8} Ωm [3], the cross sectional area of the wire (a) was calculated from the wire's diameter [3] to be 1.4×10^{-7} m^2 and the total length of the wire (d_{wire}) is the length of wire in the coil plus the average distance between a key and the end of the keyboard, which we measured to be 120 mm. This resistance was calculated to be 0.040 Ω, which we then used in the power equation; $P = V^2/R$ to obtain a value of 2.2×10^{-9} W.

Finally, we found the energy supplied by one key movement by multiplying this value of power by Δt from earlier (0.05 s), which we found to be 1.1×10^{-10} J.

Analysis

Given the average character count detailed in the introduction of this paper, the theoretical energy output of the keyboard after typing one report is 6.4×10^{-7} J. To determine the efficiency of the keyboard, we then calculated an estimate for the mechanical energy expended by a person typing a report. Using $W = Fd_{key}$, where W is the energy expended per keystroke, F is the force required to press a key (12.9 N [4]), and d_{key} is the distance the key is pushed in which we find to be 4 mm.

This would mean that the energy expended by an author in one keystroke is 0.052 J, leading to a total of 300 J being expended to type out a report. This means that the proposed theoretical keyboard is wildly inefficient, converting only 2.1×10^{-7}% of the total energy into electrical energy. There are several ways you could make the keyboard more efficient, such as using a material with a lower resistivity in the wiring, e.g. silver. Another way to make the keyboard more efficient is to increase the number of turns on the coil under the key-cap, although this is somewhat limited by the space under each key-cap. A final way we could suggest to increase the efficiency of the keyboard is to use a stronger magnet, however this is not advised as it could cause problems with the keyboard itself or nearby hardware.

Conclusion

In conclusion, the theoretical keyboard detailed in this paper would be an inefficient way to generate energy from the process of typing a report, producing 6.4×10^{-7} J if built to the specification described in this report, and approximately 300J if all the mechanical energy expended by a person typing an average length report was converted successfully. There are ways the design could be improved to maximise the energy output, however compared to the energy output and storage capabilities of modern devices this wouldn't be beneficial. Not such a powerful paper after all!

References

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