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Analysis of temperature oscillations due to low current in a circuit of a resistor and a thermostat's bimetallic plate

Oscillations have been well-studied in many branches of physics due to their periodic behavior and the solution compactness of the solutions, which allows a variety of applications. In addition to electromagnetic or mechanical oscillation experiments usually available in the university or high school physics laboratories, the setup that undergraduate students can explore the oscillation of other parameters, especially those that involve direct observation, would engage their learning. The safer (e.g., from electrical hazards) the apparatus is, the more widely it would be adopted. Here, we present a simple circuit of a resistor exchanging heat with a thermostat, creating a temperature oscillation with an ultra-low frequency. We propose an analysis that considers the dynamics of carefully chosen bimetallic plates of the thermostat and the heat transfer between the two components. The model during oscillations comprises two phases: (i) temperature rising in the closed circuit and (ii) temperature dropping in the open-circuit configuration. Our setup achieves the ultra-low frequency of 5-50 mHz at the working current of < 1A. Furthermore, we also found a relatively good agreement between the observed and predicted frequencies. This work highlights the importance of equipment selection that eases the demonstration of a niche oscillation phenomenon that student can comprehend and apply the physical concepts.

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