Experimental Designs to Approach the Internal Relation of Lorentz Force law and Faraday's Flux Rule

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Abstract

In this paper, two experimental designs are proposed to approach the internal relation of Lorentz Force law and Faraday's Induction Law. In the two experiments, when a part of a conductor loop moves in a uniform magnetic field, there is only one of the two mechanisms working (either Lorentz Force Law or Faraday's Flux Rule). By the experimental results, the deeper relation of the two laws could be further revealed.

Keywords: Induced electromotive force; Lorentz force law; Faraday's induction law; Electromagnetic induction; Flux rule.

Introduction

In classical electromagnetic system, it is a very familiar fact that an electric motive force (EMF) will be created in a conductor loop when part of the loop moving or deforming in a magnetic field. This phenomenon can be well explained either by Lorentz Force Law or by Faraday's Flux Rule. Both of the two mechanisms give the same quantitative results on the EMF in the loop.[1,2,3]

Figure 1 is a typical example used to demonstrate how an EMF created in a conductor loop when it is placed in a uniform magnetic field. There is a conductor loop which consists of two parts, a fixed U shape frame (a) and a moveable crossbar (b). The whole conductor loop is placed in a uniform magnetic field with the field is perpendicular to the plane of U frame. When the crossbar moves along the two sides of the U frame, the motion of the crossbar is cutting the magnetic force line and meanwhile the magnetic flux through the loop is changing. During the process, an EMF will be produced in the loop. This phenomenon can be well explained either by Lorentz Force Law or by Faraday's Flux Rule. Both give exactly the same quantitative result of the EMF,[1]

$$\varepsilon = wvB$$

In this case, the two independent mechanisms are so compatible in explaining the electromagnetic phenomena and perfectly predict the same result on the EMF in the loop.

However, when the crossbar moving, if there is only one of the two effects exist, what is the result? That is, if the crossbar is only moving across magnetic field but it does not result in magnetic flux change through the loop or if the moving crossbar is not cutting the magnetic force line but it does make the magnetic flux change through the loop, will an EMF be produced in the loop? If yes, will the EMF still be ***wvB*** ? Or will it be half of ***wvB*** ? It is the questions that we will approach in this paper.

Here, two experimental designs are proposed, in which, we can achieve only one of the two mechanisms working when the crossbar is moving. The experimental results will tell us what the EMF is if only one of the two mechanisms is working in the system of figure 1.

Experimental design and analysis

In figure 1, if the U frame is covered with a magnetic shielding material, the magnetic field cannot go through the loop, as shown in figure 2. In this system, we can achieve that the crossbar is moving across the magnetic field, but there is no flux change through the loop, in following two situations:

(1)U shaped frame keeps still and the crossbar slides on the two sides of the U frame together with the magnetic shielding cover. The crossbar is moving and cutting the magnetic force-line, but the flux through the loop does not change, due to screening effect of the magnetic cover. It keeps the flux through the loop be always zero.

(2)The crossbar, U frame and the magnetic shielding cover as an integral move across the magnetic field. Only crossbar is moving and cutting the magnetic force-line, but no flux change through the loop.

As Lorentz Force Law the EMF should be wvB, but as Faraday's Flux Rule the EMF should be zero. What should it be?

In figure 3, the crossbar is covered with magnetic material but not the U frame. Thus, the magnetic field cannot reach the crossbar. When the crossbar moves along the two sides of the U frame, the flux through the loop is changing, but the motion of the crossbar is not cutting the magnetic force-line. As Lorentz Force Law the EMF should be zero, but as Faraday's Flux Rule the EMF should be wvB. Opposite result is predicted compared to figure 2.

As our analysis above, in the system of figure 2 only Lorentz Force Law works and in that of figure 3 only Faraday's Flux Rule works. In the system of figure 1, both mechanisms work. So, will the EMF in figure 2 or figure 3 be the half of that in figure1? Or will it be still wvB ? By performing the experimental designs of this paper, the answer will be provided.

Unfortunately, I have no conditions to set up the experiments. So, hope some ones, who are interested in this question, can set up the experiments to provide us the answer to the question. It is not difficult for a professional laboratory to set up and perform the experiments.

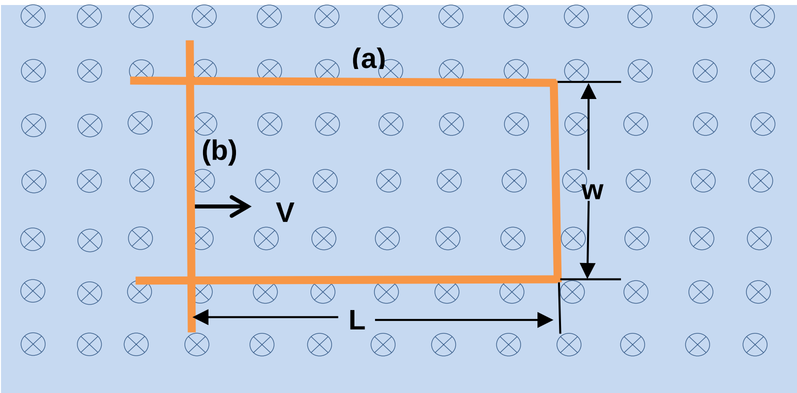

Fig.1. A conductor loop consists of two parts, a fixed U shaped frame（a）and a movable crossbar（b）. The whole loop is placed in a uniform magnetic field which is perpendicular to the plane of the U frame.

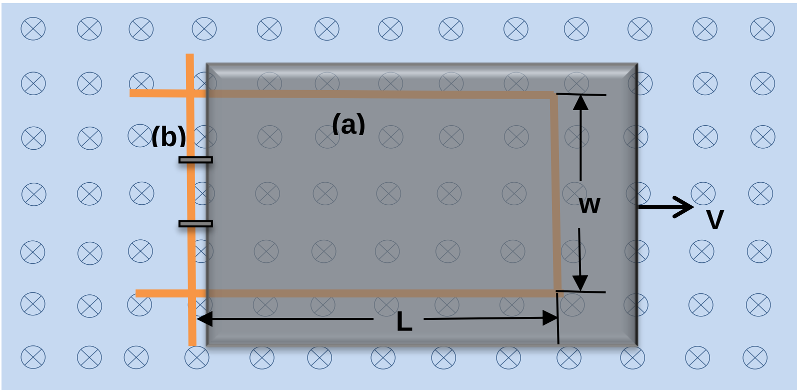

Fig.2. The U shaped frame was covered with magnetic shielding material that makes the magnetic field not go through the loop. The others are the same as in figure 1.

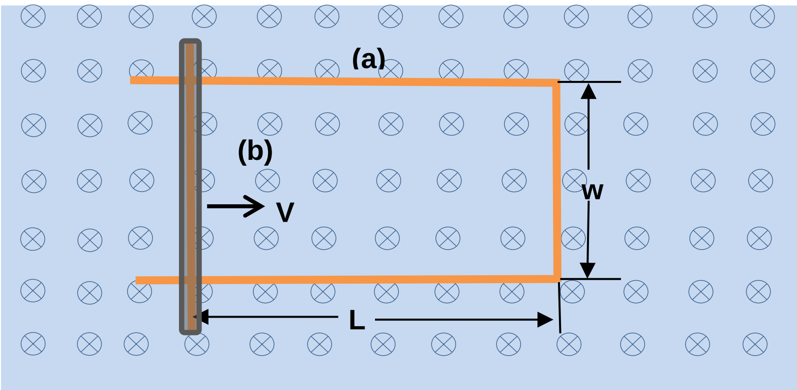

Fig.3. The crossbar is covered with magnetic shielding material that makes the magnetic field not reach the crossbar. The others are the same as in figure 1.

Reference

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