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Measurement of electrostatically induced voltages in two metal boxes using spark gaps and electromagnetic wave sensors

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ABSTRACT

Electrostatically induced voltages are generated in metal boxes when a charged human body moves near boxes that have openings. The induced voltages occasionally cause malfunction and failure of electronic equipment. When a human body walks in office that uses air conditioner, the body is electrified. Hence, when a charged body, such as charged human body, moves near metal boxes, high induced voltages are generated in them. In the experiments, two metal boxes similar to the boxes of electronic equipment are used. The induced voltages generated in the two metal boxes are measured. The results will help to resolve electrostatic problem.

1. Introduction

Electronic equipment malfunctions can be caused by an electrostatically induced voltage generated in the metal box that covers the equipment [1–22]. An electronic device malfunctions or experiences failure with the occurrence of induced voltages of around 10 V when a charged human body moves near the electronic equipment. The voltage of the charged human body may occasionally reach 10 kV or more in an office. When such a charged body moves near the metal box of electronic equipment, it can cause a high induced voltage to appear in the metal box.

The measurement of induced voltages in partially open metal boxes is not easy without an electrical connection when a charged body moves near the metal boxes. The reason is that such an electrical connection between the charged object and the measuring instrument disturbs the electrical field in the metal boxes. One of the best measurement methods for induced voltages in metal boxes is one that does not require an electrical connection. In high voltage engineering, voltage measurement is frequently performed using an electrical spark gap. In this study, the non-contact measurement of induced voltages in metal boxes is performed using spark gaps and electromagnetic wave sensors. Thus, the measurement of the induced voltages in two metal boxes is performed.

The next results on the topic of induced voltage were obtained by using a spark gap, the EMI locator of an electromagnetic wave sensor, an electrostatic voltmeter, *etc*. (1) The measured results showed that the potential difference for a piece of foil grounded in a metal box is approximately 80% larger than that for both foils ungrounded in the metal box [23]. The potential difference decreases linearly with the increasing logarithm of the distance between the charged body and the front of the metal box. (2) The induced voltage increases by up to 1.6 times when the area of the induction electrode in the metal box is 10 times larger ($100\ cm^2$) than $10\ cm^2$, and the induced voltage does not change so long as the area of the ungrounded metal foil is not changed [24]. (3) An induced voltage of 3 kV is generated in an ungrounded metal box when a 10 kV charged body moves near the ungrounded metal box [25]. (4) It is clear that the polarity of the induced potential difference of the object contained in the metal box changes when a charged body moves in the vicinity of the box [26]. (5) The induced voltage generated in the metal box is independent of the volume of the metal box (the depth of the box) [27]. (6) When the ratio of the width of the shielding conductors to that of the opening of the metal box increases, the induced voltage generated in the metal box decreases [28]. (7) When the charged body moves away from the metal box, the value of the induced voltage of the metal box is −3 times the voltage of the moving charged body [29]. (8) The percentage ratios of the induced voltage in the metal box to the voltage of the charged body are 56% for the measurement and 69%–78% as per the calculations, at a distance of 10 mm between the charged body and the metal box [30]. (9) The induced voltages and the electric charges increase as the facing area between the metal box and the charged body increases [31]. (10) Induced voltages that are −0.42 times the voltages of the charged body are generated in the metal box when the charged body moves away from the metal box [32]. (11) For a metal box resembling a vertical A4-sized notebook (laptop) computer, the induced voltage generated in the metal box when the charged body moves away from the metal box is −4 times the voltage of the charged body when the body approaches the metal box [33]. These results were obtained for one metal box when a charged body

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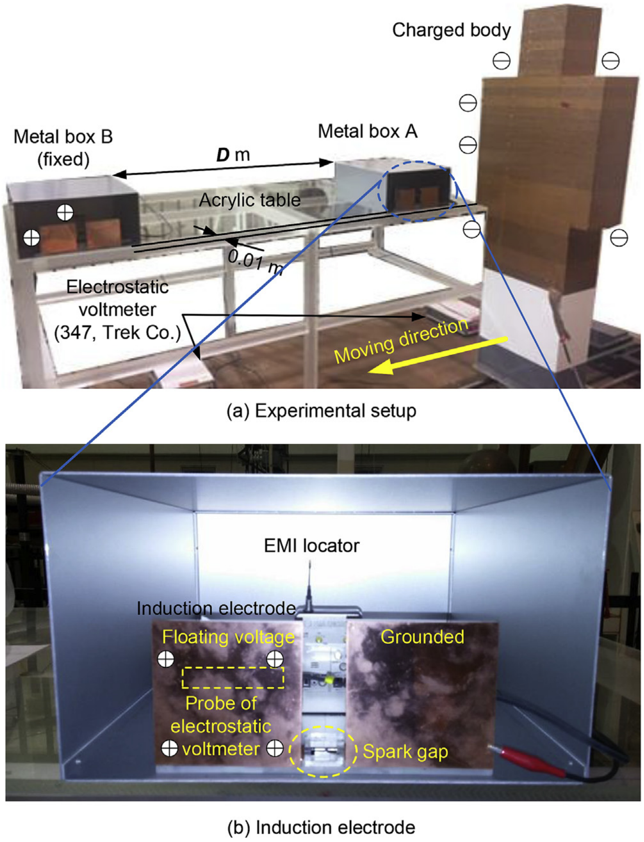

Fig. 1. Experimental setup.

moves near the metal box.

The measurement of induced voltages in two metal boxes has not been performed before, though some experiments with one metal box have been performed. There are several metal boxes of electronic equipment, like desktop computers *etc*., in an office. The measurement of the induced voltages in two metal boxes is necessary to consider a real electrostatic problem and its preventive measures. How high are the induced voltages generated in the two metal boxes when a charged body moves in front of the metal boxes? A solution to the electrostatic problem is required. In the experiments, induced voltages in the two metal boxes are measured using two spark gaps and electromagnetic wave sensors when the distance between the two metal boxes is varied [34]. The results will be helpful for solving such electrostatic problems and suggesting preventive measures for the malfunctioning of electronic equipment.

2. Experimental setup and method

Fig. 1 shows the experimental setup. The setup represents a situation where a charged body, like a charged human body, moves near two partially open metal boxes. The charged body consists of copper tapes and a polystyrene foam body. A whole part of the metal body of the charged body is connected to a DC high voltage power supply. The charged body is put on a transporting stage and moves automatically with a velocity of approximately 0.5 m/s. The dimensions of the charged body are 1.8 m height, 0.55 m width, and 0.2 m length. A movable distance of the charged body is 2.04 m.

The two metal (aluminum) boxes represent the metal boxes of electronic equipment. The two metal boxes each have an opening on the front and are grounded (earth). The two metal boxes are put on an acrylic table 1 m in height. The front surfaces of the two metal boxes coincide with the front of the acrylic table. The distance D between the two metal boxes is changed by changing the position of metal box A. The dimensions of the two metal boxes are 0.2 m height, 0.35 m width, and 0.4 m length. The distance between the front of each metal box and the charged body is 0.01 m.

One induction electrode is put on each of the bases of metal box A and metal box B (see Fig. 1a). The induction electrode consists of a spark gap and two metal (copper) plates (see Fig. 1b). For each induction electrode, the metal plate on the right side is grounded. The voltage of the left metal plate of the induction electrode becomes a floating potential (voltage) because the left metal plate is not grounded. The electrostatic voltmeter probe is attached to the back of the left metal plate of the induction electrode. Then, the induced voltage of the induction electrode is also measured by the 347-electrostatic voltmeter

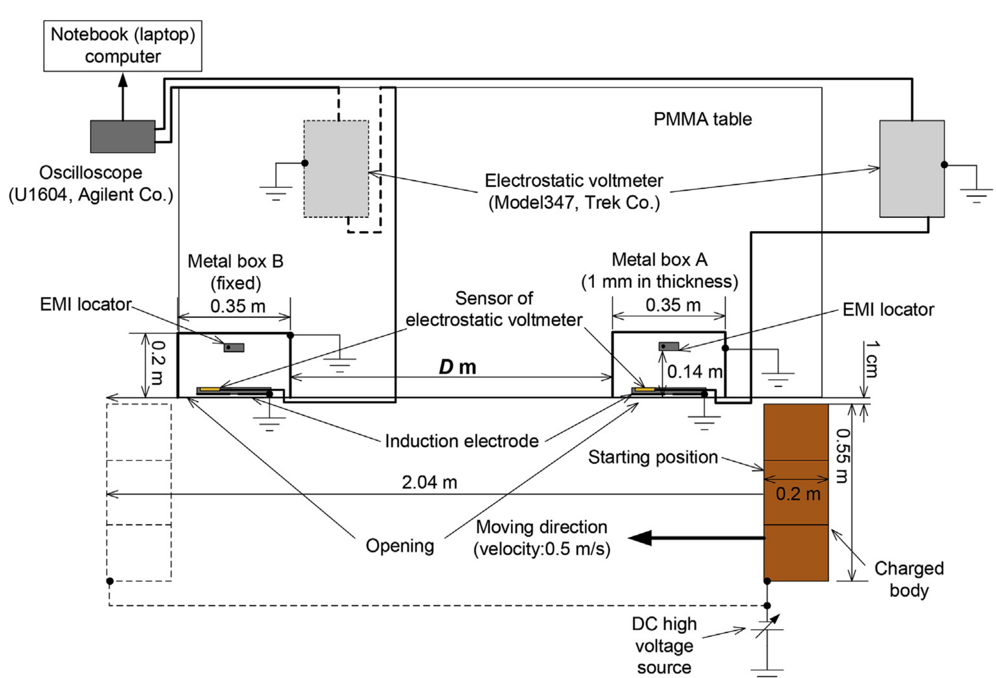

Fig. 2. Schematic diagram of experimental setup.