Electrical field of electrical appliances versus distance: A preliminary analysis

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Abstract. Every household electrical appliance that is plugged in emits electric field even if it is not operating. The source where the appliance is plugged into and the components of household electrical appliance contribute to electric field emission. The electric field may cause unknown disturbance to the environment or also affect the human health and the effect might depends on the strength of the electric field emitted by the appliance. This paper will investigate the strength of the electric field emitted by four different electrical appliances using spectrum analyser. The strength will be captured at three different distances; (i) 1m (ii) 2m and (iii) 3m and analysis of the strength of the electrical field is done based on the three different distances. The measurement results show that the strength of the electric field is strongest when it is captured at 1m and the weakest at 3m from the electrical appliance. The results proved that the farther an object is located from the electrical appliance; the less effect the magnetic field has.

1. Introduction

AC power produces electric field and a magnetic field. The difference between electric field and magnetic field is that an electric field is produced by voltage while magnetic field results from the flow of current through wires or electrical devices. These two fields together are referred to as electric and magnetic fields, or EMFs. Electric field is present everywhere in the environment but is invisible to the human eye. This is because all charged objects create an electric field that travels into the space that surrounds it. Electric field increase in strength as voltage is raised and it can be detected even if the equipment is switched off but not unplugged from the main power socket [1].

Studies have shown that magnetic field has a higher potential to affect the human’s health [2-5] while electric field is said to be harmless because it is easily shielded and can be avoided by earthing and screening [4]. This is only true if the electric appliances are made to comply with the national guidelines but if the appliance is not complying with the national standard as reported in [1] where the fields emitted by the junction box on the workstation and the desk-light exceeded those suggested guidance levels for computers, then further research on electric field is found necessary.

The strength of the electric field is dependent upon how charged the object creating the field is and upon the distance of separation from the charged objects. Since the distance between electrical device and object is one of the factors that contribute to the strength of electric field emission, it is the main
objective of this paper to investigate the strength of electric field from four different household electrical appliances such as stand fan, liquid-crystal display (LCD) television, desk lamp and microwave oven.

2. Data Collection
This paper involves data collection of electric field emitted from electrical appliances using spectrum analyzer, Spectran 1010E, which is capable to detect the strength of the electric field within 0 to 30,000 kHz. The appliance is placed at one fixed point while the spectrum analyzer is placed 1m from the appliance where the strength of the electric field is recorded. Once the strength is recorded, the spectrum analyzer is moved 2m before the strength of the electric field is recorded. Then, the spectrum analyzer is placed 3m from the appliance and again the strength of the electric field emitted by the appliance is recorded. Figure 1 illustrates the data collections methodology.

![Figure 1. The flow of data collection method.](image)

Even though the data is not collected in a controlled environment, precautions are taken to minimize the possibility of interference of electric field from the environment where all other electrical devices in the laboratory such as air conditioner and fan are turned off. This is to avoid the electrical field detected by the spectrum analyzer is mixed with other unwanted radiation from other appliances. Moreover, the Spectran 1010E device is guarded against any human or biological physical contact when in use. Instead, the commands are made through the LCS Software operated from a laptop which is placed as far as possible from the spectrum analyzer.

Since the electrical appliance delivers non-identical electric field when in off or on mode, the data is collected in three phases: (i) OFF state in 2 minutes (ii) ON state is 5 minutes and (iii) OFF state is 3 minutes. This is to make sure that the data collected is consistent for all appliances.

3. Results and Discussion
The electric field emission is measured for the frequency range between 0kHz to 1200kHz. The electric field emitted by four appliances are measured by varying the distance (1 meter, 2 meter and 3 meter) between appliance and spectrum analyzer. Figure 2 shows that the strength of the electric field emits from the LCD television decreases as the spectrum analyzer is placed farther.
Figure 2. Electric field at 1m, 2m at 3m emitted from a LCD television

Figure 3 shows the strength of the electric field emitted by a stand fan. It shows that the strength of the electric field varies approximately between -4 to 2 V/m when the spectrum analyzer is placed 1m from the stand fan. The strength of the electric field is significantly lower when the spectrum analyzer is placed 2m from the stand fan. At 3m the strength is approximately between 0.4423 to -0.489 V/m. From the observations, LCD television emits weaker electric field compared to the stand fan for the range between 300 to 1200 kHz.

Figure 3. Electric field at 1m, 2m at 3m emitted from a stand fan

The electric filed emitted by the desk lamp is weak as shown in Figure 4, which is approximately between 0.6744 to -0.9288 V/m in frequency range of 500 to 1100 kHz. As the spectrum analyzer is placed farther from the desk lamp, the strength of the electric field still show reduction but not significant. However, at 0 kHz it can be seen that the highest strength of the electric field is 14.53 V/m at 1m, followed by 7.897 V/m at 2m and 2.826 V/m at 3m.

Figure 4. Electric field at 1m, 2m at 3m emitted from a desk lamp
The electric field emitted by the microwave oven is shown in Figure 5 where it does not show a significant reduction as the spectrum analyzer is put farther from the microwave oven at frequency more than 600 kHz. However, the reduction is seen approximately between frequencies 0 to 200 kHz.

![Electric field at 1m, 2m at 3m emitted from a microwave oven](image)

**Figure 5.** Electric field at 1m, 2m at 3m emitted from a microwave oven

4. **Conclusion**
From the results, LCD television and desk lamp emitted stable electric field where the strength of the electric field does not vary much between frequencies. However, the reduction of the electric field can still be seen between 0 to 200 kHz for LCD television and desk lamp. The electric fields emitted by the stand fan and microwave oven are more dynamic due to its motor component inside the appliance. For the stand fan, the reduction in the strength of electric field is clearly shown as the spectrum analyzer is put farther. On the other hand, the reduction of the electric field emitted by the microwave oven is clearly seen between 0 to 200 kHz. The same electric field pattern (reduction of electric field) can be seen for all four tested appliances between 800 to 1200 kHz. In conclusion, from the four appliances tested, it shows that the strength of the electric field decreases as the field travels away from the appliance.

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6. **References**
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