Experimental Method for Visualizing RF Electromagnetic Waves

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Abstract. This paper presents a method to visualize the result of the interaction of radiofrequency electromagnetic waves radiated by a log-antenna and gas-filled tubes. The test waves were in the frequency range of 200-500 MHz. Frequency and Voltage supplied to a log-antenna for gas excitation were investigated to determine the energy for light emission of the media under test. We used low-energy sources to perform the experiments in a controlled electromagnetic enclosure. We experimentally demonstrated that gas-filled lamps could emit light as a result of the interaction with RF electromagnetic radiation.

1. Introduction

The electromagnetic waves are present in all aspects of the modern life and all the electrical and electronic devices are subject to the environmental radio electric noise. The phenomena of ultra low frequency (ULF) wireless power transmission was firstly showed by Nikola Tesla in the last decade of the XIX century [1]. The interaction of ULF-electromagnetic radiation with light bulbs was experimentally shown. The possibility of turning on a light bulb has been shown using microwave ovens, but explanation about the phenomena is not precise yet. It is a popular believe that the electromagnetic waves excites de tungsten filament, but in fact it was demonstrated that the waves excites the gas molecule. Not only the correct wavelength could excite the electrons, but signal amplitude can reach this energy state.

Radiofrequency (RF) is considered as non-ionizing radiation and its interaction with physical mediums is not visible for the humans. Ionizing is understood as the procedure for taking-off an electron from an atom in its ground state. The electric potential necessary for this process is called ionizing potential [2]. Air gases have a lower ionizing potential than noble gases but the effect cannot be seen at first sight until an electrostatic discharge happens, which requires a high voltage source.

The human should protect himself from those harmful and undesired effects of the environmental RF noise; this is the principal objective of regulatory agencies and their normativity or guidelines. In many cases is impractical speak about non-visible waves, so a way to raise awareness is to show the effects and behaviour of the electromagnetic waves over a physical media.

In this work we present a method for showing the interaction of radiofrequency (RF) waves with noble gases contained in tubes, as a result of the gas excitation process visible light can be appreciated [3, 4].
The proper Electric Field to produce light emission depends on the amplitude, frequency and the kind of transducer (antenna design), so the parameters for a logarithmic antenna were investigated.

2. Method

A number of mixtures of argon-neon were employed, for exciting them and obtaining a beam of light as a function of the incident electromagnetic waves. Amplitude and frequency of the incident waves for the excitation of gases were investigated. Sinusoidal non-modulated RF waves in the range of 200-500MHz were generated using a signal generator (Rohde & Schwarz SML03, München, Germany), which has a maximum output level of +10 dBm. These signals were amplified by a power amplifier (Amplifier Research 250W100A, Bothell, USA) and finally a logarithmic antenna (ETS Lindgren Biconilog 3148, Austin, USA) was connected to radiate the signal to the air [5, 6]. Fig. 1 shows a schematic of the experimental setup.

The experiments were performed in a Semianechoic Chamber (ETS Lindgren, Austin, USA) to avoid any unwanted interference caused by any surrounding electrical-electronic devices. The chamber is 6 m x 6 m x 7 m and it can be operated from 30 MHz to 1 GHz with a normalized attenuation of +/- 3 dB and, from 1.1 GHz to 18 GHz with a normalized attenuation of +/- 4 dB.

![Figure 1. Experimental setup to generate the RF electromagnetic waves to ionize the gas mixtures.](image)

First, the dipole of the antenna that generates the maximum radiation with the minimum input voltage at each frequency was identified. A tube lamp was located parallel to the dipole at a half-length as it is shown in Figure 2, and an ionizing condition was visually determined. The distance between the lamp and the dipole was 5cm, and a voltage sweep with the signal generator was performed for each frequency and each dipole.
Second, we varied the frequency from 200 MHz to 500 MHz with a step size of 100 MHz. A Spectrum Analyzer (Anritsu MS2711D, Tohoku, Japan) was employed for measuring the total voltage supplied to the log-antenna.

3. Results

Table 1 shows the measured voltage amplitude when the lighting condition was achieved for a particular frequency.

| Frequency [MHz] | Amplitude [V] |
|----------------|--------------|
| 200            | 45.8±0.6     |
| 300            | 37.8±0.7     |
| 400            | 32.9±0.9     |
| 500            | 24.9±0.5     |

The measured voltage shows a decrement as the frequency is increased. It means that a minor voltage level is required for gas excitation when the work frequency is higher.

In Fig. 3 light emission is shown for two gas mixtures located near to the same dipole.
The principal dipole is the only one capable to excite the electrons of the gas in the lamp. The lighting phenomena can be prolonged by keeping the lamp in the vicinity, i.e. the lamp can be separated beyond the 5 cm or can be located at the surrounding dipoles, and the produced light will be still visible. In noble gases once a lighting condition was achieved, only low energy it is necessary for maintaining the emission of photons.

The experiments were performed considering the instantaneous response of the lamp gases to the RF wave. Another important aspect is the time duration that the lamps remain glowing as shown in Fig. 3. The time exposure will be studied in further experiments.

4. Conclusions

We have shown the interaction between Electromagnetic RF Energy and gases contained in a tube lamp. The controlled levels and electromagnetic environment, allowed us to quantify the Electric Field necessary for switching on the lamps using this type of no ionizing radiation. It is important for people to observe the interaction of different kinds of energy present in their daily life in a way to prevent future damage caused by the long time exposition to the multiple energy sources.

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