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Assessment of Electric and Magnetic Fields Exposures for Different Types of Street Lights

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Abstract: ***The use of solid-state lightings using energy saving lights such as light emitting diodes (LEDs), High Pressure Sodium Vapour (HPSV) and induction light in the illumination has represented a major technological breakthrough in recent years. Several recent studies focus on the development and performance of energy saving street lighting systems such as LED, induction etc. These modern lamps use electronic ballasts contain a switching power supply circuit typically operate in the range of 20kHz to 60kHz to achieve low power consumption in which may cause interference to communication equipment as well as health effect to human body, which is not an issue in traditional electromagnetic 60Hz ballasts. This paper investigates the electromagnetic and electric field exposure to human body from three street lights systems; LED, HPSV and Induction lights. The electromagnetic and electric field measurement are conducted in the laboratory that represents a controlled environment in which free from external factors or interferences. The electromagnetic and electric field exposure measurements are conducted using the Aaronia SPECTRAN hand held spectrum analyzer model NF-5030 on five streetlights from three different types in accordance to MS2230-2009 standard. The results presented in this paper can be utilized as references for measurement in open space that may have some interferences from other sources as well.***

Keywords: ***Electromagnetic Field, Electric Field, Electromagnetic Interference, LED, Street lights***

I. INTRODUCTION

Light-emitting diode (LED) lamps have become widely accepted and used in recent years due to their longer life span and most importantly higher energy efficiency compared to the other light sources. LED lamps are not only being used indoor but also widely used for streetlights, traffic lights and signage to name a few. Taking streetlights as examples, LED lamps have more advantages against the conventional incandescent lamps.

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Conventional incandescent and old florescent lamps operate by directly connecting the filament or the inductive ballast to the power source depending on the local national power grid voltage and these lamps emit electromagnetic interference (EMI) [1-3]. The LED lamps on the other hand, use 10% of energy required by the conventional incandescent lamps but the use
of LED lamps possesses a greater challenge because LED lamps and the drivers have the active components, all of which emit electromagnetic interference. The high switching frequencies in the drivers, that convert AC to DC and to stabilize the DC output are responsible in creating the EMI problems. The induction lamps have been around for more than a century pioneered by Nikola Tesla. The electronic ballasts and generators are parts of the lamps and these lamps are extensively used in street lighting. Induction lamps use high frequency generators with couplers which produce radio frequency magnetic field to excite the gas fill. The ballasts used in these induction lamps are held responsible for the electric and magnetic interference [4]. The High Pressure Sodium Vapor lamps use sodium to produce light. HPSV lamps have inductive ballast that made up of wire windings and these coils create the magnetic field when current is applied. In general the electrical ballasts are seen as major contribution of noises to the power system and to the surrounding [5].

Light-emitting diode (LED) usage has penetrated many fields not only to be used in street lighting but also in medical and wireless communications. Shadowless lighting has been used in the surgical rooms to improve the lighting of the operative field. The use of LED, which comes together with switching power supply, may cause EMI with some wireless communications and broadcasts in the surgical room [6-8]. Electromagnetic tracking based surgical navigation may have metal instruments in the operating environment, which affect the magnetic field. The LED Shadowless lighting radiates EM noise and thus will affect the surgical navigation system. The finding in [6] shows that the induced interference will hardly affect the EM surgical navigation systems in common operations if the source of the interference is placed in a sufficient distance. Matsumoto et al in his paper [9] investigated the noise radiated by the LED light bulbs. In 2010, when the traditional light bulbs were replaced by LEDs, poor reception of analogue TV and audio broadcasting occurred. To analyze the interference of the LED noise it is essential to model the noise by using two mutually complementary approaches name, time-domain modeling and statistical modeling. The measurement set-up comprises two receiving ends to measure the EM noise and to measure the LED intensity.

A detector detects the EM noise, and a condenser focuses the intensity of the measured LED. The combination of the detector and low pass filter produces the frequency response which will detect the changes in LED intensity caused by the switching operation.

A large scale use of LED, HPSV and induction lighting raises concerns about electromagnetic interference to the surrounding that could effect radio signal and the public in overall. In this paper, a series of experiments under controlled environments were done to measure the electric field and magnetic exposure and serve as references.

II. EXPOSURE MEASUREMENTS METHODOLOGY

Modern lamps use electronic ballasts contain a switching power supply circuit typically operate in the range of 20kHz to 60kHz to achieve low power consumption [A]. The high frequency and may cause interference with communication equipment that did not occur with traditional electromagnetic 60Hz ballasts. It has been reported that the switching power supply circuit mounted in LED lighting devices may cause electromagnetic interference (EMI) with some wireless communications and broadcasts [B, C]. Electromagnetic Interference (EMI) can cause static on radio communications or interfere with the operation of any electronic device especially wireless communication devices. There are two type EMI; conducted and radiated EMI. Conducted EMI is injected back into the power system through the ballasts conductors. This type of EMI may cause interference with devices on the same electrical distribution network. Radiated EMI is radiated into the air by the fluorescent lamp, ballast, conductors, or ungrounded fixture. Thus, it is crucial to investigate the effect of EMI from the modern lamps e.g. LED, HPSV and induction lighting.

In this work, two important parameters will be investigated; the electromagnetic and electric field exposure from the operation of the selected streetlights. The electromagnetic and electric field exposure measurements are conducted using the Aaronia SPECTRAN hand held spectrum analyzer model NF-5030 on five streetlights from three different types as shown in Table 1.

Table. 1 Types of streetlights used for measurement

No.	Types
1	Induction Light Brand A
2	Induction Light Brand B
3	High Pressure Sodium Vapor (HPSV) Light
4	Light Emitting Diode (LED) Light Brand A
5	Light Emitting Diode (LED) Light Brand B

Aaronia SPECTRAN hand held spectrum analyzer model NF-5030 is capable of measuring signal from 1Hz to 1Mhz and magnetic and electric field exposure respectively ranging from 1pT to 500µT and 0.1V/m to 5000V/m. The measurements are conducted in accordance to the MS2230-2009 standard. Table 2 shows the EMF general public exposure limits according to MS2230-2009 standard. EMF exposure beyond the recommended limits might cause health effects to general public and interference to sensitive electronic devices. Hence, it is crucial to investigate the magnetic and electric field exposure from these streetlight systems and confirm its exposure level are within the range of permissible exposure limits or otherwise as outlined by the above-mentioned standard [10-12].

Table. 2 EMF General Public Exposure Limits According to MS2230-2009 Standard

EMF General Public Exposure Limits	Level
Electric Field	5 kV/m
Magnetic Field	1000 mG (100 µT)

The measurements of magnetic and electric field are conducted under a controlled environment for which Semi-Anechoic Chamber is used. This is to ensure the measurement results are valid and free from background magnetic and electric field exposure. The magnetic and electric field exposure reading are measured using spectrum analyzer at 0.3 meter from the light sources. Figure 1 shows the experimental setup of magnetic and electric fields measurements conducted in the semi-anechoic.

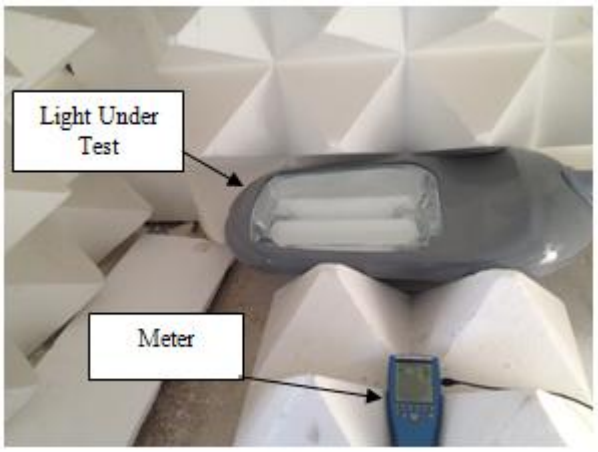

Fig. 1 EMF Measurement Conducted in the Semi-Anechoic Chamber

III. RESULTS AND DISCUSSIONS

Results

Figures 2-10 show the electric field background reading in the Semi - Anechoic Chamber whereas Figures 11-18 illustrate the EMF reading.

Electric Field Measurements

Figure 2 shows the electric field background reading in the Semi - Anechoic Chamber. The background measurement is necessary in acquiring the actual electric field exposure from the light systems. The actual electric field exposure is obtained by subtracting the reading of electric field background exposure from the light exposure. The measurements are then conducted for every light systems as in Table 1. Figures 3 to 5 show the profile sample of electric field exposure obtained from induction light A, B and HPSV measured in the semi - anechoic chamber.

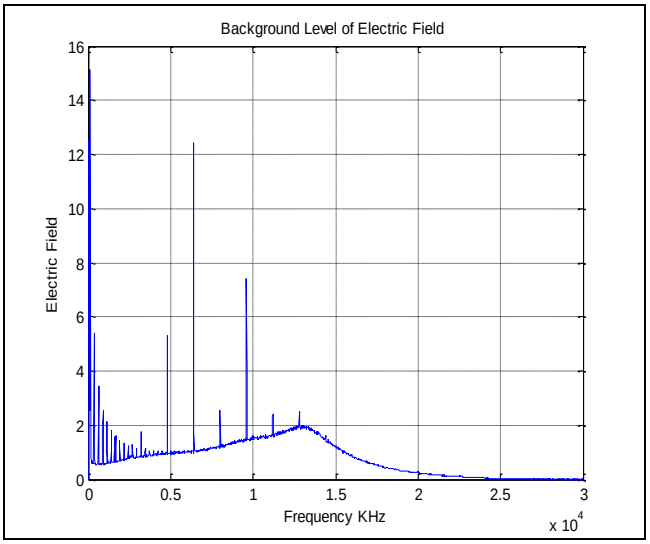

Fig. 2 Electric Field Background Exposure in the Semi - Anechoic Chamber

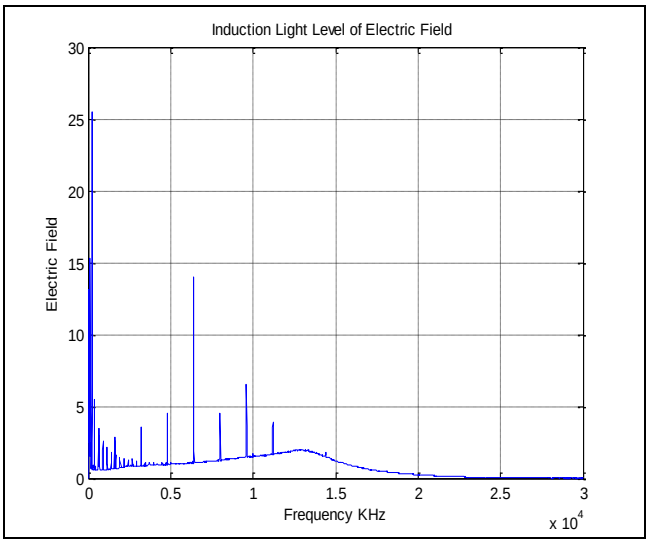

Fig. 3 Electric Field Reading Exposure for Induction Light A for Measurement Conducted in the Semi - Anechoic Chamber

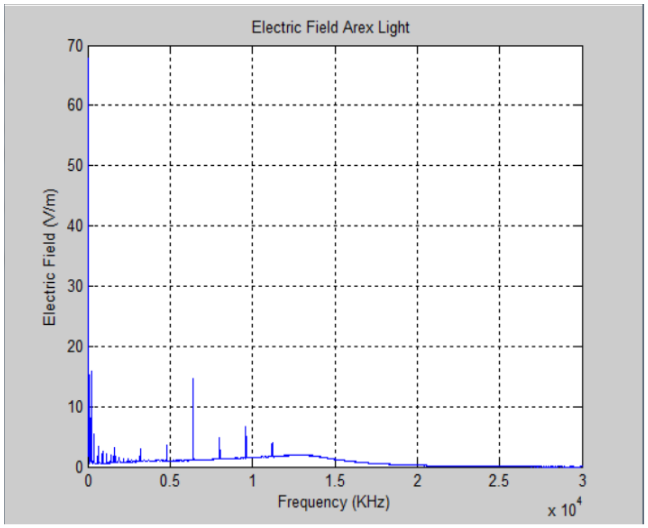

Fig. 4 Electric Field Exposure for Induction Light B for Measurement Conducted in the Semi - Anechoic Chamber

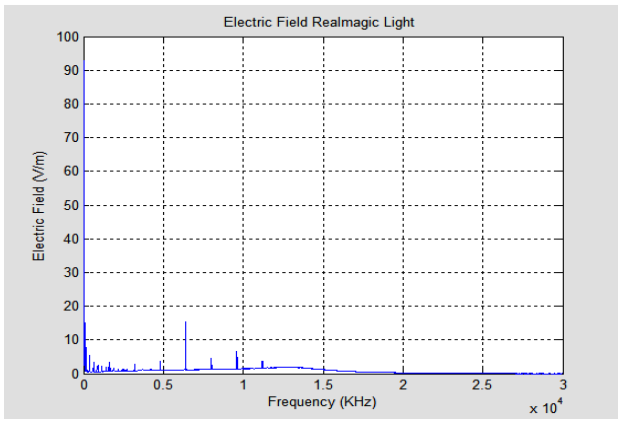

Fig. 5 Electric Field Exposure for HPSV Light for Measurement Conducted in the Semi - Anechoic Chamber

To obtain the net exposure level, the recorded background exposures are subtracted from the recorded exposures for the different lights. Figures 6 to Figure 10 show the net exposure for every induction light A, induction light B, HPSV, LED light A and LED light B. The numerical values of electric field exposure of each lights is summarized in Table 3.

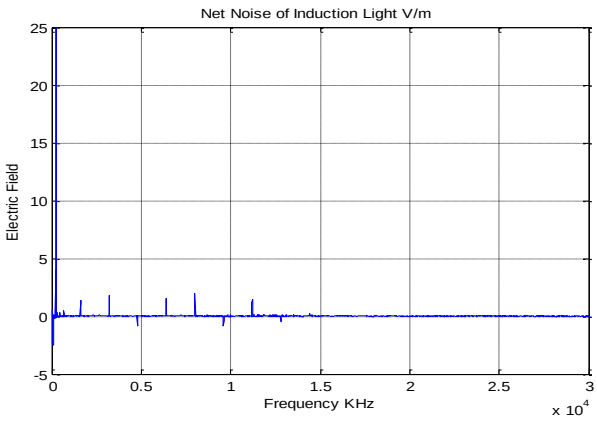

Fig. 6 The Net Electric Field Exposure for the Induction Light A for Measurement Conducted in the Semi - Anechoic Chamber

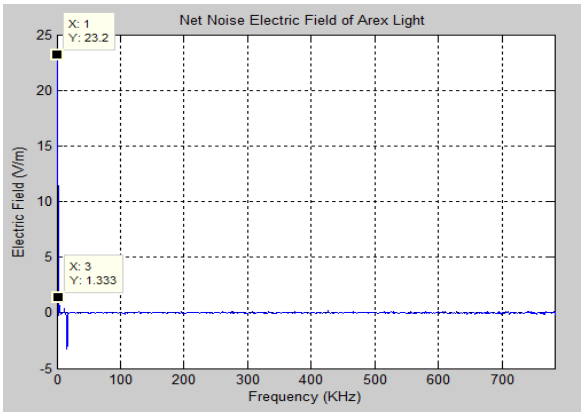

Fig. 7 The Net Electric Field Exposure for Induction Light B for Measurement Conducted in the Semi - Anechoic Chamber

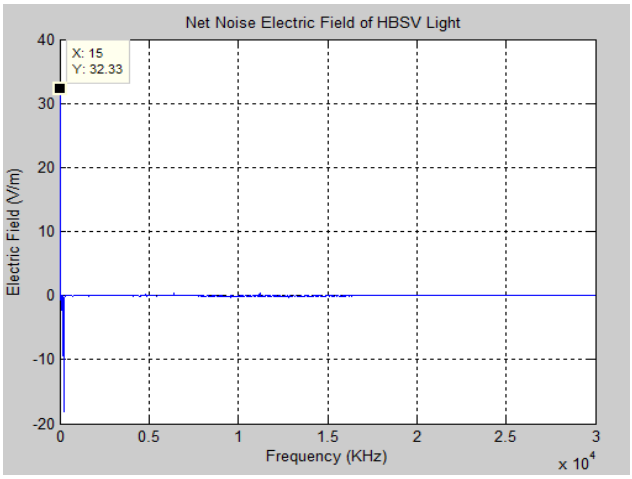

Fig. 8 The Net Electric Field Exposure for the HPSV Light for Measurement Conducted in the Semi - Anechoic Chamber

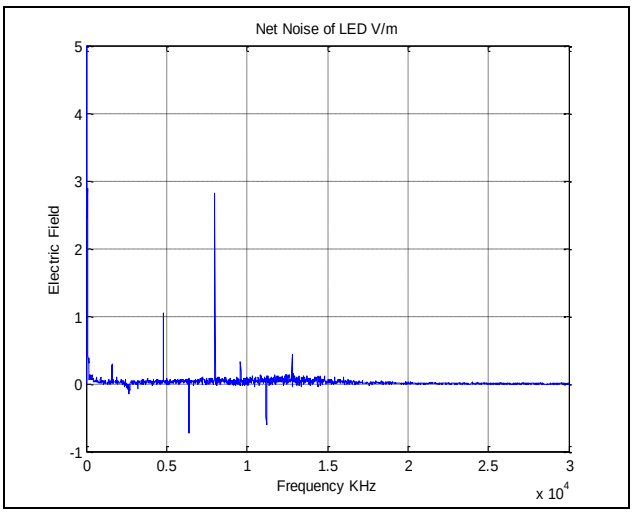

Fig. 9 The Net Electric Field Exposure for LED Light A for Measurement Conducted in the Semi - Anechoic Chamber

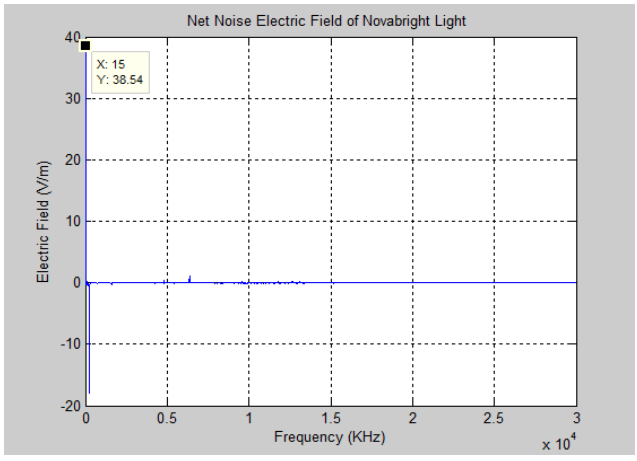

Fig. 10 The Net Electric Field Exposure for LED Light B for Measurement Conducted in the Semi - Anechoic Chamber

Magnetic Field Measurements

Magnetic field exposure measurements are performed using the same procedure as electric field measurements. The measured magnetic fields are also taken at a distance of 0.3m away from all sources. Figure 11 shows magnetic field background reading taken in the Semi- Anechoic Chamber while Figures 12 and 13 are samples of net magnetic field exposure results for LED and inductive lights.

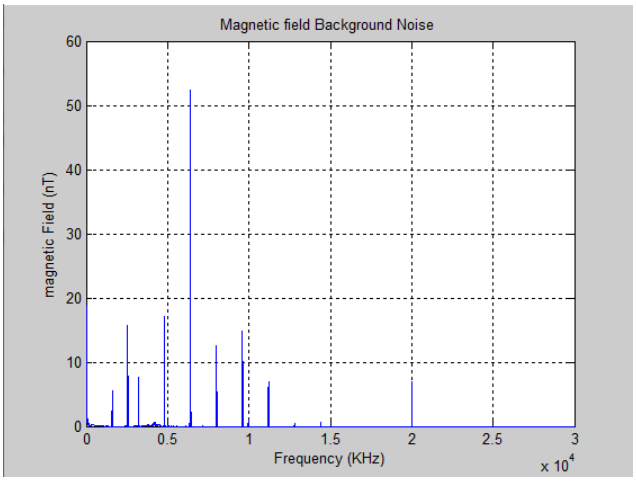

Fig. 11 Magnetic Field Background Exposure in the Semi - Anechoic Chamber

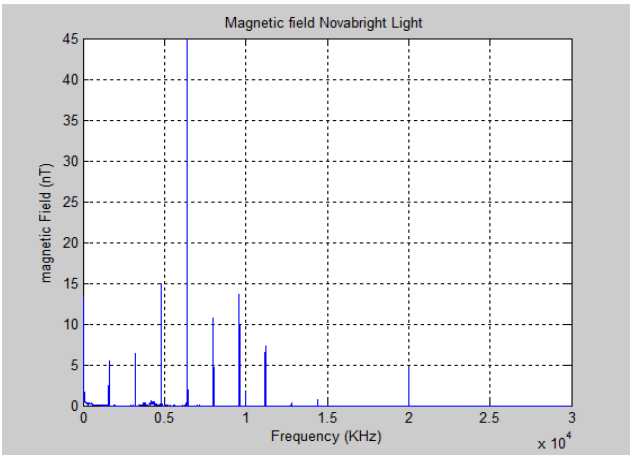

Fig. 12 Magnetic Field Exposure for LED Light A for Measurement Conducted in the Semi - Anechoic Chamber

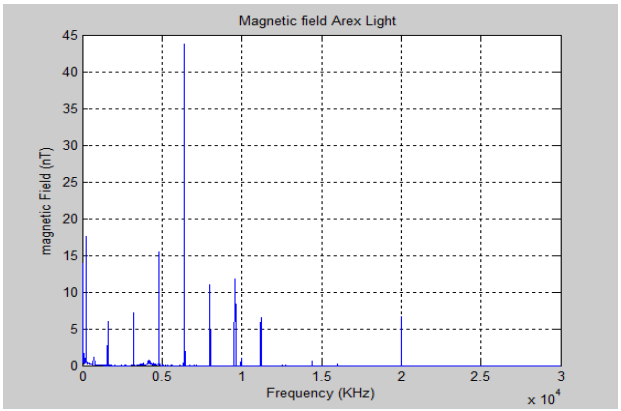

Fig. 13 Magnetic Field Exposure for Induction Light B for Measurement Conducted in the Semi - Anechoic Chamber

To obtain the net exposure level, the recorded background exposures are subtracted from the recorded exposures for the different lights. Figures 14 to 18 show the samples of net exposure of EMF for HPSV, LED light A, LED light B induction light A, induction light B.

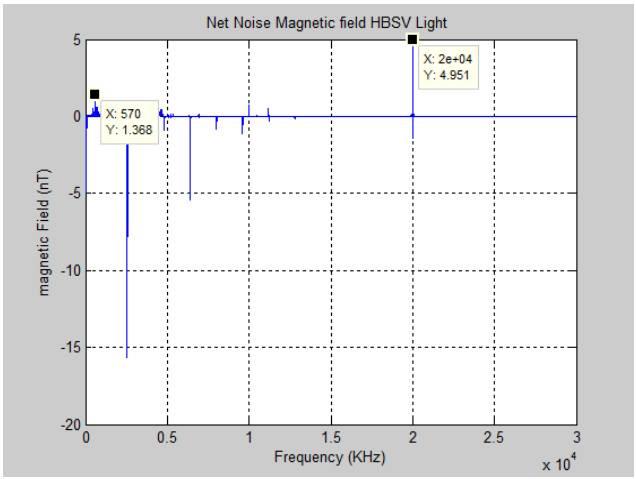

Fig. 14 Net Magnetic Field Exposure for HPSV Light for measurement Conducted in the Semi - Anechoic Chamber

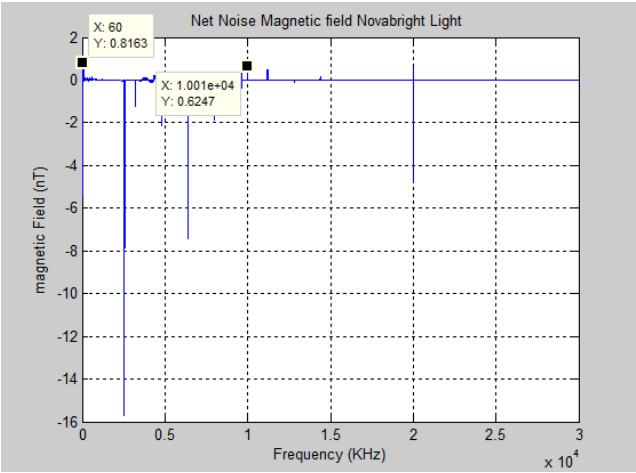

Fig. 15 Net Magnetic Field Exposure for LED Light A for Measurement Conducted in the Semi - Anechoic Chamber

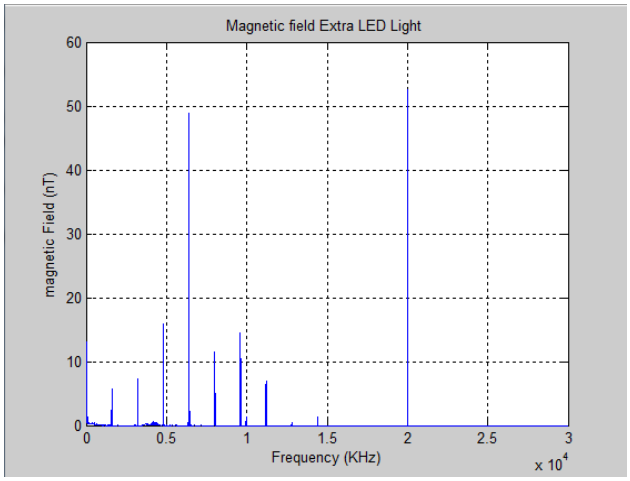

Fig. 16 Magnetic Field Exposure for LED Light B for Measurement conducted in the Semi - Anechoic Chamber

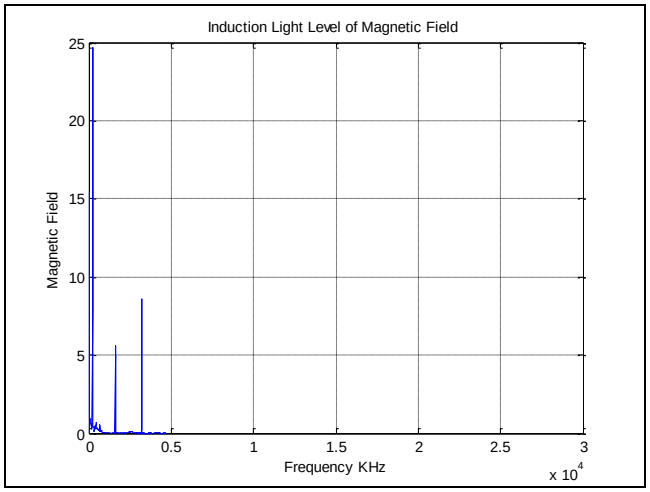

Fig. 17 Net Magnetic Field Exposure Induction Light A for Measurement Conducted in the Semi - Anechoic Chamber

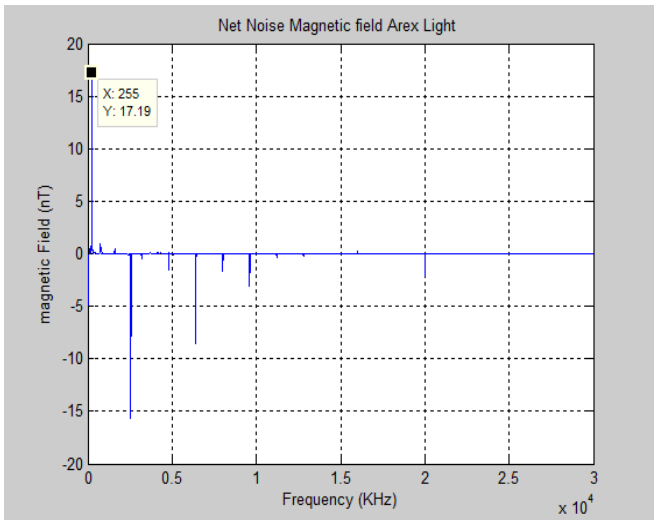

Fig. 18 Net Magnetic Field Exposure for Induction Light B for Measurement Conducted in the Semi - Anechoic Chamber

Table. 3 The Net Exposure Levels Emitted for Different Types of Street Lights in Semi-Anechoic Chamber

No.	Type	Exposure Measurements (Maximum peak)	
		Electric Field	Magnetic Field
1.	HPSV	32.33V/m at 15kHz	4.951nT at 2 MHz
2.	LED A	2.90 V/m at 15kHz	13.17nT 3MHz
3.	LED B	38.54V/m at 15kHz	0.8163nT at 60kHz
4.	Induction A	24.92 V/m at 225kHz	24.50nT at 300kHz
5.	Induction B	23.2V/m at 1kHz	17.19nT at 255kHz

From Table 3, LED B produces the lowest EMF exposure, followed by HPSV, LED A, Induction B and induction A. While the lowest electric field is produced by LED A, followed by induction B, induction A, HPSV and LED B. However, the EMF and electric exposure from all lights are far below the General Public Exposure Limits as stated in Table 1.

Table 4 summarizes the exposure levels emitted for every types of street lights measured at sites. It is obvious that even the maximum levels of magnetic and electric field exposure are found to be much lower than the recommended value of 1000mG or 100μT and 5kV/m respectively as in the standard.

Table. 4 The Exposure Levels Emitted for Different Types of Street Lights measured at sites

No.	Types	Exposure of magnetic field (mT) – Maximum peak		Exposure of electric field (V/m) – Maximum peak	
		daytime	night	daytime	night
1	Induction A	6	6	8.2	9.4
2	Induction B	10.8	5.8	9.2	8.4
3	HPSV	6.3	6.3	9.1	9.1
4	LED A	6	29.5	9.3	8.6
5	LED B	6	29.5	9.2	8.8

It has been noticed that different street light types will have different field's emission while operating. The level of exposure that has been recorded from all lights shows that the EMF emission are far below than the recommended values which are 1000mG or 100μT and 5kV/m as in the standard for both electromagnetic and electric field exposure. However, it is recommended to estimate the level of the EMF exposures from each brand of the lights in order to predict the emitted field when the device is aged (i.e. after a few years). Electric and magnetic field exposure will be higher when devices are used for long time and many factors will contribute to the increase of emission such as, shielding problems, wiring problems etc. The measurement results obtained from Semi-Anechoic Chamber can be taken as a reference in this study. However, the site measurement results cannot be directly compared with the results obtained from the Semi-Anechoic Chamber as the measurement distance is not a constant. The measurement in Semi-Anechoic Chamber is done at 0.3 meter from the light while at site the distance is about 10 meter from the light. However, EMF exposure results obtained from both measurement methods shows that the EMF exposures from all types of light are far below than the recommended values.

IV. CONCLUSIONS

The levels of exposure that have been recorded from all lights show that the EMF emissions are far below than the recommended values which are 1000mG or 100μT and 5kV/m as in the standard for both electromagnetic and electric field exposure. Based on this fact, it can be concluded that the EMF exposure emitted from all types of street light involved in this measurement are deemed safe for general public exposures. The EMF exposure is low; however, the EMF exposure values recorded in this report can be used in selecting the appropriate street lights.

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