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Characterization of Electromagnetic Compatibility Performance of Trains LED Lighting by Mapping of Radiated Interference Distribution

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In order to characterize electromagnetic compatibility performance of railway LED lightings, knowledge about where interference is derived, how interference is propagated and distributed are needed. Such information is very useful to enhance railway LED lightings, so that they comply with EMC standard requirements. Interference mapping is required to determine the steps needed to minimize the interference generated from the device. This paper focuses on mapping interference which is produced by LED lights for use on train passenger coaches. From the interference map, it is clearly shown that interference of LED light is not only radiated by the LED driver but also propagated on the cables and LED circuit.

Keywords: *electromagnetic interference, interference mapping, train LED lighting*

1. Introduction

Nowadays, light emitting diodes (LEDs) are becoming increasingly popular for use in various applications, such as home lighting, street lighting, vehicle and train. LED lights increase energy saving due to the use of low power[1,2], high efficiency, low maintenance and reduce CO_2 emission[3]. LED is financially viable because payback occurs before ending the lifespan of the LED luminaires themselves[4]. LED lamp application is increasing slightly in the transportation sectors especially on passenger train. Important aspects for the passenger train like low power consumptions and high quality illumination level can be fulfilled by LED lamp.

Even though the LED lamp has a lot of advantages, there are several disadvantages caused by LED lamps mainly electromagnetic noise. Switched-mode driver of LED lamp may introduce fundamental and harmonic frequencies that are emitted through conducted and radiated mechanism[2,5,6,7]. The mechanism causes severe problems in form of electromagnetic interference (EMI) can disturb the operation of electronic devices and systems around them. As a result, performance of LED lamp may not comply with regulation and standards of electromagnetic compatibility (EMC).

CISPR 15 includes LED devices in the scope of this standard for protecting radio services against EM noise[8]. Interference measurement requirements are not only conducted emission but also radiated emission[8–10]. A simple way to determine the noise source of the LED lamp is by mapping the interference. This method is used to identify sources of interference and predict interference type.

2. Experimental Details

Mapping the electromagnetic interference (EMI) field on the LED light was made by measuring and plotting the contour of EMI level around the LED diver before and after integrated into the LED lighting system. LED driver of constant current 30W 0.4A 80V 230V and 4 set of LED strip 2ft 1550lm I-nom 330mA was used in the experiment. The steps of mapping interference are grinding measurement area, measuring the EMI level at each grinding point, frequency selection of EMI with higher level, plotting the contour of EMI level at the selected frequency and overlaying contour on the device image to produce interference map. The EMI level was measured at frequency 5 to 300 MHz using Aaronia near field sniffer probe that is integrated with a spectrum analyzer, preamplifier, and computer as shown in Figure 1.

Interference map was analyzed to know how the interference is propagated. The type of interference that will be likely detected in actual EMC test was also analyzed. EMC testing was carried out in accordance with the standards CISPR 158 to compare the interference map analysis with the actual EMC test result. The performed EMC tests are radiation emission and conducted emission testing. The test methods and the test systems are made in accordance with CISPR 15[8,11] standard terms and conditions.

3. Results and Discussion

The acceptable level of electromagnetic emission is limited by standard so as not to interfere with the performance of surrounding devices. Identifying source and spread of interference generally help to solve electromagnetic compatibility problems. The LED driver is the main source of interference in the LED lighting system. The switching circuit is the main sources of interference of the LED driver. It produces a large pulse, wide-band, and rich harmonics that could be transferred conducted via cable and radiated in the air to a neighbor circuit. The EMI measurement in interference map found that the LED driver used in this experiment was generated high EMI around frequency 6.479 MHz, 10.444 MHz, 21.289 MHz and 40.772 MHz.

Interference maps that have been created based on EMI measurement results have provided information on distribution and propagation of interference. Interference map of the LED driver as shown in Figure 2 indicates that EMI is dominantly transmitted around the LED driver at 40.772 MHz and almost dominantly propagated to input cable (AC line) in frequency 6.479 MHz, 10.444 MHz, and 21.289 MHz. Interference map of the LED lighting system in Figure 3 also showed that EMI also comes out from the LED driver and transmitted surround LED driver. EMI spread out around LED driver and some of them propagated around driver input (AC line) and driver output (LED strip).

EMI at frequency 40.772 MHz is more predominantly transmitted surround the driver as shown in Figure 3. Such emissions are measured as interference in the radiated emission test at frequency 30 MHz to 300 MHz which is required by CISPR 15. Standard requires radiated emissions (interference) to be measured using a receiver that has a quasi-peak detector (QP) and measurements made on vertical (V) and horizontal (H) polarization. The EMI level should not exceed the QP limit in electric field unit (dBuV/m).

Interference propagation at frequencies 21.389 MHz, 10.445 MHz and 6.479 MHz via input cables (Figures 2 and 3) appears in conducted emission measurement as interference at AC power input line LI and also line N. This conducted interferences are detected in the conducted emission test that measured in form electric voltage disturbance (dBuV) at frequency range 9 kHz to 30.MHz which is required by CISPR 15 as showed in Figure 6. The conducted EMI level should not exceed the QP limit measured using a quasi-peak detector and AV limit when EMI measure using an average detector.The conducted EMI problem is usually fixed by filtering with capacitors and inductors. Nevertheless, the interference propagation on these three frequencies is also evident at the driver output to the LED path as shown in Figures 2 and 3. Although the standard only requires conducted emission testing to be performed only on LED lighting input (AC lines), the interference propagation of the LED pathway is also worth noting. It is worth noting because radiated interference problems can be due to antenna-like lines formed by the device's lines or cabling[12,13].

4. Conclusion

In conclusion, mapping interference distribution of trains LED lighting could show that interference from the LED driver is not just radiated from the source but also propagated on the cable and LED circuit. Interference propagating through the input cable leads to conducted interference. Interference is propagating surrounding LED driver and also through the output cable may leads to radiated interference.

Acknowledgments
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Figure Caption

Figure 1. Interference mapping measurement setup
Figure 2. Interference map of LED driver.
Figure 3. Interference map of LED light systems
Figure 4. Radiated emission test result of LED lightning at frequency 30 MHz - 300 MHz
Figure 5. Conducted emission test result of LED lightning at frequency 9 kHz to 30 MHz

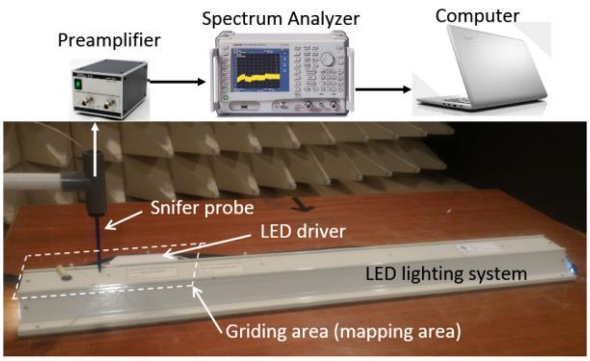

Figure 1. Wibowo et al.

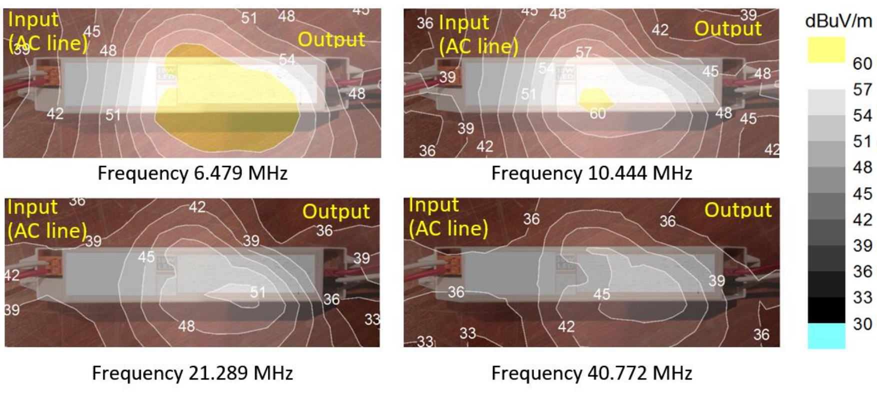

Figure 2. Wibowo et al.

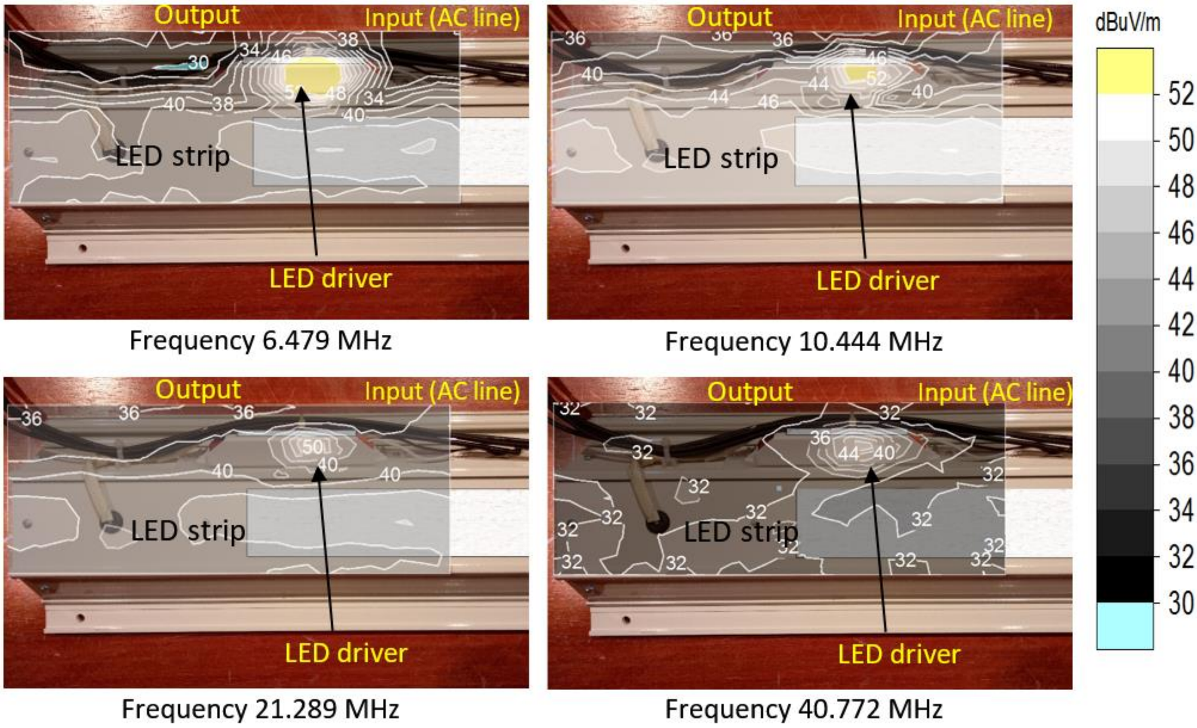

Figure 3. Wibowo et al.

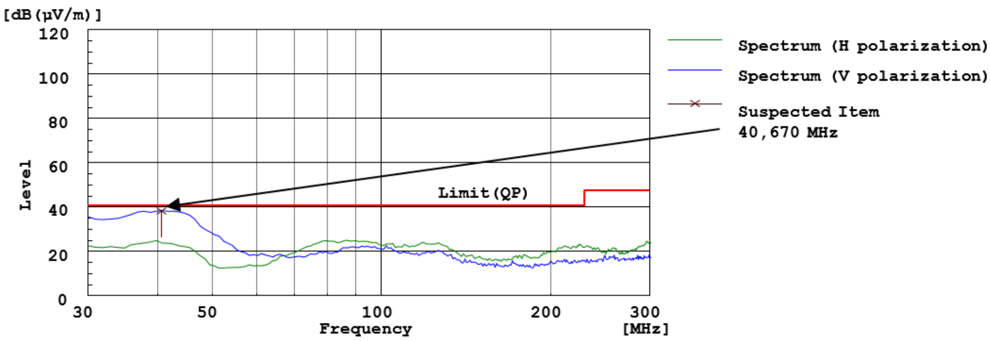

Figure 4. Wibowo et al.

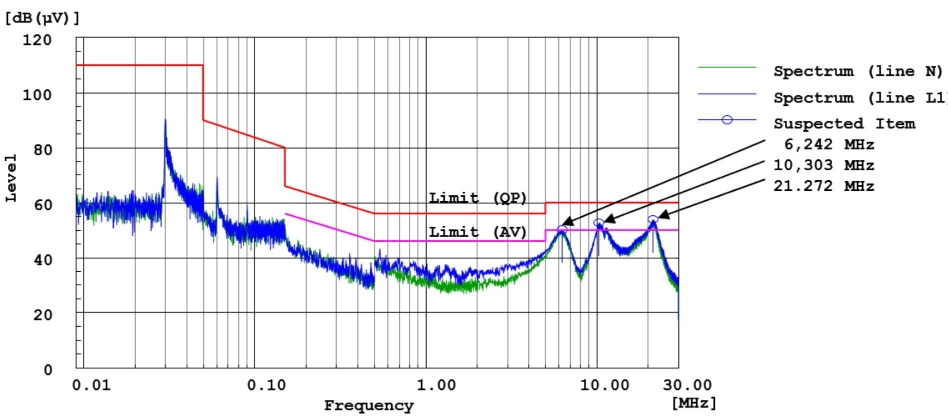

Figure 5. Wibowo et al.