

## INTISARI

SMPS (*switched mode power supply*) banyak digunakan sebagai catu daya rangkaian elektronik, termasuk dalam aplikasi catu daya *light emitting diode* (LED). SMPS selain mempunyai volume yang kecil dan ringan, juga mempunyai efisiensi yang tinggi jika dibandingkan dengan catu daya *linear*. Namun demikian, SMPS memiliki kerugian berupa *electromagnetic interference* (EMI) akibat di dalamnya terdapat *slope dv/dt* dan *di/dt* yang tinggi, yang berpotensi mengganggu perangkat lain. Beberapa solusi digunakan untuk mengurangi permasalahan EMI, diantaranya perancangan konverter, tapis EMI dan teknik *spread spectrum*. Teknik *spread spectrum* merupakan solusi yang murah dan berdaya guna dalam mitigasi EMI. Akan tetapi teknik *spread spectrum* yang telah dikembangkan masih berbasis pendekatan perangkat keras yang mempunyai masalah kompleksitas rancangan dan mempengaruhi kinerja sistem catu daya LED. Selain pemilihan metode mitigasi tersebut, pendekatan melalui prediksi memungkinkan pengembang untuk menghindari biaya dan konsumsi waktu. Berbagai metode prediksi telah dikembangkan akan tetapi masih belum akurat memprediksi *conducted* EMI.

Pada penelitian ini dikembangkan teknik mitigasi *conducted* EMI pada catu daya LED menggunakan teknik *spread spectrum* dan pemodelan *conducted* EMI. Teknik *spread spectrum* diterapkan dengan membangkitkan frekuensi *chaotic* beserta efek yang ditimbulkan berbasis *embedded system* yang diimplementasikan pada *switching* catu daya LED. Pengaruh EMI yang disebabkan oleh *switching* dengan *spread spectrum* tersebut dianalisis terhadap kinerja sistem dan dimodelkan untuk memprediksi *conducted* EMI yang dihasilkan oleh catu daya LED.

Pada penelitian ini dilakukan serangkaian percobaan menggunakan teknik *spread spectrum* periodik dan non periodik pada catu daya LED serta teknik pemodelan *conducted* EMI menggunakan *machine learning* untuk memitigasi EMI sehingga dapat sedekat mungkin mencapai standar yang ditetapkan CISPR 22 Kelas B. Pemodelan *conducted* EMI digunakan untuk memprediksi EMI yang dihasilkan oleh sistem menggunakan *machine learning* dengan menerapkan algoritme *k-NN* yang dapat mempersingkat waktu prediksi.

Kemampuan pengurangan EMI dengan teknik *spread spectrum* jenis non periodik dengan menerapkan sinyal Lorenz mencapai 37 dB. Hasil ini lebih baik jika dibandingkan CPWM melalui pendekatan simulasi, dan pendekatan perangkat keras dengan metode LFSR orde 10 dan PPWM yang menggunakan LFSR. LED *luminance* yang dihasilkan dengan teknik *spread spectrum* ini lebih baik dibandingkan dengan sinyal injeksi periodik sebesar 453 lux. Pemodelan pengujian *conducted emission* pada catu daya LED menggunakan *machine learning* dapat memprediksi spektrum *conducted* EMI yang dihasilkan oleh catu daya LED secara akurat dengan akurasi 91,92%. Hasil ini lebih baik jika dibandingkan dengan metode lain yang hanya mencapai akurasi 85%.

Kata kunci: *conducted*, *chaos*, EMI, *k-NN*, *machine learning*, SMPS, *spread spectrum*

## ABSTRACT

SMPS (switched mode power supply) is widely used as an electronic circuit power supply, including in light emitting diode (LED) applications. The SMPS, besides having a small volume and light, also has a high efficiency reaching 60-90% when it is compared to the linear power supply that only has 20-40% efficiency. However, it has high electromagnetic interference (EMI) due to high slopes of  $dv/dt$  and  $di/dt$  that potentially interfere other devices. Several solutions are used to reduce EMI problems in LED driver, such as converter design, EMI filters, and spread spectrum techniques. Spread spectrum technique is a cheap and efficient solution in the EMI mitigation. However, its techniques that have been developed are still hardware-based approaches that have design complexity issues and affect the performance of LED driver systems. In addition to the selection of EMI mitigation methods on EMI sources, a predictive approach allows developers to avoid cost and time consumption. Various EMI conducted prediction methods have been developed but they still have not been accurate in predicting conducted EMI.

In this research, it has been developed conducted EMI mitigation techniques on the LED power supply using spread spectrum and conducted EMI modeling. The spread spectrum method has been implemented by generating chaos frequency along with software-generated effects that are implemented in LED driver switching. The effect of the EMI caused by switching with the spread spectrum is analyzed for a system performance and modeled to predict the conducted EMI produced by the LM3409 LED driver evaluation board.

This study was carried out by performing a series of experiments on both periodic and nonperiodic spread spectrum techniques on the LED driver evaluation board and conducted EMI modeling techniques using machine learning to reduce EMI peaks so as to be as close as possible to the CISPR 22 Class B standard. Modeling conducted EMI is used to predict the EMI generated by the system using machine learning by applying the k-NN algorithm that can shorten the prediction time.

This study found that the EMI reduction ability with non-period spread spectrum technique by using Lorenz signal reaches 37 dB. This result is better than the simulation approach: chaos-based pulse width modulation (CPWM) and hardware approach: linear feedback shift register (LFSR) method of 10th order and probabilistic PWM (PPWM) using LFSR. LED luminance produced by applying this spread spectrum technique that is better than the periodic injection signal of 453 lux. Modeling of the LED driver conducted emission using machine learning with the k-NN algorithm can predict the conducted EMI spectrum generated by LED driver evaluation board accurately with an accuracy of 91.92%. Thus, this result is better than other methods that only achieve 85% accuracy.

Keywords: *conducted, chaos, EMI, k-NN, machine learning, SMPS, spread spectrum*