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Design OF DIRECT ALTERNATING CURRENT DRIVER SYSTEM FOR DECREASE OF FLICKER INDEX [1]

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Abstract: *This paper presents the process of design and investigation of electronic modules, as well as preparing of lighting specifiers, installers and ways to avoid flickering effects. All new generations of LED industry involve in their production a DACD (Direct Alternating Current Driver) system to decrease a production cost and provide quality products to the market. Inventors are required to achieve this aim. Applying LED lamps direct to the AC networks seems straightforward, but it should be done with care to achieve similar light quality as the conventional lamp that the user is trying to replace. Light flicker is one of the aspects that needs to be considered carefully during LED lamp design to avoid customer complaints about the field. This application note explains the LED lamp flicker phenomena in relation to driver topology and LED characteristics. A practical flicker measurement method is explained as well, that can be used to measure light flicker in LED lamps.*

Keywords: *LED, DACD, light quality, flicker index.*

INTRODUCTION

Today artificiacial lighting is a critical part of modern life. However, traditional methods of lighting such as incandescent lighting is highly inefficient. That is why LED technology is highly efficient and has extremely long life, high luminous efficiency, etc. To provide power to LED loads from AC input, Switch-Mode Power Supplies (SMPS) are generally used, since LEDs need to be driven by regulated current. Direct Alternating Current Drivers (DACD) for LEDs provide a new way to drive the LED load from an AC input with much simpler system architecture while satisfying Electromagnetic interferences (EMI) and power factor (PF) requirements with minimal effort. However, its drawback is flickering of light output at the zero crossing of AC line voltage due to loss of current to the LED load. Light flicker is a common but unwelcome phenomenon in conventional lighting applications (AbdEl-Moniem M., Azazi H., & Mahmoud S., 2014, Seo, K., Jung, J., & Park, J., 2014).

The IEEE Standards Working Group, IEEE PAR1789 “Recommending practices for modulating current in High Brightness LEDs for mitigating health risks to viewers” has been formed to advise the lighting industry, ANSI/NEMA, IEC, EnergyStar and other standards groups

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about the emerging concern of flicker in LED lighting (Wilkins, A., Veitch J., & Lehman, B., 2010).

$$F\% = \frac{Fmax - Fmin}{Fmax + Fmin} * 100\% = \frac{Area1}{Area1 + Area2} \qquad (1)$$

F% - percent flicker; F_{max} - maximum point of Luminous Flux output; F_{min} - minimum point of Luminous Flux output.

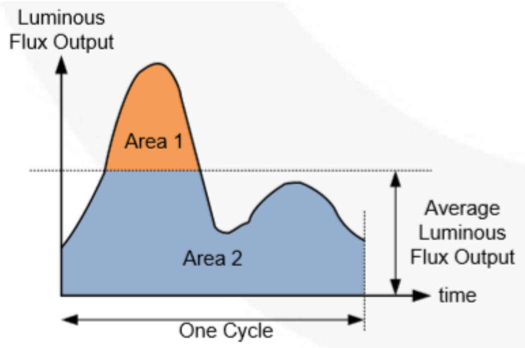

Fig. 1 Definition of Flicker Index

Though flicker is not always obvious, it can still cause headaches for a small percentage of people exposed to flickering lights for long periods (Ning, N., Chen W. B., Yu D. J., Feng C. Y. & C. B. Wang, 2013). This is a major issue for offices, schools, stores and other brightly lit commercial and industrial spaces where people spend a lot of time (Osterhaus, W., Stoffer S., & Erhardtsen I., 2014).

The aim of the paper is to develop a LED module for decrease of flicker index, with thermal tests of LEDs and the lens durability.

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Schematic diagram drawing

The company "TD Electronics" developes new products and improve existing ones in the field of lighting and luminating. The designed module is versatile (universal), as it can be customized for different LED drivers. The R&D department desing the new projects widespread software enviorentmens. The first part of development of a new product starts with schematic drawing (Fig. 1).

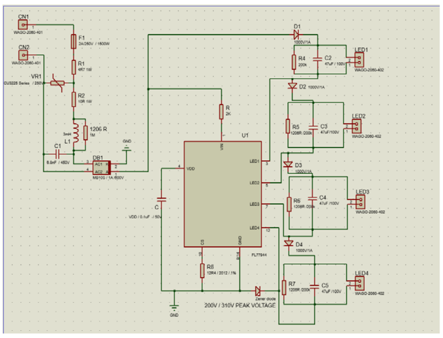

Fig. 1 Schematic diagram of DACD system

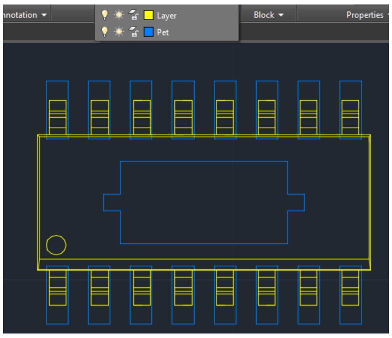

Fig. 2 Footprint of the IC

Fuse is used in the input of the circuit for protection of the device, varistor for a high voltage transient, inductor (with resistor in parallel connection) and capacitor to protect the integrated circuit from voltage spike, and Graetz Bridge to decrease polarity of AC voltage.

The control of the circuit is based on 77944 Integrated circuits (IC), a zener for protection

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from voltage spikes, resistor to ensure stable voltage. On the hand for current is controlled by a resistor, and capacitor connected to Vdd pin for reducing the ripples in the middle part.

The output control is realized by the following components: a diode for ensuring the direction of the capacitor voltage, a resistor for capacitor discharging and parallel to them, and a WAGO connector for serial and parallel combination of LEDs.

Mechanic drawing

Autocad is used for the mechanical realization. In this step the footprint of integrated circuit's pad layer is developed (Fig2). The model is imported in Proteus Isis environment.

PCB Layout

The shape and size are considered by requirements, and realized by SMD. The 3D models are generated.

Design of Prototype

In-House Prototyping technology is used in the company. This type of technology is used for design of prototype of innovative product. This laser machine is used because of producing high-quality PCBs and it gives a decisive advantage such as rapid prototyping, accurate and easy to use software. The advantages are especially evident in the development phase for complex designs. It also can work on separate leyars (top, bottom or both). One of the biggest advantages is to possibility to work with different substrate (Aluminium, Copper). The process operations are:

Mount material; Material settings; Placement; Drill fiducial, marking drills, drilling update; Milling layer; Milling insulation; Contour routing.

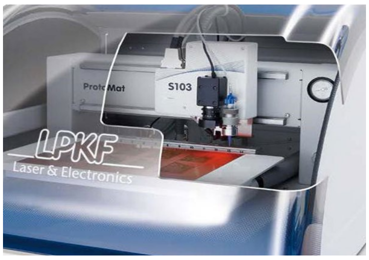

Fig. 5 LPKF machine

Fig. 6 Screen Printer

Fig. 7 Pick and Place Machine

Placement of component

The component placement is accomplished by Heller, Samsung and Snerji technology. Usually, the first prototype is done manually, but in this case the assembly line is used for the production with the following steps:

➢ **Solder Paste Screen Printer**

The Screen Printer (Fig. 6) becomes the SP710 when it is equipped with the optional Automatic Dispense unit (ADu). With one micron solid state linear encoders which is giving accurate results, the ADu can be fitted with any combination of paste and glue module, allowing to cover the module. The Screen Printer is fully equipped, with many features such as automatic rail width adjustment, fully auto stencil loading and a fully programmable Under Stencil Cleaner. The new PCB is entered in the printer, after that everything is getting automatically, size and place of pads are programmed before operation.

➢ **SMT Pick and Place Machine**

As SMT Pick and Place Machine (Fig. 7) that applies two gantries equipped with 10 SPIndles per head, which decreases the time of practical, design the element placement. In addition, it has the advantage like working fast and increases actual productivity and placement quality by applying an electrically driven high speed and high precision feeder. Electrically Driven

SM Feeder is equipped with a function to automatically align the pickup position between feeders to improve the simultaneous pickup rate. It is able to set various part supply speeds to improve the stability of partial supply. According to this technology, the machine guarantees precision placement of components on the ready PCB for the next step. This step improves the speed of the assembly line and leads to increase of the production amount.

Fig. 8 SMT Reflow Oven

Fig. 9 SAKI

Fig. 10 Unloader

- **Heat treatment**

After element placement, PCB is intering in SMT Reflow Oven (Fig. 8). Here all pieces (elements) are soldered to the pads with temperature. I use most efficient heat transfer technology with advance 5 thermocouple PCB profiling for accurately temperature control for soldering the SMT. Rapid response times and precise temperature controls assure process uniformity, regardless of component density or board loading, with identical profile performance in either air or nitrogen.

- **Control of placement**

One of the important parts in PCB design is the control of placement. For this purpose, high quality and accuracy technology for scanning and finding problems is required. SAKI technology for achieving the best results is used (Fig. 9). The tests are accomplished with a superior resolution and scanning line color CCD camera, as the AOI system provides accurate and stable inspection results. Solder fillets on components are getting smaller with increasing the density. For Character Recognition, Polarity, and Solder debug of the PCB after soldering is not required, as accurate placement and soldering are quaranteed.

- **Store place**

The last step is the storage. The Unloader machine is the place that all PCBs are isolated from the environment. The inside part where the boards are stored is completely isolated from the outside one. The production is kept at a certain temperature and humidity.

RESULTS

The PCBs have been tested by Nuve technology for different climatic conditions and stability. They also include artificial aging and storage tests. For each prototype R&D department's tests are necessary. If the product is for serial production, it is in the assembly line for the production and temperature tests are required.

Specialized temperature test room is used for accurate thermal tests of LEDs. The developed PCB has been tested as LED drivers are connected to different radiators, for determination of the influence of temperature to the device. The radiator shapes and sizes are calculated for ensuring working regimes of the developed driver in normal and critical conditions. The tests are fulfilled in technological test climate cabin (Fig. 11). During the test, agilent digital multimeter with K type of thermocouple has been used. Temperature tests for compatibility of LEDs with lens also have been implemented. The lens with optimal dispersion has been selected, as guarantee the stability at this temepature regime. Before the start of the test, some connection of thermocouple has been done. The junction point of the hot end of thermocouple is set (fig. 12). Position 1 is the connection to the LED, and position 2 is the connection to the cooling pad.

Fig. 11 Climate cabin

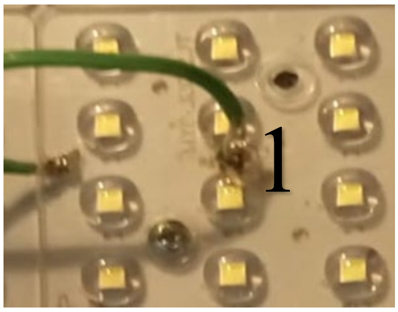

Fig. 12 Thermocouple connections

Fig. 13 Melted Lens

The test started at 09:00 and finished at 12:00 o'clock. The cabin was set to room temperature which was 23oC. The important parameter is the size and location of LEDs in the PCB. They also depend on the sizes of the cooling pads. According to the sizes of the pads the applied warming was different. The temperature results are presented in Table 1.

Table 1. Temperature test of LEDs and PCB

№	Time	Led1	Led2	Led3	PCB
1	09:00	X	X	X	x
2	10:00	86.4 °C	84.7 °C	90.1 °C	73 °C
3	11:00	86.4 °C	84.9 °C	90.5 °C	75 °C
4	12:00	86.5 °C	85.9 °C	91.1 °C	75.2 °C

As important results it can be emphasized that the used lens and LEDs are compatible. Due to the universallity of the PCB, it is possible to select other LED modules and lenses, and repeat the same compatibility test to prevent future issues. If the temperature radiation of LED module is too high for the lens, then using a radiator is a must.

Table 2. Temperature test of Lens

№	Time [s]	Temp [^{o}C]	Condition
1	60	80	OK
2	120	85.50	OK
3	180	91	OK
4	240	97.30	OK
5	300	97.80	OK
6	360	103.90	Mild
7	420	118.60	Melted

CONCLUSION

A new, simple, low cost and high efficiency AC LED driver with decrasing the flickering index, based of the designed new electronic module has been proposed in this paper. The implemented tests are for the behavior of lens and LEDs under different temperature conditions. Measurement results have demonstrated high temperature durability that the lens can gain and also the compatibility of the lens with these LEDs. The LED driver proposed can be flexibly customized to get a higher performance according to the requirement of the lighting systems by choosing the number of the LED string. The simplicity and simple design produces a cost-effective, compact solution for LED lighting applications.

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