GOCE DELCEV UNIVERSITY, SHTIP, NORTH MACEDONIA
FACULTY OF ELECTRICAL ENGINEERING

ETIMA 2021

FIRST INTERNATIONAL CONFERENCE

19-21 OCTOBER, 2021

TECHNICAL SCIENCES APPLIED IN ECONOMY, EDUCATION AND INDUSTRY

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ЕЛЕКТРОТЕХНИЧКИ ФАКУЛТЕТ

UNIVERSITY „GOCE DELCHEV” - SHTIP
FACULTY OF ELECTRICAL ENGINEERING

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PREFACE

The Faculty of Electrical Engineering at University Goce Delcev (UGD), has organized the International Conference ***Electrical Engineering, Informatics, Machinery and Automation - Technical Sciences applied in Economy, Education and Industry-ETIMA.***
ETIMA has a goal to gather the scientists, professors, experts and professionals from the field of technical sciences in one place as a forum for exchange of ideas, to strengthen the multidisciplinary research and cooperation and to promote the achievements of technology and its impact on every aspect of living. We hope that this conference will continue to be a venue for presenting the latest research results and developments on the field of technology.
Conference ETIMA was held as online conference where contributed more than sixty colleagues, from six different countries with forty papers.
We would like to express our gratitude to all the colleagues, who contributed to the success of ETIMA'21 by presenting the results of their current research activities and by launching the new ideas through many fruitful discussions.
We invite you and your colleagues also to attend ETIMA Conference in the future. One should believe that next time we will have opportunity to meet each other and exchange ideas, scientific knowledge and useful information in direct contact, as well as to enjoy the social events together.

The Organizing Committee of the Conference

ПРЕДГОВОР

Меѓународната конференција ***Електротехника, Технологија, Информатика, Машинство и Автоматика-технички науки во служба на економија, образование и индустрија-ЕТИМА*** е организирана од страна на Електротехничкиот факултет при Универзитетот Гоце Делчев.
ЕТИМА има за цел да ги собере на едно место научниците, професорите, експертите и професионалците од полето на техничките науки и да претставува форум за размена на идеи, да го зајканува мултидисциплинарното истражување и соработка и да ги промовира технолошките достигнувања и нивното влијание врз секој аспект од живеењето. Се надеваме дека оваа конференција ќе продолжи да биде настан на кој ќе се презентираат најновите резултати од истражувањата и развојот на полето на технологијата.
Конференцијата ЕТИМА се одржа online и на неа дадоа свој допринос повеќе од шеесет автори од шест различни земји со четириесет труда.
Сакаме да ја искажеме нашата благодарност до сите колеги кои допринесоа за успехот на ЕТИМА'21 со презентирање на резултати од нивните тековни истражувања и со лансирање на нови идеи преку многу плодни дискусии.

Ве покануваме Вие и Вашите колеги да земете учество на ЕТИМА и во иднина. Веруваме дека следниот пат ќе имаме можност да се сретнеме, да размениме идеи, знаење и корисни информации во директен контакт, но исто така да уживаме заедно и во друштвените настани.

Организационен одбор на конференцијата

Содржина / Table of Contents

Прва меѓународна конференција ЕТИМА
First International Conference ETIMA

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INFLUENCE DIMING OF LED LAMPS TO ELECTRICAL PARAMETERS

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Abstract
Lighting systems are currently one of the main uses of electricity. The most popular option for reducing of electricity consumption is the use of dimming. Dimming is a type of regulation in which we can regulate luminous flux of a lamps and luminaires. This system of regulation is used in the road lighting industry, but also in households. Dimming allows adaptation of the lighting system according to specific requirements and various ambient conditions such as traffic density, daylight, etc. The regulation of the luminous flux de-pending on the dimming system can affect the electrical parameters of the luminaires such as the power factor. The article deals with the electrical parameters of luminaires with various lamps at different types of dimming.

Key words
LED, Power factor, total harmonic distortion

Introduction

In recent years LED luminaires play a decisive role in the field of lighting systems. Among their most important benefits are luminous efficiency, various correlated color temperature, color rendering index and energy efficiency that leads to energy savings. LED luminaire consists of a main body, light sources, power supply (LED driver) and an optical distribution system. LED driver is a non-linear load. Designing the LED drivers is a challenging task where many problems need to be solved. The most frequently solved problems are currently harmonics reduction and power factor correction (PFC). Power supplies without power factor correction generated and reflected back to the AC power lines many unwanted harmonic currents which degrade the power quality.
The presence of harmonics in power system can cause various problems such as reducing the power factor and so on [1].

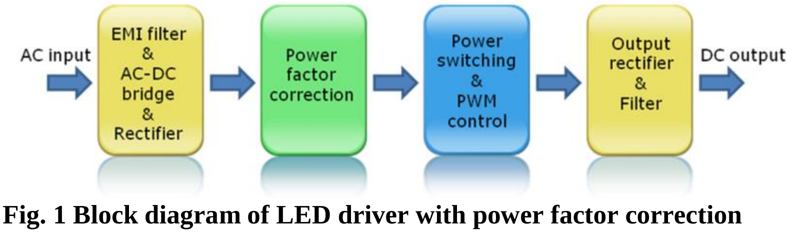

Fig. 1 Block diagram of LED driver with power factor correction

Power factor is simply defined as the ratio of real power to apparent power:

$$PF = \frac{P[W]}{S[VA]}$$

If both current and voltage are sinusoidal and in phase the power factor is 1. If both current and voltage are sinusoidal but not in phase, the power factor is the cosine of the phase angle.

$$THD_i[\%] = 100 \times \sqrt{\sum_{p=2}^{\infty} \frac{{I_p}^2}{{I_1}^2}}$$

1. Literature review

Total harmonic distortion is quadratic sum of the unwanted harmonics over the fundamental that gives the relative weight of the harmonic content with respect to the fundamental. [2] Electrical equipment in Europe must comply with the EN 61000-3-2 "Electromagnetic compatibility (EMC). Part 3-2: Limits. Limits for harmonic current emissions (equipment input current up to and including 16 A per phase)". [3] There are 4 different classes (A,B,C,D) in the EN 61000-3-2 that have different limit values. It should be taken into consideration that these limits are for individual harmonics (from 2 to 40) and do not specify total harmonic distortion (THD). Class A are Balanced 3-phase equipment, household appliances excluding equipment identified as class D, tools, excluding portable tools, dimmers for incandescent lamps, audio equipment, and all other equipment, except that stated in one of the following classes. Class B are Portable tools, arc welding equipment which is not professional equipment Class C are Lighting equipment. (Table I.) Class D are PC, PC monitors, radio, or TV receivers. Input power P ≤ 600 W. [4] If a power supply output power is grated than 25W, it must meet class C. Otherwise it can be test withed the class D standard. To pass Class C and Class D, power supply must have power factor correction.[5]

Table 1 Harmonic current limits for LED driver > 25W

Harmonic order n	Maximum permissible harmonic current expressed as a percentage of the input current at the fundamental frequency %
2	2
3	30.λ *
5	10
7	7
9	5
11 ≤ n ≤ 39	3
	* λ is the circuit power factor

2. Power factor correction

When choosing a PFC it is important to recognize that the low power factor that occurs in LED drivers is different from the power factor of traditional load. Low power factor of traditional load requires a different correction approach. This type of low power factor can be easily corrected by adding the reactive component of the opposite sign in parallel with the load. Low power factor of LED drivers is caused by nonlinear circuit elements. Low Power Factors can be improved by PFC circuits. We know the two basic types active and passive PFC.
Active PFC is more efficient, a little more expensive, generally integrated into a power supply, and can achieve a PF of about 0.98 or higher. Passive PFC is less expensive and usually corrects PF to lower values.

2. Measurement of electrical parameters
For the measurement were selected three luminaires with different drivers and powers.

Table 2 Electrical parameters of luminaire with driver 1

Driver 1					
Dimm [%]	**S [VA]**	**P [W]**	**Q [Var]**	**PF [-]**	**THDi [%]**
10					
20	6,32	1,60	6,12	0,250	16,56
30	7,40	2,43	6,98	0,328	21,06
40	7,99	3,14	7,35	0,390	21,57
50	8,55	3,91	7,61	0,456	18,49
60	8,95	4,58	7,68	0,513	15,86
70	9,46	5,52	7,67	0,584	13,91
80	9,85	6,43	7,59	0,654	12,15
90	10,56	7,25	7,43	0,693	10,81
100	10,90	8,04	7,35	0,737	10,09

Table 3 Electrical parameters of luminaire with driver 2

Driver 2					
Dimm [%]	**S [VA]**	**P [W]**	**Q [Var]**	**PF [-]**	**THDi [%]**
10	11,14	3,05	10,70	0,271	15,42
20	12,21	5,94	10,67	0,483	16,27
30	15,14	8,95	12,31	0,597	17,53
40	15,14	11,10	10,23	0,734	10,70
50	17,25	14,11	9,92	0,817	9,73
60	20,69	18,20	9,77	0,881	8,68
70	23,12	21,09	9,46	0,907	8,12
80	25,57	23,79	9,34	0,930	7,55
90	28,42	26,86	9,15	0,944	7,31
100	31,07	29,76	8,94	0,957	7,11

Table 4 Electrical parameters of luminaire with driver 3

Svietidlo 3					
Dimm [%]	**S [VA]**	**P [W]**	**Q [Var]**	**PF [-]**	**THDi [%]**
10	23,98	9,88	21,76	0,413	86,70
20	41,15	18,63	36,64	0,453	87,65
30	32,85	30,14	13,06	0,917	24,35
40	41,06	38,82	13,47	0,945	21,35
50	49,86	47,82	13,91	0,960	18,44
60	59,56	57,80	14,37	0,970	15,86
70	68,86	67,22	14,83	0,977	13,86
80	78,70	77,14	15,59	0,980	12,77
90	89,44	87,92	16,42	0,983	11,75
100	98,69	97,19	17,10	0,985	10,98

Luminaire 1 has a driver 1 with rated power 18W with range of load 3 - 18 W. Luminaire 2 has a driver 2 with rated power 35W with range of load 15 - 35 W. Both have been controlling by DALI. Luminaire 3 has a driver 3 with rated power 100W. It has been controlling by 1~10Vdc, 10V PWM, resistance and contain built-in active power factor correction function. Drivers 1 and 2 have a declared power factor of 0.95 and Driver 3 has declared power factor > 0.96 at rated power. The load of the drivers 1 (44% of rated power) and 2 (85% of rated power) is lower than rated power of drivers which are used in the selected luminaires. The load of the driver 3 is approximately equal to the rated power (97% of rated power). Electrical parameters were measured during dimming in the range of 10 - 100% of luminous flux for all luminaires. During the measurement were luminaires supplied from a stabilized AC power supply with nominal voltage 230 V. At each level of dimming were the samples stabilized for 15 minutes. Measurement of electrical parameters was performed using the precision meter for electrical power and energy measurement Applied Precision reference standard rs 2330A. The measured values of active, apparent, reactive power, power factor and total harmonic distortion of current during the dimming are shown in the tables 2 - 4. A comparison of the individual measured parameters for the selected ballasts is shown in the figures 2 - 6.

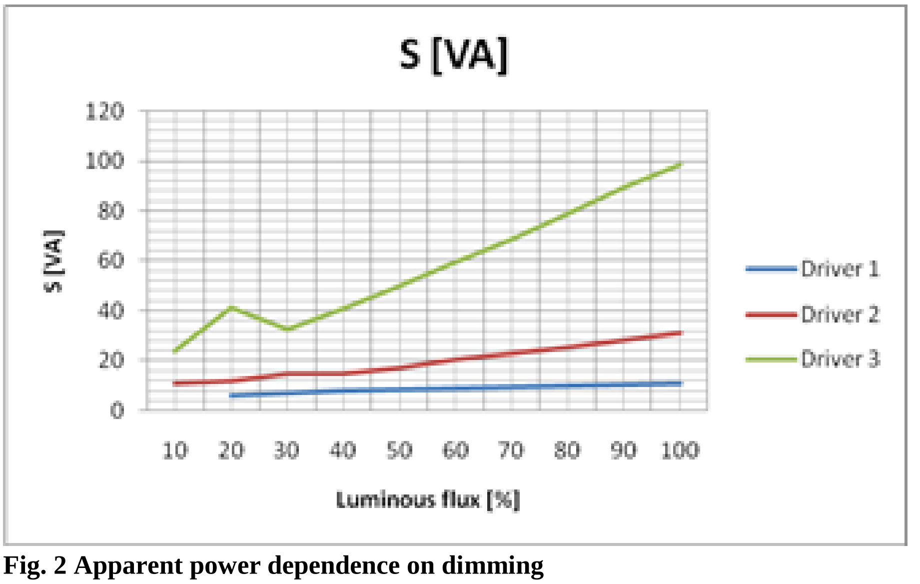

Fig. 2 Apparent power dependence on dimming

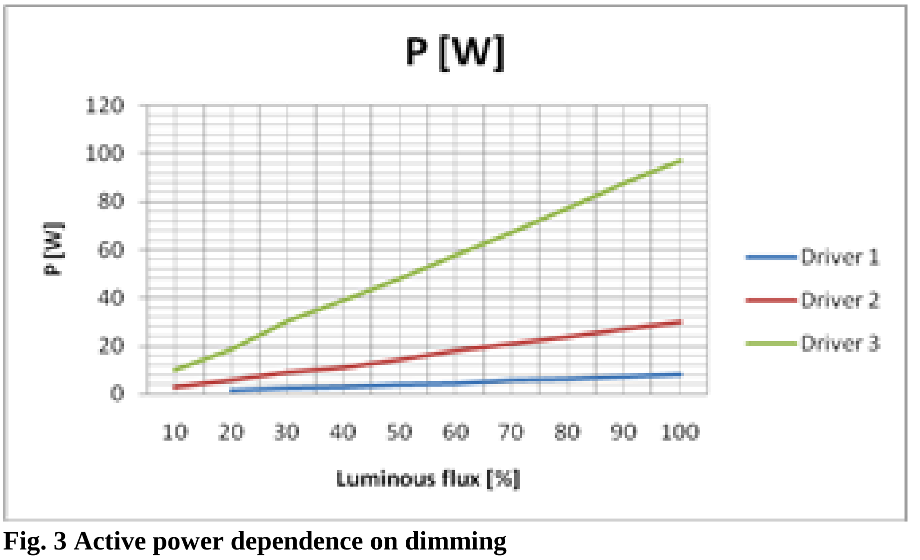

Fig. 3 Active power dependence on dimming

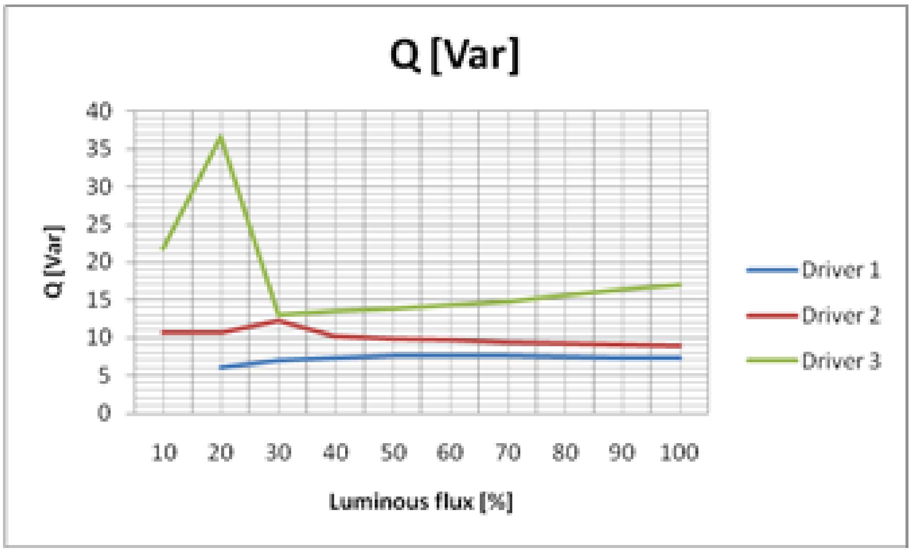

Fig. 4 Reactive power dependence on dimming

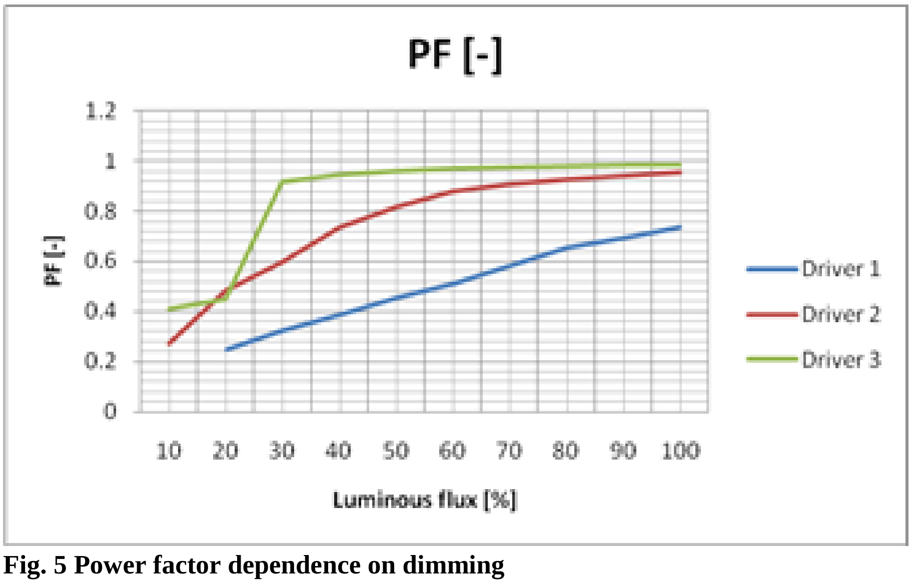

Fig. 5 Power factor dependence on dimming

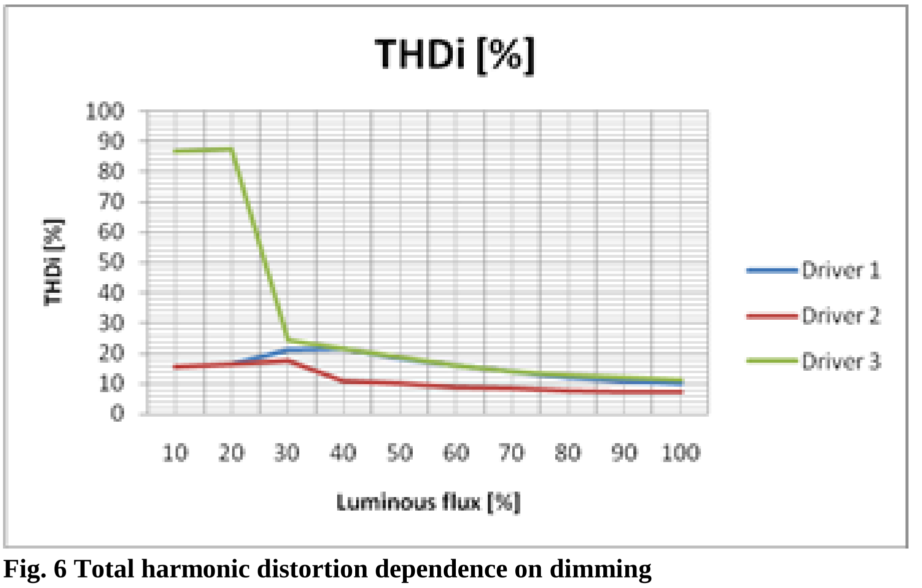

Fig. 6 Total harmonic distortion dependence on dimming

Driver 1 has a declared power factor of 0.95 at rated power. The load of the drivers 1 was 44% of rated power. This caused that at 100% (8.04W) was the maximum power factor 0.737. Driver

1 was dimmed in the range of 20 - 100%, because less power than 1.6 watts could not be set. Driver 2 has also declared power factor of 0.95 at rated power. The load of the drivers 2 was 85% of rated power. At 90% dimming (26.86 watts) was the power factor 0.944 which is less than declared 0,95. Driver 3 has declared power factor > 0.96 at rated power. The load of the drivers 3 was 97% of rated power. Measured values show that the use of dimmable drivers with power factor correction is better because it can correct power factor values better than 0.95 in the range 50 - 100% of dimming.

Conclusions

Dimming allows control of the lighting system according to specific requirements and various ambient conditions. Dimming allows to reduce the power consumption of public lighting systems at nighttime when there is a low traffic also allows the control of interior lighting systems in dependence on the availability of daylight. During dimming are electrical parameters that can affect the power quality and the electromagnetic interference changing. One of the parameters that change significantly is the power factor. In Slovakia is power factor evaluated monthly for electricity consumers. It assesses the amount of active and reactive electricity taken off. If the users or company does not comply with its tolerance values of 0.95 to 1 than the special mark-ups on the invoice apply. Lighting systems with regard to the operating time of the dimming and the used luminaires may significantly affect the value of the power factor. The solution of this problem is compensating devices which by their activity maintain the optimal values of the power factor.

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