15th International Research/Expert Conference
"Trends in the Development of Machinery and Associated Technology"
TMT 2011, Prague, Czech Republic, 12-18 September 2011

INFLUENCE OF CONTINUAL REGULATION OF LIGHT FLUX IN PUBLIC LIGHTING ON ELECTRIC ENERGY QUALITY

MA Dragan V. Brajovic , Technical College of applied studies,Cacak,Serbia
PhD Dojcilo D. Sretenovic , Technical College of applied studies,Cacak,Serbia

ABSTRACT
In this paper the problem of telemanagement (remote control and administration) is considered regarding the public lighting system with emphasis on the continual regulation of the luminous flux. All the benefits regarding the control and administration systems for public lighting are presented with usage of the modern (up-to-date) light sources. Special emphasis is put on the influence of the above mentioned system on the electrical energy quality in the areas close to the implemented system. As a consequence of the nonlinearity, problems are defined in terms of low power factor and higher voltage and current harmonics. Possible solutions are given in order to prevent the negative influence (effects) on the feeder power networks from the aspect of the electrical energy quality and possible savings regarding the electrical energy consumption.
Key words: telemenagment,light flux,continual regulation,electric energy quality.

1. INTRODUCTION

Telemanagement is a solution that enables (introduces) remote diagnostics with possibility of control (powering up and powering down) of the luminaires as well as regulation of their luminous flux (dimming). This is the only system that enables the two-way (duplex) communication, meaning that it has the possibility of sending the command impulses and also the possibility of receiving the information of the current status of the luminaires, light sources, as well as the confirmation that the command is executed. In this way, using planned dimming (lowering the power of the light sources, and therefore the luminous flux) electrical energy is saved during the late night hours when the traffic frequency is not that high or when the need for saving arises. The second great benefit of this system are the lower maintenance bills, exact information about the defective luminaire with all the data refering to that exact luminaire.
Higher demands that are put on the quality of illumination of the highways (motor-ways), junctions, streets as well as demands on the higher financial savings, are increasing the need for implementing of the remote and administration system on a daily basis.

2. ARCHITECTURE OF THE TELEMANAGEMENT SYSTEM

The most common telemanagement system consists of the three main elements:
• OLC (Outdoor Lamp Controller)
• SC (Segment Controller)
• MS (Management Software)
Telemanagement system in public lighting is designed as a network system with couple of control levels. The very nucleus of the system is the server, which is located in the control center, and is connected to one or more PCs (computers) that are used for system administration. It is possible to access the user interface using the mobile phone via the GPRS connection and the corresponding IP address, as well as using the internet to access the corresponding Web page and registering (WAN or LAN address). Server has (possesses) the applicative software that controls the whole system, gathers, analyses and processes the data. From this center it is possible to simultaneously control several

systems of the public lighting using the segment controllers that are usually located inside the feeder cubicles.
The communication of the server, i.e. the connection between the control center and the segment controllers in feeder cubicles is a two-way (duplex) communication and is performed over the TCP/IP protocols (GPS, GPRS, Edge, 3G, DSL (ADSL) technologies as well as the existing LAN connections). The segment controller is responsible for communication between the server on one side and the controller of the luminaires on the other side. The connection between the segment controller and the controller of the source (source controller) is also established using low voltage feeder network (PLC LonWorks) or telecommunication wireless network (Wireless Zigbee). This connection defines the two most known systems of telemanagement (systems for signal transfer) – using the power line (PLC communication) or wirelessly using an antenna (wireless communication in exact frequency range). Source controllers are placed on the lower level of the hierarchy than the segment controllers. Their shape is defined by the need to be put inside the luminaire. Also they could frequently be placed in the basis of a pillar when there is a special need for protection agains moistuire (in this case they are frequently called pillar controllers).
There are three main techniques that are used for control and supervision of the public lighting.

• **P**ower **L**ine **C**ommunication
• Radio frequency (radio waves or wireless frequencies (about 2.4GHz))
• Independent (separate) command line.

3. INFLUENCE OF THE LUMINOUS FLUX REGULATION SYSTEM ON THE PARAMETERS OF THE ELECTRICAL ENERGY QUALITY

Measurements were taken out on the installation of the public lighting where the Philips Starsense system is used for continual regulation of the luminous flux.
The installation of the public lighting (where the masurements were taken out) consists of 8 luminaires of the type “Selenium SGP 340“ (Philips) with electronic ballasts and sources of light type NAVP 150 W (SON-T) that illuminate the foot-path (walking trail). Each luminaire possesses the independent controller (OLC) type LLC7020/00 (Philips) for the communication with the segment controller. Segment controller (SC) type LFC7065 (Philips) is mounted in the feeder cubicle and is connected to one phase of the two-phase feeder system for the luminaires.
The aim of the measurements is to recognize all the problems that Starsense system causes to its surrounding electrical environment in different working regimes that are programmed using the Starsense software. The measurements were accomplished by using the network analyser type CIRCUTOR AR5, and the measured values are: The voltage, current, active power, reactive power, power factor, energy, frequency, higher harmonics of voltage and current. (THDU and THDI). Regimes of the changing of the luminous flux are programmed using Philips Starsense software.
The following measurement results are derived (Phase L2 is not loaded (I_{L2}=0,00 A)):

Voltage:

In accordance to the HDU diagram, it can be concluded that the 5th harmonic is dominant, and it lies betweend the allowed limits (less than 6 % for the low voltage according to the standard EN 50160L and less than 3 % according to the IEEE-519 limit).
Based on the THDU diagram it can be concluded that it is placed between the allowed limits (less than 8 % for the class 2 of the electromagnetic environment – busbar (PCC) to the public network according to the standard IEC 6100-2-4 and less than 5 % according to the IEEE-519 limit).

Current:

Based on the HDI diagram it can be concluded that the dominant harmonic is 3rd, but inside the allowed limits (less than 7% according to the IEEE-519 limit).
In accordance to the THDI diagram it can be concluded that it is placed outside of the allowed limits (higher than 8 % according to the IEEE-519 limit).
The illustration of the results of measurements is given per one loaded phase L1:

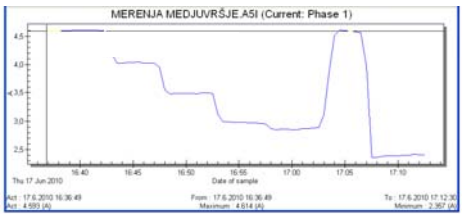


Figure 1. The current of the phase L1

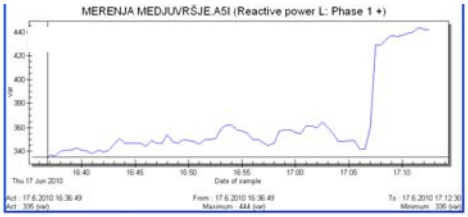


Figure 2. The reactive power of the phase L1

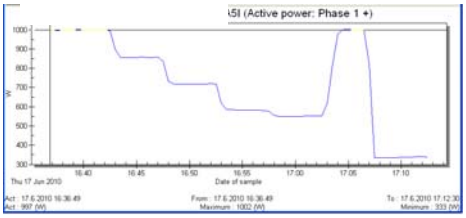


Figure 3. The active power of the phase L1

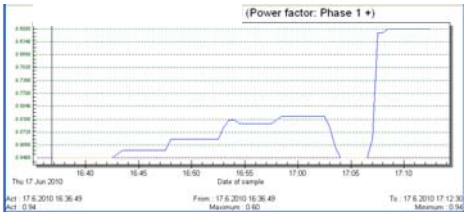


Figure 4. The power factor of the phase L1

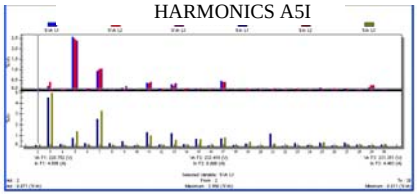


Figure 5. HDU,HDI

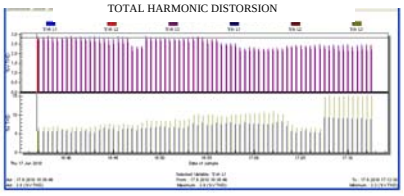
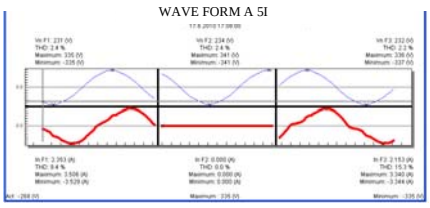


Figure 6. THDU,THDI



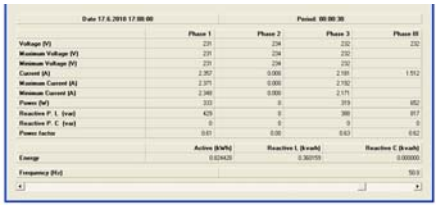


Figure 7. Waveform of the voltage and current for the maximal values of THD and illustration of the results of the measurement.

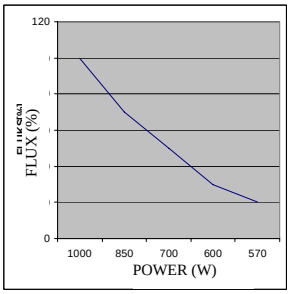


Figure 8. Dependence between the flux and the power of the source of light.

4. CONCLUSION

Based on the presented analysis of the system and taken measurements, conclusions can be made that alongside of all the benefits that come from the telemanagement system, which are based on remote control and supervision of the public lighting as well as on the savings of the electrical energy, there is a negative impact on the parameters of the electrical energy quality that cannot be neglected. Those parameters of the electrical energy quality are significant particularly for the bigger systems. If the higher harmonics of the currents in a neutral line, that have a great impact on increase of the losses in transmission lines, are also taken into account the problem becomes more significant. During the design of the telemanagement systems it is necessary to recognise the possible problems, as well as the ways of their solution through the function of the correction of the power factor, reduction of the harmonic distorsions and also the reduction of loss in the transmission lines.

5.REFERENCES

[1] Kostic M.: Osvetljenje puteva, Minel – Schreder, Beograd, 2006.
[2] Djuretic A.: Telemenadzment - pregled sistema za daljinsko upravljanje i nadzor u javnom osvetljenju, Osvetljenje, 2009.
[3] Philips: Starsense Telemanagement made Easy, 2009
[4] Philips: Chronsense and Dynadimmer – The Philips Stand-alone Dimming Solutions, 2009
[5] Schreder: Telemonitoring – technical white paper, 2008
[6] Kostic M., Jecmenica M.: Sistemi za pojedinacnu kontinualnu regulaciju svetlosnog fluksa u javnom osvetljenju, ETF, Beograd, 2009.