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Realization of automated system of monitoring and testing of gas-discharge lamps using statistical analysis of time series

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Abstract. Gas discharge lamps, including fluorescent lamps, represent a key element of modern lighting system, providing high efficiency and durability in various applications. However, ensuring reliable operation and long life of these lamps requires systematic real-time monitoring, control and testing. This paper presents an electrical model developed using Matlab Simulink software for the comprehensive testing and monitoring of discharge lamps, with the main focus on fluorescent light sources. Aspects of modeling and measurement of key parameters of gas discharge lamps are covered, making this model a handy tool for electronics engineers and researchers. The main focus of the paper is on the design and implementation of an automated system for monitoring and controlling discharge lamps, in which time series statistical analysis has been widely applied. By utilizing advanced technologies such as remote monitoring and control via cloud services, the system provides prompt and reliable control of discharge lamp parameters.
Keywords: *fluorescent lamps, discharge lamps, parameter measurement, control, statistical analysis, time series, monitoring.*

1. Introduction

Gas discharge lamps, such as fluorescent lamps, are widely used due to their high efficiency and durability. They are used in indoor lighting, street lighting, billboards and industrial installations. A fluorescent lamp made in the form of a glass tube in which the spectrum of the emitted light consists of the glow of an arc discharge in mercury vapor at low pressure and the secondary glow of a phosphor excited by the ultraviolet component of the discharge glow evenly applied to the inside of the bulb [1]. An important aspect of the maintenance of such lamps is regular testing and monitoring of their characteristics to ensure stable operation and prevent potential accidents. Modeling is a powerful tool that allows researchers to analyze and study various processes and systems in a controlled and virtual environment. Models can be useful for:

1. The study of complex systems: Modeling makes it possible to study complex systems such as lamps, where the interaction of various parameters can be difficult to understand analytically. The model provides scientists with a tool to study these interactions. As we know there are many types of model. One of them is a mathematical model. Mathematical models with differential equations are a powerful tool for analyzing and modeling dynamic systems such as gas discharge lamps. Unlike static models, which describe static or constant states of a system, differential equations consider changes in the system over time. In some works, a mathematical model with differential equations is used to implement algorithms for quality control of sodium lamps [2]-[3]. Differential equations allow us to consider dynamic processes occurring in the lamp, such as changes in temperature, voltage, and currents, as well as the influence of electrical and physical parameters on its operation.

2. Saving resources: Experimenting with real lamps can be costly and dangerous. The simulation allows researchers to conduct virtual tests without the risk of equipment damage or injury. But in several cases, it tests the lamps in real time. Due to the fact that gas discharge lamps have a much longer service life, they can be tested for more than a month. That is, by observing the lamps and their parameters for more than a month, you can conduct a statistical analysis for further work [4].

3. Study of dynamics: Modeling allows you to study the dynamics of processes such as the transition of a lamp from state to state or the change of parameters over time. This can be important for monitoring and maintaining stable operation. The model can be used to predict behavior in various conditions, which is useful for optimizing their performance and durability [5].

4. Data analysis: Models have the potential to generate vast amounts of data, which, in the future, are subjected to careful statistical analysis. The results of such an analysis can be visually presented in the form of various graphs, waveforms and other visual representations. By studying these graphical reports, researchers are able to conduct in-depth analysis, perform calculations and make forecasts. This analysis is able to reveal hidden patterns and highlight trends in the functioning of gas discharge lamps. This approach significantly enriches our understanding of the operation of these devices and creates new opportunities for their optimization and control [6-7].

2. Materials and methods

2.1. Lamp test model

We present a model that monitors and controls key lamp parameters and represents the electrical circuit of a lamp. In this paper, an electrical model was developed to perform lamp testing. In the study, we analyzed the key parameters and compared the results and performed a detailed analysis of the obtained data. The results obtained show that the models are highly effective in the context of lamp testing, which confirms their potential applicability in real-world applications.

First, an electrical circuit (Figure 1) was constructed to represent the main components including the power supply, capacitor, inductor, resistor, and lamp. These components together form an electrical circuit in which gas discharge occurs and light is produced. Various component parameters and characteristics can be modified to control the brightness, color, and efficiency of the discharge lamp according to the application requirements.

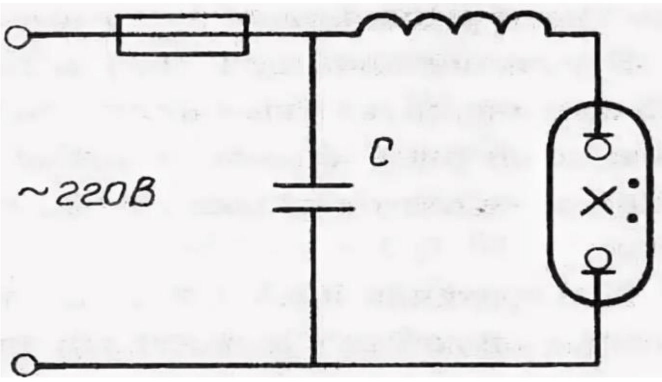


Figure 1. Fluorescent lamp switching diagram

Figure 1 shows the following designations: R - active resistance, L - choke, C - capacitor. There are various components used in a lamp, each of which performs a specific role in the operation of the lamp. Let's understand what functions the main components perform:

Power supply (DC or AC voltage) - provides the electrical energy to operate the lamp. Its role is to create the potential needed to overcome the resistance of the gas inside the lamp and start the gas discharge process. In real life, lamps are operated with alternating voltage.

Capacitor: Capacitors are used to store electrical energy and provide stability to the lamp. They can smooth out voltage ripple and provide a constant or variable voltage depending on the type of lamp.

Choke: A choke, or inductance, is used to limit the current in a circuit. It prevents excessive current, which can be important for controlling lamp operation and preventing overloading.

Resistor: Resistors limit current or create a certain resistance in an electrical circuit. They can be used to control the brightness of the lamp or to adjust the operating parameters.

We also used MATLAB Simulink to build an electrical model and integrated elements to measure the voltage, current and other characteristics of the lamp. This environment may not have the electrical elements for complex modeling, but for simple circuits they can be sufficiently modeled. Using a standard set of electrical blocks, a visual simple electrical model of the lamp was made (Figure 2). We give an AC voltage to the input.

To create the electrical model, we have taken advantage of a variety of blocks and components. It is important to emphasize that our model was designed to analyze in detail the operation of fluorescent lamps, especially low-pressure lamps. A 220V AC Voltage Source unit was used to simulate the electrical power supply to the lamp. It provided the basic voltage required for lamp functioning. Sensors were integrated to measure various parameters of lamp operation. In particular, voltage and current sensors were included in the model, allowing us to acquire and analyze relevant data in real time. A lamp unit (Lamp) was used to represent the discharge lamp itself in the model. It is important to note that a specific resistance (100 ohms) was set for the low-pressure lamps, which allowed for a more accurate modeling of their characteristics. An equation solver block (Solver Configuration) was used to efficiently solve the system of differential equations that characterize the operation of discharge lamps. It provided an accurate and stable calculation of the lamp characteristics. In our model, the capacitor (Capacitor) will represent an element of an electrical circuit that accumulates and stores electrical charge. We have defined its capacitance as 5e-6 Farads, which allows us to more accurately account for the energetic processes occurring inside the discharge lamp.

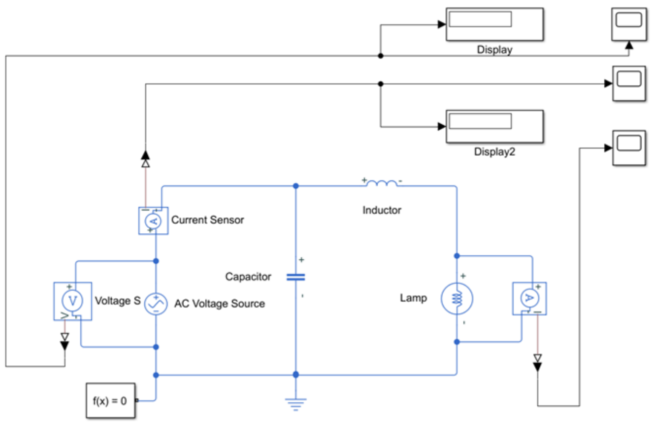


Figure 2. Electrical model of a fluorescent lamp

The choke in our model plays a role as an inductance and performs the important function of limiting the current variations in the electrical circuit. We set its inductance at 10e-3 Henry, which allows us to regulate the current flowing through the discharge lamp and influence its operating dynamics.

To observe and visualize the simulation results, we resorted to the use of a digital oscilloscope (Scope). This tool allowed us to monitor lamp parameters, plot, analyze oscillograms and draw conclusions from the data. During the simulation we measured the input voltage and the results are shown in the graph (Figure 3).

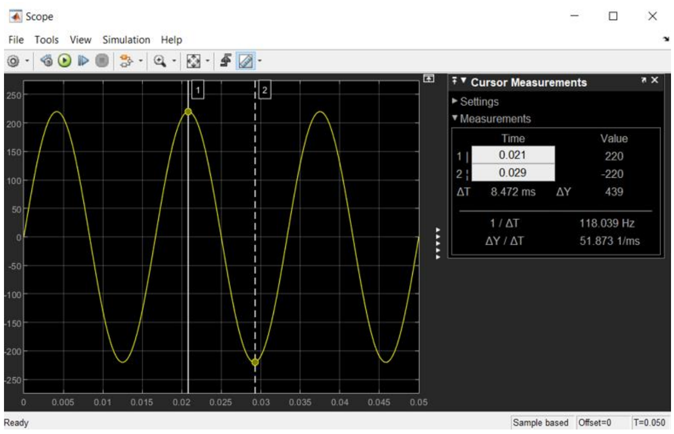


Figure 3. Input voltage in the electrical model

It is important to note that this graph shows a characteristic sinusoidal signal that continues for a period of time. This signal represents a change in the voltage applied to the lamp. Over a period of time, the maximum voltage value on the graph reaches the 220-volt level, while the minimum signal value drops to -220 volts. Thus, our graph demonstrates how the voltage is delivered to the lamp and varies within the specified values. The sinusoidal nature of the signal is due to the fact that the alternate voltage tends to have this shape.

A transient plot showing the dynamics of the current (A) change is shown in Figure 4-5.

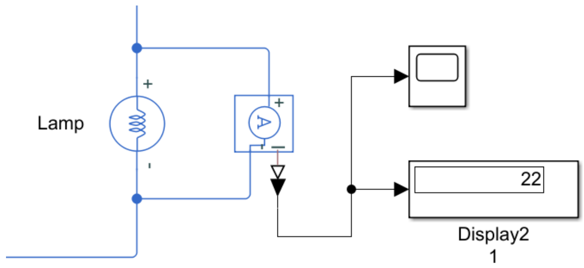


Figure 4. Measuring the output current in the lamp

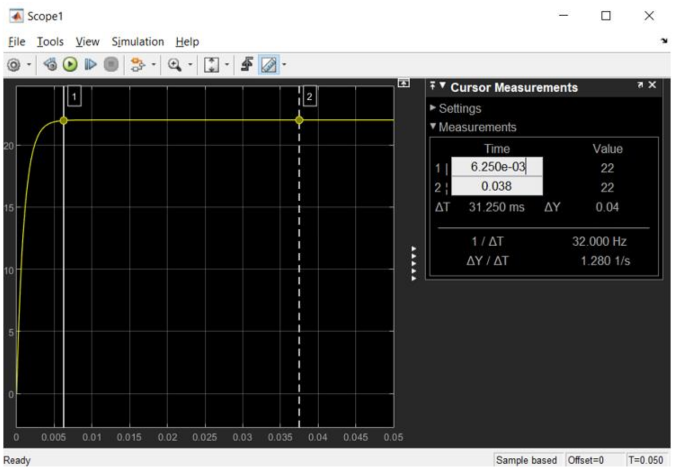


Figure 5. Result of measured output current in the lamp

At the beginning of the lamp switching on, we see that the current rises sharply. This occurs for a partial hundredth of a second (approximately 6.250e-03 seconds), at which time the current reaches a maximum value of 22A. Then, after this brief rising stage, the current stabilizes and remains at a constant level of 22 amperes. This is when we connect a constant voltage to the power supply.

This moment of current stabilization is important because it indicates that the lamp has reached its rated operating condition. It is at this point that the lamp begins to emit light output and perform its lighting function. Knowing the current establishment time can be useful for engineers and designers working with discharge lamps, as it helps to optimize the turn-on time and take it into account when designing lighting systems.

These approaches have allowed us to observe changes in key lamp parameters over a given time. Thus, we have the ability to measure both input and output parameters using specialized sensors that we can easily integrate into our model. This gives us the ability to observe changes in these parameters over a given time, which we pre-set. This work can be useful for specialists, engineers and researchers in the field of electronics, lighting.

2.2. Materials and methods of the automated monitoring and control system

The main focus of this work is the realization of an automated system for monitoring and control of discharge lamps. The system provides prompt and reliable control of lamp parameters using modern technologies such as remote monitoring and control via cloud services. This allows system operators to effectively monitor the condition of lamps, perform remote control and quickly respond to any deviations. To achieve this goal, we have physically tested the fluorescent lamp and implemented automated solutions to monitor it. This approach allows not only to test the lamp in real time, but also to monitor input and output parameters, providing operators with all the necessary information to make informed decisions. Energy-efficient lamps such as compact fluorescent lamps were chosen for the test. These lamps contain low amounts of mercury and use gas discharge to create light. This allows them to be more energy efficient and longer lasting than conventional incandescent bulbs [8]. The characterization is shown in Table 1.

Table 1. Characteristics of the tested fluorescent lamp

Type	Full spiral
Supply voltage	AC110V/220V
Power Supply	24W
Basis	E27/B22
Color temperature	6400/10000K (Daylight, white light)
Dia. Tubes	T4, 12mm, φ54, 4.5T
Material	PBT/PC plastic and flame-retardant system board for printed circuit boards
Tube lamp	Mixed powder, tri-color/Tri-luminophore
Service life	6000 hours

To measure key parameters of discharge lamps we used ESP8266 NodeMCU microcontroller in combination with PZEM004t sensor. The NodeMcu is an ESP8266-based platform designed for building Internet of Things (IoT) devices. This module has the ability to send and receive information on a local network or on the Internet using Wi-Fi. Due to its low cost, NodeMcu is widely used to create smart home systems or remotely control Arduino devices.

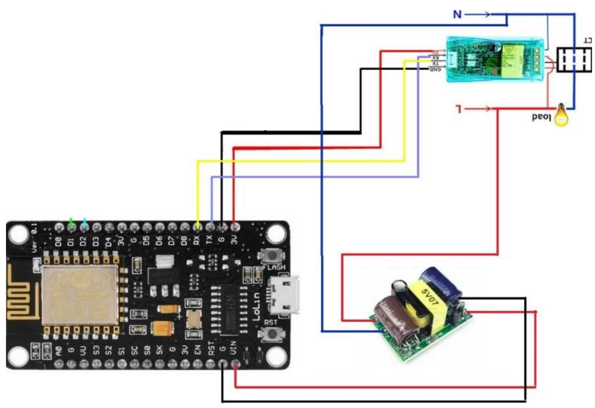


Figure 6. Wiring diagram of Esp8266 and Pzem004t for measuring fluorescent lamps

The PZEM004t sensor we used to be a kind of energy module. It provides simultaneous measurement of the following parameters:

- Measurement of current AC mains voltage 80-260V.
- Current measurement 0 - 100A.

- Measurement of active power 0 - 22KW.
- Measurement of consumed electricity.
- Measurement accuracy 1%.
- Operating frequency 45 - 65Hz.

The wiring diagram is shown in Figure 6.

As mentioned earlier, in this work, we utilized RemoteXY cloud server to continuously monitor and control the discharge lamps via smartphone. Additionally, to ensure systematic data collection, every 30 seconds we automated the recording of information to Google Table for later analysis. The complete workflow is summarized as follows:

1. Microcontroller (ESP8266) using RemoteXY:

The microcontroller (ESP8266) is configured using RemoteXY library to enable remote interface. The microcontroller code defines the connection parameters to the RemoteXY server, such as the Wi-Fi SSID and password, as well as the server address and token to ensure seamless communication.

2. RemoteXY interface design:

The RemoteXY interface is designed with various controls such as switches, text boxes, and others (Figure 7). The interface design determines what data will be sent to the RemoteXY server when interacting with the user interface.

3. Sending data to the RemoteXY server:

When you interact with a device through the RemoteXY interface (e.g., turning on a switch), data is instantly sent to the RemoteXY server.

4. Transmitting data via RemoteXY cloud service:

RemoteXY uses a cloud server to transfer data. The microcontroller sends the collected data to the RemoteXY server via Wi-Fi.

5. Receiving data on RemoteXY server side:

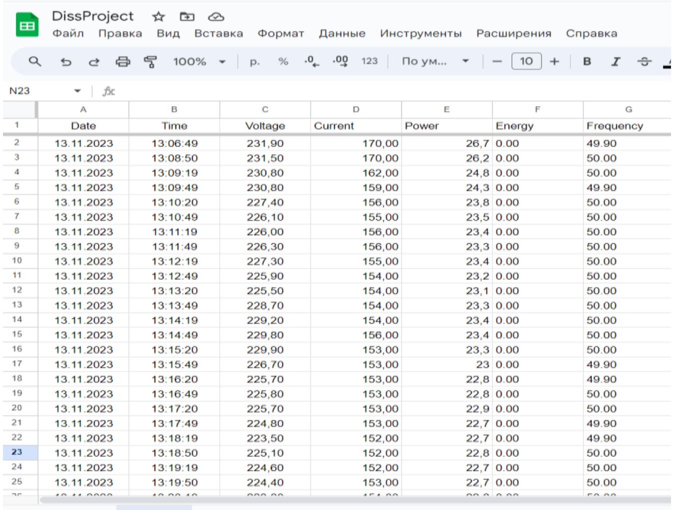
The RemoteXY server receives data from the microcontroller and performs additional operations according to the pre-defined code.

6. Sending data to Google Sheet:

The next step in the process is to transfer data to the Google shee server using HTTP requests. The Google Apps Script code processes these requests, extracts the information and writes it to the specified table sheet. Thus, the data received by the microcontroller via RemoteXY and transmitted via the RemoteXY cloud server is finally registered in the Google Table (Figure 8).

All this automated system provides an opportunity for operational monitoring and analysis of data in real time, as well as their subsequent storage for further use and analysis.

Figure 7. Interface design in the RemotXY application for lamp parameter tracking



	Date	Time	Voltage	Current	Power	Energy	Frequency
2	13.11.2023	13:06:49	231,90	170,00	26,7	0.00	49.90
3	13.11.2023	13:08:50	231,50	170,00	26,2	0.00	50.00
4	13.11.2023	13:09:19	230,80	162,00	24,8	0.00	50.00
5	13.11.2023	13:09:49	230,80	159,00	24,3	0.00	49.90
6	13.11.2023	13:10:20	227,40	156,00	23,8	0.00	50.00
7	13.11.2023	13:10:49	226,10	155,00	23,5	0.00	50.00
8	13.11.2023	13:11:19	226,00	156,00	23,4	0.00	50.00
9	13.11.2023	13:11:49	226,30	156,00	23,3	0.00	50.00
10	13.11.2023	13:12:19	227,30	155,00	23,4	0.00	50.00
11	13.11.2023	13:12:49	225,90	154,00	23,2	0.00	50.00
12	13.11.2023	13:13:20	225,50	154,00	23,1	0.00	50.00
13	13.11.2023	13:13:49	228,70	154,00	23,3	0.00	50.00
14	13.11.2023	13:14:19	229,20	154,00	23,4	0.00	50.00
15	13.11.2023	13:14:49	229,80	156,00	23,4	0.00	50.00
16	13.11.2023	13:15:20	229,90	153,00	23,3	0.00	50.00
17	13.11.2023	13:15:49	226,70	153,00	23	0.00	49.90
18	13.11.2023	13:16:20	225,70	153,00	22,8	0.00	49.90
19	13.11.2023	13:16:49	225,80	153,00	22,8	0.00	50.00
20	13.11.2023	13:17:20	225,70	153,00	22,9	0.00	50.00
21	13.11.2023	13:17:49	224,80	153,00	22,7	0.00	49.90
22	13.11.2023	13:18:19	223,50	152,00	22,7	0.00	49.90
23	13.11.2023	13:18:50	225,10	152,00	22,8	0.00	50.00
24	13.11.2023	13:19:19	224,60	152,00	22,7	0.00	50.00
25	13.11.2023	13:19:50	224,40	153,00	22,7	0.00	50.00

Figure 8. Saving real-time data collected from lamps

2.3. Application of statistical analysis of time series

One of the key tools used in our system is statistical time series analysis [9]. This method allows for more efficient monitoring and testing of discharge lamps, considering changes in their characteristics over time. Statistical analysis provides a more accurate prediction of lamp condition and allows operators to take measures to prevent and avoid possible failures.

The first step in the statistical analysis was to plot the input voltage and current, as well as the lamp power versus time (Figure 9 and Figure 10).

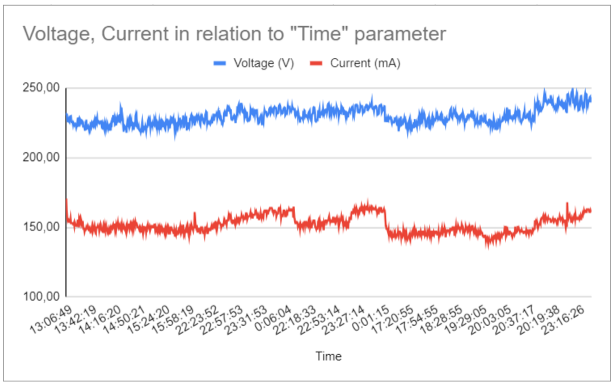


Figure 9. Graph of input voltage and current in the lamp obtained in time

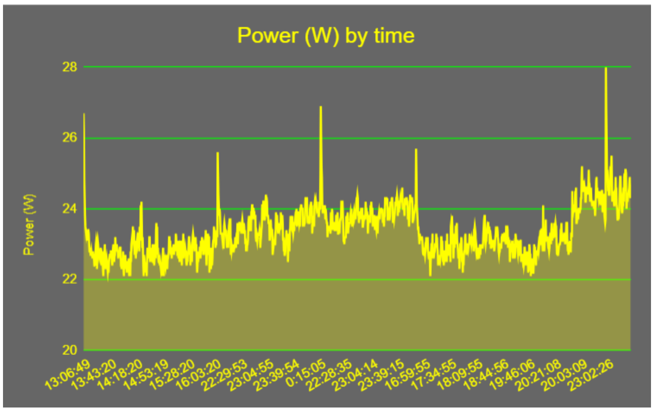


Figure 10. Lamp power graph obtained over time

Over a period of 20-30 days, we collected a significant amount of data, namely about 1500 data records for various lamp parameters. These data allowed us to perform a detailed analysis, revealing the main characteristics of the lamps' performance during this time. The analysis resulted in the following parameters (Table 2).

Table 2. Found values for voltage, current and power

Meaning	Voltage (V)	Current (mA)	Power (W)
Maximum	248.70	170.00	28
Minimum	217.80	139.00	22.1
Average	229.69	151.91	23.36178474
Standard deviation	5.560303188	5.,805393593	0.6797289787

The data analysis allows us to draw the following conclusions: in most cases the alternating voltage of the lamps exceeded 220 V, which is a significant parameter for further analysis. The output current from the lamps was approximately 151.91 mA and the average power was 23.36 W, which almost corresponds to the factory lamp specifications (24 W).

In addition, the parameter variability emphasized in the analysis, such as standard deviation, indicates the dynamics and variability of lamp performance under different conditions. This information can be useful to better understand the behavior of discharge lamps and optimize their performance.

Thus, our data analysis not only provided basic lamp characteristics, but also revealed additional aspects that may be key to further improve the monitoring and control system of discharge lamps.

Correlation: The correlation analysis performed using Pearson correlation coefficient plays a key role in our study, providing valuable information about the relationship between different parameters of discharge lamps [10]. We performed correlation analysis by calculating the Pearson correlation coefficient between time series and lamp parameters. The values of the correlation coefficient, allow us to estimate the degree of linear relationship between these quantities. The formula for the correlation coefficient is shown at the bottom:

$$R = \frac{\sum_{i=1}^{n}(x_i - \overline{x})(y_i - \overline{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \overline{x})^2}\sqrt{\sum_{i=1}^{n}(y_i - \overline{y})^2}}$$

This is how the correlation value came out for 1500 data:
- AC voltage: 0.3712255836
- Output current: 0,2004753679
- Power: 0,3380559102

The correlation coefficient value for the voltage variable (0.371) indicates that there is a positive linear relationship between voltage and other parameters. This can be interpreted as the fact that an increase in AC voltage is accompanied by an increase in current and power, which may be important for optimizing lamp efficiency.

Similarly, the correlation coefficient for current (0.200) and power (0.338) also indicates a positive linear relationship, although to a lesser extent. This emphasizes the influence of AC current and power on each other.

Correlation analysis not only allows us to evaluate the degree of relationship between the parameters, but also provides important clues for optimizing the monitoring and control system of discharge lamps. The results of correlation analysis can be used to make informed decisions about adjusting lamp operating parameters, ensuring more efficient and stable lamp operation.

3. Results and discussion

As a result of our research, we developed an electrical model for testing discharge lamps. This approach allowed us to observe changes in the key parameters of the lamp over a given time, pre-configured in the Matlab Simulink program. Thus, we are able to measure both input and output parameters using specialized sensors that we can easily integrate into our model. This gives us the ability to observe changes in these parameters over a given time, which we pre-set. In this study, we focused on measuring key parameters and the results demonstrate that the lamp performs as expected. This work can be useful to professionals, engineers and researchers in the field of electronics, lighting. It provides a detailed description of the developed model and methods for measuring lamp parameters that can be useful in design. It also serves as a basis for further research in the field of gas discharge technology and its improvement.

During the research, an automated system for monitoring and controlling gas discharge lamps based on statistical analysis of time series and the use of modern technology was still designed and implemented. The system includes ESP8266 NodeMCU microcontroller, RemoteXY cloud server, and integration with Google Tables for centralized data storage. The results of the study are presented in the form of statistical analyses and graphs, allowing to effectively monitor and control the operation of discharge lamps.

Implementation of a monitoring and control system:

The system is designed using ESP8266 NodeMCU microcontroller, which is integrated with RemoteXY for remote monitoring and control. The RemoteXY cloud server provides data transfer between the microcontroller and the operator's mobile device, as well as storing this data in real time. The data is then automatically written to Google Tables for later analysis.

Statistical analysis of time series:

The main analysis tool was statistical time series analysis presented in the form of graphs and tables. Graphs of input voltage, current and lamp power over time were plotted. More than 1500 data were obtained, allowing analysis of mean values, minima, maxima and standard deviation for each parameter.

Correlation Analysis:

Correlation analysis was carried out to evaluate the relationship between different lamp parameters. Pearson correlation coefficient values for AC voltage, current and power were calculated. This analysis reveals the degree of influence of one parameter on another and can be useful in predicting future values.

Significance of results:

The developed system provides operators with the capability of operational monitoring and effective control of fluorescent lamps. Using statistical analysis and correlation studies, the following results are achieved:

Accurate parameter monitoring: The system allows operators to continuously monitor changes in lamp parameters in real time.

Lamp performance analysis and optimization: The statistical data obtained allows analysis of lamp performance and optimization of lamp operation to improve efficiency.

4. Conclusions

In this study about 1500 data collected from lamps using ESP8266 NodeMCU and PZEM004t sensor, an automated monitoring and control system based on modern technology was designed and successfully implemented. The data were regularly saved to google table every 30 seconds for more detailed analysis. The obtained results of statistical and correlation analysis of time series allow us to draw the following conclusions:

Effectiveness of the monitoring system: The developed system provides prompt and reliable monitoring of the parameters of gas-discharge lamps. The possibility of remote monitoring and control via cloud services significantly simplifies the process of monitoring the condition of lamps and allows to respond promptly to changes.

Statistical analysis of time series: The use of statistical analysis allows not only to monitor current lamp parameters in real time, but also to perform preliminary analysis, identifying possible trends and anomalies. This is an important tool to prevent possible failures.

Correlation analysis: The calculation of Pearson correlation coefficients allows to determine the relationships between voltage, current and power variables. The resulting correlation coefficient values provide information on the degree of influence of each parameter on the others, which is an important element in optimizing lamp performance.

Electrical Model: Additionally, the electrical model developed during the study is an important tool to better understand the interrelationships and processes that occur in discharge lamps. This model enables a more accurate parameter study, which contributes to better monitoring.

Potential for further development: The study shows that the system has potential for further development. The implementation of additional parameter analysis and optimization techniques can further improve the efficiency and reliability of discharge lamps.

In conclusion, this paper not only presents a new perspective on automated monitoring of discharge lamps, but also opens the door for further research in the field of optimization and control of lighting.

References

[1] Levchenko, V.A., et al. (2015). Increase in the physical service life of powerful low-pressure gas discharge lamps. *Applied Physics, (5), 90-94*

[2] Semenov, A.D., Volkov, A.V. (2018). Experimental testing of the mathematical model of high-pressure sodium lamps. *Scientific and Technical Bulletin of the Volga Region, (1), 136-139*

[3] Volkov, A.V., Troyansky, A.V. (2017). Automation of the high-pressure lamp rejection system. In: Systems of design, modeling, production preparation, and project management CAD/CAM/CAE/PDM. *Collection of articles of the XI International Scientific and Practical Conference*

[4] Narvarte, L., Muñoz, J. & Lorenzo, E. (2001). Testing of fluorescent DC lamps for solar home systems. *Progress in Photovoltaics: Research and Applications, 9(6), 475-489*

[5] Moulay, L., Miloua, F. & El Islam, A.A.N. (2019). Model of Discharge Lamp Sodium with High Pressure. *EasyChair, 2019*

[6] Volkov, A.V. (2020). Analysis of the operation of existing systems for monitoring lamp parameter output. *XLVIII Ogarev Readings*

[7] Semenov, A.D., Volkov, A.V. (2018). Obtaining archival data in the quality control system of sodium lamps. *Fundamental and Applied Scientific Research: Current Issues, Achievements, and Innovations, 249-252*

[8] Fenton, L. (2013). Energy-saving lamps and their impact on photosensitive and normal individuals. *British Journal of Dermatology, 169(4), 910-915*

[9] Chatfield, C., Xing, H. (2019). The analysis of time series: an introduction with R. *CRC press*

[10] Chatterjee, S. (2021). A new coefficient of correlation. *Journal of the American Statistical Association, 116(536), 2009-2022*

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Аңдатпа. Газ разрядты шамдар, соның ішінде флуоресцентті шамдар әртүрлі қолданбаларда жоғары тиімділік пен ұзақ мерзімділікті қамтамасыз ететін заманауи жарықтандыру жүйесінің негізгі элементі болып табылады. Дегенмен, бұл шамдардың сенімді жұмысы мен ұзақ қызмет ету мерзімін қамтамасыз ету жүйелі монитроингті, бақылауды және нақты уақыттағы сынақтарды қажет етеді. Бұл мақалада флуоресцентті жарық көздеріне баса назар аудара отырып, разрядты шамдарды кешенді сынауға және бақылауға арналған Matlab Simulink бағдарламасын қолдана отырып жасалған электрлік модель ұсынылған. Разрядты шамдардың негізгі параметрлерін модельдеу және өлшеу аспектілері қарастырылады, бұл модельді электроника инженерлері мен зерттеушілері үшін ыңғайлы құрал етеді. Жұмыстың негізгі бағыты уақыт қатарларын статистикалық талдау кеңінен қолданылатын газ разрядты шамдарды бақылау мен басқарудың автоматтандырылған жүйесін әзірлеуге және енгізуге бағытталған. Бұлттық қызметтер арқылы қашықтан бақылау және басқару сияқты озық технологияларды пайдалана отырып, жүйе разрядты шамдардың параметрлерін жедел және сенімді басқаруды қамтамасыз етеді.

Негізгі сөздер: *флуоресцентті шамдар, разрядты шамдар, параметрлерді өлшеу, бақылау, статистикалық талдау, уақыт сериясы, мониторинг.*

Реализация автоматизированной системы мониторинга и испытания газоразрядных ламп с использованием статистического анализа временных рядов

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Аннотация. Газоразрядные лампы, включая люминесцентные, представляют собой ключевой элемент современной системы освещения, обеспечивая высокую эффективность и долговечность в различных сферах применения. Тем не менее, обеспечение надежной работы и продолжительного срока службы этих ламп требует систематического мониторинга, контроля и испытаний в реальном времени. В данной статье представлена электрическая модель, разработанная с использованием программы Matlab Simulink, предназначенная для комплексного испытания и мониторинга газоразрядных ламп, с основным акцентом на люминесцентных источниках света. Рассмотрены аспекты моделирования и измерения ключевых параметров газоразрядных ламп, что делает эту модель удобным инструментом для инженеров и исследователей в области электроники. Основное внимание работы уделено разработке и внедрению автоматизированной системы мониторинга и управления газоразрядными лампами, в которой широко применен статистический анализ временных рядов. С использованием передовых технологий, таких как удаленный мониторинг и управление через облачные сервисы, система обеспечивает оперативный и надежный контроль параметров газоразрядных ламп.

Ключевые слова: *люминесцентные лампы, газоразрядные лампы, измерение параметров, контроль, статистический анализ, временный ряд, мониторинг.*

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