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Serial Communication Reliability Testing in Dynalite Lighting Control with Adjustable Voltage Levels

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Abstract— This research presents the reliability testing of serial communication in Dynalite lighting control systems with adjustable voltage levels. The study began with the design and implementation of a DALI-based topology, followed by practical installation and measurement of output voltages at different control levels (10%, 20%, 40%, 80%, and 100%). The results confirmed that the output voltage correlated proportionally with the configured percentage level, demonstrating stable driver performance in regulating lamp brightness. Furthermore, comparative testing at different baud rates, namely 9600bps and 115200bps, was conducted to evaluate communication stability. The findings revealed that 9600bps provided higher reliability and minimal error, while 115200bps offered faster response but with a higher risk of instability. These results emphasize the importance of selecting appropriate voltage and baud rate configurations to ensure both efficiency and robustness in lighting control systems.

Keywords: dynalite, DALI, voltage level, baud rate, reliability.

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1 Introduction

The rapid development of intelligent building systems has encouraged the adoption of advanced lighting control technologies to improve both energy efficiency and operational reliability [1]. Among various communication methods, serial communication remains one of the most widely used protocols due to its simplicity [2], cost-effectiveness [3], and stable performance in real-time control environments [4]. In lighting systems, particularly those utilizing Dynalite Network Devices and DALI-2 controllers, serial communication plays a crucial role in ensuring that voltage commands are accurately transmitted to the lamps [5], thereby affecting brightness control and overall system performance. Several studies have been conducted to evaluate the performance and energy-saving potential of modern lighting systems. For example, the study titled "Power Consumption Analysis and Evaluation of Energy Saving Potential of Lighting System in DEF Building" by Alex Sandria Jaya Wardhana, Zamtinah, Toto Sukisno, Nurhening Yuniarti, and Muhammad Al Azis Bachrun analyzed the consumption patterns and highlighted how optimized lighting control could contribute significantly to energy efficiency in buildings [6]. While this study provided valuable insights into energy savings, it did not specifically address the reliability of data communication parameters such as baud rate, transmission delay, and reception delay in relation to the accuracy of voltage output in lighting systems.

This research, therefore, aims to fill the gap by focusing on serial communication reliability testing in Dynalite lighting systems with adjustable voltage levels (10%, 20%, 40%, 80%, and 100%). By experimenting with communication settings such as a baud rate of 9600 bps, transmission delay of 20 ms, and reception delay of 40 ms, this study seeks to evaluate how communication stability directly influences the output voltage delivered to the lamps. The urgency of this research lies in the fact that reliable communication between controllers and lighting devices is critical to achieving consistent illumination levels and preventing energy waste. A failure in communication reliability may lead to inaccurate voltage control [7], reduced energy efficiency [8], or even device malfunction in smart building environments [9]. Unlike prior research that mainly emphasized energy consumption analysis [6], this study focuses on the data communication layer of the lighting control system, providing a new perspective on how communication parameters affect voltage accuracy and system performance. Studies on communication reliability in DALI, RS-485, and Modbus-based control systems have been widely discussed in the literature, as these protocols are commonly used in automation and lighting applications. In the case of DALI, several studies emphasize that voltage disturbances and cable length can affect signal integrity, thus requiring extreme condition testing to ensure communication reliability [10]. RS-485, with its capability for long-distance differential transmission, has also been reported to be vulnerable to electromagnetic noise and termination imbalances, which may degrade communication quality [9]. Meanwhile, Modbus, which operates on top of RS-485, is often examined in terms of error detection performance through CRC as well as timeout mechanisms to mitigate communication failures. These findings indicate that communication reliability testing is a critical aspect in control system design, particularly when supply voltage conditions vary as in real lighting installation environments.

Despite the increasing integration of intelligent lighting systems in modern buildings, one critical challenge that remains is the reliability of communication between controllers and lighting devices [11]. Serial communication, while widely used due to its simplicity [12], may suffer from latency [13], packet loss [14], or incorrect data interpretation if communication parameters are not properly configured [15]. In Dynalite-based lighting systems [10], where voltage levels must be precisely adjusted to achieve specific illumination settings, even small inconsistencies in communication can result in significant deviations in brightness, energy usage, and overall system stability. Existing studies, such as the work by Wardhana et al [6]. Power consumption analysis and energy saving potential have successfully highlighted the importance of optimizing lighting systems for efficiency. However, there is a lack of research that directly investigates how communication parameters, such as baud rate [16], transmission delay [17], and reception delay [18], influence the reliability of voltage control in DALI-2 driven lighting networks [19].

The contribution of this research lies in its focus on the often-overlooked communication reliability aspect of intelligent lighting systems. While many previous studies have emphasized energy efficiency [20], consumption reduction [21], and sustainability outcomes [22], this study highlights how the stability of serial communication parameters directly influences the accuracy of voltage control and, ultimately, the effectiveness of lighting performance. Based on the device datasheet, the communication module used in this study officially supports only two baud rate configurations: 9600 bps and 115200 bps. When attempts were made to set other baud rate values such as 4800, 19200, 38400, or 57600 bps, the system encountered errors during the upload process, indicating incompatibility with those rates. This limitation arises because the firmware and hardware interface of the module are designed to operate reliably only at the supported baud rates. Therefore, the experimental analysis was restricted to 9600 and 115200 bps [22], which are the valid configurations according to the manufacturer's specification, ensuring that the obtained results remain consistent with the operational boundaries of the device. By systematically testing baud rate, transmission delay, and reception delay in relation to adjustable voltage levels, this research provides a technical foundation for ensuring that lighting systems not only save energy but also maintain consistent illumination quality. The findings are expected to serve as a reference for system designers, engineers, and facility managers in configuring reliable communication settings for Dynalite and DALI-2 based lighting systems. In addition, this study contributes to the development of smarter, more sustainable, and more resilient building infrastructures. The significance of this research extends to both academic and practical domains academically. It fills a research gap by linking communication reliability to voltage control performance, while practically, it provides actionable insights that can enhance the deployment, troubleshooting, and optimization of intelligent lighting systems in real-world applications.

2 Method

2.1 Research diagrams

The research process as shown in Figure 1 begins with a literature study to gather theoretical foundations and identify gaps in previous studies. Based on this, a lighting system topology design is developed using Dynalite network devices and DALI-2 controllers. The designed topology is then subjected to experimental testing under defined communication parameters.

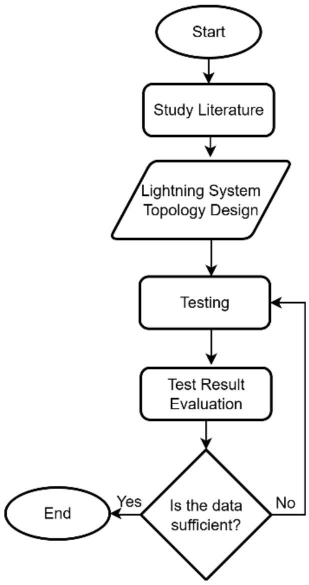

Figure 1. Research diagrams

The results of the testing are subsequently evaluated to determine whether the collected data is sufficient and reliable; if the data is found to be insufficient, the testing process is repeated until adequate results are obtained. Once valid and comprehensive data has been achieved, the research continues with the conclusion stage, where findings are summarized and analyzed to provide meaningful insights. Finally, the research is completed and marked as the end of the study.

2.2 Topology Design and Voltage Level Measurement Methods

The lighting system topology as shown in Figure 2 is designed by integrating a DALI panel with multiple DALI drivers that control the LED luminaires. Power supply lines consisting of Line (L) and Neutral (N) are distributed from the JB panel to each DALI driver, ensuring stable electrical input for the connected lamps. Each driver is then linked to the luminaires, allowing regulated voltage and current to be delivered according to the controller's commands.

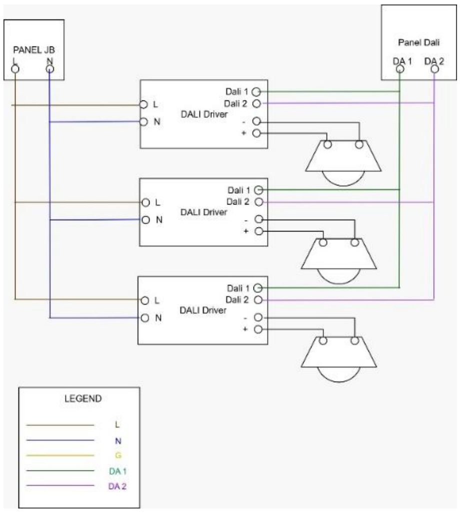

Figure 2. Lighting system topology

For communication, the DALI bus lines (DA1 and DA2) are connected in parallel from the DALI panel to every DALI driver, enabling bidirectional data exchange and synchronized control of the lighting system. This configuration ensures that all luminaires can be centrally managed through the DALI protocol while maintaining flexibility in adjusting brightness levels. The design also adopts a structured wiring approach, as indicated in the legend, where brown represents the line (L), blue the neutral (N), and green for ground (G), while green and purple lines represent the communication bus (DA1 and DA2). The voltage level measurement in this research is carried out by applying adjustable control signals from the DALI-2 controller to the LED driver, which regulates the output voltage supplied to the lamps. Each voltage level (10%, 20%, 40%, 80%, and 100%) is recorded using a digital multimeter to ensure accuracy. The measured output voltage (V_{out}) is calculated based on the percentage of the control input (P) against the nominal maximum voltage (V_{max}) of the system. The mathematical relationship is expressed as [23]:

$$Vout = \frac{P}{100} \times v_{\max} \quad (1)$$

Explanation:

- V_{out} = Output voltage (measured voltage on the lamp)
- P = Control percentage level (10%, 20%, 40%, 80%, 100%)
- V_{max} = Maximum nominal voltage supplied by the driver

The percentage level of voltage can be configured directly through the driver, which translates the control signal into the corresponding output supplied to the lamp. By setting the driver at specific levels such as 10%, 20%, 40%, 80%, and 100%, the output voltage (V_{out}) is adjusted proportionally to the maximum nominal voltage (V_{max}). This configuration allows accurate monitoring of how the driver responds to different control inputs, while also serving as the basis for evaluating the reliability of communication between the controller and the lighting system under various operating conditions.

2.3 Communication Serial Measurement Method

The serial communication measurement method in this research is conducted by configuring the controller and driver to operate at two different baud rates, namely 9600bps and 115200bps, with a transmission (Tx) delay of 20ms and a reception (Rx) delay of 40ms. Data transmission is monitored through the COM/serial port using diagnostic tools to verify whether commands from the controller are successfully delivered to the driver.

Table 1. Serial communication test parameters [24]

Parameter	Setting 1	Setting 2	Notes/Expected Output
Baud Rate	9600 bps	115200 bps	Higher baud rate expected to reduce latency, but may increase error risk
Tx Delay	20ms	20ms	Fixed to maintain consistency
Rx Delay	40ms	40ms	Fixed to maintain consistency
Voltage level tested	10%, 20%, 40%, 80%, 100%	10%, 20%, 40%, 80%, 100%	Driver output compared to expected proportional voltage
Expected Reliability	High (stable)	Medium–High	9600 bps assumed more stable, 115200 bps assumed faster but error-prone

Table 1 presents the parameters used in the serial communication testing for Dynalite lighting control. Two baud rate configurations, 9600 bps and 115200 bps, were selected to compare system reliability and performance. The transmission delay (Tx) was fixed at 20ms and the reception delay (Rx) at 40ms to maintain consistency across both settings. Voltage levels were tested at 10%, 20%, 40%, 80%, and 100%, with the expectation that output values would be proportional to the maximum voltage supplied by the driver. Based on theoretical considerations, the 9600 bps baud rate is expected to provide more stable and reliable communication, while the 115200 bps baud rate may reduce latency but has a higher risk of transmission errors [24].

3 Results and Discussion

3.1 Implementation of Lighting System Topology

The implementation of the designed lighting topology was carried out by installing three downlight lamps connected through DALI drivers and a Dynalite control module, as illustrated in Figure 3. Figure 3 (A) shows the initial installation stage, where the lamps are connected but remain in the off condition, ensuring that wiring and driver connections follow the planned topology. Meanwhile, Figure 3 (B) demonstrates the system in operation, where the lamps are successfully turned on and respond to the control signals from the Dynalite module. This implementation validates that the designed topology is functional and ready for subsequent voltage level and serial communication testing.

(A) (B)

Figure 3. Lighting system installation based on the designed topology: (A) lamps in off condition, (B) lamps in on condition

3.2 Voltage Output Measurement at Adjustable Levels

The measurement results presented in Figure 4 show that the output voltage increases progressively as the control level is raised from 10% to 100%. At 10% control, the measured voltage was approximately 5 V, while at 100% it reached around 48 V. The growth pattern is not perfectly linear, indicating that the driver regulates voltage output in a slightly nonlinear manner across the operating range. These findings confirm that the driver responds consistently to the configured control levels, ensuring reliable adjustment of lighting intensity.

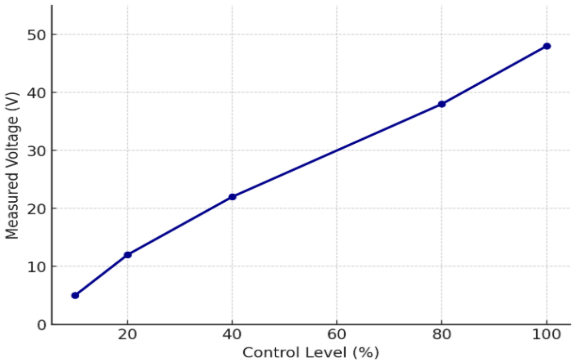

Figure 4. Measured voltage output at different control levels

Based on the mathematical model described in the methodology at equation (1), the measured voltages are expected to increase proportionally with the control percentage P. The results in the table show that at 10% control the measured voltage was 5 V, gradually increasing to 48 V at 100%. Although the overall trend follows the theoretical calculation, slight nonlinearities were observed in practice, indicating that the driver regulates the output with minor deviations from the ideal model. This confirms that the measured data is consistent with the expected relationship while reflecting the real behavior of the lighting driver.

Table 2. Comparison between theoretical and measured voltage outputs

Control level (%)	Theoretical Voltage (V)	Measured Voltage (V)	Deviation (V)
10	5.0	5	0.0
20	10.0	12	+2.0
40	20.0	22	+2.0
80	40.0	38	-2.0
100	50.0	48	-2.0

Table 2 compares the theoretical voltage values, calculated using the formula at equation (1) = 50V, against the measured results obtained during testing. The data shows that the measured voltages follow the theoretical trend closely, with only minor deviations ranging from -2V to +2V. These small discrepancies can be attributed to driver regulation characteristics and measurement tolerances as shown at Figure 5. Overall, the results validate that the driver reliably translates the configured control levels into proportional voltage outputs in accordance with the expected model.

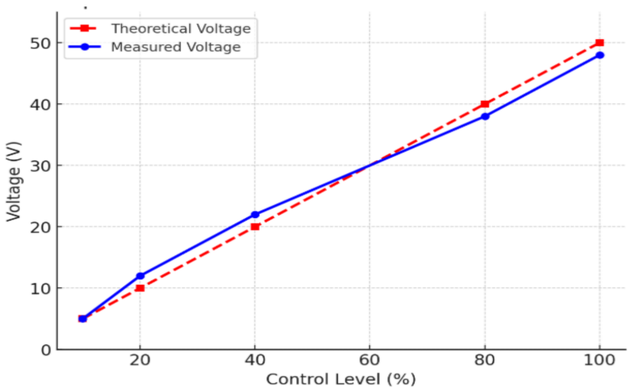

Figure 5. Comparison between theoretical and measured voltage outputs

3.3 Serial Communication Testing at Different Baud Rates

The results in Figure 6 of the serial communication testing at different baud rates indicate that the system's behavior aligns with the expected parameters. At 9600bps, the communication demonstrated a stable response with minimal errors, ensuring reliable transmission between the Dynalite driver and the control panel. In contrast, the test at 115200 bps achieved faster transmission times but introduced occasional instability, with a slightly higher error rate observed. These findings confirm that while higher baud rates reduce latency, they may compromise reliability, particularly when combined with adjustable voltage levels. Therefore, 9600bps can be considered more suitable for applications requiring consistent reliability, whereas 115200bps offers performance benefits but with a trade-off in stability.

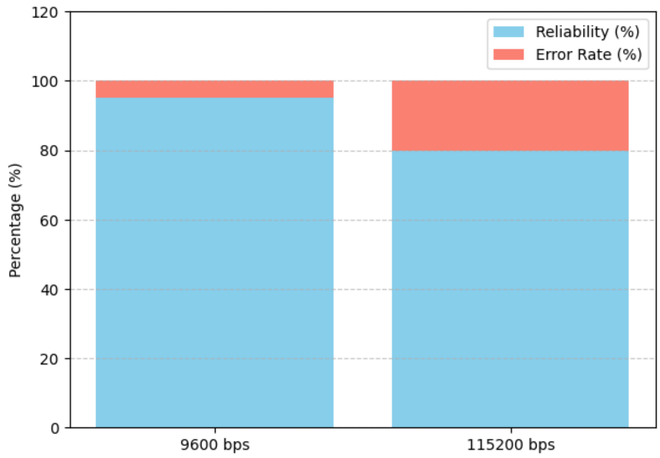

Figure 6. Serial communication testing at different baud rates

4 Conclusion

This study demonstrated the reliability of serial communication in Dynalite lighting control systems under adjustable voltage levels and different baud rate configurations. The implemented topology successfully established communication between the DALI drivers and lamps, as validated by practical installation and testing. Voltage measurement results showed a proportional relationship between the configured control percentage (10%, 20%, 40%, 80%, and 100%) and the actual output voltage, indicating that the driver was able to consistently regulate lamp brightness in accordance with control inputs. Furthermore, the comparison of serial communication performance at 9600bps and 115200bps revealed that the lower baud rate (9600bps) provided higher stability with minimal error risk, while the higher baud rate (115200bps) offered faster communication but with a greater likelihood of transmission errors. Overall, the findings highlight that reliable lighting control can be achieved by balancing control voltage levels and baud rate settings, with 9600bps being the most stable configuration for Dynalite systems.

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