IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.53
Volume 4, Issue 3, May 2024

Experimental Study on Automated Controller of Street Light Management System using IoT

Kalaimathi D[1], Mohan N[2], Jayavel M[2], Nakeswaran S[2], Sivaganaeshkumar C[2], Thirumeniraj[2]
Assistant Professor, Department of Civil Engineering[1]
Final year Students, Department of Civil Engineering[2]
Akshaya College of Engineering , Kinathukadavu, Coimbatore, India
kalaimathi@acetcbe.edu.in

Abstract: *In order to ensure public safety and support nighttime activities, street lighting is crucial to the urban landscape, and this study starts by contextualizing its importance. It then goes on to analyze the shortcomings of the current street lighting systems, which are typified by their static control methods and poor environmental response.These shortcomings underscore the urgent need for a paradigm shift towards more intelligent and adaptive solutions. The core proposition of this project lies in the design and implementation of an advanced street light management system empowered by IoT technology. At its heart, the system comprises a sophisticated network of interconnected devices, including sensors, actuators, and a central control unit. These components collaborate synergistically to capture, analyze, and act upon real-time data gleaned from the surrounding environment. Through the application of cutting-edge data analytics and machine learning algorithms, the system autonomously adjusts lighting levels in accordance with fluctuating parameters such as ambient light levels, traffic density, weather conditions, and pedestrian activity. By dynamically optimizing energy usage while ensuring adequate illumination, the system not only enhances operational efficiency but also contributes to cost reduction and environmental sustainability. Moreover, the proposed system incorporates proactive maintenance features, enabling early fault detection and remote diagnostics. This capability minimizes downtime and enhances system reliability, thereby mitigating the operational challenges associated with traditional street lighting infrastructure. The project further explores the conceptual framework of IoT, elucidating its transformative potential in revolutionizing urban infrastructure management. By seamlessly integrating physical devices with digital intelligence, IoT facilitates the creation of interconnected ecosystems wherein data-driven decision-making and automation converge to drive unprecedented efficiency and innovation*

Keywords: Street light, automatic system, IoT, Management

I. INTRODUCTION

In this dynamic landscape, the integration of IoT heralds a new epoch in urban infrastructure management, imbuing street lighting systems with intelligence, adaptability, and connectivity. This introduction sets the stage by contextualizing the significance of street lighting within the broader urban fabric, elucidating the challenges inherent in traditional systems, and delineating the imperative for innovation. The urban environment, with its bustling streets and bustling activity, is a tapestry of interconnected systems, each playing a vital role in shaping the lived experience of its inhabitants. At the heart of this urban symphony lies street lighting, casting its luminous embrace upon thoroughfares, parks, and public squares. Beyond its utilitarian function of illuminating the darkness, street lighting embodies a deeper ethos of safety, security, and communal well-being. Yet, the conventional modus operandi of street lighting, characterized by fixed schedules and simplistic photocell sensors, belies the complexities of modern urban life. Static control mechanisms, ill-equipped to respond to fluctuating environmental conditions and evolving user dynamics, often result in inefficiencies, energy wastage, and suboptimal performance. Moreover, the reliance on manual interventions for maintenance and fault detection introduces additional layers of complexity and cost, undermining the sustainability and resilience of street lighting infrastructure. Against this backdrop of challenges and constraints, the emergence of IoT technology represents a paradigm shift in street light management. By infusing physical objects with digital intelligence and connectivity, IoT enables the creation of dynamic, data-driven ecosystems wherein street lights become nodes in a vast network of interconnected devices. This transformation heralds a new era of possibility, wherein street lighting systems evolve from passive fixtures to active participants in the urban dialogue, capable of sensing, analyzing, and responding to their surroundings in real-time. The imperative for innovation in street light management is underscored by the pressing needs of contemporary urban environments. Rapid urbanization, coupled with growing environmental concerns and resource constraints, necessitates a holistic reimagining of traditional infrastructure paradigms. The proposed system seeks to address these imperatives by harnessing the transformative potential of IoT to create a smarter, more sustainable urban lighting ecosystem.

II. EXISTING SYSTEM

Traditional street lighting systems, while ubiquitous in urban environments, are often characterized by static control mechanisms and limited adaptability to dynamic conditions. These systems typically rely on simplistic approaches such as fixed schedules or photocell sensors to regulate lighting levels, lacking the sophistication necessary to optimize energy usage and enhance operational efficiency.

- **Fixed Schedule Control:** In this approach, street lights are programmed to operate according to predetermined schedules, regardless of actual environmental conditions or user requirements. While simple to implement, fixed schedules often result in unnecessary energy consumption during periods of low demand, leading to inefficiencies and increased operational costs.
- **Photocell Sensors:** Another common method employed in traditional street lighting systems involves the use of photocell sensors to detect ambient light levels. When ambient light falls below a certain threshold, the sensors trigger the activation of street lights. While effective in ensuring illumination during nighttime hours, photocell sensors lack the granularity to adjust lighting levels in response to varying conditions such as changes in traffic density or weather patterns.
- **Manual Maintenance Fault Detection:** Maintenance and fault detection in traditional street lighting systems typically rely on manual interventions, wherein maintenance crews are dispatched to inspect and repair malfunctioning fixtures. This reactive approach to maintenance often results in delays, increased downtime, and higher operational costs.

2.1 Proposed System

The proposed system represents a paradigm shift in street light management, leveraging the transformative capabilities of Internet of Things (IoT) technology to create a more intelligent, adaptive, and sustainable lighting ecosystem. At its core, the system comprises a comprehensive network of interconnected devices, including sensors, actuators, and a central control unit, orchestrated to seamlessly integrate data acquisition, analysis, decision-making, and actuation processes.The sensor network forms the sensory fabric of the proposed system, encompassing a diverse array of sensors deployed strategically throughout the urban environment. These sensors capture a wide spectrum of environmental parameters, including ambient light levels, traffic density, pedestrian activity, weather conditions, and air quality. By collecting real-time data from the surrounding environment, the sensor network provides invaluable insights into the dynamic factors influencing street lighting operations.At the heart of the system lies the central control unit, a sophisticated computing platform endowed with advanced data analytics, machine learning algorithms, and decision-making capabilities. The central control unit serves as the brain of the system, processing incoming sensor data, analyzing environmental conditions, and generating actionable insights and lighting recommendations. Through iterative learning and optimization, the control unit continuously refines its algorithms to adapt to changing circumstances and user preferences.Actuation mechanisms, comprising actuators embedded within street light fixtures, translate the decisions and recommendations generated by the central control unit into tangible adjustments in lighting levels. These actuators enable dynamic control over individual or groups of street lights, allowing for precise modulation of illumination based on real-time requirements and optimization objectives. By dynamically adjusting lighting levels in response to environmental cues, traffic patterns, and user demand, the actuation mechanisms ensure optimal visibility while minimizing energy consumption.In addition to real-time control and optimization capabilities, the proposed system incorporates proactive maintenance features to enhance system reliability and minimize downtime.

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.53
Volume 4, Issue 3, May 2024

Utilizing predictive analytics and anomaly detection algorithms, the system can identify potential faults or performance degradation in street light fixtures before they escalate into critical issues. Early detection enables preemptive maintenance interventions, thereby reducing repair costs, minimizing disruptions, and extending the lifespan of street lighting infrastructure.A key advantage of the proposed system is its ability to enable remote monitoring and control of street lighting operations. Through cloud-based connectivity and user interfaces, stakeholders such as municipal authorities, maintenance crews, and energy managers gain real-time visibility into system performance, operational metrics, and energy usage patterns. Remote control capabilities empower stakeholders to adjust lighting schedules, set optimization parameters, and diagnose issues remotely, enhancing operational efficiency and responsiveness.Furthermore, the proposed system is designed to seamlessly integrate with broader smart city ecosystems, enabling synergistic interactions with other urban infrastructure systems such as traffic management, public safety, and environmental monitoring. By sharing data and insights across interconnected systems, the proposed system contributes to holistic urban optimization efforts, fostering a more efficient, resilient, and livable urban environment.

III. COMPONENTS DESCRIPTION

3.1 LDR Module

The LDR module, comprising a Light Dependent Resistor (LDR), voltage divider circuit, Analog-to-Digital Converter (ADC), and interfacing microcontroller or processor, serves as a vital component in the automated controller for street light management systems. The LDR functions as the primary sensor, detecting variations in ambient light intensity. Incorporated within a voltage divider circuit, the LDR's resistance changes in response to light levels, generating an analog voltage output. This analog signal is then converted into digital format by the ADC for processing by the microcontroller or processor. Additionally, signal conditioning circuitry may be employed to enhance the quality of the output signal. With a stable power supply and optional communication interface, the LDR module facilitates real-time monitoring of ambient light levels, enabling the automated controller to dynamically adjust street lighting levels based on environmental conditions, contributing to energy efficiency and urban safety.

3.2 LCD SMM

The LCD SMM White, or Liquid Crystal Display (LCD) Smart Street Light Management System, White variant, represents a sophisticated solution for intelligent street light management. At its core, this system integrates LCD display technology with smart street light control capabilities to provide real-time monitoring, analytics, and control functionalities. The LCD display serves as the central interface, offering stakeholders visual access to critical information such as energy usage, system status, and performance metrics. Through intuitive user interfaces, municipal authorities, maintenance crews, and energy managers gain comprehensive visibility into street lighting operations, enabling informed decision-making and proactive management. The system leverages advanced algorithms and data analytics to optimize energy usage, enhance operational efficiency, and ensure optimal illumination levels based on environmental conditions and user preferences. With features such as remote monitoring, fault detection, and predictive maintenance, the LCD SMM White empowers cities to create smarter, more sustainable urban lighting ecosystems, contributing to enhanced safety, reduced energy costs, and improved quality of life for citizens.

3.3 100 KR Resistor

The 100KR resistor, with a resistance value of 100,000 ohms, plays a crucial role in various electronic circuits, including street light management systems. As a passive electronic component, the 100KR resistor limits or controls the flow of electric current in a circuit, thereby influencing voltage levels and signal processing. In the context of street light management systems, the 100KR resistor may be utilized in voltage divider circuits alongside sensors such as Light Dependent Resistors (LDRs) to translate physical phenomena, such as light intensity, into measurable electrical signals. Additionally, the 100KR resistor may serve as a pull-up or pull-down resistor in digital circuits, ensuring stable logic levels and preventing floating inputs. Its high resistance value makes it suitable for applications requiring precise control of current flow or voltage division. Whether in sensor interfaces, signal conditioning circuits, or microcontroller inputs, the 100KR resistor contributes to the reliable and efficient operation of electronic systems, facilitating intelligent street light management and optimization of energy usage.

3.4 IR Sensor

The Infrared (IR) sensor is a versatile electronic component widely used in various applications, including street light management systems, due to its ability to detect infrared radiation emitted by objects or sources of heat. Consisting of an infrared emitter and receiver pair, the IR sensor operates based on the principle of reflection or interruption of infrared light beams. In street light management systems, IR sensors are strategically deployed to detect the presence or movement of vehicles, pedestrians, or objects in the vicinity of street lights. When an object passes within the sensor's detection range, it reflects or interrupts the infrared light beams, causing a change in the sensor's output signal. This signal variation is then processed by the system's microcontroller or processor to trigger appropriate actions, such as adjusting lighting levels or activating/deactivating street lights. With their ability to detect motion or occupancy in real-time, IR sensors contribute to energy efficiency, safety, and responsiveness in urban lighting infrastructure, enhancing overall system functionality and effectiveness.

3.5 Breed Board Power system

The Breed Board Power Supply represents a critical component in electronic systems, providing stable and reliable power to ensure the proper operation of various circuitry, including microcontrollers, sensors, and communication modules. Designed specifically for Breed Board applications, this power supply module typically incorporates features such as voltage regulation, current limiting, and overvoltage protection to safeguard sensitive components from damage and ensure consistent performance. With its compact form factor and efficient design, the Breed Board Power Supply seamlessly integrates into Breed Board configurations, powering essential functions such as data acquisition, processing, and communication. Whether deployed in IoT-enabled street light management systems or other embedded applications, the Breed Board Power Supply plays a pivotal role in facilitating the functionality, reliability, and longevity of electronic devices, contributing to the advancement of smart, interconnected ecosystems.

3.6 Breed Board Power Supply

The 9V 1A SMPS (Switched-Mode Power Supply) is a compact and efficient power supply unit designed to convert AC (Alternating Current) voltage from mains power sources into low-voltage DC (Direct Current) output suitable for powering electronic devices. With its switching topology, the SMPS efficiently regulates voltage and current levels, minimizing energy losses and heat generation compared to traditional linear power supplies. The 9V output voltage makes it suitable for a wide range of electronic applications, including microcontroller-based systems, sensors, and communication modules commonly found in street light management systems. The 1A output current rating ensures sufficient power delivery to drive these components reliably. Equipped with features such as overvoltage protection, short circuit protection, and thermal shutdown, the 9V 1A SMPS prioritizes safety and reliability, making it an ideal choice for powering critical electronics in various industrial, commercial, and residential settings. Its compact size and universal input voltage compatibility further enhance its versatility, allowing seamless integration into diverse electronic systems while optimizing space utilization and energy efficiency.

3.7 9V IA SMPS

The 9V 1A SMPS (Switched-Mode Power Supply) is a compact and efficient power supply unit designed to convert AC (Alternating Current) voltage from mains power sources into low-voltage DC (Direct Current) output suitable for powering electronic devices. With its switching topology, the SMPS efficiently regulates voltage and current levels, minimizing energy losses and heat generation compared to traditional linear power supplies. The 9V output voltage makes it suitable for a wide range of electronic applications, including microcontroller-based systems, sensors, and communication modules commonly found in street light management systems. The 1A output current rating ensures sufficient power delivery to drive these components reliably. Equipped with features such as overvoltage protection, short circuit protection, and thermal shutdown, the 9V 1A SMPS prioritizes safety and reliability, making it an ideal choice for powering critical electronics in various industrial, commercial, and residential settings. Its compact size and universal input voltage compatibility further enhance its versatility, allowing seamless integration into diverse electronic systems while optimizing space utilization and energy efficiency.

3.8 Ardino UNO

The Arduino UNO stands as a cornerstone in the realm of open-source microcontroller platforms, renowned for its accessibility, versatility, and ease of use. Featuring an ATmega328P microcontroller at its core, the Arduino UNO offers a robust computing platform capable of interfacing with a myriad of sensors, actuators, and communication modules, making it an ideal choice for prototyping and developing a wide range of electronic projects, including street light management systems. Its extensive array of digital and analog input/output pins enables seamless integration with sensors such as Light Dependent Resistors (LDRs), Infrared (IR) sensors, and motion detectors, facilitating real-time data acquisition and environmental monitoring. Additionally, its compatibility with a rich ecosystem of libraries and development tools streamlines the software development process, empowering users to implement complex algorithms, control logic, and communication protocols with ease. Whether deployed in educational settings, maker projects, or industrial applications, the Arduino UNO embodies the spirit of innovation and experimentation, empowering enthusiasts, students, and professionals alike to bring their ideas to life and contribute to the advancement of technology and automation.

3.9 Jumper Wires

Jumper wires serve as essential interconnection tools in the realm of electronics prototyping and circuit assembly, providing a flexible and convenient means of establishing electrical connections between various components, modules, and breadboard sockets. Typically consisting of flexible insulated wires terminated with male or female connectors at each end, jumper wires enable users to quickly and easily create custom wiring configurations without the need for soldering or permanent connections. This versatility makes jumper wires indispensable in prototyping environments, allowing for rapid iteration and experimentation in the development of electronic circuits. Whether used to connect microcontroller pins to sensors, bridge gaps on a breadboard, or link components across a circuit, jumper wires facilitate seamless signal routing, enabling designers, hobbyists, and students to bring their ideas to life with minimal effort and maximum flexibility. Additionally, their affordability, availability in various lengths and colors, and compatibility with a wide range of electronic components make jumper wires a staple tool in electronics workshops, classrooms, and maker spaces worldwide, empowering enthusiasts of all skill levels to explore, create, and innovate in the exciting world of electronics

3.10 Bluetooth HC-05

The Bluetooth HC-05 module represents a versatile and widely-used wireless communication solution in the realm of embedded systems and IoT applications. Featuring Bluetooth technology, the HC-05 module enables seamless and reliable wireless data transmission between electronic devices over short distances. Its compact form factor, low power consumption, and ease of integration make it an ideal choice for adding wireless connectivity to a wide range of projects, from home automation systems and wearable devices to industrial monitoring and control applications. Equipped with serial communication interfaces, the HC-05 module can be easily interfaced with microcontrollers such as Arduino, Raspberry Pi, or ESP32, allowing for seamless integration into existing electronics projects. With its support for various Bluetooth profiles and protocols, including Serial Port Profile (SPP) and Bluetooth Low Energy (BLE), the HC-05 module offers flexibility and compatibility with a diverse array of devices and communication protocols. Whether used for wireless data logging, remote control, or sensor data transmission, the Bluetooth HC-05 module empowers developers, hobbyists, and engineers to create innovative and connected solutions that enhance convenience, efficiency, and connectivity in the world of embedded electronics and IoT.

IV. WORKING SYSTEM

The working principle of the automated controller for the street light management system unfolds through a series of interconnected processes, driven by the continuous exchange of data and decision-making:

4.1 Data Acquisition

The process begins with the collection of real-time data from sensors deployed throughout the urban environment. These sensors capture environmental parameters such as ambient light levels, traffic density, pedestrian activity, and weather conditions, providing valuable insights into the operational context of street lighting.

4.2 Data Transmission

The collected sensor data is transmitted to the central control unit via the network layer. Utilizing secure communication protocols, the data is relayed to the central control unit in near real-time, enabling timely analysis and decision-making.

4.3 Data Processing and Analysis

Upon receiving the sensor data, the central control unit processes and analyzes the incoming information using advanced data analytics and machine learning algorithms. By correlating sensor data with predefined optimization objectives and user-defined parameters, the control unit generates actionable insights and lighting recommendations tailored to the prevailing conditions.

4.4 Decision Making

Based on the insights gleaned from data analysis, the central control unit makes informed decisions regarding street light management. These decisions encompass dynamically adjusting lighting levels, scheduling lighting patterns, and initiating proactive maintenance interventions to optimize energy usage, enhance operational efficiency, and ensure adequate illumination.

4.5 Actuation

Actuators embedded within street light fixtures enact the decisions and recommendations generated by the central control unit. By modulating the intensity of illumination or switching street lights on/off in response to changing environmental conditions, the actuators ensure optimal visibility while minimizing energy consumption and operational costs.

4.6 Monitoring and Feedback

Throughout this process, the system continuously monitors environmental conditions, operational metrics, and performance indicators. Feedback loops enable iterative optimization and refinement of decision-making algorithms, ensuring adaptability to evolving user requirements and environmental dynamics.

4.7 Proposed System

The proposed system represents a paradigm shift in street light management, leveraging the transformative capabilities of Internet of Things (IoT) technology to create a more intelligent, adaptive, and sustainable lighting ecosystem. At its core, the system comprises a comprehensive network of interconnected devices, including sensors, actuators, and a central control unit, orchestrated to seamlessly integrate data acquisition, analysis, decision-making, and actuation processes. The sensor network forms the sensory fabric of the proposed system, encompassing a diverse array of sensors deployed strategically throughout the urban environment. These sensors capture a wide spectrum of environmental parameters, including ambient light levels, traffic density, pedestrian activity, weather conditions, and air quality. By collecting real-time data from the surrounding environment, the sensor network provides invaluable insights into the dynamic factors influencing street lighting operations. At the heart of the system lies the central control unit, a sophisticated computing platform endowed with advanced data analytics, machine learning algorithms, and decision-making capabilities. The central control unit serves as the brain of the system, processing incoming sensor data, analyzing environmental conditions, and generating actionable insights and lighting recommendations. Through iterative learning and optimization, the control unit continuously refines its algorithms to adapt to changing circumstances and user preferences. Actuation mechanisms, comprising actuators embedded within street light fixtures, translate the decisions and recommendations generated by the central control unit into tangible adjustments in lighting levels. These actuators enable dynamic control over individual or groups of street lights, allowing for precise modulation of illumination based on real-time requirements and optimization objectives.A key advantage of the proposed system is its ability to enable remote monitoring and control of street lighting operations. Through cloud-based connectivity and user interfaces, stakeholders such as municipal authorities, maintenance crews, and energy managers gain real-time visibility into system performance, operational metrics, and energy usage patterns. Remote control capabilities empower stakeholders to adjust lighting schedules, set optimization parameters, and diagnose issues remotely, enhancing operational efficiency and responsiveness.Furthermore, the proposed system is designed to seamlessly integrate with broader smart city ecosystems, enabling synergistic interactions with other urban infrastructure systems such as traffic management, public safety, and environmental monitoring. By sharing data and insights across interconnected systems, the proposed system contributes to holistic urban optimization efforts, fostering a more efficient, resilient, and livable urban environment. The working model for the given proposed system is as shown in the figure 1.

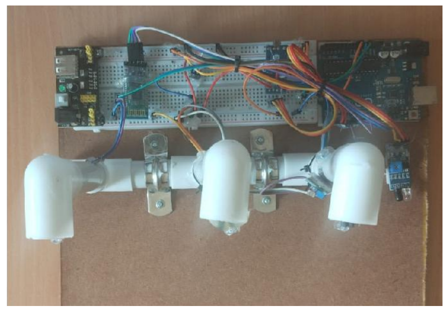

Figure.1 Working model for the proposed system

V. CONCLUSION

In conclusion, the Automated Controller of Street Light Management System (IoT) project represents a significant step forward in the realm of urban infrastructure management. By leveraging Internet of Things (IoT) technology, the project has demonstrated the potential to revolutionize street lighting operations, enhancing efficiency, sustainability, and overall functionality. Through real-time data acquisition, analysis, and dynamic control mechanisms, the system optimizes energy usage, ensures adequate illumination, and proactively addresses maintenance issues, contributing to cost reduction, environmental sustainability, and enhanced public safety. Looking ahead, the project's future scope encompasses further advancements in machine learning, edge computing, renewable energy integration, and broader smart city integration, promising even greater efficiency, scalability, and resilience in urban infrastructure management. As cities worldwide strive to embrace innovation and sustainability, the Automated Controller of Street Light Management System (IoT) project serves as a beacon of progress, paving the way for smarter, more connected, and livable urban environments.

REFERENCES

[1]. PayalRodi, LeenaChandrakar, SayleeGindeSivanantham S and Sivasankaran K, “Energy Conservation using Automatic Lighting System using FPGA”, International Confernece on Green Engineering and Technologies, 2015.
[2]. Deepak KumarRath,” Arduino Based: Smart Light Control System”, International Journal of Engineering Research and General Science Volume 4, March- April, 2016.
[3]. Gouthami. C, Santosh. C, A. Pavan Kumar, Karthik. A, and Ramya.K.R, “Design and Implementation of Automatic Street Light Control System using Light Dependent Resistor”, International Journal of Engineering Trends and Technology (IJETT) – Volume 35 Number 10 - May 2016.
[4]. Ahmed ShariqueAnees, Anupriya, AyushyChowdhary,ShaliniDubey and ShwetaVerma, “Solar Powered Led Streetlight With Automatic Intensity Control”, International journal of innovative research in electrical, electronics, instrumentation and control engineering, Vol. 3, June 2015.
[5]. Prof.K.Y.Rajput, GargeyeeKhatav, Monica Pujari and PriyankaYadav, “Intelligent Street Lighting System Using Gsm”, International Journal of Engineering Science Invention, March, 2013.
[6]. S. Suganya, R. Sinduja, T. Sowmiya and S. Senthilkumar, “Street light glow on detecting vechile movement using sensor”, International journal for advance research in Engineering and technology, 2014.
[7]. SanalMalhotra1 and Shiv Taneja, “Automatic Brightness Control Using LDR Sensors”, Advanced Research in Electrical and Electronic Engineering, 2014.

[8]. ChKavitha, Swathi, Satyaprakash and Vinitha, “Solar Powered LED Street Lighting with Auto Intensity Control”, International Journal of Scientific & Engineering Research, July, 2016.

[9]. Parkash, Prabu V and DanduRajendra, “Internet of Things Based Intelligent Street Lighting System for Smart City”, International Journal of Innovative Research in Science Engineering and Technology, May, 2016.

[10]. ThinaharanRamachandran,VasakiPonnusamy, Low Tang Jung, AnangHudaya “ZigBee Wireless Communication for Monitoring Renewable Street Light System ”2014 IEEE Journal.

[11]. Prof. V. K. Bhangdiya “Low Power Consumption of LED Street Light Based on Smart Control System”2016 International Conference on Global Trends in Signal Processing, Information Computing and Communication