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INTRODUCTION

Most of the smart cities are associated with a huge number of software applications and network devices that interlinks to the physical and social space, these applications are ranging in many activity fields like in Health care, Agriculture, Home, Infrastructure, city services, Mobility etc., The interoperability of various entities or devices work together to solve the problems collaboratively and through a policy-based agreements. There are numerous challenges are involved in the smart cities like growth, safety and sustainability. These challenges are to be achieved with the distributed systems through knowledge institutions with authenticated communication networks.

The building blocks of ICT with emerging technologies are very much essential for the growth of smart cities in reference to the energy management. Street lighting is a basic essential to ensure safety in urban areas, and enhance the quality of life. In a country like India, installation of street lighting in rural and remote villages has always played a key role in the development and improvisation of the country, decreasing the crime rates and increasing the mobility. Street lighting plays a crucial role in improving the safety of pedestrians, drivers and riders. However, the brightness required at different times of night is different and employing a system to manage the same can result in energy savings and provide cost benefits to municipalities and corporations. For instance, the brightness required during midnight is less compared to that required during the evening. The duration of the day and night varies with season, due to which although the time of switching on remains the same, the intensity has to increase gradually and not drastically.

In metropolitan cities, with an increase in pollution, visibility during the early dawn may decrease on the roads and highways, which requires more intensity of lights for better vision and decreased accidents. There are other numerous factors which require modulation of the brightness depending upon the time. The LED automated street light management system controls brightness or intensity of the light at different times of the night without any manual intervention. Statistics show that street lighting, including maintenance represents about 40 percent of the total expenditure of a community.

1.1 Smart city

The economic growth and opportunities are found in the development of smart cities through the ICT tools and Industry 4.0 technologies [3], [4]. However, there are huge opportunities and challenges are found in the growth of sustainable development and urbanization, shown in the Figure 1. Some of the challenges on the components of Smart cities are:

(i) Connectivity and configuration of various devices and its applications

(ii) Data analytics, prediction strategies, forecasting, development and deployment of AI based algorithms

Figure 1.1: Components of Smart city

1.1.1 Smart Homes

Huge number of applications is found in smart homes like security, care for elderly people, fire protection, water supply, energy saving, communication networks in case of emergency, waste management and ease of access for societal needs.

1.1.2 Smart Industry

Industrial automation found in a new shape with the revolutionary developments of Industry 4.0 technologies, such as applications based on Artificial Intelligence algorithms, cloud computing, Machine-2-Machine, Industrial IoTs, cyber security etc., These technologies are much required for the growth of Smart industry in terms of energy saving methods, ease of transportation system for dispatching the goods, fire safety, health care system in emergencies and administration systems.

1.1.3 Smart Infrastructure

The challenges of smart infrastructure involve strong monitoring and maintenance system for roads, bridges, traffic systems, drainage and garbage systems, smart energy with EV charging stations.

1.1.4 Smart transportation

Smart transportation with smart vehicles has many challenges in parking management, parking slots, traffic signaling systems for smooth flow of vehicles to avoid congestion, navigational and GPS technologies on roads like closed-circuit television systems (CCTVS). This can lead to improvements in safety, network management, traffic congestion, environmental performance, accessibility, convenience and public perception.

1.1.5 Smart Health Systems

The IoT based health systems are suitable in collection of data over time, enable preventive care of the patients and also, understand the type of therapy on patient.

The wireless IoT has several advantages:

(i) It gives better understanding of the patient health status rather than attending patients to health care.

(ii) The sensed data can be analyzed with smart algorithms, thus reduces the latency and costs.

(iii) The sensed data can be shared to health professionals for better recommendations to the patients.

There are certain challenges are found in health care system:

(i) Continuous monitoring the data from routers or gateways.

(ii) Storing the data in cloud service providers.

(iii) Development of smart algorithms for various patients.

1.2 Street light

Figure 1.2: Street light

A street light is a raised source of light on the edge of a road or path. Similar lights may be found on a platform. When urban electric power distribution became ubiquitous in developed countries in the 20th century, lights for urban streets followed, or sometimes LED.

The complexities of transportation infrastructure mean varying types of illumination are needed to ensure traffic flows smoothly, people feel safe, and cities save on costs. Smart LED street lighting is a cost-effective and sustainable choice for cities today – and into the future.

Here the pole height will depend upon pole type used: If the pole is concrete type, then, height of the pole will be about 8 meters. If the pole is ornamental type, then, height of the pole will be about 7 meters. The distance between pole will be around 12meters-35/40meters, On an average 30 meters.

Streetlights consume huge amount of power. Because, there was no automation in this field, there always require a human being to turn ON/OFF the lights according to the need of light. If the person employed for this work is absent then it would lead to huge amount of wastage of energy.

There are some cases in which lights have pre-set time for turning ON/OFF light and if due to some reason timer is not working in a proper way then it would take time to fix it because, it has long procedure of complaining then working to resolve this issue. Currently LED's are used to provide luminance and less power consumption as compared to halogen lamps, mercury lamps etc.

Another disadvantage is the dependency on battery system. If the battery is not working in proper manner or get damaged then the whole system needs to be replaced. So, for the energy conservation we require a new technology to overcome the above mentioned difficulties. This can be done by CCMS (Centralized Control Monitoring System).

1.3 Centralized Control Monitoring System(CCMS)

The CCMS is an advanced smart lighting control solutions for LED street lighting in the smart cities than in co-operates the ICT technologies. The main objective of CCMS to make the LED lighting system more reliable, efficient and flexible configuration, also, each CCMS access the data from 15 to 18 street lamps. The system accesses the data with Radio Frequency based technology which is transmitted the clod through GPS/GPRS. The data is analyzed with web enabled system for remote monitoring and controls the street lighting with auto ON/OFF based on the geographic location shown in Figure 2 and almost 70

1.3.1 Global System For Mobile Communication(GSM)

GSM in Wireless Communication stands for Global System for Mobile Communication. GSM is an open and digital cellular technology used for mobile communication. It uses 4 different frequency bands of 850 MHz, 900 MHz, 1800 MHz and 1900 MHz. It uses the combination of FDMA and TDMA. This article includes all the concepts of GSM architecture and how it works. GSM is having 4 different sizes of cells are used in GSM:

(i) Macro: In this size of cell, Base Station antenna is installed.

(ii) Micro: In this size of cell, antenna height is less than the average roof level

(iii) Pico: Small cells' diameter of few meters.

(iv) Umbrella: It covers the shadowed (Fill the gaps between cells) regions.

1.3.2 Features of GSM

(i) Supports international roaming

(ii) Clear voice clarity

(iii) Ability to support multiple handheld devices.

(iv) Spectral / frequency efficiency

(v) Low powered handheld devices.

(vi) Ease of accessing network

(vii) International ISDN compatibility.

(viii) Low service cost.

(ix) New features and services.

1.3.3 GSM security

(i) GSM offers several security using confidential information stored in the AUC and in the individual SIM.

(ii) The SIM stores personal secret data and is protected with a pin against unauthorized use.

1.3.4 Advantages of GSM

(i) Compatibility: GSM is widely used around the world, so it is compatible with many different networks and devices.

(ii) Security: GSM offers enhanced security features such as authentication, encryption and confidentiality, which helps to protect the user's privacy and data.

(iii) Efficient use of bandwidth: GSM uses a time-division multiplexing (TDM) technique which enables many users to share the same frequency channel at different times, making it an efficient use of the available bandwidth.

(iv) Roaming: GSM allows users to roam internationally and use their mobile phones in other countries that use the same GSM standard.

(v) Wide range of features: GSM supports a wide range of features, including call forwarding, call waiting, voicemail, conference calling, and more.

1.4 Scope of the Project

(i) Development of smart cities.

(ii) Energy conservation for future.

(iii) LEDs are eco-friendly as it avoids greenhouse gas emission to the environment.

1.5 Objectives

(i) To study the streetlighting using CCMS.

(ii) Power saving and Forecasting analysis using real time data

LITERATURE REVIEW

1. **Badri Narayan Sahoo, Jeeban Jyoti Mahakud, Priyabrata Pattanaik, "Automatic Street Light Control System".**

   This paper is concerned with the automation in street lighting system. The projected work describes the automatic working of street lights according to seasons and timing of a day. The system comprises of microcontroller, GPS, RTC to implement the work. Projected work overcomes the drawbacks of previous systems like is error in timing, by using the information about time with the help of GPS. Microcontroller takes the data and accordingly operation of lighting on/off is performed. RTC comes into action in case of any interruption. The system works without any operator. The developed have some advantages like energy saving as lights are on according to timings and increase in life of luminaire.

2. **Prof. M. P. Gajare, Abhijeet Deshpande, Laxman Aulwar, "IOT based Streetlight Automation System".**

   This paper is concerned about a Street light, lamppost, street lamp is a raised source of light on the edge of a road or walkway, which is turned on or lit at a certain time every night. Major advantages of street lighting include: prevention of accidents and increase in safety. Studies have shown that darkness results in many crashes and fatalities, especially those involving pedestrians; pedestrian fatalities are near to 7 times more likely in the dark than in daylight. Street lighting has been found to reduce pedestrian crashes by approximately 50 percent. A street light control system is to be developed to control and reduce energy consumption of a town's public lighting system. These range from controlling a circuit of street lights and/or individual lights with specific ballasts and network operating protocols. These may include sending and receiving instructions via separate data networks, at high frequency over the top of the low voltage supply or wireless. Various protocols are to be developed as well as compatible hardware for most types of lighting. The control Centre will deal with the data so that it can know the situation of each streetlight. As per the result the control Centre gives orders to each streetlight to control the switch state and illumination of them.

3. **Abbas Shah Syed, Daniel Sierra-Sosa, Anup Kumar and Adel Elmaghra by, "IoT in Smart Cities: A Survey of Technologies, Practices and Challenges"**

   This presents that Internet of Things (IoT) is a system that integrates different devices and technologies, removing the necessity of human intervention. This enables the capacity of having smart (or smarter) cities around the world. By hosting different technologies and allowing interactions between them, the internet of things has spearheaded the development of smart city systems for sustainable living, increased comfort and productivity for citizens. The IoT for Smart Cities has many different domains and draws upon various underlying systems

for its operation. In this paper, we provide a holistic coverage of the Internet of Things in Smart Cities. We start by discussing the fundamental components that make up the IoT based Smart City landscape followed by the technologies that enable these domains to exist in terms of architectures utilized, networking technologies used as well as the Artificial Algorithms deployed in IoT based Smart City systems. This is then followed up by a review of the most prevalent practices and applications in various Smart City domains. Lastly, the challenges that deployment of IoT systems for smart cities encounter along with mitigation measures.

4. **Bhagya Nathali Silvaa , Murad Khanb , Kijun Hana, "Towards sustainable smart cities: A review of trends, architectures, components, and open challenges in smart cities"**

   Smart city is an application of Internet of Things (IoT) notion. Unceasing growth of population and urbanization have intensified innovative ways to handle urbanization with minimal impact on environment, citizen lifestyles, and governance. Initial integration of information communication technology (ICT) into city operations have promoted telicity, information city, and digital city concepts. Later, the conception of IoT has founded the smart cities, which support the city operations intelligently with minimal human interaction. Smart city emerged as a solution to address the challenges arise with exponential growth of urbanization and population. However, smart city concept is still evolving and not mainstreamed throughout the globe due to technological, economical, and governing barriers. Therefore, this paper aims to deliver the essence of smart cities. The paper presents a brief overview of smart cities, followed by the features and characteristics, generic architecture, composition, and real-world implementations of smart cities. Finally, we present some challenges and opportunities identified through extensive literature survey on smart cities.

5. **M. Sajid Khan, Mina Woo, Kichan Nam and Prakash K. Chathoth, "Smart City and Smart Tourism: A Case of Dubai"**

   This paper presents the advent of new technology has brought about the emergence of smart cities aiming to provide their stakeholders with technology-based solutions that are effective and efficient. Insofar as the objective of smart cities is to improve outcomes that are connected to people, systems and processes of businesses, government and other public- and private-sector entities, its main goal is to improve the quality of life of all residents. Accordingly, smart tourism has emerged over the past few years as a subset of the smart city concept, aiming to provide tourists with solutions that address specific travel related needs. Dubai is an emerging tourism destination that has implemented smart city and smart tourism platforms to engage various stakeholders. The objective of this study is to identify best practices related to Dubai's smart city and smart tourism. In so doing, Dubai's mission and vision along with key dimensions and pillars are identified in relation to the advancements in the literature while highlighting key resources and challenges. A Smart Tourism Dynamic Responsive System (STDRS) framework is proposed while suggesting how Dubai may able to enhance users' involvement and their overall experience.

6. **Shiann Ming Wu, Tsung-chun Chen, Yenchun Jim Wu and Miltiadis Lytras "Smart Cities in Taiwan: A Perspective on Big Data Applications"**

   In this paper, we discuss the concept of a smart city based on information and communication technology (ICT), analyze the objectives of smart city development in Taiwan, and explain the supporting technologies that make such development possible. Subsequently, we propose a hierarchical structure framework of smart city systems with levels of complexity ranging from low to high and interconnections and interactive relationships in five dimensions: the Internet of Things (IoT), cloud computing, Big Data, Mobile Network, and smart business. We integrate each key resource of the core operation systems of cities to promote the innovative operation of

cities and further optimize city development. We then propose a Big Data platform data flow framework that uses information from ubiquitous sensor networks and information equipment to analyze the Big Data application process of smart cities and determine the resulting advantages and challenges. Additionally, we analyze the current state of development of smart cities in Taiwan. Finally, we discuss a new philosophy of smart city development and provide a practical blueprint for the formation, operation, and development of the smart cities with the aim of creating a bright future for the smart cities of Taiwan.

7. **Revathi.M, Ramya.S, Sathiyavathi.R, B.Bharathi and V. Maria Anu "Automation of Street Light For Smart City"**

   Energy consumption in metropolitan cities is increasing day by day. In every city, considerable amount of electricity is being used for the purpose of street lighting system. Some areas of the city may have low frequency of passerby, but it's observed that the amount of energy the street lights consume in these areas is same as that of areas with high frequency passerby. As a result enormous amount of energy is wasted without being used. In the proposed system, high intensity discharge lamps are replaced by LED's which can alter its intensity based on the need. Movement of vehicles is sensed using LDR (Light Dependent Resistor) and the intensity of the street light is reduced when not in use. The system also detects fault in the system and indicates it to the base station using GSM (Global System for Mobile communication) technology by sending SMS (short message service)

8. **Konard Henry, "Intelligent Street Lighting in a Smart City"**

   Intelligent Street Lighting System aims that to design and implement the advance development in the embedded system for energy efficient of street light. Currently we have a manual system which are automatically turn on and off, when there is no light detection, it becomes on mode and automatically turn off mode when it detects the light. With this the electrical energy will be wasted for some amount. This paper gives the solution for energy consumption. The smart street light system consists of AVR microcontroller, LED lights, Ultrasonic sensors, LDRs, solar panels and short-distance communication networks. The LDR sensor is used to sense the intensity of the light and the ultrasonic sensors are used to sense the object under the street pole. When object detects under the pole the light will glows with 100 percent brightness otherwise the light will remain in dim. This is done by sensing and approaching a vehicle using a real time ultrasonic transmitter and Receiver couple. Upon sensing the movement of the vehicles, the sensor will transmit the data to the microcontroller which furthermore the Light to switch ON otherwise it will be in dim. If the pole or bulb gets damaged it automatically send the message to the remote user through the Bluetooth. Automated switching reduces the energy consumption up to 55

CENTRALIZED CONTROL MONITORING SYSTEMS (CCMS)

3.1 Centralize control and monitoring system

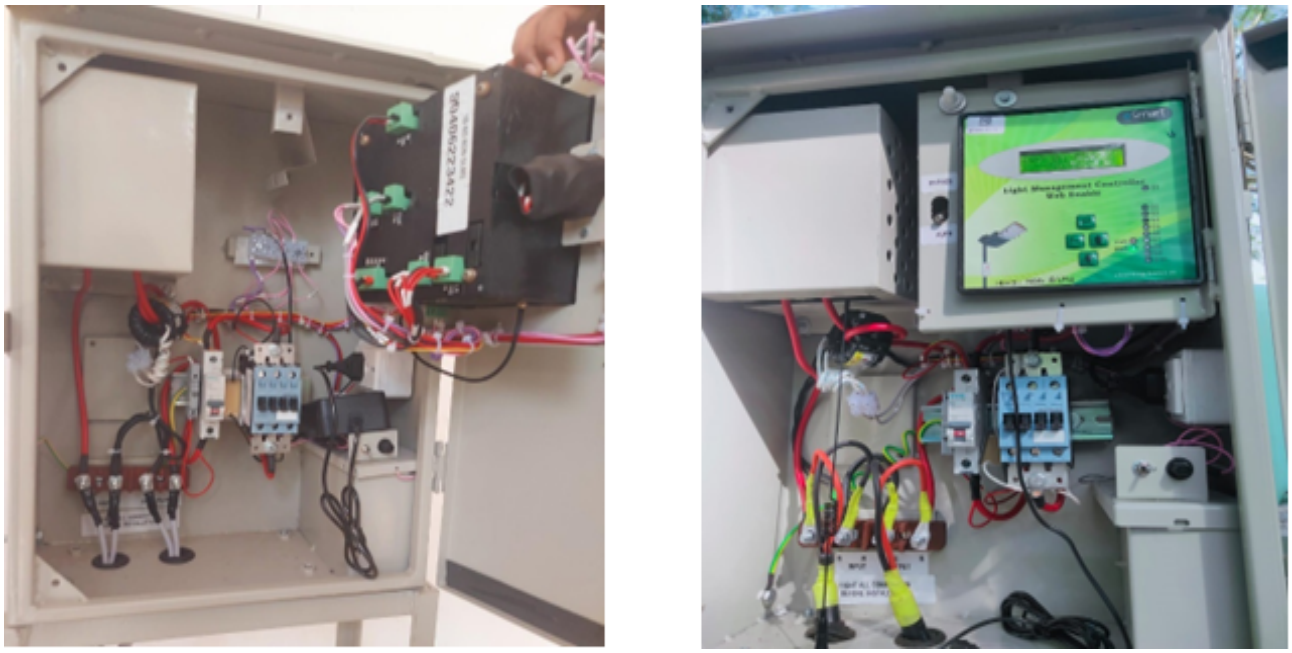


Figure 3.1: CCMS (Centralize control and monitoring system)

A CCMS is a GSM/2G/3G/4G equivalent proven technology installed in a feeder or switching point for remote monitoring and controlling a group of lights. The basic advantage of CCMS panel system is that one can control or monitor the entire city lights in one place. It is grouping wise central monitoring system. Group Controller is an Automatic light control throughout the year on basis of precise sunrise and sunset time depending on the geographical location. It performs reporting of energy metering and failure information to central control station at variable time intervals. It achieves instant fault reporting via SMS along with fault information and details of location. Group Controller has built in astronomical feature with high precision real time clock.

CCMS has self-protection from:

(i) Over load protection

(ii) Short circuit protection

(iii) Auto rectification for nuisance MCB Trips

(iv) Tolerant to input voltage fluctuations

(v) Surge protection up to 40 KA

(vi) Astronomical / Photo cell / Configurable ON/OFF timings

(vii) Event notification for faults

(viii) IP65 / IK10 Enclosure

(ix) Type tested from NABL accredited Lab

CCMS has 2 years backup data. Every 15minutes data will be updated. It Generates automatic reports on performance and energy saving. The data can be fetched from the CCMS wireless system and can be accessed in the data centers through a cloud server for forecasting and scheduling the lights based on sun set/rise.

3.2 Technical Specifications

Configuration I: System with communication system and centralized control and monitoring (cluster / group control)

Features: Controller and Metering unit.

(i) Schedule the timing of lights. (pre-programmed based on astronomical clock or on field or through central control)

(ii) ON / OFF Switch. (on field or centrally)

(iii) CCMS System to Capture the energy usage and other parameters at predetermined interval and store data for 30 days.

(iv) Ability to connect with a communication device.

(v) Ability to download data in field.

(vi) System protection against surges.

(vii) Ability to upgrade firmware on field using a communication device Enclosure.

(viii) Enclosure should be made of fire retardant FRS/ SMC material and with impact resistance of IP 55.

(ix) Dimensions of the enclosure box should be such as there should be adequate space to access components of the box for R and M purpose. The vendor must also ensure at least 20 percent space is left in the box for future up-gradation/devices to be added.

(x) The enclosure box must have a standard lock which cannot be opened by commonly available tools.

3.2.1 Communication Module

(i) Ability to communicate securely with via cellular networks (GSM / GPRS) and/ or RF networks

(ii) Communication technology between CCMS unit and central server should be 3G/4G hardware device which should be capable to run 2G/3G/4G as per availability in the site.

(iii) Two-way communicator

(iv) Ability to send data regarding energy usage, ON/OFF status etc. from controller

(v) Ability to give commands from a central level for switching ON/OFF scheduling etc.

(vi) The software for CCMS UI should have provision for providing dimming in case same is provided in the lights.

(vii) Ability to remotely upgrade the CCMS device firmware from central server.

3.2.2 Software

(i) A web-based / mobile based software package with a detailed information dashboard.

(ii) Ability to show the status of each controller on the dashboard.

(iii) Inter-operability of all support services related to CCMS units.

(iv) Ability to schedule and switch ON/OFF controllers remotely through the dashboard.

(v) Reports in form of matrix as well as graphical representation.

(vi) Incorporate logics to determine fault detection at switching point level and power thefts and execute a user defined Standard Operating procedure to aid in issue remediation.

3.2.3 Hardware

Server uptime should be minimum 99.99 percent with disaster backup and sufficient storage capacity and processing power to ensure stable operation of CCMS throughout the contract period. Maintenance of the server and software is the responsibility of the vendor.

3.2.4 Basic features of CCMS Panel

Easy to install due to wireless connectivity. Lights can be controlled as ON/OFF from any central office via computer and mobile. Easy data monitoring and data analysis. The advanced dimming solution, so can save more energy. Some parameters like current and voltage limitation can be analyzed on the existing system. Proper illumination gives better uniformity on the roads, leading to increased safety levels on the road. Reduces the wastage of electricity. Ease of installation due to the wireless system. Data compilation, analysis, and reporting are easy.

Table 3.1: Basic features of CCMS Panel

Sl.No	Items	Specified Operating Range
1.	Connection type	System for Single Phase/Three Phase Switching points
2.	Voltage	240 volts P-N (+20% to -40% Vref) on each phase
3.	Current	05 - 63 A for each phase (Withstands 120% Imax),Starting current0.2%Ib
4.	Frequency	50Hz ±5% (47.5 to 52.5)Hz
5.	Power factor	Zero(lag)-Unity-Zero(Lead)
6.	Accuracy	1.0
7.	Withstand voltage	440V up-to 5 minutes between Phase – Phase
8.	rating	Rating of the CCMS units for each phase (including rating of safety equipment's - MCB, Relay, etc.) should be - 1. For 30% quantity of CCMS units in a ULB- 3 KW connected load is to be considered 2. For 10% CCMS Units in ULB - 5 KW connected load to be considered 3. For 20% CCMS Units in ULB – 7.5 KW connected load to be considered 4. For 20% CCMS Units in ULB - 10 KW connected load to be considered 5. For remaining 20% CCMS Units in ULB - 15 KW connected load is to be considered.

3.2.5 Specifications

Single phase (240 Volt P-N, Whole Current, Class 1.0) or a Three phase system (Wires 3 * 240 Volts P-N, Whole Current, Class 1.0) electronic controller and energy controller compiled as per IS: 13779 and CBIP-88 with add on MCB. Single phase or Three phase system electronic controller and energy controller compiled as per IS: 13779 and CBIP-88 with add on MCB. Rating of the CCMS units for each phase (including rating of safety equipment's - MCB, Relay, etc.) should be

(i) For 30 percent quantity of CCMS units in a ULB- 3 KW connected load is to be considered

(ii) For 10 percent CCMS Units in ULB - 5 KW connected load to be considered

(iii) For 20 percent CCMS Units in ULB – 7.5 KW connected load to be considered

(iv) For 20 percent CCMS Units in ULB - 10 KW connected load to be considered

(v) For remaining 20 percent CCMS Units in ULB - 15 KW connected load is to be considered.

Controller is also compatible for remote communication using GPRS/GSM modem for operations like controller data downloading, and relay ON-OFF for maintenance purpose. Controller Records events like supply ON-OFF and relay ON-OFF for analysis etc. The controller should be type tested in a NABL certified Lab.

The controller should be interfaced with a communication module which would wirelessly transmit data recorded to a dedicated server or on cloud-based architecture. The communication module also relays commands to schedule and control the cluster of street lights.

3.3 Functional Specifications

1. **Data**

   The CCMS unit Should be able to capture (record) and provide following parameters at variable time intervals.

(i) Cumulative Active Energy

(ii) Average Power Factor

(iii) Power on hours

(iv) Monthly Load on/off Controller has the provision to store last 30 days data at one hour interval.

All these data is accessible for reading, recording by downloading through HHT (Hand Held Unit) through optical port or USB/Bluetooth given on controller front. For HHT, a smartphone-based solution for collecting/accessing data is also acceptable.

2. **RTC**

The controller has a built-in calendar clock, having an accuracy of +/- 1 minute per year or better, however meter may confirm to accuracy as per IS 13779. A separate internal Lithium battery back-up is provided for continuous operation of controller RTC for at least two years under controller un-powered conditions.

3. **Tampers**

Following tampers are logged with occurrence and restoration in FIFO manner:

(i) Low Load

(ii) Over load

(iii) Low Power Factor

(iv) Under voltage

(v) Over voltage

(vi) Magnet

4. **Astronomical Calendar for switching Operation**

On the basis of latitude and longitude of the installation for place controller itself decides switch on –off timings.

5. **Switch on –off operation events**

Switching events with the following reasons will be logged :

(i) Timed operation- As per astronomical calendar

(ii) Unscheduled operation – In maintenance mode

(iii) Event based like on over current ,overload switching Last 20 events will be logged in controller.

6. **Communication**

Controller stored data can be downloaded through its optical port or USB using HHT (Hand held Unit) or directly by Laptop using Base computer software. Controller should be able to interface with the communication module through a serial port

3.3.1 Display and keypad

(i) LCD (Six Digits, 10mm*5mm, 40” UHD) is provided to display the controller parameters

(ii) A keypad/ optical/ USB port/ Bluetooth/ suitable interface should be provided to access the information stored in the module and system programming

(iii) Hand Held Unit should be universal have a provision for secure login.

3.4 Constructional specifications

(i) Latching Relay/Bi-Stable Switch/Isolation device

(ii) Should conform to IEC - 61036/ 61037

(iii) Contactor confirming to relevant IEC/IS

3.4.1 Standard Polycarbonate Box – Enclosure

(i) Enclosure should be made of fire retardant FRS/ SMC material and with impact resistance of IK10. Dimensions of the enclosure box should be such as there should be adequate space to access components of the box for R and M purpose. The vendor must also ensure at least 20 percent space is left in the box for future up-gradation/devices to be added.

(ii) The enclosure box must have a standard lock which cannot be opened by commonly available tools Wiring inside the enclosure box should be done neatly with proper use connectors and numbering with use of Ferrule PVC Tube.

(iii) The enclosure should have theft control mechanism and generate alerts when opened or if the unit experiences motion of any kind beyond a configured threshold.

3.4.2 Miniature Circuit Breaker

(i) Should conform to IEC62053/62054

(ii) MCB along with design for protection and auto-recovery/self-healing is accepted.

Features:

(i) Remote ON/OFF in case bad weather, maintenance or emergency.

(ii) Remote RTC Synchronization of Street Light Controller.

(iii) Communication should be encrypted by 128-bit encryption.

(iv) Alert message in pre-defined abnormal system conditions through SMS (5 numbers) and mobile/web-based application through GSM/GPRS/RF for:

(*) Phase-wise currents on crossing threshold values

(*) Phase-wise voltages on crossing threshold values

(*) MCB trips

(*) Theft alerts

(*) Group failure of lights

(*) No output supply

3.5 Web based software

Central Control and Monitoring System functionalities:

(i) CCMS shall have a web-server to receive and record all data from the streetlight controllers.

(ii) The Main page of software to shows real-time information about the cumulative load, number of faulty lights, total number of lights on/off (uptime percent), number of faulty lights, number of faulty switching points.

(iii) A separate tab in the software to show the list of CCMS units installed in the project area along with the meter parameters being showcased against each CCMS Unit.

(iv) Alert in case of fault – describing the fault. Along with colour coding for unresolved faults based on time. Eg. One colour for fault which is unresolved since 0-12 hours, different colour for 12-24 hours and so on and so forth.

(v) A separate tab in the software to show the switch point summary which showcases the meter parameters, active alerts, link to the map page, etc.

(vi) A separate tab in the software for - monitoring and controlling, Alerts, Maps, Configuration page, Reports – uptime, fault penalty, history, energy savings, power failure, operational hour, lamp failure. The server should display the faulty lights in each phase separately, instead of giving a total figure of faulty lights for all the 3 phases together.

(vii) It should be able to communicate with any individual switching points or collectively amongst networked switching points for control and monitoring.

(viii) It should able to record, by association to a switch point, glowing and nonglowing hours of a group of LED luminaires attached to a particular switching point.

(ix) It should be able to display the power failure details of a particular switching point.

(x) It should register all fault conditions like excess voltage/current drawn, lamps failure (by association to a significant drop in consumption), no-power supply, etc. through the instantaneous alert messages sent by the CCMS unit.

(xi) It can generate MIS reports in Matrix as well as in Graphical format based on Power supply status, Energy Consumption, Over/Under Voltage/Load, System parameter / controllers i.e. Voltage, Current, Power factor, Cumulative kWh/kVAh for individual switching points

(xii) It should be able to track the failure of lamps in a particular switching point by triggering alarm due to significant drop in power consumption.

(xiii) Different user authorization levels should be settable and the central server should be capable of handling high traffic.

(xiv) GIS Mapping should be done covering all switching points and the details of each switch point shall be viewable in the web application software through a Google-map interface or web based digital map.

(xv) All the CCMS units should be remotely configured from the Central Control Unit:

(*) Setting new ON/OFF timings.

(*) Setting the RTC time of Automation unit.

(*) Knowing the current status of any particular switching point.

(*) Reset the unit.

(*) The minimum interval for the update of data should be 15 minute but programmable up to 1 minute.

(xvi) Auto synchronization of controller with server timing to be further synchronized with standard GPS clock timing.

(xvii) Further system is able to indicate various faults

(*) Failure of lights (by association to a drop in power consumption against a set benchmark)

(*) Failure of contactor

(*) Status of the incoming supply (power failure)

(*) High /low voltage

(*) Overload on the phases

(xviii) System to report Jamming/ hacking attempts and maintain status-quo in case of Jamming/ hacking attempts i.e. if lights are ON, they should remain ON till the default OFF time recorded in the system. In case lights are OFF at the time of Jamming attempt/ hacking, lights should remain OFF till default ON time recorded in the system.

(xix) Software to have asset management features for tracking of each street light, unique asset tag no., make, wattage, date of installation, date of replacement, reason forreplacement.

(xx) Software to have complaint handling system for light failures, with citizen interface and means of communicating repair update to complaining citizen through SMS.

(xxi) Ability to remotely upgrade the CCMS device firmware from central server.

3.6 Hardware, Security and Other features

(i) Each central CCMS unit is capable of handling minimum 5000 number switching point units.

(ii) CCMS shall have server preferably dedicated server set-up or cloud based arrangement to ensure 100 percent guarantee of the data transmission and real time data storage for last 2 years (24 Months) and archived data to 7 years for the contract period.

(iii) Data authenticity and validation has to be ensured.

(iv) Cyber security, safe database management, data retrieval and trouble free operation of software and allied systems (24×7) to be ensured.

(v) One dedicated or multiple display screen of UHD Resolution each of 32” size at urban utility and KELTRON project office at Delhi or any other suitable place for monitoring of CCMS operation.

(vi) Maintain a TOLL-FREE nos. to lodge a complaint by utility Officials/Public in respect of system problems.

3.6.1 Astronomical Timer for Streetlight Application

For Streetlights which are not connected in dedicated Streetlight Phase.

Features

(i) Latitude / longitude precise to the minute with time zone.

(ii) Sunrise / sunset on-off.

(iii) Set-time on-off (where client can feed the on-off time as per requirement)

(iv) 6 years battery reserve or equivalent power backup.

(v) MCB of rating suitable for connected luminary.

3.7 CCMS features and technical specifications

Table 3.2: Technical specifications of CCMS

Specification Single/Three Phase	12A/24A/32A
Rated input voltage	240V415AC,50Hz
KVA Rating	3KVA/9KVA
Current Rating	12A/24A/32A(Single Three Ph)
Connection	Single phase 2 wire/4 wire
Remote Connection	GSM/GPRS Web Enable
Energy Saving Mode	3 Modes
Mounting	Pole/Foot Mounted
Ingress Protection	IP55
Operating Temperature	-10C to +55C
Dimension L X W X H	345X410X880mm
Protection	MCB for Short Circuit Overload

3.8 Road Characteristics

The following table shows average level of illumination of different types of road along with its characteristics.

Table 3.3: Road Characteristics

Type of Road	**Road Characteristics**	**Average level of illumination on road**
A-1	Important traffic routes carrying fast traffic	30 lux
A-2	Main roads carrying mixed traffic like city main roads/streets, arterial roads, through ways	15 lux
B-1	Secondary roads with considerable traffic like local traffic routes, shopping streets	8 lux
B-2	Secondary roads with light traffic	4 lux
C	Residential road	4 lux

3.9 Geographical location of CCMS in Mysuru City

Mysuru: The 2015-16 proposal of the State Government to replace conventional streetlights with energy-efficient Light Emitting Diode (LED) lights in Mysuru has finally taken off with the Mysuru City Corporation (MCC) handing over the seven-year Public Private Partnership (PPP) model project to New-Delhi based e-Smart firm.

The agreement with e-Smart and the MCC has been signed and work of replacing 60,000 bulbs with LED has already begun from Jayachamaraja Wadiyar Circle (Hardinge Circle), Chamaraja Circle, K.R. Circle, Sayyaji Rao Road, D. Devaraj Urs Road and JLB Road. The bulbs are being replaced and the new LED bulbs are being tested every night. The installation of all the 60,000 bulbs will have to be completed within three months.

With an intention to save on energy costs, the Government, during its 2015-16 Budget, had proposed to replace conventional bulbs including tube lights, high-pressure sodium, mercury vapour and metal halide lights (halogen lamps) with LED bulbs in City Corporations outside Bruhat Bengaluru Mahanagara Palike (BBMP) and had selected Mysuru for the pilot project.

(i) 60,000 bulbs to be replaced by energy-efficient bulbs

(ii) 7-year project handed over to New Delhi-based firm

(iii) MCC will not spend even a rupee under agreement

(iv) LED project, however, will not include dark Ring Road

The figure shows the Geographical location of CCMS installed in Mysuru City.

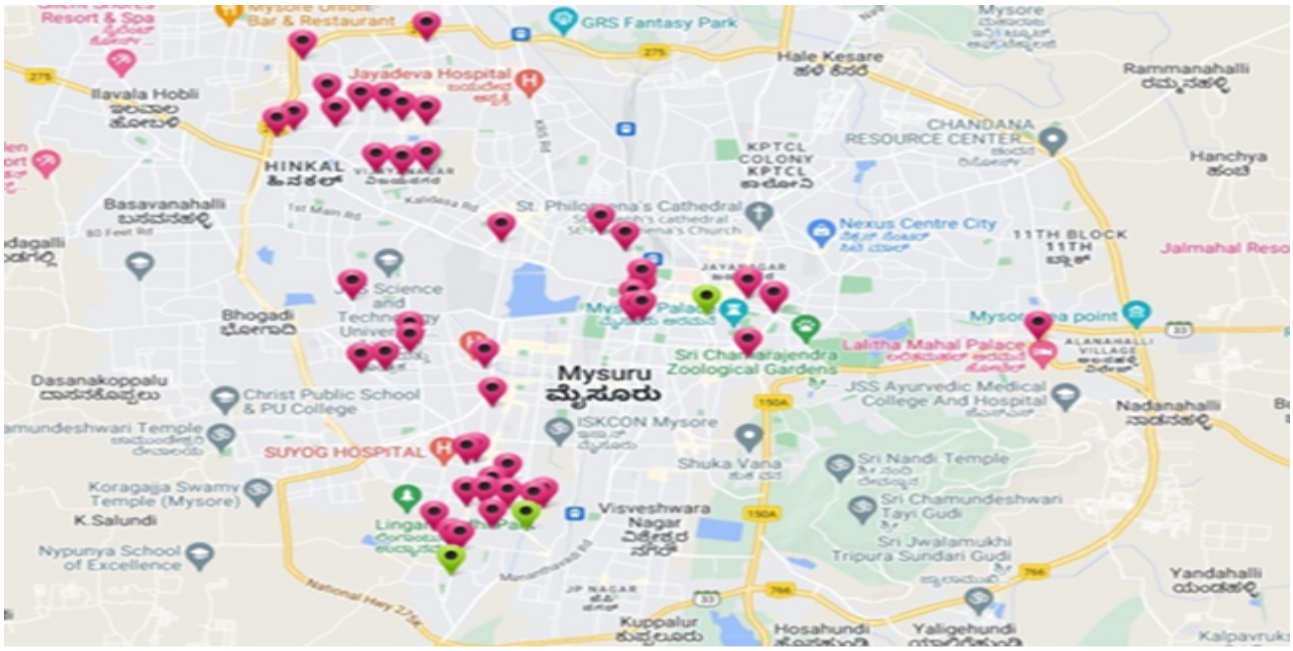


Figure 3.2: Geographical location of CCMS in Mysuru City

SOFTWARE SYSTEM CONFIGURATION

4.1 Network architectures and communication protocol for the (CCMS)

The network structures are used for transmitting the information to a sensor node before sharing to the cloud which are connected through the internet Wide Area Network is used for smart cities.

4.1.1 Wide Area Network

A wide-area network (WAN) is the technology that connects your offices, data centers, cloud applications, and cloud storage together. It is called a wide-area network because it spans beyond a single building or large campus to include multiple locations spread across a specific geographic area, or even the world.

The purpose of a WAN connection

Wide-area networks (WANs) are the backbone of enterprise today. With the digitization of resources, companies use WANs to do the following:

(i) Communicate using voice and video.

(ii) Share resources between employees and customers.

(iii) Access data storage and remotely back up data.

(iv) Connect to applications running in the cloud.

(v) Run and host internal applications.

(vi) WAN technology innovations help organizations access information in a secure, fast, and reliable way. WANs are important for business productivity and continuity.

There are several network protocols are available for various smart city applications and enables remote and control of devices and systems. Some of the network protocols used for smart city application is RFID, NFC, Bluetooth, Zigbee, Zwave, Wi-Fi, LoraWAN and 6LOWPAN. The CCMS uses low-cost Z-wave protocol for serving the data access from LED street lighting and makes simple implementation. The data collected from each CCMS is further shared to the cloud for monitoring, forecasting and power saving analysis. The parameters listed below are obtained from each street light and saved into a .csv file. The data collected from CCMS is further shared to the cloud for maintaining, forecasting and power saving analysis. Each CCMS provides device ID, voltage, current, power factor, THD (V, I), over voltage, under voltage, fault information and time stamp for every 15

minutes. The time stamp can be varied as per our convenience from 5 minutes to 1 hour. This CCMS is networked with cloud server to store the above-mentioned parameters for data analytics.

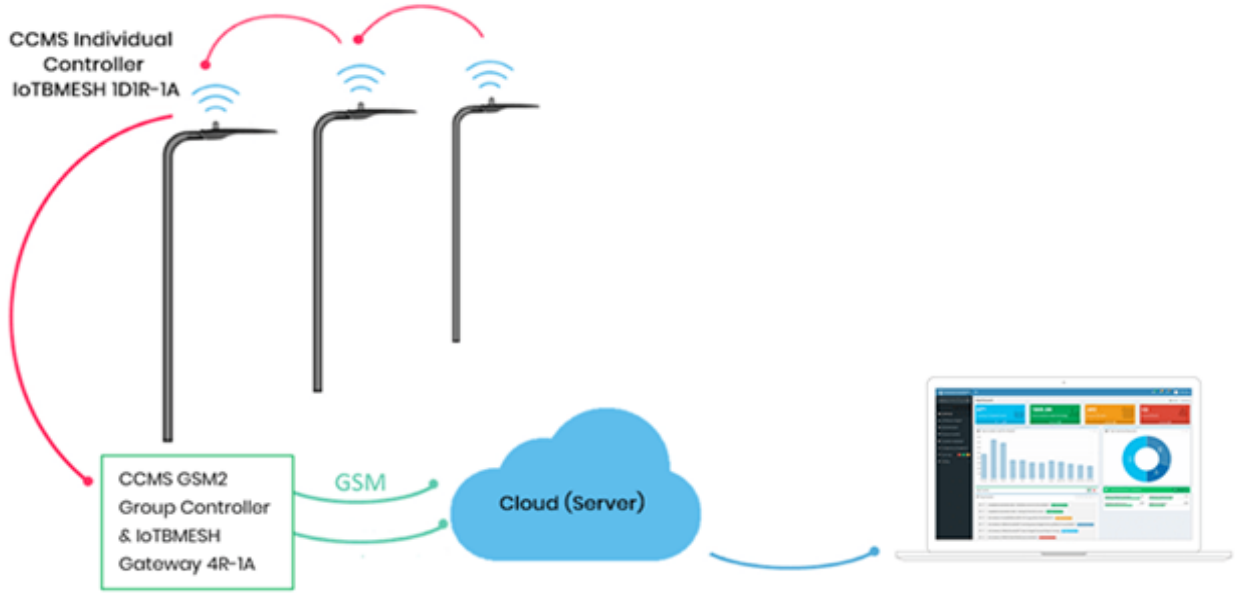


Figure 4.1: Connectivity

4.2 Dashboard

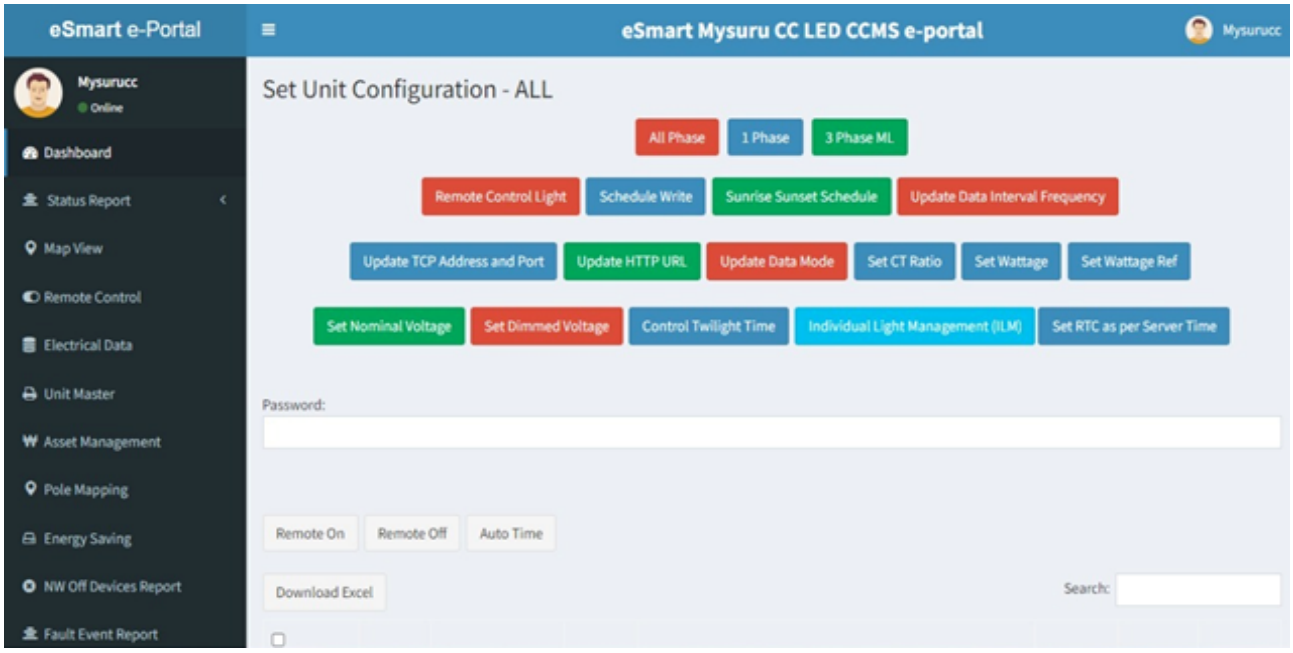


Figure 4.2: Dashboard

The application is designed in such a way that we place light sensors in all the streetlights circuit and which are responsible to switch on and off automatically. Once the lights are switched on, current sensors placed at every light pole are responsible to report problem status to the centralized system with the help of GSM module attached with the circuit. With the status available in the centralized

system, the workman now can easily locate the particular light to be taken care which minimizes the time to search it and repair. The system also collects useful information from each street light at the end of each day. The information is stored in the database and based on this information charts are derived. The charts are displayed in the street light section which contains information like power consumption, total number of burning hours, total number of interruptions, tallies the actual power consumption with the power supplied, details of fault detection i.e., actual location of street light. The system is also provided with optimal sleep scheduling protocol to increase the lifetime of the street lights. This kind of proposed effective street lighting is an important way of increasing road safety at night; it improves the quality of life for residents by deterring crime and by making people feel more secure. Lighting is also used to improve the ambience of areas, which is commercially beneficial to businesses and the prosperity of the city as a whole.

(i) The system is able to detect following failures:

- (*) Lamp failure alert and restoration
- (*) Cable fault, power theft and cable breakage
- (*) Pole breakage

(ii) Street lights can be set to remain 'ON', if Group Controller fails due to any reason. This is configurable from the Web Panel

(iii) You can do data entry of all network elements to be mapped on GIS system on cloud for example, Power Cables, Distribution Transformers, Splits in Power Cables, Street lights, garden lights, Group Controllers, etc.

(iv) The location (Latitude Longitude) of each object are fed into GIS

(v) You can create forms for data entry on the cloud based CCMS Remote Monitoring Web Panel, such as:

- (*) Adding a Network Element with its name, type, description, location, port connections, etc.
- (*) Edit / Remove a Network Element.
- (*) Connectivity Check Form for the network elements.

(vi) Location of Individual Street Light can be set as per Group Controller by assigning their latitude and longitude

(vii) Remote Fault detection along with location of fault occurred in Street light cable network (from the distribution transformer to Street light) is possible using this system

(viii) The communication between Group Controller(s) and Remote Monitoring Web Panel is bidirectional.

(ix) Get real-time reports on status (ON / OFF) of Street Lights (or Garden Lights) zone-wise as per Group Controller.

(x) Ability to control Street lights based on manual control (Remote Access), Astronomical Calendar based Control or manually programmed Time based schedules.

(xi) Plotting of Street lights with Group Controller on GIS Map.

(xii) Fault Detection Alerts and Type of Failure Identification is possible such as:

- (*) Power failure in the network
- (*) Main Cable fault (starting from distribution transformer)
- (*) Street Light (branch) cable fault

(xiii) Detect Leakage / Theft happening between zones of Group Controllers with Timestamp and Location.

(xiv) Remote Monitoring Web Panel is developed on the basis of organizational hierarchy to monitor, solve and verify faults. Non-performance of actions in stipulated time at a certain level will escalate the fault to higher level.

(xv) Super Admin and/or Admin can define roles in for a particular type of fault(s) to take necessary action to be taken against those faults.

(xvi) Fault rectification mechanism is established in the Remote Monitoring Web Panel:

- (*) Ticket is generated when fault is identified by the system and assigned to an individual
- (*) If person solves the fault, the ticket is verified by the higher level role individual
- (*) The ticket can be assigned to someone else as per necessary
- (*) The ticket is automatically escalated to higher authority in case of ticket not solved in stipulated time
- (*) Ticket activity logs are maintained by the system which can viewed by Super Admin / Admin roles.

(xvii) Easy management of User roles and access rights protection. System maintains data of all roles, descriptions, individual details to assign tickets as per fault generated.

(xviii) Get detailed logs of all events, failures / faults, type of failures / faults, analytics, downtime of Street lights in Group Controller with ticket trails.

(xix) Generate reports for Predictive maintenance analysis, so that maintenance can be done to reduce occurrence of frequency of such faults.

(xx) Mode of Operation:

- (*) Astronomical Mode
- (*) Manual/Maintenance

(xxi) Possible to do remote diagnosis, get intimation of repair / maintenance status, along with location of fault as per Group Controller zone(s) in case of Street lights failure.

(xxii) Remote Monitoring Web Panel is able to generate SMS / WhatsApp / Email Alerts to the authorities

(xxiii) Get information on status of all Group Controllers installed with Street Lights on Dashboard in consolidated format and detailed format in zone-wise / location-wise data

(xxiv) Get update of Fault identification with Timestamp on Dashboard.

(xxv) Get Reports on Daily, weekly, monthly and yearly basis.

(xxvi) Instant email alerts to authorized personnel for programmed alarms, change in status of Street Lights or fault alerts.

(xxvii) Instant update on Dashboard of any abnormality detected in system

(xxviii) Storage of data received from all Group Controllers and managed in a secured database on cloud servers.

4.3 Python

Python is an interpreted, object-oriented, high-level programming language with dynamic semantics. Its high-level built in data structures, combined with dynamic typing and dynamic binding, make it very attractive for Rapid Application Development, as well as for use as a scripting or glue language to connect existing components together. Python's simple, easy to learn syntax emphasizes readability and therefore reduces the cost of program maintenance. Python supports modules and packages, which encourages program modularity and code reuse. The Python interpreter and the extensive standard library are available in source or binary form without charge for all major platforms, and can be freely distributed.

Often, programmers fall in love with Python because of the increased productivity it provides. Since there is no compilation step, the edit-test-debug cycle is incredibly fast. Debugging Python programs is easy: a bug or bad input will never cause a segmentation fault. Instead, when the interpreter discovers an error, it raises an exception. When the program doesn't catch the exception, the interpreter prints a stack trace.

A source level debugger allows inspection of local and global variables, evaluation of arbitrary expressions, setting breakpoints, stepping through the code a line at a time, and so on. The debugger is written in Python itself, testifying to Python's introspective power. On the other hand, often the quickest way to debug a program is to add a few print statements to the source: the fast edit-test-debug cycle makes this simple approach very effective.

4.3.1 Python Features and Advantages

The following are some of the features in Python that are discussed below:

1. Easy to Code Python is a very high-level programming language, yet it is effortless to learn. Anyone can learn to code in Python in just a few hours or a few days. Mastering Python and all its advanced concepts, packages and modules might take some more time. However, learning the basic Python syntax is very easy, as compared to other popular languages like C, C++, and Java.

2. Easy to Read Python code looks like simple English words. There is no use of semicolons or brackets, and the indentations define the code block. You can tell what the code is supposed to do simply by looking at it.

3. Free and Open-Source Python is developed under an OSI-approved open-source license. Hence, it is completely free to use, even for commercial purposes. It doesn't cost anything to download Python or to include it in your application. It can also be freely modified and re-distributed. Python can be downloaded from the official Python website.

4. Robust Standard Library Python has an extensive standard library available for anyone to use. This means that programmers don't have to write their code for every single thing unlike other programming languages. There are libraries for image manipulation, databases, unit-testing, expressions and a lot of other functionalities. In addition to the standard library, there is also a growing collection of thousands of components, which are all available in the Python Package Index.

5. Interpreted When a programming language is interpreted, it means that the source code is executed line by line, and not all at once. Programming languages such as C++ or Java are not interpreted, and hence need to be compiled first to run them. There is no need to compile Python because it is processed at runtime by the interpreter.

6. Portable Python is portable in the sense that the same code can be used on different machines. Suppose you write a Python code on a Mac. If you want to run it on Windows or Linux later, you don't have to make any changes to it. As such, there is no need to write a program multiple times for several platforms.

7. Object-Oriented and Procedure-Oriented A programming language is object-oriented if it focuses design around data and objects, rather than functions and logic. On the contrary, a programming language is procedure-oriented if it focuses more on functions (code that can be reused). One of the critical Python features is that it supports both object-oriented and procedure-oriented programming.

8. Extensible A programming language is said to be extensible if it can be extended to other languages. Python code can also be written in other languages like C++, making it a highly extensible language.

9. Expressive Python needs to use only a few lines of code to perform complex tasks. For example, to display Hello World, you simply need to type one line - print ("Hello World"). Other languages like Java or C would take up multiple lines to execute this.

10. Support for GUI One of the key aspects of any programming language is support for GUI or Graphical User Interface. A user can easily interact with the software using a GUI. Python offers various toolkits, such as Tkinter, wxPython and JPython, which allows for GUI's easy and fast development.

11. High-level Language Python is a high-level programming language because programmers don't need to remember the system architecture, nor do they have to manage the memory. This makes it super programmer-friendly and is one of the key features of Python.

12. Other Advanced Programming Features Python contains several advanced programming features such as generators (used to create iterators with a different approach that most other languages) and list comprehensions (used to create new lists from other iterables). Python also has automatic memory management eliminating the need to manually allocate and free memory in the code.

4.3.2 Python fuction used in code

1. **Pandas**: Pandas is a Python library used for working with data sets. It has functions for analyzing, cleaning, exploring, and manipulating data. The name "Pandas" has a reference to both "Panel Data", and "Python Data Analysis" and was created by Wes McKinney in 2008.

2. **Matplotlib**: Matplotlib is a comprehensive library for creating static, animated, and interactive visualizations in Python. Matplotlib makes easy things easy and hard things possible. Create publication quality plots. Make interactive figures that can zoom, pan, update.

3. **Pyplot**: pyplot is a collection of command style functions that make matplotlib work like MATLAB. Each pyplot function makes some change to a figure: e.g., creates a figure, creates a plotting area in a figure, plots some lines in a plotting area, decorates the plot with labels, etc.

4. **csv**: A simple way to store big data sets is to use CSV files (comma separated files).CSV files contains plain text and is a well know format that can be read by everyone including Pandas.In our examples we will be using a CSV file called 'DeviceData1.csv'.

5. **df**: A Pandas DataFrame is a 2 dimensional data structure, like a 2 dimensional array, or a table with rows and columns.

6. **df.drop**: The drop() method removes the specified row or column. By specifying the column axis (axis='columns'), the drop() method removes the specified column. By specifying the row axis (axis='index'), the drop() method removes the specified row.

7. **df.index**: The index property returns the index information of the DataFrame. The index information contains the labels of the rows. If the rows has NOT named indexes, the index property returns a RangeIndex object with the start, stop, and step values.

8. **Plt.Plot**: The plot() function is used to draw points (markers) in a diagram.By default, the plot() function draws a line from point to point.The function takes parameters for specifying points in the diagram.Parameter 1 is an array containing the points on the x-axis.Parameter 2 is an array containing the points on the y-axis. The xlabel() function in pyplot module of matplotlib library is used to set the label for the x-axis. The ylabel() function in pyplot module of matplotlib library is used to set the label for the y-axis.

9. **autofmt**$_x date() : The autofmt_x date() method figure module of matplotlib library is used to rotate them$

10. **plt.ylim**: The ylim() function in pyplot module of matplotlib library is used to get or set the y-limits of the current axes.

11. **ax.plot**: The Axes Class contains most of the figure elements: Axis, Tick, Line2D, Text, Polygon, etc., and sets the coordinate system. And the instances of Axes supports callbacks through a callbacks attribute.

12. **ax.ticks.params**: Change the appearance of ticks, tick labels, and gridlines.Tick properties that are not explicitly set using the keyword arguments remain unchanged unless reset is True for the current style settings.

13. **plt.gca()**:The gca() function in pyplot module of matplotlib library is used to get the current Axes instance on the current figure matching the given keyword args, or create one.

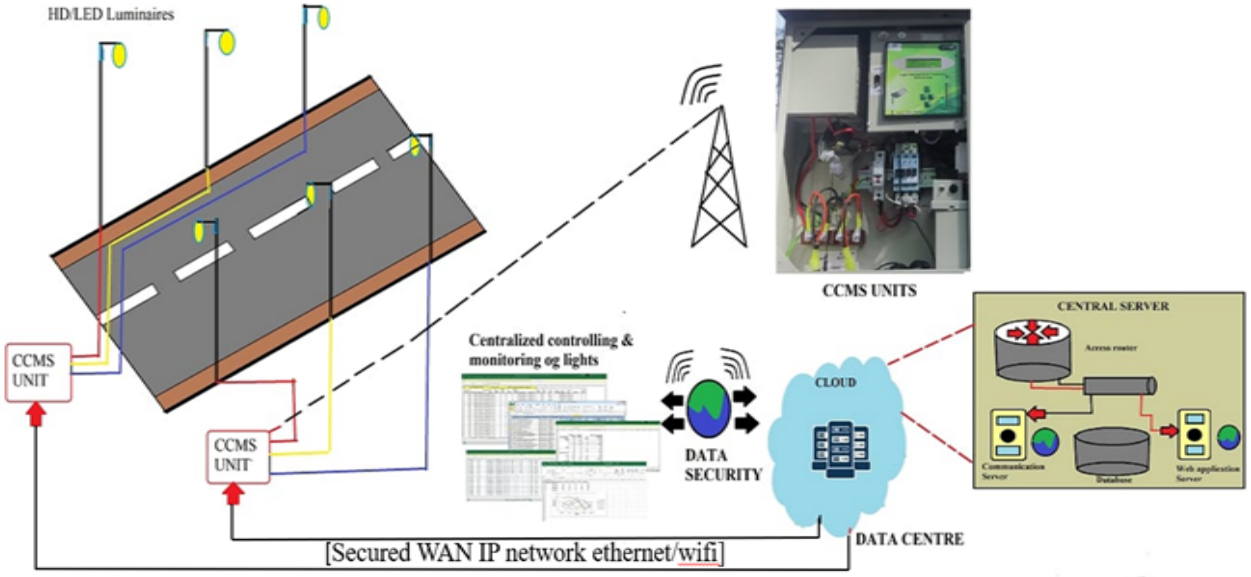
14. **plt.xticks**: The annotate() function in pyplot module of matplotlib library is used to get and set the current tick locations and labels of the x-axis.

15. **append**: Python's .append() takes an object as an argument and adds it to the end of an existing list, right after its last element.

16. **plt.savefig**: As the name suggests savefig() method is used to save the figure created after plotting data. The figure created can be saved to our local machines by using this method.

POWER SAVING STRATEGY

5.1 Methodology



The proposed method will provide baseline data to understand how the lights are working, and which areas need improvement. The parameters that can be monitored include:

1. **Energy Consumed by Lights** While LED's are said to require lesser electricity and have a longer life as compared to traditional lighting fixtures, there are no clear numbers. Analyzing energy consumption and health data will help in understanding which LED's are most cost effective in regards to energy consumption, lifetime and failure rate.

2. **Energy Consumption** By analyzing the data of how much energy is consumed by a number of lights in a given amount of time, it will be easy to understand where electricity theft is taking place. Analytics can differentiate between cases where the LED needs to be replaced, or if there is an operation leak.

3. **Effect of dimming** It has long been argued that dimming streetlights, on high traffic streets during peak hours can save electricity. However due the absence of an IOT based solution, and consequently analytics, it is unclear whether this claim holds water. Analytics of the accurate base line data will help understand dimming affect the electricity Consumption.

Streetlights brightens cities at night. This infrastructure is highly challenging to maintain. There are major challenges of light which needs to be resolved.

Streetlights have been made for our convince but due to unsolved complaints and issues users are facing problems. Sometimes Streetlights remain ON during day time also which leads to wastage of energy. Smart solutions are introduced to overcome this problem.

Introducing CCMS based smart panel with smart group controller. Wired connection between street lights and smart panels is given in 3 different phases namely r, y and b. As per our calculation there are 18 Streetlights which are connected to one CCMS unit. This can be divided into 3 groups as 6 Streetlights in a group. Either of one out of 3 phases is connected to 2 Streetlights i.e., there are 2-r phase, 2-y phase and 2-b phase Streetlights in each group the Streetlights can be turned on alternatively. And all the Streetlights are connected to one common neutral.

Whenever the fault occurs fault signal is generated automatically and will notify the concerned person on the system. On this way problem is getting auto identified. In the night after the fixed time anyone phase out of three will be turned off to save the energy. Day wise rotation of this staggering phases also can be done.

The survey report is conducted for Zone-2, Ward-63 of Mysuru region with longitude 76.63461. In this area it is found that 1,197 street lights are connected and consumes 1,74,290 Watts. For better illumination, visibility and Power saving various types of street lights like LED, SVL. Are connected to 65 switching points for monitoring and controlling. However, each CCMS access data from 18 street light and networked with data Centre via Cloud. A CCMS device that can upload this data to the Internet, and operate the lights at the same time, will help the supervisors immensely. A connection backbone of wireless technologies like Wi-Fi, GSM(2G/3G) will be the most cost-effective solution. This is a smart way of managing street lighting systems.

5.2 Pseudo code

The pseudo-code of Python programming for obtaining the Result

Algorithm 1

Step1: Import library functions
Step2: Import csv('DeviceData1.csv')
Step3: Initialize the variables ('ir','dt','kwh')
Step4: Define variables with descending order of time //as per data
Step5: Initialize data frame from 6pm to 10pm continuously and assign data for every 15 mins from 10pm to 6am
Step6: Evaluate current from 10pm to 6am and calculate power consumption
Step7: Visualize the plot
Step8: Append elements
Step9: Save the figure which is created after plotting data. =0

RESULTS AND DISCUSSION

The generated code is uploaded to Python Spyder application. The real time data collected and the code is saved in the same folder and then it is executed.

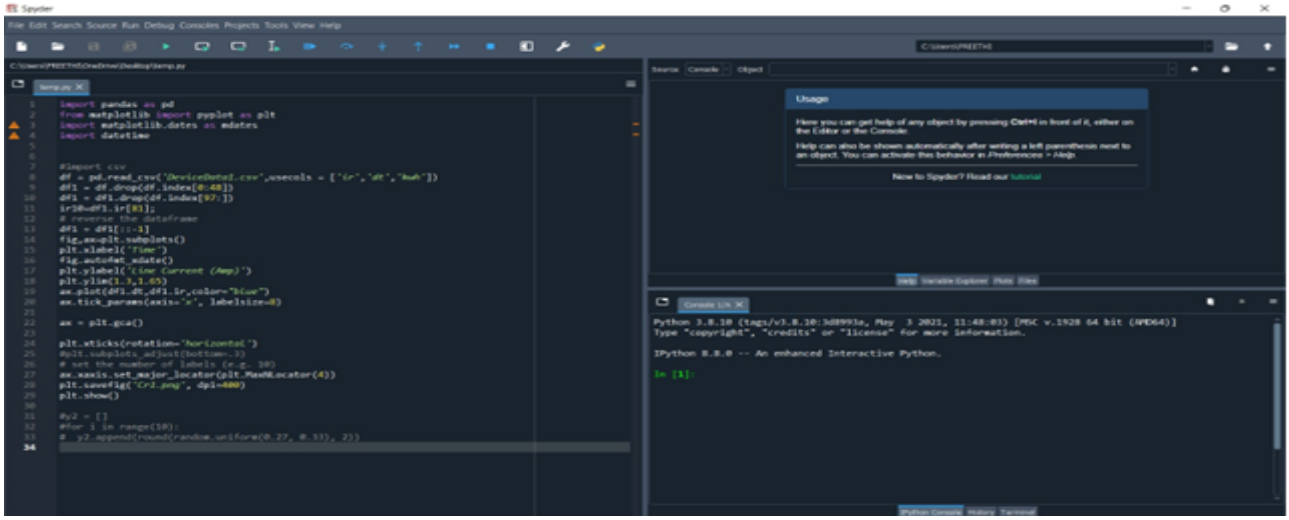


Figure 6.1: Code uploaded in Spyder software

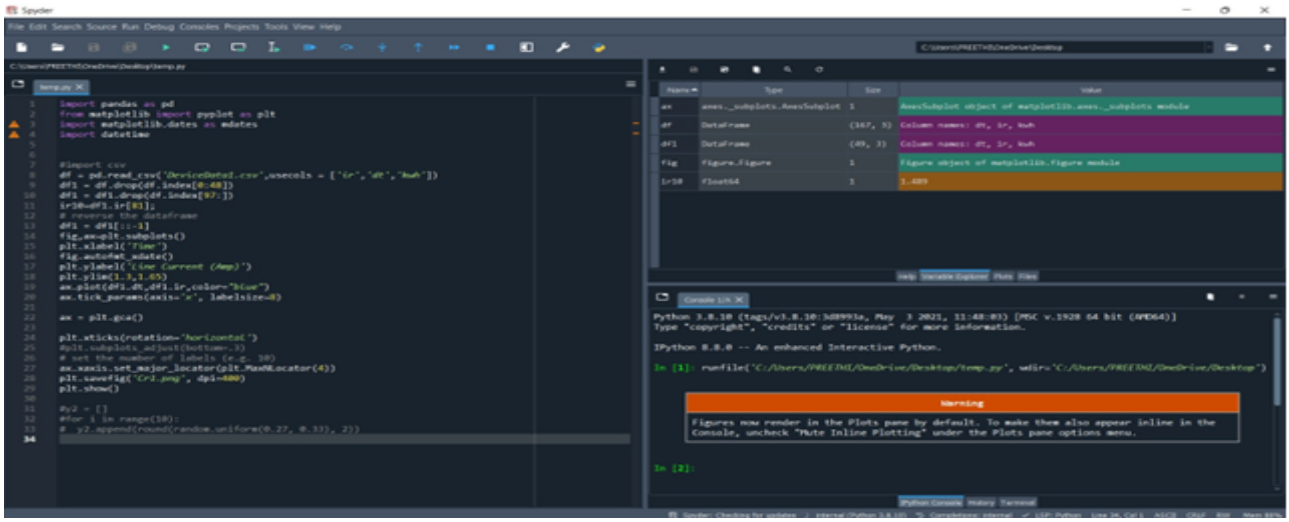


Figure 6.2: Variable output

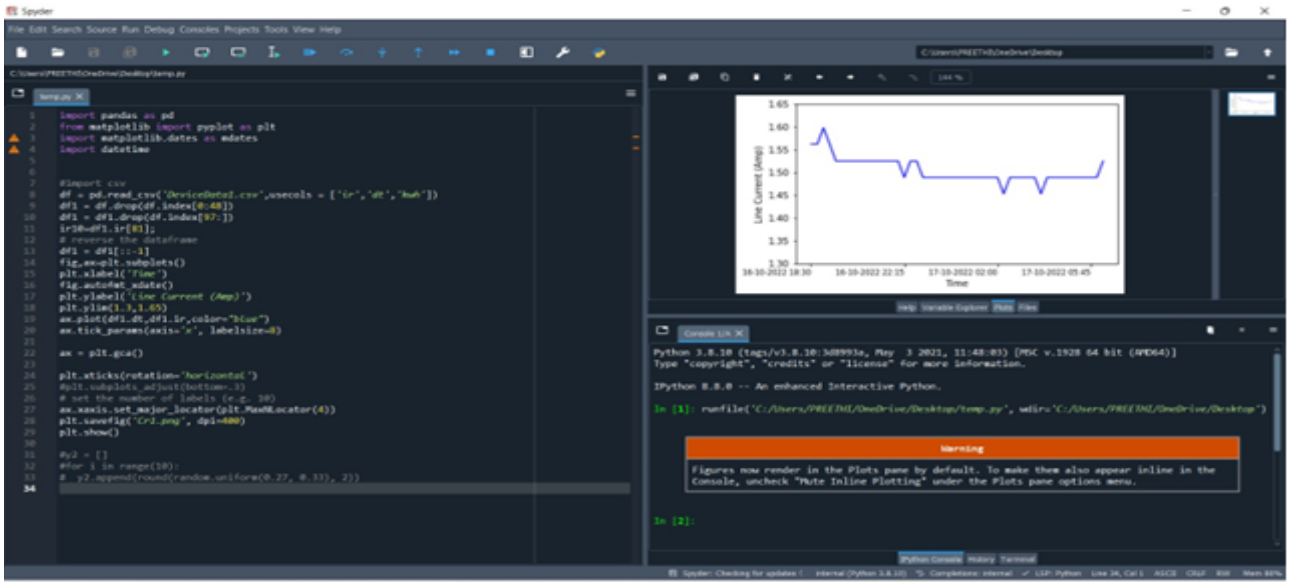


Figure 6.3: plot obtained

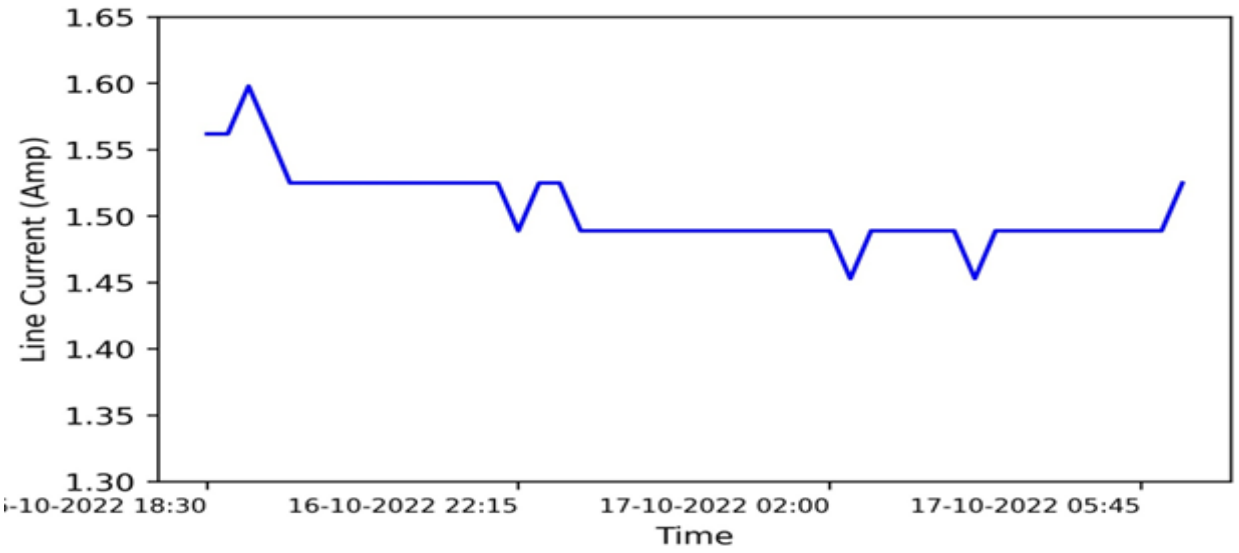


Figure 6.4: Plot of Line Current of Street Lighting (amp)

This graph represents the line current (Amp) at different intervals of time for two days on 16-10-2022 and 17-10-2022. On 16-10-2022 at 18:30pm the current drawn by the lights are high and reduces gradually as the time increases. On 16-10-2022 at 22:15pm there is slight drop in the current drawn by the lights. On 17-10-2022 at 2:00pm the current drawn by the lights are further reduced as per the power saving strategy and remains constant till morning 5.45pm.

CONCLUSION AND FUTURE SCOPE

7.1 Conclusion

It is seen in a number of cities that street lights are one of the huge expenses in a city the cost spent is huge that all the sodium vapor lamps consume more power than LEDs and also more THD and less power factor than compare to LED. Street light will be made to switch ON in the evening and switched OFF in the morning. Hence, there is lot of wastage of energy in this project. This is one of the major causes of shifting to the automatic system. Since there is less wastage of power and thus saving a lot of monetary expenses. So that expense spent on the street light can be used for development of the nation. This savings can be mainly done using Centralized Controlled Monitoring System (CCMS). CCMS or standalone street light controller is a control panel with comprehensive protection, control and monitoring station for group of station. By using the data of CCMS, forecasting analysis of energy consumption can be done.

Energy solutions on street lighting enhances the energy management and forecasting analysis, thus reducing the cost of energy and increases the life span of the equipment. Around 30 percent of the energy is saved through power saving strategies either with ON/OFF or dimming the lights based on the traffic flow. The energy management forecasting analysis are presented using real time data of the street lighting of Mysuru city, Karnataka, India.

7.2 Future Scope

1. These smart lights will help cities reduce electricity costs, lower CO2 emissions, and improve maintenance.
2. With auto-dimming, scheduling, and a host of other capabilities, cities could see a 50-75
3. The switch to LED bulbs provides substantial (and highly measurable) short-term ROI, which paves the way for the simultaneous implementation of technologies with longer paybacks and hard-to-capture ROI like real-time traffic monitoring.
4. But energy efficiency is just the beginning. Air quality monitoring, traffic control, accessible public wi-fi, security cameras, gunshot detection devices, and digital signage/advertising all represent viable candidates for implementation into urban street light infrastructure.
5. Public safety applications could reduce crime up to 10 percent.

Appendices

Python Code for power Saving Strategy analysis

```
##Implementation of matplotlib function
import pandas as pd
from matplotlib import pyplot as plt
import matplotlib.dates as mdates
import datetime

##import csv
##initialising the variables
df = pd.read_csv('DeviceData1.csv',usecols = ['ir','dt','kwh'])
##removal of specified row or column
df1 = df.drop(df.index[0:48])
df1 = df1.drop(df.index[97:])
##Initialize data frame from 6pm to 10pm continuously
ir10=df1.ir[81];
## reverse the dataframe
## Define variables with descending order of time and assign data for every
df1 = df1[::-1]
##returns a tuple containing a figure and axes object(s)
fig,ax=plt.subplots()
##Adding label on the y-axis
plt.xlabel('Time')
## Implementation of matplotlib function for dates to relplot
fig.autofmt_xdate()
##Adding label on the y-axis
plt.ylabel('Line Current (Amp)')
##set the y-limits of the current axes
plt.ylim(1.3,1.65)
## plot y versus x as lines
ax.plot(df1.dt,df1.ir,color="blue")
ax.tick_params(axis='x', labelsize=8)
## get the current Axes instance on the current figure
ax = plt.gca()

plt.xticks(rotation='horizontal')
##plt.subplots_adjust(bottom=.3)
##set the number of labels (e.g. 10)
ax.xaxis.set_major_locator(plt.MaxNLocator(4))


## save fig. created after plotting data
plt.savefig('Cr1.png', dpi=400)
## visualize the plot
plt.show()
#y2 = []
#for i in range(10):
#  y2.append(round(random.uniform(0.27, 0.33), 2))
```

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