# STUDIES ON DALI CONTROLLED LIGHTING SYSTEM OF AN INTEGRATED BUILDING MANAGEMENT SYSTEM

*A thesis submitted towards partial fulfilment*
*of the requirements of the degree of*

**Master of Engineering**
**in**
**Illumination Engineering**

*Submitted by*

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**MAY 2019**

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This is to certify that the thesis entitled **" STUDIES ON DALI CONTROLLED LIGHTING SYSTEM OF AN INTEGRATED BUILDING MANAGEMENT SYSTEM "** submitted by **SOUVIK SAHA**, (Exam. Roll No. **M4ILN19021**, Registration No.**140685 of 2017-18**) of this university in partial fulfilment of requirements for the award degree of Master of Engineering in Illumination Engineering, Department of Electrical Engineering, is a bonafide record of the work carried out by him under my guidance and supervision.

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This foregoing thesis is hereby approved as a creditable study in the area of Illumination Engineering, carried out and presented by **SOUVIK SAHA**, in a manner of satisfactory warrant its acceptance as a pre-requisite to the degree for which it has been submitted. It is notified to be understood that by this approval, the undersigned do not necessarily endorse or approved the thesis only for the purpose for which it has been submitted.

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# DECLARATION OF ORIGINALITY AND COMPLIANCE OF ACADEMIC ETHICS

I hereby declare that this thesis contains literature survey and original research work by the undersigned candidate, as part of my Master of Engineering in Illumination Engineering studies.

All information in this document have been obtained and presented in accordance with academic rules and ethical conduct.

I also declare that, as required by these rules and conduct, I have fully cited and referenced all materials and results that are not original to this work.

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# ACKNOWLEDGEMENT

I take this opportunity to express my deep sense of gratitude and indebtedness to**,** **(Prof.) Dr. Biswanath Roy** Professor, Electrical Engineering Department, Jadavpur University, for his constant guidance and supervision. I would also like to thank him for providing me his valuable time and helpful suggestions.

I would like to acknowledge my sincere thanks to **Professor Dr. Kesab Bhattacharyya, HOD of Electrical Engineering Department, Jadavpur University,** for providing me the opportunity to carry out my project work in Illumination Engineering Laboratory of Jadavpur University. I am highly indebted to **Mr. Suddhasatwa Chakraborty**, Assistant Professor, Electrical Engineering Department, **Prof**. (**Dr.**) **Saswati Mazumdar**, Professor, Electrical Engineering Department, Jadavpur University for their valuable suggestions and encouragements during that project work.

I am also thankful to, **Mr. Pradip Pal** of Illumination Engineering Laboratory for his warm cooperation during that project work. I am also thankful to **Mr. Chirantan Kumar** & **Mr. Arijit Sen** of **Bajaj Electricals Ltd.** for the continuous co-operation during the project work.

Last but not the least, I wish to convey my gratitude to my parents, whose love, teachings and support have brought me this far.

**Dated:** **SOUVIK SAHA**

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# CHAPTER – 1

# AIMS & OBJECTIVES

## 1.1 INTRODUCTION

The prime aspect of the Building Management System is to provide the basic needs of our daily life which is Safety & Security. Building Management System is a computer-based control-system installed in the buildings that controls and monitors the building's mechanical and electrical equipment such as lighting, power systems, ventilation, fire alarm systems and many other security systems. In case of building management system, different security & safety system uses different protocols for the communication purpose. What Building Management System actually does is that, it provides a gateway for the different system & helps to monitor & control different security and safety systems simultaneously. Some benefits of the Building management system are, there is a possibility of individual room control, effective monitoring and targeting of energy consumption, increase in reliability and life of the system etc. Moreover, installing a Building Management system in a plant or in a corporate office gives us the increased staff productivity with one-time investment of money and low maintenance cost.

A small part of this Building Management System is the lighting control unit. The most popular installation for the lighting control unit in accordance with the Building Management System is DALI (Digitally Addressable Lighting Interface). Nowadays, the use of conventional lighting system is decreasing in the corporate offices due to heavy energy consumption purpose and moreover the huge amount of money we are spending for this kind of system. Two types of dimming concepts are there. One is Analogue dimming and the other is Digital dimming. In case of Analogue dimming, it usually refers 1- 10 V dimming, where a D.C voltage is sent to the driver, which dims the LEDs in response to the voltage. The main advantage of digital dimming over Analogue dimming is that the fixtures used here are addressable & many more different levels of light output is achieved by using this kind of dimming application. DALI is basically a protocol for the purpose of digital dimming & for the DALI application purpose the devices used in this type of dimming should be DALI compatible which means LED control gears or drivers, LED luminaires etc. should be DALI compatible.

In our country the use of this type of applications (like IBMS & DALI) is increasing gradually. IBMS has proved its worth and now almost all newly developed buildings (be it residential or official) has IBMS installed in it. It gives the tenants or occupant a good control of internal comfort conditions, possibility

of individual room control, increased staff productivity, effective monitoring and targeting of energy consumption, improved plant reliability and life, effective response of ventilation and Air-conditioning related complaints save time and money during the maintenance.

Recently Frost and Sullivan Ltd., A growth strategy consulting and research firm has done an in-depth analysis on the IBMS industry and its future prospects. The analysis was done back in 2011 and analysis report revealed that the IBMS market earned revenues of more than INR 258.6 crores & in this report they also predicted that, the value of revenue will be reaching INR 515.5 crores marks in 2016. The government/political aspect is playing an important role behind the growth of the IBMS market.

Government’s effort to reduce carbon dioxide (CO2) emissions and energy consumptions are the main driving force. Different recent reforms to aid foreign direct investments (FDIs) have significantly aided the IBMS market.

Moreover, the spread of enterprises has inflated the urban population, which has hiked the demand for IBMS. The new commercial (offices, retail, hotel), residential and industrial buildings are picking up smarter and reliable technologies. The rapid industrial development has amplified the need for power and brought the concept of energy efficiency in attention. The IBMS market is expected to grow with the construction sector and markets for safety systems, security systems, heating, ventilation and Air-conditioning (HVAC) systems, lighting systems and energy management services.

Despite the growth of demand for IBMS, the market is stalled by the low availability of skilled manpower and qualified system integrators. Its high installation costs also deter the price-sensitive consumers, who seek guaranteed return on investments through energy and cost savings.

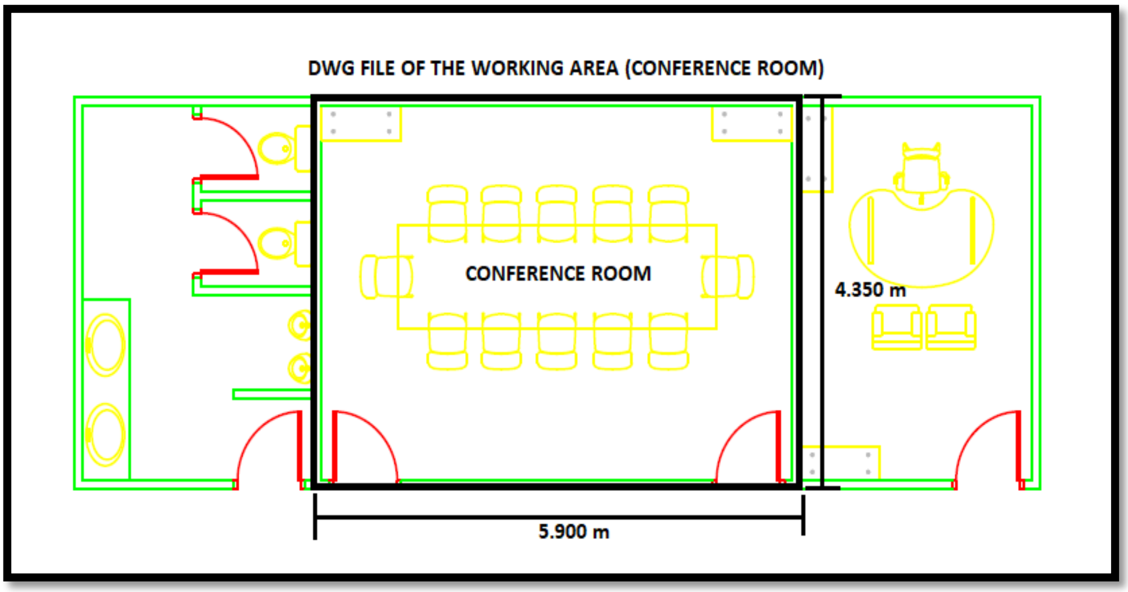
The competition further shrinks profit margins; thus, enforcing the large and medium sized market participants to offer added value propositions of top-notch designs, installations, commissioning, supervising and training.

If building safety and the ambiance are improved, IBMS can bring down energy cost, improve efficiency and diminish energy usage. Recognizing the huge opportunities many leading international and domestic players have entered the game.

## 1.2 DETAILS OF WORKPLACE

In the second chapter, there is mainly some information about the Integrated Building Management System, basically the background of IBMS, Internet of things, what type of control systems are used, information about different kind of protocols used in case of different applications, and how they are brought together into a single system or in a single gateway. Besides that, there is a general discussion on why there is a need of Building Automation and Control Systems & how the modern day IBMS works. In the same chapter, there is a discussion on BACS (Building Automation Control System) hardware and software architecture system and also a brief discussion on the BACS Automation level devices. In the third chapter, there is brief discussion on different kind of IBMS systems (for example, fire alarm system, public address system etc.). There is also a brief discussion on the working principles of every IBMS safety & security system.

After that, there is discussion on DALI systems & where I take conference room to implement the DALI system. The information about the room dimension is given in that chapter. The conference room has a sitting arrangement of 12 people. The room consists of a window and a door and eight luminaires (2×2 troffer) are used for the illumination purpose. Fig- 1.2 shows the dimension of the conference room.



[Fig 1.2] Diagram & the dimension of the workplace

## 1.3 OBJECTIVES OF THE STUDY

The objective of the thesis is as follows:

- To study the Building Automation Control System & a brief discussion on different types of BACS systems.
- To study and design implementation of modern energy efficient lighting technology using DALI in commercial buildings (here conference room) for the different modes of operation throughout the day (mainly office hours) in that particular workplace.
- To provide a single line diagram for the implementation of the DALI controlled lighting system in the workplace (Conference room) with the required DALI compatible devices.

**Steps of Execution**:

- Choose the number of DALI compatible luminaires & the wattage of luminaires required for the workplace (Conference room).
- Then define the number of “luminaire groups” required for the system.
- After that, define the number of DALI devices required for the implementation purpose & then define the number of switching points required to control the system.
- Then find the current drawn by each DALI devices & controllers and do the summation of current and check whether the total current drawn by the DALI devices & controllers is within the upper limit of DALI Power Supply current or not.
- After that choose the dimming values required for the different modes of operation & set those values in the DALI Scene & Group controllers. Then prepare a checklist of the DALI devices used in the circuit.
- At last provide a Single line diagram for the wiring purpose of the whole system.

# CHAPTER – 2

# BUILDING AUTOMATION &CONTROL SYSTEM

## 2.1 BUILDING AUTOMATION AND CONTROL SYSTEM

Building Automation and Control Systems (BACS) is an automated system that converge, integrates and connects many different facility technologies through information flow to a monitoring point. BACS are modular, formed from the integration of devices, equipment and communication platform networks with open communication protocols. BACS are also known by many other terms, such as a Building Automation System, Building Management System, Intelligent Building, Smart Buildings and even, Smart Cities. With the Internet of Things, BACS will continue to expand into areas of the built environment and everyday life. Nevertheless, regardless of name, the core principles of BACS are the same; to facilitate free information flow and automated decision-making through connectivity.

BACS technical architecture is based on three levels namely Management, Automation and Field device levels. The Management level contains the human interface, generally on the organization's enterprise network. The Automation level provides the primary control devices, connected via networked Controllers. The Field device level are the physical input sensors and output activators, connected to plant and equipment to monitor and control the environment.

One of the primary purposes of the project was to support security and facility professionals' decision-making, when undertaking BACS design, installation and security management activities. To provide such support, a BACS guideline was developed and critiqued. The BACS Guideline provides guidance to help ensure that a facility's BACS is, where necessary, protected from foreseeable threats and risks that may impact the organization. The intent of the Guideline is to provide a tool to aid decision-making, whereby security or facility professionals can address relevant security related questions to gain a level of assurance in protecting their organization, or make informed decisions to accept risk without treatment.

## 2.2 RELATED TERMINOLOGIES OF BACS

The Building Automation and Control System (BACS) and Intelligent Building (IB) developed from earlier rudimentary automation, evolving into the current systems of today, with their likely future being embedded within the Internet of Things (IoT). The following section provides an overview of the many types of BACS.

### 2.2.1 AUTOMATION

Defining automation is the starting point when considering the development of the modern-day BACS. Automation, in its most basic form, can be sourced back several hundred years to the development of machines in the industrial age, from early textiles machines through to modern day micro level digitization. The human drive for efficiency dictated the development of new and more pervasive automation technologies.

The concept of automation developed for the modern age to mean "the execution by a machine agent (usually a computer) of a function that was previously carried out by a human". Automation is the drive for ever more cost effective, efficient and reliable solutions through the gradual removal of the "weak link" or ongoing expensive element from the process; that of the human. It is widely acknowledged that in repetitive processes the digital or mechanical alternative to human labour is cheaper, more responsive, consistent and less prone to error.

### 2.2.2 BUILDING AUTOMATION SYSTEMS

The next stage in the quest for automation was the advent of Building Automation System (BAS). Often treated as an interchangeable name for a Building Management System (BMS), the distinction is slight but nonetheless important.

A Building Automation System (BAS) is where facility services, such as utilities, communicate with each other to exchange digital, analogue or other forms of information, potentially to a central control point. Facility services are utilities and installations that are supplied and distributed within a facility, which may include electricity, gas, heating, cooling, water and communications (International Organization for Standardization, 2004, p. 6). The advance in communication came with software-controlled connectivity to control many devices. To facilitate such control, computers and controllers in the BAS can be networked to the Internet or server as a standalone system for the local peer to peer controller network only. In addition, the BAS Controllers have their own internal processors, so they do not need a central computer to process the control functions.

BAS is described as a "subset of the management and control system and can be part of a larger BMS [or BACS]" (Control Solutions Inc., 2015). In contrast to BAS, BMS or BACS extends beyond plant and equipment monitoring and control, incorporating the functionality of management. BAS integration may range from small systems where facility lighting is timer controlled to a facility with thousands of automated processes linked to a centralized computer, yet sub-systems can independently carry on according to their programmed functions. Indeed, a facility may have several independent BASs in place; examples being an HVAC system designed to cool a room based on ambient temperature, and a totally separate central surveillance system with movement and heat sensors, again set up and controlled locally but with the potential to be networked.

BAS have advanced from the pneumatic controls of the 1950s through the advent of digitalization and microprocessor control in the 1980s to the present, with remote control of systems through wireless technology (Control Solutions Inc., 2015) and common communication protocols.

**A Building Automation System may be denoted as:**
An automated system where building services, such as utilities, communicate with each other to exchange digital, analogue or other forms of information, potentially to a central control point.

### 2.2.3 BUILDING AUTOMATION & CONTROL SYSTEM

Building Automation and Control Systems (BACS) are known by many terms, such as a Facilities Management System (FMS), Building Automation System (BAS), Building Automation and Control System (BACS), an Intelligent Building (IB) or a Building Energy Management System (BEMS).

A BACS could be considered a system that converges at a central point to integrate technology and processes to create a facility that is safer, more comfortable and productive for its occupants, and more operationally efficient for its owners and operators.

Smaller scale examples of a BACS include residential home automation systems providing control for services such as automated heating, lighting and audio-visual systems. At its most basic level, a BMS consists of software, a server with a database and sensors connected to a network. This falls under the same broad definition, even though the scale is entirely different, to a commercial or industrial BACS.

By 2002, the concept of modern integrated BACS was beginning to receive widespread acceptance in the facility and real estate marketplace, and were generically defined as a "computer-based control building automation systems predominate in most commercial and industrial buildings, reducing energy costs while improving system performance, operability and reliability"

**A Building Automation and Control System (BACS) may be denoted as:**
An automated system, where building services and processes, communicate with each other to exchange digital, analogue or other forms of information, to a central control point.

### 2.2.4 INTELLIGENT BUILDING OR SMART BUILDING

The next level of building automation and integration is becoming known as an Intelligent Building (IB) system. While the term IB has been used in the industry since the early 1980s, a standard industry wide accepted definition does not exist. Nevertheless, one of the earliest definitions of IB comes from the European Intelligent Buildings Institute, which described it as being one that "**creates a new environment which maximizes the effectiveness of the facility occupants while at the same time enabling efficient management of resources with minimum life-time costs of hardware and facilities**". The focus on facility services in a BACS moves in IB to the needs of the occupants.

The Asian Institute of Intelligent Buildings (AIIB) extends this explanation, adopting a definition for IB as the inclusion of nine functions, being environmental friendliness, space management, human comfort, working efficacy, culture, image of high technology, safety and security, construction and structure process and finally, life cycle cost. These elements resulted in a definition that:

**An Intelligent Building is designed and constructed on an appropriate selection of quality environment modules to meet the users' requirements by mapping with the appropriate facilities to achieve long-term building value**.

According to Smart Accelerate, an Intelligent Building is one that incorporates available concepts, materials, systems and technologies, and by integrating these, meets or exceeds the performance requirements of the facility stakeholders including the owners, managers, occupants and users. Therefore, the facility's environment should be productive, safe, healthy, and thermally, aurally and visually comfortable. These can be achieved through optimizing a facility's four basic components, namely its structure, systems, services and management. However, these views do not provide an explicit definition of IB.

**To address the ever broader technical and business functions in defining IB, we can summarize that an IB comprises of three key elements:**

a. Highly sophisticated office automation functions relying on a facility LAN and augmented by diverse office automation equipment

b. Advanced communications capabilities achieved through effective introduction of digital technologies

c. Sophisticated building automation capabilities realised through effective integration of facility management, security and energy saving systems

There is no standard consensual definition of what constitutes an IB; however, most explanations have several things in common:

a. Integrates disparate facility service systems so they can be controlled by a single and centralized common user interface

b. Maximizes facility performance and efficiency by integrating facility service systems such as lighting, HVAC, safety, power management, security, etc.

c. Uses a shared network for all facility-system communications

d. Provides significant benefits to facility owners, property and facility management professionals, and its users.

e. Uses technology and strategies that add long-term, sustainable value to the property

An Intelligent Building system may be denoted as:
An automated system where building services and corporate processes, communicate with each other to exchange digital, analogue or other forms of information, to a central control point to manage the environment.

### 2.2.5 INTERNET OF THINGS (IoT) & BUILDING INTERNET OF THINGS (BIoT)

In more recent years, the "Internet of Things" has had to be considered. Morgan defines the IoT as **"the concept of basically connecting any device with an on and off switch to the Internet (and/or to each other)".** The list of everyday items that can be connected to the Internet is limitless; through the IoT it is possible to remotely and wirelessly control washing machines, switch on or off-air conditioning, record television programs while abroad and programme the coffee pot for our arrival home from work. Such connectivity also applies to the non-domestic world. The basic premise to the IoT is that anything that can be connected to the Internet, will be connected.

As a relatively recent phenomenon, the IoT is highly relevant to the IB discussion as a system that connects all "things". At the core of the IB is the concept of connectivity and central control by the individual, through various physical electronics or engineering methods. The IoT provides the same capability of connectivity, but uses the Internet or Wi-Fi connectivity. The result is the ability to move away from the use of a dedicated network and protocols, which is a more efficient and less costly means of delivering building automation.

The IoT is already having an impact on building automation, with the convergence of the IoT and IB. For example, Young defined the Building IoT (BIoT) as **"the overlaying of an Internet Protocol (IP) network, connecting all the facility services monitoring, analysing and controlling without the intervention of humans".** There are already cloud and application-based solutions using IoT, such as Building IQ, Sky Foundry, Mios, which provide functionality not previously available.

Facility professionals are concerned with improved efficiency and reduced costs that can be achieved by the IB. However, the age of the Internet has brought about a level of cheaper and easier connectivity that takes building automation into a different realm. It is predicted that the traditional building automation will transform itself over the next technological generation into a BIoT.

## 2.3 A BRIEF DEVELOPMENT HISTORY OF BACS

Building Automation and Control System (BACS) is the drive for faster, more efficient and more stress-free ways of conducting business. With time and the development of technologies, there have always been improving methods to automate and integrate almost all areas of industry, business, and, indeed, personal lives.

Unlike automation, which originates in the early industrial era, BACS has roots in the 1970s industrial sector, from the systems and controls used to automate production processes and to optimize plant performances. The concepts and applications were then adapted, developed and modularized during the 1980s, supported by more powerful and cheaper microprocessors, enabling transferability of the technology and systems to the residential and commercial sectors.

### 2.3.1 NEED OF BUILDING AUTOMATION CONTROL SYSTEM

#### 2.3.1.1 ENERGY MANAGEMENT SYSTEMS

The history of energy management systems (EMS) started after World War II, when a need to monitor the growing number of pneumatic controls and electrical switches arose. It soon became apparent that servicing a great number of panels mounted near equipment-controlled areas was expensive and centralization became one of the key topics.
In the 1950s, engineers introduced the first-generation pneumatic sensor transmitters that allowed remote monitoring and local adjustment from the pneumatic controller. Pneumatic controllers functioned by varying the amount of compressed air powering a device attached to that unit. The system consists of air chambers, springs, linkages, orifices, diaphragms, nozzles and internal valves to regulate air pressures. By, centralizing these controllers resulted in lots of pneumatic tubing and a large display board with gauges and control switches. An operator monitored these gauges and when abnormal values were detected, a mechanic could be sent to the endpoint to resolve the problem.

Parallel to the electromechanical evolution, minicomputers and Programmable Logic Controllers (PLCs) were improved and adapted to the requirements of control systems. Due to the high energy costs during the 1970s oil crisis the need for energy saving systems became more crucial. Increasing computerized systems improved and optimized the control of system elements. In addition, fire and life safety systems from the emerging market of BACS were integrated into the already existing EMS.

Due to lower hardware costs and improved micro processing capacity in the 1980s, microcontroller-based control panels replaced the conventional pneumatic control systems. Therefore, remote panels became increasingly smarter and could carry out most of the functions that had formerly been controlled centrally. These remote intelligent nodes were connected with the central console by a proprietary Local Area Network (LAN).

Around the 1980s, the current generation introduced the concept of Direct Digital Control (DDC) and used small programmable microprocessors on remote nodes, controlled centrally by a Personal Computer (PC) (McGowan, 1995). The distributed intelligence in the field nodes led to improved speed of response and increased system reliability.

#### 2.3.1.2 PROCESS CONTROL SYSTEMS

Process Control Systems (PCS) are used to monitor and control processes in industrial plant and equipment to a centralized location, using a defined communication standard (language). The centralized location became the operators console, a human-machine interface (HMI) to monitor the values of the Remote Terminal Units (RTUs) that were regularly polled by the central host processor. However, due to the lack of common communication standards, proprietary systems were extensively used and this resulted in systems that could not communicate with each other.

During the 1970s microcontrollers were introduced, where simple process steps could be programmed into these controllers. Mainframe computers were used as a central host computer to poll the remote controllers. To poll is a communication process in which the computer or controller interrogates the status of its connected external devices on a communication line to find whether it has data to transmit or receive. A disadvantage of the centralization process was the increasing risk of a failure in the central systems, leading to a system blackout. However, low-cost 8-bit and 16-bit microprocessors slowly replaced the conventional Remote Terminal Units and provided the first so-called smart remotes.

In the 1980s more decentralized systems were introduced with intelligent field nodes that were connected to the central console by a bus system. Local Area Network (LAN) technologies and Ethernet found its way into PCS. Redundant dedicated front-end processors were used to poll the RTUs (Remote Terminal Unit), while more advanced systems performed special application and backup tasks. This approach reduced costs in contrast to pure mainframe applications and improved system reliability. Such technology development led to the Supervisory Control and Data Acquisition (SCADA) systems.

Due to the broad acceptance of PCs and decreasing hardware costs in the 1990s, overall costs for PCSs decreased. PCSs were comparable to corporate IT networks and the client server concept evolved into SCADA systems. Past monolithic programs were rewritten and new programs distributed to dedicated computers. Another step was the introduction of a set of communication standards for data exchange, for example the Object Linking and Embedding for Process Control (OPC). In terms of cutting costs and creating a standardized environment, the evolution of LANs, WANs, TCP/IP networking, communication standards and protocols, and Ethernet resulted.

### 2.3.2 MODERN DAY BUILDING AUTOMATION CONTROL SYSTEMS

Building Automation and Control System (BACS) evolved from the merging of different areas of automation, for example EMS and PCS. Integrating these systems into one Distributed Control System (DCS) for facility's takes advantage of both systems in managing the challenges in modern management. BACS systems are technically focused and can be integrated into facility management that joins BMS and Maintenance Management Systems (MMS), focused on work scheduling, maintenance planning, inventory control and accounting.

Modern BACS automate, controls and manages the services, environment and business functions within a facility. Facility services include utilities and its subsystems such as Heating, Ventilation and Air-Conditioning (HVAC), lighting, blinds, elevators, life safety (such as fire detection, fire suppression, emergency warning and intercom), and security (such as intruder alarm systems and CCTV) into one integrated facility communication system. Many manufacturers, using common connectivity protocols like BACnet and Lon Works, offer "plug and play" products for managing or controlling end nodes, specifically taking advantage of common language standards. Furthermore, the modern IB is now connected to existing enterprise management software such as SAP or Open View.

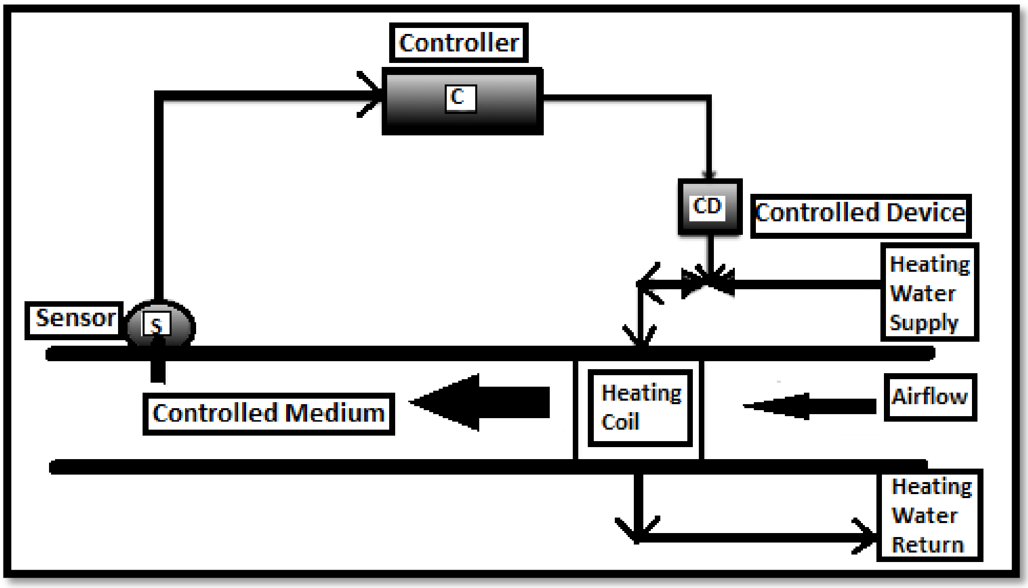
## 2.4 FUNDAMENTALS OF BUILDING AUTOMATION SYSTEMS

Building Automation and Control Systems (BACS) architecture is based on three levels, considered the (1) Management level, (2) Automation level and (3) Field level. However, in contrast to this model some consider there to be a fourth level labelled Service. In general, the (1) Management level contains the human interface (workstation), server and routing devices, all connected via an appropriate communication medium. The (2) Automation level provides the various primary control technology devices and secondary facility automation, connected via networked controllers and operating via BACnet, Lon Works, etc. communication protocols. The (3) Field level includes devices connected to specific plant and equipment sensor or activators. The Service level generally embodies remote access connectivity for service and maintenance use.

### 2.4.1 AUTOMATION CONTROL SYSTEM BASICS

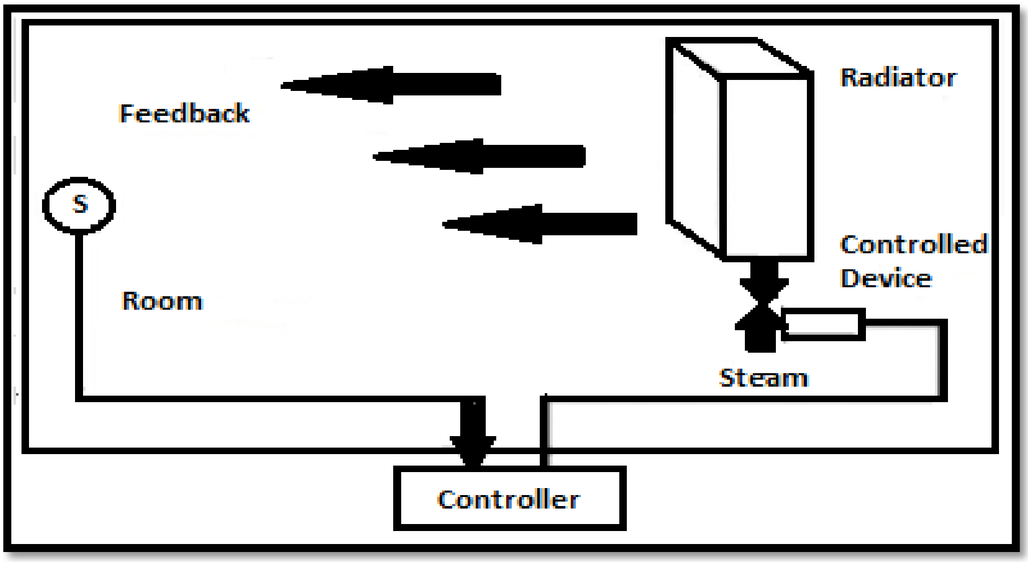
A simple control system consists of three component functions and associated parts: a sensor providing input function, a controller providing decision functions and a controlled device providing a defined system output function (Fig- 2.4.1(A)). The sensor [S] measures a variable, for example the controlled medium of temperature in the duct, and sends that information to the controller [C]. Dependent on configuration, the controller calculates the necessary output value to adjust the controlled device [CD]. Adjusting the controlled device alters the amount of heated water supply and ultimately, the duct temperature at the sensor.

There are two general types of control systems: open-loop and closed-loop control. A closed loop operating modality is closed because the effect of the control system device is used as input for the sensor.



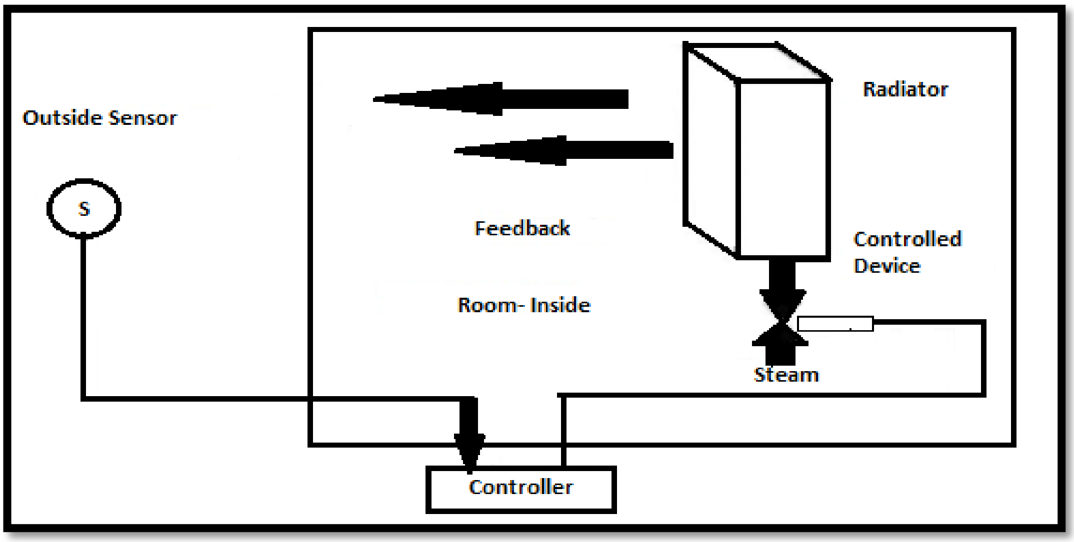
**[Fig- 2.4.1(A)] Control Systems**

Figure-2.4.1(B) shows how the temperature detected in the room is used as a continuous input for the processing controller, which compares against pre-set functions to adjust the heating output through a radiator. In other words, a control system where the output acts upon the process in such a way as to reduce the difference between the measured value and the desired set-point.



**[Fig-2.4.1(B)] Closed Loop Control Systems**

In contrast, open-loop circuits embody a system where the sensor measures a completely independent variable. In other words, a control system where one or more measured inputs control the output without any influence from the process. For example, Figure-2.4.1(C) shows that the measurement of the temperature that occurs outside the building and controls the internal radiator.



[Fig-2.4.1(C)] Open Loop Control Systems

### 2.4.2 AUTOMATION CONTROL LOGIC

Two formats of information or logic are used to exchange or inputs into automation, digital and analogue data. Digital(binary) information communicates through two distinct states, namely on [logic 1] or off [logic 0]. For example, this is used to monitor whether an engine is running or not. In contrast, analogue information is represented as a floating value, for example from 0 to 5 volts, and is used to measure continuously changing or modulating environments.

In earlier automation systems, the controller logic was hard-wired and more representative of analogue technologies, whereas current systems use software to calculate values and is digital in nature. However, some basic types of building automation controllers can still be distinguished: two-position, floating, proportional, proportional plus integral and proportional plus integral plus derivative (PID) controllers.

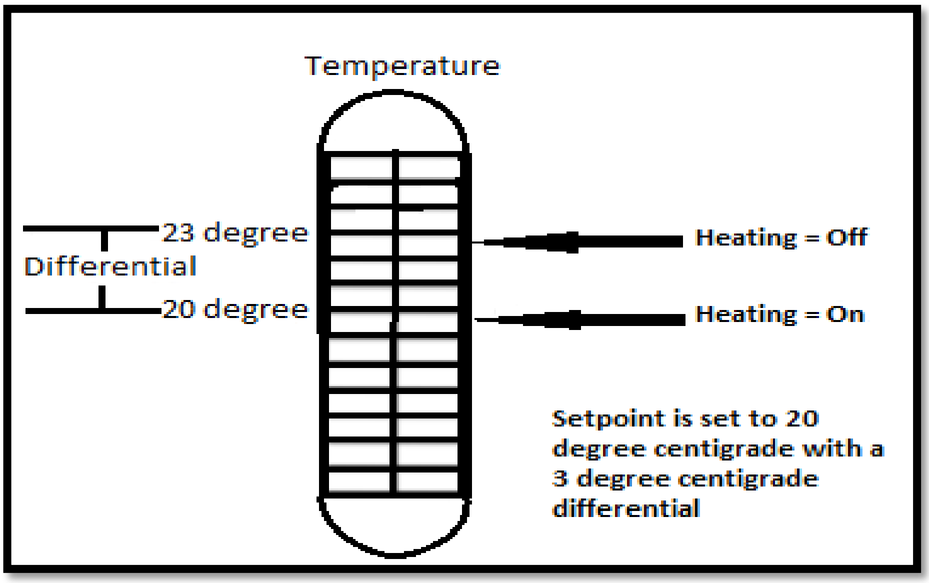
The two-position control, also known as digital or on/off control, defines a set-point and a differential value to this set-point. The controlled device is switched to on when it reaches the set-point and switched to off when it leaves the differential area to the set-point. In Figure-2.4.2, a radiator is activated when reaching 20 degrees and turns off again when reaching 23 degrees.

Floating control is a type of two-position control and defines three states: increasing, decreasing or off. An example is a controlled device such as a valve for mixing hot with cold water. When the water is too hot, the controller signals to close the valve and stops when the valve reaches its mid-position.

Proportional controllers adjust the output proportional to the input signal, used for example, to correct deviation to the defined set-point. The output signal is proportional to the difference of the set-point and is off when the set-point is reached. When an integral is added to the proportional controller the divergence to the set-point is integrated over time.

Hence, the proportional plus integral (PI) controller combines the advantages of proportional control and integration, and is; therefore, one of the most widely used controls in HVAC.

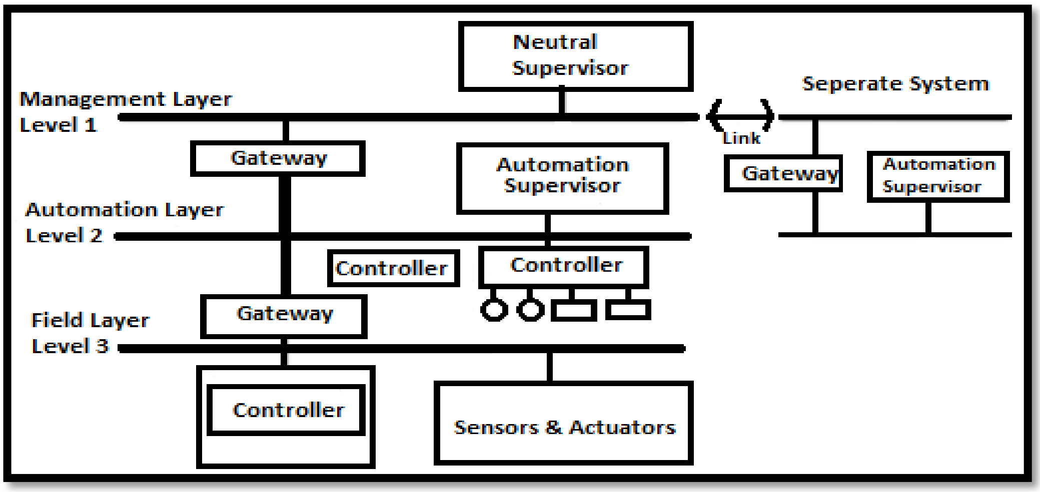
A proportional plus integral and proportional plus integral plus derivative (PID) control adds derivation to the calculation of outputs. For example, when controlling a valve, the speed of closing or opening the valve is dependent on how large the difference between the measured value and the set-point are.



[Fig-2.4.2] Two-position Control Configuration

## 2.5 BACS HARDWARE ARCHITECTURE

The European Committee for Standardization (CIBSE, 2000), in their International Standard for Building Automation (2004), divides building automation architecture and communications into three distinct layers or levels of Management, Automation and Field devices (Figure-2.5(A)). The advantage of such architecture is that there is a clear separation of duties and a reduction of network traffic in the management level; however, for smaller systems a separation of networks can be expensive.



[Fig-2.5(A)] Three-layer BACS Architecture

MANAGEMENT LEVEL

The Management level is generally the company's Information Technology and Communications (ITC) network.

The Management level comprises operator stations, monitoring and operator units, programming units and other peripheral computer devices connected to a data processing device i.e., a server to support the information exchange monitoring and management of the automation system. For example, a personal workstation that has dedicated automation software installed. Several autonomous systems can be connected to support the human interface for monitoring and management purposes.

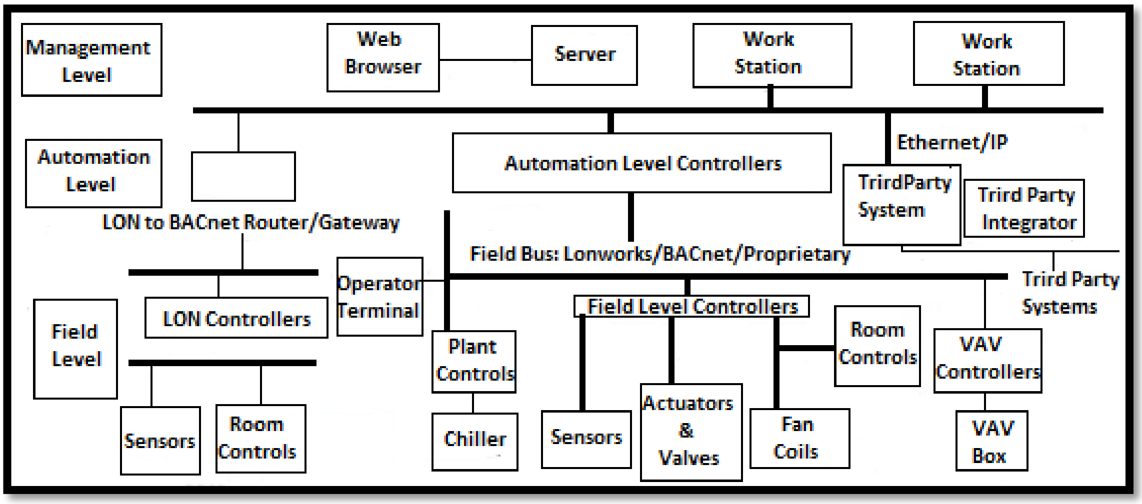
AUTOMATION LEVEL

The Automation level is generally a dedicated communications network for the sole purpose of building device connectivity, communication and control (automation).

The Automation level comprises **"control devices and monitoring and operator units, programming units, operator stations or panels and/or programming units connected to a data processing device i.e., a server"** (International Organization for Standardization, 2004, p. 53). This level is associated with controllers that serve main plant, such as the air handling units, chillers and boiler units, etc.

FIELD LEVEL

The Field level comprises devices that are generally self-contained physical units. Field level devices are connected to automation level controllers, either application specific or generic controllers. Application specific controllers operate using communications protocols such as M-bus or other proprietary protocols. Fig-2.5(B) illustrates the BACS three-layer Architecture system.



[Fig-2.5(B)] **Illustration of BACS Three-layer Architecture**

## 2.6 BACS SOFTWARE ARCHITECTURE

As with BACS hardware, the International Standard for Building Automation (2004) divides its software architecture and communication networks into three distinct levels of Management, Automation and Field.

The following sections provide a background and overview of the more commonly used automation protocols, such as BACnet and Lon Works.

### 2.6.1 BACS INDUSTRY STANDARDS & PROTOCOLS

For BACS to function, there is a requirement for connectivity and common language communication. Connectivity is achieved through various communication networks that link and integrate the many discrete devices. Communication is achieved through standardized logic code. Such a requirement has led to a number of building automation network and communication protocols being established. Table-1 shows the BACS key industry standards & protocols.

**Table 1: BACS Key Industry Standards & Protocols Attributes**

| BACS Standards | Attributes |
|---|---|
| BACnet | American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE) standard, modelled on the Open Systems Interconnection (OSI) reference that shields BACnet from obsolesce with respect to networking. Adopted worldwide as ISO 16484-5:2003 |
| ZigBee | Short range, low-powered wireless communication standard |
| CEBus | Electronics Industry Association (EIA) standard, covers devices that communicate through mains power cabling, low voltage twisted pair, coaxial cable, infrared, RF and fibre optics |
| DALI | Digital Addressable Lighting Interface. Network-based systems that control lighting in buildings |
| Dynet | Dynalite network and protocol |
| EHSA | European Home Systems Association (EHSA) allows connection to a network using any collection of media and therefore supports an open system |
| EnOcean | Battery-less, interoperable and wireless standard |
| KNX | System for local device control |
| LonTalk | Part of the Lon Works platform. Created by Echelon Corporation for networking devices. ISO standard numbers for building automation worldwide are ISO/IEC 14908-1, ISO/IEC 14908-2, ISO/IEC 14908-3, and ISO/IEC 14908-4 |
| LonWorks | Local Operating Network that was designed for automation control. A worldwide standard that includes a communication media similar to CEBus. Focus of Lon Works is the “Neuron” chip, which acts as the network node and communication protocol |

| | |
|---|---|
| NEST | Novell Embedded Systems Technology, aimed to be used everywhere for devices in offices, homes, cars, etc. |
| OPC | Standard used widely in manufacturing, process control, and building automation. The open standard transfers, values, historical data, and alarms and events |
| S-BUS | Smart-BUS, SBUS, an open protocol, open source |
| X10 | Oldest available technology, allowing limited control of devices via power reticulation |

### 2.6.2 BACS OPERATING PROTOCOLS

The more commonly applied BACS automation protocols include BACnet, Lon Woks, KNX and Modbus. However, application, region and the market dictates which protocol is more likely used.

**BACnet:**

The ASHRAE BACnet (Building Automation and Control Networks) protocol was developed specifically to address the needs of building automation and control systems in various capacities. Created in 1987 at Cornell University, it became an ANSI standard under the auspices of the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE). BACnet was modelled on the Open Systems Interconnection (OSI) reference model.

The focus of BACnet was to ensure a high level of inter-operability in an environment that involved many vendors and multiple types of building plant, equipment and systems. In 1995, BACnet became ASHRAE1/ANSI2 Standard 135 and was published as International Standard ISO 3/IEC416484-5:2003. Since January 2006, BACnet International is the official initiative for promoting and developing BACnet.

**LonWorks:**

Local Operating Network (Lon Works) is a widely used standard for many types of automation and control applications. It was created by the manufacturer Echelon around 1989, and in 1999 it was accepted as a standard by ANSI for control networking (ANSI/CEA-709.1-B).

Echelon had the goal to design a microprocessor that possessed a standardized communications interface, where each device was able to “talk and work” with every other device, regardless of manufacturer and to carry out its specific task as decentralized intelligence within a network. Lon Works is part of the BACnet MAC layer.

In 2008, the Joint Technical Committee of the International Organization for Standardization (ISO) and the International Electro Technical Commission (IEC) formally approved Lon Works control networking technology as ISO/IEC 14908, Parts 1, 2, 3, and 4 (Landmark International, 2017).

## KNX:

KNX is a worldwide communication standard for home and building control, using OSI-based (Open Systems Interconnection) network communications protocol. The protocol was created in 1999 by Konnex Association (now KNX Association). It is a combination of three previous standards, namely the European Home Systems Protocol (EHS), BatiBUS and European Installation Bus (EIB or Instabus). KNX has been standardized through EN 50090 and ISO/IEC 14543).

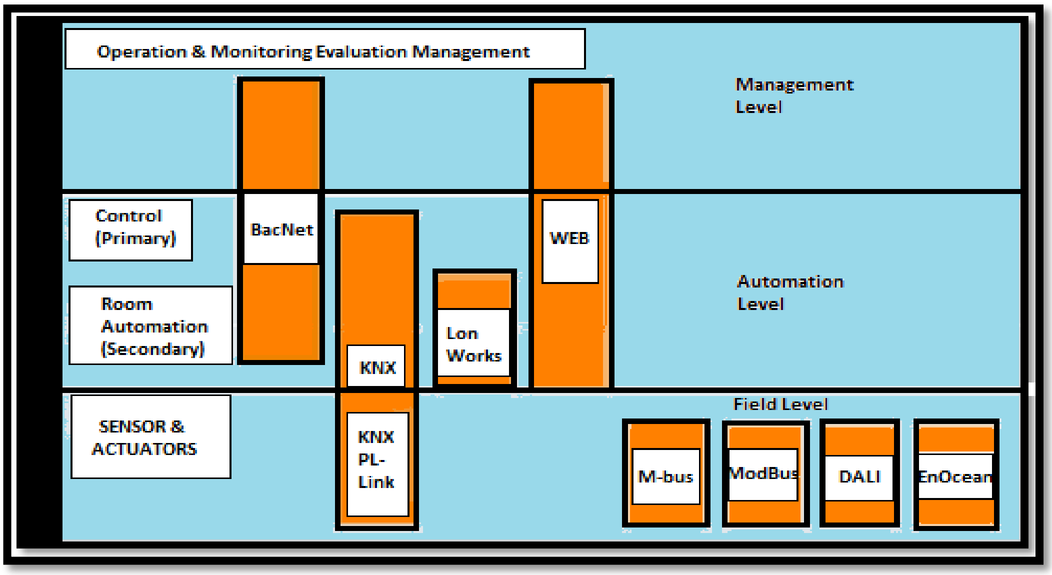
## MODBUS:

Modbus is a serial communications protocol, developed in 1979 by Modicon (now Schneider Electric). Originally created as part of the programmable logic controllers (PLCs) market, it was released as an open protocol in 2004.

The Modbus protocol uses a client/server architecture to manage communication between a host and device. In building automation, it is used to control equipment such as chillers, boilers and fans. The protocol continues to be used at the application device level because it is easy to understand, is an open system and can be used royalty-free. However, Modbus is not restricted to just building automation, and can be found in numerous diverse automation industries including industrial control automation.

### 2.6.3 BACS ARCHITECTURE OF OPERATING PROTOCOLS

The many types of protocols provide connectivity at the various BACS automation levels. As with its hardware, automation protocols can be divided into levels (Figure-2.6.3), although typically software straddles levels. In general, the Management level contains the human interface (workstations), server and routing devices, all connected via an appropriate communication medium such as LAN/WAN using TCP/IP/BACnet. The Automation level provides the various primary control and secondary room automation, connected via networked controllers using twisted pair cables and operating BACnet, LonWorks or KNX. Finally, at the Field level, devices are connected to specific plant and equipment sensor or activators operating M-bus, KNX or their own proprietary protocol.



**[Fig-2.6.3] BACS Software Architecture**

## 2.7 BACS AUTOMATION LEVEL DEVICES

In this section, BACS automation levels are discussed to provide an oversight of the typical parts within the automation architecture. Typical physical devices for the levels of Management, Automation and Field are discussed.

### 2.7.1 FIELD LEVEL DEVICES

Field level devices are physical equipment that connects the BACS to its physical environment, providing the system with information and the means to adjust the building environment. These are generally self-contained physical units, either as actuators or sensors. Typical field devices are light switches, PIRs, fan motors, air volume boxes, temperature sensors, etc.

ACTUATORS Actuators allow control of plant process, and operate electrically, pneumatically or hydraulically, to influence the flow of mass or energy. They are typically motorized electromechanical devices for the control of valves or dampers.

SENSORS A sensor is a device or instrument designed to detect or measure a variable. Typical sensors may be a switch (binary), thermostat (binary) or temperature gauge (analogue). For example, a typical sensor is an electronic average transmitter that converts data from four duct air temperature sensors into one averaged signal.

### 2.7.2 AUTOMATION LEVEL DEVICES

The Automation level devices generally comprise Controllers that provides an interface between the system's field and management levels, and which contain some distributed decision intelligence. Controllers are typically designed to provide either specific application functionality or generic functionality, although most provide a degree of both (multi-functionality). Controllers are generally compact and may be used in standalone or in network mode and are freely programmable. They include inputs and outputs, from 6 to 40 inputs/outputs (Table 2).

| TYPE OF INPUT/OUTPUT | TYP. NUMBER |
|---|---|
| Digital Inputs | 2-4 |
| Thermistors Inputs | 2-4 |
| Universal Inputs | 4 |
| Analogue Inputs | 3 |
| Digital outputs [Relay] | 3-6 |
| Digital Outputs [Triac] | 0-6 |

**TABLE 2: TYPICAL CONTROLLER INPUTS & OUTPUTS**

| INPUT/OUTPUT | REQUIREMENTS |
|---|---|
| Operating voltage | 24 V AC/DC ±20%, 50/60 Hz |
| Power consumption | Max. 5 W |
| Operating temperature | 0 to +50°C |
| Data backup in event of power failure | 72 h RAM-Backup |
| Dimensions incl. base | 180mm x 110mm x 77.4 mm |
| Transceiver Protocol | FTT-10, LonTalk |
| Transmission rate | 78 Kbits/s, TP/FT-10 |
| Input variable | Max. 15 Network variables |
| Output variable | Max. 30 Network variables |
| Serial connection | RS232, RJ45 |

**TABLE 3: TYPICAL CONTROLLER OPERATING PARAMETERS**

Table-3 shows the typical operating parameters of any type of controllers used in a network.

### APPLICATION SPECIFIC CONTROLLERS

Application specific Controllers are devices for controlling secondary plant and equipment systems, such as HVAC, elevators, etc. These controllers can be adapted to individual requirements using a degree of flexible configuration settings. A typical application specific controller is the Variable Air Volume (VAV) Controller, which is a room controller for HVAC applications. The Controller keeps a constant temperature in the zone by controlling the air flow, heating stages and fan-in sequence. With a carbon dioxide sensor, the air quality can be zone controlled.

### 2.7.3 MANAGEMENT LEVEL DEVICES

The Management level device primarily consists of the information technology and communications (ITC) network, with connected **“operator stations, monitoring and operator units, programming units and other peripheral computer devices connected to a data processing device i.e., a server”**. In addition, one or a number of data and information processing (software) packages that allows human system interface such as a Graphical User Interface (GUI). Manufacturers provide such software packages in various modules, allowing designers and users to select what most suits their building. Software packages range from simple information processing systems that control a single room via the Internet to complex whole of building services function, running not only the building plant and equipment, but also security, energy management, lighting, etc.

# CHAPTER – 3

# TYPES OF SYSTEM UNDER BACS

## 3.1 DIFFERENT TYPES OF SYSTEMS IN BACS

In case of BACS there is mainly two types of systems available in the market. These two types of systems are mainly Safety systems & Security systems. Practically in case of smart or intelligent buildings these two types of systems are much required. So, in this chapter we will discuss about the different kinds of Safety & Security systems with a brief detailing.

### 3.1.1 SAFETY SYSTEMS

As we discussed earlier that, in case of smart building the primary or the main focus should be on the Safety support systems. It is the backbone of the Smart or Intelligent Building Management Systems. As of now, some main safety support systems, generally used in case of BACS are:

- Fire alarm System
- Public Address System
- Gas Suppression System
- Very Early Smoke Detection System/ Aspiration Smoke Detection System

### 3.1.2 SECURITY SYSTEMS

The other types of systems which are as much important as the Safety Systems in case of Building Automation & Control Systems (BACS) are the Security Systems of the Buildings. There are many Security Systems available in the recent market for BACS, but some of them are most essential in terms of Security purpose, namely:

- Access Control Systems
- CCTV (Closed Circuit Television)
- Building Management Systems
- Rodent Repellent Systems
- Water Leak Detection Systems

### 3.1.1 SAFETY SYSTEMS:

#### (A) FIRE ALARM SYSTEM

Fire safety is the set of practices intended to reduce the destruction caused by fire. Fire safety measures include those that are intended to prevent ignition of an uncontrolled fire, and those that are used to limit the development and effects of a fire after it starts. In case of monitoring system of any Fire Alarm System, there are mainly these type of monitoring systems: Fire Detectors, Smoke Detectors, Sensitive Detectors, Alarm Systems etc.

To monitor the whole system some numbers (say 16) of addressable loops are created and each and every loop a certain number of monitoring devices (say 250 devices per loop) are connected.

This is how the networking is done in case of Fire Alarm system. Fig-3.1.1(A-1) represents the fire alarm system networking & Fig-3.1.1(A-2) represents different types of point detectors

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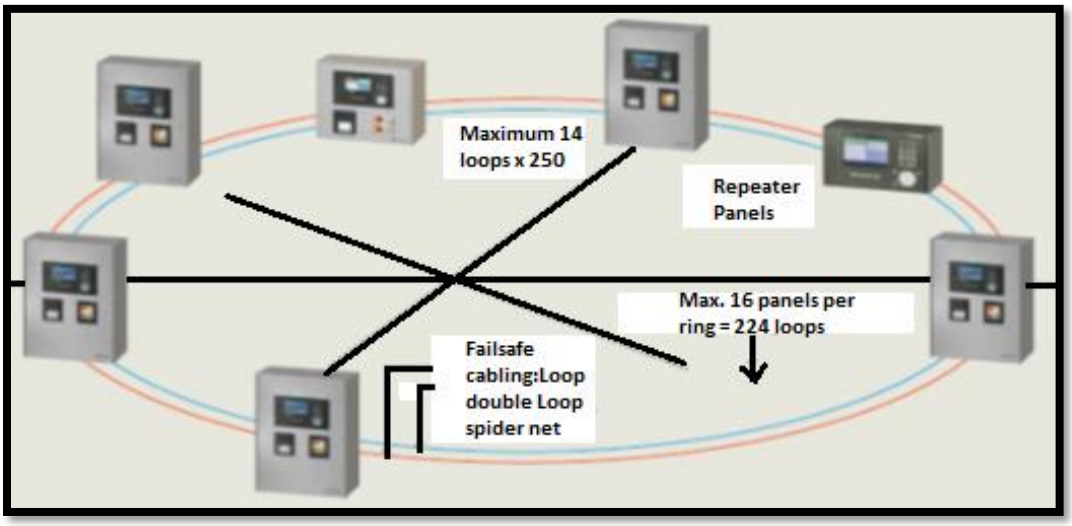


**[Fig-3.1.1(A-1)] Fire Alarm System Networking**

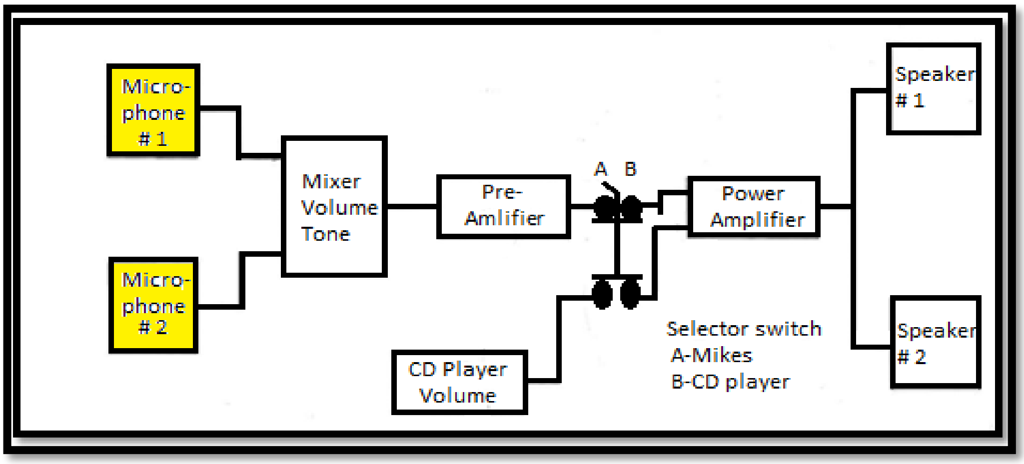
**[Fig-3.1.1(A-2)] Different types of point Detectors**

## (B) PUBLIC ADDRESS SYSTEM

A Public Address System is an electronic sound amplification and distribution system with a Microphone, Amplifier and Loudspeakers used to allow a person to address a large public. The term is also used for systems which may additionally have a mixing console, and amplifiers and Loudspeakers suitable for music as well as speech, used to reinforce a sound source, such as recorded music or a person giving a speech or distributing the sound throughout a venue or building. Public Address System consists of Input Sources, Amplifiers, Control & Monitoring equipment, and loudspeakers.

The primary input sources are microphones for live announcements and a source of recorded sound. There may be a system which allows operators, or automated equipment, to select from a number of standard pre-recorded messages. These input sources are fed into preamplifiers and signal routers that determine the zones to which the audio signal is fed.

The pre-amplified signals are then passed into the amplifiers. Depending on local practices these amplifiers will usually amplify the audio signals to 50V, 100V or 100V speaker line level. Control equipment monitors the amplifiers and speaker lines for faults before it reaches to the loudspeakers. This control equipment is also used for separating zones in a PA System. The loudspeaker is used to convert electrical signals into sound. Fig-3.1.1(B) represents the basic block diagram of Public Address System.



**[Fig-3.1.1(B)] Basic Block Diagram of Public Address System**

## (C) GAS SUPPRESSION SYSTEM

Gaseous fire suppression is a term to describe the use of inert gases and chemical agents to extinguish a fire. The system typically consists of the agent, agent storage containers, agent release valves, fire detectors, fire detection system (wiring control panel, actuation signalling), agent delivery piping, and agent dispersion nozzles. Less typically, the agent may be delivered by means of solid propellant gas generators that produce either inert or chemically active gas. These Agents are governed by the NFPA (The National Fire Protection Association) Standard for Clean Agent Fire Extinguishing Systems When it comes to protecting the information and hardware in a datacentre.

Gaseous fire suppression systems have some obvious advantages. People choose gaseous systems is because they don’t want water all over their computer systems. The system typically consists of the agent, agent storage containers, agent release valves, fire detectors, fire detection system (wiring control panel, actuation signalling), agent delivery piping, and agent dispersion nozzles. Less typically, the agent may be delivered by means of solid propellant gas generators that produce either inert or chemically active gas.

Merits of the gas suppression system:

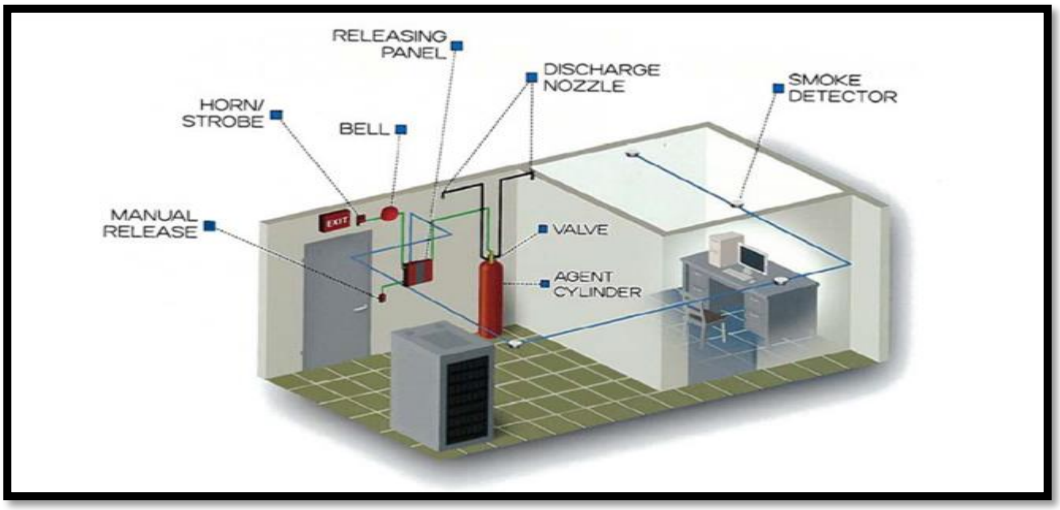
- Fast and effective against a wide range of Class A, B and electrical fires.
- Safe for occupied areas.
- Non-corrosive and electrically non-conductive.
- No post-discharge residue and clean-up.

- Environmentally acceptable.
- 25 / 42 bar system
- Range of system release options.
- Low installation and maintenance costs.
- Computer design maximizes effectiveness of system.
- Clean agent Gas based Fire suppression system shall comply the international standards like BS 6266, NFPA 2001 and NFPA 72E.

Fire Suppression System in Datacentre is considered with Simultaneous Flooding in the following areas:

- Room Void.
- Ceiling Void (Above False ceiling)
- Floor void (Below False Flooring, if available)

**[Fig-3.1.1(C-1)] Some Gas Suppression Products**



**[Fig-3.1.1(C-2)] Basic Structure of a Gas Suppression System**

Figure-3.1.1(C-1) shows some products of Gas Suppression system & Figure-3.1.1(C-2) represents the Basic structure of a Gas Suppression system.

(D) VERY EARLY SMOKE DETECTION/ ASPIRATION SMOKE DETECTION SYSTEM

An **Aspirating smoke detector** (**ASD**) is a system used in active fire protection, consisting of a central detection unit which draws air through a network of pipes to detect smoke. The sampling chamber is on a Nephelometer (A Nephelometer is an instrument for measuring the concentration of suspended particles in a liquid or gas colloid) that detects the presence of smoke particles suspended in air by detecting the light scattered by them in the chamber. ASDs can typically detect smoke before it is visible to the naked eye.

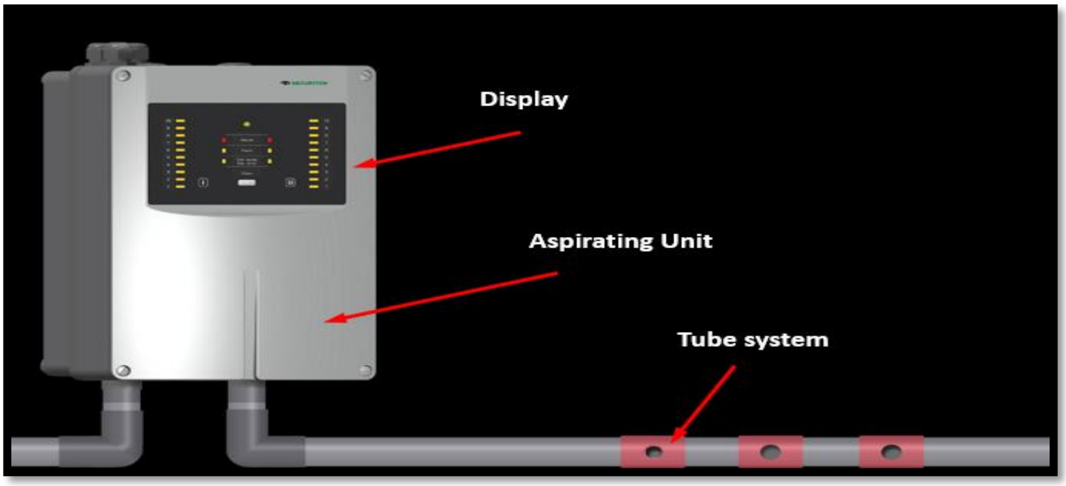
ASD design corrects shortcomings of conventional smoke detectors by using a sampling pipe with multiple holes. The air samples are captured and filtered, removing any contaminants or dust to avoid false alarms and then processed by a centralized, highly sensitive laser detection unit. If smoke is detected, the systems alarm is triggered, and signals are then processed through centralized monitoring stations within a few seconds.

Unlike passive smoke detection systems, including spot detectors, ASD systems actively draw smoke to the detector through bore holes within a piping system that runs throughout the protected area. Furthermore, ASD systems incorporate integrity monitoring to ensure an alert is raised at any time the ASD’s ability to detect smoke is compromised. This is not the case with passive devices that are generally only electrically monitored with no ability to determine if smoke can actually reach the detection element.

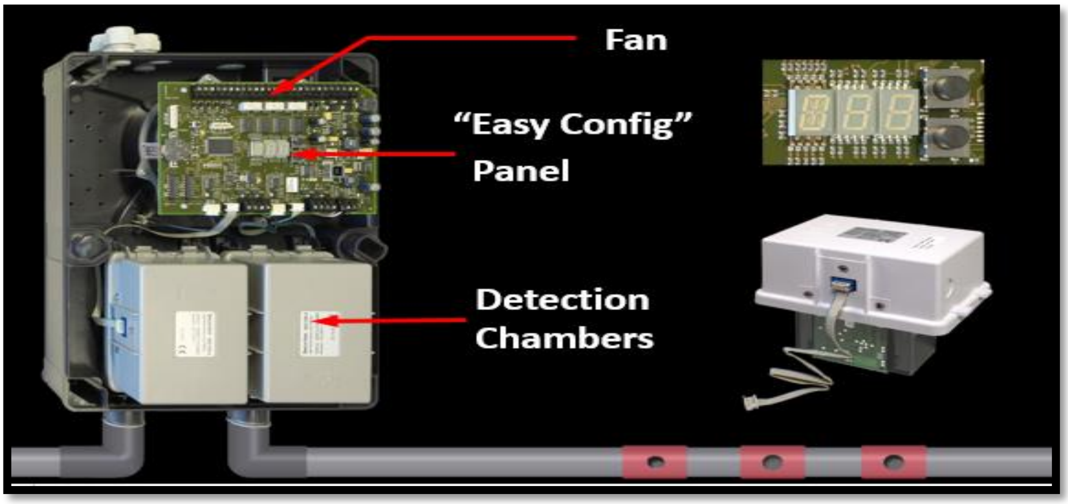
ASD systems incorporate more than one level of alarm. This allows an ASD system to provide very early warning of an event (Pre-Alarm), prompting investigation at the earliest smouldering stage of a fire when it is easily addressed. Other alarm levels may be configured to provide fire alarm inputs to fire systems as well as releasing suppression systems. ASD alarm sensitivities (Typically 0.002 - 10 % Obs/m) are configurable and can be programmed to levels ranging from thousands of times more sensitive than a conventional detector, to much less sensitive. The detectors work best in non-volatile environments.

MAIN FEATURES OF ASPIRATION SMOKE DETECTION SYSTEM:

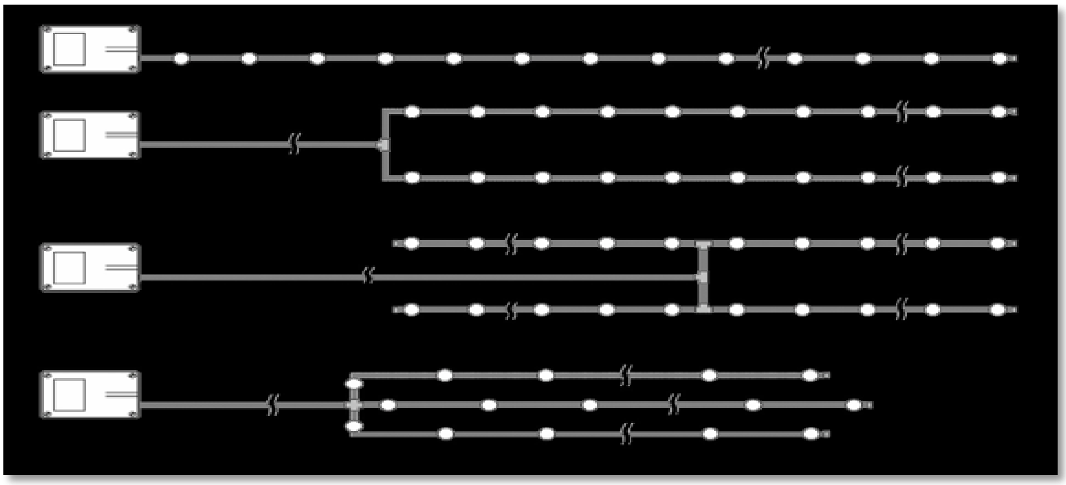
- Wide Sensitivity Range from 0.002 to 10 % obs/m.
- Three different pre-signals adjustable.
- Best against contamination.
- Features for Auto Learning.
- Selectable 5 speed for Fans through software.
- 1 or 2 Sampling pipes with separate air flow monitoring.
- Low noise Level.
- Seamless integration with FAS system.
- Powerful software for piping designing i.e. Pipe flow software.
- Software to monitor ASD through software i.e. Easy Configuration software



[Fig-3.1.1(D-1)] Basic Structure of an Aspiration Smoke Detection System



[Fig-3.1.1(D-2)] Basic Components of an Aspiration Smoke Detection System



[Fig-3.1.1(D-2)] Piping Topology of an Aspiration Smoke Detection System

Figure-3.1.1(D-1) shows the Basic structure, Fig-3.1.1(D-2) shows the basic Components & Figure-3.1.1(D-1) shows the Piping Technology of the Aspiration Smoke Detection System.

### 3.1.2 SECURITY SYSTEMS:

#### (A) ACCESS CONTROL SYSTEMS

Access control is a means to authorize, restrict or deny entrance or exit of people and/or vehicles into a specific area. It is used to protect property, employees and other assets such as inventory, equipment, information and cash. Although access control can refer to any method for achieving this, such as locks and keys or security guards, it specifically describes a more effective, high-tech means of protection.

#### BENEFITS OF ACCESS CONTROL

- Asset Protection
- Prevention of Illegal Entries
- Enhancement of Personal Safety
- Reduction of Security Costs
- Facilities Management

#### DIFFERENT TYPES OF ACCESS CONTROL SYSTEMS

#### MULTI-FACTOR PKI (PUBLIC KEY INFRUSTRUCTURE) AUTHENTICATION

PKI (or Public Key Infrastructure) is the framework of encryption and cybersecurity that protects communications between the server (your website) and the client (the users). It works by using two different cryptographic keys, a public key and a private key.

#### MULTI-FACTOR AUTHENTICATION

In this type of authentication systems HID cards are used. HID cards are basically a simple Proximity card which is branded by the HID Global Corporation. This type of authentication has some benefits such as, Mobile Authentication, Authentication Server, OTP Tokens, Smart Cards. This type of authentication system is basically used in business & government organizations.

#### VISITOR MANAGEMENT SYSTEM

Automated Visitor Management systems lend a more professional appearance to check in systems, enhance security & meet compliance mandates for the collection and auditing of visitor data.

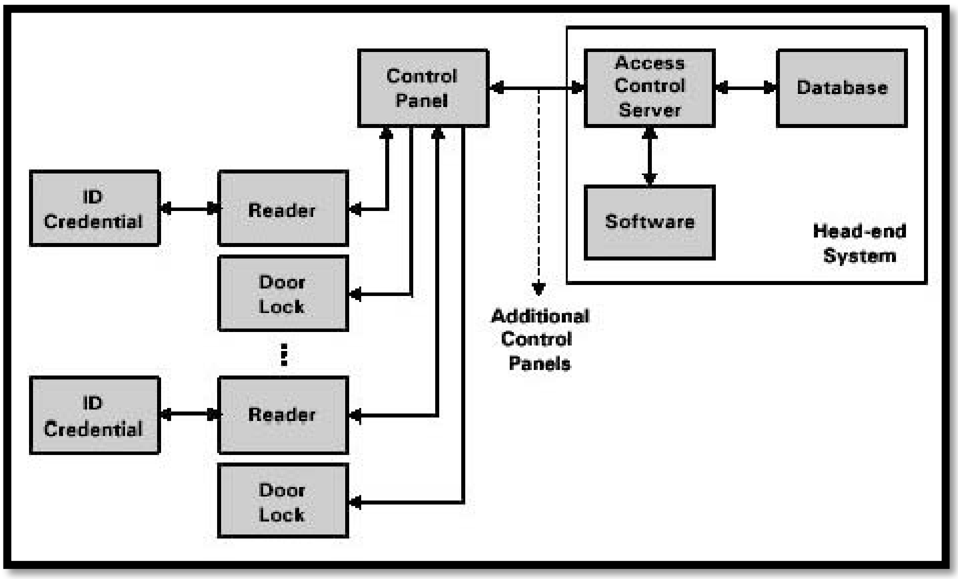
This type of system has some advantages as follows:

- Enhance the professionalism of the enrolment process and visitor check-in with a digital check in system.
- Provide additional safeguards by screening against felony and sex offender watch lists if applicable.
- Improve security by identifying who is in a facility quickly and accurately, especially in emergency situations.
- Conduct analysis/reporting on visitor data, quickly and easily via visitor management software.

## BIO-METRIC AUTHENTICATION

Biometric Authentication solutions bring multispectral imaging technology to any identity application where knowing "WHO" matters. Biometric authentication offers this assurance with secure, convenient and reliable solutions for reading fingerprints. Figure-3.1.2(A) shows the Basic Block Diagram of the Access Control System. This type of system has some advantages:

- Enhanced with security features including data encryption and tamper detection/response.
- Multispectral fingerprint plus contactless card authentication on a single device.
- Superior performance and liveness detection with enhanced accuracy and image capture speed.
- Compact, Durable module for integration, with multispectral usability and liveness detection



**[Fig-3.1.2(A)] Basic Block Diagram of Access Control System**

## (B) CCTV SYSTEMS

CCTV system shall be provided for obtaining live view of the authorized / unauthorized entry, unauthorized intrusion, abnormal conditions in process areas and recording the events for future investigation. CCTV system shall be integrated into IBMS for escalation of violations in security protocols and unauthorized intrusion into the facility. The integration shall be carried out at higher level without use of dry contact/physical wired connections between the systems.

The high-level interfaces shall be **MODBUS** interface to facilitate higher number of alarms being passed between the systems using data interface. The data interfaces shall be based on industry standard open standard protocols.

In addition, the above systems shall also be integrated to Process Control Systems (PCS) using MODBUS protocol for exchange of data between the systems.

## CCTV SYSTEM FUNCTIONAL REQUIREMENTS

- The CCTV system shall be used to monitor the perimeter for unauthorized entry in to the premises and associated facilities by breaching the perimeter of the building and common areas.

(1) Monitor and record personnel and vehicles entering the facility with high resolution.
(2) Monitor common areas for safety of personnel and critical equipment like DG, UPS etc

- The CCTV System shall be an integrated system for the building with IP based camera and centralized server with storage. The system shall be supplied and installed based on PAL standard.
- CCTV System shall comprise of:
  - Outdoor Weather Proof PTZ Cameras
  - Dome/Bullet IR Colour Camera
  - Minimum 3 Megapixel camera
  - Optical Transceivers
  - Matrix Switcher
  - Multiplexers
  - Keyboard
  - IP video Encoders
  - Network Storage units
  - Video management system
  - Server
  - Ethernet switches
  - Gateway
  - Monitors
- To ensure stability in the picture all outdoor cameras shall be installed on wall using with mounting bracket to a maximum possible extent.
- Perimeter Security cameras shall be mounted on the boundary wall. Boundary wall shall have reinforced concrete columns for installation of cameras.
- The IP Based Video Management System shall provide an open standard interface for high level integration with Access Control and IBMS system for moving cameras to pre-set positions in case of an alarm or an event.
- All Outdoor cameras Maximum coverage shall be achieved by positioning of cameras in optimised locations. Position of cameras shall be closely coordinated with the operations team and security team during the execution stage of the project.
- Megapixel cameras shall be connected via CAT6 cables to the IBMS Domain Ethernet Switch.

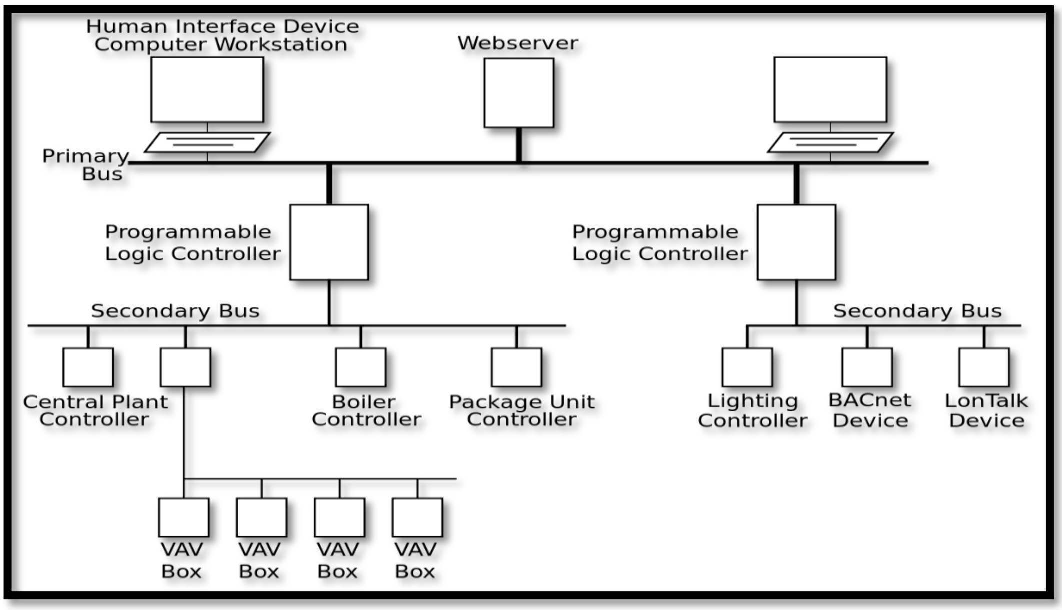
## (C) BUILDING MANAGEMENT SYSTEM

In all buildings there are some form of mechanical and electrical services in order to provide the facilities necessary for maintaining a comfortable working environment. These services have to be controlled by some manual switching, time clocks, or temperature switches. So, if BMS system is introduced, we are able to get a comfortable working environment in an efficient way.

## FEATURES OF BMS SYSTEM

- Central controlling facility
- It is an automated system and it can take control of various operations
- It can manage and coordinate various system
- It provides a comfortable working environment in an efficient way

The purpose of BMS is to control, monitor and optimize building services e.g., lighting; heating and cooling; security; audio-visual and entertainment systems; ventilation and climate control; time and attendance control and reporting. Figure-3.1.2(C) shows the Basic Block Diagram of BMS System.



**[Fig-3.1.2(C)] Basic Block Diagram of BMS System**

## (D) RODENT REPELLENT SYSTEM

Rodent Repellent System is an intelligent system which helps in keeping the rodent away from the protected area with high frequency ultrasonic sounds. This powerful ultrasonic sound waves are generated by the transducers of repellers are within the hearing range of many pests and cause them pain and dis comfort.

The components of the Ultrasonic rodent system are a microcontroller-based system, transducers and a 2-core cable bundle. A power electronic circuit is embedded into the microcontroller-based system, which generates a pattern of ultrasonic sound waves and fed into the transducers. All the parameters such as start frequency, end frequency, sweep time, wave pattern etc are pre-programmed in the system. The transducers emit intensive sound at high decibels, which is painful to the rodents but harmless for humans.

Rodents will easily adopt to the ultrasound if single or fixed frequency is used. So, the system sweeps the frequency in a determined time from start frequency to the end frequency in order to avoid adaptation of ultrasound frequency associated with fixed frequency technology.

In case of BACS all the parameters including sweep-time can be configured and monitored through menu navigation from panel and also through MODBUS communication. Figure-3.1.2(D) shows the diagram of Ultrasonic Rat Repellent system.

**[Fig-3.1.2(D)] Ultrasonic Rat repellent**

## (E) WATER LEAK DETECTION SYSTEM

Water leak detector offers an effective environment monitoring solution for problems associated with water leak in server, data and computer rooms. This type of device with its intelligent sensor cables monitor, detect and communicate the presence of liquid via audio-visual alarms to the server administrators. Its user-friendly software offers the technicians unsurpassed flexibility in navigation and damage control.

The critical problematic areas include the assets of Data centre:

- Areas below the raised server racks
- Water leaks associated with air conditioners
- Blocked ventilation system around machines cause condensation
- Areas around pipe leaks
- Areas of the false ceilings

Cause of Damage:

- Insulation breakdown due to soaked cables lead to signal breakdown and other malfunctions.
- Premature hardware failure due to formation of rust.
- Loss of critical data, backup tapes and equipment
- Loss of manpower time due to comprehension and rectification of unseen faults.

Features of Control Panel:

- The Controller has inbuilt software to sense, receive and recognize the signals sent by the sensor cables.
- In the event of any abnormal condition or malfunction it activates an alarm that has to be acknowledged physically and reset.
- Has optional 2 to 8 zones (areas) adaptability
- Software for monitoring and report generation.
- LED’s are provided for individual water leakage sensor to indicate status of respective sensors.
- Relay outputs are provided for individual water leakage sensor. Relay output activates after Short / Alarm condition of respective sensor.
- Relay output for hooter is provided which is activated in Short / Alarm condition occurs in any sensors.

# CHAPTER – 4

# LIGHTING SYSTEM OF BUILDING AUTOMATION & CONTROL SYSTEM

## 4.1 A GENERAL DISCUSSIONS ON LIGHTING CONTROL

A lighting control system is an intelligent network-based lighting control solution that incorporates communication between various system inputs and outputs related to lighting control with the use of one or more central computing devices. Lighting control systems are widely used on both indoor and outdoor lighting of commercial, industrial, and residential spaces. Lighting control systems serve to provide the right amount of light where and when it is needed.

The term lighting controls is typically used to indicate stand-alone control of the lighting within a space. This may include occupancy sensors, Timeclocks, and photocells that are hard-wired to control fixed groups of lights independently. Adjustment occurs manually at each device's location. The term lighting control system also refers to an intelligent networked system of devices related to lighting

control. These devices may include relay, occupancy sensors, photocells, light control switches or touchscreens, and signals from other building systems (such as Fire alarms or HVAC). Adjustment of the system occurs both at device locations and at central computer locations via software programs or other interface devices.

Lighting control systems are employed to maximise the energy savings from the lighting system, satisfy building codes or comply with green building and energy conservation programs. Lighting control systems are frequently termed as Smart Lighting Control System.

## 4.2 REQUIREMENT OF SMART LIGHTING CONTROL SYSTEM

19% of energy use in the world is used for lighting, and 6% of greenhouse emissions in the world derive from this energy used for lighting. In the United States, 65 percent of energy consumption is used by commercial and industrial sectors, and 22 percent of this is used for lighting. So, there is a need of control system by which we can minimise the energy consumption of the lighting system all over the world.

Smart lighting is a technology mainly based on or designed for Energy Efficiency of the system. This may include high efficiency fixtures and automated controls that make adjustments based on conditions such as occupancy or daylight availability.

Lighting is the deliberate application of light to achieve some aesthetic or practical effect. For example, in case of any conference room or any Meeting room, we use the technique of Smart lighting control, where we mainly focus on the different kind of modes of operation, basically for aesthetic purpose rather than focussing on the Energy efficiency of the system. Smart lighting control systems also includes the Task lighting, Accent lighting and General lighting.

## 4.3 MAJOR TECHNIQUES OF SMART LIGHTING CONTROL SYSTEMS

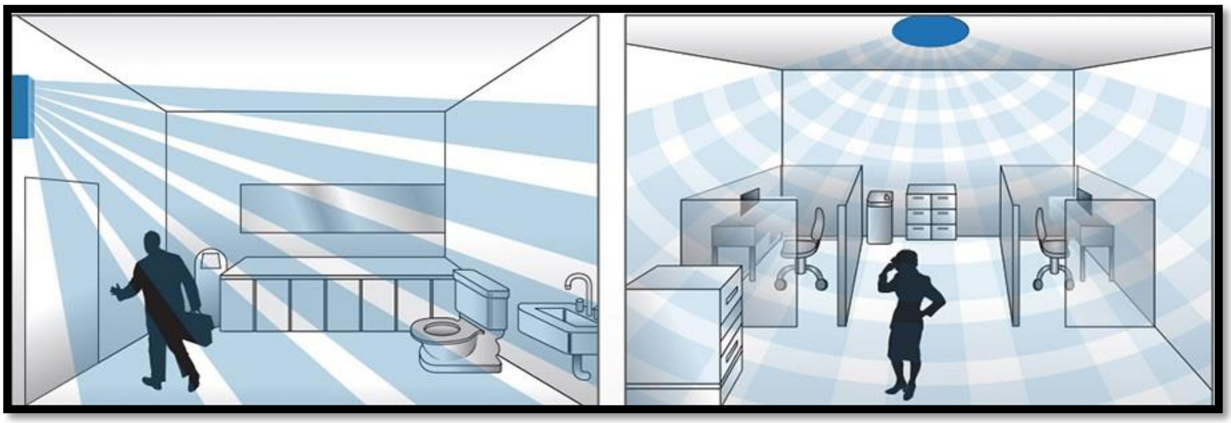
**SMART LIGHTING CONTROL**: The use of automatic light dimming is an aspect of smart lighting that serves to reduce energy consumption. Manual light dimming also has the same effect of reducing energy use.

USE OF SENSORS: It is confirmed that, automatic lighting systems including occupancy sensors and individual (personal) controls are suitable for open-plan office environments and can save a significant amount of energy (about 32%) when compared to a conventional lighting system, even when the installed lighting power density of the automatic lighting system is ~50% higher than that of the conventional system.

COMPONENETS OF SENSOR: A complete sensor consists of a motion detector, an electronic control unit, and a controllable switch/relay. The detector senses motion and determines whether there are occupants in the space. It also has a timer that signals the electronic control unit after a set period of inactivity. The control unit uses this signal to activate the switch/relay to turn equipment on or off. For lighting applications, there are three main sensor types: Passive Infrared, Ultrasonic and Hybrid.

**DAYLIGHT SENSING**: In response to daylighting technology, daylight-linked automated response systems have been developed to further reduce energy consumption. These technologies are helpful, but they do have their downfalls. Many times, rapid and frequent switching of the lights on and off can occur, particularly during unstable weather conditions or when daylight levels are changing around the switching illuminance. Not only does this disturb occupants, it can also reduce lamp life. A variation of this technology is the 'differential switching' or 'dead-band' photoelectric control which has multiple illuminances it switches from to reduce occupants being disturbed.

**OCCUPANCY SENSING**: An occupancy sensor is an indoor motion detecting devices used to detect the presence of a person to automatically control lights or temperature or ventilation systems. The sensors use infrared, ultrasonic, microwave or other technology. The term encompasses devices as different as PIR sensors, hotel room key card locks and smart meters. Occupancy sensors are typically used to save energy, provide automatic control and comply with building codes. Figure-4.3 shows the Wall-mount & Ceiling-mount PIR Sensors.



**[Fig-4.3] Wall mount & ceiling mount PIR sensors**

ULTRASONIC SENSING

The advantages of ultrasonic devices are that they are sensitive to all types of motion and generally there are zero coverage gaps, since they can detect movements not within the line of sight.

OTHER TYPE OF SENSING

Motion-detecting (Microwave), heating-sensing (infrared), and sound-sensing; optical cameras, infrared motion, optical trip wires, door contact sensors, thermal cameras, micro radars, daylight sensors. These are the other type of sensing technologies we can use.

Lighting control systems typically provide the ability to automatically adjust a lighting device's output based on:

- Chronological time (time of day)

  Chronological time schedules incorporate specific times of the day, week, month or year.
- Solar time (Sunrise/Sunset)
  Solar time schedules incorporate sunrise and sunset times, often used to switch outdoor lighting. Solar time scheduling requires that the location of the building be set. This is accomplished using the building's geographic location via either latitude and longitude or by picking the nearest city in a given database giving the approximate location and corresponding solar times.
- Occupancy using occupancy sensor
  Space occupancy is primarily determined with occupancy sensors.
- Daylight availability using photocells
  Electric lighting energy use can be adjusted by automatically dimming and/or switching electric lights in response to the level of available daylight. Reducing the amount of electric lighting used when daylight is available is known as Daylight harvesting.
- Alarm conditions
  Alarm conditions typically include inputs from other building systems such as the fire alarm or HVAC system, which may trigger an emergency 'all lights on' or ' all lights flashing' command for example.
- Program logic
  Program logic can tie all of the above elements together using constructs such as if-then-else statements and logical operators.

## 4.4 BENEFITS OF SMART LIGHTING CONTROL SYSTEMS OVER CONVENTIONAL LIGHTING SYSTEM

The major advantage of a lighting control system over stand-alone lighting controls or conventional manual switching is the ability to control individual lights or groups of lights from a single user interface device.

This ability to control multiple light sources from a user device allows complex lighting scenes to be created. A room may have multiple scenes pre-set, each one created for different activities in the room.

A major benefit of lighting control systems is reduced energy consumption. Longer lamp life is also gained when dimming and switching off lights when not in use. Wireless lighting control systems provide additional benefits including reduced installation costs and increased flexibility over where switches and sensors may be placed.

In case of wireless Smart lighting control system, the wireless network is based on the open source protocol, which communicates much faster than a powerline network by using a large number of communication channels, each channel with maximum bandwidth. So, the **Efficiency** of the system is high.

In case of wireless communication, mesh type of network is mainly used, which gives the **reliable** communication path. This type of system includes self-healing & re-routing features. In worst case scenarios the data transmission system is much higher than the powerline communication techniques.

A network based on wireless technology offers complete freedom to incorporate sensors and luminaires. It provides an optimised installation for the best dimming scenario. So, in case of wireless communication the **Freedom** of communication is much higher than the powerline communication technique.

This type of network can be **upgraded** by adding new features. This type of system can easily be enlarged by incorporating new lighting points, independently of the electricity supply without cabling.

The **Accessibility** of wireless Smart lighting control system is much higher than the power line communication technique. The dimming profile can easily be changed by simply connecting wirelessly a laptop to one luminaire without using any tools. These are the main benefits of Smart lighting control system over conventional or static lighting system.

## 4.5 DALI & LIGHTING CONTROL SYSTEMS

### 4.5.1 A BRIEF DISCUSSION ON DALI STANDARD

DALI stands for “Digital Addressable Lighting Interface” and is an interface protocol for digital communication between electronic lighting equipment (electronic ballasts, transformers, etc.). The DALI system is based on simplicity of operation. However, the demands on electrical system designers and electricians have increased enormously.

The agreement by the lighting industry to adopt a common protocol for digital addressable control of luminaires has opened up a virtually unlimited number of options for regulating artificial lighting in all applications. This common protocol is the DALI protocol (Digital Addressable Lighting Interface), which has now been internationally standardised through the IEC (International Electrotechnical Commission).

With the right choice of individual DALI components an extremely wide range of requirements can be met, from operating the lighting system from a simple light switch to lighting management systems for entire office complexes with thousands of light sources.

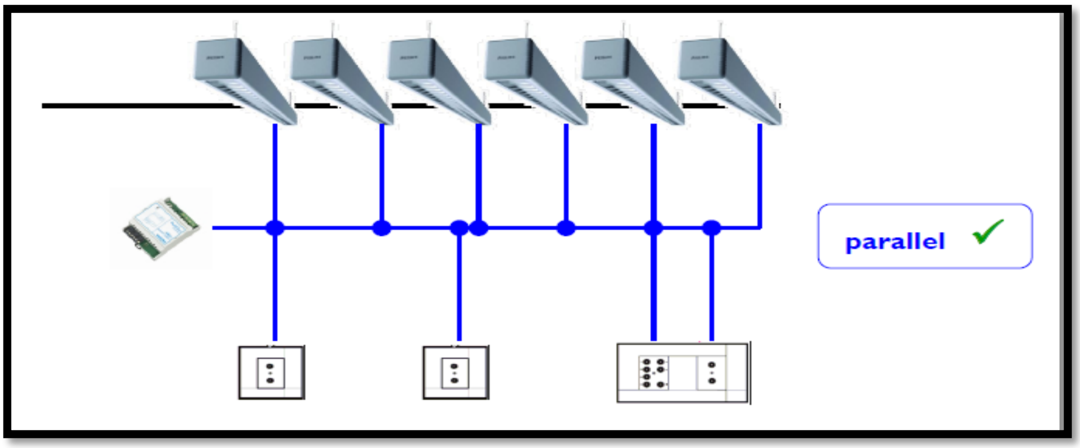
The new standardisation means that there are no longer any restrictions on the application of this technology. Any light source, including incandescent lamps, fluorescent lamps, highintensity discharge lamps and even LEDs, can be controlled irrespective of whether they are installed in an office, a restaurant or a street light.

The DALI standard was defined in EN 60929 Annex E until 2009 but is now defined in IEC 62386. This standard also describes the differences between the various types of device. As a result, long-term compatibility among manufacturers are guaranteed and the DALI standard is ensured a secure future. In addition, compatibility between products from different manufacturers is supported by a test procedure standardised by the DALI Activity Group. All products that carry the logo of the DALI Activity Group have successfully passed this standardised test.

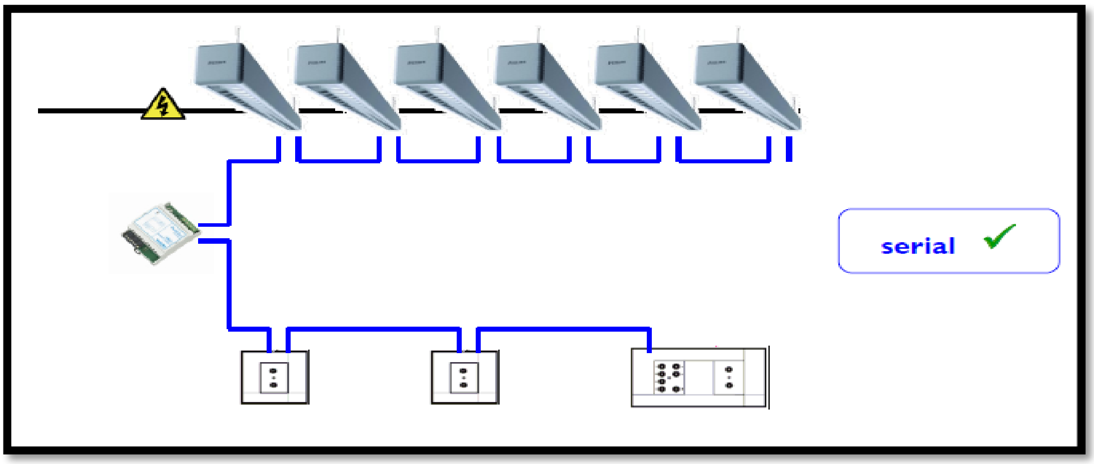
### 4.5.2 FEATURES OF DALI

Simplified Installation:

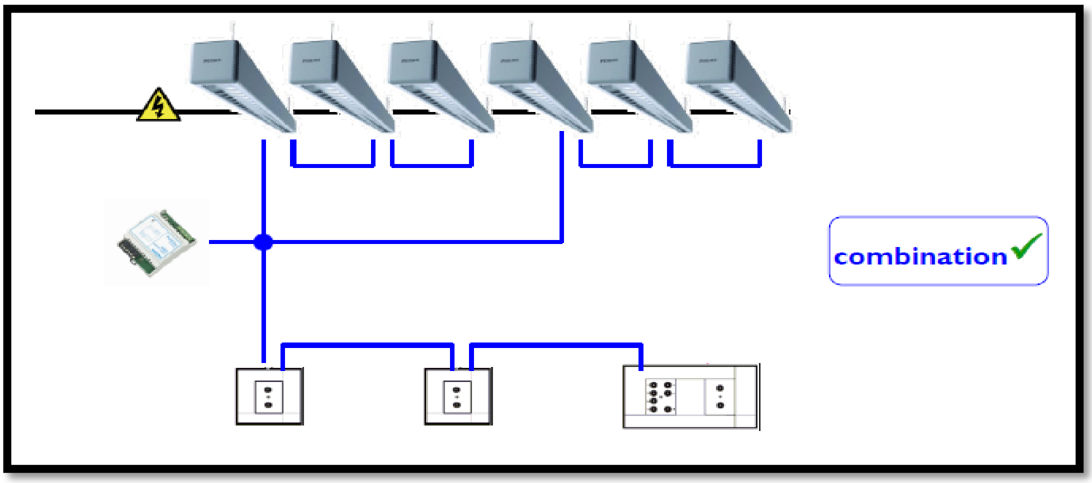
The **installation** of DALI is very simple. In case of DALI power lines and control lines can be laid together in the same cable. The wiring may be series, parallel, or may be mixed.



**[Fig-4.5.2(A)] Parallel connection of DALI components**



**[Fig-4.5.2(B)] Series connection of DALI components**



**[Fig-4.5.2(C)] Series-Parallel connection of DALI components**

[Figure-4.5.2[(A), (B), (C)]] shows the different kind of circuit combination using the DALI Components (i.e. Series, Parallel & Series-Parallel Connection).

Polarity: There is no need to worry about the **polarity** (+/-) of the DALI control line. DALI control cable exists of 2 wires, and they are polarity insensitive.

Stable dimming function: DALI gives the **stable dimming** function in the system. All the luminaires connected through DALI receive the same interference-free digital signal and therefore the same dimmer value.

Distributed intelligence: DALI uses a system of **distributed intelligence**. There are multiple controllers in the system (e.g. DALI Group control) communicate with intelligent ballasts. Each controller operates as a "Master" and controls communication on the control line. Ballasts reacts only as "slaves" at the request of "Master". Certain parameters are stored directly in the DALI unit (e.g. scene values, group address).

Status feedback: Status reports can be issued by the DALI units. Information on faulty lamps for example can therefore be transferred directly to a higher-ranking system. DALI controllers can communicate with the luminaires by single addressing technique or group addressing technique. It can give some information or display some information of the lighting system or individual luminaire, for example it can show the luminaire life, dimming level of the luminaire etc.

Flexibility: Group assignment is set up by means of parameters and not by hard wiring. Lighting scene values are stored in the DALI unit. In case of DALI you can create different control groups by taking different individual luminaire for any certain requirement. It can also provide a large number of scene control as per the requirement.

Logarithmic dimming curve: DALI provides the digital dimming in the system which is much better than the analogue type of dimming technique. Analog dimming gives the step dimming of the system, which is not good for the adaptation of eye, but in case of DALI it gives the discrete type of dimming, which is good for human eye. The dimming curve is matched to the sensitivity of the eye.

### 4.5.3 TECHNICAL FEATURES OF DALI CIRCUIT

**(a) Maximum numbers of units** in a single line is 64. Therefore, **Maximum number of addresses** is also 64.

**(b) DALI signal level voltage** is usually in the range of 9.5-22.5 volt. Typically, the DALI signal voltage is 16 volts.

**(c) DALI system current** is maximum 250 mA and it is dependent on installed DALI power supply.

**(d) Data transfer rate** of DALI system is usually 40 messages per second or 1200 baud.

**(e)** The maximum **cable length** depends on the maximum permitted voltage drop along the DALI cable which is defined as maximum 2 volts. This corresponds to a maximum cable length of 300 meter for a line cross-section of 1.5 sq.mm.

**(f) Cable type** in case of DALI is, any 2-wire unshielded cable.

**(g)** There are different types of **Cable topologies** in case of DALI system. These different type of cable topologies are like line, star, tree, ring etc.

**(h)** DALI is not SELV (separated extra-low voltage). So, for **safety** purpose DALI cable must be treated as mains wiring.

**(i)** A DALI system contains one current source, a controller and inputs. In case of idle state, the current signal is “high”. So, there is a current in the circuit. An input can be detected if there is a current in the circuit.

**(j)** In idle state, the driver input current is 2 mA. So, the nominal current for 64 inputs is 128 mA.

**(k)** Information is transferred by short circuiting the current and Communication is always started by the controller.

### 4.5.4 DALI SCENE AND GROUP CONCEPT

DALI SCENES: DALI is basically used to create different modes of aesthetics in lighting system. To create this type of lighting environment we require different kind of light scenes and DALI group concept. With DALI it is possible to store 16 different lighting scenarios in each DALI unit so that predefined lighting moods can be called up for a room (for example the "presentation" scene in a conference room, or a "morning" scene in a wellness centre).

The values of the 16 scenes are stored in the control gear. For example, as soon as the unit receives the command "Go to scene 1” it fades up or down to the value stored in memory. The cross-fade time for the scene call is also stored in the unit and can be set in steps between 0.7 and 90.5 seconds with the "Fade Time “parameter. Figure-4.5.4(A)&(B) represents the different kinds of Light Scenes of a Showroom by using DALI Scene & Group Control system.

**[Fig-4.5.4(A)] Daytime showroom scene (Visual example of different kind of light scenes)**

**[Fig-4.5.4(B)] Night-time showroom scene (Visual example of different kind of light scenes)**

<u>DALI GROUPS</u>: With DALI it is possible to define 16 groups in a DALI circuit. A group is a meaningful collection of luminaires. Group assignment can be edited in DALI. It is possible for one DALI unit to belong to several groups. This reduces the amount of wiring needed and greatly increases flexibility compared with non-addressable systems because in these systems the groupings are hard-wired.

### 4.5.5 POSITIONING OF DALI

DALI is not a new system for building control such as LON, KNX and other building management systems (such as BACnet) but a useful addition for the practical application of lighting controllers.

DALI gives the ideal support for different building control systems and enables each light source to be individually addressed. Even small installations in which a building control system would not be economical need not forego the convenience of digital technology. DALI can be used in such installations as an independent lighting management system.

Digital technology has taken over from analogue technology in lighting control systems because of the universal application of DALI units and their reliable control.

### 4.5.6 DIFFERENT COMPONENTS USED IN CASE OF DALI

## DALI CONTROLLERS & INTERFACE MODULES

### (A) DALI Power Supply (Controller Module):

DALI power supply modules have rated current of 200 mA(typically). In some cases, some DALI power supply module has a rated current of 240 mA. The power supply modules differ from each other mainly on the basis of their casing design. These power supply modules are suitable for installing in switching cabinets, in suspended ceilings and cavities.

Central DALI power supply rated at 200 mA (DALI standard allows max. 250 mA). The controls interface of a DALI ballast normally sources 2 mA, with 64 individual addresses this will source 128 mA. The remaining 72 mA can be used to power other DALI controls without an internal power supply such as the DALI GC (group control) and DALI SC (scene control). DALI power supply has a LED display which indicates the operating status. For example, if there is a green signal in the panel, it means the normal operating mode of the DALI power supply & if there is a red signal, it means short circuit or excessive load at DALI control line.

Figure-4.5.6(A) shows the different types of DALI Power Supply module.

Technical Specification:

| | |
|---|---|
| Rated supply voltage | 230-240 V |
| Mains frequency | 50/60 Hz |
| Power | 4 W |
| Output | DALI |
| Max. output current, DALI | 200mA |
| Ambient Temperature | 0-50 °C |
| Type of protection | IP 20 |

**TABLE 4: TECHNICAL SPECIFICATIONS OF DALI POWER SUPPLY**

**[Fig-4.5.6 (A)] Different power supply modules**

## (B) DALI Group Controllers (Controller Module):

DALI group controller is a multi-functional device for DALI system. You can choose group control designed to control different groups, or scene control designed to control different scenes by DIP switch. This DALI controller complies with DALI standard protocol IEC60929 /62386 and is compatible with various master controllers, so you can use one or more DALI group controller installed parallelly in a DALI system.

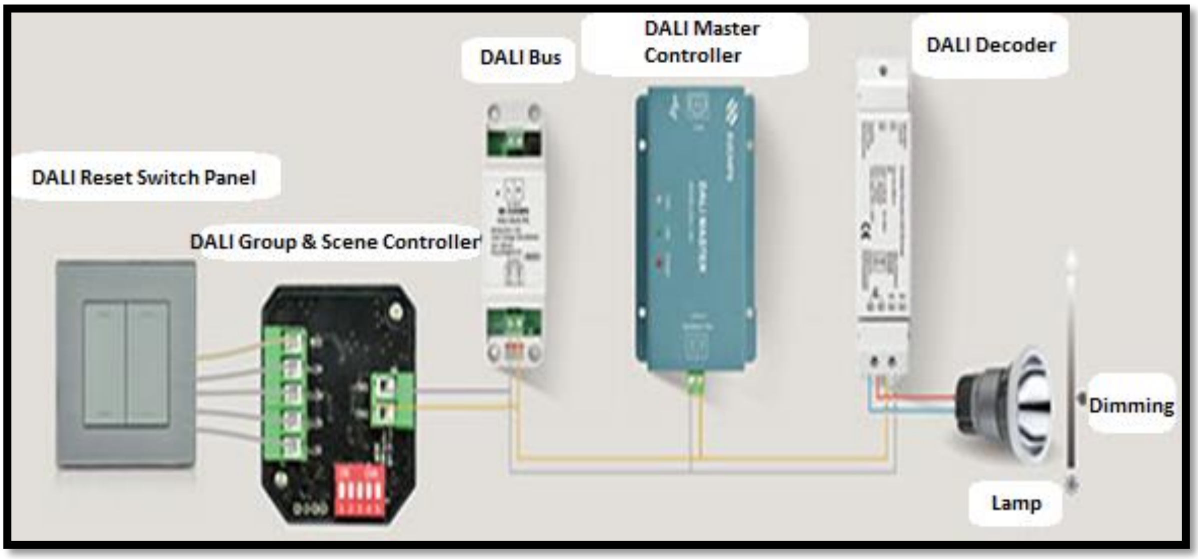
Features of DALI group controller:

- This type of controller can control different control groups by using DIP (dual in line package) switch.
- DALI group controllers can control maximum 4 numbers of groups separately.
- By using this we can achieve smart scene control and energy efficient lighting.
- This type of controller can compatible with various master controllers
- You can choose group or scene control by DIP switch to meet your different requirements and achieve the goal of energy conversation.

Technical specifications

| | |
|---|---|
| Power supply | Via DALI signal line |
| Input | 12-24 V DC |
| Signal current | 2 mA |
| Output | Dimming/ON/OFF for 4 groups separately (for group control |
| Working temperature | 0~60℃ |

**TABLE 5: TECHNICAL SPECIFICATIONS OF DALI GROUP CONTROLLERS**



**[Fig-4.5.6 (B-1)] Wiring diagram of DALI system**

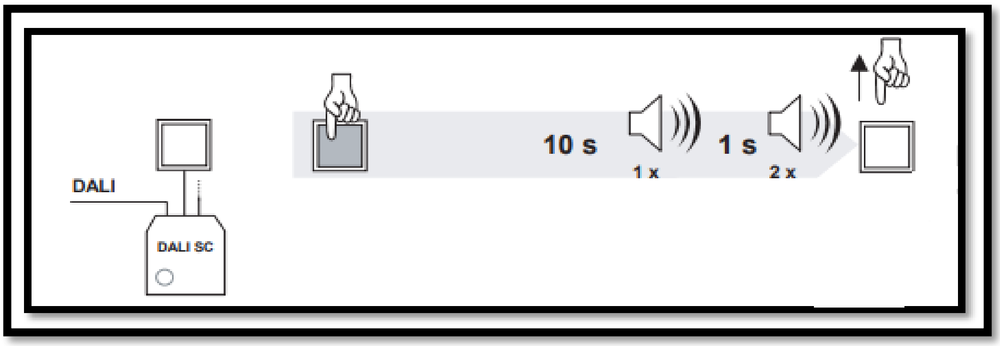
Figure-4.5.6(B-1) shows the wiring diagram of a DALI Controlled System by using DALI Group & Scene Controllers & other DALI compatible components. Figure-4.5.6(B-2) shows the diagram of the DALI Group Controllers.

**[Fig-4.5.6 (B-2)] DALI Group Controllers**

## (C) DALI Scene Controllers (Controller Module):

The DALI Scene Control (SC) switch input module supports the ability to program scene levels and recall up to 4 scenes (A, B, C, D). A scene aloud to memorize and recall different light levels at different devices. The module input is configured for use with a standard momentary switch(s). Output communications signal is compatible for use in applications using DALI communications. The scene command(s) will be sent as a broadcast signal to all devices (ballasts) connected on the DALI bus installation.

Programming/ Recalling scenes: A scene is recalled when a short push (< 1 second) is detected at any of the four switch inputs. Pressing any of the 4 switch inputs, for more than 9 seconds will be confirmed by a beep. Keep the button pressed for a further second, the actual scene (current light levels) will be stored in the connected devices. The module will confirm by two beeps. The scene number stored is based on the setting of the Scene selector located on the back of the module (refer to Table-6 for setting). The next time the scene is recalled the newly assigned level will be selected. Figure-4.5.6(C-1) shows the flow diagram of the programming or recalling scenes of the DALI Scene Controllers.

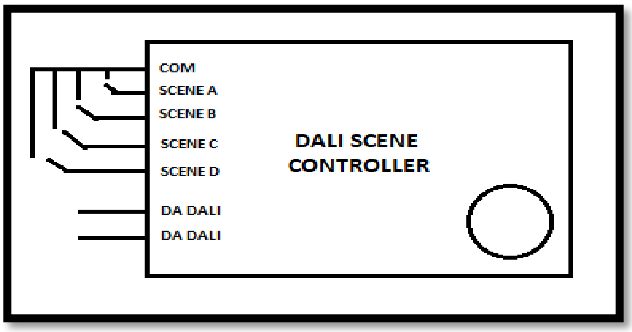


**[Fig-4.5.6 (C-1)] DALI Scene Controllers Programming/Recalling scenes**

| Push | Function |
|---|---|
| 40 msec – 1 sec | Recall of memorized scene |
| > 10 sec | Memorizing the actual light level of all ballasts as scene based on the rotary selector switch setting. (scene selector) The module will sound a short beep confirming new scene level has been communicated and two beeps when memorized. |

**TABLE 6: OPERATING PRINCIPLES OF DALI SCENE CONTROLLERS**

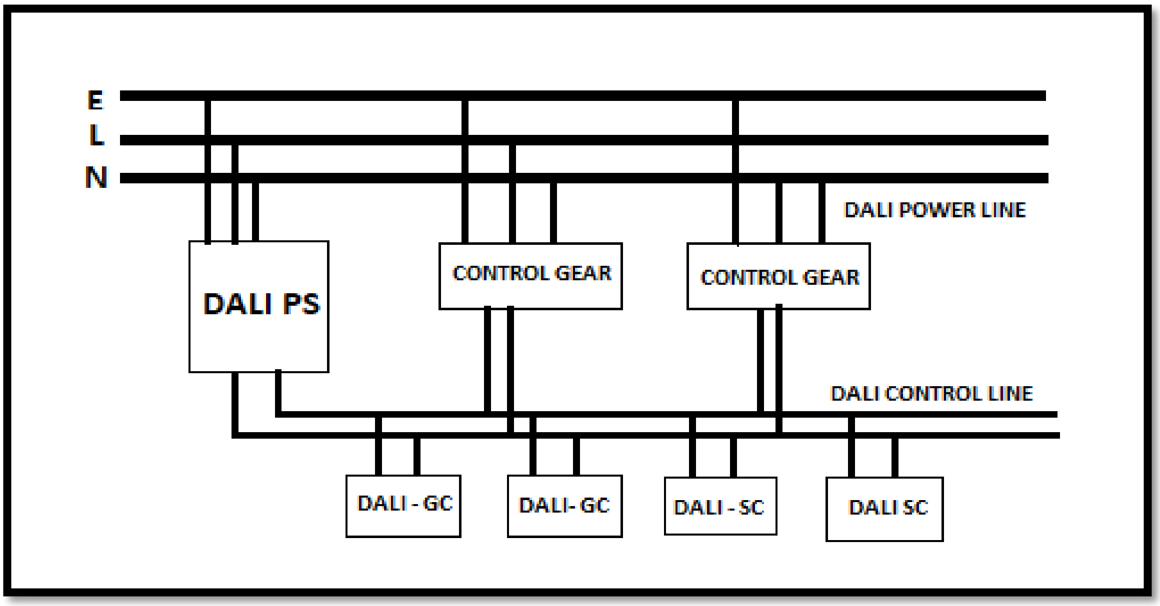
Technical Specifications: The DALI SC module is designed to connect directly (regardless of polarity) to the DALI communication bus. The module consumes 5-7mA and draws its power from the DALI bus. It is important to note that a DALI power supply must be present somewhere on the communications bus installation to support the DALI SC module and other DALI compatible loads. Connect momentary switch wiring as shown in the Figure-4.5.6(C-2) below. Fig-4.5.6 (C-3) shows the Wiring of DALI Control System with Scene controller & Group controller.



**[Fig-4.5.6 (C-2)] Momentary switch wiring of DALI scene controller**

| | |
|---|---|
| Input Voltage | 9.5 V – 22.5 V |
| Input Current | 10 mA |
| Power Consumption | Less than 1 watt |
| Wiring | Polarity independent control wiring. Suitable for class 1 and class 2 wiring installation |

**TABLE 7: TECHNICAL SPECIFICATIONS OF DALI SCENE CONTROLLERS**



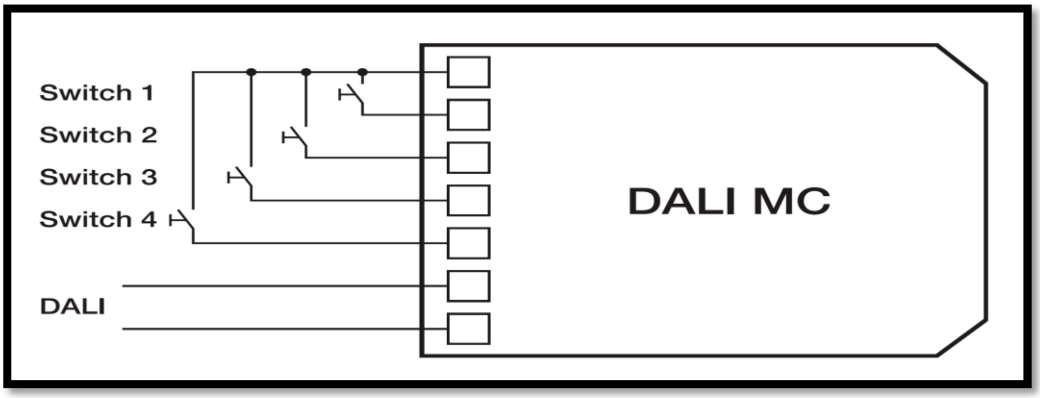
**[Fig-4.5.6 (C-3)] Wiring of DALI with Scene controller & Group controller**

## (D) DALI Multi Controllers (DALI MC) (Controller Module):

The DALI MC is a multifunctional control module for the DALI circuit. It has four independent inputs with freely configurable functions. Any standard switches compatible with mains voltage can be connected to the module. It is also possible to control the inputs of the DALI MC via relays.

There is also the option of providing a power supply monitoring system with the DALI MC. When the power supply returns a predefined lighting, status is retrieved by the DALI MC. Its compact design means that the DALI MC can be installed together with standard switches in a flush-mounted box. The DALI circuit can therefore be decentralised.

The four inputs are configured by means of master CONFIGURATOR. The DALI MC module is multi-master-compatible so several control modules can be used in a DALI circuit. Figure-4.5.6(D) shows the connection diagram of the DALI Multi-controller.



**[Fig-4.5.6 (D)] Connection Diagram of DALI Multi-Controller**

In short, we can say that DALI multi controller gives the extra facility for the integration of different kind of systems with the lighting control system.

DALI multi controller gives the DALI emergency functions along with the DALI group or scene control. Besides that, it will give you Relay output (typically 230 V / 16 A), Thermo relay outputs (typically 230 V / 10 W), Binary inputs, Sensor terminal, Temperature control terminal.

Technical Specification:

| TYPICAL TECHNICAL DATA OF DALI MULTI CONTROLLER (KNX) | | |
|---|---|---|
| Power | Operating voltage, Main | 230 V AC, 50 Hz |
| | Operating voltage, KNX | 21-30 V DC |
| | Power consumption, KNX | Normal 10 mA / Peak 20 mA |
| Output Relay | Number of potential free contacts | NA |
| | Number of 230V outputs | 1 |
| | Un rated voltage | NA |
| | In rated current | 16 A |
| | DALI output | Broadcast/ 4 groups |
| | Numbers of EVGs | 12 |
| | Power loss at max. load | 4 W |
| Connections | KNX | WAGO Winsta KNX |
| | Load Current Circuits | WAGO Winsta MIDI |
| | Inputs | Via connection terminal without screws |
| | Wiring | 0.5-2.5 mm2 |

| | | |
|---|---|---|
| | Connection of local sensor | RJ45 |
| Inputs | Number of inputs | 2 |
| | Polling voltage | 16V |
| | Sensing current | 1 mA |
| | Permitted cable length | 10 meters |
| Operating and display elements | Through control panel in front | NA |
| DALI Voltage | ELV 16 V DC (Extra low voltage) | NA |
| Temperature range | Operation | 5 °C -45 °C |
| | Storage | Minus 25 °C to +65 °C |
| | Transport | Minus 25 °C to +65 °C |
| Movement Detector | Detection area at floor (diameter) | 8 meters |
| | Installation height | 3 meters |

**TABLE 8: TECHNICAL SPECIFICATIONS OF DALI MULTI- CONTROLLERS**

### (E) DALI Touch panel (Controller Module):

The DALI-TOUCHPANEL is a multi-functional device for the DALI circuit. It combines the functions of DALI-GC and DALI-SC in a single module and has six freely definable buttons. The six buttons are configured using the Master CONFIGURATOR. Wiring diagram of DALI Touch-panel with the DALI Group & Scene Controllers is shown below in the Figure-4.5.6 (E).

There are three types of configurations are possible:

- On/off switching of individual addresses, groups or broadcast
- Up/down fading of individual addresses, groups or broadcast
- Scene selections

Description of the DALI Touch panel

• DALI Touch panels are the Control panels and controllers for DALI systems for controlling multiple luminaire groups and calling up pre-set lighting scenes

• The design of the DALI Touch Panel is flexible. Individual design can be used for DALI Touch Panel.

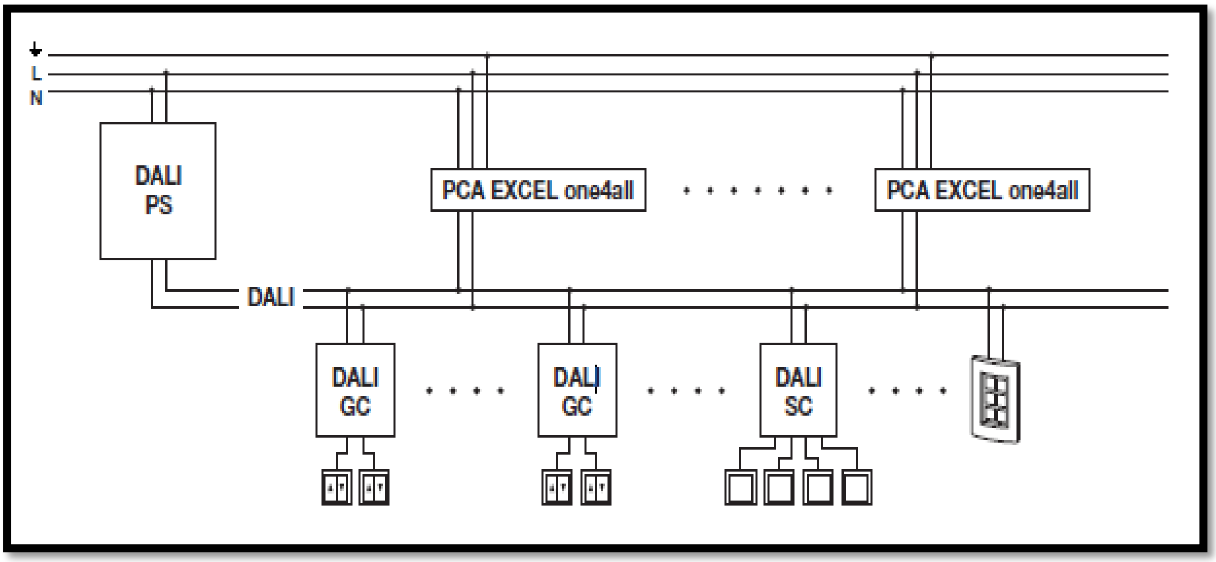
• The DALI Touch panel is Multi-master compatible. Multiple control modules can be configured in a DALI system

- Power supply for the Touch panel is taken from the DALI line. In case of normal operation, it draws a current of 6 mA and in case of service mode it takes roughly 10 mA.
- Individual adjustment of the control panel and button assignments with configuration software
- It can set group addresses or "broadcast" along with the scene setting.
- Tunable white (colour converter) control (colour temperature along the Planckian Locus, Colour temperature Tc).

Technical specification:

| | |
|---|---|
| Supply | Via DALI Cable |
| Current draw | 6 mA |
| Output | DALI |
| Ambient temperature | 0-50 °C |
| Storage temperature | 0-50 °C |
| Humidity | 5 % to max. 85 % (non-condensing) |
| Type of protection | IP20 |

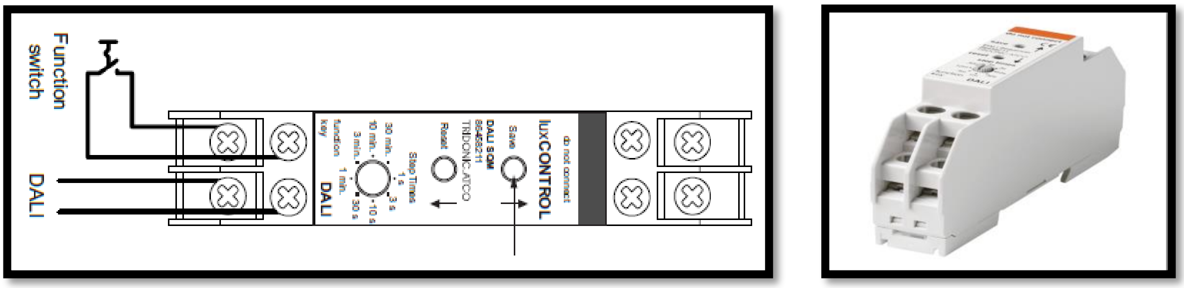
**TABLE 9: TECHNICAL SPECIFICATIONS OF DALI TOUCH-PANEL**



**[Fig-4.5.6 (E)] Wiring diagram of DALI Touch panel with Scene controller & Group controller**

## (F) DALI Sequencer Module (Controller module):

The SQM sequencer module enables a predefined time-controlled sequence to run automatically. The DALI SQM constantly sends DALI signals with the set "step time". These are broadcast-addressed scene calls. DALI scenes 0 to 15 can be called up. The end scene, after which scene 0 is called up again, can be programmed and set to DALI scene 7(for example) on delivery. This means that a sequence of eight scenes is recalled.



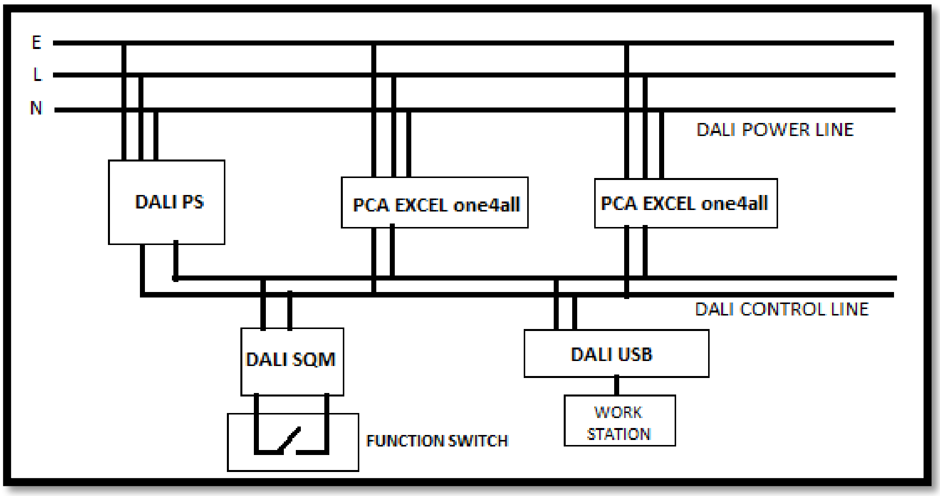
**[Fig-4.5.6 (F-1)] DALI Sequencer Module and its connection diagram**

The DALI SQM is connected directly to the DALI circuit and does not need a separate power supply. It is powered via the DALI circuit (current draw = 9 mA). It can be connected to the DALI circuit with either polarity. Figure-4.5.6 (F-1) shows the DALI Sequencer Module (DALI-SQM) & its Connection diagram & Figure-4.5.6 (F-2) shows the Wiring diagram of DALI-SQM.

<u>Technical Specification</u>:

| | |
|---|---|
| Power Supply | Via DALI Line |
| Current Inputs | 9 mA |
| Inputs | rotary switch, 1 s – 30 min.<br>function switch: max. cable length 100 m |
| Output | DALI |
| Permissible Ambient Temperature | 0 °C – 50 °C |

**<u>TABLE 10: TECHNICAL SPECIFICATIONS OF DALI SEQUENCE MODULE</u>**

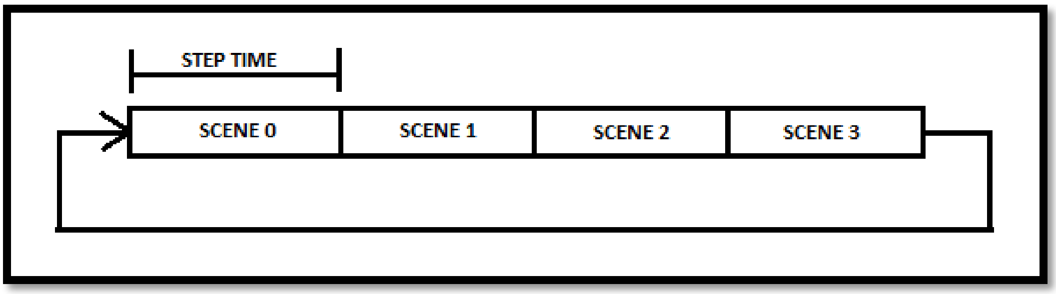


**[Fig-4.5.6 (F-2)] DALI Sequencer Module and its wiring diagram**

Function Switch:

- Function switch is closed, means, the sequencer module is Active.
- Function switch is open, means, the sequencer module is not Active.
- Function switch is opened, means, the installation switches off because of the broadcast command "off" is sent.

Step Time: The "Step Times" rotary switch is used to set the step time. There is a choice of eight time (1 s, 3 s, 10 s, 30 s, 1 min., 3 min., 10 min. and 30 min.) (Shown in the Figure-4.5.6(F-3)). The step time is the time for which a particular scene is active before the next scene is activated.

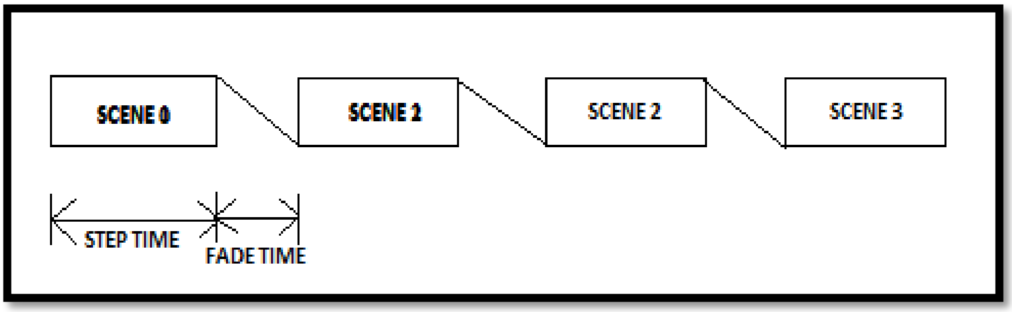


**[Fig-4.5.6 (F-3)] Step time arrangement in DALI Sequencer Module with different scenes**

Example: For a step time of 30 seconds the module sends a new scene Command every 30 seconds.

Setting of the Fading time:

Based on DALI specification, the changes from the one scene to the next scene in a sequence would be extremely abrupt. The colours for the individual scenes would come on instantly (within 0.7 seconds). To ensure that the transition is smooth and gentle you can change the fade time in the ballasts. The time during which the colour is changing can be set between 0.7 s and 90.5 s with the aid of configuration TOOL software and a DALI USB. If the step time is less than the fade time the next scene will be selected even if the fade time has not been completed. [Fig-4.5.6 (F-4)] shows the Step time and Fade time diagram in DALI Sequencer Module with different scenes.



**[Fig-4.5.6 (F-4)] Step time and Fade time diagram in DALI Sequencer Module with different scenes**

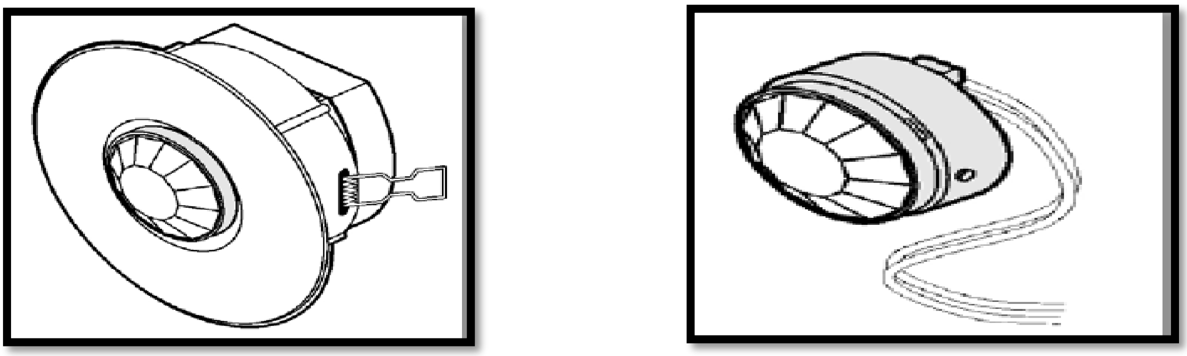
## (G) DALI Sensor Module (Controller Module):

The DALI Sensor 02 is a digital controller that can be used to control the control gear of a DALI group collectively. The sensor combines three functions in one control device:

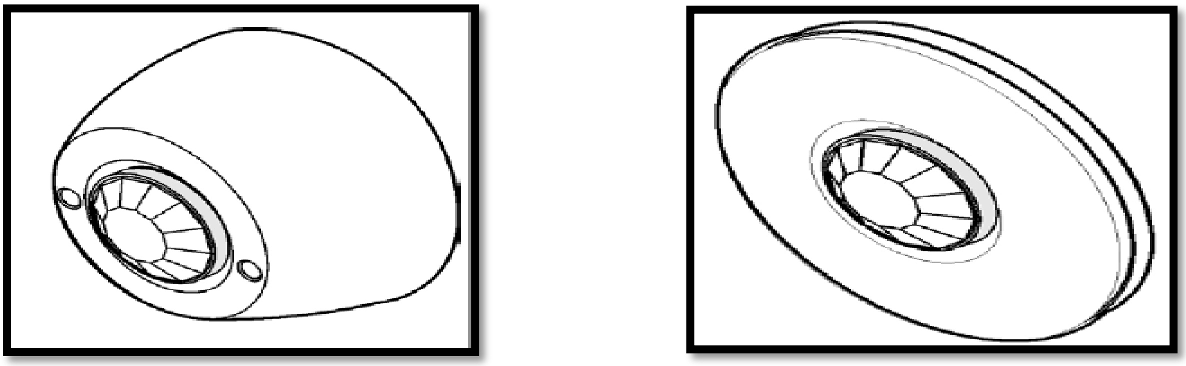
- Constant light (Constant light control makes it possible to match the lighting in a room to the naturally available ambient light.) control by means of ambient light sensors
- Presence based control by means of PIR motion sensor or presence detector
- Remote control via an infrared input for two different IR remote controls

DALI sensors have mainly four type of housing designs (Shown in the Figure-4.5.6(G-1)). The four type of designs are as follows:

- Fitted in luminaire type
- Recessed in ceiling type
- Surface mounted type
- Box mounted type



**Fitted in luminaire** **Recessed into ceiling**



**Surface mounted** **Box mounted**

**[Fig-4.5.6 (G-1)] Different type of DALI Sensors**

The DALI sensors are designed for the following principal application areas:

- Individual offices
- Open plan offices
- Training/Presentation rooms
- Corridors, Passageways or Garages

The DALI Sensor 02 either controls all the units on the DALI circuit or a DALI group. The DALI sensor is Multi-master compatible, i.e. it can be used in conjunction with other DALI controllers.

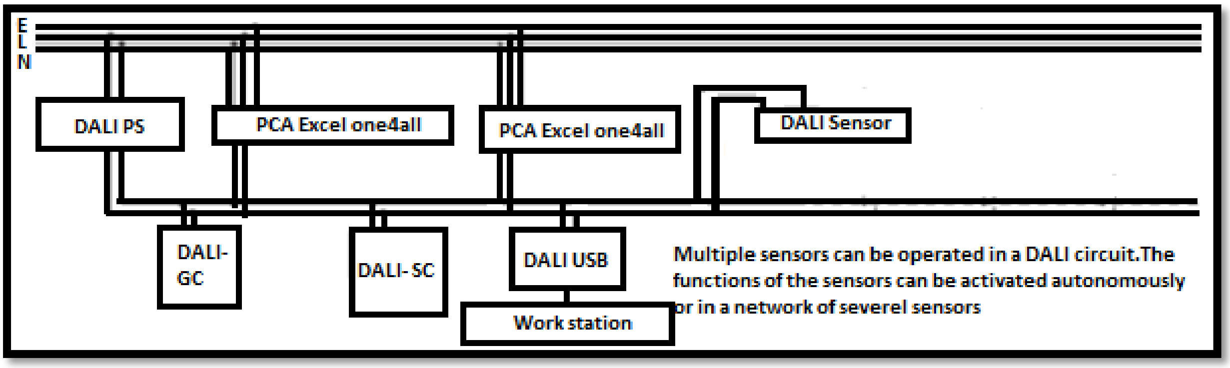
This allows the DALI sensor to be addressed and grouped in the same way as DALI control gear and makes it easy to configure the system. Fig-4.5.6 (G-2) shows the wiring diagram of DALI Sensor.

The DALI sensor 02 is connected directly to the DALI circuit and does not need a separate power supply. It is powered via the DALI circuit (current draw = 6 mA). It can be connected to the DALI circuit with either polarity.

Technical Specifications:

| | |
|---|---|
| Supply | Via DALI cable |
| Current draw | 6 mA from DALI cable |
| Mounting height | 5 meters |
| Detection angle for PIR detection | 90° |
| Detection angle for light measurement | 70° |
| Operating temperature | 0-50 °C |
| Storage temperature | (-)25-55 °C |
| Type of protection | IP20 |

**TABLE 11: TECHNICAL SPECIFICATIONS OF DALI SENSOR MODULE**



**[Fig-4.5.6 (G-2)] DALI wiring diagram with the DALI Sensor**

## (H) DALI Remote Controller (Controller Module):

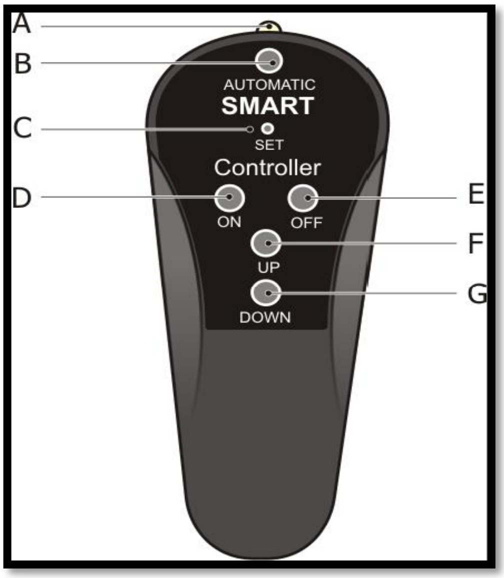
The DALI Sensor can be operated mainly with two remote controls:

- IR Smart Controller [shown in the Fig-4.5.6(H-1)]
- DALI RC [shown in the Fig-4.5.6(H-2)]

IR Smart Controller:

The IR SMART Controller is used to operate the assigned luminaire group in the DALI system. This remote control offers the following functions:

- Switching luminaire group on/off
- Dimming luminaire group up/down
- Activation of light control
- Definition of the brightness setpoint value



**[Fig-4.5.6 (H-1)] DALI IR Smart Controller**

| Points in the IR Smart controller diagram | Description of that point |
|---|---|
| A | IR Sender |
| B | Automatic Control mode ON/OFF |
| C | SET – Saves the current light control value |
| D | ON – Luminaire group on |
| E | OFF- Luminaire Group off |
| F | UP – Increase light value |
| G | DOWN – Reduce light value |

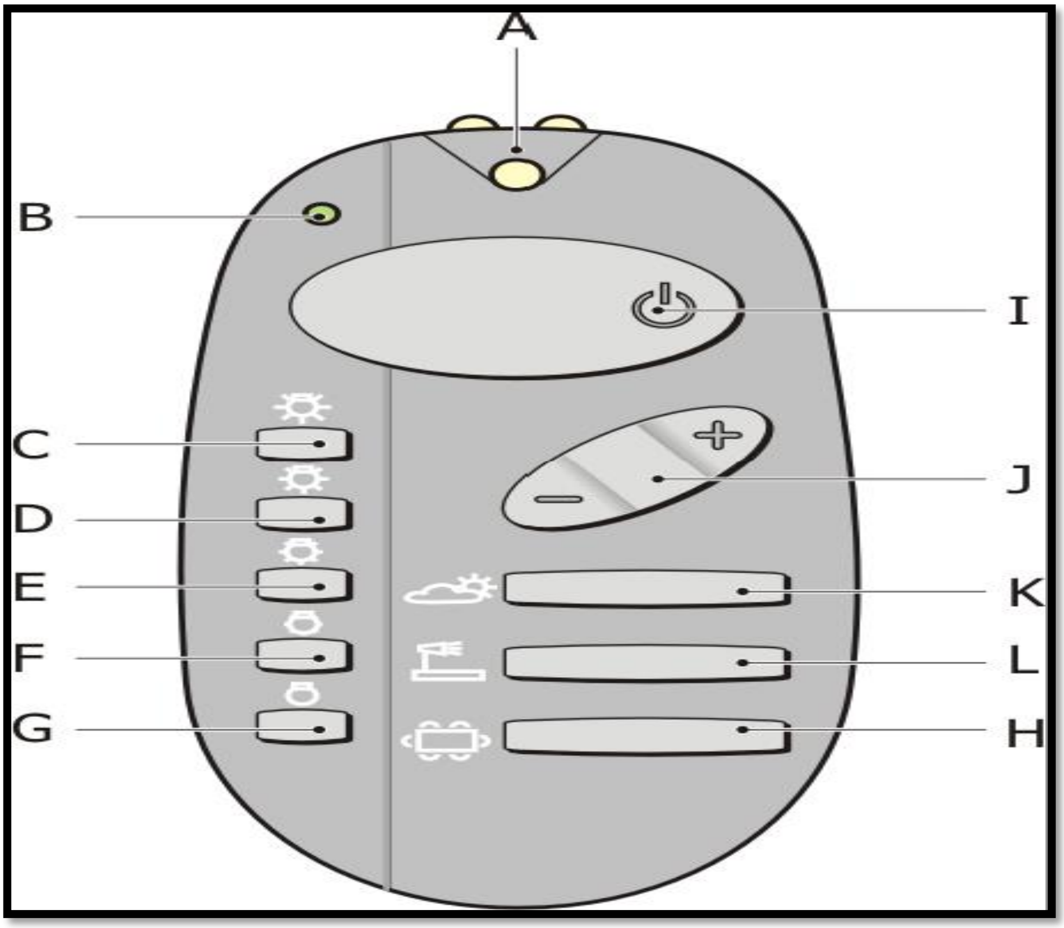
**TABLE 12: DIFFERENT TYPE OF OPERATIONS OF DALI IR SMART CONTROLLER**

DALI RC:

The DALI RC offers the following functions:

- It can switch all the luminaires or the selected group on/off.
- It can dim all the luminaires or the selected group up/down.
- It can activate of light control.
- It can Call up two scenes.
- It can define the brightness setpoint value.

In order to ensure that the remote control can be used straight away without any complicated set-up procedure, the buttons are pre-programmed with a default setting. The button assignment in User mode is as follows:



**[Fig-4.5.6 (H-2)] DALI RC (Remote Controller)**

| Points in the DALI RC Diagram | Description of that point |
|---|---|
| A | IR sender |
| B | LED – Status display |
| C | Light value 100% Brightness |
| D | Light value 50% Brightness |
| E | Light value 25% Brightness |

| | |
|---|---|
| F | Light value 12% Brightness |
| G | Light value 6% Brightness |
| H | Call up Scene 1 |
| I | Switch all luminaires in the DALI system ON or OFF |
| J | Increase or reduce the light value (dimming the DALI system) |
| K | Automatic control Mode on |
| L | Call up Scene 2 |

**TABLE 13: DIFFERENT TYPE OF OPERATIONS OF DALI REMOTE CONTROLLER(RC)**

**(I) DALI USB (Controller Module)**: The DALI USB interface module [Figure-4.5.6(I)] enables the DALI installation to be set up and parametrised with the aid of a PC. DALI USB interface is mainly used for the communication between DALI Systems and PC applications.

Features of DALI USB

- By using the DALI USB interface, we can handle bidirectional data transfer.
- The DALI USB is generally applicable to address and configure DALI components. It can be used for status requests and parameter setting as well.
- It can support standard DALI protocol and various extended DALI protocols.
- It can monitor the DALI Communication.
- USB and DALI line are electrically isolated.

**[Fig-4.5.6 (I)] DALI USB interface**

Technical Specification:

| | |
|---|---|
| Geometry (LXWXH) | 102x51x30 |
| USB Cable | 1.8 meters |
| Current consumption | DALI:6 mA & USB: 10 mA |
| Ambient temperature | 0°C-50°C |
| Protection class | IP20 |

**TABLE 14: TECHNICAL SPECIFICATIONS OF DALI USB**

## (J) DALI RS232 INTERFACE (Controller Module):

The DALI RS232 Interface PS/S combines a DALI interface module and a power supply module in one and the same device. The rated current of the power supply is 240 mA. Via the RS232 interface it is possible to put the DALI system into operation and to set its parameters. During normal operation the interface can be used for service purposes. The RS232 interface is accessed via an RJ45 socket. An optional connecting cable from the RJ45 socket to an RS232 plug is available as an accessory. Additional adapters (to USB for example) are available from various manufacturers.

Technical Specifications:

| | |
|---|---|
| Rated supply voltage | 110-240 V |
| Permitted input voltage | 110- 260 V |
| Mins frequency | 50/60 Hz |
| Power | 1-6 W |
| Standby power | 1 W |
| Max. output current, DALI | 240 mA |
| Output voltage | 16 V ±5 % |
| Operating temperature | 0-50 °C |
| Storage temperature | (-)20 to 60 °C |
| Maximum casing temperature | 80 °C |
| Permitted relative humidity | 10 – 90 %, not condensed |
| Mounting | DIN rail mounting, 35 mm |
| Casing material | PC, flame retardant, halogen-free |
| Type of protection | IP20 |

**TABLE 15: TECHNICAL SPECIFICATIONS OF DALI RS232 INTERFACE**

## (K) DALI DSI (DIGITAL SERIAL INTERFACE) (Interface Module):

The DALI DSI converter [Fig-4.5.6(K-1)] converts DALI commands into DSI signals so that DSI-based units can be integrated in DALI lighting control systems. This type of system typically integrates up to 5 DSI based ballast in the DALI systems. The module is powered directly by the DALI-line, no additional supply required. [Fig-4.5.6(K-2)] shows the wiring diagram of DALI DSI interface module.

Electrical data:

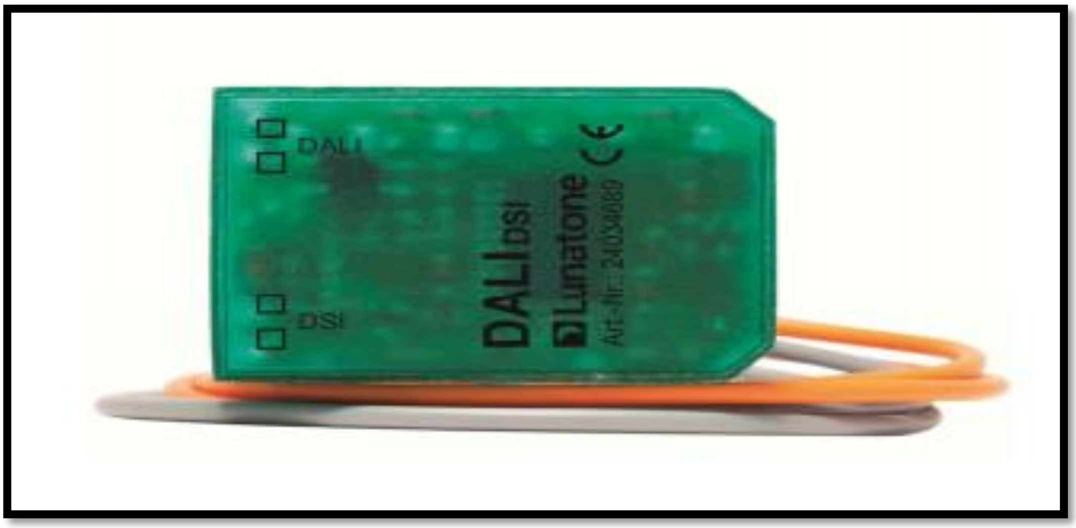
| | |
|---|---|
| Supply | Via DALI line |
| Current consumption | 16 mA |
| Number of DALI address | 1 |
| Output | DSI |
| Maximum number of DSI device | 5 |

**TABLE 16: ELECTRICAL SPECIFICATIONS OF DALI DSI**

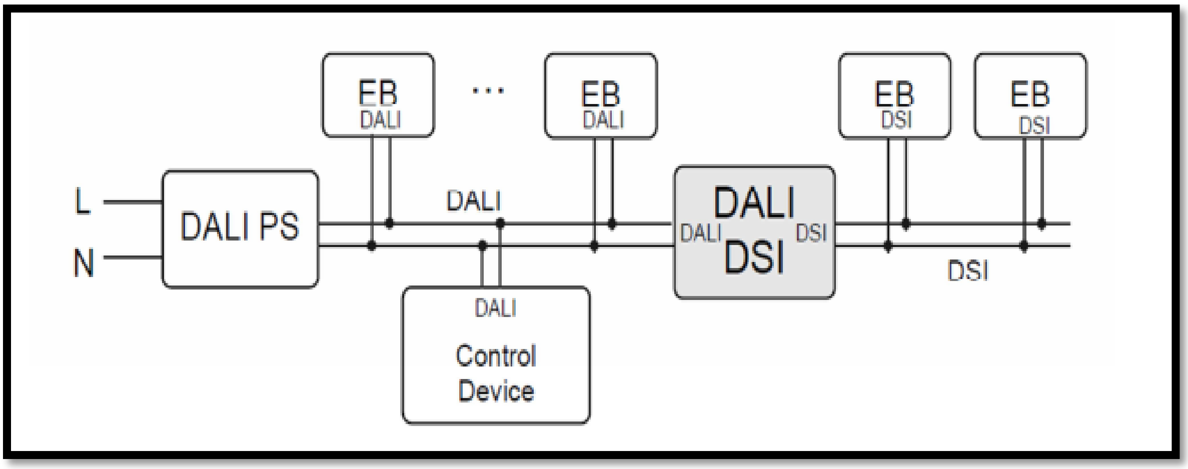
Technical data:

| | |
|---|---|
| Storing and transportation temperature | -20°C … +75°C |
| Operating ambient temperature | -20°C … +75°C |
| Protection class | IP20 |
| Connecting wires | 250mm / 0.75 mm2 |
| Mounting | Back box |
| Dimensions | 41mm x 30mm x 11mm |

**TABLE 17: TECHNICAL SPECIFICATIONS OF DALI DSI**



**[Fig-4.5.6 (K-1)] DALI DSI interface**



**[Fig-4.5.6 (K-2)] DALI DSI interface module wiring diagram**

## (L) DALI MOTOR CONTROLLER INTERFACE (Interface Module):

With this interface, motor controllers can be integrated in the DALI circuit. The DALI motor controller interface can control up to four blinds independently. The blind positions (height and angle) are stored like lighting scenes.

The lighting and the blind positions can be stored under one and the same scene. Lighting moods can be conjured up using different blind positions.

The DALI motor controller interface supports 16 DALI groups and 16 DALI scenes. It is incorporated into the DALI circuit like a DALI electronic ballast. The blind positions (height and angle) are stored just like lighting scenes.

Whenever the saved scene is called up, the blind moves to the pre-set position. It is possible to save and recreate a scene using the DALI SC, for instance. This makes it possible to save light and blind positions in a single scene.

The polarity of the motor controller interface terminals must be observed during the installation.

Technical specifications:

| | | | |
|---|---|---|---|
| Electrical Supply | Mains voltage | V | 220-240 |
| | Frequency | Hz | 50/60 |
| | Maximum current | mA | 20 mA |
| Input | Number | - | 1 |
| | Power consumption DALI bus | mA | 6 |
| | Number of DALI addresses | - | 4(one per motor) |
| Output | Number | - | 1 |
| | Maximum number of selectable motors | - | 4 |
| Mounting | Mounting type | - | Remote mounting |
| | Mounting position | - | Any |

|  |  |  |  |
|---|---|---|---|
| Typical Mechanical details | Dimensions (LXWXH) | Cubic mm | 101x51x29 |
|  | Weight | kg | 0.155 |
| Protection | Protection type | - | IP20 |
| Temperature | Ambient temperature | °C | 0-50 |
|  | Storage temperature | °C | (-)20 to 70 |

**TABLE 18: TECHNICAL SPECIFICATIONS OF DALI MOTOR CONTROLLER INTERFACE**

## (M) DALI RELAY MODULE CONTROLLER (Interface Module):

The DALI RM relay module [Fig-4.5.6(M-1)] controller enables a contactor (12/24 VDC or 230VAC) to be controlled so that different loads can be switched via DALI commands. Loads that do not have a DALI input can therefore be integrated in the DALI circuit. The loads can be switched on and off via DALI.

**Features:**

(1) Loads must not be connected directly to the DALI RM. The load must always be switched via an external contactor.

(2) The maximum load that can be connected to the DALI RM is the load of a contactor coil.

(3) When selecting the correct contactor please check the inrush currents of the switched loads. Electronic ballasts may have very high inrush currents. Check with the contactor manufacturer.

(4) If DC contactor coils are controlled, they must be equipped with an appropriate free-wheeling diode.

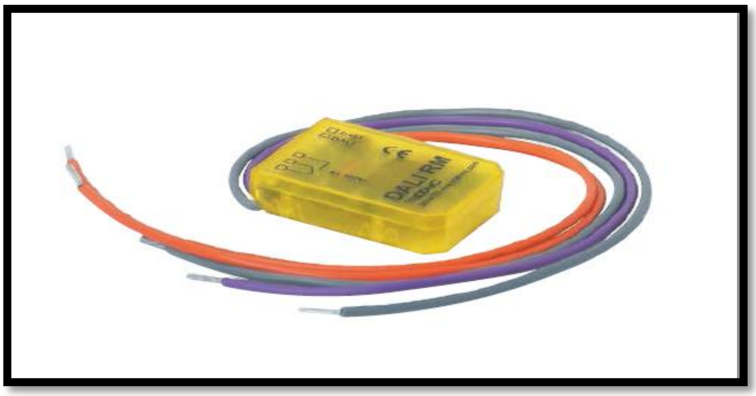
(5) Relay switches on when ACTUAL LEVEL is above the MAX-LEVEL. Relay switches off when ACUTAL LEVEL is below the MIN-LEVEL.

(6) The DALI RM is powered directly by the DALI line, hence in case of missing supply the relay-contact opens. Therefore, the SYSTEM FAILURE LEVEL is meaningless.

(7) It is not possible to receive information about the state of the loads. Hence error messages do not make sense in this application and QUERY LAMP FAILURE will always send NO as an answer. The QUERY STATUS bits 0&1 are not implemented. The physical selection method is not implemented.

(8) When storing a scene level, besides the ACTUAL LEVEL, the relay state will be stored as well. When storing scenes, it is important that the relay is in the required state.

(9) DALI is not SELV. The installation instructions for low voltage therefore apply.



**[Fig-4.5.6 (M-1)] DALI Relay module**

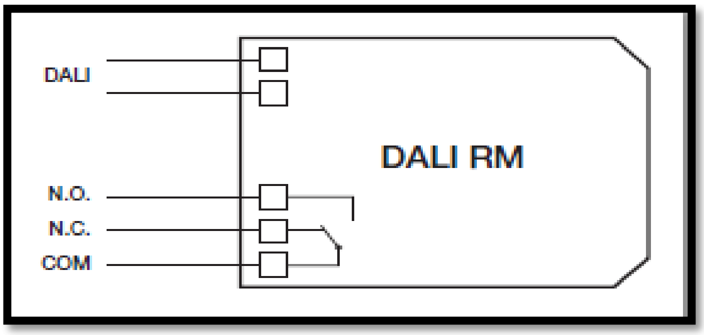
Technical Specification:

| Type | | DALI Relay Module |
|---|---|---|
| Input, Relay | DALI control input | 1 |
| | Current draw | 12 mA from DALI |
| | Number of DALI addresses | 1 |
| Output, Relay | Maximum switching voltage AC | 250 V |
| | Maximum switching voltage DC | 35 V |
| | Type of contact | 1 Changeover |
| | Minimum contact load | 12 W |

**TABLE 19: TECHNICAL SPECIFICATIONS OF DALI RELAY MODULE**

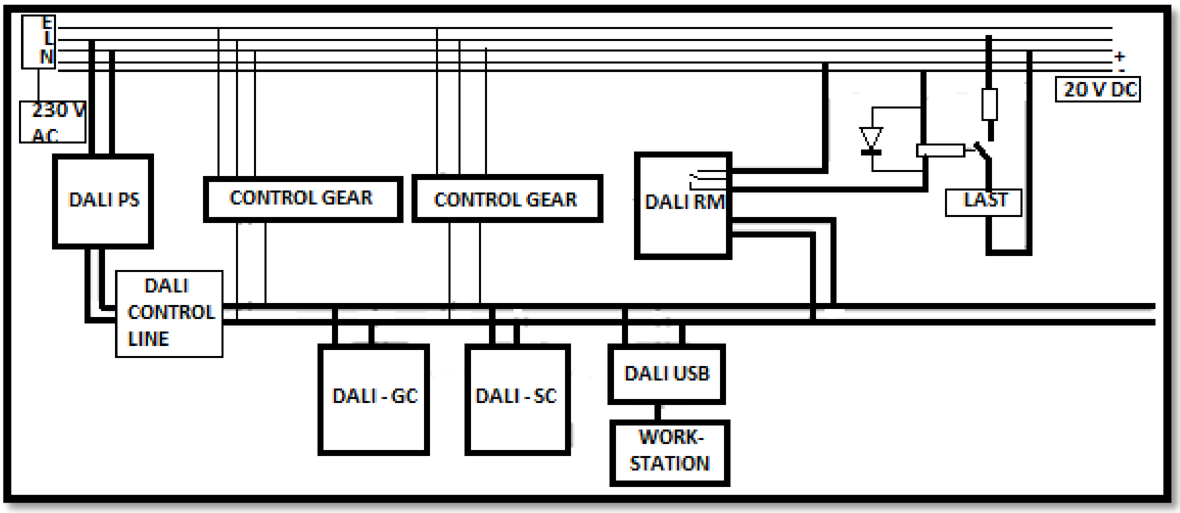
[Fig-4.5.6(M-3)] shows the wiring diagram of DALI Relay module with 12/24V Contactor coils & [Fig-4.5.6(M-4)] shows the wiring diagram of DALI Relay module with 230V AC Contactor coils.

## Connection Diagram of DALI Relay Module:

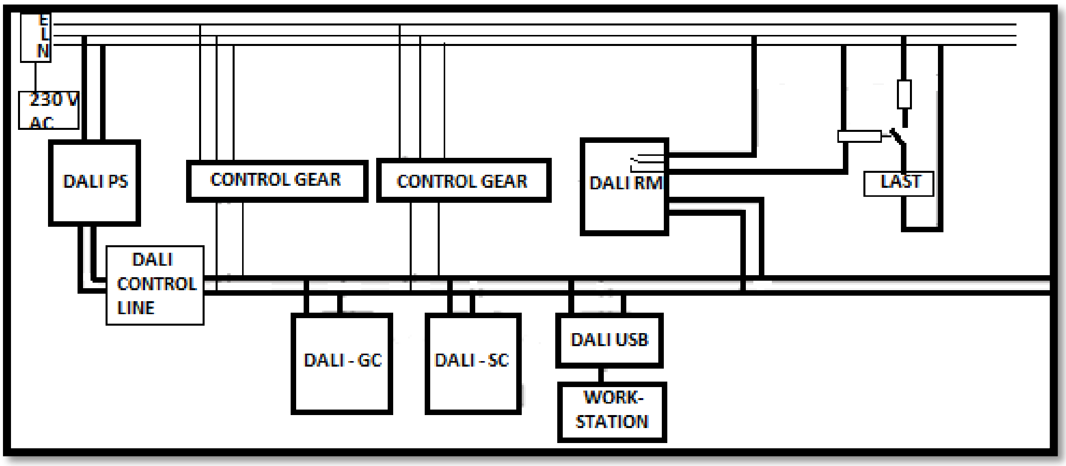


**[Fig-4.5.6 (M-2)] Connection diagram of DALI Relay module**

## Wiring diagram:



**[Fig-4.5.6 (M-3)] Switching of 12/24 V DC contactor coils**



**[Fig-4.5.6 (M-4)] Switching of 230 V AC contactor coils**

## DALI DEVICES

### (A) ELECTRONIC LED CONTROL GEAR:

Electronic LED control gear [Fig-4.5.6(A)] is a digitally dimmable, constant current device with adjustable output current and can be controlled via DALI, DSI and automatically adjusts to the control signal. This type of control gear supports DALI devices for tunable white. Colors can be set via X-Y coordinates or via the color temperature. In this type of control gear, there are 16 scenes (predefined color temperatures) preprogrammed in the control gear & these scenes can be reprogrammed by using the Master configurator. LED control gear has three output channels for dimming purpose of light emitting diodes with 24 V. This type of control gear draws a current of 350 mA roughly. (value of drawing of current is more or less same for different control gears)

**[Fig-4.5.6 (A)] Electronic LED control gear**

### (B) ELECTRONIC FLUORESCENT CONTROL GEAR:

Electronic fluorescent control gear [Fig-4.5.6(B)] is a digitally dimmable control gear for fluorescent lamps. It has the option of control via DALI, DSI and automatically adjusts to the control signal and is designed for use in building management systems. It also has a large number of intelligent functions and is therefore suitable for a wide range of applications. It also has a large number of intelligent functions and is therefore suitable for a wide range of applications.

**[Fig-4.5.6 (B)] Electronic Fluorescent control gear**

## (C) ELECTRONIC HID CONTROL GEAR:

This type of control gear [Fig-4.5.6(C)] mainly used for outdoor applications and it enables DALI, DSI and Step DIM functionality. Depending on the used lamps, this type of control gear can dim down to 40% to save energy.

**[Fig-4.5.6 (C)] Electronic HID control gear**

## (D) ELECTRONIC TRANSFORMERS:

This type of electronic safety transformer [Fig-4.5.6(D)] is used for low-voltage halogen lamps. It enables low-voltage halogen lamps to be integrated directly in the DALI circuit. This type of transformers can also fade the low voltage halogen lamps up and down as per the requirement.

**[Fig-4.5.6 (D)] Electronic Transformers**

## (E) PHASE DIMMERS:

Phase dimmers [Fig-4.5.6(E)] are digital leading-edge and trailing-edge equipment, mainly used for ceiling & switching cabinets installation. They enable equipment such as electronic or magnetic transformers for low-voltage halogen lamps or incandescent lamps to be integrated in a DALI system. Load connected with the phase dimmers are in the range of 30 VA – 300 VA for ceiling installation and 40 VA – 1000 VA for switching cabinet installation.

**[Fig-4.5.6 (E)] Electronic Phase Dimmers**

## MISCELLANEOUS DALI DEVICES

(A) DALI REPEATER:

The DALI Repeater is an amplifier module for refreshing the DALI signal. With the DALI Repeater it is possible to increase the maximum length of the DALI control line from 300 m to 600 m. Power supply for the DALI repeater is taken from the DALI line. A star type of network can be formed by using the multiple DALI repeaters. It is mainly used in the switching cabinets.

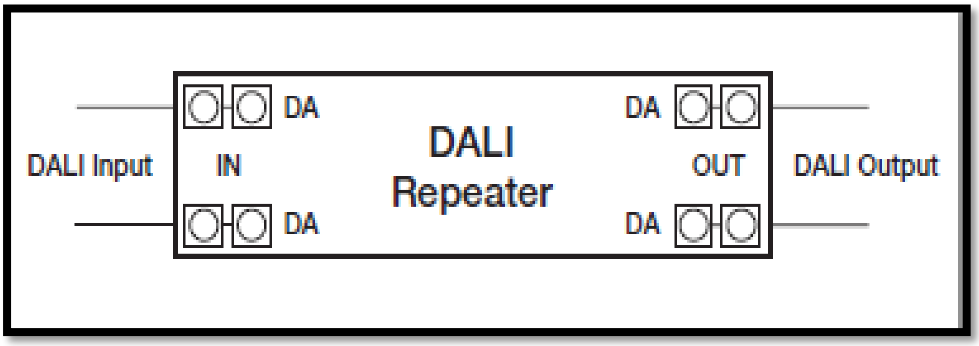
DALI repeaters cannot be used in series because of the signal delay. By using the DALI repeater in the circuit, there will be no increase of DALI unit in the main and sub-ordinate circuit. Because of the electrical isolation between the main circuit and the subordinate circuit an additional DALI power supply unit is needed for each DALI repeater.

Technical Specification:

| | |
|---|---|
| Supply | Via DALI cable |
| Current draw for main control circuit (IN) | 6 mA from DALI |
| Current draw for subordinate control circuit (OUT) | 4 mA from DALI |
| Starting time | < or equal to 2 seconds |
| Input | DALI |
| Output | DALI |
| Operating temperature | 0-50 °C |
| Storage temperature | (-)20 to 70 °C |
| Housing material | Polyamide |
| Protection type | IP20 |
| Protection class | SK 2 |

**TABLE 20: TECHNICAL SPECIFICATIONS OF DALI REPEATER**

Connection Diagram of DALI Repeater circuit:



**[Fig-4.5.6 (A)] Connection Diagram of DALI Repeater circuit**

# CHAPTER – 5

# DALI CONTROLLED LIGHTING SYSTEM

## 5.1 SYSTEM DESIGN

This section is implemented to simplify the planning and configuration of DALI installation. Using examples from different application guide it discusses the typical requirements of a DALI system and the special features of different products. The following two aspects deserve special attention when designing a DALI application.

Conceptual aspect

In this aspect we have to identify, what characteristics must the application have? Should there be daylight-dependent control? Are special lighting scenes or color applications required? Etc.

Technical aspect

In this aspect we have to know about the, what is possible with DALI? What are the limitations of DALI & how do this affect the application? Etc. In most cases, the prime consideration will be the conceptual aspect. What are the characteristics of the lighting application and what requirements and criteria should they meet? You will then consider the technical aspect and attempt to find the right products to meet these criteria.

The technical aspect of the DALI installation is closely associated with the planning process. The key to a successful DALI installation starts with the installation plan. The installation plan should contain the following points:

- The position of all the DALI devices (including the device type and device name).
- The grouping of DALI devices.
- The DALI short address (optional); in some applications it makes sense to define the address at the planning stage.
- The wiring of DALI circuit including the junction boxes (if there are multiple DALI circuits it is best to colour code them).
- The cable length for each DALI circuit.

### 5.1.1 CONVENTIONAL WIRING OF DALI

If a requirement profile calls for flexible lighting control in which the assignment of the luminaires and control gear can be changed this must be defined in every detail before the installation phase. For conventional lighting management (without DALI) planners have to take into account all the possible lighting control options before work actually commences. Conventional planning would provide for multiple control lines per room section to cover all the possible options.

With DALI all the lighting control options remain open even after the installation is complete and changes are needed to a particular control variant (planning security). There are no additional costs for multiple control lines or rewiring control lines. The decision to opt for DALI or a conventional control system depends on the functionality required and the flexibility with which the lighting system is to be controlled.

### 5.1.2 DALI DESIGN CONSIDERATIONS

A number of points deserve special attention when designing A DALI application.

- Maximum 64 DALI devices per DALI circuit.
- Maximum of 16 DALI groups per DALI circuit.
- Maximum of 16 DALI scenes per DALI circuit.
- The current on the DALI circuit must not exceed the maximum current of the power supply. (typically, 200 mA to 250 mA)
- The maximum cable length depends on the maximum permitted voltage drop along the DALI cable; This is defined as 2 V maximum. This corresponds to a maximum cable length of 300 mA for a line cross-section of 1.5 sq.mm; Contact resistance must be taken into account. A voltage drops of maximum 2 V must not be exceeded.
- The recommended minimum cable cross-section is 1.5 sq.mm

### 5.1.3 CURRENT DRAW OF A DALI CIRCUIT

Each device in the DALI circuit consumes current via the DALI circuit. The total current draw on the DALI circuit must not exceed the maximum current of the DALI power supply.

To determine the current draw of a DALI circuit both the current draw of the DALI devices and the current draw of the DALI controllers must be taken into consideration. The current draw of a DALI device is defined in the DALI standard as 2 mA. The current draw of the individual DALI controllers is shown in the relevant data sheets.

It is important that the current draw of the DALI circuit does not exceed the maximum current of the power supply.

Example: DALI circuit with 25 LED dimmable control gears, 4 DALI group controllers & 4 DALI scene controllers.

Current draw of different DALI components (from relevant data sheets)

- Dimmable LED control gear = 2 mA
- DALI group controllers = 6 mA
- DALI scene controllers = 6 mA

Total current = ∑ current draw of DALI devices + ∑ current draw of DALI controllers.

Total current = 25× Dimmable LED control gear + 4× DALI group controllers + 4× DALI scene controllers

Total current = 25× 2 mA + 4× 6 mA + 4× 6mA = 98 mA

So, from this example, we can tell that the total drawing current by the DALI devices cannot exceed the DALI power supply current. The supply current is typically about 200-250 mA.

### 5.1.4 MAXIMUM CABLE LENGTH

The maximum cable length depends on the maximum permitted voltage drop along the DALI cable; this is defined as 2 V max. Typically; this requirement is safely met for a cable length of 300 m and a cable cross-section of 1.5 mm². Additional voltage drops at terminal points must be taken into consideration. For cross-sections smaller than 1.5 mm² the maximum cable length is reduced accordingly.

CALCULATING THE VOLTAGE DROP:

The formula for calculating the voltage drop is as follows:

$$U = \frac{2 \times \mathrm{L} \times \mathrm{I}}{\gamma \times \mathrm{S}}$$

Where, U = Voltage drop in Volts; L = Cable length in meters; I = Current in Ampere (typically, 250 mA or 0.25 Ampere); g=Electrical conductivity in m/ (Ω $\mathrm{mm}^2$); for example, for copper cable, the value of γ is 56 m/ (Ω $\mathrm{mm}^2$); S = Cross sectional area in $\mathrm{mm}^2$ of the cable.

Note: Maximum current is taken as 250 mA for the calculation of voltage drop by using the formula.

Calculation:

$$x = \frac{2 \times 300 \text{ meter } \times 0.25 \text{ Ampere}}{56 \left(\frac{meter}{\Omega \times \mathrm{sq.mm}}\right) \times 1.5 \text{ sq. mm}}$$

$$x = \frac{2 \times 300 \times 0.25}{56 \times 1.5} = 1.7857 = 1.786\ volts$$

Note:

A further voltage drop is taken as 0.214 volts, which is available for terminal points i.e. for the contact resistance.

Exact result

- For 300 meters cable the voltage drop is equal to 1.786 volts.
- Additional voltage drops of 0.214 volts, for the contact resistance.

Thumb rule:

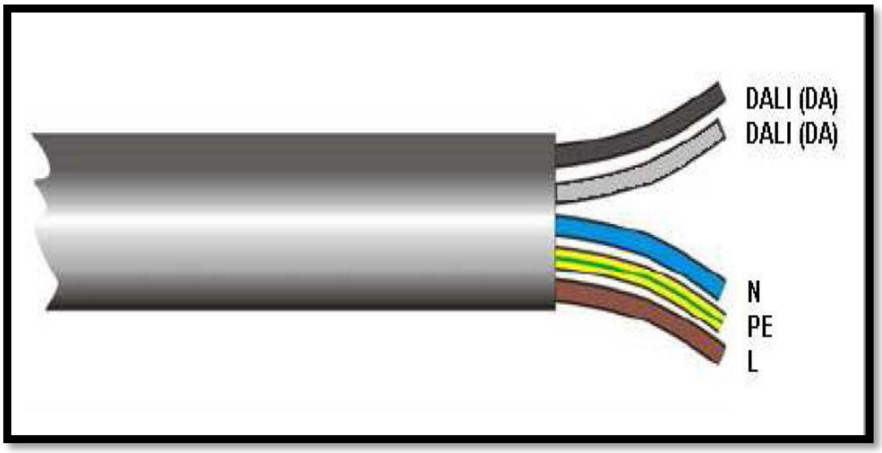
As it is somewhat tricky to calculate the cable length based on the voltage drop the rule of thumb is as follows:

1. If cross-section of cable 1.5 $\mathrm{mm}^2$ is used, the maximum cable length is 300 meters.
2. If a smaller cross-section is used, the possible cable length is reduced accordingly.

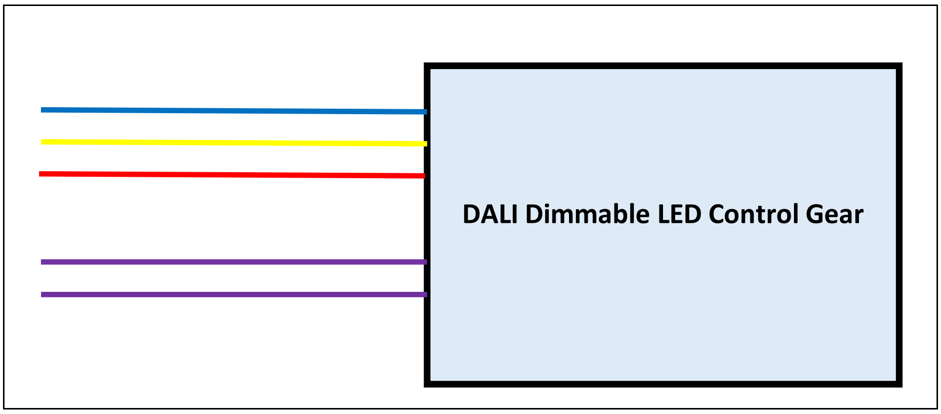
Note: As per DALI installation, the manufacturers mainly say that, to use the 1.5 $\mathrm{mm}^2$ cable for the DALI control lines.

5.1.5 WIRING

- DALI systems are installed using conventional wiring material for line voltage.
- Two-wires are needed for the DALI control circuit. The line-voltage and the bus line bus line may be routed in the same cable (L, N, PE, DA, DA) [Fig-5.1.5(A)].
- There is no need to worry about polarity of the DALI control line.
- The DALI signal is not SELV. (separated extra low voltage). The installations for low voltage therefore apply.
- There are no special network topology requirements. (star and mixed networking are permitted).



[Fig-5.1.5(A)] Typical texture of used wire



[Fig-5.1.5(B)] Typical connection of DALI devices & different polarities of DALI lines

In the above figure [Fig-5.1.5(B)], the blue, yellow & red lines represent the power line, where blue represents Neutral, yellow represents Earth & red represents Live. There are also two violet lines in the picture. These two lines are the DALI control lines & there is no need to check the polarities of the control lines.

Note: According to DIN VDE 0100/T520/Part 6, main circuits and associated auxiliary circuits may be laid together even if the auxiliary circuits carry a lower voltage than the main circuits. Make sure to use cable designed to take the maximum operating voltage.

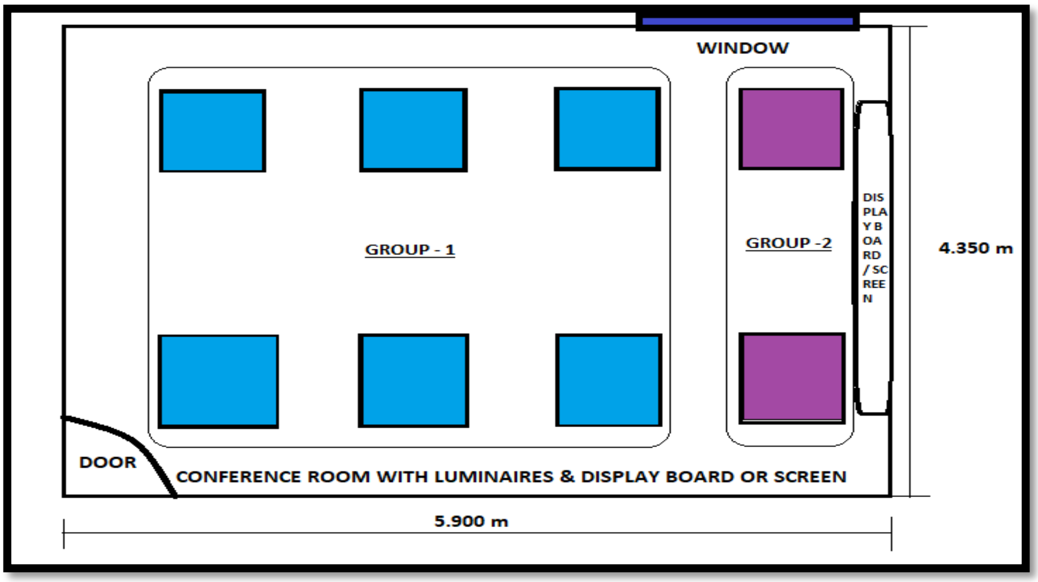
# CHAPTER – 6

## A CASE STUDY OF DALI CONTROLLED LIGHTING SYSTEM

In this chapter we will discuss about the implementation of DALI system in the conference room & for different mode of operation (like presentation mode, discussion mode) how the dimming is done. We will also discuss about the connection diagram and the single line diagram of the conference room for the implementation of DALI system.

### 6.1 APPLICATION AREA:

The application area [Fig-6.1] for the implementation of DALI system is a conference room where 12 people can seat at a time. The room contains with a window, a door & a screen or a display board for the use of a projector. The room dimension is (5.900 m ×4.350 m ×2.743 m). Digitally dimmable LED troffers (2×2) are used as per the luminaire requirements. The numbers of troffers used in the conference room is eight & each troffer has the wattage of 36 watt.



**[Fig-6.1] Typical 2-d diagram of the conference room with the room dimensions**

For the dimming purpose the luminaires are divided into two groups. The blue colored luminaires are kept in Group-1 & the violet colored luminaires are kept in the Group- 2.

### 6.2 REQUIREMENT FOR THE DALI IMPLEMENTATION

The lighting in the conference room consists of 8 troffers. Six troffers (Group-1) are kept in one group & two troffers (Group-2) are kept in the other. The requirement for the lighting control is as follows:

- The luminaires should be switched and controlled at either of two control points. Between these two control points one point is in the door side & other control point is in the window side. The proper diagram & the explanation of these two control points will be discussed in the later section.

- There should be a section of different lighting scenarios (e.g. Presentation mode, discussion mode etc.).
- The luminaires must be capable of dimmed. The dimmable troffers used in the conference room are the product of BAJAJ ELECTRICALS LTD. & the product description will be given in the next section.

## 6.3 SOLUTION WITH DALI GROUP CONTROLLERS & DALI SCENE CONTROLLERS:

Grouping of luminaires

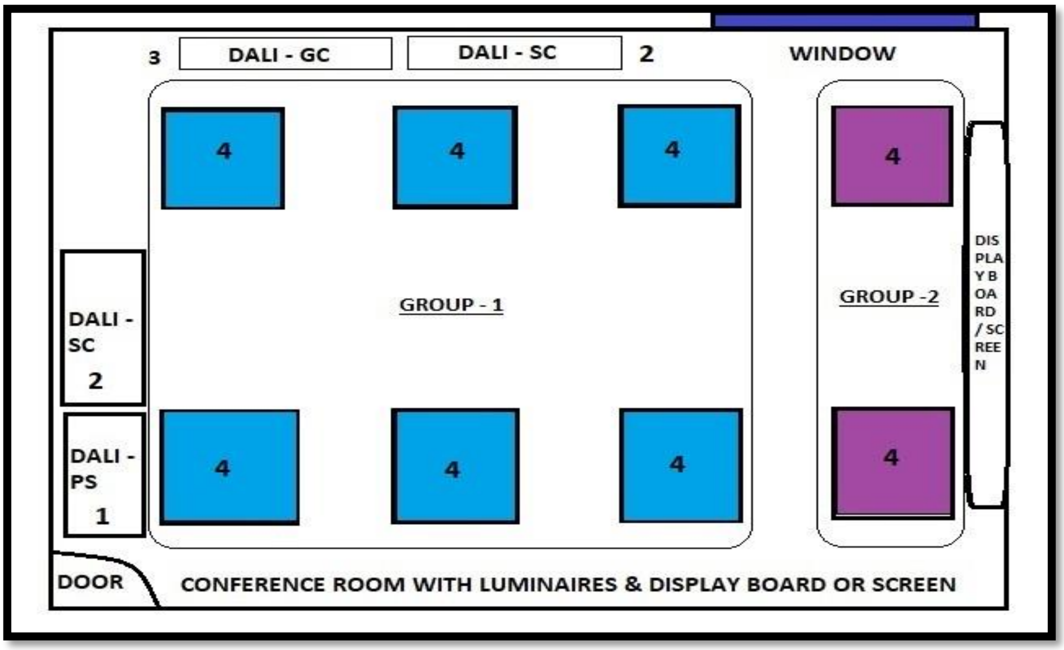
As mentioned above, there are two group of luminaires. In one group there are 6 luminaires & in the other group there are 2 luminaires. Each luminaire has the wattage of 36 W. The product description of the dimmable luminaire is BAJAJ 13671 BZRSQL 36W GZ WH (2×2 troffer).

Switching points

First switching control point: The first switching control point is kept near the door. This is because of the switching the lights on & off mainly. This is implemented by a DALI Scene Controller (DALI- SC) with the scenes “Lighting On” & “Lighting Off”.

Second switching control point: This switching control point is kept beside the window (near the screen). The second switching control point is implemented with a DALI Scene Controller (DALI-SC) & a DALI Group Controller (DALI-GC). By using these controllers, we can enable any of the four scenes (here four scenes mean, on & off and 40% dimming state & 50% dimming state for the presentation mode & the discussion mode or meeting mode of operation) to be retrieved & both luminaire groups to be individually dimmed.

Fig-6.3 represents the conference room with luminaires & DALI equipments when the wiring is not done.



**[Fig-6.3] Installation for the conference room without wiring**

## 6.4 LIST OF PARTS OR EQUIPMENTS USED

| Position in the diagram | Quantity | Description of the Product |
|---|---|---|
| 1 | 1 | DALI Power Supply |
| 2 | 2 | DALI Scene Controller |
| 3 | 1 | DALI Group Controller |
| 4 | 8 | DALI LED Control gear for LED Troffers |

**TABLE 21: LIST OF PARTS OR EQUIPMENTS USED**

For the implementation of DALI, some equipments are required. The basic thing which is required is a DALI Power Supply, which is capable of giving around 200 mA to 250 mA as discussed earlier. Besides that, we need DALI- GC & DALI- SC as the controlling unit. Besides that, we also need eight dimmable LED Troffers with DALI LED Control gears. The positions of the equipments are given in the table with reference to the Fig-6.3.

## 6.5 TYPICAL CURRENT DRAW BY THE DALI DEVICES & THE DALI CONTROLLERS (DALI-GC & DALI-SC)

The current draw by the DALI devices & the DALI controllers are typically given in the data sheets are as follows:

- Each Dimmable LED Control Gear for Troffers = 2mA
- Each DALI Group Controller = 6 mA
- Each DALI Scene Controller = 6 mA

Note: Summation of the current drawing by DALI individual component cannot exceed the maximum current of the power supply which is typically in the range of 200 mA to 250 mA.

Calculation:

Total current = ∑ current draw of DALI devices + ∑ current draw of DALI controllers.

Total current = 8× Dimmable LED control gear + 1× DALI group controllers + 2× DALI scene controllers

Total current = 8× 2 mA + 1× 6 mA + 2× 6mA = 34 mA

So, from the calculation we can see that the current draw by the DALI devices is not exceeded the DALI power supply current. So, from this we can conclude that, the DALI circuit is perfect to implement. As discussed, earlier chapter, in case of DALI implementation, a 5-core cable is used. In the 5-core cable there are three cables (N, PE, L) which is called power line & other two lines are called DALI Control lines.

## 6.6 GROUPING OF LUMUNAIRES

Luminaires can be grouped into two ways:

- With the DALI Group Controller itself.
- Or, with the Master configurator configuration software.

| | |
|---|---|
| 6 Troffers | Group 1 |
| 2 Troffers | Group 2 |
| DALI Group Controller | *Switch Position*<br>Group 1 = Switch for 4 Troffers<br>Group 2 = Switch for 2 Troffers |

Table-22: Table of Grouping of Luminaires in the conference room

## 6.7 SCENE ASSIGNMENT OF LUMINAIRES

Scenes are called up from two locations:

- Directly next to the door, there is a double switch for switching the light on and off.
- Secondly, the control point next to the screen can also be used to switch the light on and off. In addition, two further user defined scenes can be called (e.g. Presentation mode, Meeting mode etc).

| DALI Scene Controller | Control point near door | Control point near screen |
|---|---|---|
| | Switch Position = 1<br>(SCENES = 1 to 4)<br>Scene-1 = Light off<br>Scene-2 = Light on/Light 100%<br>Scene-3 = Not Wired<br>Scene-4 = Not Wired | Switch Position = 2<br>(SCENES = 1 to 4)<br>Scene-1 = Light off<br>Scene-2 = Light on/Light 100%<br>Scene-3 = Presentation mode<br>Scene-4 = Discussion mode/Meeting mode |

Table-23: Table for scene assignment

Different Scenes of Operation

- **Presentation Mode:** In case of Presentation mode of operation, the dimming value is taken as 60%. As per the DIALUX convention, we have to put 40% in the dimming values of every control group. This value can be checked in the **Planning data** of the DIALUX Output.
- **Discussion/ Meeting Mode:** In case of Meeting mode of operation, the dimming value is taken as 50%. As per the DIALUX convention, we have to put 50% in the dimming values of every control group. This value can be checked in the **Planning data** of the DIALUX Output.

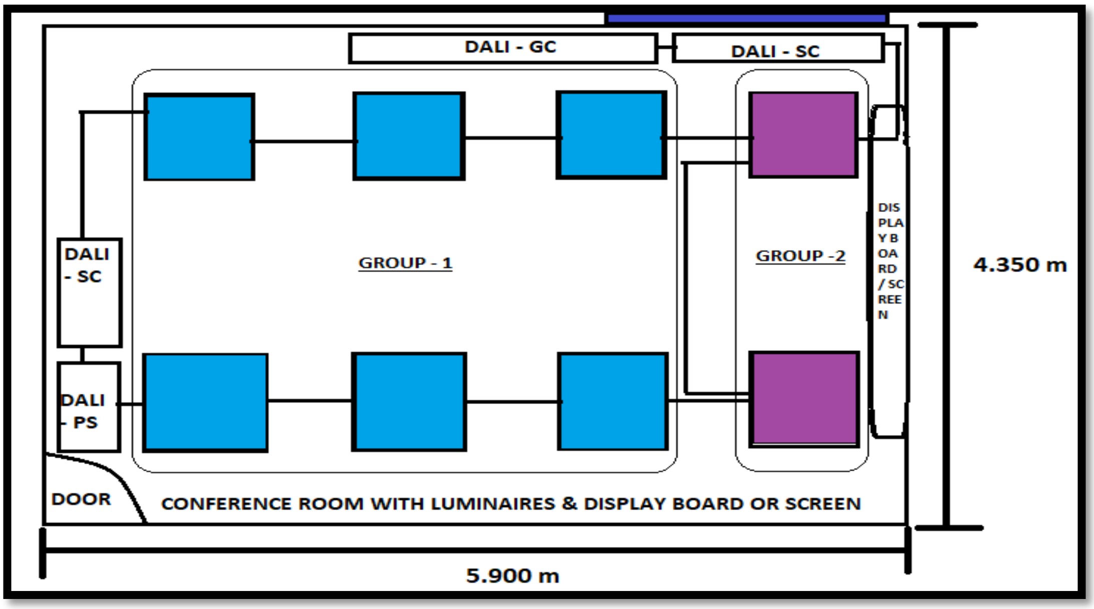
## 6.8 DALI CHECKLIST

This checklist is done at the time of installation of the DALI circuit. This is done because of the record of the DALI devices which are used in the circuit & check whether the implemented circuit is DALI compatible or not.

| DALI CONDITION | PLANNED/PRESENT | CHECKLIST |
|---|---|---|
| Maximum of 64 DALI ECG'S (Electronic Control Gears) | 8 DALI devices | Checked |
| Maximum 16 Groups | 2 DALI Groups | Checked |
| Maximum 16 Scenes | 4 DALI Scenes | Checked |
| DALI Circuit current < Rated DALI power supply current | 34 mA | Checked |
| Line length < 300 meters (for 1.5 mm$^2$) | Approximately 40 meters | Checked |
| 5 Wires to each Luminaires | 5× 1.5 mm$^2$ = 7.5 mm$^2$ | Checked |

Table-24: Table for DALI Checklist

## 6.9 INSTALLATION DIAGRAM FOR CONFERENCE ROOM WITH WIRING



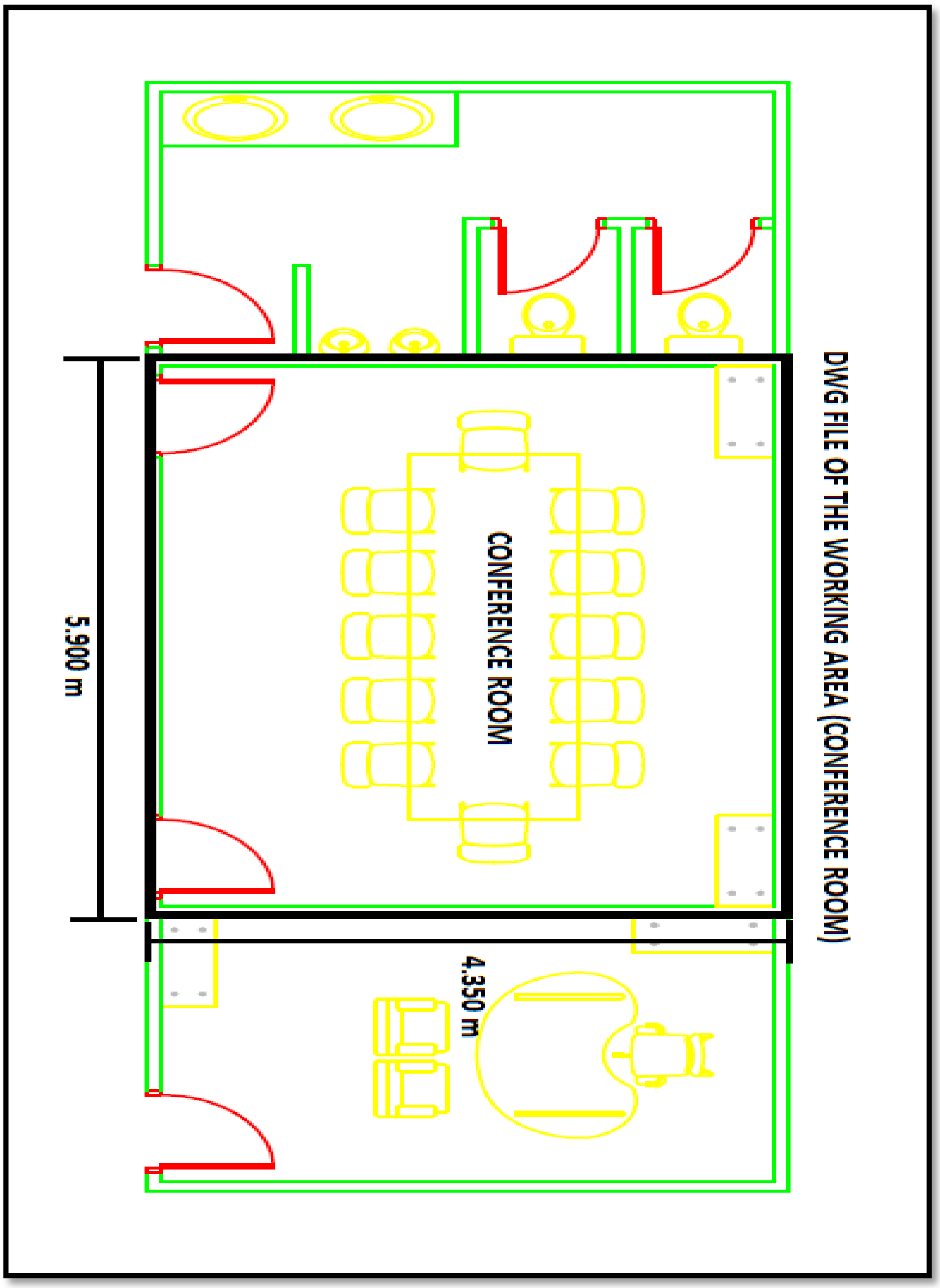
**[Fig-6.9] DALI Controlled System Installation for the conference room with wiring**

In this diagram [Fig-6.9], the components used are as follows:

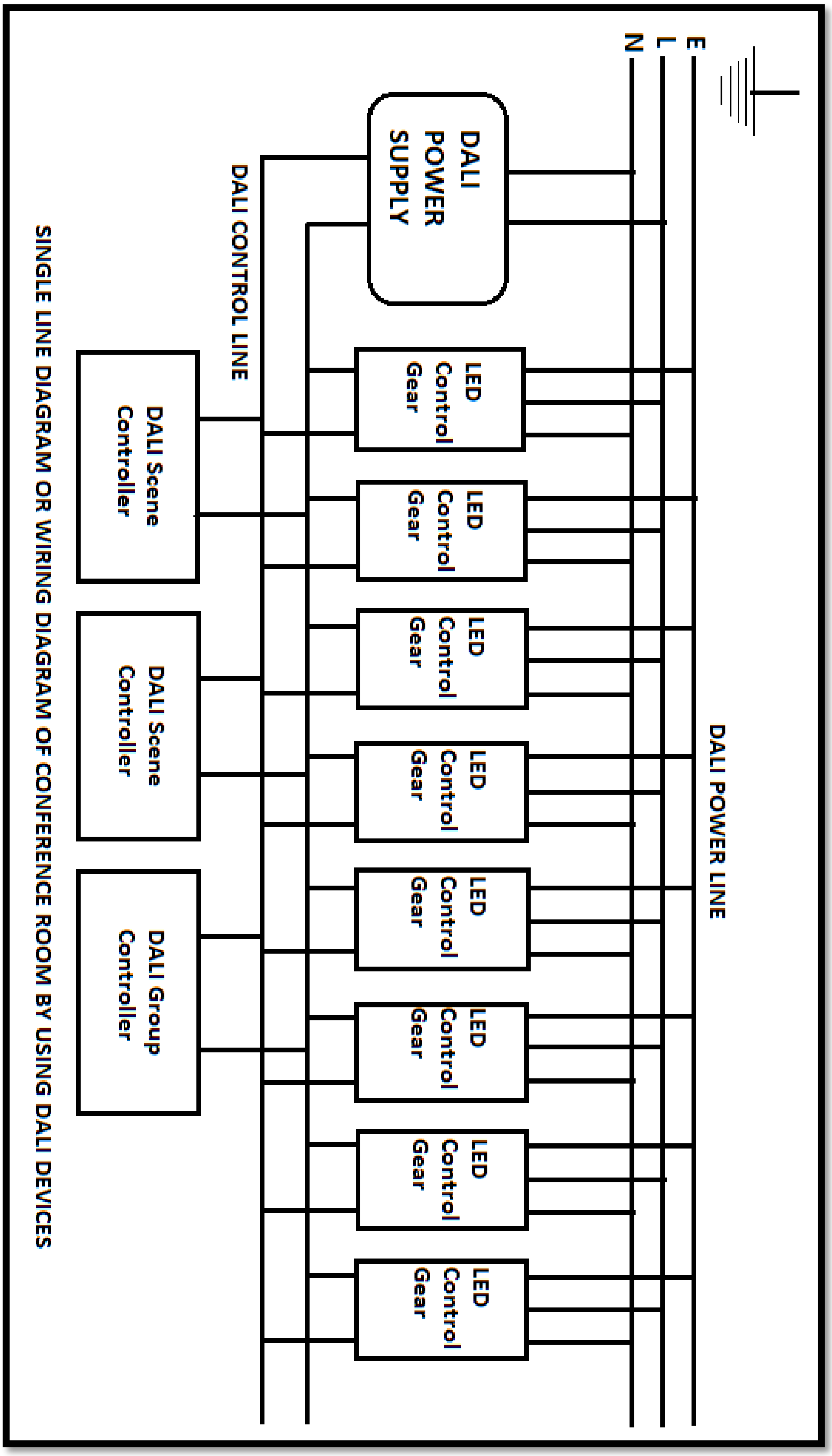
- DALI -SC = DALI Scene Controller.
- DALI -GC = DALI Group Controller.
- DALI -PS = DALI Power Supply.

## 6.10 SINGLE LINE DIAGRAM OF THE TOTAL INSTALLATION IN THE CONFERENCE ROOM:

The single line diagram [Fig-6.10(B)] of the total DALI installation of the conference room consists of mainly six components. First of all, the Power line which consists of Live, Neutral & Earth wires & the DALI control line (polarity independent) which is used for the DALI addressing purpose. One DALI Group controllers, two DALI Scene controllers & eight Digitally dimmable electronic LED control gears are used as DALI devices for the lighting control of the conference room. Fig-6.10(A) shows the actual DWG file of the Conference room.



**[Fig-6.10(A)] Actual DWG File of the Working area or Conference Room**



**[ Fig-6.10(B)] Single Line Diagram or Wiring Diagram of the Conference Room**

# RESULTS & CONCLUSIONS:

The aim of this whole study is to provide a suitable solution for energy efficient dynamic lighting system in the indoor commercial buildings such as residential buildings, corporate office buildings. Here the whole study is based on a conference room of an office building, where the need of lux level on the workplace is different for different modes of work performed throughout the office hours. The use of conference room is basically for two kinds of work. One is for Presentation purpose & the other is for Meetings and discussions. If there is no lighting control system in the conference room, then the lux level is same for different kind of works & the energy consumption of whole system is much more than a smart lighting control system. If we use any smart lighting control system in the conference room, not only the energy consumption is less but also, we can control the lighting systems as per the different mode of work performed in that conference room. The results of these two types of system i.e. without the lighting control system & with the lighting control system is given as follows:

| $E_{avg}$ (lux) | $E_{min}$ (lux) | $E_{max}$ (lux) | Uniformity ($U_0$) | $E_{min}/E_{max}$ |
|---|---|---|---|---|
| 650 | 328 | 859 | 0.504 | 0.382 |

Table-25: Value Chart of the calculation surface of the conference room without any lighting control system

| $E_{avg}$ (lux) | $E_{min}$ (lux) | $E_{max}$ (lux) | Uniformity ($U_0$) | $E_{min}/E_{max}$ |
|---|---|---|---|---|
| 253 | 138 | 319 | 0.546 | 0.434 |

Table-26: Value Chart of the calculation surface of the conference room for the Presentation mode of operation with lighting control system

| $E_{avg}$ (lux) | $E_{min}$ (lux) | $E_{max}$ (lux) | Uniformity ($U_0$) | $E_{min}/E_{max}$ |
|---|---|---|---|---|
| 317 | 173 | 398 | 0.546 | 0.434 |

Table-27: Value Chart of the calculation surface of the conference room for the Discussion mode of operation with lighting control system

The results of the calculation surface area are taken 0.900 meter above from the floor level of the conference room in each case & the maintenance factor for each case is taken as 0.80 (assume the room is clean). The value charts given above is simulated from the DIALUX software & the copy of the simulation results are attached in the next section.

From the value charts the conclusion is that the requirement of lux level for different modes of work is not same and the uniformity in each case is good enough though the uniformity is not an issue.

So, from that the conclusion is as follows:

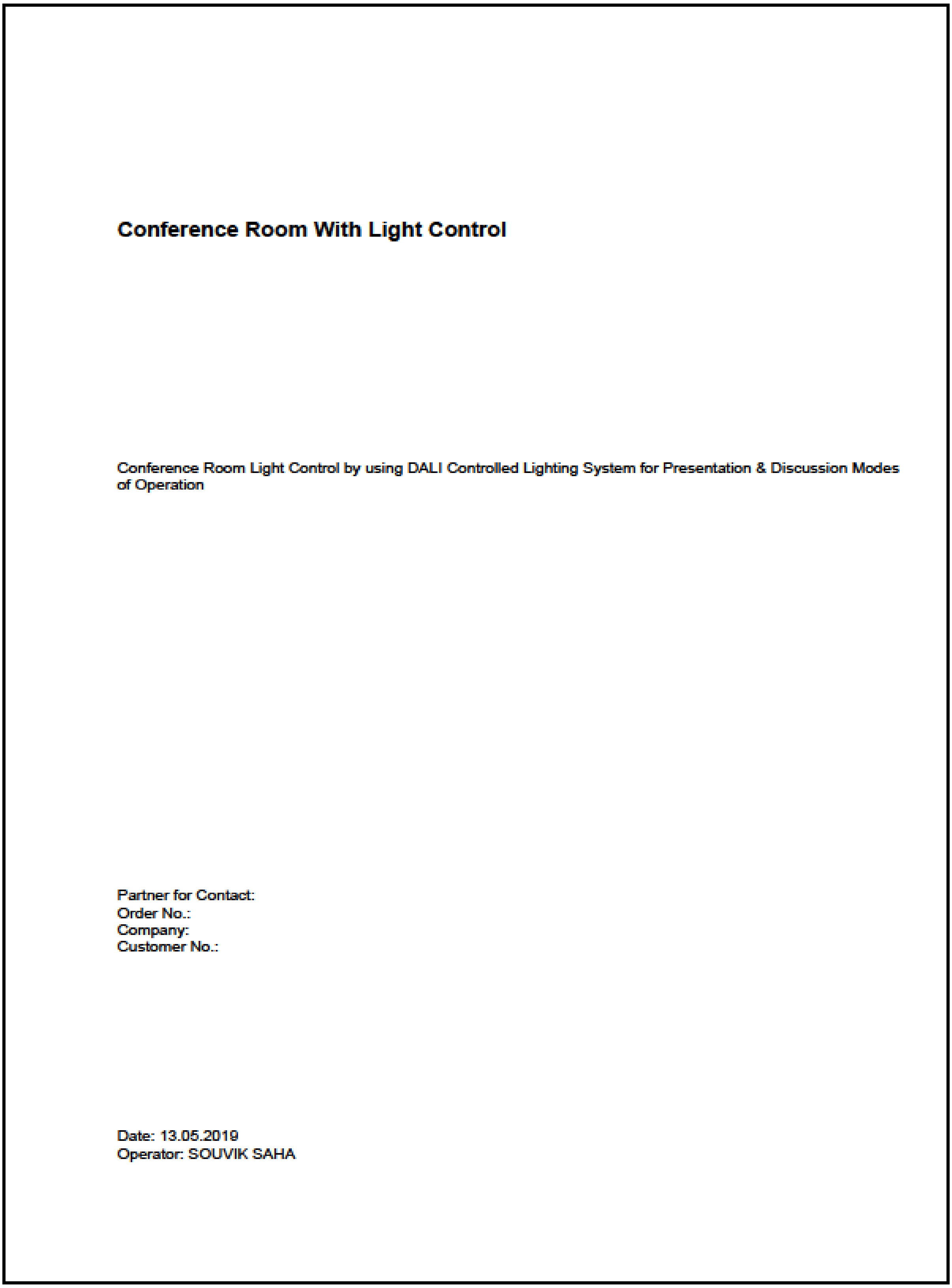
- Use of DALI control system in case of dynamic lighting is energy-efficient in comparison with the conventional lighting system.

- The control technique is much easier & user-friendly. By group control and scene control option, user can easily set different kind of lighting modes as per their requirement.
- DALI control system is easily connected by a gateway with the other building management systems in a Building Management System. So, the compatibility of DALI control system is also good.
- It has some disadvantages also. The equipments used in the whole system should be DALI compatible. The initial cost for the installation of DALI control system is higher than the conventional lighting system but it is very useful for long run.

## FUTURE SCOPE:

Lighting system is basically controlled via manual buttons and switches. Nowadays different kinds of lighting technology give us a huge opportunity to convert the conventional lighting system to a dynamic smart lighting system. Although this type of change in any lighting system is costly, but by doing this any lighting system is more reliable than the previous existing system and easily accessible by the users. This type of lighting control system saves the energy & there by saves the money also. The lighting control system used here (Conference room) is DALI & the future scope of DALI is given as follows:

- DALI is extensively used in the indoor commercial buildings to control the illumination level by dimming the luminaires (sensing the occupancy of the room by using different kinds of sensors) by sending digital address (individual addressing, group addressing or broadcasting) to the control gears of the luminaires. But in case of Daylight integration technique the use of DALI is not so popular till date. So, there is a scope to use DALI to control the lighting system in this kind of system.
- Energy consumption data, Dimming data, Occupancy data of DALI controlled system may be used for the other building management systems to achieve the optimum results in those systems.

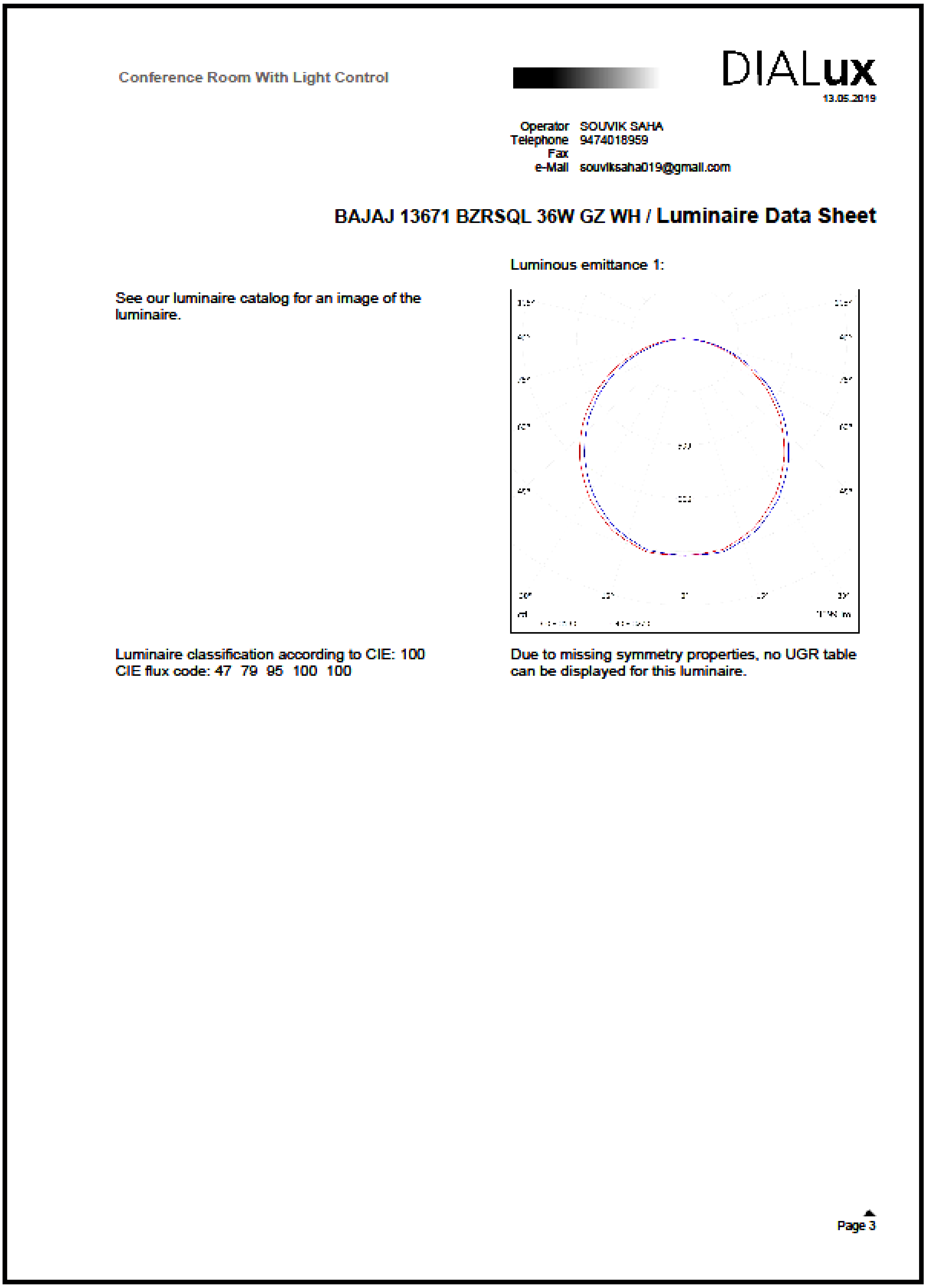


# Conference Room With Light Control

Conference Room Light Control by using DALI Controlled Lighting System for Presentation & Discussion Modes of Operation

Partner for Contact:
Order No.:
Company:
Customer No.:

Date: 13.05.2019
Operator: SOUVIK SAHA



Conference Room With Light Control

DIALux
13.05.2019

Operator SOUVIK SAHA
Telephone 9474018959
Fax
e-Mail souviksaha019@gmail.com

## BAJAJ 13671 BZRSQL 36W GZ WH / Luminaire Data Sheet

Luminous emittance 1:

See our luminaire catalog for an image of the luminaire.

Luminaire classification according to CIE: 100
CIE flux code: 47 79 95 100 100

Due to missing symmetry properties, no UGR table can be displayed for this luminaire.

Page 3

Conference Room With Light Control

**DIALux**

13.05.2019

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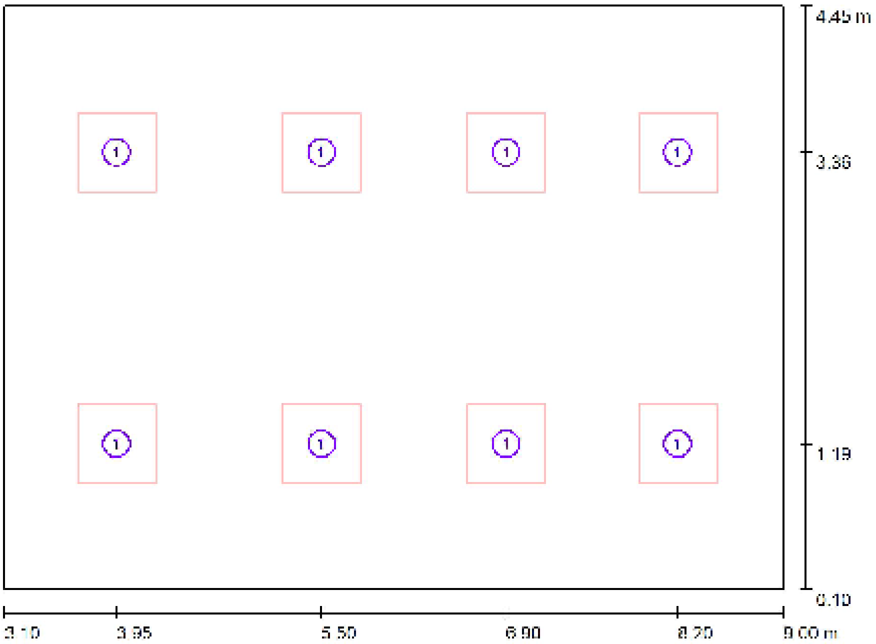
### Conference Room / **Luminaires (layout plan)**



Scale 1 : 43

**Luminaire Parts List**

| No. | Pieces | Designation |
|---|---|---|
| 1 | 8 | BAJAJ 13671 BZRSQL 36W GZ WH |

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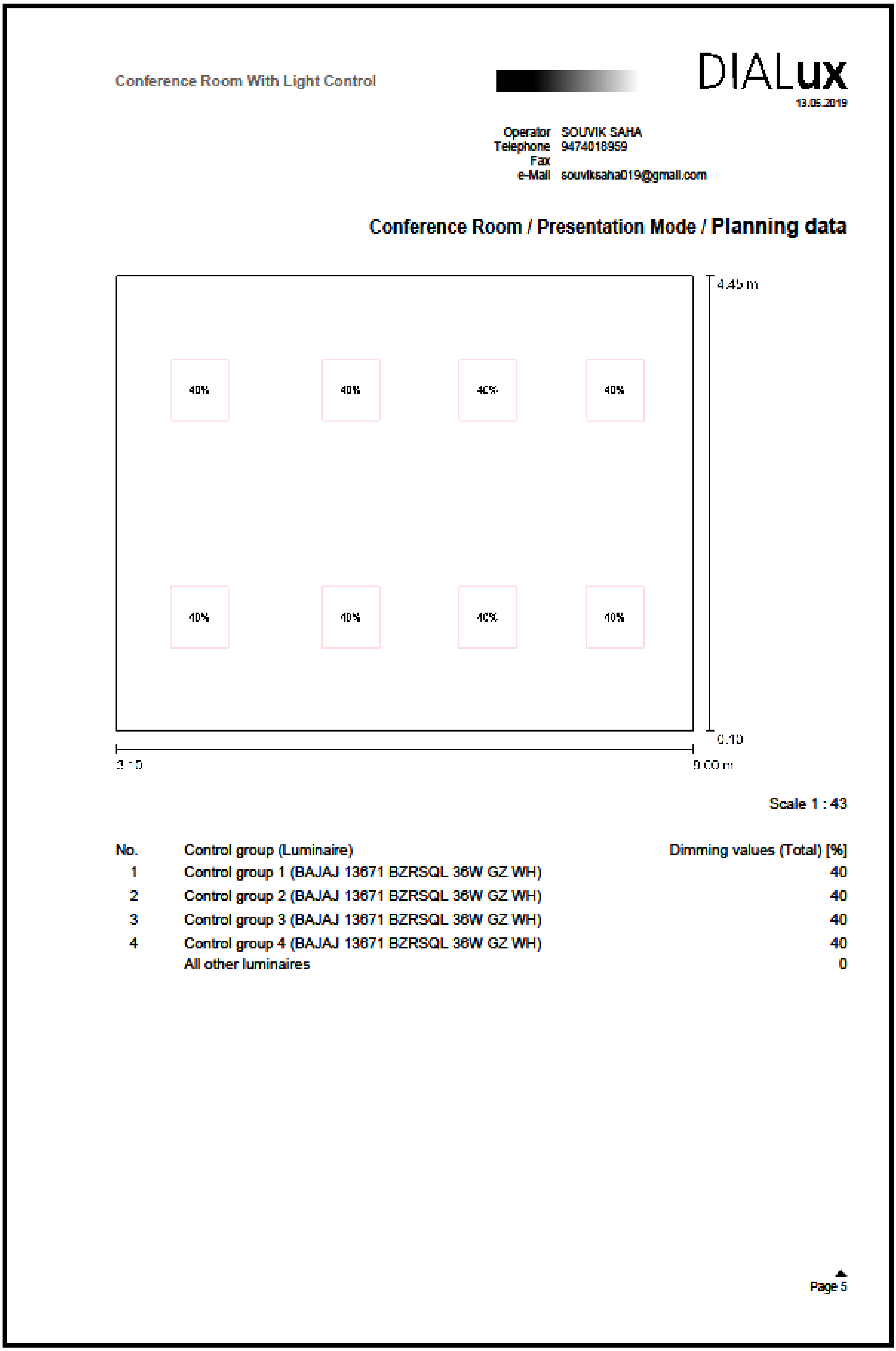

Conference Room With Light Control

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13.05.2019

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## Conference Room / Presentation Mode / **Planning data**

Scale 1 : 43

| No. | Control group (Luminaire) | Dimming values (Total) [%] |
|---|---|---|
| 1 | Control group 1 (BAJAJ 13671 BZRSQL 36W GZ WH) | 40 |
| 2 | Control group 2 (BAJAJ 13671 BZRSQL 36W GZ WH) | 40 |
| 3 | Control group 3 (BAJAJ 13671 BZRSQL 36W GZ WH) | 40 |
| 4 | Control group 4 (BAJAJ 13671 BZRSQL 36W GZ WH) | 40 |
|  | All other luminaires | 0 |

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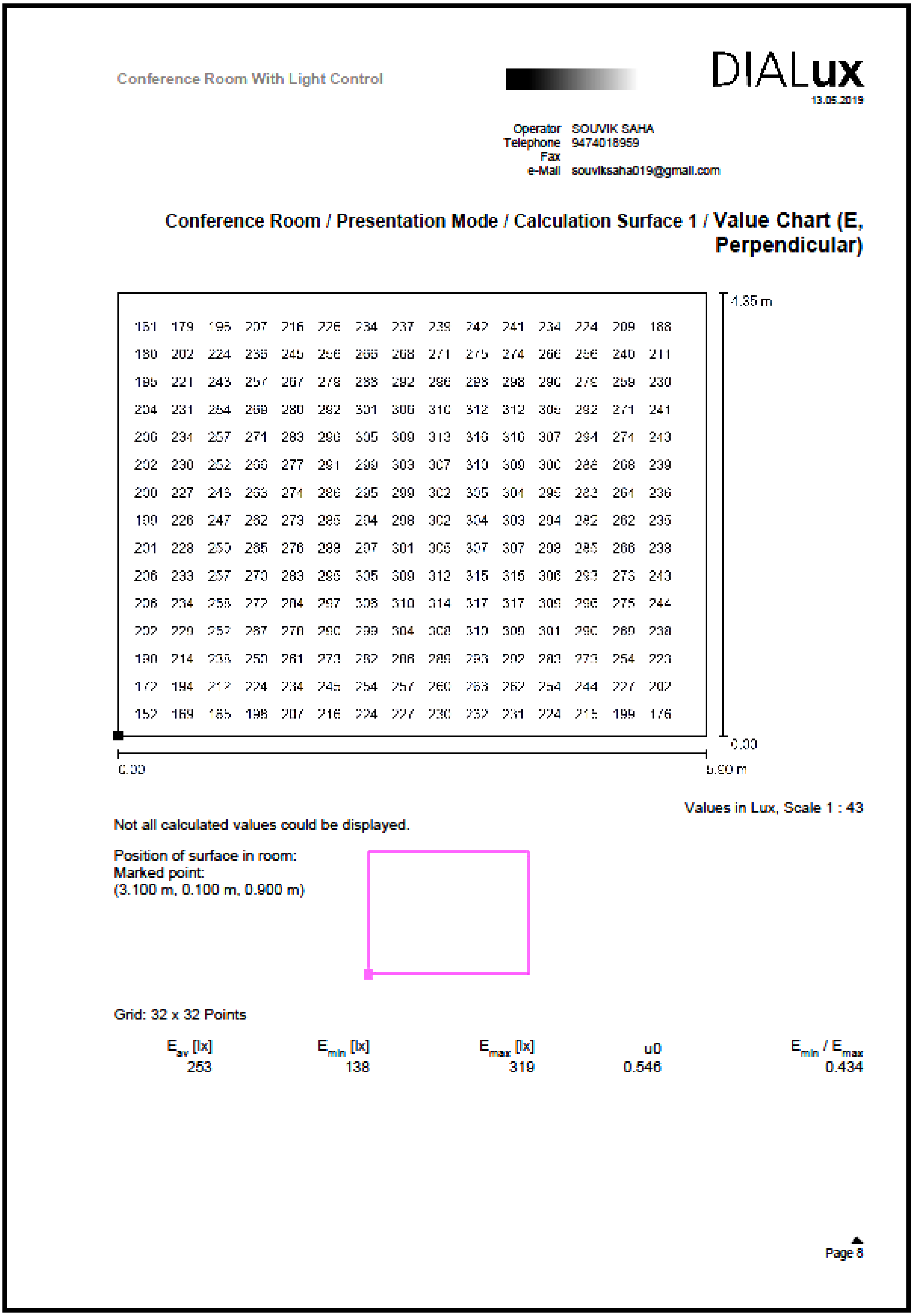

Conference Room With Light Control

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## Conference Room / Presentation Mode / Calculation Surface 1 / Value Chart (E, Perpendicular)

4.35 m

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 151 | 179 | 195 | 207 | 216 | 226 | 234 | 237 | 239 | 242 | 241 | 234 | 224 | 209 | 188 |
| 180 | 202 | 224 | 236 | 245 | 256 | 266 | 268 | 271 | 275 | 274 | 266 | 256 | 240 | 211 |
| 195 | 221 | 243 | 257 | 267 | 278 | 288 | 292 | 286 | 298 | 298 | 290 | 279 | 259 | 230 |
| 204 | 231 | 254 | 269 | 280 | 292 | 301 | 306 | 310 | 312 | 312 | 305 | 292 | 271 | 241 |
| 206 | 234 | 257 | 271 | 283 | 290 | 305 | 309 | 313 | 316 | 316 | 307 | 294 | 274 | 243 |
| 202 | 230 | 252 | 266 | 277 | 291 | 299 | 303 | 307 | 310 | 309 | 300 | 288 | 268 | 239 |
| 200 | 227 | 248 | 263 | 271 | 286 | 295 | 299 | 302 | 305 | 301 | 295 | 283 | 261 | 236 |
| 199 | 226 | 247 | 262 | 273 | 285 | 294 | 298 | 302 | 304 | 303 | 294 | 282 | 262 | 235 |
| 201 | 228 | 250 | 265 | 276 | 288 | 297 | 301 | 306 | 307 | 307 | 298 | 285 | 266 | 238 |
| 206 | 233 | 257 | 270 | 283 | 295 | 305 | 309 | 312 | 315 | 315 | 306 | 293 | 273 | 243 |
| 206 | 234 | 258 | 272 | 284 | 297 | 308 | 310 | 314 | 317 | 317 | 309 | 296 | 275 | 244 |
| 202 | 229 | 252 | 267 | 278 | 290 | 299 | 304 | 308 | 310 | 309 | 301 | 290 | 269 | 238 |
| 190 | 214 | 235 | 250 | 261 | 273 | 282 | 286 | 289 | 293 | 292 | 283 | 273 | 254 | 223 |
| 172 | 194 | 212 | 224 | 234 | 245 | 254 | 257 | 260 | 263 | 262 | 254 | 244 | 227 | 202 |
| 152 | 169 | 185 | 198 | 207 | 216 | 224 | 227 | 230 | 232 | 231 | 224 | 215 | 199 | 176 |

0.00

0.00

5.90 m

Values in Lux, Scale 1 : 43

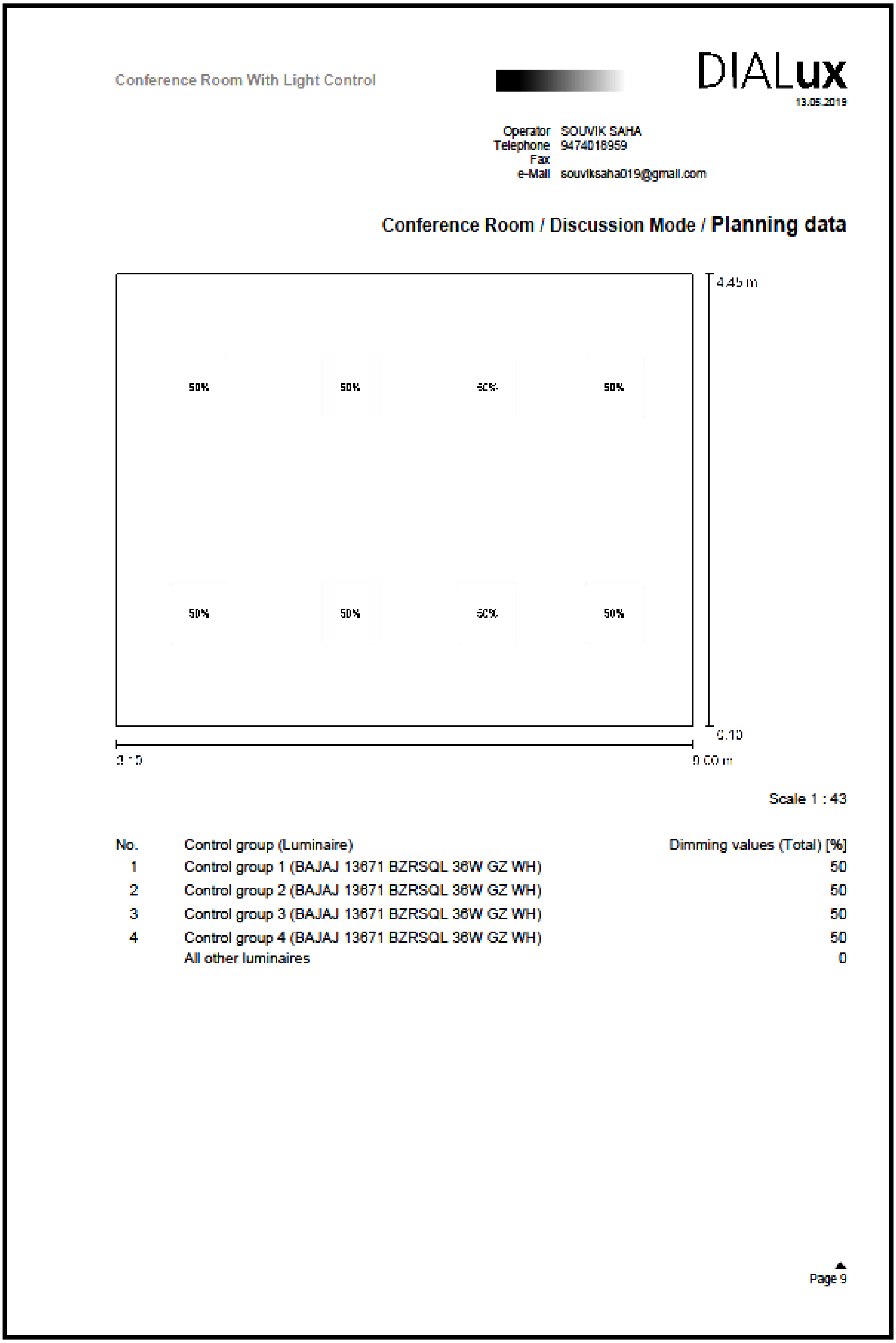
Not all calculated values could be displayed.

Position of surface in room:
Marked point:
(3.100 m, 0.100 m, 0.900 m)

Grid: 32 x 32 Points

| $E_{av}$ [lx] | $E_{min}$ [lx] | $E_{max}$ [lx] | u0 | $E_{min}$ / $E_{max}$ |
|---|---|---|---|---|
| 253 | 138 | 319 | 0.546 | 0.434 |

Page 8



Conference Room With Light Control

DIALux
13.05.2019

Operator SOUVIK SAHA
Telephone 9474018959
Fax
e-Mail souviksaha019@gmail.com

## Conference Room / Discussion Mode / **Planning data**

Scale 1 : 43

| No. | Control group (Luminaire) | Dimming values (Total) [%] |
|---|---|---|
| 1 | Control group 1 (BAJAJ 13671 BZRSQL 36W GZ WH) | 50 |
| 2 | Control group 2 (BAJAJ 13671 BZRSQL 36W GZ WH) | 50 |
| 3 | Control group 3 (BAJAJ 13671 BZRSQL 36W GZ WH) | 50 |
| 4 | Control group 4 (BAJAJ 13671 BZRSQL 36W GZ WH) | 50 |
|  | All other luminaires | 0 |

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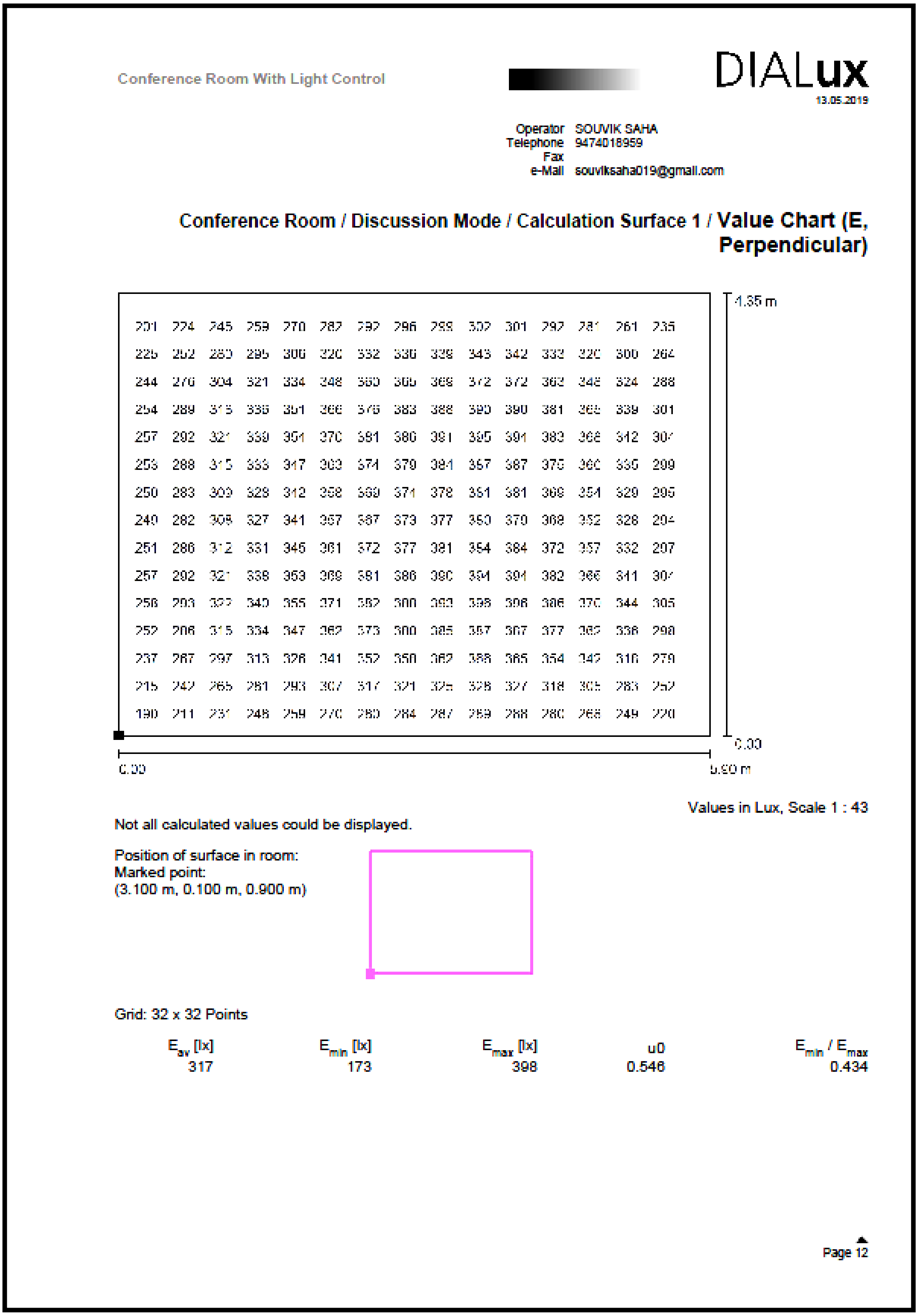

Conference Room With Light Control

DIALux
13.05.2019

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## Conference Room / Discussion Mode / Calculation Surface 1 / Value Chart (E, Perpendicular)

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 201 | 224 | 245 | 259 | 270 | 282 | 292 | 296 | 299 | 302 | 301 | 297 | 281 | 261 | 235 |
| 225 | 252 | 280 | 295 | 306 | 320 | 332 | 336 | 338 | 343 | 342 | 333 | 320 | 300 | 264 |
| 244 | 276 | 304 | 321 | 334 | 348 | 360 | 365 | 368 | 372 | 372 | 362 | 348 | 324 | 288 |
| 254 | 289 | 315 | 336 | 351 | 366 | 376 | 383 | 388 | 390 | 390 | 381 | 366 | 339 | 301 |
| 257 | 292 | 321 | 339 | 354 | 370 | 381 | 380 | 391 | 395 | 394 | 383 | 368 | 342 | 304 |
| 253 | 288 | 315 | 333 | 347 | 363 | 374 | 379 | 384 | 357 | 387 | 375 | 360 | 335 | 299 |
| 250 | 283 | 309 | 328 | 312 | 358 | 369 | 371 | 378 | 351 | 381 | 369 | 354 | 329 | 295 |
| 240 | 282 | 308 | 327 | 341 | 357 | 367 | 373 | 377 | 350 | 370 | 368 | 352 | 328 | 204 |
| 251 | 286 | 312 | 331 | 345 | 361 | 372 | 377 | 381 | 354 | 384 | 372 | 357 | 332 | 207 |
| 257 | 292 | 321 | 338 | 353 | 369 | 381 | 386 | 390 | 394 | 394 | 382 | 366 | 341 | 304 |
| 256 | 293 | 322 | 340 | 355 | 371 | 382 | 300 | 393 | 398 | 306 | 386 | 370 | 344 | 305 |
| 252 | 206 | 315 | 334 | 347 | 362 | 373 | 300 | 385 | 357 | 307 | 377 | 362 | 336 | 298 |
| 237 | 267 | 297 | 313 | 326 | 341 | 352 | 350 | 362 | 388 | 365 | 354 | 342 | 316 | 279 |
| 215 | 242 | 265 | 281 | 293 | 307 | 317 | 321 | 325 | 328 | 327 | 318 | 305 | 283 | 252 |
| 190 | 211 | 231 | 248 | 259 | 270 | 280 | 284 | 287 | 259 | 288 | 280 | 268 | 249 | 220 |

Values in Lux, Scale 1 : 43

Not all calculated values could be displayed.

Position of surface in room:
Marked point:
(3.100 m, 0.100 m, 0.900 m)

Grid: 32 x 32 Points

| $E_{av}$ [lx] | $E_{min}$ [lx] | $E_{max}$ [lx] | u0 | $E_{min}$ / $E_{max}$ |
|---|---|---|---|---|
| 317 | 173 | 398 | 0.546 | 0.434 |

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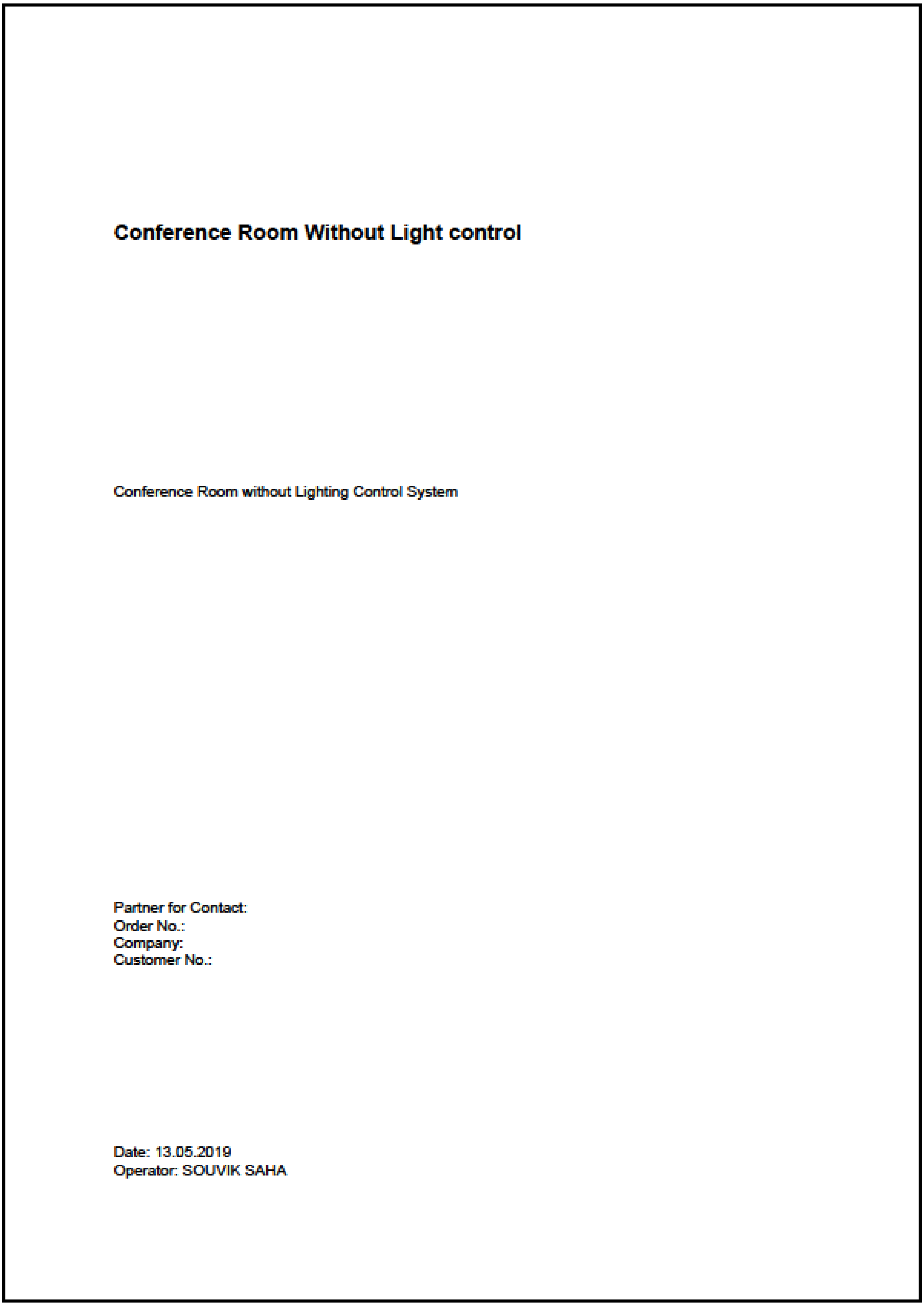
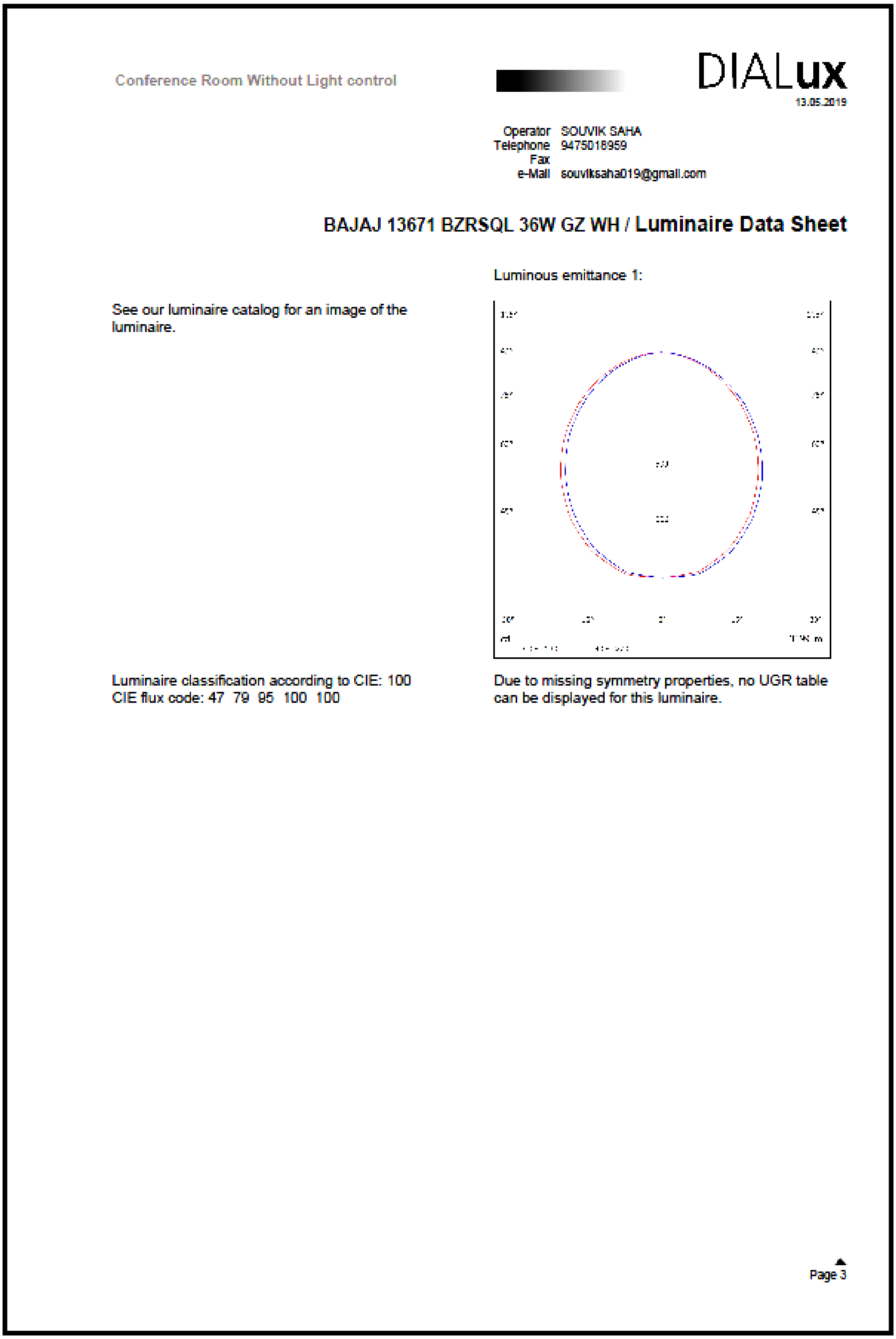


# Conference Room Without Light control

Conference Room without Lighting Control System

Partner for Contact:
Order No.:
Company:
Customer No.:

Date: 13.05.2019
Operator: SOUVIK SAHA



Conference Room Without Light control

DIALux

13.05.2019

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## BAJAJ 13671 BZRSQL 36W GZ WH / **Luminaire Data Sheet**

See our luminaire catalog for an image of the luminaire.

Luminous emittance 1:

Luminaire classification according to CIE: 100
CIE flux code: 47 79 95 100 100

Due to missing symmetry properties, no UGR table can be displayed for this luminaire.

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Conference Room Without Light control

DIALux

13.05.2019

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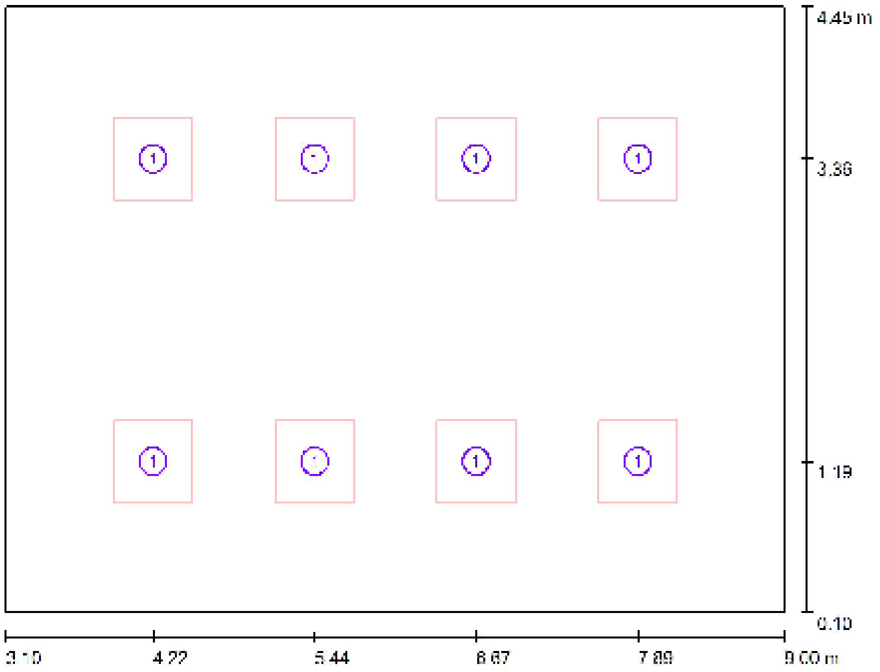
## Conference Room / Luminaires (layout plan)



Scale 1 : 43

**Luminaire Parts List**

| No. | Pieces | Designation |
|---|---|---|
| 1 | 8 | BAJAJ 13671 BZRSQL 36W GZ WH |

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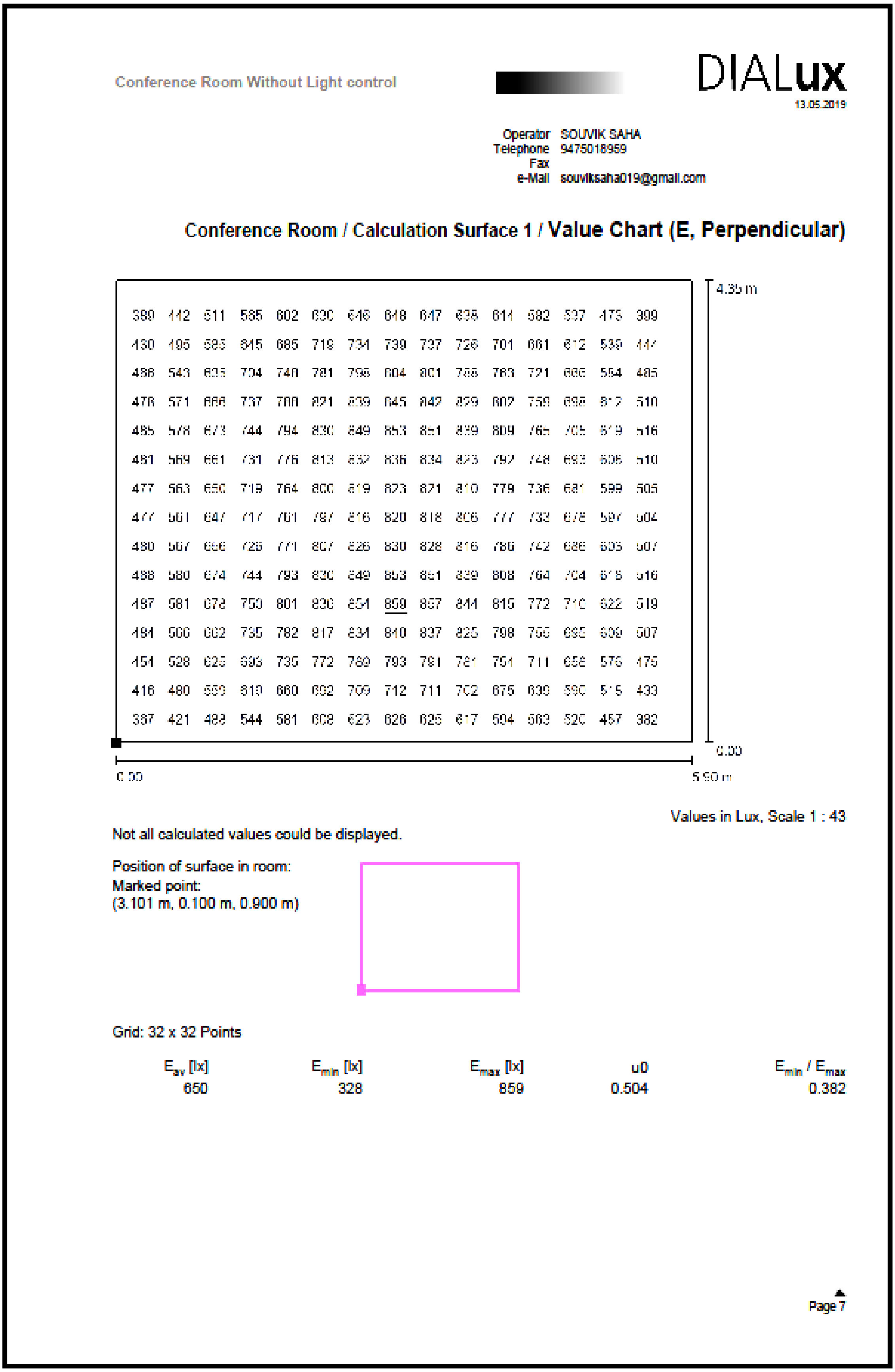

Conference Room Without Light control

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## Conference Room / Calculation Surface 1 / Value Chart (E, Perpendicular)

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 389 | 442 | 511 | 585 | 602 | 630 | 646 | 648 | 647 | 638 | 614 | 582 | 537 | 473 | 399 |
| 430 | 495 | 583 | 645 | 685 | 719 | 734 | 739 | 737 | 726 | 701 | 661 | 612 | 539 | 447 |
| 486 | 543 | 625 | 704 | 740 | 781 | 796 | 804 | 801 | 788 | 763 | 721 | 666 | 594 | 485 |
| 478 | 571 | 666 | 737 | 788 | 821 | 839 | 845 | 842 | 829 | 802 | 759 | 698 | 612 | 510 |
| 485 | 578 | 673 | 744 | 794 | 830 | 849 | 853 | 851 | 839 | 809 | 765 | 705 | 619 | 516 |
| 481 | 569 | 661 | 731 | 776 | 813 | 832 | 836 | 834 | 823 | 792 | 748 | 693 | 606 | 510 |
| 477 | 563 | 650 | 719 | 764 | 800 | 819 | 823 | 821 | 810 | 779 | 736 | 681 | 599 | 505 |
| 477 | 561 | 647 | 717 | 761 | 797 | 816 | 820 | 818 | 806 | 777 | 733 | 678 | 597 | 504 |
| 480 | 567 | 656 | 725 | 771 | 807 | 826 | 830 | 828 | 816 | 786 | 742 | 686 | 603 | 507 |
| 488 | 580 | 674 | 744 | 793 | 830 | 849 | 853 | 851 | 839 | 808 | 764 | 704 | 618 | 516 |
| 497 | 591 | 678 | 750 | 801 | 836 | 854 | 859 | 857 | 844 | 815 | 772 | 710 | 622 | 519 |
| 494 | 590 | 682 | 735 | 782 | 817 | 834 | 840 | 837 | 825 | 798 | 755 | 695 | 609 | 507 |
| 451 | 528 | 625 | 693 | 735 | 772 | 789 | 793 | 791 | 781 | 754 | 711 | 658 | 576 | 475 |
| 416 | 480 | 559 | 610 | 660 | 692 | 709 | 712 | 711 | 702 | 675 | 639 | 590 | 515 | 433 |
| 387 | 421 | 482 | 544 | 581 | 608 | 623 | 626 | 625 | 617 | 594 | 563 | 520 | 457 | 382 |

4.35 m
0.00
0.00
5.90 m

Values in Lux, Scale 1 : 43

Not all calculated values could be displayed.

Position of surface in room:
Marked point:
(3.101 m, 0.100 m, 0.900 m)

Grid: 32 x 32 Points

| $E_{av}$ [lx] | $E_{min}$ [lx] | $E_{max}$ [lx] | u0 | $E_{min}$ / $E_{max}$ |
|---|---|---|---|---|
| 650 | 328 | 859 | 0.504 | 0.382 |

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