Monitoring Lighting system using SCADA

by

‘Izzati Farhana binti Ab Aziz

Dissertation submitted in partial fulfillment of
the requirements for the
Bachelor of Engineering (Hons)
(Electrical and Electronics Engineering)

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CERTIFICATION OF APPROVAL

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Approved by,

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(Dr.Taib bin Ibrahim)
Project Supervisor

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

June 2010

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

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‘IZZATI FARHANA BINTI AB AZIZ

ACKNOWLEDGEMENT

First of all, I would like to extend my gratitude to all those who had guided and supported me throughout the preparation and completion of this project. Learning to be more independent in term of searching for extra information does help me to be prepared on the real-working environment. The study period allows me to experience the actual SCADA system thus contributes a lot to my direction of research.

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Finally, an appreciation and great thanks to my parents, Ab Aziz bin Ab Rahman and Amrah binti Paimin for all their supports upon completion of this study.

ABSTRACT

Efficient power system monitoring and analysis enables economical use of power by using field measurements and computer modelling to analyze the power systems. This project was initiated due to issue on difficulties of monitoring the street lighting by maintenance personnel. Limited access to the online monitoring, cost and time consuming was the reason why most of the street lighting is left-out without knowing the actual condition. In this project, the monitoring system will be designed to retrieve the status information and transmit to the SCADA system. Intellution FIX software is used to design the window of the lighting system. In order to integrate the system, PROFIBUS Module is used. The system should be able to control the switching mode and receiving the feedback signal from the external devices.

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LIST OF ABBREVIATION

Analog	- Data representation of physical quantities that can be varies
Database	- A continuously updated file of related information, abstracts, or references on a particular subject, arranged for ease and speed of search/retrieval on a computer. Most library databases are periodical indexes. - A large collection of data organized for rapid search and retrieval - A program that manages data, and can be used to store, retrieve, and sort information
Dialog box	- A box on the computer screen that can be used to enter information, set options, or give commands to the computer. The dialog box gives the user choices (such as open file, delete, save) which can be selected by clicking with the mouse
Digital	- Data representation in binary format; discrete
Host computer	- A machine designed to receive and send data to other devices; installed with appropriate software for controlling and monitoring of the system
Interface	- A program that controls a display for the user (usually on a computer monitor) and that allows the user to interact with the system

I/O Driver	- Input/ Output Driver - FIX Software interface to acquire raw data from the process. Sensors and controls send data to registers in the process hardware
Link	- A real-time connection to a data point in the database using the FIX graphics package
MMI	- Machine-Machine Interface; ability to know what is happening in a process by interacting with instrumentation or computers
SCADA	- Supervisory Control and Data Acquisition, *further explained in CHAPTER 2*
Standalone	- Refers to a computer which is not connected to a network. - Operating, functioning, or existing without additions or assistance; independent; able to be separate or separated

CHAPTER 1
INTRODUCTION

1.1 Background of Study

This study emphasizes on application of the SCADA system, which is to be implemented on a modelled lighting system. SCADA is a system designed to control and monitors an application from a centralized centre. The design concept of the SCADA monitoring system will involve the usage of software for the user to sketch, design and link the system with the hardware. The detail process of the system will be further study for easier switching, monitoring and controlling of lighting by user.

1.2 Problem Statement

Monitoring of lighting unit especially the street lighting is very expensive. The monitoring process requires many hours of labour and proper vehicle to inspect the system. It is more expensive especially in a large scale area.

Therefore, the aim of this project is to reduce the cost consumption of the monitoring system. An automatic system will be introduced to monitor the lighting units, retrieve status information and transmitting the signal to the SCADA system. This new monitoring system may offer advantages especially reduction in cost and time. In this case, maintenance personnel would only need to attend those units that require maintenance rather than visiting all lighting units. Furthermore, this project is a part of smart grid system.

1.3 Objective of Study

The objective of the research:

- To study the features of SCADA System
- To design and model electrical lighting system
- To interface the design model with SCADA

1.4 Scope of Study

The project developments are divided into two phases, which are:

FYP1

- Familiarization of software Intellution FIX
- Literature review of lighting system
- Designing and modelling including simulation and real time application

FYP2

- Interface the lighting system using SCADA, involve assignation of Master and Slave module
- Prototype design and load system integration

CHAPTER 2
LITERATURE REVIEW

2.1 Background of SCADA

SCADA is the acronym for Supervisory, Control and Data Acquisition. SCADA is an online-based system where a person can monitor and controlling any specified process from a centralized centre. SCADA systems are basically a Process Control Systems (PCS), specifically designed to automate systems such as traffic control, power grid management, waste processing etc. [1]

SCADA systems are a standalone, semi-isolated entities that are designed using proprietary hardware and software platforms to perform specific functions. The processing capacity of these systems were limited to only those designed functions with little to no additional processing power remaining to run other programs or perform additional tasks. Proprietary communication protocols are developed to allow data and command and control information to be sent to local and remote computers in deterministic time. [2]

2.1.1 Benefits of using SCADA

The advantages are:

- Reduces operational costs
- Provides immediate knowledge of system performance
- Improves system efficiency and performance
- Increases equipment life

- Reduces costly repairs
- Reduces number of man-hours (labour costs) required for troubleshooting or service
- Frees up personnel for other important tasks

By connecting a system to a computer, it should be able to provide the power system monitoring with fast decision making and more efficient operation. An intelligent power monitoring networks can collect and analyze information from electrical distribution systems. [9]

2.1.2 SCADA in technical aspect

The key technical challenges revolve around the limitations of what can be installed and configured on the SCADA systems and the technical limitations of other components within the SCADA environment. Also, what testing can be performed within this electronic security perimeter in order to ascertain the presence of vulnerabilities. This information is needed to better understand the true risk of this environment. [2]

2.1.3 SCADA and its application in modern industry and infrastructure

SCADA is widely used in most well-known and successful industry. Most manufacturers around the world rely on SCADA system for their comprehensive monitoring, control and distribution of their plant-wide data.

Together with the advancement of the new technology, SCADA system was introduced to many industries that employ control systems in their system operation. Good system monitoring would help to increase the industry production and profitability.

Here are few examples of industries that have been using SCADA within their monitoring and controlling system:

Table 1 Application of SCADA in modern industry [1]

Type of industry	Application
Power-based Industry	to control the power distribution network, etc
Chemical Industrial	use control systems to monitor tank levels and to ensure that ingredients are mixed in the proper proportions, etc
Oil & Gas Industry	used in the drilling and refining of oil and natural gas, etc
Manufacturing Industry	used for process control
Water Industry	used in water security system

For Oil and Gas Industries, application of SCADA is not limited to drilling and refining of oil and natural gas only. SCADA does provide industry with various aspect of monitoring that did contribute to their efficient product management. Here are list of activities that SCADA offer to the Oil and Gas Industry:

- To monitor and control the field devices using remote terminal units (RTU) at geographically dispersed sites.
- Delivering business system integration with midstream SCADA operations
- Providing energy companies with migration planning and management solutions to enable business process changes
- Developing the Intelligent Oilfield concept
- Enhancing integrity management programs to achieve cost effectiveness
- Making security issues a top priority

SCADA does not only offer an easier monitoring system but also security for the system. Most of the industries choose SCADA to be as their monitoring system due to their concern on their production security system. The introduced system would be tolerant of efforts to defeat it. It would continue operating if the powers were cut off or a communication line severed. It would be accessible to operations people even if the control room were disabled or evacuated. Apart from that, it would provide their system with security from hacking.

2.2 Intellution FIX Software

Intellution FIX software was chosen to be the ideal software choice since it provide small installation package for large and networked configurations. It allows mixing of computers of different source or platform into a single processing control strategy. Intellution FIX requires Windows NT as processing platform for complete access of the software application. [6]

2.2.1 Intellution FIX basic function

The core software performs the basic function that allows specific applications as to perform their assigned task. The two basic functions are:

i. *Data Acquisition*

Data Acquisition is define as the ability for the software to retrieve data from the plant floor (user), process data in a usable form and establish a direct two-way communication between the user and the I/O Driver. Intellution FIX has an extensive catalogue of I/O drivers that support the specialty of the I/O devices. The I/O drivers can access any I/O devices that connected within the network even though the devices are from different manufacturers. [6]

ii. <u>Data Management</u>

Once when the data were already acquired, the data will then be manipulated and channelled according to the request of software applications. Since Intellution FIX software runs on industry-standard computer hardware, user can take advantage of the existing computer hardware by investing in the appropriate FIX platform. Different user may use different computer hardware. Intellution FIX provide cross-platform data request where few users can connected to the same network by communicating with nodes running on the platform. [6]

2.2.2 User Interface (HMI)

A SCADA system includes a user interface, usually called Human Machine Interface (HMI). The HMI of a SCADA system is where data is processed and presented to be viewed and monitored by a human operator. This interface usually includes controls where the individual can interface with the SCADA system.

Originally, HMI's are an easy way to standardize the facilitation of monitoring multiple RTU's or PLC's (programmable logic controllers). HMI's can also be linked to a database, which can use data gathered from PLC's or RTU's to provide graphs on trends, logistic info, schematics for a specific sensor or machine or even make troubleshooting guides accessible. [4]

2.2.3 Basic System Architecture

i. <u>Node</u>

A node is any computer that runs FIX Software. For simulation purposes, ‘Stand Alone’ Node was used because this node does not require a network for single-user simulation.

ii. *Master and Slave*

Master was attached to the SCADA computer meanwhile Slave referring to the input and output devices such as Analog Input, Analog Output, Digital Input, Digital Output.

2.2.4 Input/ Output Drivers (Hardware)

Intellution FIX provides wide variety of high-performance I/O drivers. Intellution FIX also allows different devices from different manufacturers to access the software. The I/O driver that will be used for this project is the Digital Output module.

Table 2 Input/ Output Field bus module

I/O Drivers	Description
SM 231 Analog Input (AI)	User able to send few bits of data (Controlling amount of voltage to be send to load)
SM 223 Digital Input (DI)	User able to send data in binary 0 or 1 (Switching button ON or OFF)
SM 232 Analog Output (AO)	Data received by user in signal format (Current or voltage readings provide by loads)
SM 222 Digital Output (DO)	Data received by user in binary 0 or 1 (Status signal from loads either ON or OFF)

2.3 Proposed Design

The project main objective is for student to be able to design a system so that signal from the electrical devices could be received by the student. Below is the overview of the system layout for the proposed design:

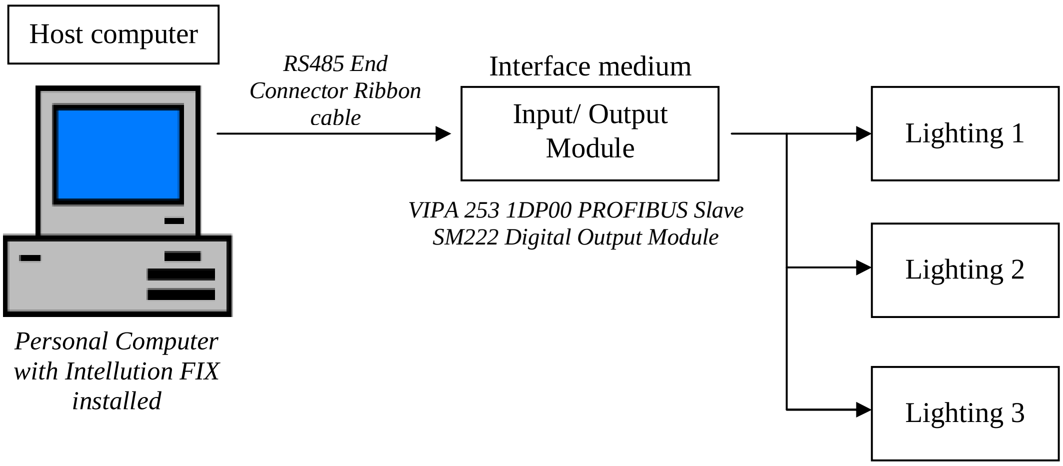


Figure 1 Proposed System Layout of Proposed Design

The system process will start with student controlling the Host Computer by inserting input through the ON/OFF push-button module software and send a signal to the Input/ Output module. The signal will be send to the Input/ Output Module via the RS485 End Connector Ribbon Module, which will be connected between the Host Computer and the VIPA 253 1DP00 PROFIBUS Slave. Beside the VIPA 253 1DP00 PROFIBUS Slave, an Input and Output Module will be attached together as to allow signal from the main slave to be transmit to the Input/ Output Module. The Input/ Output Modules are SM221 Digital Input Module and SM222 Digital Output Module respectively. For the purpose of monitoring the ON/OFF function, the electrical device will be connected to the Output module via a single wire.

CHAPTER 3
METHODOLOGY

3.1 Methodology and Project activities

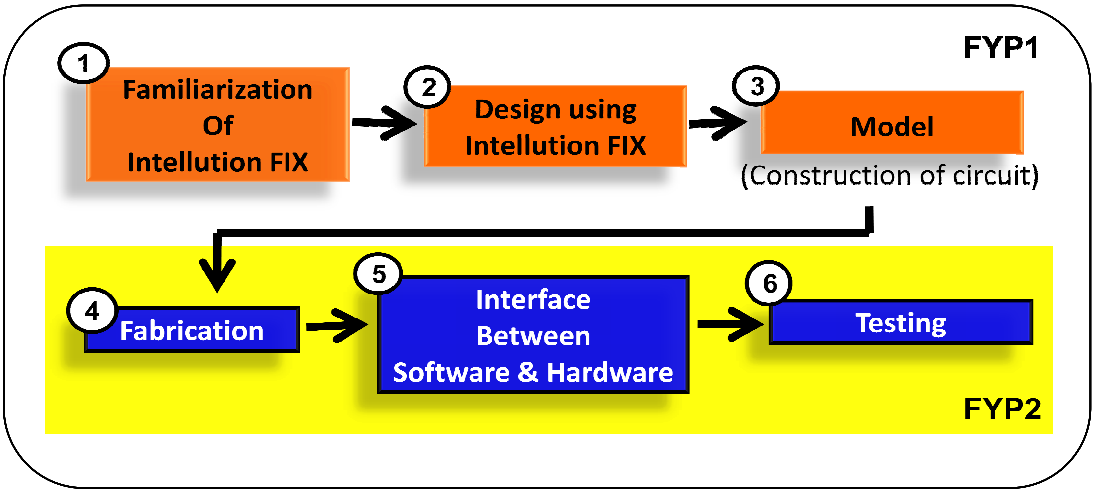


Figure 2 Methodologies Flowchart

Several structured procedures and activities were decided in completing the project. Basically the activities were planned as to get further understanding and exact information of the project. Among of the activities does include:

- Seek for personal whom familiar with Intellution FIX software and SCADA system.
- Close coordination and keep on follow up with lab technicians on lab and hardware availability.
- Choosing of suitable hardware for better design performance.
- Accurate modelling of the lighting system to be used in the design of the project.

3.2 Tools/ Software Required

The project is mostly dealing with design simulation. Decision on choosing the right software will help towards better monitoring and controlling of power system. Intellution FIX software was chosen for designing of the project. For the complement of Intellution FIX software, CIF Driver and PROFIBUS SyCon were also being installed in the Host Computer. CIF Driver is used for real-time application or in simpler meaning, to convert the software design to the hardware application. Meanwhile PROFIBUS SyCon is used for design configuration where student able to assign the Master and Slave module to be used for the design system. Both CIF Driver and PROFIBUS SyCon are complement software for complete application of Intellution FIX. A dongle were used as a key to run the Intellution FIX software. [6] And below are the lists of electrical and electronics components to be used as to set-up the design hardware: [5]

1) 24V Bulb
2) VIPA 253 1DP00 PROFIBUS Slave
3) SM222 Digital Output Module
4) RS485 End-Connector Ribbon cable

CHAPTER 4
RESULTS AND DISCUSSIONS

4.1 Connection of Hardware

Figure 3 shows the terminal of VIPA Profibus Digital Output module which can be connected to other digital output applications; CR1, CR2, CR3 and CR4. These terminals are determined by referring to SM222 1HD10 Digital Output (Appendix 4). By referring to the said appendix, there are a set of four identical switches that can be controlled, which can also be illustrated as shown in Figure 3.

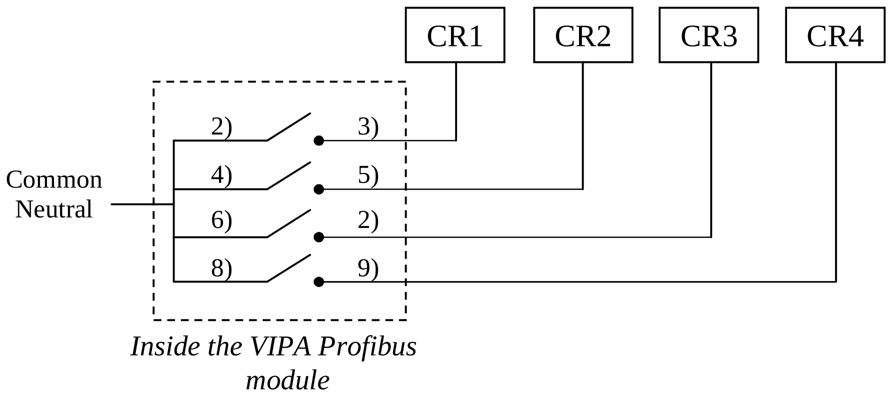


Figure 3 Layout of VIPA Profibus module

CR1, CR2, CR3 and CR4 can be replaced with Bulb 1, Bulb 2, Bulb 3 and Bulb 4 respectively. The 24V supply for the four bulbs will be connected to terminal 2, 4, 6 and 8, as shown in Figure 4 and 5.

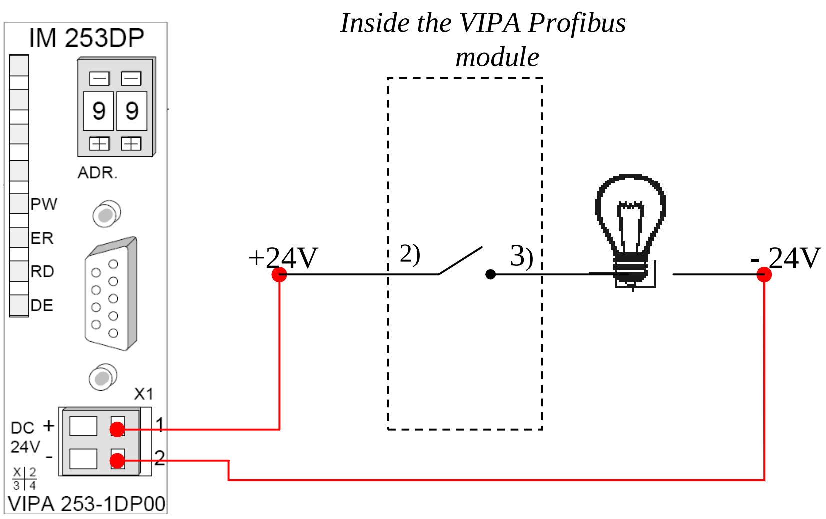


Figure 4 Connection for one set of bulb to the VIPA Profibus Module

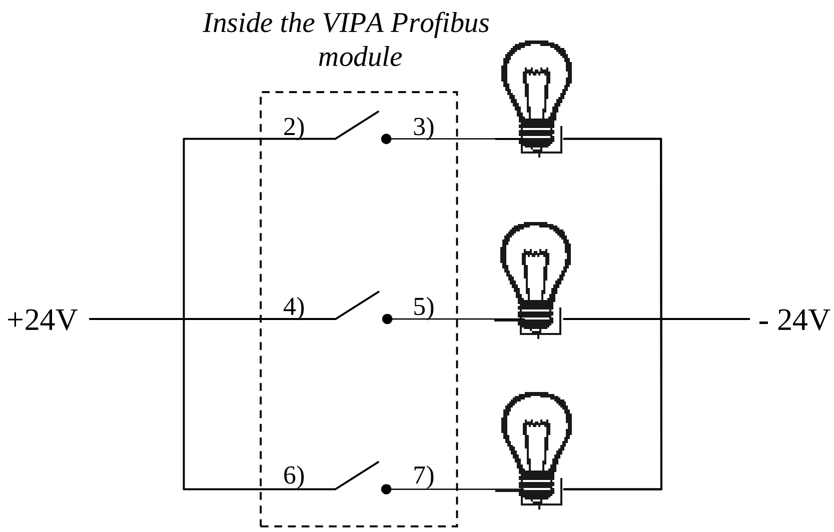
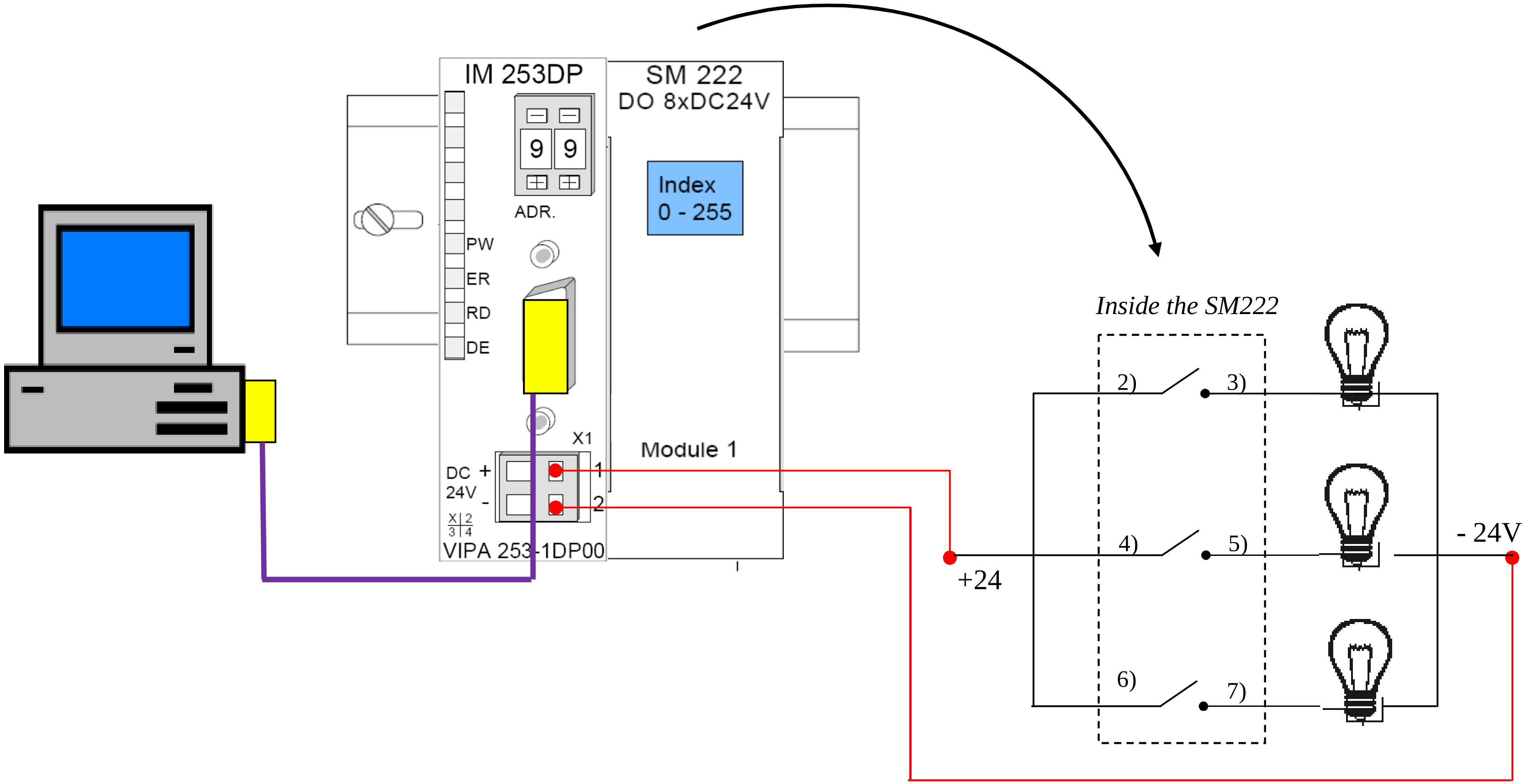


Figure 5 Connection of three sets of bulb

Figure 6 shows the overall design and connection for the lighting monitoring system which include the computer, VIPA Profibus module and the bulb.



4.2 Design Procedure

This section shows the procedure to design and simulate the street lighting system. The section is divided to two parts:

i. Pre-processor on *FIX Draw*
ii. Post-processor on *FIX View*

4.2.1 Pre-processor on FIX Draw

As to be efficiently monitor and control the design system, detailed and accurate setting of the block are required as for easier control and reference by user. The first step towards efficiently monitor the design system is to set the address of the bulb and followed by linking the block to the 'Status block' so that status of the bulb can be monitored and controlled from the computer.

This section will illustrate the process to design lighting system using the Intellution FIX.

Step1: Designing the dynamo

Firstly, a dynamo should be construct as to represent the design system.

Instruction:

Toolbar > *Dynamo* > *Open Dynamo Set* then choose the related dynamo

Then followed by setting up the dynamo properties for the bulb which can be access via the '*Dynamic properties*' as shown in Figure 9 and Figure 10. Dynamic properties are objects attributes that can be changed in FIX View based primarily on changes in database values. It produces a real-time effect like colouring and animation.

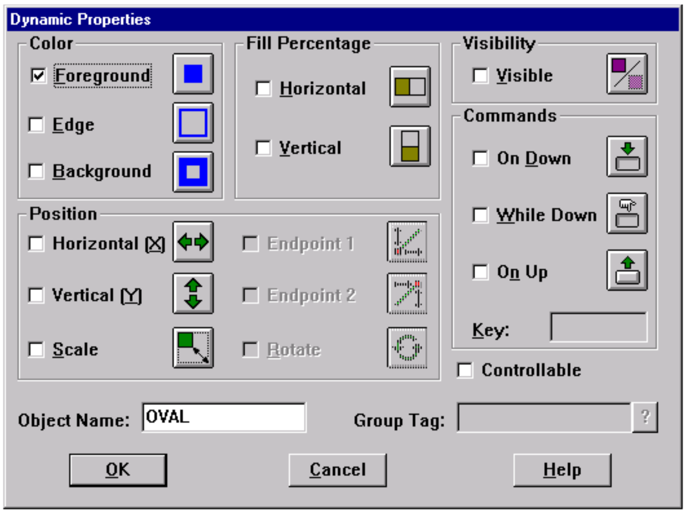


Figure 7 Dynamic Properties for the bulb

Setting colour indication for the bulb

- ➔ At ‘0’ condition (open), set the grey to indicate bulb is on ‘OFF’ condition
- ➔ At ‘1’ condition (close), set yellow to indicate bulb is on ‘ON’ condition

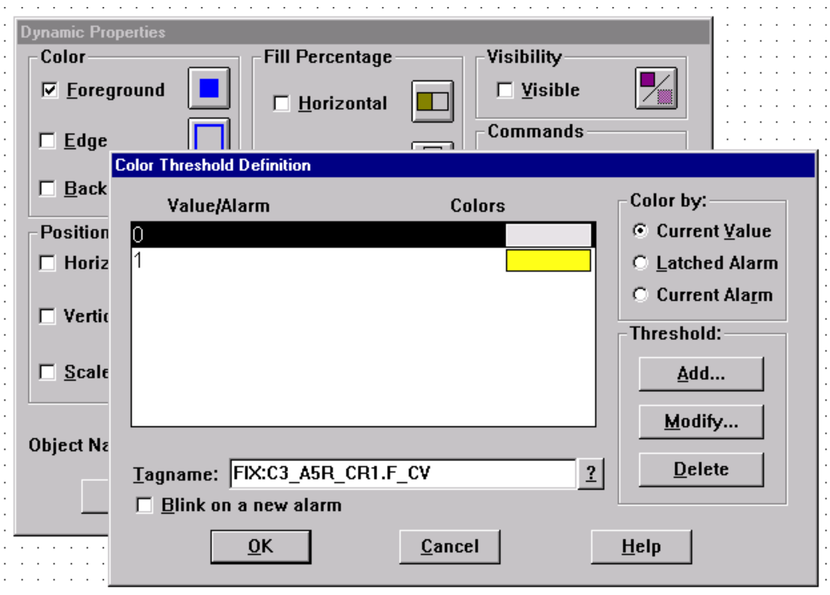


Figure 8 Setting the colour indicator

Step 2: Setting the 'Digital Register Block' for the bulb

Upon completion of the designing process of the dynamo, next step is to assign a Digital Register Block to the designed block by referring to the instruction provided.

Instruction:

Toolbar > Database > Add > Digital Register

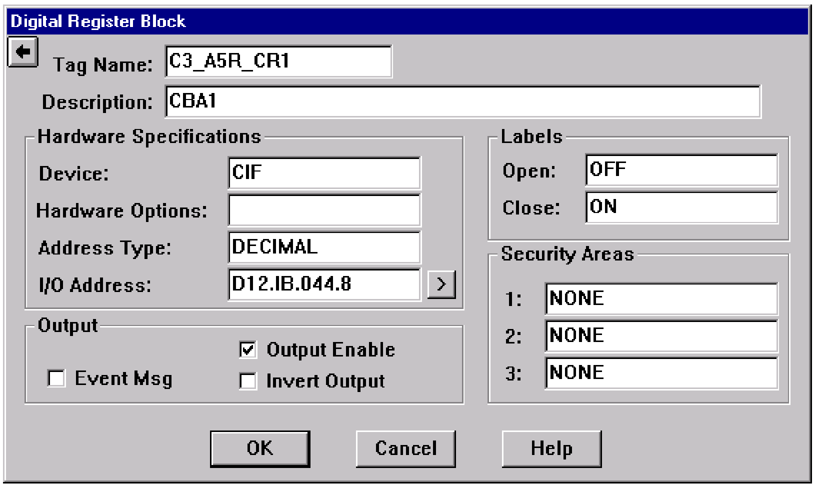


Figure 9 Setup for Digital Register Block

Digital Register is a compact and flexible block that quickly reads and writes digital values to the I/O hardware. It provides both input and output capacity in a single block using a minimum amount of memory. Users can read and write digital value to I/O points using *FIX VIEW* Display links that access the block.

Step 3: Integrating bulb and the status block using ‘Data Link’

Purpose of Data Link is to connect one location to another for the purpose of transmitting and receiving data. As for this project, Data Link is used to link between the ‘bulb’ and the ‘Status block’. Setting for Data Link is shown in Figure 10.

Instruction:

Toolbox > Data Link

[redacted]

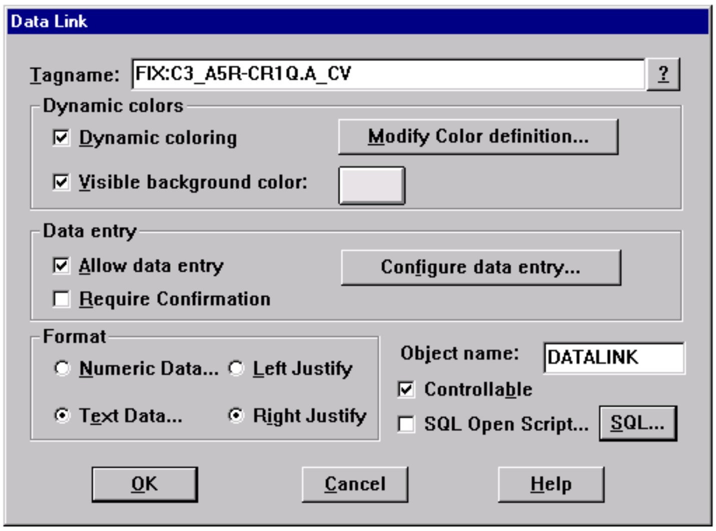


Figure 10 Data Link dialog box

Step 4: Setting for ‘Status’ block

Setting for ‘Status block’ is important as to display the output (or status) of the bulb. The setup are slightly the same with the Dynamic Properties for the dynamo but different in term of properties. The output status of the bulb will either be ‘1’ or ‘0’

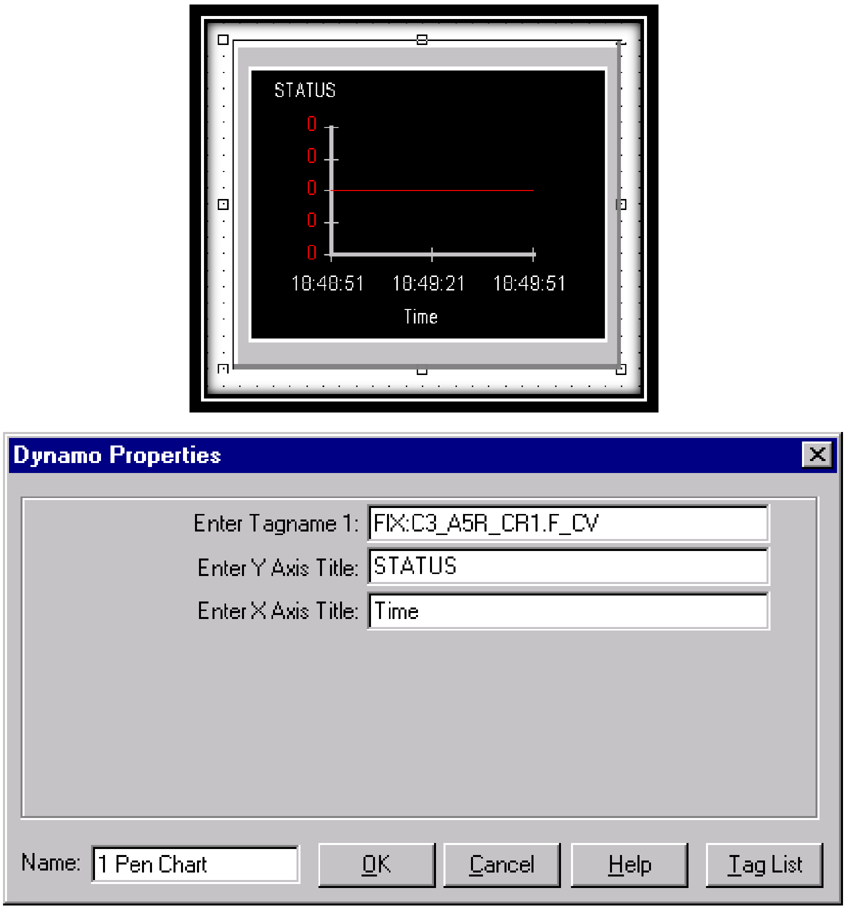


Figure 11 Dynamo Properties for Status Block

4.2.2 Post-processor on FIX View

The bulb switching is controlled by the 'Switch Block'. Once a user click on the 'Switch block', a dialog box will pop-up, that request for the user input; either ON, OFF or Cancel the preferences, as shown below:

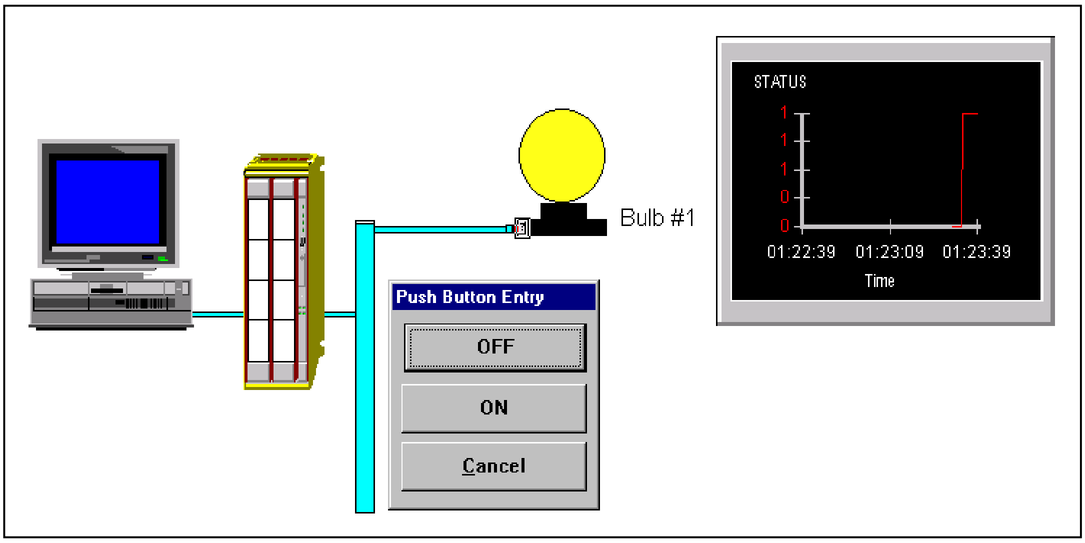


Figure 12 Push button Entry

Therefore, Table 3 shows the detail operation for each button.

Table 3 Push-Button Entry description

Push Button Entry	Description
OFF	Select to turn OFF the bulb
ON	Select to turn ON the bulb
Cancel	Decide to exit the selection process

Figure 13 shows presentation of the bulb status. Operation of the bulb is as simple as the ‘Rule of Thumb’. The bulb is illuminates when turned ON and *vice versa*. When turning ON, the bulb changes its status from ‘0’ to ‘1’.

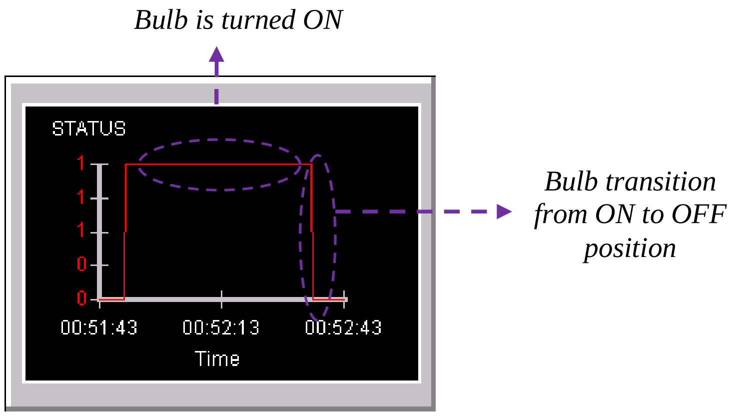


Figure 13 Status Block; shows the status of the bulb; 1 = ON, 0 = OFF

Figure 14 shows the system that has been successfully design. As what being proposed earlier, there will be three sets of bulb that represent three different conditions; ON, OFF, Trip.

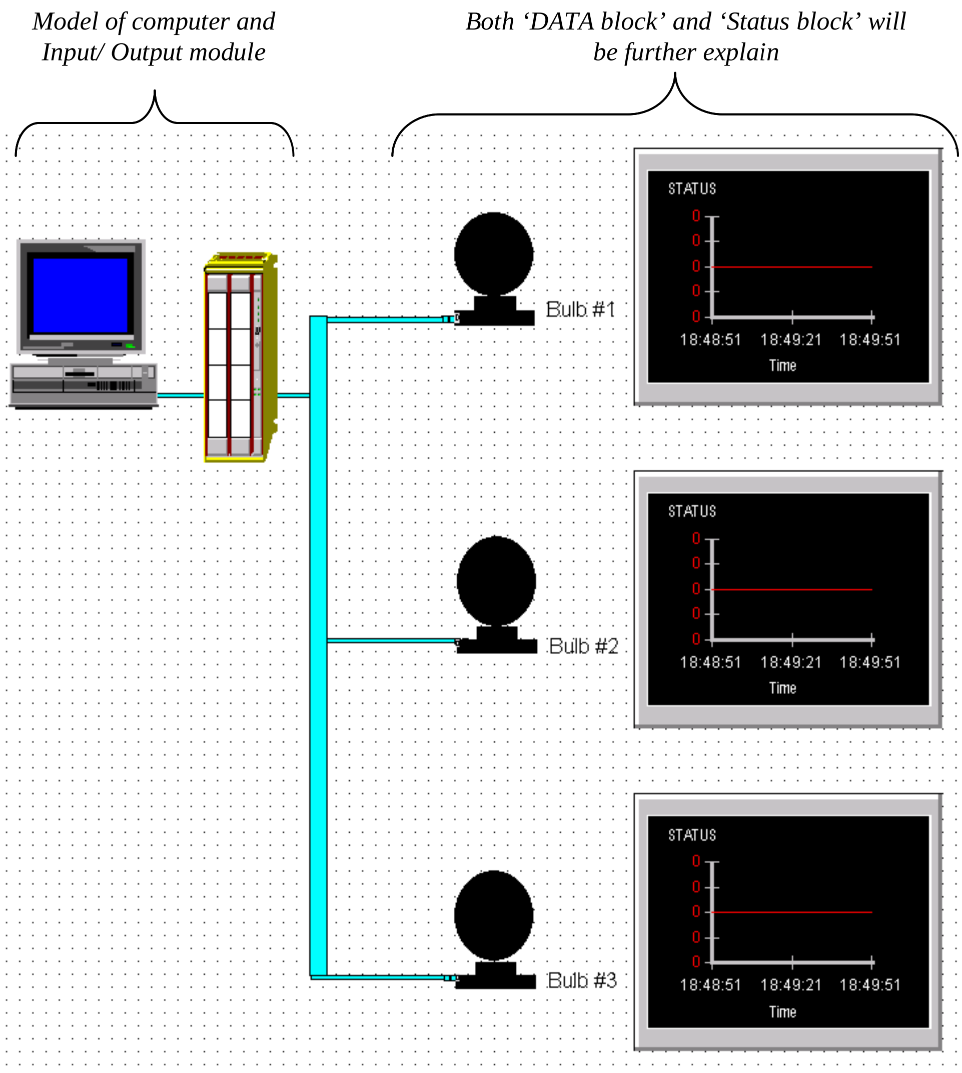


Figure 14 Conceptual design of street lighting system

As in Figure 15 below, the figure shows the simulated design on the *FIX View* window for the three different bulbs with three different conditions.

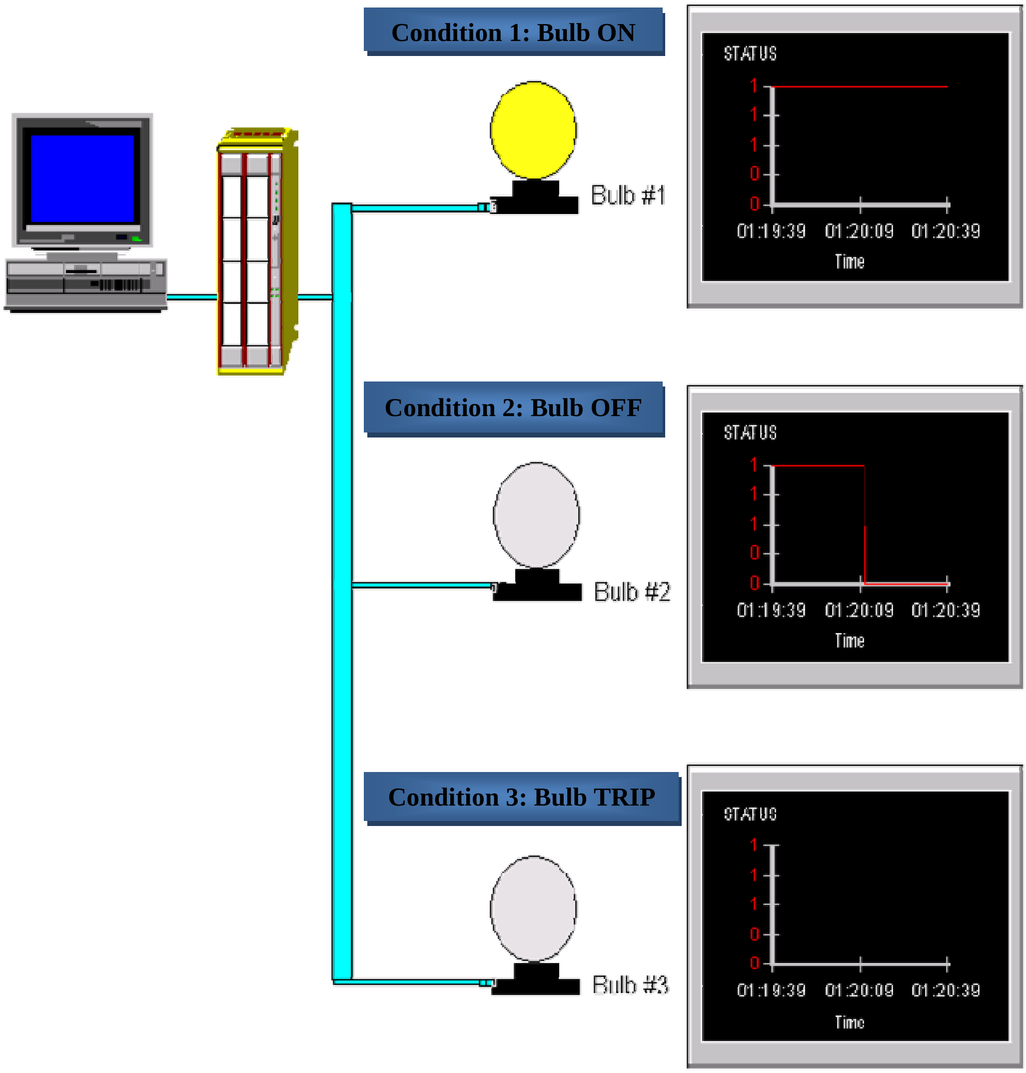


Figure 15 Simulated result of street lighting system

As will be seen on Bulb #1, when the bulb was turned ON, the status is 1. Significantly, when a start button was clicked, it will cause the light to illuminate meaning that the lighting is in operation mode. Then followed by Bulb #2, where the bulb was switched OFF, meaning that no current or supply voltage is flowing through the bulb. So no light illumination will happen and the bulb status will be zero. For Bulb #3, it was design as to represent the short-circuit operation of the bulb. If there is a "break" (discontinuity) on the bulb filament, the bulb will refuse to light up and the connecting wires are getting warm. It is due to lower-resistance path bypassing across the current around the bulb that preventing enough voltage from being dropped across the bulb to light it up.

CHAPTER 5
CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Literature review on SCADA system has been conducted. There are various industries that used SCADA system to monitor their operation such as chemical industry, oil and gas, power-based industry and also manufacturing industry.

This project provides student the opportunity to learn and practice the knowledge and skills she has been exposed throughout the project. As SCADA is widely used in most industrial companies, the knowledge of SCADA system can offer student an extra skill for their future working demand. It is a very good exposure for student to understand new knowledge in electrical and instrument field.

The monitoring of street lighting using SCADA system has been shown in the project which includes the conceptual design and also the prototype. The results are very encouraging.

5.2 Recommendation

The project can be further improved for other applications such as in room, building, plant, etc. For the purpose of communicating between the software and hardware, this project can be redesign using a wireless system since that wireless system does provide better communication between the two path and as well as reducing the cost and time to carry out the wiring process.

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APPENDICES

APPENDIX 1

Gantt chart for FYP1

No	Activity	Week															
		1	2	3	4	5	6	7	8	9	Mid-Sem Break	10	11	12	13	14	15
1	Briefing from Coordinator																
2	Selection and approval of Project Title, Synopsis and Assignment of Supervisor																
3	Allocation of Approved Project Title																
4	Literature Review - SCADA System				*Submission of* ***Preliminary Report*** *- 14 August -*												
5	Familiarisation of software (Intellution FIX) and testing of standard experiment								*Submission of* ***Progress Report*** *- 11 September -*								
6	Mid-Term Seminar																
7	Drawing of lighting system design (simulation)														*Submission of* ***Draft Report*** *- 19 October -*		
8	Interface lighting system with SCADA															*Submission of* ***Interim Report*** *- 26 October -*	
9	Oral Presentation Work - Slide Preparation																***Oral Presentation*** *- 2 till 6 November -*

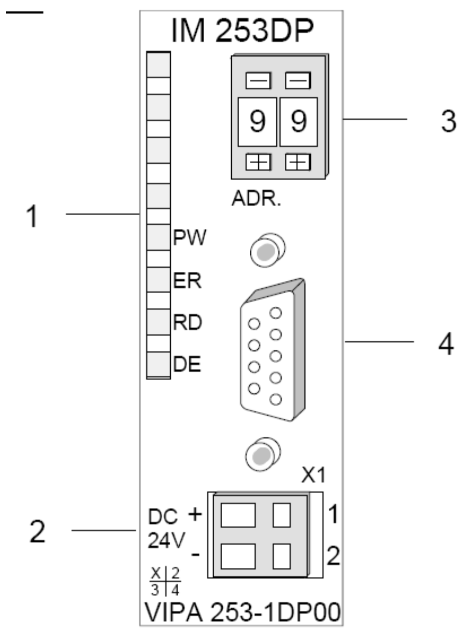
APPENDIX 2

Gantt chart for FYP2

FYP 2																
No	**Activity**	**Week**														
		1	**2**	**3**	**4**	**5**	**6**	**7**		**8**	**9**	**10**	**11**	**12**	**13**	**14**
1	Prototype preparation								**Mid-Sem Break**							
2	Interface lighting system with SCADA				*Submission of* ***Progress Report 1***											
3	Improve design and develop a feedback signal from the lighting system									*Submission of* ***Progress Report 2***						
4	Seminar															
5	Preparation for Poster Exhibition - Poster - Template												***Poster Exhibition***			
6	Project Dissertation Work (Soft bound)													*Submission of* ***Project Dissertation***		
7	Oral Presentation Work - Slide Preparation														***Oral Presentation***	
8	Project Dissertation Work (Hard Bound)															*Submission of* ***Project Dissertation***

APPENDIX 3

IM 253-1DPx0 - DP-V0 slave – Structure



[1] LED status indicators

[2] Connector for DC 24V power supply

[3] Address selector

[4] RS485 interface

Properties

- Profibus (DP-V0)
- Profibus DP slave for max. 32 peripheral modules (max. 16 analog modules)
- Max. 152Byte input data and 152Byte output data
- Internal diagnostic protocol
- Integrated DC 24V power supply for the peripheral modules (3.5A max.)
- Supports all Profibus data transfer rates

Components

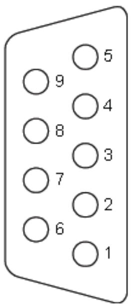
LEDs

The Profibus slave modules carry a number of LEDs that are available for diagnostic purposes on the bus and for displaying the local status. The following table explains the different colors of the diagnostic LEDs.

Label	Color	Description
PW	green	Indicates that the supply voltage is available on the backplane bus. (Power).
ER	red	Turned on and off again when a restart occurs and is permanently on when an internal error has occurred.
		Blinks when an initialization error has occurred.
		Alternates with RD when the master configuration is bad (configuration error).
		Blinks in time with RD when the configuration is bad.
RD	green	Is turned on when the status is "Data exchange" and the V-bus cycle is faster than the Profibus cycle.
		Is turned off when the status is "Data exchange" and the V-bus cycle is slower than the Profibus cycle.
		Blinks when self-test is positive (READY) and the initialization has been completed successfully.
		Alternates with ER when the configuration received from the master is bad (configuration error).
		Blinks in time with ER when the configuration is bad
DE	green	DE (Data exchange) indicates Profibus communication activity.

RS485 interface (at IM 208DP)

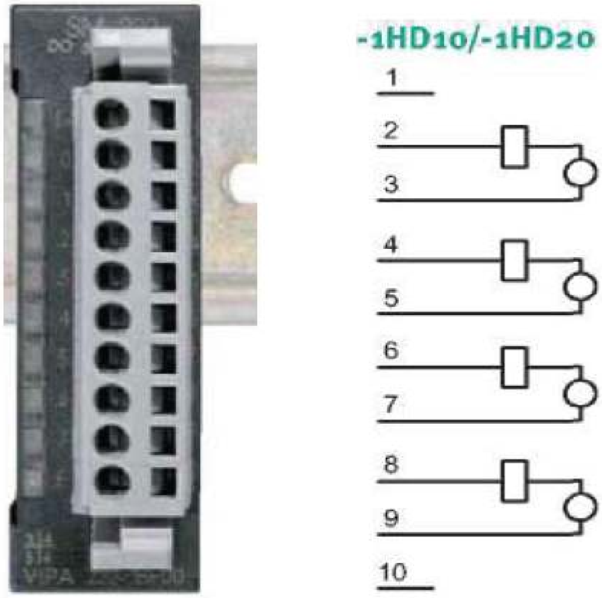
The VIPA Profibus master is connected to your Profibus network via the 9pin socket. The following figure shows the assignment of the individual pins:



Pin	Assignment
1	shield
2	n.c.
3	RxD/TxD-P (Line B)
4	RTS
5	M5V
6	P5V
7	n.c.
8	RxD/TxD-N (Line A)
9	n.c.

APPENDIX 4

SM222 1HD10 Digital Outputs



APPENDIX 5

Proper procedure of removing the fieldbus from the passive backplane