UNIVERSITI TEKNIKAL MALAYSIA MELAKA

APPLICATION OF PROGRAMMABLE LOGIC CONTROLLER (PLC) ON THE LOW VOLTAGE DISTRIBUTION AUTOMATION SYSTEM (DAS)

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electrical Engineering Technology (Industrial Power) with Honours.

by:

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DEDICATION

Dedicated to my beloved parents,

MOHAMMED KHIR BIN OSMAN

FARIDAH BINTI SAMAN

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **APPLICATION OF PROGRAMMABLE LOGIC CONTROLLER (PLC) ON THE LOW VOLTAGE DISTRIBUTION AUTOMATION SYSTEM (DAS)**

SESI PENGAJIAN: 2017/2018

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Electrical Engineering Technology (Industrial Power) with Honours. The member of the supervisory is as follows:

……

(Project Supervisor)

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ABSTRACT

Distribution Automation System (DAS) is the technology implemented in electric power system on distribution level. Some of the electrical components of distribution level are automated in order to improve the service reliability and efficiency. One of the purposes of DAS is to increase the reaction speed during outages and reduce the outage duration. Therefore, in this study, a DAS technology is built in a low voltage (LV) substation so that a Fault Location, Isolation and Service Restoration (FLISR) can be implemented. A Human Machine Interface (HMI) is constructed using Indusoft software. The HMI provides the Supervisory Control and Data Acquisition (SCADA) operations for the system so that it can be monitored and controlled remotely.

ABSTRAK

Automasi Sistem Pengagihan (DAS) adalah teknologi yang diaplikasikan dalam sistem elektrik pada tahap pengagihan. Sesetengah komponen-komponen elektrik di peringkat pengagihan diautomasikan untuk meningkatkan kebolehpercayaan dan kecekapan perkhidmatan elektrik. Salah satu tujuan DAS adalah untuk meningkatkan kelajuan tindak balas semasa gangguan dan mengurangkan tempoh gangguan itu. Oleh itu, dalam kajian ini, satu teknologi DAS dibina pada pencawang voltan rendah (LV) supaya "*Fault Location, Isolation and Service Restoration (FLISR)*" dapat dilaksanakan. Satu "*Human Machine Interface (HMI)*" dibina dengan menggunakan perisian Indusoft. "*HMI*" dapat menyediakan operasi-operasi "*Supervisory Control and Data Acquisition (SCADA)*" untuk sistem ini supaya ia dapat dipantau dan dikawal dari jauh.

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I/O	-	Input/Output
kΩ	-	kiloOhms
kV	-	kiloVolt
mV	-	milliVolt
V	-	Volt

LIST OF ABBREVIATIONS

ABB	-	ASIA Brown Boveri
CDMA	-	Code Division Multiple Access
DAS	-	Distribution Automation System
DNP	-	Distributed Network Protocol
ELCB	-	Earth Leakage Circuit Breaker
FLISR	-	Fault Location, Isolation and Service Restoration
GSM	-	Global System for Mobile Communication
GUI	-	Graphical User Interface
HMI	-	Human Machine Interface
IEC	-	International Electrotechnical Commission
IED	-	Intelligent Electronic Device
IEEE	-	Institute of Electrical and Electronics Engineers
IWS	-	Indusoft Web Studio
KEPCO	-	Korea Electric Power Corporation
LAN	-	Local Area Network
LV	-	Low Voltage
MODEM	-	Modulator/Demodulator
NC	-	Normally Close
NO	-	Normally Open
OLDC	-	Operation Logic Down-Counter
OLUC	-	Operation Logic Up-Counter
PIC	-	Peripheral Interface Controller
PLC	-	Power Line Carrier
PLC	-	Programmable Logic Controller
RS	-	Recommend Standard
RTU	-	Remote Terminal Unit
SCADA	-	Supervisory Control and Data Acquisition
SOE	-	Sequence of Events
TDD	-	Total Demand Distortion
TNB	-	Tenaga Nasional Berhad

UDAS	-	Underground Distribution Automation System
UTeM	-	University Technical Malaysia Melaka
VB	-	Visual Basic
WAP	-	Wireless Application Protocol
WLAN	-	Wireless Local Area Network
WMAN	-	Wireless Metropolitan Area Network
WNIC	-	Wireless Network Interface Card
WPAN	-	Wireless Personal Area Network
WWAN	-	Wireless Wide Area Network

CHAPTER 1
INTRODUCTION

1.1 Project Background

Electricity has become one of the major needs in everyday life, especially with increasing demand for energy nowadays. Electric power system is divided into several parts such as generation, transmission, distribution and load (customers). The power grids transmit electricity at different voltage levels for each part, which are Extra High Voltage (above 230 kV), High Voltage (35 kV to 230kV), Medium Voltage (1 kV to 35 kV), and Low Voltage (up to 1 kV) [1]. Automation of the electric parts or components on distribution level is called Distribution Automation System (DAS), and it is in the Low Voltage level. According to IEEE, "DAS is a system that enables an electric utility to monitor, coordinate, and operate distribution components in a real-time mode from remote locations [2]."

The main purpose of DAS is to remotely control the switches in order to locate faults, isolate the faults and restore the supply services to the consumers [3]. This is known as Fault Location, Isolation and Service Restoration (FLISR). Some of the terms used to describe FLISR are "self-healing" and "smart-grid". FLISR will locate a fault occurred in the distribution power line, isolate the fault by controlling reclosers and sectionalizers, and restore supply to the healthy section of the power system. A Human Machine Interface (HMI) is used to establish a Supervisory Control and Data Acquisition (SCADA) on the system. HMI will interface with the real components in the substation through a communication protocol. In addition, the HMI is a useful component in which aids the operating personnel in handling the system.

In this project, a distribution substation model is build for the DAS application. The distribution substation consists of the incoming, outgoing, and the load. The controller circuit of this substation is based on input and output of PLC. Moreover, a HMI will be constructed and interfaced with this substation so that its functions can be monitored and controlled from remote locations. Developments will be made so that the distribution substation will be able to perform the FLISR operation.

1.2 Problem Statement

When a fault occurs in distribution power lines, the supply will be interrupted and there will be outage of power. This outage results in disturbances for consumers, especially for industries which wanted to reach a production target. The outages often cost industries a huge amount of money. This affects the reliability and efficiency of the electric utility in providing electric supply. The main challenge for any power distribution utility is to locate or identify the faulty section, isolate them and restore the non faulty sections as quickly as possible. This is impossible to be achieved with manual procedure in which the utility staffs have to patrol in the area for hours to locate the faulty section.

Thus, Distribution Automation System (DAS) provides the solution for this problem. DAS with FLISR implementation will automatically locate the fault, isolate the fault and restore the supply to unaffected areas. The fault can be easily located and repaired by the utility staffs. This saves the time and fuel cost needed for patrolling since the fault can be located and identified through HMI. Furthermore, the operating personnel can monitor and control the automated devices from a remote location via HMI. Thus, the outage time of the distribution supply is mitigated. After the faulty section is repaired and cleared, the DAS will restore the original condition of the distribution system.

1.3 Objectives

The objectives of this project are:

1) To build a low voltage substation prototype with controls circuits for automation implementation.

2) To construct a Human Machine Interface (HMI) using Indusoft software for SCADA purposes.
3) To integrate with PLC and build a town model which is capable to execute the Fault Location, Isolation, and Service Restoration (FLISR) function.

1.4 Project Scope

The main objective of this project is to build complete components of the Distribution Automation System (DAS). The substation model will be built by installing the necessary equipments or components in the substation. Some of the devices that are installed in the substation for the automation purposes are Programmable Logic Circuit (PLC), Intelligent Electronic Device (IED), and communication protocols. The PLC used is OMRON PLC Training Kit (OPLC-TK-V3)while the IEDs used are MK2200 and UMG96S.

MK2200 is an over current and earth fault detection relay, while UMG96S is a universal measuring device used to measure the electric parameters. The communication protocols that are used include RS485, RS232, and IEC61850. These protocols are responsible for communication between the devices. What is more, a Human Machine Interface (HMI) will be constructed using Indusoft software and will be interfaced with the hardware for future development. Indusoft is a powerful and efficient HMI SCADA software platform that provides supervisory control and data acquisition applications [4]. Thus, the operating personals can monitor and control the operation of the substation using the HMI from remote locations.

Besides, a town model will be build and it must be capable to perform the FLISR function so that the substation can perform the self-healing process. The

FLISR system will locate the fault, isolate the fault and restore the supply to unaffected areas. Some algorithm will be developed in future and uploaded in the system. The algorithm programs are responsible to make the system to take decisions during fault conditions.

1.5 Contribution of Project

This project is anticipated to contribute to the modernization of electric distribution networks in our country. There are numerous benefits from the implementation of this project. Some of the benefits are to the operational, maintenance, financial, and customers. This project will improve the reliability by mitigating outage duration using auto restoration process. It also provides better fault detection and diagnostic analysis. Besides, it also minimizes man hour and man power in managing the utility.

From financial viewpoint, application of this project increase revenue due to quick restoration. Quick restoration means more power is being sold by the utility. Moreover, utility with the implementation of this project will be customer's first choice because of their improved quality of supply. For customers, they will obtain better service and minimization of interruption cost especially for industrial or commercial customers. Last but not least, this work can be a guideline for other researchers who want to make advancements on this project at the later time.

CHAPTER 2
LITERATURE REVIEW

2.1 Overview

In this chapter, it will describe the theoretical information and methods that have been used in order to accomplish the objectives. Numerous studies have been carried out which comprises the hardware and software parts. Moreover, information from previous works also has been analyzed in this chapter. Thus, this chapter provides comprehensible information about the system.

2.2 Distribution Automation System (DAS)

As stated by the IEEE, DAS is a system that enables an electric power provider to monitor, coordinate, and operate distribution components or devices in a real-time mode from remote locations [2]. Distribution automation system utilizes the modern communication technologies in carrying out its interaction between devices. The rapid development of communication technologies, such as wireless devices contributes to the feasibility of constructing automation systems.

In addition, DAS consists of SCADA systems which assist the operating personnel in carrying out the necessary actions from remote locations. There are 3 levels of architecture for the distribution automation system. Level 1 consists of field devices such as switch gears, current transformers, and power transformers. It carries out the measurement of system parameters. In level 2, the protection and control devices such as protective relays, RTUs, and IEDs are situated. The data received from level 1 is processed at this level. On the other hand, level 3 is composed of

operator displays and workstations for executing, monitoring, and controlling the program [5].

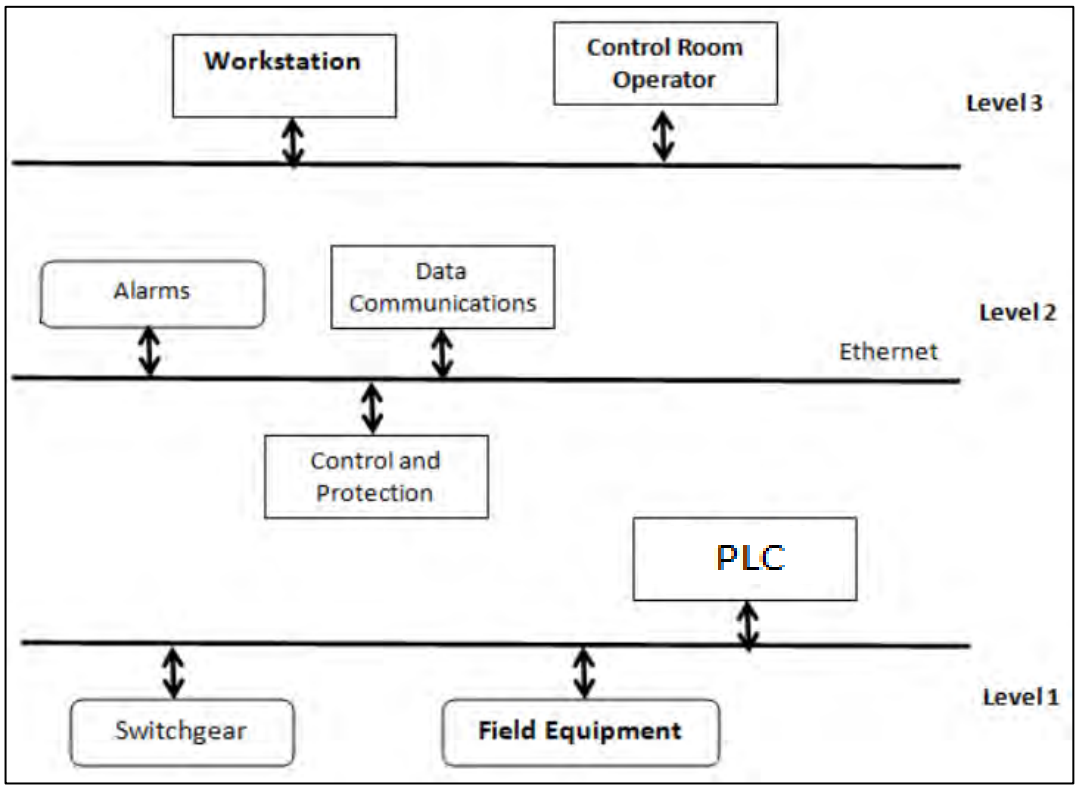

Figure 2.1: Architecture for Distribution Automation System [5].

2.2.1 Benefits of Distribution Automation System (DAS)

The significant benefits of automation are as follows:

a) Enhanced electric service efficiency, quality, and reliability.

b) Mitigate manpower intervention and operating costs.

c) Power outage duration is minimized by the implementation of auto restoration process.

d) Data can be collected and stored for improvement and maintenance of the system.

e) Improvised fault detection and behavior analysis.

f) Quick regeneration contributes to revenue elevation.

g) Interruption cost is mitigated, especially for important customers such as industrial and commercial customers.

2.3 Fault Location, Isolation, and Service Restoration (FLISR)

FLISR implementation has the objective of locating a fault on a distribution line, isolating the fault, and restoring service to the healthy sections in an automated fashion without or with slight personnel intervention. FLISR implementation increases reliability and reduces outage duration. It also contributes to the efficient use of personnel and resources such as vehicles. In fact, reliability is naturally increased since shorter time is required for locating and isolating the faulted areas, as well as for restoring consumers located on unaffected areas. Figure 2.2 below depicts the comparison of time taken to solve faulted section by FLISR and conventional restoration. On the other hand, Figure 2.3 illustrates a simple FLISR operation.

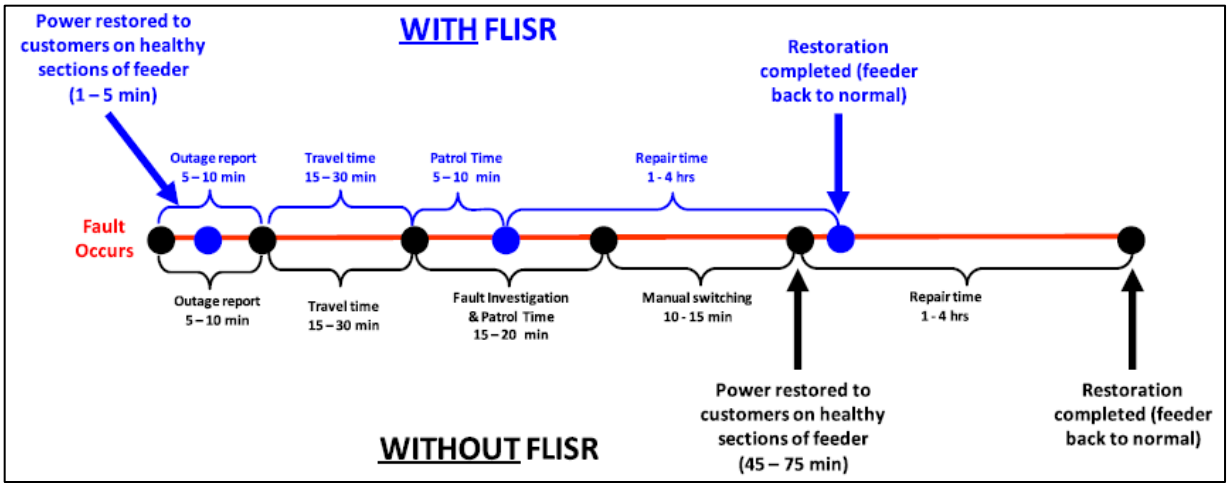

Figure 2.2: Difference between conventional restoration and FLISR implementation.