
# UNIVERSITI TEKNIKAL MALAYSIA MELAKA

## DEVELOPMENT OF REMOTE TERMINAL UNIT FOR DISTRIBUTION AUTOMATION SYSTEM

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

by

**TUAN NURUL HUSNA BINTI TUAN ZAKARIA**

**B071310709**

**940816-03-5880**

FACULTY OF ENGINEERING TECHNOLOGY

2016

# UNIVERSITI TEKNIKAL MALAYSIA MELAKA

## BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK : Development of Remote Terminal Unit for Distribution Automation System

SESI PENGAJIAN : 2016/2017 Semester 1

Saya **TUAN NURUL HUSNA BINTI TUAN ZAKARIA**

mengakumembenarkanLaporan PSM inidisimpan di PerpustakaanUniversitiTeknikal Malaysia Melaka (UTeM) dengansyarat-syaratkegunaansepertiberikut:

1. Laporan PSM adalah hak milik Universiti Teknikal Malaysia Melaka dan penulis.
2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja dengan izin penulis.
3. Perpustakaan dibenarkan membuat salinan laporan PSM ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. **Silatandakan (✓)

| | | |
|---|---|---|
| ☐ | SULIT | (Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia sebagaimana yang termaktub dalam AKTA RAHSIA RASMI 1972) |
| ☐ | TERHAD | (Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan) |
| ☐ | TIDAK TERHAD | |

Disahkan oleh:

AlamatTetap:

**PT 79, TAMAN DESA WANGI,**

**16150, PASIR TUMBOH**

**KOTA BHARU, KELANTAN.**

Cop Rasmi:

Tarikh: _____

Tarikh: _____

**JikaLaporan PSM ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh laporan PSM ini perlu dikelaskan sebagai SULIT atau TERHAD.

# DECLARATION

I hereby, declared this report entitled “Development of Remote Terminal Unit for Distribution Automation System” is the results of my own research except as cited in references.

Signature : .....

Author’s Name : TUAN NURUL HUSNA BINTI TUAN ZAKARIA

Date : 5 JANUARY 2017

# APPROVAL

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

.....

(Encik Ahmad Idil bin Abdul Rahman)

# ABSTRACT

Remote Terminal Unit (RTU) is a data acquisition device that implements in the Distribution Automation System (DAS). The major function of the RTU is to monitor electrical parameter data, such as voltage from line distribution before transmit to consumers. The sensed data will be analysed by RTU and transmit commands to a central computer to take action automatically based on the fault occur. The design of this project will be focused on designing fault detection sensor to emphasis on any value differences in voltage by using Arduino microcontroller. The types of fault will be detected are under voltage and overvoltage. As a result, the fault detection sensor is able to detect either under voltage or overvoltage faults and ready to interface with complete Remote Terminal Unit project.

# ABSTRAK

Remote Terminal Unit (RTU) adalah alat pemerolehan data yang melaksanakan dalam Sistem Pengagihan Automasi (DAS). Fungsi utama RTU adalah unutk memantau data parameter elektrik, seperti voltan dari pengedaran barisan sebelum menghantar kepada pengguna. Sistem RTU akan menganalisis data dan menghantar arahan kepada komputer utama untuk mengambil tindakan secara automatik berdasarkan kesalahan yang berlaku. Reka bentuk projek ini akan memberi tumpuan kepada bentuk kesalahan komponen pengesan untuk memberi penekanan kepada apa-apa perbezaan nilai voltan dengan menggunakan mikropengawal Arduino. Jenis-jenis kesalahan yang akan dikesan ialah bawah voltan atau kekurangan voltan dan bersedia untuk menghubung dengan projek Remote Terminal Unit dengan lengkap.

# DEDICATION

To my beloved parents and family

# ACKNOWLEDGEMENT

First and foremost, I would like to praise ALLAH S.W.T for His blessing. He gave me physical and mental strength to carry on my final year project up to completion.

I would like to express gratitude and thanks to my supervisor, Encik Ahmad Idil bin Abdul Rahman for his supervision, encouragement, guidance, advice and unfailing patience through the duration of the project. His encouragement and guidance are truly appreciated. Not to forget co-supervisor Prof Madya Mohd Ariff bin Mat Hanafiah who also encouraged me to complete this project. Otherwise, this project has not been possible to achieve the objective.

I would like to express my big thanks and deepest gratitude from the bottom of my heart to all my colleagues for their supports, encouragements and inspiration I obtain through the duration of this project.

Last but not least, I would like to thank my family, especially my parent for giving me their full support, understanding and patience. Without their support, I would not have been able to finish my project. Their support and lovely companionship are important source of strength for me.

# TABLE OF CONTENT

# LIST OF TABLES

# LIST OF FIGURES

# LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

| | | |
|---|---|---|
| DAS | - | Distribution Automation System |
| RTU | - | Remote Terminal Unit |
| SCADA | - | Supervisory Control and Data Acquisition |
| GSM | - | Global System for Mobile |

# CHAPTER 1

# INTRODUCTION

## 1.1 Introduction

This chapter describes the electrical power industry, power outages, the potential industrial usage of Remote Terminal Unit (RTU) devices in their applications, discussing the faults of power disturbances which are studied based on power quality monitoring such as voltage sags whereby decrease in RMS voltage down to 90% to 10% of nominal voltage. The distribution automation system can enhance reliability, efficiency, and quality of electric service with regards to application of the utilities to implement flexible control in distribution field of automation. The implementation of the Distribution Automation System (DAS) will be highlight based on two factors which are benefit of distribution automation system implementation and in the area of distribution automation system implementation.

## 1.2 Background

Electrical power systems are very important to deliver electricity to the consumers in an electric power distribution system. The distribution automation system can enhance reliability, efficiency, and quality of electric service with regards to application of the utilities to implement flexible control in distribution automation system. There are two factors that will be highlight in implementation of Distribution Automation System (DAS) which are the benefit of distribution automation system implementation and in the area of distribution automation system implementation. The first factor includes the advantages of DAS, covering three major areas which are operational and maintenance benefits, financial benefits and for customer related benefits.

The operational and maintenance benefits include reducing outage duration to improve reliability by using auto restoration scheme, improved voltage control, the man hour and man power can be reduced and the data information will be accurate and useful planning. The fault detection, diagnostic analysis, management of system and component loading will be more better for operational and maintenance benefits.

For the financial benefits, Distribution Automation System can increased revenue due to quick restoration, improved utilization of system capacity and customer retention for improved quality of supply. On the other hand, the customer related benefits in DAS implementation can give a better service reliability, reduce interruption cost for industrial or commercial customers and get a better quality of supply.

Meanwhile, the second factor of distribution automation system refers to the distribution substation and feeder automation and consumer location automation. The distribution automation on substation and feeder are usually integrated to share common monitoring and controlling equipment or devices. Distribution substation automation includes supervisory control of circuit breakers, regulators, switches and substation capacitor banks. To achieve the effective use of the supervisor control function, the remote data acquisition is required.

The consumer location automation includes the ability to remotely read the meters, connects or disconnects services and control consumer loads (Parikh, 2009).

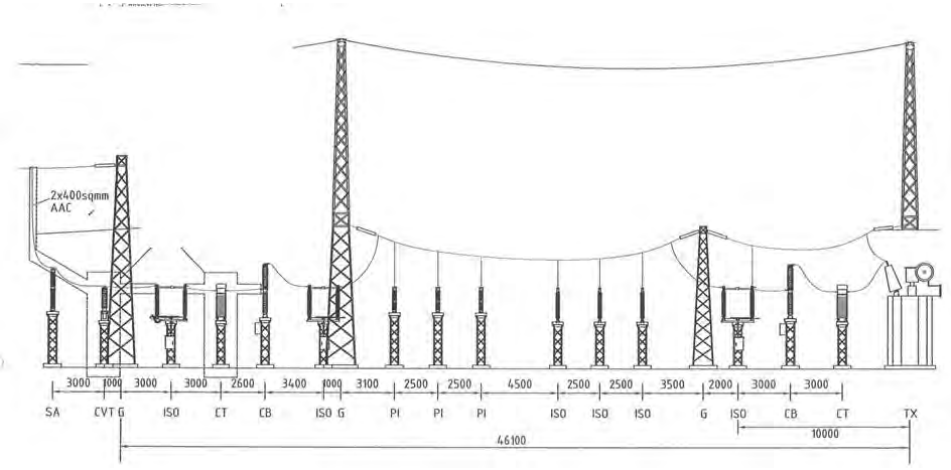


Figure 1.1 : Substation Primary Equipment

In this report, the fault tested on the RTU board are under voltage and overvoltage fault. The under voltage happens when the value of voltage is lower than the desired value. This may occur from the load which is not suitable to use in circuit or lack of electrical equipment to functioning. Thus, it can cause other instruments in the distribution system to operate under normal condition.

Meanwhile, overvoltage is a situation where the value of voltage increases over 100% from rated voltage. It can cause a fast reduction in loads, failure of electrical control instrument such as voltage regulators, cause insulation failure and others. There are two types can be classified for overvoltage in power system such as external overvoltage and internal overvoltage.

External overvoltage is a situation generated by atmospheric disturbance and lightning is the most common and the most severe. The internal overvoltage is generated by changes in the operating conditions of the network. It can be divided into two types, switching overvoltage and temporary overvoltage.

Remote Terminal Unit (RTU) is an electronic control device that interfaces with distributed control system, such as SCADA (Supervisory Control and Data Acquisition). It will analyze the electrical parameter at the distribution system. The data are collected from process equipment at remote locations and transfer back to a central unit to define data condition. The remote terminal unit will read the data in three conditions such as analog input, digital (status input) and digital (control outputs). The data read in an electrical parameter such as RMS value of voltage and current, frequency, power and others.

This project involved development of Remote Terminal Unit (RTU) where it is suitable to use in power system distribution. Voltage fault detection can be describes into three states which is under voltage fault, overvoltage fault and stable condition.

## 1.3 Problem Statement

In an electricity network, there are many causes of power failures including faults at power stations, electrical transmission line, substations or distribution system, or overloading or short circuit of electricity mains. All these causes take a longer time for fault detection, isolation and distortion due to lack of the implementation of distribution automation system. It will affect in manufacturing sectors and residential areas. For manufacturing sectors, it can lead to economic problems and instability while for residential areas, it can cause extensive damage to home appliances. It may take a longer time for TNB's engineers or technicians to investigate the cause of disruption whether the customers may report to TNB because the system is too complex to handle the fault, and may require higher number of man-hours to rectify the fault.

Thus, it is necessary to design and develop Remote Terminal Unit (RTU) which can be implemented in different applications especially in distribution automation system. The existing RTU is very expensive and it is only used for certain applications or purpose which are compatible with its program setting. Imported RTU costs more due to shipping fees, taxes, and need the requirement to hire an instructor for first time users. In case the imported RTU has problems, it may take a longer time to repair and return.

## 1.4 Project Objectives

The objectives of this project consist of three main aims which are :

1) To design and develop an innovative modelling and algorithm Remote Terminal Unit for hardware and software.
2) To make a system that can monitor type of faults by using Arduino Mega 2560.
3) To build a complete RTU automation system in the form of hardware and software system that can be implemented remotely.

## 1.5 Results for the Project

After the completion of this project, the results and benefits will be achieved :

1) Able to provide an RTU system that can continuously collect, process and store data, operate independently through programming.
2) Save time and costs.
3) Reduce the number of man-power needed for onsite substation inspections, adjustments, data collection and system monitoring to increase system efficiency.
4) Contribute to the research on intelligent distribution system through SCADA system technology.

## 1.6 Scope of the Project

This project is restricted to :

1) Only for low voltage distribution automation system of 400/230V.
2) The RTU used is based on microcontroller with Arduino Mega 2560.
3) The communication link is based on wireless protocol using GSM modem.

The limitation of iRTU design is only focused on detecting and monitoring overvoltage and under voltage instead of other faults. The signal will be send by using GSM modem.

## 1.7 Report Outline

This thesis contains five chapters. An overview of Remote Terminal Unit, Global System for Mobile (GSM) and the other part of communication system are described in Chapter 1. The objectives, result for the project and scope of work also including in this chapter. Chapter 2 is a Literature Review presents an overview of design and development of Remote Terminal Unit. This includes the past and current RTU development, the interfacing using GSM modem system and the communication links. For Chapter 3, the hardware and software of designing and programming the RTU board and programming software to create the GSM interface will be described. The simple circuit is design for the RTU board, Arduino software is used to program the RTU function. Chapter 4 will be focus on the results of this project which presents the complete board of RTU development tested in overvoltage and under voltage fault value. The fault value sent to the monitoring system via GSM communication. Finally in Chapter 5 presents the general conclusions and recommendations for future work.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Introduction

This chapter explains the background and basic concept of Remote Terminal Unit (RTU). The principle ideas are established before the design of RTU is continued. This chapter will also cover the researches related to the subject. This will provide a clearer understanding of the system and its design.

## 2.2 Project Background

Based on IEEE dictionary, the meaning of power quality is the concept of powering and grounding sensitive equipment in a matter that is suitable to the operation of that equipment. Remote Terminal Unit (RTU) is a part of distribution automation (DA). It allows remote monitoring and control of substation. The role of RTU is to allow the operators at the network control center to manage and operate the power system.

A remote terminal unit (RTU) is a microprocessor-controlled electronic device that interfaces objects in the physical world to a central unit by transmitting the required data to the system and sometimes by using messages from the central unit to control connected objects. RTU consist three major parts which are sensors, microprocessor or controller and communication parts.

## 2.3 Past and current of RTU development

There are many definitions of Remote Terminal Unit (RTU) based on the understanding of each individual appropriate application. One of them is a multipurpose device used for remote monitoring and control of various devices and systems for automation. In any remote monitoring system, Remote Terminal Units exist as one of the important parts. Remote Terminal Units are also suitable for monitoring and controlling target applications both locally or remotely. It can be programmed as PLC device which can control the highest demanding target applications locally without user interaction or user can monitor the measurement data and make controls from the remote control room.

Based on the paper review of Remote Terminal Unit (RTU) and Gateways for Digital Oilfield Deployments written by Francis Enejo Idachaba (2012) define the RTU is a microprocessor-based device connected to sensors, transmitters or process equipment for the purpose of remote telemetry and control (Idachaba, Francis Enejo., 2012). Shahzad A., S.Musa, A. Aborujilah and M.Irfan (2014) explain that RTU act as slave stations in SCADA architecture. Remote Terminal Unit is usually connected with physical environment through actuators or sensor. It is responsible to collect information and process information back to master station. (Stouffer and Kent, 2006; Musa et al., 2013b).

A Remote Terminal Unit (RTU) is a microprocessor-controlled electronic device that interfaces objects in the physical world to a central unit or SCADA by transmitting the required information to the system and sometimes by using messages from the central unit to control associated objects. There are three major parts in remote terminal unit which are sensors, microprocessor or controller and communication part (Eng. Wael E.Matti & Dr. Jabir S. Aziz, 2012). Microcontrollers are devices also known as computer in a chip, the design in cooperates all of the features found in a microprocessor (CPU, ALU, PC, SP and all registers) it has also other added features need it to be a complete computer : ROM, RAM, serial and parallel I/O, counters and a clock circuit. The function of microcontroller is to control the operation of RTU by using a fixed program which is stored in ROM (Nebojsa Matic, 2005).

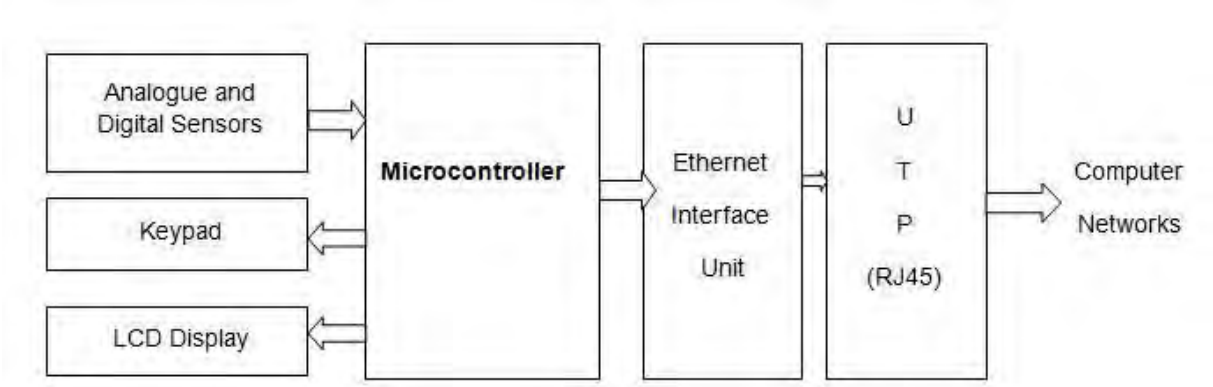


Figure 2.1 : The block diagram of the proposed R.T.U

(Eng. Wael E.Matti & Dr. Jabir S. Aziz, 2012).

The function of power quality should have in all Remote Terminal Unit (RTU). RTU will send immediately the information that items went beyond setting value if it detects the power quality is bad. Thus, operator can choose to command the data acquisition of waveform file of three phase voltage and current. The old version of RTU has an all Analog Input (AI), Analog Output (AO), Digital Input (DI), Digital Output (DO) functions, but there is no power quality monitoring function. But new RTU has the function of analysing power quality. In case of flowing fault current in distribution networks, RTU will save all the information.

The RTU have a few main functions such as communication between host and FRTU, measuring of analog data in current (I) and voltage (V), monitoring of current status, control execution with digital output, fault detection and monitoring of fault current, monitoring of operation counter, display and setting and the function of saving historical data. If there are overshoot or undershoot during power quality monitoring, RTU produces the event about what time and which item happened, and sends the information to main station through communication media directly (Boknam HA, Shinyeol PARK, Changhoon SHIN, Seongchul KWON, Soyeong PARK, 2007).