UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEVELOPMENT OF REMOTE TERMINAL UNIT (RTU) FOR POWER QUALITY MONITORING SYSTEM

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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…….

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DEDICATION

To my beloved parents

Zainal bin Mohd Yusof

Kamariah binti Saad

Siblings

Muhammad Hafizuddin bin Zainal

Nor Zalika binti Zainal

Muhammad Hafizi bin Zainal

Muhammad Hazman bin Zainal

Muhammad Haikal bin Zainal

Supervisor

Mr. Ahmad Idil bin Abdul Rahman

Co-Supervisor

Mr. Johar Akbar bin Mohamat Gani

Thank you very much for the support, love, encouragement, help and blessing.

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ABSTRACT

This project introduces the design and development of a low cost Remote Terminal Unit (RTU) for power quality monitoring system to increase the reliability of power for the consumers. RTU plays an important role in detecting fault and assigned to send message immediately to the control room. The RTU provides monitoring fault operation and data collection for analysis. The design of this project will be focused on developing a comprehensive set of basic models to simulate voltage sag using MATLAB/SIMULINK with SimPowerSystems. The microchip will be programmed to a specific type of fault for the condition voltage sag when it receives data from MATLAB/SIMULINK. After that, the status is shown in the LCD display and XBee will send the information to control room operators to alert them on the current situation via Graphical User Interface (GUI). Finally, the system is able to detect either voltage sag or normal voltage and ready to be interfaced with complete Remote Terminal Unit.

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ABSTRAK

Projek ini memperkenalkan reka bentuk dan pembangunan Unit Pemantauan Jarak Jauh (RTU) kos rendah untuk sistem pemantauan kualiti kuasa bagi meningkatkan kebolehpercayaan kuasa kepada pengguna. RTU memainkan peranan penting dalam mengesan kesalahan dan ditugaskan untuk menghantar mesej dengan segera ke bilik kawalan. RTU menyediakan pemantauan operasi kesalahan dan pengumpulan data untuk analisis. Reka bentuk projek ini akan memberi tumpuan kepada membangunkan satu set model asas yang komprehensif untuk mensimulasikan voltan lendut menggunakan MATLAB/SIMULINK. Microchip akan diprogramkan kepada beberapa jenis kesalahan khusus untuk keadaan voltan lendut apabila ia menerima data dari MATLAB/SIMULINK. Selepas itu, status kesalahan tersebut akan dipaparkan dalam paparan LCD dan XBee akan menghantar maklumat tersebut ke bilik kawalan untuk memberi amaran kepada mereka mengenai keadaan semasa melalui Paparan Grafik (GUI). Akhirnya, sistem ini dapat mengesan sama ada voltan lendut atau voltan biasa dan bersedia untuk dihubungkan dengan Unit Pemantauan Jarak Jauh yang lengkap.

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LIST OF SYMBOLS & ABBREVIATIONS

CAN	-	Controller Area Network
DAS	-	Distribution Automation System
DNP	-	Distributed Network Protocol
GSM	-	Global System for Mobile Communication
GUI	-	Graphical User Interface
HMI	-	Human Machine Interface
I/O	-	Input/Output
IEC	-	International Electro-Technical Commission
IEEE	-	Institute of Electrical and Electronics Engineers
kV	-	kiloVolt
LG	-	Line-to- Ground
LLG	-	Line-to-Line-to-Ground
LLLG	-	Line-to-Line-to-Line-to-Ground
LV	-	Low Voltage
MODEM	-	Modulator/Demodulator
ms	-	millisecond Second se
mV	-	milliVolt
PIC	-	Peripheral Interface Controller
PQ	-	Power Quality
PQM	-	Power Quality Monitoring
pu	-	Per Unit
RMS	-	Root Mean Square
RTU	-	Remote Terminal Unit
SCADA	-	Supervisory Control and Data Acquisition
TCP/IP	-	Transmission Control Protocol/Internet Protocol
TNB	-	Tenaga Nasional Berhad
UTeM	-	University Technical Malaysia Melaka
V	-	Volt
VB	-	Visual Basic
VB	-	Visual Basic
VRMS	-	Voltage Root Mean Square
WLAN	-	Wireless Local Area Network
WPAN	-	Wireless Personal Area Network

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CHAPTER 1
INTRODUCTION

1.0 Introduction

This beginning chapter will explain about the project background, problem statement, scope, expected results and objectives with regard to this project.

1.1 Background

Nowadays, electrical power systems are very important to deliver electricity to consumers due to increasingly high demand for energy consumption. Generation, transmission, distribution and load (consumers) is a part of the electrical power system. There are two voltage level networks in electrical power system that commissioned by Tenaga Nasional Berhad (TNB), which are transmission voltage (500kV, 275kV and 132kV) and the distribution voltage (33kV, 11kV and 400/230V) [1]. However, in Perak and Johor their distribution voltages level might also include 22kV and 6.6kV. These supply frequencies are 50Hz ± 1%.

According to Institute of Electrical and Electronics Engineers (IEEE), Distribution Automation System (DAS) is a system that enables an electrical utility to monitor, coordinate, and operate distribution components in a real-time mode from remote locations [2]. DAS also known as systems that consist of the electrical parts or components on distribution level that operate automatically, and it is in the low voltage level. The main purpose of DAS is to remotely control the system in order to locate

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faults, isolate the faults and restore the supply services to the consumers [3]. Automatically monitoring, protecting and controlling switching operations is defined as the application of automation in distribution power system. This can be achieved through intelligent electronic devices (IED) in order to restore power service during fault and maintain better operating to ensure the system back to normal operations. The DAS can enhance efficiency, reliability and quality of electric service with regards to application of the utilities.

One of the vital devices for implementation of DAS is the Remote Terminal Unit (RTU). It basically allows remote monitoring and controlling of the substations. RTU plays an important role in allowing the operators at the control center to manage and operate the distribution system. It will analyze the electrical parameter at the distribution system. The data are collected from process equipment at remote locations and transferred back to the central unit to define data condition. The remote terminal unit will read the data in three conditions which are analog input, digital (status input) and digital (control outputs). The data reading in an electrical parameter such as Root Mean Square (RMS) value of voltage and current, frequency, temperature and power [5].

In this project, the fault tested on the RTU board is the Three Phases to Ground Fault (L-L-L-G), Single Line to Ground (L-G) and Double Line to Ground (L-L-G) fault which are causes from the voltage sag disturbances. This fault coming from power quality disturbances, thus the power quality disturbance should be monitored by using RTU to ensure the good quality of electric services. Generally, power quality is defined as the electrical network's ability to supply a clean and stable power to consumer. Besides that, power quality creates a perfect power supply that is always available, has a pure noise-free sinusoidal wave shape and is always in range of their standard frequency and voltage. However, with increasing the energy demands from various industrial processes, many loads frequently impose to these disturbances [4].

Voltage sags is considered one of the harmful power quality problems because it affects the stable operation of several types of end-user equipment. This issue is known

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as short-duration reduction in RMS voltage caused by events such as power failure from a fault, load variations and the start of large induction motors or load. Based on IEEE standard 1159/95, sag or dip is a decrease to between 0.1 per-unit (pu) and 0.9 pu in RMS voltage or current at the power frequency for durations of 0.5 cycles to 1 minute [7]. Figure 1.1 shows the voltage sag waveform.

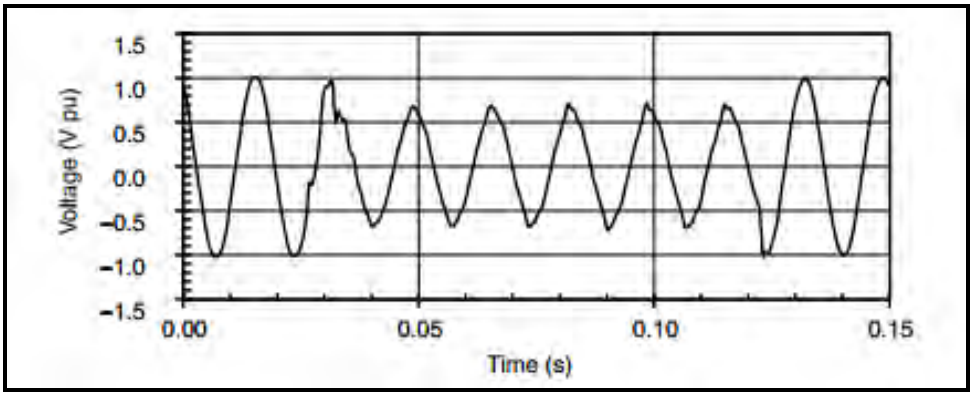

Figure 1.1: Voltage Sag Waveform [7]

Thus, this project involved the development of RTU where it is suitable to use in power system distribution. However, this project will only consider the normal voltage and voltage sag disturbances.

1.2 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 such as overloading and short circuit of electricity mains due to power quality disturbances. All these causes take a longer time for fault detection and due to lack of the implementation of distribution automation system. It will affect the manufacturing sectors and residential areas.

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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 Tenaga Nasional Berhad's (TNB's) engineers or technicians to investigate the cause of interruption whether the customers may report to TNB because the fault cause the system is complex to handle and may require higher number of man-power to fix the fault.

Thus, it is necessary to design and develop a Remote Terminal Unit (RTU) which can detect and monitor the type of fault and power quality disturbances. The RTU can also be implemented in different applications especially in distribution automation system. The existing RTU is very expensive and it is only limited to be 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.

Hence, the developed system presented by this project are aimed to:

1. Save time for fault detection, isolation and distortion.
2. Save cost and time to investigate the cause of interruption.
3. Reduce the number of man-power needed for onsite substation inspections, adjustments, data collection and system monitoring.

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1.3 Objectives

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

1. To simulate and analyze the model of power quality disturbances using MATLAB Simulink.
2. To make a system that can monitor and detect type of faults and disturbances by using Arduino UNO with Visual Basic (VB) interface for power quality monitoring system.
3. To perform testing and analysis of the complete RTU system.

1.4 Scope

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 UNO and the GUI interfacing is run using Visual Basic (VB).
3. The communication link is based on wireless protocol using XBee communication.

The limitation of RTU design is only focused on detecting and monitoring normal voltage and voltage sag disturbances (fault type A, B and E). The designed Graphical User Interface (GUI) is limited to the capability of visual the basic (VB) and its customization features.

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1.5 Report Outline

This report contains five chapters. An overview of Distribution Automation System, Remote Terminal Unit and Power Quality Monitoring System are described in Chapter 1. The problem statement, objectives 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, power quality disturbances and the communication links**.** Chapter 3 describes the methodology of this project consist of hardware and software. The input signal for the RTU board is designed using MATLAB/Simulink software that acts as sensor in the real RTU board. Arduino software is used to program the RTU function and the Visual Basic (VB) is used to create the interface for the monitoring system. Chapter 4 will be focused on the results of this project which presents the complete board of RTU development tested in normal condition and voltage sag fault. The fault signal will be sent to the monitoring system via XBee wireless communication. Finally, Chapter 5 presents conclusions and recommendations for future work.

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