Faculty of Electrical and Electronic Engineering Technology

DEVELOPMENT OF IOT BASED SAG AND SWELL IDENTIFICATION FOR POWER QUALITY MONITORING

SITI NUUR IRSALINA BINTI SAJOHAN

Bachelor of Electrical Engineering Technology (Industrial Power) with Honours

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DEVELOPMENT OF IOT BASED SAG AND SWELL IDENTIFICATION FOR POWER QUALITY MONITORING

SITI NUUR IRSALINA BINTI SAJOHAN

A project report submitted
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Disahkan oleh:

IrsalinnaSajohan

(TANDATANGAN PENULIS)

Alamat Tetap:
LOT 831, KG GONG JERING, SELISING,
16810 PASIR PUTEH, KELANTAN

Ahmad Idil

(COP DAN TANDATANGAN PENYELIA)

AHMAD IDIL BIN ABDUL RAHMAN
Pensyarah Kanan
Jabatan Teknologi Kejuruteraan Elektrik
Fakulti Teknologi Kejuruteraan Elektrik Dan Elektronik
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I declare that this project report entitled "Development of IoT Based Sag and Swell Identification for Power Quality Monitoring" is the result of my own research except as cited in the references. The project report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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Student Name : SITI NUUR IRSALINA BINTI SAJOHAN

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I hereby declare that I have checked this project report and in my opinion, this project report is adequate in terms of scope and quality for the award of the degree of Bachelor of Electrical Engineering Technology (Industrial Power) with Honours.

Signature : Ahmad Idil

Supervisor Name : TS. AHMAD IDIL BIN ABDUL RAHMAN

Date : 11/1/2022

Signature : JoharAkbar

Co-Supervisor Name (if any) : TS. JOHAR AKBAR BIN MOHAMMAT GANI

Date : 11/1/2022

DEDICATION

To my beloved parents

Sajohan bin Zakaria

Zurina binti Ab Rasid

Siblings

Muhamad Hazlami bin Sajohan

Muhamad Hamizan bin Sajohan

Siti Nuur Hidayati binti Sajohan

Siti Nuur Sabihah binti Sajohan

Supervisor

Ts. Ahmad Idil bin Abdul Rahman

Co-Supervisor

Ts. Johar Akbar bin Mohamat Gani

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

ABSTRACT

The purpose of developing a quality control system based on a low-cost Remote Terminal Unit (RTU) platform that is integrated with The Internet of Things (IoT) is to improve power reliability for consumers. Power quality refers to a wide range of differences in the electric power delivered to utility consumers. It can protect a switching transients, wiring issues, harmonic generation, load variations, and many more. The RTU is an important microprocessor-based computer that tracks and manages field equipment or faults before connecting to plant control or SCADA (supervisory control and data acquisition) systems. The proposed RTU is simple to set up and use in a variety of applications, especially in the distribution automation system. The design of this project will be aimed on developing a set of basic models to simulate a voltage sag and voltage swell using MATLAB/Simulink. The microchip will be programmed to a specific type of fault for a voltage sag and voltage swell condition when it receives the data from the MATLAB/Simulink. After that, the status is shown in the LCD display and Wi-Fi Module will send the information directly to control room as warning the operators on the current situation via Graphical User Interface (GUI). Finally, the system is able to detect the fault whether it is a voltage sag, voltage swell or normal voltage and the starting and ending time of the disturbance occurred, thus ready to be interface with the Remote Terminal Unit (RTU).

ABSTRAK

Tujuan utama memperkenalkan sistem pemantauan kualiti kuasa yang berdasarkan platform Unit Pemantauan Jarak Jauh (RTU) serta berasaskan Internet Pelbagai Benda (IoT) ialah untuk meningkatkan kebolehpercayaan kuasa bagi pengguna. Kualiti kuasa merujuk kepada perbezaan kuasa elektrik yang disampaikan kepada pengguna utiliti. Ia dapat melindungi peralihan sementara, masalah pendawaian, penjanaan harmonik, variasi beban dan banyak lagi. RTU adalah komputer berasaskan mikropemproses yang penting dalam mengesan dan menguruskan peralatan atau operasi kesalahan di lapangan sebelum dianalisiskan ke Sistem Kawalan Penyeliaan dan Pemerolehan Data (SCADA). RTU dicadangkan kerana ia mudah dipasang dan digunakan dalam pelbagai aplikasi terutama dalam sistem automasi pengedaran. Reka bentuk projek ini juga turut bertujuan bagi mengembangkan model asas untuk mensimulasikan voltan lendut dan voltan ampul menggunakan perisian MATLAB/Simulink. Seterusnya, status ataupun keputusan akan ditunjukkan dalam paparan LCD dan modul Wi-Fi akan menghantar maklumat secara langsung ke bilik kawalan sebagai amaran kepada pengendali mengenai keadaan semasa melalui Paparan Grafik (GUI). Akhirnya, sistem dapat mengesan kesalahan sama ada voltan lendut dan voltan ampul ataupun voltan normal dan juga masa permulaan dan akhir gangguan berlaku sehingga siap untuk dihubungkan dengan Unit Pemantauan Jarak Jauh yang lengkap.

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LIST OF SYMBOLS

kV	-	kiloVolt
pu	-	Per-unit
V	-	Volt
%	-	percent
s/sec	-	seconds
MVA	-	Mega-Volt-Ampere
$\psi(t)$	-	Continuous Function in Both Time Domain
MHz	-	Mega Hertz
$\bar{\psi}(t)$	-	Operation of The Conjugate Continuous Function
km	-	kilometres
ms	-	miliseconds
mV	-	miliVolt

LIST OF ABBREVIATIONS

V	-	Voltage
DAS	-	Distribution Automation Aystem
GUI	-	Graphical User Interface
IEEE	-	Institute of Electrical and Electronic Engineers
PQM	-	Power Quality Monitoring
RMS	-	Root Mean Square
RTU	-	Remote Terminal Unit
SCADA	-	Supervisory Control and Data Acquisition
GSM	-	Global System for Mobile Communication
LG	-	Line-Ground
LLG	-	Line-Line-Ground
LLLG	-	Line-Line-Line-Ground
LL	-	Line-Line
VRMS	-	Voltage Root Mean Square
CWT	-	Continuous Wavelet Transform
DWT	-	Discrete Wavelet Transform
TNB	-	Tenaga Nasional Berhad
HMI	-	Human Machine Interface
IoT	-	Internet of Things

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CHAPTER 1

INTRODUCTION

This part will describe further about the project background, problem statement, objectives, scope of project and expected results for the RTU project in brief.

1.1 Background

Power distribution system is the last stage of the power delivery chain, which channel electrical energy from the transmission or grid supply system (GSS) network to consumers of electricity. Due to rapid increase in electricity demand, distribution feeders and transformers are getting more extensive, covering wide geographical areas and operating continuously with the expectation of being reliable, safe, and secured. Nowadays, electrical power systems are extremely important for delivering electricity to consumers since the increase of high demand for energy consumption. This electrical power system has a standard network that supply power to the area. Tenaga Nasional Berhad (TNB) has commissioned two voltage networks in the electrical power system which are transmission voltage networks (500kV, 275kV, and 132kV) and distribution voltage networks (33kV, 11kV, and 400/230V) respectively (TNB, 2019). All of these frequencies are 50Hz.

Electric power distribution system is an important part of electrical power systems in delivery of electricity to consumers. When a distribution automation system (DAS) is built, it will improve the reliability, performance, and quality of electrical service. The problem also can be solved in a short time. Electrical services that use a DAS and a SCADA system usually have extensive power over delivery equipment. The DAS can improve the efficiency, reliability and quality of electric service when it comes to the application of the utilities. The advancements in DAS and automation applications make it easier to observe, manage and regulate the switches of the framework where it very well can be practiced through the intelligent electronic devices (IED).

The Remote Terminal Unit is an important aspect for DAS implementation, as it effectively works as a remote that allows for substation monitoring control. It will analyse the electrical parameter at remote locations and transferred back to the central unit to define data condition. This RTU system is designed to warn in the event of a failure and works only for the low voltage supply 400/240V system. The measured electrical variables will be determined by the RTU at the distribution system. The RTU is specifically used to detect faults due to the voltage sag and voltage swell on the transformers. The breakdown fix will go smoothly and be easy to manage. This RTU can interpret data in three different states which are in analogue input, digital status input and digital control output.

In this project, the faults tested on the RTU board is the single-line to ground (L-G), double line to ground (L-L-G) and three phase to ground (L-L-L-G) fault which are causes occurrence voltage sag and voltage swell disturbances (Gururajapathy, Mokhlis and Illias, 2017). Since these faults are caused by power quality fluctuations, the power quality fault should be checked using RTU to ensure that the quality of electric supplies is maintained. Thus, this project involved the development of RTU where it is suitable to use in power system distribution and will covers the normal voltage, voltage sag and voltage swell.

1.2 Problem Statement

Power quality assessment is an important performance measurement in industrial facilities nowadays. When the power is disrupted in a factory, it can cause the malfunction and prematurely break down of expansive equipment. This issues that usually happens are overloading and short circuit of electricity at centre due to disruption of power quality. Subtle power quality incidents often go undetected by standard security networks, resulting in infrastructure loss over time. Thus, it is important to control inputs and disturbances caused by the load in order to resolve power quality issues.

There are variety of reason for power outages occur in the electrical system which are faults at power stations, substations, distribution systems or transmission line. All these issues take a quite long time to identify the fault disturbances due to lack of implementation using DAS. When the power outages occur in residential areas, it will affect the household equipment. When traditional switch gears are used in distribution systems, it takes far too long to identify problem locations and disconnect the faulty lines (Lin, 2015). For the manufacturing sectors, this issue has the potential to cause economic problems such as failure of electronic and electrical equipment substantially while for residential areas, it can cause extensive damage to household appliances. Since there is no integration of the DAS in the current situation, identifying the issue for these failures will take some time. Identifying these common issues necessitates the creation and construction of a RTU.

As a result, it is essential to identify and monitor power quality disturbances as well as the types of failures that occur in the distribution system. This may be accomplished by creating and implementing a RTU. The RTU can be used in various spots at the same time but some of the RTU configurations are restricted to rigid and unadaptable program settings.

1.3 Project Objective

This project conducted has three main aims to be achieved, which are:-

1. To develop an IoT based system that can monitor and identify the type of faults and disturbances by using Arduino ESP32 with Blynk app interface for power quality monitoring system.

2. To determine the duration of voltage sag and voltage swell by using Wavelet method.
3. To study real time fault with complete RTU system.

1.4 Scope of Project

This project's scope will be limited to these conditions, which are:

1. The RTU operates based on the microcontroller with Arduino ESP32 and the Graphical User Interface (GUI) is operate using Blynk application.
2. This project is applied for low voltage distribution automation system of 400/230V.
3. The communication link is base-founded using the wireless protocol Wi-Fi module.
4. Mainly fault type detect on RTU are LG, LLG, LLLG and LL.

The RTU configuration is only centralized on tracking and observing the fault disturbances at normal voltage, voltage sag and swell situation. The wavelet method will develop a procedure that accurately identifies the voltage sag and swell duration from its start throughout the end time.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Chapter before has been discussing about the problem statement, objectives and also the project's scope. Now in this chapter, it will be discussing the literature review and existing product. The literature review is commonly based on the several resources such as journal articles, web page, website, technical report and white paper. This section will focus on survey writing as well as strategic objectives. The information concerning this application concept gathered through manuals, printed sources, and the internet will be focused on in order to aid in the construction of a better application that fits all of the requirements. The theory of the Wavelet method are clarified in this chapter as this information are vital in completing this project. The overall goals of this chapter are to conduct a literature study of any past project or product that has evolved and is connected to current project.

2.2 Power Quality

Nowadays, the most common issue in power distribution system is power quality. Power quality refers to a wide range of differences in the electric power delivered to utility consumers. It can protect a switching transients, wiring issues, harmonic generation, load variations, and many more. In engineering situation, the quality of voltage is comparable to power quality. The resulting power is proportional to the product of the voltage and current. In an electrical system, power quality is crucial to improve that the system operates with minimal failure and destruction. In the absence of power quality management, the situation might form series issues on electrical devices along with load failure such as short-lived lifespan, malfunction or instability (Muni and Sangepu, 2015). As a result, power quality is critical in maintaining supply voltage within particular limitations.

2.2.1 Power Quality Issues

A Power Quality problem can be defined as deviation of magnitude and frequency from the ideal sinusoidal wave from. Good power quality is benefit to the operation of electrical equipment, but poor power quality will produce great harm to the power system. In daily user applications, a high quality power system constantly operates at the rated frequency and nominal voltage. As a result, it creates a clean sinusoidal waveform of electrical power to all sensitive equipment at industrial or commercial areas. Unfortunately, most of the distorted eruption assuredly occur resulting in the failure of load and equipment. Electronic equipment are functionally used to create a stable clean sine wave.

Eruption in electrical power systems hit in many actions such as voltage swing, over limit voltage, under voltage, voltage sags, voltage swell, harmonic, frequency deviation, unbalance voltage and flexion of transient (Ogheneovo Johnson, 2016). However, voltage sag and swell are the most trivial of power quality issues at the moment. They can cause problems with machinery and overall power quality in a plat. Thus, this consequences makes the quality of energy become poor. For this project, voltage sag and swell disruptions and its wavelets will be targeted.

Categories		Typical voltage magnitude in per-unit (pu)	Duration
Instantaneous	Sag	0.1 - 9.0 pu	0.5 cycles - 1 min
Memontary	Sag	0.1 - 9.0 pu	30 cycles - 3s
Temporary	Sag	0.1 - 9.0 pu	3 s - 1 min

Table 2.1: Classification and typical sag characteristic

Categories		Typical voltage magnitude in per-unit (pu)	Duration
Instantaneous	Swell	1.1 - 1.8 pu	0.5 cycles - 1 min
Memontary	Swell	1.1 - 1.4 pu	30 cycles - 3s
Temporary	Swell	1.1 - 1.2 pu	3 s - 1 min

Table 2.2: Classification and typical swell characteristic

The sample waveform of normal voltage, voltage sag and voltage sag respectively are displayed in figure below. For the normal voltage, the contepmlated value was 1.0 pu, while for the voltage sag the voltage waveform demonstrate that the voltage level is under-voltage as it below normal voltage. Voltage swell level shows a over-voltage in Figure 2.1.

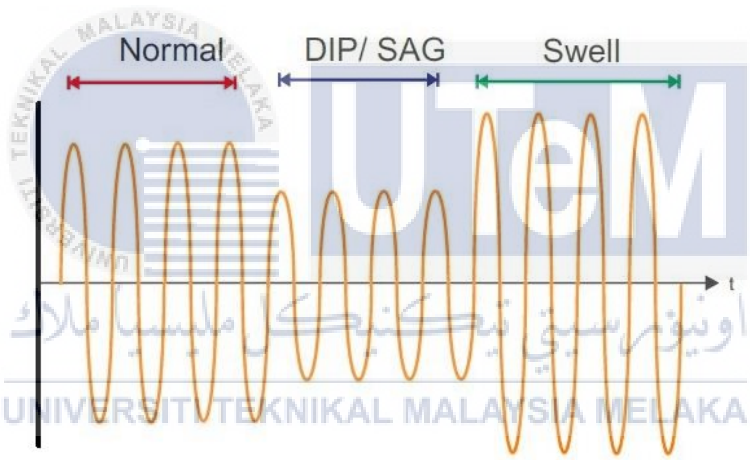

Figure 2.1: Comparison between normal, sag and swell voltage waveform

Unstable power quality can lead to the corruption of unstable equipment and other supplies, resulting in economic losses, as well as energy losses and a decrease in productivity. New users of electronic appliances or office facilities should be aware of the dangers of using electrical utilities with the breed of volatile electronic in their daily usage if they are disordered or malfunctioning. A few seconds of spikes or outages can shut down any firm for hours or days, resulting in significant financial losses. As a result of this difficulty, it has become clear that power quality monitoring is critical for effectively