Development of Early Warning Voltage and Frequency Fluctuation System

By

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DEDICATION

To Precious Father

To Beloved Mother

To Dear My Husband

To Dear Brother (Ali)

To Dear Sister (Alaa)

To My Children My Son and My Daughter (Mohammed & Fatima)

ACKNOWLEDGMENT

(In The Name Of Allah, the Most Gracious, the Most Merciful)

I would like grateful to Allah for providing me with his generosity and blessing to finish this research.

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LIST OF ABBREVIATION SYMBOL

AC	Alternative current
ADC	Analog to Digital Converter
ALU	Arithmetic Logic Unit
CLKIN	Clock In
CLKOUT	Clock Out
CPU	Central Processing Unit
DC	Direct current
DIP	Dual In-Line Package
EEPROM	Electrical Erasable Programmable Read Only Memory
EPROM	Programmable Read-Only Memory
EPROM	Programmable Read-Only Memory
FDR	Frequency Disturbance Recorders
FNET	Frequency Monitoring Network
HEX	Hexadecimal
I / O	Input /Output
IC	Integrated Circuit
IMS	Information Management Server
LCD	Liquid Crystal Display
LED	Light Emitting Diode
MCLR	Master Clear
MCU	Microcontroller Unit
PC	Personal Computer
PCB	Printed Circuit Board
PIC	Peripheral Interface Controller

PIC	Peripheral Interface Controller
PMU	Phasor Measurement Unit
RAM	Random Access Memory
RFR	Required Frequency Rang
ROM	Read Only Memory
RVR	Required Voltage Rang
TV	Television
VSM	Virtual System Modelling

Pembangunan Voltan Amaran Awal dan Frekuensi Sistem Turun Naik

ABSTRAK

A mikropengawal PIC 16F877 - litar pemantauan berasaskan direka bentuk, simulasi dan dilaksanakan. Litar ini telah bertujuan untuk memantau bekalan kuasa utama dan memberi amaran untuk melindungi peranti elektronik terhadap voltan dan kekerapan turun naik. Litar ini telah direka untuk terus memantau bekalan kuasa utama dan memastikan bahawa voltan utama dan kekerapan adalah dalam julat yang dikehendaki voltan (RVR) dan julat frekuensi yang diperlukan (RFR). Litar ini memberikan dua jenis jika voltan dan / atau kekerapan jatuh di bawah atau di atas RVR dan RFR masing-masing memberi amaran buzzer dan cahaya merah. Selain itu, melalui litar relay akan putuskan sambungan bekalan kuasa utama jika salah satu atau kedua-dua kejatuhan voltan dan frekuensi di bawah atau di atas RVR dan RFR. Juga, litar akan menyambung semula bekalan kuasa utama jika kedua-dua voltan dan kekerapan kembali stabil dalam RVR dan RFR. Perisian (Proteus) telah digunakan untuk mensimulasikan litar. Reka bentuk ini telah dilaksanakan dengan jayanya. Litar ini membolehkan pemantauan masa nyata sempadan kestabilan dan margin yang sama untuk titik operasi yang diperhatikan, yang digunakan untuk menyediakan pemantauan bagi masalah kestabilan baru muncul. Kajian ini telah dilanjutkan untuk memperkenalkan teknik logik kabur untuk menilai Sag dan Swell fenomena yang biasanya mendahului turun naik sistem bekalan kuasa dan kerosakan. Alat simulasi MATLAB digunakan untuk siasatan kini mengendur dan membengkak fenomena

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ABSTRACT

A microcontroller PIC 16F877 – based monitoring circuit was designed, simulated and implemented. The circuit has been intended to monitor main power supply and gives a warning to protect electronic devices against voltage and frequency fluctuations. The circuit was designed to continuously monitor a main power supply and ensure that the main voltage and frequency are within required voltage range (RVR) and required frequency range (RFR). The circuit gives two types of warning buzzer and red light if the voltage and/or the frequency fall below or above the RVR and the RFR respectively. Moreover, the circuit through a relay will disconnect the main power supply if either or both voltage and frequency drop below or above RVR and RFR. Also, the circuit will reconnect the main power supply if both voltage and frequency fall back stable in the RVR and RFR. The software (Proteus) was used to simulate the circuit. The design was implemented successfully. The circuit enables real-time monitoring of stability boundaries and the corresponding margin to the observed operating point, which is used to provide a monitoring for emerging stability problems. This study was extended to introduce the fuzzy logic technique to evaluate Sag and Swell phenomena that usually precede power supply system fluctuations and malfunctions. MATLAB simulation tool was used for the present investigations of sag and swell phenomena.

CHAPTER 1

INTRODUCTION

1.1 Introduction

The frequent and repeated blackouts and accidents of power systems had disastrously affect economy and social stability. Therefore, preventing power failure is an extremely important task for power engineers. The series of blackouts took place in many electrical systems demonstrated the need for reliable supply of electricity. Major system blackouts are initiated by a single severe disturbance (loss of generator or a tripping of a critical line connection) or even a multiple related event such a fault and a subsequent relay disoperation.

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A real-time monitoring of the stability boundaries have been used for obtaining an early warning for the occurrence of the emerging stability problem, thereby providing an increased time window for applying appropriate countermeasures that prevent the emerging blackout and the electrical system faults are the greatest threat to the continuity of electricity supply.

Electrical power system control centres contain large number of alarms received as a result of different types of faults. To protect these systems, the faults must be detected and isolated accurately. The development of an apparatus for detecting imminent failure of electric output power provided by an electric power supply due to the reduction or loss of input power becomes a necessity (Basil Hamed, 2012).

There are many apparatuses for detecting imminent failure of electric power supply either in the research stage or under commercialization. They range from simple design to very complex circuits. Each apparatus uses certain principles of operation. Recently, the use of wavelet transform technique becomes very common in diagnostic apparatuses. Wavelet transform is based on the decomposition of a signal and extract what is called frequency spectrum of the signal. However, wavelet transform is considered by researchers a powerful tool of analysis, but it is difficult to be used for field tests and measurement at present time.

The difficulty in using wavelet transformation for early warning systems voltage and frequency fluctuation is due to the need of expert system that substitute the need for the human expertise to interpet the sag and swell effect on the running of the power supply system. This need meets what is known as fuzzy logic technique (FLT). Fuzzy Logic is being used extensively in electrical engineering applications, and recently it is used in high voltage power system (HVPS). HVPS are classified into high voltage direct current (HVDC) and high voltage alternating current (HVAC). Both of them use FLT to control either power generation or power supply systems. FLT uses linguistic variables rather than crisp variables. This introduces difficulty and simplicity at the same time. The difficulty comes from the need to approporaitely define the membership functions. The simplicity is due to easy programming that is based on certain assumptions.

The present researche focus on integrating the monitoring and protection functions through voltage & frequency monitoring and relay mechanism. The aim of this research is to design an early warning system using PIC 16F877 microcontroller to monitor voltage and frequency amplitudes of the main power system and interrupts the supply when either or both voltage and frequency drop or exceed programmed ranges. The circuit will reconnect the power supply once the voltage and frequency amplitudes are recovered.

The PIC 16F877 microcontroller is a microprocessor and considered as a minicomputer that houses Read only memory (ROM), Random acses memory (RAM), serial communications ports, Analog to Digital Converter (ADC). The name microcontroller refers to the word (micro) which means small in size and the word (controller) which means the logic circuitry that controls machines, gadgets, etc. A microntroller can be used to build an intelligent machine, write a program on a host computer, download the program into the microcontroller via the parallel or serial port of the Personal Computer (PC), and then disconnect the programming cable and let the program run the machine that will enable voltage and frequency monitoring, protection, and recovery (Paul Scherz, 2000).

1.2 Problem Statement

Electric power systems have been reported to suffer repeated blackouts due to load-supply imbalances. This leads to major damage of electric and electronic devices. So, the need for alerting power workers becomes a necessity. As voltage and frequency fluctuations precede most of blackouts phenomena, an accurate measuring and monitoring of both voltage and frequency can be used as an alert and early warning for probable blackout occurrence. Integrating protection system into an early warning system will ensure safe and secure power supply and may prevent devices damage.

System recovery is the mechanism that restores the power when the voltage and frequency go back again to normal ranges.

1.3 Objectives

1. To design a programmable system based on PIC 16F877A microcontroller for real-time monitoring electrical power systems from overvoltage, under voltage, over frequency and under frequency impacts.
2. To maintain power system protection and restoration each-time voltage and frequency deviate from normal ranges through an efficient relay mechanism that disconnects and reconnects the power system.
3. Developed expert system to detect voltage and frequency fluctuation based fuzzy logic (FL).

1.4 Scope

1. Circuit design and components identification (voltage and frequency sensors, opt couplers, diodes, PIC type, relay type, etc.).

2. Define normal ranges of operation for both; voltage and frequency.

3. Simulate the circuit using Proteus software and perform system analysis.

4. Circuit implementation and testing.

1.5 Expected Results

To have an early warning and protection of power system based on PIC 16F877A microcontroller that is able to real-time monitor voltage and frequency of power supply systems and protect them in case of voltage and frequency instability. The expected results of both monitoring and protection functions of the circuit are accurate and highly responsive due to high performance of the PIC microcontroller.

1.6 Thesis Outlines

This project report is divided into five chapters. Each chapter have specific information, results and discussions related to this project. The detailed information for each chapter as described below:

Chapter 1: This chapter includes introduction of the project, objectives, problem statement and project scope. It also contains the main idea of this project and mainly what needs to be achieving in this project.

Chapter 2: This chapter will discuss on literature searched related to this project based on former researcher. Significant findings from former researcher also included.

Chapter 3: The third chapter holds the entire process on how the project is conducted in sequence. All the progress regarding simulation embedded smart early warning power failure system design with microcontroller PIC, fuzzy logic, programming PIC and hardware development are placed here.

Chapter 4: This chapter displays the results and discussion for the developed project .Compared between simulation and real hardware prototype is analyzed.

Chapter 5: The final chapter contains project summary, and future recommendation.

CHAPTER 2

LITERATURE REVIEW

2.1. INTRODUCTION

Most electrical devices and computer systems usually require early warning of imminent power failure, to provide sufficient time for an organized system shutdown. During the shutdown, sufficient energy must be stored in the power supply to maintain the output voltages above the minimum specified values. Literature shows that the progress of modelling has increasingly improved the research over the last few years and resulted into what is known electric power disturbance event (Keith Billings and Taylor Morey, 2011).

Real time modelling of power systems enables researchers and workers to act manually or automatically to counteract disturbances at early stages and provides enough time to reduce oscillations and control transient stability. (J. Daume, 1997) had shown that regional early warning system can be applied to warn operators for electric power disturbances and enable them to take proper actions just in time. These actions are usually preceded islanding. However, (Paul W. Oman and Jeff Roberts, 2002), indicated the following obstacles to build early warning system for electric power;

1. Lack of communications.
2. Vulnerability of the telecommunications and internet systems.
3. The absence of interoperability of substation communications protocols.

Recently, emerging technologies based on computer technologies might be used to stimulate development of early warning system (Hui Ren, Member, IEEE, 2012).

Therefore; to realize blackout's early warning, a need to determine how far the system is from the critical state is very crucial. Simulation is the powerful technique to perform the necessary computation and identify the criticality of the power system; moreover, it provides indicative indices and helpful aids for the operator (Rahamat Mohammad, Akhtar Kalam, 2013). Early warning system with up to 32 digital inputs (expandable up to 64) and up to 16 analog input channels, effectively makes use of the existing GSM Network for communication (Pourbeik, P., Kundur, 2006). To develop new solutions that aim at avoiding large scale blackouts to occur, it is important to understand causes and involved mechanisms in the process leading to a blackout. Figure 2.1 is derived from and illustrates a general sequence of events that can lead to a blackout (Voropai & Efimov, 2008).

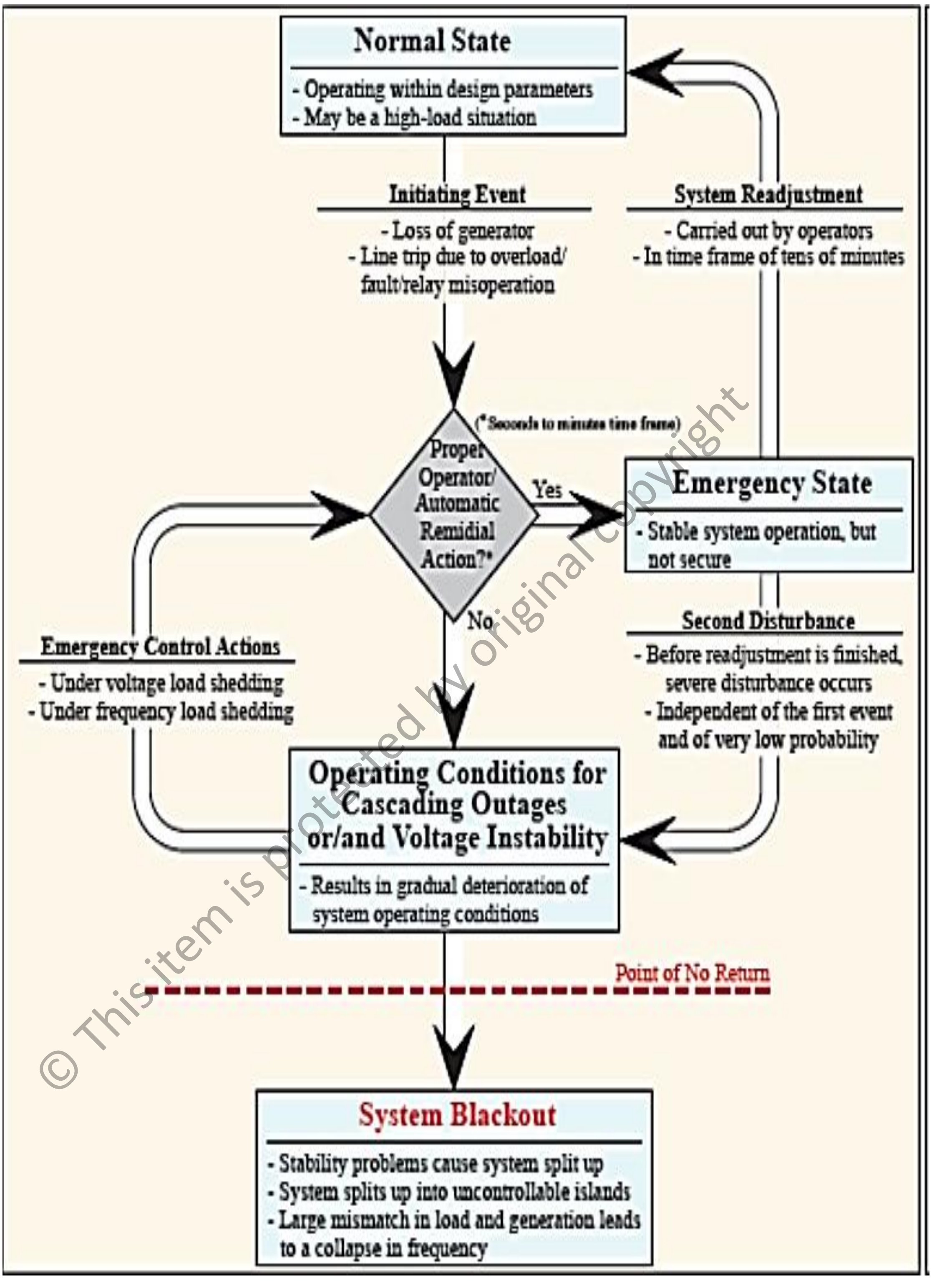

Figure 2.1: General Sequence of Events Leading To Blackout
(Pourbeik et al. 2006, Voropai & Efimov, 2008)

The increase in the impedance between the load and generation, as transmission lines trip, can lead to a number of stability problems (NERC Training resource working group, 2003). The frequency characteristics (time & space) usually vary with any disturbance, and it develops the properties of the electromechanical wave propagation phenomena (Adly, G. William & L. Peterson, 1990). The response of the frequency is property of the load - generation balance within control area (Adly, G. William & L. Peterson, 1990).

2.2. Load-Generation Balance

It was shown in the literature that when large generators are isolated from a power network, a remarkable frequency response is observed. It was also proven that the repetition of generator's loss is much higher that the loss of load. Therefore, the frequency response is discussed in the context of a loss of a generator (Adly, G. William & L. Peterson, 1990). The energy consumption must be equivalent to the energy generation to maintain stable frequency. It has been found that frequency is uniform throughout an interconnection and can be easily measured. The data collected from monitoring systems of power networks, which are related to frequency can be used to do system analysis and control. Normally, static frequency is widely measured (H. Karimi, 2004) and available.

2.3. Measuring and monitoring tools

Electrical engineers have developed many measuring tools to watch and monitor the dynamics of a power system.

2.3.1. Phasor Measurement Unit (PMU)

The synchronized phasor measurement unit (PMU) was one of those measuring tools that developed and commercialized in the late 1980's. Many applications have been developed using wide-area measurement systems. Early work resulted into the need of wide-area measurement coverage (Y. J Shin, et al, 1999). To obtain a low cost frequency measuring tool with reasonable accuracy, a wide-area GPS synchronized system is to be installed and used for an early warning systems (Novosel and Udren, 1996).

If a disturbance takes place in power systems, a considerable variation in space and time of frequency will occur (Martinez and Dortolina, 1994). Any system that utilizes these variations in time and space of frequency may be used to watch and monitor power systems based on frequency in-real time change. Therefore, it is possible to predict any power system malfunction or contingency. Such contingency or malfunction could be loss of generation that can be indicated as oscillation and fluctuations of voltage and frequency. Because of the dynamic problems of the power systems, it is very difficult to be operated and control. The instability of a frequency was shown to happen when a noticeable mismatch between generation and load occurs (J. Chen, 1994).

2.3.3. Fuzzy Logic (FL) Systems

Fuzzy Logic (FL) Systems which was historically introduced in 1965 at university of California Berekly by a mathematician and computer scientist named Lotfi Askar Zadeh the concept of (FL) to control electrical systems. A fuzzy logic system has four blocks as shown in Figure 2.2. Raw input from this device is adapted into fuzzy values for each input fuzzy set with the fuzzification block. The universe of discourse of the input variables determines the required scaling for correct per-unit operation. The scaling is super critical because the fuzzy system can be retrofitted with other devices or ranges of operation, by just converting the scaling of the input and output. The decision-making-logic determines how the fuzzy logic processes are performed (Sup-Min inference), and alongside the knowledge base controls the output of each fuzzy IF-THEN rules. Those are merged and improved to crispy values within the defuzzification block.

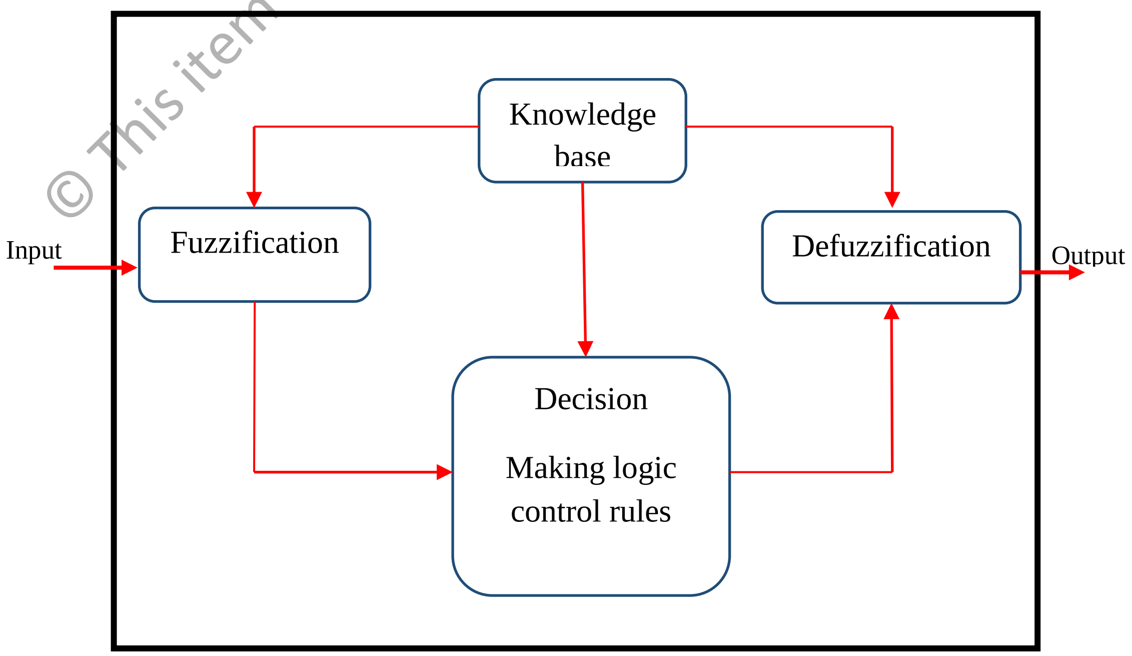

Figure 2.2: Fuzzy Controller Block Diagram