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UNIVERSITI PUTRA MALAYSIA

GLOBAL SYSTEM FOF MOBILE-BASED DATA ACQUISITION FOR MONITORING OF POWER DISTRIBUTION SYSTEM

MUBASHAR M. B. KASSIM

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By

MUBASHAR M. B. KASSIM

Thesis Submitted to the School Graduate Studies, Universiti Putra Malaysia, in Partial Fulfillment of the Requirement for the Degree of Master of Science

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GLOBAL SYSTEM FOF MOBILE-BASED DATA ACQUISITION FOR MONITORING OF POWER DISTRIBUTION SYSTEM

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MUBASHAR M. B. KASSIM

September 2008

Chairman: Senan Mahmod Bashi, PhD

Faculty: Engineering

Modern electrical distribution systems are monitored and controlled remotely using Supervisory Control and Data Acquisition (SCADA) System. A control center that receives on-line information about the network must control and monitor the medium and large power distribution system that usually covers large geographical area.

GSM network currently covers almost all the parts of the country and this makes it possible in terms of feasibility to place and collect data from distribution power system using this communication network which reduces the cost of establishing the system communication for large geographical area like the distribution of power system.

A prototype of power factor correction and remote data acquisition with control center based GSM network has been presented in this thesis. The operating parameters of the power distribution system have been monitored in the control center beside the operation of the power factor correction. The proposed design of the prototype

integrate sensors package with GSM controller which was programmed using Java to Micro Edition (J2ME). The GSM controller was programmed to control the power factor and send the acquired information to store it in the database of the control center. This database will be a useful source for the utility of distribution system after analyzed it to help the distribution system in monitoring the operational behavior and identify faults before any problem failure thus resulting in significant cost saving beside the improve of system reliability. The measurements obtained have a small error when compared to previous work. The error was 6 mV on a 5000mV scale while the previous work of Al_Ali *et al*., (2004(a)) was 10 mV on the same scale. By sending and receiving Short Message Service (SMS), the system achieves the functions of data transmitting, data processing, system diagnosing, alarm sending and report generating.

Abstrak tesis yang dikemukakn kepada Senat Universiti Putra Malaysia sebagai memenuhi keperlan untuk ijazah Master Sains

PEMEROLEHAN DATA BERASASKAN SISTEM SEJAGAT MUDAH GERAK UNTUK PEMANTAUAN SISTEM PENGAGIHAN KUASA

Oleh

MUBASHAR M. B. QASSIM

September 2008

Pengerusi: Senan Mahmod Bashi, PhD

Fakulti: Kejuruteraan

Sistem Penjanaan Kuasa Moden sekarang dikawal dan dikendalikan menggunakan Sistem Mengawasi Kawalan dan Pengumpulan Maklumat (SCADA). Pusat pengumpulan maklumat yang menerima informasi rangkaian ini mesti perlu mengwal sistem penjanaan kuasa secara sederhana dan besar yang meliputi kawasan geografi yang terlibat.

Pada masa sekarang, rangkaian GSM meliputi semua kawasan di negara ini, dan ia membuatkan sistem ini mampu dilaksanakan bagi mendapatkan maklumat dari sistem penjanaan kuasa dengan menggunakan rangkaian komunikasi yang akan menyebabkan pengurangan kos bagi membina sistem komunikasi di kawasan geografi yang besar seperti penjanaan bagi sistem kuasa.

Prototaip bagi pembetulan faktor kuasa (power factor correction) dan kawalan pengumpulan data (remote data acquisition) yang mengawal pusat maklumat

rangkaian GSM telah dilaksanakan dalam tesis ini. Operasi parameter bagi penjanaan kuasa telah diawasi di dalam pusat pengumpulan maklumat sambil operasi pembetulan faktor kuasa (power factor correction) dilakukan. Rekabentuk yang dicadangkan bagi prototaip penyatuan pakej sensor menggunakan kawalan GSM ini diprogramkan mengunakan Java ke edisi mikro . Pengawal GSM ini telah diprogramkan untuk mengawal factor kuasa dan menghantar maklumat yang diperolehi untuk disimpan di dalam system pengumpulan maklumat pusat kawalan. Maklumat terrkumpul yang telah dianlisa merrpakan sumber bergrna untuk pengguraan sistem pengagiham kuasa, seterusnya membantu sistem pengagiham dalam pemantauan prestasi operasi dan mengenalpasti permasalahan sebelum sebarang kerosakan berlaku, yang diperolehi mempunyai ralat yang kecil berbanding dengan hasil kajian sebelum ini. Ralat yang di perolehi ialah 6mV berdasarkan skala 5000mV, sementara ralat daripada hasil kajian Al-Ali *et al*., (2004(a)) ialah 10 mV berdasarkan skala yang sama. Melalui penghantaran dan penerimaan khidmat mesej ringkas (SMS), sistem ini mampu melakukam penghantaran data, pemprosesan data, pemeriksaan sistem, penghantaran penggera dan penjanaan laporan..

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I certify that a Thesis Examination Committee has met On 19 September 2008 to conduct the final examination of Mubashar Mohammed Basheer Kassim on his thesis entitled "Global System for Mobile-Based Data Acquisition for Monitoring of Power Distribution System" in accordance with Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

Member of the Examination Committee were as follows:

Raja Syamsul Azmir b. Raja Abdullah, PhD
Lecturer
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

Mohd Fadlee A. Rasid, PhD
Lecturer
Faculty of Engineering
Universiti Putra Malaysia
(Internal Examiner)

Hashim b. Hizam, PhD
Lecturer
Faculty of Engineering
Universiti Putra Malaysia
(Internal Examiner)

Azah Mohamed, PhD
Professor
Faculty of Engineering
Universiti Kebangsaan Malaysia
(External Examiner)

_____
HASANAH MOHD. GHAZALI, PhD
Professor and Dean
School and Graduate Studies
Universiti Putra Malaysia

Date: 29 January 2009

This thesis submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Master of Science. The members of the Supervisory Committee are as follows:

Senan Mahmod Bashi, PhD
Associate Professor
Department of Electrical and Electronic Engineering
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

Norman Marium, PhD
Professor
Department of Electrical and Electronic Engineering
Faculty of Engineering
Universiti Putra Malaysia
(Member)

Ishak b. Aris, PhD.
Associate Professor
Department of Electrical and Electronic Engineering
Faculty of Engineering
Universiti Putra Malaysia
(Member)

HASNAH MOHD.GHAZALI
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 12 February 2009

DECLARATION

I declare that the thesis is my original work expert for quotations and citation, which have been duly acknowledged. I also declare that it has not been previously and is not concurrently submitted for any other degree at UPM or at any other institutions.

Mubashar M. B. Kassim

Date: 1 / 12 /2008

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

A/D	Analogue to Digital
AC	Alternating Current
AN	Analogue Input
API	Application Program Interface
AT	Command Language
CDC	Connected Device Configuration
CLDC	Connected Limited Device Configuration
CMOS	Complementary Metal-Oxide Semiconductor
COM	Common Output
CPU	Central Process Unit
CSD	Circuit Switched Data
CT	Current Transducer
DA	Distribution Automation
DAS	Data Acquisition System
DCC	Distribution Control Center
DCS	Distributed Control System
DTMS	Distribution Transformer Monitoring System
EGPRS	Enhanced General Packet Radio Services
GSM	Global System for Mobile communication
GPRS	General Packet Radio Service
HMI	Human Machine Interface
HSCSD	High Circuit Switched Data
HTTP	Hypertext Transfer Protocol
I/O	Input/Output
I	Current
IEEE	Institute of Electrical and Electronic Engineers
IED	Intelligent Electronic Device
IMLET	Java Application that Runs According to the Information
IMP	Information Module Profile
J2EE	Java 2 Enterprise Edition
J2ME	Java To Micro Edition

J2SE	Java 2 Standard Edition
JVM	Java Virtual Machine
LAN	Local Area Network
LED	Light Emitting Diode
M2M	Machine to Machine
MIDP	Mobile Information Device Profile
MTU	Master Terminal Unit
NCL	Normally Closed Output
NMT	Nordic Mobile Telephone
NOP	Normally Open Output
P	Real Power
PC	Personal Computer
PDC	Personal Digital Cellular
PF	Power Factor
PLC	Programmable Logic Controllers
PMU	Phasor Measurement Unit
PT	Potential Transformer
Q	Imaginary Power
R	Resistance
RAM	Read Access Memory
RF	Radio Frequency
ROM	Read Only Memory
RPF	Reading Power Factor
RTU	Remote Terminal Unit
SCADA	Supervisory Control And Data Acquisition
SCC	Signal Condition Circuit
SMS	Short Message service
SMSC	Short Message Service Center
SPDT	Single Pole Double Throw
TACS	Total Access Communication System
USB	Universal Serial Bus
V	Voltage
VB	Visual Basic language program

W	Watt
WDP	Wireless Datagram Protocol
WMA	Wireless Messaging API
WTK	Wireless Toolkit
WTP	Wireless Transaction Protocol
Θ	Phase Angle Between Current and Voltage

CHAPTER 1

INTRODUCTION

1.1 Importance of This Study

In the modern electric power system, elements such as generators, transformers and transmission lines are usually monitored and controlled from remote control centers. The importance of this monitoring and control leads to the reduction of system losses, a higher quality and more reliable power supply in addition to the decrease peak demand and rich return of revenue (Gupta and Srivastava, 2004).

The system of Supervisory Control and Data Acquisition is called SCADA, however, this term is generally accepted to describe the system that monitor and control the distribution of critical infrastructure public utilities (water, electricity, oil and gas). The use of SCADA system became popular in the 1960's as a step for a more efficient monitor and control on the distribution remote equipment. Many early SCADA systems used mainframe computer technology, making these system hierarchical, centralized and required human oversight to make decision (Clarke *et al*., 2004).

The development of SCADA can be traced back to the early 1900's with the advent of telemetry which involves the transmission and collection of data obtained by sensing real-time conditions (Graham and Patel, 2004). While SCADA systems have been employed to monitor and control industrial facilities for decades, the designs of these systems, their components, and the communications protocols are primarily

proprietary. With the advent of the Internet, many SCADA monitoring and control networks have been connected at some level, to be open networks (Ward, 2004).

The problem statement of this work is to incorporate mobile technology into distribution measurement of SCADA system by design a prototype of Power Factor Correction (PFC) operation and remote Data Acquisition System (DAS) as apart of SCADA to serve as control and monitor devices using SMS. As a consequence of substantial research in the area of remote monitoring and control in village power network and the shortage existing in the current communication method, an attempt of applying Global System for Mobile communication (GSM) network with SMS service in remote data collection device was made. This method is currently available and is being used for monitoring the distribution system and to control some elements which the real time does not require.

1.2 Aim of Study

The aim of this study is to design a prototype of PFC and remote DAS with Control Center (CC). This system as a part of SCADA system based on GSM network, monitor the operating parameters of power distribution system such as Voltage (V), Current (I), power Factor (PF), Real Power (P) and Reactive Power (Q), send information as SMS text message periodically to CC, give alarm notification for abnormal conditions and store the operating parameters on data base for future analysis. The operation of PFC has been implemented and monitored beside the other parameters. The proposed system has been designed and fabricated with field instrumentation that contains the pack sensors and Signal Condition Circuit (SCC). In

addition, the hardware of the relay with the bank capacitor is constructed in order to achieve the operation of PFC as shown in figure1.1.

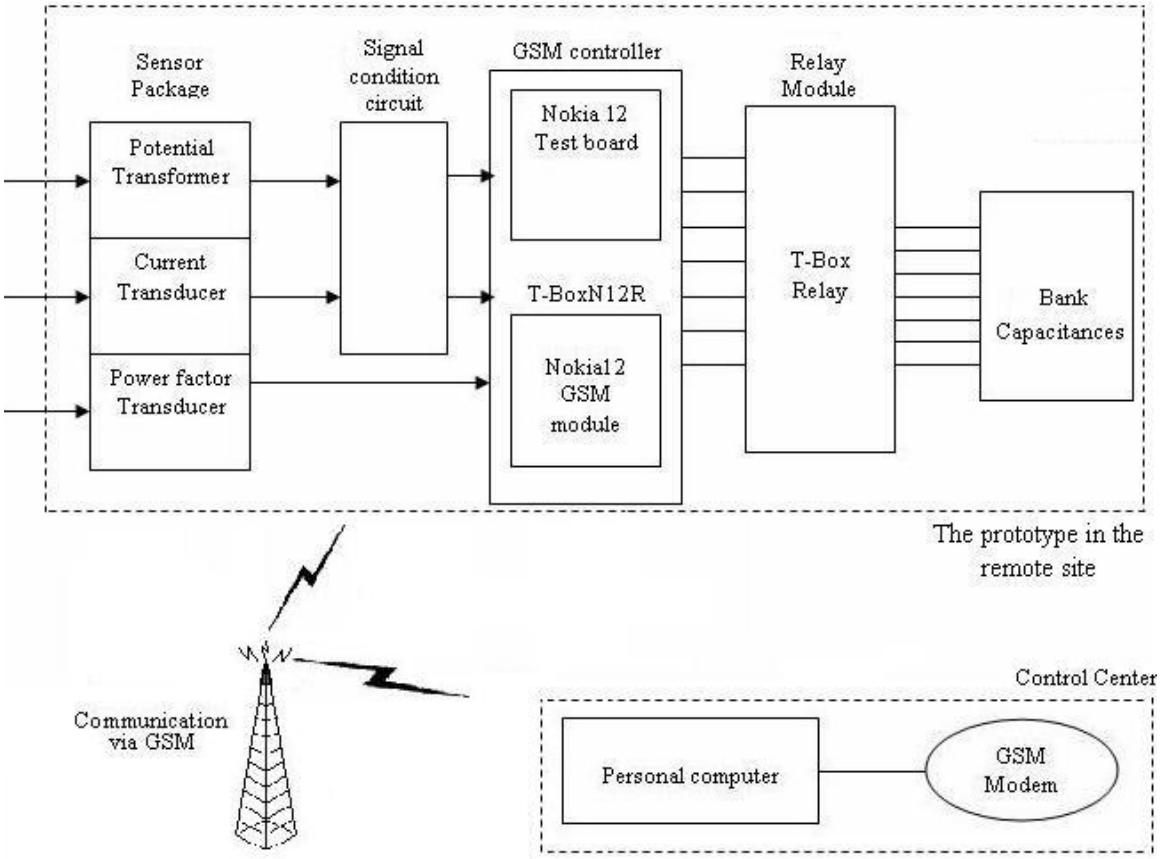

Figure1.1: Block Diagram for the Prototype Model of PFC and Remote DAS Based GSM Network

Remote Terminal Unit (RTU) represented with GSM controller (T-BoxN12R) which communicates with the CC via GSM network SMS service. CC consists of Personal Computer (PC) connected to GSM modem to receive/sent SMS sent from/to GSM controller. The Capabilities of Nokia 12 IMP 1.0 Concept Simulator has been used to test the functionality of the software program before uploading it to the GSM controller which has been developed with J2ME. The main program in the CC has been designed using Visual Basic (VB) program language. In UAE, GSM based data

acquisition and monitoring has been applied in distribution transformer using SMS message to monitor and record the operation parameters of the transformer like load current, transformer oil and ambient temperatures. The CC was not involved in this project. In UK, the GSM has been used as communication interface between the RTU and the CC in Manchester. In power plants also the GSM network has been used for remote control and monitoring in the plant. In the field of environment, the GSM network has been applied for remotely distributed environmental monitoring devices.

1.3 Objective

The major objectives of the work reported in this research are as follow

- To review the data acquisition system used in the electrical distribution and other distribution systems.
- To come-up with the design of GSM prototype in the remote site based data acquisition for monitoring the operating parameters of the power distribution system.
- To achieve the functions of PFC, data transmitting, system diagnosing and alarm sending via SMS.
- To come up with control center for data presenting, processing and report generating.
- To connect the prototype to actual feeder and test the operation of remote monitoring based SMS.

1.4 Thesis Organization

This thesis is organized in five chapters; Chapter One gives an introduction to the project. The objectives and scope of the study are also presented.

Chapter Two contains a critical literature review of common SCADA used as well as the communications methods used in monitoring and acquiring the operation parameters in power system utilities. This chapter also discusses the used of GSM network as a communication method with SMS services and its implementation in the power system and other utilities.

Chapter Three describes the design of the hardware and software for the prototype of PFC and remote DAS based GSM network to monitor and acquire the operation parameters of power distribution system. Different components such as transducers, transformers and capacitors have been chosen in order to construct the circuit according to the proposed rating. This chapter also gives an introduction to JAVA language and the steps to developed program (J2ME) which has been used in the GSM controller. In addition, the function of the GSM controller has been checked using Nokia 12 IMP 1.0 Concept Simulator. The design and implementation of hardware and software requirement of the system are identified.

Chapter Four presents the result obtained from the implementing and testing the prototype in the laboratory and by connecting the prototype to actual feeder for monitoring and acquiring the operating parameters in power distribution system.

Chapter Five deals with conclusion drawn from the work reported in this research. The laboratory implementation and the testing of hardware and software of the prototype based GSM network for monitoring the operation parameters and correcting the PF provide satisfactory results. The recommendations of the future studies related to the same topic are also mentioned.