Mohd Ruddin Ab Ghani
Professor of Electrical Engineering, Universiti Teknikal Malaysia Melaka
System Engineering and Control- Energy and Distribution Automation System-Optimization - Operational Research
Verified email at utem.edu.my

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Authors
W.N.S.E. Wan Jusoh, M.A. Mat Hanafiah, S.H. Raman, M.R. Ab Ghani
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Development of a New Modeling Circuit for the Remote Terminal Unit (RTU) with GSM Communication

[1,1]W. N. S. E. Wan Jusoh*, [1,2]M.A. Mat Hanafiah, [1,3]S.H. Raman, [1,4]M.R. Ab. Ghani
[1]Faculty of Electrical Engineering, Universiti Teknikal Malaysia Melaka (UTeM), Durian Tunggal, Melaka, Malaysia
[1]M011210005@student.utem.edu.my, [2] ariff@utem.edu.my,
[3]M011210004@student.utem.edu.my, [4]dpdruddin@utem.edu.my

Abstract— **This paper introduces the design and development of Intelligent Remote Terminal Unit (RTU) which is to be applied as an automation technique for operating and controlling the low voltage (LV) downstream of 415/240V to enhance reliability of power for the consumers. The design proposed based on Global System for Mobile (GSM) communication and this paper also presents an efficient design for distribution automation system and its implementation in remote/automatic monitoring and controlling of the relays (circuit breaker) by means of GSM Short Message Service (SMS) services, automatic decision making and continuous monitoring of distribution system components in real time [1]. The systems has been equipped with microcontroller as a main component which act as an RTU programmed using Microcontroller PRO compiler software. The RTU provides monitoring fault operation, controlling functions and data collection for analysis. RTU will initiate the transaction with the digital and output modules. The master of this system is RTU and the slaves are digital and output modules. RTU plays an important role in detecting fault and assigned to serve message immediately in the control room. This system involves the detection of fault connected to the microcontroller (PIC18F77A) and GSM modem. When the fault occurs, the sensor will send the signals to the PIC16F77A. The PIC is programmed to process the data and send the signals to the GSM modem. Once received the data, GSM will send the message to the control room operators or other authorized personnel to alert them on the current situation through cellular phone. The results are then communicated between hardware circuit and simulation circuit for the final conclusion with the properly functional algorithm.**

Keywords—**Remote Terminal Unit (RTU); Global System for Mobile (GSM) communication; Intelligent Microcontroller**

I. INTRODUCTION

This remote terminal unit (RTU) system is designed to alert in the event of fault on the low voltage supply 415/240V systems only. The main task of this RTU is to detect faults due to the over voltages and miss-setting voltages of the Taps on the transformers. It is also to facilitate the process of monitoring and maintenance in the event of faults. The breakdown repair works will be smooth and easy to control. This method utilizes automation concept on creating of an intelligent RTU through modification and innovations.

In general, the project is fully hardware configuration and categorized into two parts: The electronics and telecommunications. This project used the transmitter, which sends a signal to a receiver that links to the controller system operated through the PIC microcontroller. The Microcontroller PRO Compiler is used to monitor and control signals to the modem by connecting the RS232 serial port communication between GSM modem and hardware. AT commands are simple standards to control the modem function.

This system involves tracking the fault systems associated with the PIC and GSM modem. When a fault is detected, a signal is immediately sent to the PIC. The status is shown in the LCD display. Next, the PIC will process the data and send a signal to the GSM modem. After that, the GSM modem will immediately send an SMS to the control room through the mobile phone. The Microcontroller is the key elements that control the entire operation, including the real time taken to process the SMS data to be sent.

II. ARCHITECTURE OF SYSTEM

The proposed system architecture consists of two parts. The first part is designing the new modeling circuit of an intelligent RTU which equipped with microcontroller, current and voltage sensors and the protection relay. The second part is the communication of GSM modem network. The changes occur will be monitored by Master Terminal Unit (MTU) which is consists of personal computer such as Human Machine Interface (HMI) or computer hyper-terminal. The concept of designing RTU start with creating a program for the microcontroller which act as a field interface devices that transfer the compatible language. The microcontroller is also able to convert electronics signals received from field devices using communication protocol to transmit data over GSM communication. The measurement devices used are voltage and current sensors which provide information data that could informed the operator on the approximately higher than the rated interrupting current and voltage.

Designing a system for monitoring and controlling machine and devices in remote locations can be done through a variety of communications options such as wireless LAN technology, dial-up modems, private radio networks, satellite communication, and cellular network. Among these options the

most convenient solution for remote access is GSM technology, available almost everywhere and require no cabling; its costs are sinking now due to the struggle for market share between GSM operators, making it very attractive solution for designing of distribution automation system [1]. GSM modem functions as a communication media that do not required a physical link between transmitter and receiver to transfer data to and from different sites. The overall concept of the system is shown in Figure 1.

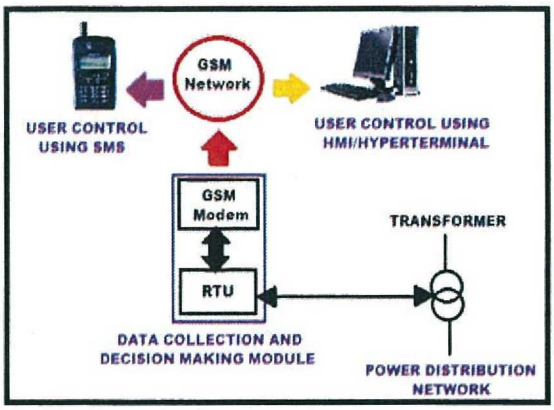

Fig1. The RTU system via GSM network [1]

III. HARDWARE CIRCUIT DESIGN

Figure 2 shows the hardware architecture of the proposed systems. It is consist of microcontroller (PIC16F877A), data collection part, accessory part, GSM modem and power supply with a backup battery, surge protection against spikes, real time clock and watchdog timer to ensure that it restarts when operating in the sleep mode.

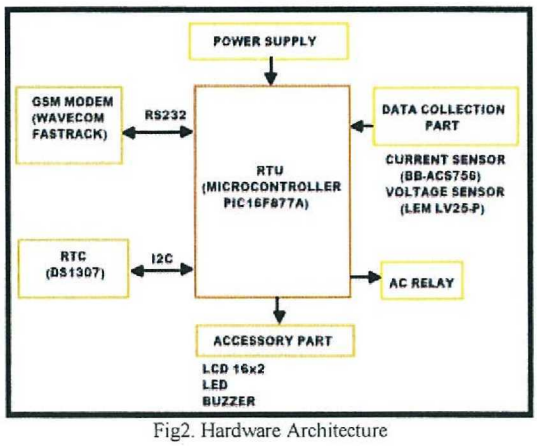

Fig2. Hardware Architecture

PIC16f877A is belonging to the class of 8-bit microcontrollers of RISC architecture. The CPU or microcontroller is the core components of microcomputers and it require the external components such ROM, RAM and I/Os for accomplish their purposes. PIC can be operating using 5V DC voltage. It is DIP layout (dual in line package) and sufficient for the whole project. The digital output of the PIC is 5V to give the signal 1 and 0V for the 0 signal, which means that when the PIC pins are set as digital inputs, it will detect input voltage 5V as signal 1 and 0V as signal 0. PIC has 40 pins, but only 33 I/O pins can be assigned as digital input or output [4]. The crystal oscillator used is 20MHz, which execute every single program line in the system. 20MHz is used because it is the maximum frequency that the PIC can support.

The data collection part consist of two sensors, they are current sensor and voltage sensor. In this project, the BB-ACS756 current sensor is chosen because of it precision and consists of low-offset linear Hall sensor circuit with a copper induction path located near the die. When current is applied through this copper conduction path, it generates a magnetic field which is then sensed by the integrated Hall IC and converted into a proportional voltage [2]. The LV25-P is a voltage transducer that acts as a voltage sensor because it used the principle of voltage measurement. A current proportional to the measured voltage must be passed through an external resistor which is selected by the user and installed in series with the primary circuit of the transducer [3].

The RTC is used to set actual time operation that function as a timer to microcontroller. RTC used in this architecture is DS1307. The benefit of this RTC is it could keep track of the time even the power supply is cut off because it has 3V backup battery supply. In conjunctions to cut off the power supply when fault current is detected, AC relay is used. SRS 05VDC-SH is the type of AC relay used in this system. This relay is a single pole double throw type of relay that operates with maximum voltage of 5VDC and current of 3A.

For the accessory part, LCD 16x2 is used for display unit. The purpose of this LCD is, it will display all the microcontroller activities to acknowledge the user the current and voltage operation that occur in real time. A keypad is added to the LCD display so that the indicated data of voltage and current at RTU board can be sent to the computer interface via communication media. The RTU keypad also can be used to set the password which means only the developer and the team could control or change the setting of the RTU.

Figure 3 shows the connection between PIC16F877A to the GSM modem through RS232 cable with MAX232 converter. The system uses GSM modem brand Wavecom fastrack and controlled by AT command for all kinds of operations.

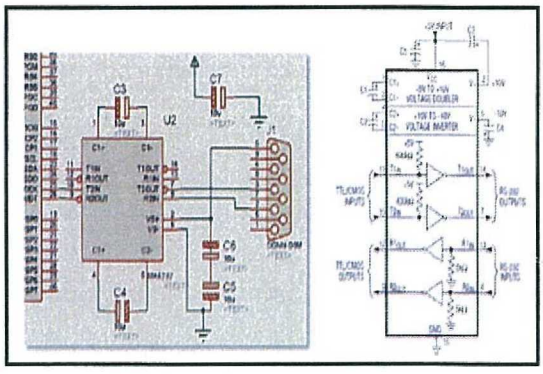

Fig3. Connection between PIC16F877A and GSM modem with MAX232 circuit

In order to transmit signal to GSM modem, it must uses MAX232. It allows transmission in RS232 cable. The MAX232 device is a dual driver/receiver that includes a capacitive voltage generator to EIA-232 voltage levels from a single 5V. MAX232 chip used in the circuit is for the interfacing between the Receiver module (Rx module) and the GSM modem. The MAX232 is also acts as a buffer driver, by converting the digital logic 0-5V receiving signal into RS232 standard -12 to 12V. It requires five extra 1uF capacitors, which are used to generate the 12V and -12V swing.

The system uses the AT commands to deal with the GSM modem. In fact the AT commands are the commands that allow a modem performing certain functions. They begin with the command AT. The modem initialization string consists of a series of commands. It prepared the modem for communications, setting such features as dialing mode (tone or pulse), waits, detection of the busy signal and any other settings. Newer modem communications programs reset the initializations string according to which menu options selected or which features are enabled prior to the introduction of the Bulletin board system, modems typically operated on dedicated point-to-point telephone lines that always terminated to a modem at the far end. In other situations, the user would dial the phone manually before connecting, or pick it up if it rang. In a few cases the computers themselves had to call a selection of numbers, and for this task they used a separate "dialer", plugged into a different input or output port on the computer (typically on RS-232 port).

The modem could switch itself to one of the two modes:

- Data mode in which the modem sends the data to the remote modem. A modem in data mode treats everything it receives from the computer as data and sends it across the phone line.
- Commands mode in which the data is interpreted as command to the local modem (a command to execute by the local modem).

The following section describes the AT- command set. The commands can be tried out by connecting a GSM modem to one of the PCs COM ports. Table 1 gives an overview of the implemented AT-Commands in the application.

TABLE I. SETTING FOR GSM

COMMAND	DESCRIPTION
AT+CMGF	SMS string format, how they are compressed
AT+CSMP	Text parameter
AT+CPMS	Selection of SMS memory
AT+CNMI	Display of new incoming SMS

The use of the commands is described in the Table 2 below:

TABLE II. APPLICATION FOR GSM SETTING

COMMAND	DESCRIPTION
AT+CMGS	Send message from a given recipient
AT+CMGR	Read new message from a given memory location
AT+CMGD	Delete message
AT+CMGL	Read all message

The schematic circuit connection between PIC16F877A and GSM communication by Proteus simulation is shown in Figure 4.

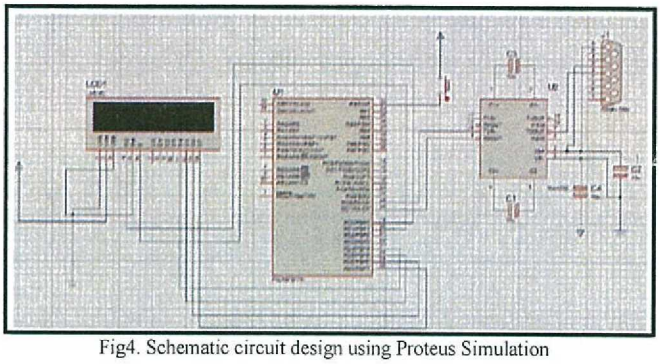

Fig4. Schematic circuit design using Proteus Simulation

Based on the simulation, the flowchart of the GSM communication is coded and programmed to indicate the sequence process of data transmitted and received by RTU. The flowchart is shown in Figure 5.

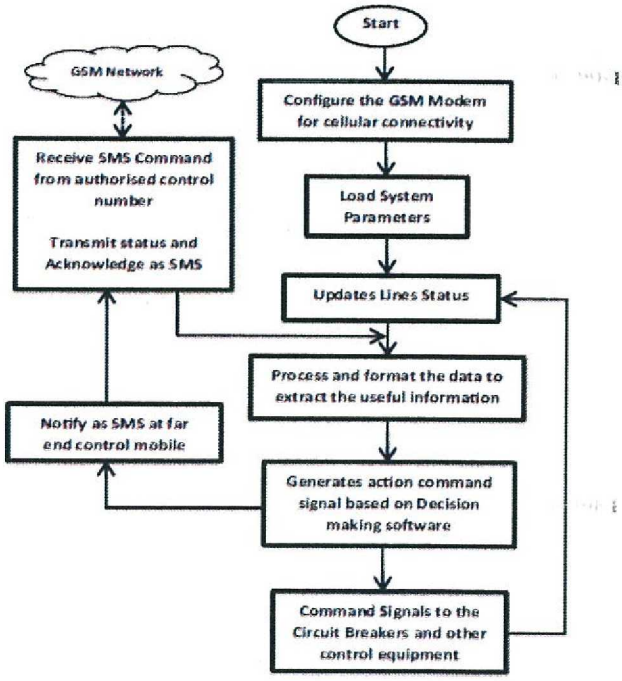

Fig5. Software flow for the proposed design [1]

IV. RESULT AND DISCUSSION

Remote Terminal Unit for DAS via SMS serve as a warning or alert system to the control room operators as fast as possible in the event of faults in the distribution system, which is often a power failure to the user. If a fault is detected, the system will get the pulse from RTU which then will immediately send a signal to the PIC microcontroller. The PIC immediately processes the data received and sends a signal to the GSM modem. Within few seconds, the GSM modem will send a SMS to the phone of the operator in the control room or other authorized personnel. So that the operator in charge of the control room is alert and immediately contact the maintenance or take other steps to overcome the problems. In general, the project schematics circuit and overall testing are properly functioning. Nevertheless, further research will be carried out for continuous improvement.

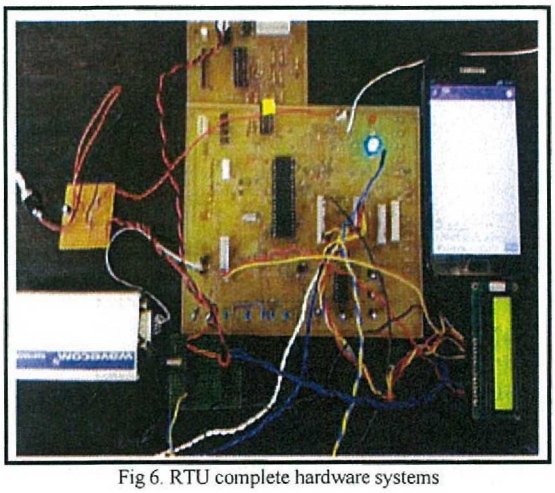

Fig 6. RTU complete hardware systems

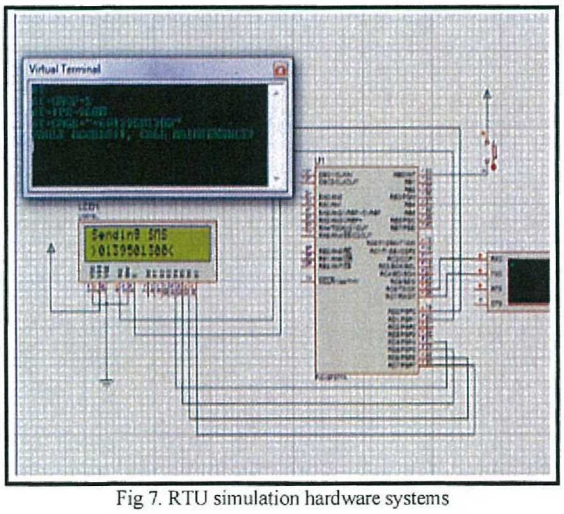

Fig 7. RTU simulation hardware systems

V. CONCLUSION

RTUs are small computerizes units deployed in the field at the specific sites and locations. RTUs serve as local collection points for gathering reports from sensors and delivering commands to control relays. The contribution of this paper is giving the novelty for the design and development of a new modeling circuit for the remote terminal unit (RTU) hardware and it functions. The developed system is designed to detect the fault location and cut off the power supply before the fault causing damage to the loads. The operating system described in this paper is capable to identify the fault location automatically and effectively. Hence, reduces the time for fault detection and identification.

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