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Session 7C - Day 4, 23rd May 2014 (Friday) **Smart Distribution System** **Room : Room 3** **Time : 8.30 a.m. – 10.30 a.m.** **Chair : Razali Budin**	
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9.15	**Remote Terminal Unit (RTU) Hardware Design and Development for Distribution Automation System** *By: Wan Nor Shela Ezwane Wan Jusoh (Universiti Teknikal Malaysia Melaka, Malaysia); Datuk Prof. Dr. Mohd Ruddin Ab Ghani (UTeM, Malaysia); Mohd. Ariff Mat Hanafiah (Universiti Teknikal Malaysia Melaka, Malaysia); Siti Hajar Binti Raman (Universiti Teknikal Malaysia Melaka, Malaysia)*
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Remote Terminal Unit (RTU) Hardware Design And Development For Distribution Automation System

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Abstract— **This paper introduces the design and development of Remote Terminal Unit (RTU) circuit and hardware implementation which represented in Distribution Automation System (DAS). The design based on microcontroller using PIC16F877A and also introduces the Orcad software to design circuit for the RTU. RTU is a standalone data used to monitor status and alarm, sequence of events, counters/pulse accumulators, binary code decimals and analog inputs. The function of RTU is to collects all the data from the plant, digitize them and send to the master station through the communication network. RTU also receives command from control center (master station) and executes it at the substation.**

Keywords—Remote Terminal Unit (RTU); microcontroller; Orcad software; Distribution Automation System (DAS)

I. INTRODUCTION

Remote Terminal Unit (RTU) is a part of SCADA system (Supervisory Control and Data Acquisition) or DA system (Distribution Automation) [1-3]. It essentially allows remote monitoring and control of plan/substation. The roles of RTU is to allow the operators at the network control center to manage and operate the power system, provide historical and sequence of event (SOE) data for fault investigations, provide historical trend data for networking planning and monitor plant parameters that can be used to trigger maintenance (condition based maintenance) as well as trend data for predictive maintenance [4].

Based on the relevant researched, the hardware design started from the sketch with the consideration to the previous RTU developer. In 2012, Eng.Wael E. Matti and Dr. Jabir S.Aziz [5] with the journal titled "Design and Implementation of General Purpose Remote Terminal Unit (RTU)" have developed the hardware with supply voltage of 5V, operating frequency at 5Mhz, output current 100mA, bit rate 10Mbs and when the RTU is switched ON, the other parts (sensors, microcontroller, communication) activated and connected to the central unit, connection started requesting RTU to send its processed data to the central unit. In 2011, Hong Chan Chang et al. [6] with the paper titled "Design and Implementation of RTU for Feeder Automation System with High Performance Microcontroller" developed the hardware with power supply DC 24V and DC 3.3V, 80Mhz operating frequency, 16 digital input, 8 digital output, memory mapping, optical coupler, Circuit switches by RS232 port through RS485, Modbus protocol and status display 8 LEDs.

When RTU is not dynamic data, RTU could have high performance at low cost.

The RTU architecture comprises of a main board which has a power supply with a backup battery, CPU (microcontroller-PIC16F877A), volatile and nonvolatile memory for processing and storing data and programs. It also has a real time clock (RTC) and watchdog timer to ensure that it restarts when operating in the sleep mood. The RTU communicates with other devices via either Universal Asynchronous Receiver Transmitter (UART) or serial communication ports [7]. Figure 1 shows the block diagram of a typical RTU configuration.

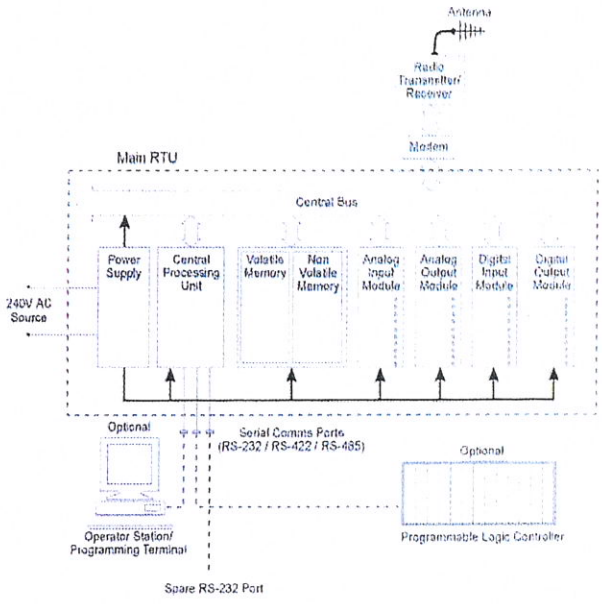

Figure 1: Hardware Functionality in RTU [8]

II. HARDWARE COMPONENTS SELECTION

The selection of the RTU hardware started from identifying all parts for the main circuit. The hardware consists of power supply, main board itself which has microcontroller, digital input and digital output, analog

input, UART and serial communication port, real time clock and accessory part consists of LED Indicators, Buzzer and LCD Display [8-10].

A. Power Supply

Power supply is use to provide power for an electronic circuit. RTU power supply module shall be able to operate from an input substation DC power supply with a tolerance of +20% and -15% of nominal input voltage and maintain full normal operation over the input supply range. The RTU power supply circuit is shown in Figure 2.

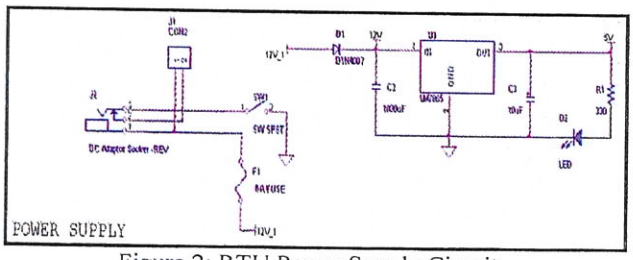

Figure 2: RTU Power Supply Circuit

B. Main Board

The PIC 16F877 microcontroller has 40 pins and can be programmed to accept either analogue or digital input; the other input-output pins are for digital inputs interface. The first step of implementing the proposed design of Ethernet system is to interface the microcontroller (16F877A) with sensors, accessory parts and Ethernet controller. The I/O consists of 8 opto-couplers with digital input, 8 open-collector digital outputs (to drive relays etc.) and 4 10-bit analogue inputs. The RTU main board circuit is shown in Figure 3.

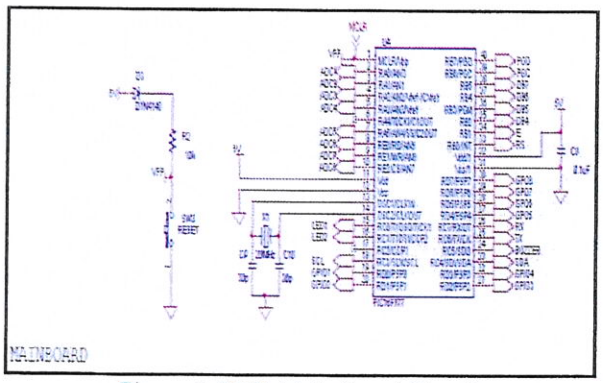

Figure 3: RTU Main Board Circuit

C. Digital Input

The digital input subsystem shall be made up of modules and termination assemblies to monitor the state of devices and alarms through the sensing of the state contacts. RTU will provide the sensing voltage in two methods. For sensing digital inputs they are provided by sensing voltage across the digital input point and it common. Second, it is provided by making the contact across the digital input point and it common. The RTU must be able to detect the process of any events for at least 5ms in duration. Any events with less than 5ms duration shall be regarded as contact bounce or spurious signals. The RTU shall have a programmable de-bounce filter that can be configured to reject pulses from 5ms to 25ms in width, in 1ms steps. A digital filter is preferred for this application. The RTU digital input circuit is shown in Figure 4.

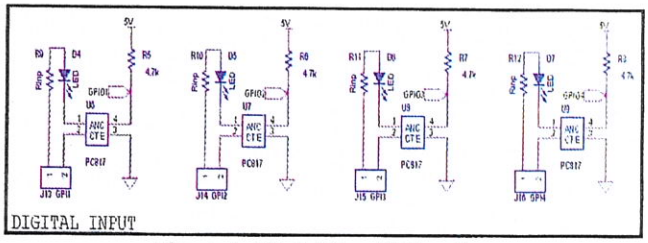

Figure 4: Digital Input Circuit

D. Analog Input

Analog input modules can provide instantaneous values. A/D conversion shall be with a minimum resolution of 10 bits, plus the sign bit for bipolar conversion giving an overall range of -1024 to +1024. The overall accuracy of the DC analog input subsystem, from input terminal to digital value shall be better than ±0.1% for current input and ±0.05% for voltage input. For the 4-20mA dc analog input, 4mA will correspond to a count of 0. 20mA will correspond to the maximum count, while 0mA will give a corresponding negative count. For a 10 bit ADC, 4mA will correspond to 0 counts, 20mA to 1024 while 0mA will give a reading of -1024 counts. The RTU analog input circuit is shown in Figure 5.

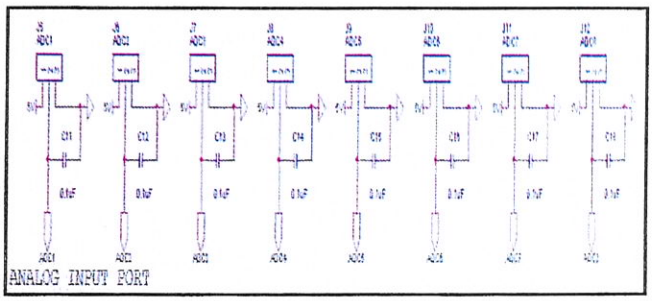

Figure 5: Analog Input Circuit

E. Serial Communication Port

Figure 6 shows the connection between PIC16F877A to GSM modem through RS232 cable with MAX232 converter. The system uses GSM modem brand Wavecom Fastrack controlled by AT command for all kinds of operations. 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 for interface between the Receiver module (Rx module) and the GSM modem. The MAX232 also can 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 [8].

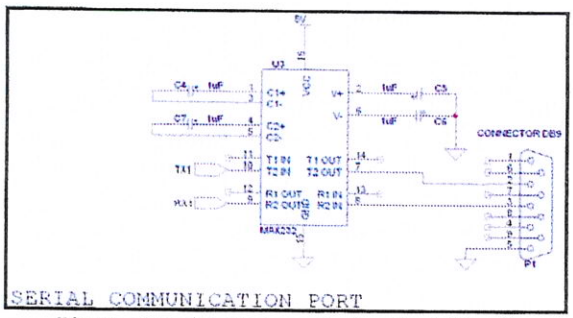

Figure 6: Serial Communication Port Circuit

F. Real Time Clock

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 single pole double throw type of relay that operates with maximum voltage of 5VDC and current of 3A. The real time clock circuit is shown in Figure 7.

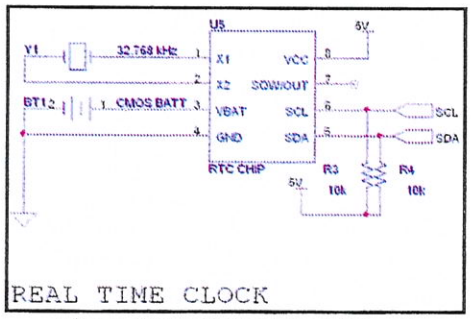

Figure 7: Real Time Clock Circuit

G. LCD Display

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 level in the real time. Adding a keypad and LCD display to the proposed RTU to indicate the data of voltage and current at RTU board and sent to the computer interface via communication media [11, 12]. 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. The LCD circuit is shown in Figure 8.

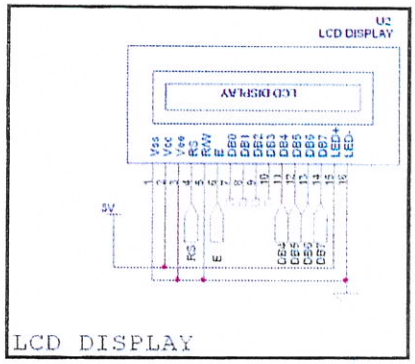

Figure 8: LCD Display Circuit

III. SOFTWARE CIRCUIT DESIGN

Orcad-PSpice is an electronic simulator used to test and design analog and digital circuits as well as designing printed circuit boards. The Orcad Capture is only one part of the Orcad-PSpice family of programs which is used to test and design circuits. Orcad-PSpice has the following features allowing designs to be high-speed and exact [13]:

- Quick and easy schematic editing
- Library can be edited or designed from scratch
- Working with other CAD applications
- The files used to design different devices can be used to upload the information into the devices
- Design complete printed circuit boards (PCB) including auto routing

The first step using Orcad is to choose the right component and if component needed are not included in it library, ones can design the component by following the specification and save them. Then arrange the component properly and routed the component before printing on the double layer board. iRTU circuit design is as shown in Figure 9.

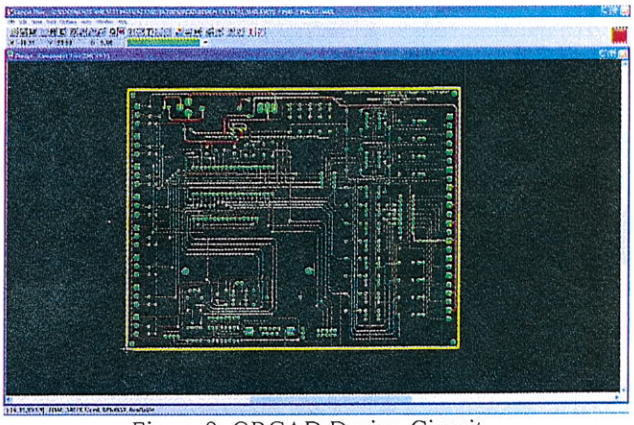

Figure 9: ORCAD Design Circuit

IV. RESULT AND DISCUSSION

The RTU provides monitoring fault operation, controlling, functions and data collection for analysis. RTU will initiate the transaction with the digital and analogue output modules. The master of this system is RTU and all the information can be monitored at the master station. RTU plays an important role in detecting fault and assigned to serve data and information immediately.

A. Product Developed

Figure 10 shows a complete developed RTU circuit. The designed RTU is ready to be tested is shown in Figure 11.

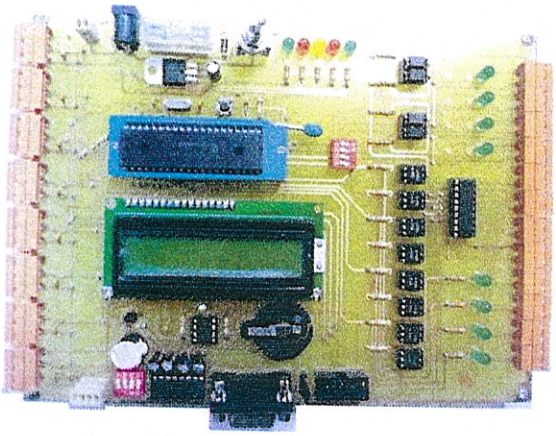

Figure 10: RTU Circuit

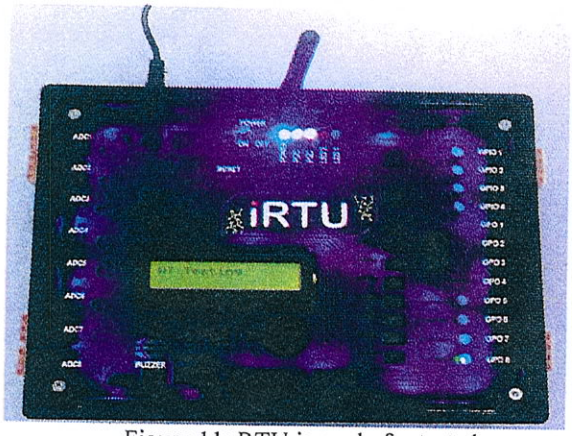

Figure 11: RTU is ready for tested

B. Product Function

The function of RTU is it can detect the type of fault in real time operation. When fault occurred, the LCD display at the RTU board will shows the data and relay will cut-off and LED turned on to indicate fault. The data is shown in Figure 12.

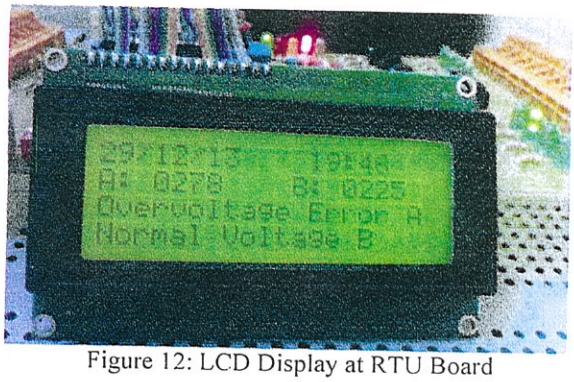

Figure 12: LCD Display at RTU Board

After that the data/information will be sent to the master station. So that, the operators will know which substation having a fault and immediate action can be taken. The data at the master station is shown in Figure 13.

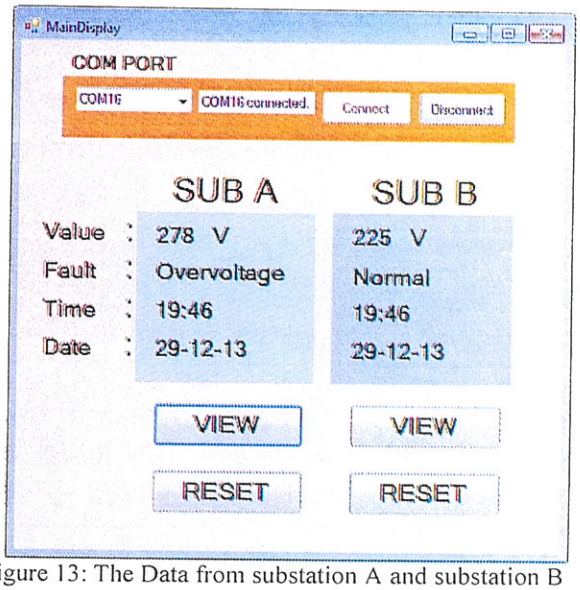

Figure 13: The Data from substation A and substation B

V. CONCLUSION

The paper is contributes to design and development of Remote Terminal Unit (RTU) in order to detect fault with real time operation. This RTU is locally designed and fabricated and the features of this RTU are low cost, easy to install, control and monitor system for long distance and can be used on wire or wireless application.

VI. ACKNOWLEDGEMENT

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