REMOTE TERMINAL UNIT (RTU) BASED ON ELECTRICAL LOAD CONTROLLER

MOHD NUR YASSIEEN BIN MAT ZAKI
B010410139

7 MAY 2008

“I hereby declare that I have read through this report and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Industrial Power)”

Signature : ………………………………………

Supervisor’s Name : DR. MUSSE MOHAMUD AHMED

Date : ………………………………………

REMOTE TERMINAL UNIT (RTU) BASED ON ELECTRICAL LOAD CONTROLLER

MOHD NUR YASSIEEN BIN MAT ZAKI

This Report Is submitted In Partial Fulfillment Of Requirement For The Degree of Bachelor In Electrical Engineering (Industrial Power)

Fakulti Kejuruteraan Elektrik
Universiti Teknikal Malaysia Melaka

May 2008

" I hereby declare that this report is a result of my own work except for the experts that have been cited clearly in the reference."

Signature : ………………………………………

Name : MOHD NUR YASSIEEN BIN MAT ZAKI

Date : ………………………………………

TABLE OF CONTENTS

ACKNOWLEDGEMENT

First of all, I would like to thank Allah, who has given me a chance and strength to complete my Projek Sarjana Muda 2 and my report. I would like to thank Universiti Teknikal Malaysia Melaka (UTeM) especially Faculty of Electrical Engineering(FKE) for giving me an opportunity to do my Projek Sarjana Muda 2(PSM 2) in fulfillment for Bachelor of Electrical Engineering.

Then, I would to thank my supervisor, Dr. Musse Mohamud Ahmed for supervising me in this project and giving me full support and teach me whatever i did not know. Without him, I cannot obtain more knowledge about Remote Terminal Unit and complete this project. The knowledge that I acquired about this Remote terminal Unit is precious because as an electrical power student, I did not take this subject and it maybe useful when I go through the working environment

Lastly, I would like to thanks my parents, all my friends, and everyone who has given me full support to do this Projek Sarjana Muda 2 (PSM 2). Without them I could not the work that has been assigned to me. Only Allah can pay them for all the supports that they have given to me.

ABSTRACT

This project is to design and develop Remote Terminal Unit (RTU) Based on Electrical load Controller. This project has required RTU hardware and Isagrah 3.4 as the main software to program the RTU. Remote Terminal Unit (RTU) is a device located at a remote site to collect data and transmit data back to a SCADA. RTU usually equipped with input channels for sensing or metering, output channels for control, indication or alarms and communication ports. For this project RTU model I-7188XG that have 4 input and 4 output channels has been used to control the loads in the system automatically. RTU also will be interfaced and combined together with SCADA for monitoring system. Final results of this project will be a full fledged and automated RTU which is capable of controlling, monitoring and operating the electrical distribution system.

ABSTRAK

Projek ini adalah projek mereka bentuk dan membangunkan RTU berdasarkan pengawal beban elektrik . Projek ini memerlukan RTU dan Isagrah 3.4 sebagai perisian utama untuk memprogramkan RTU. RTU adalah sebuah alat pengawal yang terletak di pusat pengawal bagi mengumpul dan menghantar segala data ke sistem SCADA. RTU biasanya dilengkapi dengan saluran-saluran masukan proses permeteran, saluran-saluran pengeluaran untuk mengawal, petunjuk atau sistem kecemasan dan ruang komunikasi. Untuk projek ini RTU model I_7188XG dengan 4 masukan dan 4 keluaran saluran telah digunakan untuk mengawal beban di dalam sistem secara automatik.RTU juga akan berhubung dan disatukan bersama SCADA untuk sistem pemerhati. Keputusan akhir projek ini adalah RTU yang mampu mengawal, memantau dan beroperasi secara automatik dalam sistem agihan elektrik.

LIST OF FIGURES

CHAPTER **CONTENT**

PAGE

LIST OF APPENDIXS

CHAPTER I

INTRODUCTION

REMOTE TERMINAL UNIT (RTU) BASED ON ELECTRICAL LOAD CONTROLLER

1.1 Overviews

Power distribution automation is being popular among the electric utilities to reduce the operational problems of the distribution system. So the automated power distribution system using remote terminal unit is the best solution to reduce the operational problems. Remote terminal units (RTUs) are essentially intelligent data acquisition and control units. RTUs serve as an efficient front-end for SCADA applications in a variety of industries. Whether it is in a coal plant, a power substation, a mine or along a railway track or an oil-pipeline, the rugged and versatile RTU can be easily installed, maintained and adapted to the most diverse and demanding physical environments.

1.2 Project Objectives

- To program the RTU as the controller that can operate, control, and monitor electrical distribution system automatically.

- To Interface Remote Terminal Unit (RTU) with SCADA.

- To run the distribution and the connected system automatically

1.3 Problem Statement

Normal and ordinary electrical apparatus and equipment use conventional operation and control means to function. Automated electrical apparatus and equipment such as automated distribution panels need to use RTU and SCADA. This project will use RTU as a controller to operate, monitor and control the electrical distribution system and the connected load.

1.4 Scope of Project

In this project report there are 5 chapters altogether. Chapter 1 gives some introduction, objective and problem statements about this project. The literature review of this project is reported in chapter 2. This chapter reviews the basic information about RTU, system interfacing and RTU software. Chapter 3 will discuss about project methodology from the start to the end of the project. Chapter 4 of this report will discuss about the programming of the RTU that includes ladder diagram programming. This chapter also brings discussions about the project. Chapter 5 will be the conclusion of this report.

CHAPTER II

LITERATURE REVIEW

2.1 General

Remote terminal units (RTU) collect data automatically and connect directly to the sensors, meters, loggers or process equipment. They serve as slave units to supervisory controllers or supervisory control and data acquisition (SCADA) masters. Remote terminal units are located near the monitored process and transfer data to the controller unit on command. They often include integral software, data logging capabilities, a real-time clock (RTC) or totalizer, and a battery backup. Intrinsically safe remote terminal units are designed to operate safely in hazardous environments. Devices with weather tight enclosures are designed to prevent the moisture, dust or other environmental contaminants. Closed loop systems use proportional, integral and derivative (PID) control; proportional and integral (PI) control; proportional and derivative (PD) control; or proportional (P) control. Redundant RTUs are complete remote terminal units that contain all of the transceivers, encoders, and processors needed for proper functioning in the event that a primary RTU stops working. [2]

Important specifications for remote terminal units (RTUs) include communication type, number of ports, and memory size. Serial devices use communication protocols such as RS232, RS485, and RS422. Networked products often use Ethernet, a local area network (LAN) protocol that uses a bus or star typology and supports data transfer rates of 10 Mbps. Remote terminal units that use radio, video, telephone, or current loop communications are also available. Fiber optic devices use optical cables to transmit light signals over long distances. Web-enabled RTUs use the Internet for communications. Programmable logic controllers (PLC) can be used as stand-alone devices or in conjunction with a SCADA or other control systems. In terms of ports, most manufacturers specify the number of analog or digital input/output (I/O) ports. Memory size is usually measured in megabytes (Mb). [3]

Remote terminal units differ in terms of features. Devices that include alarms, buzzers, or visual indicators such as blinking lights alert operators about various conditions. Auto-dialing RTUs automatically call a non-dedicated phone number whenever data needs to be transferred. Differential inputs eliminate electrical noise from small amplitude signals. Isolated inputs convert electrical signal inputs into optical signals which are then converted back to electrical signals. Remote terminal units with an expansion card provide additional data storage or processing power. Devices that are designed for environmental monitoring check weather conditions or indoor air quality. Some remote terminal units are suitable for indoor use and mount in standard 19” telecommunications racks. [1]Others are designed for process monitoring in applications such as oil field exploration.

2.2 RTU and Supporting Equipment Description

a. Purpose:

The RTU shall interface to existing data acquisition systems or other field instrumentations, and shall gather and store data, and facilitate telecommunication with the Central Station Computer.

b. Environment:

i. Logical Environment:

The signal chain includes the process equipment, sensing devices, data acquisition system, RTU, modem, communications link and Central Station.

ii. Physical Environment:

Typical environments shall include "friendly" and "Central Station" environments. Friendly environments include clean, air conditioned areas such as computer rooms and offices. [4]Hostile environments may include exterior spaces or interior spaces without benefit of air conditioning, and areas where free floating air particulates may impede the normal operation of exposed electronics. Each RTU shall be mounted in such a manner as to be environmentally qualified.

iii. Electrical Environment:

1) Connected Devices:

Each RTU may receive information from a local computer (DAS) or various field sensing devices, calculate and/or store the specified parameters and shall make its data available to local and Central Stations.

2) Sensor-based Data to be acquired:

Where applicable, the RTU shall be able to directly monitor transducers which sense variables required for compliance determinations. At a minimum, input analog conversion hardware should operate with a medium level of resolution (i.e. 12 bit resolution) and a sampling rate sufficient to accurately characterize the sensor based data.[2]

iv. Description of Data to be transmitted:

All data shall be made available at data output ports in ASCII format as described below:

1) Data Sampling:

2) Rule-specific Data Sets

c. Functions:

The RTU shall provide the following functions:

i. Power-Up/Restart Mode:

Upon resumption of power after a loss, the RTU shall automatically restart and reset itself to predetermined system settings.

ii. Non-Communicating Mode:

When in the non-communicating mode the RTU shall operate independently of the communications ports as well as store its transactions for later communications with the Central Station.

iii. Failure Mode:

In the event the RTU is unable to initiate communications with the Central Station, the RTU shall perform the following actions:

1) The RTU shall first make four subsequent attempts to establish communications with the Central Station.

2) Upon failure of the fourth attempt, the RTU shall:

   a. Revert to the non-communicating mode for a period of fifteen (15) minutes and then again attempt to establish communications with the Central Station.

   b. Each failure shall result in the execution of the failure mode sequence.

3) Error Tolerance:

The RTU shall perform its specified functions without misinterpretation of input information, errors in output signals, damage to internal components, and loss or change of stored information with either common mode to ground or differential mode transients present on the communication ports, circuits or power sources which shall be connected to the inputs and power supply terminals to the equipment.

2.3 RTU versus PLC

The RTU (Remote Terminal Unit) is a ruggedized computer with very good radio interfacing. It is used in situations where communications are more difficult. One disadvantage of the RTU is its poor programmability. However, modern RTUs are now offering good programmability comparable to PLCs.

The PLC (Programmable Logic Controller) is a small industrial computer usually found in factories. Its main use is to replace the relay logic of a plant or process. Today, the PLC is being used in SCADA systems to due its very good programmability. Earlier PCL's have no serial communication ports for interfacing to radio for transferring of data[7]. Nowadays, PLC's have extensive communication features and a wide support for popular radio units being used for SCADA system. In the near future we are seeing the merging of the RTU's and the PCL's. [7]

Micrologic is offering an inexpensive RTU for SCADA system wherein the PLC may be an overkill solution. It is a microcontroller-based RTU and can be interfaced to radio modems for transmitting of data to the CMS.

Figure 2.1 : Remote terminal unit in distribution panel box

2.4 RTU Interconnection

a. Interconnection between RTU and instrumentation.

Standards should cover voltages and currents, contact ratings, polarity, timing, connector types, wire diameters. There are a number of new instrumentation which have serial communication capability - the standards that cover this include connection (e.g. RS-232, RS-485, protocol (e. g. HART, Modbus) and format (e. g. the meaning and position of relevant data within each data message). With the exception of serial protocols most of the interfacing is well covered by standards and what is not is often easily modified to comply. [8]

b. Interconnection between RTU and communications system.

The communications system can typically be radio, landline, Public Switched Telephone Network (PSTN), Digital Data Network, X.25, Optical Fibre. [8] These communications bearers have vastly different characteristics and systems that work one may well not work on another. The standards should cover physical connections characteristics such as impedance, signalling strength, connector type and pinout. They should also cover data rate, frequency and size of data packets.

c. Interconnection between RTU and master system.

This area has the widest scope for standards. There are many areas that need to be covered and a good grasp of all the issues is required before "marrying" various RTU and base station components. [3] The comms bearer is part of the interconnection and the relevant standards are outlined above. In addition there are the issues of communications protocol, and data format within the message transmitted via the protocol.

2.5 Interfacing RTU and SCADA

The way the SCADA system network (topology) is set up can vary with each system but there must be uninterrupted, bidirectional communication between the RTU for a SCADA or Data Acquisition system to function properly. This can be accomplished in various ways, i.e. private wire lines, buried cable, telephone, telemetry hardware like wireless radios and modems, microwave dishes, satellites, or other atmospheric means, and many times, systems employ more than one means of communicating to the remote site. This may include dial-up or dedicated voice grade telephone lines, DSL (Digital Subscriber Line), Integrated Service Digital Network (ISDN), cable, fiber optics, WiFi, or other broadband services. [8]

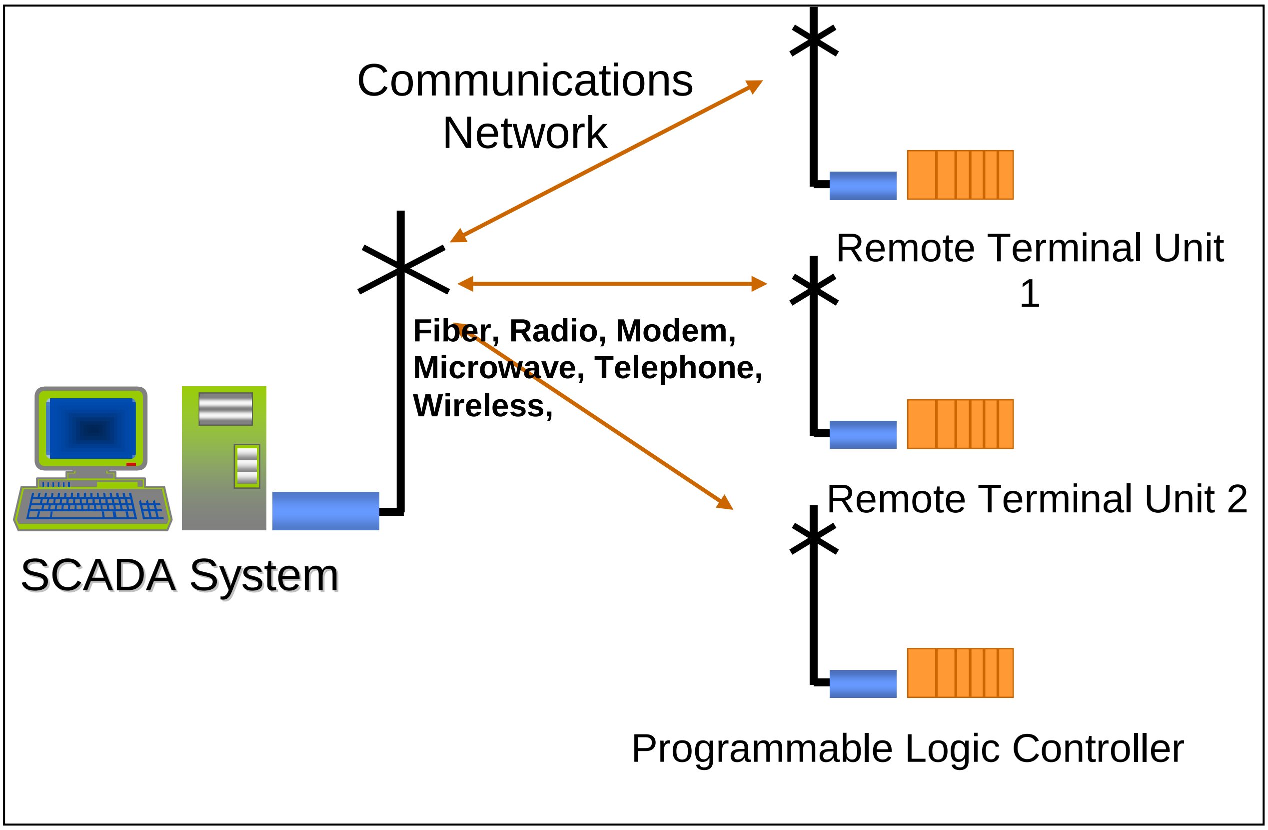

Figure 2.2: Interfaced system between RTU and SCADA

2.6 RTU Programming Software

This project required Isagraf 3.4 as the main software to program the RTU hardware. Isagraf supports the following 6 traditional control programming languages such as structured text, FBD editor, Quick LD editor, SFC editor, ST editor, IL editor, and Flow chart editor.

2.6.1 ISaGRAF Workbench

The ISaGRAF workbench, which is a Windows 95, 98, NT or Windows 2000 PC compatible, runs the ISaGRAF workbench software. The ISaGRAF workbench software includes:

Graphical Editors for programming:

- Quick Ladder Diagram
- Function Block Diagram
- Sequential Function Chart
- Flow Chart

Text Editors for programming:

- Instruction List
- Structured Text

Powerful tools for:

- Application download
- On-line debugger and controller
- Simulation
- Cross referencing

2.6.2Quick LD Editor

The Ladder Diagram (LD) is one of the most familiar methods of representing logical equations and simple actions. Furthermore contacts representing input arguments and coils representing output results are utilized. The ISaGRAF Quick LD Editor offers you the best compromise between high level graphic capabilities and easy to use keyboard driven programming.

2.6.2.1 Using the Quick LD editor

The LD language enables graphic representation of boolean expressions. Boolean AND , OR, NOT operators are explicitly represented by the diagram topology. Boolean input variables are attached to graphic contacts. Boolean output variable sare attached to graphic coils. The ISaGRAF Quick LD editor provides easy LD diagram entering using either keyboard or mouse. Elements are automatically linked and arranged on rungs by the Quick LD editor. No connection is drawn manually by the user. The Quick LD editor also arranges rungs in the diagram so that the space filled by the diagram is always optimized. [9]

2.6.2.2 Basics of the LD language

An LD program is expressed as a list of **rungs** where contacts and coils are arranged. Below are the basic components of an LD diagram:

├─ ***Rung head (left power rail)***

Each rung begins with a left power rail, which represents the initial "TRUE" state. ISaGRAF Quick LD editor automatically creates the left power rail when the first contact of the rung is placed by the user. Each rung may have a logical name, which can be used as a label for jump instructions. [9]

┤├ ***Contacts***

A contact modifies the boolean data flow, according to the state of a boolean variable. The name of the variable is displayed upon the contact symbol. The following types of contacts are supported by ISaGRAF Quick LD editor: [9]

┤├.................... direct contact

┤/├.................... negated contact