RENEWABLE ENERGY (SOLAR POWER) MINI PROTOTYPE PLANT WITH SCADA SYSTEM

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BEKP

MAY 2010

" I hereby declare that I have read through this report entitle "Renewable Energy (Solar Power) Mini Prototype Plant with SCADA System" and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Industrial Power)"

Signature : ....

Supervisor's Name : MR. MASLAN BIN ZAINON

Date : 12th MAY 2010

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A report submitted in partial fulfillment of the requirements for the degree of Electrical Engineering (Industrial Power)

Faculty of Electrical Engineering
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2010

I declare that this report entitle "*Renewable Energy (Solar Power) Mini Prototype Plant with SCADA System*" is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ....

Name : MUHAMMAD NASHRIQ BIN MOHD HARIS

Date : 12th MAY 2010

To my beloved mother and father

ACKNOWLEDGEMENT

First and foremost, I would like to express my thankfulness and gratitude to Allah S.W.T who has given me inspiration and strength for me to complete this progress report.

Besides, I wish to express my sincere appreciation to my supervisor, Mr. Maslan bin Zainon, for give me a lot of encouragement, guidance critics and support to accomplish this progress report. I also would like to show my appreciation to all my lectures and technical staffs that have taught me with strong theories especially in electrical subjects to fulfil the requirement of this project.

Furthermore, I would like to thank my friends and fellow classmates for sharing and discussing knowledge and ideas to give me the inspiration in completed this report. Their supports, opinions, and advises will be not forgotten. Not forget to technicians in UTeM that have spent their time to explain and help me in this project.

Finally I want to express my sincere appreciation to my beloved family who giving me full of support and encouragement to finish this report.

ABSTRACT

This project is focusing on the designing and constructing an attractive prototype solar power plant for teaching and learning kit. The aim of this project is to give people especially student the overview of operations of solar power plant in generating electricity in attractive way. Through this approach, people will be more interested to learn about the operation of solar power plant and at the same time this renewable energy can be implemented widely in this country. This prototype will be implemented with Supervisory Control and Data Acquisition (SCADA) system to monitor and control the solar prototype plant. User or operator can observe the actual operation of solar power plant in graphical method through the PC. DC and AC load switching is implemented through SCADA system. In this project, programmable logic controller (PLC) will be used to interface between hardware parts and software parts. Solar prototype plant is basically consisting of solar photovoltaic panel, charge controller, rechargeable battery, power inverter, SCADA software and PLC.

ABSTRAK

Projek ini tertumpu kepada rekaan dan penghasilan sebuah janakuasa solar prototaip sebagai bahan pengajaran dan pembelajaran. Matlamad projek ini adalah untuk memberikan masyarakat terutamanya para pelajar mengenai gambaran operasi sebuah janakuasa solar dalam cara yang lebih menarik dan berkesan. Melalui pendekatan ini, mereka akan lebih berminat untuk mempelajari mengenai operasi janakuasa solar di samping dapat memperluaskan penggunaan tenaga solar di negara ini. Prototaip ini akan menggunakan system SCADA untuk memantau dan mengawal sistem prototaip ini. Pengguna atau pemerhati dapat memerhati sistem sebenar janakuasa solar dalam bentuk grafik melalui komputer. Penyambung dan pemutus litar bagi beban DC dan AC telah diaplikasikan di dalam sistem SCADA. Dalam projek ini, PLC akan bertindak sebagai medium penghubung antara bahagian perkakasan dan bahagian perisian. Prototaip janakuasa solar ini secara asasnya mengandungi panel solar PV, pengawal caj, bateri cas semula, penyongsang kuasa, perisian SCADA dan PLC.

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LIST OF ABBREVIATION

PV	-	Photovoltaic
C	-	Capacitor
R	-	Resistor
D	-	Diode
Q	-	Transistor
T	-	Transformer
V	-	Voltage
I	-	Current
LED	-	Light Emitting Diode
GUI	-	Graphical User Interface
MPPT	-	Maximum Power Point Tracker
AC	-	Alternating Current
DC	-	Direct Current
PLC	-	Programmable Logic Controller
SCADA	-	Supervisory control and data acquisition
I/O	-	Input/ Output
RTU	-	Remote Terminal Unit
FYP	-	Final Year Project
UTeM	-	Universiti Teknikal Malaysia Melaka

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

This chapter will discuss the background of solar renewable energy and solar power plant, the aims and specified objectives of the project, project scope and problem statements. The project outline is also listed at the end of this chapter.

1.1 Project Background

In today's climate of growing energy needs and increasing environmental concern, alternatives to the use of non-renewable and polluting fossil fuels have to be investigated. One such alternative is solar energy. Nowadays, solar applications are widely use in developed country such as United State and most of country in Europe. In Malaysia, solar energy has opportunity to develop since this country has high sun radiation and this condition can be used to convert solar energy into electricity. With proper study about the operations of solar power plant, electricity can be generated by solar energy as a back up to the ordinary or non-renewable source of energy such as diesel, steam and coal power plant. An attractive approach need to be exposed especially to students. With certain approach that is attracting and interesting, students will be more interested to learn and understand the operations of solar power plant. This project will focus on the design and development of a prototype of solar power plant system. This prototype will be implemented with Supervisory Control and Data Acquisition (SCADA) system and Programmable Logic Controller (PLC) to monitor and control solar prototype power plant in graphical. This method can gives more attractive to students in learn about the solar power plant operations.

1.2 Problem Statement

Solar energy is a part of a widely recognized renewable energy sources. The solar energy source is free of cost and clean energy whereby environmental impacts are negligible. In tropical countries like Malaysia, potential in solar energy is developing but still has not been implemented widely especially in teaching and learning applications. This problem is due to lack of knowledge among people and students especially in operation of solar power plants. At the same time people are not aware about the importance of solar energy in future.

Most of students will prefer to something attractive rather than just theory and formulae. Solar prototype plant for educational can be implemented with SCADA system which will attracts student to learn and understand the operations of solar power plant. All systems need to be monitored and controlled to make sure the system is running steadily. Same with solar power plant system itself. The system need to be stabilized in order to prevent any interruption that will cause to many problems such as unstable power supply and power cut out. These problems can be overcomed with proper monitoring and controlling system.

1.3 Project Objective:

The objectives of this project are:

- to analyze and understand the operations of solar power plant system.
- to design and develop power plant prototype for teaching and learning based on solar energy.
- to design SCADA system and control (on/off) DC load in solar power plant system.
- to explore solar renewable energy as an alternative to support electricity generations.

1.4 Project Scope:

In order to achieve the objective of the project, there are several scope has been specified.

The scope of this project includes:

- This prototype power plant is for teaching and learning kit.
- 12V, 2.4Watt Solar PV Panel.
- Charge controller rating current up to 1A.
- Rechargeable battery 12V, 1.2Ah.
- Power Inverter (12Vdc – 240ac)
- SCADA software and Programmable Logic Controller (PLC)

1.5 Project Outline

Chapter 1 represents the introduction part, project background, problem statement, project objectives, project scopes, and project outline. Chapter 2 represents the literature review part. These parts are including review on related project based on solar charge controller, inverter, SCADA system, and other component. Chapter 3 represents project planning and project methodology that will be applied in this project. Chapter 4 represents result and analysis for this project. Finally Chapter 5 represents the discussion and conclusion of this project.

CHAPTER 2

LITERATURE REVIEW AND THEORETICAL BACKGROUND

2.1 Solar Module Monitoring Expert System for PV System Model Design

For a large number of applications, PV technology is simply the least-cost option. It is important to determine the correct system size, in terms of both peak output and overall annual output, in order to ensure acceptable operation at minimum cost.

Parameters require in order to accurately predict the electrical output of the systems:

- Influence of solar angle of incidence
- Influence of solar spectrum
- Temperature coefficient for the open circuit voltage and maximum power voltage
- Temperature coefficient for the short circuit current and the maximum power current
- Module operating temperature as a function of ambient temperature, wind velocity and solar radiation.

To investigate the fundamental characteristics of the PV modules, the long term measurement is ongoing. Table 2.1 indicates the specification of PV module .used for the measurements. The modules are set with the slop of 35 to 90 degrees.

Table 2.1: Specification of PV Module.

Max Power	75 W
Short Circuit Current	4.75 A
Open Circuit Voltage	21.4 V
Optimum Operating Current	4.45 A
Optimum Operating Voltage	17 V

In addition the environmental factors, such as the irradiation, temperature, humidity and wind velocity are measured at the same interval by using personal computer based measurement system. In Figure 2.1 and Figure 2.2, data of ambient temperature and solar radiation were collected for every half an hour every day

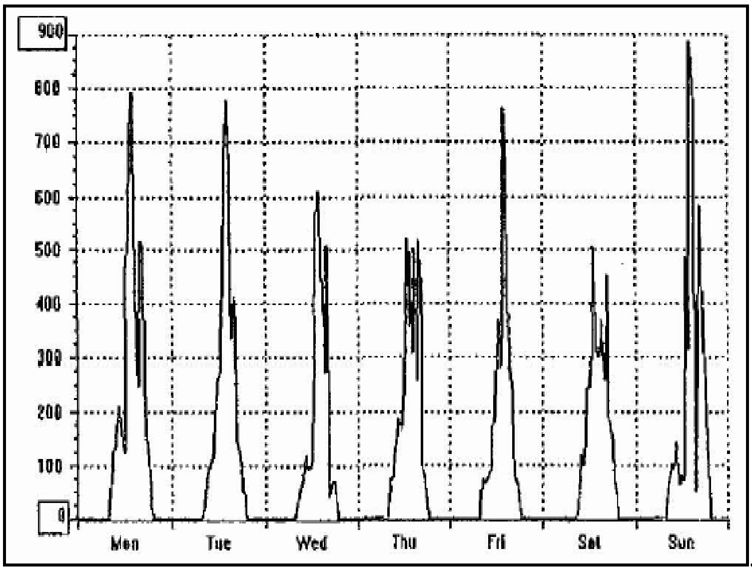

Figure 2.1: Sample Data of Solar Radiation for a Week

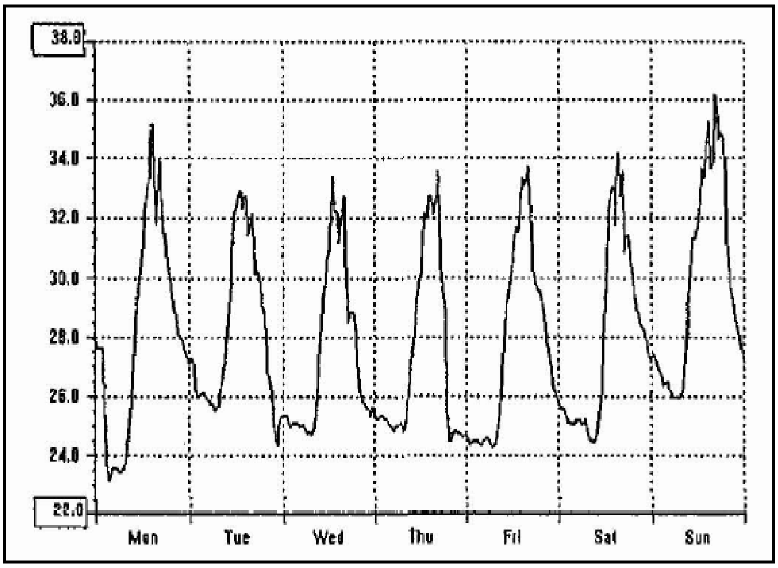

Figure 2.2: Sample Data of Ambient Temperature for a Week

The earth rotates about its axis every twenty-four hours, therefore any location faced to the sun about 12 hours a day. Hence, assume that the solar energy available 12 hours per day. In peninsular Malaysia, the average solar insulation is 4.5 kWh per meter square per day. Considering the available solar radiation, module area and angle, these parameters can derive total solar energy per day as in Equation (1).

$$S_{ep} = I_{total}\ x\ S\ x\ [\sin(\alpha)\sin(\beta) + 1] \qquad (1)$$

Where:

- S_{ep} solar energy per day
- I_{total} is global solar radiation
- S is area of PV module
- α is duration available for solar energy conversion and varies between $0^{o} < \alpha < 180^{o}$, 15 ° per hour and also is a sun trajectory from the east and west.
- β is a degree of PV module's angle, it varies from 0^{o} of the negative direction of zenith to 90 °at coordination of north and south, east and west orientation.

The amount of energy produced by a PV device depends not only on available solar energy but also on how well the device converts sunlight to the electrical energy i.e. the efficiency of the cell or module used. The conversion efficiency can be measured by the equation below:

$$\eta = \frac{P_{max}}{S_{rad}\ x\ Area}\ x\ 100 \qquad (2)$$

Where:

- P_{max} is the maximum output power (kWh)
- S_{rad} is the solar radiation intensity (kWh/m^2)
- Area is the total area of the cell or module (m^2)

There are two parts in the system development, hardware and software. In hardware part, all the data are collected by the microsystem before send to the monitoring pc. The microsystem of data acquisition as related to photovoltaic systems gives comprehensive support to the design of a PV system for general users. The system is not only limited to collecting data but the system also analyze and remedy the performance of PV systems.

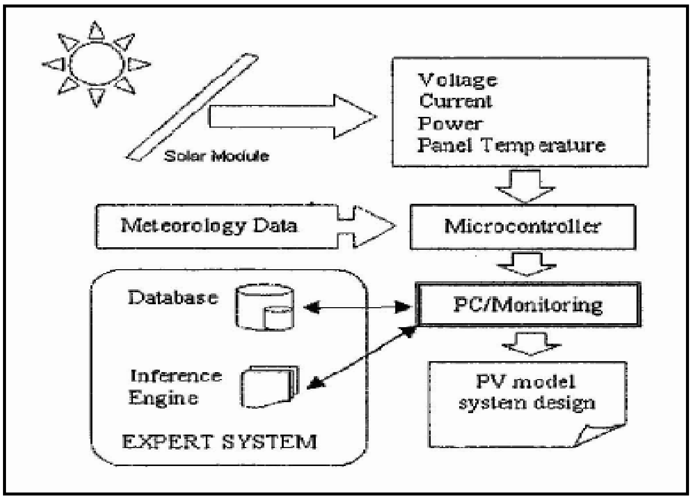

Figure 2.3: System's Block Diagram

The microsystem architecture uses a microcontroller to control and monitor the data acquisition as represented in Figure 2.4. The analog part is composed essentially of one adaptation and an analog multiplexer allowing the acquisition of many meteorological parameters and the parameters related to the PV system. The numerical part of microsystem allows the transfer of data between the analog-to-digital converter (ADC) and the data bus. The treatment of data is in real time in the microsystem and the transfer of data to the pc is carried out through a bidirectional serial port using an RS232 protocol.[3]

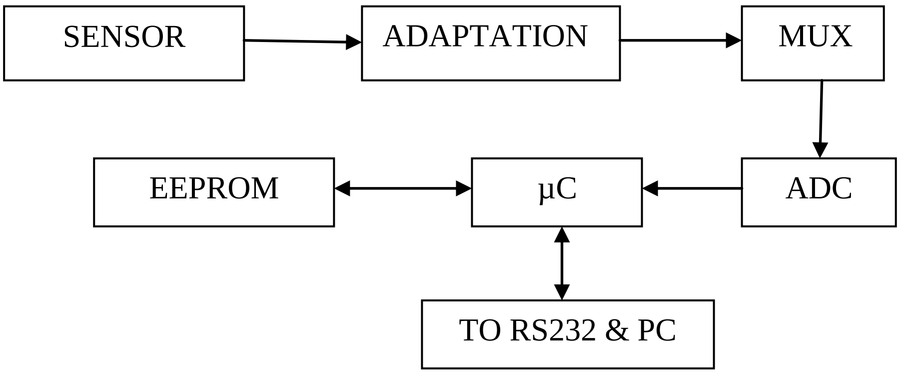

Figure 2.4: Microsystem Architecture

The data are collected from real weather condition i.e. solar radiation, ambient temperature and humidity. At the same lime, the data also collected from PV module where all the output from PV module such voltage, current and power are recorded. These two major parameters (weather condition and PV module monitoring) will be analyzed by ES to evaluate the best PV system model for that location.[3]

2.2 5 kW Grid Connected Photovoltaic

Power supply reliability and power quality have become important issues for all kind of power electronic systems including photovoltaic systems. Interconnecting a photovoltaic system with utility, it is necessary that the PV system should meet the harmonic standard and the active power supply requirement. Several utility connected photovoltaic systems have been proposed. Among these systems, the most common type is the parallel running PV with bi-directional power flow to provide unity power factor on the utility line. In this system, an inverter connected to the photovoltaic array supplies the power to the utility. Photovoltaics (PV) are the direct conversion of sunlight to electricity by solar cells. When photons of sunlight are absorbed in solar cells, the photons free electrons from the cell's atoms, creating a voltage potential.

Figure 2.5 is a block diagram description of a PV utility-interactive system. The PCS is primarily responsible for converting the DC PV power into utility compatible AC power and for synchronizing and transferring that Ac power safety into the utility grid. The DC to AC commutated inverter utilizes the utility voltage as a means of commutation (turn-off) of transistor or thyristor switching devices.[8]

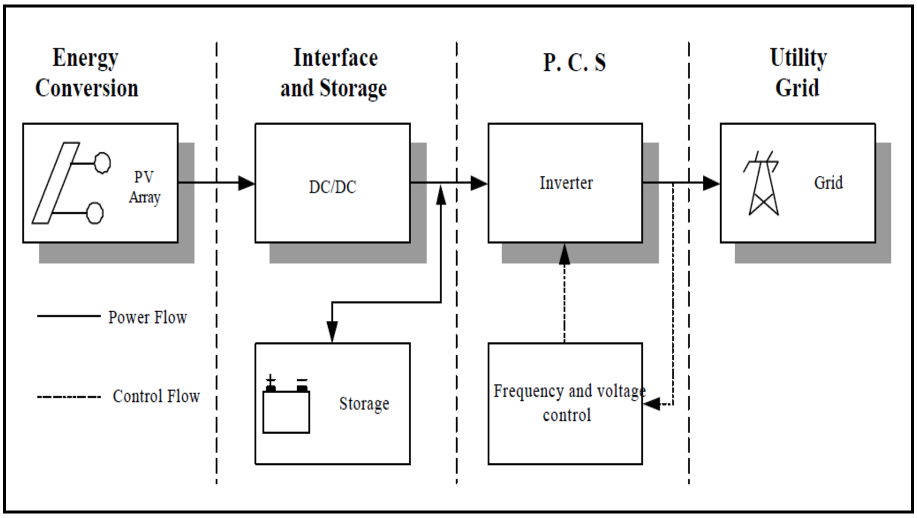

Figure 2.5: Block Diagram of a Typical PV Utility Grid Interconnection