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Data acquisition system for solar panel monitoring / Ang
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DATA ACQUISITION SYSTEM FOR SOLAR PANEL MONITORING

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DATA ACQUISITION SYSTEM FOR SOLAR PANEL MONITORING

ANG WEI YIH

**A report submitted in partial fulfilment of the requirement for the Degree of
Mechatronic**

Faculty of Electrical Engineering

Universiti Teknikal Malaysia Melaka

Year 2012

I declare that this report entitle “Data Acquisition System for solar panel monitoring” 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.

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Special dedicated to my family and friends

ABSTRACT

The climatic conditions in Malaysia are favourable for the development of solar energy due to abundant sunshine. Research and development of solar energy as a renewable energy for industrial and domestic used are widely implemented in Malaysia. However, there are not yet known data or analysis provided on the solar optimum output power for the climates in Malaysia. With the motivation, the project is to develop a portable data acquisition system (DAQ) for solar panel output power monitoring system based on the angle of inclination of solar panel in FKE, UTeM is proposed. In this project, monitoring is described as collection, recording and transmission of the measured data or parameter to storage which is the multimedia memory card and off site analysis of the data acquisition system performance in the computer. This microcontroller based approach portable DAQ is designed to collect the data in term of voltage, current, date and time. From the analysis that carried out by the portable DAQ developed, the optimum output power due to the solar panel of 2° harnessing the most angles according to movement of sun.

Key words: Portable data acquisition system (DAQ), optimum power, solar panel, angle of inclination (tilt)

ABSTRAK

Keadaan cuaca di Malaysia yang menggalakkan bagi pembangunan tenaga solar yang disebabkan oleh cahaya matahari yang banyak. Penyelidikan dan pembangunan tenaga solar sebagai tenaga yang boleh diperbaharui untuk digunakan industri dan domestik dilaksanakan secara meluas di Malaysia. Walau bagaimanapun, tidak lagi dikenali data atau analisis yang disediakan mengenai optima kuasa keluaran solar untuk iklim di Malaysia. Dengan motivasi ini, projek ini adalah untuk membangunkan sistem perolehan data mudah alih (DAQ) untuk pemantauan panel solar kuasa dari segi keluaran kuasa optima berdasarkan sudut kecondongan panel solar di FKE, UTeM adalah dicadangkan. Dalam projek ini, pemantauan digambarkan sebagai koleksi, rakaman dan penghantaran data yang diukur atau parameter untuk simpanan dalam dan analisis tentang sistem pemerolehan data dijalankan dalam komputer. Pendekatan ini berasaskan mikropengawal DAQ mudah alih direka untuk mengumpul data dalam voltan, arus elektrik, masa dan tarikh. Daripada analisis yang dijalankan oleh DAQ mudah alih yang dihasilkan, kuasa keluaran yang optimum oleh panel solar 2° merupakan sudut yang paling memanfaatkan mengikut pergerakan matahari.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Portable DAQ (data acquisition system) is described as a small, paperless and yet ubiquitous device that designed for data acquisition, drawing an increasingly amount of attraction ranging from academicians to industries engineers and also researchers. DAQ plays a vital role in environmental monitoring, which is a major issue in event of environmental awareness and energy saving effort. Technically, a data acquisition system is a sampling signals manipulated from computer, capable of quantifying actual physical conditions and to convert resulting samples into digital numeric values. At the same time, DAQ is constantly upgraded to perform various complex functions, namely to gather useful measurable data and to store it for future analysis in terms of characterization, monitoring or controlling. On the other hand, Inexhaustible clean energy or photovoltaic (PV) being the uprising issues current community is looking into for development and future implementation. In short, the invention of the microcontroller DAQ is simply to collect data in terms of output power of solar energy through a fix load and the orientation of the solar panel. The approach of portable DAQ is designed to collect the data in term of voltage (V), current (I), time and date. A suitable angle of inclination will be analysed to obtain an optimum output power of solar energy as well as the accuracy of the DAQ.

1.2 Problem statement

Global environmental issues, for example fossil fuel exhaustion, global warming and pollution caused by conventional power generation are on the rise. Among the renewable resources, solar energy, being the most future potential of development compared to wind generator, wind, hydro, wave biomass, geothermal and others. The ability to remotely monitor data on solar panels power output is of vital in terms of proper long-term maintenance of solar energy systems.

There are two problem statements of this project:

1. There are no special portable DAQ for solar panel power data storage.

Unfortunately, existing remote monitoring technologies are limited in their application. Traditional photovoltaic monitoring system is a process where maintenance staff carries out close monitoring or site monitoring to continuously analyze the data shown in the equipment, the corresponding action. If PV plant in is constructed in remote areas, where it is not sustainable under different environment for a long duration.

2. Optimum output power from the solar panel is not yet known for the the climates in Malaysia especially in Melaka.

Measured data and analysis on the power output cannot be provided in Malaysia.

Hence to solve these problems, this project is initiated to develop a microcontroller base portable DAQ to remotely monitoring the performance of solar panel in term of output power for the climates of Melaka area is implemented and designed.

1.3 Objective

The main objective of this project:

1. To develop a portable Data Acquisition system for solar panel output power monitoring system.
2. The analysis based on the inclinations angle (tilt) of solar panels and output power obtained over time.

1.4 Scope

The scope of this project is focused onto the development of DAQ portability, compatibility and also capability of self powered for data collection purpose. The main component of this portable DAQ is the PIC18F452 microcontroller which came with the feature of 10 bit analogue to Digital converter (ADC). For the storage of data, a 1 gigabyte (Gb) multimedia card (MMC) is used in DAQ system to expand the storage of the system.

The 6V solar panel used in this project are placed at the FKE, UTeM with 2° and 22° angle (tilt). The monitoring system will be carried out for 1 day from 10am to 5 pm and the voltage and current measured will be display 10 s each. For the data logging section, the voltage and current measured data will be stored every minute in the Multimedia card (MMC). The data acquisitions from the DAQ are voltage (V), current (I), time and date. Analysis carried out on the output power with 470Ω load versus the inclinations angle (tilt) of solar panels. This DAQ is design for education purpose and house hold used.

CHAPTER 2

LITERATURE REVIEW

2.1 Portable DAQ

The rapid evolution of renewable energy especially in solar energy resulted numerous of data acquisition system have been develop and available in the market today. The invention of the DAQ is to gather and process such data, as well as monitor the performance of solar system under operation in order to evaluate their performance during the last to decade. According to The Free Dictionary, “Portable” mean able to be carried, or moved easily from place to place or easily or conveniently transported. In other words, portable can be describe as light, compact, convenient, lightweight, manageable, movable, easily carried and portative.

The ideal portable data acquisition system for most users like us is a compact, lightweight unit powered by either a self-powered with battery or a single DC power source, involve no other connection to function other than the sensors are supervised. Working in remote areas, a user interface and means of communication with the device become important features. Signal conditioning such as gain and filtering as well as high-capacity non-volatile data storage are other vital considerations. [1, 2]

2.2 Design of DAQ

Balan et al. [3] had presented a microcontroller based data acquisition system (DAS) which measure the value of the total and diffuse radiation intensity, using the original electronic conversion module CONV. RS-232 serial interfacing is used to recorded transmission value to PC. The 50 seconds time step is for the instant measured value reading and storing into database operated using “Acquisition software” component. The PC used as a server computer for the purposed if distance monitoring so that the display of recorded data in database (MySQL) can be realized on a web based interface.

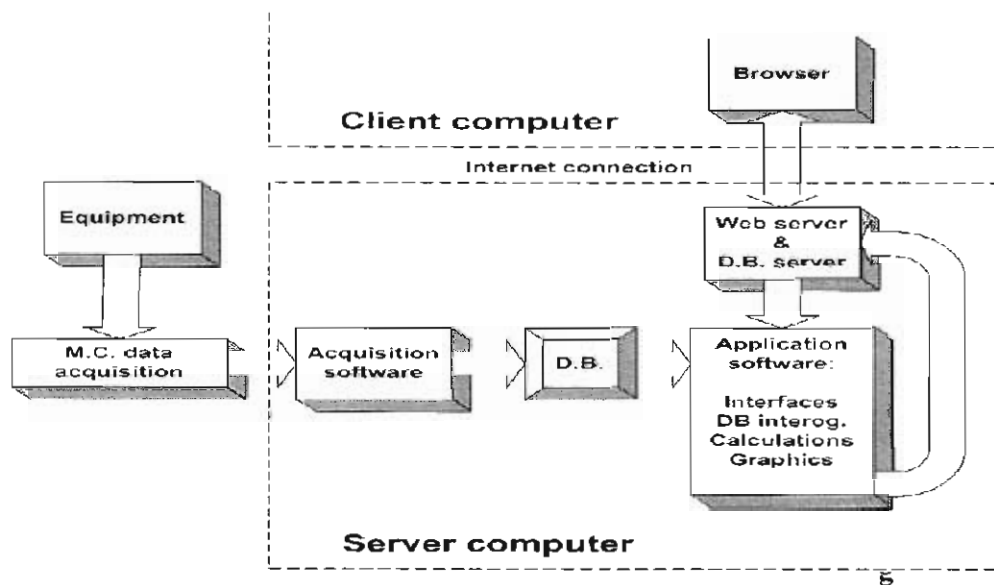


Figure 2-1 Working principle scheme of the DAQ and monitoring system[3]

Mukaro,R et.al had proposed a microcontroller-based data acquisition system used to measure the solar radiation. The internal A/D converter used to convert the data collected and stored in the external serial I2C EEPROM until uploaded to PC. To minimize the power consumption of the DAS, whereby only interrupted when PC is connected to retrieve the stored data. The internal timer is provided to operate in 10 minutes intervals to sample and store the data or to change the operational conditions. Towards the end of each the data collection period, the acquired data is transmitted to the computer through RS232 serial interface. [4]

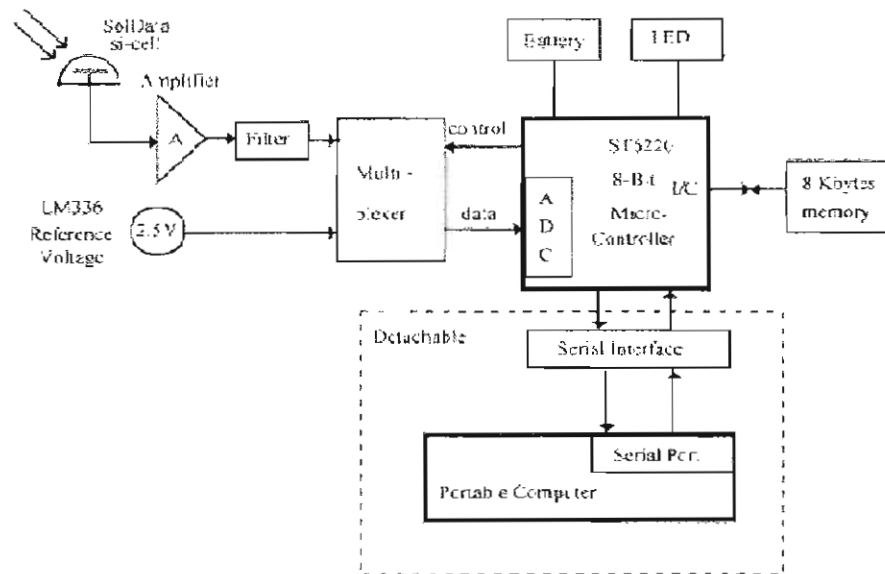


Figure 2-2 Block diagram of the data acquisition system[4]

An integrated microcontroller based data acquisition system (DAS) is developed to measure the atmospheric and soil condition, as well as the quantities of energy produced by hybrid PV/ wind generator power system, such as photovoltaic array current and voltage, the wind generator speed developed by *Koutroulis .E et.al*. The first collected data conditioning using precision electronic circuit and interface to PC using RS232 serial interface. The LABVIEW program is used to further processed, displayed on the monitor and stored in the hard disk. [5]

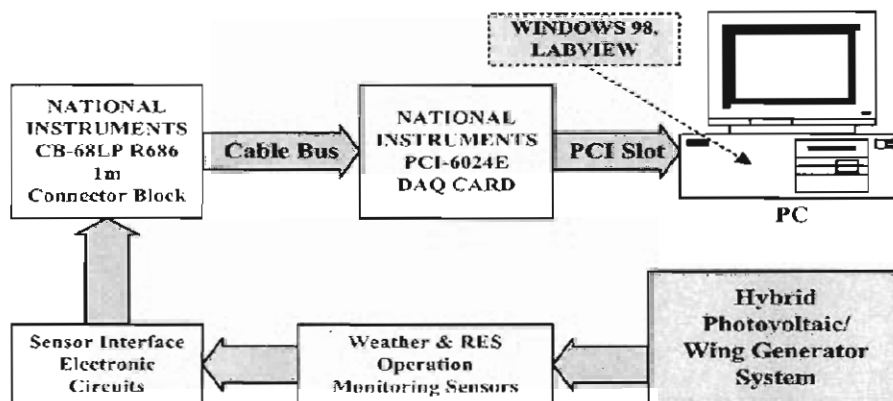


Figure 2-3 Data-acquisition architectures for RES systems[5]

A low cost concept internal USB interface microcontroller based data acquisition system (DAS) is capable to measure digital wind speed and analog pressure and voltage data from a PV powered water pump is to measure digital wind speed, analog pressure and voltage data from a PV powered water pump. All the I^2C chips and USB connection with the PC are managed by the microcontroller. The RTC RAM and data reading from the external EEPROM are setting by the computer through the USB channel. Interface for GSM/GPRS using the TTL/RS-232 transceiver for data transmission in wireless networks whereas the TTL/RS-485 transceiver used in Modbus device networks. The data from sensor is read every minute and stored in external EEPROM every 10 min. The free monitoring software via USB used to set up and record the memories of the supervisory system and database. [6]

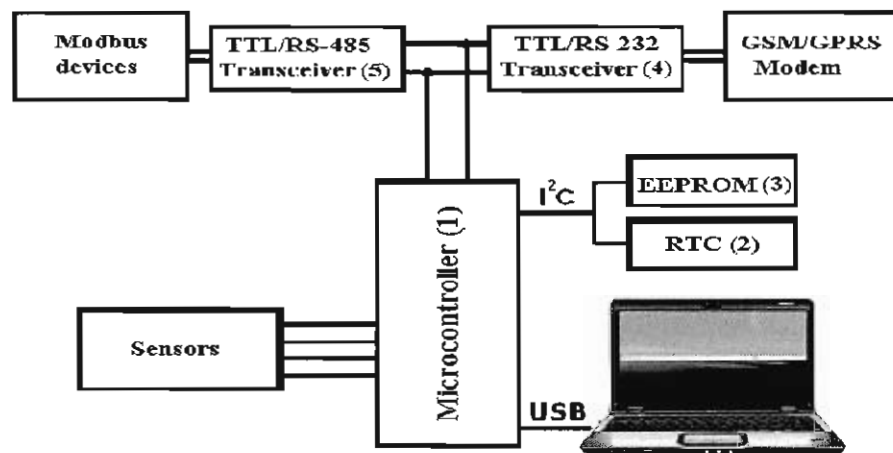


Figure 2-4 Block diagram of DAQ [6]

A wireless data acquisition system (DAQ) with radio frequency (RF) transceiver used in composed of remote station and base station. The remote station consists of sensors, microcontroller, RF emitter circuit and power supply. The data distribution system is based on the Client/Server architecture, while the data transmission is carried out through the internet. For the base station, RF receiver circuit, microcontroller, RS232 serial interface and graphical environment software and a PC. Analyses on meteorological and electrical parameter are carried out on data acquisition system for remote monitoring system operation and control of renewable energy systems plants. Parameters measured such as solar radiation, wind direction and speed, temperature, humidity and barometric pressure. The DAQ transmit the measured data every 1 min is adequate since the rate of change of measured signal low [7].

Table 2-1 Summary of data acquisition system (DAQ)

Authors	Controller	Storage	Network access	Parameter
Balan,M; Damian, M; Jantschi,L,2009 [3]	Microcontroller	PC hard disk	Yes	Solar radiation intensities (total, diffuse and direct)
Mukaro,R; Carelse,X.F; 1999 [4]	ST62E20 8bit microcontroller	External EEPROM (4kbytes)	No	Solar radiation
Sandro C.S.Juca, Paulo C.M.Carvalho and Fabio T.Brito, 2011[6]	Microcontroller	External EEPROM (32kbytes)	Yes (GSM/GPRS/Modbus Network)	Wind speed, analog pressure and PV voltage
Koutroulis, E; Kalaitzakis,K; 2003 [5]	National Instruments PCI-6024E type data acquisition (DAQ) card	PC Hard disk	No	Atmospheric and soil condition, PV array current and voltage, the wind generator speed
Kalaitzakis K, Koutroulis E, Vlachos V, 2003[7]	Microcontroller	PC hard disk	Yes	Solar radiation, wind direction and speed, temperature, humidity and barometric pressure

2.3 Review of design DAQ

This project offers a portable DAQ used for data collecting and monitoring which applied to solar panel for further monitoring analysis. Considering that most of the DAQ found in the literature review, the data storage [3, 5, 7] presented is through PC hard disk, whereby there is a requirement to provide constantly a dedicated powered PC on site only for this purpose, which increase the cost of the monitoring system. The proposed portable DAQ, the data collected are stored directly in the Multimedia Card (MMC), making the complete monitoring system portability, whereas PC hard disk usage for computer is not portable.

In most of the application with provided a network (wireless) access in mentioned **Table 2-1**. The requirement of network connectivity is necessary for the data collecting and monitoring purpose whereby the installation of network on site only for this purpose which is not cost effective and increase the complexity of the internal architecture as well as the size (e.g. network card is required). A different approach has proposed in this project, this project is developing portable DAQ, whereby no internet access is required to monitoring the system. Relative observation can be made from time to time without remote access.

On the other hand, a common characteristic of the design methods used microcontroller as the core of the DAQ which applied to collect or measure the signal of interest. The advantages of using microcontroller are easy to buy in the local market and cheap firmware recorder device.

2.4 System Hardware design

2.4.1 Microcontroller

Microcontroller is a kind of miniature of computer which applied at the most of our electronic appliances nowadays. *Micro* suggests that the device is miniature, and *controller* tells you that the device might be used to control substance, process, or event. Another term to describe a microcontroller is *embedded controller*, because the microcontroller and its support circuits are often built into, or embedded in, the devices they control.[8]

This miniature microcontroller chip consists of basic function such as central processing unit (CPU), random-access memory (RAM), read-only memory (ROM), input and output (I/O), serial, parallel and Ethernet ports, sometimes other built-in peripheral such as analogue to digital (A/D) and digital to analogue (D/A) converter [9]. With incorporating these basic functions inside of a microcontroller, this chip can be compact and simple in feature as well as low in cost [10].

The core component of DAQ is the PIC microcontroller, 8 bit system with 5 analogue input channels of 10 bits analogue to digital converter (A/D) as **Figure 2-5**. The A/D converter has conversion time of 200ns for 20MHz crystal oscillator. With a +5V power supply the converter has a resolution of 4.88ms[11].

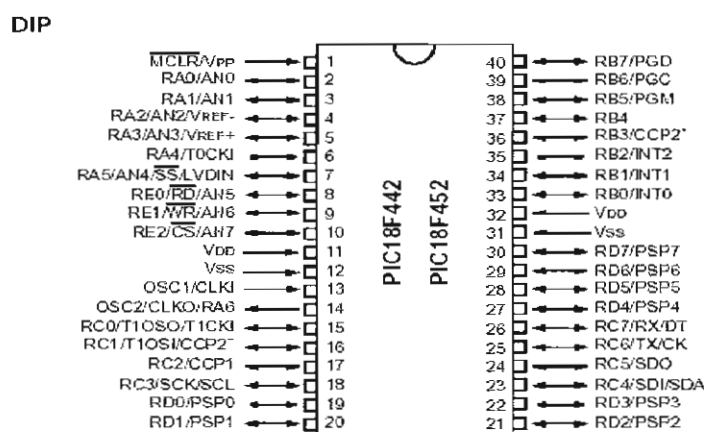


Figure 2-5 Pin Diagram of PIC18F8542 microcontroller

2.4.2 Multimedia card (MMC)

The Multimedia Card (MMC) is a flash memory card that about the size of a postage stamp: 24 mm × 32 mm × 1.4 mm. MMC is used as a storage medium for a portable device, in a form that can easily be removed for access by a PC. MMC are available in size up to 128GB.

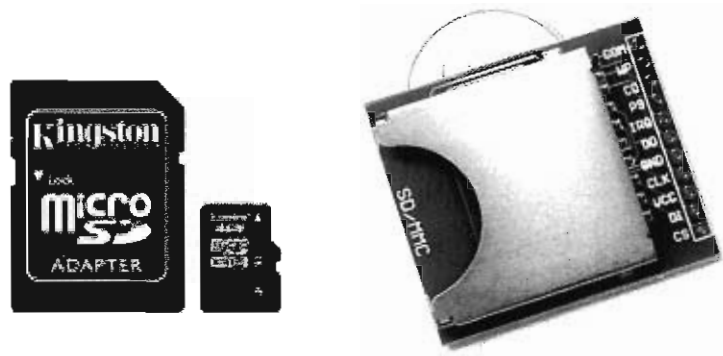


Figure 2-6 Breakout Board for SD-MMC Cards

This is the new Push-Push type socket. The board has 11 pins[12]:

COM : Common - Connects to the housing

WP : Write Protect Detect Switch

CD : Card Detect Switch

P9 : Not used in SPI Mode (Pin 9 on SD Card)

IRQ : Not used in SPI mode (Pin 8 on SD Card)

DO : Serial Data Out

GND : Ground - Connect this to COM to ground the housing

CLK : Serial Clock

VCC : 3.3V Power

DI : Serial Data In

CS : Chip Select