SMART GREENHOUSE USING PIC16F877A MICROCONTROLLER

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APRIL 2007

"I hereby declared 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 (Control, Instrumentation and Automation)"

Signature : ....

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This Report Is Submitted In Partial Fulfillment of Requirements for the Degree of Bachelor in Electrical Engineering (Control, Instrumentation and Automation)

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Universiti Teknikal Malaysia (UTeM)

April 2007

"I hereby declared that this report is a result of my own work except for the excerpts that have been cited clearly in the references."

Signature : ....

Name : Muhammad Muizz Bin Mohd Nawawi

Date : 17 / 04 / 2007

For my beloved father and mother
Mohd Nawawi Bin Harun and Fauziah Binti Abd Ghani
In appreciation of supported and understanding.

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Alhamdulilah, praise be to Allah, the Cherisher and Sustainer of world, most Gracious, most Merciful Lord.

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ABSTRACT

For the sake of the government will toward the high technology agriculture industry in Malaysia through it 'Dasar Pertanian Negara Ketiga (DPN) 1998 – 2010' and 'Rancangan Malaysia Ke 9 (RMK9)'. A challenge was carry out through control engineering field to produce a system that can monitor and control the environment inside the greenhouse to increase and maximize the crops quality and quantity for an effective production.

Smart Greenhouse, this project is focusing on the automatics environmental monitor and control system that base on a PIC16F877A microcontroller. This Smart Greenhouse is stand alone systems that can be operated with or without human handling or interface to maintain targeted atmospheres inside the greenhouse.

Smart Greenhouse is a system that capable to monitor the temperature, lighting and humidity of the environment adopted. All the data and result will display on the HyperTerminal in the computer and indicator unit. The system also can operate in two mode system, whether in automatics mode or in manual mode function.

ABSTRAK

Demi menyahut seruan kerajaan merevolusikan industri pertanian berteknologi tinggi melalui 'Dasar Pertanian Negara Ketiga (DPN) 1998 – 2010' dan 'Rancangan Malaysia ke 9 (RMK9)'. Cabaran ini disahut dalam bidang kejuruteraan kawalan untuk pertanian dalam rumah hijau bagi meningkatkan dan memaksimumkan kualiti dan kuantiti hasil pertanian, untuk pengeluaran yang efektif.

Projek 'Smart Greenhouse' ini memfokuskan pada pemantauan dan kawalan secara automatic oleh sistem yang berasaskan PIC16F877A mikropengawal.Smart Greenhouse adalah sistem yang beroperasi secara sendiri tanpa perlu pengendalian manusia untuk mengekalkan persekitaran dalam rumah hijau.

Smart Greenhouse adalah sistem yang mampu memantau suhu, pencahayaan dan kelembapan dalam persekitaran rumah hijau. Semua data dan keputusan akan dipaparkan pada *Hyper Terminal* dan *indicator* LED pada *indicator* unit.

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INTRODUCTION

Smart Greenhouse is a system capable in handling the **Environment** inside the greenhouse. The environmental control are focusing on the temperature, humidity and lighting of the atmospheres inside. These systems operate by applying the ventilation concept to maintain the desire atmosphere.

Environmental control includes the day-to-day management decisions that characterize greenhouse crop production. In typical greenhouses, controls are a mix of manual adjustments, timed events, and thermostatically regulated actions. In complexes operations, automates system are used.

Commercially raised plants are predictable. For example, the well understood relationship between day length and flowering in poinsettias is essential information in timing the crop for the market. Growers fully understand the importance of properly controlling "day length" to obtain the brilliant red leaves that customers want. Growers are also aware of the relationship between temperature and crop development. Foliage plants that take nine weeks to grow to market size in the summer, can take 12 weeks in the winter. Most growers know that the growth rate can be sped up by raising greenhouse temperatures

The success of greenhouse operations hinges on the fact that crop after crop responds consistently to its environment. In recognizing the mechanistic relationship between a crop and its greenhouse environment, growers have increasingly come to rely on automatic control systems to provide consistent, favorable environmental conditions

1.1 Problem statement

Typically all growers have a problem when low humidity and high temperature occur. The situation will become worse if the humidity in the greenhouse environment drop bellow 30%RH. Where plant will suffer from slow growing process or it will halt the plant growing process.

Numerous plant disease problems can arise in greenhouse situations. These diseases can cause extensive damage of allowed to develop unchecked. Since plant diseases are strongly affected by temperature and humidity, the best way to combat disease is to manipulate the greenhouse environment. Unlike the weather outdoors, we can control the greenhouse environment.

High humidity levels encourage the development of many plant diseases. The relative humidity is usually 25%-70% during the day in greenhouses and 90-100% during the night.

Ventilation is importance to provide fresh air as a primarily needed to lower the humidity and air temperature. It also replenishes carbon dioxide (CO_2) that plants consume during daylight hours in process of photosynthesis.

The ventilation fans applied to exhaust the warm moist air from the greenhouse. The warm moist greenhouse air is replaced with cool/cold, moist air from outdoors. When this outside air is heated in the greenhouse it becomes much drier than the previous greenhouse air. This management practice greatly reduces the relative humidity in the greenhouse and reduces potential disease problems.

Light limits the photosynthetic productivity of all crops and is the most important variable affecting productivity in the greenhouse. The transpiration rate of any greenhouse crop is the function of three variables; ambient temperature, humidity and light. When light levels are limiting, supplementary artificial lighting are needed to increase plant growth and yield in greenhouse.

There will become a vital need to take control of those elements in order to have an efficient and profitable production of greenhouse agriculture product.

1.2 Project objectives

The following objective will be based on PIC16F877A programming:

1. To develop a system that can ***monitor*** the temperature, lighting and humidity inside the greenhouse.

2. To develop a system that can send information to a computer and allow user interface to the control system.

3. To develop a system that can ***control*** the temperature, lighting and humidity inside the greenhouse.

4. To develop a system that has an automatic mode and a manual mode controlling.

5. To build a Smart Greenhouse prototype plant.

1.3 Scope of project

The project final results;

System that can monitor and control the temperature, lighting and humidity of the greenhouse. Based on the PIC16F877A microcontroller as the heart of the system.

Approach used in this project;

By controlling the lighting condition, flow in fan, flow out fan system and ventilation fan system inside the greenhouse.

The systems will immediately response to any changes in the environment inside the greenhouse for any changes on the humidity, temperature and lighting.

Controlling the environment by applying the ventilation concepts.

The project involved;

#Hardware;

The hardware development consists of the design, redesigns, testing and troubleshoots all the circuit involved.

#Software;

The software part will base on the simulations for all the system parts on the smart greenhouse

#Firmware;

This part consists of programming the entire system using PCW C Compiler stage by stage toward the end. Design and develop the complete automated system that will control the targeted atmosphere.

CHAPTER 2.0

LITERATURE REVIEW

2.1 Malaysia agriculture industry policy

Third National Agricultural Policy (1998 - 2010)

The Third National Agricultural Policy (NAP3) which sets the strategic directions for agricultural and forestry development to the year 2010. This policy has been formulated to ensure that the capability of the agricultural sector's strategic role in national development is sustained and enhanced in light of new and emerging challenges facing agricultural development.

Towards this end, NAP3 will focus on new approaches to increase productivity and competitiveness, deepen linkages with other sectors, venture into new frontier areas as well as conserve and utilize natural resources on a sustainable basis. The policy aims to set in place the enabling and supportive measures as well as a conducive environment to promote growth in the agricultural sector. The policies and strategies formulated will continue to emphasize productivity and market driven growth.

The overriding objective of NAP3 is the maximization of income through the optimal utilization of resources in the sector. This includes maximizing agriculture's contribution to national income and export earnings as well as maximizing income of producers.

Specifically, the objectives of the Policy are:

i to enhance food security;

ii to increase productivity and competitiveness of the sector;

iii to deepen linkages with other sectors;

iv to create new sources of growth for the sector; and

v to conserve and utilize natural resources on a sustainable basis.

As underlined in the 2005 report by the Ministry of Finance, the Government is currently focusing its efforts to develop Malaysia's agriculture sector as the country's third machine of economic growth. To this end, the Government provides various forms of schemes and support toward encouraging investments in this sector

During the 2006-2010 period, the agriculture sector is expected to grow at a higher average annual rate of 5 percent and, with the inclusion of the agro-based industry, the growth rate is expected to reach 5.2 percent. In line with the new emphasis on agriculture, a total of 11.4 billion ringgit (3.08 billion U.S. dollars) will be provided to carry out various agricultural programs and projects in this country, an increase of 7 percent compared with the eighth plan.

Modern farming

The Government has allocated RM11.4bil under the Ninth Malaysia Plan (9MP) to transform the agriculture sector into a modern, dynamic and competitive sector. This represents a 70% increase, or an additional RM4.7bil, over the allocation under the 8MP. The sector is expected to grow by 5% annually during the 9MP period, up from 3% previously. With the inclusion of the agro-based industry, the growth rate is expected to be 5.2%.

The focus will be on developing New Agriculture to revitalize the agriculture sector to become the third engine of growth after the services and manufacturing sectors. It will involve large-scale commercial farming, the wider application of modern technology, production of high quality and value-added products, unlocking the potential in biotechnology, increased convergence of information and communications technology (ICT), and the participation of entrepreneurial farmers and skilled workforce.

Budget 2007

Budget 2007 has a strategic objective as it sets out key policies to kick-start the Ninth Malaysia Plan (9MP), which is a five-year strategic plan from 2006 to 2010.Our Malaysia Prime Minister, Abdullah Badawi is also keen to develop the agriculture sector as Malaysia's third engine of economic growth (after manufacturing and services). A sizeable RM3.6 billion has been allocated to agricultural development with a RM200 million agriculture fund established to finance technology-intensive agricultural projects in the 2007 budget.

2.2 Greenhouse concept applied

Ventilation systems

The ventilation system provides the means by which the greenhouse air is circulated, mixed and exchanged. It allows for a more uniform climate and helps to distribute heat from the heating system (Jackson and Darby 1990) as well as removing heat from the greenhouse when cooling is required. In combination with the heating system, ventilation also provides a means for dehumidifying the greenhouse environment. Ventilation is required throughout the year, however the ventilation required varies with the outside environment.

Ventilation and Air Circulation

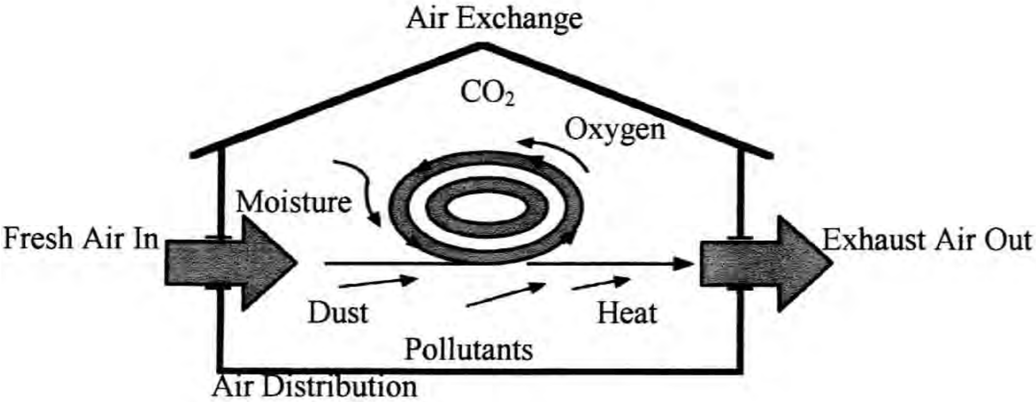

Figure 2.1: The Greenhouse Ventilation and Air Circulation

2.3 Greenhouse temperature theory

Temperature Management

Development and flowering of plants relates to both root zone and air temperature (Khah and Passam 1992), and control of temperature is an important tool for the control of crop growth (De Koning 1996).

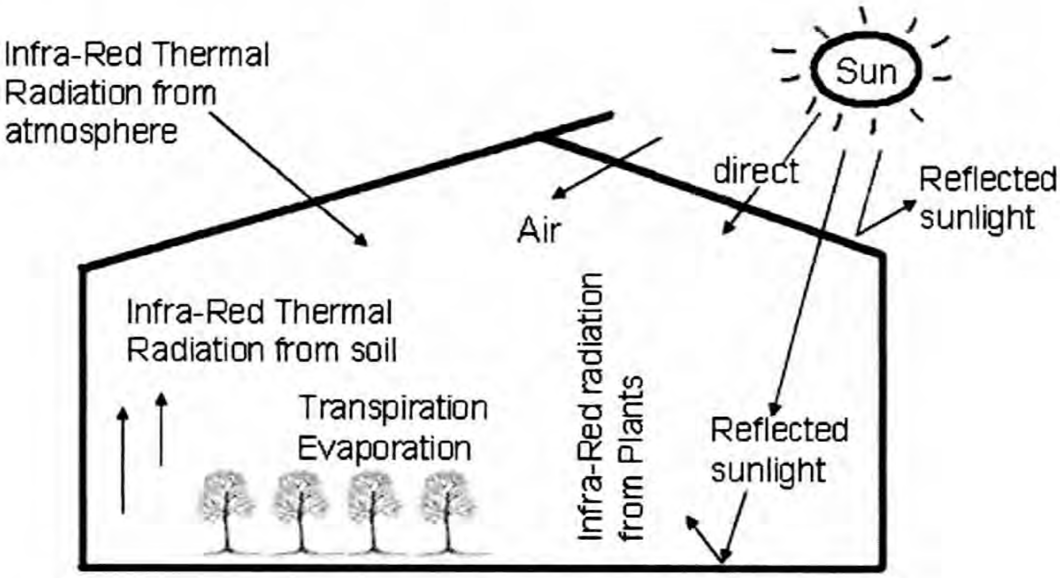

Figure 2.2: The Greenhouse Phenomena

Managing air temperatures

The optimum temperature is determined by the processes involved in the utilization of assimilate products of photosynthesis, example like the distribution of dry matter to shoots, leaves, roots and fruit (De Koning 1996). For the control of crop growth, average temperature over one or several days is more important than the day/night temperature differences (Bakker 1989, De Koning 1996). This average temperature is also referred to as the 24-hour average temperature or 24-hour mean temperature (Bakker 1989, Portree 1996). Various greenhouse crops show a very close relationship between growth, yield and the 24-hour mean temperature (Bakker 1989, Portree 1996).

With the goal of directing growth and maintaining optimum plant balance for sustained high yield production, the 24-hour mean temperature can be manipulated to direct the plant to be more generative in growth, or more vegetative in growth. Optimum photosynthesis occurs between 21 to 22 °C (Portree 1996), this temperature serves as the target for managing temperatures during the day when photosynthesis occurs. Optimum temperatures for vegetative growth for greenhouse peppers is between 21 to 23 °C, with the optimum temperature for yield about 21 °C (Bakker 1989). Fruit set, however, is determined by the 24-hour mean temperature and the difference in day - night temperatures (Bakker 1989), with the optimum night temperature for flowering and fruit setting at 16 to 18 °C (Pressman 1998). Target 24-hour mean temperatures for the main greenhouse vegetable crops (cucumbers, tomatoes, peppers) can vary from crop to crop with differences even between cultivars of the same crop.

The 24-hour mean temperature optimums for vegetable crops range between 21 to 23 °C, depending on light intensity. The general management strategy for directing the growth of the crop is to raise the 24-hour average temperature to push the plants in a generative direction and to lower the 24-hour average temperature to encourage vegetative growth (Portree 1996). Adjustments to the 24-hour mean temperature are made usually within 1 to 1.5 degrees Celsius with careful attention paid to the crop response.

One assumption that is made when using air temperature as the guide to directing plant growth is that it represents the actual plant temperature. The role of temperature in the optimization of plant performance and yield is ultimately based on the temperature of the plants. Plant temperatures are usually within a degree of air temperature, however during the high light periods of the year, plant tissues exposed to high light can reach 10 to 12 °C higher than air temperatures. It is important to be aware of this fact and to use strategies such as shading and evaporative cooling to reduce overheating of the plant tissues. Infrared thermometers are useful for determining actual leaf temperature.

2.4 Greenhouse lighting theory

Light limits the photosynthetic productivity of all crops (Wilson et al 1992) and is the most important variable affecting productivity in the greenhouse (Wilson et al 1992, Papadopoulos and Pararajasingham 1997). The transpiration rate of any greenhouse crop is the function of three variables; ambient temperature, humidity and light (Stanghellini and Van Meurs 1992, Van Meurs and Stanghellini 1992). Of these three, it is light which is usually out of our control as it is received from the sun (Stanghellini and Van Meurs 1992, Van Meurs and Stanghellini 1992). Supplementary lighting does offer opportunity to increase yield during low light periods, but is generally considered commercially unprofitable (Warren et al 1992, Papadopoulos and Pararajasingham 1997). The other means for manipulating light are limited to screening or shading (Stanghellini and Van Meurs 1992) and are employed when light intensities are too high. However, there are also general strategies to help maximize the crop's access to the available light in the greenhouse.

Properties of light and its measurement

In order to understand how to control the environment to make the maximum use of the available light in the greenhouse, it is important to know about the properties of light and how light is measured. Considerable confusion has existed regarding the measurement of light (LI-COR Inc.), however it is worthwhile for growers to approach the subject.

Light has both wave properties and properties of particles or photons (Tilley 1979). Depending on how light is considered, the measurement of light can reflect either its wave or particle properties. Different companies provide a number of different types of light sensors for use with computerized environmental control systems. As long as the sensors measure the light available to plants, for practical purposes it is not as important how light is measured, as it is for growers to be able to relate these measurements to how the crop is performing.

Light is a form of radiation produced by the sun, electromagnetic radiation. A narrow range of this electromagnetic radiation falls within the range of 400 to 700 nanometers (nm) of wavelength. One nanometer being equal to 0.000000001 meters. The portion of the electromagnetic spectrum which falls between 400 to 700 nm is referred to as the spectrum of visible light, this is essentially the range of the electromagnetic spectrum that can be seen. Plants respond to light in the visible spectrum and use this light to drive photosynthesis.

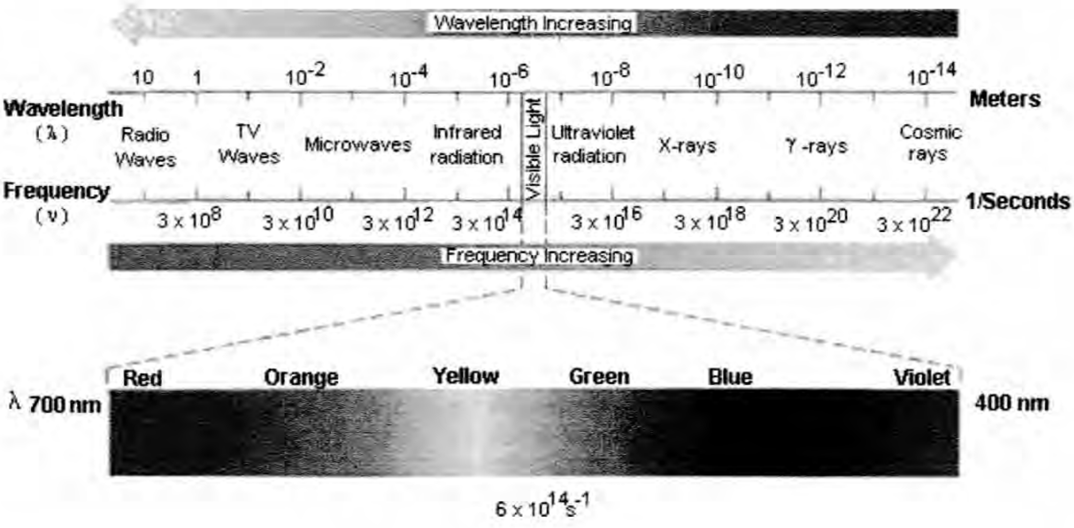

Figure 2.3: The Visible Spectrum.

2.5 Greenhouse humidity theory

Management of the Relative Humidity Using Vapors Pressure Deficits

Plants exchange energy with the environment primarily through the evaporation of water, through the process of transpiration (Papadakis et al 1994). Transpiration is the only type of transfer process in the greenhouse that has both a physical and biological basis (Papadakis et al 1994). This plant process is almost exclusively responsible for the subtropical climate in the greenhouse (Papadakis et al 1994). Seventy percent of the light energy falling on a greenhouse crop goes towards transpiration, the changing of liquid water to water vapour (Hanan 1990), and most of the irrigation water applied to the crop is lost through transpiration (Papadakis et al 1994).

Relative humidity (RH) is a measure of the water vapour content of the air. The use of relative humidity to measure the amount of water in the air is based on the fact that the ability of the air to hold water vapour is dependent on the temperature of the air. Relative humidity is defined as the amount of water vapour in the air compared to the maximum amount of water vapour the air is able to hold at that temperature (Tilley 1979, Portree 1996). The implication of this is that a given reading of relative humidity reflects different amounts of water vapour in the air at different temperatures. For example air at a temperature of 24 °C at a RH of 80% is actually holding more water vapour than air at a temperature of 20 °C at a RH of 80%.

The use of relative humidity for control of the water content of the greenhouse air mass has commonly been approached by maintaining the relative humidity below threshold values, one for the day and one for the night (Stanghellini and Van Meurs 1992). This type of humidity control was directed at preserving low humidity (Stanghellini and Van Meurs 1992), and although humidity levels high enough to favour disease organisms must be avoided (Stanghellini and Van Meurs 1992), there are more optimal approaches to control the humidity levels in the greenhouse environment. The sole use of relative humidity as the basis of controlling greenhouse air water content does not allow for optimization of the growing environment, as it does not provide a