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Hardware Design of Microcontroller Based Automated Plant Nursery System

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Abstract: Microcontroller Based Automated Plant Nursery System introduced a basic yet important system that automatically waters the plants, provides conditional temperature and moisture as needed by the crops. This system consists of automated plant irrigation, temperature controller and saturation control elements. Microcontroller PIC16F877 is been used as a main controller to control the entire three main functional unit. This controller is been used as it is suitable for an experimental, measurement and basic controlling application because of its low price, wide range of applications, high quality, and ease of availability. This system is real time based which able to indicate the exact condition and temperature of the nursery and to perform needed action in providing an ideal condition for the plants. This paper is a review of the hardware design of the system.

Key words: automated plant nursery system, microcontroller, PIC16F877, irrigation

1. Introduction

Industrializing agriculture in Malaysia will lead to a remarkable growth and development of Malaysian economy (Mohamad Idham Md Razak et al., 2015). This could be achieved by increase the productivity and reduce the overall cost of farming. The major issues in agriculture farming are high dependency on climate conditions and labors (Bakar, 2009). Unpredictable climate changes effects the quality and growth of the plants/seedlings. Climates also limits the duration of cultivation. Being a labor intensive industry, hiring and managing labors is also being one of the big challenges. Workers in farms and plantation is given huge workloads and required to work in a very unconditional work place. Work have to be done at the right time without considering the hot sun or raining day. Nurseries and vegetable houses nowadays still using the manual management system whereas it has a potential to be managed automatically.

The disadvantages of the current nurseries system are the requirements of the huge man powers, improper irrigation system which wastes a lot of water and the dependency on the natural resources. By improving these elements, nurseries and farms can increase the productivity.

Microcontroller Based Automated Plant Nursery System is an automatic system which able to control the

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temperature and composite's moisture in order to provide a conditional environment for plants. This system as shown in Figure 1, includes the systematical plant irrigation, cooling and roofing system. Irrigation system is an automatic system that can water the plant twice daily by using the timing program. Meanwhile, temperatures are controlled by using temperature controlled fan which can turn on/off automatically. It also controls the fan's speed linearly to the temperature of the room. The third element, moving roof is used in order to prevent over saturation which can harm the plant during the raining season. A rain detector triggers the motor rotation in order to move the roof to a proper location to block rain water. The main controller for this system is PIC 16F877 microcontroller. BASIC language is been used to write the programs for this microcontroller. All the sensing and detector circuit is designed in order to provide the required output and the program is written accordingly to deal with the possible outputs of the sensing circuits.

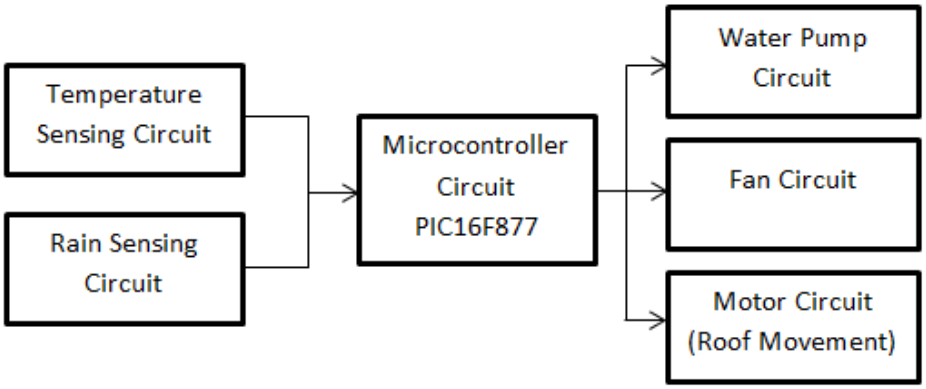

Figure 1 Block Diagram of Microcontroller Based Automated Plant Nursery System

2. Circuit Design

The design of Microcontroller Based Automated Plant Nursery System involves the combination of hardware and software design. The hardware design includes Microcontroller circuit, Alphanumeric LCD Circuit, Power Supply Circuit, Irrigation System Circuit, Temperature Controlled Fan System, Temperature Sensing Circuit, Saturation Controller Circuit and a Motor Driver Circuit. The arrangement of the overall circuits diagram can be referred in Appendix A. All the circuit used in this system is the modification of the existing circuit.

2.1 Microcontroller Circuit

PIC 16F877 microcontroller is main controller of the system, it can monitor all the sensors simultaneously. Basically, microcontroller executes a user program which is loaded in its program memory. Under the control of the program, data is received from external devices, manipulated and then the data is sent to external output devices in order to perform certain task.

In this design, the main controller circuit receives the output of sensor circuits and provides controls and monitors the function. These are done by connecting output and inputs of sensors to PIC's pin. Data received from sensor circuit will be used to trigger the other circuit.

2.2 Irrigation System Circuit

This circuit involves the usage of the relay as the switching component to open and close the irrigation valve.

A relay is an electrical switch that opens and closes under the control of another electrical circuit (Shiraz Pasha B. R. & Yogesha B., 2014). The microcontroller will trigger the relay according to the timing that been set through the program. Once the relay receives the input from the PIC16F877, it will on the electronic valve. This will allow the flow of water to the plant. The duration of the irrigation valve to be in an open state is determined by the time setting done in program. The functional diagram of Irrigation System circuit is as shown in Figure 2.

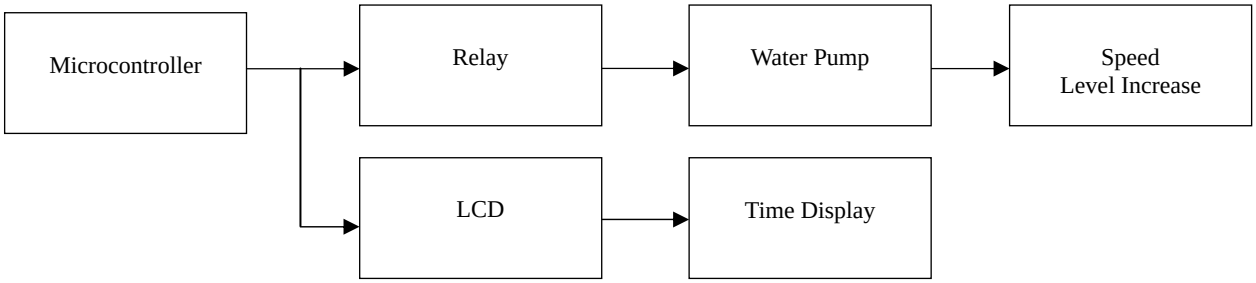

Figure 2 Block Diagram Irrigation System

2.3 Temperature Controlling Circuit

Temperature controlled circuit is a circuit that system that able to control the temperature of the nursery by controlling its fan automatically. The fan was been control to be on, increase speed and off automatically according to the room temperature. The functional diagram of Temperature Controlled Fan System circuit is as shown in Figure 3.

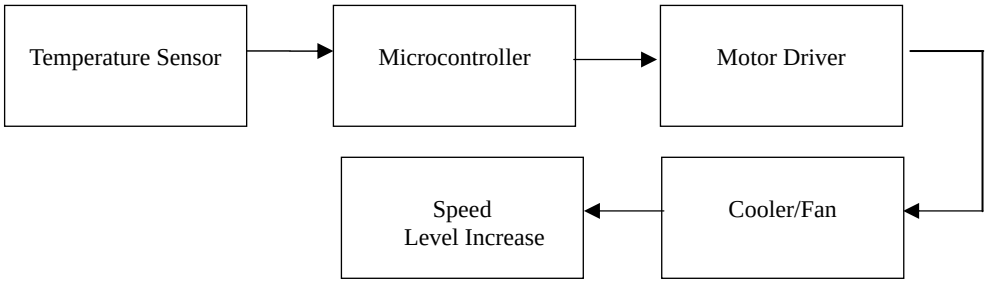

Figure 3 Block Diagram of Temperature Controlled System

The microcontroller PIC16F877 received the temperature data that have been converted into voltage range and it controls the cooling rate of the fan in order to decrease the temperature of the nursery (Serhat Yilmaz, Burak Tombaloglu, Kursat Karabulutlu, Yener Gumus, 2014).

In the design, LM355 is used as it is water proof with acceptable precision and can be calibrated easily (Texas Instruments, 2013). It converts instantaneous temperature into voltage. The temperature measurement output LM355 is fed directly to the RA0 of PIC (Pin 2), which is an Analog-to-Digital-Converter (ADC) input.

The output of the sensor can be expressed as:

$$Vout_T = Vout_{T0} \times \frac{T}{T_0}$$

where T is the unknown temperature and T_0 is a reference temperature, both expressed in degrees Kelvin. By calibrating the output to read correctly at one temperature the output at all temperatures is correct. Nominally the output is calibrated at 10 mV/°K (Texas Instruments, 2013).

2.4 Saturation Controller Circuit

Saturation Controller is a system that used a rain detector sensor in order to control the saturation rate of the soil. To prevent the soil from being over saturated during the raining season a moveable roofing system is been used. This roof will close automatically when it rains. The rain detector used in this system can be constructed by etching the cooper board as shown in the Figure 4 (Swagatam M., 2014).

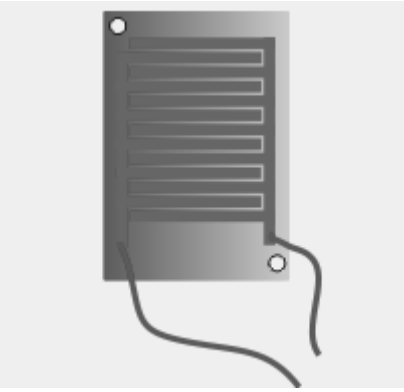

Figure 4 Etched Cooper Rain Detector Sensor

When the water exist at the rain sensor the, PIC will trigger the DC motor, in order to move the roof in the reverse or forward direction. The functional block diagram of the Saturation Control System is as shown in Figure 6 (Khan & Gupta, 2015).

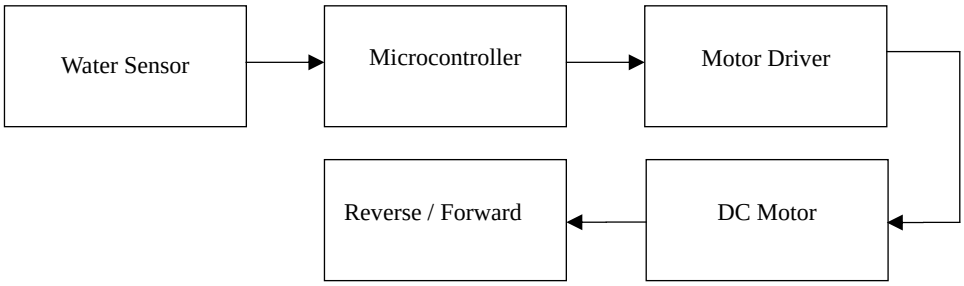

Figure 5 Block diagram of Saturation Control System

2.5 Motor Driver Circuit

This motor driver circuit is designed to drive high current brush motor. There is two relays been used to control the movement of the roof. The activation and rotation of the motor is done by providing inputs to the relay 1; clock wise (CW) and relay 2; counter clock wise (CCW). For the motor driver which controls the movement of the roof, a constant 5V is provided to PWM pin as there is no speed control is required.

3. Result

The following is the result produced by the system:

3.1 Display Test

Initially, a message of “PLANT MANAGEMENT” is displayed on the LCD display. This message will be displayed on the LCD every time when the reset switch of the microcontroller circuit is pressed.

After the initial display, LCD screen will display all the information regarding the activities of the Automated Plant Nursery System. The display will show the temperature reading of the room, the time counting for the irrigation pump, and condition of the roof. When the automatic switch is been pressed, the display will display the status of the system as AUTO.

For the irrigation system, the display will provide the period of the irrigation system been on. Here, the count up will be shown for 1 minute. The location of the roof also will be displayed, when the roof is moving forward, the display will show FRWD and when it is moving backward it will shows BACK on the LCD. The display of LCD is shown in Figures 6 and 7.

Figure 6 LCD Display When Automatic Option Been Selected

Figure 7 LCD Display When Manual Option Been Selected

3.2 Automatic Irrigation System

Irrigation of the plant can be done manually or automatically. When the manual system is been chose, the water pump can be on and off by switch on the irrigation switch. The pump will be on as long as the switch is been turned on. For the automated system, the pump will turn on 1 minute for every 12 hours. LCD display and LED indication during the pump in on state is shown in Figure 8.

Figure 8 LCD Display and LED Indicator When Pump is on

3.3 Temperature Control System

The fan can be turn on manually and automatically. For manual operation the fan will turn on when the fan switch is been on. When the system operates in automated control system, the temperature sensor will measure the temperature of the room. The reading of the temperature will be displayed through the LCD. As the temperature rise above 30 degree, the fan will turn on automatically. As the temperature is between 30 until 33 degree, the fan will operates in a speed level one and the speed increased as the temperature increase above 33 degree. The fan will rotate at the full speed as the temperature is above 38 degree.

3.4 Saturation Controller System

The roof of the Automated Plant Nursery System can be controlled by manual or automatic. When the roof switch is been pressed, the roof will move forward and stops when it touch the front limit switch and the roof will moved backward when the roof switch is been pressed again. For the automated system, the roof will moved forward when there is existence of water on the water detector sensor. The roof will back to the initial condition when the water on the water sensor dries up. The motor movement is as in Table 1.

Table 1 Truth Table of Motor Movement

CW	CCW	Motor(+)	Motor(-)	Comment
1	1	H	H	Brake to Power(+)
1	0	H	L	Clockwise
0	1	L	H	Counter Clockwise
0	0	L	L	Brake to Power(-)

4. Conclusion

In conclusion, the proposed Automated Plant Nursery System is an efficient system that capable to provide automatic irrigation, temperature and saturation control for crops. The changes in the temperature, roof movement and irrigation can be observed easily through the readout facilities of the system. Apart from automated control, this all elements can be also controlled manually by using switch provided. By providing the manual control, any changes can be done easily without affecting the farming activity. The design and construction requires the implementation of all the electronic and programming knowledge. As this system includes the hardware and real time based programming, the interfacing both element had been a challenging task in completing this system.

5. Recommendation

This Microcontroller Based Automated Plant Nursery System can be improvised for a better performance. Firstly, the accuracy of the results observation can be improved by using a better temperature sensor. The temperature sensor, LM 355 which is been used in this system unable to provide accurate temperature. The changing rate of the temperature of this sensor is very slow.

The second improvement can be done by implementing the soil saturation sensor (Mehamed, Gebremedhn, & Tsigabu, 2015). This sensor will be useful if this system is aimed to be implemented in the hydroponic plantation system. This sensor able to detect the over saturation condition of the soil and able to on or off the pump accordingly based on the water level.

The third improvement can be done by implementing the solar energy as the power source. By implementing

this, a very economical and reliable system can be provided for the large scale plantation. Improvement also needed to be done by applying keypad to control the amount of the water or to time delay for the pump to be on. In the current system, the program has to change in order to change the amount of the water.

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Appendix A Schematic Circuits Diagram of Microcontroller Based Automated Plant Nursery System