Creation of the Environmental Conditions of an Automatic Greenhouse Control System

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Abstract

Today, automatic control systems are enabling greenhouses to grow crops faster, more efficiently, more sustainably, and in almost every external condition. The proposed system is designed to develop a greenhouse environment monitor and control system which switches the solenoid valve ON/OFF on sensing the moisture of the soil, the pump motor ON/OFF on sensing the water level of the overhead tank, the lamp ON/OFF control on sensing the light intensity and cooling fan ON/OFF on sensing the surrounding temperature on the plants respectively. This system uses a PIC16F877A microcontroller which is programmed to receive the input signal of varying moisture conditions of the soil, water level of the overhead tank, light, and the atmospheric temperature through the sensing arrangements. Two water level probes are interfaced with microcontroller input. The remaining three sensing arrangements are achieved by using transistors which act as the interface between the sensing arrangements and the PIC microcontroller. Once the controller receives this signal, it generates an output that drives a relay for operating the solenoid valve, water pump, cooling fan, and lamp. A 2 × 16 LCD is also interfaced with the microcontroller to display the status of the actuators.

Keywords– PICmicrocontroller16F877A, an NTC thermistor, an LDR, two water level probes, a soil moisture sensor, a 12VDC water pump, a solenoid valve, a CFL lamp, a cooling fan

INTRODUCTION

Myanmar is a large country in the world. Agriculture is the backbone of Myanmar's economy. The application of greenhouse technology for the commercial production of several high-value horticulture crops is growing rapidly. The main objective is to design a simple, easy-to-install system that monitors and controls the greenhouse parameters to achieve maximum plant growth in a greenhouse. This system consists of various sensors, namely soil moisture sensor, thermistor sensor, water level sensor, and light-dependent sensors. These sensors sense various parameters and are sent to the PIC 16F877A MCU.

In this research, four sensors are used. A negative temperature coefficient thermistor is used to sense the temperature of the greenhouse environment. A soil moisture sensor is used to check the conductivity of the soil. Two probes of this sensor are inserted into the soil. If the soil is wet, then conductivity is more and resistance is less. If the soil is dry, then conductivity is less and resistance is high. LDR is a light-dependent resistor used as a light sensor. LDR's resistance depends on the intensity of the light. As the light on the LDR change, the resistance of the LDR also change. Two water level sensors are used to sense the water level of the overhead tank. The Block diagram of the automatic greenhouse control system is shown in Figure 1.

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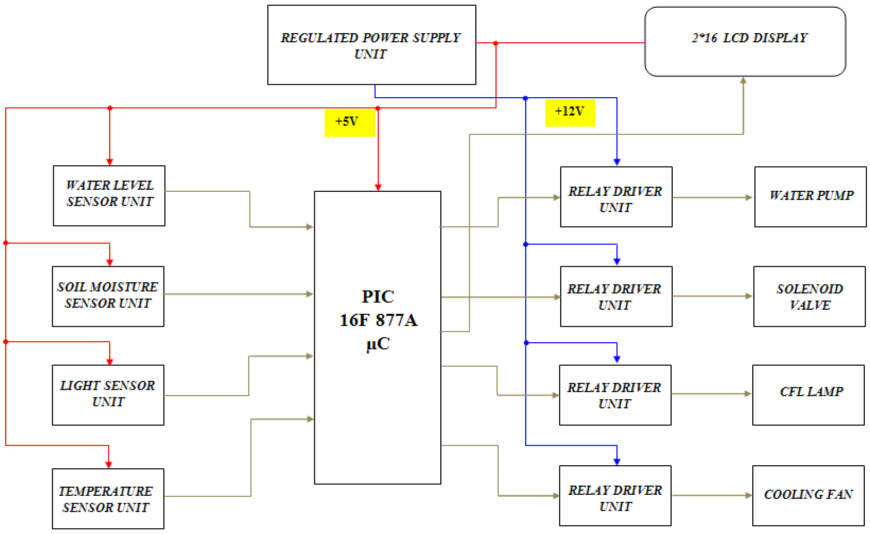

Figure 1. Block diagram of an automatic greenhouse control system

Theory Background of Hardware System Devices

In this research paper, the following hardware units have been used:

PIC 16F877A Microcontroller

The PIC (Peripheral Interface Controller) was intended for simple control applications. Figure.2 shows the description of PIC 16F877A. The families are identified by the first two digits of the device code. The 'F' means the incorporation of Flash memory technology. After the number, 'A' indicates a technological upgrade on the first issue device.

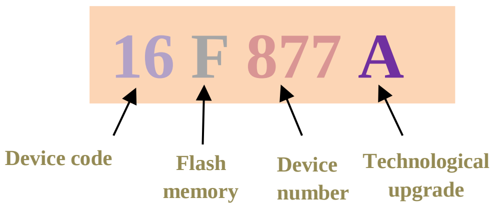

Figure 2. Description of PIC 16F877A

The baseline and mid-range families use 8-bit wide data memory, and the high-end families use 16-bit data memory. The PIC 16F877A has 33 I/O pins distributed across five ports. The pin connections diagram of the 16F877A, for the dual-in-line packages, is shown in Figure 3.

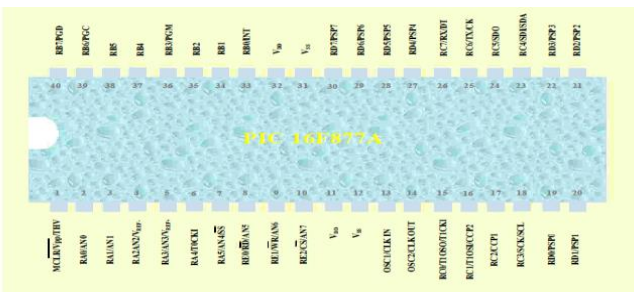

Figure 3. Pin connection diagram of a PIC 16F877A microcontroller

Soil Moisture Sensor

Soil moisture sensors measure the amount of water contained in the soil. Two probes of the soil moisture sensor are used to measure the volumetric content of water in the soil. The two probes allow the current to pass through the soil and it gets the resistance value for the moisture of the soil. Therefore, the moisture level will be lower. In this research paper, the soil moisture sensor FC-28 is used in Figure 4.

The soil Moisture sensor FC-28 has four pins

- VCC: For power
- A0: Analog output
- D0: Digital output
- GND: Ground

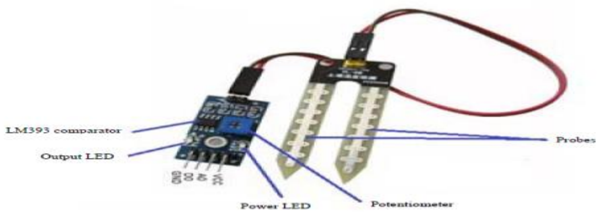

Figure 4. Pin connection diagram of a soil moisture sensor FC-28

Thermistor

A thermistor is a thermal - resistor whose resistance depends on the temperature. The NTC thermistor has the characteristic of resistance falling with increasing temperature. NTC thermistors are characterized by their base resistance at room temperature, that is 25^{o}C, (77^{o}F) as a convenient reference point. In this research paper, the NTC thermistor is used to sense the temperature of the greenhouse environment. NTC thermistor use in this research work is shown below in Figure 5.

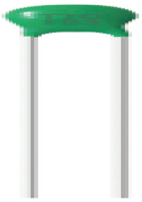

Figure 5. NTC Thermistor

Water Level Sensor

A water sensor is used for the detection of water levels for different applications. In this research work, the water level sensor consists of two water level probes which are used to sense the water level of the overhead tank. When the water level reaches the upper probe, a switch opens to stop the water pump; when the level reaches the lower probe, the switch closes to start the pump The current required to pass through the wire is in milliamps (mA).

Light Sensor

Photo resistors such as light-dependent resistors (LDR) are light-sensitive devices that are used to measure the intensity of light. LDR is used in this research work as shown in Figure 6.

Figure 6. Light-dependent resistor

In the dark, LDR's resistance is very high up to 1MΩ, but when the LDR sensor is exposed to light, the resistance drops dramatically, even down to a few ohms, depending on the light intensity. LDRs have a sensitivity that varies on the wavelength of the light intensity applied to the research paper.

HD 44780 LCD

LCD modules are mostly used in embedded projects, due to their cheap price, availability, and programmer-friendly. In this paper, HD 44780 (2×16) LCD is used which means 2 rows and 16 characters per line and there are two such lines. It has eighteen pins and each character is displayed in a 5 x 8-pixel matrix. This LCD has registers, Commands, and Data. The command register gives the command instructions to the LCD. A command is an instruction given to an LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, and controlling the display. The data register gives the data to be displayed on the LCD. The pin diagram of a 2×16 LCD is shown in Figure 7. Each character LCD has an 8-bit data port to connect with external controllers. In this research work,4-bit mode means four data pins are used.

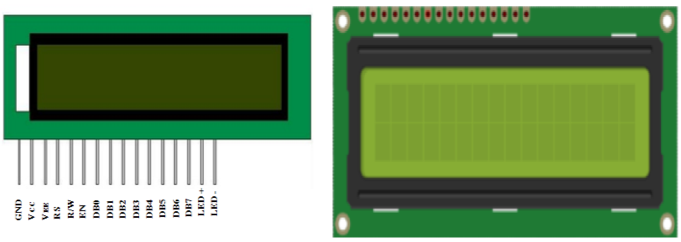

Figure 7. Pin connection diagram of a 2×16 LCD

Design and Operation of the Greenhouse Control System

As shown in Figure 1, the construction of the Automatic Greenhouse Control System consists of two parts: the hardware and software implementations. Both software and hardware will be accomplished using a PIC 16F877A microcontroller.

A. Hardware Design

Automatic Greenhouse Control System consists of four systems, namely automatic water level control system, automatic temperature control system, automatic moisture control system, and light control system. In the water level control system, two copper wires are used as water level sensor probes, one is a low-level sensor and the other is a high-level sensor. These two sensors are dipped in the water of the overhead tank. The low water level sensor is connected to the RC0 input and the high-level sensor is connected to the RC1 input of the PIC 16F877A microcontroller IC. The soil moisture condition of the greenhouse is sensed by the FC-28 soil moisture sensor. Which is connected to the RC2 input of this microcontroller IC via transistor Q1's collector. Similarly, Light Dependent Resistor (LDR) is connected to the RC4 input of the microcontroller via transistor Q3's collector. Moreover, the temperature of the greenhouse environment is sensed by the Negative Temperature Coefficient (NTC) thermistor which is connected to the RC3 input of the microcontroller via transistor Q2's collector.

B. Circuit Operation of the Greenhouse Control System

Figure 8 shows the schematic diagram of the Automatic Greenhouse Control System.

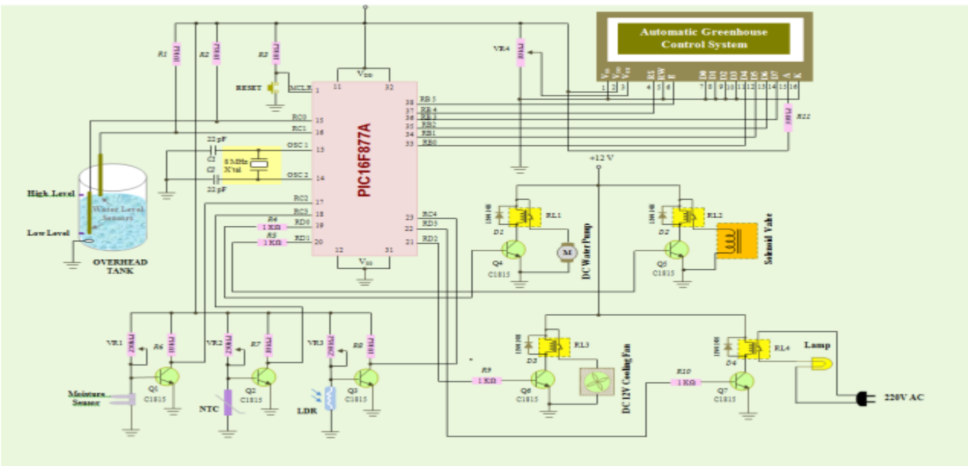

Figure 8. Schematic diagram of the Automatic Greenhouse Control System

In this circuit diagram PIC, 16F877A microcontroller is the main component that is used for controlling other devices. Two different DC voltage levels are used in this system. The power supply unit of this construction is shown in Figure.9. DC 12 V supply is used for electromagnetic relays, DC water pumps, and solenoid valves while DC 5 V supply is used for microcontroller, LCD, and other input sensors networks.

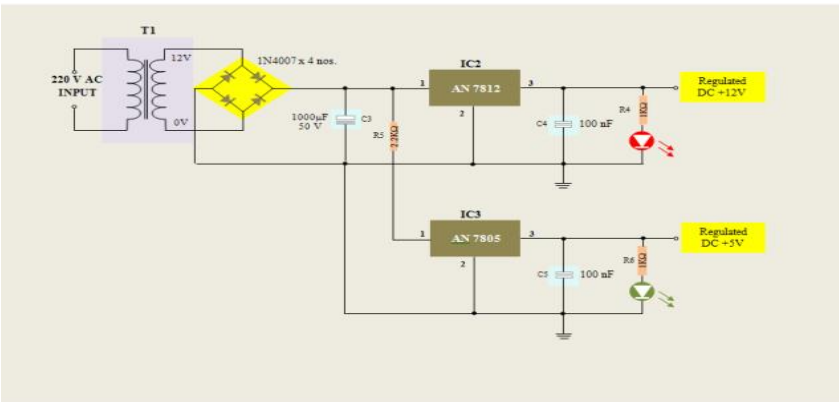

Figure 9. Power supply unit of the technical support for the greenhouse environment control system

The practical implementation of the simulated circuit has been presented in Figure.10. The soil moisture sensor is connected to the RC2 input of the MCU via transistor Q1. VR1 is used for adjusting the sensitivity of soil moisture. RD1 output of the MCU is connected to RL2 via transistor Q5. When the soil is wet, the resistance of the moisture sensor decreases, and the voltage across the sensor is decreased. The output voltage of this sensor is fed to the base of transistor Q1. Therefore Q1's base voltage is "low" and its collector voltage is "high". This voltage is applied to the RC2 input of the MCU and the corresponding output voltage “low” is achieved from output RD1. This voltage is applied to the base of transistor Q5. Transistor Q5 reaches the cut-off condition and relay RL2 is de-energized. In this condition, the solenoid valve is not activated and the LCD display “Soil is Wet”, and “Stop Watering”. When the soil is dry, the resistance of the moisture sensor increases and the voltage across the sensor is increased. The output voltage of this sensor is fed to the base of transistor Q1. Therefore Q1’s base voltage is “high” and its collector voltage is “low”. This voltage is applied to the RC2 input of the MCU and the corresponding output voltage “high” is achieved from output RD1. This voltage is applied to the base of transistor Q5. Transistor Q5 is turned on and relay RL2 is energized. In this condition solenoid valve is activated and “Soil is Dry”, and “Watering” information is displayed on the LCD.

NTC thermistor is connected to the RC3 input of the MCU via transistor Q2. VR2 is used for adjusting the temperature of the greenhouse environment. When the temperature of the greenhouse environment is decreased, the resistance of the thermistor is increased and the voltage across the thermistor is also increased. The thermistor’s voltage is applied to the base of transistor Q2. Q2 turns on and its collector voltage is low. The low collector voltage is supplied to the RC3 input of the MCU and the corresponding output voltage is achieved from the RD2 output of the MCU. If the RC3 input is “low”, RD2 output is “low”. Port D (RD2) output of the MCU is connected to RL3 via transistor Q6. The output voltage of the RD2 output is applied to the base of transistor Q6 via a 1kΩ resistor. relay RL3 is reached a de-energized state and the cooling fan turns off. So, “Temp. is Low” and “Cooling Fan Stop” information is displayed on the LCD. When the temperature of the greenhouse environment is increased, the resistance of the thermistor is decreased and the voltage across the thermistor is also decreased. The low voltage of the thermistor is applied to the base of transistor Q2. Q2 is cut off and its collector voltage is high. The high voltage is applied to the RC3 input of the MCU and the output voltage is achieved from the RD2 output of the MCU. RD2 output is “high” and the output voltage of the RD2 is applied to the base of transistor Q6 via a 1kΩ resistor. Transistor Q6 is turned on and relay RL3 is reached energized state. So, a cooling fan turns on and the LCD displays “Temp. is High”, and “Cooling Fan Run Level High” information. LDR is connected to the RC4 input of the MCU via transistor Q3. VR3 is used for adjusting the sensitivity of light intensity.

When the greenhouse is dark, the resistance of the LDR is increases and the voltage across the LDR is also increases. The base voltage of the transistor Q3 is “high” and Q3 is turned on. Thus, the collector voltage of the Q3 is “low” and this voltage is applied to the RC4 input of the MCU. Corresponding output voltage “high” is achieved from the RD3 output of this MCU. The output voltage of the RD3 is given to the base of transistor Q7 via a 1kΩ resistor. Q7 is turned on and relay RL4 is reached energized state. In this condition, the Lamp is on, and “House is Dark”, and “Lamp is ON” information is displayed on the LCD. When the greenhouse is bright, the resistance of the LDR is decreased and the voltage across the LDR is also decreased. This voltage is applied to the base of Q3. The base voltage of the transistor Q3 is “low” and Q3 is cut off. Thus, the collector voltage of the Q3 is “high” and this voltage is applied to the RC4 input of the MCU. Corresponding output voltage “low” is achieved from the RD3 output of this MCU. The output voltage of the RD3 is given to the base of transistor Q7 via a 1kΩ resistor. Q7 is cut off and relay RL4 is reached a de-energized state. In this condition, the Lamp is off, and “House is Bright”, and “Lamp is OFF” information is displayed on the LCD.

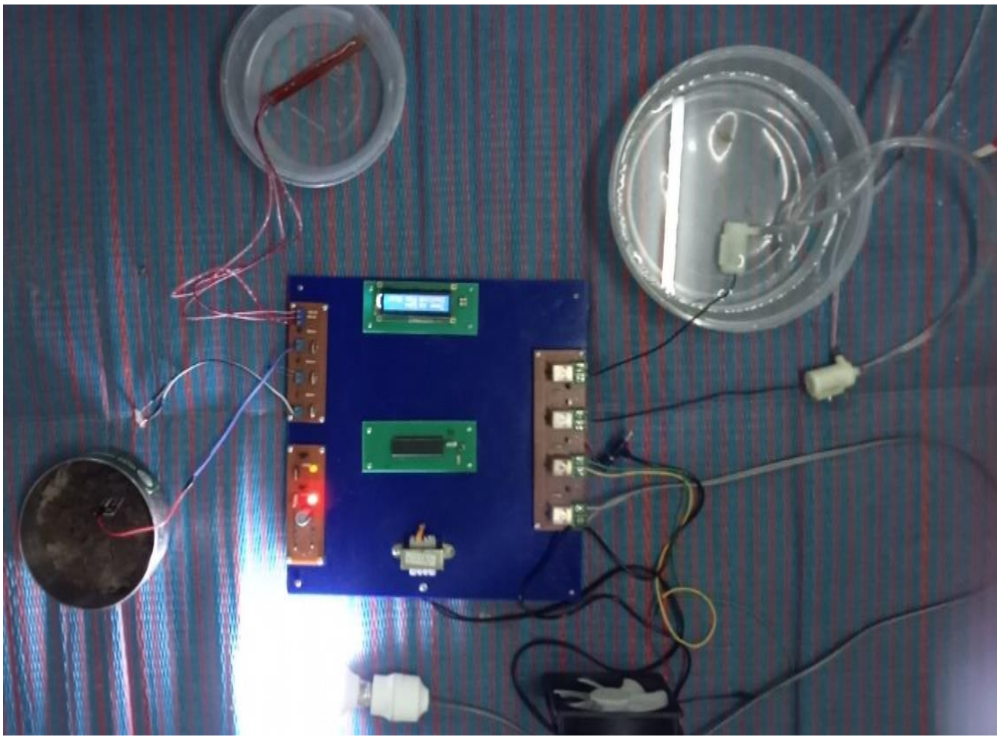

Figure 10. The practical implementation of the simulated circuit

Two water level probes are used to sense the water level of the overhead tank. The high-level probe is connected to RC1 and the Low-level probe is connected to the RC0 input of the MCU. When the water level of the overhead tank reaches a low level, the RD0 output of the MCU is "high". This RD0 output voltage is applied to the base of Q4 via 1kΩ. Q4 is turned on and relay RL1 is energized. In this condition, the water pump turn on, and "Water Level Low", and "Pump is Running" information is displayed on the LCD. When the water level of the overhead tank reaches to "high" level, the RD0 output voltage of the MCU is "low". This voltage is applied to the base of Q4 via a 1kΩ resistor. Q4 is cut off and relay RL1 is de-energized. In this condition, the water pump is turned off, and "Water Level High", and "Pump is Stop" information is displayed on the LCD.

C. Software Design

For a software implementation, Figure.11 shows the flowchart of the software in technology support for the greenhouse environment control system. MikroC Pro compiler is used in this system. Mikro C Pro IDE is a high-level programming language IDE for PIC microcontrollers; it is based upon ANSIC language. According to its high-level features, it is suitable for both educational and commercial purposes. The file extension for this IDE is. mcppi**.** If the PIC program is completed, it is pressed the build/compiled

button. In non-error conditions, build successful will appear in the message box of this IDE. The Hex code is downloaded into the PIC 16F877A microcontroller C by the use of the PIC Kit 2 programmer circuit.

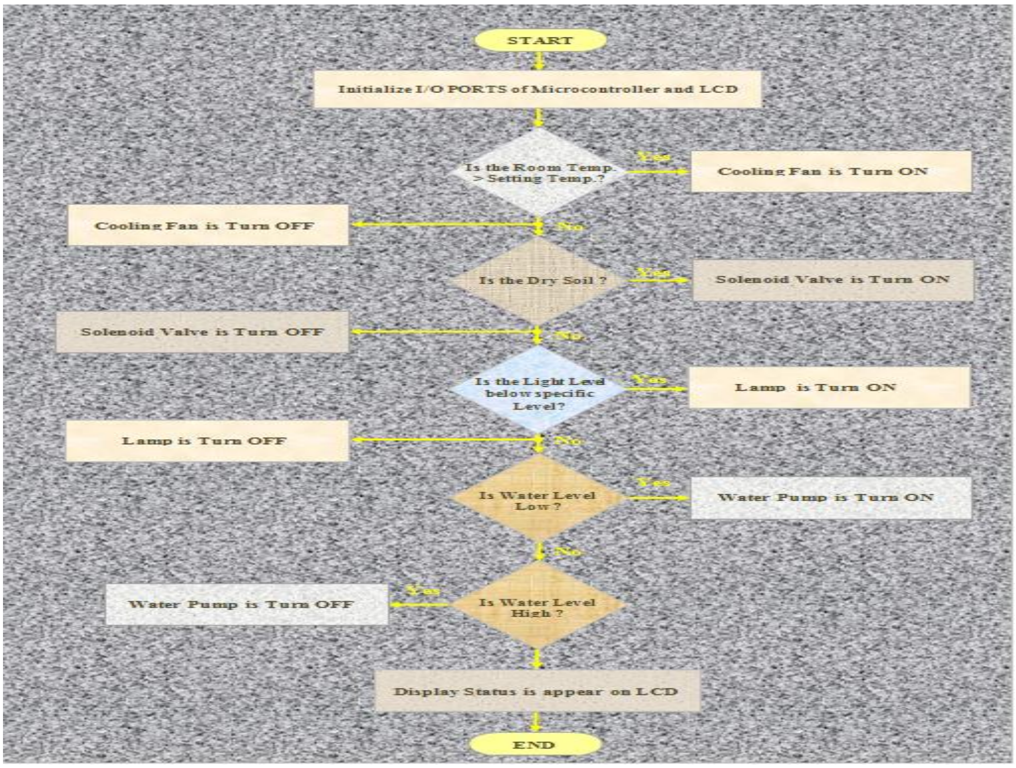

Figure 11. Flowchart of the greenhouse control system

RESULTS AND DISCUSSION

In this research paper, the technical support for the greenhouse environment control system is mainly based on PIC microcontroller IC 16F877A. Four different sensors like temperature sensors, soil moisture sensors, light sensors, and water level sensors were used to sense the conditions of the greenhouse environment. These parameters are sent to the microcontroller to control the environmental conditions of the greenhouse. The operation condition of the technical support for the greenhouse environment control system is shown in table 1. Parameters of the greenhouse and the status of the actuators were displayed on a 2× 16 LCD.

Table I. Operation condition of the technical support for the greenhouse environment control system

Water pump Status

High Water Level Sensor Output	Low Water Level Sensor Output	`Output Voltage at PIC 16F877A's Pin 19	Voltage at Q4			Relay (RL1) Status	Water Pump Status
			B	C	E		
High	High	4.6V	0.8V	0V	0V	ON	ON
High	Low	4.6V	0.8V	0V	0V	ON	ON
Low	Low	0V	0V	12V	0V	OFF	OFF

Solenoid Valve Status

Condition	Output Voltage at PIC 16F877A's Pin 20	Voltage at Q5			Relay (RL2) Status	Solenoid Valve Status
		B	C	E		
Soil is Dry.	4.6V	0.8V	0V	0V	ON	ON
Soil is Wet.	0V	0V	12V	0V	OFF	OFF

Lamp Status

Condition	Output Voltage at PIC 16F877A's Pin 22	Voltage at Q7			Relay (RL4) Status	Lamp Status
		B	C	E		
Light is Dark.	4.6V	0.8V	0V	0V	ON	ON
Light is Bright.	0V	0V	12V	0V	OFF	OFF

Cooling Fan Status

Condition	Output Voltage at PIC 16F877A's Pin 21	Voltage at Q6			Relay (RL3) Status	Cooling Fan Status
		B	C	E		
Temperature is High.	4.6V	0.8V	0V	0V	ON	ON
Temperature is Low.	0V	0V	12V	0V	OFF	OFF

In water pump status, when the high-water level sensor and low-water level sensor output are high, the water pump is watering up. when the high-water level sensor and low-water level sensor output are high and low, the water pump is watering up. when the high-water level sensor and low-water level sensor output are low- low, the water pump is pumping off. In solenoid valve status, when the soil is dry, the solenoid valve is watering up on the plants of the greenhouse control system. when the soil is wet, the solenoid valve is watering off on the plants of the greenhouse control system. In lamp status, when the greenhouse is lightening, the lamp is turned off. when the greenhouse is dark, the lamp is turned on. In cooling fan status, when the temperature of the greenhouse is high, the fan is turned on. when the temperature of the greenhouse is low, the fan is turned off.

CONCLUSION

The four main external devices that were used to make alterations to the environment are a DC fan, a water pump, a solenoid valve, and growing lights. These devices use large amounts of current (as compared to what the microcontroller is capable of sourcing) and so they are connected to relays which the microcontroller can interact with. Four different sensors were used to monitor the environment which includes a moisture sensor (that detects the amount of water in the soil), a temperature sensor, water level sensors, and a light sensor. The software in the controller was written in Mikro C language and the project was created in Mikro C Pro for PIC V.6.6.3. The constructed "Technical Support for Greenhouse Environment Control System" circuit can be supported for the Myanmar agriculture technology. Further improvements can be done by adding more features to the proposed system such as a wireless connection to interface with the PC to transmit and save the parameter. The system can be modified with the use of a data logger and a graphical LCD panel showing the measured sensor's data over some time.

Acknowledgements

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