Microcontroller Based Soil Moisture Monitoring System

Aung Naing Oo[1], Mar Mar Cho[2], Phyo Myat Lin[3]

Abstract

Soil moisture sensor detects the amount of moisture present in the soil. Then it produces the analog voltage corresponding to the amount of moisture. This analog voltage is sent to PIC microcontroller. The criteria for the system are set for three levels of moisture amount in the soil. They are lower level, normal and upper level. The lower level represents dry condition of soil, the normal level represents moderate condition of soil and the upper level represents wet condition of soil. According to these conditions, program is written and downloaded into PIC microcontroller. Processing is made and output signals are also produced. Alarms for watering and drying are also activated by the microcontroller. The operating conditions are shown by liquid crystal display.

Keywords: Soil moisture sensor, PIC16F877A microcontroller, Pic BASIC Pro language.

Introduction

Soil moisture sensors measure the volumetric water content in soil. There are two types of soil moisture sensor. One is frequency domain sensor, which has an oscillating circuit. It measures the soil water content by measuring the soil's dielectric constant, which determines the velocity of an electromagnetic wave or pulse through the soil. When the soil's water content increases, the dielectric also increases, which can be used to estimate how much water the soil holds. The other one is neutron moisture gauge, which utilize the moderator properties of water for neutrons. The principle is that fast neutrons are emitted from a decaying radioactive source, and when they collide with particles having the same mass as a neutron (i.e., protons, H^+), they slow down dramatically. Because the main source of hydrogen in soils is water, measuring the density of slowed-down neutrons around the probe can estimate the volume fraction of water content the soil holds.

PIC Microcontroller

A microcontroller is a single chip computer. Micro means that the device is small, and controller means that the device can be used in control applications.

A microcontroller differs from a microprocessor in many ways. The main difference is that a microprocessor requires several other components for its operation, such as program memory and data memory, I/O devices and external clock circuit. A microcontroller, on the other hand, has all the support chips incorporated inside the same chip. All microcontrollers operate on a set of instructions (or the user program) stored in their memory. A microcontroller fetches the instructions from its program memory one by one, decodes these instructions, and then carries out the required operations.

In the constructed system, PIC16F877A microcontroller is used as the main control device which is manufactured by the Microchip Technology Inc. It is a 40-pin device with 8K bytes of flash program memory. The PIC16F877A has five I/O ports, PORTA, PORTB, PORTC, PORTD and PORTE. Some pins for these I/O ports are multiplexed with an alternate function for the peripheral features on the device. In general, when a peripheral is enabled, that pin may not be used as a general purpose I/O pin.

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Some important features of PIC16F877A are it requires only 35 single word instructions for RISC CPU, operating speed of DC-20MHz clock input, 8K x 14 words of flash program memory, wide operating voltage range: 2V to 5.5V, 1000,000 erase/write cycles and 8 channels of analog-to-digital converter. Fig.(1) shows pin diagram and photograph of PIC16F877A.

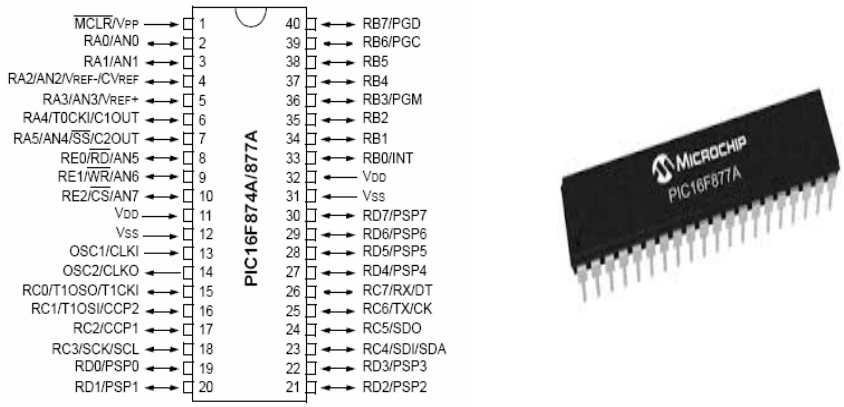

Figure (1). Pin diagram and photograph of PIC16F877A

High Sensitivity Moisture Sensor

The moisture sensor uses immersion gold which protects the nickel from oxidation. This nickel immersion gold has several advantages over more conventional surface platings such as solder, including excellent surface planarity, good oxidation resistance, and usability for untreated contact surfaces such as membrane switches and contact points. This moisture sensor can read the amount of moisture present in the soil surrounding it. It can be used to detect the moisture of soil just inserting it into the soil. The sensor uses the two probes to pass current through the soil.

The working voltage is 3.3V to 5V. It has digital output (D0) and analog output (A0). Digital output (D0) can directly connect with the microcontroller though the microcontroller to detect high and low levels. It can also directly drive relay module and buzzer module. Analog output (A0) can be connected with the AD module through the AD conversion and accurate soil moisture can be obtained. Fig. (2) shows the photograph of high sensitivity moisture sensor.

Figure (2). The photograph of high sensitivity moisture sensor

Design and Construction

There are five main parts in the work of "Microcontroller Based Soil Moisture Monitoring System". They are (i) Regulated Power Supply Unit (ii) Soil Moisture Sensing Unit (iii) Microcontroller Control Unit (iv) Indicator Unit and (v) Display Unit. Fig.(3) shows the block diagram of "Microcontroller Based Soil Moisture Monitoring System"

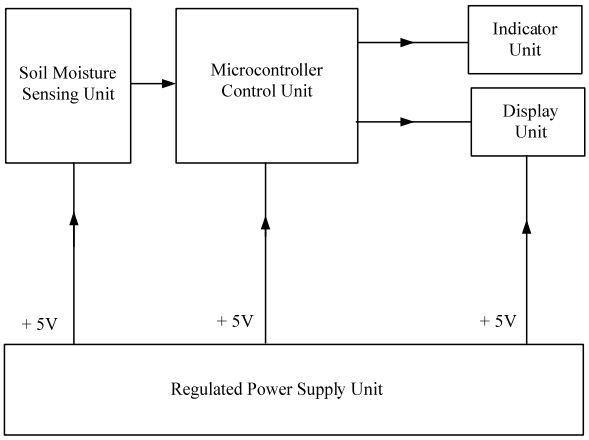

Figure (3). Block diagram of "Microcontroller Based Soil Moisture Monitoring System"

Regulated Power Supply unit

The PIC16F877A microcontroller functions properly at DC +5V. The required DC voltage is taken from voltage regulator (LM7805). The pin 1 (input pin) of LM7805 is connected to positive terminal of DC +6V, 4A battery. The pin 2 (ground pin) of LM7805 and negative terminal of battery are connected to ground. The output voltage of DC +5V is taken from pin 3 (output) of LM7805.

Soil Moisture Sensing Unit

This unit detects the moisture of soil. Pin (V_{CC}) of the soil moisture sensor is connected to DC +5V. Pin (Gnd) is ground. The analog output voltage corresponding to the amount of moisture in the soil is taken from pin (A0). This analog output pin is connected to pin 2 (AN0) of PIC16F877A microcontroller.

Microcontroller Control Unit

This unit controls the whole operation of the system. PIC16F877A microcontroller is used in this unit. Pin 11 (V_{DD}) and Pin 32 (V_{DD}) are connected to DC +5 V and Pin 12 (V_{SS}) and Pin 31 (V_{SS}) are grounded. A 4 MHz crystal oscillator is fixed at pin 13 (OSC1) and pin 14 (OSC2). Two 22 pF capacitors are connected to the crystal oscillator and ground. Pin 1 ($\overline{\text{MCLR}}$) is connected to DC +5 V through 10 kΩ resistor. When RESET SWITCH is pressed, the pin 1 ($\overline{\text{MCLR}}$) is grounded and the microcontroller is reset condition. Pin 2 (AN0) is connected to the pin 1 (A0) of soil moisture sensor. Pin 33 (RB0), pin 34 (RB1), pin 35 (RB2), pin 36 (RB3), pin 37 (RB4) and pin 38 (RB5) are connected to pin 11 (DB4), pin 12 (DB5), pin 13 (DB6) and pin 14 (DB7), pin 6 (E) and pin 4 (RS) of liquid crystal display (2004A) respectively. The pin 15 (RC0), pin 16 (RC1) and pin 17 (RC2) of PIC16F877A are connected to anodes of GREEN LED, YELLOW LED and RED LED through 100Ω resistor respectively.

Indicator Unit

The indicator unit shows the conditions of soil such as wet, moderate or dry. In this unit, the GREEN LED is for wet, YELLOW LED is for moderate and RED LED is for dry. These light emitting diodes are switched on and switched off by PIC16F877A microcontroller. The anode pin of GREEN LED is connected to pin 15 (RC0) of PIC16F877A microcontroller through 100Ω resistor. Similarly, the anode pin of YELLOW LED is connected to pin 16 (RC1), the anode pin of RED LED is connected to pin 17 (RC2) of PIC16F877A microcontroller through 100Ω resistors respectively. The cathode pins of three light emitting diodes are grounded.

Display Unit

The operating condition of the constructed system is shown by display unit. A 20 characters x 4 lines liquid crystal display (2004A) is used in this unit. Pin 2 (V_{DD}) is connected to DC +5 V. The pin 1 (V_{SS}), pin 5 (R/$\overline{W}$) and pin 16 (K) are grounded. The pin 15 (A) is connected to DC +5 V through 100 Ω resistor. The pin 3 (V_{EE}) is connected to middle pin of 5 kΩ variable resistor. The pin 11 (DB4), pin 12 (DB5), pin 13 (DB6), pin 14 (DB7), pin 6 (E) and pin 4 (RS) are connected to pin 33 (RB0), pin 34 (RB1), pin 35 (RB2), pin 36 (RB3), pin 37 (RB4) and pin 38 (RB5) of PIC16F877A microcontroller respectively.

Results and Discussion

The required program for this work is written in Pic BASIC Pro language in Microcode studio software. Then it is compiled and downloaded into PIC16F877A microcontroller with the help of GTP USB Lite programmer. The pin 2 (RA0) is configured as input pin. The pin 33 (RB0), pin 34 (RB1), pin 35 (RB2), pin 36 (RB3), pin 37 (RB4), pin 38 (RB5), pin 15 (RC0), pin 16 (RC1) and pin 17 (RC2) are configured as output pins. The RESET switch is fixed at pin 1 ($\overline{MCLR}$) of PIC16F877A microcontroller.

When the constructed system is powered, soil moisture sensor produces analog voltage which is according to the amount of water in the soil. The microcontroller (PIC16F877A) takes this analog voltage as input signal. The embedded program processes this input signal and the analog voltage is shown by the liquid crystal display (2004A).

If voltage is 0 V to 1.9 V, it is defined as WET condition. The GREEN LED is turned on. The first line of liquid crystal display is "MOISTURE MONITORING". The second line is "PHYSICS DEPT. (YDB)". The third line is "LEVEL 1 WET". The fourth line is "**NO NEED WATERING**". If voltage is from 2 V to 3.9 V, it is defined as MODERATE condition. The YELLOW LED is turned on. The first line of liquid crystal display is "MOISTURE MONITORING". The second line is "PHYSICS DEPT. (YDB)". The third line is "LEVEL 2 MODERATE". The fourth line is "***NEED WATERING***". If voltage is from 4 V to 5 V, it is defined as DRY condition. The RED LED is turned on. The first line of liquid crystal display is "MOISTURE MONITORING". The second line is "PHYSICS DEPT. (YDB)". The third line is "LEVEL 3 DRY". The fourth line is "**URGENT WATERING!**".

Table.(1) shows the function table of the constructed system. In this work, PIC16F877A microcontroller is supplied by DC +5V. The program is written as 10-bit A/D converter. Therefore, the microcontroller unit is working in the bit resolution of 5/1024 = 4.88 mV.

Soil moisture measurement is made for three kinds of soil. They are sandy soil, clay soil and compost soil. The analog voltage is taken by digital multi meter and constructed

system simultaneously. According to the measurements, it is found that the maximum difference is 0.51volts for sandy soil, 0.51 volts for clay soil and 0.56 volts for compost soil. Table.(2) shows for sandy soil measurement. Table.(3) shows for clay soil measurement. Table.(4) shows for compost soil measurement.

Fig.(4) shows the photograph of constructed internal circuit diagram. Fig.(5) shows the photograph of measuring soil sample. Fig.(6) shows the complete circuit diagram of "Microcontroller Based Soil Moisture Monitoring System".

Conclusion

Appropriate soil water level is necessary for plant growth and to avoid stress from excess or empty of water. To monitor the amount of water in the soil, "Microcontroller Based Soil Moisture Monitoring System" is designed and implemented by using soil moisture sensor and PIC16F877A microcontroller. The system can be used at garden or plantation to indicate whether watering is needed or not. The system can also be modified for automatic watering. Other soil moisture monitoring system of using different sensors and electronic devices are also suggested to be carried out as further works.

Table (1). Function table for the constructed system

Analog Voltage (V)	Indicator LED			LCD
	YELLOW	GREEN	RED	
0 – 1.9	OFF	ON	OFF	MOISTURE MONITORING PHYSICS DEPT. (YDB) LEVEL 1 WET **NO NEED WATERING**
2 – 3.9	ON	OFF	OFF	MOISTURE MONITORING PHYSICS DEPT. (YDB) LEVEL 2 MODERATE *** NEED WATERING***
4 – 5	OFF	OFF	ON	MOISTURE MONITORING PHYSICS DEPT. (YDB) LEVEL 3 DRY ** URGENT WATERING!**

Table (2). Data collection for Sandy Soil

Sample Name: Sandy Soil

Pot Weight: 924 g

Soil Weight: 2096 g

Initial Weight (Pot + Soil + Water): 3706 g

No.	Weight (g)		Digital Multi Meter (V)	LCD (V)
	Total	Water		
1	3706	686	1.80	1.83
2	3612	592	3.20	3.26
3	3526	506	3.51	3.57
4	3280	260	4.31	3.74
5	3134	114	4.42	3.84
6	3020	0	4.90	4.34

Table (3). Data collection for Clay Soil

Sample Name: Clay Soil

Pot Weight: 864 g

Soil Weight: 1792 g

Initial Weight (Pot + Soil + Water): 3186 g

No.	Weight (g)		Digital Multi Meter (V)	LCD (V)
	Total	Water		
1	3186	530	1.63	1.66
2	3102	446	1.69	1.72
3	3028	372	1.58	1.61
4	2892	236	1.62	1.65
5	2832	176	1.75	1.78
6	2186	0	4.90	4.34

Table (4). Data collection for Compost Soil

Sample Name: Compost Soil

Pot Weight: 998 g

Soil Weight: 1052 g

Initial Weight (Pot + Soil + Water): 3060 g

No.	Weight (g)		Digital Multi Meter (V)	LCD (V)
	Total	Water		
1	3060	1010	1.70	1.73
2	2952	902	1.82	1.85
3	2858	808	1.63	1.65
4	2600	550	1.71	1.74
5	2444	394	2.54	2.58
6	2050	0	4.89	4.33

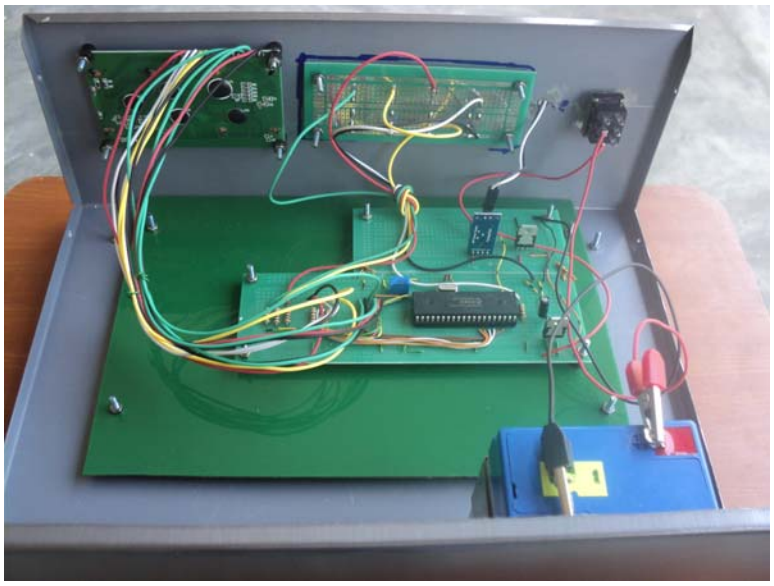

Figure (4). The photograph of constructed internal circuit diagram

Figure (5). The photograph of measuring soil sample

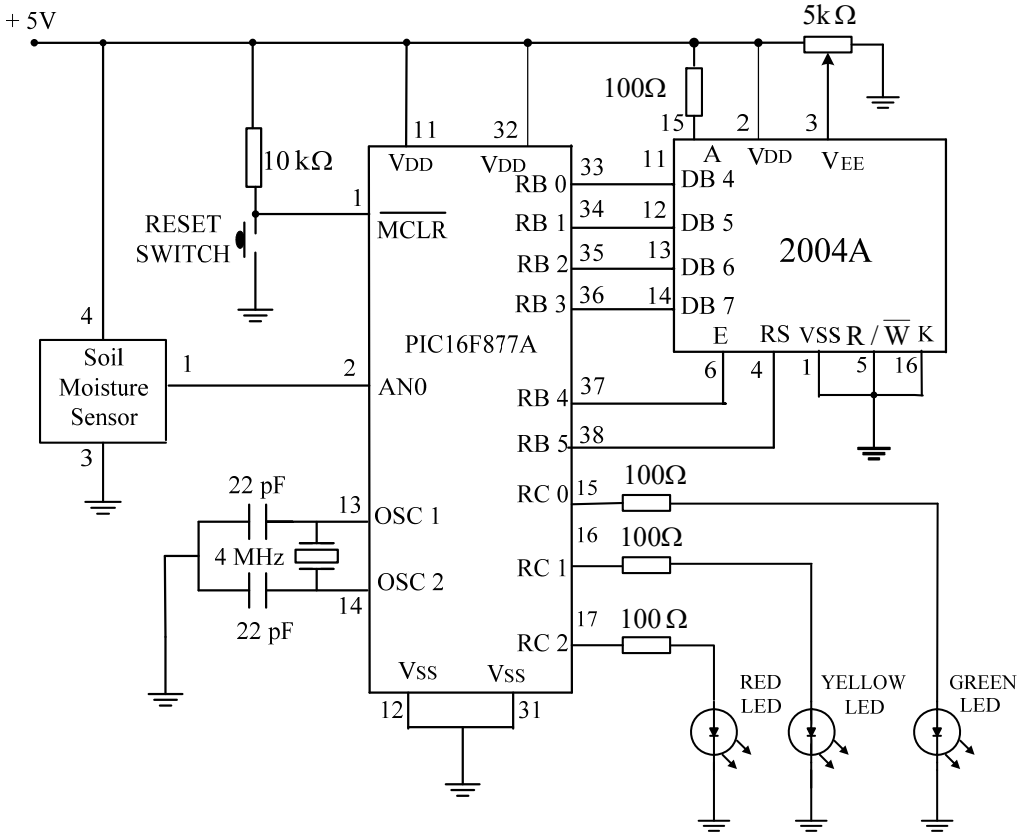

Figure (6). The complete circuit diagram of "Microcontroller Based Soil Moisture Monitoring System"

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