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Design and Implementation of Automatic Irrigation Control System

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Abstract: *The objective of irrigation is to keep measure on food security and the aim of automatic irrigation control system is to minimize the intervention of the human operator (gardener) in irrigation activities. The automatic irrigation control system is used to achieve this aim. This control system is built around ATMEGA32microcontroller programmed using embedded C language. Inputs are the signals from four sensors namely soil moisture sensor using hygrometer module, water level sensor using the LM 324 Op-amp was configured here as comparator, light sensorwith the aid of Light dependent resistor and temperature sensor using LM 35. The microcontroller processes the input signals by using the control software embedded in its internal ROM to generate three output signals, using one of the output signals to control a water pump that irrigates the garden, the second output signals to control a water pump that draws water from the river to the reservoir or storage tank while the other to switch a buzzer that alerts the gardener when there is shortage of water in a tank that supplies the garden.The project can be applied in agricultural area of any type where water readily available for irrigation. It can also be applied in agricultural research institutes such as the Michael Okpara University of Agriculture, (MOUAU).Umudike.*

Keywords:*ATMEGA32, Automatic, Control,Embedded C language, Irrigation,Microcontroller, Sensor.*

Introduction

Agriculture isthekeytofoodsecurity for everynation.Foodsecurityisasituationinwhichallpeopleat alltimeshavephysicalandeconomicaccesstosufficient,safe and nutritiousfoodto meettheirdietaryneedsandfood preferences foranactiveandhealthylife.Chiefamonghigh cropyieldfactorsisirrigation.Irrigationistheactorprocess ofcausing watertoflowoverlandstonourishplants,or the wateringoflandby artificialmeanstofosterplantgrowth [1].

After independence, successive Nigeria governments have adopted irrigation agriculture as a policy instrument for achieving the set objective of self-reliance and self-sufficiency in food production. The strategy of irrigation projects is primarily designed to mitigate the effects of drought and desertification on crop yield especially in the northern parts of Nigeria and increase crop production to meet the greater demands for food by the ever-increasing population of the country.

Irrigation can be described as the application of water to the soil to make available essential moisture for plant growth. It also serves as insurance against drought and to provide a cooling effect on the soil environment for plant growth and development. Irrigation is also aimed at improving and raising the productivity of soil resources. The principle, according to [2] is that the environment is characterized by fair to good soils but poor and unreliable low precipitation as it is the case in dry and semi-dry lands.

Themanualmethodofirrigation isusedpredominantly byruralfarmersinmostdeveloping countriesespeciallyin areas wherethe seasonofrainfallisveryshort. Earlierhumansusedtodocontrolmanually butthisalwaysinvolvederrors.Sothese controllershadtobeautomated.

Irrigation iscarriedoutmainlythroughtheuseofsurfaceorfloodirrigationandthe drip irrigation type. In thesurfaceirrigation,wateris appliedand distributedover thesoil surfaceby gravity.Thedripirrigation allowswatertodripslowlytotherootsof plantseitherontothesoilsurfaceordirectlyontotheroot zonethroughanetworkofvalves,pipesandtubes.

The dripirrigation hasmanyadvantagesoverbasinfloodand localizedmethodsofirrigation; iteliminates thepossibility ofsoilerosionandcanbe used fortheapplicationofliquidfertilizers [3]. Inthemodernworldoftoday,automationisencompassingnearlyeverywalk of life. Automation solutions aremoreaccurate,reliableandflexibleandso havereplacedhuman effortsright from agriculture to space technologies,mayitbeformonitoringa process,recordingitsparameters,analyzingthetrendof outputorcontrollingthedesired parameter.Thesedaysplantautomation is the necessity of themanufacturing industries to survive in the globallycompetitive markets.For anyprocesstobe automated,weneed mostessentiallya realtime automaticcontroller that is microcontroller based [4].

Withtheadventofdigital electronicsandhenceinvention of microprocessors andmicrocontrollers,cametheconceptofautomation.Thecontrollers developed,couldbeimplementedinrealtimewiththehelpofthesemicroprocessors or microcontrollers.Hencewecouldcontrol irrigation process and thelevelofaliquidatadesiredsetpointof different parameters with the helpofapropercontrollerusinganembeddeddevicelikemicroprocessorormicrocontroller toimplementthecontrolalgorithm.

According to [5]ineverydaylife,theremustbesomephysicalelementsthatneedtobecontrolledinorderforthemtoperform their expectedbehaviours. Acontrolsystemthereforecanbedefinedasa device,or setofdevices,that manages,commands, directsorregulatesthebehaviourofotherdevice(s)orsystem(s). Consequently,automaticcontrolling involves designingacontrolsystemtofunctionwithminimalornohumaninterference. Intelligent systemsarebeingusedina widerangeoffieldsincludingfrommedicalsciencestofinancialsciences,education, law,andsoon.Severalofthem areembeddedinthedesignofeverydaydevices.

An automated irrigation system has important advantagesover other manual methodsusedbythelocalfarmers:it ensures a more precise application and conservationof water,highcropyieldaswellasremovalofhumanerrors.Thecurrenttrendinirrigation istoshiftfrom manuallyoperatedtype ofirrigationtoautomatedtypes.

Hence, the parameters that influence irrigation control are Temperature of the environment, soil moisture content, light and source of water. Temperature is the degree of coldness and hotness of a body and commonly expressed in degree Celsius. This climatic factor influences all plant growth process such as photosynthesis, transpiration rate, seed germination, protein synthesis and transcolation, In general plant survive within a temperature range of 0 to 50^0.

Light is a climatic factor that is essential in the production of chlorophyll and in photosynthesis. Soil Moisture content is the amount of water in the soil. All this influence plant growth and development.

I. RelatedWorks

An automatic irrigation system based on embedded and Global System for Mobile Communication (GSM) technology was developed using ATMEL (AT89S52). The developed system incorporates: Sensing devices which sense the dry condition of the defined field or farmland and pass the state to the sensing logic of the automation system, A Control algorithm for water flow regulation. The deficiencies in this irrigation system were: The system lacked the ability to detect soil temperature; the system had no timer mechanism for irrigation scheduling [6].

[7]Designed and developed a mobile irrigation lab for water conservation. The developed system comprises of Sprinkler irrigation management device and Water management and irrigation scheduling software program. The software program has essential functionalities to perform device calibration, fuel cost evaluation, pumping cost evaluation and also scheduling of pumping. The novelty in their design is the integration of both the hardware and software components. The system lacks detailed notifications based on sensed parameters and actions taken by the system when in action.

[8] Used an advancemicrocontrollerLM3S5T36whichis32-bitARM®Cortex™-M3withfeaturesof32kbsingle flashmemory,12kbRAM, three32bittimersandtwo10bitanalogto digitalconverter developed an automatic drip irrigation system.However, the inability of this architecture to determine the exact temperature at which irrigation should commence due to the absence of temperature sensor makes it ineffective as irrigation can commence at any time even when it is sunny (high) which might affect the plant.

II. MaterialsandMethods

Thehardwarecomponentsusedin thisdesign include; ATEGA 32 Microcontroller, sensors,relayand ULN 2803 driver,Electric motor,Liquidcrystal display,Transistors,Capacitors,Resistorsand Buzzer.

The LM35Temperaturesensoris an integratedcircuitsensorthatcanbeusedto measuretemperature hencetheanalogueelectrical outputsignalisproportional tothetemperaturein degreeCelsius.Thelightdependentresistoris a resistivelightsensorthatchangesits electrical resistancefromseveralthousandohmsinthedark toonlyafewhundredohmswhenlightfallsupon it.Theneteffectisadecreasein resistanceforan increaseinillumination.

Water level sensor part is built using op-amp IC LM324. Op-amp was configured here as comparator for each water level. Soil Moisture Sensor is a Soil Hygrometer Detection Modulesensestheamountofmoisture presentinthe soiland presentsanoutputintheformofanalogvoltage.

ULN2803relaydriver is ahigh-voltage,highcurrentDarlingtontransistor array. Eachdriverconsistsof sevenNPNDarlington pairs thatfeature high-voltage outputswithcommon-cathodeclampdiodesfor switching inductiveloads.Thecollector–currentratingof a single Darlingtonpairis500mA. The Darlingtonpairscanbe paralleledforhighercurrentcapability fortheoutputtothefeedersystem.

The Liquidcrystaldisplay(LCD)isathin,flat electronic visual displaythatusesthelight modulatingpropertiesof liquidcrystals(LCs).This projectused LCD16x 2asadisplaysystem.. The LCD 16x 2has tworows, whereeachrowdisplays16characters.

The Atmega 32 has an on-chip oscillator but requires an external clock to run it. A 16MHz quartz crystal oscillator is connected to inputs XTAL1 (pin13) and XTAL2 (pin12) for clocking of the microcontroller [9].

Thesimulatedsoftwarealgorithmbeganwithflow-chart(Fig. 10)andfinallyan embedded Clanguageprogram developed,which isconvertedtoitsmachinecode(HEXfile)andwrittentothemicrocontroller's internalROMfortheappropriate controlling ofthedevice [10].

Thespecificsoftwaretooldeployedforthevirtualdesignandtheimplementation ofthedeviceistheProteus simulationsoftware [11]. Thesoftwarehastwoenvironments; theISISandtheARESenvironments. WeusedtheISIS environmentforthecircuitdesignandinsteadofimplementingthe printingofthecircuitboard(PCB)intheARES,we useda Veroboardforourhardwareimplementation.

Thediagrambelowdescribestheflowofoperationsinthesystemaswellastheirinter-operability (Fig.1).

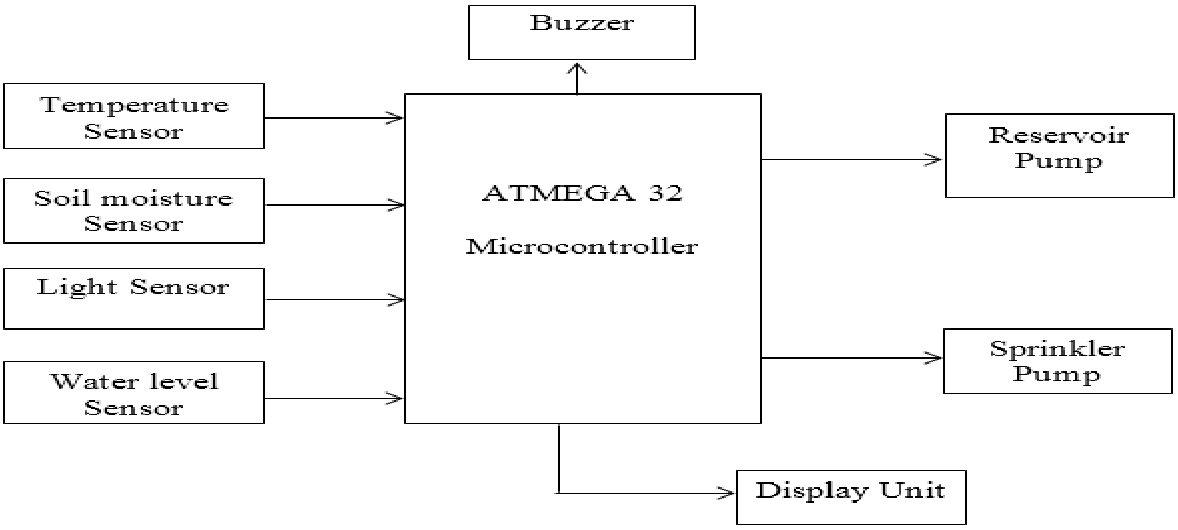


Fig.1: Block diagram of Automatic Irrigation control System.

This system consists of four inputs (temperature, Water level Sensor, Soil moistureand LDR sensor) and four output (buzzer, Sprinkler/drip water pump, Reservoir water pump and display unit). The Atmega 32 Microcontroller act the main brain for these system because it controls the overall irrigation process. It also has inbuilt ADC for conversion of analog signal from the sensors to digital form.

Temperature sensor used to detect the temperature in the farm environment. When the temperature sensor detects a high temperature, it gives an output voltage linearly proportional to the sensed temperature value. The Microcontroller will send the output signal to the relay base on the pre-set temperature value contained in the embedded program stored in the microcontroller to either ON or OFF the sprinkler pump.

The microcontroller receivesasinputsignalsfromlight andmoisturesensors.Depending ontheinputreceivedit takes decisionto letwaterouttothesprinklersystem. Then, when water levelsensor detects water, the microcontroller receivesit as inputssignal.Depending ontheinputreceived, it takes decisionto closeorpumpswaterfromtheriver tothe reservoirtank.

Hence, the value of the four monitored parameters are displayed on a 16 * 2 LCD Display. While the buzzer sounds an alarm when the water level in the reservoir is below 10%.

III. System Design and Implementation

This workisdivided intohardware andsoftware sections. The hardwarepart consistsofthree sub- systems which include; the input sub-system, controlsub-systemandoutputsub-system.

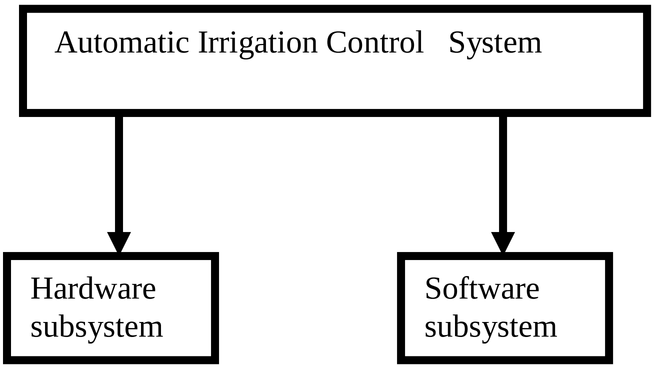


Fig. 2: System Components of the Automatic Irrigation Control System

4.0 Hardware Sub System Design

4.1: Interfacing of Soil Moisture Sensor

Asoilmoisturesensoris excitedbygivingsuitablepowersupplyof5V andisconnectedtoonebitofPortA (PA3/ADC3). PortA pinsareinternally connected toADConchip whichisof10bit resolution.Thesensorsensestheamountofmoisture presentinthe soiland presentsanoutputintheformofanalogvoltage rangingbetween5V(fully wetcondition)to0V (completely driedcondition)respectively as illustrated in the figure 3 below using a potentiometer which is essentially an adjustable voltage divider used for measuring electric potential. As the moisture content increases, the resistance decreases and vice versa leading to change in analog voltage at the input pin (PA3/ADC3). The relation between the measured resistance and soil moisture is then calibrated in software to depict percentage of water present in soil.

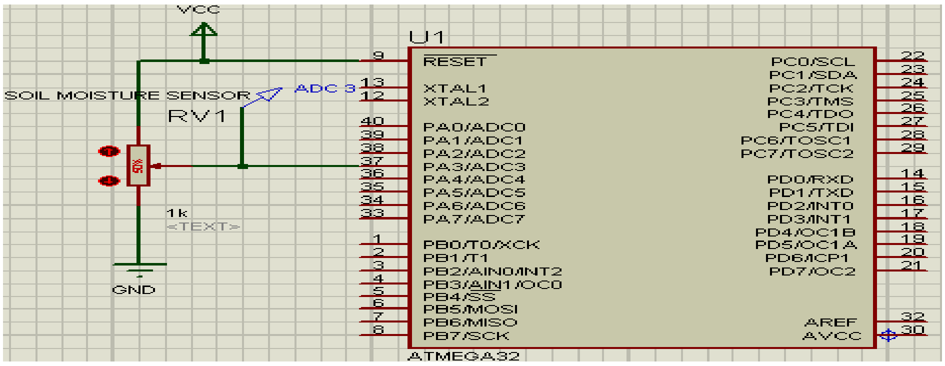


Fig.3: Interfacing circuit of soil moisture sensor to Atmega 32

Thesensorvalueswhichareinanalogformareconvertedtodigitalvalues in real timeandare storedintheADCdataregistersADCLandADCHrespectivelyand isusedto decidetheconditionoftherelaywhichcontrolsthe valveand thuswateringthe fieldforpredefinedamountoftime. Thissystemusesthemoisturerangeinbetween 1% to50%.Itcanbe changedmanually wheneverwewant.

4.2: Interfacing of Light Sensor.

Alight dependent resistor (LDR)sensor isexcitedbygivingsuitablepowersupplyof5V andisconnectedtoonebitofPortA (PA2/ADC2). PortA pinsareinternally connected toADConchip whichisof10bit resolution.

Thesensorsensestheamount of light intensity and presentanoutputintheformofanalogvoltagerangingbetween0(low light intensity)to5V (high light intensity)respectively as illustrated in the figure below using an LDR and a resistor which is essentially a voltage divider adjustable and used for varying electric potential to PortA (PA2/ADC2).

As the light intensity incident on the LDR increases, the resistance decreases and vice versa leading to change in analog voltage at the input pin (PA2/ADC2). As shown in Figure 4.

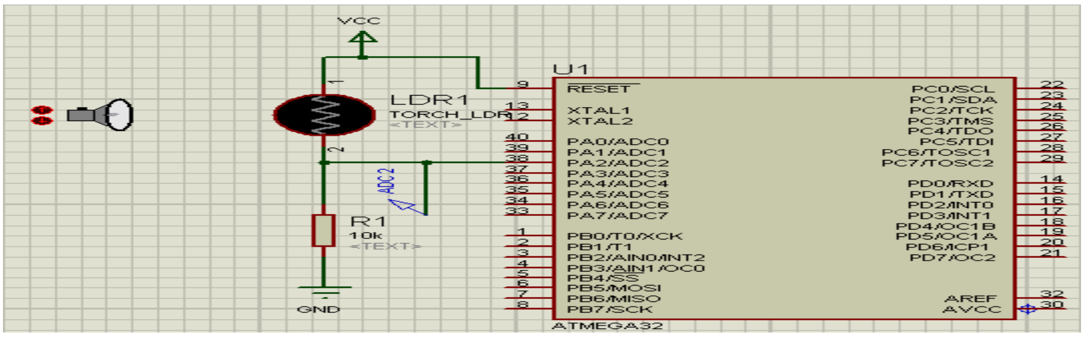


Fig. 4: Interfacing circuit of light sensor to Atmega 32

Thesensorvalueswhichareinanalogformareconvertedtodigitalvalues in real timeandare storedintheADCdataregistersADCLandADCHrespectively.Theaverageofall the sensorvalues iscomputedand isusedto decidetheconditionoftherelaywhichcontrolsthe pumpand thuswateringthe fieldforpredefinedamountoftime.

4. 3: Interfacing of Temperature Sensor

The LM 35 temperature sensorare excitedbygivingsuitablepowersupplyof5V andisconnectedtoonebitofPortA (PA1/ADC1) while the third Pin is grounded. PortA pinsareinternally connected toADConchipwhichhisof10bitresolution.Thesensorsensesthe ambient temperature of the environmentand gives an output analog voltage linearly proportional to the Centigrade temperature rangingbetween0V(low temperature)to5V (high temperature)respectively.

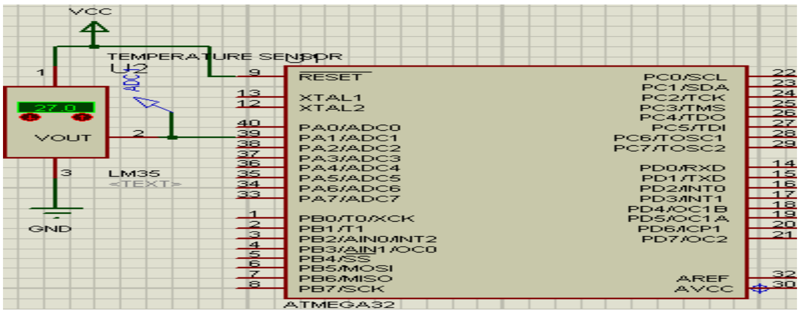


Fig. 5: Interfacing circuit of temperature sensor to Atmega 32

Thesensorvalueswhichareinanalogformareconvertedtodigitalvalues in real timeandare storedintheADCdataregistersADCLandADCHrespectively.Theaverage ofall the sensorvalues iscomputedand isusedto decidetheconditionoftherelaywhichcontrolsthe valveand thuswateringthe fieldforpredefinedamountoftime. Thissystemmaintains the temperature range between0^{0}C to40^{0}C.This value manually ischangedaccordingtothe seasonaltemperatureusingthe manualmode.

4.4: Interfacing of Water Level Sensor

The water level sensor used in this project is acomparator;LM324(LowPowerQuadOperational Amplifiers). Thevoltage outputfromtheLM324 tothe controller is0v when the non-inverting input of the LM324 is not in contact with water. If the watersensorprobe (non-inverting input) detectswater, it conducts and if the voltage sensed is greater than the reference voltage, it gives a high output. Conversely, thevoltage fromthe LM324tothecontrollerisabout4.7V (High).

It measures the level or height of water in a container using the conductive property of water. It’s made up of electrodes positioned at different levels in the container housing the liquid. As water rises in the container the electrodes make new connection with a varying analog voltage at different levels.

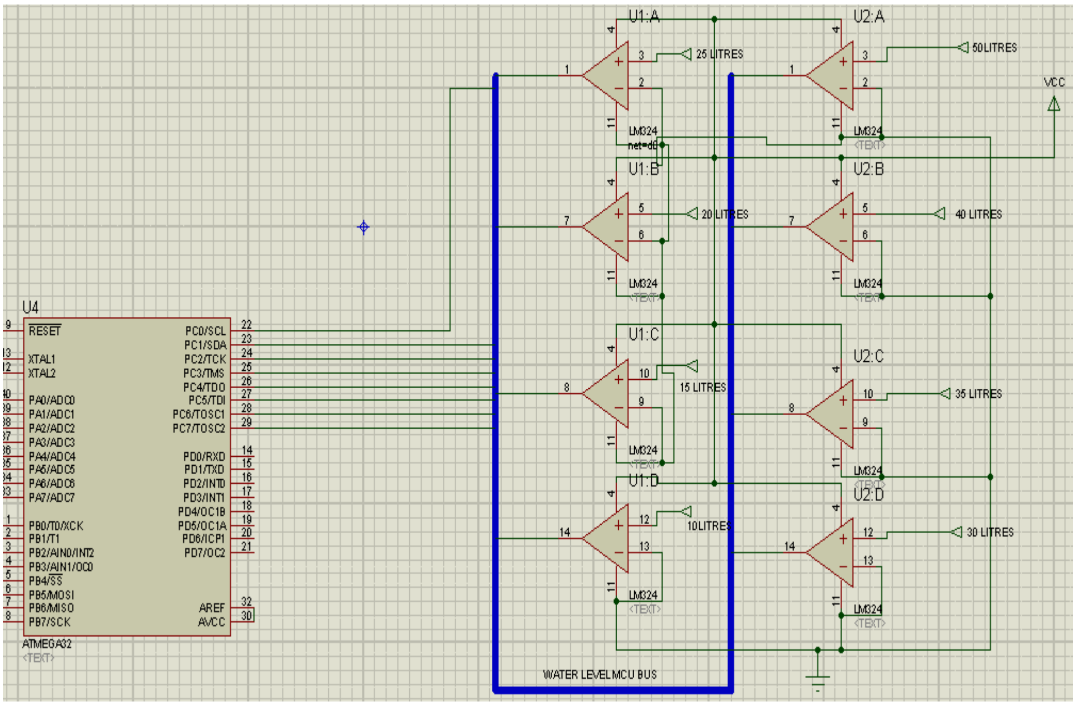


Fig. 6: Interfacing circuit of Water Level to Atmega 32

Theaverage ofall the sensorvalues iscomputedand isusedto decidetheconditionoftherelaywhichcontrolsthe valveand thuswateringthe fieldforpredefinedamount oftime. The output interfacing to the relay to switch on and off sprinkler reservoir pump as well as audible alarm circuit.

4.5: Output Interfacing Circuit

4.5.1: Interfacing of Relay and AC Motor with ATMEGA 32

The output port B of the ATMEGA 32 is interfaced with the river pump via a ULN 2803 Darlington Array driver and a 5V relay.

Relays are devices which allow low power circuits to switch a relatively high Current/Voltage ON/OFF. For a relay to operate a suitable pull-in & holding current should be passed through its coil. Generally relay coils are designed to operate from a particular voltage often its 5V or 12V.

If you want to connect more relays to microcontroller then you can use ULN 2003 for connecting seven relays or ULN 2803 for connecting eight relays.

Figure 7: Shows how to connect a relay to microcontroller using ULN 2003/ULN 2803. These IC’s are high voltage, high current darlington transistor arrays with open collector outputs and free-wheeling clamping diodes hence there is no need of a diode across the relay. Also there is no need of the series base resistor as the IC has an internal resistor of 2.7KΩ.

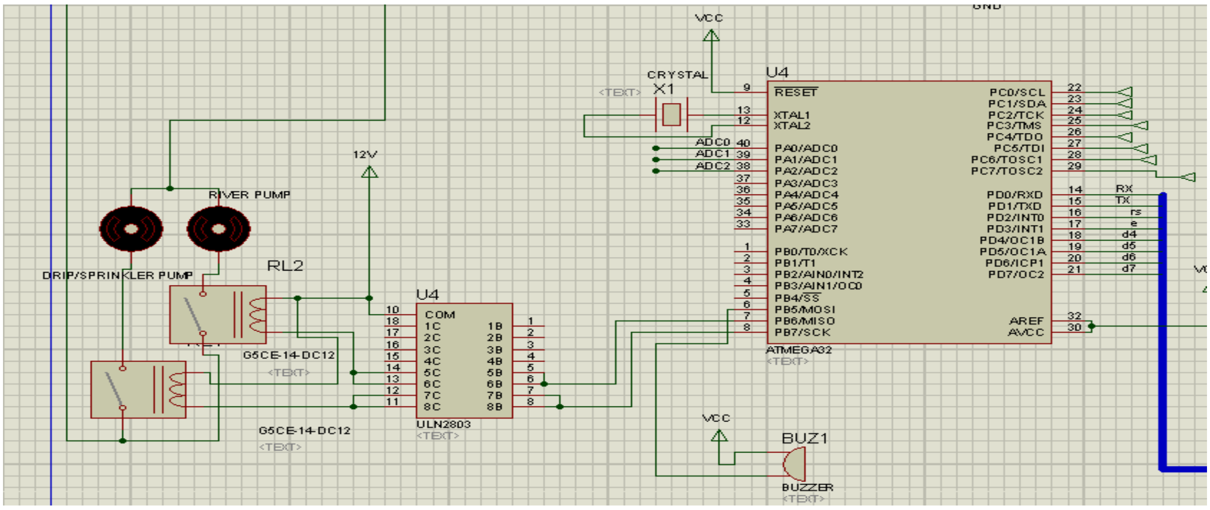


Fig. 7: Interfacing Circuit of AC Water Pumps to ATMGA 23

When the water level in the reservoir is low, the output of the output of the microcontroller port B (PB6/MOSI) which is same as the input of the ULN 2803 (PIN 5B and 6B) is high while the output at PIN 5C and 6C connected to the armature coil of the relay will be low. Hence the relay will be energized and the switch which is normally open will close, turning ON the river AC water pump.

When the water level in the reservoir is High (Filled), the output of the microcontroller port B (PB6/MOSI) which is same as the input of the ULN 2803 (PIN 5B and 6B) is low while the output at PIN 5C and 6C connected to the armature coil of the relay will be high. Hence the relay will be denergized and the switch which is normally open will open, turning OFF the river AC water pump.

When the Preset value the sensors such Temperature, soil moisture and light is ok for irrigation is attained, the output of the microcontroller port B (PB7/SCK) which is same as the input of the ULN 2803 (PIN 7B and 8B) is high while the output at PIN 7C and 8C connected to the armature coil of the relay will be low.

Hence the relay will be energized and the switch which is normally open will close, turning ON the Drip AC water pump.

When the Preset value the sensors such Temperature, soil moisture and light is not ok for irrigation, the output of the output of the microcontroller port B (PB6/SCK) which is same as the input of the ULN 2803 (PIN 7B and 68) is low while the output at PIN 7C and 8C connected to the armature coil of the relay will be high. Hence the relay will be denergized and the switch which is normally open will open, turning OFF the drip AC water pump.

4.5.2:Interfacing Circuit for LCD and Virtual Terminal

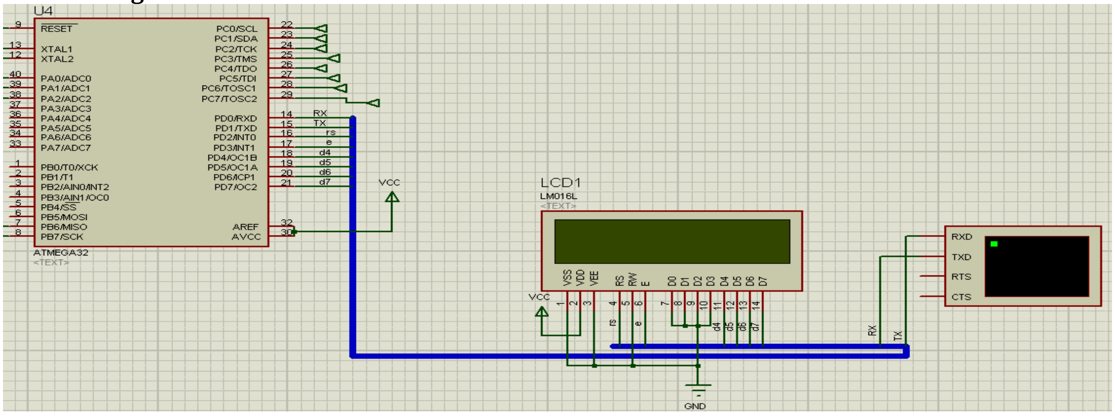


Fig. 8: Interfacing Circuit for LCD and Virtual Terminal

Like many microcontrollers AVR also has a dedicated hardware for serial communication this part is called the USART – Universal Synchronous Asynchronous Receiver Transmitter. This special hardware make life easier for programmer. You just have to supply the data you need to transmit and it will do the rest.

In this project, Serial communication occurs at standard speeds of 9600 bps and this speeds are slow compared to the AVR CPUs speed.

The advantage of hardware USART is that you just need to write the data to one of the registers of USART and you're done, you are free to do other things while USART is transmitting the byte. Also the USART automatically senses the start of transmission of RX line and then inputs the whole byte and when it has the byte it informs you (CPU) to read that data from one of its registers

4.6: Software Sub System Design

The software subsystem design involves programming of the microcontroller using embedded C programming language. A lot of registers of the microcontroller were configured in the control software burned into the microcontroller.

4.6.1: USART of AVR Microcontrollers

The USART of the AVR is connected to the CPU by the following six registers.

- **UDR** – USART Data Register: Actually this is not one but two register but when you read it you will get the data stored in receive buffer and when you write data to it goes into the transmitters' buffer.
- **UCSRA** – USART Control and status Register A: As the name suggests it is used to configure the USART and it also stores some status about the USART. There are two more of these kinds the **UCSRB and UCSRC**.

- **UBRRH** and **UBRRH**: This is the USART Baud rate register, it is 16 bit wide so UBRRH is the High Byte and UBRRL is Low byte. But as we are using C language it is directly available as UBRR and compiler manages the 16 bit access.

4.6.2: UCSRA - USART Control and Status Register A

Table4.1: USART Control and Status Register A

7	6	5	4	3	2	1	0
RXC	TXC	UDRE	FE	DOR	PE	U2X	MPCM
0	0	0	0	0	0	0	0

The binary value of the register is 00000000 while the hexadecimal equivalent is 00 hence UCSRA = 0X00

4.6.3: UCSRB - USART Control and Status Register B

Table4.2: USART Control and Status Register B

7	6	5	4	3	2	1	0
RXCIE	TXCIE	UDRIE	RXEN	TXEN	UCSZ2	RXB8	TXB8
1	0	0	1	1	0	0	0

The binary value of the register is 10011000 while the hexadecimal equivalent is 98 hence UCSRB = 0X98

4.6.4: UCSRC - USART Control and Status Register C

Table4.3: USART Control and Status Register C

7	6	5	4	3	2	1	0
URSEL	UMSEL	UPM1	UPMO	USBS	UCSZ1	UCSZ0	UCPOL
1	0	0	0	0	1	1	0

The binary value of the register is 10000110 while the hexadecimal equivalent is 86 hence UCSRC = 0X86

4.7:Setting the Baud Rate for Serial Communication with the Virtual Terminal

USART Baud rate register is 16 bit wide, so **UBRRH** is the High Byte and **UBRRL** is Low byte. But as we are using C language it is directly available as UBRR and compiler manages the 16 bit access.

This register is used by the USART to generate the data transmission at specified speed (say 9600Bps).

The USART needs a clock signal that determines the baud rate. It is generated in the chip by dividing the CPU clock frequency by the UBRR register value. It must be 16 x higher than the desired baud rate.

The x16 factor is used by the USART to sub-sample the received serial data, it improves noise immunity by calculating the received bit value from the average of 16 samples. UBRR value is calculated according to following formula.

$$UBRR = \frac{\text{fosc}}{16 \text{ x Baud Rate}} - 1$$

So if the desired baud rate is 9600 baud and the CPU clock is 16 MHz then UBBR is
(16000000 / (16 x 9600)) - 1 = 103.167.
Round that to the closest integer = 103
Converting 103 from decimal to binary gives 01100111.
Hence 01100111 converting to hexadecimal give 67.
Which makes UBRRL = 0x67, UBRRH = 0x00.

4.8:Setting the Clock Frequency for ADC

ADC Prescaler Selects Bit: Thesebitsdeterminethe divisionfactor betweentheXTAL frequencyandtheinputclocktothe ADC.

ADPS2-ADPS0 Bit –

These bits selects the Prescaler for ADC. We set the ADC frequency to 1000 KHzi.e using Frequency of crystal Oscillator/Prescaler factor

16MHZ/16 = 1000 KHz

A Prescaler of 16 is chosen for this project

Table 4.4: ADC Prescaler Selects Bit

ADPS2	**ADPS1**	**ADPS0**	**DIVISION FACTOR**
0	0	0	2
0	0	1	2
0	1	0	4
0	1	1	8
1	0	0	16
1	0	1	32
1	1	0	64
1	1	1	128

4.9: Setting ADC Status and Control Register

Table 4.5: ADC Status and Control Register A

7	6	5	4	3	2	1	0
ADEN	ADSC	ADATE	ADIF	ADIE	ADPS2	ADPS1	ADPS0
1	0	0	0	0	1	0	0

Bit7–ADEN:ADCEnable – Set this to 1 to enable ADC
ADPS2-ADPS0 – These selects the Prescaler for ADC. We picked a prescaler of 16
ADC Start Conversion
ADSCRA= 0X40 i.e 01000000

Table 4.6: ADC Status and Control Register B

7	6	5	4	3	2	1	0
ADEN	ADSC	ADATE	ADIF	ADIE	ADPS2	ADPS1	ADPS0
0	1	0	0	0	0	0	0

Bit6–ADSC:ADCStartConversion - We need to set this to one whenever we need ADC to do a conversion.

Table 4.6: ADC Status and Control Register C

7	6	5	4	3	2	1	0
ADEN	ADSC	ADATE	ADIF	ADIE	ADPS2	ADPS1	ADPS0
0	0	0	1	0	0	0	0

Bit4ADIF:ADCInterruptFlag – This is the interrupt bit this is set to 1 by the hardware when conversion is complete. So we can wait till conversion is complete by polling this bit like while ((ADCSRA & 0X10 ==0). The loop does nothing while ADIF is set to 0, it exits as soon as ADIF is set to one, and i.e. conversion is complete.ADSCRA= 0X10 i.e 00010000

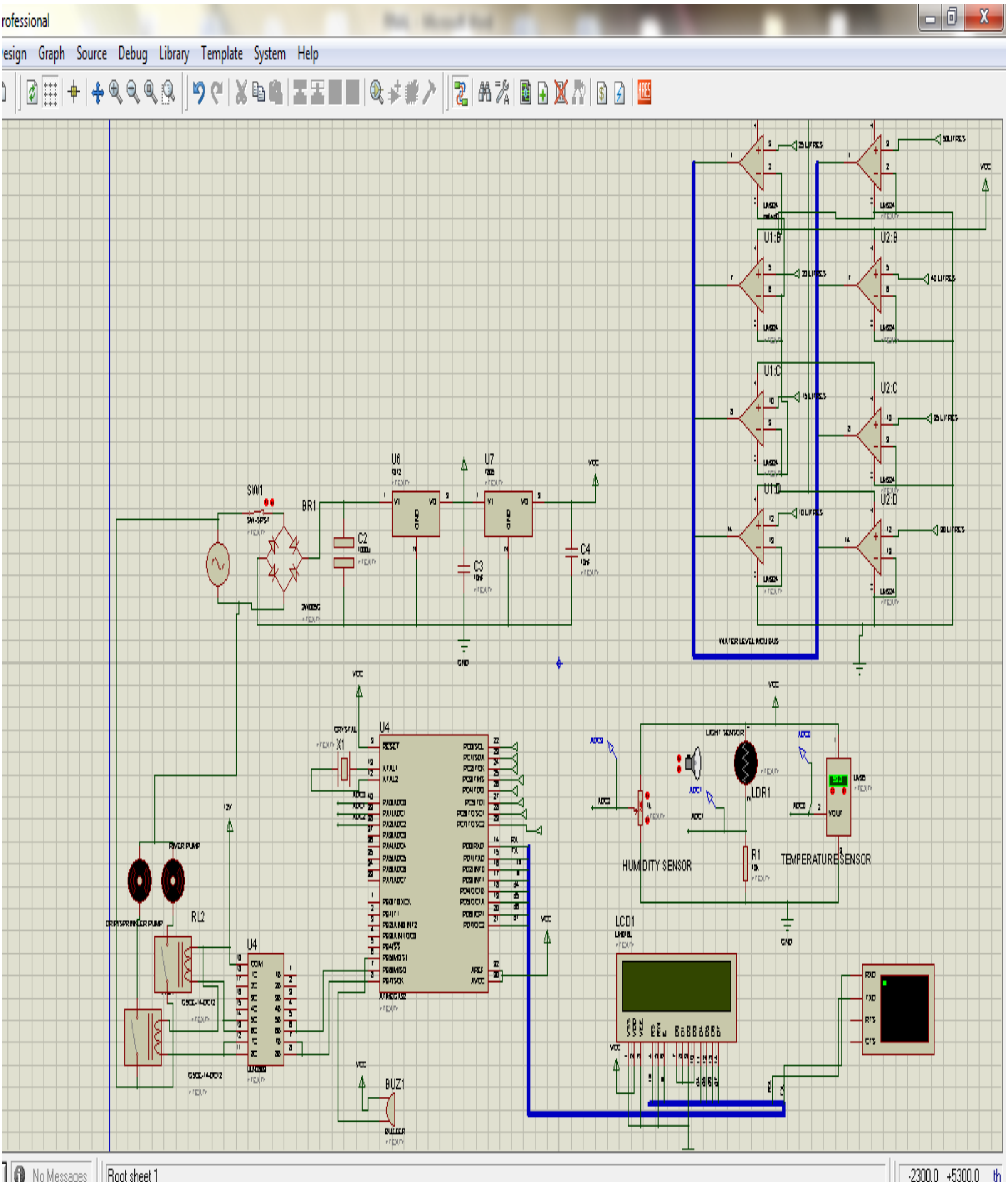


Fig 9: Circuit Design of Automatic Irrigation Control System

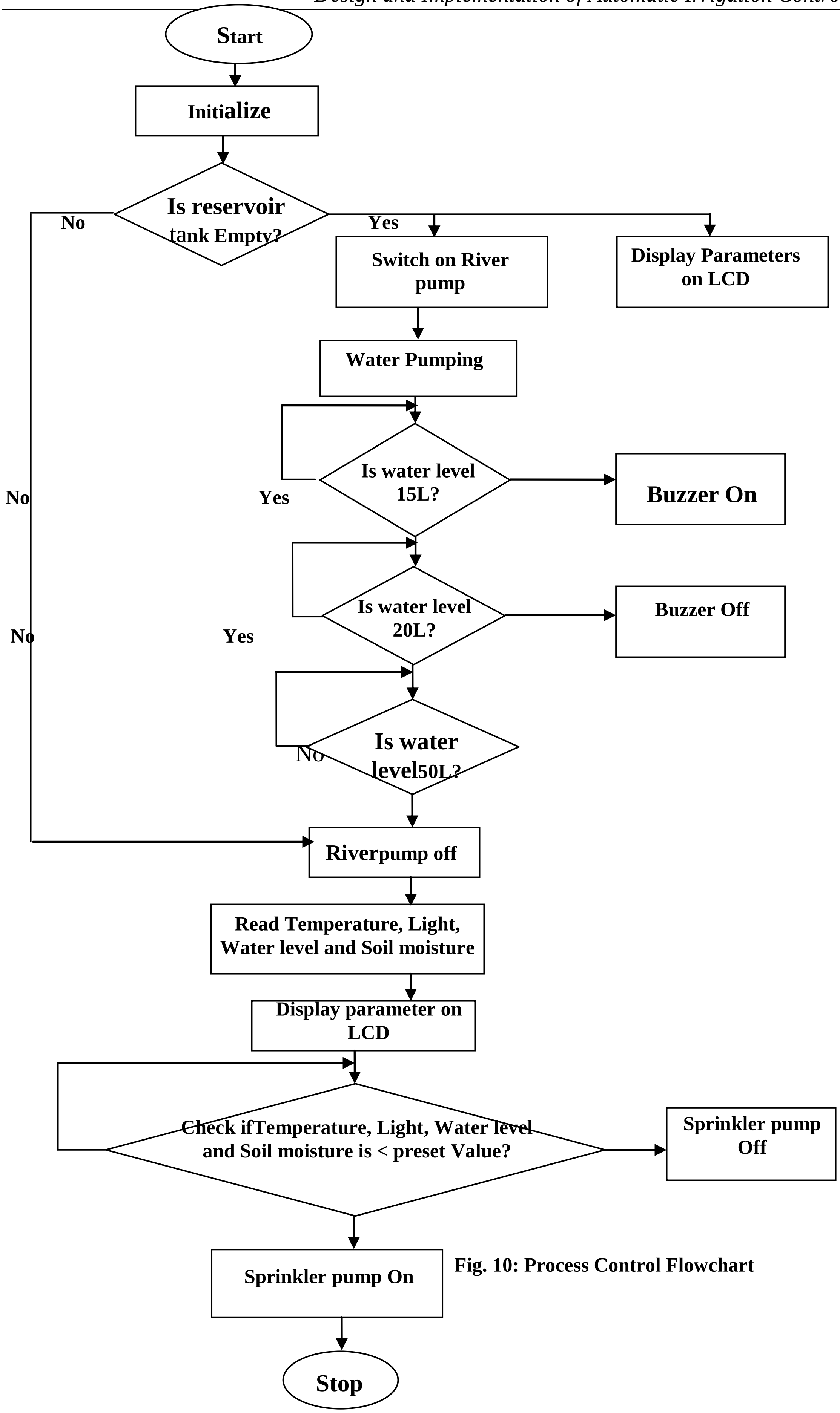


Fig. 10: Process Control Flowchart

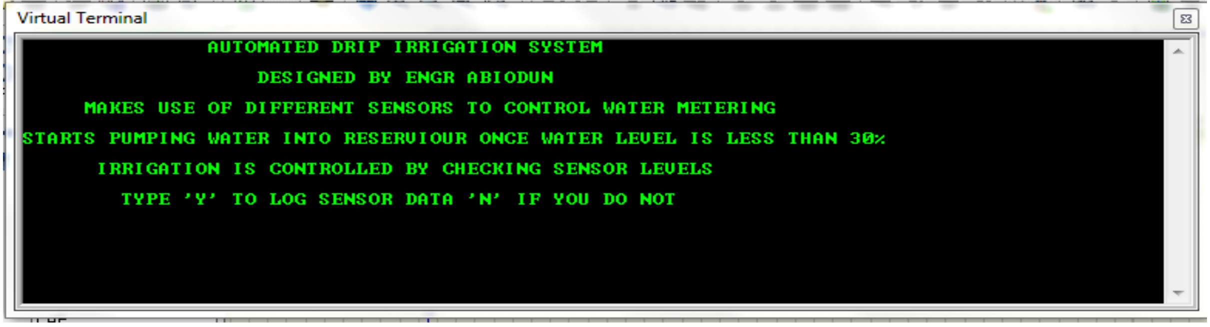
IV. System Testing And Result

Test Plan

Testing was done to ascertain the performance of the sub-circuits and then whole system degree of accuracy as well as the reliability. The testing of this automated irrigation control system was carried out in sequential manner starting from the individual component to the sub-circuits and finally the whole system as mentioned above.

This was done to know whether the system is performing well or not, and if the design specifications conform with the systems operations.

Result of Simulation Using Proteus Virtual Simulation Module



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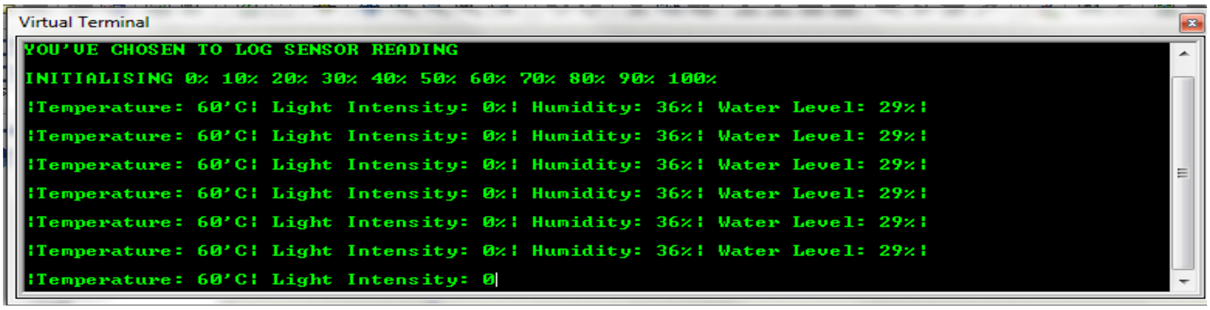
              AUTOMATED DRIP IRRIGATION SYSTEM
                  DESIGNED BY ENGR ABIODUN
     MAKES USE OF DIFFERENT SENSORS TO CONTROL WATER METERING
STARTS PUMPING WATER INTO RESERUIOUR ONCE WATER LEUEL IS LESS THAN 30%
      IRRIGATION IS CONTROLLED BY CHECKING SENSOR LEUELS
        TYPE 'Y' TO LOG SENSOR DATA 'N' IF YOU DO NOT
```

Fig. 11: Simulation Result on Proteus VSM via Virtual Terminal



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YOU'UE CHOSEN TO LOG SENSOR READING
INITIALISING 0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
|Temperature: 60'C| Light Intensity: 0%| Humidity: 36%| Water Level: 29%|
|Temperature: 60'C| Light Intensity: 0%| Humidity: 36%| Water Level: 29%|
|Temperature: 60'C| Light Intensity: 0%| Humidity: 36%| Water Level: 29%|
|Temperature: 60'C| Light Intensity: 0%| Humidity: 36%| Water Level: 29%|
|Temperature: 60'C| Light Intensity: 0%| Humidity: 36%| Water Level: 29%|
|Temperature: 60'C| Light Intensity: 0%| Humidity: 36%| Water Level: 29%|
|Temperature: 60'C| Light Intensity: 0
```
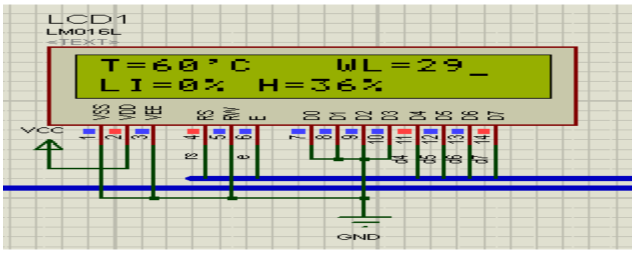

Fig. 12: Simulation Result on Proteus VSM Virtual Terminal showing the logged Data.



```
T=60'C     WL=29_
LI=0%  H=36%
```

Fig. 13: Simulation Result on Proteus VSM via LCD

The actual implemented hardware result is shown in figure 13 and the Proteus simulated result tallies. Forthefirsttimeeveritispossibletodrawacompletecircuitforamicro-controller basedsystemandthentestitinteractively,allfromwithinthesamepieceofsoftware.

V. Conclusion

The process control design meets all of the objectives set forth while satisfying the constraints. The step by step processes in the design of a microcontroller-based irrigation control has been presented in this project.

Atmega32 microcontroller is programmed to automate irrigation process and simulated using Proteus VSM and the result are satisfactorily executed and verified with physical prototype.

It is also important to mention that the entire system was implemented using readily available components and no formal training is necessary to operate the system for past users of manual irrigation. This project particularly is significant in view of the fact that our nation Nigeria is at the moment of commercializing agricultural activities which automated irrigation is a key to it success.

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