International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 3 Mar 2022, pp: 685-700 www.ijaem.net ISSN: 2395-5252

Design and Implementation of a Progrmmable Rain Detector with Alert System

Isizoh A.N.[1], Ebih U.J.[2], Obianyo O.R.[3], Alagbu E.E.[4], Ejimofor I.A.[5]

1,2,4: Dept. of Electronic and Computer Engineering, Nnamdi Azikiwe University, Awka, Nigeria,
3,5: Dept. of Computer Engineering, Madonna University of Nigeria, Akpugo Campus.

Submitted: 10-03-2022 Revised: 21-03-2022 Accepted: 23-03-2022

ABSTRACT
This research presents the design and implementation of a programmable rain detector which alerts a user whenever rain begins to fall. It is a programmed system designed with various electronic devices/components among which were transformer, voltage regulator, AT89C52 microcontroller, crystal oscillator, buzzer, Light Emitting Diode (LED), etc. A block diagram design of the system was first achieved, after which each unit was carefully analyzed, developed, and brought together for a complete functional system. The system algorithm was designed; from where a program, written in Assembly language for the control of the microcontroller operation was developed. A prototype of the system was constructed and it tested okay.

KEYWORDS: AT89C52 Microcontroller, crystal oscillator, buzzer, transformer.

I. INTRODUCTION

1.1 Background of Study

Rain is liquid water in form of droplets that have condensed from atmospheric water vapor and then precipitated—that is, become heavy enough to fall under gravity. Rain is a major component of the water cycle and is responsible for depositing most of the fresh water on the Earth. It provides suitable conditions for many types of ecosystems, as well as water for hydroelectric power plants and crop irrigation [1].

Rain water is very necessary in life, and it is important to know when rain wants to fall. In some cases, rainfall is not needed. Of course, having rainfall at a time someone wants his/her cloth outside to dry is not good; and needed to monitor when rain starts to fall. This cannot be effectively done by man but by an intelligent device which is called rain detector [2].
Rain detector will detect rainfall and makes an alert. It is used in the irrigation field, home automation, communication, automobiles, etc.

So a rain detector circuit is a device which does rain monitoring and gives an alert to a user. It is a device which will generate an alerting signal when rain comes. The frequency will be more when the rain is heavier and the frequency is very less when the rain will be low. It all means that the frequency will depend upon the rain.

In order to achieve this detection, rain sensor is used. A rain sensor or rain switch is a switching device activated by rainfall [3]. There are two conventional applications of rain sensors. The first one is a water conservation device connected to an automatic irrigation system that causes the system to shut down in the event of rainfall.

The second one is a device used to protect the interior of an automobile from rain and to support the automatic mode of windscreen wipers. An additional application in professional satellite communications antennas is to trigger a rain blower on the aperture of the antenna feed, to remove water droplets from the Mylar cover that keeps pressurized and dry air inside the wave-guides [4].
A typical block diagram of a simple rain detector circuit which uses IC 555 timer is shown in figure 1.

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 3 Mar 2022, pp: 685-700 www.ijaem.net ISSN: 2395-5252

Figure 1: Block Diagram of a Simple Rain Detector which Uses IC 555 Timer

Rain water sensor is the main component in the circuit. It uses a simple rain sensor, made up of wires. It can be done by taking a piece of mica board and aluminum wires. Mica board should be made completely flat and aluminum wires should be pasted on the flat board as shown in Figure 2. Care should be taken so that there should be no spaces between the wire and board. When the rain water sensor is completed, it should get connected to the circuit and voltage should be passed through the wires [5].

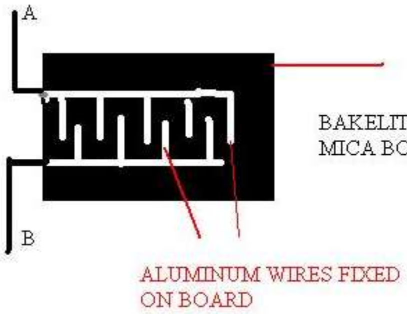

Figure 2: Rain Water Sensor Using Aluminum Wires

If there is no rain, the resistance between the wires will be very high and there will be no conduction between the wires in the sensor. If there is rain, the water drops will fall on the rain sensor which will also decrease the resistance between the wires; and these wires on the sensor board will conduct and trigger the NE555 timer through the transistors circuitry. Once NE555 is triggered, it will make the output pin high and this action causes the buzzer to make an alarm.

A typical rain water detector alarm circuit is shown in Figure 3, together with its rain sensor.

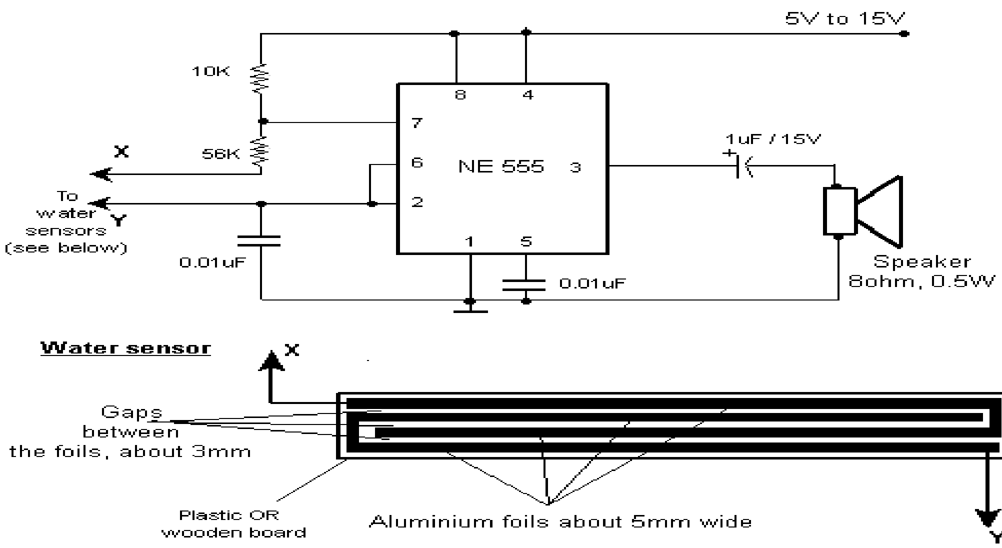

Figure 3: A Typical Rain Water Detector Alarm Circuit, with its Sensor

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 3 Mar 2022, pp: 685-700 www.ijaem.net ISSN: 2395-5252

This circuit gives out an alarm when its sensor is wetted by water. A 555 astable multivibrator is used here which gives a tone of about 1kHz upon detecting rain water. The sensor when wetted by water completes the circuit and makes the 555 oscillate at about 1kHz. The sensor position is also shown in the circuit diagram.

It has to be placed making an angle of about 30 – 45 degrees to the ground. This makes the rain water to flow through it to the ground and prevents the alarm from going on due to the stored water on the sensor.

The metal used to make the sensor has to be aluminum and not copper. This is because copper forms a blue oxide on its layer on prolonged exposure to moisture and has to be cleaned regularly. The aluminum foils may be secured to the wooden/plastic board via epoxy adhesive or small screws.

The contact X and Y from the sensor may be obtained by small crocodile clips or using screws.

II. LITERATURE SURVEY

2.1 Review of Related Works

Many literatures have been written in the past about rainfall and its detection systems. Rain detector will give you a heads-up the instant it starts to rain, hopefully giving you time to close windows and bring in possessions [6].

A review of the publication by Jinon [7] shows that the world's first rain gauge, uryanggye, was invented in 1441. The inventor was Jang Yeong-sil, a Korean engineer of the Joseon Dynasty, under the active direction of the king Sejong the Great. It was installed in irrigation tanks as part of a nationwide system to measure and collect rainfall for agricultural applications. With this instrument, planners and farmers could make better use of the information gathered in the survey.

K. Garg and S. K. Nayar [8] worked on the detection and removal of rain from videos, which was published in the Proceedings of the 2004 IEEE Computer Society Conference on, Vol.1 of July 2004, Pgs I-535. In that paper, they stated that the visual effects of rain are complex. And that rain consists of spatially distributed drops falling at high velocities. Each drop refracts and reflects the environment, producing sharp intensity changes in an image. A group of such falling drops creates a complex time varying signal in images and videos. In addition, due to the finite exposure time of the camera, intensities due to rain are motion blurred and hence depend on the background intensities. Thus, the visual manifestations of rain are a combination of both the dynamics of rain and the photometry of the environment.

In that paper, they presented the first comprehensive analysis of the visual effects of rain on an imaging system. They developed a correlation model that captures the dynamics of rain and a physics-based motion blur model that explains the photometry of rain. Based on these models, they developed an efficient algorithm for detecting and removing rain from videos.

Ruiyue Chen et. al [9] once researched on the Impact of the Vertical Variation of Cloud Droplet Size on the Estimation of Cloud Liquid Water Path and Rain Detection. Their results were published in the Online Journal of the American Meteorological Society, USA in 2007. They developed different algorithms for the impact analysis.

According to Robert [10], in 1958, the Cadillac Motor Car Division of General Motors experimented on a water-sensitive switch that triggered various electric motors to close the convertible top and raise the open windows of a specially-built Eldorado Biarritz model, in case of rainfall. The first such device appears to have been used for that same purpose in a concept vehicle designated Le Sabre and built around 1950–51.

For model year 1996, Cadillac once again equipped cars with an automatic rain sensor; this time to automatically trigger the windshield wipers and adjust their speed to conditions as necessary.

The most common modern rain sensors are based on the principle of total internal reflection: an infrared light is beamed at a 45-degree angle into the windshield from the interior — if the glass is wet, less light makes it back to the sensor, and the wipers turn on. Most vehicles with this feature have an "AUTO" position on the stalk [11].

Vaisala's DRD11A rain detector [12] offers fast and accurate precipitation detection (ON/OFF). It operates on the basis of droplet detection, rather than signal level threshold. The capacitive principle utilizes the RainCap sensor plate. A special delay circuitry allows about a two-minute interval between raindrops before assuming an OFF (no rain) state. This means the sensor can accurately distinguish between rain cessation and light rain.

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 3 Mar 2022, pp: 685-700 www.ijaem.net ISSN: 2395-5252

The sensor also features an analog rain signal for estimating rain intensity. The default rain categories of the estimated intensity are: low, moderate and heavy rain. An internal heating element is provided to ensure that the detection surface dries quickly. The same element also protects the surface from fog and condensed moisture. It is activated at low temperatures in order to melt snow, thus enabling snow detection as well.

The current Vaisala's multi-variable weather instruments: the FD12P and PWD11, combine Vaisala's forward-scatter visibility measurement and RainCap capacitive rain detection technology. These sensors detect precipitation type, measure precipitation intensity, calculate precipitation accumulation, and also calculate the water equivalent of frozen precipitation and snow accumulation [13].

It is noted that in [14], there is Rain Bird RSD Series Rain Sensor which automatically shuts off sprinkler system when it rains, so there is no worry if the user is at home or away. Figure 4 shows a model of Rain Bird RSD Series Rain Sensor.
Also this RSD Series Rain Sensor easily connects to most irrigation system controllers.

Figure 4: Model of Rain Bird RSD Series Rain Sensor

Rain sensors for irrigation systems are available in both wireless and hard-wired versions, most employing hygroscopic disks that swell in the presence of rain and shrink back down again as they dry out — an electrical switch is in turn depressed or released by the hygroscopic disk stack, and the rate of drying is typically adjusted by controlling the ventilation reaching the stack. However, some electrical type sensors are also marketed that use tipping bucket or conductance type probes to measure rainfall.

Wireless and wired versions both use similar mechanisms to temporarily suspend watering by the irrigation controller — specifically they are connected to the irrigation controller's sensor terminals, or are installed in series with the solenoid valve common circuit such that they prevent the opening of any valves when rain has been sensed.

Some irrigation rain sensors also contain a freeze sensor to keep the system from operating in freezing temperatures, particularly where irrigation systems are still used over the winter.

DIY electronics recently developed a rain alarm circuit that will give you an indication of rain with the help of an LED. This circuit can also be connected to a buzzer to sound an alarm. It detects rain and save some water or use it for different applications in different fields such as home automation, automobiles and irrigation field.
This circuit is very useful to close your window doors and can manage your outside setting before heavy rain. This low cost circuit consumes only less power. Initially it consumes no current when the sensor is dry. This same circuit can be used for different applications such as tank overflow indicator and water level indicator circuit [15].

2.2 The AT89C52 Microcontroller

The AT89C52 microcontroller is the type of microcontroller used for this research. Just like other microcontrollers, it is simply a miniaturized microcomputer and became very popular after Intel licensed other manufacturers like Atmel, Phillips, AMD, Infineon (formerly Siemens), Matra, Maxim, Nuvoton, etc. to produce varying but code compatible versions of the microcontroller [16].

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 3 Mar 2022, pp: 685-700 www.ijaem.net ISSN: 2395-5252

It is an example of a microcontroller in the 8051 family of Atmel Corporation, and possesses the following features:
8K Bytes of In-System Reprogrammable Flash Memory
Endurance: 1,000 Write/Erase Cycles
Fully Static Operation: 0 Hz to 24 MHz
Three-level Program Memory Lock
256 x 8-bit Internal RAM
32 Programmable I/O Lines
Three 16-bit Timer/Counters
Eight Interrupt Sources
Programmable Serial Channel
Low-power Idle and Power-down Modes

2.3 Internal Components of AT89C52 Microcontroller

The CPU: The Central processing Unit (CPU) of the microcontroller comprises of the arithmetic and logic unit (ALU) which performs arithmetic and logic operations on the data fetched from the data memory. It has an instruction decoder that decodes machine code instruction words. It also has registers that store operand addresses/instructions and the control unit [17].

The Interrupt Control: The AT89C52 microcontroller has two external interrupt control pins INT0 and INT1. When the external interrupt mode is selected, hardware components connected to these pins can be serviced when they send an interrupt request IRQ by making either INT0 or INT1 active (low). When this occurs, the normal execution of programs stops while the microcontroller services the hardware (runs a special subroutine known as the interrupt service routine ISR for the interrupting device) and when the hardware has been serviced, the program execution continues from where it stopped before the interrupt. This sequence of actions is handled by the interrupt controller [18].

Bus Control: This controls the flow of instructions as well as data within the microcontroller. It prevents bus contention.

The Timer Counters: Timer 0 and timer 1 provide time measurement and counts events. It is also employed in generating clock pulses (baud rates) when the microcontroller is used in serial communication [19].
The I/O Ports: The AT89C52 microcontroller has I/O ports used for interfacing the microcontroller to external devices like keypads, relay, sensors, ADC's etc [20]. Apart from the use as I/O ports, three out of the four ports have alternate functions. Port 0 and Port 2 are used when interfacing with external memory and all the pins in port 3 have alternate functions as illustrated in Table 1.

Table 1: Alternate Functions of Port 3

Pin	Alternate Functions
P3.0	RXD (serial input port)
P3.1	TXD (serial output port)
P3.2	$\overline{\text{INT0}}$ (external interrupt 0)
P3.3	$\overline{\text{INT0}}$ (external interrupt 1)
P3.4	T0 (timer 0 external input)
P3.5	T1 (timer 1 external input)
P3.6	$\overline{\text{WR}}$ (external data memory write strobe)
P3.7	$\overline{\text{RD}}$ (external data memory read strobe)

Those functions that have a bar above them are made active when low.

Program Memory (On-Chip ROM): This is where the control programs executed by the microcontroller are stored [21]. The sizes and types of ROM vary in order to meet consumer's needs; but generally, they are in the other of a few kilobytes and flash ROMs are common these days.

Data Memory (On-Chip RAM): The AT89C52 microcontroller has an on-chip base memory of 256bytes; out of which 128bytes (memory addresses 00h-7Fh) are reserved for the user. The remaining 128bytes (memory addresses 80h-FFh) are reserved for the special function registers (SFR). Figure 2.3 shows the AT89C52 microcontroller RAM Structure. However, the RAM is usually defined with respect to the base memory available to the user [22].
Hence, if a RAM is said to be 128bytes, it means that 128bytes is available to the user (without taking into account the special function registers).
The on-chip RAM memory is divided as follows: the first 32 bytes made of four memory bank (bank 0-bank 3) are 8-bit registers with each bank possessing eight registers (R0-R7) of one byte each. The next 16 bytes are made up of 128 bit addressable memory locations from 00h through 7Fh, occupying 20h to 2Fh of internal RAM. The remaining 80bytes occupying RAM location 30h to 7Fh is the General Purpose Memory/Registers [23].

Serial port: The AT89C52 microcontroller has a universal asynchronous receiver and transmitter (UART) otherwise known as serial port which it uses for transmission of data in the form of pulses over longer distances where parallel connection is impracticable [24]. The AT89C52 takes care of the protocols needed for serial communication and all the programmer needs to do is to select the serial communication mode and the baud rate (number of sent/received bits per second) and then the data to be sent can be placed on the SBUF register.

Oscillator: The oscillator produces equalized pulses needed to ensure the harmonic and synchronous operation of all the parts of the microcontroller [25].

III. METHODOLOGY

3.1 Design Methodology

Several steps were taken in developing this project. These are stated thus:
1) Understanding the problem and gathering information.
2) Choosing the appropriate method that will be used in solving the problem based on the information gathered.
3) Selection of design tools and sourcing of components.
4) Hardware construction and testing.
5) Software design and testing.
6) Software and hardware integration and final testing.

The chart in Figure 5 summarizes the design methodology employed.

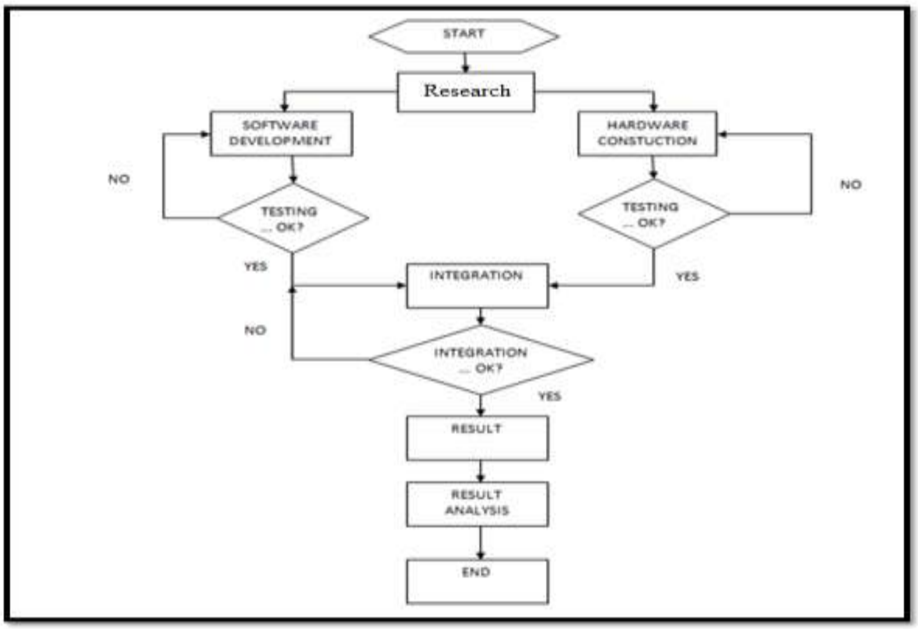

Figure 5: Design Methodology Chart

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 3 Mar 2022, pp: 685-700 www.ijaem.net ISSN: 2395-5252

3.2 Block Diagram of the Proposed System

The block diagram of the system consists of the Power supply unit, Controller unit, Rain sensing unit, Lighting unit, and Sound unit. These units are represented in the block diagram, shown in figure 6.

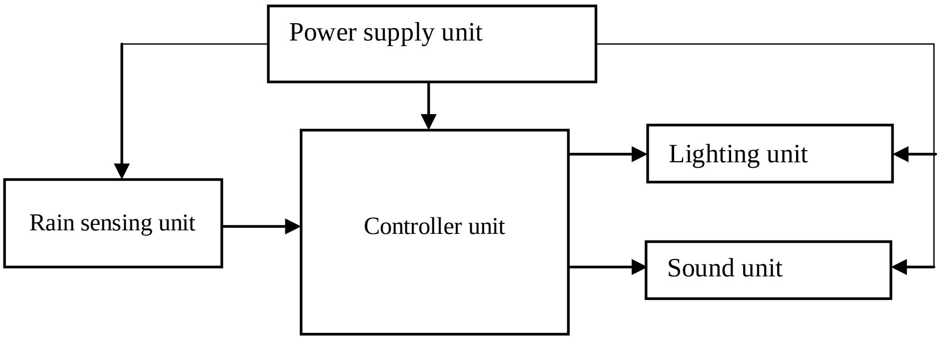

Figure 6: Block Diagram of the Proposed Rain Detector System

The proposed programmable rain detector system comprises of different units brought together to form the overall designed system. Each of these units is made up of discrete components that are joined to achieve a particular purpose. These separate units are:

The power supply unit
The controller unit
The rain sensing unit
The lighting unit
The sound unit

Power Supply Unit

The power supply unit is shown in Figure 7. It consists of a 220/12V step down transformer in which the primary turns are connected to an ac supply, while the secondary turns are connected to a bridge rectifier whose function is to convert an alternating current (AC) input to a direct current (DC) output. A 1000µF capacitor is connected to the bridge rectifier to filter the D.C. signal that is produced.

The positive terminal of the bridge rectifier with that of the capacitor is connected to the V_{in} of the 7805 regulator which produces 5V. The negative terminal of the bridge rectifier is connected together with the ground of the capacitor and the regulator. The 5V signal is supplied to the microcontroller, the LED and the buzzer.

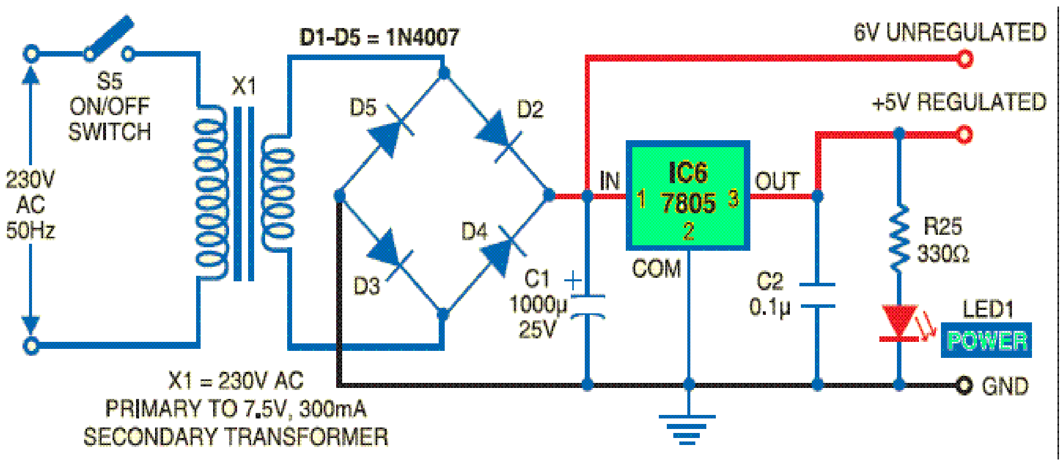

Figure 7: The Power Supply Unit

Controller unit

The Controller unit is the main brain of the system because all the processes are controlled by this hardware device according to how it is programmed. It consists of one important device called microcontroller. Figure 8 shows the layout structure of the microcontroller used, which is AT89C52.

However, the pin configuration of the microcontroller is shown in the Figure.

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 3 Mar 2022, pp: 685-700 www.ijaem.net ISSN: 2395-5252

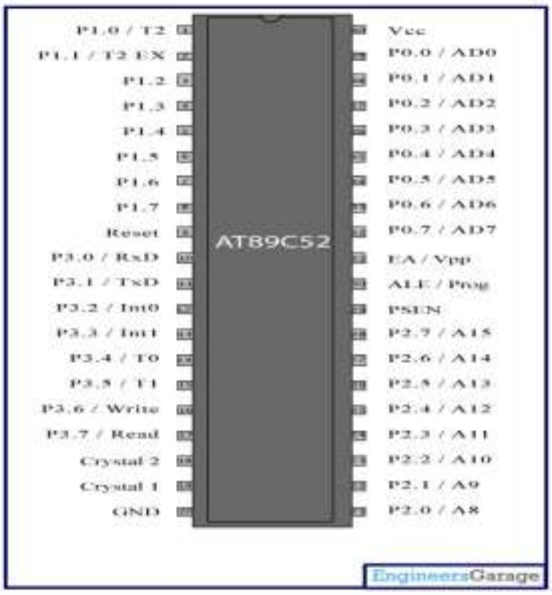

Figure 8: Pin Configuration of AT89C52 Microcontroller

The work of the microcontroller is to monitor when rain starts to fall and to give out an alert signal indicating sign of rainfall. The microcontroller used is an Atmel product (AT89C52) which has 8 special pins and 32 programmable input and output pins.

Rain sensing unit

This unit primarily consists of wires arranged in zig-zag form as shown in Figure 9. The wires are placed on a Bakelite or mica board with gaps to accommodate rain droplets.

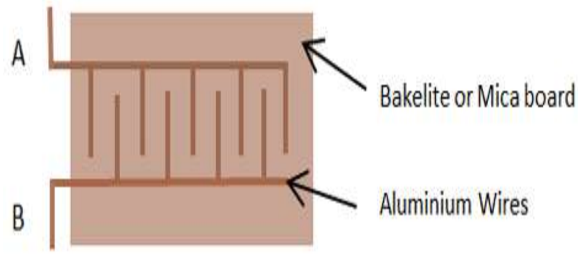

Figure 9: Arrangement of Wires in the Sensing Unit

Lighting Unit

Lighting Unit mainly consists of Light Emitting Diodes **(**LED**),** is the most commonly used components, usually for displaying pins digital states. Typical uses of LEDs include alarm devices, timers and confirmation of user input such as a mouse click or keystroke. Figure 10 shows the circuit symbol of a Light Emitting Diode (LED).
The work of this unit is to give out light showing that rain is falling. In any case, it is a unit for light indication of rainfall.

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 3 Mar 2022, pp: 685-700 www.ijaem.net ISSN: 2395-5252

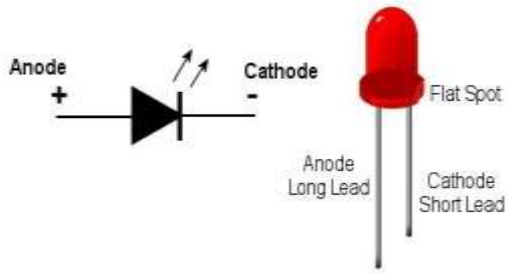

Figure 10: Circuit Symbol of a Light Emitting Diode (LED)

Sound Unit

This unit produces an alarm (sound) when the system senses rainfall. The device that produces this sound is the buzzer which uses a low voltage of 5volts. The Figure 11 shows how buzzer is connected to a circuit, though the circuit is not a programmable type of system.

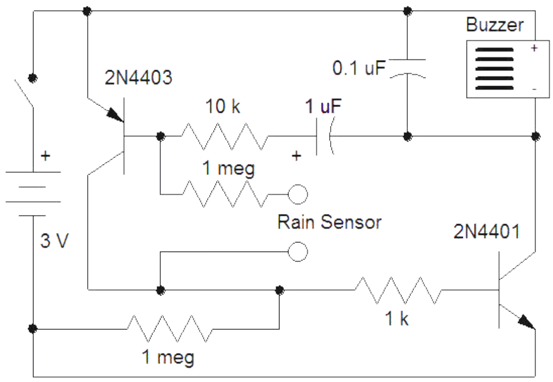

Figure 11: Buzzer Connection to a Circuit

IV. SYSTEM DESIGN

4.1 Design Considerations

The design of the system is based on the developed block diagram. Each block unit is designed in form of module. When all the modules are interconnected, they form a complete intelligent rain detector system. Modular design is done using required electronic components or devices as the case may be. A system is constructed with certain components and every component has its own function. When integrated, the components form the modules, which in turn form the entire system.

Since the system requires the use of microcontroller, the design consists of two parts: hardware and software. Hardware is constructed and integrated module by module for easy troubleshooting and testing. The software on the other hand is embedded-oriented in nature. It is worthy to note that the system is smart (intelligent) in nature because of the use of the stored control program for its operation.

4.2 The System Architecture

The system architecture of an intelligent rain detector system can be divided into modules. The modules are:

(1) Power supply module
(2) Controller module
(3) Rain sensing module
(4) Lighting module
(5) Sound module

The Power Supply module

The module supplies 5volts to the whole circuit. This module is made up of a transformer, a bridge rectifier, an electrolytic capacitor, and a 5V regulator.

The transformer: The transformer used is a simple step-down transformer with primary winding of 220V/50Hz, a secondary winding of 12V and current of 1000mA (which is greater than the current requirement of the circuit). The primary and the secondary windings are related by the equation:

$$\frac{Vp}{Vs} = \frac{Is}{Ip} = \frac{Np}{Ns} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where Vp , Is and Np = primary voltage, secondary current and number of turns of the

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 3 Mar 2022, pp: 685-700 www.ijaem.net ISSN: 2395-5252

primary coil; Vs, Ip and Ns = secondary voltage, primary current and number of turns in the secondary coil.
Since the maximum required voltage is 12V and the mains voltage supply is 220V, we have:

$$\frac{220}{12} = \frac{Np}{Ns} = \frac{55}{3} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Hence the ratio of the primary to the secondary coil of the transformer used is 55:3. Figure 12 shows a transformer circuit arrangement.

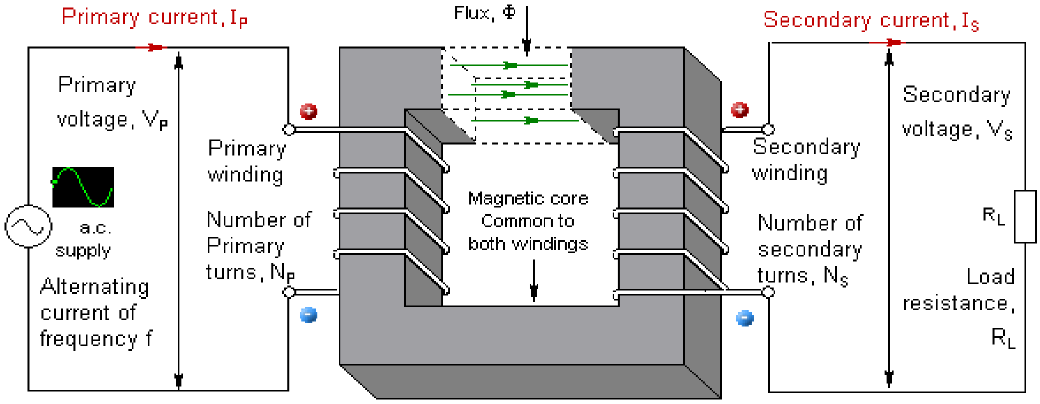

Figure 12: The Transformer Circuit Arrangement

The Bridge rectifier: A full wave bridge rectifier is used with a step-down transformer to convert the AC voltage coming into the circuit into a DC voltage. There are basically four diodes used. D1 and D2 are forward biased and conduct current when the input cycle is positive. The positive half of the input cycle is made from the voltage across the load resistance, D3 and D4 are reversed biased. Throughout the negative input cycle, D3 and D4 are forward biased and conduct current. A voltage is again made across the load resistance in the same direction as during the positive half-cycle.

The filter: A capacitor is positioned in parallel with the output of the bridge rectifier to minimize the ripples in the rectified voltage, which will create a clean DC voltage. The formula below was used to calculate the capacitance value for the filtering capacitor:

$$C = \frac{I}{2Vpp\ f} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where:

V_{pp} is the peak-to-peak ripple voltage
I is the current in the circuit
f is the frequency of the ac power
C is the capacitance.
From the transformer used,
$V_{pp} = \sqrt{2}\times 11.5 = 16.26V$;
I = 0.5A; f = 50Hz.

Hence, $C = \frac{0.5}{2\times 16.26\times 50} = 307.44\mu F$

The minimum capacitance that the calculations give when using the formula is not used. In practice a larger value is used so that the capacitor can charge more, hence 1000μF was used in the research.

Regulator: The voltage regulator IC called 7805 was used to produce the required 5V needed by the microcontroller, LED and the buzzer.
The circuit is represented in Figure 13. The output from the filter circuit is 12.5V when tested, and after regulation we have 5V.

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 3 Mar 2022, pp: 685-700 www.ijaem.net ISSN: 2395-5252

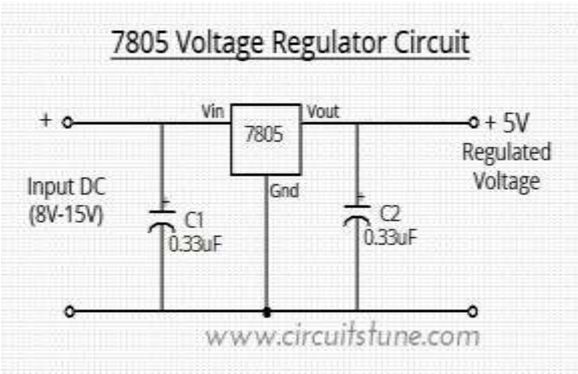

Figure 13: The 7805 Voltage Regulator Circuit

The Controller Module

The AT89C52 microcontroller was chosen as the controller for the research since it offers various functions needed for the research. A microcontroller is a single chip computer. It is shown in Figure 14. The AT89C52 is the most available microcontroller in the market. It has a power circuit, reset circuit, and clock circuit.

Power circuit: The power circuit provides power for the microcontroller. The AT89C52 uses a voltage of 5V DC and this is supplied by the power module. The power circuit of the microcontroller simply involves connecting pin-40 of the controller to 5V supply and pin-20 to ground.

The reset circuit: This circuit resets the device when a high is on the reset pin (pin-9) for two machine cycles.

Clock circuit: This provides timing for the microcontroller. The AT89C52 can generate its own internal clock signal. In order to generate clock for the microcontroller, the output of the clock circuit must be connected to XTAL1 (pin-18) and XTAL2 (pin-19). An oscillator and 2 capacitors are required for the connection. If a crystal oscillator is used, then the capacitors required will be 30pF±10 and if a resonator is used, the capacitors will be 40pF±10.

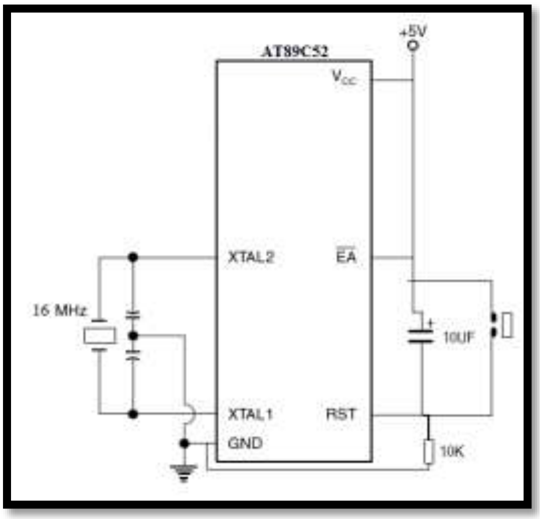

Figure 14: The Controller Module

The Rain Sensing module

When rain starts to fall, the droplets hit the gap of the sensor module. If this happens, the wire gap is bridged and current passes through the wire to the microcontroller. A type of sensing module is made up of funnel which collects the rain drops. This is shown in Figure 15. But in this project, broken wires were used and inter-connected randomly with the two terminals connected to the microcontroller.

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 3 Mar 2022, pp: 685-700 www.ijaem.net ISSN: 2395-5252

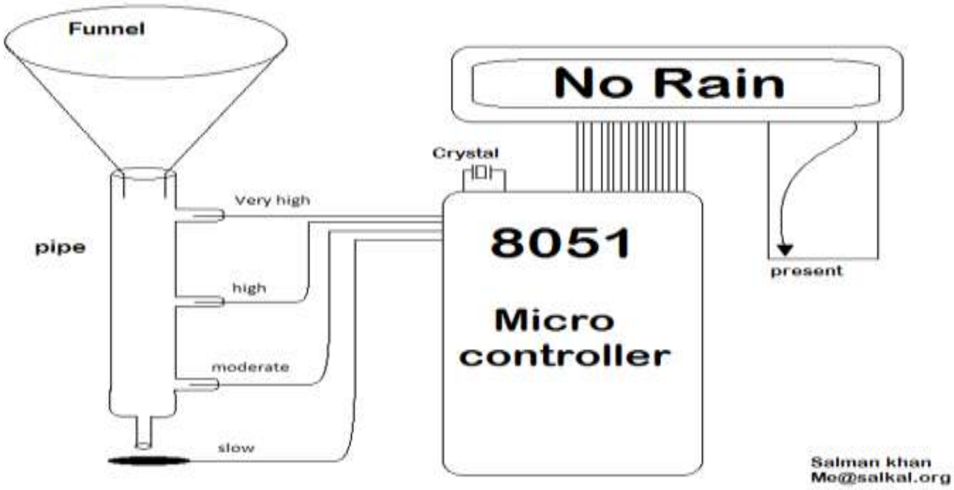

Figure 15: Sensing Module that is made up of Funnel

The Lighting Module

This module comprises of the LED and biasing resistors. They are interfaced to the microcontroller. As seen in the circuit diagram in Figure 17, the anode is connected through a resistor to GND and the cathode is connected to the Microcontroller pin. So when the port pin is HIGH, the LED is OFF and when the port pin is LOW, the LED is turned ON.

The Sound Module

The sound module consists of a buzzer and a driver transistor. The two are interfaced to the microcontroller. The driver for the buzzer is BC337 transistor. The choice of this type of driver is stated below:

1) The BC337 is a voltage controlled device.
2) It is compatible with the microcontroller because microcontroller can directly drive the BC337.
3) It is less temperature dependant and harder to false trigger due to the threshold voltage required to turn it on.
4) It is better to use in high frequency operations to minimize switching losses.

The transistor is controlled by the microcontroller in such a manner that when a high is applied to the base, a voltage drop of 5V develops across R1 which will cause a minimum current of 1mA (which will produce a current of 100mA at the collector circuit since BC337 has a gain of 100 enough to drive the relay which requires a minimum of 30mA ($\frac{12V}{400\Omega}$)) to flow through the base when a high is on that pin.

$$R1 = \frac{Vc}{i} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(4)}$$

$$= \frac{5}{1mA} = 5000\Omega$$

Program Flowchart

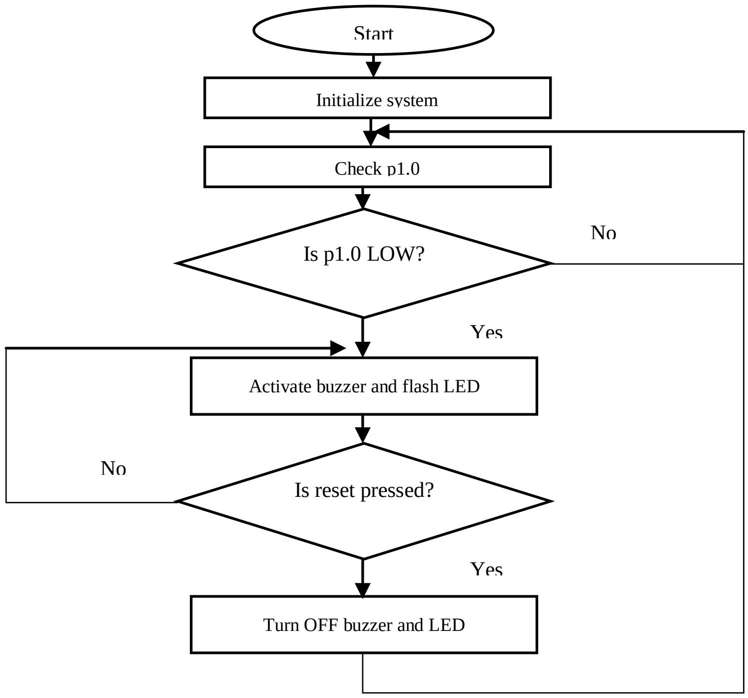

Figure 16: The Program Flowchart

V. SYSTEM ANALYSIS, CONSTRUCTION AND TESTING

5.1 System Analysis

The programmable (intelligent) rain detector is a system that detects rain splashes and alerts the user of an impending rain fall. It consists of a rain sensor/detector module, a controller, an indicator and a buzzer as shown in the circuit diagram of Figure 17.

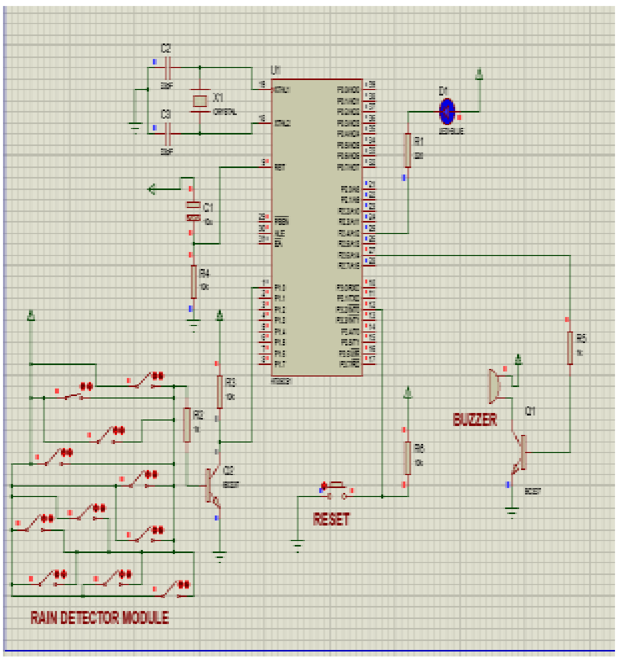

Figure 17: Circuit Diagram of a Programmable Rain Detector

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 3 Mar 2022, pp: 685-700 www.ijaem.net ISSN: 2395-5252

The rain sensor/detector module is an array of conducting wires. Each of the conducting wires is separated into two by a small gap. One side of each of the wires are looped together and connected to 5V. The other ends are also joined together and connected to the base of an NPN transistor (BC337) through a biasing resistor.

The conducting capability of water is utilized. When rain drops on the gap between the conducting wires, the gap is closed and current flows through the 5V and biases the transistor causing the pin P1.0 of the microcontroller to go LOW.

The program checks when P1.0 goes LOW. When this happens, the microcontroller activates the buzzer and continues flashing the indicator LED until the reset button is pressed. The buzzer will not be deactivated even if the reset button is pressed until the drop of water between the conducting wire(s) is/are wiped thoroughly.

5.2 Construction

In the construction of the programmable rain detector system, several components and devices were used. They include capacitors, resistors, transformer, crystal oscillator, bridge rectifier, regulator, microcontroller, Vero-board, etc. Each module listed in Section IV was constructed and later joined together to form the entire programmable rain detector system.

5.2.1 Power Supply Module

The transformer is connected to mains of 240/50Hz through a power cord. The transformer's secondary output (12V/1000mA) is connected to the bridge rectifier source inputs. An output is taken from the negative and positive terminals of the rectifier and connected to the corresponding pins in the 1000µF/45v capacitor. This bridge rectifies the supply while the capacitor filters the ac ripples and equally smoothens the signal to a pure D.C. voltage of 12V DC.

The positive terminal of the capacitor is connected to pin 1 of the 7805 voltage regulator, while the negative terminal connected to pin 2 of the regulator. This regulator produces an output of +5V between pin 3 and pin 2(Ground). The 5V is used for powering the microcontroller.

5.2.2 Microcontroller Unit

As already discussed, the microcontroller chip used for this design is AT89C52. The port 0 is pulled up with 1k resistors so as to make it function like other ports (port 1, port 2 and port 3). On the other hand, one pin is taken from port 2 (P2.6) for the sound module. The pin is connected through a 1k resistor to the base of the transistor (Q1). This resistor limits the current that passes through the transistor. The forward current biases the transistor, hence closing the switch. This in turn switches on the buzzer.

Another pin is taken from port 2 (P2.4) for the lighting module. The pin is again connected through a 1k resistor to the LED directly. This resistor limits the current that passes through the LED. When the P2.4 is low, the forward current (I_f) so created makes the majority carriers of the P-N materials of the LED to conduct.

All the special pins (pin 9, pin 18, pin 19, pin 20, pin 29, pin 30, pin 31 and pin 40) are connected appropriately.

5.3 Program Development

Having constructed the hardware, the AT89C52 chip is as good as nothing if there is no software to direct the actions of the microcontroller. The sequence of operation used to solve a program is often called an algorithm. It is this sequence of operation that constitutes the actions of the microcontroller chip. A very simple way of representing these sequences of actions is by the use of Program descriptive language (PDL).

This is a guide in writing the assembly language program that runs the microcontroller. In designing the program, the system is made to flash light and makes sound whenever rain starts to fall. The developed Assembly language program is shown in appendix A.

5.4 Testing

Testing is necessary in determining if a circuit meets the desired purpose for which it was constructed as well as for optimization. The circuit of this system was tested module by module as it is being integrated. These tests include:

a) All the components were checked to see if they are ok before they were used in the circuitry.

b) The power supply was properly checked to see if it falls within the tolerance value theoretically, so as to avoid damage to the components.

c) The components which were not functioning properly were changed as soon as possible, to avoid other components being affected by the damaged.

d) Testing equipment was in proper range of the output measured at any point of the circuit, or component so as to avoid wrong readings.

VI. SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.1 Summary

This programmable (intelligent) rain detector system is a programmable system that alerts a user whenever rain wants to fall. The system was designed with various devices/components, among which are microcontroller, transistors, buzzer, LED, crystal oscillator, capacitors, resistors and other electronic components. The microcontroller which is the heart of the system was programmed with 8051 Assembly language.

The system block diagram was carefully done, followed by the design of the circuit diagram. All the components in the circuit diagram including the programmed microcontroller were connected together and a complete programmable intelligent rain detector with alert system was obtained.

6.2 Conclusion

The design and implementation of this programmable (intelligent) rain detector with alert system was carried out considering some negative factors which includes unavailability of components, unavailable research materials, etc.

The completed system when tested, met the expected design specification and performance. The system was designed and constructed in such a way that maintenance and repairs can easily be done in a case of emergence of fault.

This developed system (Rain detector) can be used in agricultural fields to detect rain and stop irrigation system immediately. Moreover, in a case of a farmer who usually travels out of home, this system will make it possible for him to know when rain has irrigated his farm. It is however mostly used as a simplest way to automatically stop irrigation during rainfall.

It can be used in home automation applications such as closing the windows and doors when raining outside.

In automobiles, it can be used to detect rain and starts the wiper automatically. Also, in newer techniques for flood monitoring and detection systems, rain detectors are used.

6.3 Problems Encountered

Indeed there is no good work without some hitches. The major problem encountered in this research is that the power supply unit was designed and constructed on a number of times before arriving at the one presently in use.

The problem was short circuitry or "bridging" of components on the Vero board initially used for the research. This necessitated the use of dotted Vero board instead of lined board.

6.4 Recommendations

The recommendations made here arose from discoveries and problems encountered during the research, design and construction.

In order to achieve this result-oriented design and implementation, it is recommended that:

1) This present design should serve as a stepping stone for further development of the research. It should not in any way be seen as the end of this aspect of technology especially in this part of the world. This is because the idea and understanding gained from this research work could be expanded to integrate other forms of detection and control systems.

2) Enough research should be carried out in the area of Embedded Systems Design and Real-Time System Programming & Control so as to improve on this kind of research.

REFERENCES

[1]. M.G. Boss, "Rainfall System Today", International Institute for Land Reclamation and Improvement (ILRI), Wageningen, The Netherlands, 2013, Pps. 13-19.

[2]. Kujot Y.U., "Water System Technology", Chad and Company Ltd, New Delhi, 2012, Pps.1115-1210.

[3]. www. Google. Rain Sensor. com, retrieved on July 2, 2016.

[4]. Palanisarni, K. and Flinn, J.C., "Evaluating the Performance of Rain Detection Systems", Conference on Water Technology, London, 2013.

[5]. John G. Webster etal, "The Measurement, Instrumentation and Sensors Handbook" CRC press LLC, 2013. Pg 939, 951-968.

[6]. John Hewes, "Rainfall Detection Principles", www.kpsee.freeuk.com, retrieved on July 17, 2016.

[7]. Jinon P.K., "Uryanggye: The First Ever Rain Gauge", International Water Management Institute (IWMI), Colombo, Sri Lanka and AgroWater Consultants, Maurik, The Netherlands, 2013.

[8]. K. Garg, S. K. Nayar , "Detection and removal of rain from videos", Proceedings of the 2004 IEEE Computer Society Conference on, Vol.1, July 2004, Pgs I-535.

[9]. Ruiyue Chen, Fu-Lung Chang, Ralph Ferraro, Fuzhong Weng, "Impact of the Vertical Variation of Cloud Droplet Size on the Estimation of Cloud Liquid Water Path and Rain Detection", Online Journal of the American Meteorological Society, USA, 2007.
[10]. Robert A. Houze Jr., "Stratiform Precipitation in Regions of Convection: A Meteorological Paradox?", Bulletin of the American Meteorological Society, 2014, Pps. 7-9.
[11]. Palanisarni, K. and Flinn, J.C., "Evaluating the Performance of Water Irrigation Systems", Conference on Agricultural Systems, London, 2013.
[12]. Yute Bet, "Vaisala's DRD11A Detector for Fast and Accurate Precipitation Rain Detector Detection", International Journal of Biometeorology, 2015, Pps. 134–143.
[13]. Sivagurunathan, S., "Conservation of Water Project for Improved Water Management", Institute of Engineers Transactions for 2005, Sri-Lanka, Pps.14-21.
[14]. www. Google. RSD Series Rain Sensor.com, retrieved on 19th July, 2016.
[15]. www. Google. Water Systems. com, retrieved on July 2, 2015.
[16]. Muhammad Ali Mazidi, Janice Gillispie Mazidi, Rolin D. McKinlay, "The 8051 Microcontroller and Embedded Systems", Prentitce Hall, New Jersey USA, 2009.
[17]. Isizoh A.N., NwobodoNzeribe H.N., Aniedu A.N., "Assembly Language Programming for Embedded Systems and Real-Time Applications", Scoa Heritage Publishers Ltd, Awka, Nigeria, 2018.
[18]. Douglas. V. H., "Microprocessor & Interfacing", Tata McGraw Hill, New Delhi, 2011, Pp. 153-162.
[19]. Hall D.V., "Programming Techniques for Microcontrollers , McGraw Hill Inc, New York, 2012, Pps. 25-33.
[20]. Maxda. F. F., "Designs Using Microcontrollers", Cambridge University Press, London, 2014, Pps. 150-160.
[21]. Timesys publication, "The Concise Book of Real Time Systems" Timesys Corporation, Pittsburgh, 2012.
[22]. Schuster A., "Microcontroller Principles and Applications", Maxon Press Ltd, Rochester, 2008.
[23]. Predko Myke, "Handbook of Microcontrollers", McGraw Hill, New York, USA, 2007, Pp 1-17.
[24]. Douglas V.H., "Microcontrollers and Interfacing: Programming Hardware" McGraw Hill Inc, New York, 2008, Pp 270-344.
[25]. Holliday D. and Resmick Robert, "Fundamentals of Microcontrollers", Don Peters Press Ltd, Fulmar, 2008, P 88.

APPENDIX A
THE CONTROL PROGRAM

```
ORG 00H
MOV P1,#0FFH
MOV P3,#0FFH
MOV P2,#00H
CLR P2.6
SETB P2.4
START:
NEXT: JB P1.0,NEXT
CALL DELAY
CALL BUZZ
BUZZ: CPL P2.6
CPL P2.4
CALL DELAY1S
RESETT: JB P3.2, BUZZ
CLR P2.6
SETB P2.4
JMP START
DELAY1S: PET:MOV R1,#124
MOV R2,#154
MOV R3,#8
MEG: DJNZ R1,MEG
DJNZ R2,MEG
DJNZ R3,MEG
RET
DELAY:
PET1: MOV R1,#22
MOV R2,#134
MOV R3,#2
MEG1: DJNZ R1,MEG1
DJNZ R2,MEG1
DJNZ R3,MEG1
RET
END
```