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DESIGN AND IMPLEMENTATION OF AN AUTOMATIC SENSOR WATER TAP FOR HAND WASHING

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ABSTRACT

This research is a design and implementation of an automatic sensor water tap for hand washing. The work aimed to switch ON and OFF a water tap automatically without the need of turning it manually. It employs a passive Infrared (PIR) Sensor which has a maximum sensitivity of about 3m. The sensor detects the presence of a user within its viewing range and responds by giving a high at its output. The automatic sensor water tap incorporates a microcontroller (PIC16F628A) which was programmed using the 'C' programming language and turns ON the tap automatically whenever the sensor senses the user's hand, and turns OFF when the hand is withdrawn.

1 INTRODUCTION

Life is driven by technology. In addition, man has a deep desire for an easy and comfortable life. The "automatic sensor water tap for hand washing" is one of the many present day technologies, which are no longer analogue but digital. They are environmentally friendly and give man the basic comfort he desires (www.ukessay.com/). Automatic sensor water taps incorporate state-of-the-art design and technology to provide the ultimate convenience. It uses a special sensor known as a "PIR (Passive Infrared) sensor". The PIR sensor is a pyroelectric device which detects presence or motion by measuring changes in the infrared levels emitted by surrounding objects. The sensor, working along with some other circuitry which will be discussed in chapter two (2) can be used to turn ON a tap whenever there is a presence of human hand within its viewing range, and then turns OFF the tap when the hand is withdrawn from its viewing range. The PIR based systems are mostly used in Hotels, kitchens, airport lavatories and other places where health and hygiene are a serious concern. The PIR sensors can also be used in security systems (Hareendran, 2015).

Automatic sensor taps offer the benefit of improved hygiene, by eliminating the need to physically turn the knob of the tap ON or OFF. This eliminates the chance of re-contaminating one's hand by touching the same handle that was previously touched by not only your unwashed hands, but by that of those before you. This tap greatly reduces the chances of water wastage which may arise if one forgets to turn off the tap after use or turned it only partially off out of haste. By implication, when installed in home, sensor taps alleviate the need for parents to ensure that their children have turned off taps. Economically, sensor taps use less water, resulting in direct savings on water bills. More about how automatic sensor taps operates and their construction is discussed in the subsequent chapters.

2 STATEMENT OF THE PROBLEM

Usually, most of the water taps in the market used the old system where it uses manual control to turn ON or OFF the system. The water tap is easy to be spoiled due to frequent turning as some people do not know how to carefully handle it. Another disadvantage of the older system is that, when users wash their hands, their hands are not always clean because they still have a direct contact with the messy tap which is exposed to germs. There is also a high chance of water wastage, as people may forget to turn OFF the tap or turn it only partially OFF.

3 LITERATURE REVIEW

Automatic control systems did not appear until the middle eighteenth century. The first automatic control system "the fly-ball governor", to control the speed of steam engines was invented by James Watt in 1770 (Nagrath and Gopal, 2010). Automatic taps were first developed in the 1850s but were not produced for commercial use until the late 1950s when they first appeared to general public at airport lavatories. Story has it that the first airport to adopt this technology is the Chicago O'Hare International Airport. They are now found in places other than the airports, for example; restaurants, hotels, academic institutions, casinos, malls, sport arenas as well as residential areas (www.ukessay.com/). Due to their assistive qualities, automatic taps are making their presence felt at living establishments and places where elderly and/or handicapped individuals called home. Automatic water taps are water saving devices, they help in saving great amount of water that would otherwise be wasted. Most of the existing projects based on PIR sensors are for security purposes. For example; sensor-based cameras for human detection, pet's detection and flame detection. This project however uses the PIR sensor along with other components to either turn ON or OFF a water tap. Electronic circuits consist of interconnections of electronic components. Components are classified into passive and active devices.

The PIR sensor is a device that can sense the infrared (IR) light within its viewing range. This sensor is a passive device that simply measures the change in the IR levels emitted by surrounding objects. It is also called "Pyroelectric Infrared Sensor" (Soyer, 2009).

PIR will detect any object emitting IR radiation, heat or changes in the background IR level. Infrared radiating objects include humans, animals, vehicles and wind. The sensor by itself has a short range of approximately 1m maximum, but using a lens that focuses the IR radiation on the sensor we can increase the sensing range to up to 30m. Therefore, Passive Infrared Detectors (PIDs) are more suitable for indoor applications or short range outdoor applications. The PIR sensor does not come alone, it normally comes as a module. This module incorporates four (4) key components: The Fresnel lens, the PIR, Amplifier and Comparator circuit.

4 DESIGN

The process of circuit design can cover systems ranging from complex electronic circuit all the way down to the individual transistors.

-The PIC16F628A IC used in this work has an in-build circuit made up of several electronic components.

-The PIR sensor comes in a module and is made up of several components which includes: resistors, transistors, capacitors and many others.

-The LCD is a complete system of its own and is consists of several components.

The design of an electronic circuit usually involves the following stages:

i. Calculating the component value to meet the operating specifications under specified conditions.
ii. Performing simulation to verify the correctness of the design. This is usually done using "electronic workbench" and other special soft wares.
iii. Building the breadboard of the design and testing against specification.
iv. Making any alterations to the circuit to achieve compliance.

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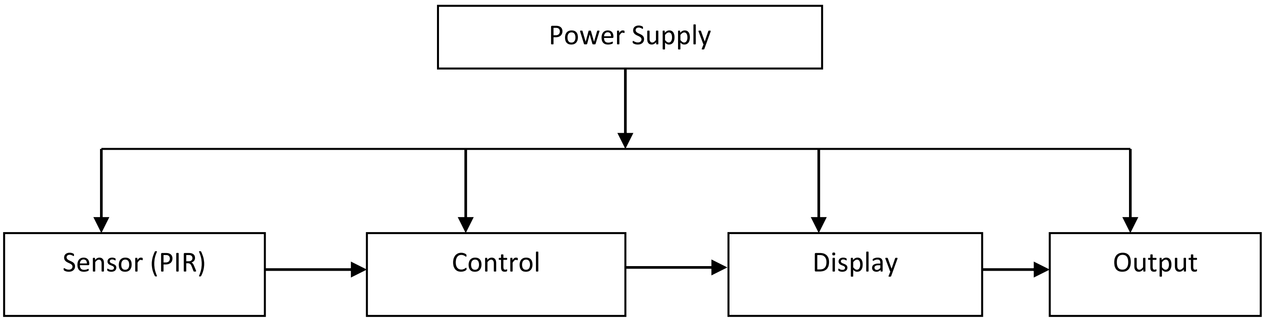
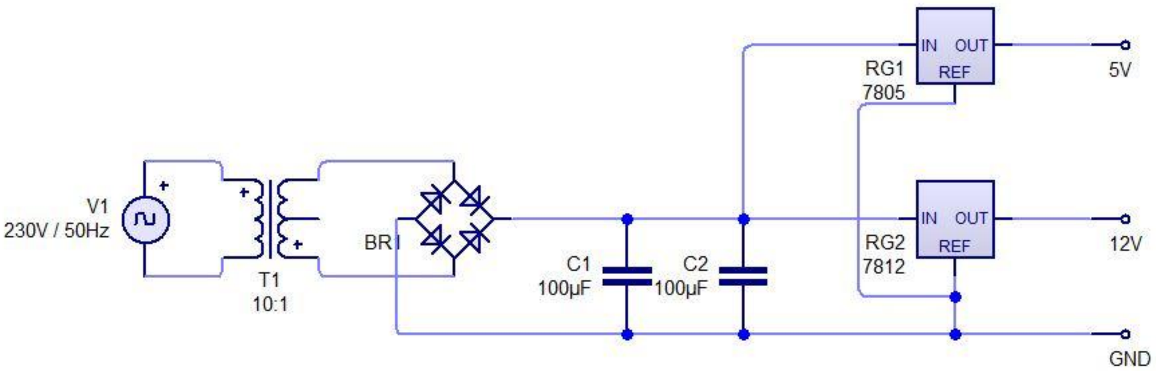


Figure 1: Schematic block diagram of the automatic sensor water tap

POWER SUPPLY

The power supply as explained in chapter two is responsible for starting up or powering the entire circuit. It is a regulated power supply which gives two different voltages to the circuit; that is 12V and 5V DCs. The transformer (240V/12V), the bridge rectifier, the two filtering capacitors (100µF/50V), and the voltage regulators (7805 and 7812) are the components that made up the power supply unit. 5V from the power supply powers the sensor, the IC and the LED, while the 12V output from the power supply powers the relay.



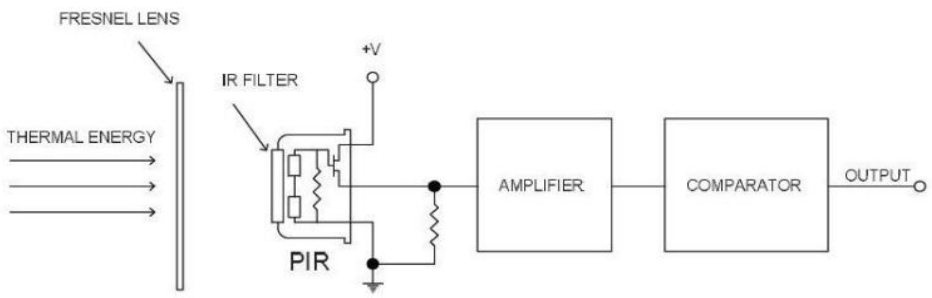


Figure 2: Power supply section of an automatic sensor water tap

THE SENSOR SECTION

The sensor section is basically the PIR (Passive Infrared) sensor module. The module incorporates four basic components: The Fresnel lens, the PIR, the Amplifier and the Comparator Circuit. These four components work together to sense the presence of an infrared radiating body e.g. human body (in this came, human hand) and gives an appropriate response to the IC (PIC16F628A) through a transistor. The sensor has the ability to cover up to a range of 7m, but in this case, it is adjusted to sense within the range of 10cm to 30cm.

THE CONTROL UNIT

The control unit or section is the IC (Integrated Circuit). For this project, the IC used is “PIC16F628A”. The IC is programmed using the ‘C’ programming language. When powered, can run the tap ON or OFF when it senses a high from the PIR sensor with the help of other components like, the relay, transistor and the solenoid valve.

PROGRAMMING THE PIC16F627A/628A/648A

The PIC16F627A/628A/648A is programmed using a serial method. The Serial mode will allow the PIC16F627A/628A/648A to be programmed while in the user’s system. This allows for increased design flexibility. This programming specification applies to PIC16F627A/628A/648A devices in all packages.

Hardware Requirements

The PIC16F627A/628A/648A requires one programmable power supply for V_{DD} (2.0V to 5.5V) and a V_{PP} of 12V to 14V, or V_{PP} of 4.5V to 5.5V, when using low voltage. Both supplies should have a minimum resolution of 0.25V.

Programming Mode

The Programming mode for the PIC16F627A/628A/648A allows programming of user program memory, data memory, special locations used for ID, and the Configuration Word

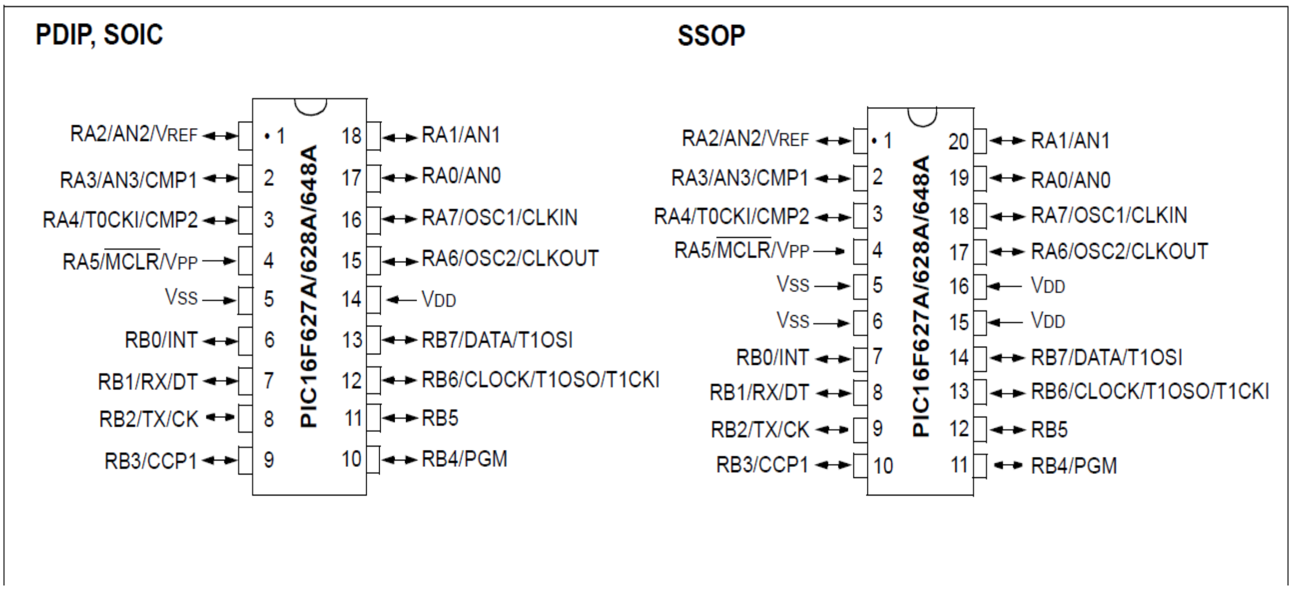


Figure.3: Pin Diagram of PIC16F627A/628A/648A

Table 1: PIN DESCRIPTIONS (DURING PROGRAMMING) PIC16F627A/628A/648A

Pin Name	During Programming		
	Function	Pin Type	Pin Description
RB4	PGM	I	Low voltage/programming input if configuration bit equals 1
RB6	CLOCK	I	Clock input
RB7	DATA	I/O	Data input/output
MCLR/VPP	Programming Mode	P(1)	Program Mode Select
V_{DD}	V_{DD}	P	Power Supply
V_{SS}	V_{SS}	P	Ground

Legend: I = Input, O = Output, P = Power **Note 1:** In the PIC16F627A/628A/648A, the programming high voltage is internally generated. To activate the Programming mode, high voltage needs to be applied to MCLR input. Since the MCLR is used for a level source, this means that MCLR does not draw any significant current.

Program/Verify Mode

The programming module operates on simple command sequences entered in serial fashion with the data being latched on the falling edge of the clock pulse. The sequences are entered serially, via the clock and data lines, which are Schmitt Trigger inputs in this mode. The general form for all command sequences consists of a 6-bit command and conditionally a 16-bit data word. Both command and data word are clocked LSB first. The signal on pin DATA is required to have a minimum setup and hold time (see AC/DC specifications), with respect to the falling edge of the clock. Commands that have data associated with them (Read and Load), require a minimum delay of TDLY1 between the command and the data.

THE DISPLAY UNIT

The LCD functions as the display unit of the entire circuit. When the circuit is powered, the LCD indicates accordingly. When there is a presence of an infrared radiating body (in this case human hand) before the PIR sensor, it also gives an indication accordingly. As long as the tap is ON, an indication is shown on the LCD, the reverse also applies.

THE OUTPUT SECTION

The output section basically consists of the transistor, the relay and the solenoid valve as shown in the Figure 4.

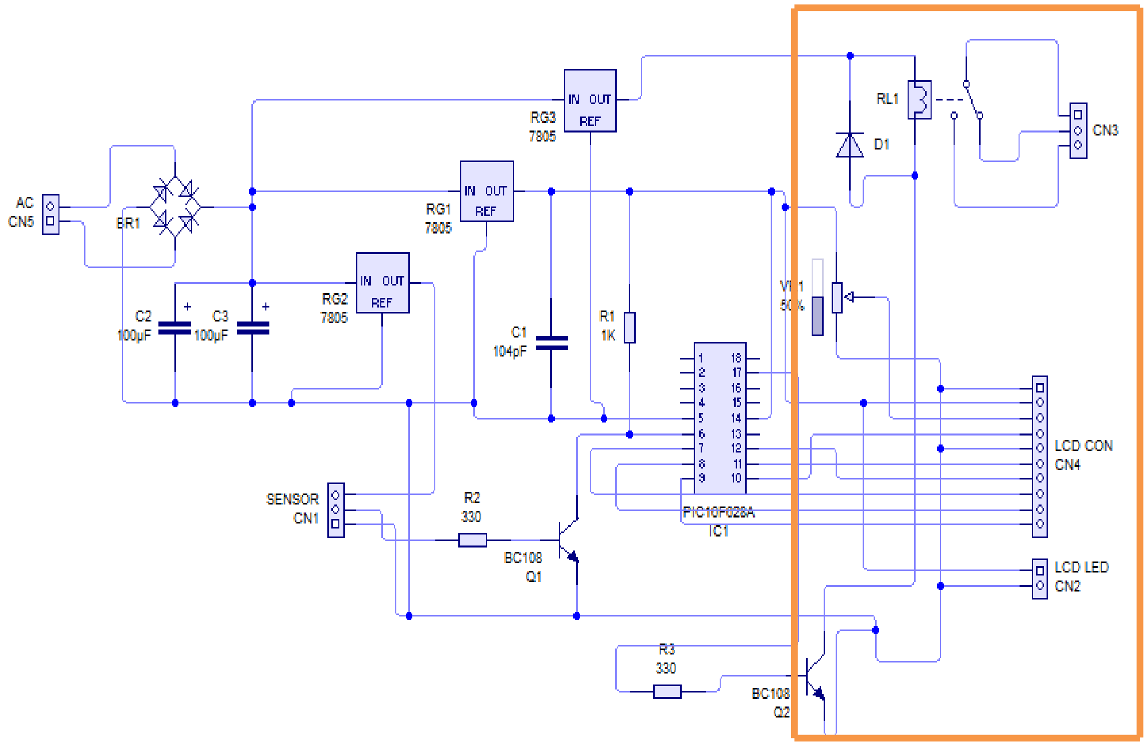


Figure 4: The Output Unit of the automatic sensor water tap

METHOD OF CONSTRUCTION

In this section, about three steps were taken. The first step involved programming the microcontroller, the second has to do with assembling the electrical components and the third step took care of the casing.

CIRCUIT OPERATION

The power supply of the automatic sensor tap comprises of a 12V step-down transformer, the bridge rectifier, the filtering capacitors and the voltage regulators. The output from the power supply unit powers the entire circuit.

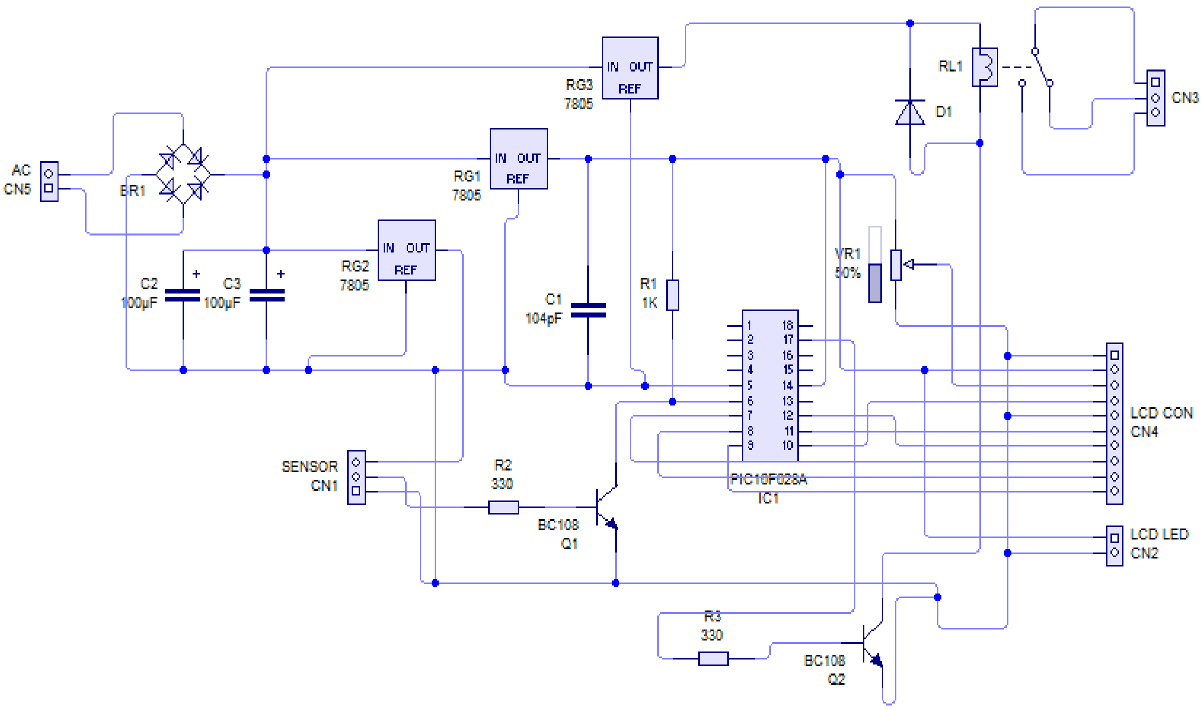


Figure 5: The complete circuit diagram of the automatic sensor water tap

The sensor gets it power through the voltage regulator 7805. The microcontroller also gets its power through the voltage regulator 7805. Once there is an infrared emitting body (in this case hand) within the sensing range, the sensor gives an output which switches On the transistor and also gives a signal to the microcontroller. The microcontroller which is programmed to control the flow of the water will then turn ON the relay, which also turns ON the solenoid valve thereby allowing water to flow. When there is no longer any

IR emitting body within the sensing range of the sensor, the IC disengages the relay which also stops the flow of the water to avoid any wastage. While the tap is ON, information is displayed on the screen of the LCD. An information is also indicated when the tap is OFF.

CONSTRUCTION OF THE CASING

Plastic was used for casing the electronic circuit and its circuitry. The casing is made up of a plastic sheet of the following dimensions; length 18cm, breadth 15cm and height 8cm. A space was created on the top of the box to accommodate the LCD. The system uses a plastic tank of volume 30 litres. The solenoid valve used has a diameter of 0.5 inch.

Figure 6: A complete setup of the automatic sensor water tap for hand washing

5 TEST/RESULT AND DISCUSSION

TEST/RESULT

After the components were mounted on the PCB (Printed Circuit Board), test was carried out using digital mustimeter (DMM). The test was carried out as follows:

POWER SUPPLY

The table below contains the result of the voltages dropped across the various components on the circuit as measured with the DMM.

Table 2: The circuit voltages across the power supply unit

Voltage	Measured Value (v)
Voltage from mains into transformer	228.2V (ac)
Output voltage from transformer	12.90V (ac)
Output from rectifier & filtering circuit	15.99V (dc)
Output voltage from regulator RC_1	4.98V (dc)
Output voltage from regulator RC_2	4.98V (dc)
Output voltage from regulator RC_3	12.02V (dc)

The PIR sensor receives 4.9V from the regulator RC_2

The PIC 16F628AIC receives 4.98V from the regulator RC_1

THE SENSOR

The PIR sensor I used to have a viewing range of up to 7m. However, because it is used in a tap system, the viewing range is adjusted to about 0.5m. The shorter the distance, the more the sensitivity as shown in table 3.

Table 3: The Sensitivity/distance of the Sensor

Distance (m)	Sensitivity
0.5	Very sensitive
1.0	Very sensitive
3.0	Very sensitive
7.0	Less sensitive
10.0	Not sensitive (no response)

THE OUTPUT

As long as the sensor receives no 1R signal, the solenoid remains closed and hence no water is received at the tap. But when the tap receives an IR signal, it turns ON the solenoid valve which allows water to flow from the tap.

- When tap is ON, voltage across solenoid is 3mV

- When tap is OFF, voltage across solenoid is 5.35v.

6 DISCUSSION

At the end of the design and implementation, automatic sensor water tap was achieved. The sensitivity of the PIR sensor was adjusted to about 0.5m and it responds immediately when an infrared radiating body (human hand) is brought within its viewing range. It also returns to its normal state (closed state) when the body is out of its viewing range.

The LCD also displays the following information on its screen when the circuit is powered.

- “Automatic sensor tap”
- “Innocent Dayer”
- “Sci/2015/513/0008”
- “Put your hand to ON Tap”

When the tap is ON, the LCD displays the information as “Tap is ON”

7 CONCLUSION

The various blocks of the automatic sensor water tap for hand washing were designed and mounted on the Printed Circuit Board (PCB), they were tested for workability. From the output unit, it can be concluded that this aim of the design and the implementation is achieved, since the solenoid valve was turned ON when it senses an IR radiation and also switched of when the IR body is no more. However, the tap does not turn OFF immediately after the hand is withdrawn as expected. It delays for about 3 to 4 seconds. The design and implementation of the automatic sensor water tap for hand washing was a very interesting one. The tap turns ON immediately when it senses human hands. However, it exhibits a delay of about 3 to 4 seconds before it turns OFF. further work should be carried out on this topic to eliminate this delay so that water wastage will be completely avoided. Because of the advantages of the automatic water sensor tap in modern technology, there is the need to widen its field of application.

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APPENDIX A

Detail of the Program in C Language

```
// LCD module connections
sbit LCD_RS at RB4_bit;
sbit LCD_EN at RB5_bit;
sbit LCD_D4 at RB6_bit;
sbit LCD_D5 at RB1_bit;
sbit LCD_D6 at RB2_bit;
sbit LCD_D7 at RB3_bit;
sbitLCD_RS_Direction at TRISB4_bit;
sbitLCD_EN_Direction at TRISB5_bit;
sbit LCD_D4_Direction at TRISB6_bit;
sbit LCD_D5_Direction at TRISB1_bit;
sbit LCD_D6_Direction at TRISB2_bit;
sbit LCD_D7_Direction at TRISB3_bit;
// End LCD module connections

void main()
{
Lcd_Init();                    // Initialize LCD
Lcd_Cmd(_LCD_CLEAR);           // Clear display
Lcd_Cmd(_LCD_CURSOR_OFF);      // Cursor off
Lcd_Out(1,1,"AUTOMATIC");      // Write text in first row
Lcd_Out(2,1,"SENSOR TAP");     // Write text in first row

   TRISA = 0x00;
   PORTA = 0x00;
   TRISB = 0x01;
   PORTB = 0x00;
```

```
Delay_ms(2000);


Lcd_Cmd(_LCD_CLEAR);              // Clear display
Lcd_Cmd(_LCD_CURSOR_OFF);         // Cursor off
Lcd_Out(1,1,"INNOCENT DAYER");              // Write text in first row
Lcd_Out(2,1,"SCI/2015/513/008");              // Write text in first row


Delay_ms(2000);


do {
if(PORTB.RB0 == 0)
   {
      PORTA = 0xFF;
Lcd_Cmd(_LCD_CLEAR);              // Clear display
Lcd_Cmd(_LCD_CURSOR_OFF);         // Cursor off
Lcd_Out(1,1,"TAP IS 'ON'");       // Write text in first row
   }
else
   {
    PORTA = 0x00;
Lcd_Cmd(_LCD_CLEAR);              // Clear display
Lcd_Cmd(_LCD_CURSOR_OFF);         // Cursor off
Lcd_Out(1,1,"PUT YOUR HAND");     // Write text in first row
Lcd_Out(2,1,"TO ON TAP");   // Write text in first row
   }
  } while(1);
}
```

Assembly Language Equivalence

```
_main:

;SLT.c,17 ::         void main()
;SLT.c,19 ::         Lcd_Init();                  // Initialize LCD
    CALL    _Lcd_Init+0
;SLT.c,20 ::         TRISA = 0x00;
    CLRF    TRISA+0
;SLT.c,21 ::         PORTA = 0x00;
    CLRF    PORTA+0
;SLT.c,22 ::         TRISB = 0x01;
    MOVLW   1
    MOVWF   TRISB+0
;SLT.c,23 ::         PORTB = 0x00;
    CLRF    PORTB+0
;SLT.c,25 ::         Lcd_Cmd(_LCD_CLEAR);         // Clear display
    MOVLW   1
    MOVWF   FARG_Lcd_Cmd_out_char+0
    CALL    _Lcd_Cmd+0
;SLT.c,26 ::         Lcd_Cmd(_LCD_CURSOR_OFF);    // Cursor off
    MOVLW   12
    MOVWF   FARG_Lcd_Cmd_out_char+0
    CALL    _Lcd_Cmd+0
;SLT.c,27 ::         Lcd_Out(1,1,"AUTOMATIC");    // Write text in first row
    MOVLW   1
    MOVWF   FARG_Lcd_Out_row+0
    MOVLW   1
    MOVWF   FARG_Lcd_Out_column+0
    MOVLW   ?lstr1_SLT+0
```

```
      MOVWF     FARG_Lcd_Out_text+0
      CALL      _Lcd_Out+0
;SLT.c,28 ::         Lcd_Out(2,1,"SENSOR TAP");      // Write text in first row
      MOVLW     2
      MOVWF     FARG_Lcd_Out_row+0
      MOVLW     1
      MOVWF     FARG_Lcd_Out_column+0
      MOVLW     ?lstr2_SLT+0
      MOVWF     FARG_Lcd_Out_text+0
      CALL      _Lcd_Out+0
;SLT.c,30 ::         Delay_ms(2000);
      MOVLW     11
      MOVWF     R11+0
      MOVLW     38
      MOVWF     R12+0
      MOVLW     93
      MOVWF     R13+0
L_main0:
      DECFSZ    R13+0, 1
      GOTO      L_main0
      DECFSZ    R12+0, 1
      GOTO      L_main0
      DECFSZ    R11+0, 1
      GOTO      L_main0
      NOP
      NOP
;SLT.c,32 ::         Lcd_Cmd(_LCD_CLEAR);         // Clear display
      MOVLW     1
      MOVWF     FARG_Lcd_Cmd_out_char+0
      CALL      _Lcd_Cmd+0
```

```
;SLT.c,33 ::        Lcd_Cmd(_LCD_CURSOR_OFF);        // Cursor off
    MOVLW    12
    MOVWF    FARG_Lcd_Cmd_out_char+0
    CALL     _Lcd_Cmd+0
;SLT.c,34 ::        Lcd_Out(1,1,"INNOCENT DAYER");        // Write text in first row
    MOVLW    1
    MOVWF    FARG_Lcd_Out_row+0
    MOVLW    1
    MOVWF    FARG_Lcd_Out_column+0
    MOVLW    ?lstr3_SLT+0
    MOVWF    FARG_Lcd_Out_text+0
    CALL     _Lcd_Out+0
;SLT.c,35 ::        Lcd_Out(2,1,"SCI/2015/513/008");        // Write text in first row
    MOVLW    2
    MOVWF    FARG_Lcd_Out_row+0
    MOVLW    1
    MOVWF    FARG_Lcd_Out_column+0
    MOVLW    ?lstr4_SLT+0
    MOVWF    FARG_Lcd_Out_text+0
    CALL     _Lcd_Out+0
;SLT.c,37 ::        Delay_ms(2000);
    MOVLW    11
    MOVWF    R11+0
    MOVLW    38
    MOVWF    R12+0
    MOVLW    93
    MOVWF    R13+0
L_main1:
    DECFSZ   R13+0, 1
    GOTO     L_main1
```

```
      DECFSZ    R12+0, 1
      GOTO      L_main1
      DECFSZ    R11+0, 1
      GOTO      L_main1
      NOP
      NOP
;SLT.c,39 ::            do {
L_main2:
;SLT.c,40 ::            if(PORTB.RB0 == 0)
      BTFSC     PORTB+0, 0
      GOTO      L_main5
;SLT.c,42 ::            PORTA = 0xFF;
      MOVLW     255
      MOVWF     PORTA+0
;SLT.c,43 ::            Lcd_Cmd(_LCD_CLEAR);          // Clear display
      MOVLW     1
      MOVWF     FARG_Lcd_Cmd_out_char+0
      CALL      _Lcd_Cmd+0
;SLT.c,44 ::            Lcd_Cmd(_LCD_CURSOR_OFF);      // Cursor off
      MOVLW     12
      MOVWF     FARG_Lcd_Cmd_out_char+0
      CALL      _Lcd_Cmd+0
;SLT.c,45 ::            Lcd_Out(1,1,"TAP IS 'ON'");      // Write text in first row
      MOVLW     1
      MOVWF     FARG_Lcd_Out_row+0
      MOVLW     1
      MOVWF     FARG_Lcd_Out_column+0
      MOVLW     ?lstr5_SLT+0
      MOVWF     FARG_Lcd_Out_text+0
      CALL      _Lcd_Out+0
```

```
;SLT.c,46 ::          }
      GOTO      L_main6
L_main5:
;SLT.c,49 ::          PORTA = 0x00;
      CLRF      PORTA+0
;SLT.c,50 ::          Lcd_Cmd(_LCD_CLEAR);          // Clear display
      MOVLW     1
      MOVWF     FARG_Lcd_Cmd_out_char+0
      CALL      _Lcd_Cmd+0
;SLT.c,51 ::          Lcd_Cmd(_LCD_CURSOR_OFF);      // Cursor off
      MOVLW     12
      MOVWF     FARG_Lcd_Cmd_out_char+0
      CALL      _Lcd_Cmd+0
;SLT.c,52 ::          Lcd_Out(1,1,"PUT YOUR HAND");    // Write text in first row
      MOVLW     1
      MOVWF     FARG_Lcd_Out_row+0
      MOVLW     1
      MOVWF     FARG_Lcd_Out_column+0
      MOVLW     ?lstr6_SLT+0
      MOVWF     FARG_Lcd_Out_text+0
      CALL      _Lcd_Out+0
;SLT.c,53 ::          Lcd_Out(2,1,"TO ON TAP");   // Write text in first row
      MOVLW     2
      MOVWF     FARG_Lcd_Out_row+0
      MOVLW     1
      MOVWF     FARG_Lcd_Out_column+0
      MOVLW     ?lstr7_SLT+0
      MOVWF     FARG_Lcd_Out_text+0
      CALL      _Lcd_Out+0
; SLT.c,54 ::          }
```

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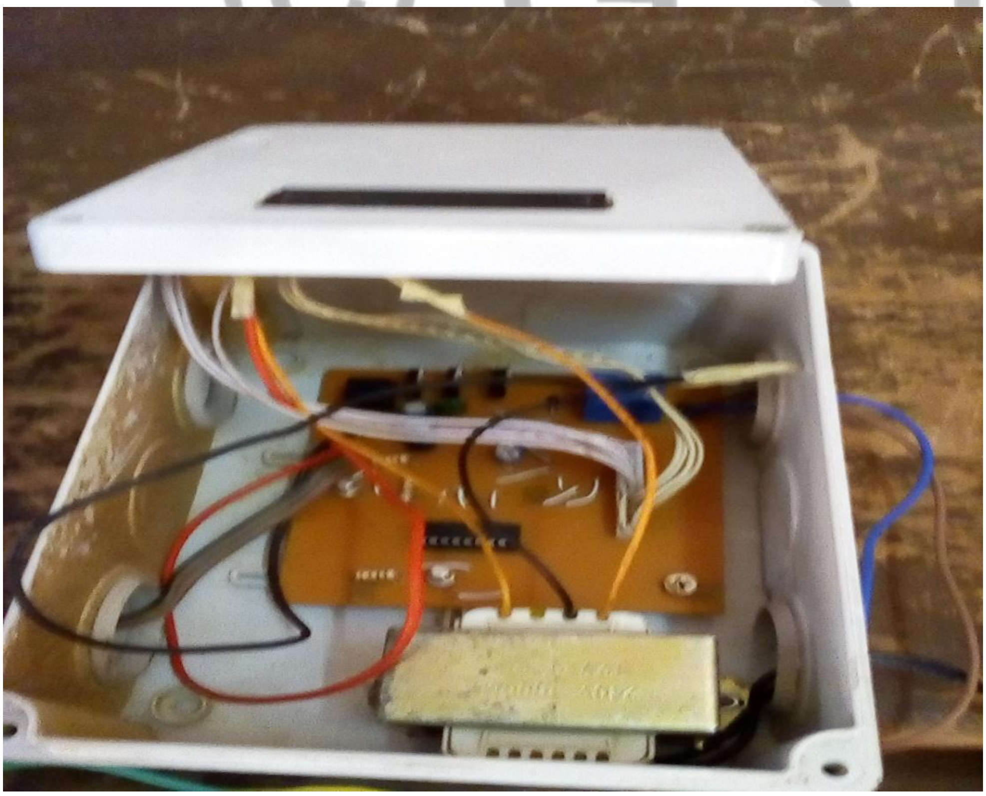
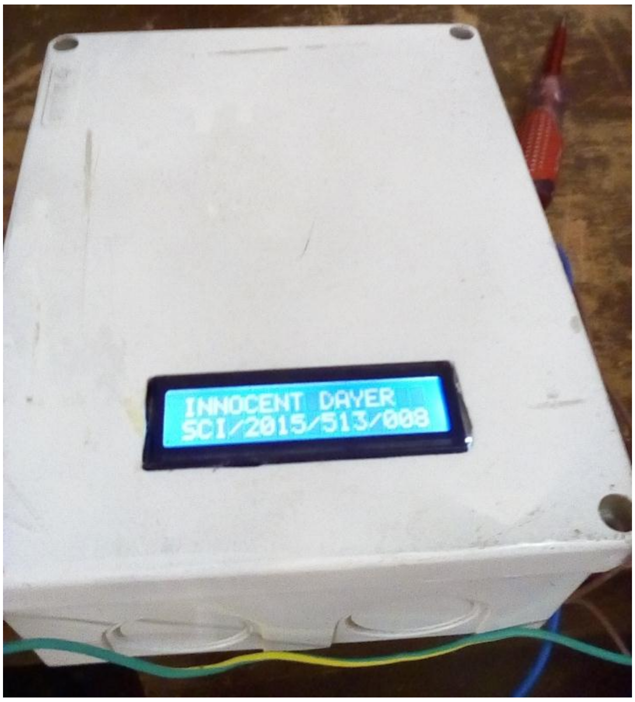
```
L_main6:
; SLT.c, 55::            } while(1);
      GOTO      L_main2
; SLT.c,56 ::            }
L_end_main:
      GOTO      $+0
; end of _main
```

APPENDIX B

Picture showing the tap running



Picture of the exposed circuitry of the tap system



Picture showing LCD Display

Testing of the hand washing tap