Construction and Design of Microcontroller Embedded Based Viscometer

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ABSTRACT

Ostwald Viscometer with Photo – Detector system is developed by using Light Emitting Diode and Light Dependent Resistor. The flow time is measured with Microcontroller and output displayed on Liquid Crystal Display. Software is written in computer for the measurement of flow time in embedded `c` and hardware designing is described. The accuracy of the newly designed instrument is in milliseconds.

1. INTRODUCTION

Viscosity is the property of the fluid arising from collisions between neighboring particles that are moving at different velocities. Viscosity is measured with different types of viscometers. In conventional Ostwald Viscometer, flow time is measured between two fudicial marks with stop watch. By reducing human errors we are developed a newly designed Ostwald Glass Capillary Viscometer with a photo - Detector System [1]. The flow time measured by using hardware and software explained in the next sections.

2. HARDWARE DESIGNING

The block diagram of experimental set up for the measurement of viscosity is shown in fig. 1. The function of each block is explained below.

5V D. C. POWER SUPPLY

One of output of computer is taken as input to the ARDUINO BOARD. It gives 5V D. C. power supply constantly.

VISCOMETER

Now we are using Ostwald Capillary Viscometer shown in Fig. 2. It consists of two wider bulbs A and B having different capacities. Bulb A is called reservoir with more capacity and bulb B with less capacity. In between these bulbs there is a U – tube possess capillary E and F below bulb B. There are two fudicial marks U and L one above the bulb B and one lower the bulb B. A fixed mark G is placed above the bulb A to maintain constant volume.

PHOTO DETECTOR SYSTEM FOR UPPER MARK `U`

This system consists of Light Emitting Diode (LED) L 1 and a Light Dependent Resistor (LDR) R 1. These two are placed exactly in opposite direction, because the light coming from LED is exactly falling on LDR. These LED and LDR are placed in small glass tubes fixed with araldite to the upper fudicial mark of the viscometer. The power of LED is taken from ARDUINO BOARD Supply Out. Hence bidirectional arrows are used at Photo - Detector System for upper mark `U`.

PHOTO DETECTOR SYSTEM FOR LOWER MARK `L`

Lower mark Photo Detector System also consists of one Light Emitting Diode (LED) L 2 and one Light Dependent Resistor (LDR) R 2 exactly in opposite direction placed in glass tubes. These two glass tubes are fixed with viscometer by araldite. The power of LED L 2 is taken from ARDUINO BOARD Supply Out, so bidirectional arrow marks are used.

THERMISTOR

Thermistor means Thermal Resistor, having negative temperature coefficient of temperature. Thermistor is highly sensitive to temperature variations and gives correct temperature. The power of Thermistor is taken from ARDUINO BOARD Supply Out. Therefore bidirectional arrows are used.

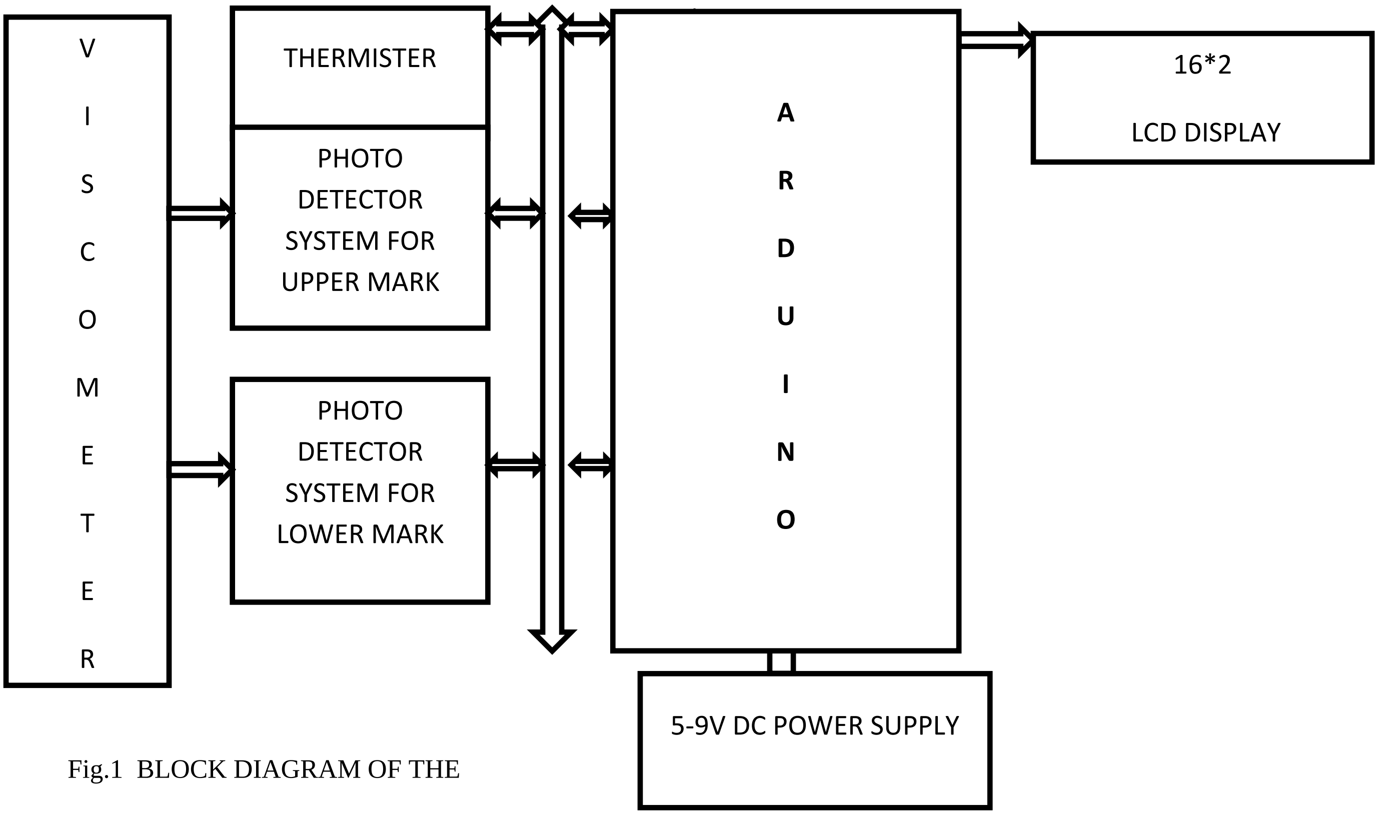


Fig.1 BLOCK DIAGRAM OF THE EXPERIMENTAL SET UP

Fig.2 VISCOMETER

Arduino uno board:

An Arduino uno board is one which depends on the atmega 328 microcontroller. It has 14 input / output digital pins , 16 MHZ oscillator, 6 analog pins acting as inputs, one USB jack, one power jack and one reset button. The Arduino hardware is an open source with Atmel processor and input / output support. The programming software consists of a standard language which runs with the help of boot loader on the board. Arduino uno Board is shown in Fig. 3.

Arduino Summary:

Microcontroller	ATmega 328
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I / O Pin s	14 (of which 6 provide PWM output)
Analog Input Pins	6
Flash Memory	32 KB (ATmega 328) of which 0.5 KB used by boot loader
SRAM	2 KB (ATmega 328)
EEPROM	1 KB (ATmega 328)
Clock Speed	16 MHz

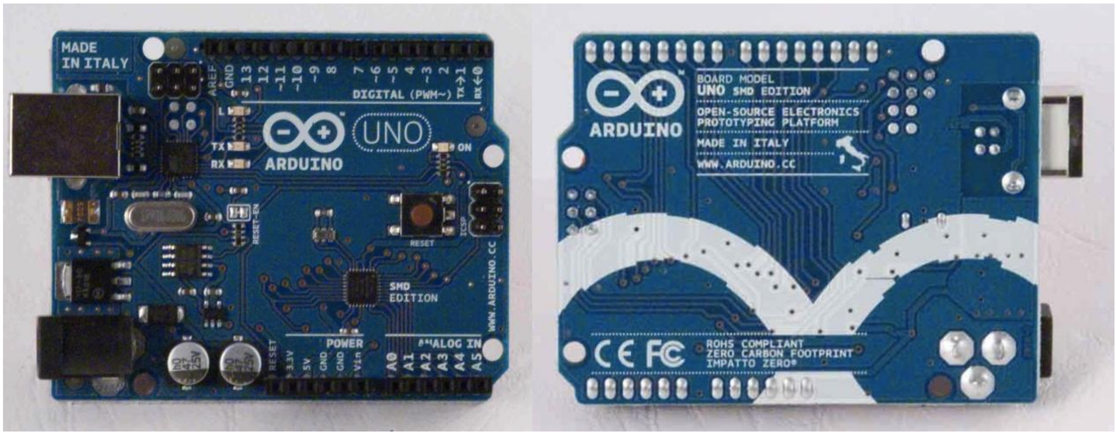


Fig. 3 Arduino uno Board

Atmega 328 features:-

The atmega 328 controller consists of 8k bytes of flash memory which is In-system programmable, it comprises of 512 bytes of EEPROM, 23 input / output lines, 1 kilobyte static RAM, 32 general purpose registers, 3 timer / counters, 6 ADC channels, programmable USART serial interface, 5 adjustable power saving modes, watch dog timer with internal oscillator. Atmega 328 pin numbers and the associated Arduino pins are shown in Fig. 4. Internal connection of Arduino Board with LCD and components are shown in Fig. 5. The flow chart developed for measuring viscosity is shown in Fig. 6 and program IN EMBEDDED `C` is given in Fig. 7.

Arduino pin mapping with Atmega 328:

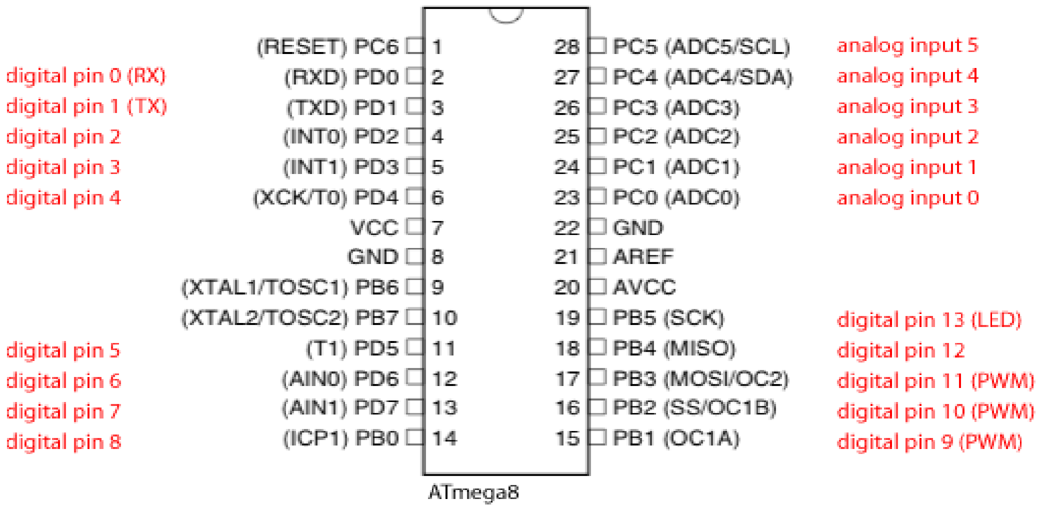


Fig 4 ATMEGA 328 PIN NUMBERS AND ASSOCIATED ARDUINO PINS.

LCD pin mapping with ARDUINO

1 - Ground Rail	11 - Digital 5
2 - 5v Rail	12 - Digital 4
3 - To potentiometer	13 - Digital 3
4 - Digital 12	14 - Digital 2
5 - Ground Rail	15 (Backlight) - 5v Rail
6 - Digital 11	16 (Backlight) - Ground Rail

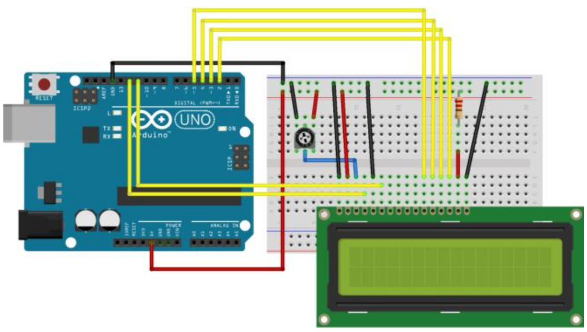
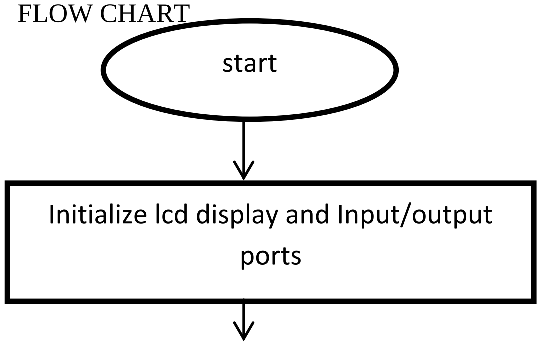
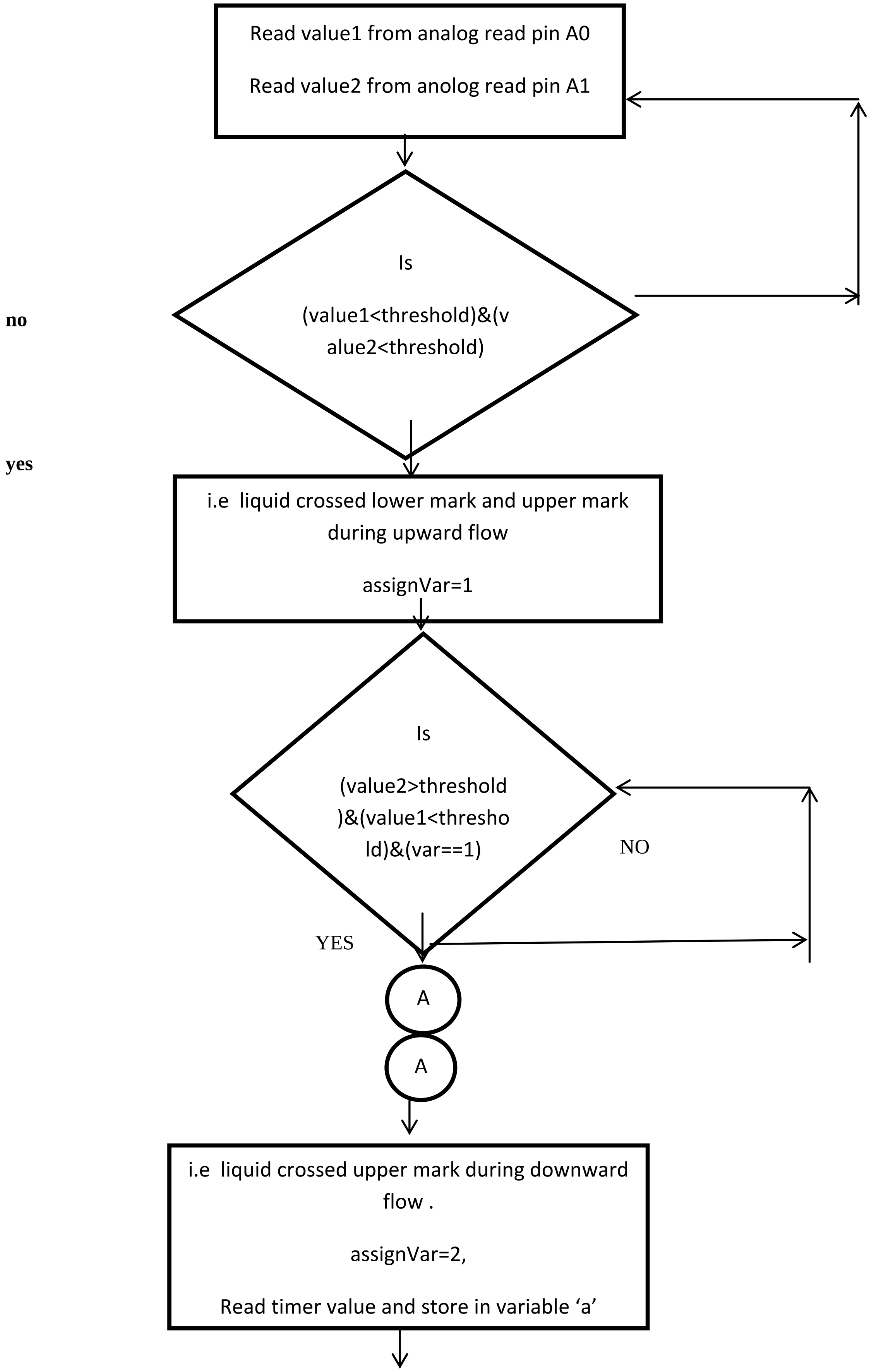


Fig. 5 INTERNAL CONNECTIONS OF ARDUINO BOARD WITH LCD AND OTHERS

3 SOFT WARE

FLOW CHART




Read value1 from analog read pin A0
Read value2 from anolog read pin A1
Is
(value1<threshold)&(v
alue2<threshold)
no
yes
i.e liquid crossed lower mark and upper mark
during upward flow
assignVar=1
Is
(value2>threshold
)&(value1<thresho
ld)&(var==1)
NO
YES
A
A
i.e liquid crossed upper mark during downward
flow .
assignVar=2,
Read timer value and store in variable ‘a’

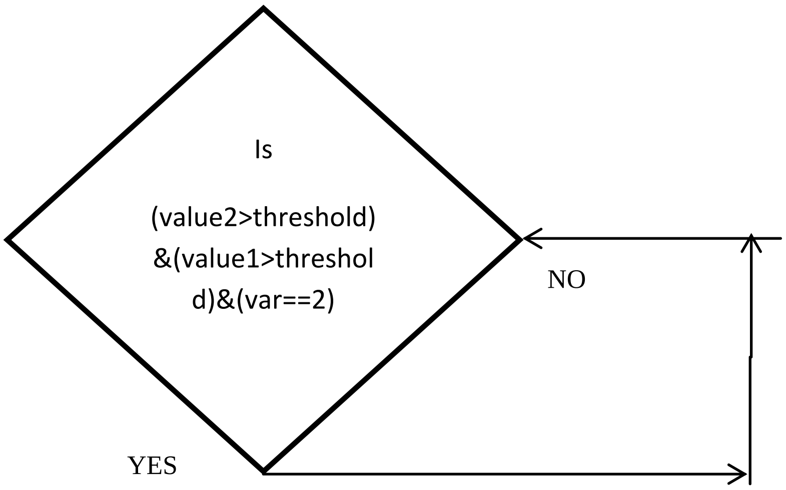


Fig. 6 FLOW CHART FOR MEASURING VISCOSITY.

PROGRAM IN EMBEDDED C:

```
#include<LiquidCrystal.h>
#include <math.h>
LiquidCrystallcd(12,11,5,4,3,2);
unsigned long a=0;
unsigned long b=0;
unsigned long c=0;
unsigned long var=0;
unsigned long d=0;
void setup()
{
Serial.begin(9600);
pinMode(A0,INPUT);
pinMode(A1,INPUT);
pinMode(A3,INPUT);
lcd.begin(16,2);
}
double Thermister(intRawADC) {
  double Temp;
  Temp = log(((10240000/RawADC) - 10000));
  Temp = 1 / (0.001129148 + (0.000234125 * Temp) +
(0.0000000876741 * Temp * Temp * Temp));
  Temp = Temp - 273.15;           // Convert Kelvin to
Celcius
  return Temp;
}
void printTemp(void) {

  double temp = Thermister(analogRead(A3));  // Read
sensor
lcd.clear();
lcd.setCursor(0,1);
lcd.print("Temp is:");
lcd.setCursor(9,1);
lcd.print(temp);
lcd.print(" C / ");

  }
```

```
void loop()
{
int value1;
int value2;
lcd.setCursor(3,0);
lcd.print("VISCOMETER");
while(1)
{
value1=analogRead(A0);
value2=analogRead(A1);
double temp = Thermister(analogRead(A3));
printTemp();
delay(1000);
Serial.println(value1);
Serial.print("\t");
Serial.println(value2);
if((value1<240)&&(value2<150))
{
var=1;
}
if((value2>150)&&(var==1)&&(value1<240))
{
var=2;
a=millis();
}
if((value1>240)&&(value2>150)&&(var==2))
{
b=millis();
lcd.clear();
c=(b-a)/1000;
d=(b-a)%1000;
lcd.setCursor(1,0);
lcd.print(c);
lcd.setCursor(4,0);
lcd.print("sec");
lcd.setCursor(8,0);
lcd.print(d);
lcd.print("msec");
```

	c=0;
	d=0;
	var=0;
	delay(60000);
	}
	}
	}

Fig. 7. PROGRAM IN EMBEDDED `C`.

4. EXPERIMENTAL PROCEDURE

First clean the viscometer with distilled water thoroughly. To remove the traces of water rinsed the viscometer with acetone and dried. The viscometer is then cooled to room temperature. After that the viscometer is rinsed with the experimental liquid. Now the viscometer is filled with the experimental liquid under investigation upto a fixed mark. For all measurements the same mark is used for better reproducibility of results.

Here we are using A. C. for temperature control. Thermistor shows the exact temperature of A. C. At that time only we are taking the readings with in $\pm$ 0.5℃. The viscometer is placed in this position more than half an hour to reach equilibrium position and to attain steady state temperature.

The logic for measuring the flow time of viscometer is as follows.

5. CONDITIONS OF FLOW

1. If liquid does not flows through the lower fudicial mark of viscometer, then value 1 > threshold 1.
2. If the liquid flows through the lower fudicial mark of viscometer, then value 1 < threshold 1.
3. If liquid does not flows the upper fudicial mark of viscomete, then value 2 > threshold 2.
4. If liquid flows through the upper fudicial mark of viscometer, then value 2< threshold 2.

While flowing liquid in upward and downward directions the following cases arises.

Case 1. There is no liquid in the upper and lower marks, then value 1 > threshold 1 and value 2 > threshold 2.

Case 2. If the liquid cross the lower fudicial marks of viscometer, then value 1 < threshold 1 and value 2 > threshold 2. Assuming var = 1 (means liquid is flowing in upward direction).

Case 3. If liquid cross the upper fudicial mark, in upward direction, then value 1 < threshold 1 and the value 2 < threshold 2. Assuming var = 2 (here also liquid moving in upward direction only) .

Case 4. If liquid moves in downward direction, value 2 > threshold 2, value 1 < threshold 1 and var = 2. Timer starts counting, then a = milliseconds.

Case 5. If liquid cross the lower fudicial mark of the viscometer, value 2 > threshold 2, value 1 > threshold 1 and var = 2. Then b = milliseconds.

The difference of these two readings gives c i. e., c = (b – a). The value of c is displayed on LCD.

In programming also the same steps involved. Here A 0, A 1 and A 3 are taken as analog inputs. If the liquid cross the lower mark in upward direction, then value 1 < 240 & value 2 > 150, then var = 1 (case 2). The liquid cross upper mark in downward direction (Case 4) value 2 > 150 & value 1 < 240 &var = 2, assign a = millis. The value 1 > 240 & value 2 > 150 &var = 2 (Case 5), then b = millis. Calculate the values of c and d using the formula c = (b – a) / 1000 and

d = (b – a) % 1000. Finally print c, d and temperature values on LCD. Here the liquid is present in upper and lower fudicial marks gives more intensity (240) than without liquid at that mark (150), because multiple reflections takes place within the liquid and also from the internal surface of the glass. These intensity values are suitable for transparent and almost colorless liquids only. For color liquids these values changes according to their concentrations.

6. STANDARDIZATION OF VISCOMETER

Viscometer is first filled with deionized water, the flow time is calculated and the experiment is repeated 3 to 5 times, the average value of all these readings are taken.

The density of water is taken from viscopedia [2] data from IAPWS 2008. The viscometer constant B is calculated by using the formula

$$B = \eta / \rho t \quad \text{------}\rightarrow \quad (1)$$

Where η is the viscosity of the deionized water

ρ is the density of the deionized water and

t is the flow time of the deionized water.

TABLE 1.

VISCOSITIES OF SOME PURE LIQUIDS

S. No.	Liquid	Viscosity at 23℃ (10^{-3} Nsm^{-2})
1	Benzene	0.744 at 20 °C [5] 0.6187 at 23 °C present study 0.604at 24 °C [9] 0.5640 at 25 °C [7] 0.603 at 25 °C [5] 0.601at 27 °C [16] 0.5407 at 30 °C [8] 0.65 at 30 °C [5] 0.562 at 30℃ [2]
2	Nitrobenzene	1.4153 present study 1.863 at 24℃ [9] 1.415 at 25 °C [7]
3	Acetone	0.327 at 20 °C [10] 0.325 at 20 °C [11] 0.322 at 20 °C [12] o.300 at 20 °C [13] 0.32 at 20 °C [14] 0.33 at room temperature[15] 0.3090 present study 0.306 at 24 °C [9] 0.3049 at 25 °C [18] 0.3050 at 25 °C [19] 0.3332 at 25 °C [20] 0.3150 at 25 °C [21] 0.306 at 25 °C [22] 0.306 at 26 °C [12] 0.316 at 27 °C [16] 0.306 at 28 °C [3] 0.30 at 30 °C [17]
4	Water	1.0016 at 20 °C [2] 1.002 at 20 °C [3] 0.01 at 20 °C [14] 1.00 at 20 °C [23] 0.9877 present study 0.89 at 25 °C [2] 0.91 at 25 °C [3] 0.89 at 27 °C [12]

Now the viscometer is filled with experimental liquid, for which the viscosity is to be calculated. The flow time for that liquid is measured, the experiment is repeated 3 to 5 times , the average value flow time is calculated. The viscosity of the liquid or liquid mixture is calculated from the formula

$$\eta = \rho B t \quad \text{------}\rightarrow \quad (2)$$

Viscosities of some pure liquids are determined and tabulated in Table 1. These viscosities are compared with the literature data are in good agreement with the standard values.

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