DESIGN AND CONSTRUCTION OF MICROCONTROLLER BASED INDUCTANCE AND CAPACITANCE METER

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A PROJECT REPORT SUBMITTED TO THE DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING, SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY, MODIBBO ADAMA UNNIVERSITY OF TECHNOLOGY YOLA, IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF BACHELOR OF ENGINEERING

DECEMBER, 2012

DECLARATION

I hereby declare that this project was written by me and is a record of my own research work. It has not been presented before in any previous application for a bachelor's degree. References made to published literature have been duly acknowledged.

.... Date....................................

Olajide, Oluwaseun

(Student)

The above declaration is confirmed

.... Date....................................

Idris Ibn Idris

(Supervisor)

CERTIFICATION

This project entitled "**DESIGN AND CONSTRUCTION OF MICRO CONTROLLER BASED INDUCTANCE AND CAPACITANCE METER"** by **Olajide, Oluwaseun** (EE/07/0592) meets the regulations governing the award of bachelor's degree of the Federal University of Technology, Yola and is approved for its contribution to knowledge and literary presentation.

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Idris Ibn Idris

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(Head of Department)

.... Date...

Prof. E. E. Omizegba

(External supervisor)

DEDICATION

This project is dedicated to the almighty God, my parent and siblings

ACKNOWLEDGEMENTS

My profound gratitude goes to God almighty, the author and finisher of my faith, for his guidance and protection through my years of study. I wish to extend my deepest gratitude to Mr and Mrs Olajide Emmanuel for their relentless prayers and supports, in making this project a success. Also my supervisor, in person of Mr. Idris Ibn Idris for his guidance and direction in the course of this project work, the head of department Electrical and Electronics Engineering, Engr. I.M. Visa and other staff and students that has contributed to the success of this project.

I wish to extend my warm gratitude to my dearest siblings, Olajide Toyin, Olajide Bukola, Olajide Kemi, Olajide Dare, Olajide Gbenga, for their care and support in numerous ways. And to my bosom friends; Femi, kufala, Umar, Salau, Sulaiman, Yemi, Lopotee's and my dearest Faith, only God can reward all of you, but as for me, I say thank you and God bless

ABSTRACT

A microcontroller measuring instrument for capacitance and inductance measurement is described. It is based on an oscillator circuit with the oscillation frequency dependent on a measured element. The output of the oscillator circuit that is the measured elements is passed into microcontroller which can compute the value of the measured element following a written program command in the microcontroller and displays the result via a 16×2 LCD screen.

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ABBREVIATION AND SYMBOLS

LCD: Liquid Crystal Display

CPU: Central Processing Unit

RST: Reset

VCC: Power Supply

GND: Ground

CHAPTER ONE: INTRODUCTION

1.0 BACKGROUND

A micro- controlled instrument for capacitance and inductance measurement is described. It is based on oscillator circuit with the oscillator frequency dependent on a measured element. An analysis of the oscillator used is also given , equations for the oscillation frequency and its deviation from the resonance frequency controlling resonance circuit are derived. The measured result can be transferred into a micro-controller, which can process and display these results.

Electronic methods of capacitance and inductance measurement are based on different principles [1]. They include bridge methods, vector impedance methods, resonance method, digital RLC method, voltage and current measurement methods and phase shift measurement methods. All of these methods have some advantages but also suffer from some drawbacks.

The most precise are bridge methods but the construction and measurement by such instrument are complicated. Digital RLC methods use feedback amplifiers and allow measurement frequencies [2]. The measurement circuit in these methods is simple but accuracy is relatively low. Resonance methods use the use the known dependence of the resonance frequency on the values of an inductance and capacitance elements of a series or parallel resonance circuit, for the finding of resonance frequency, they are inaccurate.

A modified version of the resonance methods is based on the measurement of the frequency of an oscillator with the measured element connected into a frequency controlling resonance circuit. Digital frequency measurement is accurate and yields the desired digital output of the instrument.

Between any known inductor and capacitor in parallel, there is a frequency that is always present. This frequency is independent of the source given to these two components.

Since this calculates the resonant frequency of the parallel LC circuit, we can use the same equation to calculate an unknown inductance value by simply rearranging the equation and if the resonant frequency has been measured beforehand.

1.1 PROBLEM STATEMENT

In recent times, you can measure all other component such as resistors, capacitors etc with the simple multimeter, but not an inductor, so therefore you have to use other indirect and uncomfortable ways e.g. look up chart provided in some manual handbooks and also the cost of obtaining an LC meter is very high.

1.2 OBJECTIVE

- The main objective of this project is simply to create an inductance and capacitance meter that uses a microcontroller.
- To measure an unknown capacitance or inductance with a known frequency, generated by the LC oscillator circuit

1.3 SIGNIFICANCE

- LC Meter is designed for unprecedented measurement accuracy and offers great value at low cost.
- The LC meter finds its place in the manufacture of electronic equipments and it's of immense value in the manufacture of receivers, transmitters or transceivers etc.
- With this project, one can instantaneously change inductors or capacitors and measure its value without hassle.

1.4 SCOPE

The scope of the project is to design and create a microcontroller based inductance and capacitance meter by taking advantage of the natural frequency of the LC circuit.

CHAPTER TWO: LITERATURE REVIEW

2.0 INTRODUCTION

The idea of the construction of an inductance and capacitance measuring instrument with a microcontroller and an LCD seems to have originated from Bill Carver [3].

We generally use capacitor and inductors to store energy in the oscillating circuit. Capacitor stores energy in an electric field while inductor does the same in a magnetic field.

A microcontroller measuring instrument for a capacitance and inductance meter is based on the oscillator circuit with the oscillating frequency dependent on the measured element.

2.1 REVIEW OF RELEVANT WORKS

According to [4] a microcontroller based inductance and capacitance meter which measures inductance and capacitance was built, the hardware component used were of 10% tolerance from nominal value. This will mean the calculated inductance will have a 10% error margin from nominal value if the time measurement of the microcontroller was precise.

This error in [4] was reduced by using component with tolerance of 1% from their value thereby increasing the3 accuracy of measurement. Instead of an entire development board LM311 IC was used, this can be programmed to detect the comparators output wave form and to generate the oscillator frequency [5].

Some people had problems with the erratic function or lack of precision and related this to LM311 IC in [5]. This problem was traced to spurious oscillation in the high frequency region around 12Mhz. The problem was solved by a 2.2Pf capacitor from pin 7 to pin 2 of the LM311 IC [6].

Further improvement was made on [6]. An LC meter that uses a microcontroller, the heart of the LC meter is an Atmel microcontroller that reads the frequency of a tuned circuit formed with inductor or capacitor being measured.

The controller computes the value of the component under test and announces the readings in mores via a miniature speaker. When the uses press the C button the capacitance is announced. When the user presses the L button the inductance is announced. The limitation with this LC meter was the range of measurement with was quite small and it is bulky.

An improvement was made on [6]. An auto ranging microcontroller based LC meter that is able to measure an unknown inductor and capacitance was built. It is quite portable and can be used as hand held meter. the major challenge with this project was measuring small capacitances. This was traced to the errors in the calibration of the LC meter [7]

An improvement over the LC meter [7], is the enhanced capacitance self calibration LC meter, the AVR ATTINY861 it was a further improvement over the auto ranging microcontroller based LC meter, it has a great deal of accuracy and could measure the small inductance [8]

An inductor meter was built in [9] using the RL oscillator circuit, it could measure the inductance of an unknown inductor, but with a big error margin, this is because most inductor require a minimum current for their magnetic core to work properly, so his attempt in using a 5mA for the inductor proved pretty bad. This problem was solved by incorporating a field effect transistor to the RL oscillator to get enough curremt to make the inductor work perfectly.

To avoid the initial problem encountered in [9[a transistor oscillator circuit ws incorporated in the inductance meter built in [10]. This measures small inductances by measuring the frequency of oscillation and applying the formula for resonance frequency to compute the value of the unknown inductor.

Further limitation on the inductance meter in [9] was encountered when programming the microcontroller using a 32 bit floating point routine to code the program. The 32 bit floating point nearly filled the entire chip, this left no room for frequency measurement, inductance and display instructions.

This problem was solved in [11] where an inductance meter was built that made use of a microchip (PIC16F84), it did not take long to load the program into the PIC16F84 and the codes were very short. Instead of using the 32 bit floating point routine, microchip 24 bit floating point code was used, which allows space for the entire program and thus achieve less numerical errors

CHAPTER THREE: DESIGN AND CONSTRUCTION PROCEDURES

3.0 INTRODUCTION

This chapter covers the design and construction of the entire system, the block diagram, theory of operation of the devices used and their implementation. The system is made up of various units and these units were designed separately.

3.1 COMPONENTS AND MATERIAL SELECTION

Several components were chosen based on their voltage capacity. These components and materials includes Zener diode as voltage regulator, filtering capacitors, resistors, LC oscillator circuits (colpitts oscillator, 555 Timer) 16 X 2 LCD, microcontroller. The entire design is incorporated in a suitable 4×4 plastic case box with lighter weight compare to the other types of casing. It’s durable and long lasting. It prevents against electrocution and its very portable.

3.2 SYSTEM BLOCK DIAGRAM

A block diagram for the designed instrument for microcontroller based inductance and capacitance measurement is shown in figure 3.0

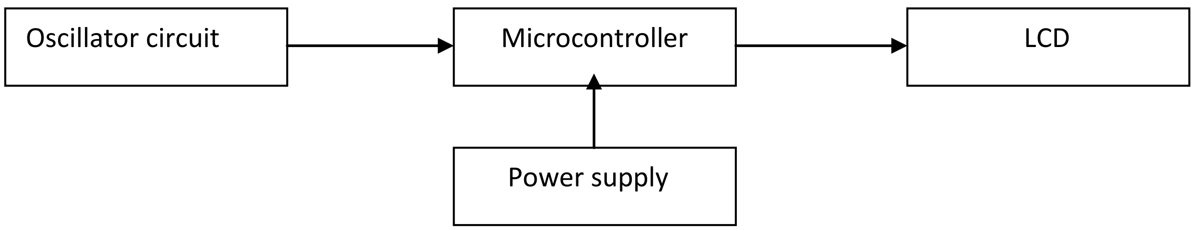

Figure 3.0: Block diagram

From the block, the measured element, an unknown inductor or capacitor is passed into the oscillator resonance circuit which generates a frequency based on the value of the inductance or capacitance. With a reference resistance R_1 and R_2 the value of the capacitance is generated and the value measured via the microcontroller.

3.3 POWER SUPPLY UNIT

The power supplied to the circuit is a rated 9V DC battery which is regulated by a rated voltage 5.1V Zener diode connected in parallel with a 100ohm resistor to 5V, the 1000uF capacitor serves as a filter to smoothens the waveform at the output V_{out} = 5V

The voltage regulation function of the Zener diode is aim to keep the voltage of the DC supply constant the 5V at the output is the required voltage needed to power the microcontroller.

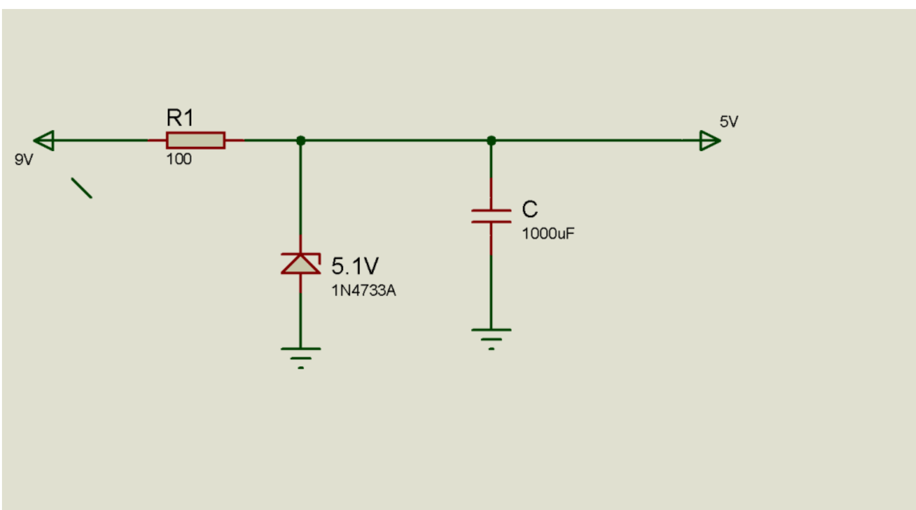

Figure 3.1: Power supply circuit diagram

$V_{out} = V_{in} - IR$……………………………………………………………….3.1

$V_{in} = 9V\ DC$

$R = 100$

$V_z = 5.1V$

I = Current across the 100Ω resistor

$I = V_{in} - V_z$……………………………………………………………………3.2

$\frac{9-5.1}{100}$ = 3.9mA

$Substitute\ for\ I,\ V_{in}\ and\ R\ in\ equation\ 3.1$

$V_{out} = 9 - 3.9mA \times 100\Omega$

$V_{out} = 5.1V \cong 5V$

From the block, the method used in the designed instrument is based on the oscillator, the frequency of which depends on the measured value of an inductance or capacitance.[6]. The condition for the oscillations is given by the expressions [24]

Loop gain $A_V\beta > 1$

Total loop phase circuit = 0 =360^0

Loop gain $A_V\beta = 1$

Where β is the feedback attenuation, A_V is the close loop voltage gain. The feedback network normally composed of reactive components (RC or LC). The purpose of the reactive network is to determine the frequency of oscillation. The amplifier gain is needed to make up for signal losses in the reactive network in order to sustain oscillations.

A 2No pole switch is used to switch between capacitance and inductance measurement

It is been pushed inward for capacitance measurement and outward for inductance measurement. The measured element, an unknown inductor or capacitor is passed into the oscillator circuit which generates a frequency based on the value of the inductor or capacitor. The capacitance is measured with the use of a 555 Timer IC configured in an astable mode, while inductance is measured with the use of the colpitts oscillator

the measured value is then passed to the microcontroller which measures the frequency of oscillation After measuring the time period of the output square wave, the program will ultimately calculates the inductance the capacitance the show it at the 16*2 LCD display screen

For capacitance measurement, the measuring oscillator is the LM555 timer IC configured as an astable multivibrator. The 555 Timer is a very popular IC. It can be connected as a one-shot or as an astable multivibrator or as free running oscillator. The figure below shows hoe the external components can be connected to a 555 so that it operates as a free running oscillator. The output of the oscillator is a repetitive rectangular waveform as shown below [12].

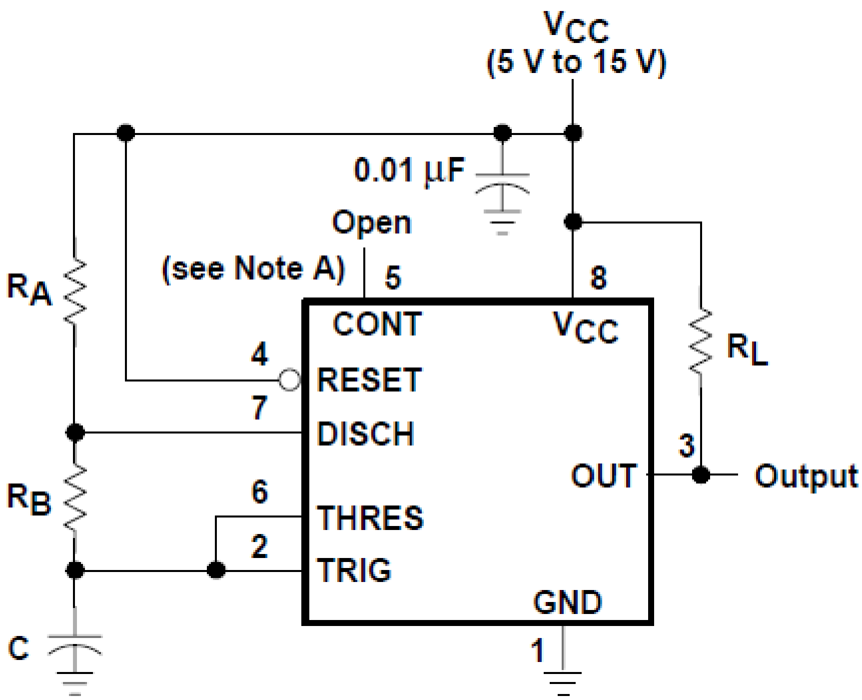

Figure 3.2: 555 Timer used as an astable multivibrator

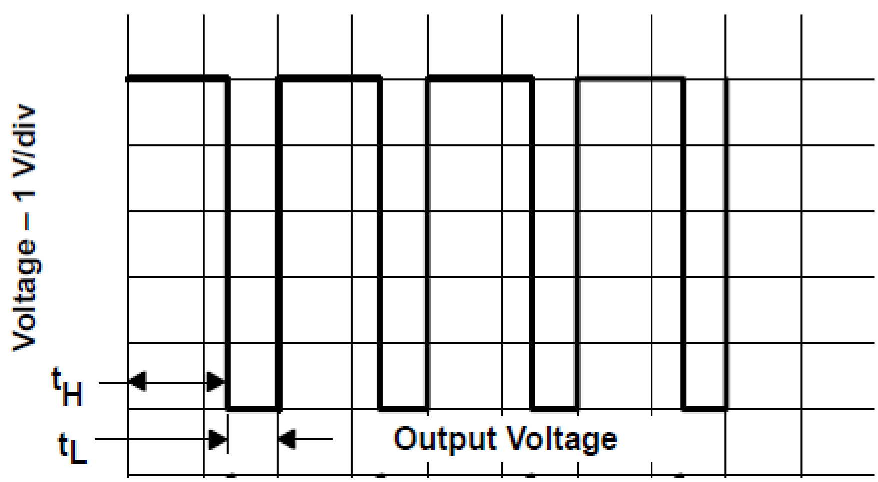

Figure 3.3: Typical Astable waveform

The capacitance to be measured is connected between the ground terminal and the pin 2/6 of the 555 timer, with known value of resistance chosen to be 1KΩ and 10KΩ respectively. This induces an oscillation with frequency measured via the microcontroller.

The capacitance is computed with the formula below

$$T = T_{high} + T_{low} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \qquad 3.3$$

$$= 0.693(R_A + R_B)C + 0.693R_BC$$

$$= 0.693C(R_A + 2R_B)$$

$$F = \frac{1}{0.693C[R_A+2R_B]}$$

$$C = \frac{1.4}{F_o(R_A+2R_B)} \text{ (F)}$$

R_A = 1K, R_B = 10K, F_o = 313154Hz

C = $\frac{1.4}{1K+2\times10K\times313154}$

= $\frac{1.4}{6576234000}$

= 0.000000000212 (F)

= 0.000212uF

The inductance is measured via a Colpitt oscillator with known values of capacitance ‘C’, C_1& C_2. The Colpitt oscillator is one of a number of designs for electronic oscillator circuits using the combination of an inductance (L) with a capacitor (C) for frequency determination, thus also called LC oscillator [13]. The distinguishing feature of the Colpitts circuit is that the feedback signal is taken from a voltage divider made by two capacitors in series. One of the advantages of this circuit is its simplicity; it needs only a single inductor. Uses a combination of an inductance L and capacitance C which induces an oscillation whose frequency is measured by the microcontroller the inductance can therefore be measured by the formula below.

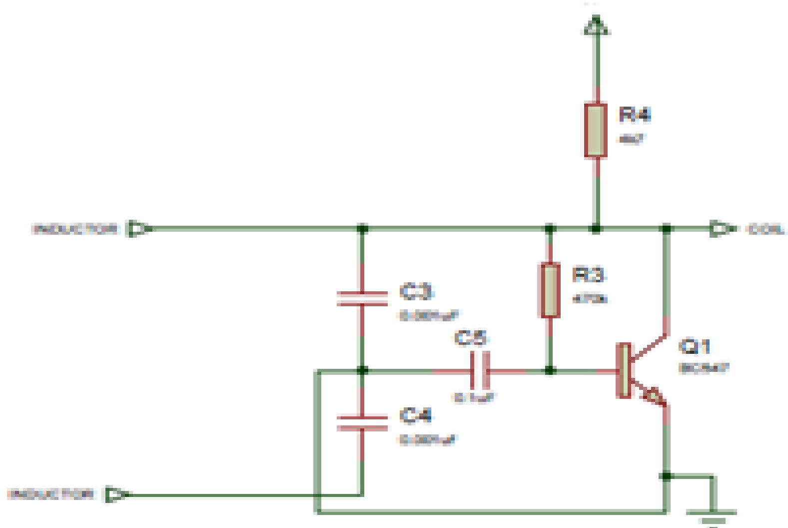

Figure 2.2 Colpitts oscillator circuit

$$C = \frac{C_3 C_4}{C_3 + C_4} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad 3.4$$

$F = \frac{1}{2\pi\sqrt{LC}}$ ……………………………………….. 3.5

$C_3 = 0.001uF$, $C_4 = 0.001uF$, $F_o = 302563H_z$

$C = \frac{C_3 C_4}{C_3 + C_4}$

$= \frac{0.001 \times 0.001}{0.001 + 0.001}$

= 0.0005F

From equation 3.4

$L = \frac{1}{4\pi^2 Fo^2 LC}$……………………………………… 3.6

$$\frac{1}{4 \times 3.1421^2 \times 302563 \times 302563^2 \times 0.0005}$$

$$\frac{1}{1807482042.477}$$

L = 0.0000000005533

L = 0.000553uF

3.4 MICROCONTROLLER

The heart of the microcontroller based inductance and capacitance digital meter is the microcontroller chip STC12C5A60S2 (8051) which measures the frequency of oscillation of the discrete analogue component.

STC12C5A60S2 is a single-chip microcontroller based on a high performance 1T architecture 80C51 CPU, which is produced by STC MCU Limited. With the kernel, STC12C5A60S2 executes instructions in 1¬6 clock cycles (about 6¬7 times the rate of a standard 8051 device), and has a fully compatible instruction set with industrial-standard 80C51 series microcontroller. In-system-programming (ISP) and In-Apllication-Programming (IAP) support the users to upgrade the program and data in system. ISP allows the user to download new code without removing the microcontroller from the actual end product, IAP means that the device can write non-volatile data in Flash memory while the application program is running. The STC12C5A60S2 retains all features of the standard 80C51. In addition, the STC12C5A60S2 has two extra I/O ports (P4 and P5), a 10-sources, 4-priority-level interrupt structure, 10-bit ADC, two UARTs, on-chip crystal oscillator, a 2-channel PCA and PWM, SPI, a one-time Watchdog Timer**.** [14]

FEATURES

- Enhanced 80C51 Central Processing Unit, 1T per machine cycle, faster 6¬7 times than the rate of a standard 8051
- Operating voltage range:5.5V ¬ 3.5V OR 2.2v ¬ 3.6V (STC12C5A60S2).

- Operating frequency range: 0 – 35MHz, its equivalent to standard 8051:0 ¬ 420MHz
- On-chip 8/16/20/32/40/52/56/60/62K FLASH program memory with flexible ISP/IAP capability
- On-chip 1280 byte RAM
- Be capable of addressing up to 64K byte of external RAM
- Dual Data pointer (DPTR) to speed up data movement
- Code protection for flash memory access
- Excellent noise immunity, very low power consumption
- 10 vector-address, 4 level priority interrupt capability
- One enhanced UART with hardware address-recognition and frame-error detection function
- Secondary UART with self baud-rate generator
- Three power management modes: idle mode, slow down mode and power-down mode
- Five package type: LQFP-44, LQFP-48, PDIP-40, PLCC-44, QFN-40

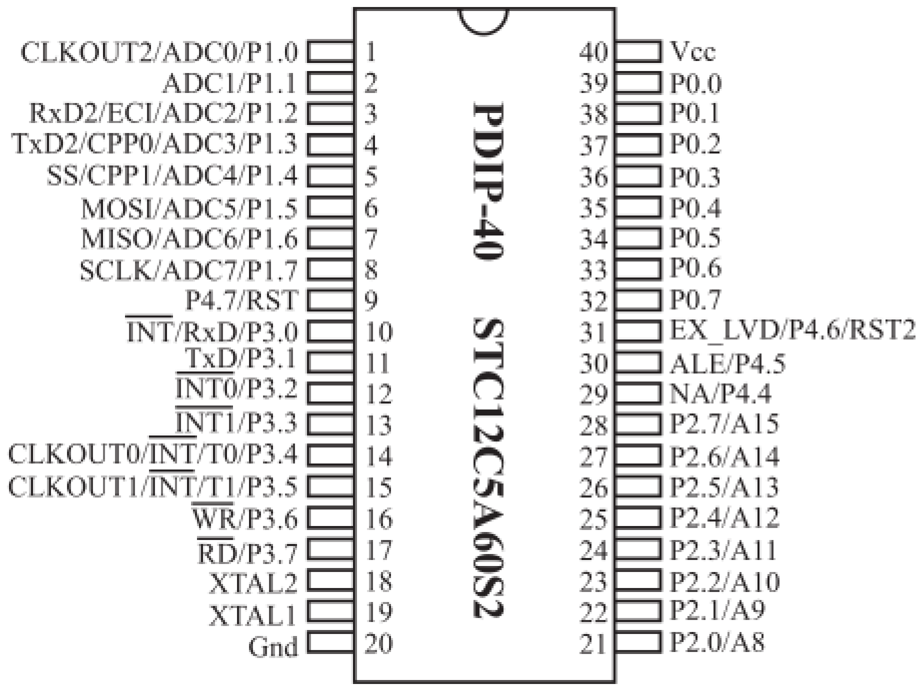

Figure 3.0 STC12C5A60S2 PIN Configuration

TABLE 3.0: PIN DESCRIPTIONS

PIN	DESCRIPTION
VCC	Supply voltage.
GND	Ground.
Port 1	Port 1 : General-purpose I/O with weak pull-up resistance inside. When 1s are written into Port1, the strong output driving CMOS only turn-on two period and then the weak pull-up resistance keep the port high
Port 3	Port 3 pins P3.0 to P3.5, P3.7 are seven bidirectional I/O pins with internal pull-ups. General-purposed I/O with weak pull-up resistance inside. When 1s are written into Port3, the strong output driving CMOS only turn-on two period and then the weak pull-up resistance keep the port high. Port3 also serves the functions of various special of STC12C5A60S2
RST	A high on this pin for at least two machine cycles will reset the device
XTAL1	CRYSTAL1 Input to the inverting oscillator amplifier. Receives the external oscillator signal when an external oscillator is used
XTAL2	CRYSTAL2 Output from the inverting oscillator amplifier. This pin should be floated when an external oscillator is used

3.5 THE LIQUID CRYSTAL DISPLAY (LCD)

A liquid crystal display (LCD) is a thin, flat display device made up of any number of color or monochrome pixels arrayed in front of a light source or reflector. It uses very small amounts of electric power, and is therefore suitable for use in battery powered electronic devices. Each pixel consists of a column of liquid crystal molecules suspended between two transparent electrodes, and two polarizing filters, the axes of polarity of which are perpendicular to each other. Without the liquid crystals between them, light passing through one would be blocked by the other. The liquid crystal twists the polarization of light entering one filter to allow it to pass through the other [15]

More microcontroller devices are using 'smart LCD' displays to output visual information. LCD displays designed around Hitachi's LCD HD44780 module, are inexpensive, easy to use, and it is even possible to produce a readout using the 8x80 pixels of the display. Hitachi LCD displays have a standard ASCII set of characters plus Japanese, Greek and mathematical symbols.

For an 8-bit data bus, the display requires a +5V supply plus 11 I/O lines. For a 4-bit data bus it only requires the supply lines plus seven extra lines. When the LCD display is not enabled, data lines are tri-state which means they are in a state of high impendence (as though they are disconnected) and this means they do not interfere with the operation of the microcontroller when the display is not being addressed.

3.5.1 The LCD also requires 3 control lines from the microcontroller:

- **Enable (E):** This line allows access to the display through R/W and RS lines. When this line is low, the LCD is disabled and ignores signals from R/W and RS. When (E) line is high, the LCD checks the state of the two control lines and responds accordingly.
- **Read/Write (R/W):** This line determines the direction of data between the LCD and microcontroller. When it is low, data is written to the LCD. When it is high, data is read from the LCD.
- **Register select (RS):** With the help of this line, the LCD interprets the type of data on data lines. When it is low, an instruction is being written to the LCD. When it is high, a character is being written to the LCD.

The LCD pins that are interfaced with the microcontroller is shown in figure 3.6 below;

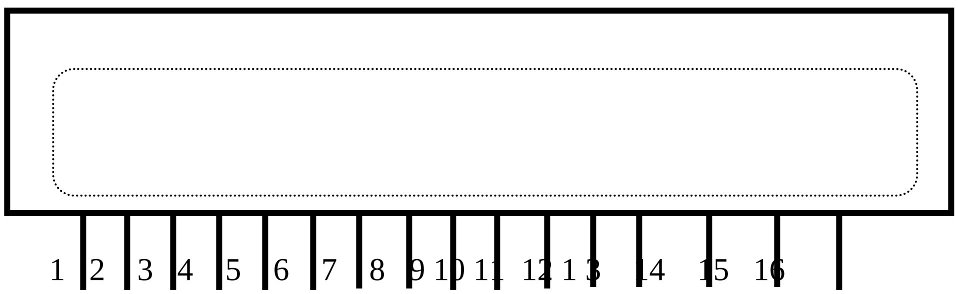

Figure 3.6 LCD pin configuration.

3.5.2 Features of the 16X2 LCD

- Interface with either 4-bit or 8-bit microprocessor.
- Display data RAM
- Character generator ROM
- Display data RAM and character generator RAM may be
- Accessed by the microprocessor.
- Numerous instructions
- Clear Display, Cursor Home, Display ON/OFF, Cursor
- Built-in reset circuit is triggered at power ON.
- A general purpose alphanumeric LCD, with two lines of 16 characters

3.5.3 LCD Pin Description

The various LCD pins and their peculiar functions are described below

TABLE 3.1: LCD pin description

PIN	SYMBOL	FUNCTION
1	Vss	Power Supply(GND)
2	Vdd	Power Supply(+5V)
3	Vo	Contrast Adjust
4	RS	Instruction/Data Register Select
5	R/W	Data Bus Line
6	E	Enable Signal
7-14	DB0-DB7	Data Bus Line
15	A	Power Supply for LED B/L(+)
16	K	Power Supply for LED B/L(-)

In table 3.1, V_{cc} and V_{ss} are supply pins and VEE (Pin no.3) is used for controlling LCD contrast. Pin No.4 is Rs pin for selecting the register, there are two very important registers inside the LCD. The RS pin is used for their selection as follows; If RS=0, the instruction command code register is selected, allowing the user to send data to be displayed on the LCD. R/W is a read or writes Pin, which allows the user to write information to the LCD or read information from it. R/W=1 when reading R/W=0 when writing. The LCD to latch information presented to its data pins uses the enable (E) pin. The 8-bit data pins, D0-D7, are used to send information to the LCD or read the contents of the LCD’s internal registers. To display letters and numbers, we must send ASCII codes for the letters A-Z, and number 0 -9 to these pins while making RS=1.

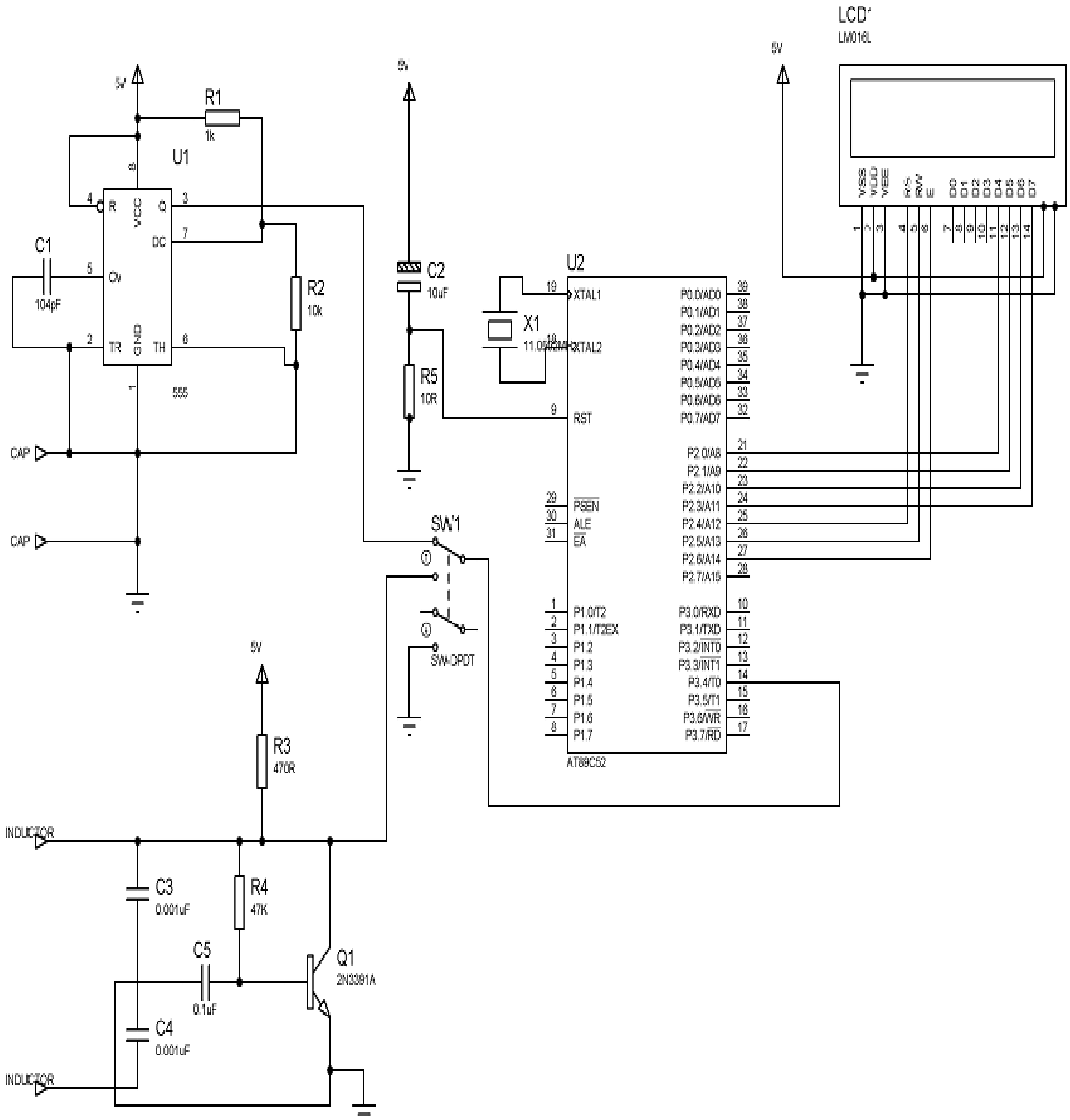

Figure 3.7: Circuit diagram of an inductance and capacitance meter

CHAPTER FOUR: PERFORMANCE AND COST EVALUATION

4.0 INTRODUCTION

This chapter covers the various tests, results and cost evaluation gotten from the complete project design. The chapter rounds up the entire procedure for the design and construction of an Inductance and Capacitance Digital meter.

4.1 TEST

The microcontroller inductance and capacitance digital meter can be used to calculate the unknown inductors and capacitors.

- The meter is turned on by a turn on and off switch it displays the generated frequency and the capacitance or inductance to be measured on the idle screen
- A 2 number pole switch is pressed inward for capacitance measurement and outward for inductance measurement
- The unknown capacitor or inductor is placed at the input terminal indicated on the meter “L” for inductance measurement “C” for capacitance measurement.
- The meter displays the value of the unknown inductor or capacitor via an 16×2 LCD screen

TABLE 4.0: TEST RESULT

S/N	ACTUAL VALUES		METER READING	
	L(μH)	C(μH)	L(μH)	C(μH)
1	106.5	1	106.5	1.04
2	156.4	10	156.4	11.11
3	345.5	22	345.5	22.22

4.2 PERFORMANCE EVALUATION

The performance the microcontroller inductance and capacitance meter was tested and evaluated and confirmed satisfactory. The meter reading of the measured elements (inductor and Capacitor) is compared with the theoretically calculated value to determine the accuracy of measurement of the meter

PLATE 4.0: Inductance and Capacitance measurement device

4.2.1 ACCURACY OF THE METER

$$Accuracy = \frac{Average\ Meter\ Reading - Average\ \ Actual\ Value}{Average\ Actual\ Value}$$

Average Meter Reading $= (22.22 + 11.11 + 1.04)/3 = 11.45\mu F$

Average Actual value $= (1 + 22 + 10)/3 = 11.00\mu F$

$$Accuracy = \frac{11.45 - 11.00}{11.45} \times 100$$

$$= \frac{0.45}{11.45} \times 100$$

$$= 0.039 \times 100$$

$$3.9\% \cong 4\%$$

Accuracy of the meter is 4%

That is the meter can measure components with 4% error from its nominal value

4.3 COST EVALUATION

The cost of various components used in the construction of a microcontroller based inductance and capacitance meter is listed in the table below.

TABLE 4.1: COST EVALUATION

S/N	COMPONENTS	QTY	COST (Naira)
1	Liquid Crystal Display 16×2 (LCD)	1	1,200
2	Microcontroller (STC12C5A60S2)	1	1,200
3	Crystal Oscillator 11.059MHz	1	100
4	Capacitor (0.1uf) ,, ,, (0.001uf) “ “ (104pF)	1 1 1	20 20 20
5	“ “ (10uF)	1	20
6	Resistor (10k) ,, ,, (4.7k) ,, ,, (470k)	1 1 1	40 10 10
7	Vera Board	1	100
8	Casing (Plastic)	1	300

GRAND TOTAL	3,080

From table 4.0, the inductance and capacitance meter is a low cost meter and can be applicable for commercial use.

CHAPTER FIVE: CONCLUSIONS

5.0 SUMMARY

The microcontroller based inductance and capacitance meter measures the inductance of an unknown inductor ad capacitance of an unknown capacitor using the LC resonance oscillator circuits with a microcontroller which computes the value of the measured inductance and capacitance, the measured value via a 16×2 LCD screen.

5.1 CONCLUSIONS

The microcontroller inductance and capacitance meter measures the inductance of an unknown inductor and capacitance of an unknown capacitor with 4% accuracy on the measured element. That is, the measured elements are prone to a 4% error margin. This may due to the tolerance value of each component measured. The components used are within 10% tolerance value.

5.2 RECOMMENDATIONS

Since the components used in this project are non-ideal, each will have a value that will be different than the stated nominal values. The goal of this project is to measure and calculate the unknown inductance and capacitance within a 10% margin. If one were to recreate the project, components with lower tolerance value can be used to achieve a lower percentage error while at the same time the code for the program may be reused and untouched. In this project, manual switches are been used, this switches allows for stray capacitances which affects the measured values. Further work on this project, the manual switch can be replaced with relay switch which blocks off stray capacitance and thereby producing accurate measurement values.

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APPENDIX A: SOURCE CODE

```
/* FILENAME   : DIGITAL_INDUCTANCE_CAPACIATNCE_METER

#include<reg52.h>

#include<stdio.h>

#include<stdlib.h>

#include<math.h>

#define LCD_PRINTF

#define LCD_STYLE

#include <Lib_Delay.h>

#include"Lcd_4.h"

////////////////////////////////////////////////////////////////////////////

volatile float Frequency;

volatile float Timer_Count;

volatile unsigned char Counter;

short Timer1_overflow_counts;

short Timer0_overflow_counts;

#define R1 1000

#define R2 10000

#define CT 0.0005

#define Pi 3.1416

float CAP,L;

sbit Measure =P1^0;


////////////////////////////////////////////////////////////////

converts HEX to decimal in base ten

//////////////////////////////////////////////////////////////

volatile int Hex_To_Int(int Hex,char bits)
```

```
            int Hex_2_Int;
            char byte;
            Hex_2_Int=0;

            for(byte=0;byte<bits;byte++)
            {
            if(Hex&(0x0001<<byte)) Hex_2_Int+=1*(int)(pow(2,byte));
            else Hex_2_Int+=0*(pow(2,byte));
            }
 return Hex_2_Int;
//////////////////////////////////////////////////////////////
// Timer 0 overflow interrupt routine
////////////////////////////////////////////////////////////
void ISR_Timer0(void) interrupt 1
            Timer0_overflow_counts=Timer0_overflow_counts+1;
            TF0=0;              //clear timer0 overflow flag
            TH0=0x00;           //reset the timer0 values
            TL0=0x00;
////////////////////////////////////////////////////////////////
//Timer 1 overflow interrupt routine
//          The frequency of the signal is calculated as thus;          //
//          (TH0x256)+TL0 +(Timer0 _overflow_counts*65536).                  //
//////////////////////////////////////////////////////////////
void ISR_ex0(void) interrupt 3
interrupt no. 1 for Timer 0
```

```
TF1=0; //clear timer1 over flow flag
TH1=57;                          //Reload timer values
TL1=176;        //load timer 0 lower nible
Timer1_overflow_counts++;
if(Timer1_overflow_counts==40)                              //(40x25)ms ==1000ms==1s
        TR0 = 0;                      //stop timer0
        Timer_Count=(float)Hex_To_Int(TH0,8);    convert timer0 values to decimal
        Frequency=(float)Hex_To_Int(TL0,8);

        Frequency=(float)((256*Timer_Count)+Frequency);   compute the frequency of the signal
        Frequency+=(float)(Timer0_overflow_counts*65536);
        Timer0_overflow_counts=0;

TH0=0x00; reset timer0 values for another count cycles
TL0=0x00;
TR0 = 1;  start timer
Timer1_overflow_counts=0; reset Timer1_overflow_counts
return;

////////////////////////////////////////////////////////////////////////////
//BODY OF THE MAIN PROGRAMME
/////////////////////////////////////////////////////////////////////////////
void main(void)
        //intialise global variables
        CAP=0;
        Timer1_overflow_counts=0;
```

```
Timer0_overflow_counts=0;
Frequency=0;
Counter=0;
//////////////////////////////////////////////////
Delay_ms(500);
Lcd_Init();        //  intialise the lcd module
Lcd_Cmd(_LCD_CLEAR);      // clear lcd.
Out_Path=Lcd;           //  write the out put to lcd.
Delay_ms(100);
        Lcd_Write(1,1,"    WELCOME ");                //print this at startup
        Lcd_Write(2,1,"  Please Wait... ");
Delay_ms(100);
Lcd_Cmd(_LCD_CLEAR);      // clear lcd.
Lcd_Scroll("      DIGITAL INDUCTANCE AND CAPACITANCE METER BY OLAJIDE
SEUN. ID. NO. EE/07/0592");
//print this at startup
//////////////////////////////////////////////
P3=0xff;//set port 3 as input
P1=0xff;//set port 3 as input
IE = 0x8A; enable timer0 and timer1 interrupts respectively
IP=0x08; set timer1 priority as 1

TMOD=0x15; configure timer0 and timer1
TH1=0x00; here, timer0 is configure for 16 bit counter with external clock source(T0),while timer1
TL1=0x00; is configures as a 16 bit timer.
TH0=0x00; reset all timer values
```

```
TL0=0x00;

TR0 = 0; start timer0

TR1 = 1; start timer1

//////////////////////////////////////////////////////////////////

while(1)

        Lcd_Cursor(1,1);

        printf("Fo: %4.1f Hz                ",Frequency);//print the signal frequency with auto range

        if(Measure)

        CAP=(float)(14/(float)((float)10*(Frequency*(R1+(2*R2)))));

                Lcd_Cursor(2,1);

                printf("C= %2.6f uF.          ",(float)((CAP*1000000)));//print the signal frequency
                                                                           with auto range


        else{

                Lcd_Cursor(2,1);

        L=(float)1/(float)(4*(Pi*Pi)*(Frequency*Frequency)*(float)(CT*pow(10,-6)));

        printf("L= %2.1f uH.        ",(float)((L*100000)));//print the signal frequency with auto
                                                             range
```