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Embedded Based Ethernet Measurement System For The Studies Of Di-Electric Constant Of Binary Liquids

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Abstract

An embedded based dielectric constant measurement setup has been developed to measure dielectric constant of binary liquid mixtures using Cygnal 8051F120 mixed signal microcontroller. It is based on the principle that the change in frequency of an IC MAX 038 frequency generator. When the liquid forms the dielectric medium of the dielectric cell, the dielectric constant is measured with a microcontroller. A simple C8051F120 (8-bit) based microcontroller and its associated peripherals are employed for the hardware. Ethernet based measurement system has a provision to store and retrieve the data whenever required with real time and to display on LCD and web server simultaneously. Further, the Hardware and Software details of the system are also discussed.

Keywords: *Dielectric constant measurement, Cygnal C8051F120 microcontroller, Ethernet Sytem and Si-Labs IDE C cross compiler.*

1. Introduction

Determination of dielectric constant plays an important role in the investigation of the molecular structure of a polar substance as its measurement is being widely used in the determination of conformation characteristics of macromolecules in solution. Dielectric studies of binary mixtures of polar molecules are important for understanding of the intermolecular interactions in the mixtures due to the dipole-dipole interactions and hydrogen bonding [1]. Dielectric characterization has great potential in studying the H-bond interactions; dipolar alignments, hydrogen bond connectivity and stoichiometric ratio of stable adduct formation in mixed solvents [2]. The effect on the dielectric properties of the alcohols having nearly the same dipole moments but a large difference in their static dielectric constant values, on addition of rigid polar molecules of considerably different dipole moments and dielectric constants over a range of concentrations, has been studied in the present paper.

Several experimental techniques were developed for the measurement of capacitance and in turn the dielectric constant over a wide frequency range. In general, a bridge method or resonance technique is employed to determine the capacitance with or without the sample. Among them heterodyne beat method is popular at radio frequencies. All these methods suffer from some of the following drawbacks.

i) Manual control (human intervention) for adjusting a bridge or in attaining resonance is essential. Hence, some amount of time is required to reach the steady state and to sharply determine the capacitance. Scope for human error is not eliminated. Reproducibility of the results with higher precision is rather limited.

ii) The apparatus usually consists of complex circuits and it is expensive.

Hence, it is proposed to design a technique using a slightly different principle with IC version function generator. Several investigators developed the conventional dielectric constant measurement systems [3] [4], both analog and digital. However, the attempts to design and develop the ethernet based embedded system for the measurements of dielectric constant in binary liquid mixtures offer many advantages.

The rising trend in Electronics and particularly in embedded system design is *Implementing Ethernet based*

Solutions. Ethernet-based solutions provide many intrinsic advantages over the older networks, mainly in the areas of speed, scalability, and flexibility. Ethernet networks offer faster transmission times, and the ability to spread that network over a wider area. For providing the results to host PC this system has ethernet module CP2200 is used for communication. The Cygnal microcontroller C8051F120 is used for processing and communication with ethernet module and LCD display controllers.

Hence, in the present study, a humble attempt is made to design and develop an ethernet based embedded system [5] for the studies on dielectric constants of binary liquid mixtures.

2. Design Principle

The dielectric constant (ε) of a liquid [6] is defined as the ratio of the electrical capacitance of a cell when the liquid / solution forms the dielectric medium (C_s) to the capacitance of the cell when air forms the dielectric medium (C_0) at a given temperature, which is represented by the following equation

$$\varepsilon = (C_s) / (C_0) \quad \text{------ (1)}$$

The dielectric cell consists of two parallel metallic plates which act as electrodes. The cell acts as a capacitor while the liquid acts as a dielectric medium. The cell has to be first standardized to measure the dielectric constant of unknown solutions. This is accomplished by considering a pure liquid such as benzene as the standard liquid. The dielectric constant of an unknown liquid (ε_x) can be determined by measuring the capacitance of the cell in air (C_0), the capacitance of cell in reference liquid (C_r) such as benzene and the capacitance of the cell in liquid whose dielectric constant has to be measured (C_x) using the relation

$$\varepsilon_x = 1 + [(C_0 - C_x) / (C_0 - C_r)] \times (\varepsilon_r - 1) \quad \text{------ (2)}$$

Where ε_r is the dielectric constant of the reference liquid.

The IC MAX038 acts as RC oscillator and its output frequency can be controlled over a frequency range of 0.1Hz to 20MHz by an internal band gap voltage reference and an external resistor and capacitor. The frequency of oscillations depends on the values of timing resistor R and timing capacitor C. The value of R is kept constant. The dielectric cell acts as a capacitor C that varies with dielectric medium. Consequently the frequency of the oscillator also changes. The measurement of frequency of the oscillator enables one to measure the value of capacitance of the cell and thus the dielectric constant of the medium. In the present study, with suitable interface of the oscillator circuit with an 8051F120 Cygnal microcontroller, the frequency of the oscillator is measured. The dielectric constant of the medium is evaluated (Equation (2)) and displayed on the 4x4 LCD and simultaneously displayed on LAN through ethernet module.

3. Experimental Procedure

3.1 Hardware Design (Block Diagram)

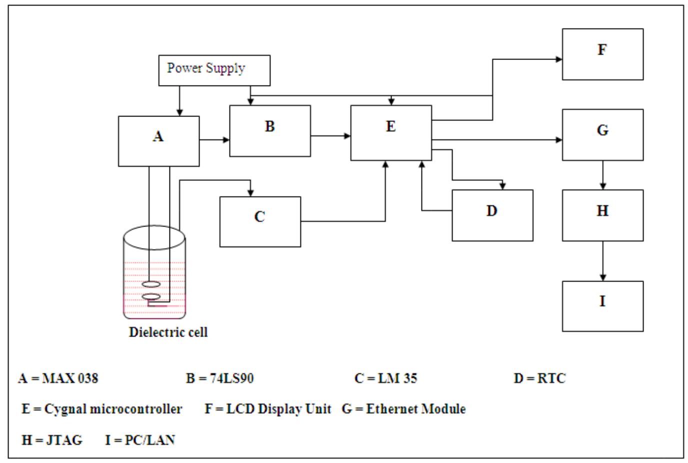

Figure 1: Block Diagram of the ethernet enabled embedded system based dielectric constant measurement for Binary Liquid Mixtures

3.2. Design Description

The block diagram of the microcontroller-based system for the measurement of dielectric constant of Binary Liquid Mixtures is shown in Figure1. Each functional unit of the system is explained as follows.

3.2.1. MAX 038 (Frequency Generator)

The MAX038 [7] is a high-frequency precision function generator producing accurate, high-frequency triangle, square, sine and pulse waveforms with a minimum of external components with good accuracy. It acts as an RC oscillator. The output waveforms can be both amplitude and frequency modulated by an external voltage. The frequency of operation can be selected over a range of 0.1 Hz to 20MHz linearly using the external resistor and capacitance combinations. The symmetry of all waveforms can be adjusted with external timing resistors.

The frequency of oscillation f_0 is determined by the external timing capacitor C across pin 5 and 6, and by the timing resistor R, connected to either pin7 or 8. The frequency is given as

$$\mathbf{f_0} = 2*2.1 / R* C \qquad \text{--------- (3)}$$

It can be adjusted by varying either R or C.

3.2.2. 74LS90 (Decade Counter)

The IC 74LS90 is high-speed 4-bit ripple type counters partitioned into two sections. Each counter has a divide-by-two section and either a divide-by-five (74LS90), divide-by-six or divide-by-eight section, which are triggered by a HIGH-to-LOW transition on the clock inputs. Each section can be used separately or tied together (Q to CP) to form BCD, bi-quandary, modulo-12, or modulo-16 counters. All of the counters have a 2-input gated Master Reset (Clear), and the 74LS90 also has a 2-input gated Master Set (Pre-set 9). It counts the input pulses and the output is received as a 4-bit binary number through the output pins Q_A, Q_B, Q_C and Q_D.

3.2.3. LM35

The LM35 [8] series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM-35 is three-terminal device that produces the output voltages proportional to degree Celsius (10mv/°C), so the terminal output voltage is 250mv at 25°C and 1.000V at 100°C. These sensors can measure temperatures below 0°C by using a pull down resistor from the output pin to voltage below the ground pin. The LM35 is more accurate (±1°C from -55°C to +150°C vs ±3°C from -20°C to +100°C). The LM35 thus has an advantage over linear temperature sensors calibrated in degree Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient centigrade scaling. The LM35's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy.

3.2.4. Real Time Clock

The DS1307 serial real-time clock (RTC) [9] is a low power, full binary-coded decimal (BCD) clock/calendar transferred serially through an I^2C bidirectional bus. It counts seconds, minutes, hours, date of the month, month, day of the week and year. It has 56 bytes of general purpose RAM memory with battery backup. It consists of automatic fail detect and switch circuitry. It is implemented with Inter Integrated protocol.

3.2.5. Cygnal Microcontroller

The Cygnal Microcontroller device C8051F120 [10] is a fully integrated mixed-signal, system-on-chip with 64 digital I/O pins. It is a high speed pipelined 8051 compatible CIP-51 Microcontroller core and it can execute 25 million instructions per second. The C8051F020 device is truly standalone system-on-a-chip solution. The advantages of single chip Microcontroller is small size, reliability, rapid response, compatibility to standard CMOS technology and on-chip signal processing, Ion-Sensitive Field Effect Transistor (ISFET)-based transducers are increasingly being applied in physiological data acquisition and environment monitoring. A single-chip programmable platform that integrates most of hardware blocks required in the design of embedded system chips like ADC, DAC and I^2C etc.

All analog and digital peripherals are enabled/disabled and configured by user firmware. The flash memory can be reprogrammed even in circuit i.e. it contains non-volatile data storage, and also allowing field upgrades of the 8051 firmware. On board JTAG (Joint Test Access Group) debug circuitry allows non- intrusive (without disturbing on chip resources), fully speed, and in-circuit debugging.

3.2.6. LCD Display Unit

In the present module the Liquid Crystal Display [11] (Lampex) is used for displaying measured frequency, dielectric constant, temperature of any liquid. It also displays time and date with the help of real time clock. The display module is a dot matrix liquid crystal display that display alphanumeric, characters and special symbols. The built-in-controller & driver provide convenient connectivity between a dot matrix LCD and a microprocessor or microcontroller.

All functions required for dot matrix liquid crystal display are provided internally. Internal refresh is provided by the Lampex. The CMOS technology makes the devices ideal for applications in hand held portable and other low powered instruments.

3.2.7. Ethernet Module

The Embedded Ethernet [12] Development Kit (Ethernet-DK) provides all the hardware and software required to develop real-world embedded as shown in figure2. The TCP/IP protocol stack is developed specifically for embedded processors and is freely distributed in an easy-to-use library. A TCP/IP Configuration Wizard is provided to generate a highly customized library optimized for user selected protocols. It also generates the framework code required to use the library and a project file that can be managed in the Silicon Laboratories Integrated Development Environment (IDE).The Embedded Ethernet Development Kit hardware includes a C8051F120 Target Board, Ethernet Development Board, USB Debug Adapter, and all necessary cables to debug the MCU and connect it to an Ethernet network. The TCP/IP Library includes a built-in driver for the CP2200 and has a custom driver interface with auto-generated templates to allow drivers for any Ethernet controller to be written. Projects with up to 4 kb of object code and unlimited library code can be developed using the included toolset.

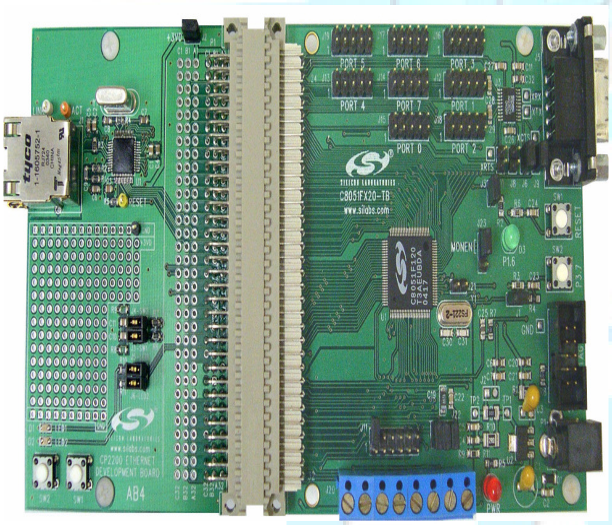

Figure2. C8051F120 Target Board and Ethernet Development Board

3.2.8. JTAG

The signal microcontroller has an on-chip JTAG interface and logic to support boundary scan for production and in-system testing, flash read/write operations, and non-intrusive in-circuit debug. The Flash memory can be programmed directly over the JTAG interface using the flash Control, flash data, flash address, and Flash Scale registers. It has on-chip debug logic that provides non-intrusive, full speed, in-circuit debug support using the production part installed in the end application, via the four pin JTAG I/F. Cygnal's debug system supports inspection and modification of memory and registers, breakpoints, and single stepping. No additional target RAM, program memory, or communications channels are required.

3.2.9. PC/LAN

The Pc is connected to the embedded controller using LAN connection. The dielectric constant value, Output frequency and Time stamp values are displayed on the host PC using LAN connectivity.

3.3. Design Procedure

The block diagram of the Ethernet enabled embedded system based dielectric constant measurement for Binary Liquid Mixtures is shown in figure 1. The designed cell is connected between pins 5 and 6 of the MAX 038 using a BNC connector. The dielectric cell acts as a capacitor C whose capacitance can be measured in terms of frequency. The block A consists of MAX 038 function generator. The output of the RC oscillator (the square wave output (pin 19) is TTL compatible. In the present study, the MAX 038 function generator generally operates at 1MHz to 20 MHz frequencies. The output of the MAX 038 is given to the interrupt 0 external input, which is available on the mixed Cygnal microcontroller (port 0). But, the microcontroller can measure the frequency accurately up to a few hundred KHz frequencies. Hence, the divide counter is used as is shown in block B.

The 74LS90 IC decade counter (which acts as a divide counter (÷10, ÷12 and ÷4-bit binary counter) that divides the RC oscillator output by 10 times. The output of the 74LS90 is given to the INT0 external input, which is available on the microcontroller (port 0). The microcontroller counts the clock pulses that are given from the 74LS90 over an interval of 1 sec, which gives the frequency of the oscillator. The block C of LM35 is a sensor to measure the temperature of the solution.

The output of the temperature sensor is fed to the on-chip analog to digital converter of the microcontroller of block E. The ADC0 subsystem for the microcontroller consists of a 8-channel, configurable analog multiplexer (AMUX0), a programmable gain amplifier (PGA0), and a 500 Ksps, 12-bit successive approximation registers ADC with integrated track-and-hold and programmable window. The block D is DS1307 serial real-time clock (RTC),which gives the measured frequency time stamp in HH:MM:SS format using I^2C communication.

The results like frequency, dielectric measurements of liquid mixtures, temperature, and real time clock are displayed which is shown in block F. The block G is Ethernet module (CP2200) is used for transmitting and receiving Ethernet packets, non-volatile data storage. The device is controlled using direct and indirect internal registers accessible through the parallel host interface. The block H is JTAG, which is the communicator for ethernet module and to personal computer for data transfer. The block I of PC / LAN module, this displays the data on hyper terminal of the personal computer and web server simultaneously with date and time.

3.3.1. Schematic Diagram

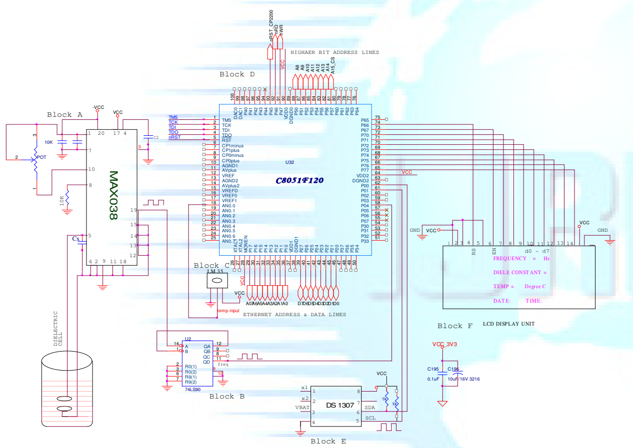

Figure 3: Schematic Diagram

The schematic diagram of the microcontroller-based system for the measurement of dielectric constant of Binary Liquid Mixtures is shown in Figure 3. The cell is placed in liquid mixture. The IC MAX038, The controller C8051F120, RTC and LCD modules are shown in the schematic.

4. Experimental Setup

The experimental technique of this module for measuring frequency, dielectric constant can be accomplished by developing the necessary software for the entire electronic system. The algorithms are realized on Cygnal Microcontroller using 'C' language in C-cross compiler Si-Lab IDE. The experimental setup of "Embedded Based Ethernet Measurement System for the Studies of Dielectric constant of Binary Liquid Mixtures" is shown in figure 4.

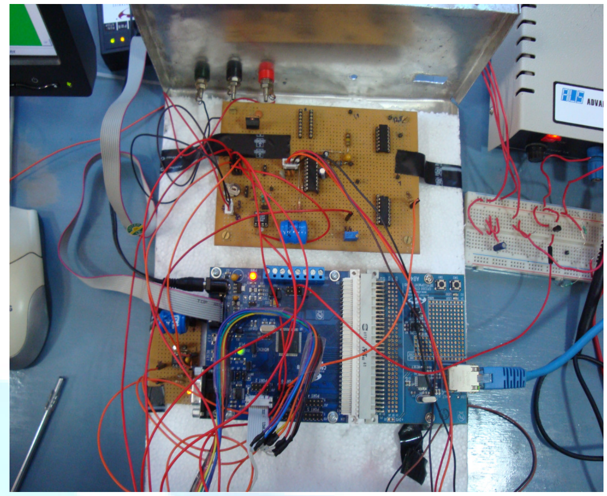

Figure 4: Photograph of the experimental setup of Dielectric constant measurement for binary Liquid mixtures

5. Flow Chart

The flowchart is so drawn that it is self-explanatory and gives the complete idea of how embedded system sequentially does the different steps involved in measurement of liquids The flowchart of ethernet based embedded system for studies of dielectric constant in liquids is shown

The main role of the software in the present study is to test the activities of the following hardware modules.

1. To measure the frequency of the Oscillator.
2. To measure the capacitance and dielectric constant.
3. To measure the temperature of the any mixed solution.
4. To display the real time clock,date,month and year
5. To display the measured data on LCD Module.
6. To display the data through ethernet on web server.

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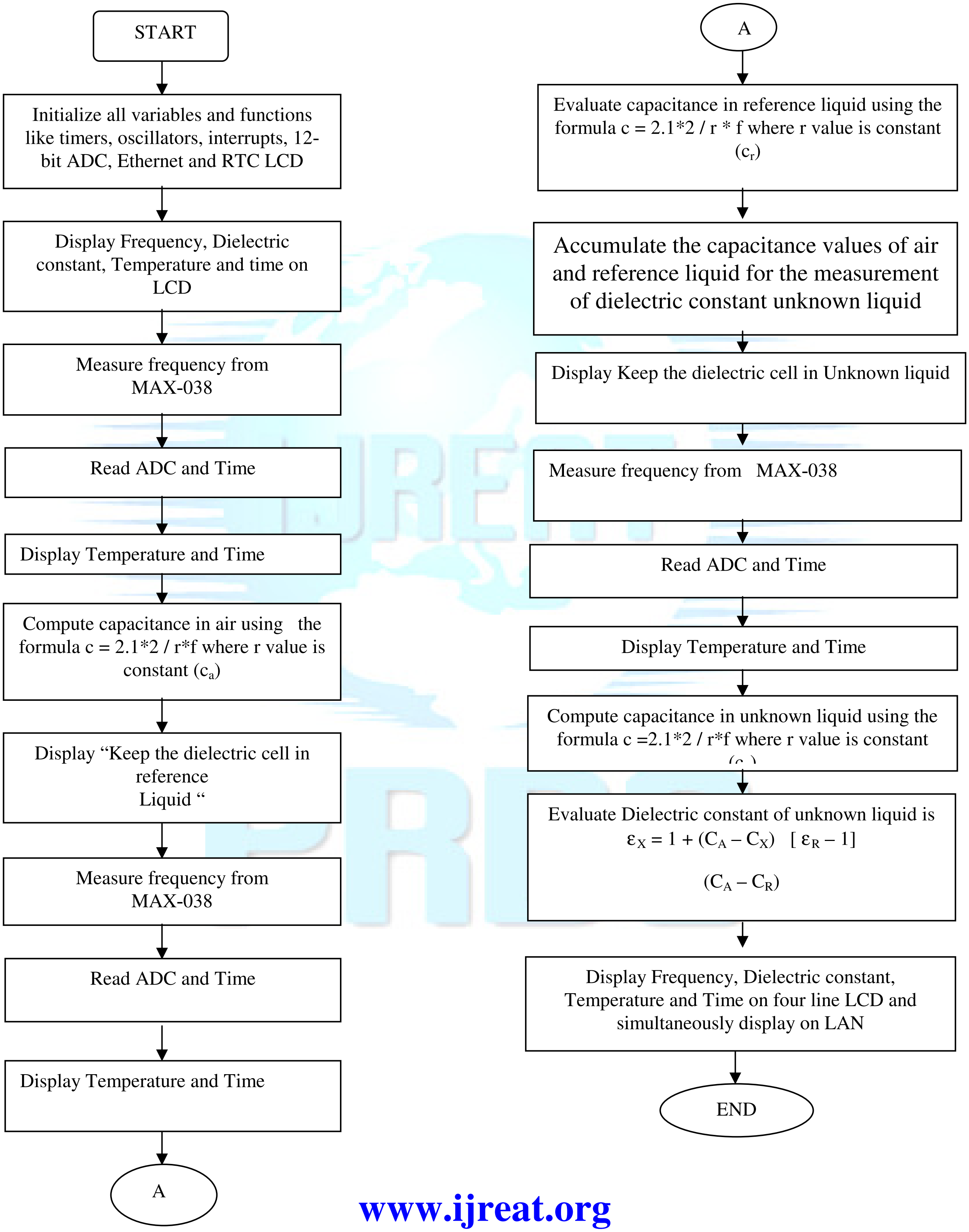

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Figure 5: Flow chart of the Ethernet based embedded system for the measurement of dielectric constant in binary liquid mixtures

6. Experimental Results

6.1. Toluene + Ethanol

An attempt is made to measure the dielectric constant for the liquid mixture: Toluene + Ethanol at 25^0C, 35^0C and 45^0C and at different concentrations. The results of measurements are presented in Table 1. The data is shown graphically in Figure 6. It is observed that at a given temperature the dielectric constant varies as a function of concentration. It is found that as the temperature increases the dielectric constant decreases. Prasad et al [13] have reported dielectric constants in liquid mixtures of polar compounds with toluene as common component. They observed as the temperature increases dielectric constant decreases. Our results support this viewpoint.

S. No	Concentration (mole fraction)	Dielectric Constant at 25° C	Dielectric Constant at 35° C	Dielectric Constant at 45° C
1	0	2.12	1.98	1.95
2	0.1	4.18	4.01	3.67
3	0.2	5.89	5.25	5.1
4	0.3	6.72	6.32	6.12
5	0.4	8.12	7.9	7.25
6	0.5	10.56	10.12	9.85
7	0.6	12.89	12.25	11.76
8	0.7	14.62	14.12	13.8
9	0.8	19.23	18.75	18.25
10	0.9	21.52	21.23	21.1
11	1	24.21	23.85	23.25

Table 1: Dielectric constant for Toluene + Ethanol mixture at 25^0, 35^0 and 45° C

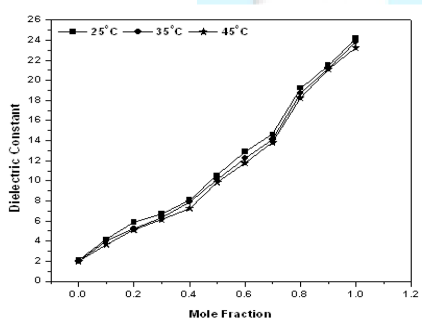

Figure 6: Dielectric constant for Toluene + Ethanol mixture versus concentration at 25^0, 35^0 and 45° C.

6.2. Toluene + Methanol

The dielectric constant for the liquid mixture: toluene + methanol [14] at 25^0C, 35^0C and 45^0C and at different concentrations is measured in the present study. The results of measurements are presented in Table 2. The data is shown graphically in Figure 7. It is observed that at a given temperature the dielectric constant varies as a function of concentration. It is found that as the temperature increases the dielectric constant decreases. Bayles et al [15] have reported dielectric constants in liquid mixtures of polar compounds with toluene as common component. They observed as the temperature increases dielectric constant decreases. Our results are in tune with their results.

Table 2: Dielectric constant for Toluene + Methanol mixture at 25^0, 35^0 and 45° C

S. No	Concentration (mole fraction)	Dielectric Constant at 25° C	Dielectric Constant at 35° C	Dielectric Constant at 45° C
1	0	2.2	2.1	2
2	0.1	6.14	5.98	5.65
3	0.2	7.82	7.12	6.95
4	0.3	11.52	11.25	11.1
5	0.4	12.86	12.32	12.1
6	0.5	16.93	15.89	15.35
7	0.6	19.21	18.75	18.23
8	0.7	22.38	21.25	20.95
9	0.8	25.96	25.35	24.98
10	0.9	29.31	28.86	28.01
11	1	31.89	31.35	30.98

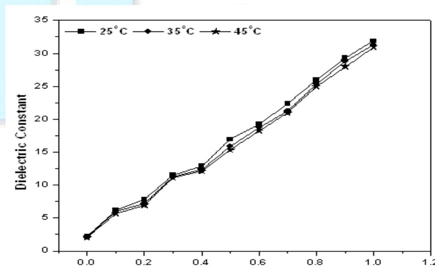

Figure 7: Dielectric constant for Toluene + Methanol mixture versus concentration at 25^0, 35^0 and 45° C.

6.3. Toluene + Propanol

The dielectric constant measurement for the liquid mixture: Toluene + Propanol at 25^0C, 35^0C and 45^0C and at different concentrations. The results of measurements are presented in Table 3. The data is shown graphically in Figure 8. It is observed that at a given temperature the dielectric constant varies as a function of concentration. It is found that as the temperature increases the dielectric constant decreases. Letcher et al [16] have reported dielectric constants in liquid mixtures of polar compounds with toluene as common component. They observed as the temperature increases dielectric constant decreases. Our results support this viewpoint.

Table 3: Dielectric constant for Toluene + Propanol mixture at 25^0, 35^0 and 45° C

S. No	Concentration (mole fraction)	Dielectric Constant at 25° C	Dielectric Constant at 35° C	Dielectric Constant at 45° C
1	0	2.18	2.15	2.05
2	0.1	3.24	3.12	2.95
3	0.2	4.68	4.25	4.1
4	0.3	6.24	6.12	5.9
5	0.4	8.12	7.85	7.25
6	0.5	10.35	10.12	9.75
7	0.6	12.15	11.95	11.34
8	0.7	14.83	14.32	14.12
9	0.8	17.12	16.85	16.25
10	0.9	18.23	17.82	17.25
11	1	20.25	20.12	19.82

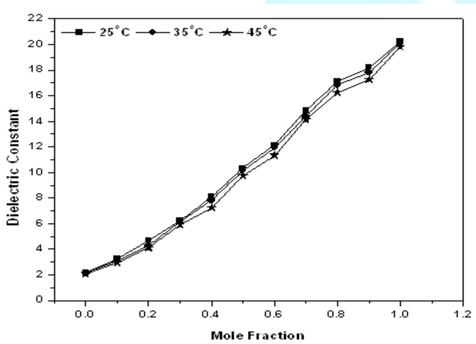

Figure 8: Dielectric constant for Toluene + Propanol mixture at 25^0, 35^0 and 45° C

As can be understood from the above results, the properties of the studied mixtures indicate some molecular interactions. Because of alcohols are associate liquids, they can interact with each other and with other molecules. The measurement of dielectric constant was the most affected parameter from these interactions.

7. CONCLUSIONS

The circuit for the embedded based Ethernet measurement of dielectric constant of binary liquid mixtures has been designed and developed The measurement of dielectric constant over a wide range is a special feature of the present study. The necessary software is developed in C, using Silabs's C-cross compiler. The system has a provision to store and retrieve the data whenever required with real time and the date is displayed on LCD and web server simultaneously.

REFERENCES

[1] Lee, S.hyun. & Kim Mi Na, (2008) "This is my paper", ABC Transactions on *ECE*, Vol. 10, No. 5, pp120-122.

[2] Gizem, Aksahya & Ayese, Ozcan (2009) Coomunications & Networks, Network Books, ABC Publishers.

[3] "Automatic Measurement of Complex Dielectric Constant and Permeability at Microwave Frequencies" by William B.Weir, Member, IEEE, Proceedings of the IEEE.

[4] "An overview of dielectric properties measuring techniques", M.S.Venkatesh and G.S.V. Raghavan, Canadian Bio Systems Engineering, Volume 47, 2005.

[5] "Design and Implementation of Microcontroller-Based Ethernet Communication", by Javed Sheikh, Sumedh Gawande, Sachin Charbhe; International Journal of Application or Innovation in Engineering & Management (IJAIEM),

[6] "The Measurement of Dielectric Properties of Liquids at Microwave Frequencies Using Open-ended Coaxial Probes", A. Boughriet, Z. Wu, H. McCann, and L. E. Davis, 1st World Congress on Industrial Process Tomography, Buxton, Greater Manchester, April14-17, 1999.

[7] "A Review on different methods of Designing and controlling Induction Heating Application" Ashishkumar B. Patel, Payal D. Kansagra and R. B. Patel, IJSRD - International Journal for

Scientific Research & Development‖ Vol. 2, Issue 01, 2014 ‖

[8] "A Microcontroller- based Room Temperature Monitoring System", Theophilus Wellem and Bhudi Setiawan, International Journal of Computer Applications, Volume 53– No.1, September 2012.

[9] "Embedded Management System for Out Patient Department", C. Kavitha, A. Venkat Ramana, S. Sushma Raj", International Journal of Embedded Systems and Applications (IJESA) Vol.2, No.3, September 2012.

[10] "Design and Implementation of a Digital Parking Lot Management System", Xiaolong Li and Uma Kanth Ranga, the Technology Interface Journal/Fall 2009.

[11] "A Precision Temperature Controller Using Embedded System", Aakanksha Pimpalgaonkar, , Mansi Jha, Nikita Shukla, Kajol Asthana, International Journal of Scientific and Research Publications, Volume 3, Issue 12, December 2013.

[12] "Ethernet Enabled Digital 1/0 Control in Embedded Systems", Mr. Suyog A. Wani and Prof. R.P.Chaudhari, 2012 International Conference on Computing, Electronics and Electrical Technologies [ICCEET].

[13] Prasad, N., Singh, R., Prakash, O. and Prakash, S., Indian J. Pure and Appl. Phys.,14, 676 (1976).

[14] "Dielectric behavior of acetonitrile + methanol binary mixtures at microwave frequency", A.P. Jogdand and Dr. P.L. Kadam, IOSR Journal of Applied Physics (IOSR-JAP) . Volume 6, Issue 1 Ver. II (Feb. 2014), PP 14-22.

[15] Bayles, J.W. and Letcher, T.M., J.Chem. Eng. Data, 16, 266 (1971).

[16] Letcher, T.M., J. Chem. Thermodynamics, 4, 159 (1972).