DIELECTRIC CONSTANT MEASUREMENT SETUP FOR POLYMER FILMS USING CEREBOT MX3CK AND PMOD

[1]THALARI CHANDRASEKHAR,[2]C.MANIKUMAR,[3]VISHNU CHITTAN,[4]SHIVAMURTHAIAH M,[5]RAVIKIRAN Y.T

[1]Assistant professor, [2] Assistant professor, [3]Research scholar, [4]Assistant professor, [5]Assistant professor.

[1]Department of Electronics, Government Science College, Chitradurga, Karnataka, India
[2]Dept. of Engineering Physics,Gitam University, vishakhapatnam,

[3] School of computer science and IT Garden City University.

[4,5]Department of PG Studies in Physics, Government Science College, Chitradurga, Karnataka, India.

Abstract

An embedded based (cerebot MX3ck and Pmod AD5933) system for the measurement of dielectric constant for Polymer Films has been designed & developed. It is based on the technique that utilizes high precision impedance measurement for determination of capacitance using the cerebot MX3ck microcontroller. The converting impedance, when the solid forms the dielectric medium of the dielectric cell, is measured with a microcontroller.Further, an LCD module is interfaced with the microcontroller. The results of the instrument displayed on LCD and the data is stored in Personal Computer simultaneously for further characterizations. Software is developed in C using MPIDEC-cross compiler. The instrument system covers a wide range of dielectric constant for various polymer films. The system is quite successful in the measurement of dielectric constant for polymer films. The paper deals with the hardware and software details.

Index Terms : Dielectric constant, Pomd(AD5933),Impedance converter, impedance measurement, C using MPIDE's C-cross compiler, and MicrocontrollerCerebot Mx3ck.

I INTRODUCTION

The dielectric constant is a property of major concern in understanding it behavior in various polymer films. A "dielectric" is a substance that can sustain an electric field and acts as an insulator. Dielectrics are basically insulator materials having a special property of storing and dissipatingelectrical energy when subjected to electromagnetic fields [1]. The dielectric constant of materialscontains detailed information about physical and chemical composition and structure [2].Some solids and liquids can serve as good dielectric materials, having a special property of storing and dissipating electrical energy when subjected to electromagnetic fields. Dry air is an excellent dielectric. Dielectric measurements are useful for detecting explosives, plastic and metal weapons, drugs, chemical agents, and biological agents. The dielectric cell consists of two parallel metallic plates which act as electrodes. The cell acts as a capacitor, while the solids sample acts as a dielectric medium. Dielectrics find extensive use in electrical and electronic industries. They are used for insulation purposes [3].In the present study, the technique utilizes frequency measurement for determination of capacitance using PIC microcontroller is a tool, while most of the conventional techniques measure the capacitance using bridge methods[4]. It is very important to evaluate their electrical and physical characteristics such as molecular structure and density [5]. The interest in the study of dielectric properties of materials, spring from both the practical need for dielectrics in technical devices and the interest of physicists and physical chemists in the molecular structure and dynamics of condensed matter [6].

II .PRINCIPLE OF WORKING:

The Pmod Impedance analyzer AD5933 is a high precision impedance converter system. The signal from the impedance is sampled by the on-board ADC and a discrete Fourier transform (DFT) is processed by an on-board DSP engine and returns a real (R) and imaginary (I) data-word at each output frequency. The PIC microcontroller read the data from the serial I2C interface.The dielectric cell acts as acapacitorC that varies with the dielectric medium. Consequently, the impedance also changes. The measurement of the impedance of the sample enables one to measure the values of the capacitance of the cell and, thus the dielectric constant of the medium. In the present study, with suitable interface of the circuit with a cerebot MX3ck microcontroller, the impedance of is measured. The dielectric constant of the medium is computed and is displayed on the LCD and the data is sending to computer simultaneously for analysis. The dielectric constant ε is represented by the following equation

The DFT magnitude is given by

$$\text{Magnitude} = \sqrt{I^2 + R^2} \quad (1)$$

where: *R* is the real number stored at Register Address 0x94 and Register Address 0x95.

I is the imaginary number stored at Register Address 0x96 and Register Address 0x97.

$$\text{Gain factor} = \frac{1}{Magnitude * calibration - imp} \quad (2)$$

$$\text{Impedance} = \frac{1}{Gain factor * magnitude} \quad (3)$$

$$\text{Capacitance} = \frac{1}{6.286 * impedance * currentFrequency} \quad (4)$$

The dielectric constant of the medium is computed using following Eq. 6 & 7 and is displayed [7-9]. The dielectric constant ε of a solid is defined as the ratio of the electrical capacitance of a cell when the sample forms the dielectric medium (Cs) 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

$$\varepsilon = (C\ s) / (C_0) \quad (5)$$

The dielectric cell consists of two parallel metallic plates which act as electrodes. The cell acts as a capacitor while the solid acts as a dielectric medium.

The dielectric constant ε of the sample is given by

$$\varepsilon = (C_X - C_L) / (C_A - C_L) \quad (6)$$

where C_X = actual capacitance of the cell with the sample

C_L = Lead capacitance C_A = Actual capacitance of the cell with air

III . EXPERIMENTAL RESULTS

The AD5933 is a high precision impedance converter system, that combines an on-board frequency generator with a 12-bit, 1 MSPS, analog-to-digital converter (ADC). The impedance of the sample is measured using CEREBOT MX3CK AND PMOD. Pmod AD5933 consiston-board ADC and a discrete Fourier transform (DFT). The DFT measured and send a real (R) and imaginary (I) data-word at each output frequency,which can be read from pic microcontroller MX3Ck using serial I2C. Once calibrated, the magnitude of the impedance is calculated at each frequency point. The dielectric constant of the medium is computed usingequation (2) and is displayed on the LCD, hyper terminal of the computer and web serversimultaneously.

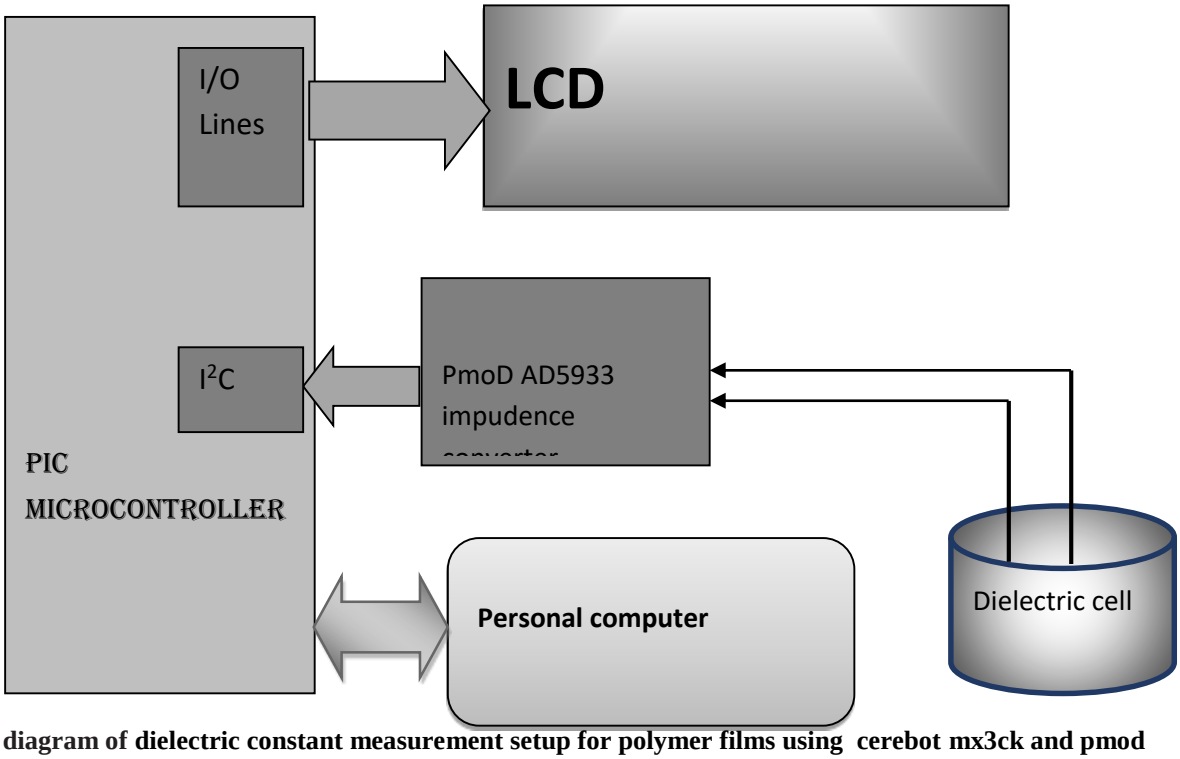


Fig:1. Block diagram of dielectric constant measurement setup for polymer films using cerebot mx3ck and pmod

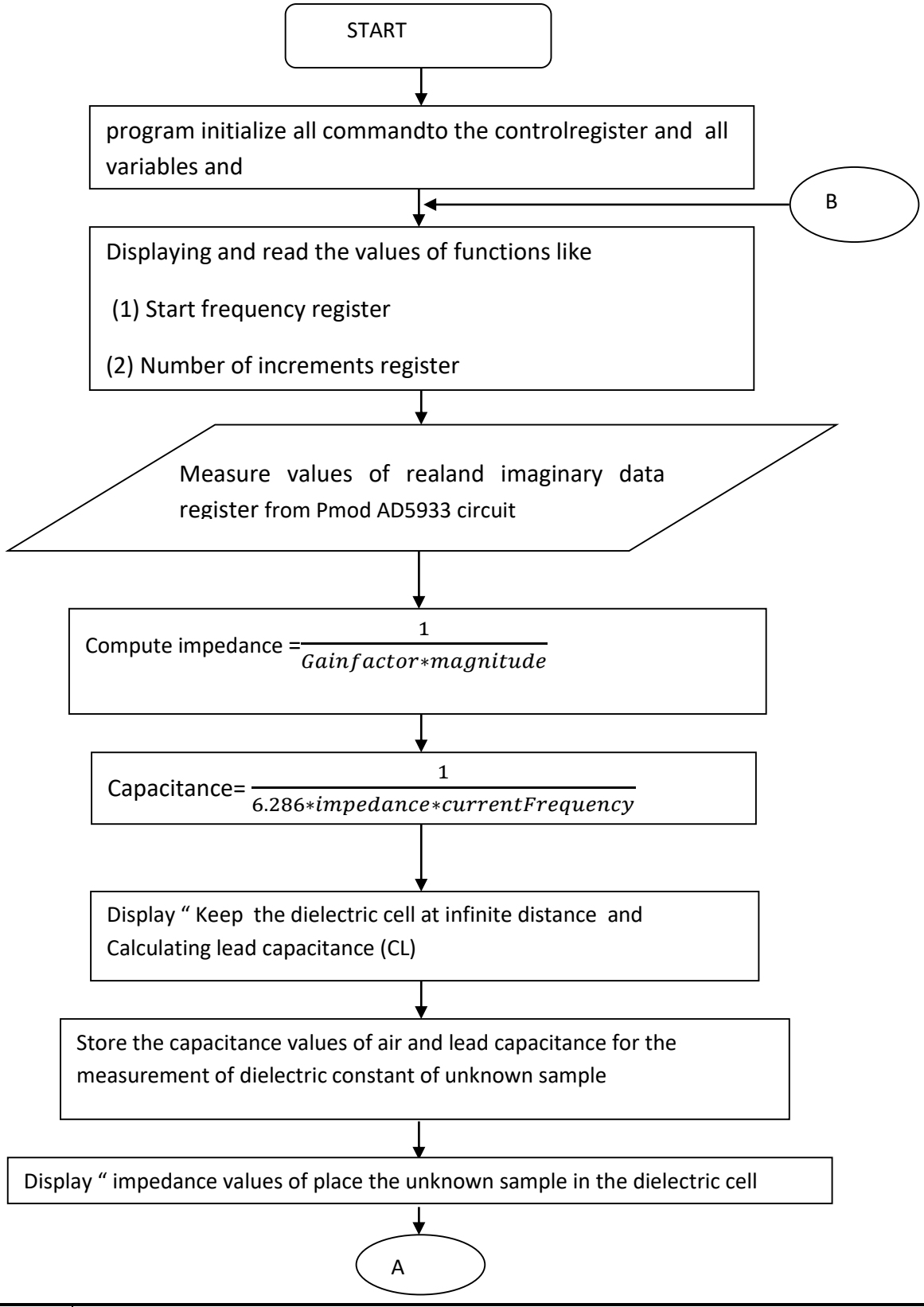
IV SOFTWARE DEVELOPMENT

The software for the development of Dielectric constant measurement setup for polymer films using cerebot mx3ck and pmodis developed usingC using MPIDEC-cross. The main role of the software in the present study is to test the following hardware modules activities.

1. To measure the impedance of from Pmod chip.
2. To compute the capacitance and dielectric constant.
3. To display the measured data.

4.1 FLOWCHART :

The flowchart is so drawn that it is self-explanatory and gives the complete idea of how designed system sequentially does the different steps involved in measurement of solids.



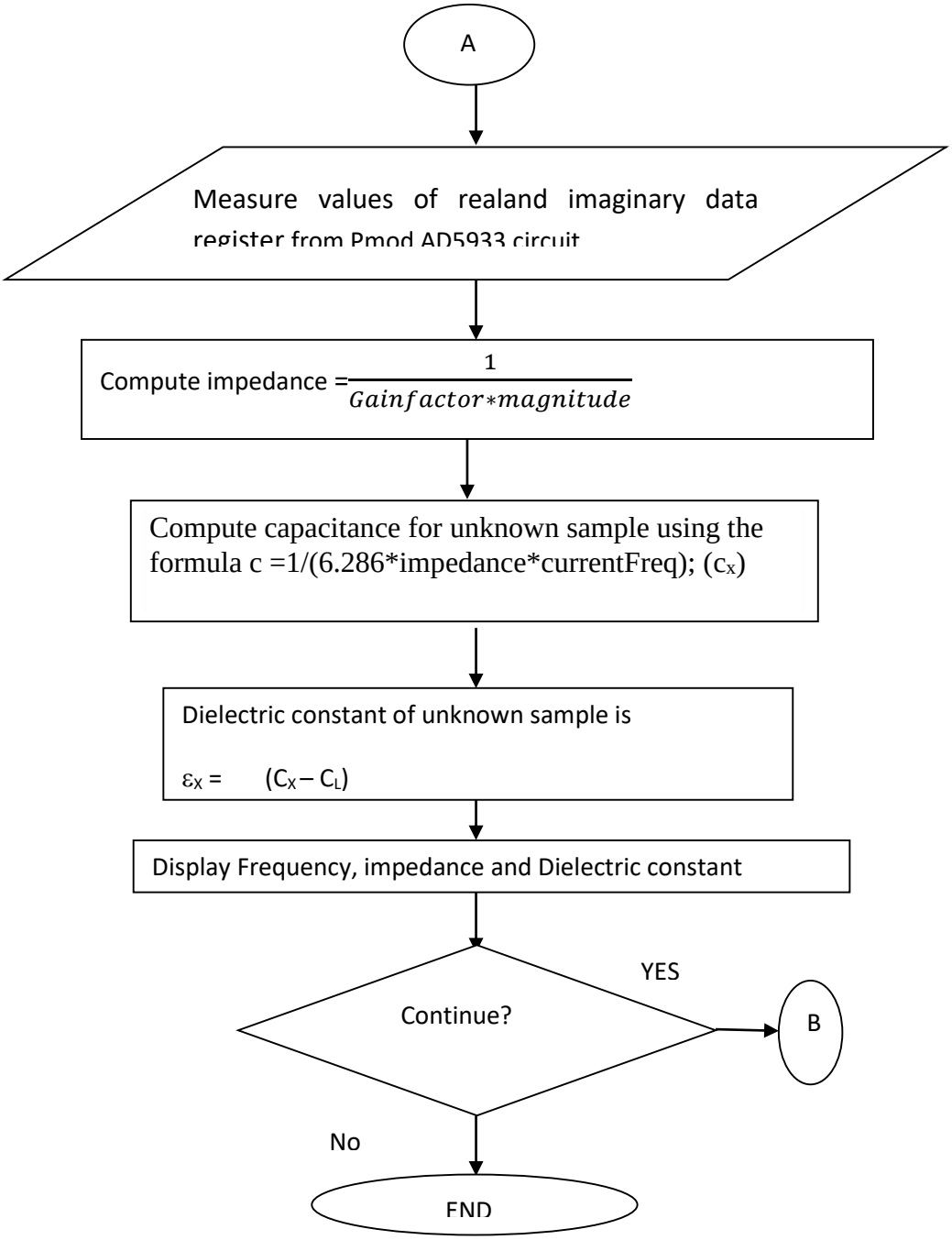


Fig.2 Flow chart of dielectric constant measurement setup for polymer films using cerebot mx3ck and pmod

V EXPERIMENTAL PROCEDURE:

The experimental procedure involves the following major steps

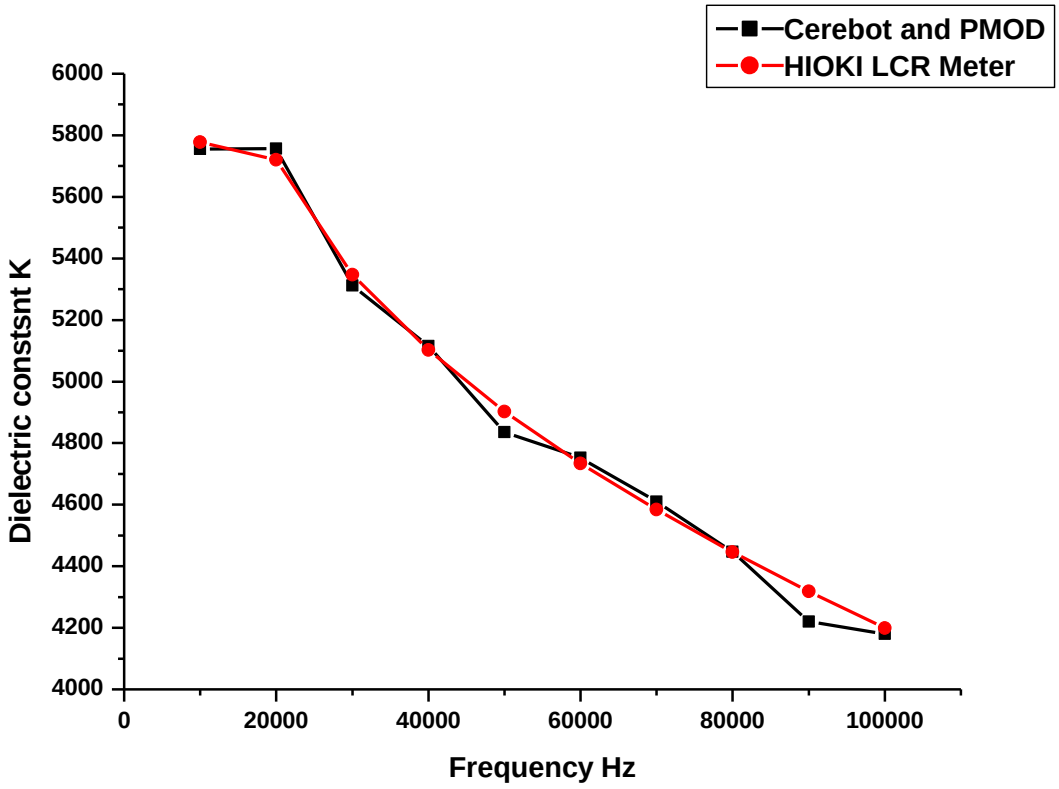
1. Design of the system as shown in the block diagram
2. Developing software
3. Measuring the impedance
4. Storing the frequency data and calculating dielectric constant
5. Observing the procedure for different samples

VI RESULTS AND DISCUSSION:

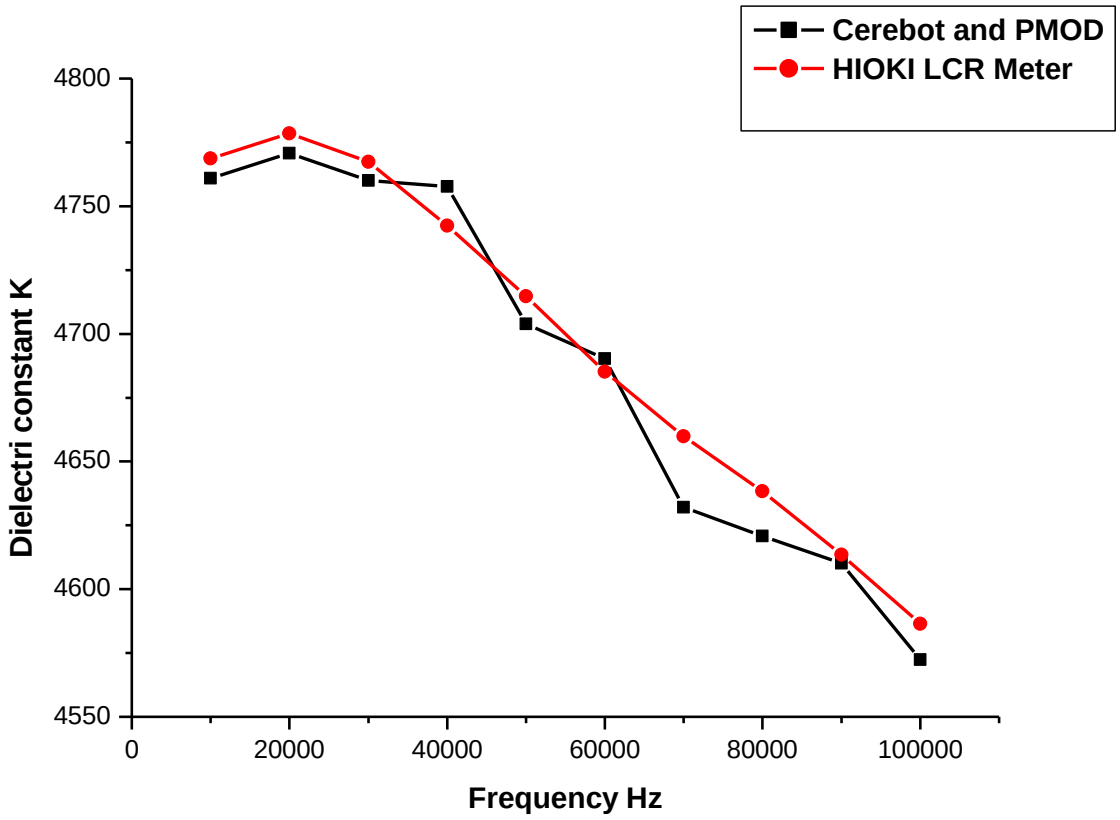
The dielectric constant measurement setup for polymer films using cerebot mx3ck and pmodsystem is designed and constructed. The performance of the system is studied and tested for different samples of polymers at room temperature. The function of the systems is found satisfactory.The performance of the system for the measurement of dielectric constant in materials is investigated by comparing its response with the results by other methods. The results are presented in table. The samples are selected to cover the wide range. The results of the present study are in good agreement with the literature values.Further this can be extended to process and change the characteristics of samples.This operation on the dielectric involved are cell designing, decoding, measuring impedance, calculating. Hence this sample design would give an idea on measuring the conductivity and dielectric constant, resistivity etc.

Tabular column

sample	Frequency in Hz	Impedance (Ω)	Capacitance (F)	Dielectric constant(k)	HIOKI LCR Meter
	Frequency	Impedance	capacitance		
	F	Z	S	Real Diele.RD	
	10000	4108.5	2.31E-09	5755.01	5778.083
	20000	2836.5	2.16E-09	5757.02	5720.742
	30000	2143.6	2.06E-09	5312.13	5347.038
Pani+	40000	1721.7	1.98E-09	5115.66	5101.856
Y2O3	50000	1446.6	1.92E-09	4835.69	4902.152
	60000	1252.5	1.85E-09	4752.51	4733.589
	70000	1108.5	1.80E-09	4610.12	4583.564
	80000	997.49	1.75E-09	4446.8	4446.39
	90000	909.48	1.70E-09	4220.26	4318.609
	100000	837.82	1.65E-09	4180.36	4198.49



sample	Frequency in Hz	Impedance (Ω)	Capacitance (F)	Dielectric constant(k)	HIOKI LCR Meter
Pani+CMC	10000	783.26	7.39E-10	4760.9	4768.627
	20000	779.51	7.40E-10	4770.78	4778.568
	30000	777.44	7.39E-10	4760.13	4767.336
	40000	768.44	7.35E-10	4757.74	4742.354
	50000	762.6	7.30E-10	4703.95	4714.66
	60000	755.36	7.26E-10	4690.32	4685.224
	70000	746.83	7.22E-10	4632.01	4659.79
	80000	738.05	7.19E-10	4650.78	4638.423
	90000	729.41	7.15E-10	4630.12	4613.505
	100000	720.49	7.10E-10	4572.43	4586.393



VII CONCLUSION:

An inexpensive hardware and software are designed and developed using cerebot MX3ck and Pmod AD5933 controller. The measurement of dielectric constant over a wide range is a special feature of the present study. The necessary software is developed in C, usingMPIDEC-crosscompiler. The system has a provision to store and retrieve the data whenever required and displayed on LCD.The system is quite successful for the measurement of dielectric constants in solids with an accuracy of ± 0.1 %.

VIII ACKNOWLEDGMENTS

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REFERENCES:

[1]. A. Rajendran, P. Neelamegam "Microcontroller Based Dielectric Constant Measurement"jornal of Sensors & Transducers Magazine, Vol.41, Issue 3, March 2004, pp.181 - 190
[2]. Hoppe Walter, Bio Physics, Springer-Verlog, NewYork, 1983
[3]. Arthur R.VonHippel, John Wiley & Sons Ltd., "Dielectric materials and applications", New York (1958).
[4]. Akhmarch A.R., Lazarescu M.T., Tarig O.B., Lavagno L. A Tagless Indoor Localization SystemBased on Capacitive Sensing Technology. Sensors, vol. 16, 1448; doi: 10.3390/s16091448, 2016.
[5]. C.P.Smyth, "Dielectric behaviour and structure", McGraw Hill, New York (1955).
[6]. B.Szigeti. Trans. Faraday Soc. 45, 155 (1949).
[7]. CH.V.V.Ramana & K.Malakondaiah, "Microcontroller based system for the Measurement of dielectric constant in liquids", Instrumentation Science & Technology (Taylor & Francis), Vol.35, 6, pp 599-608 (2007).
[8]. Manikumar C.,NagabhushanRaju K., Ramana C. H., NagamaniG.,ChandraSekhar T. M. 'Design and Implementation of Ethernet Based Embedded System for the Measurement of Dielectric Constant in Solids' Sensors & Transducers Journal, Vol. 135, Issue 12, December 2011, pp. 70-79.
[9]. T. Chandrasekhar, Ravikiran Y.T, C.Mani Kumar, Ch.Vv.Ramana "PC based Dielectric Constant MeasurementSystem for Solid Polymer Films" journal of IJIRCCE, Vol.5, Special Issue 2, April 2017, 228-232
[10]. J.Y.H.Chan, R.J.W.LeFerre and J.Tardif, J. Chem. Soc, 2293 (1957).
[11]. IC AD5933 high precision impedance analyser Datasheet;
[12]. Dielectric constant data, www.clippercontrols.com.
[13]. Dielectric constant data, www.deltacnt.com