PREFACE

Capacity of capacitor is one of the important oldest concepts linked with static electricity, but still it is the most sought-after concept even in today’s modern world of Electronics and Instrumentation. Faraday made major contributions to capacitor technology, including the concept of dielectric constant apart from the invention of the first practical fixed and variable capacitors. His contributions to capacitor technology are recognized in the unit for capacitance. The main reason for its significance is the tremendous application potentiality in various fields of Science and Technology where the material characterization is an important aspect. There are various traditional methods of measurement of the capacitance of a capacitor available viz, Bridge method, Auto-balance method, resonant method, I-V Method and RF I-V method etc., But the recent advancements in Science and Technology made it possible to measure the capacitance of a capacitor very accurately and precisely to the study of variations of the capacitance of a material by the influence of temperature and frequency which is of prime importance. These studies are playing vital role and throw certain light of information in understanding the intermolecular interactions of the various materials. But for precise study of these things we need the most modern technologies where the accuracy is a prime concern.

Keeping in view of these facts an attempt has been made in the present thesis work to measure the variation of capacitance of a material by the influence of both
frequency and temperature using a novel method called Autobalance Bridge Method. The core of the design is the ARM Processor which is a high speed and low power device highly recommended for efficient processing. The ARM7 processors LPC21xx from Philips are proved to be vital in the mobile and embedded electronics applications at a relatively low cost. It is ideal for applications where miniaturization is a key requirement. A blend of serial communication interfaces ranging from a USB 2.0 full speed device, multiple UARTS, SPI, SSP to I²C and on-chip SRAM of 8kB made these devices suitable for communication gateways and protocol converters, soft modems, voice recognition and low end imaging providing both large buffer size and high processing power.

A Graphical User Interface (GUI) is developed using the software tools of MATLAB to depict the variation of the capacitance with frequency and temperature graphically on ON-LINE and Real-time basis. The main advantage of the present system is not only the speed and accuracy but unlike the systems reported in the literature, it can measure the capacitance ranging from few Hertzs to Mega Hertzs in terms of frequency (Hz) and temperature (°C). The entire thesis is presented in five chapters.

The main objectives of this research work are as follows

(i). To study the behavior of Capacitance of a capacitor by the influence of Frequency and Temperature
(ii). To study the properties of materials in the usable range of Electronics.

(iii). To visualize the Capacitance measurement variation on online basis as the measurement proceeds thereby getting instant results over the measurement range

(iv). Automation of entire setup provides excellent results in terms of results and maintenance

Luis Ares[2] presented a system that allows the measurement of electrical parameters (namely resistance and capacitance) to be carried out through the direct connection of the target component to an FPGA, without the need for an analog-to-digital converter or excitation circuits. The system is based on a measurement method previously described in the literature, in which sensors are directly connected to microcontrollers.

As integrated circuits become increasingly laden with metal interconnects, the resulting inter-metal capacitances are rapidly becoming the bottleneck in the design of faster chips. Past on-chip interconnect capacitance techniques have relied on reference capacitor and or a complicated test-structure design and measurement setup. In this paper, authors not only introduce an improved version of the test structure layout, but provide an on-chip signal generator and an entirely new measurement scheme as well. The resolution limit of our methodology is estimated to be 0.01pF, hence making it more than adequate for characterizing parasitic interconnect capacitances. We call this technique as Charge-Based Capacitance Measurement.
This technique relies upon the exponential rate of charge of the test specimen when driven from a step input. The time elapsed from an initial state (zero time) and a reference level is determined by means of a comparator with inputs connected between the RCx junction and a reference voltage level. The time taken to charge to reference voltage and the resistors used to charge the capacitor determine the capacitance.

Several methods have been proposed for measuring capacitance which employs the use of monostable circuits. In this technique a pulse generator is used to trigger the monostable which produces a train of output pulses. Each pulse has a period directly proportional to the value of the test capacitor Cx. These pulses may be averaged to yield an analog output voltage which is directly proportional to Cx. Alternatively, the timing pulses may be used to gate clock pulses into a counter thus providing a direct digital display of capacitance.

In most of the works surveyed so far it is observed that there has been little focus on the use of advanced processors in particular ARM. In the present work ARM7 processor is used for the design and development of instrumentation system for the studies of frequency and temperature effects on capacitance. Due to their tiny size and low power consumption LPC214x are ideal for applications where miniaturization is a key requirement, handheld devices such as access control, portable field measuring devices.
Even today most of the laboratory standard equipment is not portable. With respect to new instruments issues that are need to be addressed are: size, power consumption, speed of measurement, applicability to other areas of research. An attempt has been made in the present work to miniaturize the hardware needed to measure capacitance under the influence of frequency and temperature.

The chapter 1 gives the introduction to the present work. A brief account of experimental techniques of capacitance measurement of solids is presented along with the factors which influence the capacitance of solids and also the need of embedded based system design used for many applications. The important features of ARM processor and the salient features of the programming languages like MATLAB tools used in developing Graphical User Interface (GUI) are also presented in this chapter.

The chapter 2 is dedicated to the hardware development of Microprocessor - PC based system design. The block diagram of the design and development of Instrumentation system for the studies of frequency and temperature effect on capacitance measurement is given and the details of each units are explained. A controlled heating environment is created electrically and the temperature is measured with a thermocouple. Temperature measurement unit using Instrumentation amplifier gives temperature in the cell. To control all these devices an ARM processor is used. The instrumentation system measures capacitance over wide range of frequency and temperatures that influences the capacitance. The system is quite successful for the measurement of capacitance in solids with an accuracy of \( \pm 0.2\% \).
The chapter 3 deals with the software development of the Microprocessor - PC based system design and development of Instrumentation system for the studies of frequency and temperature effect on capacitance measurement. The C programs are developed using the Keil C- cross compiler tool. The variation of capacitance with frequency and temperature are displayed using the Graphical User Interface developed using the MATLAB environment. All the necessary details are presented in this chapter.

The chapter 4 deals with the various polymer materials used in the present work and the details of sample preparation and their characteristics is also discussed by testing of the material at different frequencies and temperatures. The effect of frequency and temperature on the capacitance of these materials are analyzed and presented using Graphical User Interface (GUI). The chapter also deals with the implementation of hardware and software for the present study.

The chapter 5 is dedicated to the results and conclusions of the present work. The graphical representation of the capacitance variations with the influence of frequency and temperature for different polymer samples is presented. The results are discussed in the light of the chemical composition and the applicability of these materials to industrial applications. The importance of these materials for various applications is probed and new conclusions were proposed.

The measured Capacitance values with respect to frequency and the capacitance values with respect to temperature are shown. The software program developed for the
The present study in MATLAB will acquire the data with online graphical display and the data also stored for the future analysis. The results are compared with the standard instrument which are in good agreement with accuracy of ±0.2% over the entire range and with less cost. The future enhancements for the present system are also discussed in this section.
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