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Measuring the frequency of a PZT by Interfacing Dielectric Cell with 8051MCU through MAX038

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Abstract— The present setup is used to measure the dielectric constant of PZT pellet. The main principle behind this work is to measure the frequency of PZT sample using P89V51RD2 microcontroller trough MAX 038 IC. The MAX038 IC is a high frequency function generator which can generate Sine, Square and Triangular waveforms from 0.1Hz to 20MHz without much distortion. The PZT pellet is placed in the dielectric cell and further connected to MAX 038. The output frequency of MAX038 is measured with a simple P89V51RD2 microcontroller and displayed on LCD.

Keywords— Dielectric cell interfacing, MAX 038, Frequency measurement, 8051, Dielectric constant

I. INTRODUCTION AND DESIGN PRINCIPLE

The dielectric materials are rapidly emerging in the field of electronic applications especially MEMS, Pyrro-electric sensors and numerous applications are there in interdisciplinary sectors too such as material science, biological research and chemical research etc [1]. The dielectric constant of the material describes the electrical and magnetic properties of the material which can be used to analyse the structure of the material. Measuring the dielectric constant plays an important role to determine the physical, chemical and electrical properties of the material [2]. Numerous methods have been developed to measure the dielectric constant of materials; those are Transmission line technique, free space technique, co-axial probe technique, parallel plate and resonant cavity techniques [3]. The Parallel plate technique is used in this present work. In this technique a parallel plate holder is used to hold the dielectric sample and further the parallel plate is connected to measuring unit, i.e., embedded controller. The dielectric constant of the material is derived by measuring the capacitance of the sample. The capacitance of the material can be measured by deriving the frequency of the sample. The main object of the present work is to measure the frequency of a dielectric sample and further to measure the dielectric constant of the dielectric sample.

$$\epsilon = \frac{Cs}{C_0}$$

Where **ε** dielectric constant, C_s is capacitance of the sample and C_0 is capacitance of the material. The air capacitance is measured by deriving the thickness and area of the sample.

$$C_0 = \frac{\epsilon_0 A}{T}$$

Where $\boldsymbol{\varepsilon_0}$ = permittivity of free space (8.85 x 10-12 F/m), A= Cross section are of sample and T= thickness of the sample. The capacitance of the dielectric sample is measured by knowing the frequency output of the sample, which can be derived from the output pin of the MAX038 function generator.

$$F_0 = \frac{2 \times 2.5\,V}{R_{IN} \times C_F}$$

Where F_0 is the output frequency of the MAX 038, 2.5V is the ref voltage, R_{IN} is the input resistance for the input terminal and C_F is the capacitance value of the capacitor which is placed between 5th and 6th pins of MAX 038 IC. The output frequency is inversely proportional to the capacitance. The parallel plate of the dielectric cell is connected in parallel with this C_F capacitor.

II. EXPERIMENTAL TECHNIQUE

The dielectric cell is a setup which holds the dielectric sample between two plates; hence it acts as a capacitor. The capacitance value varies with respect to the dielectric medium of sample. Lead Zirconate Titanate (PZT) is used as the sample in this current work. This setup is further connected to MAX038, The RC oscillator. The oscillations of the MAX038 depend on the R_{IN} and C_F values. By measuring the frequency of the oscillations enables to measure the capacitance and further dielectric constant of the respective sample. In this present work the dielectric cell and MAX038 IC are interfaced with P89V51RD2 microcontroller. The frequency output is displayed on 16x2 LCD. The Fig 1 shows the block diagram of the experiment.

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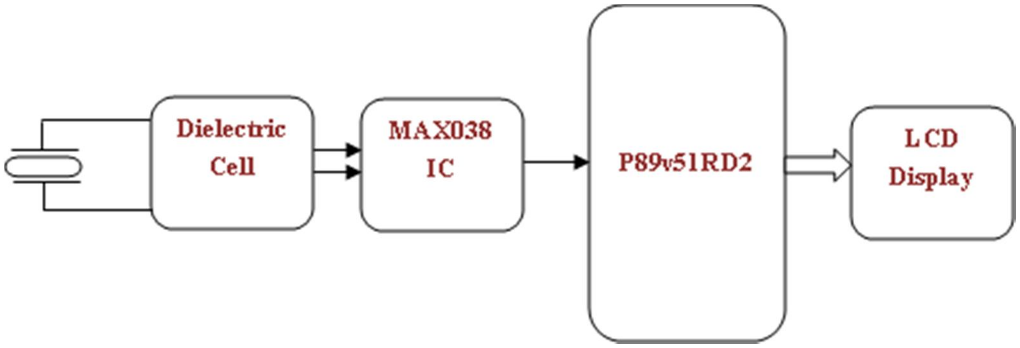

Fig. 1 Block diagram of the experiment.

A. P89V51RD2

P89V51RD2 [5] microcontroller is an 8051 core microcontroller. It has 64 kilo-Bytes of on-chip flash memory. It is a 40 pin DIP IC with four 8 bit ports. The operating frequency limit of this microcontroller is 40 MHz A quartz crystal of frequency 11.0592 MHz is connected to XTAL1 and XTAL2 pins of microcontroller. This controller supports the In System Programming (ISP) because of having flash memory. It has in built UART controller, Programmable Watch Dog Timer (WDT) and Serial Peripheral Interface (SPI).

B. MAX038

It is a high frequency function generator [4] and generates Triangle, Sine and Square waves from 1Hz to 20MHz without noise. It is a 20 pin DIP package IC. The basic operating principle of this IC is relaxation oscillator principle. An external capacitor C_F varies the output frequency by alternately charging and discharging. The output frequency is controlled by the reference voltage (V_{REF}) and the external capacitor (C_F) and I_{IN} current. The I_{IN} current can be varied from 2uA to 750uA.This variation of current is controlled by a 20KΩ variable resistor and is connected between V_{REF} and I_{IN}. The capacitance range from 20pF to 100uF is used to generate frequencies from 1Hz to 20 MHz. The formula for output frequency is $F_0= V_{REF}/C_F*R_{IN}$.

C. Liquid Crystal Display

The LCD is used to display the alphanumerical values in 5x7 or 6x8 matrix pixel format. In this current work 16x2 LCD with 5x7 Matrix display format is used. The output frequency of the MAX038 is displayed on the LCD as shown in Fig.2.

Fig. 2: 16x2 LCD

D. Dielectric Cell

The dielectric cell is a setup which contains a parallel plate to hold the sample and also it contains a screw gauge to measure the thickness of the sample. The Fig.3 shows the dielectric cell with PZT as a dielectric sample. The frequency output of the PZT sample is measured using MAX 038 and out is displayed on LCD through 8051 microcontroller.

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Fig. 3: Dielectric cell with PZT sample

III. EXPERIMENTAL SETUP

The experimental setup of this module for measuring the frequency of the PZT sample is shown in the Fig 4. The PZT sample is placed between the parallel plates of dielectric cell. The dielectric cell provides two probes for measuring the capacitance of the sample. These two probes are connected to 5^{th} and 6^{th} pins of MAX 038 IC. The RC oscillations are kept constant by selecting the adequate values for required frequency. The output of the MAX 038 IC is connected to the microcontroller. The microcontroller measures the frequency [6] of the waveform, which is from MAX038 and displays the output frequency on the LCD.

Fig. 4: Frequency measurement setup.

IV. EXPERIMENTAL RESULTS

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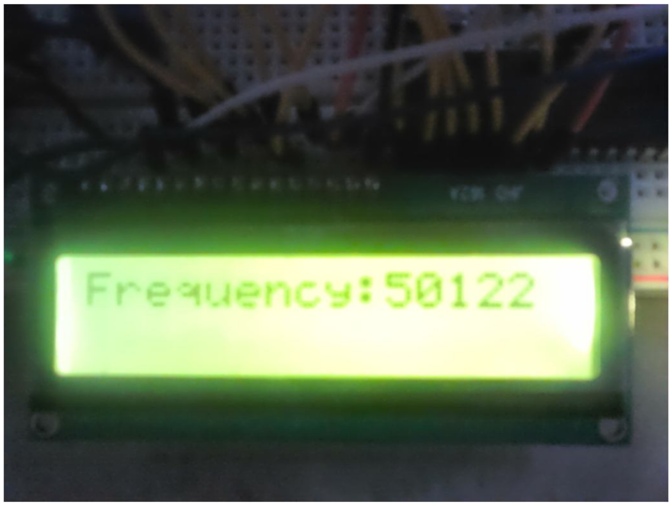
The output frequency of the PZT cell is measured by using the P89V51RD2 microcontroller and displayed it on LCD. This output is compared with Digital CRO output. The Fig.5 and Fig.6 shows the output frequency of the PZT sample. The output frequency is compared by Digital CRO too. The MAX038 can be directly connected to the CRO for comparing the output frequency of the P89V51RD2 microcontroller. The output frequency of the PZT sample is 50.122 KHz and the same sample frequency on CRO is 50.63 KHz. The error is because of Push board and connecting wires

Fig. 5: Frequency output using P89V51RD2 microcontroller

Fig.6: Frequency output using Digital CRO



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V. FUTURE WORK

The dielectric constant of a solid pellet sample is derived from its output frequency and capacitance. This measurement of the dielectric constant of solid materials can be upgraded using the present system.

VI. CONCLUSION

The Experimental setup of measuring the frequency of a PZT cell by interfacing dielectric cell with P89V51RD2 through MAX 038 has been designed and further this system can be upgraded to measure the dielectric constant of solid materials. The software for measuring the frequency is developed by using the Embedded-C language on KIEL compiler.

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