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Capacitance Measurement of MOS Structure

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Abstract: The aim of this project is designed to develop capacitor measurement circuit for MOS structure by using DC RC charging discharging method. Different capacitors have different properties, such as high capacitance or variable capacitance depending on the input voltage. This is the second most common feature in MOS architecture. To measure this variable capacitance, it's necessary to use measuring device which is capable of changing input voltage and measuring capacitor voltage during the all charging process. Capacitor measurement circuit done by the atmega32 and Op- Amp .Op-Amp are used for the measured capacitor charging voltage and controller are measured charging time. These tests are done on both ceramic and non-ceramic capacitors at room temperature. The results are discussed.
Keywords: Capacitance, Measurement, MOS Structure, Capacitor Measurement, ceramic and non-ceramic capacitors

I. INTRODUCTION

The acronym MOS stands for Metal oxide semiconductor. The MOS capacitor is made of a semiconductor body or substrate, an insulator and a metal electrode called a gate. The metal is probably a highly doped layer n + poly-silicon that acts as a metal membrane. The dielectric material are used between capacitor plates is SiO_2. The metal acts as one plate capacitor and a semiconductor layer which may be negative type or positive type as another plate.

The capacitance of the Metal Oxide Semiconductor structure be based on the applied voltage on the gate terminal of the MOS device like IGBT, MOSFET. Usually, the body is grounded when the gate voltage is applied.

So measured this types of capacitor I study different types of capacitor measurement method as shown below.

1) Series Bridge method
2) LCR Impedance method
3) Dc RC Charge - Discharge method

Capacitance of MOS structure measurement done by using Dc RC Charge and Discharge method.

II. DC RC CHARGE - DISCHARGE METHOD

Both the above measurement techniques will only measure the small signal characteristics of the test capacitor, be it under large dc bias voltages. It will also not allow a study of the detailed characteristics of the dielectric used in the capacitor. The RC charge - discharge circuit is to measure the large signal characteristics (up to a few kilovolt) at quasi dc frequencies (normally a few hertz). The circuit can be adapted to increase the frequency range to include low frequencies, similar to the series bridge.

In the RC charge - discharge circuit, the test capacitor is charged and discharged alternately by connecting the capacitor to a dc supply or short circuit and a measuring resistance, as shown in Figure 3.1.4. The capacitance is calculated by measuring the voltage across the known series resistance (R) and assuming that for a short interval Δt, the capacitance is constant. The capacitance at a voltage (v) is then given as

$C(v) = \Delta t/(R \ln(\Delta v))$,

Where R is the measuring resistance.

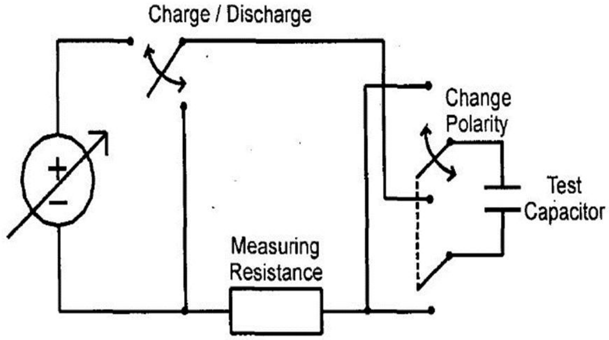

Figure 1 Dc RC Charge - Discharge Circuit

For measurement purposes, the test capacitor is first depolarised and then charged and discharged through five measurement intervals (0-4) displayed on a D-E graph in Figure 2. At the start of intervals 2 and 4, the supply polarity is reversed. In each of these intervals (T) of 130ms, 1600 samples are taken. The measuring resistance is chosen such that

$T=4RC_{est}$,

Where C, is an estimated capacitance value measured by other means (the measurement interval is four times the RC time constant). Thus, if the capacitance estimate is accurate for the voltage range, the test capacitor should charge to 98% ($1 - e^{-4}$) of the bus voltage during a charge interval. Similarly, the capacitor will discharge to 2% of the bus voltage (e^{-4}) during a discharge interval. This is to maximise the resolution of the measurement interval. For nonlinear capacitors, this resistance value can be changed to give a similar voltage range over the measurement interval.

The output can be given as a C-V graph for each of the five intervals and a single D-E graph (similar to Figure.2).

For this measurement, the test capacitor is modelled by a capacitance only. The dissipation factor can, however, be calculated for the area in-closed within the D-E graph (shaped area). It should be noted that the calculated losses are for the maximum Voltage used only.. To determine the losses at lower voltages, it will be necessary to repeat the experiment at the required voltage

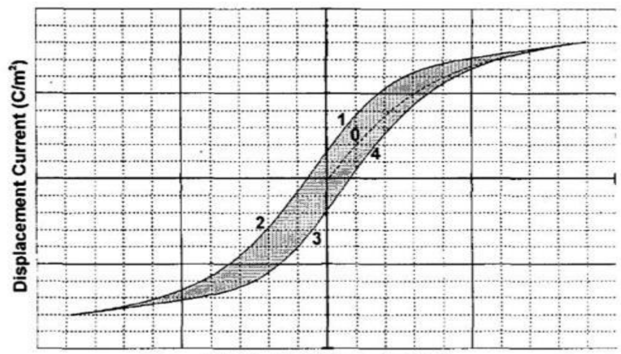

Figure 2 D - E Graph

III. BLOCK DIAGRAM AND WORKING OF CAPACITANCE MEASUREMENT CIRCUIT

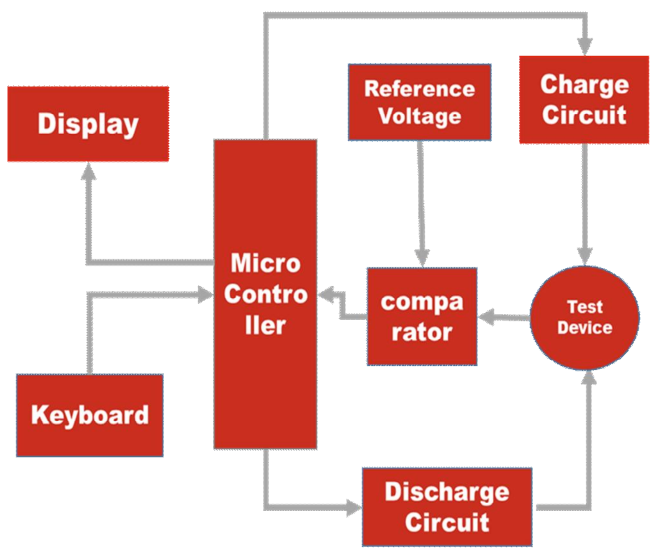

Figure 3 Block Diagram of Capacitance Measurement Circuit

Capacitance measurement done by using Quasi-dc RC Charge and Discharge Circuit. Block diagram of capacitance measurement circuit is showing figure 3.

In above method we need charging time (T) and charging register value R (fix 1 MΩ).

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T = R x C.

Where T = time required to charge 63.2% of applied voltage.

Here T measure by below process.

When we start measurement of capacitance microcontroller turn on charging circuit and charging circuit apply voltage (5 volt) between testing object and testing object start charging throw 1 MΩ series register. In block diagram comparator is used to compared charging voltage and reference voltage (63.2% of apply voltage).test object charge 63.2% of apply voltage that time comparator give signal to the microcontroller .microcontroller measure charging time (time between turn on charging circuit and comparator signal) And at time turn off charging circuit and turn on discharging circuit.as per programing microcontroller calculate capacitance and show capacitance value on display.

IV. SCHEMATIC DIAGRAM OF CAPACITANCE MEASUREMENT CIRCUIT

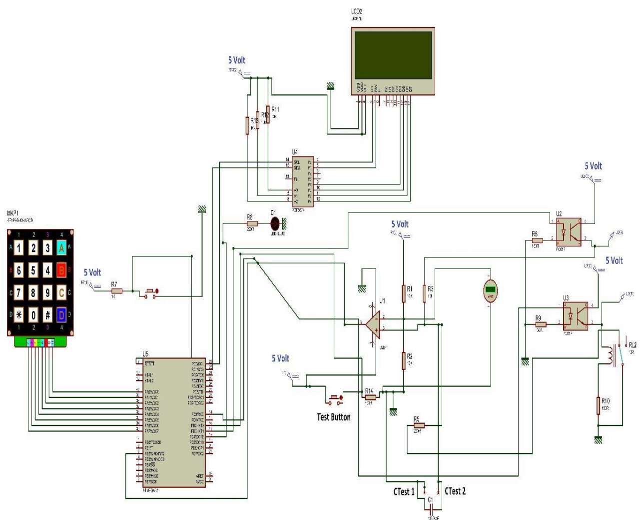

Figure 4 Schematic Diagram of Capacitance Measurement Circuit

In this circuit I use atmega32 microcontroller. For display capacitor value used 20x4 LCD with I2c communication. Comparator made by using LM324 OP-amp IC. Reference voltage of chagrining voltage of 63.2% made by voltage divider circuit. And for I2c communication LCD to microcontroller used PCF8574 IC.

V. HARDWARE OF CAPACITOR MEASUREMENT CIRCUIT

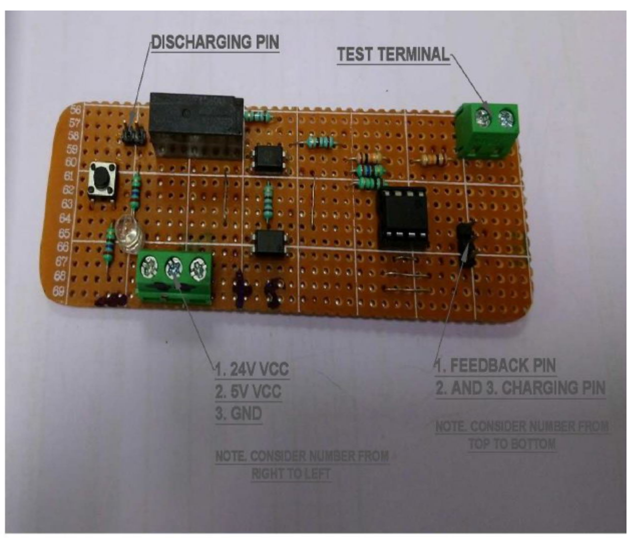

Figure 5 Top View of Current Triggering Circuit

In hardware discharging and charging pin are connected to microcontroller input pin and feedback pin are connected to controller interrupt 0 pin.

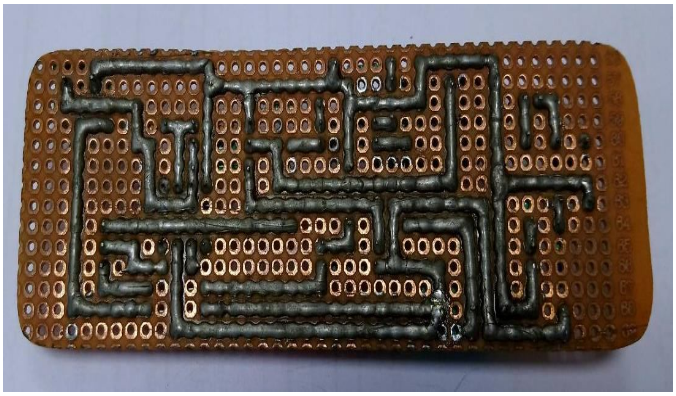

Figure 6 Bottom View of Current Triggering Circuit

VI. CONCLUSION

In this paper I learn about different types of capacitor measurement technics. I chose Dc RC Charge - Discharge method for measurement of MOS structure capacitor. And capacitor measurement circuit successfully measured with 10
pF to 1 µF range of capacitor. This circuit also used for disk type capacitor or ceramic.

I measure capacitance with 98% to 99% accuracy by using capacitor measurement circuit. And its error is ±1 %. Error and accuracy are reference with calibrated LCR meter. In addition, we can measure any types of capacitor value from 10pF to 1F.

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