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Experiment No. 1

Aim :- To determine the Coupling co-efficient of a Piezoelectric crystal.

Apparatus

RF Oscillator Frequency Source
Inductance Box
Resistance Box
Capacitance Box
Piezo electric crystal
AC Voltmeter
AC Milli-ammeter
One way Key
Two way Key
Connection leads

Formula used

Coupling co-efficient $(K_c) = \frac{1}{Q}$

where $Q = \frac{1}{R}\sqrt{\frac{L}{C}}$

Series Resonant Frequency $(f_s) = \frac{1}{2\pi\sqrt{LC}}$ Hz

Parallel Resonant Frequency $(f_p) = \frac{1}{2\pi\sqrt{LC_T}}$ Hz

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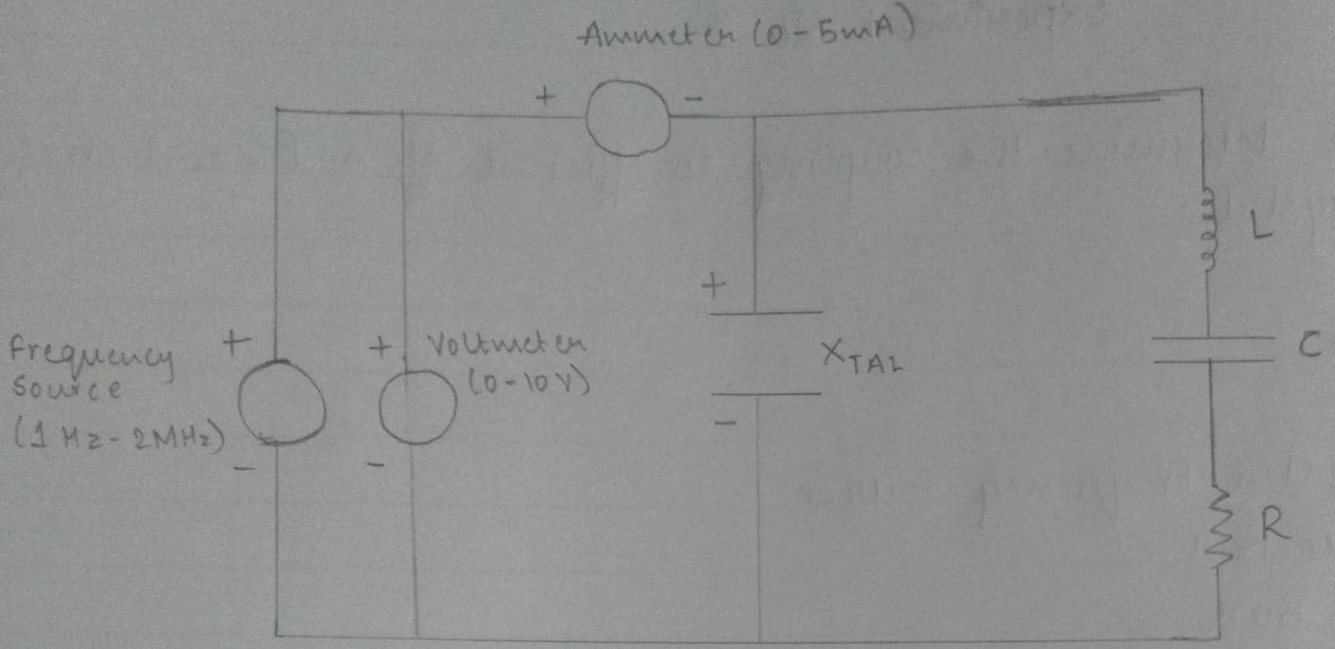
Ammeter (0-5mA)
+
-
L
+
Frequency source
(1 Hz - 2MHz)
+
-
+
-
Voltmeter
(0-10 V)
X_{TAL}
C
R

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Where, L = Inductance in Henry
C = Capacitance in Farads

Theory

A quartz crystal exhibits the property that when mechanical stress is applied across the faces of a crystal, a difference of Potential develops across opposite faces of the crystal. This property of a crystal is called the piezoelectric effect. Similarly, if a voltage applied across the one set of faces of the crystal causes mechanical distortion in the crystal shape.

When alternative voltage is applied to crystal, mechanical vibrations are set up. These vibrations having a natural resonant frequency dependent on the crystal.

Although crystal has electro mechanical resonance, we can represent the crystal action by an equivalent electrical resonant circuit. The inductor L and capacitor C electrical equivalents of the crystal mass and compliance. While resistance R is an electrical equivalent of the crystal structure is internal friction. The shunt capacitance shows the capacitance due to mechanical mounting of the crystal. Because the crystal losses are small, the equivalent crystal Q (Quality factor) is high, typically 20,000 values of Q upto 106 can be achieved by using crystal.

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Series and Parallel Resonance

Crystal as represented by the equivalent circuit can have two resonant frequencies.

- One resonant condition occurs when the reactance of the series RLC leg are equal and opposite. For this the series resonant impedance is very low.

- The other resonant condition occurs at a higher frequency when the reactance of the series resonant leg equal the reactive of the capacitor. This is parallel or anti resonance condition of the crystal. At this frequency the crystal offers very high impedence to the external circuit.

Procedure

1. Make the connections according to the fig.

2. Connect the resistance box, capacitance box, inductance box in series and connect this RLC series circuit with parallel to piezoelectric crystal box with the help of connecting leads.

3. Connect the frequency source parallel to voltmeter and current meter in the series with the circuit.

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4. Now select the value of RLC and piezoelectric crystal with the help of band switch.

5. Switch on the frequency source and set the voltage with the help of potentiometer as given on the front panel of the frequency source, read it in the voltmeter 0-10 V.

6. Now start to increase frequency from 1 Hz, we will see the current also start to increase in the ammeter at particular frequency.

7. Initially current will increase with frequency but at particular frequency, current starts to decrease. The frequency at which current start to decrease is called series resonant frequency. At this stage current will be maximum but impedence will be low. So circuit will work as series resonance circuit.

8. Now, if we are increasing the frequency continously current will be decreasing. Again, at a particular frequency current will start to increase. This is called anti resonant condition and frequency is called anti resonant frequency. Thus circuit behaves as parallel resonant circuit.

9. Note the value of RLC, piezoelectric crystal, voltage and current from the circuit.

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10. Finally plot the graph between the frequency and current or impedence Z.

11. Note the f_1 and f_2 from the graph and calculate the coupling co-efficient with the help of formula and compare it with theoretical value.