MODEL NO:AL-E859
BSC PHYSICS

DIGIT-ALL

LAB INSTRUMENTS

OPERATING MANUAL

AL-E859 COUPLING COEFFICIENT OF PIEZOELECTRIC CRYSTAL

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SCOPE OF LEARNING:

COUPLING COEFFICIENT OF PIEZOELECTRIC CRYSTAL

TECHNICAL SPECIFICATIONS:

Digital Meters:

- Ammeter 2000µA AC.
- Voltmeter 20V AC.

Power Supplies:

- Operated on Mains power 230V, 50Hz ±10%

Digital Function Generator:

- 0-2/3MHz Sine, Square and Triangle

Components are mounted on the panels are:

- 05 Nos. of Resistors selected by Rotary Switch.
- 05 Nos. of Capacitors selected by Rotary Switch.
- 05 Nos. of Inductors selected by Rotary Switch.
- 05 Nos. of Piezo Crystal selected by Rotary Switch.

SALIENT FEATURES:

- Front panel built with high class insulated Printed Circuit Board sheet with well printed circuits and symbols.
- Fuse for Short Circuit protection
- Instruction manual.
- Connections are brought out through 4mm Colored Sockets.
- Patch Cords 4mm.
- The trainer is housed in ABS Plastic cabinet.
- Size of the trainer set 12"x10"

OPTIONAL ACCESSORIES:

- Function Generator

INSTRUCTION MANUAL FOR CCPC

EXPERIMENT:-

to determine the coupling co-efficient of piezoelectric crystal.

Apparatus used:-

1. Piezoelectric crystal: - 5 nos. of crystals of standard values mounted inside the box and connections brought on the terminals on the top of the panel.
2. Resistance box: - 05 nos. of resistances connected inside the box which is selectable with selector switch in step of 20 Ω.
3. Inductance box: - 100 mH – 500 mH. in step of 100 mH.
4. Capacitance box: - 22 pf – 110 pf. In step of 22 pf.
5. AC Voltmeter: - one AC Voltmeter (0 – 20) Volt is given.
6. AC Current meter: - one AC Current meter (0 – 2000) µA.
7. Function Generator: - one function generator (1Hz – 3MHz).

8. Connecting leads.

Formula used: - We will calculate the coupling co-efficient of piezoelectric crystal with the help of formula as given below.

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

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

Series resonant frequency $fs = \frac{1}{2\pi}\sqrt{LC}$ Hz

Parallel resonance frequency $fp = \frac{1}{2\pi}\sqrt{LC_T}$ Hz

Where **L - Inductance in Hennery' (H)**

C - Capacitance in Farads (F)

$$C_T = \frac{C \times C_m}{C + C_m}$$

Where $Q = \frac{f_s}{f_2 f_1}$

Theory:- a quartz crystal exhibits' the property that when mechanical stress is applied on the phases of the of the crystal , a difference of potential develops across the opposite faces of 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 resonance circuit as shown in fig. 1. 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 Cm shows the capacitance due to mechanical mounting of the crystal. Because the crystal losses represented by internal resistance **R** are small, the equivalent crystal **Q** (Quality factor) is high typically 20,000 values of **Q** up to 106 can be achieved by using crystal.

Series and parallel resonance:-

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

1. 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(equal to**R**)
2. The other resonant condition occurs at high frequency when the reactance of the series resonant leg equal to the reactive of the capacitor C_m. this is a parallel or anti resonance condition of the crystal. At this frequency the crystal offers very high impedance to the external circuit. The graph between frequency and current **(I)**or impedance **(Z)**as shown in fig. 2.

Circuit diagram: -

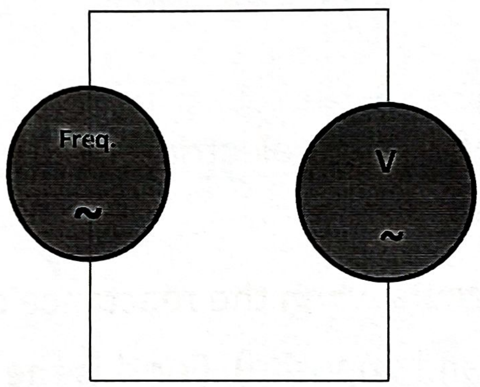


Fig.1a:-connection to measure the amplitude

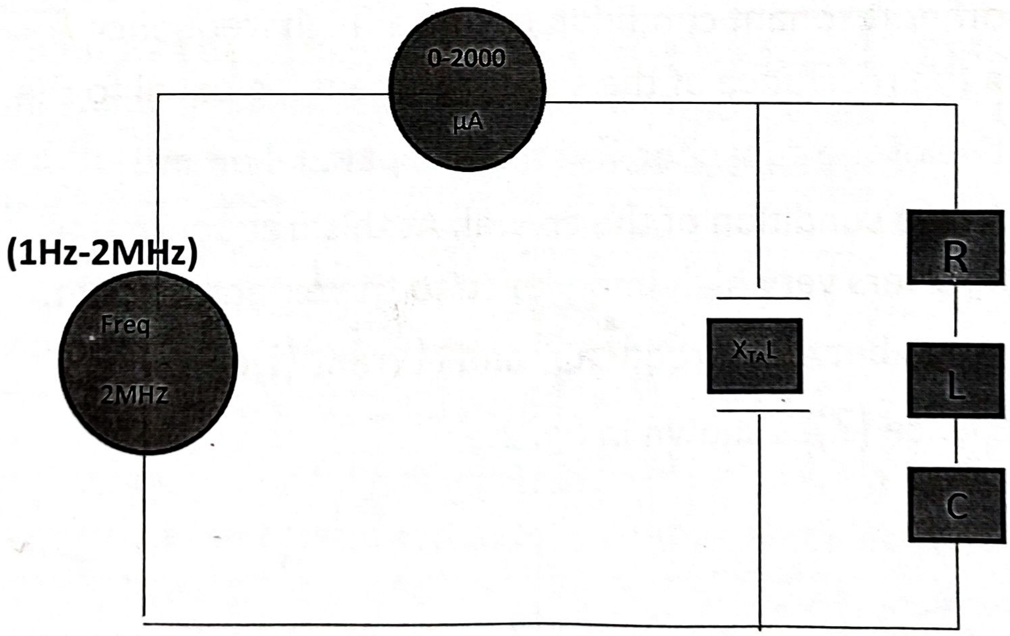
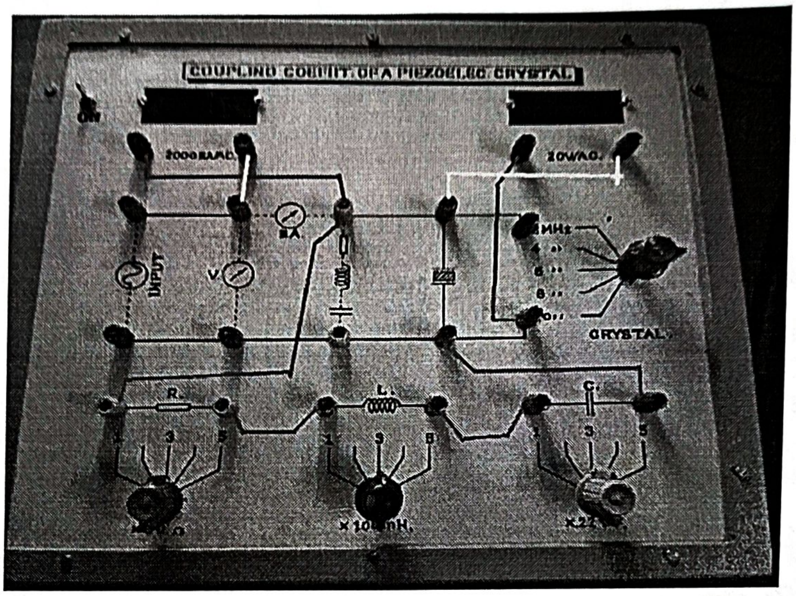


Fig.1b:-connection diagram .

Connection Diagram



Working procedure:-

1. First of all make a adjustment of function generator as
   a. Keep both the press keys as marked. 2Volt and 2Volt unpressed (upside position) to get the maximum amplitude in the AC Voltmeter (will be show approx. 7-8Volt.)
   b. To measure the amplitude set the frequency at 1KHz.
2. Now connect the frequency source, piezoelectric crystal, resistance box, inductance box and capacitance box according to fig.1.
3. Measure the amplitude of the source by connecting the AC Voltmeter in parallel with the output of the source by switching ON both the devices source and voltmeter.

Measure the amplitude one time and there is no need again to measure the amplitude throughout the experiment.

4. Now connect the components according to fig.1.
5. Insert the main leads of frequency source and AC milliameter (0-2000) μA .in to the mains sockets.
6. Finally switch ON the app. and set the value of components with the help of selector switch as given on the components mount.
7. Suppose we are selecting crystal=11MHz, R=60 Ohms, L=200mH and C= 44 pf.
8. Now start to increase the frequency in the step of Hz initially, then in KHz and in the last in step of MHz.
9. As we increase the frequency current will also be increase note down the corresponding current. Current will be increase up to peak level (at particular frequency) as we are going to increase the frequency continuously. This frequency is first resonance frequency.
10. After the peak level current will start to decrease with increase of frequency.
11. The frequency at which current will start to decrease, is called series resonant frequency at this stage current will be maximum but impedance will be low. So circuit behaves as a series resonant circuit.

12. Now if we are increasing the frequency continuously current will be decrease. Again at a particular frequency (at higher frequency) current will start to increase, this is called anti resonant condition and frequency is called anti resonant frequency. This circuit behaves as a parallel resonant circuit.
13. Note down the value of R,L,C and piezoelectric crystal, voltage and current from the circuit.
14. Finally plot the graph between frequency and current (I) or impedance (Z).
15. Note the F1 and F2 from the graph and calculate the coupling coefficient with the help of formula and make the observation table.

Observations:-

Select the values of R, L, C and crystal with the help of sector switch as provided on the mount

R= ………………. Ohm

L=………………. mH=…………..H.

C=………………. pf=…………..Farad.

X_{Tal} =……………MHz.

V=…………….volt (at 1KHz one time)

Sr.no.	Frequency Hz - MHz	Current (i) mA	Impedance. $Z = \frac{V}{I}$ Ohm.
1.			
2.			
3.			
4.			
5.			
……			
……			
……			
……			

Table no. 2:- capacitance of piezoelectric crystal measured by capacitance meter serial wise as selected by the switch provided on the mount.

Sr. no.	X_{Tal} MHz	Capacitance C_m - pf
1.	3.57MHz	4.2
2.	4 MHz	4.4
3.	6.14MHz	5.6
4.	8 MHz	3.2
5.	10MHz	3.6

Calculation:-

Plot the graph between frequency and impedance **Z.**

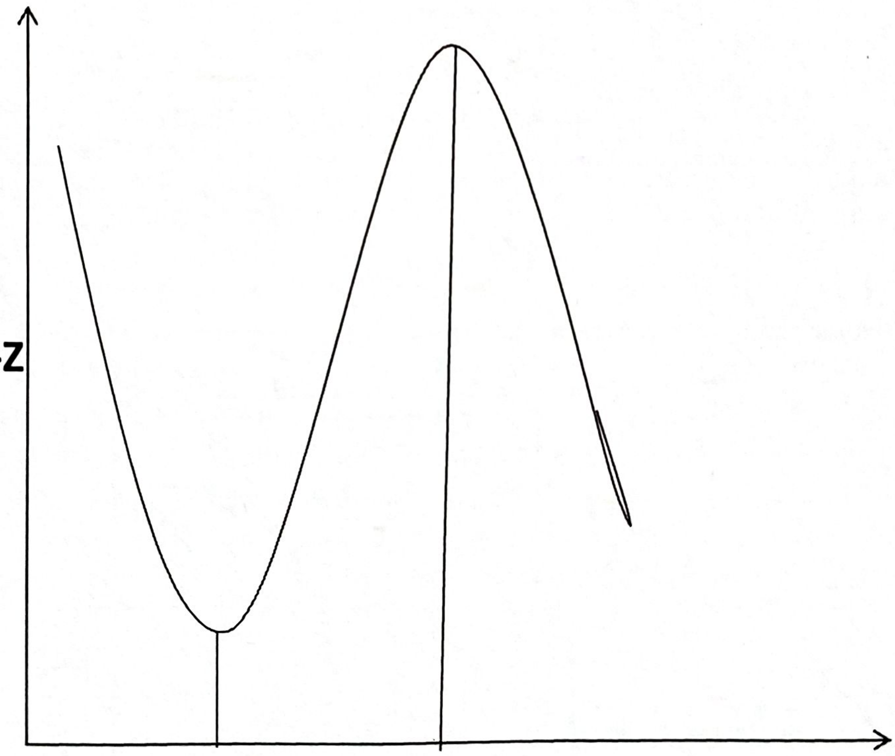
Value of coupling coefficient $K_C = \frac{(F_2 - F_1)}{F_1}$ ... from the graph.

Theoretical value of coupling coefficient $K_C = \frac{1}{Q}$

Percentage error = ...%.

Z

Impedance--Z



Frequency-------MHz

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WARRANTY

1) We guarantee the instrument against all manufacturing defects during 12 months from the date of sale by us or through our dealers.

2) The guarantee covers manufacturing defects in respect of indigenous components and material limited to the warranty extended to us by the original manufacturer and defect will be rectified as far as lies within our control.

3) The guarantee will become **INVALID.**

   a) If the instrument is not operated as per instruction given in the instruction manual.
   b) If the agreed payment terms and other conditions of sale are not followed.
   c) If the customer resells the instrument to another party.
   d) Provided no attempt have been made to service and modify the instrument.

4) The non-working of the instrument is to be communicated to us immediately giving full details of the complaints and defects noticed specifically mentioning the type and sr. no. of the instrument, date of purchase etc.

5) The repair work will be carried out, provided the instrument is dispatched securely packed and insured with the railways. To and fro charges will be to the account of the customer.

DISPATCH PROCEDURE FOR SERVICE

Should it become necessary to send back the instrument to factory please observe the following procedure:

1) Before dispatching the instrument please write to us giving full details of the fault noticed.

2) After receipt of your letter our repairs dept. will advise you whether it is necessary to send the instrument back to us for repairs or the adjustment is possible in your premises.

Dispatch the instrument (only on the receipt of our advice) securely packed in original packing duly insured and freight paid along with accessories and a copy of the details noticed to us at our factory address.