Q-METER

1.What is a Q-meter?

Q-meter **is an instrument designed for measuring Quality factor (Q) of a coil as well as for the measurement of inductance, capacitance, and resistance of an electric circuit at radio-frequency. Q-meter is also known as** RLC meter.

2.What is Quality factor of the coil?

The ratio of the inductive reactance to the effective resistance of the coil is called the Quality factor of the coil. It is denoted by Q.

$$Q=X_L/R$$

Every inductor has a certain amount of resistance, which is undesirable as it causes a power loss. The ratio of inductive reactance to the resistance of the coil is called quality factor or Q factor of the coil. i.e.

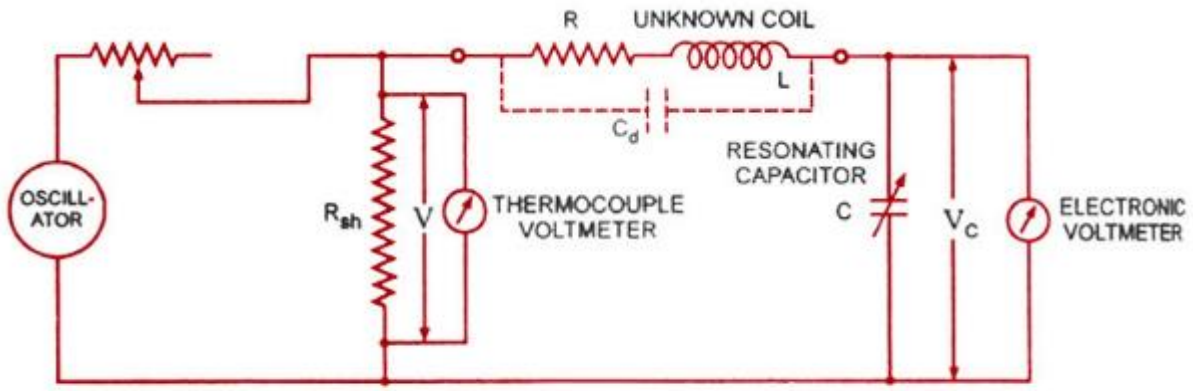
$$Q = \frac{X_L}{R} = \frac{\omega L}{R}$$

Special meters are designed to measure Q-factor correctly. These are called **Q meters**.

where X_L and X_C are the inductive and capacitive reactances resp.

Principle of Operation of Q-meter

The Q-meter operates on the principle of series resonance i.e. under the resonant condition of an AC series circuit voltage across the **capacitor** is equal to the applied voltage times of Quality factor of the circuit. If the applied voltage across the circuit is kept-constant then voltmeter connected across the capacitor can be calibrated to indicate Quality factor value directly.



Circuit Diagram of a Q-meter

Fig 1. Circuit Diagram of Q-meter

The practical circuit for measurement of Quality factor is shown in Figure 1. The wide range oscillator acting as a supply source is set to the desired frequency.The shunt resistance R_{sh} introduces negligible resistance to the ckt and therefore represents a constant voltage source of magnitude E that can be measured by a themocouple voltmeter. The tuning capacitor (C) is adjusted for maximum value which can be read by the electronic voltmeter.

C_d is the distributed capacitance of the coil. To measure Q, the unknown coil to be measured is connected between the test terminals (AB) of the instrument and the circuit is tuned to resonance either by varying frequency of the oscillator or by varying the capacitor C.

The losses in the capacitor and the R_{sh} are included in the reading of the Q meter, so the actual (effective) value of Q will be somewhat greater than the reading

The value of Q is read by the electronic voltmeter calibrated in terms of Q. The measured value of Quality factor value is defined for the whole circuit, not of the coil alone.

$$\text{At resonant frequency } f_o, \text{ we have } X_c = X_L$$

$$\text{where capacitance reactance } X_c = \frac{1}{2\pi f_o C}$$

$$\text{Inductive reactance, } X_L = 2\pi f_o L$$

$$\text{Resonant frequency, } f_o = \frac{1}{2\pi\sqrt{LC}}$$

$$\text{Current at resonance, } I_o = \frac{V}{R}$$

$$\text{Voltage across capacitor, } V_c = I_o X_c = I_o X_L = I_o \omega_o L$$

$$\text{Input voltage, } V = I_o R$$

$$\therefore \frac{V_c}{V} = \frac{\omega_o L}{R} = Q$$

$$\therefore V_c = QV$$

Measurement of Inductance using a Q-meter:

The value of inductance is given by

$$L = \frac{1}{4\pi^2 f_0^2 C}$$

the values of f_0 and C are known and therefore the value of inductance may be calculated.

Measurement of Effective Resistance using a Q-meter:

The value of effective resistance may be computed from the relation

$$R = \frac{\omega_0 L}{Q_{true}}$$

Measurement of Self-Capacitance using a Q-meter:

The self-capacitance of the coil is measured by making two measurements at different frequencies. The capacitor is set to a high value and the circuit is resonated by adjustment of the oscillator frequency. The Resonance is indicated by the circuit Q-meter. Let the value of the tuning capacitor be C_1 and that of frequency be f_1 under this condition. Therefore,

$$f_1 = \frac{1}{2\pi\sqrt{L(C_1 + C_d)}}$$

The frequency is now increased to twice its initial value and the circuit is resonated again this time with the help of the tuning capacitor. Let the values of the tuning capacitor be C_2 and that of frequency be f_2 under this condition. Therefore,

$$f_2 = \frac{1}{2\pi\sqrt{L(C_2 + C_d)}}$$

Now, $f_2 = 2 * f_1$

Then distributed capacitance, C_d is given by

$$C_d = \frac{C_1 - 4C_2}{3}$$

Applications of Q-Meter:

1. As the name implies, it can measure Quality factor and is generally used to check the Quality factor of inductors.

2.It is used to measure self-capacitance of the coil.

3. Q-meter is used for the measurement of capacitance. The capacitor sample is resonated with a selected inductor by adjusting the source frequency and by using the tuning capacitor set to a low value on its calibrated scale.

Questions & Answers:

Q1. On what principle does a Q-meter operate?
Answer. The Q-meter operates on the principle of series resonance i.e., under a resonant condition of an ac series circuit voltage across the capacitor is equal to the applied voltage times of Q of the circuit.

Q2. What are the different parameters that can be measured using a Q-meter?
Answer. The Q-meter is used for measuring Q-factor, inductance, effective resistance, self-capacitance, bandwidth and capacitance.

Q3. Why the actual Q-factor of the coil is somewhat larger than the calculated Q-factor?
Answer. The calculated value of Q-factor is somewhat smaller than its actual value because Q-factor measurement includes the losses of the resonating capacitor, voltmeter and the shunt resistance R_{sh}.

Q4. What is Q-factor of the coil?
Answer. The ratio of the inductive reactance to the effective resistance of the coil is called the Q-factor of the coil.

Q5. What is Q-meter?
Answer. The Q-meter is an instrument designed for measurement of Q-factor of a coil as well as for the measurement of electrical properties of coils and capacitors.

Q6. What are the factors which affect the measurement accuracy of Q-meter?

Answer. The factors affecting measurement accuracy are

1. Distributed capacitance or self-capacitance of the coil
2. Residual inductance of the instrument
3. Conductance of voltmeter
4. Shunt resistor of Q-meter

LCR Meter: LCR bridge

LCR meters or LCR bridges are items of test equipment or test instrumentation used to measure the inductance, capacitance, and resistance of components.

For further reading visit

https://www.electronics-notes.com/articles/test-methods/lcr-meter-bridge/primer-basics.php

RLC bridge

The RLC Bridge is the single bridge which can be used for measurement of all the three parameters viz., resistance, inductance and capacitance.

It consists of signal source (ac or dc) and a detector along with following inbuilt bridges:

Wheatstone Bridge: For measurement of resistance.

Maxwell's or Hay Bridges: For measurement of inductance.

De Sauty Bridge: For measurement of capacitance.

For further reading visit

https://electricalworkbook.com/rlc-bridge/#:~:text=The%20RLC%20Bridge%20is%20the,Bridge%3A%20For%20measurement%20of%20resistance.