5.1 MEASUREMENT OF SELF INDUCTANCE OF A COIL

AIM

1) To show that the impedance of a coil of resistance R_L and self inductance L varies with frequency as

$$Z_{coil} = (R_L^2 + 4\pi^2 f^2 L^2)^{1/2}$$

2) To measure the self-inductance of the coil.
3) To measure the resistance of the coil

APPARATUS REQUIRED

1) Signal generator
2) R-L-C box,
3) DMM to measure both AC voltage in the range 2V to three decimal places, and frequency.

THEORY

A coil with a self-inductance L and resistance R_L has an impedance $Z_{coil}(\omega)$ given by

$$Z_{coil}(\omega) = R_L + j\omega L \qquad (2.1)$$

where $j = \sqrt{-1}$) and $\omega = 2\pi f$, f being the frequency of the AC supply. The magnitude of the impedance is $(R_L^2 + \omega^2 L^2)^{1/2}$. If we connect an AC source across a resistance R in series with the inductor, then the rms voltage across R and across the coil will be in the ratio

$$V_{coil}/V_R = |Z_{coil}|/R = (R_L^2 + \omega^2 L^2)^{1/2}/R \qquad (2.2)$$

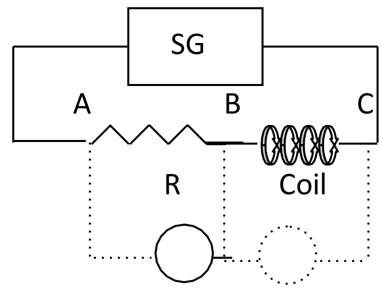
If we measure V_{coil}/V_R at different frequencies, a plot of $(V_{coil}/V_R)^2$ vs. f^2 will give a straight line, the slope of which is given by (⍰⍰L/ R)^2. From the slope one can determine L knowing R.

It is not necessary to keep the amplitude of the signal constant as one varies the frequency because we are only taking the ratio V_{coil}/V_R.

The total applied voltage is less than the sum of the measured voltages across the resistance R and the coil

$$V_{app}^2 = V_R^2 + V_{coil}^2 + 2V_R V_{coil}\cos\Phi \qquad (2.3)$$

PROCEDURE



1) The two terminals of the signal generator are connected to the terminals A and C on the R-L-C box.
2) The signal generator voltage is applied across the resistance and the coil in series. The output of the signal generator is kept at around 1 Volt.
3) A DMM in AC 2 V range connected between A and B measures the rms voltage drop V_R across the resistance.
4) The same DMM connected between B and C measures the rms voltage drop V_{coil} aross the coil.
5) Connected between A and C the DMM measures V_{app}.
6) The frequency of the signal is varied between 200 and 2000 Hz in steps of 200 Hz and V_{coil}, V_R and V_{app} are measured.
7) plot a graph of $(V_{coil}/V_R)^2$ vs f^2.
8) Plot a graph of $\tan\Phi$ vs f.

OBSERVATIONS AND CALCULATIONS

f Hz	f^2 $(KHz)^2$	V_{coil} volts	V_R volts	V_{app} volts	$(V_{coil} / V_R)^2$	$\cos(\Phi)$	$\tan(\Phi)$
200							
400							
600							
800							
.							
.							
.							
1800							
2000							

1) plot a graph of $(V_{coil}/V_R)^2$ vs f^2.

Slope of the graph (α) =

Self-inductance of the coil $L = (\alpha^{1/2} R)/2\pi$

2) Plot a graph of $\tan\Phi$ vs f

$$V_{app}^2 = V_R^2 + V_{coil}^2 + 2V_R V_{coil} \cos\Phi$$

Using the above formula we may calculate $\cos\Phi$ from the measured values of V_{app}, V_R and V_{coil}

$\cos\Phi$ =

Φ =

$\tan\Phi$ =

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Slope of the graph (β) =

$\beta = 2\pi L/R_L$

R_L =

RESULT

1) Self inductance of the coil L =
2) Resistance of the coil R_L =

PRECAUTION

1) $\tan(\Phi)$ increases with f. At high frequency Φ will approach 90 degrees. $\tan(\Phi)$ will increase rapidly with Φ as approaches 90 degrees. That is the reason why the measurements are restricted to frequencies below 2 kHz.