Experiment No. 7
AC-Bridge Meter

Objective:

(1) To measure unknown capacitance.

(2) To find out the total impedance for parallel or serial connections.

Equipment:

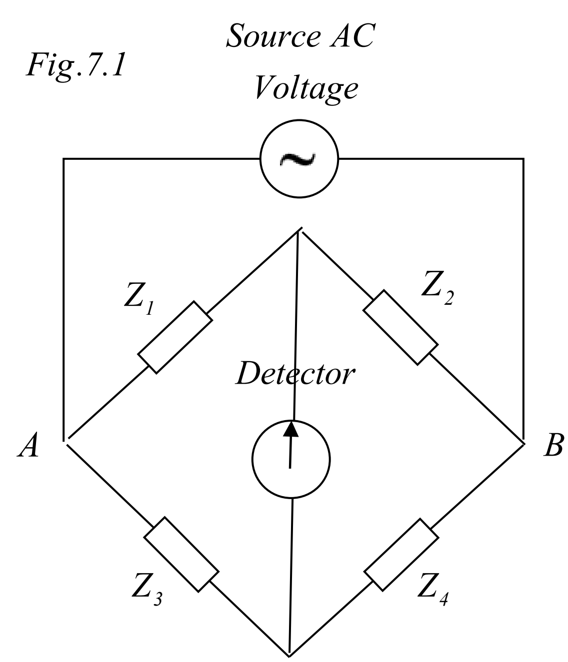
(1) Oscilloscope CRT.
(2) AC power supply.
(3) Unknown capacitors.
(4) The Potentiometer.

Theory

Measuring a complex impedance with an alternating current (A. C.) is to use some of the types of AC-Bridges, which is an extension of the DC-Wheatstone Bridge.

A generalized diagram for the AC Wheatstone Bridge is shown in Fig. 7.1.

Fig.7.1



When the voltage across the detector is zero (Detector reads zero), the voltages at both sides of the bridge must be the same. This means that both sides have voltages of the same values for amplitudes and phases. When this balance condition is satisfied (Detector reads zero) it involves two balancing conditions for real and imaginary parts of the complex impedance which must be satisfied simultaneously. Therefore one can use two variable impedances (say for example two capacitances) which can be varied independently the detector reads a minimum value.

When the minimum is achieved, the balance condition for an AC bridge as shown in Fig. 1 is given by

$$\frac{Z_1}{Z_2} = \frac{Z_3}{Z_4}$$

With this equation both balance conditions for real and imaginary parts of the impedances are satisfied simultaneously.

In particular, the AC bridge is used to measure capacitance and the same general balance equation given above can be applied when a balance condition is achieved.

Resistances and capacitances are variable impedances and can be used to reach a balance condition to determine the value of unknown capacitance. This general bridge is shown in fig. 7.2. The unknown capacitor (or condenser) C_x is represented by the series grouping of C_x and the standard capacitor C_s on the same arm. The capacitance value C_s should be known and well defined. The value of the resistances R_1 and R_2 are variable since they are determined by the two lengths L_{AC} and L_{CB} of the wire resistor (cross sectional area is same) when the balance condition is reached,

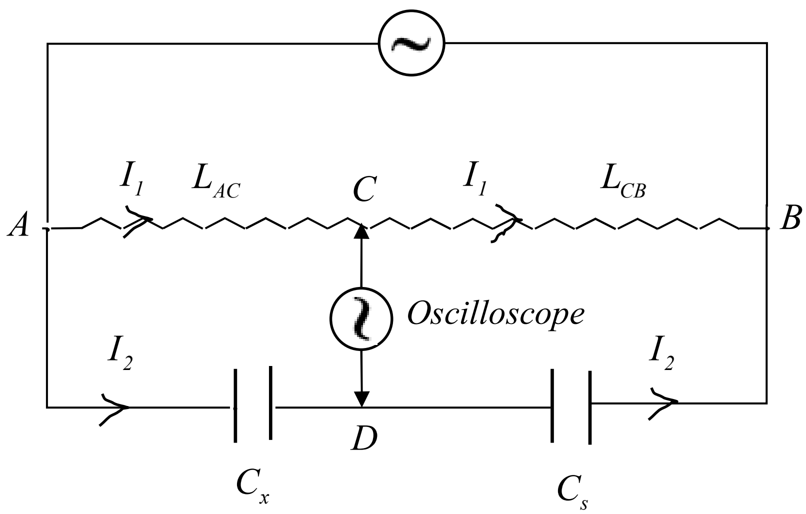


Fig.7.2

The Balance condition can be expressed as follows:

$$V_D - V_C = 0$$

For the left branch

$$V_{AD} + V_{DC} + V_{CA} = 0$$

$$V_{AD} + V_{CA} = 0,$$

$$V_{AD} = -V_{CA} = V_{AC}$$

$$I_1 R_{AC} = I_2 Z_x$$

Same for the right branch $V_{BD} = V_{BC}$

$$I_1 R_{CB} = I_2 Z_s \qquad \Rightarrow \frac{I_1 R_{AC}}{I_1 R_{CB}} = \frac{I_2 Z_x}{I_2 Z_s} \qquad \text{and} \qquad \Rightarrow \frac{R_{AC}}{R_{CB}} = \frac{Z_x}{Z_s}$$

$$\Rightarrow \frac{\rho \frac{L_{AC}}{A}}{\rho \frac{L_{CB}}{A}} = \frac{j/\omega C_x}{j/\omega C_s}, \qquad \Rightarrow \frac{L_{AC}}{L_{CB}} = \frac{C_s}{C_x} \qquad \Rightarrow \quad C_x L_{AC} = C_s L_{CB}$$

$$\boxed{C_x = C_s \frac{L_{CB}}{L_{AC}}} \qquad \text{or} \qquad \boxed{C_s = C_x \frac{L_{AC}}{L_{CB}}}$$

Which determine the unknown capacitance C_x at the balance condition (which appears as a minimum amplitude at the oscilloscope screen)

PROCEDURE

(1) Use the experimental arrangement shown in Figure 7.2 to determine C_{x1}.

(2) Adjust the standard capacitance C_s = 68 µF.
(3) Record the distance AC when the balance condition is satisfied (signal on the oscilloscope shows minimum zero amplitude)
(4) Repeat step 3 for C_s = 100, 470, and 1000 µF and 4 ohms.
(5) Repeat the procedure for another unknown C_{x2}.
(6) Repeat the same measurements for series and parallel capacitance for C_{x1} and C_{x2}.
(7) Tabulate your results in table 4.1.
(8) Plot on the same graph C_s versus L_{AC}/L_{CB}.
(9) Find the slope for each graph, this will give the value of the corresponding C_x.

Experiment No. 7
AC bridge meter

Name: ………………………………….................................... Day and Date: ……….……………

Student's No.: ……………………………………………..………...….. Sec: ……………..…………..

Partners Names: …………………………………………………………….……………………………

Data and Calculation:

C_{x1} true value = ( ) μF				C_{x2} true value = ( ) μF			
C_s(μF)	L_{AC}(cm)	L_{CD}(cm)	$\frac{L_{AC}}{L_{CB}}$	C_s(μF)	L_{AC}(cm)	L_{CB}(cm)	$\frac{L_{AC}}{L_{CB}}$
68							
100							
470							
1000							
$S_1 = C_{x1} =$				$S_2 = C_{x2} =$			

C_{xs} true value = ( ) μF				C_{xp} true value = ( ) μF			
C_s(μF)	L_{AC}(cm)	L_{CB}(cm)	$\frac{L_{AC}}{L_{CB}}$	C_s(μF)	L_{AC}(cm)	L_{CB}(cm)	$\frac{L_{AC}}{L_{CB}}$
68							
100							
470							
1000							
$S_s = C_{xs} =$				$S_p = C_{xp} =$			

Plot** C_s **vs.** L_{AC} / L_{CB} **on the same graph below for each values and determine the slope of each line.

(1) From your graph determine each value of C_x =S.

(2) Find the percentage error for each value of C_x for:

C_{x1}:

C_{x2}:

C_{xs}:

C_{xp}:

*(3) Show **from your values** of slopes that* $C_{xp} = C_{x1} + C_{x2}$ *and* $\frac{1}{C_{xs}} = \frac{1}{C_{x1}} + \frac{1}{C_{x2}}$.