BRIDGES
IMPEDANCE MEASUREMENT

Experiment # 4

EE 312
Basic Electronics Instrumentation Laboratory
Fall 2000

September 20, 2000

OBJECTIVES:

- The first objective of this experiment is to learn how to use bridges used to measure values for Resistance R, Capacitance C, & Inductance L
- The second objective is to determine the **precision, accuracy and probable error** in the measured values.

In this experiment, you will learn to measure:

Resistance	using a	Wheatstone Bridge,
Capacitance	using a	Desaulty Bridge*,
Inductance	using a	Maxwell Bridge.

* The name Desaulty could not be found in IEEE Standard Dictionary of Electrical & Electronics Terms, IEEE-Std-100-1992.

Components:

1. Isolation Transformer (1:1)
2. Four Resistance Boxes
   - a) Heathkit Precision Box c) EICO Industrial Box
   - b) Industrial Precision Box d) Heathkit Substitution Box
3. Two Capacitance Boxes & Two Capacitors
   - a) Precision Box c) Unknown Capacitor
   - b) Substitution Box d) 200 uF Capacitor
4. 1mH Inductor

Experiment # 4

Part I- Resistance Measurement

- Wheatstone Bridge

Part II- Capacitance Measurement

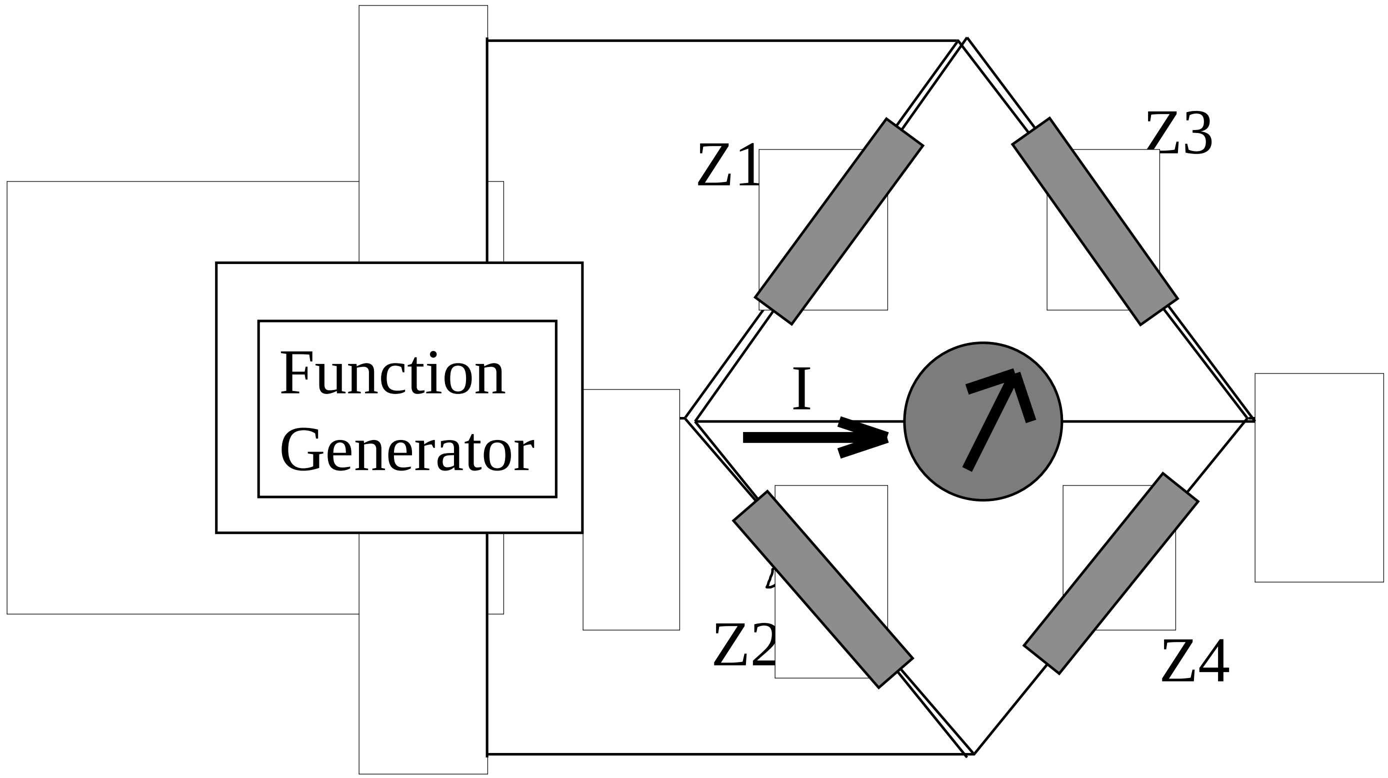
- DeSaulty Bridge

Part III- Inductance Measurement

- Maxwell Bridge

At balance I = 0

Z1 . Z4 = Z2 . Z3



At balance $I = 0$

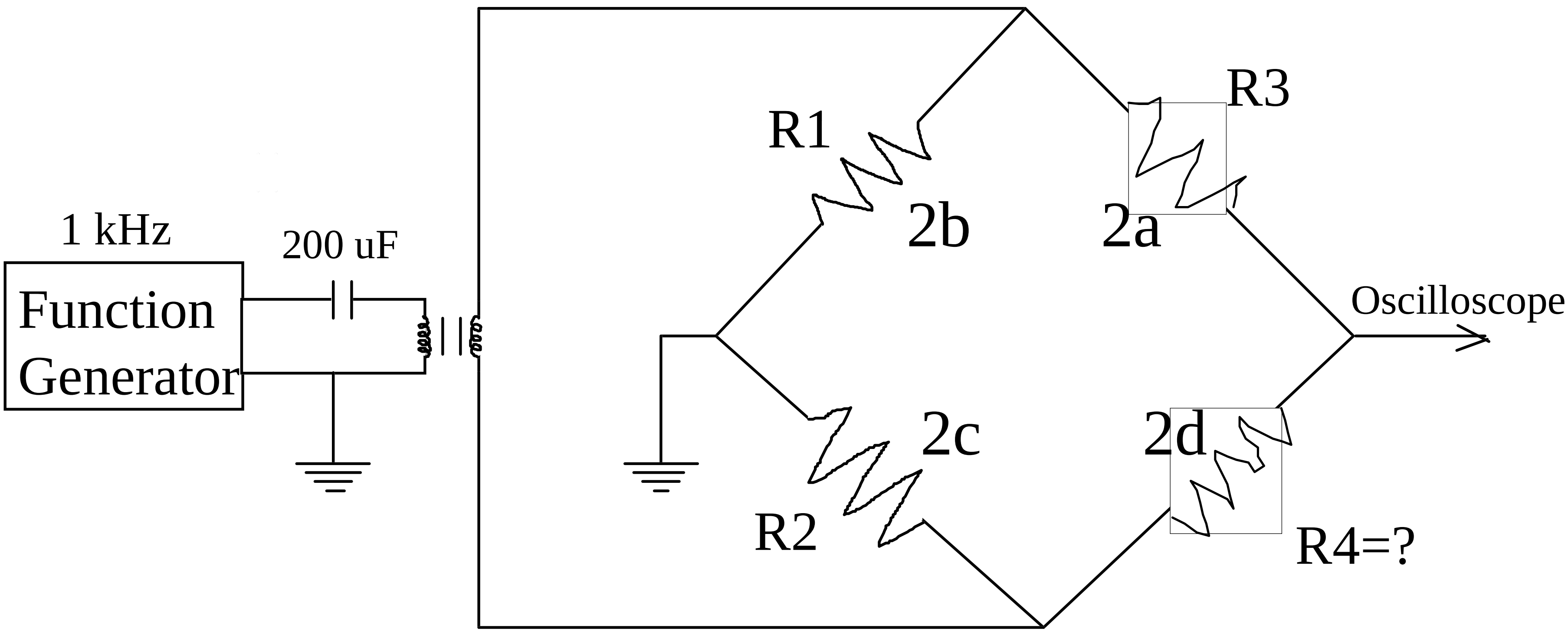
The voltages on each side of the meter must be equal. Thus

$$V(FG) \times Z2/(Z1+Z2) =$$
$$V(FG) \times Z4/(Z3+Z4)$$

Cross multiply and simply to obtain

$$Z2 \,.\, Z3 = Z1 \,.\, Z4$$

Part I- Resistance Measurement



$$Z2 \cdot Z3 = Z1 \cdot Z4$$

$$R2 \cdot R3 = R1 \cdot R4$$

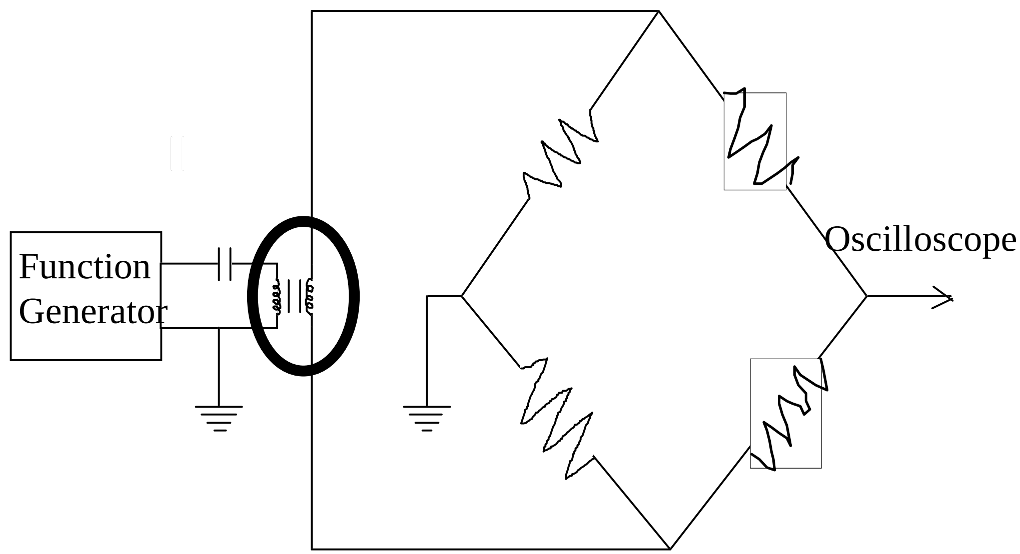
$$R4 = R3 \times (R2/R1)$$

$$R4 = R3 \div (R1/R2)$$

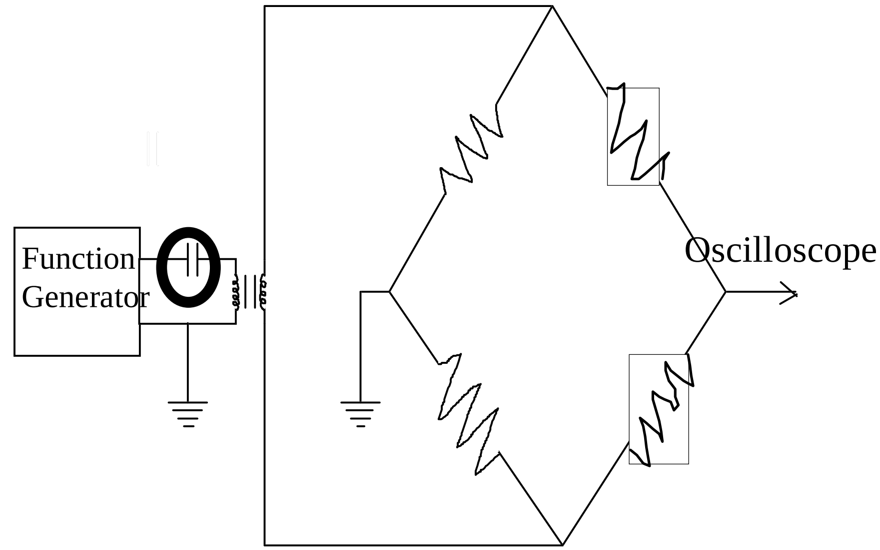
If R3 is viewed as the standard, then the unknown R4 equals the standard multiplied by the ratio R2/R1 or divided by the ratio of R1/ R2. The sharpest null is obtained by keeping the ratio R2/R1 = 1. However, this can be done only if a standard equal to the unknown is available.

Record values for R1, R2, R3, & R4.

- Transformer between the function generator and the bridge is used to isolate **grounding** of the bridge circuit as shown. This, in turn, makes possible the use of a single channel of the oscilloscope instead of a differential mode for balancing the bridge.

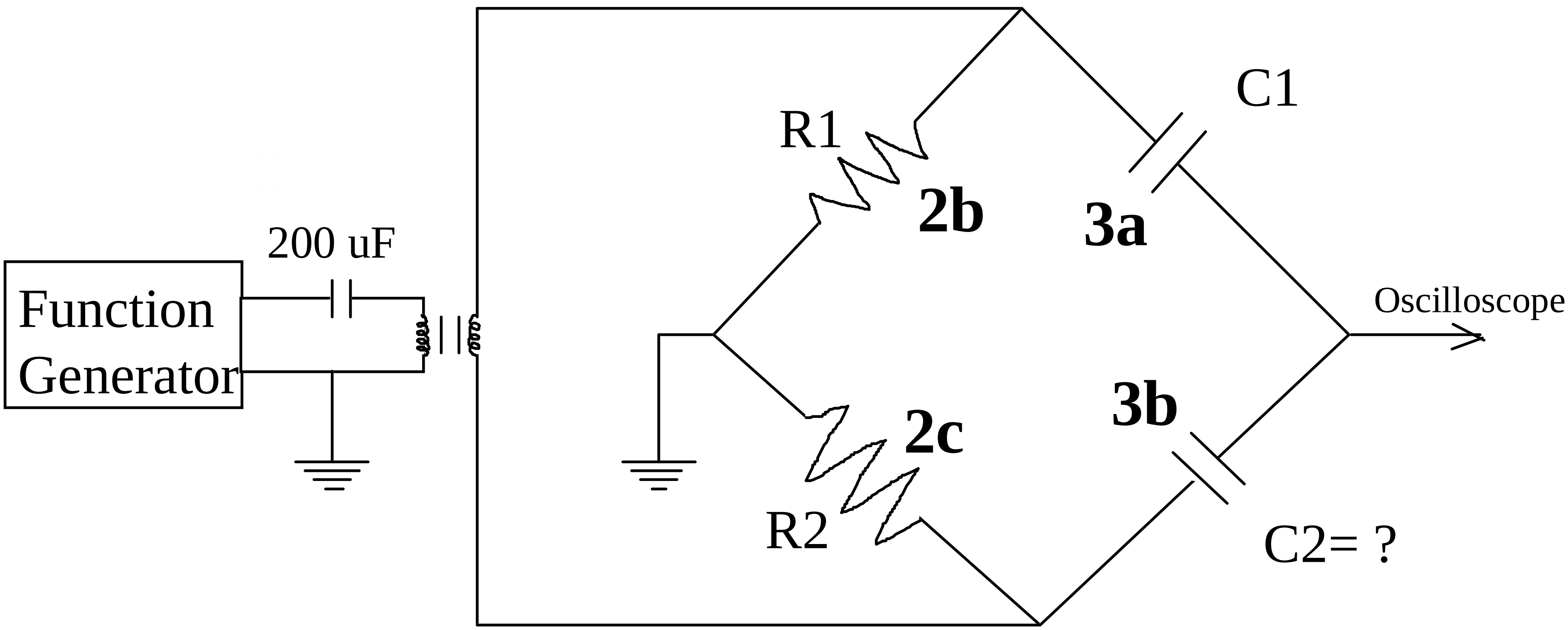


- The capacitor between the function generator and the transformer is used to prevent accidental dc bias to the transformer and electrical shock if a lead is disconnected.



$$V(t) = L \times \frac{dI}{dt}$$

Part II- Capacitance Measurement



$Z2 . Z3 = Z1 . Z4$

$R2 . (1/j\omega C1) = R1 . (1/j\omega C2)$ & $R2C2 = R1C1$

$C2 = C1 \times (R1/R2)$

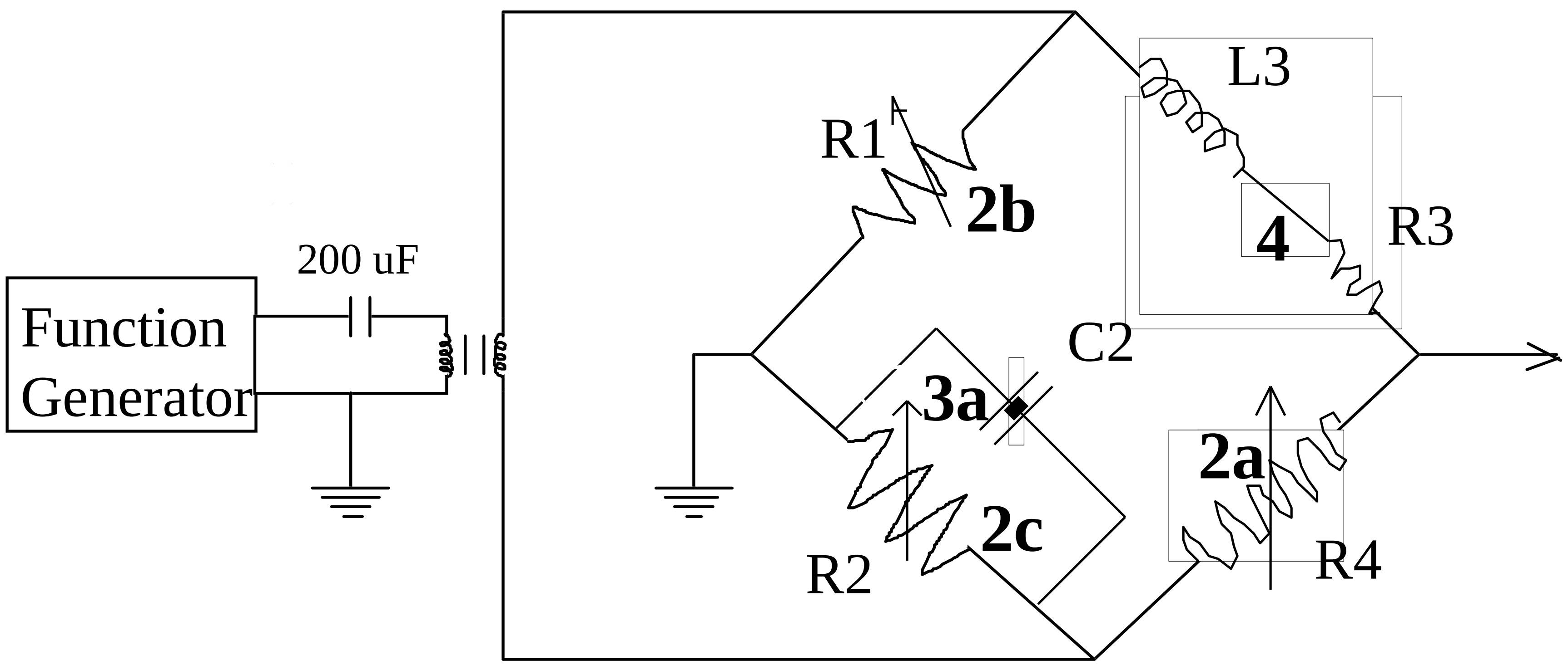
$C2 = C1 \div (R2/R1)$

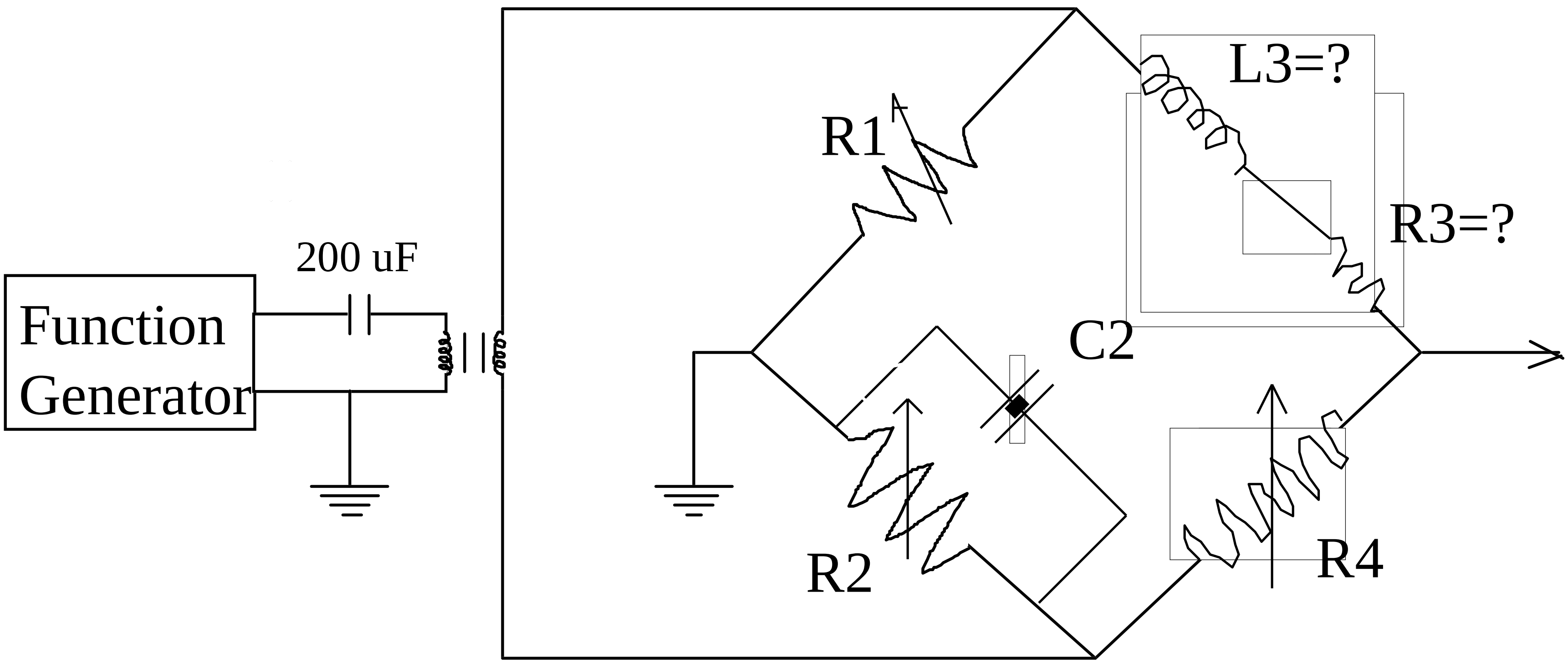
If C1 is viewed as the standard, then the unknown C2 equals the standard multiplied by the ratio R1/R2 or divided by the ratio of R2/ R1. The sharpest null is obtained by keeping the ratio R2/R1 = 1. However, this can be done only if a standard equal to the unknown is available.

Record values for R1, R2, C1, & C2.

A capacitor of unknown (to you) value will be supplied by an instructor. Measure the value of this capacitance and then find out from the instructor what the actual value is.

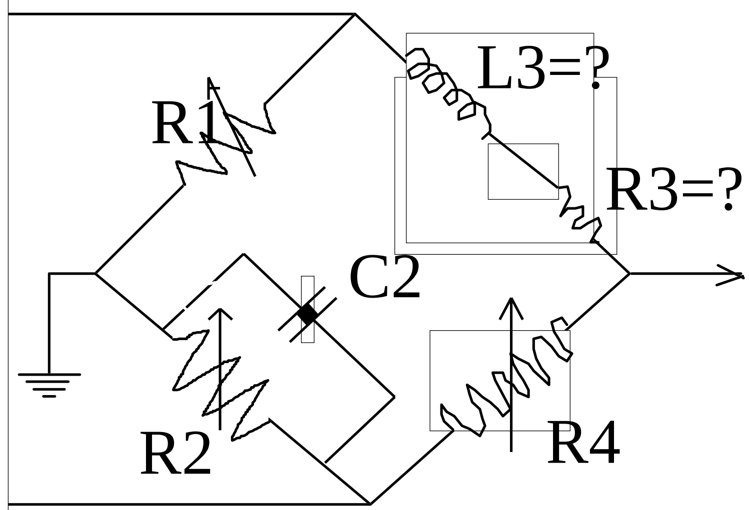
Part III- Inductance Measurement





- Measure the values for inductance L3 of an unknown inductor and its internal resistance R3. The nominal inductance equals 1 mH.
- Measure the dc value for the resistance R3 of the inductor with a Fluke DMM. Skin effect could cause the ac resistance to increase as the ac frequency increases.

Can you explain skin effect?



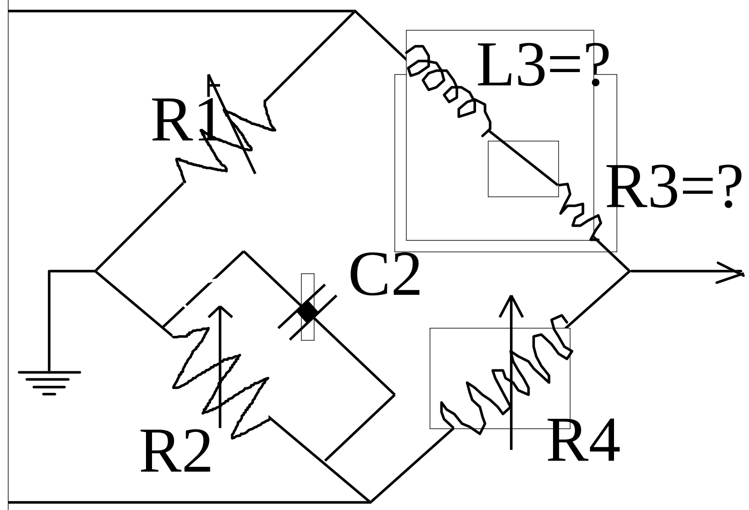
$$Z_1 \times Z_4 = Z_2 \times Z_3$$

$$R_1 \times R_4 = (R_3 + j \cdot L_3 \cdot \omega) \cdot \left(\frac{1}{\left(\frac{1}{R_2} + j \cdot \omega \cdot C_2 \right)} \right)$$

$$R_1 \cdot R_4 + \mathrm{j} \cdot \omega \cdot R_1 \cdot R_2 \cdot R_4 \cdot C_2 = R_2 \cdot R_3 + \mathrm{j} \cdot \omega \cdot R_2 \cdot \mathrm{L}_3$$

$$R_3 = \frac{R_1 \cdot R_4}{R_2}$$

$$L_3 = R_1 \cdot R_4 \cdot C_2$$



- Keep C2 & R4 constant .
- Vary R1 & R2 until balance reached.

New Task for 2000

- : Eliminate the isolation transformer & repeat Maxwell Bridge Exp. using CRO Differential Measurement Technique.

No Report for Experiment 4 Bridges

Since there is no report, your Laboratory Notebook (LN) should be done carefully and should include discussion and conclusions.

The weighting factor for the Laboratory Notebook grade for E4 will be higher than that for E3.