Instituto Politécnico Nacional

Ingeniería en Sistemas Computacionales

Laboratorio de Instrumentación

Practica N° 4 “Acondicionamiento de Sensores de Reactancia Variable”

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Fecha de elaboración: 06/10/21.

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Objective

The student will implement alternating current bridge circuits for the conditioning of variable reactance sensors.

Equipment employed

- Computer
- Software tool for electronic circuit simulation (Multisim or PROTEUS).
- Internet connection.

Introduction

Variable reactance sensors

Before we begin, we will return to the definition of reactance, which refers to the opposition to the passage of alternating current by inductors or capacitors; its unit of measurement is ohms.

Then the variable reactance sensors are those whose impedance changes with some physical magnitude.

The variation of the reactance of a circuit provides measurement alternatives to those offered by resistive sensors. Most of them do not require physical contact with the system to be measured, therefore they provide better solutions for linear and angular displacement measurements.

These sensors do not have a linear behavior, but in some cases it is corrected by differential sensors.

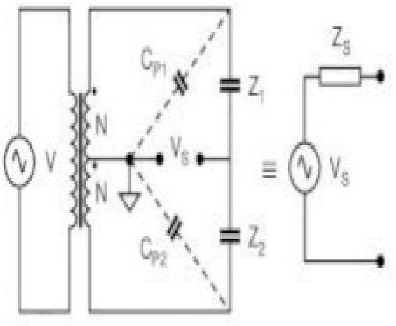
On the other hand, they have a limitation in the maximum admissible variation frequency in the measurement variable, which must be lower than the frequency of the supply voltage used, necessarily alternating.

These sensors are classified as capacitive e inductive.

Blumlein bridge for capacitive sensors

In order to acondicionado variable reactance sensors the classic solution is to use a measure configuration in an alternate feeding bridge. In this way the output tension Vs, has the same frequency that the input tension and its amplitude is modulated for the measured magnitude.

The Blumlein bridge looks like this:

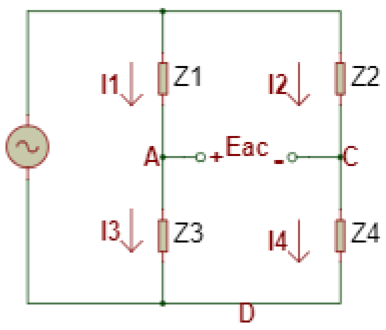


And its mathematical model is:

$$V_S = \frac{V}{2} \cdot \frac{Z_2 - Z_1}{Z_1 + Z_2} \quad y \quad Z_S = Z_1 \| Z_2$$

AC Bridge

used to measure unknown inductances and capacitances,consists of 4 branches and a sine-wave source
It is similar to the wheatstone bridge but in its inductors or capacitors, and this is a example of AC bridge:



when the bridge is in balance:

$$Z_1 Z_4 = Z_2 Z_3$$

$$(R_1 + j\omega L_1)R_4 = (R_2 + j\omega L_2)R_3$$

$$R_1 = \frac{R_3}{R_4} R_2 \ldots \ldots . equ(1)$$

$$j\omega L_1 R_4 = j\omega L_2 R_3$$

$$L_1 = \frac{R_3}{R_4} L_2 \ldots \ldots . equ(2)$$

The I1 and R1 are the unknown quantities that are measured in terms of R2, R3, R4, and I2. From equation (1) and (2) the following points are concluded.

- The two balance equations are always obtained from AC bridges.
- The unknown quantities are determined through the balanced equations. The unknown quantities are usually inductance, capacitance, and resistance.
- The balance equations are independent of frequency.

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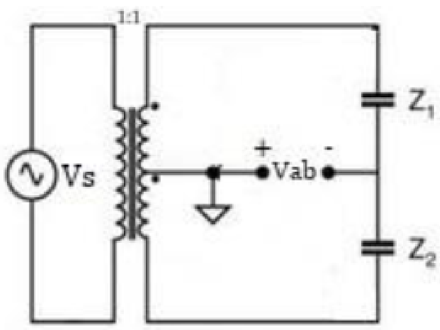
Development

1. Blumlein bridge circuit for capacitive sensors.

In the circuit simulation software tool, assemble the circuit in Figure 1 using the capacitors as a differential capacitive sensor. Determine the minimum and maximum capacitance values needed in the differential capacitive sensor, considering that the AC bridge circuit must deliver a maximum output voltage of ±1.5V RMS and that in equilibrium it develops capacitances of 90pf.

$$V_{ab} = \frac{V_S}{2}\left(\frac{C_2 - C_1}{C_2 + C_1}\right)$$

Adjust the capacitive values with the calculated value and then to the transformer to deliver a voltage of 5V RMS at a frequency of 60HZ.Check the operation of the circuit, measuring with an AC voltmeter the minimum and maximum output voltage of the bridge circuit and note it in Table 1.Modify the value of the capacitances by inverting their maximum and minimum values by reversing the operation of the differential capacitive sensor.



C1 (pf)	C2 (pf)	Vab(rms) (Volts)
144	36	-1.48
90	90	0
36	144	1.48

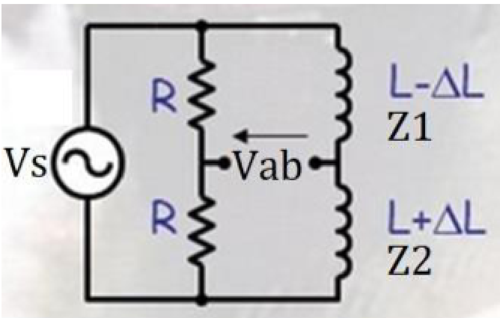
Table 1.Capacitances in the differential capacitive sensor.

2. **CA bridge for inductive sensors.**

In the circuit simulator, build the circuit in Figure 2 using the inductors as a differential inductive sensor. to deliver a maximum output voltage of ± 1.5V effective and that in equilibrium develops inductances of 50mH.

$$V_{ab} = \frac{V_S}{2}\left(\frac{L_1 - L_2}{L_1 + L_2}\right)$$

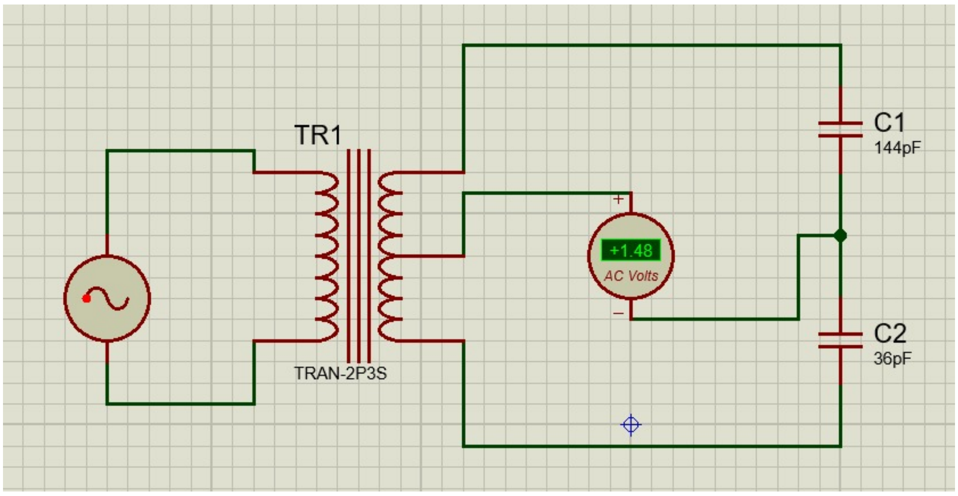
Adjust the resistive as well as the inductive values with the calculated value and then the AC source to deliver an effective voltage of 5V at a frequency of 60HZ Verify the operation of the circuit by measuring the minimum and maximum output voltage of the bridge circuit with a voltmeter from AC and write it down. in Table 2. Modify the value of the inductances by inverting their maximum and minimum values when inverting the operation of the inductive differential sensor.



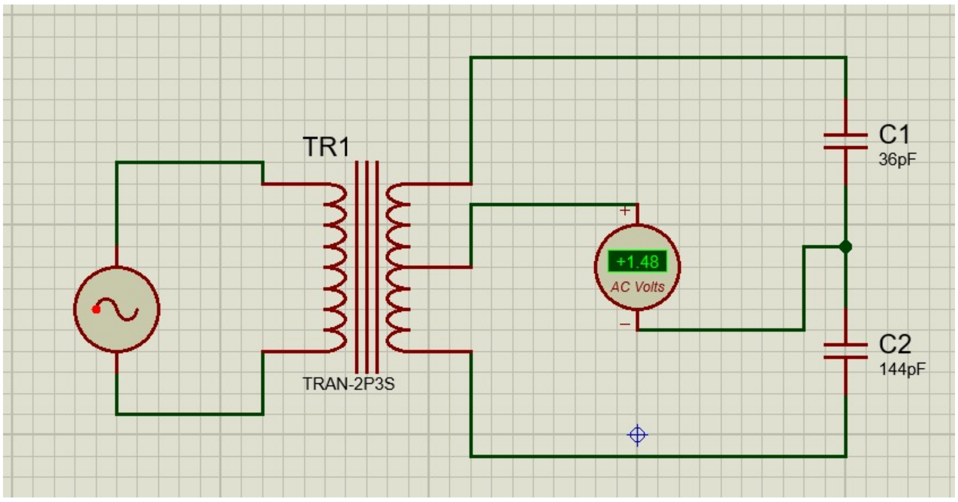
L1 (mH)	**L2 (mH)**	**Vab(rms) (Volts)**
86.25	13.75	1.28
50	50	0
13.75	86.25	1.28

Table 2. Inductances in the differential inductive sensor.

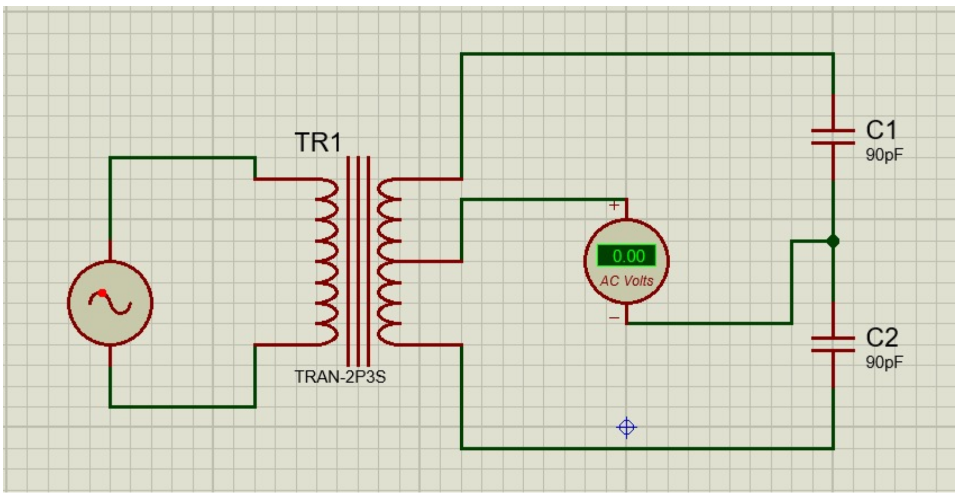
Evidence circuit 1



C1=144pF, C2=36pF, Vab=1.48V

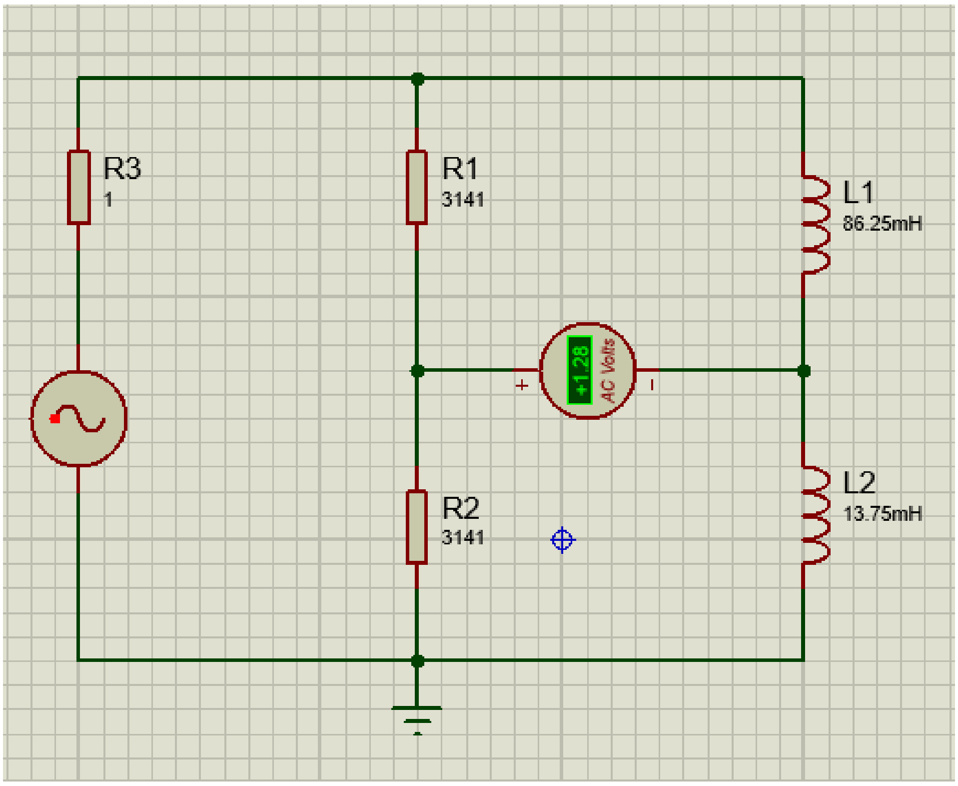


C1=36pF, C2=144pF, Vab=1.48V

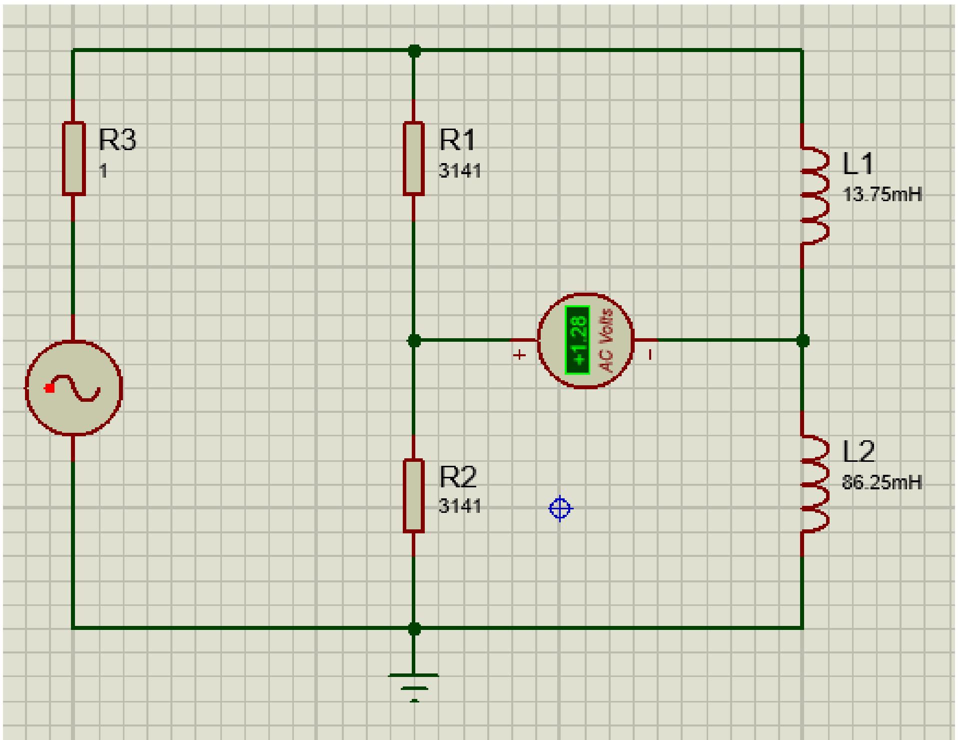


C1=90pF, C2=90pF, Vab=0V ->Balance

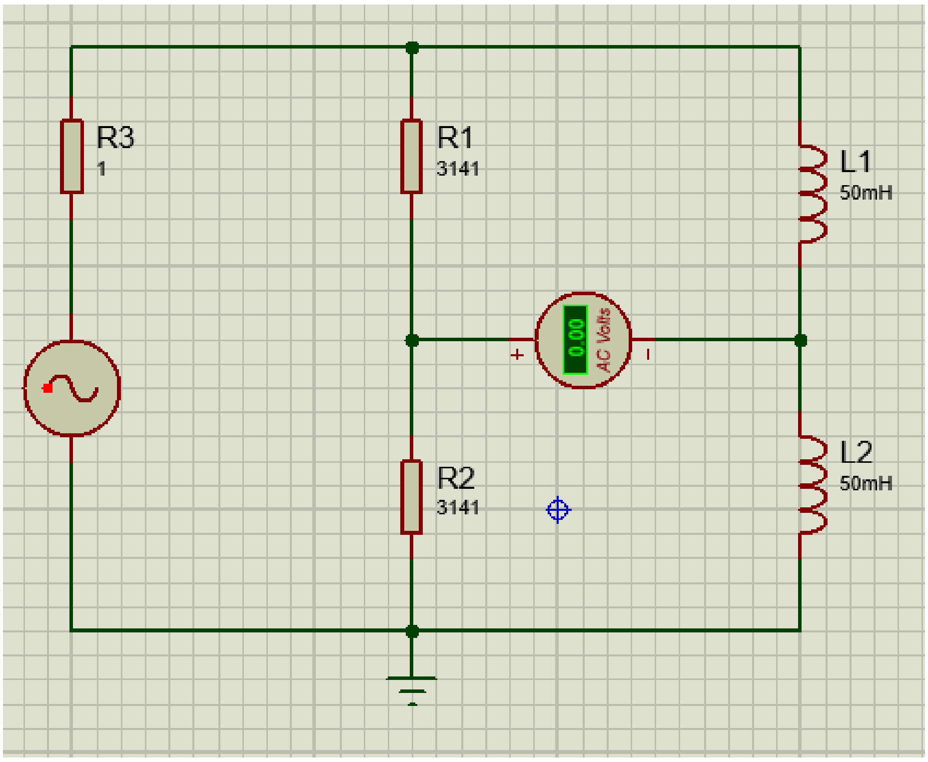
Evidence circuit 2



L1=86.25mH, L2=13.75mH, Vab=1.28V



L1=13.75mH, L2=86.25mH, Vab=1.28V



L1=50mH, L2=50mH, Vab=0V -> Balance

Calculations

CALCULOS FIGURA 1

$$V_{ab} = \frac{V_s}{2}\left(\frac{C_2 - C_1}{C_2 + C_1}\right) \qquad \Delta C = \frac{2C_0(V_{ab})}{V_s}$$

$$C_2 = C_0 + \Delta C \qquad C_1 = C_0 - \Delta C$$

C_1	C_2	V_{ab}
144	36	-1.5
90	90	0
36	144	1.5

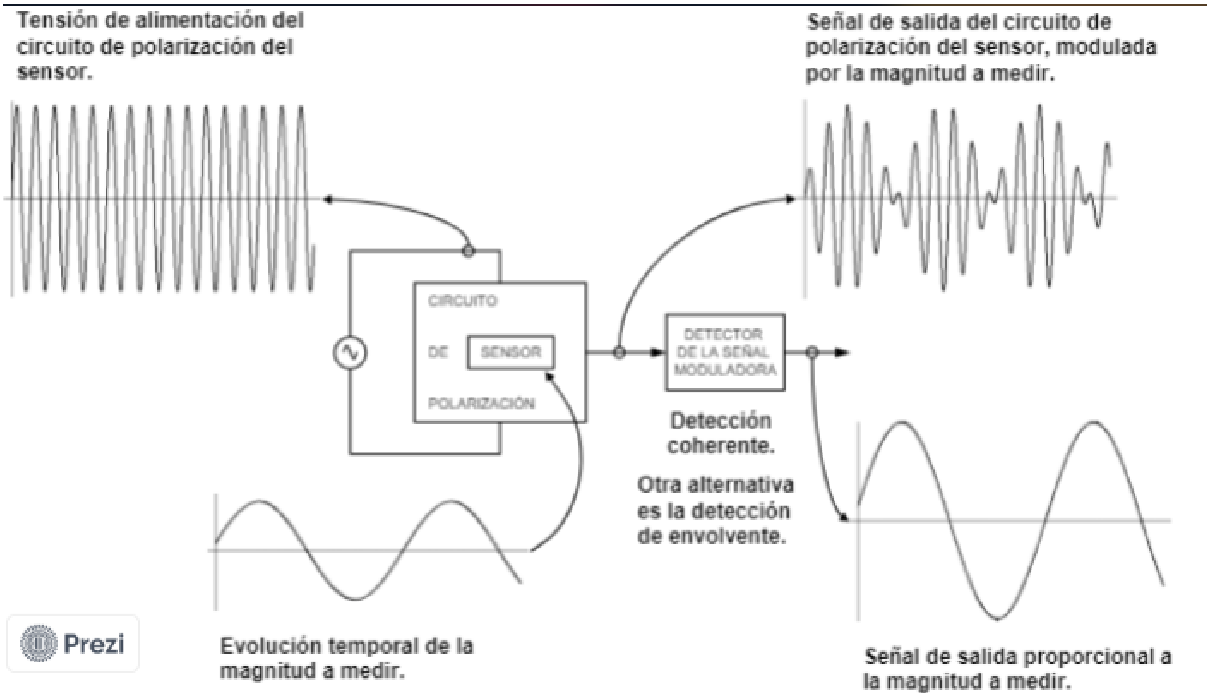
$$\Delta C = \frac{(180)(1.5)}{5} = 54$$

$$C_2 = 90 + 54 \qquad C_1 = 90 - 54$$

$$C_2 = 144 \qquad C_1 = 36$$

Questionnaire

1. What is reactance?
   R= **Reactance is a property that opposes a change in current and is found in both inductors and capacitors. Because it only affects changing current, reactance is specific to AC power and depends on the frequency of the current.**
2. How are variable reactance sensors classified?
   R= **They are classified into capacitive and inductive.**
3. Indicate some quantities that can be measured with variable reactance sensors.
   R=**They can measure pressure, displacement, angle, vibration, speed, compositional analysis, medium characteristics, among others.**
4. Draw the general conditioning scheme of variable reactance sensors.



Conclusions

In this practice we learn how to build different types of circuits in A.C. working with capacitors and inductors, conditioning the variable reactance sensors we used in lessons before. These sensors can measure many magnitudes, similar with the previous ones we saw. Also we found ways to condition these circuits that resemble some of the techniques we use in previous practices, this is the case of the Blumlein bridge and the A.C. bridge.

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