Physics Investigation 1 Teacher Manual

Observation

Joan opened up the case of a radio and found inside a variable air capacitor and an inductive coil. She noticed that when she tuned the radio to channels of different frequencies, she was actually adjusting the variable air capacitor.

Problem

How does the air capacitor affect the frequency of the radio circuit? Does the resistance of the circuit affect the frequency of the radio circuit?

Hypothesis

The frequency of a radio circuit is affected by the capacitance of the air capacitor and not affected by the resistance in the circuit.

Aim

To investigate how the capacitance of the capacitor and resistance of the resistor affect the frequency of the radio circuit.

Principle

When a capacitor is charged by a battery and then discharged through an inductor and a resistor, the current (voltage) in the circuit oscillates with a frequency, say f_o. The frequency of the oscillation can be studied by measuring the voltage across the inductor, capacitor or resistor.

The process of tuning a radio circuit involves changing the frequency of the oscillation in the circuit so that it is the same as the frequency of a particular radio station. Resonance is said to occur and the current in the circuit is maximum. A strong signal is then received.

In this investigation, the following variables are involved :

Independent variables - capacitance of capacitor and resistance of the circuit

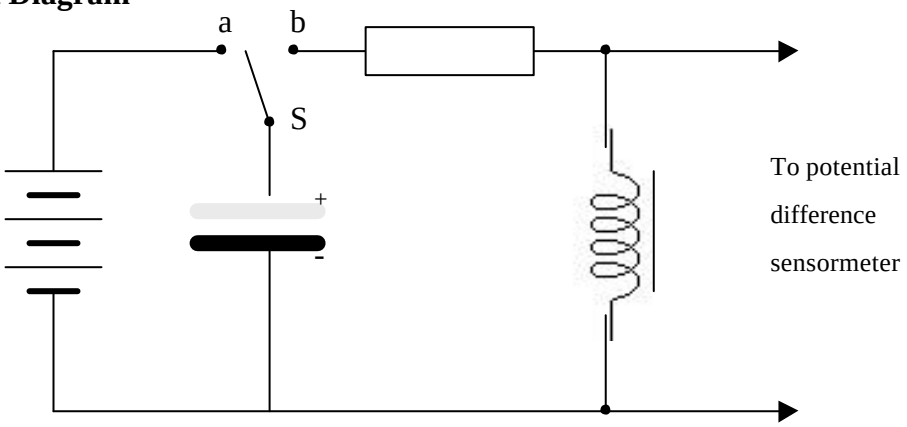
Dependent variable - frequency of oscillation

Equipment and materials

- One desktop computer
- One datalogging interface
- One potential difference sensormeter
- Capacitors (47 μF, 220 μF, 470 μF, 1000 μF)
- One high inductance coil (1100 turns)

- One resistance substitution box
- One double C-core and clip
- One clip component holder
- One two-way switch
- One battery 4.5V
- Connecting leads

Circuit Diagram



Procedure

1. Connect up a circuit as shown above;
2. Set up the computer and the interface. Connect the leads of the potential difference sensormeter across the inductor;
3. Load and run the Datadisc 32 program;
4. Set the switch S to a to charge the capacitor, then set the switch to b to discharge it through the inductor. At the same time start recording;
5. Display the voltage-time graph. Measure the frequency of the oscillation;
6. Repeat step 4 and step 5 using different capacitors, keeping the resistance of resistance substitution box unchanged;
7. Repeat step 4 and step 5 by increasing the resistance in the resistance substitution box, keeping the capacitance of the capacitor unchanged.

Precautions

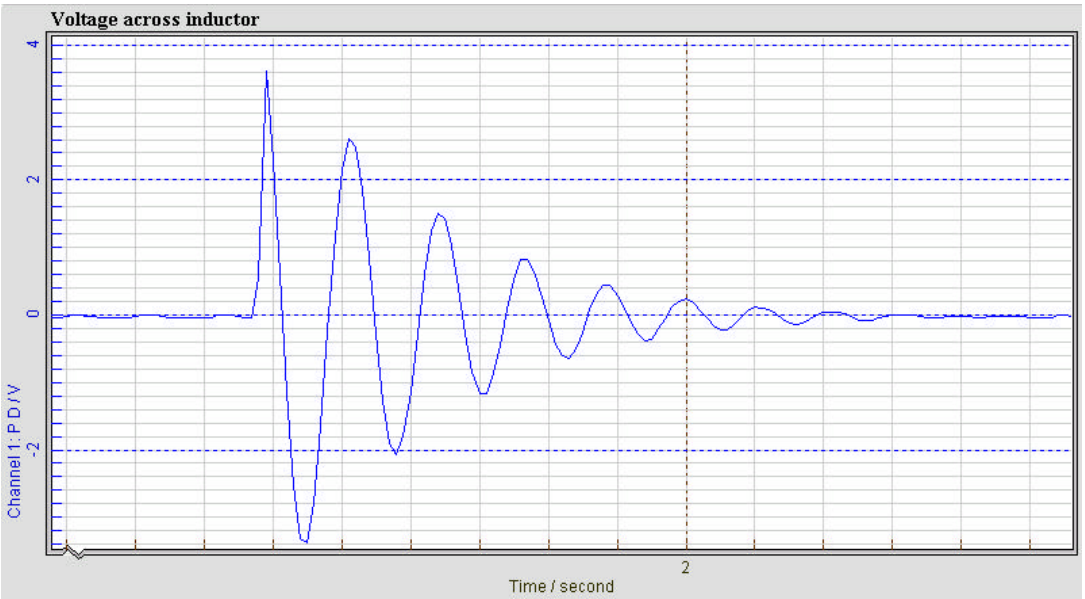
1. In order to study the effect of the capacitance on the oscillation frequency, the resistance of the resistance box should not be too high (not more than a few ohms).

Results:

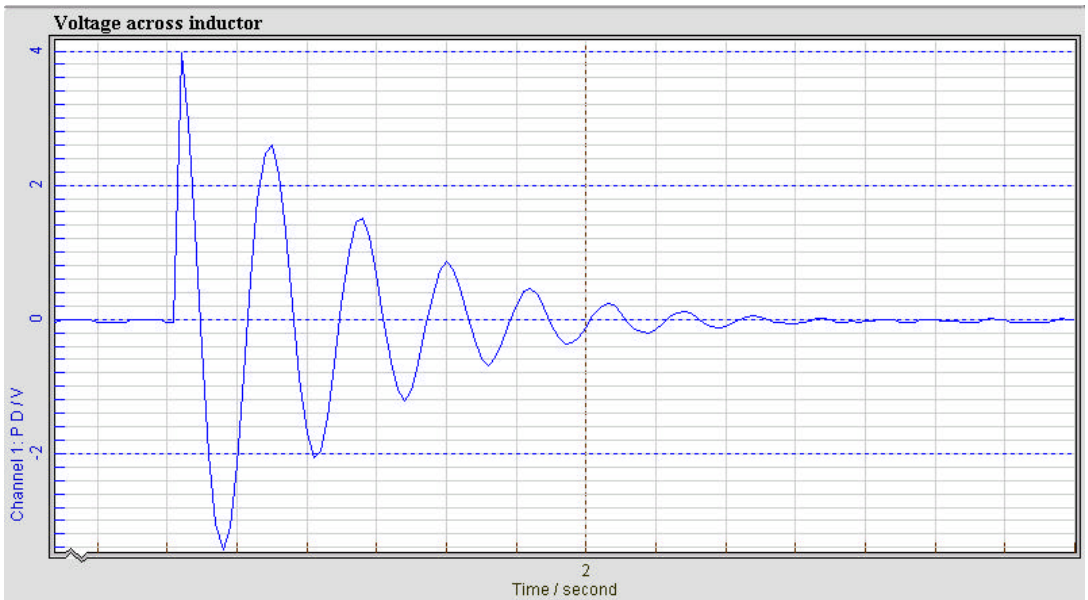
Graphs obtains :

Graphs showing the effect of varying capacitance on the oscillation frequency

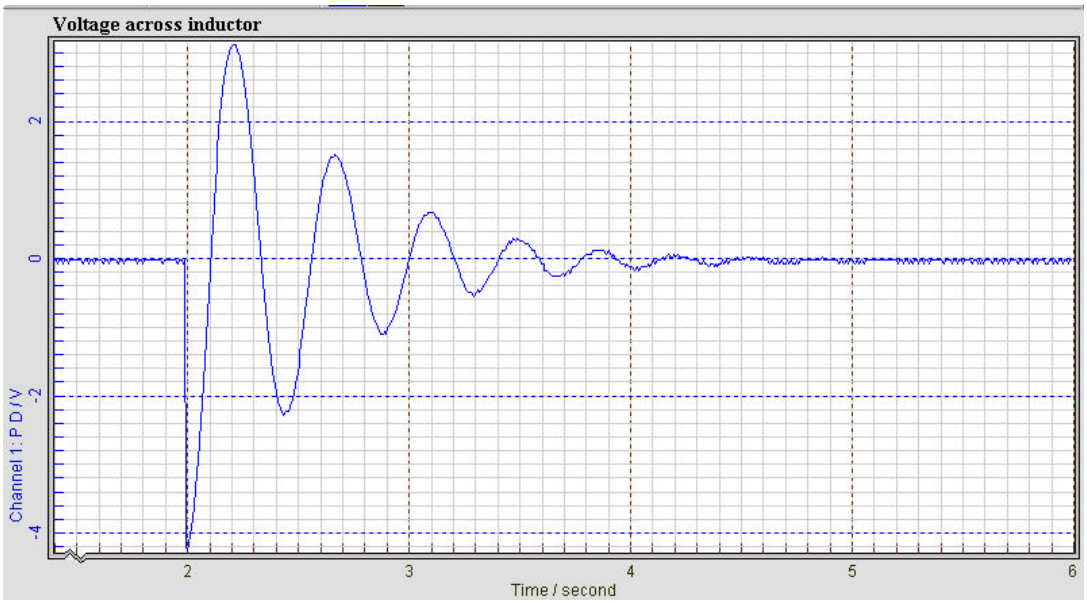
(a) 47 μF, 1Ω, 8.28 Hz



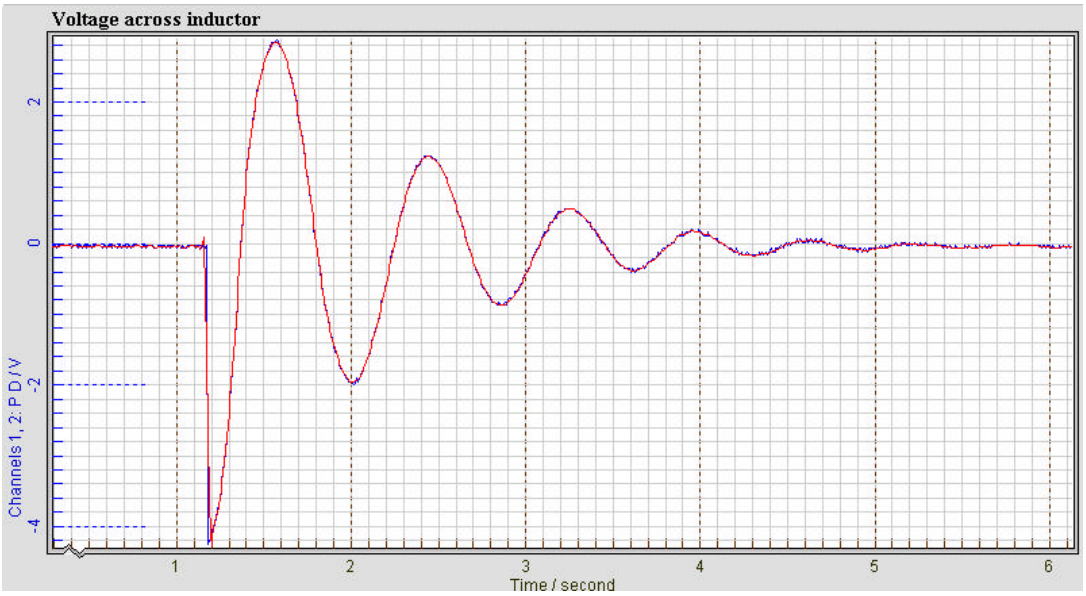
(b) 220 μF, 1Ω, 8 Hz



(c) 470 μF, 1Ω, 2.28 Hz

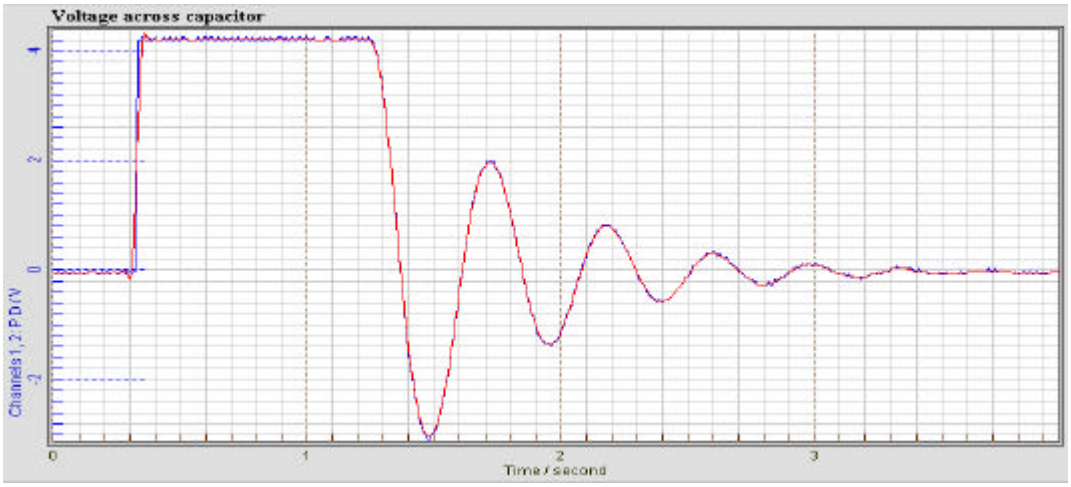


(d) 1000 μF, 1Ω, 1.94 Hz

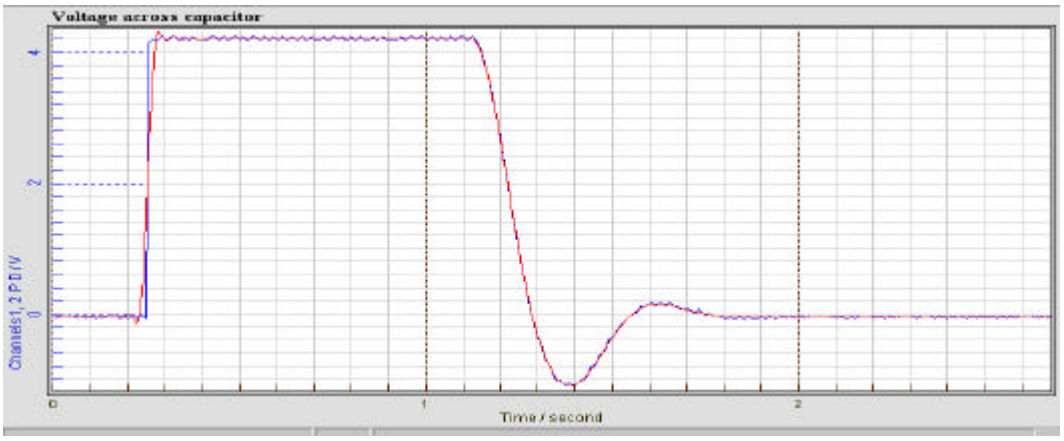


Graphs showing the effect of varying resistance on the oscillation frequency

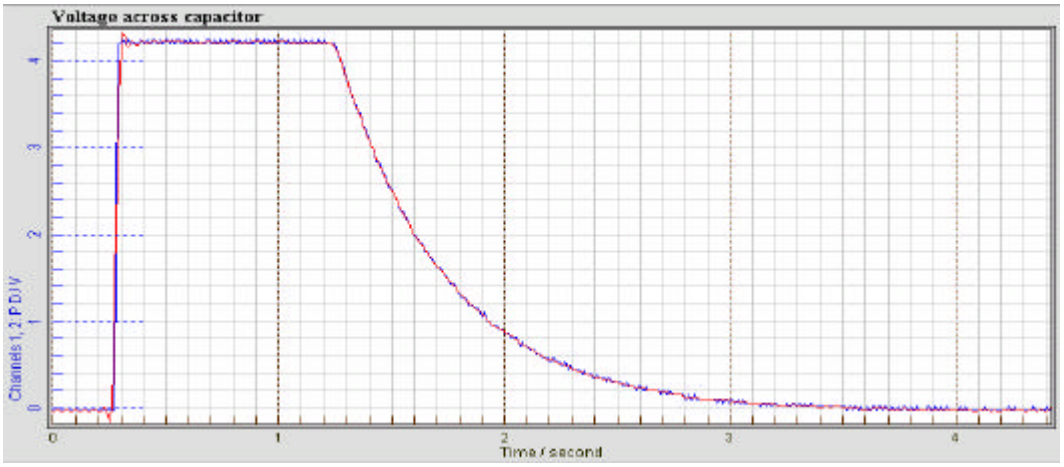
(e) 470µF, 10Ω, 2.3Hz



(f) 470µF, 100Ω



(g) 470µF, 1000Ω



The results were tabulated as follows :

a) Frequency of oscillation vs Capacitance of capacitor

Capacitance / μF	Resistance / Ω	Frequency / Hz
47	1	8.28
220	1	8
470	1	2.28
1000	1	1.94

b) Frequency of oscillation vs Resistance

Capacitance / μF	Resistance / Ω	Frequency / Hz
470	1	2.28
470	10	2.3
470	100	cannot be measured
470	100	cannot be measured

Interpretation

The voltage across the inductor oscillated a few times with a decreasing amplitude but there was no change in frequency.

When the capacitance of the circuit was increased, the period of oscillation increased, and the frequency of the circuit decreased (graphs (a) - (d)).

If the resistance was increased, the frequency did not change significantly (graphs (c) and (e)). For smaller resistance, the oscillation died off faster than for higher resistance (graphs (c) and (e)). If the resistance was high, there was no oscillation and the current just returned to zero (graphs (f) and (g)). The resistance did not affect the frequency of oscillation, but it affected the amplitude of oscillation. This was called the damping effect.

Possible errors

1. The resistance of the inductor and the connecting wires had not been taken into account;
2. The capacitance of the capacitor might not be the same as the values marked on the capacitor;
3. Stray capacitance from nearby objects such as connecting wires might affect the results;
4. Due to the damping effect, not many cycles of oscillation were observed. As a result, the measurement of the frequency might not be accurate enough.

Improvement

1. The resistance of the circuit should be low (a few ohms) so that more oscillations could be observed in order to raise the accuracy in measuring the frequency;
2. Different inductive coils can be used in the experiment so that the effect of number of turns on the frequency of oscillation can be studied.

Conclusion

An increase in capacitance of capacitor resulted in a decrease in the frequency of the radio circuit. The resistance of the circuit caused the oscillation to die down.