Inductors In AC Circuits

# Underlying Physics:

An inductor is an electrical component that stores electrical energy in a magnetic field (that opposes the direction of the current) (when current flows through it). The inductance of an inductor is the ratio of the voltage against the rate of change of the current and is measured in henrys (H)

A perfect inductor has no resistance, instead it has what is called Inductive reactance .

The reactance is the inductor resisting changes in the current or voltage in the circuit.

In an inductor the reactance occurs as when the current flowing through the inductor changes the magnetic field produced by the inductor gets stronger, and as the field opposes the direction of the current passing through inductor making it ‘harder’ for the current to flow, meaning it opposes changes in the current.

The reactance can be found using the equations:

# Aim:

To find the inductance of an inductor in an AC circuit using measurements of the current, voltage and frequency of the supply.

# Apparatus:

* A signal generator
* A digital oscilloscope
* A voltmeter (multimeter)
* An ammeter (second multimeter)
* An inductor

# Method:

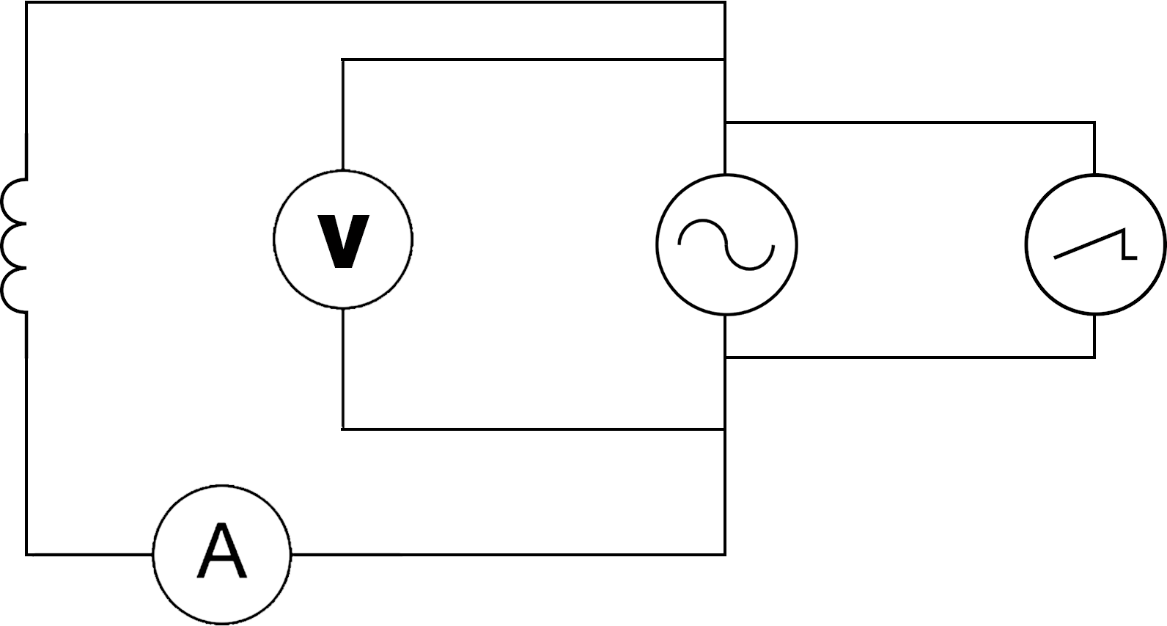
## Setup:

The inductor and ammeter are set up in series with the signal generator as the supply.

The voltmeter is then set up in parallel to the signal generator to get the supply voltage.

The oscilloscope is also set up in parallel to the signal generator to double check the frequency of the supply.

### Circuit Diagram:



## Procedure:

The signal generator is set to a frequency which is recorded, the voltage is adjusted to be 5V, and the current is measured, then the signal generator is switched off and on again to get a repeat reading. The frequency is then lowered 0.5kHz and repeat. The range of frequencies measured were from 4.5kHz and 1.5kHz.

# Results:

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | | |  | |  | | Current (mA) | |  | |  |  | | |  | |  | |  | | |  | |  |  |  |
| Frequency (KHZ) | | 1/F (s) | Voltage (V) | | 1 | | 2 | 3 | 4 | | 5 | | | avg |  | |  | |  | | Δtotal | Δ% | |
| 4.5 | | 0.0002222 | 5 | | 0.442 | | 0.444 | 0.444 | 0.445 | | 0.445 | | | 0.444 |  | |  | |  | | 0.022231 | 5.006894 | |
| 4 | | 0.00025 | 5 | | 0.527 | | 0.526 | 0.525 | 0.525 | | 0.525 | | | 0.5256 |  | |  | |  | | 0.026302 | 5.004197 | |
| 3.5 | | 0.0002857 | 5 | | 0.623 | | 0.622 | 0.622 | 0.622 | | 0.622 | | | 0.6222 |  | |  | |  | | 0.031127 | 5.002686 | |
| 3 | | 0.0003333 | 5 | | 0.752 | | 0.749 | 0.75 | 0.749 | | 0.749 | | | 0.7498 |  | |  | |  | | 0.037508 | 5.002418 | |
| 2.5 | | 0.0004 | 5 | | 0.921 | | 0.918 | 0.917 | 0.916 | | 0.917 | | | 0.9178 |  | |  | |  | | 0.045912 | 5.002374 | |
| 2 | | 0.0005 | 5 | | 1.152 | | 1.151 | 1.15 | 1.15 | | 1.15 | | | 1.1506 |  | |  | |  | | 0.05754 | 5.000876 | |
| 1.5 | | 0.0006667 | 5 | | 1.531 | | 1.529 | 1.53 | 1.527 | | 1.529 | | | 1.5292 |  | |  | |  | | 0.076471 | 5.000701 | |

# Uncertainties:

Current Δs: Frequency Δ:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Δcal | Δread | Δrand | Δtotal | Δ% |
| 0.0222 | 0.001 | 0.0006 | 0.022231 | 5.006894 |
| 0.02628 | 0.001 | 0.0004 | 0.026302 | 5.004197 |
| 0.03111 | 0.001 | 0.0002 | 0.031127 | 5.002686 |
| 0.03749 | 0.001 | 0.0006 | 0.037508 | 5.002418 |
| 0.04589 | 0.001 | 0.001 | 0.045912 | 5.002374 |
| 0.05753 | 0.001 | 0.0004 | 0.05754 | 5.000876 |
| 0.07646 | 0.001 | 0.0008 | 0.076471 | 5.000701 |

Δcal was 1\*10^-2

Which is so small it’s negligible.

Δread = 0.001

Δtotal = 0.001

Voltage Δ:

Δcal = 0.8% + 3 of the

least sig figs = 0.07 (0.04+ 0.03)

Δread = 0.01

Δtotal = 0.071

∆% = 1.42%

# Graph:

gradient = 2.432703936 As-1

intercept = -7.52532x10-5 A

∆ gradient = 0.044827 As-1

%∆ gradient = 1.842698475 1.84%

# Calculations:

|  |  |
| --- | --- |
|  |  |

# Conclusion:

The average inductance of the inductor was 0.3278x10-3 H over a range of 4.5-1.5 KHz

# Evaluation:

Looking at the graph reveals that there was a systematic error in the experiment as the line of best fit does not go through the origin, the intercept is ≈-7.5x10-5 when it should be 0. To reduce this error, I could have used a more modern signal generator as while I used the oscilloscope to double check the frequency and the voltmeter to double check the voltage, these values weren’t exactly on the desired ones and they constantly fluctuated slightly, using a more modern signal generator would likely reduce this effect.

I would also lower the range to around 150Hz as the given value for the inductance of the inductor I used was 0.5H at 50Hz. This may not decrease the uncertainty but it would make analysing the results easier.

# References:

<https://en.wikipedia.org/wiki/Faraday%27s_law_of_induction>

https://en.wikipedia.org/wiki/Electrical\_reactance

http://hyperphysics.phy-astr.gsu.edu/hbase/hframe.html