Higher Colleges of Technology

DC Electrical Fundamentals

AVT 2103

Inductance/Inductor

Module 3.11

Learning Outcomes

CLO 4 – Describe the characteristics and solve problems relating to DC circuits (resistance, voltage, current and power) containing resistors, capacitors and inductors

Characteristics of Inductance

- Inductance is the characteristic of an electrical circuit that opposes the starting, stopping, or a change in value of current.
- Inductance is the characteristic of an electrical conductor that **opposes change in current**.
- The symbol for inductance is L and the basic unit of inductance is the HENRY (H).

- An inductor has an inductance of 1 Henry if an EMF of 1 volt is induced in the inductor when the current through the inductor is changing at the rate of 1 ampere per second.

In many practical applications, millihenries (mH) and microhenries (µH) are more common units.

a physical analogy of inductance

Anyone who has ever had to push a heavy load (wheelbarrow, car, etc.) is aware that it takes more work to start the load moving than it does to keep it moving.

Once the load is moving, it is easier to keep the load moving than to stop it again. This is because the load possesses the property of **inertia**.
Inertia is the characteristic of mass which opposes a **change** in velocity.

Inductance has the same effect on current in an electrical circuit as inertia has on the movement of a mechanical object. It requires more energy to start or stop current than it does to keep it flowing.

The Physical Parameters

Some of the physical factors that affect inductance are:

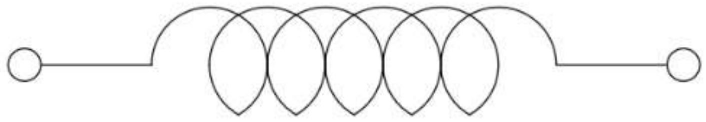
1. The number of turns of the coil : Doubling the number of turns in a coil will produce a field twice as strong, if the same current is used. General rule, the inductance varies as the square of the number of turns.

2. The cross-sectional area of the coil: The inductance of a coil increases directly as the cross-sectional area of the core increases. Doubling the radius of a coil increases the inductance by a factor of four.

3. The length of a coil: Doubling the length of a coil, while keeping the same number of turns, halves the value of inductance.

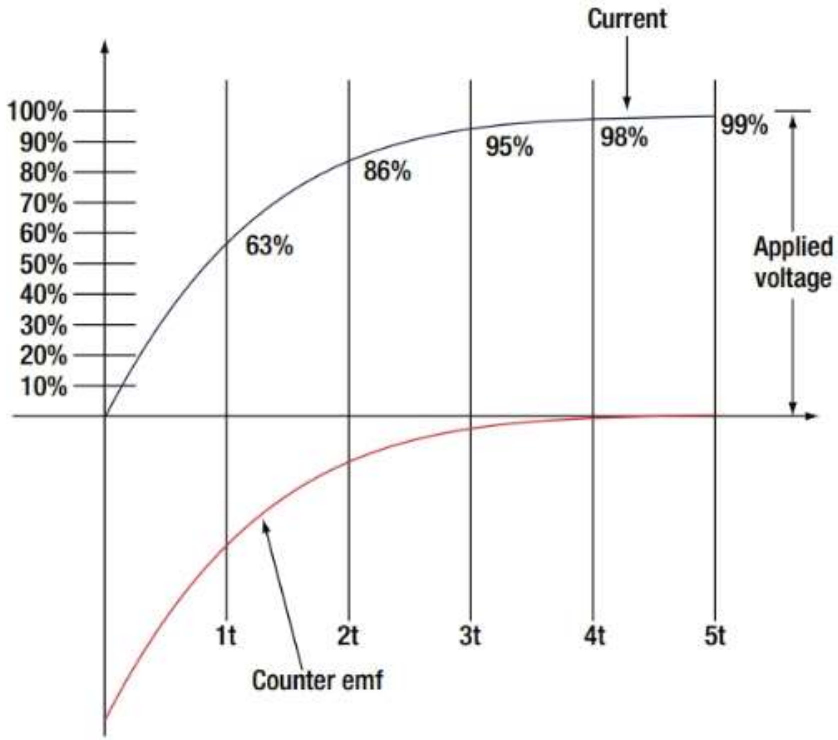
4. The core material around which the coil is formed: Coils are wound on either magnetic or nonmagnetic materials.

Symbol of Inductance



The RL Time Constant

- Because the inductor's basic action is to oppose a change in its current, it then follows that the current cannot change instantaneously in the inductor.
- A certain time is required for the current to make a change from one value to another.
- The rate at which the current changes is determined by a time constant represented by the Greek letter tau (τ).



Current, counter emf, and applied voltage in an inductive circuit.

Figure 11-2. Inductor curve.

The time constant for the RL circuit : $\tau = \frac{L}{R}$

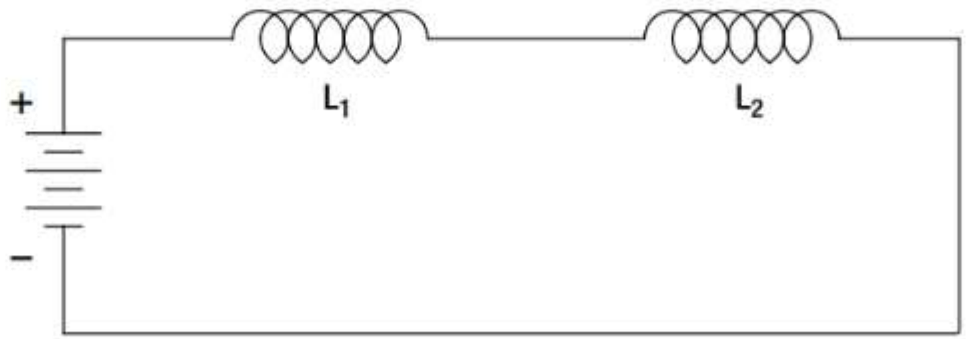
Where:

τ = seconds

L = inductance (H)

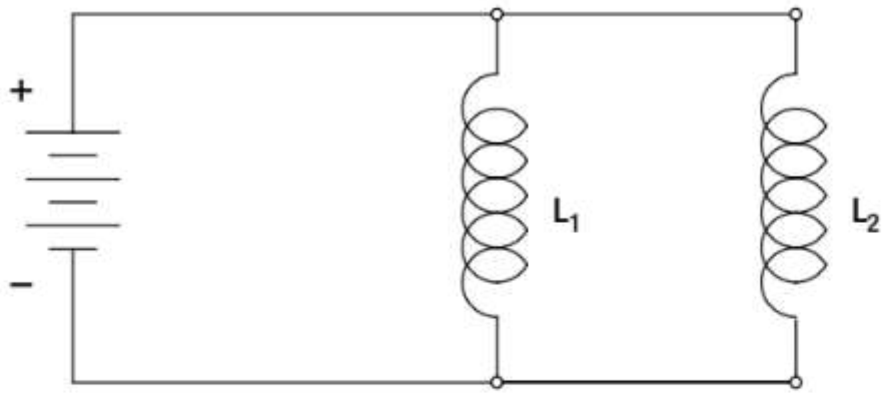
R = Resistance (Ω)

Inductors in Series



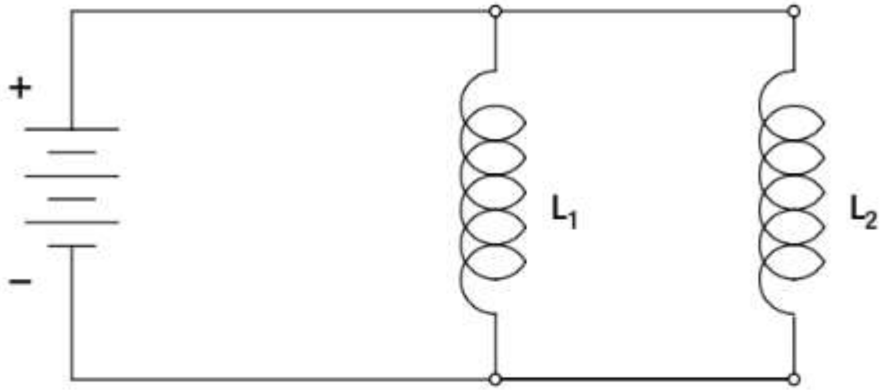
$$L_T = L_1 + L_2 + L_3 + \ldots L_N$$

Inductors in Parallel



$$L_T = \cfrac{1}{\cfrac{1}{L_1} + \cfrac{1}{L_2} + \cfrac{1}{L_3} + \ldots \cfrac{1}{L_N}}$$

Inductors in Parallel



L_1 = 10mH, L_2 = 5mH, L_3 = 2mH

$$L_T = \frac{1}{\frac{1}{10mH} + \frac{1}{5mH} + \frac{1}{2mH}}$$

$$L_T = \frac{1}{0.8mH}$$

$$L_T = 1.25mH$$

Inductive Reactance

- Alternating current is in a constant state of change; the effects of the magnetic fields are a continuously inducted voltage opposition to the current in the circuit.

- This opposition is called inductive reactance, symbolized by $\mathbf{X_L}$.
- Inductive reactance is a measure of how much the countering EMF in the circuit will oppose current variations.

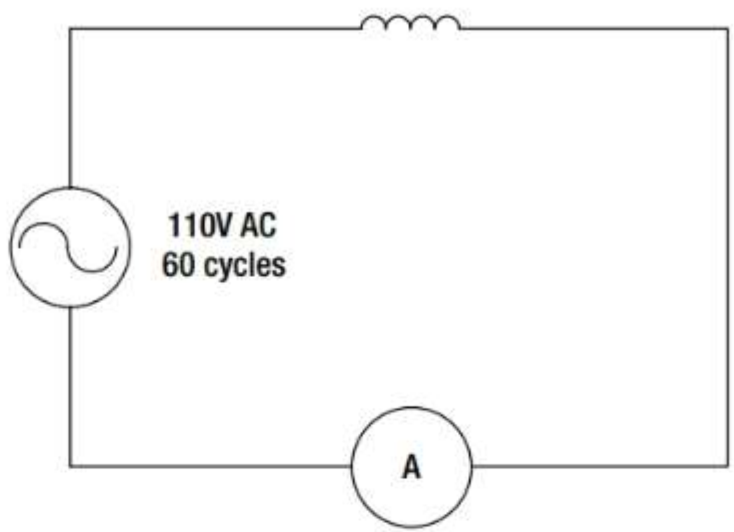
$$X_L = 2\pi fL$$

Where:

X_L = inductive reactance in ohms

f = frequency in cycles per second

π = 3.141 6



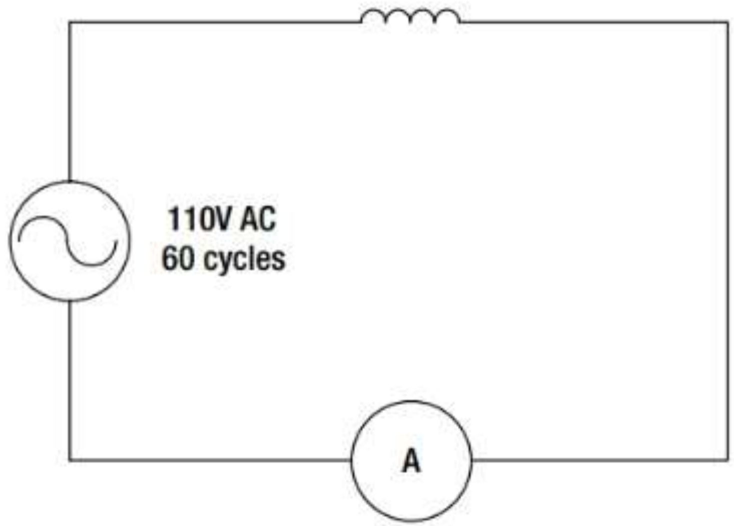
AC circuit containing inductance.

Inductive Reactance

Example:

an AC series circuit is shown in which the inductance is 0.146 Henry and the voltage is 110 volts at a frequency of 60 cycles per second.

$$X_L = 2\pi \times f \times L$$
$$= 6.28 \times 60 \times 0.146$$
$$= 55 \text{ Ohms}$$



AC circuit containing inductance.

To find current:

$$\text{Current} = \frac{\text{Voltage}}{\text{Reactance}} \text{ or } I = \frac{E}{X_L}$$

$$I = \frac{E}{X_L}$$

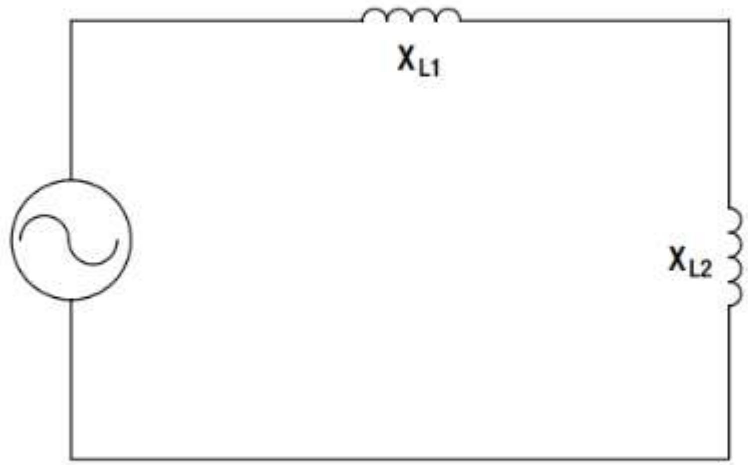
$$I = \frac{110}{55}$$

$$I = 2 \text{ amperes}$$

Inductors in Series

The total reactance of inductances

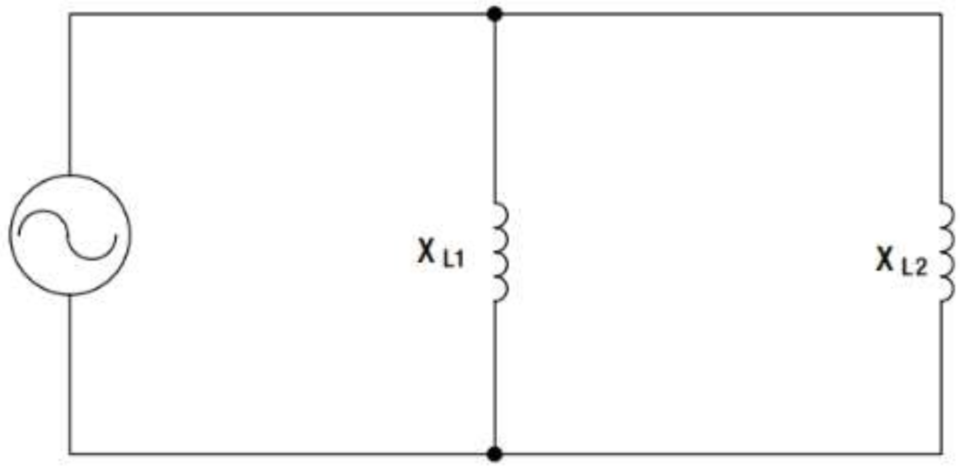
$$(X_L)_T = (X_L)_1 + (X_L)_2$$

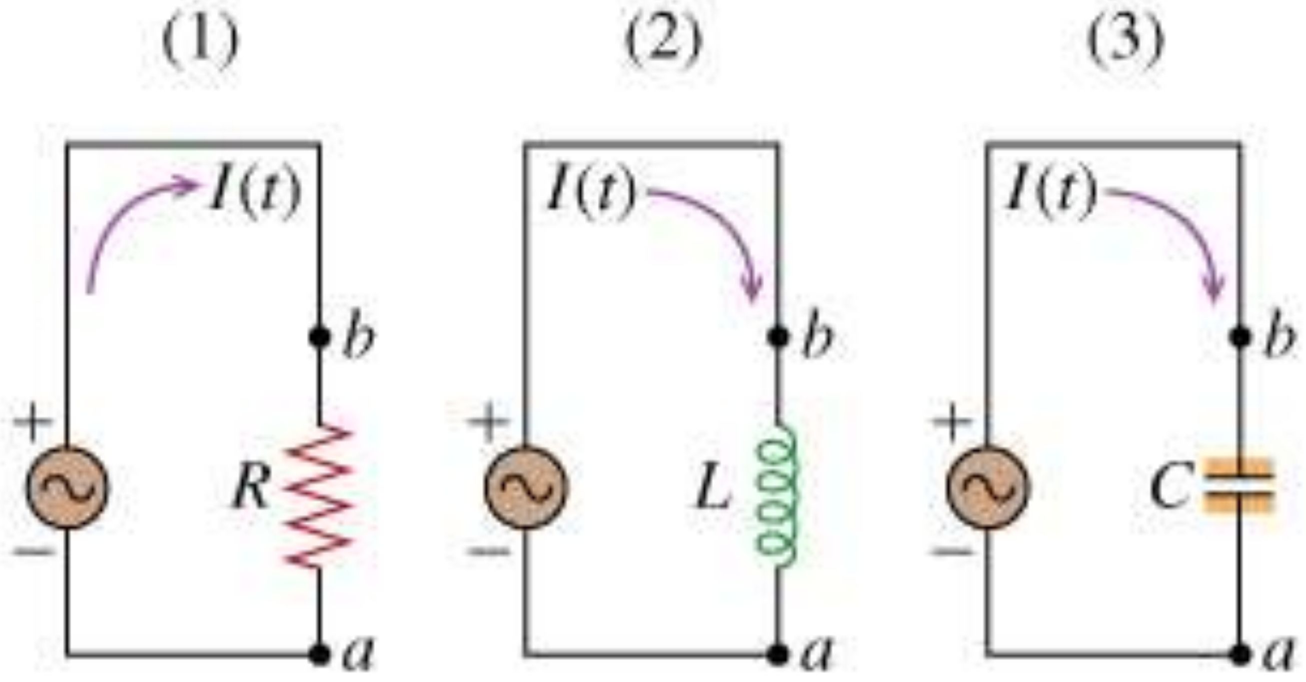


Inductors in Parallel

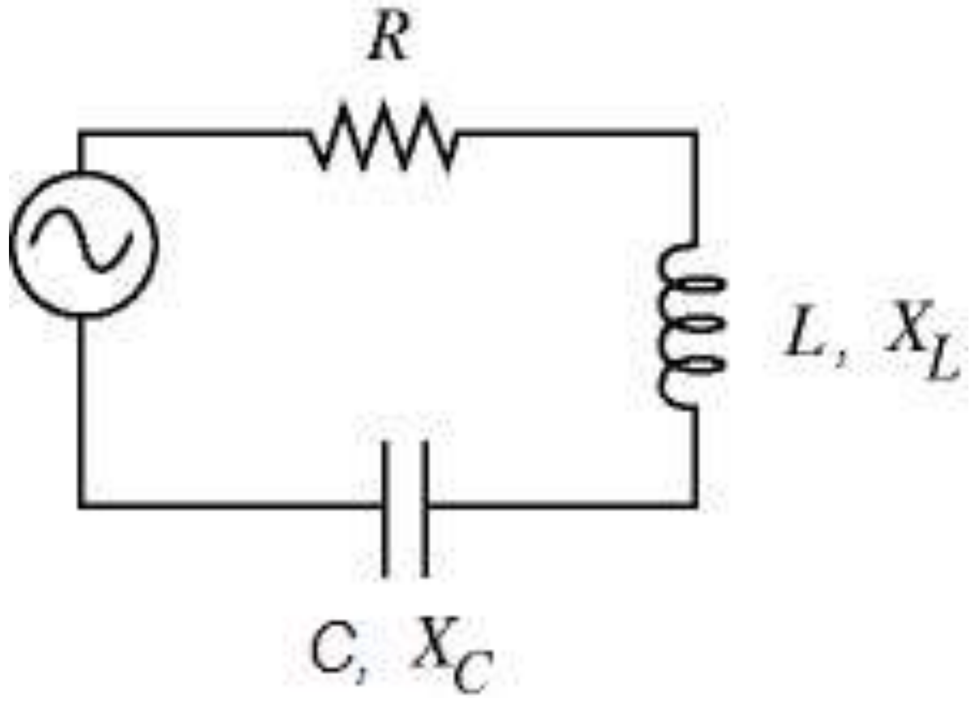
The total reactance of inductances

$$(X_L)_T = \frac{1}{\frac{1}{(X_L)_1} + \frac{1}{(X_L)_2}}$$





(1)
(2)
(3)
I(t)
I(t)
I(t)
b
b
b
+
+
+
R
L
C
−
−
−
a
a
a

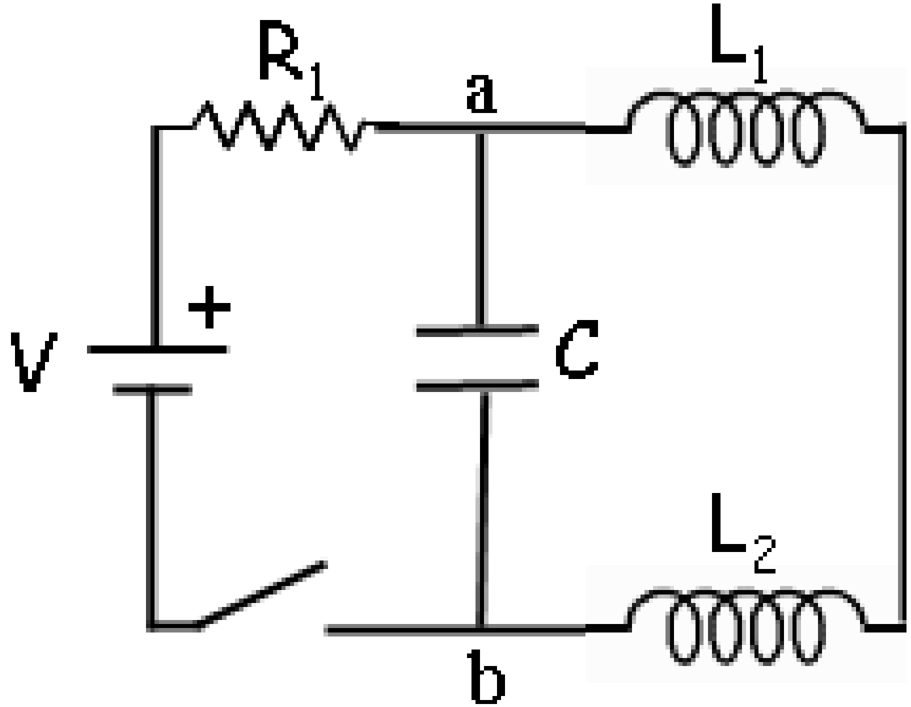


An AC series circuit is shown in which the inductance of a inductor is 0.133 Henry , the capacitance of a condenser is 26.5 μf, the resistance of a resistor is 70 Ω and the voltage is 110 volts at a frequency of 60 cycles per second.

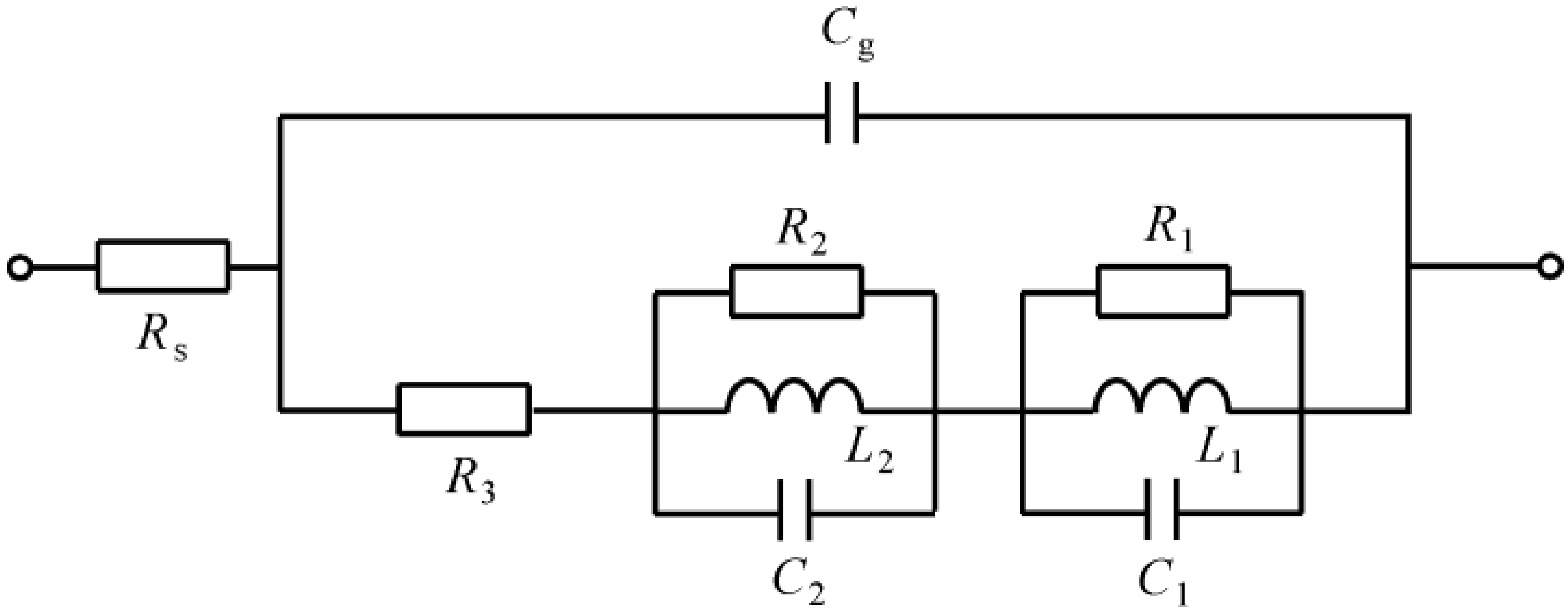
Calculate : (a) the time constant for inductor and capacitor

(b) total current

(c) power at inductor and capacitor



R1
a
L1
+
V
C
L2
b



C_g
R_s
R_2
R_1
R_3
L_2
L_1
C_2
C_1