

Fundamentals of Electrical Engineering
Prof. Debapriya Das
Department of Electrical Engineering
Indian Institute of Technology Kharagpur

Lecture - 28
Capacitors & Inductors (Contd.)

So, we will take another example, then we will move to the inductors right.

(Refer Slide Time: 00:25)

The screenshot shows a presentation slide with a yellow background. At the top, it says "Ex-5.9: The voltage pulse described by the following equations is impressed across the terminals of a 0.5 μF capacitor: (23)". Below this, the voltage pulse $v(t)$ is defined as a piecewise function: $v(t) = \begin{cases} 0 \text{ Volt} & \text{for } t \leq 0 \\ 4t \text{ Volt} & \text{for } 0 \leq t \leq 1.0 \\ 4e^{-(t-1)} \text{ Volt} & \text{for } 1 \leq t < \infty \end{cases}$. The number 23 is circled in red. At the bottom, it says "(a) Derive the expressions for the c...". A small video inset of the professor is visible in the bottom right corner.

So, this is another example of voltage pulse distributed by the following equation is impressed across the terminals of a 0.5 micro farad right; so and it is given $v(t)$ is equal to 0 volt for t less than equal to 0, it is you make less than 0 less than less than right. So it is $4t$ volt for in t in between 0 and 1 second and your 4 into e to the power minus t minus 1 volt when you when t is greater than 1, but I mean in between 1 and infinity right. So, let me clear it so you have to find out few things.

(Refer Slide Time: 01:09)

The screenshot shows a presentation slide with a white background and a blue border. At the top, there is a title bar for a software application named 'C-S Capacitors and Inductors'. Below the title bar, there is a toolbar with various icons. The main content of the slide is a piecewise function for voltage $v(t)$ in Volts:

$$v(t) = \begin{cases} 0 \text{ Volt} & \text{for } t \leq 0 \\ 4t \text{ Volt} & \text{for } 0 \leq t \leq 1.0 \\ 4e^{-(t-1)} \text{ Volt} & \text{for } 1 \leq t \leq \infty \end{cases}$$

Below the function, there are three questions labeled (a), (b), and (c):

- (a) Derive the expressions for the capacitor current, power and energy
- (b) Sketch the energy as function of time
- (c) Specify the interval of time when

In the bottom right corner of the slide, there is a small video inset showing a man in a green shirt speaking.

You have to first is v t is 0 volt for some time till less than I have told till less than 0 and $4t$ volt 20 greater than 0 less than 1 and $4e$ to the power minus t minus 1 for t greater than 1 less than infinity.

(Refer Slide Time: 01:22)

The screenshot shows a presentation slide with a white background and a blue border. At the top, there is a title bar for a software application named 'C-S Capacitors and Inductors'. Below the title bar, there is a toolbar with various icons. The main content of the slide is four questions labeled (a), (b), (c), and (d):

- (a) Derive the expressions for the capacitor current, power and energy
- (b) Sketch the energy as function of time.
- (c) Specify the interval of time when energy is being stored in the capacitor
- (d) Specify the interval of time when energy is being delivered by the capacitor

In the bottom right corner of the slide, there is a small video inset showing a man in a green shirt speaking.

So, you have to find out derive the expression for the capacitor current power and energy this is the first thing. Sketch the energy as function of time, then specify the interval of time when energy is being stored in the capacitor and specify the integral of time when the energy is delivered by the capacitor.

(Refer Slide Time: 01:44)

(d) Specify the interval of time when energy is being delivered by the capacitor

(e) Evaluate the integrals $\int_0^1 p dt$ and $\int_1^{\infty} p dt$ and comment on their significance.

Soln.

(a) From eqn (5.5), $i = C \frac{dv}{dt}$,
 $C = 0.5 \mu\text{F} = 0.5 \times 10^{-6} \text{ F}$

And evaluate the integrals 0 to 1 p dt p is power and 1 to infinity p dt and comment on their your significance right. So, we know again very simple.

(Refer Slide Time: 01:57)

Soln.

(a) From eqn (5.5), $i = C \frac{dv}{dt}$,
 $C = 0.5 \mu\text{F} = 0.5 \times 10^{-6} \text{ F}$

Hence, expression for the capacitor current i is given as:

$$i = \begin{cases} (0.5 \times 10^{-6})(0) = 0 & \text{for } t < 0 \\ (0.5 \times 10^{-6})(4) = 2 \mu\text{Amp} & \text{for } 0 < t \end{cases}$$

It is look we know from equation 5 that i is equal to C into dv by dt C is given 0.5 micro farad that is 0.5 into 10 to the power minus 6 farad, you can say expression for the capacitor current is given as I mean just for each integral you apply C into dv by dt right. So, first case voltage was 0 so C into your dv by dt 0. So, it is 0 for t less than 0 and then

in second case between 0 and 1 v t is equal to 4 t. So, if you take the derivative with respect to it will we 4 and multiplied by C.

(Refer Slide Time: 02:24)

$$i = \begin{cases} (0.5 \times 10^{-6})(0) = 0 & \text{for } t < 0 \\ (0.5 \times 10^{-6})(4) = 2 \mu\text{Amp} & \text{for } 0 < t < 1 \\ (0.5 \times 10^{-6})(-4e^{-(t-1)}) = -2e^{-(t-1)} \mu\text{Amp} & \text{for } 1 < t < \infty \end{cases}$$

Expression for power (Eqn. 5.8) is given as
 $p = vi$

$$\therefore p = \begin{cases} 0 \text{ W} \\ (4t)(2) = 8t \mu\text{W} \end{cases}$$

So, it will be 2 micro ampere because 10 to the power minus 6 is here that is t greater than 0 less than 1 and third one it has given 4 here it is it was given 4 in e to the power minus t minus 1, you take the derivative of it C into dv by dt. And if you do so it will 0.5 that is into 10 to the power minus 6 that is C value in farad into minus 4 e to the power minus t minus 1. So, it is minus 2 e to the power minus t minus 1 that is micro ampere for t greater than 1 less than infinity.

So, expression of power from equation you know that power is equal to v into i right, so this is your v into I am not marking it is understandable v into i. So, v is 0 4 t less than 0, so it should be 0 watt and then v is equal to 4 t right and i is equal to 2 micro ampere by what you call 2 micro ampere here it is written for t greater than 0 less than 1. So, multiplied by 2 it will be 8 t micro watt right, it is in micro watt and there are another one similarly.

(Refer Slide Time: 03:36)

$$\therefore p = \begin{cases} 0 \text{ W} & \text{for } t < 0 \\ 4t(2) = 8t \text{ mW} & \text{for } 0 \leq t < 1 \\ (4e^{-(t-1)})(-2e^{-(t-1)}) = -8e^{-2(t-1)} \text{ mW, for } 1 \leq t < \infty \end{cases}$$

Energy expression follows directly from eqn.(5.10).

$$\therefore w = \begin{cases} 0 & \text{for } t < 0 \\ 4t^2 \text{ mJ} & 0 \leq t < 1 \\ -2(t-1) & 1 \leq t < \infty \end{cases}$$

The last one will be 4 into e to the power t minus 1 into that is your v t right into current minus 2 into e to the power 2 sorry minus t minus 1 is if you just multiply, it will be minus 8 into e to the power minus 2 t minus 1 right. So, this is micro watt for t greater than 1 less than infinity this is the power, the energy expression as follows that directly we get from your what you call equation 10 right. So, you know half series square energy is equal to, so first one is v h 0 so it is 0, second case your v was given your 4 t right.

(Refer Slide Time: 04:13)

Energy expression follows directly from eqn.(5.10).

$$\therefore w = \begin{cases} 0 & \text{for } t < 0 \\ 4t^2 \text{ mJ} \checkmark & 0 \leq t < 1 \\ 4e^{-2(t-1)} \text{ mJ} \checkmark & 1 \leq t < \infty \end{cases}$$

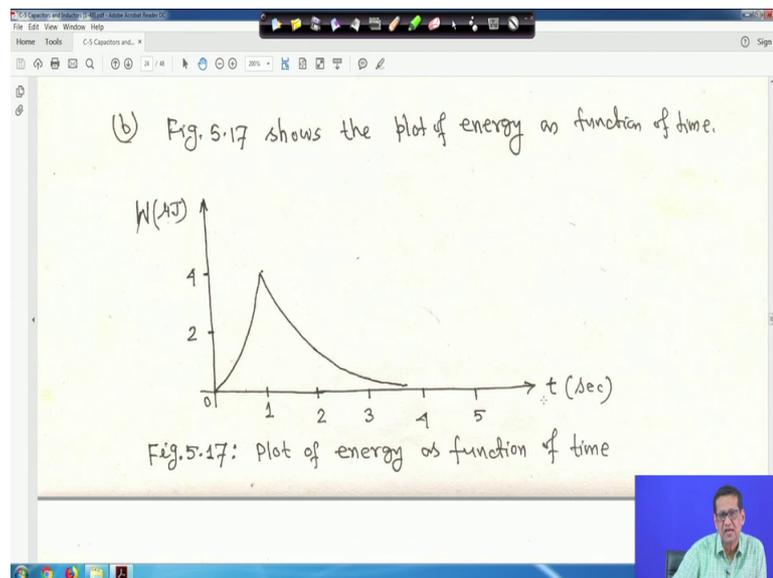
(b) Fig. 5.17 shows the plot of energy as function of time.

w(mJ) ↑

So, just simplify C is equal to 0.5 into 10 to the power minus 6 farad, so half C v square simplify you will get 4 t square micro joule your this is your it will be less your less than less than less than some where equal to it has gone right. I am correcting it so and third case half C v square it will become 4 into e to the power minus 2 sorry minus 2 into t minus 1 micro joule these are all micro just you do it please do it I have done it for a simple thing right.

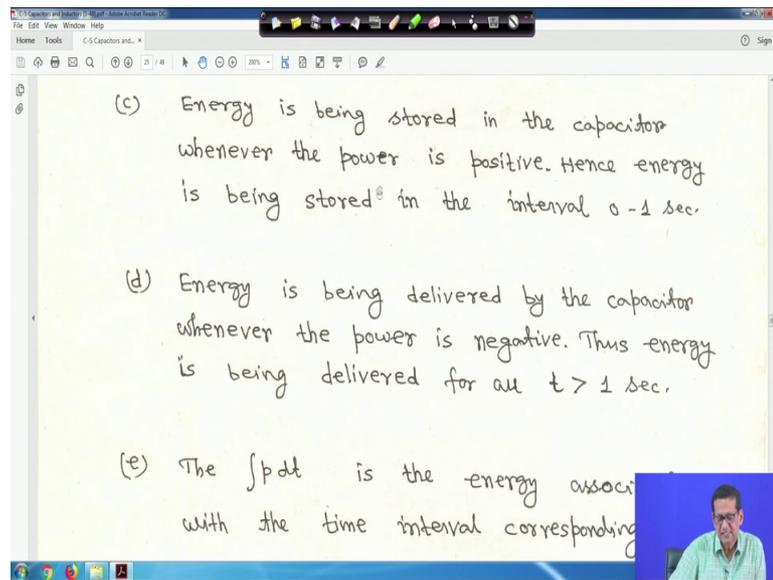
So, this is your what you call energy expression, now just let me clear it. So, figure 7 shows the plot of energy function right. So, 1 is 4 t square micro joule so it looks first part will be up to 0 to 1, so it looks like in parabola right and then 4 into e to the power minus 2 into t minus 1 micro joule, so it is exponentially decay.

(Refer Slide Time: 05:08)



So, this side is W in terms of micro joule and this time you are this time is your x axis is your time second, if you plot it is 4 t square up to this and then that your what you call that your other part in between t greater than 1 less than infinity. So, this is your 4 e to the power this part 4 e to the power minus 2 into t minus 1 this part is 4 t square and this part is 4 into e to the power minus 2 into your t minus 1 right. So, this is your energy plot function plot.

(Refer Slide Time: 05:47)



(c) Energy is being stored in the capacitor whenever the power is positive. Hence energy is being stored in the interval 0 - 1 sec.

(d) Energy is being delivered by the capacitor whenever the power is negative. Thus energy is being delivered for all $t > 1$ sec.

(e) The $\int p dt$ is the energy associated with the time interval corresponding

Now energy second thing is that energy is being stored in the capacitor whenever the power is positive; that means, when power is positive that energy is being stored. So, if you come to the power expression p that $8t$ micro watt, so it is positive that means, energy is being stored and when power is negative when t greater than 1 less than infinity it is negative, that means power is being delivered.

So, here that your energy is being stored in the capacitor whenever the power is positive, hence energy is being stored in the interval 0 to 1 second right and energy is being delivered by the capacitor whenever the power is negative. Thus, energy is being delivered for all t greater than 1 right second.

(Refer Slide Time: 06:29)

(e) The $\int p dt$ is the energy associated with the time interval corresponding to the limits on the integral. Thus the first integral represents the energy stored in the capacitor between 0 and 1 sec, whereas the second integral represents the energy returned, or delivered, by the capacitor in the interval 1 sec to ∞ .

So, now next is the integration of $p dt$ so the it is it if the energy associated with the time interval corresponding to the limits on the integral right. So, thus the first integral represents energy stored in the capacitor because, if you look into that it is given 0 to 1 $p dt$ that is in between that p is positive right.

(Refer Slide Time: 06:46)

limits on the integral. Thus the first integral represents the energy stored in the capacitor between 0 and 1 sec, whereas the second integral represents the energy returned, or delivered, by the capacitor in the interval 1 sec to ∞ :

$$\int_0^1 p dt = \int_0^1 (8t) dt = 4 \mu J$$
$$\int_1^{\infty} p dt = \int_1^{\infty} (-8e^{-2(t-1)}) dt = -4 \mu J,$$

So, if it is given $p dt$ your $p dt$ and p is equal to v into i right your earlier, we have given that p is equal to v into i , so it is 8 t your micro watt. So, here if you see that it is energy

being stored right. So, so whenever in the second integral represent the energy returned or delivered by the capacitor in the interval 1 second to infinity.

So, when 0 to 1 p dt it is 0 to 1 8 t dt so you integrate right it is in the definite integral you will get 4 micro joule and 1 to infinity when you make it is 1 to infinity and in that case minus 8 e to the power minus 2 into t minus, so integrate and simplify you will get minus 4 micro joule. So, energy stored is equal to energy delivered so it is there matching right.

(Refer Slide Time: 07:43)

$$\int_1^{\infty} p dt = \int_1^{\infty} (-8e^{-2(t-1)}) dt = -4 \mu J,$$

The voltage applied to the capacitor returns to zero as time increases without limit, so the energy returned by this ideal capacitor must equal the energy stored.

So, the voltage applied to the capacitor returns to 0 as time increases without your limit, so the energy returned by this ideal capacitor must equal the energy stored right. So, this is what we take this example for our understanding right. So, next we will take the inductors right.

(Refer Slide Time: 08:03)

5.4: INDUCTORS

An inductor is an electrical component that opposes any change in electrical current. It is composed of a coil of wire wound around a supporting core (Fig. 5.18) whose material may be magnetic or nonmagnetic.

Core material

So, after that we will move to your first order circuit. So, inductors so an inductor just look into that.

(Refer Slide Time: 08:13)

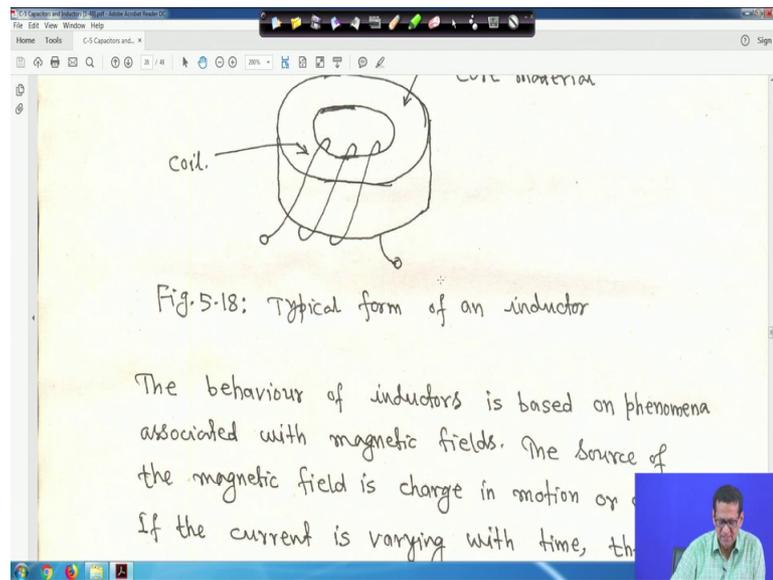
An inductor is an electrical component that opposes any change in electrical current. It is composed of a coil of wire wound around a supporting core (Fig. 5.18) whose material may be magnetic or nonmagnetic.

Core material

Coil.

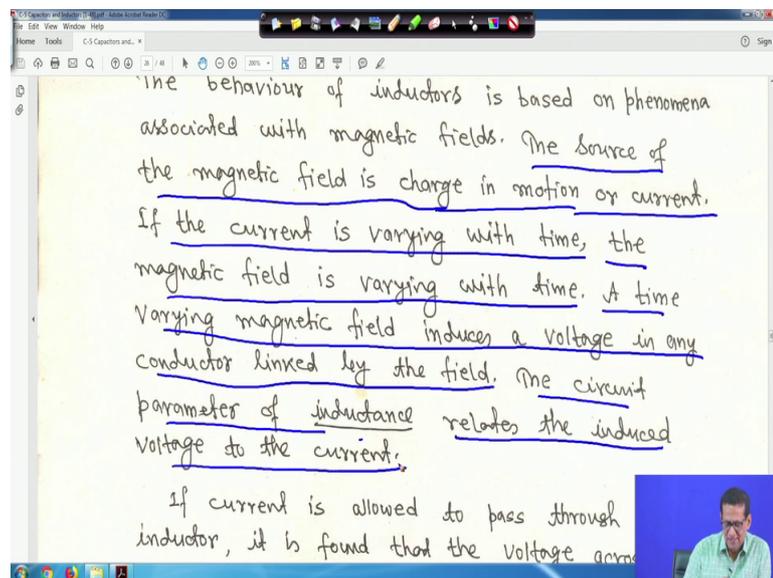
An inductor is an electrical your electrical component right that that opposes any change in electrical current little bit you know about from your (Refer Time: 08:25) physics. So, it is composed of a coil of wire wound around it your supporting core that is this figure this is figure 18 right; whose material may be magnetic or non-magnetic, so this is coil wound and this is the core material. So, let me clear it so this is your figure right.

(Refer Slide Time: 08:47)



The behavior of inductor is based on phenomenon associated with magnetic fields.

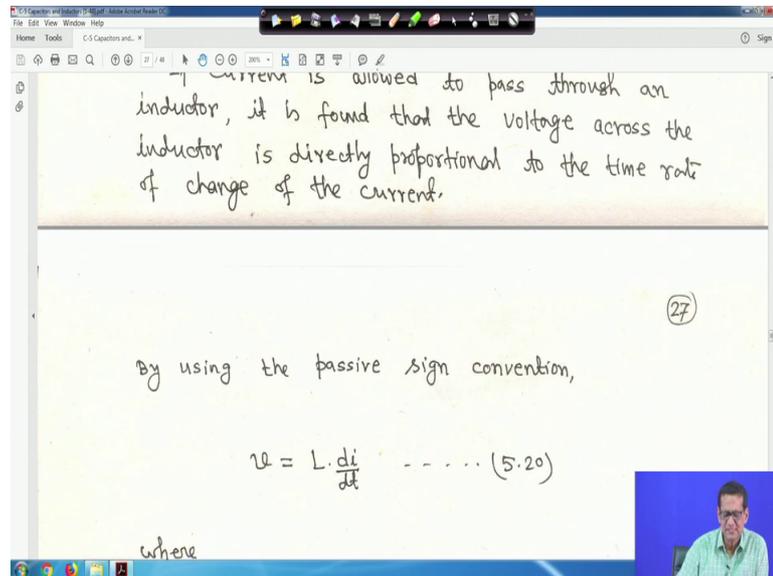
(Refer Slide Time: 08:52)



So, the source of the magnetic field is here what you call charge in motion that is current dq by dt or current charge in motion that is i is equal to dq by dt your current right. If the current is varying with time that you know then the magnetic field is varying with time right, so a time varying magnetic field induces a voltage in any conductor linked by the field this you know.

The circuit parameter of the circuit parameter of inductance you relates the induced voltage to the current, this you know in general you know v is equal to L into dy by dt will come to that right. So, let me clear it.

(Refer Slide Time: 09:42)



→ current is allowed to pass through an inductor, it is found that the voltage across the inductor is directly proportional to the time rate of change of the current.

(27)

By using the passive sign convention,

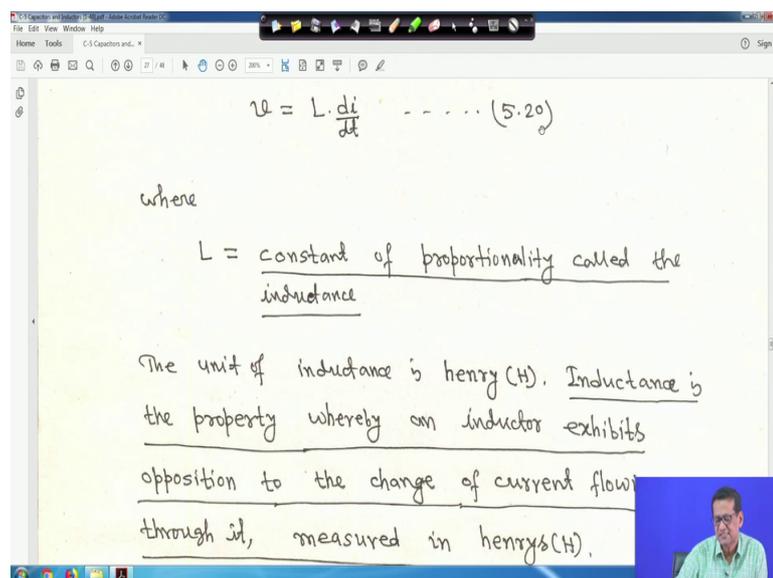
$$v = L \frac{di}{dt} \dots \dots (5.20)$$

where

Video inset: A man in a green shirt speaking.

So if the current is allowed to pass through an inductor it is found that the voltage across the inductor is directly proportional to the time rate of change of current. So, by using the passive sign convention right v is equal to L into di by dt .

(Refer Slide Time: 09:54)


$$v = L \frac{di}{dt} \dots \dots (5.20)$$

where

$L =$ constant of proportionality called the inductance

The unit of inductance is henry (H). Inductance is the property whereby an inductor exhibits opposition to the change of current flow through it, measured in henrys (H).

Video inset: A man in a green shirt speaking.

Say this is equation 20 where L is constant of proportionality called inductance this you know right. The unit of inductance is Henry and inductance is the property right.

(Refer Slide Time: 10:07)

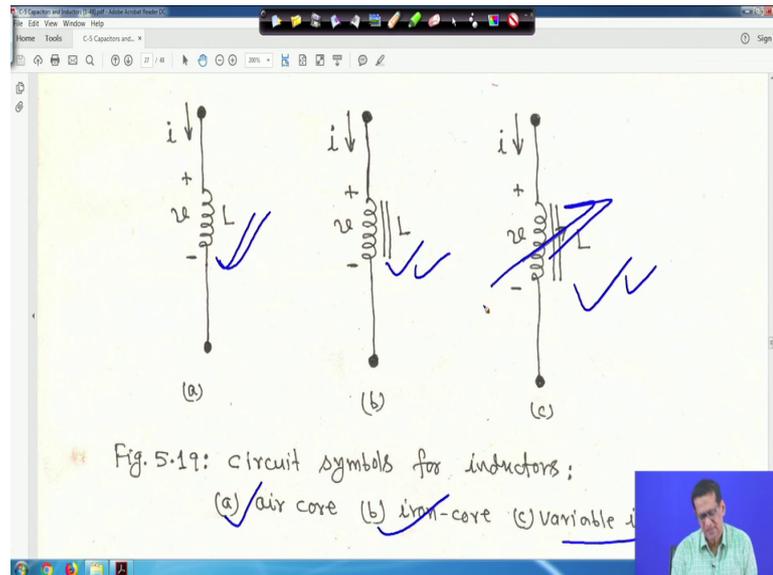
The unit of inductance is henry (H). Inductance is the property whereby an inductor exhibits opposition to the change of current flowing through it, measured in henrys (H).

The circuit symbols for inductors are shown in Fig. 5.19, following the passive sign convention.

The slide shows three circuit symbols for inductors, each consisting of a vertical line with a downward-pointing arrow labeled 'i' and a '+' sign at the bottom, representing the passive sign convention. A small video inset of a presenter is visible in the bottom right corner of the slide.

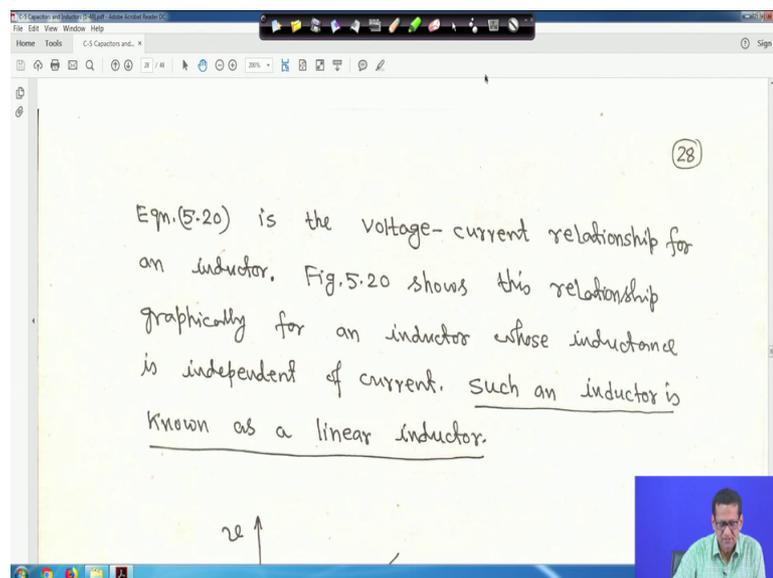
So, that you inductance actually is the property whereby an inductor exhibits opposition to the change of current flowing through it measured in henrys right. So, this is actually your what you call little bit of your many things you know this is simple thing. But just to just to start this introduction so little bit I wrote for you right. So, let me clear it so the circuit symbols for inductors are shown in figure 9 have following passive sign convention.

(Refer Slide Time: 10:41)



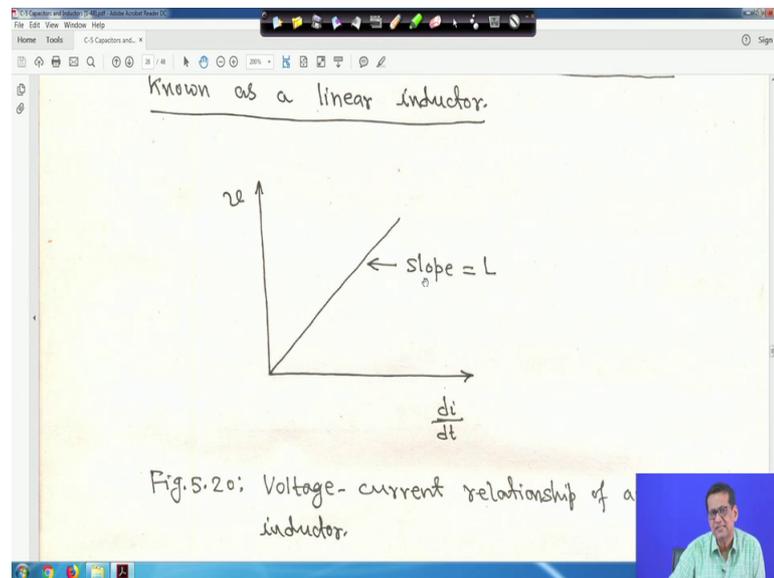
This one your this one your e this is the sign of inductor when it is air core it is here it is written figure a air core. When this symbol is there it is iron core here it is written it is iron core when this variable sign is there that arrow is there this is variable iron core. So, this is your symbols of the your what you call the inductor your inductors right, so it is it is when you write like this it is air core. When you make 2 bar then it is iron core and if it is a variable iron core then 2 bar and then make arrow right, so this is the symbol of the inductor so let me clear it.

(Refer Slide Time: 11:25)



So, equation 20 that is v is equal to L into di by dt right that the voltage for a relationship for an inductor. So, this figure 20 shows the relationship graphically for an inductor whose inductance is independent of the current.

(Refer Slide Time: 11:40)



Like capacitor also how we saw R is equal to C into dv by dt such an inductor is known as linear inductor right, when inductor is independent the L is independent of the current then this side is v y axis x axis is di by dt and simple straight line passing through the origin and this is the slope that L slope is actually in this case inductor. So, L is not a function of I current right so it is an need then it is linear inductor right, so this the voltage current relationship simple it is.

(Refer Slide Time: 12:14)

The screenshot shows a digital whiteboard with the following content:

$$di = \frac{1}{L} v dt \quad \dots (5.21)$$

Integrating eqn.(5.21), gives,

$$i = \frac{1}{L} \int_{-\infty}^t v(t) dt \quad \dots (5.22)$$

or

$$i = \frac{1}{L} \int_{t_0}^t v(t) dt + i(t_0) \quad \dots (5.23)$$

A small video inset in the bottom right corner shows a man in a green shirt speaking.

Now, if v is equal to L into di by dt that means we can write di is equal to 1 upon L v dt this is equation 21; now if we integrate then I should be is equal to 1 upon L then minus infinity to t v dt v t dt right v t is function of t this is equation 22. So, if you integrate same like capacitors same philosophy and it will be 1 upon L t_0 to t v t dt plus i t_0 that is equation 20 3 where i t_0 .

(Refer Slide Time: 12:42)

The screenshot shows a digital whiteboard with the following content:

$$i = \frac{1}{L} \int_{t_0}^t v(t) dt + i(t_0) \quad \dots (5.23)$$

(24)

where

$$i(t_0) = \text{total current for } -\infty < t < t_0.$$

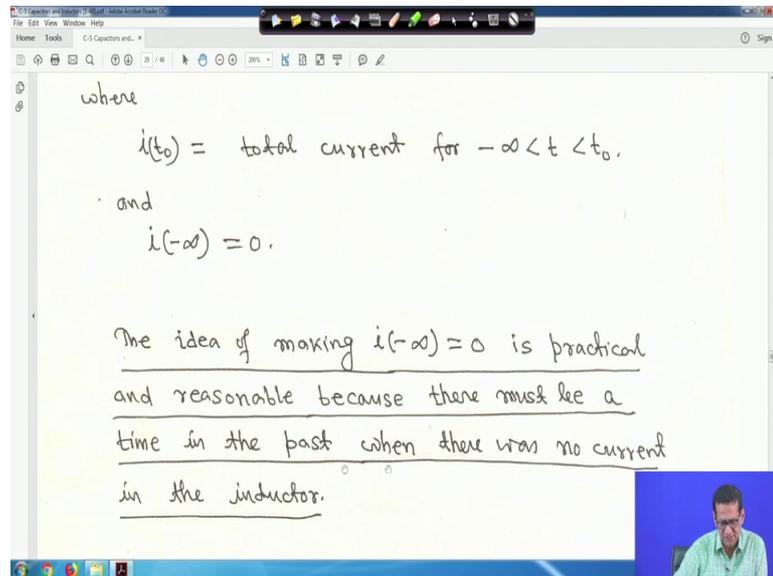
and

$$i(-\infty) = 0.$$

A small video inset in the bottom right corner shows a man in a green shirt speaking.

Like capacitor also we explain something same philosophy the total current for in between minus infinity t greater than minus infinity less than t 0 and i minus infinity is always take 0 right.

(Refer Slide Time: 12:58)



where

$$i(t_0) = \text{total current for } -\infty < t < t_0,$$

and

$$i(-\infty) = 0.$$

The idea of making $i(-\infty) = 0$ is practical and reasonable because there must be a time in the past when there was no current in the inductor.

The image shows a video lecture interface. At the top, there is a title bar for a software application. Below it is a menu bar with 'File', 'Edit', 'View', 'Window', and 'Help'. A toolbar with various icons is visible. The main area is a whiteboard with handwritten text and equations. The text defines $i(t_0)$ as the total current for $-\infty < t < t_0$ and states $i(-\infty) = 0$. A paragraph explains that this is practical and reasonable because there must be a time in the past when there was no current in the inductor. The text is underlined. In the bottom right corner, there is a small video inset showing a man in a green shirt.

So, the idea of making i minus infinity 0 is the practical and reasonable, because they are must be a time in the past when there was no current in the inductor. So, it is my it is past only past history so in some time there was no current in the inductor right. So, it is very practical of this kind of assumption, so i minus infinity we take it as a 0 right and the power delivered to the inductor will be p is equal to v into I right.

(Refer Slide Time: 13:25)

time in the past when there was no current
in the inductor.

The power delivered to the inductor is

$$p = vi = \left(L \frac{di}{dt} \right) i \quad \dots (5.24)$$

The energy stored is

$$w = \int_{-\infty}^t p dt = \int_{-\infty}^t \left(L \frac{di}{dt} \right) i dt$$

So, v is equal to L into di by dt into i so this is equation 24.

(Refer Slide Time: 13:32)

The energy stored is

$$w = \int_{-\infty}^t p dt = \int_{-\infty}^t \left(L \frac{di}{dt} \right) i dt$$

$$\therefore w = L \int_{-\infty}^t i di = \frac{1}{2} L i^2(t) - \frac{1}{2} L i^2(-\infty) \quad \dots (5.25)$$

since $i(-\infty) = 0$,

$$w = \frac{1}{2} L i^2 \quad \dots (5.26)$$

The energy stored is that w is equal to minus infinity to t p dt , that is minus infinity to t L into di by dt into i right and if you integrate this 1 then it will be it basically it will be L minus infinity to t i vi . So, that is $\frac{1}{2} Li^2$ minus $\frac{1}{2} Li^2$ minus infinity that is i your i minus infinity square right this is equation 25. But just we have seen that i minus infinity is equal to 0 right since it is 0 i minus infinity; therefore, energy stored is equal to $\frac{1}{2} Li^2$ this is equation 26 simple thing right.

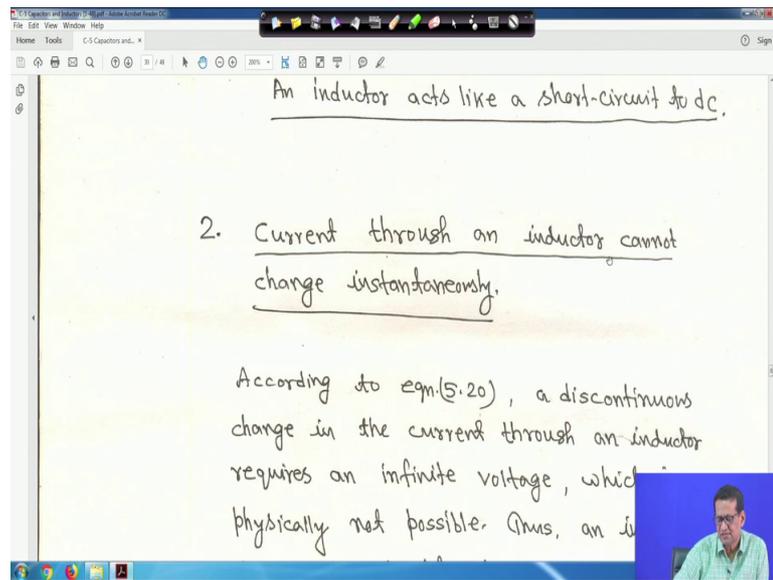
(Refer Slide Time: 14:14)

From eqn.(5.20), following important properties of an inductor can be noted.

1. It can be noted from eqn.(5.20) that when the current is constant, the voltage across an inductor is zero. Thus, An inductor acts like a short-circuit

So, equation 20 that means, this equation 20 as well you are following important properties of an inductor can be noted like capacitor also we solve some property. So, it is same way will see pure inductor that is v is equal to equation 20 v is equal to L into di by dt . So, it can be noted from equation 20 that when the current is constant because, v is equal to L into di by dt , if i is constant then di by dt is equal to 0 right. Therefore, the voltage across an inductor is 0 thus an inductor acts like a short circuit to dc right. So, when will solve numerical study state condition we have to assume that inductor acts like a short circuit to dc.

(Refer Slide Time: 14:53)



An inductor acts like a short-circuit to dc.

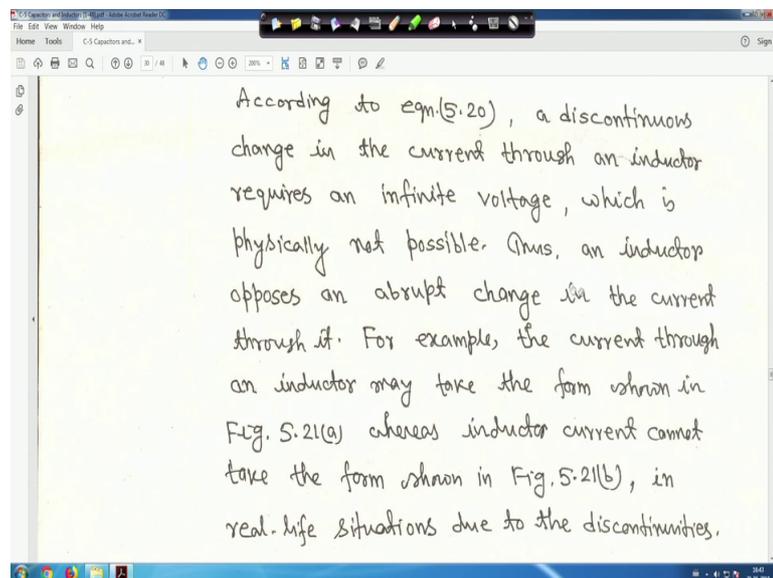
2. Current through an inductor cannot change instantaneously.

According to eqn.(5.20), a discontinuous change in the current through an inductor requires an infinite voltage, which is physically not possible. Thus, an inductor

The slide is a screenshot of a presentation window. It features a white background with handwritten text in black ink. The text is organized into three main sections: a statement about inductors acting as short-circuits to DC, a numbered point stating that current through an inductor cannot change instantaneously, and a paragraph explaining that a discontinuous change in current requires an infinite voltage, which is physically impossible. A small video inset of a man is visible in the bottom right corner of the slide.

Second one is the current to inductor cannot change instantaneously.

(Refer Slide Time: 14:59)

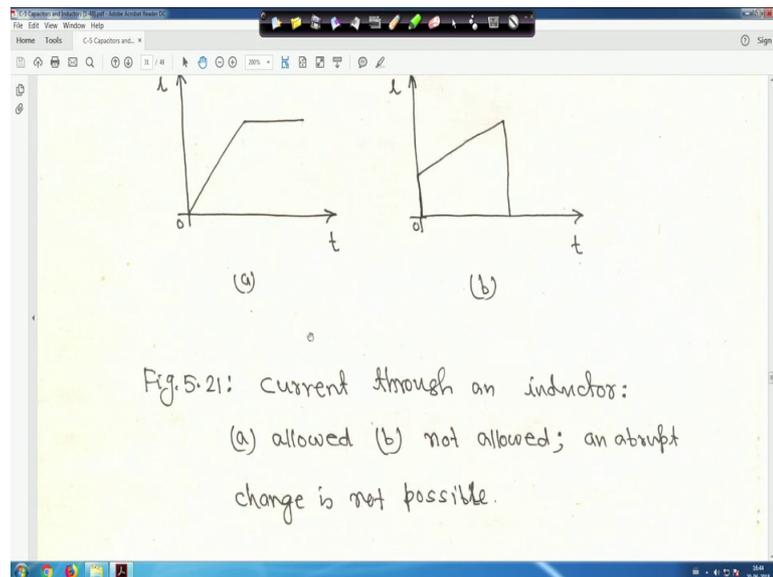


According to eqn.(5.20), a discontinuous change in the current through an inductor requires an infinite voltage, which is physically not possible. Thus, an inductor opposes an abrupt change in the current through it. For example, the current through an inductor may take the form shown in Fig. 5.21(a) whereas inductor current cannot take the form shown in Fig. 5.21(b), in real-life situations due to the discontinuities.

The slide is a screenshot of a presentation window. It features a white background with handwritten text in black ink. The text explains that a discontinuous change in current through an inductor requires an infinite voltage, which is physically impossible. It states that an inductor opposes an abrupt change in current. It provides an example where the current through an inductor may take the form shown in Fig. 5.21(a) but cannot take the form shown in Fig. 5.21(b) in real-life situations due to discontinuities.

So, your in this case according to equation 20 that is v is equal to L into di by dt a discontinuous change in the current to an inductor requires an infinite voltage which is physically not possible. Thus, an inductor opposes an abrupt change in the current through it; for example, the current through an inductor may take the form shown in figure 21a. I will come to that whereas, inductor current cannot take the form shown in figure 21 b I real life situation in real life situation due to your discontinuities.

(Refer Slide Time: 15:34)



That means, this kind of change for inductor in figure a it is an it is ok, but here abruptly suddenly it is directly suddenly from here it is falling to 0 it is it is not it is not possible in real life right. So, this kind of discontinuous not possible right so this is given current through inductor this is not allowed right. But this kind of thing not allowed right and abrupt change is not possible in the inductor right.

(Refer Slide Time: 15:59)

However, the voltage across an inductor can change abruptly.

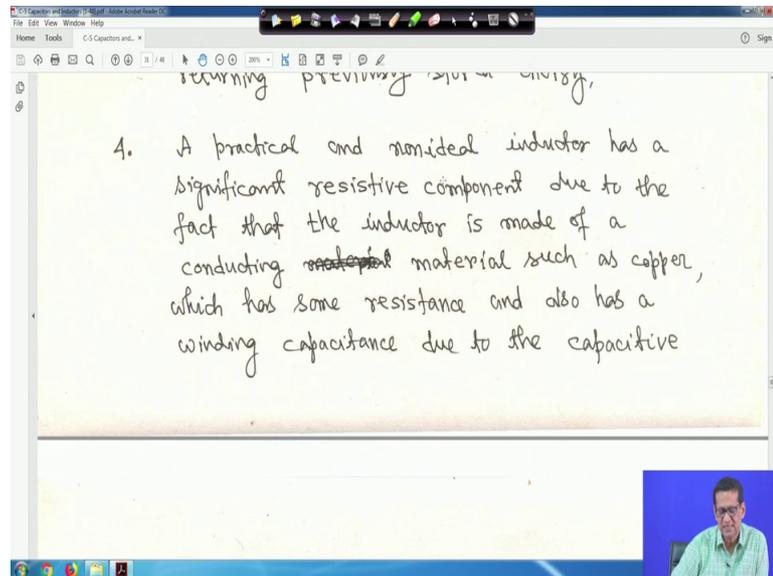
3. An ideal inductor does not dissipate energy. The energy stored in inductor can be retrieved at a later time. The inductor takes power from the circuit, when storing energy and delivers power to the circuit when returning previously stored energy.

4. A practical and nonideal inductor has

However the voltage across an inductor can change abruptly, next 1 is an ideal inductor does not dissipate energy right. The energy stored in the inductor can be retrieved at a

later time it is same philosophy like capacitor whatever we have just seen before; the inductor takes power from the circuit when storing energy and delivers power to the circuit when returning your previously stored energy right.

(Refer Slide Time: 16:29)



So, if practical and non ideal inductor has a significant resistive component, it has significant resistive component due to the your fact that the inductor is made of a your what you call conducting material such as copper, which has some resistance and also has a winding capacitance due to the your capacitive coupling between the conducting coils; that means, it has resistance also some capacitance is there right.

(Refer Slide Time: 16:56)

coupling between the conducting coils. Fig.5.22 shows the circuit model for a practical inductor.

Fig.5.22: Circuit model for a practical inductor

So, it is the it is that your what you call exact circuit for an inductor right; practically inductor, but generally R_w is the resistance of that coil inductive coil and C_w is that your capacitance in between that your coupling capacitance between the your what you call 2 winding say so many windings are there.

So, this is called cup C_w coupling capacitor so this is a exact circuit for the inductor, but in reality R_w is very negligible and C_w also negligible. So, we only consider inductor resistance we generally not consider for some problem we also consider to find out the resistance and inductance of the inductor that we will see later and C_w generally we do not consider for our as far as our circuit is considered circuit analysis is concerned.

(Refer Slide Time: 17:46)

Fig.5.22: Circuit model for a practical inductor.

In Fig.5.22, resistance R_w is called the winding resistance and capacitance C_w is called the winding capacitance. The presence of R_w makes it both an energy storage device and an energy dissipation device. Since R_w and C_w are very small, and hence they can be ignored in most of the cases.

So, in figure 22 that that I told you R_w is called winding resistance and capacitance C_w is called the winding capacitance right. So, the presence of R_w makes both an energy storage device because resistance is there and then energy dissipation device right because, inductor store energy can be dissipated in the form of a heat say in the resistor since R_w and C_w are very very small and hence they can be ignored right in most of the cases so we will ignore that. Next is series and parallel inductors right.

(Refer Slide Time: 18:20)

ignored in most of the cases.

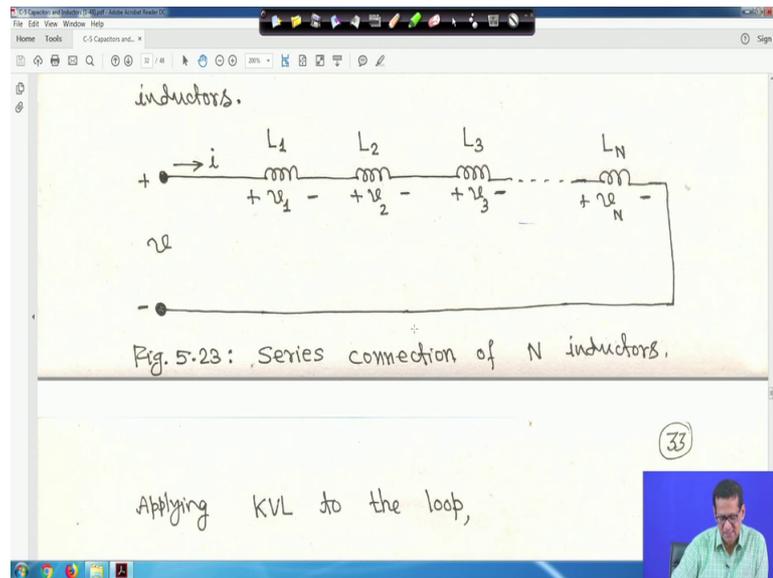
5.5: SERIES AND PARALLEL INDUCTORS

Fig.5.23 shows a series connection of N inductors.

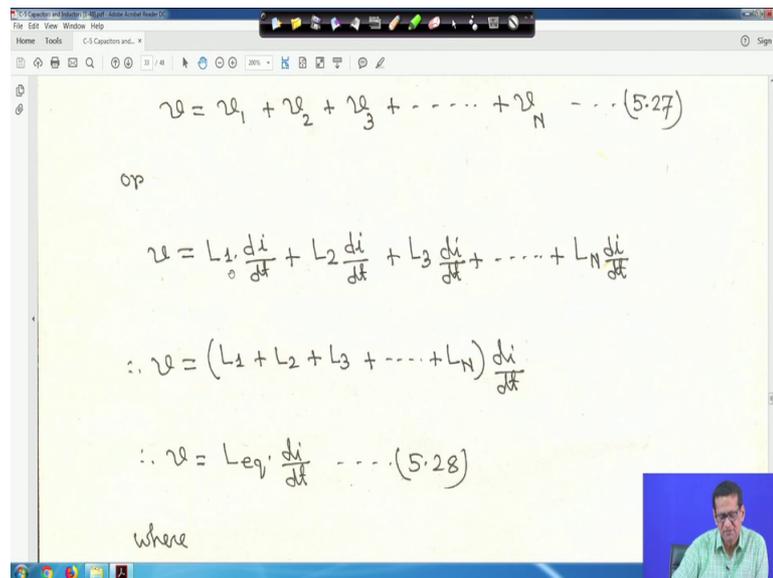
The diagram shows a series circuit with N inductors labeled $L_1, L_2, L_3, \dots, L_N$. The current i flows from the positive terminal on the left. The voltage across each inductor is labeled $+v_1 -$, $+v_2 -$, $+v_3 -$, and $+v_N -$ respectively. The total voltage across the series combination is labeled v .

So, this is a simple circuit that your 23 shows series combination of N inductors, where voltage v is there L 1 L 2 L 3 all are up to L N all are connected in series current flowing to this i voltage across L 1 is v 1 and L 2 is v 2 like this across L N is v N right, so this is series connection of N inductor.

(Refer Slide Time: 18:42)



(Refer Slide Time: 18:44)



So, you apply KVL. Then will write v is equal to v 1 plus v 2 up to v N sum it up this equation 27, then or v is equal to L 1 into di by dt plus L 2 into d 2 by di by dt plus L 3 di by dt and so on up to L N di by dt right you take L 1 L 2 L 3 all common. So, it will be

into di by dt right or v is equal to $L \frac{di}{dt}$ this is equation 28. Where L is equal to $L_1 + L_2 + L_3 + \dots + L_N$ equation 29 right.

(Refer Slide Time: 19:16)

where

$$L_{eq} = L_1 + L_2 + L_3 + \dots + L_N \quad \dots (5.29)$$

Fig. 5.24 shows the equivalent for the series inductor.

Fig. 5.24: Equivalent circuit for the series inductor.

Therefore equation 24 shows the equivalent equivalent for the series inductor, it is like a resistance this for inductor case it is like a resistor in series when $R_1 R_2 R_3$ all resistance are in series we add it you do the same thing, but inductor also just you add it right. So, this is an equivalent circuit and this is L_{eq} is equal to $L_1 + L_2 + L_3$ and so on all the inductors you add equivalent circuit for the series inductor.

(Refer Slide Time: 19:43)

Fig. 5.24: Equivalent circuit for the series inductors.

Inductors in series are combined in exactly the same way as resistors in series.

Let us now consider a parallel connection

So, inductor in series are combined in exactly the same way as resistors in series right.

(Refer Slide Time: 19:50)

34

Let us now consider a parallel connection of N inductors, as shown in Fig.5.25. The inductors have the same voltage across them.

The diagram shows a circuit with a positive terminal on the left and a negative terminal on the right. A current i is shown entering the positive terminal. The circuit branches into N parallel paths, each containing an inductor. The current through each inductor is labeled $i_1, i_2, i_3, \dots, i_N$.

So, now consider the your parallel connection of N inductors that shown in figure 25, the inductor have the same voltage your across them.

(Refer Slide Time: 19:58)

Fig.5.25: A parallel connection of N inductors

Applying KCL,

The diagram shows a circuit with a positive terminal on the left and a negative terminal on the right. A current i is shown entering the positive terminal. The circuit branches into N parallel paths, each containing an inductor. The current through each inductor is labeled $i_1, i_2, i_3, \dots, i_N$. The inductors are labeled $L_1, L_2, L_3, \dots, L_N$.

So, this is the voltage and this $L_1 L_2 L_3$ up to L_N all inductors are connected in parallel and this is the current entering into i right and then $i_1 i_2 i_3$ all current going through inductor 1 inductor 2 like this. Therefore, Kirchhoff's if you apply your KCL right then i is equal to i_1 plus i_2 up to i_N right.

(Refer Slide Time: 20:20)

Applying KCL,

$$i = i_1 + i_2 + i_3 + \dots + i_N$$

$$\therefore i = \left[\frac{1}{L_1} \int_{t_0}^t v dt + i_1(t_0) \right] + \left[\frac{1}{L_2} \int_{t_0}^t v dt + i_2(t_0) \right]$$

$$+ \dots + \left[\frac{1}{L_N} \int_{t_0}^t v dt + i_N(t_0) \right]$$

$$\therefore i = \left(\frac{1}{L_1} + \frac{1}{L_2} + \dots + \frac{1}{L_N} \right) \int_{t_0}^t v dt + i_1(t_0) + i_2(t_0) + \dots + i_N(t_0)$$

If you make it i is equal to i_1 plus i_2 plus i_3 up to i_N right and we know that i_1 is equal to $\frac{1}{L_1} \int_{t_0}^t v dt + i_1(t_0)$ that is initial inductor current or like like capacitor whatever we do it same thing plus $\frac{1}{L_2} \int_{t_0}^t v dt + i_2(t_0)$ and up to what you call $\frac{1}{L_N} \int_{t_0}^t v dt + i_N(t_0)$.

(Refer Slide Time: 20:47)

$$\therefore i = \left(\frac{1}{L_1} + \frac{1}{L_2} + \dots + \frac{1}{L_N} \right) \int_{t_0}^t v dt + i_1(t_0) + i_2(t_0) + \dots + i_N(t_0)$$

$$\therefore i = \frac{1}{L_{eq}} \int_{t_0}^t v dt + i(t_0) \quad \dots (5.30)$$

Now, collect all the terms of your what you call multiplied by integration $\int_{t_0}^t v dt$. It is $\frac{1}{L_1} + \frac{1}{L_2} + \dots + \frac{1}{L_N}$ into $\int_{t_0}^t v dt + i_1(t_0) + i_2(t_0) + \dots + i_N(t_0)$.

0 plus $i_2(t_0)$ plus your up to $i_N(t_0)$ or you can write i is equal to 1 upon L_{eq} t_0 to t v dt plus $i(t_0)$.

(Refer Slide Time: 21:14)

$$\frac{1}{L_{eq}} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3} + \dots + \frac{1}{L_N} \dots (5.31)$$

and

$$i(t_0) = i_1(t_0) + i_2(t_0) + \dots + i_N(t_0) \dots (5.32)$$

Inductors in parallel are combined in the same way as resistors in parallel.

Ex-5.10: The current through a 0.01 henry

Whereas, $1/L_{eq}$ is equal to $1/L_1$ plus $1/L_2$ plus $1/L_3$ plus 1 upon up to L_N , it is same as that your resistance are in parallel when 1 upon R_{eq} is equal to 1 upon R_1 plus 1 upon R_2 like this same as resistor and there initial thing $i(t_0)$ is equal to $i_1(t_0)$ plus $i_2(t_0)$ up to $i_N(t_0)$ this is equation 31 and this is equation 32 right. So, inductors in parallel are combined in the same way as resistors in parallel, next will take 2 3 examples.

(Refer Slide Time: 21:45)

Inductors in parallel are combined in the same way as resistors in parallel.

EX-5.10: The current through a 0.01 Henry inductor is $i(t) = 5t e^{-20t}$ Amp. Determine the voltage across the inductor and the energy stored in it.

Soln:

Since $v = L \frac{di}{dt}$ and $L = 0.01 \text{ H}$,
 $i(t) = 5t e^{-20t}$

So, just look into this the current that current through a 0.01 Henry inductor is $i(t)$ is equal to $5t e^{-20t}$ ampere. Determine the voltage across the inductor and the energy stored in it since we know that v is equal to $L \frac{di}{dt}$ and L is given 0.01 Henry and $i(t)$ is given $5t e^{-20t}$ it is given it is given, so v is equal to your what you call $L \frac{di}{dt}$.

(Refer Slide Time: 22:20)

Since $v = L \frac{di}{dt}$ and $L = 0.01 \text{ H}$, and
 $i(t) = 5t e^{-20t}$,

$$v = 0.01 \frac{d}{dt} (5t e^{-20t})$$
$$\therefore v = 0.05 e^{-20t} + 0.05 t (-20) e^{-20t}$$
$$\therefore v = 0.05 (1 - 20t) e^{-20t} \text{ Volt.}$$

The energy stored is

$$w = \frac{1}{2} L i^2 = \frac{1}{2} \times 0.01 \times 25 t^2 e^{-40t}$$

So, if you do if you take the derivative of it will become $0.05 e^{-20t}$ plus $0.05 t$ into minus 20 into e^{-20t} . If you simply it will be v is

equal 0.05 into 1 minus $10t$ into e to the power minus $10t$ volts, so energy stored is half Li square.

(Refer Slide Time: 23:38)

The screenshot shows a digital whiteboard with the following handwritten content:

$$\therefore v = 0.05 e^{-20t} + 0.05 t (-10) e^{-10t}$$

$$\therefore v = 0.05 (1 - 10t) e^{-10t} \text{ Volt.}$$

The energy stored is

$$w = \frac{1}{2} Li^2 = \frac{1}{2} \times 0.01 \times 25 t^2 e^{-20t}$$

$$\therefore w = 0.125 t^2 e^{-20t} \text{ Joule}$$

At the bottom of the whiteboard, the text reads: "Ex-5.11 Find the current through a 5 mH". A small video inset of a man in a green shirt is visible in the bottom right corner.

So, half L into this is your i square right, so $25 t$ square into e to the power minus $20 t$. So, it is basically $0.125 t$ square e to the power minus $20 t$ joule right, so this is simple example next 1 is find the current through a 5 milli Henry inductor if the voltage across it is $v(t)$ is equal to $30 t^2$ for t greater than 0 and it is 0 for t less than 0 this is given right.

(Refer Slide Time: 23:06)

The screenshot shows a digital whiteboard with the following handwritten content:

(56)

Ex-5.11 Find the current through a 5 mH inductor if the voltage across it is

$$v(t) = \begin{cases} 30 t^2, & \text{for } t > 0 \\ 0, & \text{for } t < 0 \end{cases}$$

Also determine energy stored within $0 < t < 0.5$ sec.

Soln.

A small video inset of a man in a green shirt is visible in the bottom right corner.

So, also determine the energy stored within $0 < t < 0.5$ second this is also asked to do it.

(Refer Slide Time: 23:17)

Also determine energy stored within
 $0 < t < 0.5$ sec.

Soln.

We know,

$$i = \frac{1}{L} \int_{t_0}^t v(t) dt + i(t_0)$$

Given that $L = 5 \text{ mH} = 5 \times 10^{-3} \text{ Henry}$

$$\therefore i = \frac{1}{5 \times 10^{-3}} \int_0^t 30t^2 dt + 0 = 2000t^3 \text{ Amp.}$$

So, you know that i is equal to $\frac{1}{L} \int_{t_0}^t v(t) dt + i(t_0)$ right, so given that L is equal to 5 milli Henry. So, it is 5 into 10 to the power minus 3 Henry and i is equal to $\frac{1}{L} \int_{t_0}^t v(t) dt + i(t_0)$ that is 5 into 10 to the power minus 30 to t third v is equal to 30 $v(t)$ is equal to 30 t square given dt plus 0 that is that is your $i(t_0)$ is equal to actually 0 right. Because anything that $v(t)$ is given and find the current your 5 milli ampere if the voltage across because, $v(t)$ is 0 for t less than 0 right, so your in this case your $i(t_0)$ is equal to 0.

(Refer Slide Time: 23:56)

Given that $L = 5 \text{ mH} = 5 \times 10^{-3} \text{ Henry}$

$$i = \frac{1}{5 \times 10^{-3}} \int_0^t 30t^2 dt + 0 = 2000t^3 \text{ Amp.}$$

The power,

$$p = vi = 30t^2 \times 2000t^3 = 6 \times 10^4 t^5$$

and the energy stored is then

$$W = \int_0^{0.5} p dt = \int_0^{0.5} 6 \times 10^4 t^5 dt = 6 \times 10^4 \times \frac{1}{6} t^6 \Big|_0^{0.5}$$

So, it is $2000 t^3$ ampere so the power p is equal to $v i$ p is equal to thirty t^2 into $2000 t^3$ is equal to $6 \times 10^4 t^5$ right.

(Refer Slide Time: 24:11)

The power,

$$p = vi = 30t^2 \times 2000t^3 = 6 \times 10^4 t^5$$

and the energy stored is then

$$W = \int_0^{0.5} p dt = \int_0^{0.5} 6 \times 10^4 t^5 dt = 6 \times 10^4 \times \frac{1}{6} t^6 \Big|_0^{0.5} \text{ Joule}$$

$\therefore W = 156.25 \text{ Joule}$

And the energy stored is then given by we it has been asked in between 0 and 0.5, so integrate this 0 to 0.5 $p dt$ p is equal to $6 \times 10^4 t^5$. So, you substitute here and integrate you will get your W is equal to 156.25 joule right it is a simple example simple example.

(Refer Slide Time: 24:35)

Ex-5.12: Fig. 5.26 shows a simple circuit. Under dc conditions, determine i , v_C , v_L and the energy stored in capacitor and inductor.

Now, another 1 is that figure 26 shows the simple circuit under dc condition, determine i , v_C , v_L and the energy stored in the what you call in the capacitor. So, you have this is the simple circuit is given this is and you have to find out under dc condition you have to find out i , v_C , v_L right.

This is i and this is v_C and this is your voltage your what you call and your v_L right and energy stored in the capacitor and inductor this we have to find out.

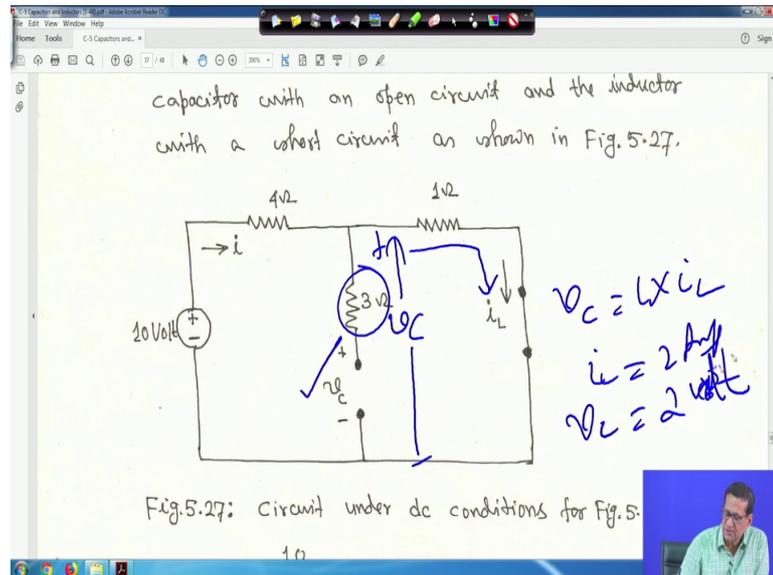
(Refer Slide Time: 25:05)

Fig. 5.26: Circuit for Ex-5.12

Soln.
Under dc conditions, we replace the capacitor with an open circuit and the inductor with a short circuit.

So, question is that under dc condition right under dc condition.

(Refer Slide Time: 25:11)



We replace the capacitor with an open circuit for dc just we have seen for capacitor and for dc condition inductor should be short circuit. So, it is short circuit inductor is short circuit; that means, this 3 ampere there is no current is flowing through 3 ampere because it is open circuit right no current is flowing.

So, then what will be i it is $4 + 1 = 5$ ohm and 10 volt. So, it will be $10 / 5 = 2$ ampere, so i is equal to 2 ampere and same condition this is the simple series circuit then nothing is flowing here so i and i_L this it is same right. So, i is equal to i_L is equal to $10 / (4 + 1) = 2$ ampere and v_C is equal to voltage across the capacitor is actually this is this 1 your this is your voltage v_C this is your voltage v_C no current is flowing here. So, basically this is actually I can write in better way this is actually v_C and it is your what you call this current i your i_L is flowing to this. So, v_C is equal to $1 \times i_L$ right and i_L is equal to 2 ampere therefore, v_C is equal to basically 2 volt right.

(Refer Slide Time: 26:27)

Fig.5.27: Circuit under dc conditions for Fig.5.26,

$$i = i_L = \frac{10}{4+1} = 2 \text{ Amp}$$

$$V_c = 1 \times i_L = 1 \times 2 = 2 \text{ Volt.}$$

The energy stored in the capacitor is 38

$$W_c = \frac{1}{2} C V_c^2 = \frac{1}{2} \times 0.1 \times 10^{-6} \times (2)^2 \text{ Joule}$$

$$\therefore W_c = 0.2 \mu\text{J}$$

So, let me clear it so that that is why V_C is equal to 2 volt now energy here what you call energy stored in the capacitor is W_c is equal to half $C V_C^2$ square. So, we have got your half C is given 0.1 into 10 to the power minus 6 farad because 0.1 micro farad. So, farad into V_C is equal to 2 volts or 2 square joule so 0.2 micro joules right and that in the inductor will be your half $L i^2$ square.

(Refer Slide Time: 26:57)

$$W_c = \frac{1}{2} C V_c^2 = \frac{1}{2} \times 0.1 \times 10^{-6} \times (2)^2 \text{ Joule}$$

$$\therefore W_c = 0.2 \mu\text{J}$$

and that in the inductor is

$$W_L = \frac{1}{2} L i_L^2 = \frac{1}{2} \times 0.2 \times 10^{-3} \times (2)^2$$

$$\therefore W_L = 0.4 \text{ mJ}$$

Ex-5.13: In Fig.5.28, $i(t) = (2 - e^{-10t})$ mAmp.

So, it will be half into 0.2 into 10 to the power minus 3 to 2 square, so W_L is equal to 0.4 micro milli joule right. So, this is your what you call that your energy stored in that inductor right. So, next is next is this problem another problem so simple problem it is simple problem. So, in figure this that your in this figure.

(Refer Slide Time: 27:21)

∴ $\omega L = 0.4 \text{ mJ}$

EX-5.13: In Fig.5.28, $i(t) = (2 - e^{-10t}) \text{ mA}$. If $i_2(0) = -1 \text{ mA}$, find $i_1(t)$, $v(t)$, $v_1(t)$, $v_2(t)$, $i_1(t)$ and $i_2(t)$.

That this figure $i(t)$ is given $2 - e^{-10t}$ milli ampere if initial condition of $i(t)$ is given minus 1 milli ampere find initial conditions $i_1(0)$ then $v(t)$ then $v_1(t)$ then $v_2(t)$ then $i_1(t)$ and $i_2(t)$ all you have to find it out right, so this is the circuit is given.

(Refer Slide Time: 27:41)

$v_2(t)$, $i_1(t)$ and $i_2(t)$.

$(2+3) = 5H$

$\frac{4 \times 12}{4+12} = 3H$

Fig.5.28: Circuit for EX-5.13

Soln.
Given that $i(t) = (2 - e^{-10t}) \text{ mA}$ and $i_2(0) = -1 \text{ mA}$

This is the circuit is given when 2 inductors are there in parallel right so and these 2 inductors are in parallel means that this inductor this inductor and this inductor these are parallel means that equivalent inductance will be 12 H into 12 divided by 4 plus 12 right.

So, it will be your 3 Henry right and then 2 Henry is in series to find out your same like a resistor, inductor case whatever you whatever series parallel combination you have done for resistor for inductor case it is same right and this and then this 2 Henry is there. So, 2 plus this 3 equivalent your thing will be 5 Henry equivalent inductors right so let me clear it.

(Refer Slide Time: 28:36)

Fig. 5.28: Circuit for EX-5.13

Soln.

Given that $i(t) = (2 - e^{-10t})$ mA and $i_2(0) = -1$ mA

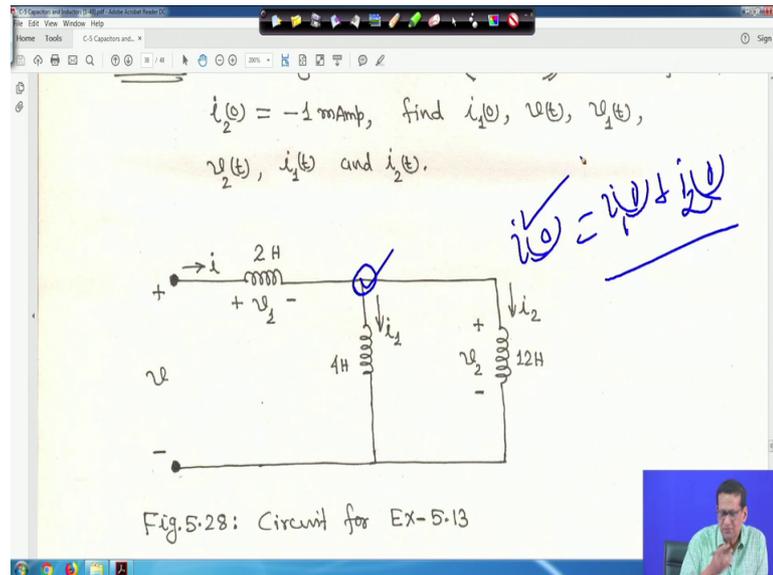
at $t = 0$, $i(0) = (2 - 1) = 1$ mA

$$i(0) = i_1(0) + i_2(0)$$

$$\therefore 1 = i_1(0) - 1 \quad \therefore i_1(0) = 2 \text{ mA.}$$

So, in this case the given that $i(t)$ is equal to 2 minus e^{-10t} milli ampere and $i_2(0)$ is given minus 1 milli ampere it is given. Now, at t is equal to 0 you find out that t is equal to 0 you put here in this expression that t is equal to 0 right. So, in that case you will get $i(0)$ is equal to 2 minus 1, so 1 milli ampere.

(Refer Slide Time: 29:03)



Therefore, if you apply your KCL in at this node right, for initial condition you can write that i_0 is equal to i_1 plus i_2 right. So, then and 1 of them is given and i_0 also we have computed so other 1 easily you can get it, so let me clear it. So, i_0 then i_0 is 1 we have got it and i_2 is given minus 1 ampere therefore, i_1 initial condition that is your initial current that is 2 milli ampere right the L_{eq} equal to that.

(Refer Slide Time: 29:45)

$L_{eq} = 2 + \frac{4 \times 12}{4 + 12} = 5 \text{ H}$

Thus,

$v(t) = L_{eq} \cdot \frac{di}{dt} = 5 \times \frac{d(2 - e^{-10t})}{dt} \text{ mV}$

$\therefore v(t) = 50e^{-10t} \text{ mV}$

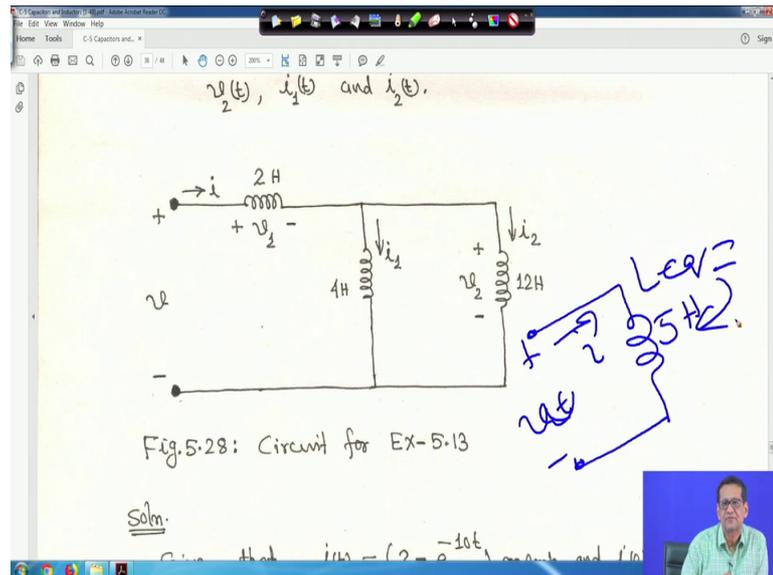
and

$v_1(t) = 2 \frac{di}{dt} = 2 \frac{d(2 - e^{-10t})}{dt} = 20e^{-10t} \text{ mV}$

39

We just calculated I just show you how to calculation it will be 2 plus 4 into 12 upon 4 plus twelve it will be 5 Henry; just I showed you therefore, $v(t)$ is equal to that means, this is the circuit. So, this is your v so $v(t)$ is equal to I mean if you draw the equivalence circuit if you draw the equivalence circuit, so this is actually your v , v is equal to say $v(t)$ plus minus and this is actually your 5 Henry right and this is the current say i right.

(Refer Slide Time: 30:18)



So, that is why and this is actually your L_{eq} is equal to this 5 Henry right. So, let me clear it so $v(t)$ is equal to $L_{eq} \frac{di(t)}{dt}$. So, L_{eq} is 5 and I is equal to 2 minus e^{-10t} milli amp. So, if you just take the derivative it will become $v(t)$ is equal to 50 e^{-10t} milli volt right.

(Refer Slide Time: 30:49)

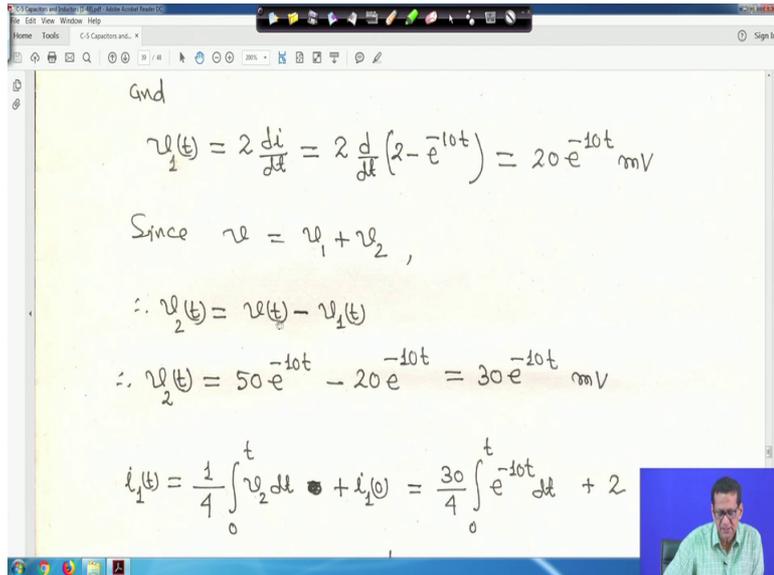
And

$$v_1(t) = 2 \frac{di}{dt} = 2 \frac{d}{dt} (2 - e^{-10t}) = 20e^{-10t} \text{ mV}$$

Since $v = v_1 + v_2$,

$$\therefore v_2(t) = v(t) - v_1(t)$$

$$\therefore v_2(t) = 50e^{-10t} - 20e^{-10t} = 30e^{-10t} \text{ mV}$$

$$i_1(t) = \frac{1}{4} \int_0^t v_2 dt + i_1(0) = \frac{30}{4} \int_0^t e^{-10t} dt + 2$$


Now, therefore $v_1(t)$ will be $2 \frac{di}{dt}$ right I mean if you if you your what you call this is this is 2 your Henry and voltage across is v_1 . So, it will be 2 into that is your L into di by dt . So, here it will be your v is equal to your 2 into di by dt if i you know this is given. So, it is $20e^{-10t}$ milli volt now since v is equal to v_1 plus v_2 right; therefore, I mean this v_2 that means.

(Refer Slide Time: 31:31)

$v_2(t)$, $i_1(t)$ and $i_2(t)$.

$v = v_1 + v_2$

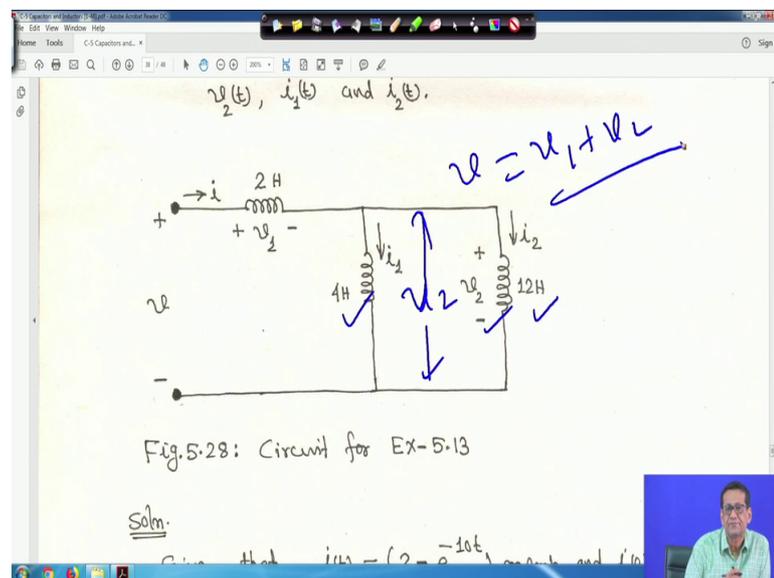
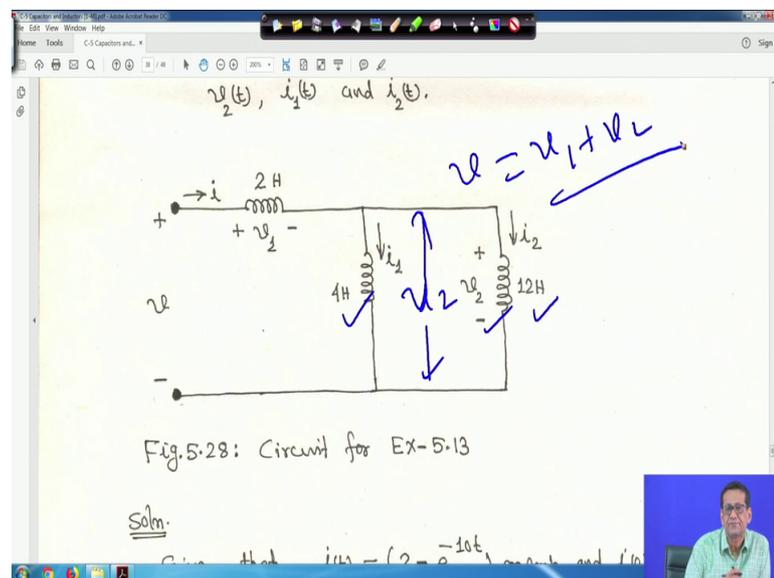


Fig.5.28: Circuit for EX-5.13

Soln.

Given that $i(t) = (2 - e^{-10t})$ amp and $v(t)$



This is actually voltage v_2 right that means, voltage across these and across these it is v_2 therefore, if you apply KVL so it will be v is equal to v_1 plus v_2 right. Therefore let me clear it therefore, your v_2 is equal to $v_2(t)$ is equal to $v(t)$ minus $v_1(t)$, $v(t)$ we have computed earlier $50e^{-10t}$ and $v_1(t)$ minus $20e^{-10t}$ the power

minus 10 t equal to 30 e to the power minus 10 t milli volt right i 1 t will be is equal to 1 up on 4 0 to v 2 dt plus i 1 0.

(Refer Slide Time: 32:05)

The image shows a digital whiteboard with handwritten mathematical derivations. The equations are as follows:

$$i_1(t) = \frac{1}{4} \int_0^t v_2 dt + i_1(0) = \frac{30}{4} \int_0^t e^{-10t} dt + 2$$

$$\therefore i_1(t) = -\frac{3}{4} e^{-10t} \Big|_0^t + 2$$

$$\therefore i_1(t) = -\frac{3}{4} (e^{-10t} - 1) + 2 = (2.75 - 0.75 e^{-10t}) \text{ mA}$$

$$i_2(t) = \frac{1}{12} \int_0^t v_2 dt + i_2(0) = \frac{30}{12} \int_0^t e^{-10t} dt + (-1)$$

$$\therefore i_2(t) = -\frac{1}{4} (e^{-10t} - 1) - 1 = (-0.75 - 0.25 e^{-10t}) \text{ mA}$$

$$i_2(t) = -(0.75 + 0.25 e^{-10t}) \text{ mA}$$

So, 30 by 4 right and your then 0 to t e to the power v minus 10 t dt and i 1 0 is equal to 2 right. If you just simplify integrate and simplify you will get i 1 2 i 1 t is equal to 2.75 minus 0.75 e to the power minus 10 milli ampere you please simplify.

(Refer Slide Time: 32:32)

The image shows a digital whiteboard with handwritten mathematical derivations. The equations are as follows:

$$\therefore i_1(t) = -\frac{3}{4} (e^{-10t} - 1) + 2 = (2.75 - 0.75 e^{-10t}) \text{ mA}$$

$$i_2(t) = \frac{1}{12} \int_0^t v_2 dt + i_2(0) = \frac{30}{12} \int_0^t e^{-10t} dt + (-1)$$

$$\therefore i_2(t) = -\frac{1}{4} (e^{-10t} - 1) - 1 = (-0.75 - 0.25 e^{-10t}) \text{ mA}$$

$$\therefore i_2(t) = -(0.75 + 0.25 e^{-10t}) \text{ mA}$$

Similarly, for i 2 t 1 upon twelve 0 to t v 2 dt plus i 2 0. So, it is it will be 30 by twelve 0 to t e to the power minus 10 t you put here v 2 t is equal to right plus your i 2 0 is given

known it is minus 1 and then you integrate and simplify you will get $i = 2t$ is equal to minus of 0.75 plus 0.25 e^{-10t} milli ampere this is i in t . So, with this capacitor inductors topic is closed 1 and 2 example is given here.

(Refer Slide Time: 33:02)

5.1: In Fig. 5.29, $i(0) = 0$ and for $t > 0$,
 $i = 10t e^{-5t}$ Amp. (a) Determine v (b) At what instant of time is the current maximum? (c) At what instant of time does the voltage change polarity?

The circuit diagram shows a current source i in series with an inductor of 100 mH . The inductor's voltage v is indicated with a positive terminal at the top and a negative terminal at the bottom.

Like example 1, you will solve it for that so this is the that you read it and am not reading everything is given here right so and the answer is answer is also given this is the answer this is the answer is given right.

(Refer Slide Time: 33:13)

Fig. 5.29: Circuit for ~~Fig. 5.29~~ Problem-5.1

Ans: (a) $e^{-5t} (1 - 5t)$ Volt
 (b) 0.2 sec
 (c) 0.2 sec.

5.2: Fig. 5.30 shows a simple circuit and give that $i(t) = 0$ for $t < 0$ and

So, one only one problem here I will giving here and this is the answer and this is your problem right.

Thank you very much we will be back again.