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Pract: 7-3 The Capacitor
(Pg 224 8th Ed HKD)

Calculate the energy stored in a 1000 μF capacitor at t = 50 μs if the voltage across it is $1.5 \cos 10^5 t$ volts.

Solution: We know

$$w_c(t) = \frac{1}{2} C\, v(t)^2$$

$$= \frac{1}{2} \times 1000 \times 10^{-6} (1.5)^2 \cos^2 10^5 \times 50 \times 10^{-6}$$

$$w_c(t) = 500 \times 2.25 \times 10^{-6} \cos^2 5$$

Now $$\cos^2\alpha = \frac{1}{2}(1 + \cos 2\alpha)$$

and $$\sin^2\alpha = \frac{1}{2}(1 - \cos 2\alpha)$$

So $$\cos^2 5 = \frac{1}{2}(1 + \cos 2\times 5) = \frac{1}{2}(1 + \cos 10)$$

$$= \frac{1}{2}(1 - 0.839) = \frac{0.16092}{2}$$

$$\cos^2 5 = 0.08046$$

So $$w_c(t) = 1.125 \times 0.08046\ \mu J$$

$$w_c(t) = 90.52\ \mu J$$

Note: $\cos 5 = 0.28366$

$(\cos 5)^2 = 0.08046$

C

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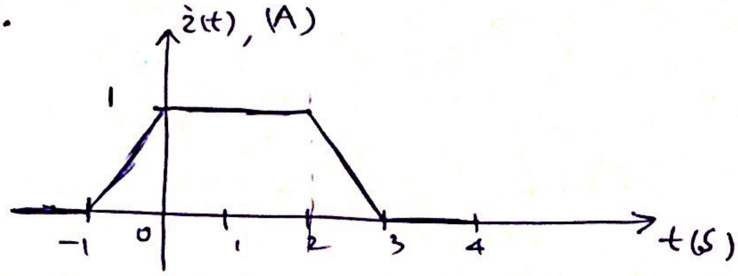
Example 7.4 The Inductor
(PP 227 8th Ed HKD)

Given the waveform of the current in a 3 H inductor as shown. Determine the inductor voltage and sketch it.



Solution: We know $v = L\frac{di}{dt} = 3\frac{di}{dt}$

— The current is zero for $t < -1$ s, the voltage is zero in this interval.

— Then current begins to increase at a linear rate of 1 A/s and thus a constant voltage of

$$L\frac{di}{dt} = 3\text{ V is produced.}$$

— During the following 2 second interval, the current is constant and the voltage is therefore zero.

— The final decrease of the current results in

$$\frac{di}{dt} = -1\text{ A/s} \quad \text{and it produces}$$

$$v = -3\text{ V}$$

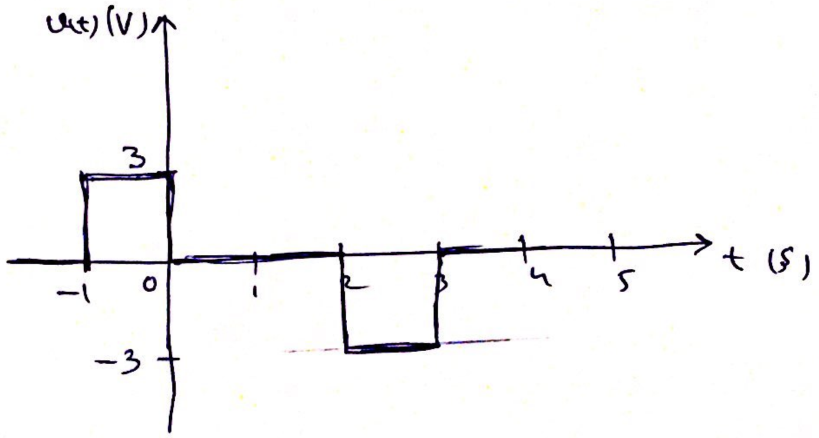
——————— contd

c

— contd (2.27)

— For $t > 3$ s, $i(t)$ is a constant (zero), so that $v(t) = 0$ for that interval.

— The complete voltage waveform is sketched as follows:-



(Practice)

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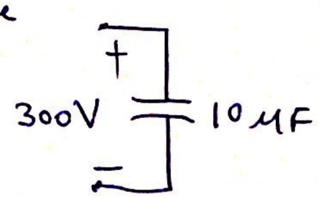
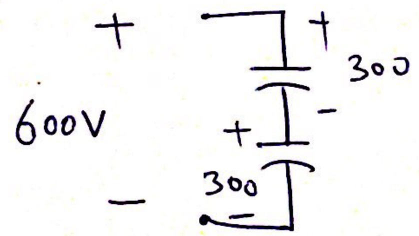
Example: Capacitors in Series/Parallel

Use 10-μF capacitors rated at 300 V to design a capacitor bank of 40-μF rated at 600 volts.

Solution: We have

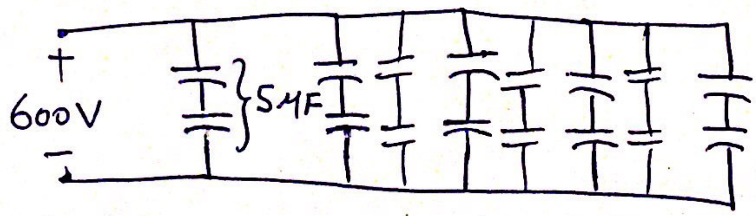


— For 600 volts, we connect two capacitors in series:



— Together these give us a total capacitance of 5 μF.

— So we need to connect '8' pairs of these to get 40 μF.



— Note, A total of 16 capacitors are needed.

(Important)
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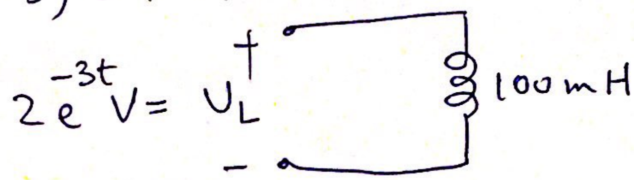
Practice 7-6 Inductor : Voltage – Current

(PP 231 8th Ed HKD)

A 100 mH inductor has voltage $U_L = 2e^{-3t}$ V across its terminals. Determine the resulting inductor current if $i_L(-0.5) = 1A$.



Solution: Now $U_L = L\dfrac{di}{dt}$

or $i_L(t) = \dfrac{1}{L}\int U_L\,dt + K$ {This is indefinite integral with a constant of integration}

So $i_L(t) = \dfrac{1}{100\times10^{-3}}\int 2e^{-3t}\,dt + K$

$= \dfrac{1}{10^{-1}}\times 2 \times \dfrac{e^{-3t}}{-3} + K = -\dfrac{20}{3}e^{-3t} + K$

$i_L(t) = -\dfrac{20}{3}e^{-3t} + K$

Now $i_L(-0.5) = -\dfrac{20}{3}e^{-3(-0.5)} + K = 1$

So $K = 1 + \dfrac{20}{3}e^{1.5} = 1 + 29.9$

or $K = 30.9$

Hence $i_L(t) = -\dfrac{20}{3}e^{-3t} + 30.9$ A

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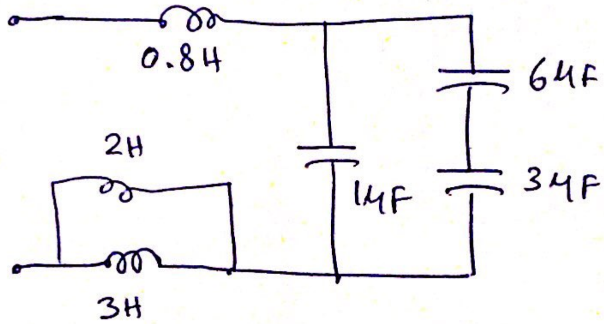
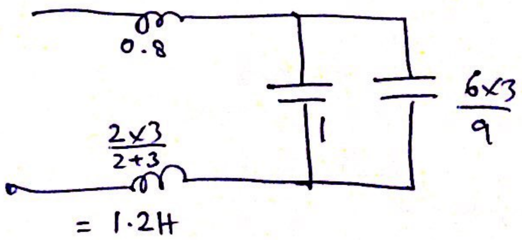
Example 7-8 Series/Parallel Combinations

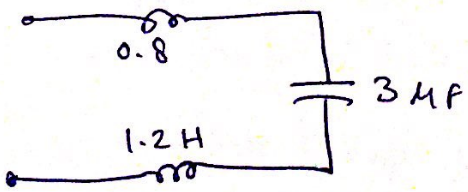
(PP 237 8th Ed HKD)

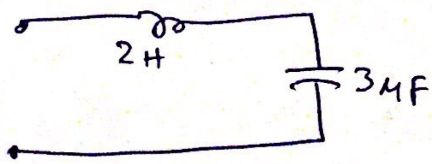
Simplify the network using series/parallel combinations.



Solution:







(Interesting)

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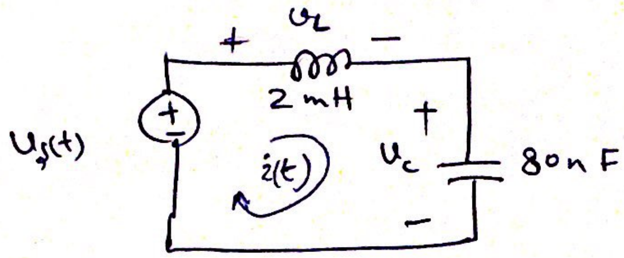
Practice 7-9 Consequences of Linearity

(pp239 8th Ed HKD)

If $v_c(t) = 4\cos 10^5 t$ V in the following circuit, find $v_s(t)$.



Solution: We know $v_s(t) = v_c(t) + v_L(t)$ —— KVL

and $v_L(t) = L\dfrac{di}{dt}$

and $i = C\dfrac{dv_c}{dt}$

So $i = 80\times10^{-9}\times(-4\times10^5 \sin 10^5 t)$ A

$i = -320\times10^{-4}\sin 10^5 t$ A

Hence $v_L(t) = 2\times10^{-3}\times -320\times10^{-4}\times10^5 \cos 10^5 t$

$= -640\times10^{-2}\cos 10^5 t$ Volts

$v_L(t) = -6.4\cos 10^5 t$ V

Finally $v_s(t) = [4+(-6.4)]\cos 10^5 t$ V

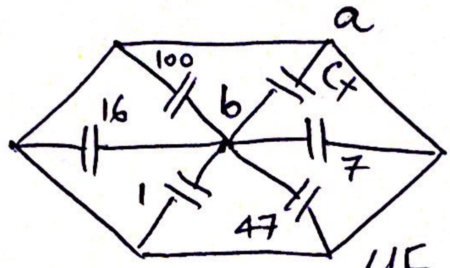
$v_s(t) = -2.4\cos 10^5 t$ Volts.

(V. Good)
Do it

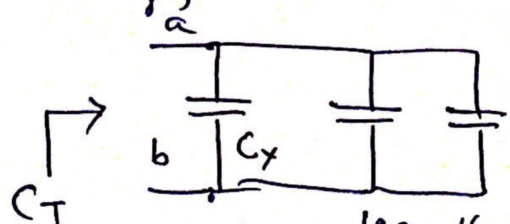
(Pdf)

Prob 7-37 Capacitance Combination
(PP 216 7th Ed HKD SIE)

The following network stores 534.8 μJ when a voltage of 2.5 V is connected to terminals 'a' and 'b'. What is the value of C_x?



Solution: Rearranging



100, 16, 1, 47, 7 and C_x.

So

$$C_T = C_x + 100 + 16 + 1 + 47 + 7$$

or $C_T - C_x = 171\ \mu F$

Without C_x, the energy stored is

$$E(C_T - C_x) = \frac{1}{2}(171)\times10^{-6}(2.5)^2$$
$$= 534.375\ \mu J$$

Given $E_{C_T} = 534.8\ \mu J$

So $E_{C_x} = 425\ nJ$ (i.e. 534.8 − 534.375)

Now $E_{C_x} = \frac{1}{2}C_x V^2 = \frac{1}{2}C_x(2.5)^2 = 425\ nJ$

So $C_x = 136\ nF$

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