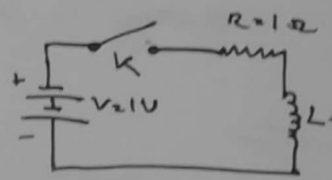
27. In the circuit shown, K is closed at $t=0$. The current follows in the circuit is given by the equation $i=(1-e^{-t})$ amp, $t>0$. At a certain time the current has a value of 0.63 amp. a) At what rate is the current charging? b) What is the value of total flux linkages c) What is rate of change of flux linkage (d) What is the voltage across inductor (e) How much energy is stored in magnetic field of inductor (f) What is the voltage across the resistor (g) Rate at which energy is being stored (h) at what rate energy is being dissipated (i) At what rate battery is supplying energy.

Soln



given $i(t) = 0.63 = 1-e^{-t}$

$\therefore \; e^{-t} = 0.37$

$t = -\ln 0.37 = 0.994$ sec

a) rate of change of current, $\frac{di}{dt} = e^{-t} = e^{-0.994} = 0.37$ A/sec

b) $\phi = L\, i(t) = 1(1-e^{-t}) = 0.67$ weber (at $t=0.994$ sec)

c) rate of change of flux linkage, $\frac{d\phi}{dt} = e^{-t} = 0.37V$

d) Using KVL :- $-V + iR + V_L = 0$

$V_L = 1 - 1(0.67) = 0.37V$

e) energy stored by inductor, $E = \frac{1}{2} L I^2 = \frac{1}{2} \times 1 \times 0.63^2 = 0.1984J$

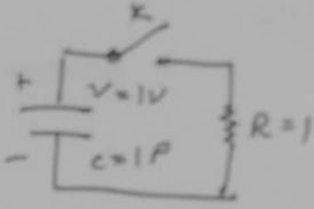
f) Voltage across resistor, $V_R = iR = 0.63 \times 1 = 0.63V$

g) Rate at which energy is being stored, $P_L = \frac{E}{t} = \frac{0.198}{0.994} = 0.199$ J/s

h) Rate at which energy is being dissipated, $P_R = \frac{I^2R}{t} = \frac{(0.63)^2}{t} = 0.39$

i) Rate at which battery is supplying energy, $P_B = VI = 1 \times 0.63 = 0.63$

1-25 In the circuit shown the capacitor is charged to a voltage V and at t=0 the switch k is closed. The current in the ... is known to be of form $i(t) = e^{-t}$ amp $t > 0$ at a certain time current has a value of 0.37 A. a) At what rate voltage across the capacitor charging b) what is the value of charge on the capacitor c) what is the rate of change of product cv? d) what is the voltage across capacitor e) How much energy is stored in electric field of capacitor f) what is voltage across resistor? g) At what rate is energy being taken from the electric field of the capacitor h) At what rate energy is being dissipated as heat.



Soln:

given $V = 1V$ $C = 1F$

$i(t) = e^{-t}$ $t = 0.994$ sec

a)

$$i = c\frac{dv}{dt} \Rightarrow \frac{dv}{dt} = \frac{i}{c} \Rightarrow \frac{0.37}{1} = 0.37 V/sec$$

b) $C = \frac{Q}{V}$ charge of capacitor $Q = CV = 1 \times 1 = 1$ coulomb

c) $$\frac{d\,cv}{dt} = \frac{dQ}{dt} = i(t) = e^{-t} \Rightarrow 0.37$$

d) Using KVL :-

$$-V_c + iR = 0$$

$$V_c = 0.37 \times 1 = 0.37V$$

e) energy stored in the capacitor $E = \frac{1}{2}CV_c^2 = \frac{1}{2} 1 \times 0.37^2 = 0.0684J$

f) voltage across the resistor $V_R = iR = 0.37V$

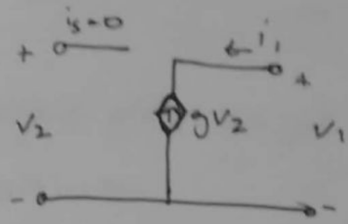
g) Rate of energy being taken from capacitor $P = \frac{E_c}{t} = \frac{0.0684}{0.994} = 0.0688$

h) Rate of energy being dissipated as heat $P_r = I^2R = 0.37^2 = 0.13694$

2-1 For the controlled source shown in figure, prepare a plot similar to that given

Sol From the above figure we can see that

$V_2 = gV_1$



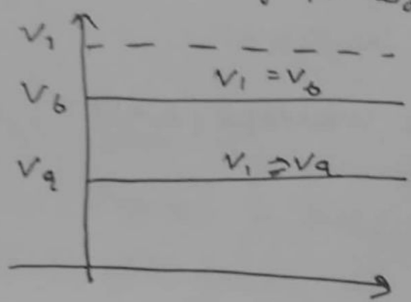
when $V_1 = V_a$

$V_2 = gV_a$

& when $V_1 = V_b$

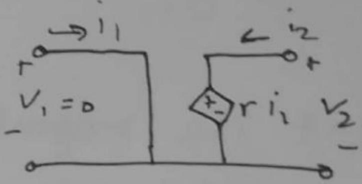
$V_2 = gV_b$

hence we can plot the graph as follows:-



2-2 Repeat problem 2-1 for the controlled source given in below figure

Sol From the above figure we can see that



$V_2 = ri_1$

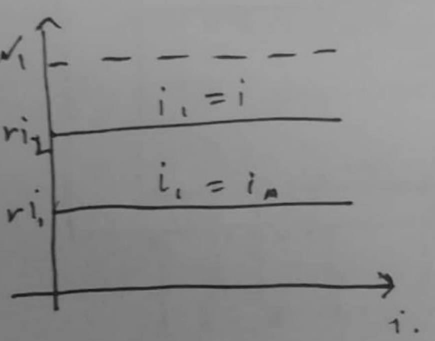
when $i_1 = i_a$

$V_2 = ri_a$

when $i = i_b$

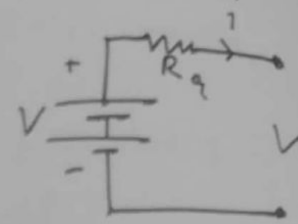
$V_2 = ri_b$

hence we can plot the graph as follows:-



2-3 The circuit of the figure is a model for a battery of terminal voltage V & internal resistance R_b. For this circuit is a function v. Identify features of the plot such as slopes, intercepts on.

By applying KVL in the above loop we get:-



$$-v + iR_b + V = 0$$

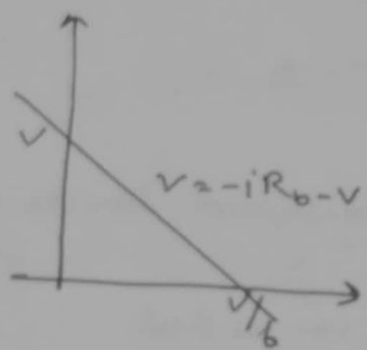
$$\cancel{v} = -iR_b + v$$

the above equation is in the form

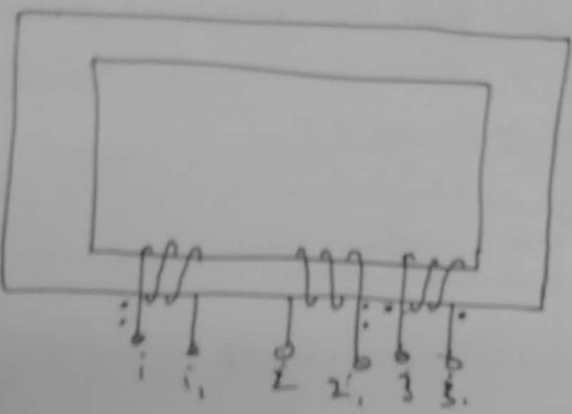
$$y = mx + c$$

∴ the slop $m = -R_b$ & the intercept, $c = v$

therefore the graph is



2-4 The magnetic system shown has three windings mark 1-1', 2-2' and 3-3'. Using diffrent forms of dots establish polarity marking



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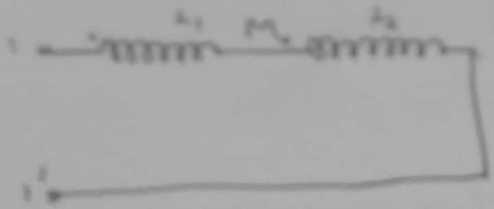
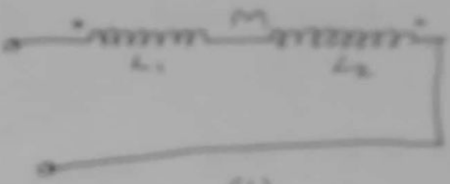
Q-8 Each schematic in figure shows two inductors with coupling but with different dot marking. For each of the two systems determine the equivalent inductance of the system at terminal 1-1' by combining inductances



(a)



(b)

Ans

a> In fig <a> when the current enters the dotted terminal of L_1 & then leaves & then enters through L_2 the inductance of the flux gets adds up due same polarity.

$$e_1 = L_1 \frac{di}{dt} + M\frac{di}{dt} = (L_1+M)\frac{di}{dt}$$

similarly, $e_2 = (L_2+M)\frac{di}{dt}$

$$e = e_1+e_2 = (L_1+L_2+2M)\frac{di}{dt}$$

$$\frac{e}{\frac{di}{dt}} = L = L_1+L_2+2M$$

eq :- L_1+L_2+2M.

b) In fig <b> when current enters the dotted end of L_1 & leaves it will enter the non dotted terminal resulting in opposite polarity & in turn subtracting flux

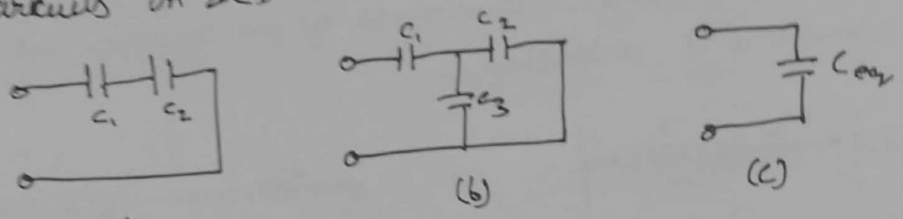
$$e_1 = L_1\frac{di}{dt} - M\frac{di}{dt} = (L_1-M)\frac{di}{dt}$$

$$e_2 = (L_2-M)\frac{di}{dt}$$

$$e = e_1+e_2 = (L_1+L_2-2M)\frac{di}{dt}$$

equ. $L = L_1+L_2-2M$

S-1 What must be relationship between C_{eq} & C_1 & C_2 in (a) & (b) circuits in S(a) S(c) equivalent repeat for circuit in (b)



(a) (b) (c)

Soln a) In the circuit (a) current is same through C_1 & C_2 & we can be given by.

$$V_1 = \frac{1}{C_1}\int i\,dt \quad \& \quad V_2 = \frac{1}{C_2}\int i\,dt$$

If V is the voltage across C_{eq} :-

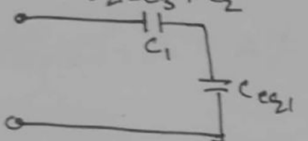
$$V = V_1 + V_2$$

$$\frac{1}{C_{eq}}\int i\,dt = \frac{1}{C_1}\int i\,dt + \frac{1}{C_2}\int i\,dt$$

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2}$$

b) In the figure (b) we can see current through each capacitor is diffrent. but C_2 & C_3 are ||el with each other.

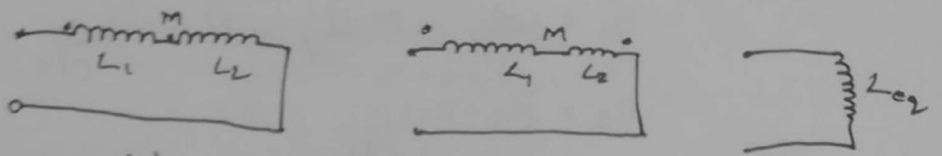
$$C_{eq1} = C_3 + C_2$$



C_1 & C_{eq1} are in sereis $1/C_{eq} = 1/C_1 + 1/C_{eq1}$

$= 1/C_1 + 1/(C_2+C_3)$

3-2 What must be relationship between L_{eq} & L_1 & L_2 & M for the circuits of Fig (a) and (b) to be equivalent with (C)?



(a) (b) (c)

Soln a) In fig (a) current enters through dotted terminal of L_1 & then enters dotted terminal of L_2 :-

$$\therefore e = e_1 + e_2 = L_1\frac{di}{dt} + L_2\frac{di}{dt} + 2M\frac{di}{dt}$$

$$L_{eq} = L_1 + L_2 + 2M$$

c) In fig (6) when the current enters dotted terminal at L_1 but undotted terminal at L_2 :-

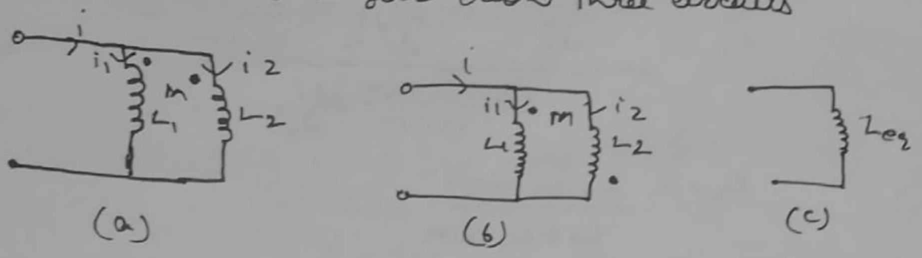
$\therefore$

$$e = e_1 + e_2$$

$$e = L_1\frac{di}{dt} + L_2\frac{di}{dt} - 2M\frac{di}{dt}$$

$$L_{eq} = L_1 + L_2 - 2M$$

3-3 Repeat Prob 3-2 for below three circuits



a) In fig (a) :- $e_1 = L_1\frac{di_1}{dt} + M\frac{di_2}{dt}$

$$= L_1\frac{di_1}{dt} + M\frac{d(i-i_1)}{dt} \qquad \therefore i = i_1 + i_2$$

$$e_2 = L_2\frac{di_2}{dt} + M\frac{di_1}{dt}$$

$$= L_2\frac{d(i-i_1)}{dt} + M\frac{di_1}{dt}$$

$$e = e_1 + e_2 \Rightarrow L_1\frac{di_1}{dt} \mp L_2\frac{di}{dt} \pm L_2\frac{di_1}{dt} \mp \cancel{M\frac{di_1}{dt}} + M\frac{di}{dt} - \cancel{M\frac{di_1}{dt}}$$

$$\Rightarrow (L_1 \mp L_2)\frac{di_1}{dt} + (L_2 + M)\frac{di}{dt} = 0$$

$$\Rightarrow (L_1 + L_2 - 2M)\frac{di_1}{dt} = M(L_2 - M)\frac{di}{dt}$$

$$= \frac{di_1}{dt}\left(\frac{L_1 + L_2 - 2M}{L_2 - M}\right) = \frac{di}{dt}$$

b) In fig (b) :- $e_1 = L_1\frac{di_1}{dt} - M\frac{di_2}{dt} \Rightarrow L_1\frac{di_1}{dt} - M\frac{d(i-i_1)}{dt}$

$$e_2 = L_2\frac{di_2}{dt} - M\frac{di_1}{dt} \Rightarrow L_2\frac{d(i-i_1)}{dt} - M\frac{di_1}{dt}$$

$$e_1 = e_2$$

$$L_1\frac{di_1}{dt} - M\frac{di}{dt} + M\frac{di_1}{dt} = L_2\frac{di}{dt} - L_2\frac{di_1}{dt} - M\frac{di_1}{dt}$$

$$\Rightarrow \left(\frac{L_1 + L_2 + 2M}{M + L_2}\right)\frac{di_1}{dt} = \frac{di}{dt}$$

$\cancel{L_{eq} = \frac{L_1 L_2 - M^2}{L_1 + L_2 - 2M}}$

$e = e_1$

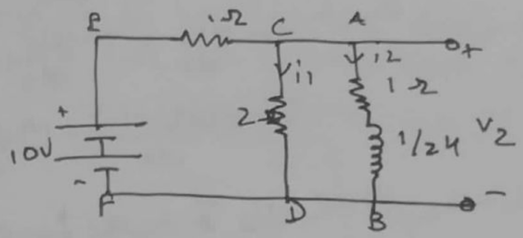
$L_{eq} \frac{di}{dt} = L_1 \frac{di_1}{dt} - M \frac{di_2}{dt}$

$L_{eq} = \dfrac{L_1 \frac{di}{dt} - M \frac{di_2}{dt}}{di/dt}$

$L_{eq} = \dfrac{L_1 \frac{di_1}{dt} - M \frac{di_1}{dt}\left(\frac{L_1 + L_2 + 2M}{L_2 + M}\right)}{\left(\frac{L_1 + L_2 + 2M}{L_2 + M}\right)\frac{di_1}{dt}}$

$L_{eq} = \dfrac{L_1 L_2 - M^2}{L_1 + L_2 + 2M}$

3-6 The problem may be solved using the two kirchoff law and voltage current relationships for the elements. Refer to B. At time t_0 after the switch K was closed, it is found that V_2. Determine the values of $i_2(t_0)$ and $\frac{di_2(t_0)}{dt}$



Sol

given $V_2 = +5V$

Let V_{AB} be the voltage across AB

$V_{AB} = R i_2 + L \frac{di_2}{dt}$

$= i_2 + \frac{1}{2}\frac{di_2}{dt}$

Since V_2 is in parallel with AB we can say that

$V_{AB} = V_2$

$i_2 + \frac{1}{2}\frac{di_2}{dt} = 5$

$\frac{1}{2}\frac{di_2}{dt} = 5 - i_2$

$\frac{di_2}{dt} = 10 - 2i_2$

$\frac{di_2}{\cancel{dt}\,5 - i_2} = 2dt$

$$\int_0^{i_2} \frac{di_2}{5-i_2} = \int_0^{t} 2\,dt$$

$$\ln(5-i_2) - \ln(5) = 2t$$

$$\ln(5-i_2) = 2t + \ln 5$$

$$5 - i_2 = e^{2t + \ln(5)}$$

$$i_2 = 5 - 5e^{2t_0}$$

Let $V_{CD} = 10 - i_1$

we know that V_{CD} is parallel with V_2

$$10 - i_1 = 5$$

$$i_1 = 5$$

by applying KVL in loop CDEF

$$10 - 5\times 1 = 2i_1$$

$$5 = 2i_1$$

$$i_1 = 2.5$$

by applying KCL at node C.

$$i = i_1 + i_2$$

$$i_2(t_0) = 7.5A$$

$$② \Rightarrow 5 - 5e^{2t} = 2.5$$

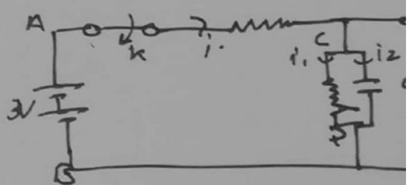
$$5e^{2t} = 2.5$$

$$t = -0.3465\,sec$$

$$\frac{di(t_0)}{dt} = \underline{-10e^{2t}}$$

$$= -5A/se.$$

3-7 This proble is similar to 3-6. In the circuit given in fig :- it is give that $V_2(t_0) = 2V$ & $(dV_0/dt)(t_0) = -10V/sec$, where t_0 is the time of the switch K was closed. Determine the value of C



V_{CD} the potential $= 3 - 2i$

$V_{CD} = V_2$ parallel

$$3 - 2i = 2$$

$$2i = 1$$

$$i = 0.5A$$

Let VR be potential drop across $R = 1\Omega$

$$V_R = V_2$$

$$1 \times i_1 = V_2 = 2$$

$$i_1 = 2A$$

by using KCL in node C

$$i = i_1 + i_2$$

$$i_2 = 0.6 - 2 = -1.5A$$

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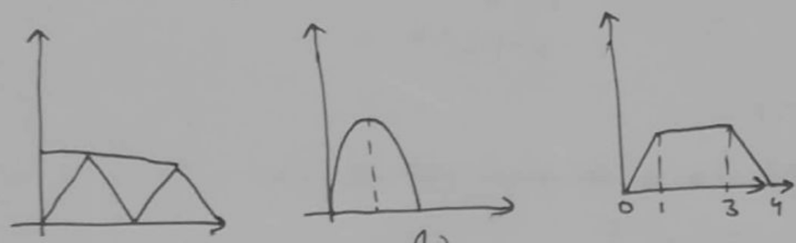
we know that for a capacitor

$$i_2 = C\frac{dV}{dt}$$

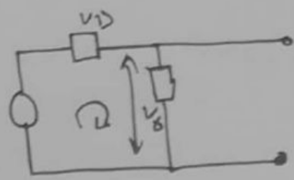
$$-1.5 = C(-10)$$

$$\Rightarrow C = 0.15F$$

3-12 $\quad R = 2\Omega \quad C = 1F$



(b) d)



since V_b is in parallel with V_2 we can say that

$$V_B = V_2$$

By KVL

$$V_1 + V_A + V_B = 0$$

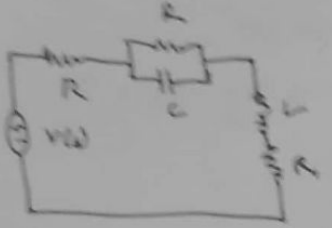
$$V_1 - iR + V_B$$

$$V_2 = V_1 = 2i - V_2$$

b)

..n each of the following circuit shown in Fig. determine the number of independent loop currents and the number of independent node-node voltages that may be used in writing equations for Kirchoff's law.

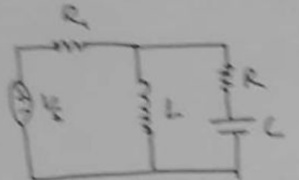
a)



Number of independent loop current 3

Number of independent node to node voltage 4

b)



Number of independent loop current - 3

Number of independent node to node voltage - ~~3~~

c)

Number of independent loop current - 3

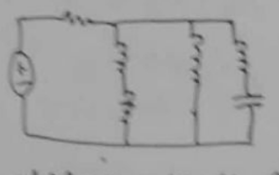
Number of independent node to node voltage - 2

d)

Number of independent loop current - ~~8~~ 12

Number of independent node to node voltage - 4.

3-24 The circuit of Fig that of fig but with diffrent loop current variables chosen. Using specified currents, write the kirchoff voltage law equations for the circuit



by applying KVL loop 1

$$R_2(i_1-i_2)-v(t)+R_1 i_1+L_1\frac{d(i_1-i_2)}{dt}+M_{12}\frac{d(i_2-i_3)}{dt}-M_{13}\frac{di_3}{dt}=0$$

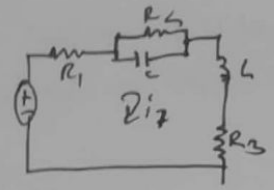
by apply KVL loop 2

$$+M_{13}\frac{di_3}{dt}-M_{12}\frac{d(i_2-i_3)}{dt}+R_2(i_2-i_1)+L_1\frac{(d\,i_2-i_1)}{dt}+L_2\frac{d(i_2-i_3)}{dt}+M_{21}\frac{d(i_1-i_2)}{dt}=0$$

by applying KVL in loop 3

$$M_{23}\frac{di_3}{dt}-M_{21}\frac{d(i_1-i_2)}{dt}+L_2\frac{d(i_3-i_2)}{dT}+L_3\frac{di_3}{dt}+\frac{1}{C}\int i_3\,dt-M_{31}\frac{d(i_1-i_2)}{dt}=0$$

3-21

a) 

Applying KVL

$$R_2 i_1 = 1/C \int (i_1 - i_2)\, dt$$

Applying KVL in loop 2 we get

$$V(t) - R_1 i_2 - 1/C \int (i_2 - i_1)\, dt - L\frac{di_2}{dt} - R_3 i_2 = 0$$

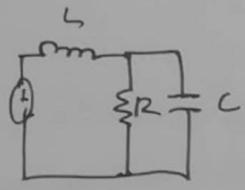
b) 

Applying KVL in loop 1 we get

$$V(t) - i_1 R_1 - L\frac{d(i_1 - i_2)}{dt} = 0$$

Applying KVL in loop 2 n

$$L\frac{d(i_2 - i_1)}{dt} + R_2 i_2 + 1/C \int i_2\, dt = 0$$

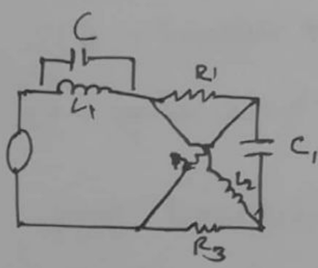
c) 

Applying KVL

$$V(t) - L\frac{di_1}{dt} - R(i_1 - i_2) = 0$$

Applying loop 2

$$R(i_2 - i_1) + 1/C \int i_2\, dt = 0$$



KVL

Loop 1: $V(t) - L_1\frac{d(i_1 - i_4)}{dt} - R_1(i_1 - i_2) - 1/C \int (i_1 - i_2 - i_3)\, dt - R_3(i_1 - i_3) = 0$

2: $R_1(i_2 - i_1) + 1/C_2 \int (i_2 - i_1 - i_3)\, dt + L_2\frac{di_2}{dt} = 0$

3: $R_2 i_3 + R_3(i_3 - i_1) + 1/C_2 \int (i_3 - i_1 - i_2)\, dt = 0$

4: $L_1\frac{d(i_4 - i_1)}{dt} + 1/C_1 \int i_4\, dt = 0$

for the circuit shown in Fig

node 4: $\frac{v_4}{R} + \frac{C\,d(v_4-v_3)}{dt} + \frac{v_4-v_1}{R} = \frac{v_2-v_4}{R}$

$2(v_4-v_2)+2v_4+\frac{1}{2}\frac{d(v_4-v_3)}{dt}+2(v_4-v_1)=0$

node 3: $\frac{C\,d(v_3-v_4)}{dt} + i_2 + \frac{dv_3}{dt} + \frac{C\,d(v_3-v_1)}{dt} = 0$

$i_2+\frac{1}{2}\frac{d(v_3-v_4)}{dt}+\frac{1}{2}\frac{dv_3}{dt}+\frac{1}{2}\frac{d(v_3-v_1)}{dt}=0$

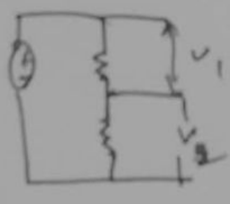
node 2: $-i_2+\frac{V_2}{R_6}+\frac{V_2-V_1}{R}=0+\frac{V_2-V_4}{R}=0$

node1 $= \frac{V_1-V_4}{R}+\frac{V_1-V_2}{R}=\frac{C\,d(v_1-v_3)}{dt}=0$

$4V_1-2V_2+\frac{1}{2}\frac{d(v_1-v_3)}{dt}-2V_4=0$

node 1,2,3,4 is node equation.

3-58 Consider the circuit shown in Fig



$V_1 = iR_1$

$V_2 = iR_2$

by KVL we get

$V = V_1+V_2$.

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