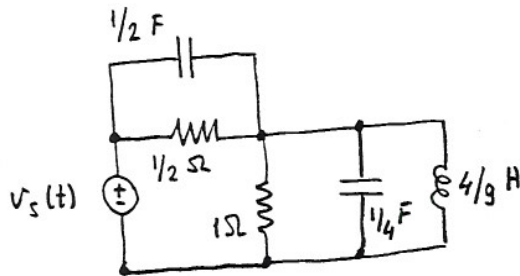
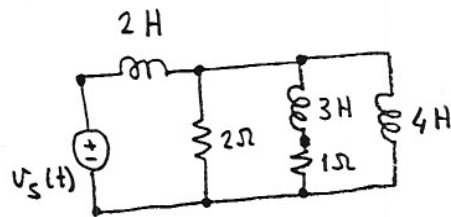


- 1) Obtain in matrix form (i) the modified node equation, (ii) the node equation, (iii) the mesh equation.

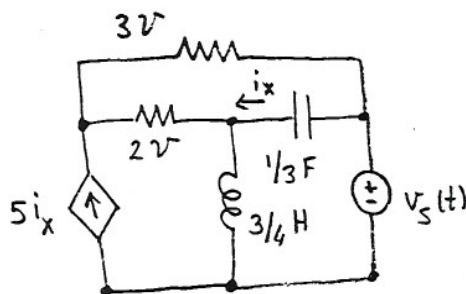
Find the natural frequencies of the circuit.



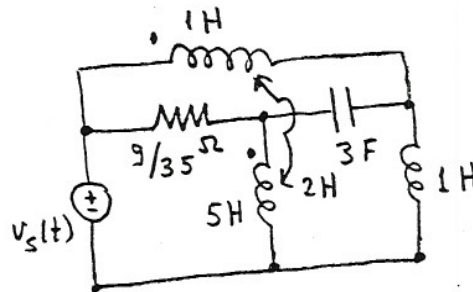
(a)



(b)

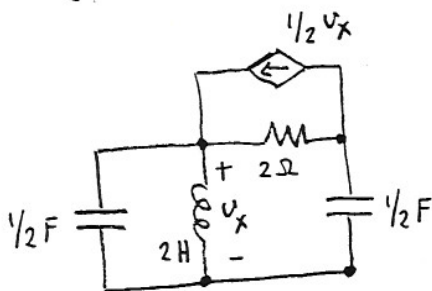


(c)

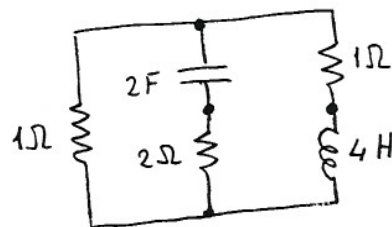


(d)

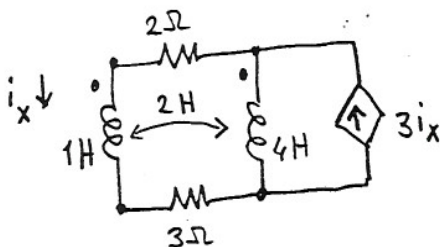
- 2) Find the natural frequencies and sets of (real) initial conditions exciting the modes.



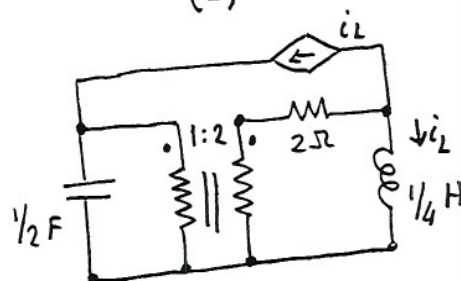
(a)



(b)



(c)

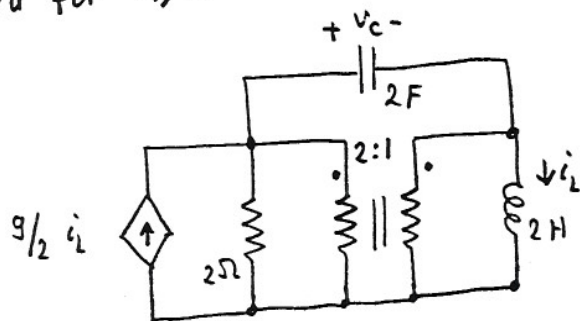


(d)

3) Obtain the modified node equation in matrix form.

Find the natural frequencies.

Determine V_0 and I_0 so that the currents and voltages are bounded for $t \geq 0$.

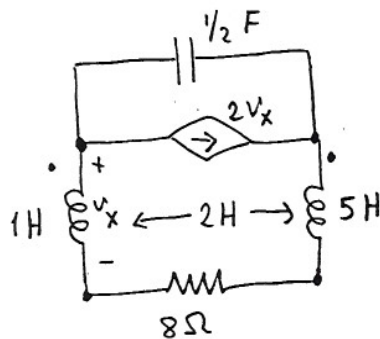


$$V_C(0) = V_0$$

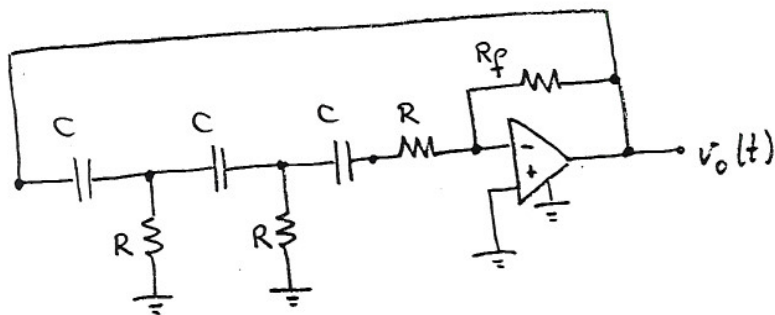
$$i_L(0) = I_0$$

4) Obtain the mesh equation in matrix form.

Express $v_x(t)$ in terms of the initial values of dynamic elements specified at $t=0$.



5)



The op-amp is ideal and operating in the linear region.

(a) Obtain the node equation in matrix form.

(b) Let $R=1\Omega$ and $C=1F$. Find R_F so that the circuit has a natural frequency at $-1/6$. Find the other natural frequencies. Is the circuit stable? Discuss.

(c) Let $R=1\Omega$, $C=1F$ and the initial time be zero.

Find R_f so that $v_o(t)$ is a sinusoid for large values of t .

What is the frequency f_o of this sinusoid?

Scale the circuit (find R_f and C) so that $R=10\text{ k}\Omega$ and $f_o=4\text{ kHz}$.

6) Given the differential equation

$$(D^3 + D^2 + 2D + 2)x(t) = (3D + 6)u_s(t).$$

(a) Find the homogeneous solution.

(b) Find the particular solution for $u_s(t)$

(i) $3e^{2t}$, (ii) $4e^{-t}$, (iii) $5e^{-2t}$, (iv) $5\cos(2t+30^\circ)$,

(v) $5e^{-t}\cos(t+30^\circ)$, (vi) $\delta(t)$, (vii) $u(t)$.

7) Given the matrix differential equation

$$\begin{bmatrix} D+1 & -1 \\ 1 & D+3 \end{bmatrix} \begin{bmatrix} x_1(t) \\ x_2(t) \end{bmatrix} = \begin{bmatrix} 1 \\ -2 \end{bmatrix} u_s(t), \quad u_s(t) = 2\cos(2t)$$

(a) Find the homogeneous solution.

(b) Find the particular solution.

(c) Find $\begin{bmatrix} x_1(0) \\ x_2(0) \end{bmatrix}$ so that the solution has no transient part.

8) Given the matrix differential equation

$$\underbrace{\begin{bmatrix} D+4 & -3 \\ 2 & D-1 \end{bmatrix} \begin{bmatrix} x_1(t) \\ x_2(t) \end{bmatrix}}_{\underline{x}(t)} = \begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix} \underline{u}_s(t), \quad \underline{u}_s(t) = \begin{bmatrix} 6e^t \\ 12\cos(2t+75^\circ) \end{bmatrix}$$

Find $\underline{x}(t)$ for $t \geq 0$ given $\underline{x}(0) = \begin{bmatrix} 2 \\ 3 \end{bmatrix}$.

9) Given the matrix differential equation

$$\begin{bmatrix} D+1 & 2 & 0 \\ -1 & D-1 & 1 \\ 0 & 0 & D+2 \end{bmatrix} \begin{bmatrix} x_1(t) \\ x_2(t) \\ x_3(t) \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} u_s(t)$$

(a) Find the homogeneous solution.

(b) Let $u_s(t)=0$.

Determine real initial values $x_1(0), x_2(0), x_3(0)$ so that $x_1(t), x_2(t), x_3(t)$ are sinusoids for $t \geq 0$.

(c) Let $u_s(t)=0$.

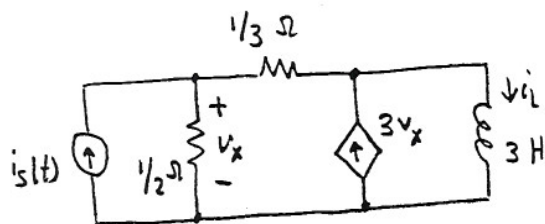
Given $x_1(0)=1, x_2(0)=-2, x_3(0)=3$, find $x_1(t), x_2(t), x_3(t)$ for $t \geq 0$.

(d) Let $x_1(0)=0, x_2(0), x_3(0)=0$.

Find $x_1(t), x_2(t), x_3(t)$ for $t \geq 0$ when

$$u_s(t) = 4 + 3e^{2t} + 2\cos(2t+30^\circ).$$

10)

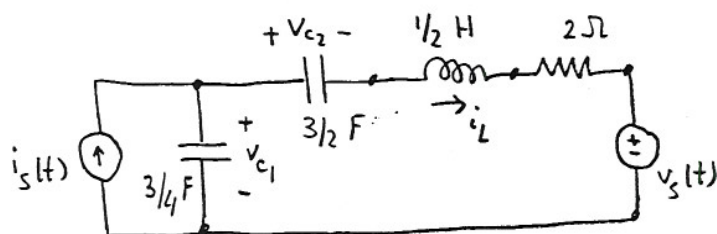


$$i_s(t) = 5\cos(2t-24^\circ) \text{ A}$$

$$i_L(0) = 2 \text{ A}$$

Find $i_L(t)$ and $v_x(t)$ for $t \geq 0$.

11)



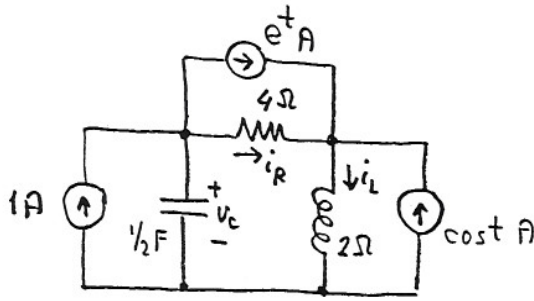
$$i_s(t) = 4\sin(2t+30^\circ) \text{ A}$$

$$v_s(t) = 3e^{-4t} \text{ V}$$

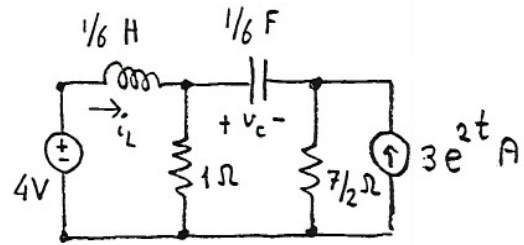
$$v_{c1}(0) = 2 \text{ V}, v_{c2}(0) = 5 \text{ V}, i_L(0) = 3 \text{ A}$$

Find $v_{c1}(t)$ and $i_L(t)$ for $t \geq 0$.

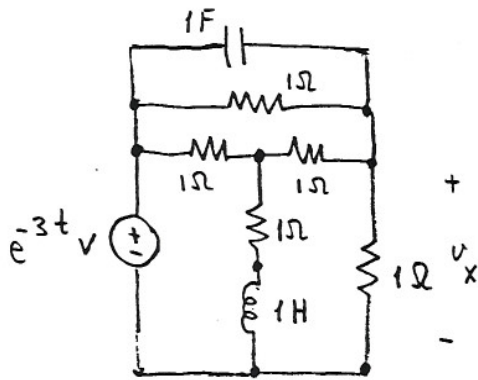
12) Find the homogeneous and the particular solutions for the indicated variables.



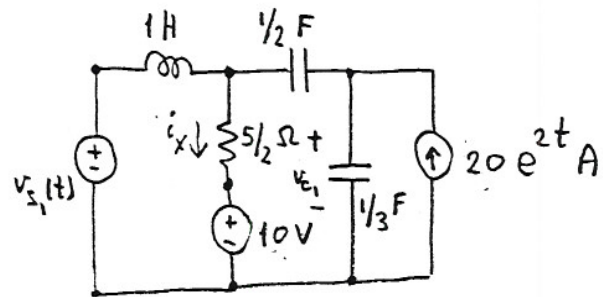
v_c, i_L, i_R
(a)



v_c, i_L
(b)

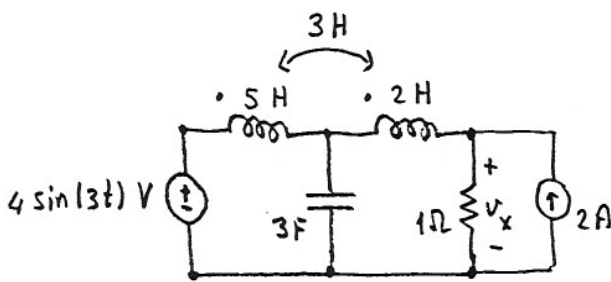


v_x
(c)

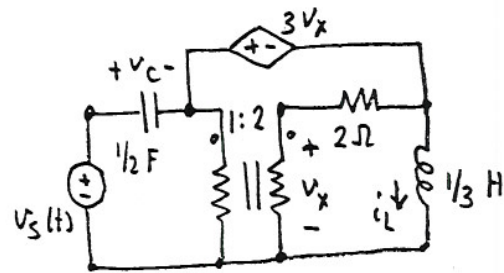


$v_{s1}(t) = 10 \cos(2t + 45^\circ) V$

i_x, v_{c1}
(d)



v_x
(e)



$v_{s1}(t) = 6 \cos(2t + 10^\circ) V$

v_c, i_L
(f)