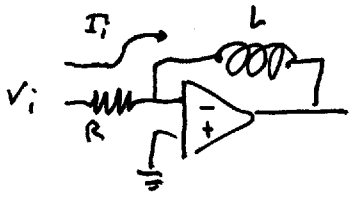
Instrumentação Electrónica

exam 3/02/2012

1] a) See lecture notes

b)



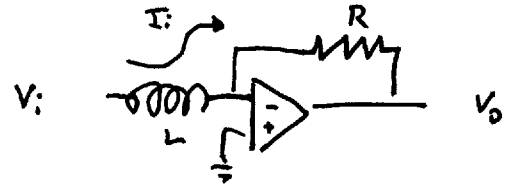
$\rightarrow$ virtual ground at V_n

$$I_i = \frac{(V_i - 0)}{R}$$

forced through L

$$V_L = L \frac{d I_i(t)}{dt} = \frac{L}{R} \frac{d V_i(t)}{dt}$$

$$V_o = 0 - V_L = -\frac{L}{R} \frac{d V_i(t)}{dt}$$



$$V_L = L \frac{d I_i(t)}{dt} \Rightarrow I_i = \frac{1}{L} \int V_L(t)\, dt$$

$$V_o = -I_i R = -\frac{R}{L} \int V_i(t)\, dt$$

2] a) $$C = \varepsilon_d \frac{W h}{h} = \frac{\varepsilon_d(h)\, W(h)\, L(h)}{h}$$

$$\frac{dC}{dh} = -\frac{\varepsilon W L}{h^2} + \frac{\varepsilon L}{h} \cdot \frac{dW}{dh} + \frac{\varepsilon W}{h} \frac{dL}{dh} + \frac{WL}{h} \cdot \frac{d\varepsilon}{dh}$$

$$K = \frac{dC}{dh} \cdot \frac{h}{C} = \frac{dC}{dh} \cdot \frac{h^2}{\varepsilon W L} = -1 + \frac{h}{W} \frac{dW}{dh} + \frac{h}{L} \frac{dL}{dh} + \frac{h}{\varepsilon} \frac{d\varepsilon}{dh}$$

$$= -1 - \nu - \nu + \frac{d\varepsilon/\varepsilon}{dh/h}$$

$$= -1 - 2\nu + \frac{d\varepsilon/\varepsilon}{dh/h}$$

b) $V = wLh$, V is constant $\Rightarrow \frac{dV}{dh} = 0$

$$\frac{dV}{dh} = wL + Lh\frac{dw}{dh} + wh\frac{dL}{dh} = 0$$

divide by wL :

$$1 + \frac{h}{w}\frac{dw}{dh} + \frac{h}{L}\frac{dL}{dh} = 0$$

$$1 - 2\nu = 0 \quad \Rightarrow \quad \nu = 1/2$$

in a) , with $d\varepsilon/dh = 0$

$$-1 - 2\nu = -2$$

c) $K = -2$, $\frac{\Delta h}{h} = 1\%$

$$\Delta C = \Delta h \cdot \frac{dC}{dh} = \Delta h \cdot \frac{C}{h} \cdot \left(\frac{h}{C}\cdot\frac{dC}{dh}\right) = C \cdot \frac{\Delta h}{h} \cdot K$$

$$= 1\,\mu F \cdot 1\% \cdot -2 = -20\ nF$$

$\Delta C = -20\ nF \Rightarrow C = 98\% \times 1\,\mu F = 980\ nF$

d) $\varepsilon = 7\varepsilon_0 = 6.198\ F/m$

$L = 0.1\ m$, $W = 0.01\ m$, $h = 10^{-5}\ m$

$C = \frac{\varepsilon WL}{h} = 6.2\ nF$

e) $E = P/\varepsilon = 0.05\ GPa = 5 \times 10^7\ Pa$

$\nu = 0.5 \Rightarrow K = -2$ (ε is constant)

$$S = \frac{dC}{dF} = \frac{dC}{dh}\cdot\frac{dh}{dF} = \left(\frac{dC}{dh}\cdot\frac{h}{C}\right)\cdot\frac{dh}{dF}\cdot\frac{C}{h} = K\cdot\frac{dh/h}{dF}\cdot C$$

$$= K\,\frac{C}{EWL} \qquad \left(E = \frac{P}{\varepsilon} = \frac{dF/WL}{dh/h}\right)\left(dF = EWL\,dh/h\right)$$

$$= 2\cdot\frac{1\,\mu F}{5\cdot 10^7 P \cdot 0.01\ m \cdot 0.1\ m} = 4\cdot 10^{-11}\ F/N = 40\ pF/N$$

f) $S = \frac{dC}{dm} = \frac{dC}{dF}\cdot\frac{dF}{dm} = 40\ \frac{pF}{N} \cdot 9.81\ \frac{N}{kg} = 3.924\ 10^{-10}\ F/kg$

$= 392.4\ pF/kg$

g) $\Delta m = \frac{\Delta C}{S} = \frac{10\ pF}{392.4\ pF/kg}$ $\left(\begin{array}{l} \text{scale: } 20\ nF \\ \Delta C = 0.01\ nF = 10\ pF \end{array} \right)$

$= 25.5\ 10^{-3}\ kg$

3] See lecture notes

4] See exercises

5] See lecture notes