ECE 580
FINAL EXAMINATION
December 10, 2004
1400 - 1600 pm

Open book

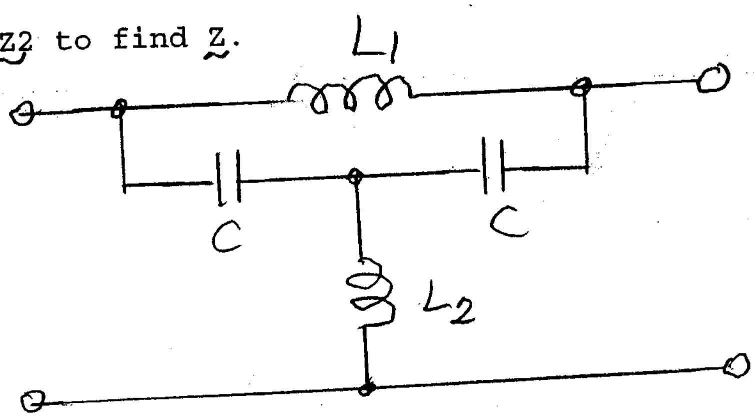
Prof. G. C. Temes

1. Find the open-circuit impedance matrix $\underset{\sim}{Z}$ of the two-port T shown, in the following steps:

a. Separate T into two series-connected simpler two-ports T1 and T2;

b. Find the $\underset{\sim}{Z}$ matrices of T1 and T2;

c. Add $\underset{\sim}{Z1}$ and $\underset{\sim}{Z2}$ to find $\underset{\sim}{Z}$.

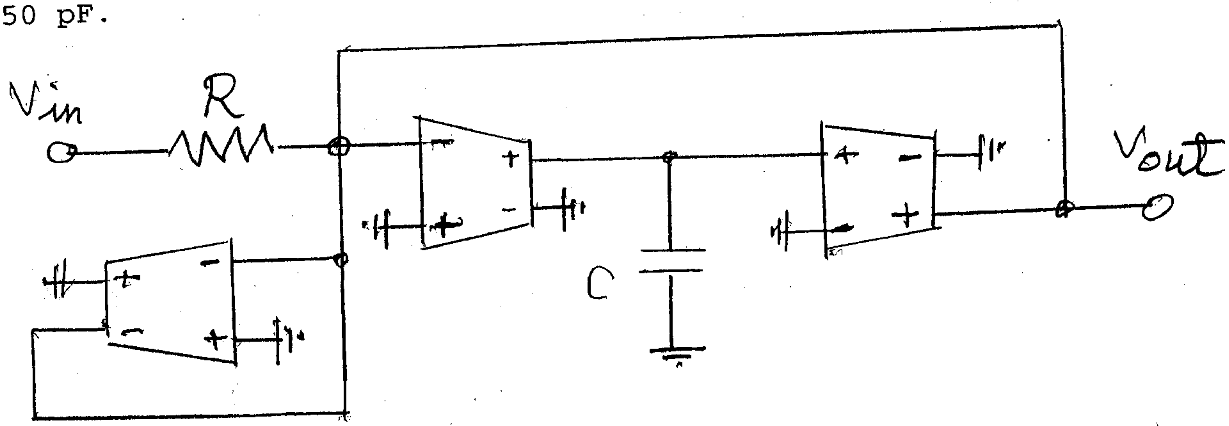


2. The gain G in the passband of a Butterworth filter must satisfy

$-1.2 \text{ dB} < G < 0 \text{ dB}$ for $|f| < 0.5$ MHz .

The maximum pole-Q allowed is 3. How much stopband attenuation can be achieved at 1 MHz?

3. Find the transfer function Av(s) = Vout(s)/Vin(s) of the two-port shown. Assume R = 5 kΩ and Gm = 0.2 mS for all transconductors, and use C = 50 pF.

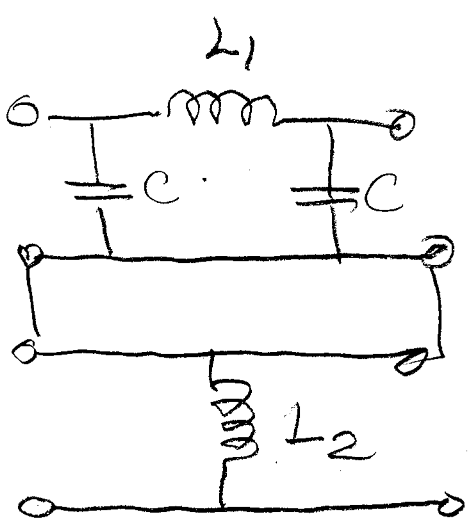


1. $$Z_{11} = sL_2 + \frac{(1/sC)(sL_1 + 1/sC)}{2/sC + sL_1}$$

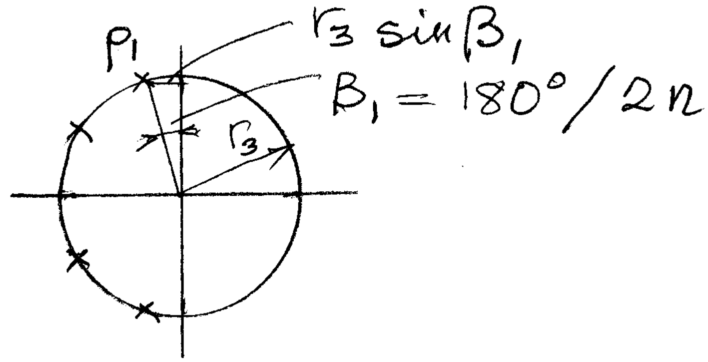
$$= sL_2 + \underbrace{\frac{1}{sC} \; \frac{s^2L_1C + 1}{s^2L_1C + 2}}_{z_{11a}} = Z_{22}$$

$$Z_{12} = Z_{21} = sL_2 + z_{11a} \frac{1/sC}{sL_1 + 1/sC}$$

$$= sL_2 + \frac{1/sC}{s^2L_1C + 2}$$



2. $k = 0.5/1 = 0.5$



$$Q_1 = \frac{r_3}{2 r_3 \sin\beta_1} \leq 3$$

$$\sin\beta_1 \geq 1/6$$

$$\beta_1 \geq 9° \, 35.5' \sim 9.6°$$

$$\frac{90°}{n} > 9.6° \, , \quad n \leq 9.4$$

$$n_{max} = 9 = \frac{\log(1/k_1)}{\log 2}$$

$$\log(1/k_1) \cong 2.71$$

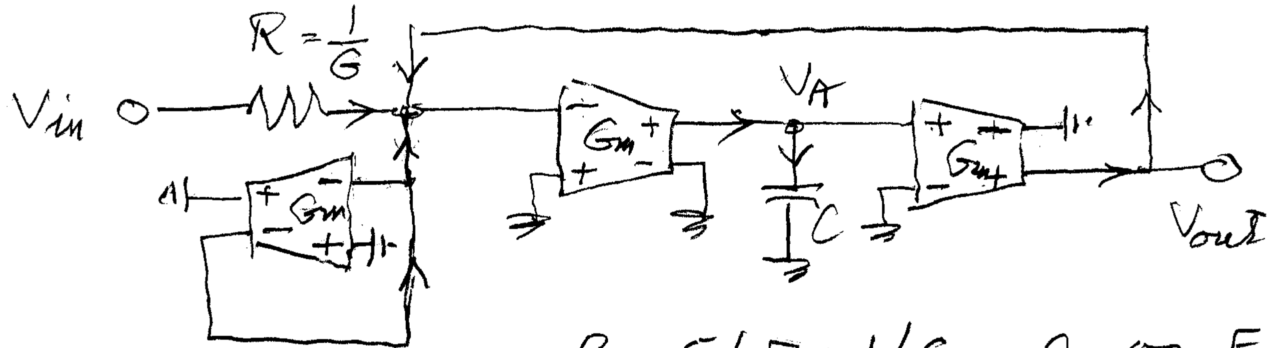
$$k_1 = \frac{1}{512} \cong \sqrt{\frac{10^{0.1 2} - 1}{10^{\alpha_s/10}}}$$

$$10^{\alpha_s/10} \cong 83,429$$

$$\alpha_s \cong 49.2 \text{ dB}$$

$V_{out}(s)/V_{in}(s)$,

3. Find the transfer function of the circuits shown



$R = 5\,k\Omega = 1/G_m$, $C = 50\,pF$

At V_{out}, KCL gives

$$G(V_{in} - V_{out}) + G_m V_A + G_m V_{out} = 0$$

At V_A,

$$-G_m V_{out} = sC V_A \rightarrow V_A = -\frac{G_m}{sC} V_{out}$$

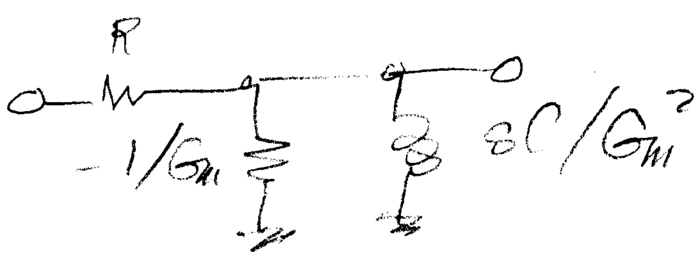
From 1^{st} eq.

$$G V_{in} = \left(G + \frac{G_m^2}{sC} - G_m\right) V_{out}$$

If $G = G_m$,

$$\frac{V_{out}}{V_{in}} = \frac{G_m}{G_m^2/sC} = \frac{sC}{G_m} = s\,\frac{5\times 10^{-11}}{0.2\times 10^{-3}}$$

$$H(s) = s \times 2.5 \times 10^{-7}$$



$$\frac{V_o}{V_{in}} = \frac{\dfrac{-R\cdot R^2 sC}{-R + R^2 sC}}{R - R^3 sC/(-R+R^2 sC)} = \frac{-R^3 sC}{-R^2} = RsC$$