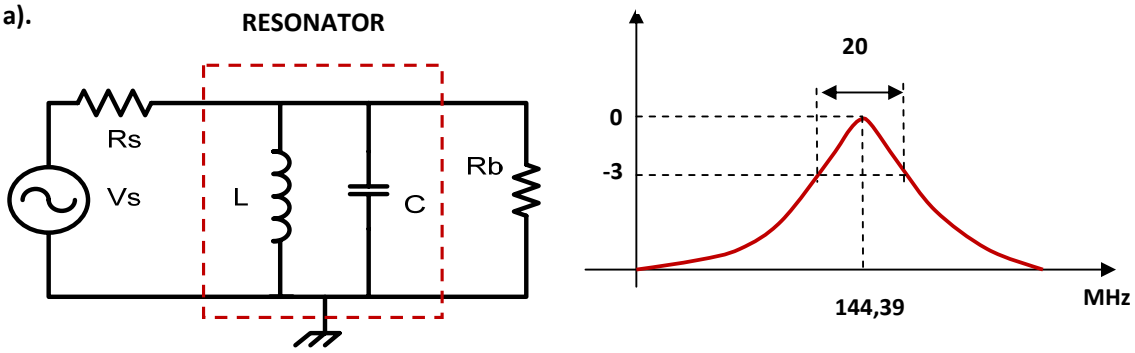
1. **RESONATOR**

Rancang sebuah rangkaian resonator yang bekerja pada **frekuensi tengah 144,39 MHz** dan **bandwidth 20 Mhz**. Diketahui **resistansi sumber 50 ohm dan beban 75 Ohm..**

a. Gambarkan rangkaian resonator tersebut dan respon frekuensi !
b. Hitung Faktor kualitas Q dari resonator tersebut
c. Hitung Nilai L dan C pada resonator tersebut (asumsi L dan C adalah lossless)
d. Bila nilai L dan C yang didapat dari poin c) bersifat lossy dengan factor kualitas masing-masing L & C sama yaitu **Q = 8** maka , hitung kembali frekuensi resonansi !
e. Hitung nilai insertion Loss (point d) dalam dB

JAWAB :

a).



b). Faktor kualitas **Q** = $\frac{\boldsymbol{f_{resonan}}}{\boldsymbol{BW\ 3\ dB}} = \frac{144{,}39}{20} = \mathbf{7{,}2195}$

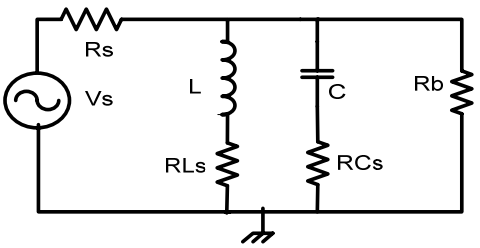
c). $\boldsymbol{Q_L = Q = 7{,}2195 = \frac{R_P}{X_L} = \frac{(R_s\ paralel\ R_b)}{2\pi\ f_r\ L} = \frac{(50\ paralel\ 75)}{2\pi\ f_r\ L} = \frac{30}{2\pi\ L \times 144{,}39 \times 10^6}}$

$$\boldsymbol{L = \frac{30}{2\pi \times 144{,}39\ \times\ 10^6\ \times\ 7{,}2195} = 4{,}58\ nH}$$

$$\boldsymbol{Q_c = Q = 7{,}2195 = \frac{R_P}{X_C} = \frac{30}{\frac{1}{2\pi\ f_r\ C}} = 30\ \times 2\pi\ f_r\ C\ ;}$$

$$\boldsymbol{C = \frac{7{,}2195}{30 \times 2\pi \times 144{,}39\ \times\ 10^6} = 265\ pF}$$

d).



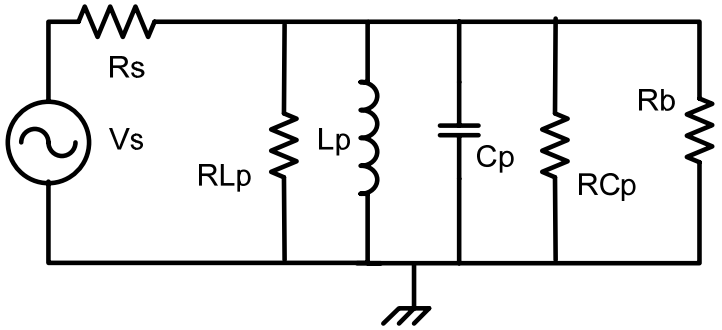
$$Q = 8\ dB = 10^{0,8} = 6{,}31$$

$$\boldsymbol{Q = 6{,}31 = \frac{X_L}{R_{Ls}} = \frac{X_C}{R_{Cs}}}$$

$$6{,}31 = \frac{2\pi\ f_r\ L}{R_{Ls}} = \frac{\frac{1}{2\pi\ f_r\ C}}{R_{Cs}} = \frac{1}{2\pi\ f_r\ C\ \times\ R_{Cs}}$$

$$\boldsymbol{R_{Ls}} = \frac{2\pi\, f_r\, L}{6{,}31} = \frac{2\pi \times\ 144{,}39\ \times\ 10^6\ \times 4{,}58 \times 10^{-9}}{6{,}31} = \boldsymbol{0{,}658\ \ Ohm}$$

$$6{,}31 = \frac{1}{2\pi\, f_r\, C\ \times\ R_{Cs}}\ ;\quad \boldsymbol{R_{Cs}} = \frac{1}{2\pi\ \times\ 144{,}39 \times\ 10^6 \times 265 \times 10^{-12} \times 6{,}31} = 0{,}659\ Ohm$$



$$\boldsymbol{R_{Lp} = R_{Ls}(Q^2 + 1)}$$

$$\boldsymbol{R_{Cp} = R_{Cs}(Q^2 + 1)}$$

$$Q = 8\ dB = 6{,}31$$

$$R_{Lp} = R_{Ls}(Q^2 + 1) = 0{,}658\ \times (6{,}31^{\,2} + 1) = 26{,}86$$

$$R_{Cp} = R_{Cs}(Q^2 + 1) = 0{,}659\ \times (6{,}31^{\,2} + 1) = \ 26{,}86$$

$$\boldsymbol{Nilai\ Q\ tetap} = 6{,}31\ jadi\ \ \boldsymbol{Q_s = Q_p = \frac{R_p}{X_L}} = \frac{26{,}86}{2\pi\, f_r\, L_p}$$

$$\boldsymbol{L_p} = \frac{26{,}86}{2\pi\ \times\ 144{,}39 \times\ 10^6 \times\ 6{,}31} = \ \boldsymbol{4{,}69\ \ nH}$$

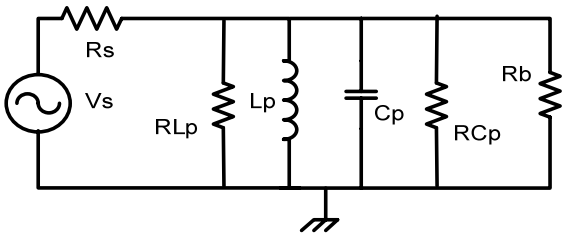
$$6{,}31\ = \boldsymbol{\frac{R_p}{X_C}} = 26{,}86\ \times\ 2\pi\, f_r\, C_p\ \rightarrow\ \boldsymbol{C_p}\ = \frac{6{,}31}{26{,}86\ \times\ 2\pi\ \times\ 144{,}39 \times\ 10^6} = \boldsymbol{259\ \ pF}$$

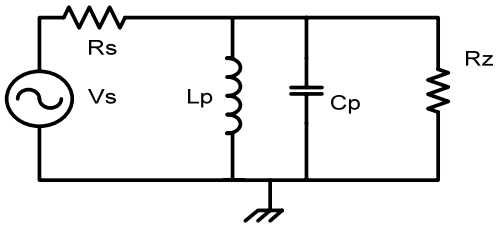
$$\boldsymbol{f_r\ berubah\ menjadi} = \frac{\boldsymbol{1}}{2\pi\sqrt{\boldsymbol{L_p\, C_p}}} = \frac{\boldsymbol{1}}{2\pi\sqrt{\boldsymbol{4{,}69 \times 10^{-9}\ \times\ 259 \times 10^{-12}}}} =$$

$$\boldsymbol{f_r^* = 144{,}405\ \ MHz}$$

e). **Insertion Loss =** $\boldsymbol{10 \times log\left(\frac{Daya\ pada\ beban\ dengan\ L\ \&\ C\ \ loss\ less}{Daya\ pada\ beban\ dengan\ L\ \&\ C\ \ lossy}\right)}$

Rangkaian Ekivalen :





$$\frac{\mathbf{1}}{\boldsymbol{R_z}} = \frac{\mathbf{1}}{\boldsymbol{R_b}} + \frac{\mathbf{1}}{\boldsymbol{R_{Cp}}} + \frac{\mathbf{1}}{\boldsymbol{R_{Lp}}} = \frac{1}{75} + \frac{1}{26{,}86} + \frac{1}{26{,}86} = 0{,}0878 \;\; ; \; \boldsymbol{R_z = 11{,}39 \; Ohm}$$

$$\boldsymbol{V_{Rb} = V_{Rz} = \frac{R_z}{R_s + R_z} \, Vs = \frac{11{,}39}{50 + 11{,}39} \, Vs = 0{,}186 \, Vs}$$

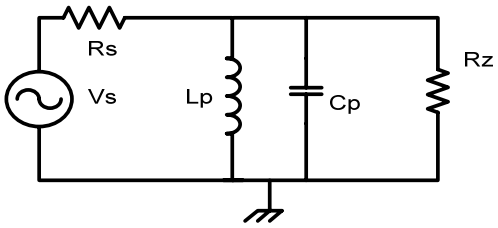
$$\boldsymbol{P_{Rb} \; losy = \frac{(V_{Rb})^2}{R_b} = \frac{(0{,}186 \, Vs \;)^2}{75} = 4{,}6128 \times 10^{-4} \, (Vs \;)^2}$$

Pada kasus L & C ideal $\boldsymbol{V_{Rb} = Vs \times \frac{R_b}{R_s + R_b} = \frac{75}{50+75} \times Vs = 0{,}6 \, Vs}$

$$\boldsymbol{P_{Rb} \; ideal = \frac{(V_{Rb})^2}{R_b} = \frac{(0{,}6 \, Vs \;)^2}{75} = 48 \times 10^{-4} \, (Vs \;)^2}$$

Insertion Loss = $\boldsymbol{10 \times log \left(\frac{48}{4{,}6128} \right) = 10{,}17 \;\; dB}$

Catt : BW 3 dB dalam kondisi komponen memiliki rugi-rugi (Lossy) :



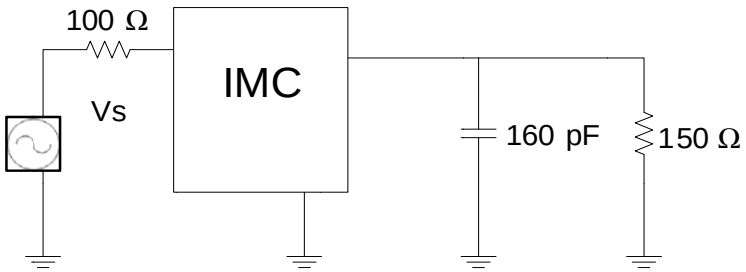
$$\boldsymbol{Q \; rangkaian = \frac{f_r^*}{BW \; 3 \; dB} = \frac{R_p}{X_p} = \frac{R_z \; paralel \; R_s}{2\pi \; f_r^* \; L_p}}$$

$$\boldsymbol{R_z \; paralel \; R_s = \frac{11{,}39 \times 50}{11{,}39 + 50} = 8{,}58 \; Ohm}$$

$$\boldsymbol{BW \; 3 \; dB = \frac{2\pi \; f_r^* \; L_p \; f_r^*}{8{,}58}} = \frac{2\pi \; (4{,}69 \times 10^{-9}) \, (144{,}405 \times 10^{6})^2}{8{,}58} = \boldsymbol{71{,}6 \; MHz}$$

2. IMPEDANCE MATCHING CIRCUIT

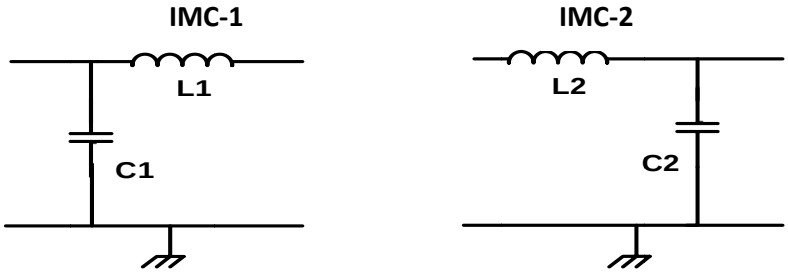
Buatlah IMC tipe Phi-section pada **frekuensi kerja 5 MHz bersifat LPF** untuk menyepadankan impedansi sumber dan impedansi beban untuk gb. di bawah ini dengan metode absorpsi. Gunakan Nilai resistansi virtual **Rv = 25 Ohm**



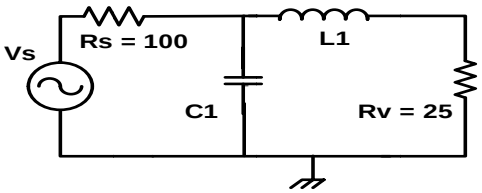
a) Gambarkan 2 buah rangk IMC yang membentuk Phi- section (tanpa harga komponen) !
b) Hitung nilai-nilai L dan C dari IMC pertama dan kedua yang akan membentuk konfigurasi Phi .
c) Gambarkan rangkaian IMC Phi lengkap dengan harga komponennya !

Jawab :

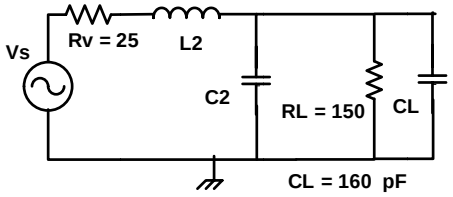
a).



b). IMC-1 menyepadankan dari Sumber dengan Rs = 100 Ohm ke beban virtual Rv = 25 Ohm



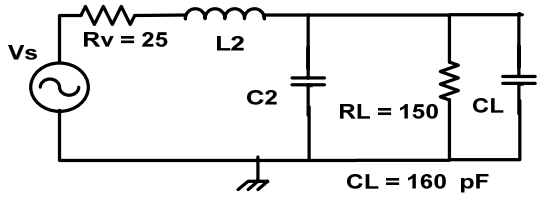
IMC-2 menyepadankan dari Sumber virtual dengan Rv = 25 Ohm ke beban RL = 150 Ohm



Asumsikan dulu CL tak ada

$$Q_s = \frac{X_s}{R_s} = \frac{2\pi f L_2}{R_V} = 2{,}2361 \rightarrow L_2 = 2{,}2361 \times \frac{25}{2\pi \times 5 \times 10^6} = \mathbf{1{,}78\ \mu H}$$

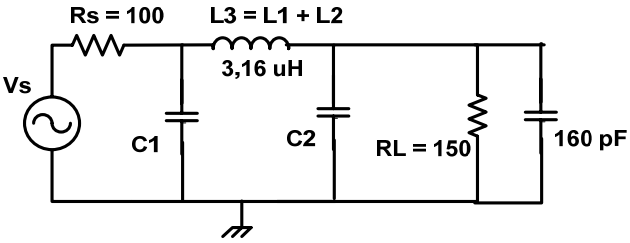
$$Q_p = 2{,}2361 = \frac{R_p}{X_p} = R_L \times 2\pi f C_2 \rightarrow C_2 = \frac{2{,}2361}{150 \times 2\pi \times 5 \times 10^6} = \mathbf{475\ pF}$$



Karena ada CL = 160 pF maka

C2 = 475 – 160 = 315 pF

c).



$C_1 = 551\ pF$

$C_2 = 315\ pF$

3. IMC DENGAN SMITH CHART

Sebuah beban **Z_L = (50 – j 20)Ω** akan disesuaikan ke sumber **Z_S = (40 + j80) Ω** menggunakan matching network **2-elemen pada frek 100 MHz** . Gunakan **factor Normalisasi N = 50**

a). Gambarkan diagram Impedansi-admitansi pd smith chart
yang mewakili 2 alternatif rangkaian IMC.

b). Pilih satu alternative kemudian gambarkan rangkaian serta hitung nilai-nilai komponennya .
Sebutkan/jelaskan pilihan anda , **apakah bersifat LPF atau HPF atau lain**nya .

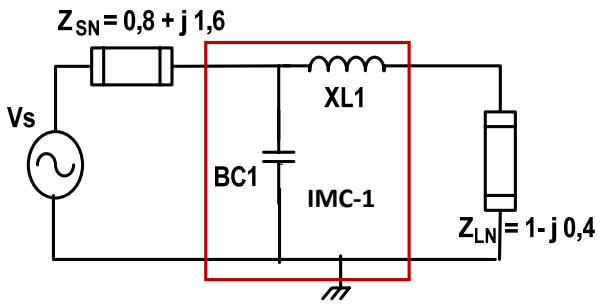
Jawab :

a). Normalisasi impedansi :

$$Z_{LN} = \frac{Z_L}{N} = \frac{50 - j20}{50} = 1 - j0{,}4 \ ; \qquad Z_{SN} \ \frac{Z_S}{N} = \frac{40 + j80}{50} = 0{,}8 + j1{,}6$$

Diagram Smith Chart alternative rangkaian IMC-1 : $Z_{SN} \rightarrow (Z_1\ atau\ Y_1) \rightarrow Z_{LN}$

Diagram Smith Chart alternative rangkaian IMC-2 : $Z_{SN} \rightarrow (Z_2\ atau\ Y_2) \rightarrow Z_{LN}$



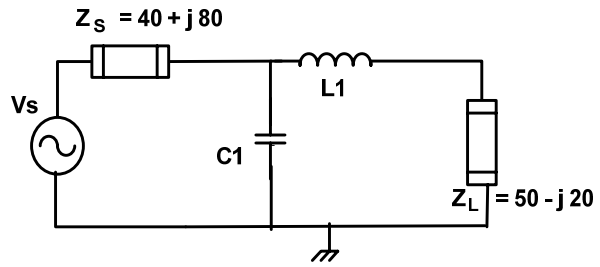
Dari smith chart :

BC1 = 0,94 ; XL1 = 1,4

$$BC1 = 2\pi f\ C1 \times N \quad ; N = 50$$

$$XL1 = \frac{2\pi f\ L1}{N} \quad ; \ f = 100\ MHz$$

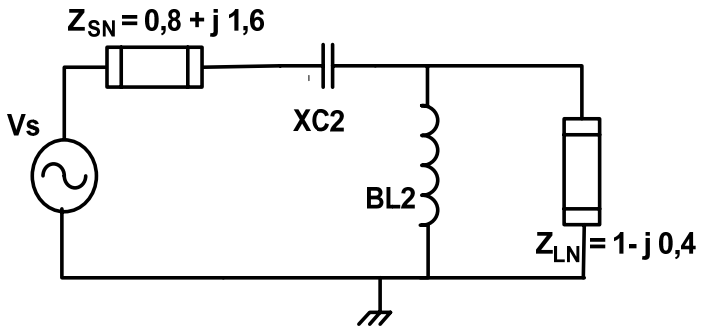
Hasil Denormalisasi :



$$C1 = \frac{0{,}94}{2\pi \times 100\times10^{6} \times 50} = 29{,}9 \text{ pF}$$

$$L1 = \frac{1{,}4 \times 50}{2\pi \times 100\times10^{6}} = 0{,}11 \ \mu\text{H}$$

Rangkaian IMC-1 bersifat meloloskan frekuensi rendah (bersifat LPF)



XC2 = - 2,13 ; BL2 = - 0,23

$$XC2 = \frac{-1}{2\pi f\, C2 \times N}$$

$$BL2 = \frac{-N}{2\pi f\, L2}$$

Setelah dilakukan Denormalisasi :

$$C2 = \frac{1}{2\pi \times 100\times10^{6} \times 2{,}13 \times 50} = 14{,}9 \text{ pF}$$

$$L2 = \frac{50}{2\pi \times 100\times10^{6} \times 0{,}23} = 0{,}35 \ \mu\text{H}$$

Rangkaian IMC-2 bersifat meloloskan frekuensi tinggi (bersifat HPF)