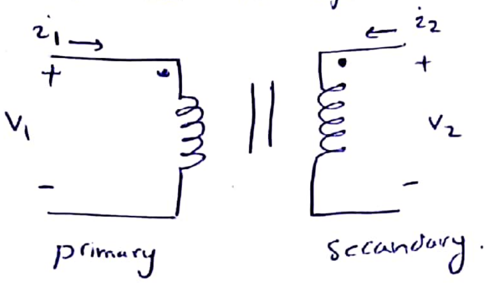
* Ideal transform :



1 : 5

$v_1 = 1$ $\qquad$ $v_2 = 5$.

$$V_1 = \sqrt{\frac{L1}{L2}} * V_2 \quad , \quad V_1 = \frac{N_1}{N_2} V_2.$$

$$\boxed{\frac{V_2}{V_1} = \frac{N_2}{N_1} = n} \rightarrow \text{Turns ratio}$$

if $N_2 > N_1$ $\rightarrow$ step-up transformor

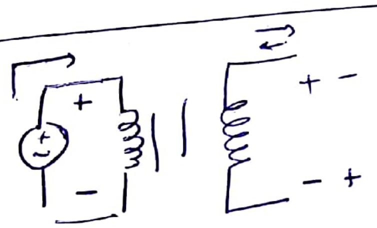
if $N_2 < N_1$ $\rightarrow$ step-down transformor.

* For a lossess transformor :-

$$S1 = S2.$$

$$|V_1||I_1| = |V_2||I_2|$$

$$\frac{|V_2|}{|V_1|} = \frac{|I_1|}{|I_2|} = \frac{N_2}{N_1} = n. \rightarrow \boxed{\frac{I_1}{I_2} = \frac{N_2}{N_1} = n.}$$

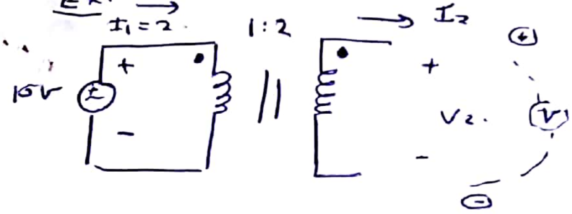


* Two Rules to define voltage polarities & current direction:

1 if V_1 & V_2 are both +ve or both -ve at the dotted terminals, use +n for $\frac{V_2}{V_1}$, otherwise, use -n.

2 if I_1 & I_2 both enters or both leaves the dotted terminal, use -n, otherwise, use +n.

Ex:

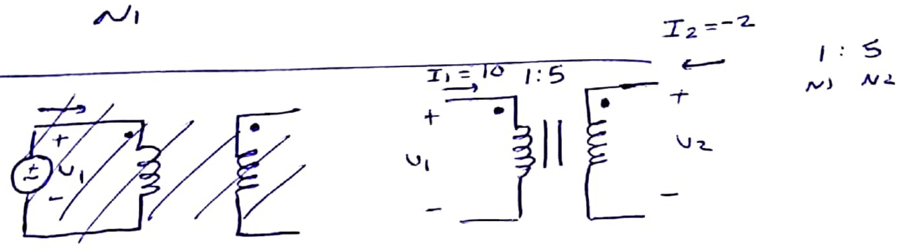


V_2 will be 20 volt, but the polarity?

$\frac{V_2}{V_1} = + \frac{N_2}{N_1} = +n$: the voltmeter will read +20 volt.
Lover.

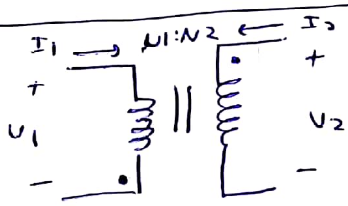
$\frac{I_1}{I_2} = + \frac{N_2}{N_1} = +n$, $i_2 = +1A$.

Ex



$\frac{V_2}{V_1} = + \frac{N_2}{N_1} = +n$, $\frac{I_1}{I_2} = - \frac{N_2}{N_1} = -n$.

Ex.



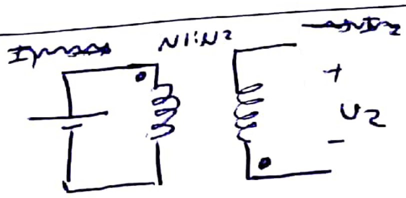
$\frac{V_2}{V_1} = - \frac{N_2}{N_1} = -n$. , $\frac{I_1}{I_2} = + \frac{N_2}{N_1} = +n$.

leaves

enters

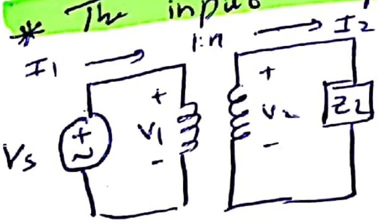
so, if $V_1 = 100v \rightarrow V_2 = -100v$

Ex.



$V_2 = 0$, DC source (No change in flux)

* The input impedance:



$V_2 / V_1 = n$.

$I_1 / I_2 = n$.

$$Z_{in} = \frac{V_s}{I_1} = \frac{V_1}{I_1} = \frac{V_2/n}{n I_2} \rightarrow Z_{in} = \frac{1}{n^2} Z_L.$$

source reflected impedance.

(تبا ال source بشوف ال Z_L)

Ex. an ideal TR is rated 2400/120 volt, (9.6) KVA & has 50 turns on the secondary side, find :-

2400 → primary coil
120 → secondary coil
9.6 → S (apparent power)

primary لل
secondary لل
(No losses).
$(S_1 = S_2 = S)$

[3]

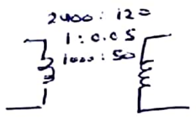
1. turn ratio,

$$\frac{V_2}{V_1} = \frac{N_2}{N_1} = n = \frac{120}{2400} = .05 .$$

2. turns on the primary side.

$$\frac{N_2}{N_1} = n \rightarrow \frac{50}{N_1} = .05$$

$$\rightarrow N_1 = 100 \text{ turns}.$$



3. the current ratings for the primary & secondary coils.

$$S_1 = V_1 I_1$$

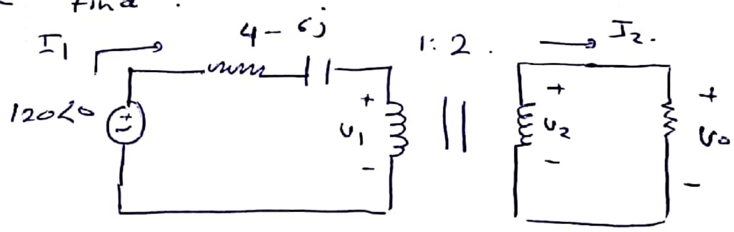
$$9600 = 2400 * I_1 \rightarrow I_1 = 4A .$$

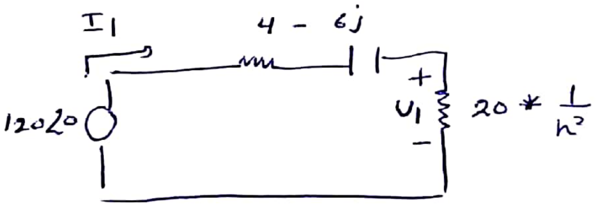
$$S_2 = V_2 I_2$$

$$9600 = 120 I_2 \rightarrow I_2 = 80A \quad \text{OR} \quad I_2 = \frac{I_1}{n} = 80 A .$$

Ex. for the shown ideal TR find :

1. the source current (I_1)
2. the output voltage (V_o)
3. The complex power supplied by the source. (S)





1. $Z_{in} = 9 - j6.$

$$I_1 = \frac{V_s}{Z_{in}} = \frac{120\angle 0}{9 - j6} = 11.09 \angle 33.7 .$$

2. $\frac{I_1}{I_2} = -n = -2 .$

$$\frac{11.09 \angle 33.7}{I_2} = -2 , \quad I_2 = -5.545 \angle 33.7 .$$

$$I_2 = +5.545 \angle 213.7$$

$$V_o = 20 * I_2 = 110.9 \angle 213.7 \text{ volt} .$$

2 **OR** $V_1 = 5 I_1$ (or voltage division).

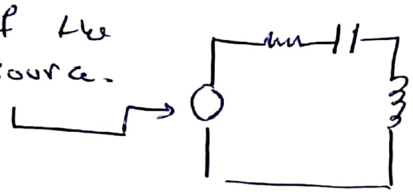
$$= 55.45 \angle 33.7 \text{ V}$$

$$\frac{V_2}{V_1} = -n = \frac{V_2}{55.45 \angle 33.7}$$

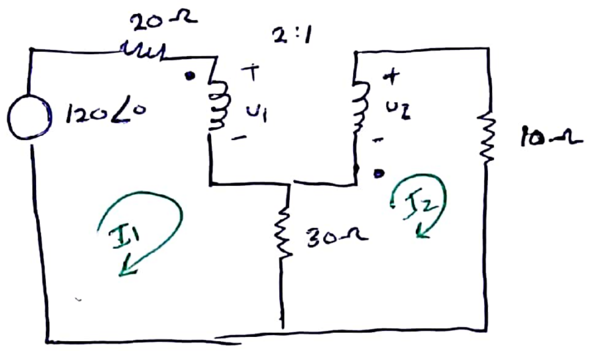
$$V_2 = 110.9 \angle 213.7 \text{ volt}.$$

3 $S = V_s I_1^* = 120\angle 0 * 11.09\angle -33.7$

S of the source.



Ex. Calculate the power supplied to the 10 Ω resistor.



التعامل مع ال
Ideal transform

→ Reflection
→ Mesh (KVL)

→ Mesh analysis.

(a) Mesh #1.

$-120\angle 0 + 20 I_1 + V_1 + 30(I_1 - I_2) = 0.$

(a) Mesh #2.

$10 I_2 + 30(I_2 - I_1) - V_2 = 0.$

$\frac{V_2}{V_1} = -\frac{1}{2} \rightarrow V_2 = -\frac{1}{2} V_1$

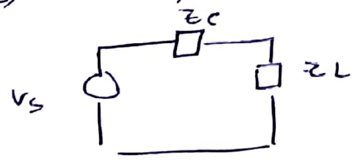
$\frac{I_1}{I_2} = -\frac{1}{2} \rightarrow I_1 = -\frac{1}{2} I_2$

نعوّض بهاد سين (تصبح معادلتين بمجهولين)

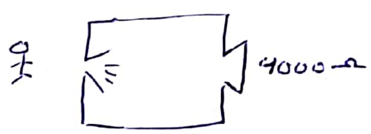
$\rightarrow I_2 = -0.7272\ A.$

$P = I_2^2 R = (-0.7272)^2 * 20 = 5.3\ W.$

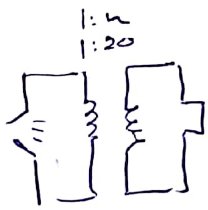
→ Transformers are used for impedance matching



$\underline{Z_L = Z_C^*}$

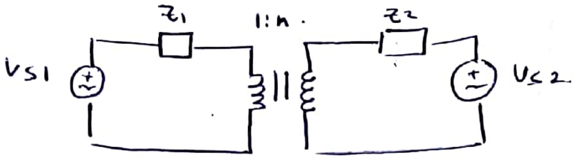


→

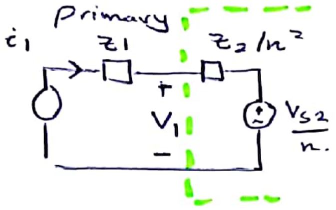


$\frac{1}{n^2} Z_L = 10 \longrightarrow \frac{1}{n^2} * 4000 = 10 \rightarrow \underline{n = 20}.$

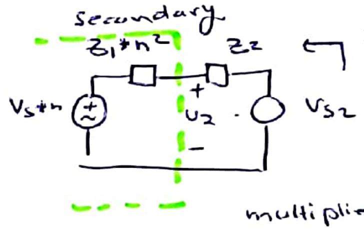
Equivelent ckT :-



refer to the primary



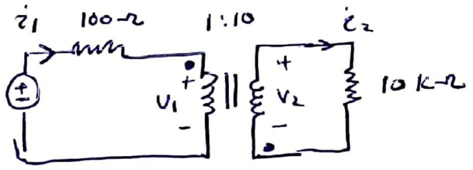
refer to secondary



multiplied by n, n^2.

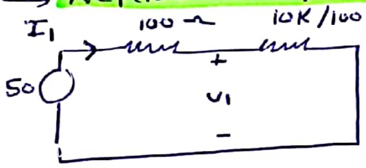
* keep the primary ckt as it
for secondary:
divide each source by $\underline{n}$
& each impedance by $\underline{n^2}$

Ex.



← انا لما اجيب اتجاه i_1, i_2
انا بفرضهم عادي .

→ **Refered to primary.**



→ $I_1 = \frac{50\angle 0}{200} = 0.25\angle 0^\circ = 0.25$.

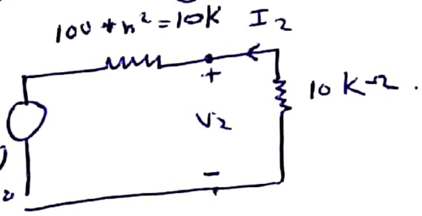
$V_1 = 25$

* to find V_2 & I_2 → Ratio, (don't forget dot conv.)

→ $\frac{V_2}{V_1} = -10$ → $V_2 = 250\angle 180^\circ$

→ $\frac{I_1}{I_2} = -10$ → $I_2 = 0.025\angle 180^\circ$.

→ Refering to secondary:

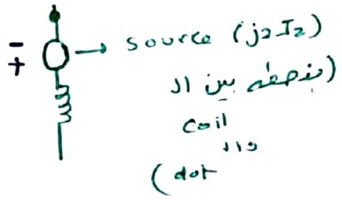


50 * (−10) = −500 volt.

↳ $= 500\angle 180^\circ$

→ $\frac{V_2}{V_1} = -10$, $I_2 = \frac{500\angle 180}{20 * 10^3} = 0.025\angle 180^\circ$.

Ex.: Write down the mesh eq. for :-



#mesh #1

$$-100\angle 0 + (4-j3)I_1 + j6(I_1 - I_2) - j2 I_2 = 0.$$

#mesh #2.

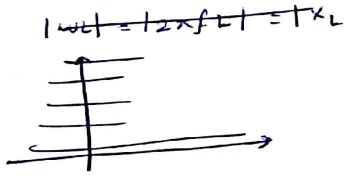
$$5 + j8 I_2 + j6(I_2 - I_1) + j2 I_2 + j2(I_2 - I_1) = 0.$$

---

* Frequency Response. *

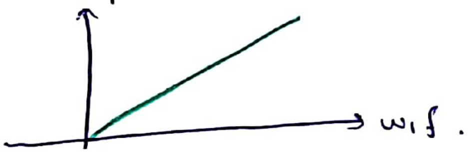
→ what if we change the frequency?

*** Resistor :-**



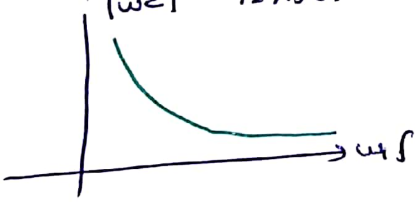
*** Inductor.**

$|\omega L| = |2\pi f L| = |X_L|$



*** Capacitor.**

$$\frac{1}{|\omega C|} = \frac{1}{|2\pi f C|} = |X_C|$$

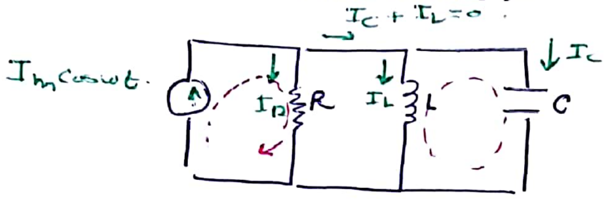


* Resonance : a CKT with L and C where the voltage & current are in-phase.

Parallel

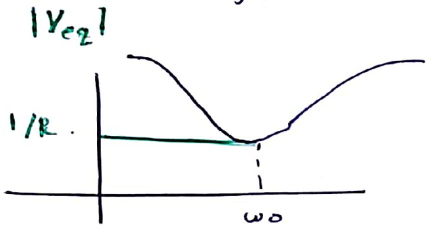
Series.

→ Parallel resonance :-



$Z_{eq} = R \parallel j\omega L \parallel 1/j\omega C$

$Y_{eq} = \frac{1}{R} + \frac{1}{j\omega L} + j\omega C$. S (℧ moh)



at $\omega = 0$ → $|Y_{eq}| = \infty$

at $\omega = \infty$ → $|Y_{eq}| = \infty$.

$Y_{eq} = \frac{1}{R} + j\left(\underline{\omega C - \frac{1}{\omega L}}\right)$

↳ at point (ω_0) they will be equal.

* at ω_0 :-

$\omega_0 C - \frac{1}{\omega_0 L} = 0$. → $\omega_0 = \frac{1}{\sqrt{LC}}$ → $f_0 = \frac{1}{2\pi\sqrt{LC}}$

$|Y_{eq}(\omega_0)| = \frac{1}{R}$.

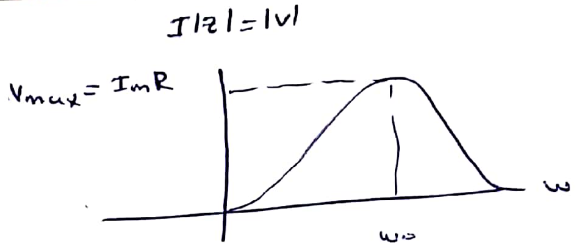
[1] at resonanse, Inductor & Capacitor will cancle each other effect.

[2] at Resonance, $I_R = I_m \cos \omega_0 t$.

$\left.\begin{matrix} I_L \neq 0 \\ I_C \neq 0 \end{matrix}\right\} \rightarrow I_L + I_C = 0$.

(الـ source بيطل شايف إلا الـ R

والـ C بيتم تغذية الـ L).



→ when we have parallel Resonance:
the voltage is maximum.

→ there is a current in L & C ; but they are equal & opposite.

→ Y is minimum $= \frac{1}{R}$, Z is maximum = R.

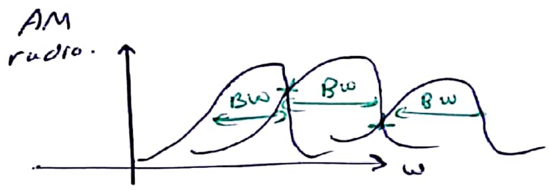
→ $\underset{\text{at resonance}}{|I_{L,0}|} = \frac{V_{L,0}}{|X_L|} = \frac{I_m * R}{|w_0 L|} = -|I_{C,0}|$.

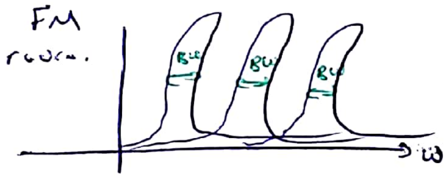
$|I_{C,0}| = \frac{V_{C,0}}{|X_C|} = \frac{I_m * R}{\left|\frac{1}{w_0 C}\right|} = |I_m R w_0 C| = -|I_{L,0}|$.

* ~~$|I_{L,0}| + |I_{C,0}|$~~ → $\boxed{I_{L,0} + I_{C,0} = 0}$.

---

* Quality factor : a parameter that ~~repo~~ represent the BW of a CKT.





Quality factor $= 2\pi \frac{\text{maximum stored energy.}}{\text{total energy lost per period.}}$

$Q_0 = \frac{2\pi \, [w_L(t) + w_C(t)]}{Q_R * T}$

at resonance.

$i(t) = I_m \cos w_0 t$, $v(t) = R I_m \cos(w_0 t)$

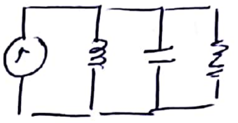
energy ~~set~~ stored in C $= \frac{1}{2} C V^2 = \frac{I_m^2 R^2 \cos^2 w_0 t}{2}$.

energy stored in L $= \frac{1}{2} L \, i_L^2 = \frac{1}{2} L \left(\frac{1}{L} \int \cdots \right)^{2}$

محاضرة قبل الامتحانا.

$\boxed{1}$

$$Q_o = 2\pi \frac{\text{maximum energy stored}}{\text{total energy lost per period.}}$$



$$= 2\pi \frac{[w_L(t) + w_c(t)]_{max}}{P_p T}.$$

$i(t) = I_m \cos(w_o t)$.

$v(t) = R I_m \cos(w_o t)$

$w_c(t) = \frac{1}{2} C v^2 = I_m^2 R^2 C \cos^2 w_o t.$

$$w_L(t) = \frac{1}{2} L\, i_L^2(t) = \frac{1}{2}\left(L\left(\int v_c(t)\cdot dt\right)\right)^2 = \frac{I_m^2 R^2 C \sin^2(w_o t)}{2.}$$

$$w_L(t) + w_c(t) = \frac{I_m^2 R^2 C}{2.}$$

$P_R = \frac{1}{2} I_m^2 R.$

$$P_R T = \frac{T\, I_m^2 R}{2}. = \frac{I_m^2 R}{2 f_o}$$

$$Q_o = 2\pi . * \frac{\cancel{I_m^2} R^2 C / \cancel{2}}{\cancel{I_m^2} R / \cancel{2} f_o} = 2\pi R f_o C = w_o R C \Rightarrow \frac{1}{\sqrt{LC}}.$$

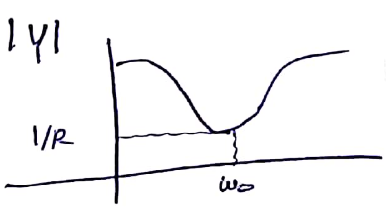
$$Q_o = w_o RC = R\sqrt{\frac{C}{L}} = \frac{R}{|X_{c,o}|} = \frac{R}{|X_{L,o}|}$$

Ex. parallel RLC ckt, $L = 2mH$, $Q_o = 5$, $C = 10nF$, find R.
& the magnitude admittance at $0.9w_o$, w_o, $1.1w_o$.

$$Q_o = R\sqrt{\frac{L}{C}}$$

$$5 = R\sqrt{\frac{10^{-8}}{2*10^{-3}}} \Rightarrow R = 2.236 * K\Omega.$$

$\rightsquigarrow$ admitance at w_o?



$$Y(w = w_o) = \frac{1}{R} = \frac{1}{2.236*10^3} = 4.422*10^{-4}\ S$$

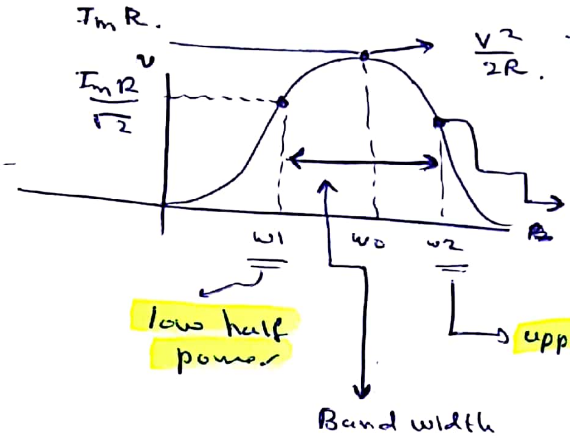
$$Y(w = 0.9w_o) \Rightarrow w_o = \frac{1}{\sqrt{LC}} = 223.6\ \text{krad/sec.}$$

$$Y(0.9*223.6k) = \frac{1}{R} + jwC + \frac{1}{jwL}$$

$$= \frac{1}{2.236*10^3} + j(0.9*223.6k)*10^{-8} + \frac{1}{j(0.9*10^3*223.6)*2m}$$

$Y[0.9\omega_o] = 6.504 * 10^{-4}\ S$

$Y[1.1\omega_o] = \frac{1}{R} + j(\omega_o * 1.1)C + \frac{1}{j(1.1*\omega_o)*L} = 6.182 * 10^{-4}\ S$.

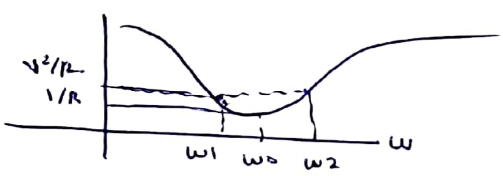


$\frac{V^2}{2R} = \frac{I_m^2 R^2}{2R} = \frac{1}{2} I_m^2 R$.

< spectrum analysis >

$\frac{|V^2|}{2R} = \frac{I_m^2 R^2}{2*2R} = \frac{1}{4} I_m^2 R$.

|Y|



* How to find the BW:

$$Y = \frac{1}{R} + j\left(\omega C - \frac{1}{\omega L}\right) * \frac{R}{R} = \frac{1}{R} + j\frac{1}{R}\left(\omega C R - \frac{R}{\omega L}\right) * \frac{\omega_o}{\omega_o}.$$

use $Q_o = \omega_o RC = \frac{R}{\omega_o L}$.

$$Y = \frac{1}{R} + j\frac{1}{R}\left(\frac{\omega \overbrace{\boxed{CR\omega_o}}^{Q_o}}{\omega_o} - \frac{\omega_o R}{\omega \omega_o L}\right) = \frac{1}{R} + j\frac{1}{R}\left(Q_o\left(\frac{\omega}{\omega_o} - \frac{\omega_o}{\omega}\right)\right)$$

$|Y(\omega_1)| = \sqrt{2}\,|Y(\omega_o)| = \frac{\sqrt{2}}{R}$

$|Y(\omega_2)| = \sqrt{2}\,|Y(\omega_o)| = \frac{\sqrt{2}}{R}$.

$|Y(\omega_o)| = 1/R$.

\# follow the same processor for w2.

$$\omega_2 = \omega_o\left[\sqrt{1+\left(\frac{1}{2Q_o}\right)^2} + \frac{1}{2Q_o}\right]$$

$$\cancel{\frac{1}{R}}\sqrt{1 + Q_o^2\left(\frac{\omega_1}{\omega_o} - \frac{\omega_o}{\omega_1}\right)^2} = \sqrt{2}\cancel{\frac{1}{R}}$$

$$Q_o^2\left(\frac{\omega_1}{\omega_o} - \frac{\omega_o}{\omega_1}\right)^2 = 1 \longrightarrow Q_o\left(\frac{\omega_1}{\omega_o} - \frac{\omega_o}{\omega_1}\right) = 1.$$

$$\omega_1 = \omega_o\left[\sqrt{1+\left(\frac{1}{2Q_o}\right)^2} - \frac{1}{2Q_o}\right]$$ Solve for ω_1.

$B \triangleq \omega_2 - \omega_1$

$B = \frac{\omega_0}{Q_0}$

$\omega_0 = \sqrt{\omega_1 \omega_2}$ $\longrightarrow$ Geometric mean.

* Approximation for high Q_0 ckt :-

for $Q_0 > 5$. " high"

$\omega_1 = \omega_0 \left[1 - \frac{1}{2Q_0}\right]$

$\omega_2 = \omega_0 \left[1 + \frac{1}{2Q_0}\right]$

$\omega_0 = \frac{\omega_1 + \omega_2}{2}$ $\longrightarrow$ Arthematic mean.

Ex. parallel RLC CKT with $R = 400\,k\Omega$. $L = 1H$, $C = \frac{1}{64}\mu F$, find the location of two half power frequencies (ω_1/ω_2) & find the approximation value of admittance at $\omega = 8200$ rad/sec.

→ solution .

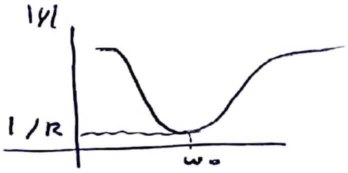
$Q_0 = \omega_0 RC$, $\omega_0 = \frac{1}{\sqrt{LC}} = 8k$ rad/sec.

$= 8 * 10^3 * 400 * 10^3 * \frac{1}{64} * 10^{-6} = \underline{\underline{5}}$ so, I can use approximation.

→ exact solution :.

$Y(\omega = 8200) = \frac{1}{R} + j\left[\omega C - \frac{1}{\omega L}\right) = \frac{1}{400 * 10^3} + j\left[\frac{1}{64} * 10^{-6} * 8200 - \frac{1}{8200 * 1}\right]$

→ approximation solution.



$Y = \frac{1}{R}[1 + jN]$

$N = \frac{\omega - \omega_0}{1/2\,B}$

→ no. of half BW off resonance.

$B = 60$

$\omega_0 = 900$

$\underline{\underline{720}}$ ω

$\frac{720 - 900}{30} = -6$

$B = \cancel{6}00$ rad/sec.

$\omega_0 = 1000$ rad/sec.

fin N @ 1200 . rad/sec .

$N = \frac{1200 - 1000}{\cancel{50}\ 300} = \underline{\underline{4}}$

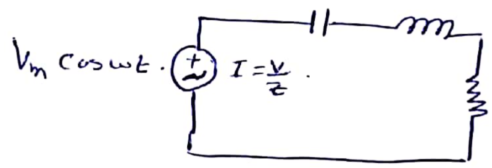
→ In our example :-

$\omega_0 = 8000$ rad/sec.
$\omega = 8200$ rad/sec.
$B = 1600$ rad/sec.

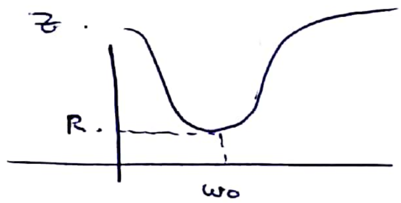
$N = \dfrac{8200 - 8000}{800} = \dfrac{1}{4} = 0.25.$

$Y[8200] = \dfrac{1}{400 \times 10^3}[1 + j0.25].$

* Series resonance :-



$Z = R + j\omega L + \dfrac{1}{j\omega C} = R + j\left[\omega L - \dfrac{1}{\omega C}\right]$

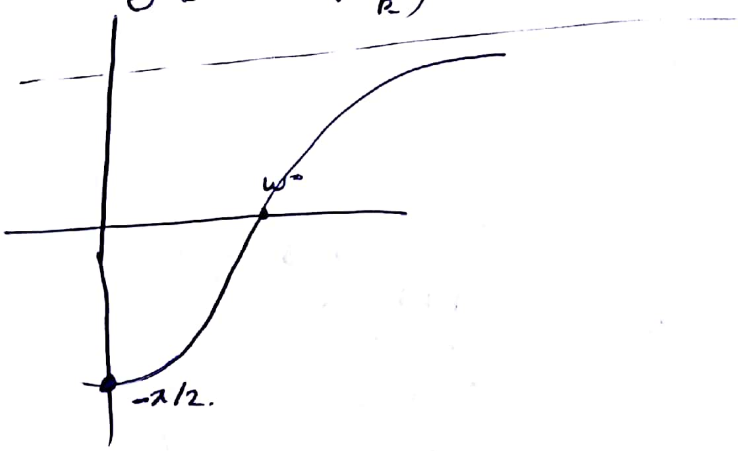


→ there is ω_0 when c effect equal & opposit to L effect.

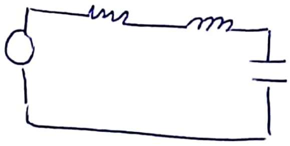
@ ω_0 $\dfrac{1}{\omega_0 C} = \omega_0 L \rightarrow \omega_0 = \dfrac{1}{\sqrt{LC}}$

$f_0 = \dfrac{1}{2\pi\sqrt{LC}}$

$\theta = \tan^{-1}\left(\dfrac{Z}{R}\right)$



Series resonance.



$$Z = R + j\omega L + \frac{1}{j\omega C} = R + j\left[\omega L - \frac{1}{\omega C}\right]$$

$$\omega_0 = \frac{1}{\sqrt{LC}}.$$

$$Q_0 = \frac{\omega_0 L}{R} = \frac{1}{\omega_0 R C} = \frac{\omega_0}{B}.$$

BW: $\omega_1, \omega_2 \longrightarrow$ half - power frequency

$$Z(\omega_1) = \sqrt{2}\, Z(\omega_0).$$

$$Z(\omega_2) = \sqrt{2}\, Z(\omega_0).$$

$$B = \omega_2 - \omega_1 = \frac{\omega_0}{Q_0}.$$

$$\rightarrow \omega_{1,2} = \omega_0 \left[\sqrt{1 + \frac{1}{(2Q_0)^2}} \mp \frac{1}{2Q_0}\right]$$

$\rightarrow$ for high Q_0 $[Q_0 \geq 5]$.

$$\omega_{1,2} = \omega_0 \mp \frac{1}{2}B = \omega_0 \mp \frac{1}{2Q_0}.$$

$$\rightarrow Z_{eq}(\omega) = R[1 + jN], \quad N = \frac{\omega - \omega_0}{1/2\, B}.$$

Ex. $V_s = 100 \cos \omega t$ mV, for series RLC CKT,

$R = 10\,\Omega$, $C = 200$ nF, $L = 2$ mH.

calculate $|I|$ if $\omega = 48$ K rad/sec.

$$Q_0 = \frac{1}{\omega_0 R C} = 50. \checkmark \quad \text{use approximation.}$$

$$\hookrightarrow \omega_0 = \frac{1}{\sqrt{LC}} = 50\text{K rad/sec.}$$

$$\omega_1 = \omega_0 - \frac{1}{2}B$$

$$\omega_2 = \omega_0 + 1/2\, B.$$

$$B = \frac{\omega_0}{Q_0} = 5\text{K rad/sec}$$

$$Z = R[1 + jN] = R + j\omega L + \frac{1}{j\omega C}$$

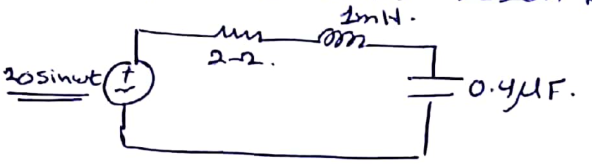
$$\rightarrow N = \frac{\omega - \omega_0}{1/2\, B} = \frac{48 * 10^3 - 50 * 10^3}{1/2 * 5 * 10^3} = -0.8.$$

Scanned by CamScanner

$Z(48k\ rad/sec) = 10(1 - j0.8) = 12.81\ \angle -36.66$.

$|I| = \frac{|V|}{|Z|} = \frac{100 * 10^{-3}}{12.81} = 7.806\ mA.$

Ex. for a series ~~reson~~ Res. CKT shown :



[1] find $\omega_1, \omega_2, \omega_0$.

$Q_0 = \frac{1}{\omega_0 RC} = \frac{\sqrt{LC}}{RC} = 25 \longrightarrow \omega_0 = 50^k\ rad/sec.$

~~$\omega_0 = 50k\ rad$~~

$\omega_1 = 49\ k\ rad/sec.$

$\omega_2 = 51\ k\ rad/sec.$

[2] find B & Q_0.

$B = \frac{\omega_0}{Q_0} = \frac{50 * 10^3}{25} = 2k\ rad/sec.$

[3] Find the magnitude of current at: $\omega_0, \omega_1, \omega_2$.

$|Z(\omega_0)| = R = 2\Omega$. (تأثير c يلغي تأثير L.)

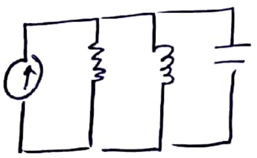
$|I(\omega_0)| = \frac{20}{10} = 2\ A.$

$|Z(\omega_1)| = \sqrt{2}\,R = 2\sqrt{2}\,\Omega. = |Z(\omega_2)|$

$|I_B(\omega_1)| = \frac{20}{2\sqrt{2}} = 7.07\ A = |I(\omega_2)|$

Ex.

10 sinωt mA.



$R = 8\ \Omega.$
$L = 0.2\ mH.$
$C = 8\ \mu F.$

[1] find $\omega_0, \omega_1, \omega_2, B, Q_0$.

[2] power dissappated at $\omega_0, \omega_1, \omega_2$.

solution.

[1] $\omega_0 = \frac{1}{\sqrt{LC}} = 25\ k\ rad/sec.$

$Q_0 = \omega_0 RC = \frac{R}{\omega_0 L} = 1600$ we approximate.

$B = \frac{\omega_0}{Q_0} = 15.625$ rad/sec.

$\rightarrow \omega_1 = \omega_0 - \frac{1}{2}B = 24992$ rad/sec.

$\rightarrow \omega_2 = \omega_0 + \frac{1}{2}B = 25008$ rad/sec.

[2] power only diss. by the resistor.

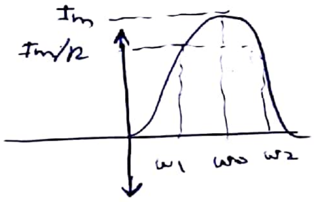
$P = \frac{1}{2} I_m^2 R$

$\quad \hookrightarrow I_R$ (only).

$P(\omega_0) = \frac{1}{2} I_m^2 R = \frac{1}{2}(10^{-2})^2 * 8*10^3 = 0.4\,W$

$P(\omega_1) = \frac{1}{2}\left(\frac{I_m}{\sqrt{2}}\right)^2 R = 0.2\,W$

$P(\omega_2) = \frac{1}{2}\left(\frac{I_m}{\sqrt{2}}\right)^2 R = 0.2\,W$

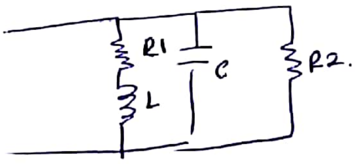


$\rightarrow$ Replacing the current source by voltage source of $10 \sin(\omega t)$ V

* the voltage on R won't change
* the magnitude of I on R won't change.
* $P(\omega_0) = \frac{1}{2} I_m^2 R$.

other resonant forms:-

$\rightarrow$ Determine the resonant frequency.



Key solution:-

$I_m[Y] = 0$

$I_m[Z] = Z$.

$$Y(\omega) = \frac{1}{R2} + j\omega C + \frac{1}{j\omega L + R1}\frac{(R1 - j\omega L)}{(R1 - j\omega L)}$$

$$= \frac{1}{R2} + j\omega C + \frac{R1 - j\omega L}{(R1)^2 + (\omega L)^2}$$

$$I_m[Y] = j\omega C - \frac{j\omega L}{(R1)^2 + (\omega L)^2}$$

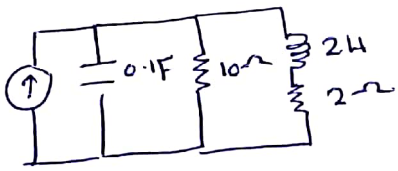
continue.

$$I_m[Y(\omega_0)] = j\omega_0 - \frac{j\omega_0 L}{R_1^2 + (\omega_0 L)^2}$$

$$\omega_0 = \sqrt{\frac{1}{LC} - \left(\frac{R1}{L}\right)^2}.$$

Ex. Find ω_0.

$$\omega_0 = \sqrt{\frac{1}{LC} - \left(\frac{R1}{L}\right)^2}$$



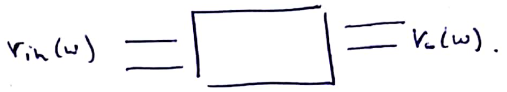
* **Frequency response**: (to find transfer function of frequency).

<that relates input to output>

CKT

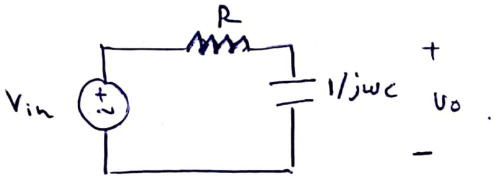
الدارة [illegible] [illegible]

$$T.F = H_v(w) = \frac{V_o(w)}{V_{in}(w)}$$



$$T.F = H_I(w) = \frac{I_o(w)}{I_{in}(w)}.$$

Ex. for the voltage shown, find the voltage transfer function.



$$H_v(w) = \frac{V_o(w)}{V_{in}(w)} = \frac{\cancel{I} * \frac{1}{jwc}}{\cancel{I}[R + 1/jwc]} = \left(\frac{1/jwc}{R + 1/jwc}\right) * \frac{jwc}{jwc} = \frac{1}{1 + jwRc}$$

$$|H_v(w)| = \frac{|1 \text{ البسط}|}{|\text{المقام}|} = \frac{1}{\sqrt{1 + (wRc)^2}}$$

; $H_v(0) = 1$.

$H_v(\infty) = 0$

لـ بتعوض مكانه

$0 \leftarrow w$

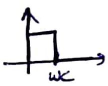
∞.

low pass filter.

(~~تعمل~~ تمرر frequency منخفضة).

---

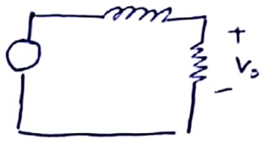
* low frequency signals & blocks high frequency signals

→ Ideal low pass filter  , $w_c = \frac{1}{Rc}$.

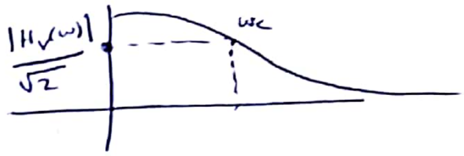
* cut off frequency is defined as the frequency at which gain $= \frac{1}{\sqrt{2}} H_w(v)_{max}$, $|H_v(w)| = \frac{1}{\sqrt{2}}$.

$$\frac{1}{\sqrt{1 + (Rc)^2}} = \frac{1}{\sqrt{2}} \Rightarrow \cancel{w_c = 1/\sqrt{2}}. \quad w_c = 1/RC.$$

* other circuit :-



$$H_v(w) = \frac{R}{R + jwL} , \quad |H_v(w)| = \frac{R}{\sqrt{R^2 + (wL)^2}} ,$$



$H(0) = 1$

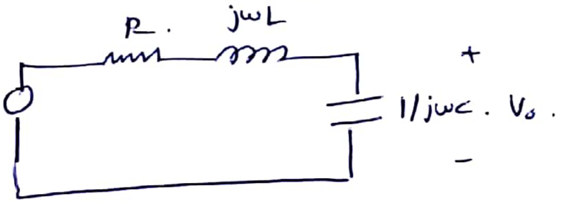
$H(\infty) = 0$

@ w_c

$$|H_v(w_c)| = \frac{1}{\sqrt{2}} = \frac{R}{\sqrt{R^2 + (w_c L)^2}} .$$

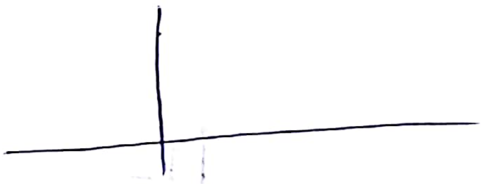
$$\boxed{w_c = \frac{R}{2}} \equiv \text{cut off frequency}$$

Ex. find the voltage. T.F (gain) for shown CKT.



$$H_v(w) = \frac{V_o(w)}{V_{in}(w)} = \frac{1/jwc}{R + jwL + 1/jwc} = \frac{1}{1 + jwRC - w^2LC} .$$

$$|H_v(w)| = \frac{1}{\sqrt{1 + (wRC)^2 + (w^2LC)^2}}$$



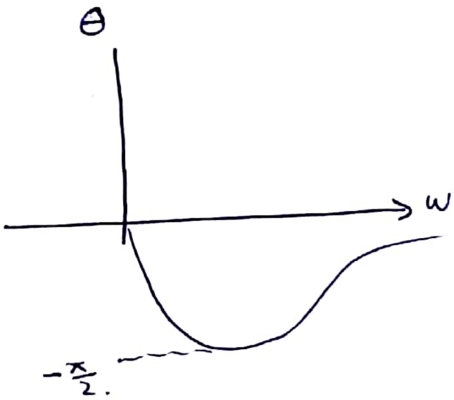
LPF.

$H(0) = 1$

$H(\infty) = \infty$

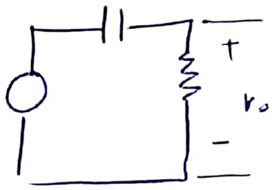
$$\measuredangle H_v(w) = - \tan^{-1}\left(\frac{wRC}{1 - w^2LC}\right) \quad \begin{matrix} \rightarrow \text{Im} \\ \rightarrow \text{Re.} \end{matrix}$$

زاوية البسط - زاوية المقام.



* **High pass filter**: is one that passes the high frequencies & reject low frequencies.

Ex:



$$H_v(w) = \frac{V_o}{V_{in}} = \left(\frac{R}{R + 1/jwC}\right) * \frac{jwC}{jwC} = \frac{Rjwc}{1 + jwRC}.$$

$$|H_v(w)| = \frac{wRC}{\sqrt{1 + (wRC)^2}}.$$

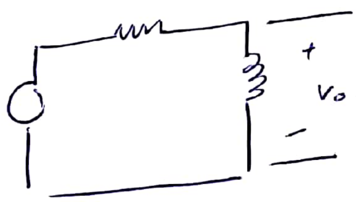
$|H_v(w)|$

w_c: is the frequency where:-

$$H_v(w_c) = \frac{1}{\sqrt{2}} |H(w)|_{max}.$$

$$H_v(w_c) = \frac{1}{\sqrt{2}} = \frac{w_c RC}{\sqrt{1 + (w_c RC)^2}} \Rightarrow \boxed{\frac{1}{RC} = w_c}$$

Ex:

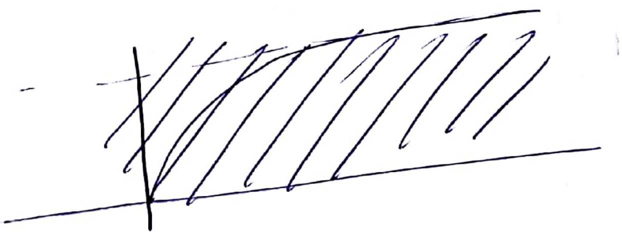


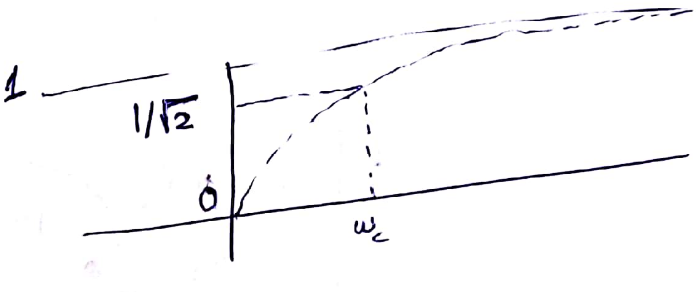
$$H_v(w) = \frac{V_o}{V_{in}} = \frac{jwL}{R + jwL}$$

$$|H_v(w)| = \frac{wL}{\sqrt{R^2 + (wL)^2}}, \quad H(0) = 0, \quad H(\infty) = 1.$$

$$\frac{1}{\sqrt{2}} = H_v(w) = \frac{w_c L}{\sqrt{R^2 + (w_c L)^2}}$$

$$\boxed{w_c = \frac{R}{L}.}$$





Types of filters :-

filter

[1] LPF. ✓ (low pass ~~freq.~~)

filter.

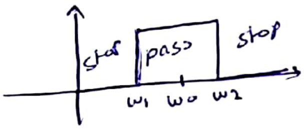
[2] HPF. ✓ (High pass ~~freq.~~)

[3] band pass filter.

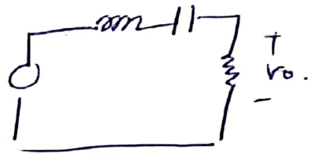
[4] band stop filter.

---

* band pass filter.



→ series RLC CKT with output taken of a resistor.



$$H_r(w) = \left(\frac{R}{R+jwL+1/jwc}\right) * \frac{jwc}{jwc} = \frac{jwRC}{jwRC - w^2LC + 1}$$

$\underbrace{jwRC}_{Im.}$ $\underbrace{-w^2LC+1}_{Real.}$

$$|H_r(w)| = \frac{wRC}{\sqrt{(1-w^2LC)^2+(wRC)^2}}$$

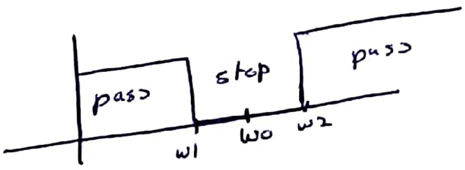
$H(0) = 0$.

$H(\infty) = 0$

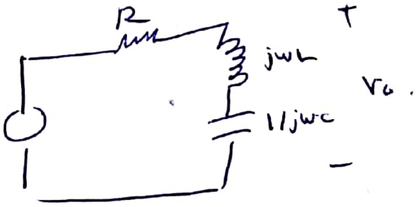
w_1, w_2, w_0 → can be calculated based on series resonance expression.

---

* band stop filter:-



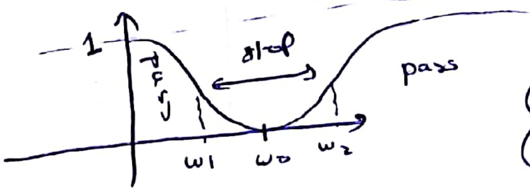
→ RLC Series CKT with the output taken at L & C.



$$H_r(w) = \frac{jwL + 1/jwc}{R+jwL+1/jwc} = \frac{1-w^2cL}{1+jwRC-w^2LC}$$

$$|H_r(w)| = \frac{1-w^2cL}{\sqrt{(1-w^2cL)^2+(wRC)^2}}$$

~~H(0)~~



$H(0) = 1$, $H(\infty) = 1$

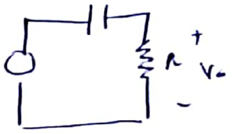
w_0, w_1, w_2 can be found by series ~~exp~~ resonance expression.

Ex. Design a high pass filter with a corner frequency of 3kHz. ...بالمحاضرة بعد الامتحان.

$\boxed{1}$

→ Choose an RC cct with output on R.

$$H_v(\omega) = \frac{R}{R + 1/j\omega C} = \frac{|V_o(\omega)|}{|V_{in}(\omega)|}$$



$$|H_v(\omega)| = \frac{\omega RC}{\sqrt{1 + (RC\omega)^2}}$$

take:-

$R = 4.7\ k\Omega$.

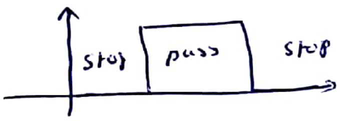
$C = 11.29\ nF$

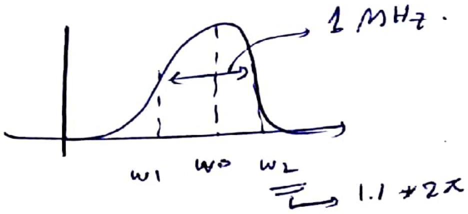
→ قيم من راس الدكتور. تحقق المعادلة.

Ex. Design a band pass filter characterized by a $BW = 1MHz$. (Bandwidth)

& upper half BW frequency of $1.1\ MHz$.

upper ↓ cut off.



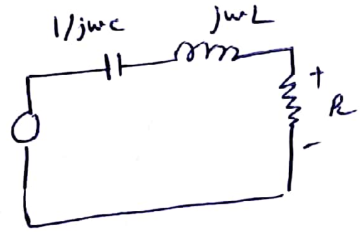


$\omega_2 = 1.1 * 2\pi * 10^6 = 6.912\ M\ rad/sec.$

$\omega_1 = \omega_2 - B = 0.1 * 2\pi = 628.3\ k\,rad/sec$

$\omega_o = \sqrt{\omega_1 \omega_2} = 2.084 * 10^6\ rad/sec.$

But



$$\Rightarrow B = \frac{\omega_o}{Q_o} = \frac{\omega_o}{\omega_o L/R} = \frac{R}{L} = 6.28 * 10^6.$$

$\boxed{1}$

$$\Rightarrow \omega_o = \frac{1}{\sqrt{LC}} = 2.084 * 10^6$$

$\boxed{2}$

take:-

$L = 50\ mH$.

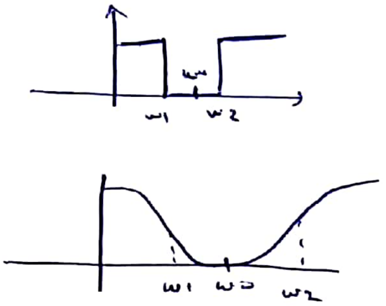
$C = 4.6\ pF$.

$R = 314\ k\Omega$

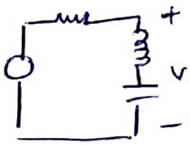
Ex.

a band stop filter is designed to reject a 200 Hz (→ center freq.) frequency while passing other frequencies.

Calculate L & C : take : $R = 150\,\Omega$, $B = 100$ Hz.



→ ckt →



$B = 2\pi * 100 = 200$ rad/sec

دايماً حوّل لل rad/sec.

$B = \frac{w_o}{Q_o} = \frac{w_o}{w_o L/R} = \frac{R}{L}$

$L = \frac{R}{B} = \frac{150}{200\pi} = 0.2387$ Hz.

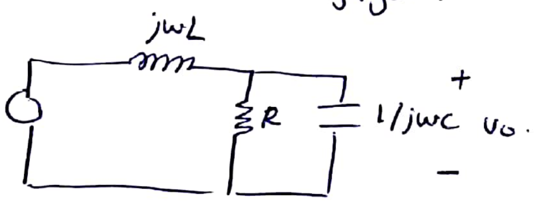
$w_o = \frac{1}{\sqrt{LC}} = 400\pi$.

?

$\Rightarrow C = 2.65\,\mu F$.

Ex.

Determine what type of filter is. Shown in figer.



* نوع ال filter يعتمد على علاقة ال input & output

so → لازم أطلع Hv(w)

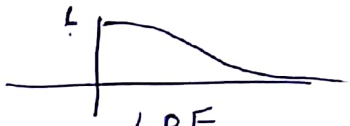
$$H_v(w) = \left(\frac{R \,//\, 1/jwc}{jwL + R // 1/jwc} \right) = \left(\frac{\frac{\frac{R}{jwc}}{R + \frac{1}{jwc}}}{jwL + \frac{\frac{R}{jwc}}{R + \frac{1}{jwc}}} \right) * \frac{jwc}{jwc}.$$

$$H_v(w) = \left(\frac{\frac{R}{1 + jwcR}}{\frac{R}{1 + jwRC} + jwL} \right) * \frac{1 + jwRC}{1 + jwRC} = \frac{R}{\underbrace{R + jwL - w^2 LRC}_{\text{Real parts}}}.$$

$$|H_r(\omega)| = \frac{R}{\sqrt{(R-\omega^2 LRC)^2 + (\omega L)^2}}$$

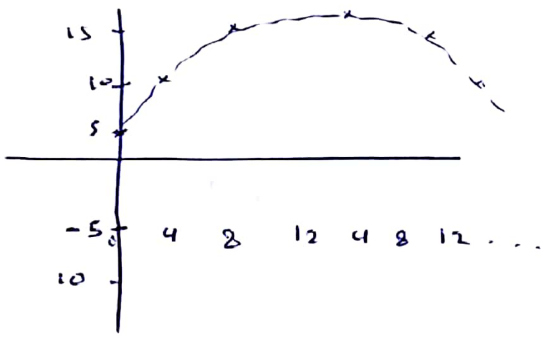
$\rightarrow H(0) = 1$

$\rightarrow H(\infty) = 0$

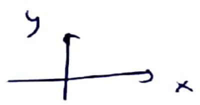


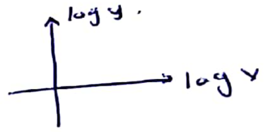
LPF
(low pass filter).

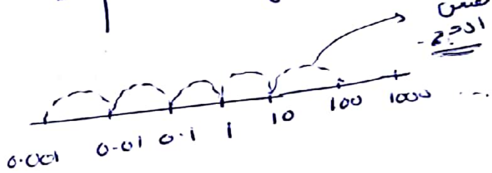
The Decibel scale:-



a : [1, 2]. $\longrightarrow$ a : [0 , log 2]
b : $[10^{-5}, 10^{-7}]$ $\longrightarrow$ b: [-5, -7]
c : $[10^{3}, 10^{5}]$ $\longrightarrow$ c : [3 , 6]







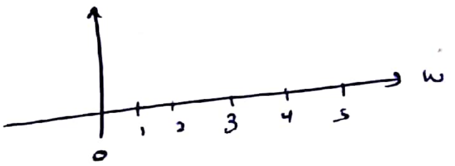
zero لن نصل لل

The Bode plots : (draw by hand accurate).

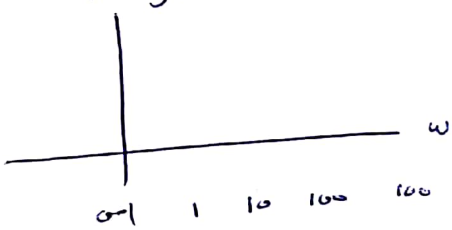
→ Bode plots is away to plot magnitude in decibels & phase vs. logarithmic scale.

$20\log|H_r(\omega)| \rightarrow$ (unit $\rightarrow$ dB)

$|H_r(\omega)| \rightarrow$ unitless



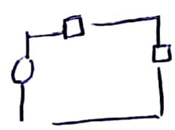
$\Rightarrow$



ω in log scale.

→ previously.

$|H_r(\omega)| = 10 \Rightarrow 20\log 10 = 20$.
10 unitless = 20 dB.



1V

1V , 10V , 0.1V

$|H_r(\omega)| = 1 \Rightarrow 20\log|H_r(\omega)| = 0$.

1 $\Rightarrow$ 0 dB.

$|H_r(\omega)| = 0.1 \Rightarrow 20\log 0.1 = -20$.

0.1 $\Rightarrow$ -20 dB.

* How to construct Bode plots:

→ write your gain function on standard form:-

$$\frac{N(\omega)}{D(\omega)} = H(\omega) = \frac{K\,(j\omega)^{\pm 1}\left[1+\frac{j\omega}{z_1}\right]}{\left[1+\frac{j\omega}{p_1}\right]}$$

$(j\omega)^{\pm1}$ → zero at zero.

$\left[1+\frac{j\omega}{z_1}\right]$ → zero at z_1

$\left[1+\frac{j\omega}{p_1}\right]$ → ~~pol~~ pole at p_1.

اصفار البسط ← zero.

اصفار المقام ← pole.

$$H(\omega) = \frac{200\, j\omega\,[j\omega+7]}{[j\omega+5]\,[j\omega+10]}$$

① write in standard form.

$$H(\omega) = \frac{200\, j\omega\, 7\left[\frac{j\omega}{7}+1\right]}{5\left[1+\frac{j\omega}{5}\right] 10\left[1+\frac{j\omega}{10}\right]} = \frac{28\; j\omega\left[1+\frac{j\omega}{7}\right]}{\left[1+\frac{j\omega}{5}\right]\left[1+\frac{j\omega}{10}\right]}$$

28 → K

$j\omega$ → zero at zero.

$\left[1+\frac{j\omega}{7}\right]$ → zero at 7.

$\left[1+\frac{j\omega}{5}\right]$ → pole at 5

$\left[1+\frac{j\omega}{10}\right]$ → pole at 10.

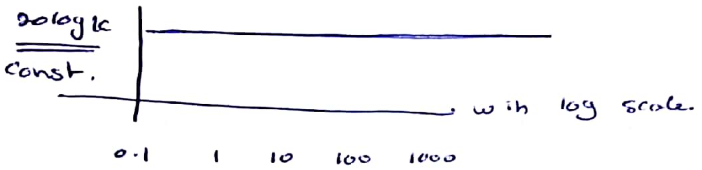
② take $20\log|H_r(\omega)|$.

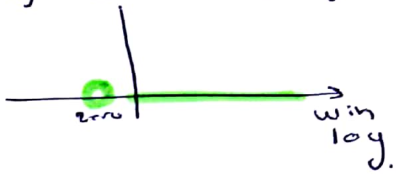
$$20\log|H_r(\omega)| = \underbrace{20\log 28 + 20\log\left|1+\frac{j\omega}{7}\right| + 20\log|j\omega| - 20\log\left|1+\frac{j\omega}{5}\right| - 20\log\left|1+\frac{j\omega}{10}\right|}_{\text{بس كدا كلهم لبعض نجمعهم.}}$$

$$|H_r(\omega)| = \frac{\left|K\,(j\omega)^{\pm1}\left(1+\frac{j\omega}{z_1}\right)\right|}{\left|1+\frac{j\omega}{p_1}\right|}$$

$$|H_r(\omega)| = \underbrace{20\log|K|}_{①} + \underbrace{20\log|j\omega|}_{②} + \underbrace{20\log\left|1+\frac{j\omega}{z_1}\right|}_{③} - \underbrace{20\log\left|1+\frac{j\omega}{p_1}\right|}_{④}.$$

① **$20 \log |k|$** $= 20 \log k$ ⇝ $H_v(\omega) = k$ $(\theta = 0)$ $\theta = \tan^{-1}\left(\frac{Im}{Real}\right)$

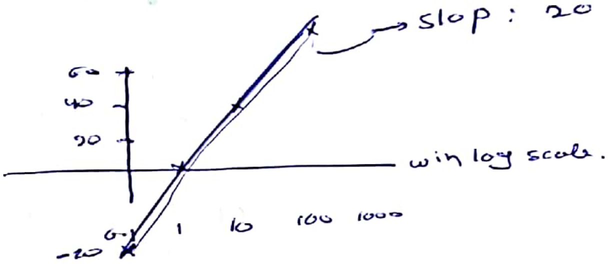




② **$20 \log |j\omega|$**

$H_v(\omega) = j\omega$.

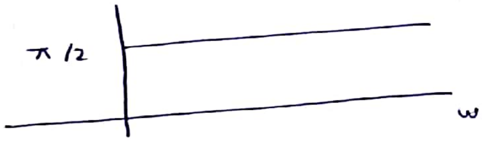
$|H_v(\omega)| = \omega$.



slop : 20 dB / decade

القفزه بـ log

$\theta = \tan^{-1}\left(\frac{Im}{Rc}\right) = \pi/2$.



③ $H_v(\omega) = \frac{1}{j\omega}$

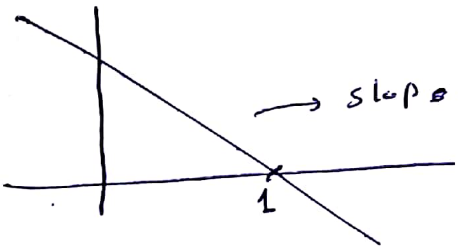
$|H_v(\omega)| = \left|\frac{1}{j\omega}\right|$

$20 \log |H_v(\omega)| =$ **$20 \log \left|\frac{1}{j\omega}\right|$** $= -20 \log |j\omega|$

نفس الرسمة السابقة

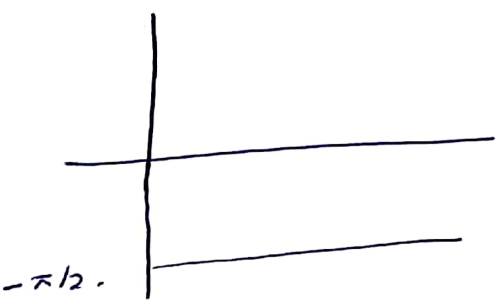
ضرب (-1)

$20 \log |j\omega|$



slope = − 20 dB / decade.

θ



4 $H_v(\omega) = 1 + \frac{j\omega}{z_1}$

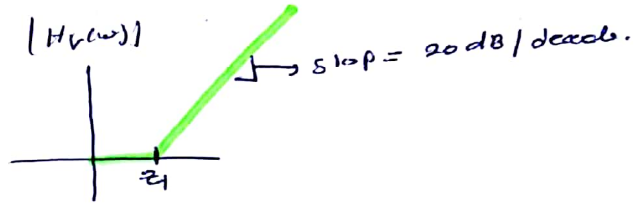
$$20 \log |H_v(\omega)| = 20 \log \left| 1 + \frac{j\omega}{z_1} \right|$$

$$|H_v(\omega)| = \sqrt{1 + \left(\frac{\omega}{z_1}\right)^2}$$

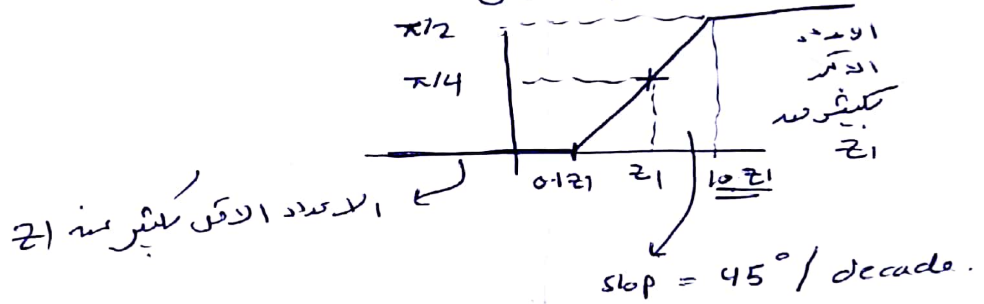
if $\omega \lll z_1$

$|H_v(\omega)| = 1$

$\log 1 = 0$.



$\theta = \tan^{-1}\left(\frac{Im}{Re} = \frac{\omega}{z_1}\right)$

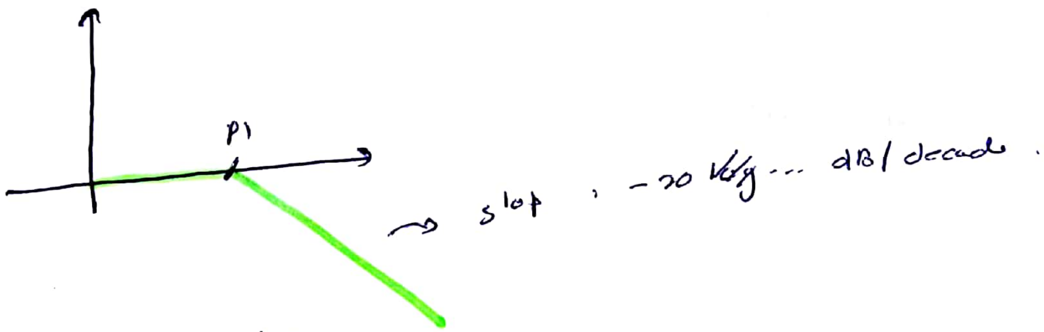


(simple pole).

$$H_v(\omega) = \frac{1}{1 + \frac{j\omega}{p_1}} = \left(1 + \frac{j\omega}{p_1}\right)^{-1}$$

$$20 \log |H_v(\omega)| = 20 \log \left| \left(1 + \frac{j\omega}{p_1}\right)^{-1} \right| = -20 \log \left| 1 + \frac{j\omega}{p_1} \right|$$

نفس الرسمة السابقة × (-1) *



$\theta = \tan^{-1}\left(\frac{\omega}{p_1}\right)$