L. C.

CALCULATION.

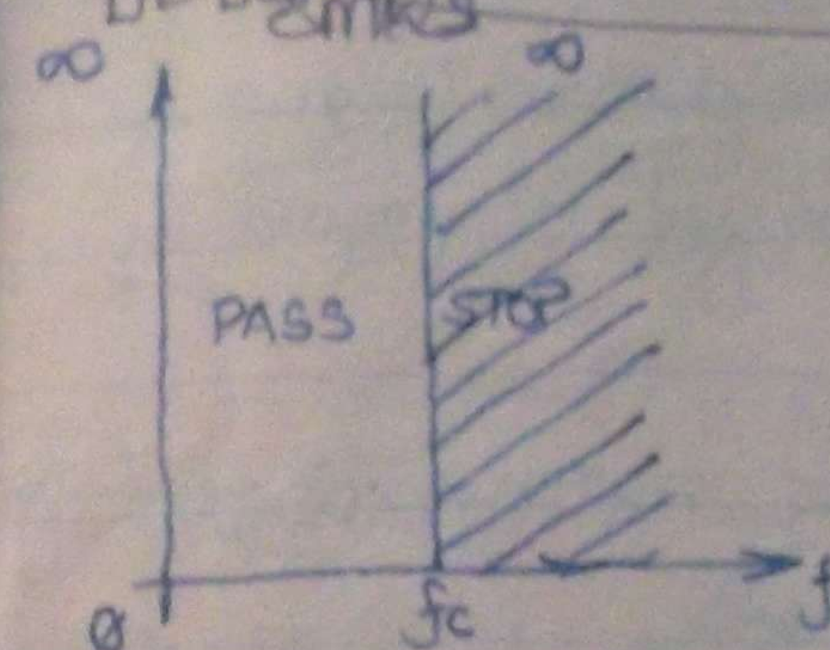
VOL. 3.

L. C.

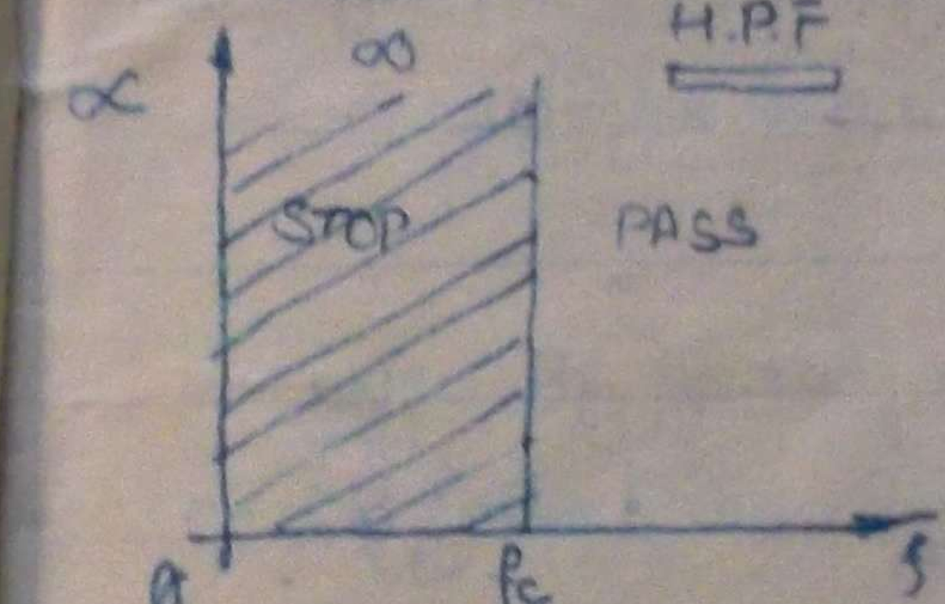
(80)

Elecric Wave Filter (Contd)

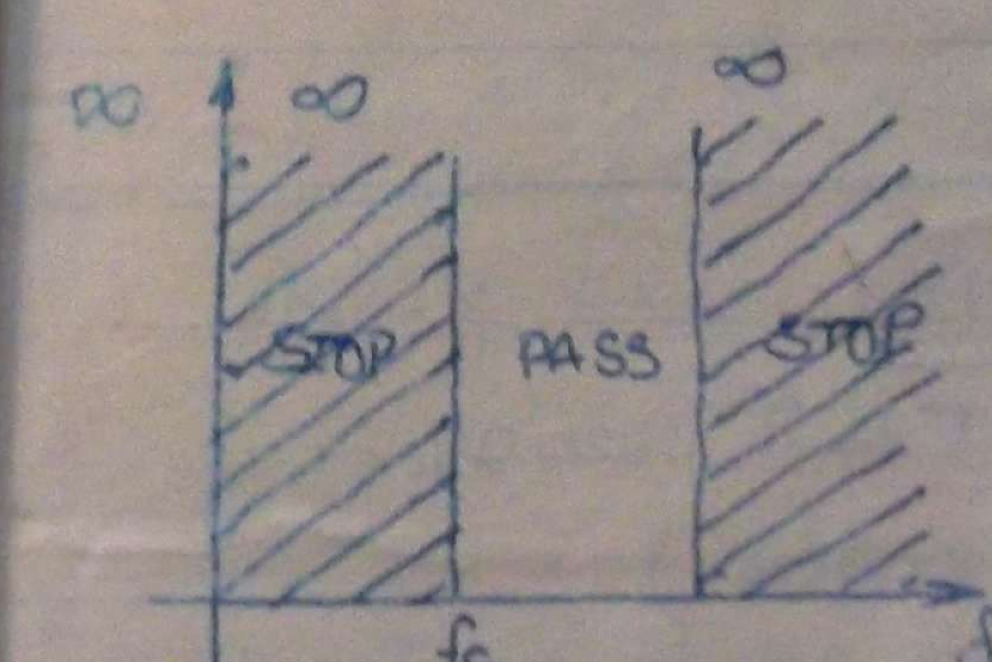
15.6.83.



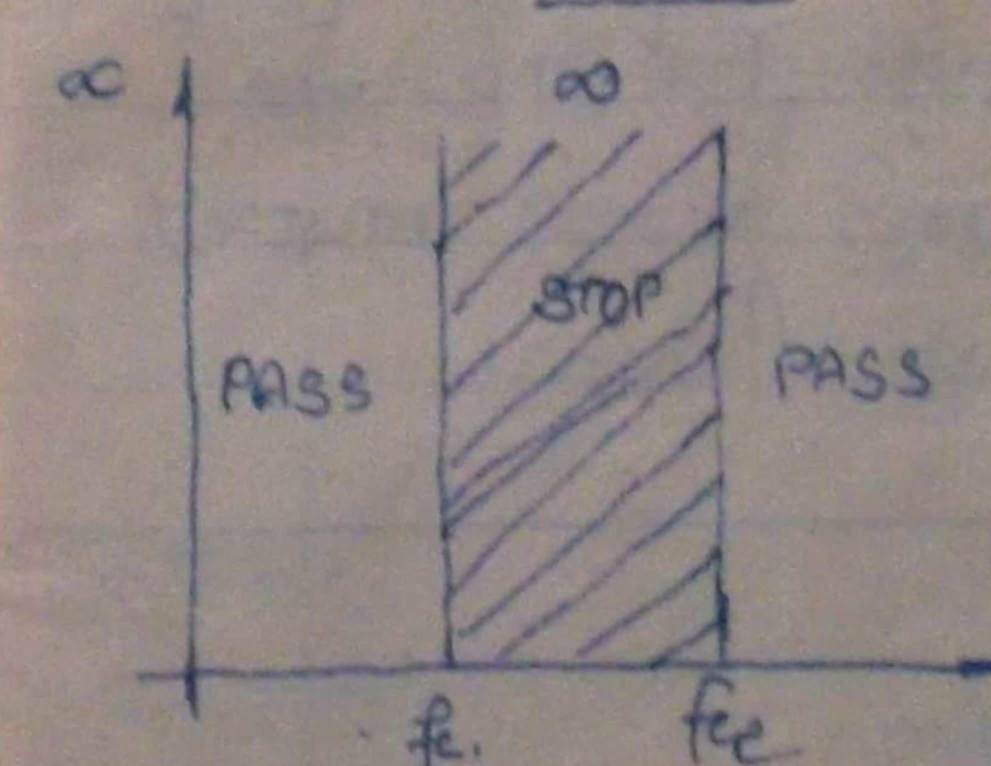
LPF



H.P.F



B.P.F.



B.E.F.

Elecric wave filterဟာ ဖြတ်သန်းစီးဆင်းလာသော လိုအပ်သော frequencyများကို ဖြတ်သန်းခွင့်ပြုပြီး၊ မလိုအပ်သော frequencyများကို တားဆီးပြစ်သောပစ္စည်းဖြစ်သည်။ ဖြတ်ကျော်ခွင့်-ပေးသော frequency bandကို pass or transmission bandဟုခေါ်ပြီး၊ တားဆီးထားသော frequency bandကို attenuation or stop bandဟုခေါ်၏။ Pass bandနှင့် stop bandတို့ခွဲခြားသော frequencyကို cut-off frequencyဟုခေါ်သည်။

Filterများကို radiotelephony, teleprinterနှင့် carrier system စသည်တို့တွင် channel တစ်ခုနှင့်တစ်ခု ကျော်ဖြတ်ခြင်းတွင် signal အမျိုးအစားများကို transmit လုပ်ခြင်းနှင့် receive လုပ်ခြင်း အတွက် အသုံးပြုလေ့ရှိသည်။

Filterများကို မိမိလိုချင်သော frequency bandအတွင်း ဖြတ်ကျော်စေသောစနစ်လုပ်နိုင်ရန် filter ဒီဇိုင်းလုပ်ရာ၌ အောက်ပါအချက်အလက်များနှင့် ပြည့်စုံရန် လိုအပ်သည်။

၁။ အသုံးပြုမည့် characteristic Zနှင့် matched ဖြစ်ရမည်၊ ၂။ Pass bandအတွင်း attenuation လုံးဝမရှိရ။ သို့မဟုတ် stop bandတွင် α အများဆုံးဖြစ်ရမည်၊ ၃။ fcသည် stop bandမှ pass bandသို့ ပြောင်းသော နယ်နိမိတ် ဖြစ်ရမည်။

Filter တို့ကို ခွဲခြားခြင်းအားဖြင့် ၄-မျိုး ခွဲခြားထားသည်။

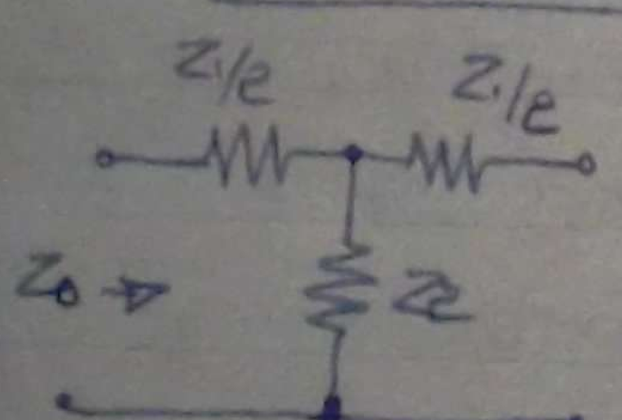
၁. <u>Low pass filter</u>:- Cut off frequency ထက်နိမ့်သော frequency signal ကို ဖြတ်သန်းခွင့်ပေးပြီး၊ cut off frequency ထက်မြင့်သော frequency signal များကို တားဆီးသည်။

၂. <u>High pass filter</u>:- f_c ထက်နိမ့်သော freq. signal များကို တားဆီးပြီး၊ f_c ထက်မြင့်သော freq. signal များကို ဖြတ်သန်းခွင့်ပေးသည်။

၃. <u>Band pass filter</u>:- Lower cut off နှင့် Upper cut off တို့ကြားရှိ freq. signal များကို ဖြတ်သန်းခွင့်ပေးပြီး၊ ထို band ၏ အပြင်ရှိသော frequency signal များကို တားဆီးသည်။

၄. <u>Band Elimination Filter</u>:- Lower cut-off နှင့် upper cut-off ကြားရှိ freq. signal များကို တားဆီးပြီး၊ ၎င်း band ပြင်ပရှိသော frequency signal များကို ဖြတ်သန်းခွင့်ပေးသည်။

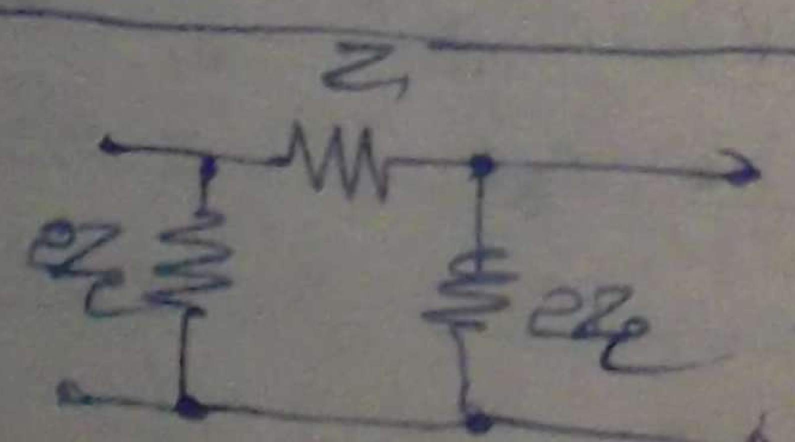
PROTO-TYPE FILTER (CONSTANT K-TYPE)



$\boxed{Z_1 Z_2 = R_K^2}$

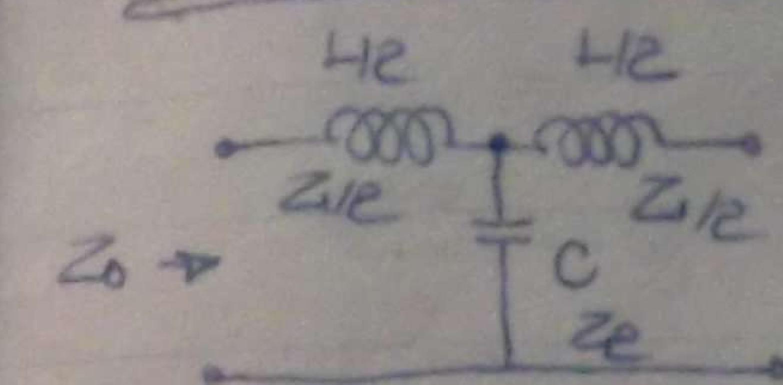
(4 terminal T & π section N/W များကိုသာ ဆွေးနွေးမည်။)

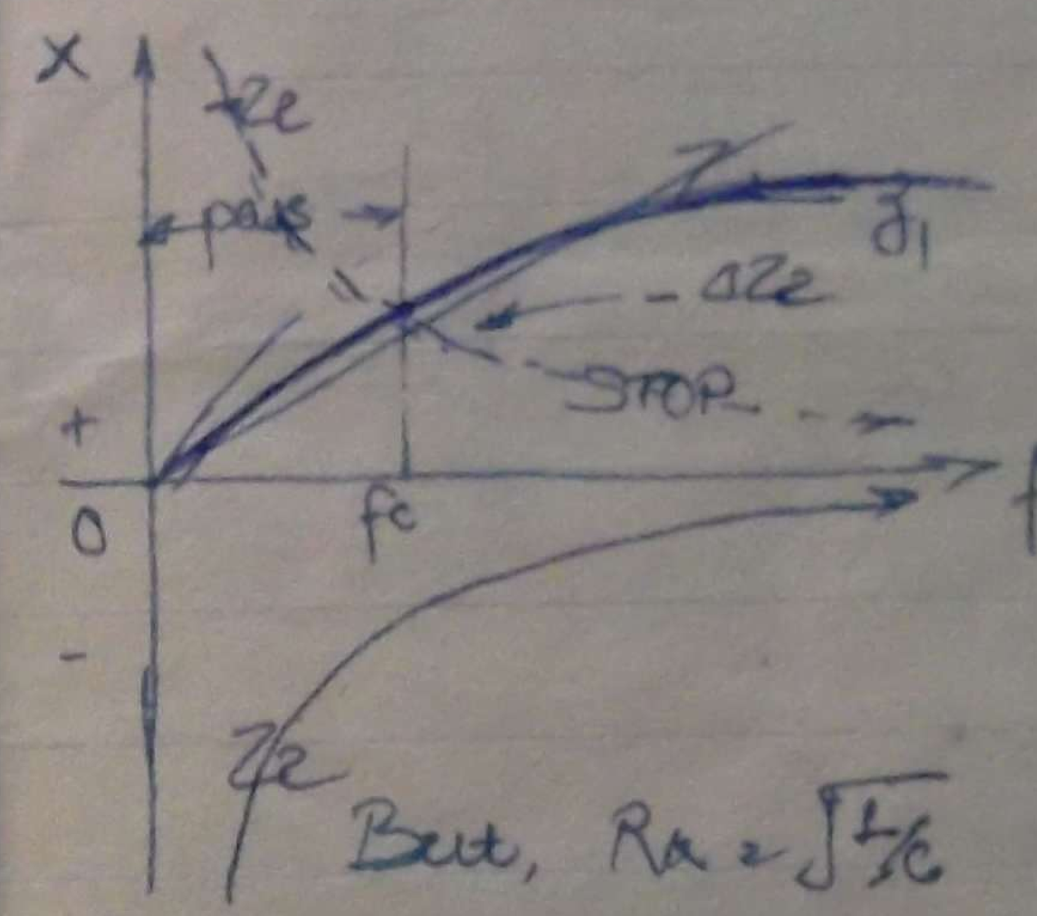
Filter များသည် 4 terminal N/W များကို အစုလိုက် ဆောက်လုပ်ထားခြင်းဖြစ်သည်။ Proto-type filter တွင် $Z_1 \times Z_2 = R_K^2$ ဖြစ်ပြီး R_K သည် constant ဖြစ်ခြင်းကြောင့် constant k filter ဟုလည်း ခေါ်ဆိုသည်။



π section
K-type

1. LOW PASS FILTER:-





$Z_1 = j\omega L$, $Z_2 = \frac{1}{j\omega C}$

$\therefore R_K = \sqrt{Z_1 Z_2}$

$\therefore \boxed{R_K = \sqrt{L/C}}$

constant, proto type

$Z_1 = -4Z_2$ (at f_c)

$j2\pi f_c L = -\frac{4}{j2\pi f_c C}$

$\therefore -4\pi^2 f_c^2 LC = -4$ $[j^2 = -1]$

$\therefore \boxed{f_c = \frac{1}{\pi\sqrt{LC}}}$

But, $R_K = \sqrt{L/C}$ → $\frac{R_K}{L} = \frac{1}{\sqrt{LC}}$

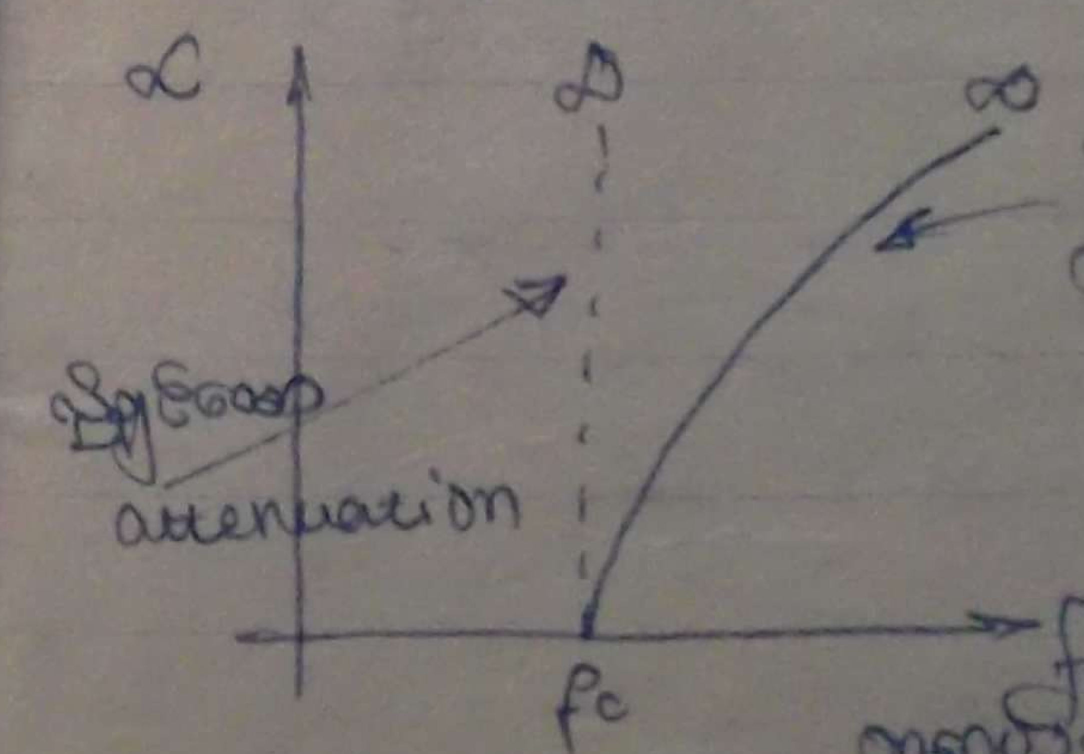
$\therefore f_c = \frac{R_K}{\pi L}$ ⇒ $\boxed{L = \frac{R_K}{\pi f_c}}$.

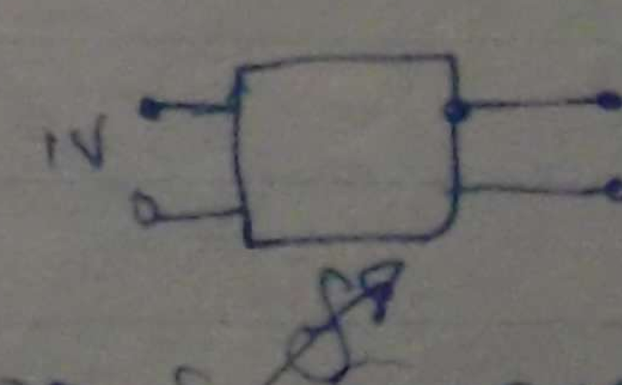
$R_K . C = \sqrt{LC}$

$\therefore f_c = \frac{1}{\pi R_K C}$ ⇒ $\boxed{C = \frac{1}{\pi f_c R_K}}$.

$R_K = Z_0$ → Z_0 နှင့် f_c သိလျှင် L, C ရှာနိုင်သည်။

(f_c ရဲ့ derive လုပ်ရာတွင် $Z_1 = -4Z_2$ ဖြစ်သောကြောင့်)

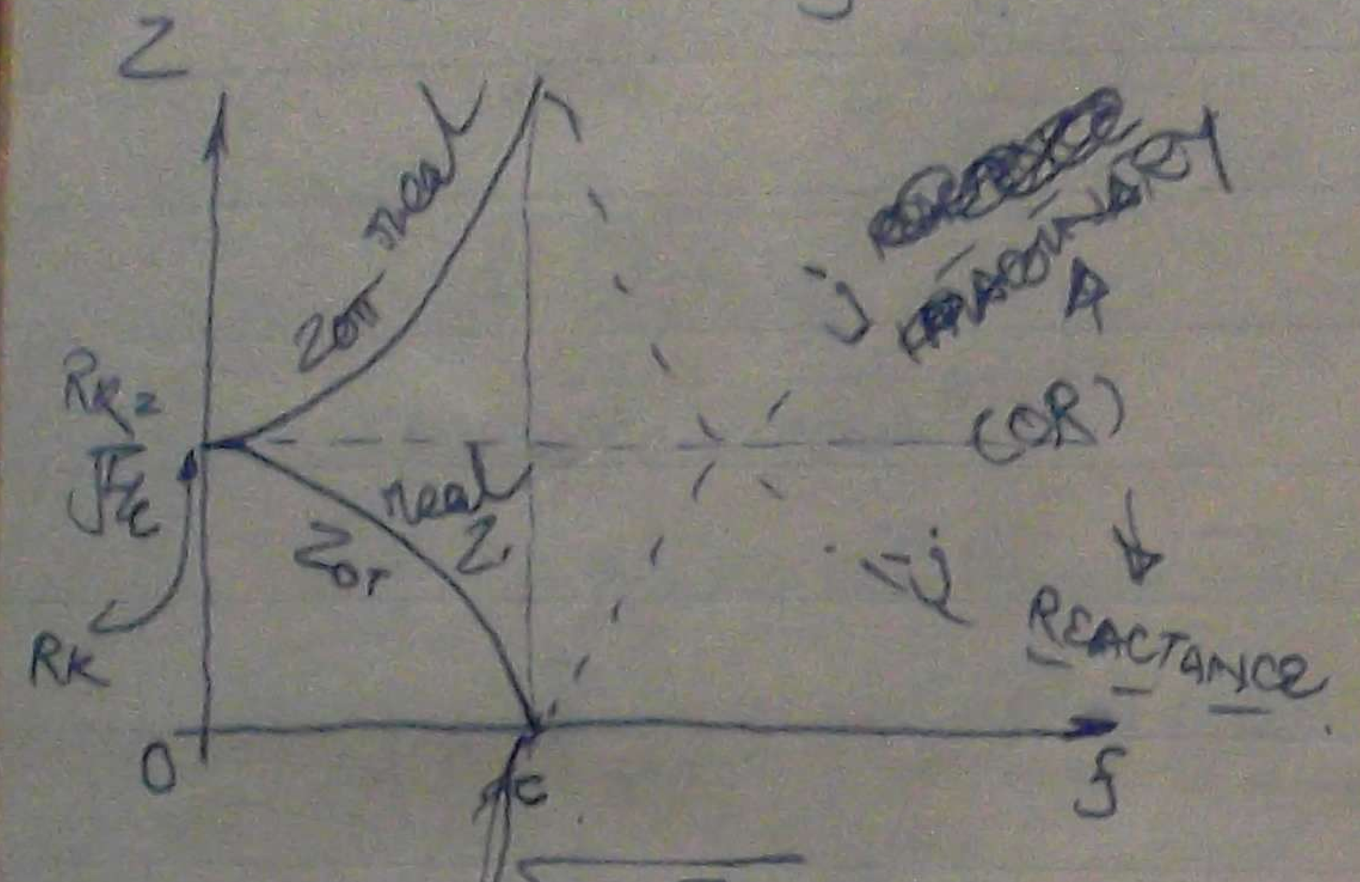




တကယ်တမ်း ခွဲခြားရာတွင် α မှာ တဖြည်းဖြည်း တိုးလာမည်ဖြစ်သည်။

(P.5 ရှိဥပမာကြည့်ရှု)

4 terminal N/W ရဲ့ Z_0 ၏ graph ကိုဆွဲပြသော် -



$$\frac{Z_1}{4Z_2} = \frac{j\omega L}{4/j\omega C}$$
$$= -\frac{\omega^2 LC}{4}$$
$$= -\frac{4\pi^2 f^2 LC}{4}$$
$$= -\frac{f^2}{\left(\frac{1}{\pi\sqrt{LC}}\right)^2}$$
$$\therefore Z_1/4Z_2 = -\left(\frac{f}{f_c}\right)^2 \quad \text{—(1)}$$

$$Z_{0T} = \sqrt{Z_1Z_2}\sqrt{1+\frac{Z_1}{4Z_2}}$$
$$= R_k\sqrt{1-(f/f_c)^2} \quad \text{—(from eq 1)}$$
$$\text{llly } Z_{0\pi} = \frac{\sqrt{Z_1Z_2}}{\sqrt{1+\frac{Z_1}{4Z_2}}} = \frac{R_k}{\sqrt{1-(f/f_c)^2}}.$$

R_k နှင့် f_c သည် constant or given များဖြစ်၍

$\therefore$ Z_{0T} နှင့် $Z_{0\pi}$ သည် f နှင့် ပြောင်းလဲကြသည် (See vector dia:)

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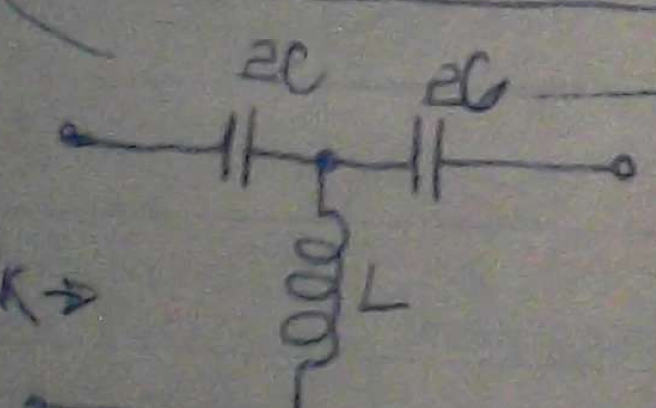
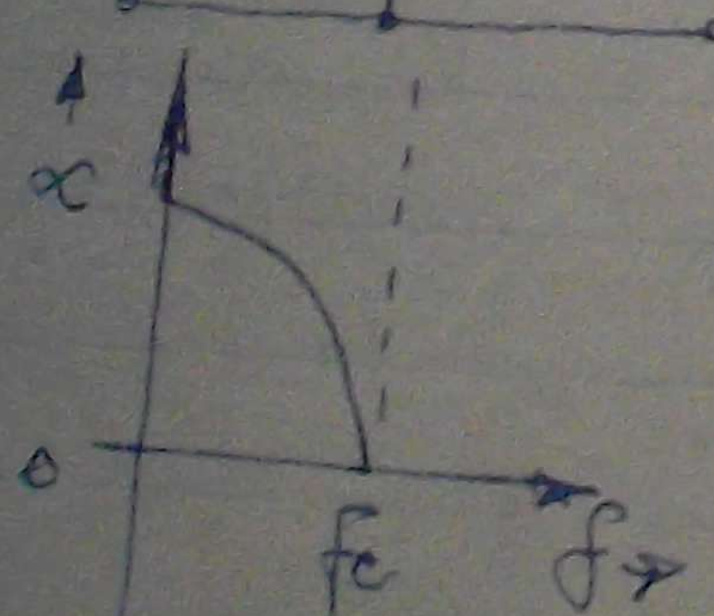
2. HIGH PASS FILTER

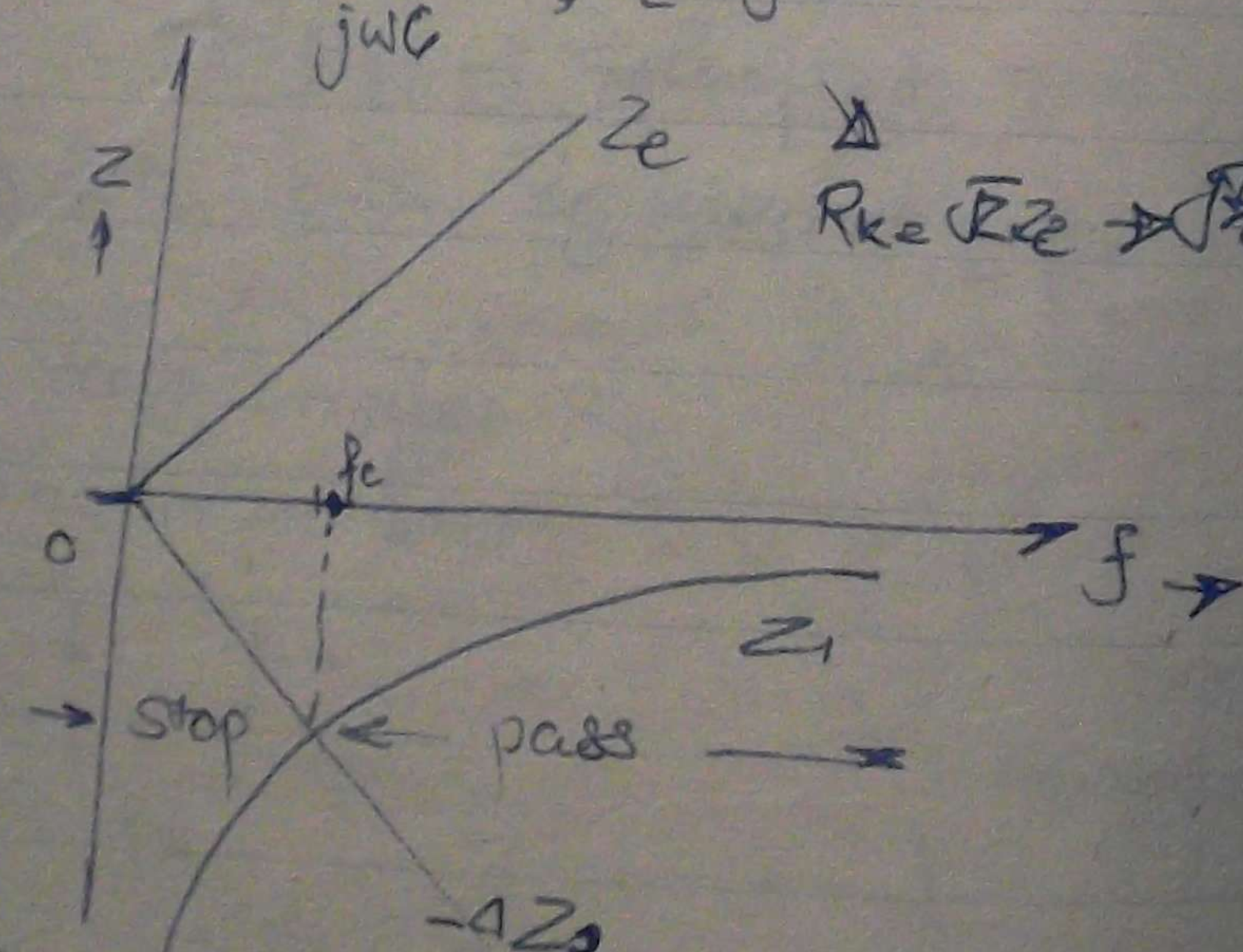
$\boxed{\text{၉၉ 4MKS}}$ ၂၂-၈-၈၃





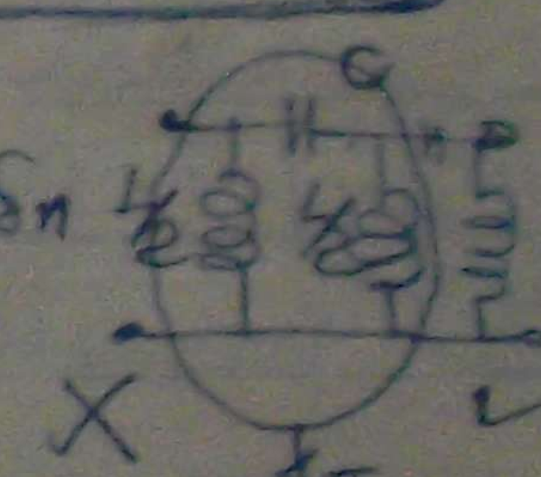
$Z_1 = \frac{1}{j\omega C}$, $Z_2 = j\omega L$

Δ $R_k = \sqrt{Z_1Z_2} \Rightarrow \sqrt{L/C}$.



$$Z_1 = -4Z_2$$
$$\frac{1}{j\omega_c C} = -4j\omega_c L$$
-ve cancelled.
$$4\omega_c^2 CL = 1.$$
$$(2\pi f_c)^2 = \frac{1}{4LC} \Rightarrow \boxed{f_c = \frac{1}{4\pi\sqrt{LC}}}$$
$$\frac{1}{\sqrt{LC}} = \frac{R_k}{L} \Rightarrow \therefore f_c = \frac{R_k}{4\pi L} \Rightarrow \boxed{L = \frac{R_k}{4\pi f_c}.}$$
$$\sqrt{LC} = R_kC \Rightarrow f_c = \frac{1}{4\pi R_k C} \Rightarrow \boxed{C = \frac{1}{4\pi f_c R_k}.}$$

(Ladder network → ဝင်း stageများ ဆက်ထားသွားရှိ၍ ဆက်ထားရှိသော စစ်ဆေးကြည့်ပါက π နှင့် T section အလယ်ဖြတ်ထားနိုင်၏



Z_0 ၏ formula →

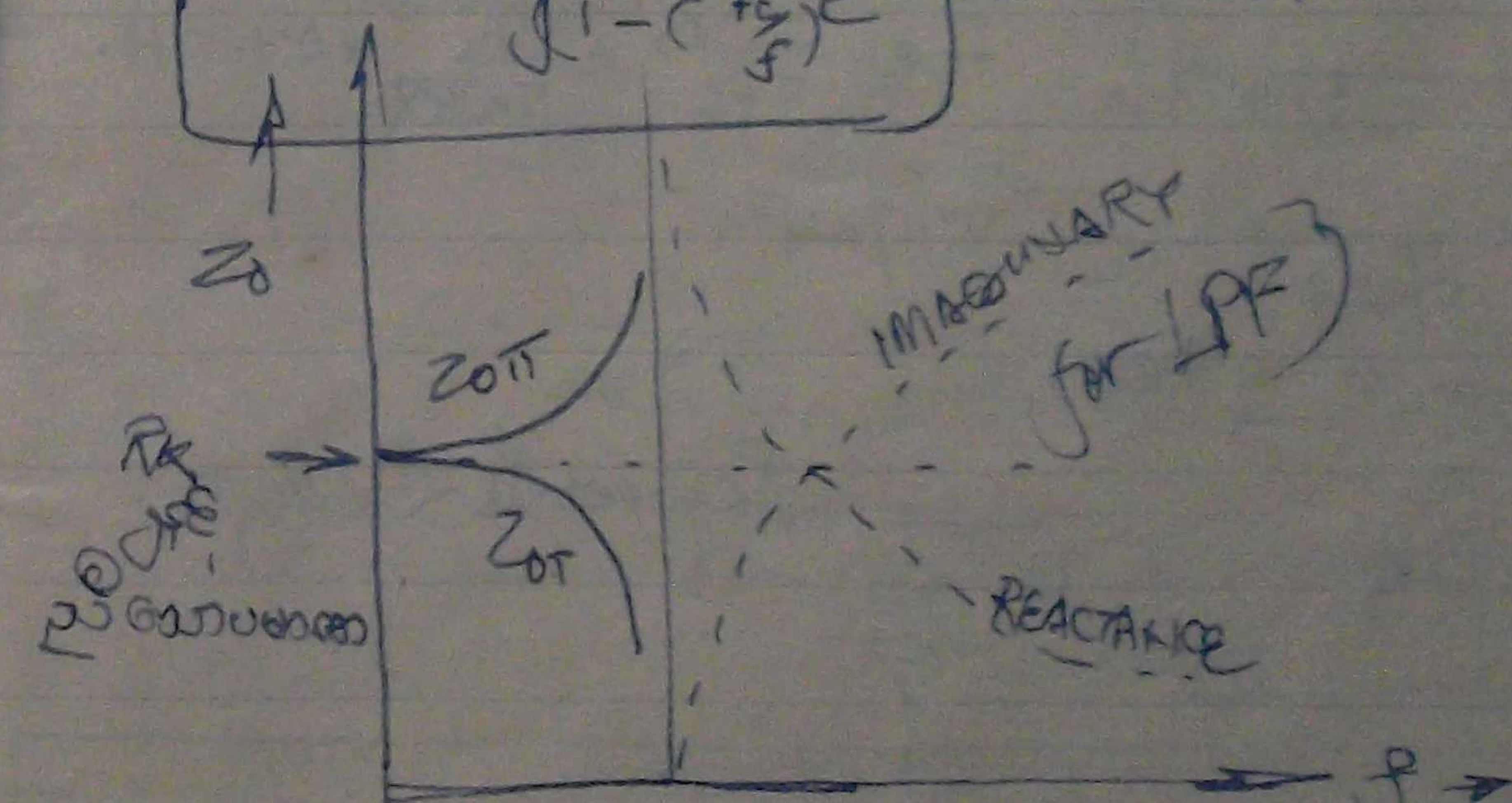
$\boxed{Z_{0T} = R_k\sqrt{1-\left(\frac{f_c}{f}\right)^2}}$ ← T - section

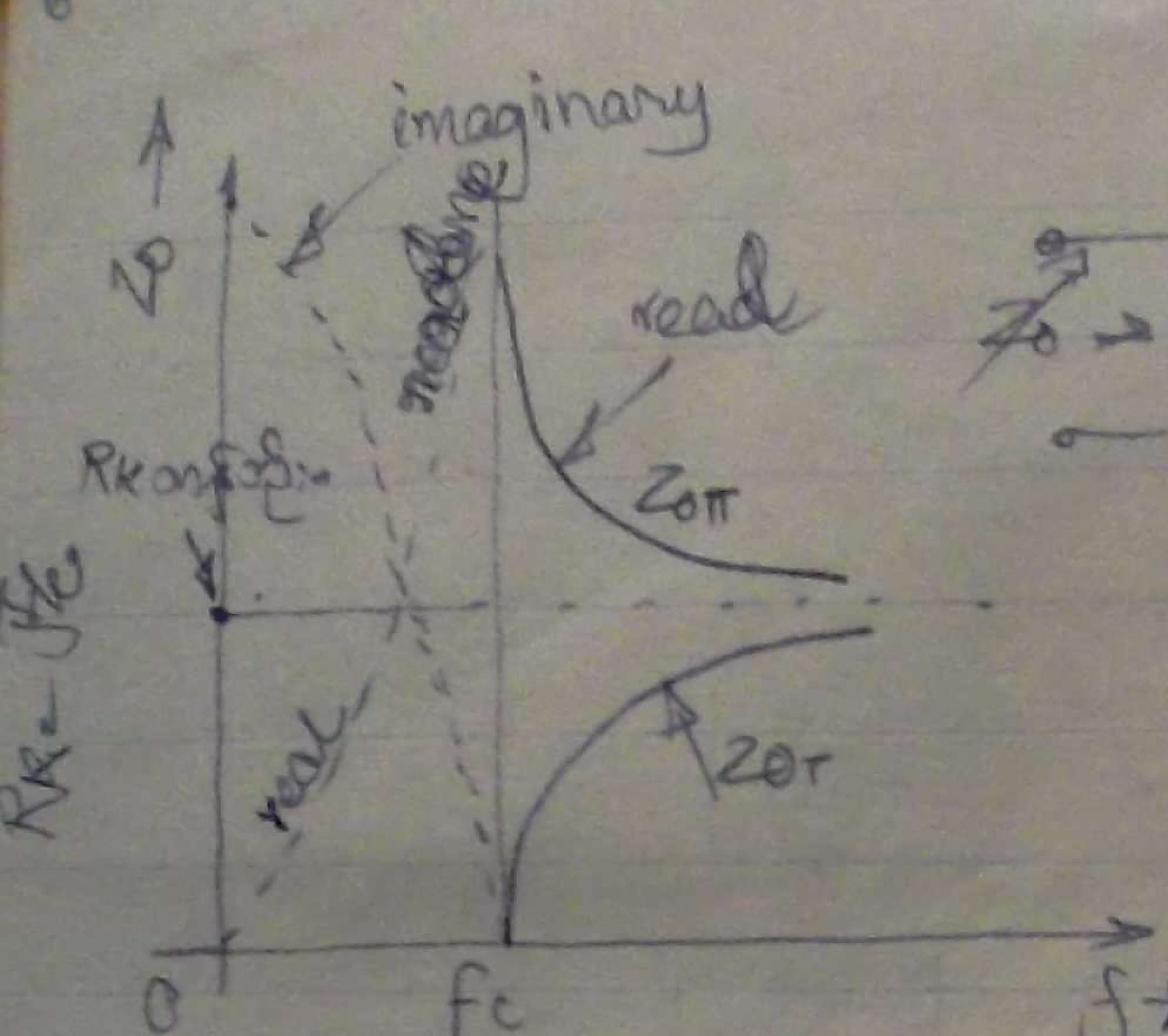
$\boxed{Z_{0\pi} = \frac{R_k}{\sqrt{1-\left(\frac{f_c}{f}\right)^2}}}$ π Section

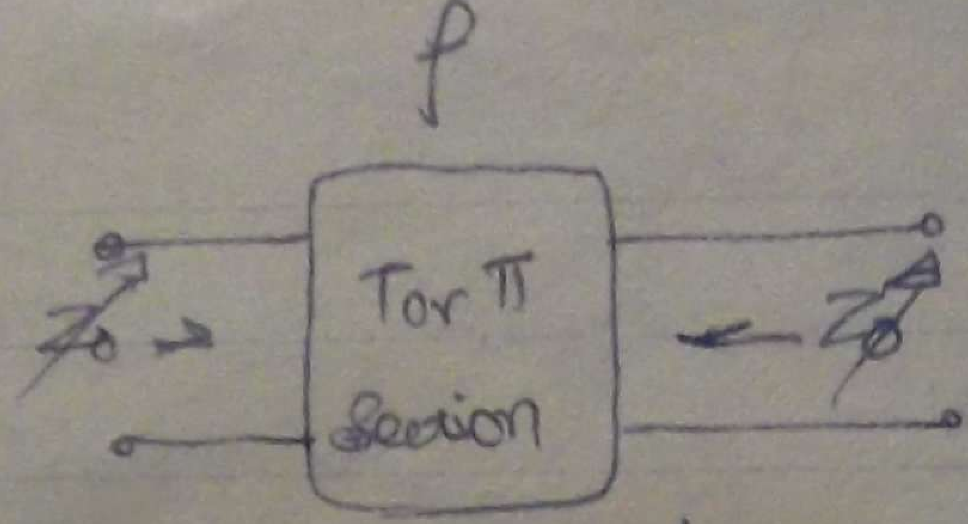
freq. ရှိ Z_0 များ၏ graph ကိုပြသော် ပြောင်းလဲပုံ

↓

HPF အတွက် ဖော်ပြပါ graph ကိုရရှိပါ၏







real → Ω

[illegible] reactance (j)

fc [illegible]

Z_0 [illegible] imaginary

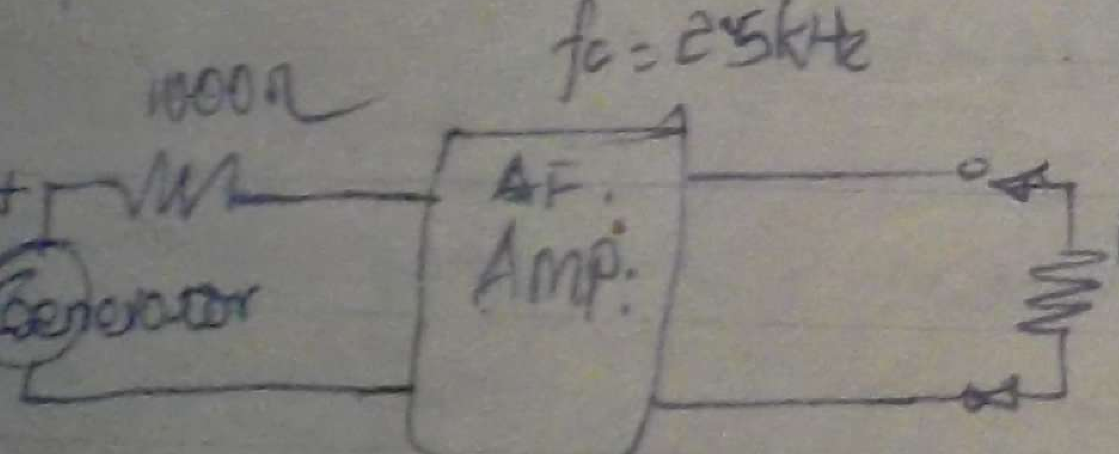
[illegible] eg. j2, j3 Ω.

fc [illegible] real value [illegible] → eg. 2, 3, 4, 10Ω.

fc [illegible] Z_0 [illegible] matching [illegible] Rk [illegible]

*R_K = 600Ω [illegible] generator [illegible]

Eg 1: Plate load resistance 1000Ω [illegible] AF amp. [illegible] low pass filter [illegible] fc = 2500Hz [illegible] prototype filter T section [illegible] design [illegible]

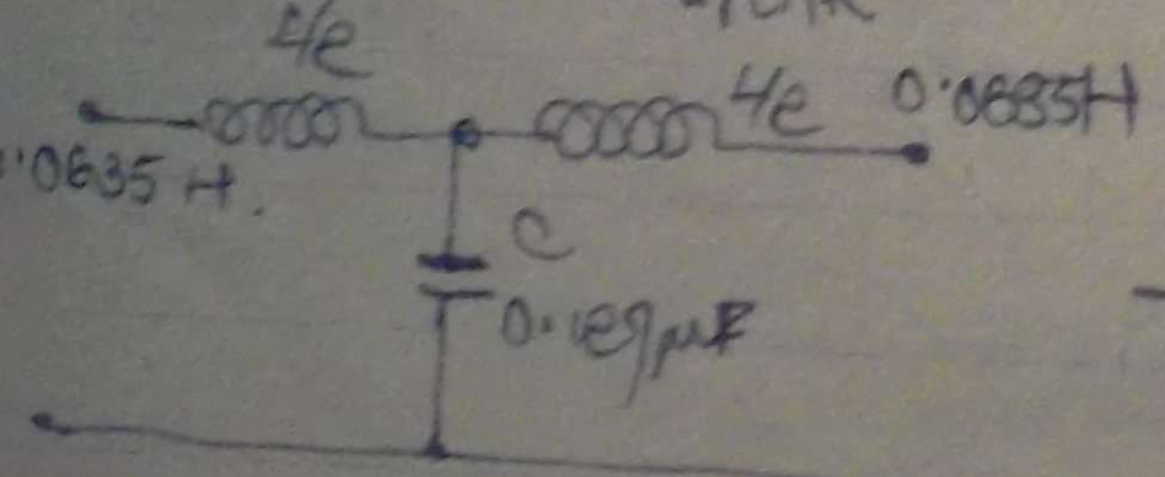


∴ $R_K = 1000\,\Omega$.

$f_c = 2500\,Hz$.

$$L = \frac{R_K}{\pi f_c} = \frac{1000}{\pi \times 2500} = 0.127H.$$

$$C = \frac{1}{\pi f_c R_K} = \text{———} \ 0.127\mu F$$



← Requested Design:

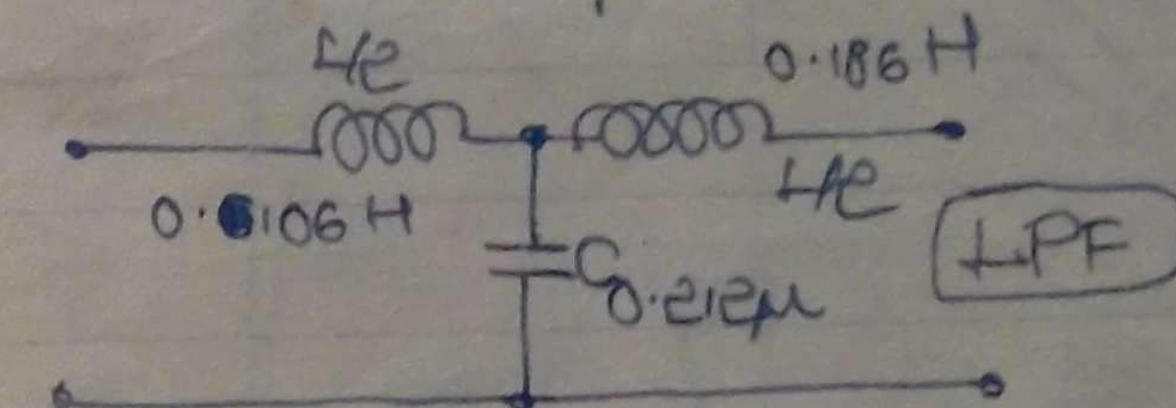
L.P

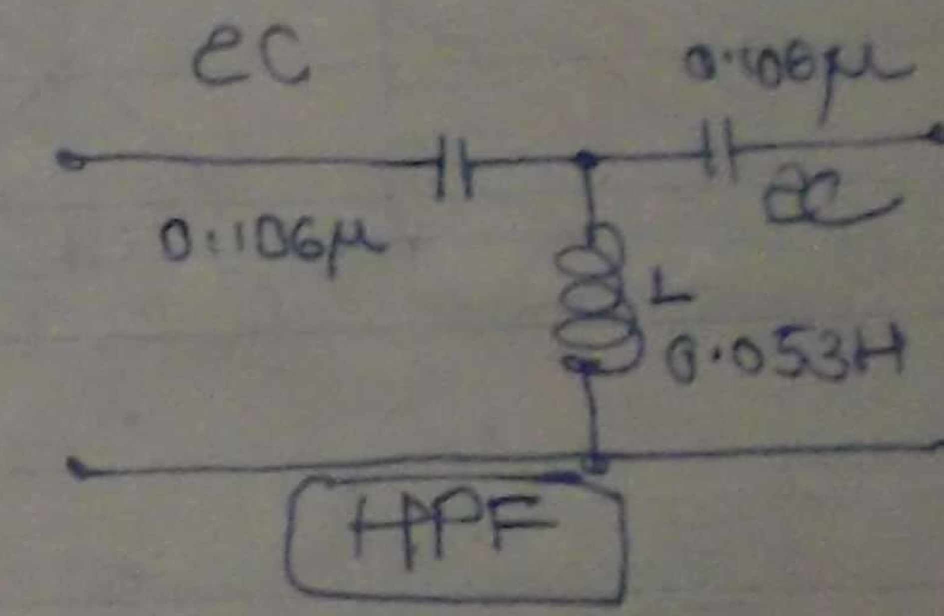
Eg 2: $R_K = 1000\Omega$, $f_c = 1500Hz$ [illegible] prototype filter [illegible] HPF [illegible]

Low Pass Filter [illegible]

$$L = \frac{R_K}{\pi f_c} = \frac{1000}{1500\pi} = 0.2123H.$$

$$C = \frac{1}{\pi f_c R_K} = \frac{10^6}{\pi \times 1000 \times 1500} = 0.2123\mu F$$





High Pass filter [illegible]

$$L = \frac{R_K}{4\pi f_c} = 0.053H.$$

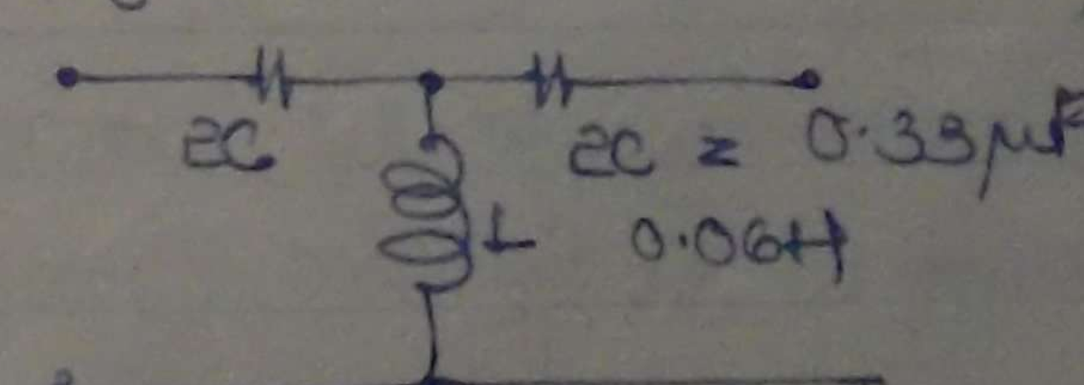
$$C = \frac{1}{4\pi f_c R_K} = 0.053\mu F$$

∴ $2C = 0.106\mu$

Eg 3 $R_K = 600\Omega$, $f_c = 796Hz$ [illegible] HPF prototype [illegible] design [illegible]

$$L = \frac{R_K}{4\pi f_c} = \frac{600}{4\pi \times 796} = 0.06H.$$

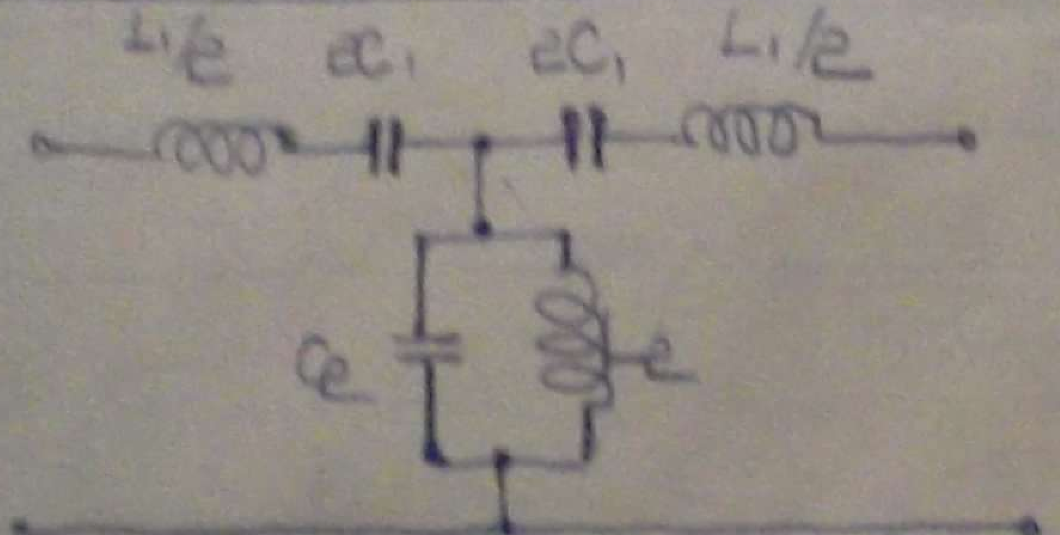
$$C = \frac{1}{4\pi f_c R_K} = \frac{10^6}{10^4 \times 600} = 0.1667\mu F \rightarrow 2C = 0.333\mu F$$



Ans:

(Band pass filter)

BAND PASS FILTER



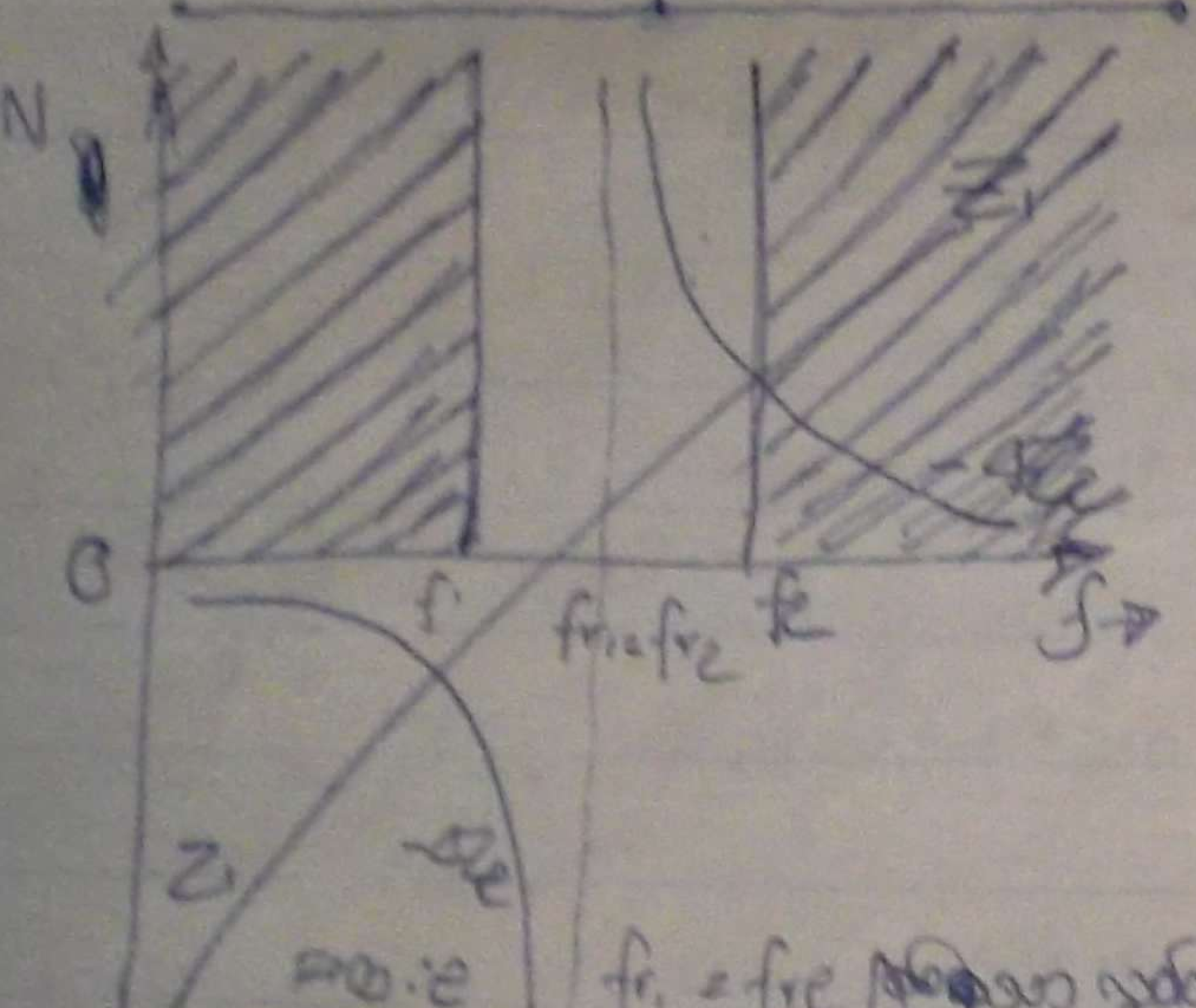


Fig: 2

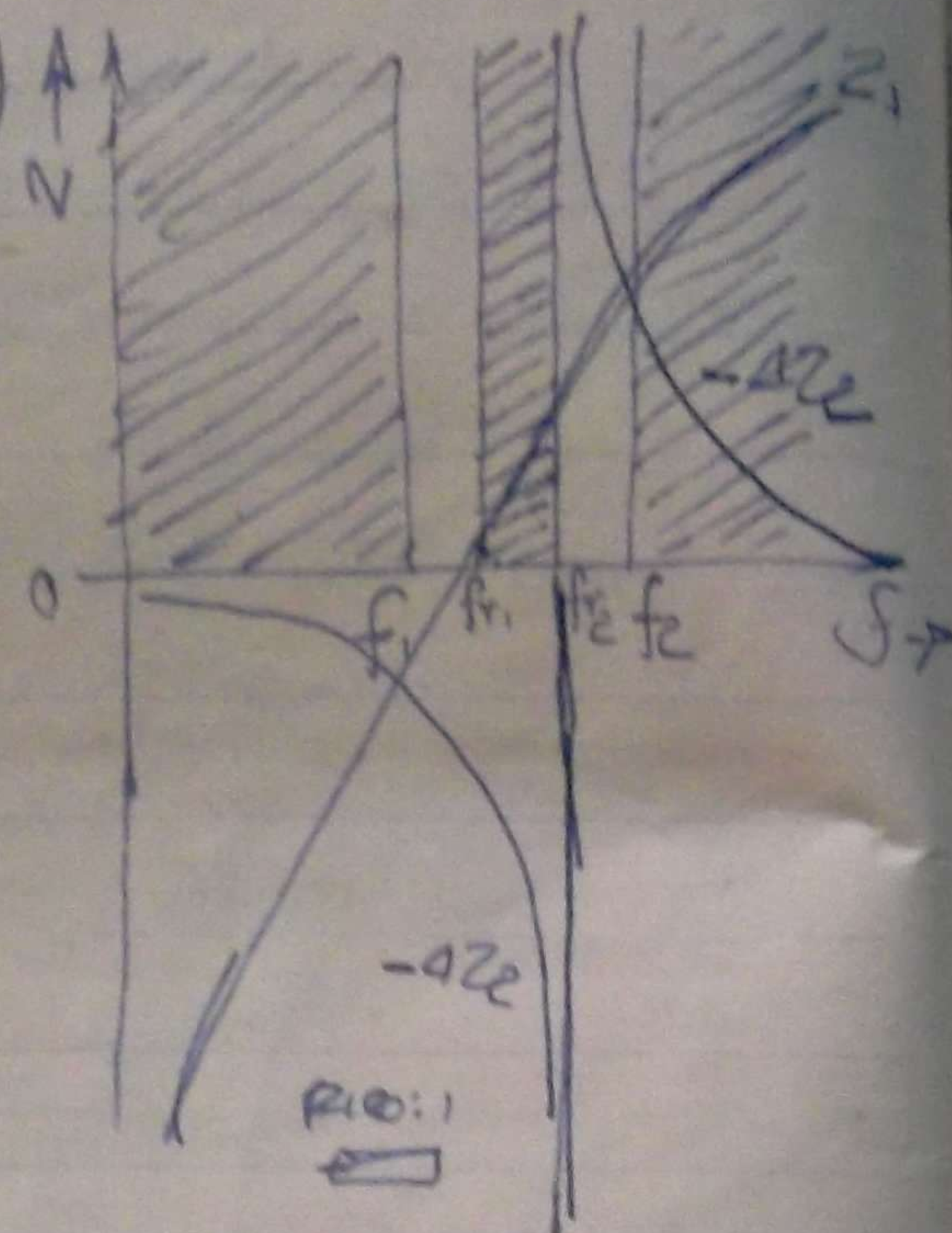


Fig: 1

$f_{r1} \neq f_{r2}$ ဖြစ်လျှင် attenuation band ပေါ်လာမည်။

$f_{r1} = f_{r2}$ ဖြစ်သော ပုံတွင် pass band ဖြစ်သည်။

6.7.83 → 21.7.83

သတ်မှတ်ထားသော frequency band အတွင်းရှိ signal များကို pass လုပ်ပြီး၊ ၎င်း band ၏ ပြင်ပတွင်ရှိသော signal အားလုံးကို attenuate လုပ်သော filter ကို ခေါ်သည်။ ၎င်းကို low pass နှင့် high pass တို့ကို ပေါင်းစပ်ထားခြင်းဖြင့် ရရှိနိုင်သည်။ Series arm နှင့် shunt arm တို့တွင် capacitor နှင့် inductor တို့ ပါဝင်ကြသဖြင့် series resonance နှင့် parallel resonance တို့ ရှိကြသည်။

ပုံ (၁) တွင် series resonance နှင့် parallel resonance ရှိသော ... f_{r1} နှင့် f_{r2} ကြားတွင်ရှိသော frequency များကို

stop လုပ်ထားပေမည်။ pass band f_1 မှ f_2 အတွင်းရှိ frequency အားလုံးကို pass လုပ်ပေးခြင်း ရှိပေသည်။ ပုံ (၁) တွင် f_{r1} နှင့် f_{r2} တူညီ ... f_1 နှင့် f_2 ကြားရှိ signal အားလုံးကို pass လုပ်ပေးသည်။ f_1 ကို <u>lower cutoff fr</u>, f_2 ကို <u>upper cutoff frequency</u> ဟု ခေါ်သည်။

Series arm resonant frequency တွင် =

$$\boxed{f_{r1} = \frac{1}{2\pi\sqrt{L_1 C_1}}}$$

Shunt arm resonant frequency တွင်

$$f_{r2} = \frac{1}{2\pi\sqrt{L_2 C_2}}$$

But $f_{r1} = f_{r2} \Rightarrow \boxed{L_1 C_1 = L_2 C_2}$

$$Z_1 = j\omega L_1 + \frac{1}{j\omega C_1} \quad (C_1 \text{ and } L_1 \text{ are series})$$

$$Z_2 = \frac{j\omega L_2 \times \frac{1}{j\omega C_2}}{j\omega L_2 + \frac{1}{j\omega C_2}} \quad (C_2 \text{ and } L_2 \text{ are parallel})$$

$$Z_1 \times Z_2 = \frac{L_2}{C_1} = \frac{L_1}{C_2} = R_K^2$$

$$\therefore \boxed{R_K = \sqrt{\frac{L_2}{C_1}} = \sqrt{\frac{L_1}{C_2}}}$$

{COP}

$$\frac{f_0}{f_1} = \frac{f_2}{f_0}$$

$f_{r1} = f_{r2} = f_0$ ဆိုပါက $\boxed{f_0 = \sqrt{f_1 \cdot f_2}}$ (တူညီသော frsonant.)

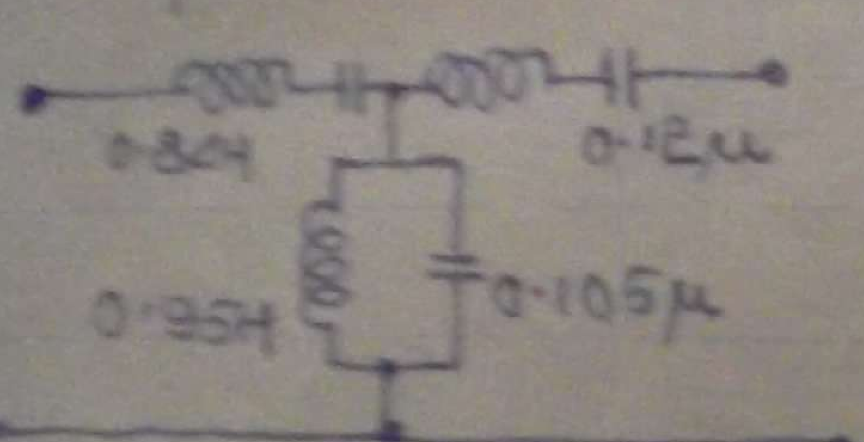
(formula derivation များ မေးမည်)

$$\boxed{C_1 = \frac{f_2 - f_1}{4\pi f_1 f_2 R_K}} \qquad \boxed{L_1 = \frac{R_K}{\pi (f_2 - f_1)}}$$

$$\boxed{L_2 = \frac{R_K(f_2-f_1)}{4\pi f_1 f_2}} \quad \boxed{C_2 = \frac{1}{\pi R_K(f_2-f_1)}}$$

Eg 4. 250 Hz [illegible] 2000 Hz [illegible] frequency [illegible] transmit [illegible] band pass filter [illegible] ($R_K = 4k\Omega$)

$f_1 = 1250\,Hz$, $f_2 = 2000\,Hz$, $R_K = 4k\Omega$



$$L_2 = \frac{R_K(f_2-f_1)}{4\pi f_1 f_2} = \frac{4000 \times 750}{4\pi \times 1250 \times 2000} = 0.095H.$$

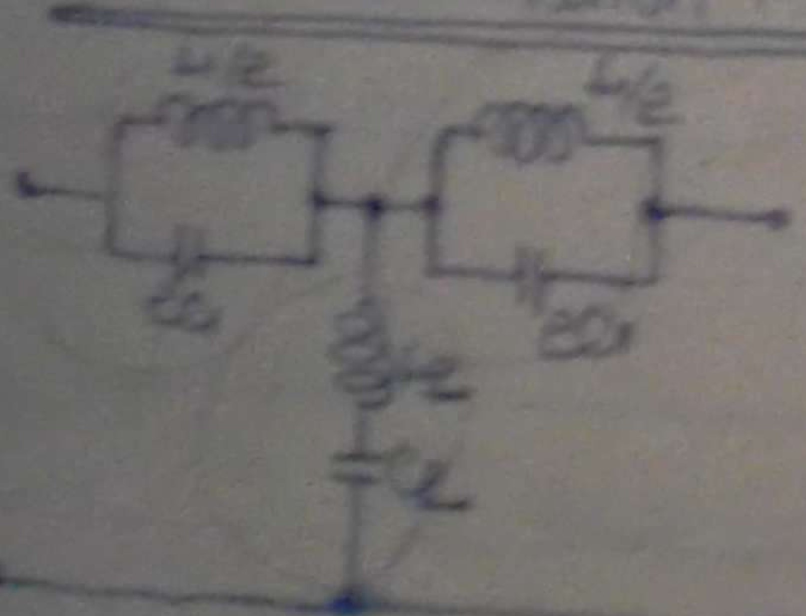
$\boxed{R_K^2 = \frac{L_2}{C_1}}$

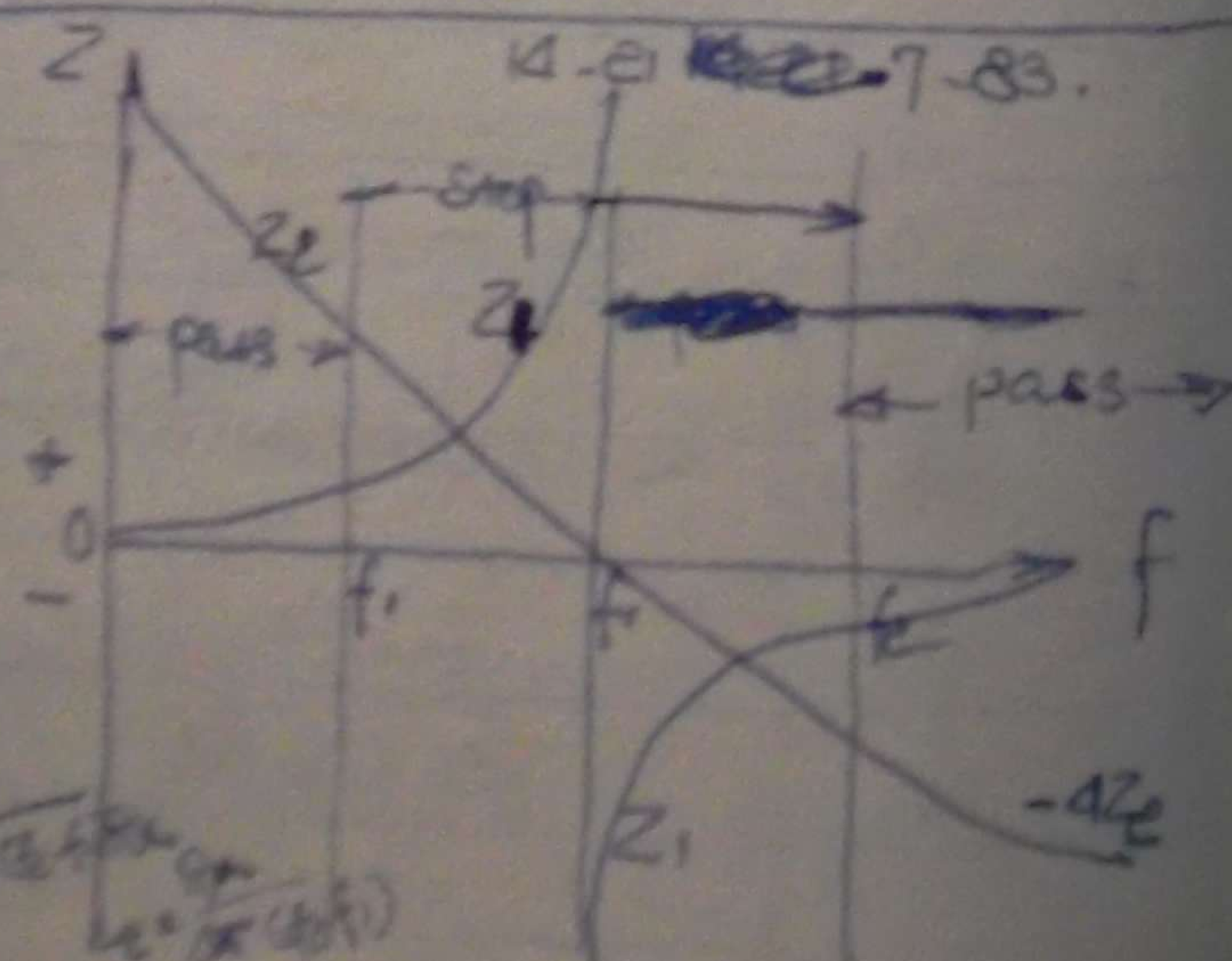
$$\therefore C_1 = \frac{L_2}{R_K^2} = \frac{0.095 \times 10^6}{(4K)^2} = 0.06\mu f$$

$$L_1 = \frac{R_K}{\pi[f_2-f_1]} = \frac{4000}{750\pi} = 1.68H$$

$$\therefore C_2 = \frac{L_1}{R_K^2} = \frac{1.68 \times 10^6}{(4K)^2} = 0.105\mu f$$

4. Band Elimination Filter





$L_1 = \frac{R_K(f_2-f_1)}{\pi f_1 f_2}$ $C_1 = \frac{1}{4\pi R_K(f_2-f_1)}$ $L_2 = \frac{R_K}{4\pi(f_2-f_1)}$

$$L_1 \text{ BPF} = \boxed{L_1 = \frac{R_K(f_2-f_1)}{\pi f_1 f_2}} \quad C_1 \text{ BPF} \rightarrow \boxed{C_1 = \frac{1}{4\pi R_K(f_2-f_1)}}$$

$$\boxed{L_2 = \frac{R_K}{4\pi(f_2-f_1)}} \quad \boxed{C_2 = \frac{f_2-f_1}{\pi R_K f_1 f_2}}$$

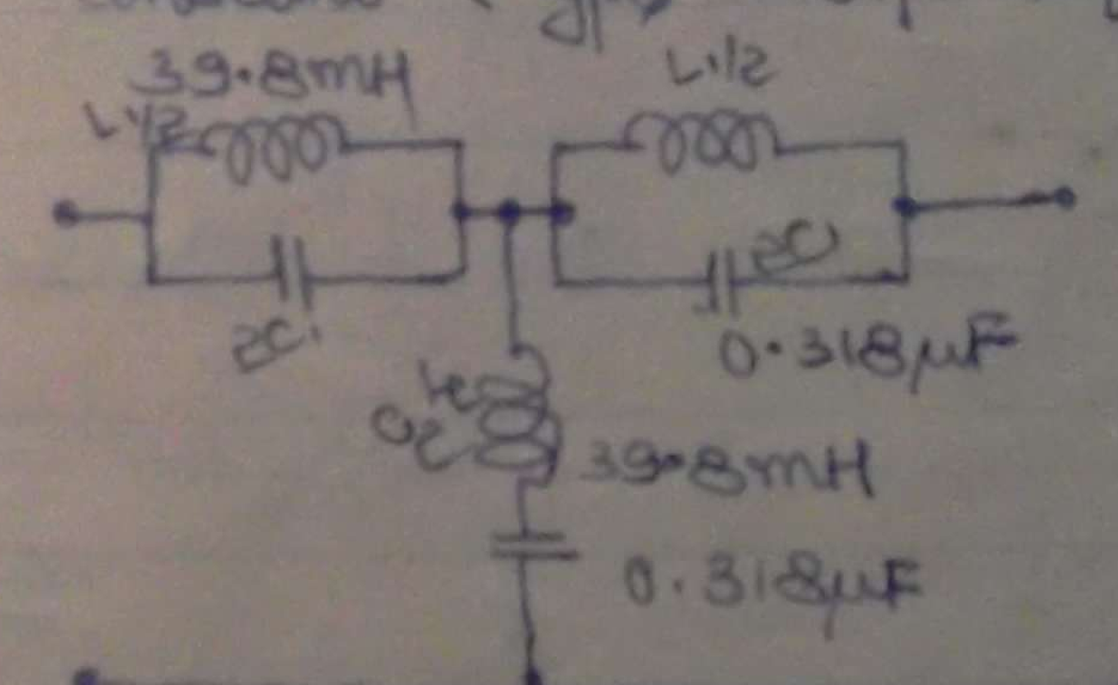
$$\boxed{f_r = \sqrt{f_1 f_2}} \quad \boxed{R_K^2 = \frac{L_2}{C_1} = \frac{L_1}{C_2}}$$

Band elimination filter [illegible] series arm [illegible] shunt arm [illegible] f_r [illegible] f_1 [illegible] f_2 [illegible] lower & upper cut-off freq [illegible] f_1 [illegible] f_2 [illegible] signal [illegible] attenuate [illegible] freq-band [illegible] signal [illegible] pass [illegible]

BEF [illegible] BPS [illegible] shunt arm [illegible] series arm [illegible] inter change [illegible] low pass filter [illegible] high pass filter [illegible] parallel [illegible] low pass filter [illegible] cut-off frequency [illegible] HPF [illegible] c/o [illegible]

I know well.

Eg 5. Lower c/o freq 1kHz [illegible] upper c/o freq 2kHz [illegible] constant k type b.e.f. [illegible] ($R_K = 500\Omega$)



$f_1 = 1kHz$, $f_2 = 2kHz$.

$$L_1 = \frac{R_K(f_2-f_1)}{\pi f_1 f_2} = \frac{500 \times 1000}{\pi \times 10^3 \times 2 \times 10^3} = 79.6mH.$$

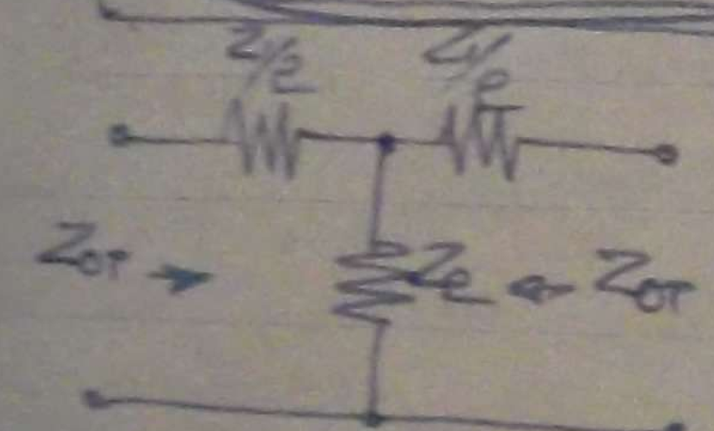
$C_2 = \frac{L_1}{R_k^2} = \frac{79.6\times10^{-3}\times10^{6}}{500^2} = 0.3184\,\mu F$

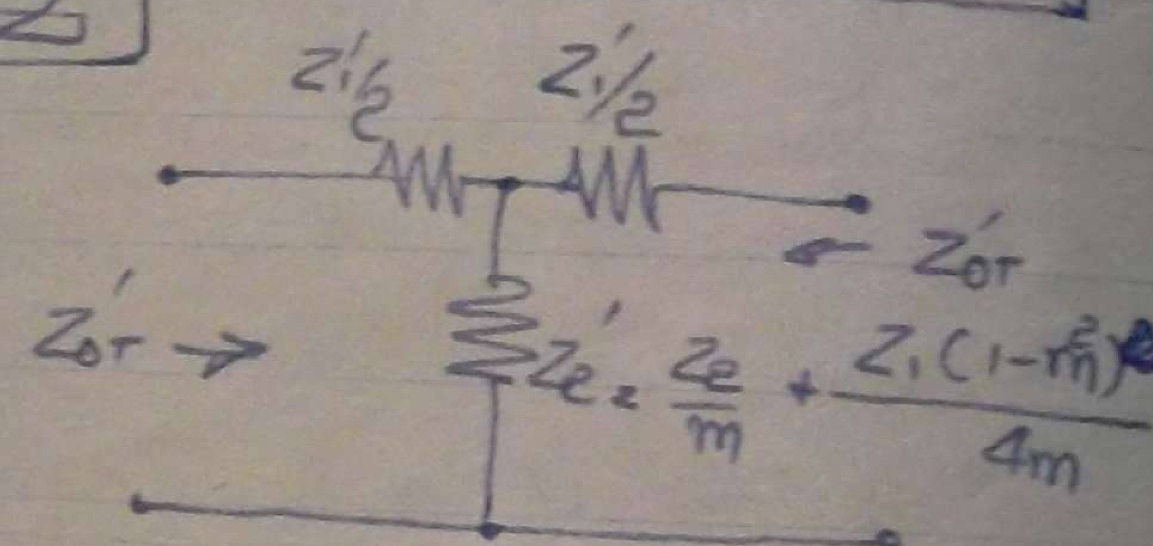
$L_2 = \frac{R_k}{4\pi(f_2-f_1)} = \frac{500}{4\times10^{3}\pi} = 39.8\,mH$

$C_1 = \frac{L_2}{R_k^2} = \frac{39.8\times10^{-3}}{500^2} = 0.159\,\mu F$

'm' derived section

13-21.7.83.





$Z_2' = \frac{Z_2}{m} + \frac{Z_1(1-m^2)}{4m}$

$Z_1Z_2 = R_k^2$

$Z_1' = mZ_1,\quad Z_0 = Z_0'$

$Z_{0T} = Z'_{0T}$

$(0 < m < 1)$

$\sqrt{Z_1Z_2 + \frac{Z_1^2}{4}} = \sqrt{Z_1'Z_2' + \frac{Z_1'^2}{4}}$

$Z_1Z_2 + \frac{Z_1^2}{4} = Z_1'Z_2' + \frac{Z_1'^2}{4}$

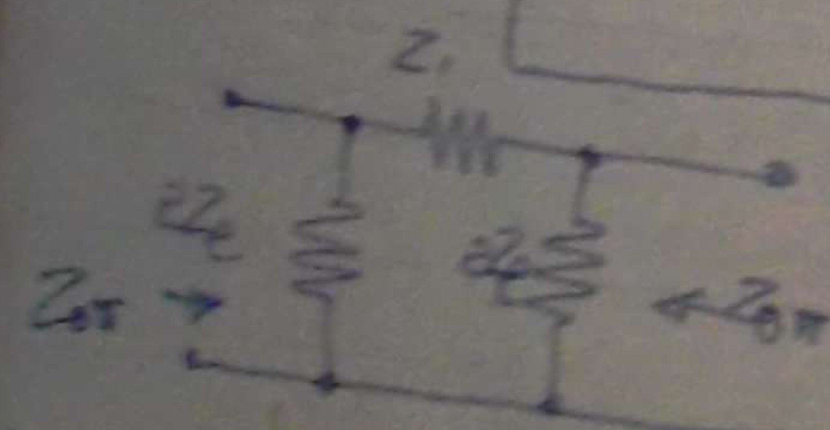
$Z_1Z_2 + \frac{Z_1^2}{4} = mZ_1Z_2' + \frac{(mZ_1)^2}{4}$

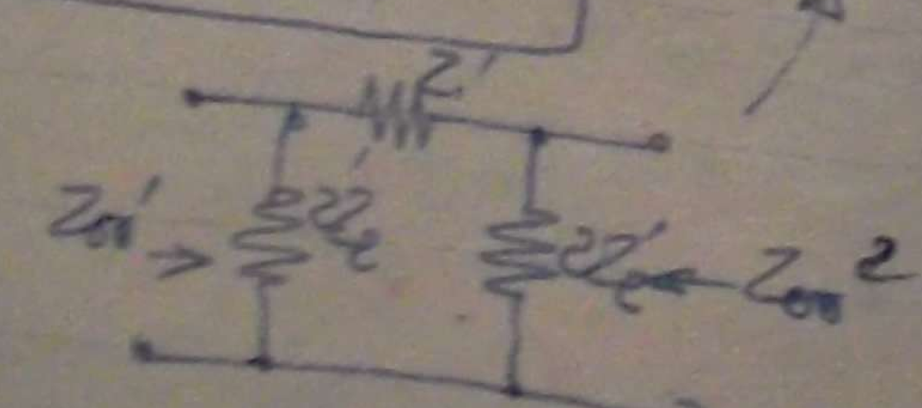
$mZ_1Z_2' = Z_1Z_2 + \frac{Z_1^2(1-m^2)}{4}$

$\therefore \boxed{Z_2' = \frac{Z_2}{m} + \frac{Z_1(1-m^2)}{4m}}$

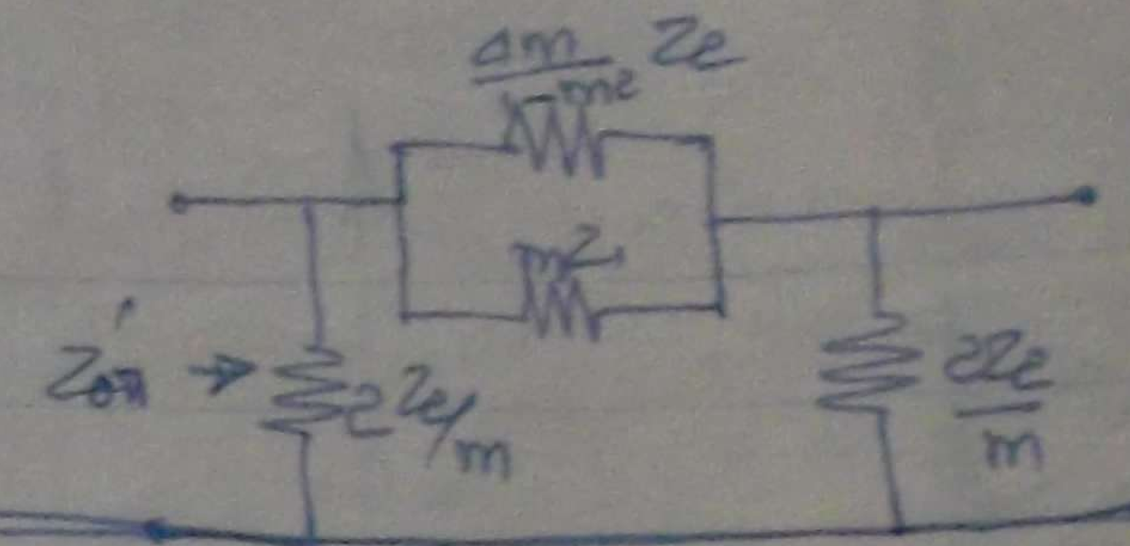
$Z_2' = \frac{Z_2}{m}$ $(0<m<1)$

$Z_{0\pi} \neq Z'_{0\pi}$

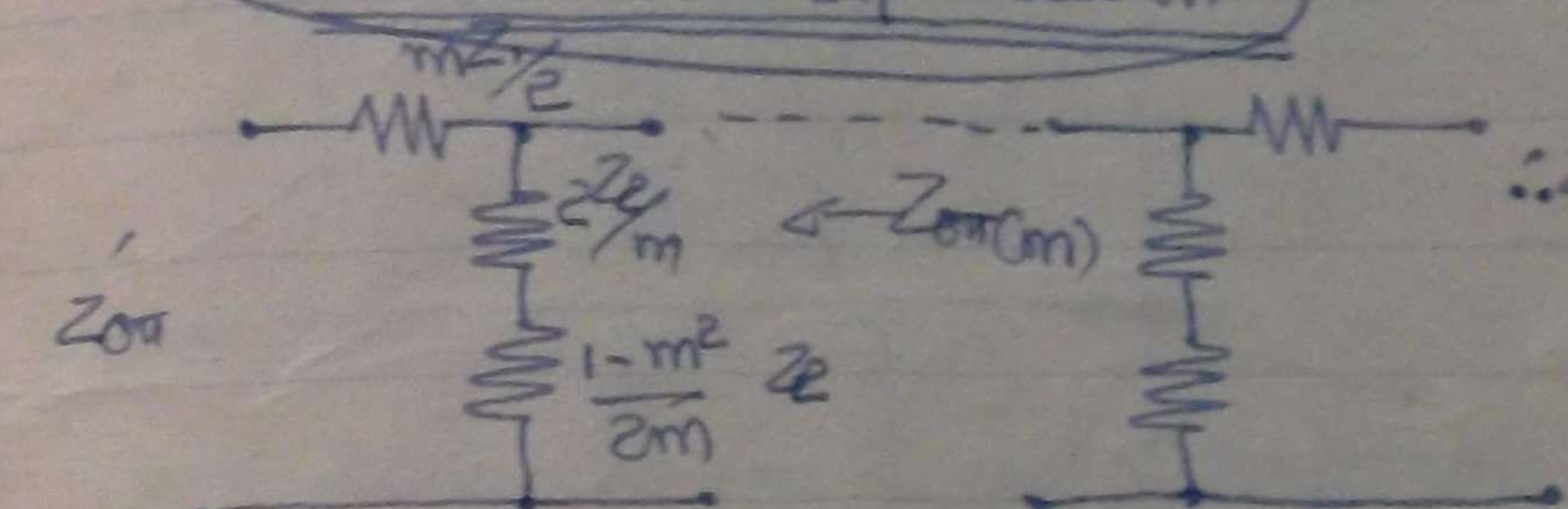




$Z_1' = \boxed{\frac{mZ_1 \times \frac{4m}{1-m^2}Z_2}{mZ_1 + \frac{4m}{1-m^2}Z_2}}$

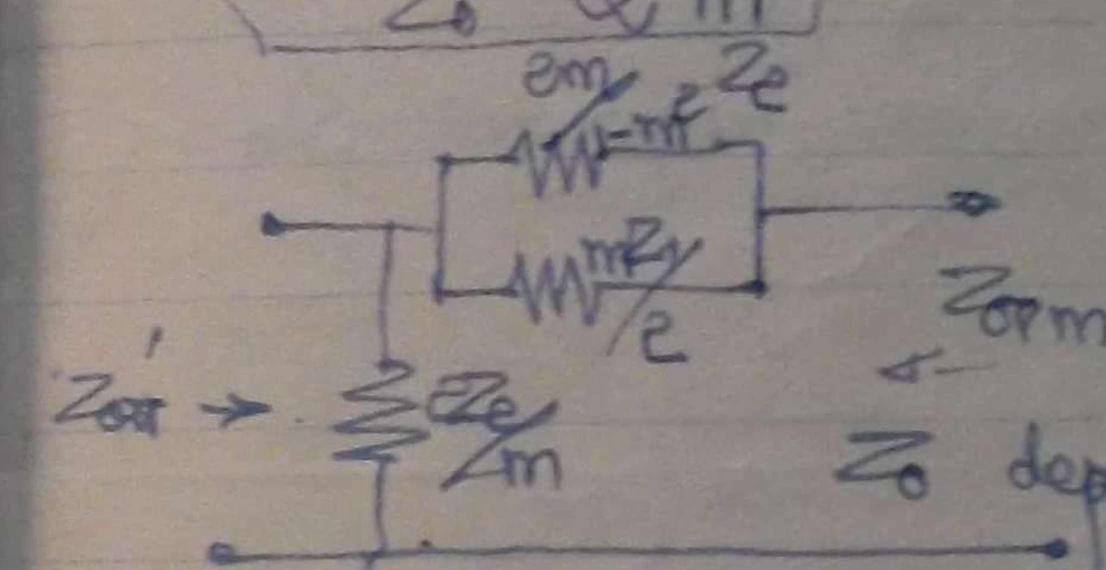


'm' derived half section



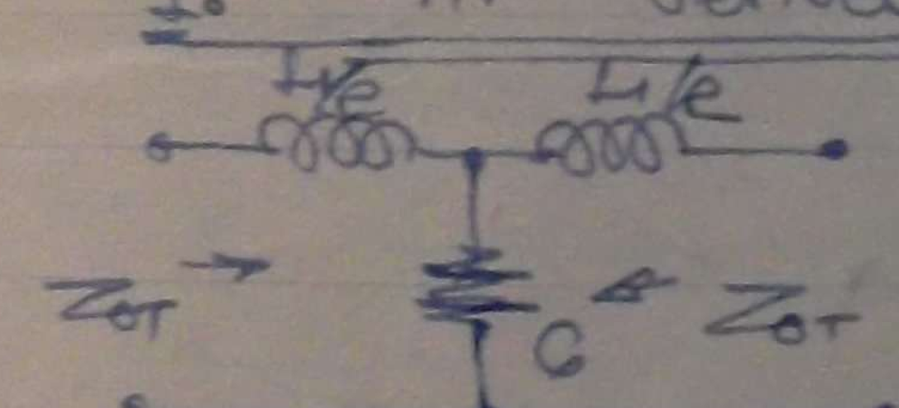
$\therefore Z_{0\pi}(m) = \left[1+(1-m^2)\frac{Z_1}{4Z_2}\right]$

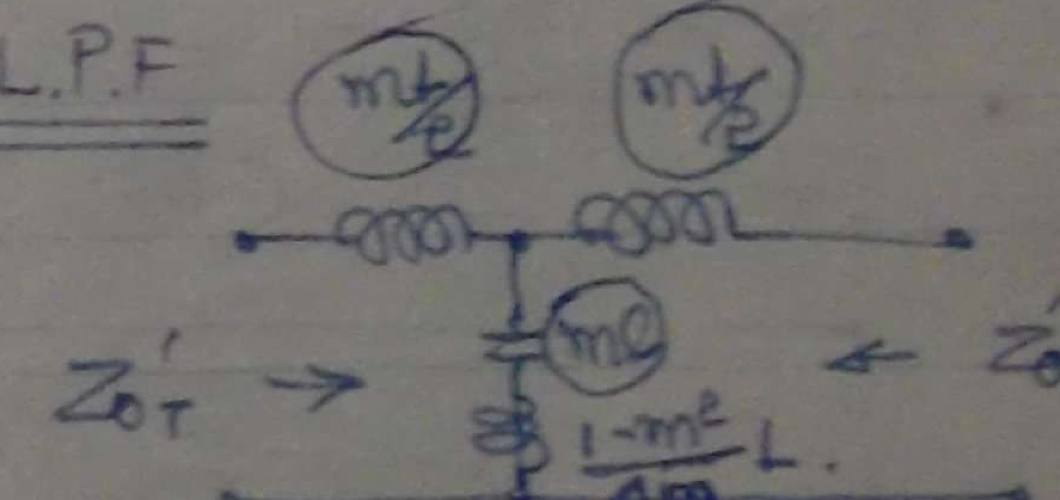
$Z_0 \propto m$



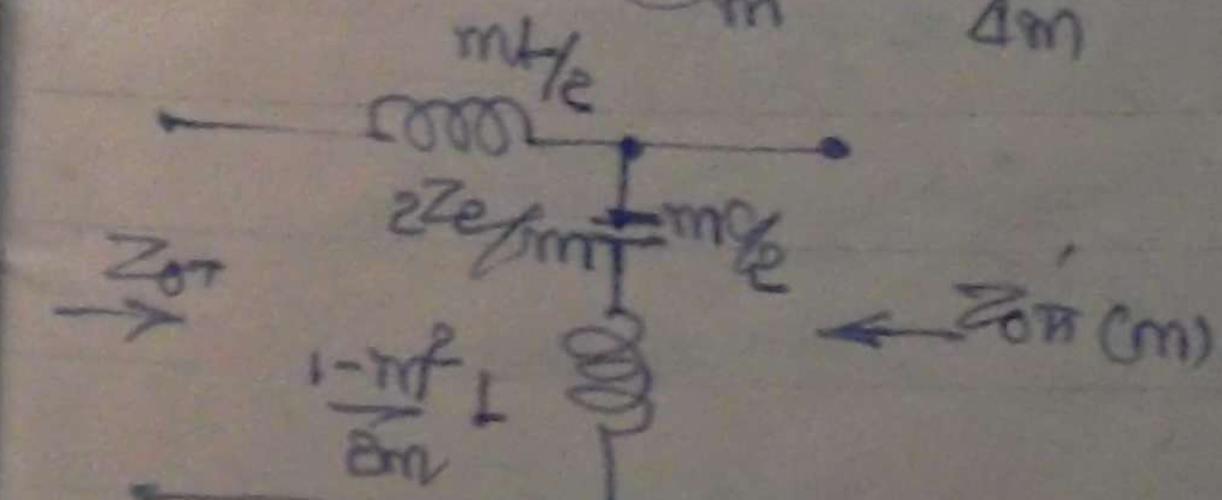
Z_0 depends on 'm'

1. 'm' derived L.P.F





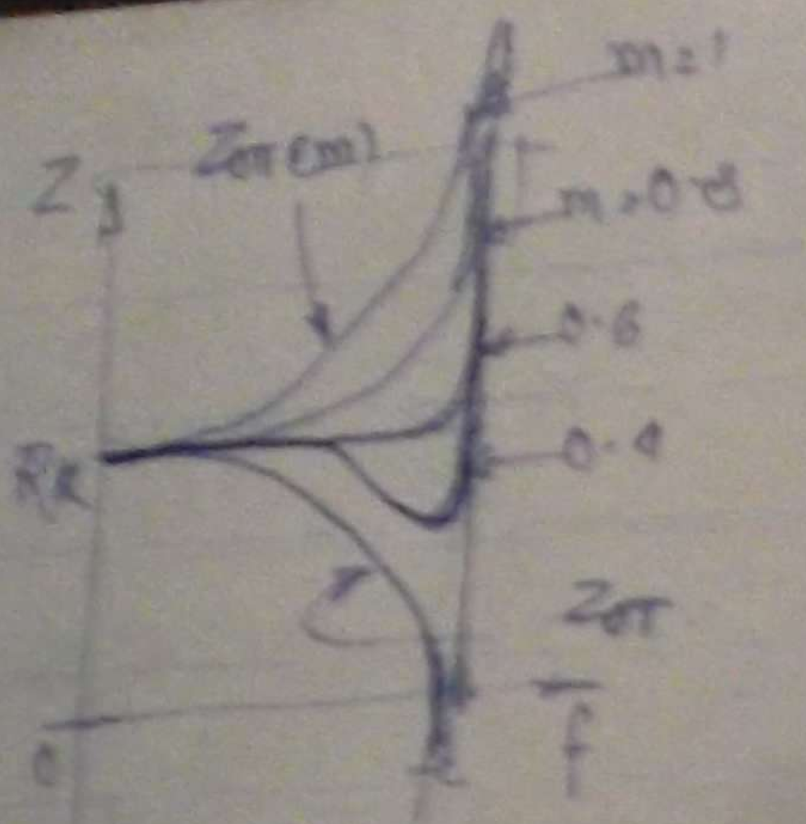
$Z_2' = \left(\frac{Z_2}{m} + \frac{1-m^2}{4m}Z_1\right)$ $\qquad Z_2 = \frac{1}{j\omega C}$

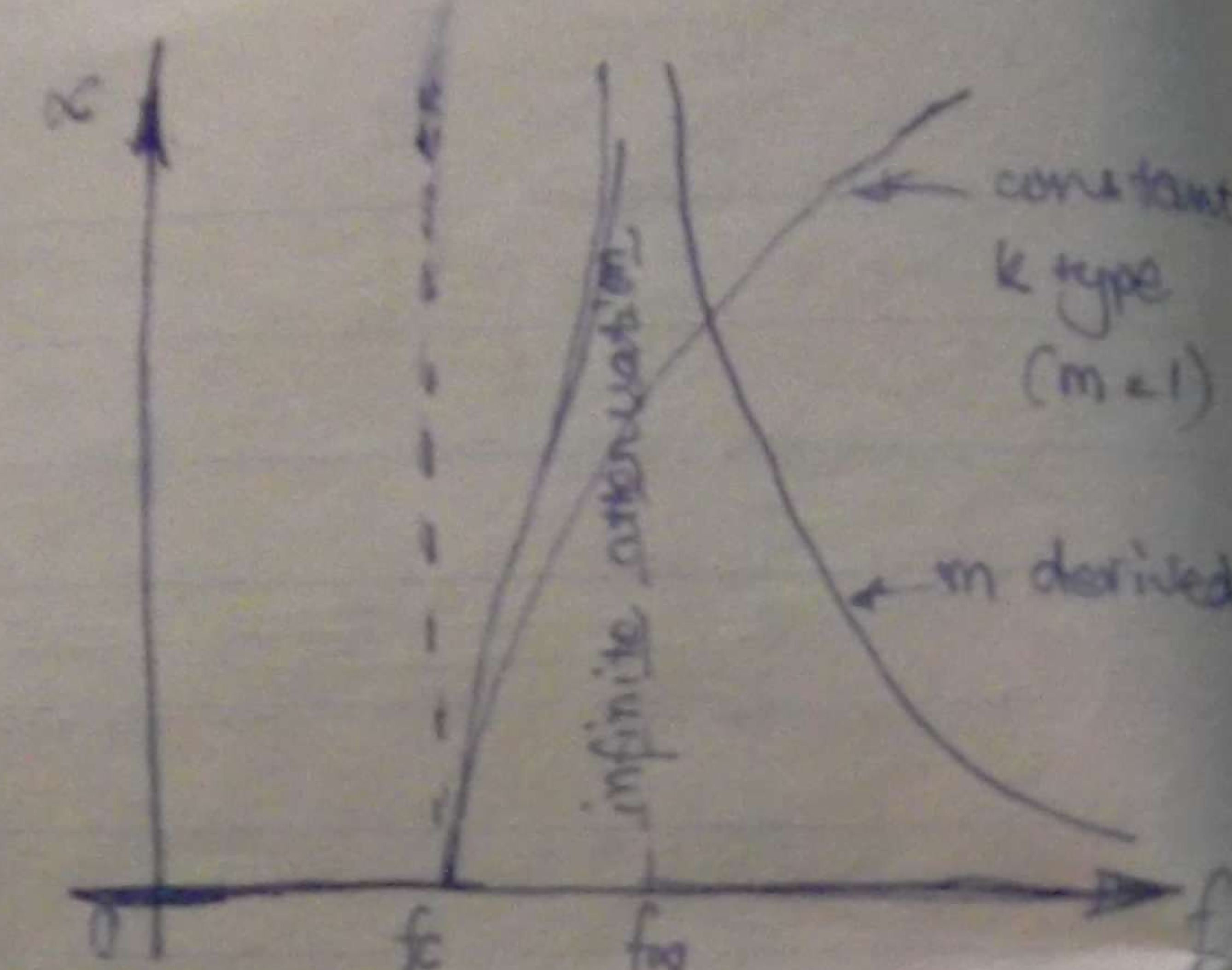


$Z_{0\pi}(m) = Z_{0\pi}$ $(m=1)$

$||^{ly}$ $Z_{0T}(m) = Z_{0T}$ $(m=1)$

Z_{0T} depends on 'm'.





f_∞ = infinite attenuation freq (or) high α freq, which is the resonance freq. of shunt arm.

(Hi-α freq ဆိုတာ shunt arm ရဲ့ resonant freq ဖြစ်ပါတယ် ။)

at $f_\infty \Rightarrow \frac{Z_2}{m} = \frac{1-m^2}{4m} \cdot Z_1$

$Z_1 = j\omega L,\ Z_2 = \frac{1}{j\omega C} \Rightarrow \frac{1}{m 2\pi f_\infty C} = \frac{1-m^2}{4m} \cdot 2\pi f_\infty L$

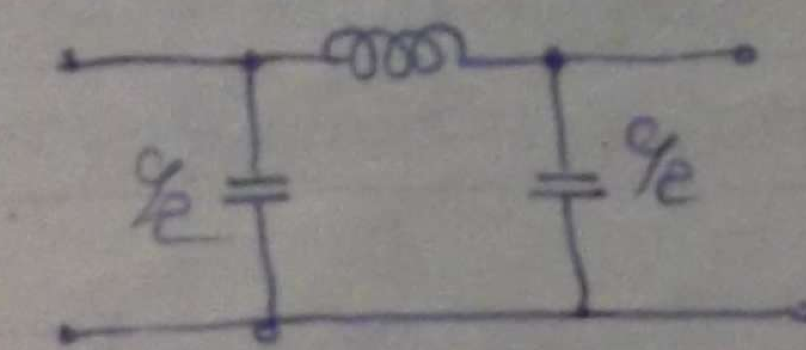
$1-m^2 = \frac{1}{\pi^2 f_\infty^2 LC}$

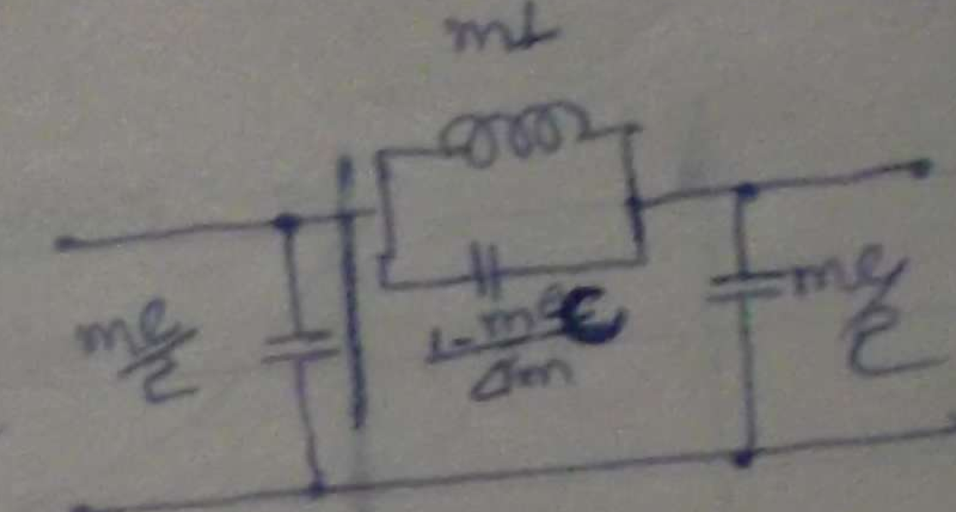
$1-m^2 = \frac{f_c^2}{f_\infty^2} \quad \left(f_c^2 = \frac{1}{\pi^2 LC}\right)$

$\therefore \boxed{m = \sqrt{1-\left(\frac{f_c}{f_\infty}\right)^2}}$

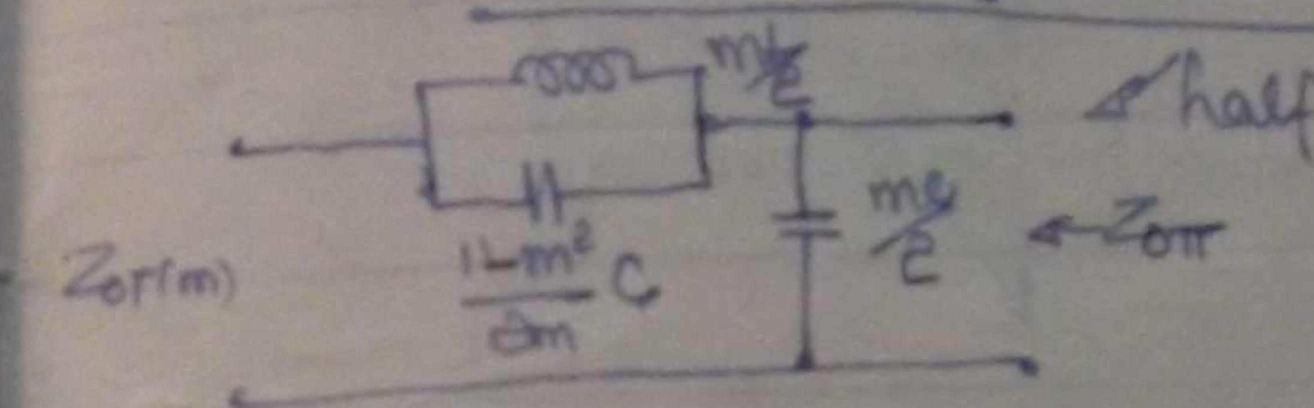
0745 BST

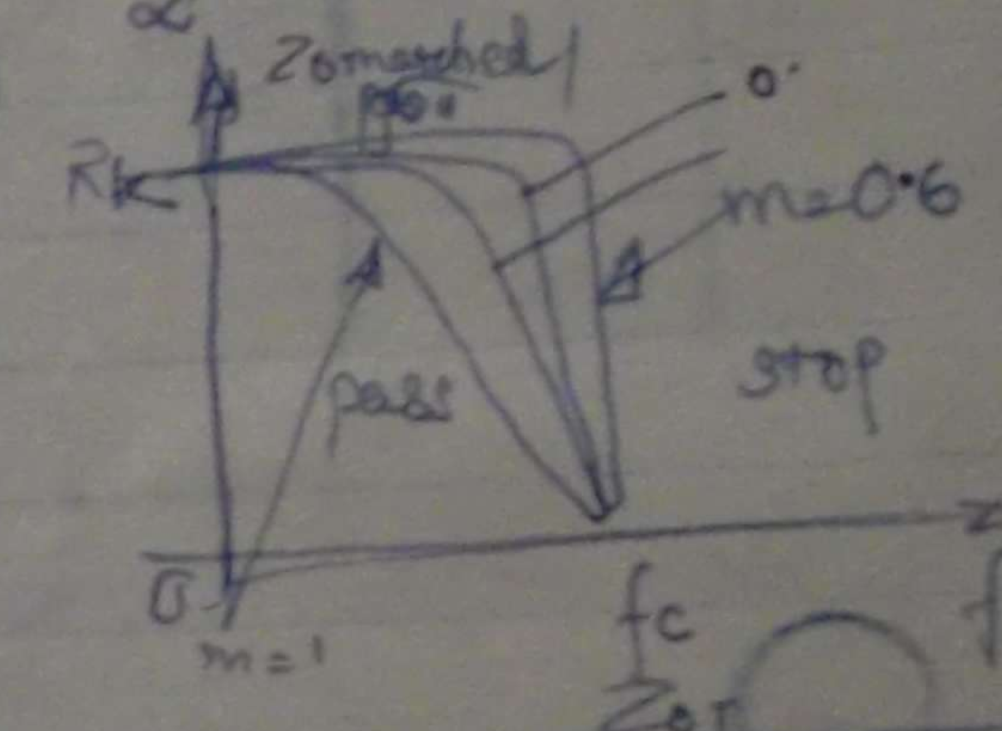
K-type π section





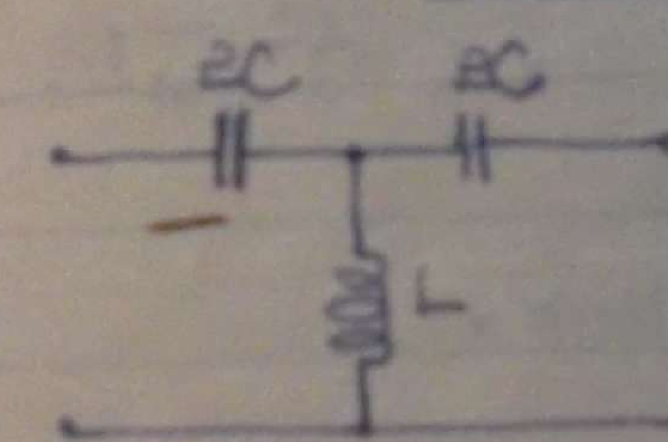
LPF 'm' derived π section

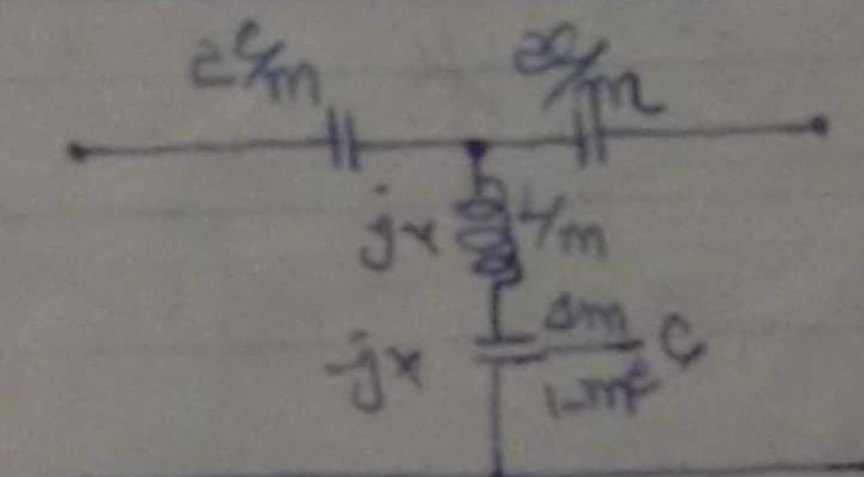


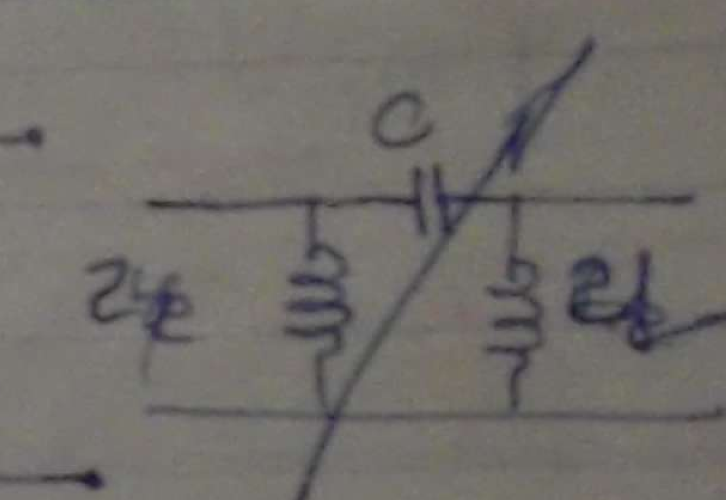


(π section ကို ½ section ဖြင့် ...ပါ ။)

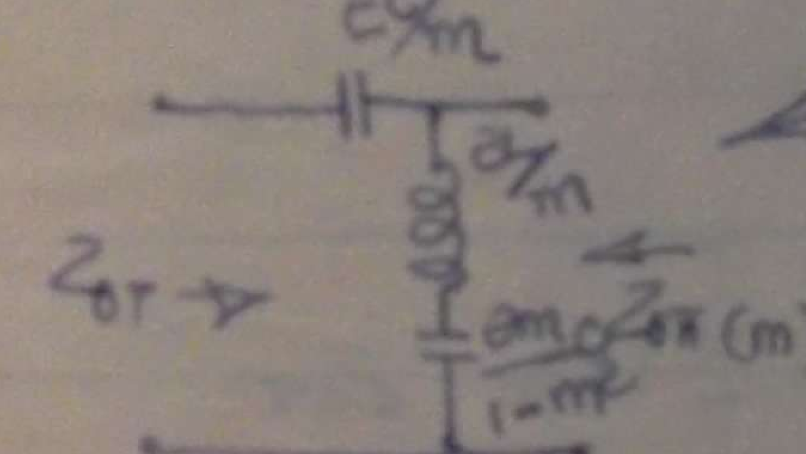
2. A. m derived High Pass Filter T-section

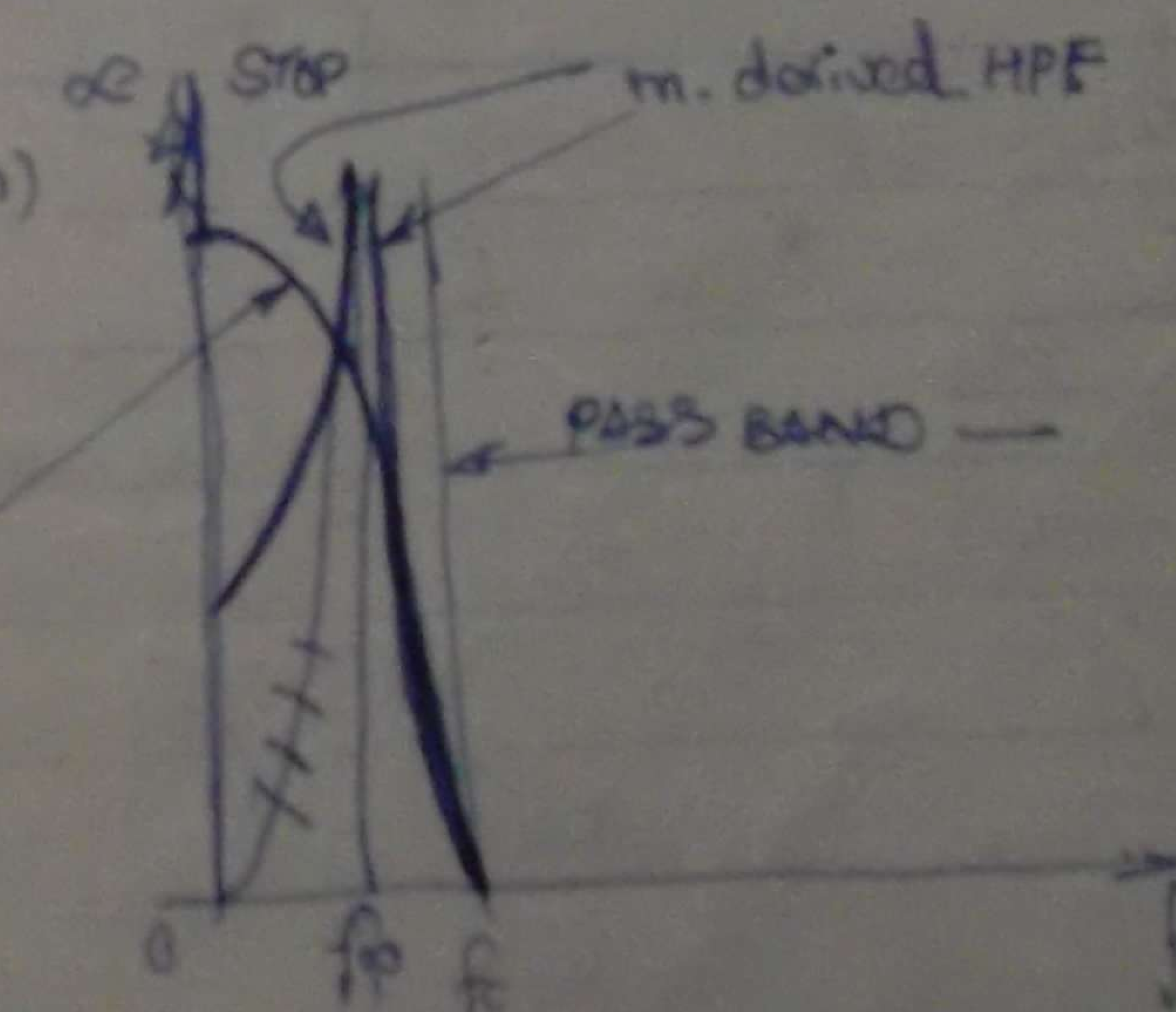




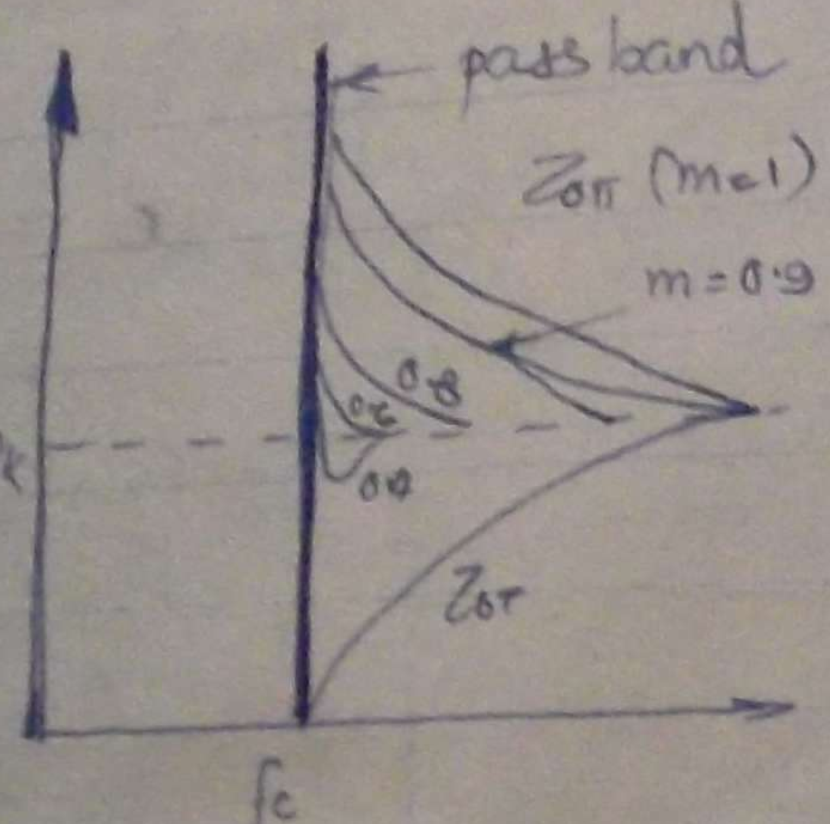


m ကိုထည့်ပြီး ပြုလုပ်သည်။

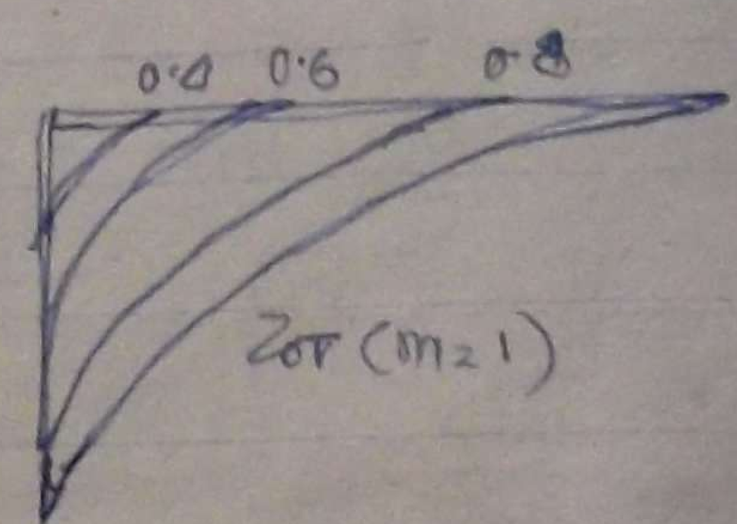




same freq. = f∞



$Z_{o\pi}(m)$ နှင့် $Z_{oT}(m)$ [illegible]
half section [illegible]



At f_∞, $X_C = X_L$, $\alpha = \infty$ ဖြစ်သည်။

$X_L \rightarrow \left|\frac{Z_2}{m}\right| = \left|\frac{1-m^2}{4m} Z_1\right| \leftarrow X_C$

$Z_1 = \frac{1}{j\omega C}$, $Z_2 = j\omega L$ ဖြစ်ရာ

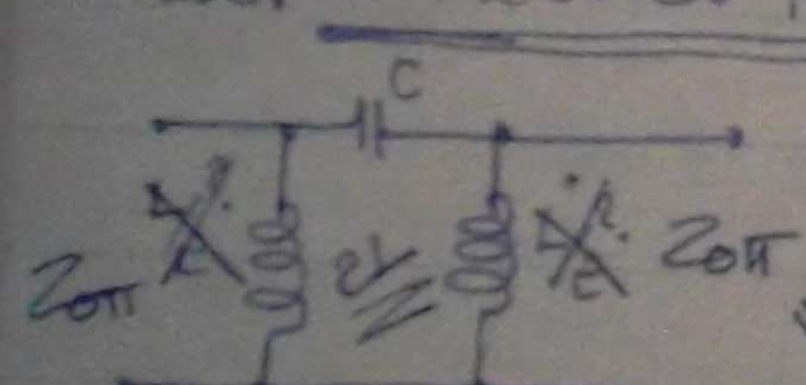
$\frac{2\pi f_\infty L}{m} = \frac{1-m^2}{4m} \cdot \frac{1}{2\pi f_\infty C}$

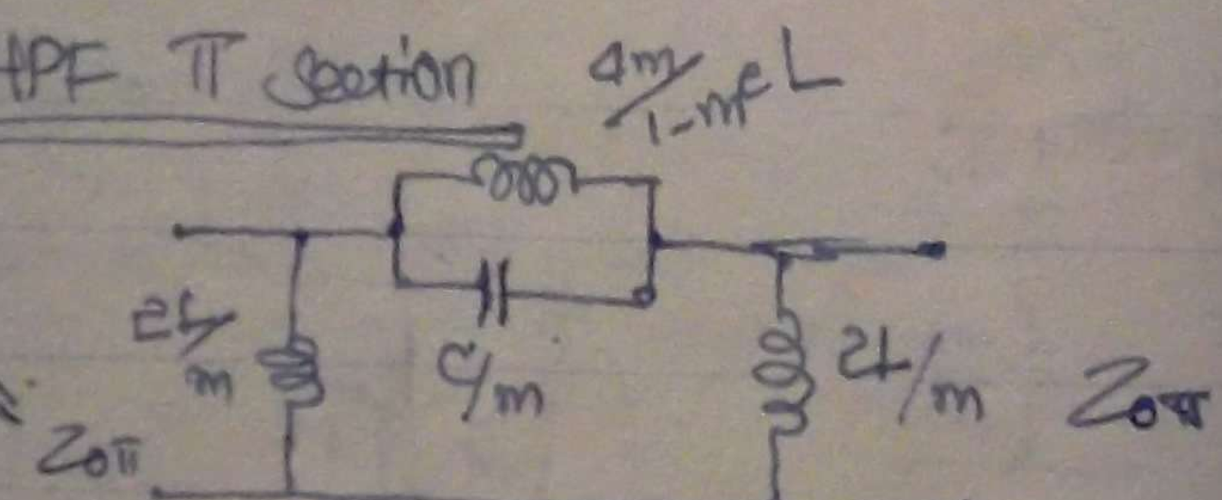
$1-m^2 = (4\pi)^2 f_\infty^2 LC$

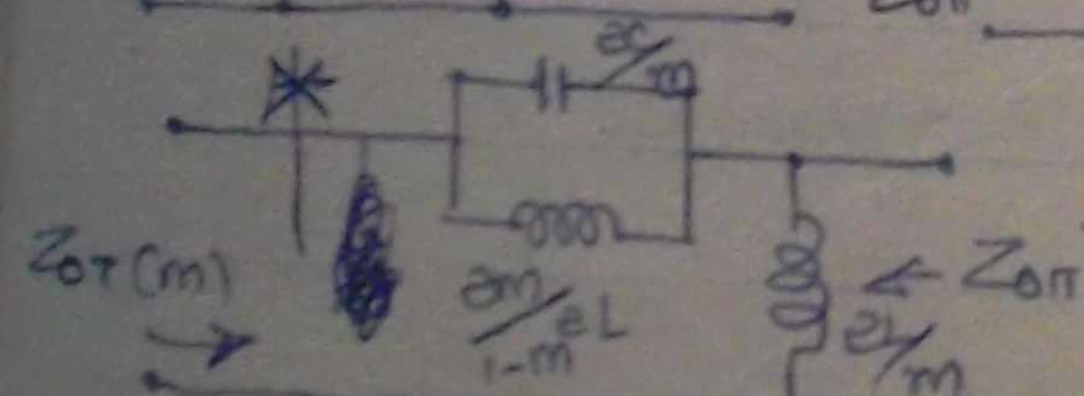
$$\boxed{m = \sqrt{1-\left(\frac{f_\infty}{f_c}\right)^2}} \ *$$

LPF တွင် $m = \sqrt{1-\left(\frac{f_c}{f_\infty}\right)^2}$ ဖြစ်သည်။

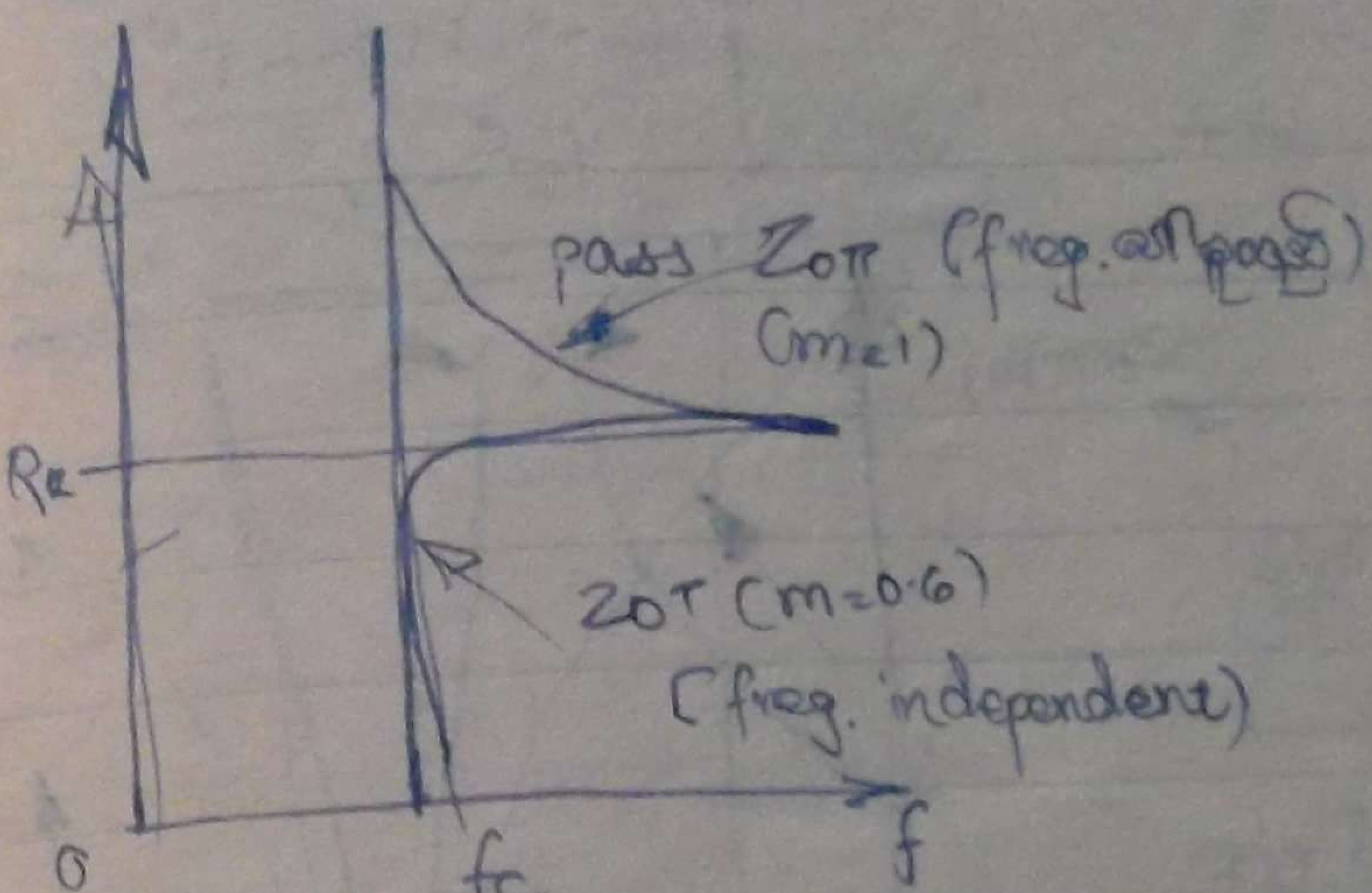
2.3. m Derived HPF π section





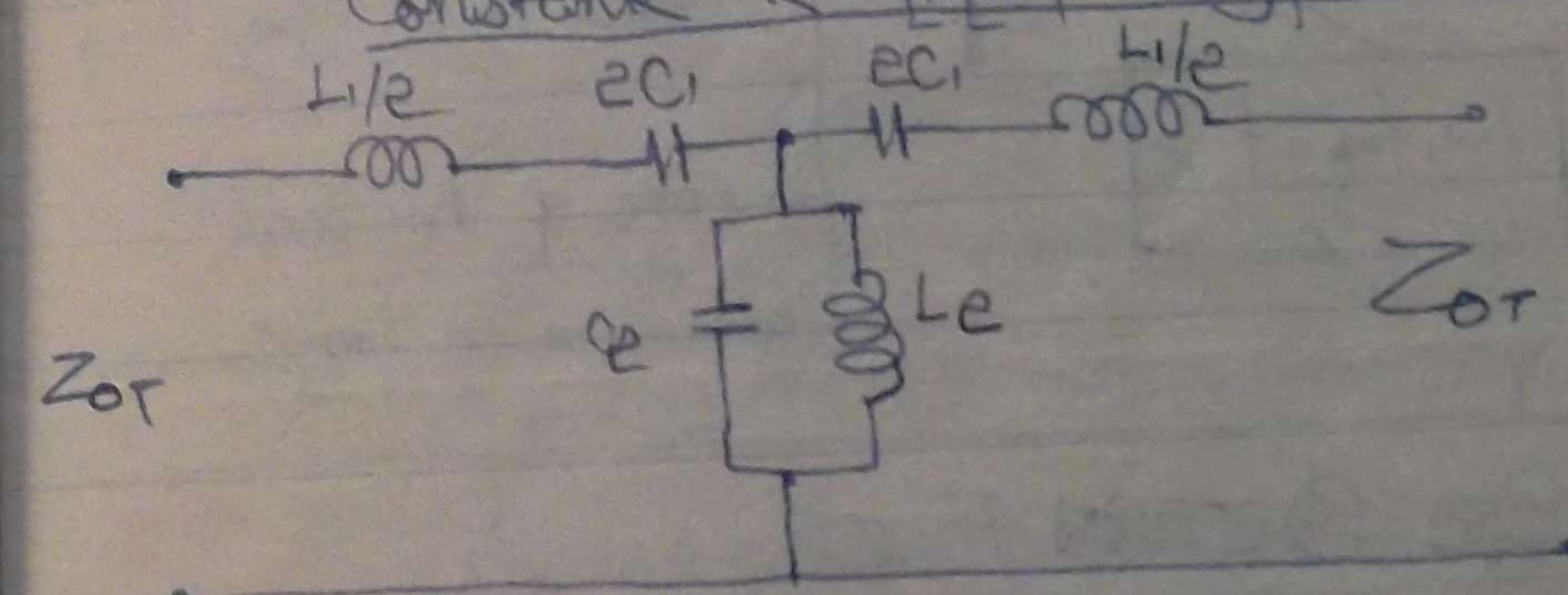


half section ဖြင့်သော်
m = 0.6 တွင် Z_{oT} မှ constant
ဖြစ်ပြီး m [illegible] $Z_{o\pi}$ သော
freq ပေါ်တွင် မူတည်[illegible]
$Z_{o\pi}$ [illegible]

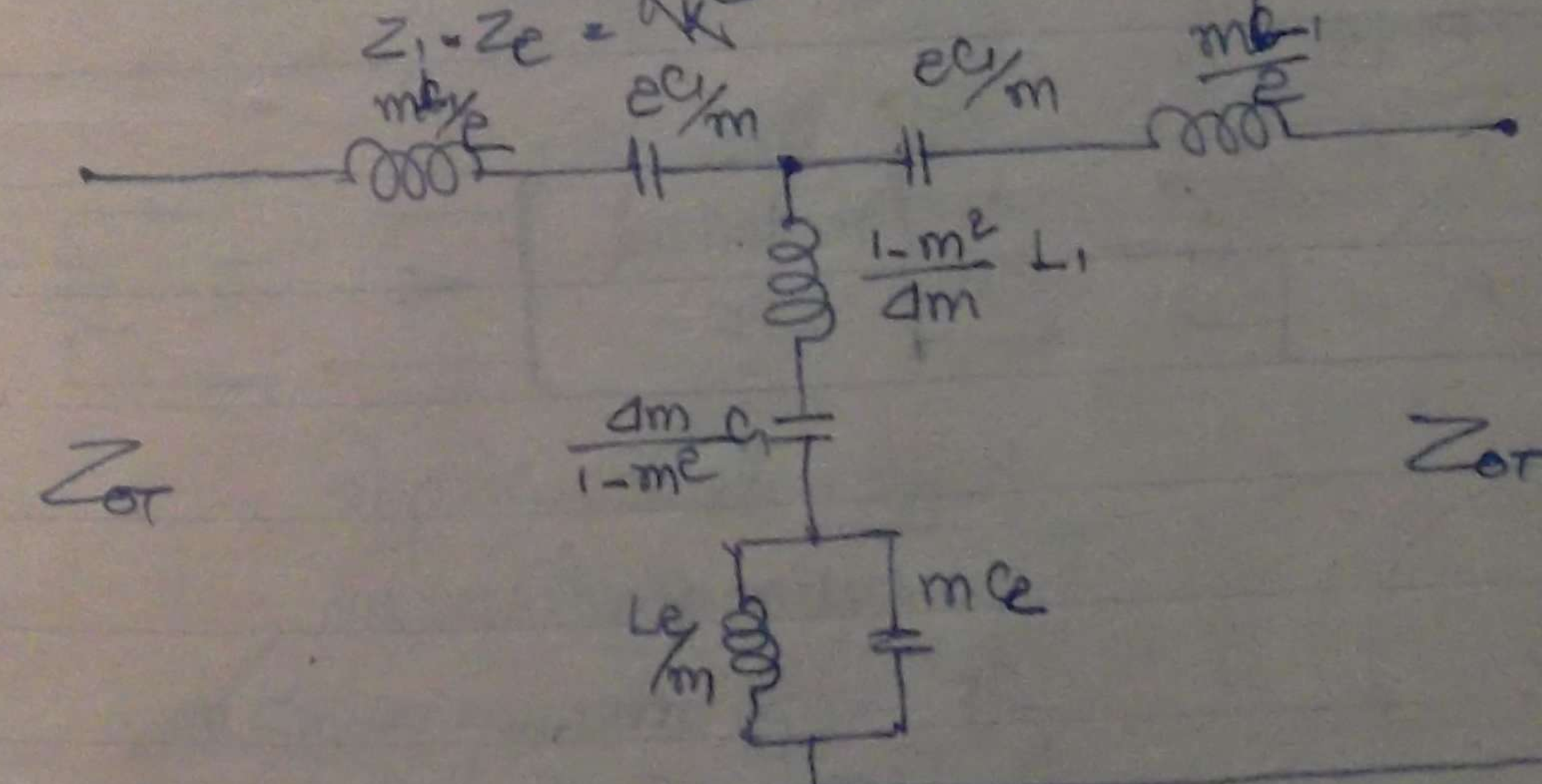


3. m - Derived Band Pass Filter

Constant K - [illegible] prototype BPF



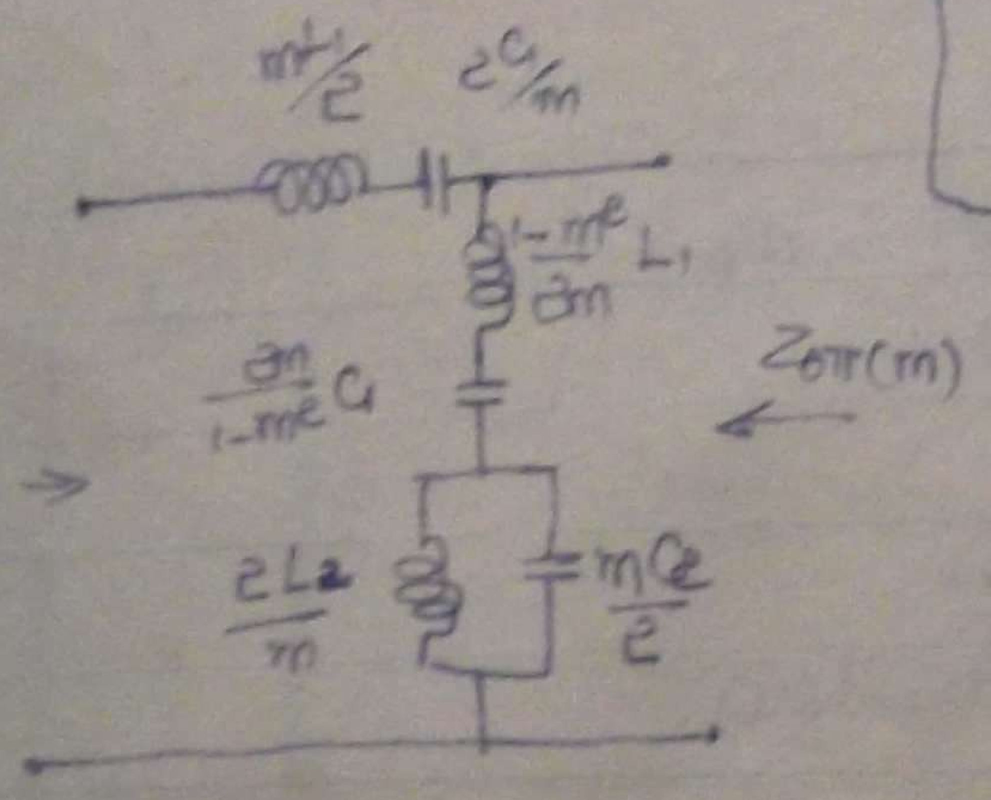
$Z_1 Z_2 = R_K^2$



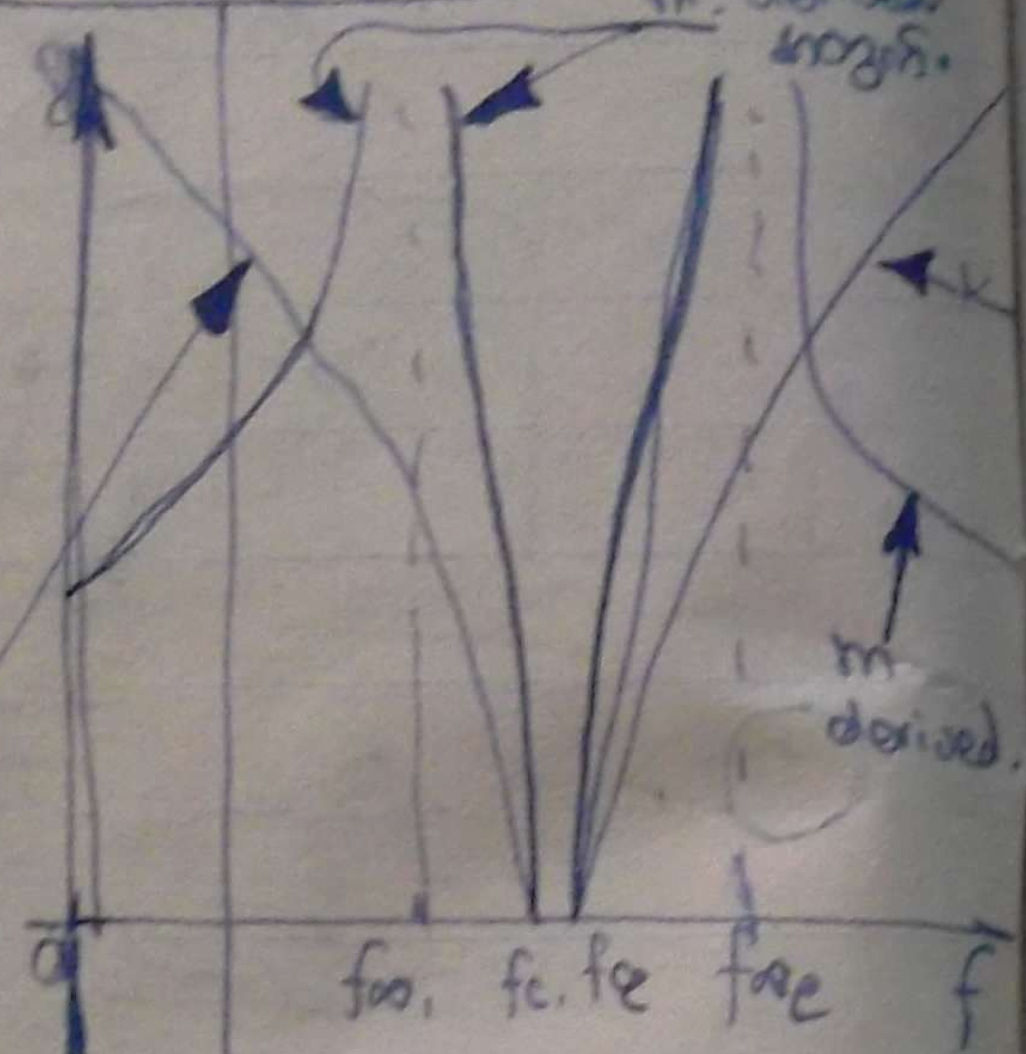
m - derived BPF

(PTO)

$$\boxed{m = \sqrt{\frac{(f_{\infty 1}^2 - f_1^2)(f_{\infty 2}^2 - f_2^2)}{f_{\infty 2}^2 - f_r^2}}}$$



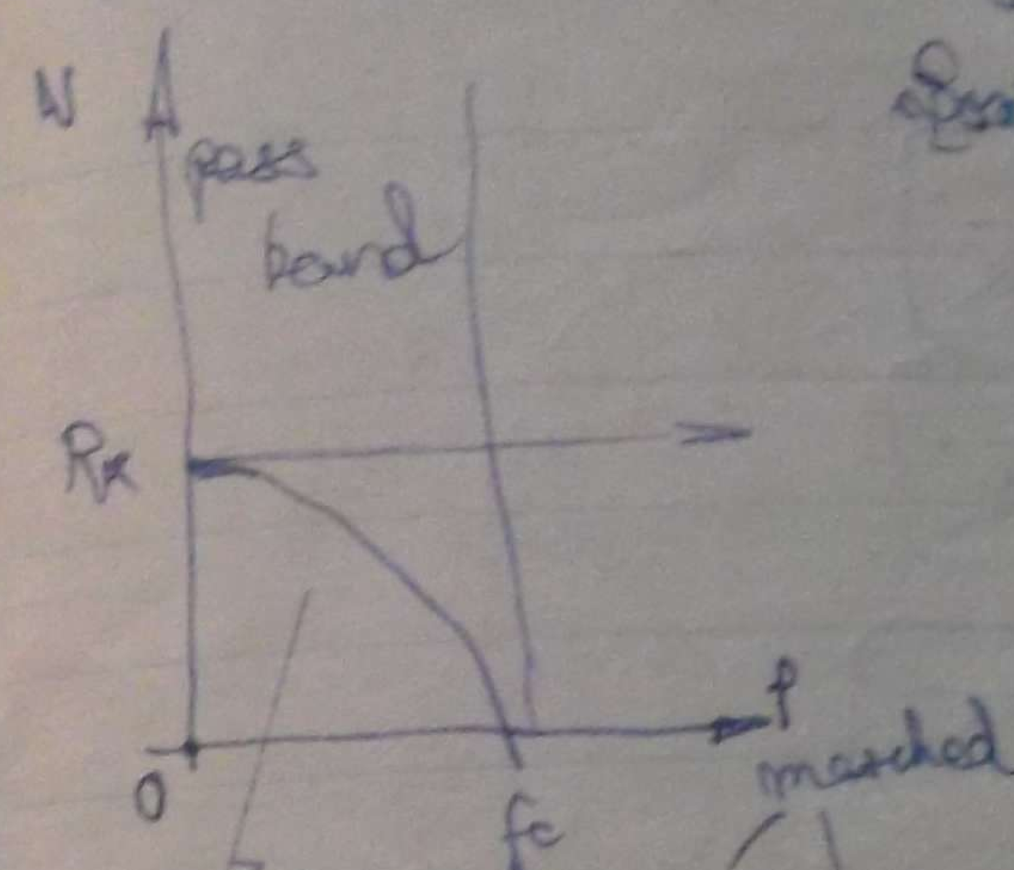
½ section m-derived BPF



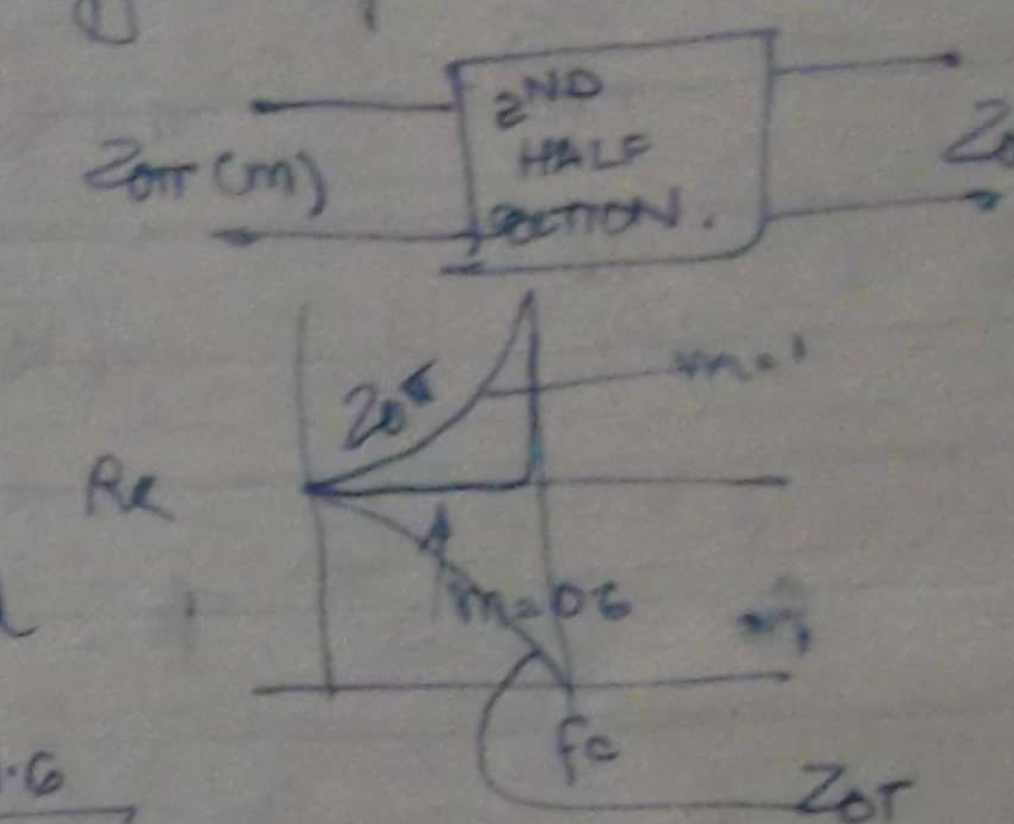
$$\boxed{f_r = \sqrt{f_{\infty 1} f_{\infty 2}}}$$

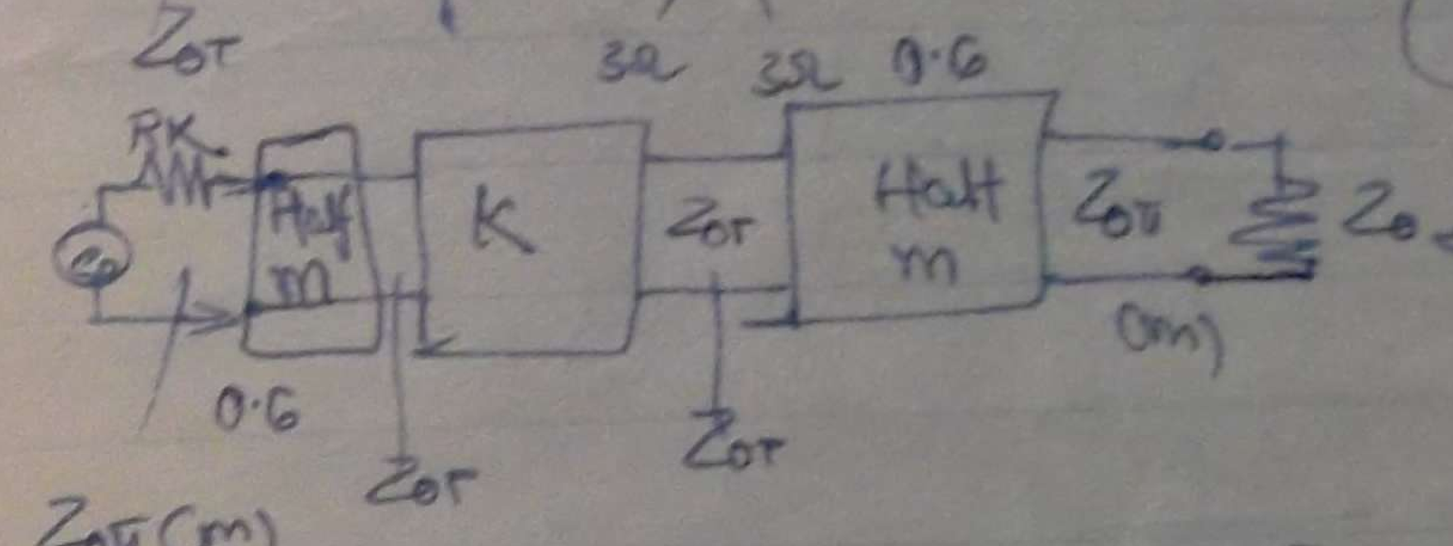
$$\boxed{f_{\infty 1} f_{\infty 2} = f_1 f_2}$$

f∞ = one of the peak attenuation frequencies.



Generator ၏ Z ... Half sect. m' derived ...





Rk ...
½ ... o/p Rk ... matched/constant ...

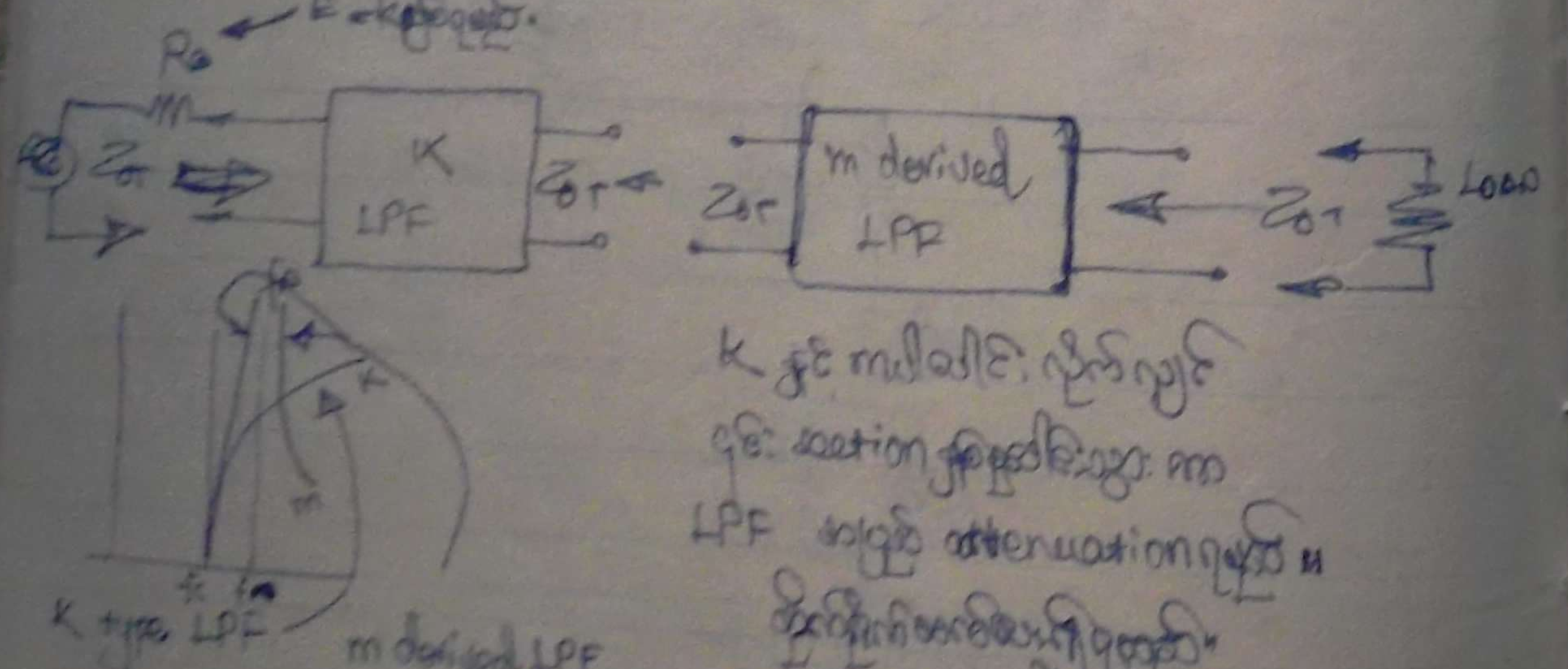
... Z0T ... freq. ...

input ... Z0π ... output ... Z0π ... $R_0 = R_k$ ...

... ½ m ... 1DX.

(... VOL - 4 ...)

COMPOSITE FILTER



K ... m ... section ... LPF ... attenuation ...

... freq. ...

balancing N/W အားဖြင့် ပေး၍ ပိုမိုကောင်းမွန်စေသည်။

West ၅ East ၅. ||

West → bridge ၏ unbalanced signal ကို → voltage divider ၏ tube ၏ output. bridge ကို ဖြတ်၍ [illegible] balancing N/W သို့ သွားသော [illegible]။ [illegible]။

၄-၄ type repeater circuit operations-

၁-၅-၆-၆၁, [illegible]

[illegible] speech signal [illegible] line west ၅ [illegible]။ [illegible] signal bridge transformer သည် balanced [illegible] signal voltage ကို induced and applied [illegible]။ [illegible] voltage divider သို့၊ [illegible] grid net work သို့ သွားသည်။ [illegible] speech signal impulse သည် amplified [illegible] output သည် [illegible] line attenuation [illegible] amplitude [illegible] speech signal သည် repeater ၏ [illegible] amplified [illegible]။

၄-၄ type repeater သည် ၄-၁ type repeater [illegible] gain [illegible]။ [illegible] ၄-၄ type repeater သည် oscillation [illegible] unbalance [illegible] oscillation [illegible]။ [illegible] ၄-၄ type repeater ကို [illegible]။

TO VOL III.

FILTERS

LPF → $L = \frac{R_k}{\pi f_c}$, $C = \frac{1}{\pi f_c R_k}$

HPF → $L = \frac{R_k}{4\pi f_c}$, $C = \frac{1}{4\pi f_c R_k}$

BPF → $L_1 = \frac{R_k}{\pi (f_2 - f_1)}$, $C_2 = \frac{1}{\pi (f_2 - f_1) R_k}$

$C_1 = \frac{f_2 - f_1}{4\pi f_1 f_2 R_k}$, $L_2 = \frac{R_k (f_2 - f_1)}{4\pi f_1 f_2}$

BEF → $L_1 = \frac{R_k (f_2 - f_1)}{\pi f_1 f_2}$, $C_1 = \frac{f_2 - f_1}{\pi f_1 f_2 R_k}$

$C_2 = \frac{1}{4\pi (f_2 - f_1) R_k}$, $L_2 = \frac{R_k}{4\pi (f_2 - f_1)}$

[illegible]