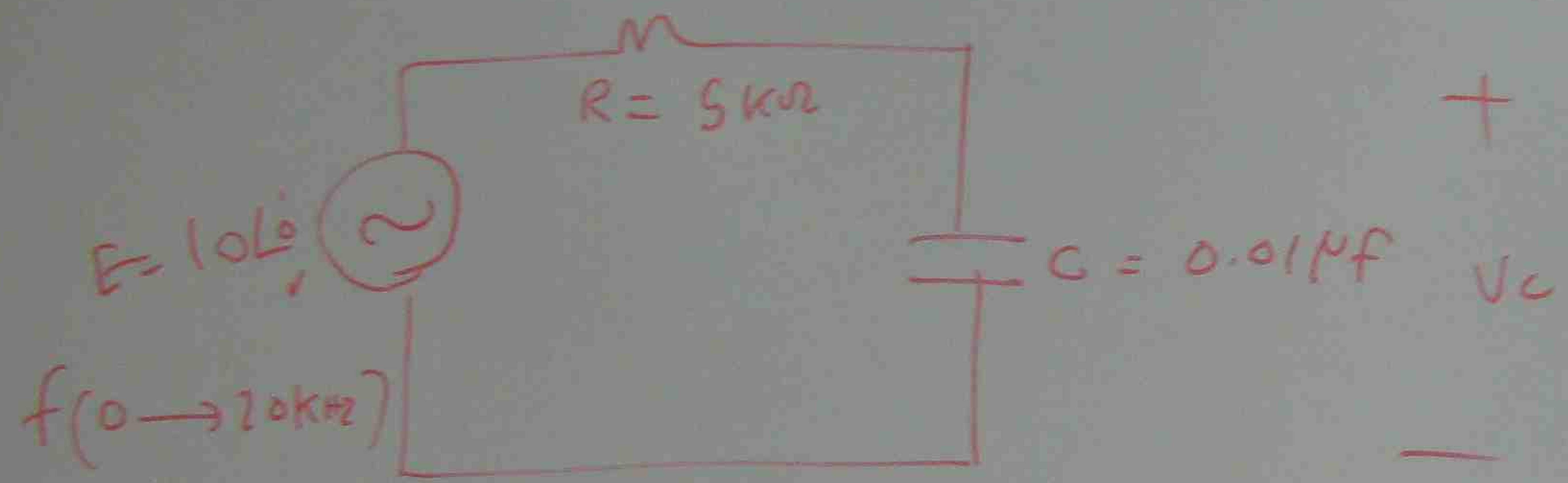
FREQUENCY RESPONSE OF SERIES RC CIRCUIT



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

$f = 0 \longrightarrow \quad X_C = \dfrac{1}{2\pi \times 0 \times C} = \alpha \qquad Z = \alpha$

$f = 100\,Hz \quad X_C = \dfrac{1}{2\pi f C} = \dfrac{1}{2 \times 3.1416 \times 100 \times 0.01 \times 10^{-6}} = 159.16\,k\Omega$

$Z_T = \sqrt{R^2 + X_C^2} = \sqrt{5^2 + 159.16^2} = 159.24\,k\Omega$

$\theta_T = -\tan^{-1}\dfrac{X_C}{R} = -\tan^{-1}\dfrac{159.16}{5} = -88.2^\circ$

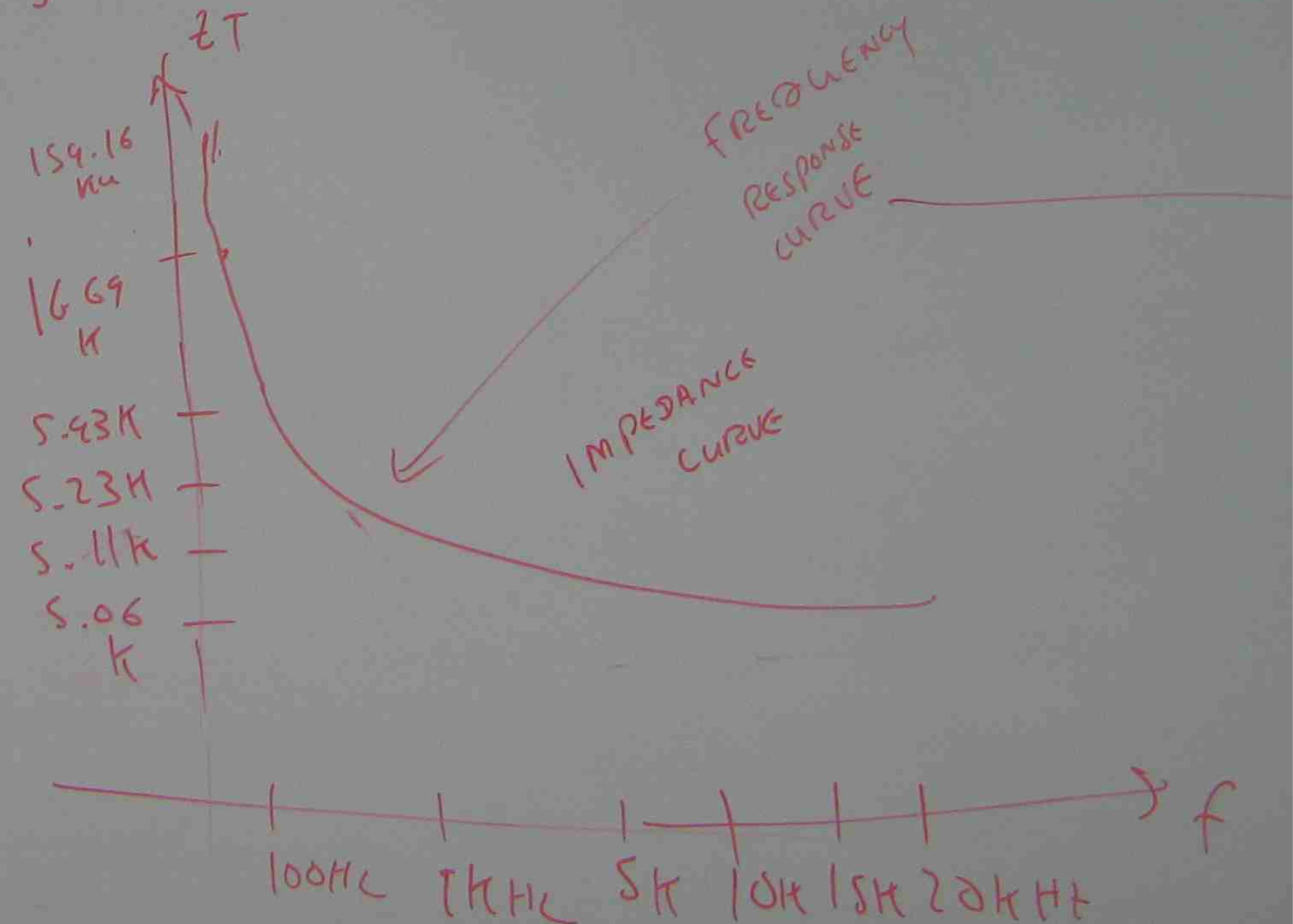
IN THIS BUILDING

$$f = 1\ kHz \Rightarrow X_c = \frac{1}{2 \times 3.1416 \times 1 \times 10^3 \times 0.01 \times 10^{-6}} = 15.92\ k\Omega$$

$$Z_T = \sqrt{5^2 + 15.92^2} = 16.69\ k\Omega$$

$$\theta_T = -\tan^{-1}\frac{X_c}{R} = -\tan^{-1}\frac{15.92}{5} = -72.54$$

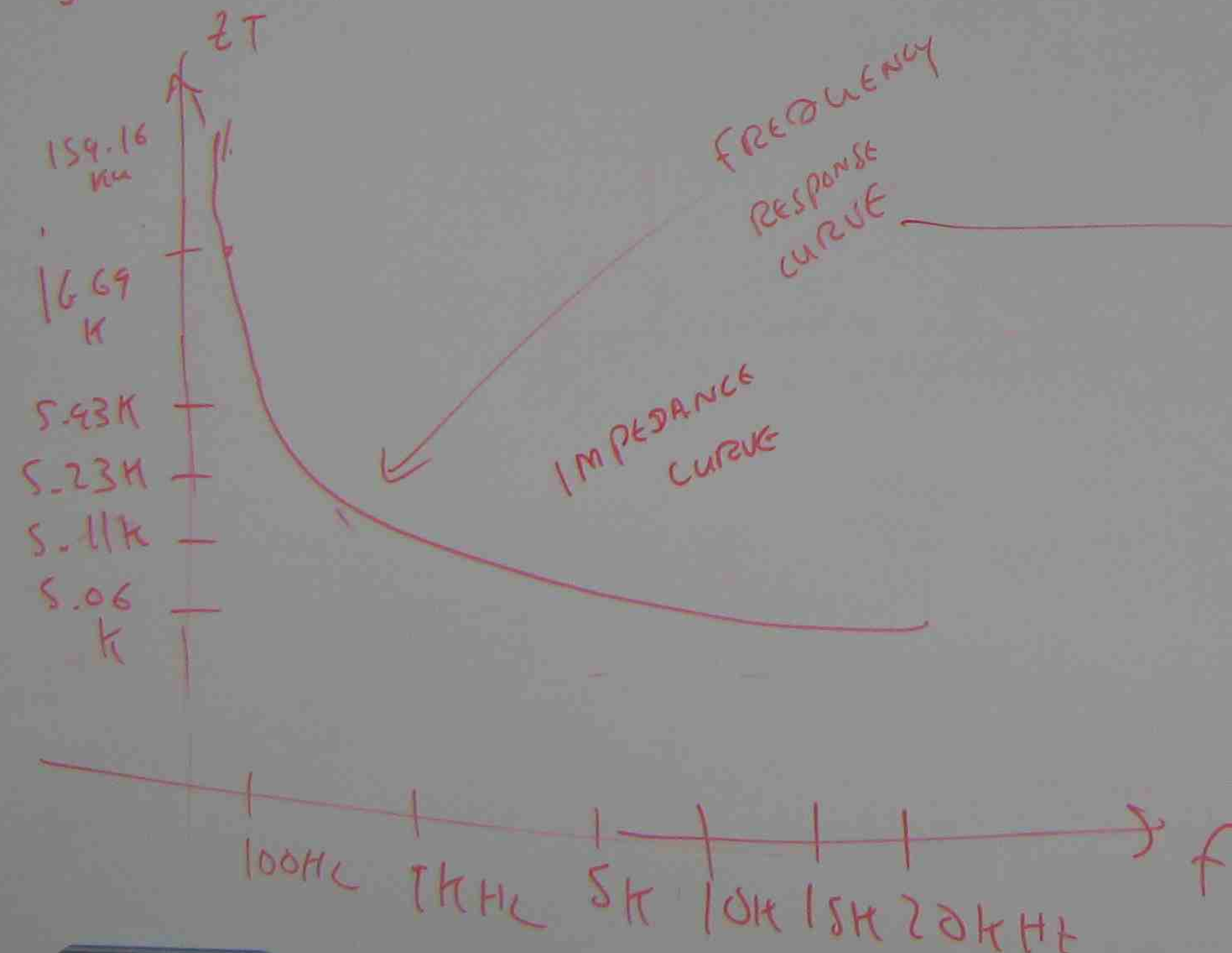
f	Z_T	θ_T
0	∞	-90°
5 kHz	5.93 kΩ	−32.48
10 kHz	5.23 kΩ	−17.66
15 kHz	5.11 kΩ	−11.93
20 kHz	5.06 kΩ	−9.04

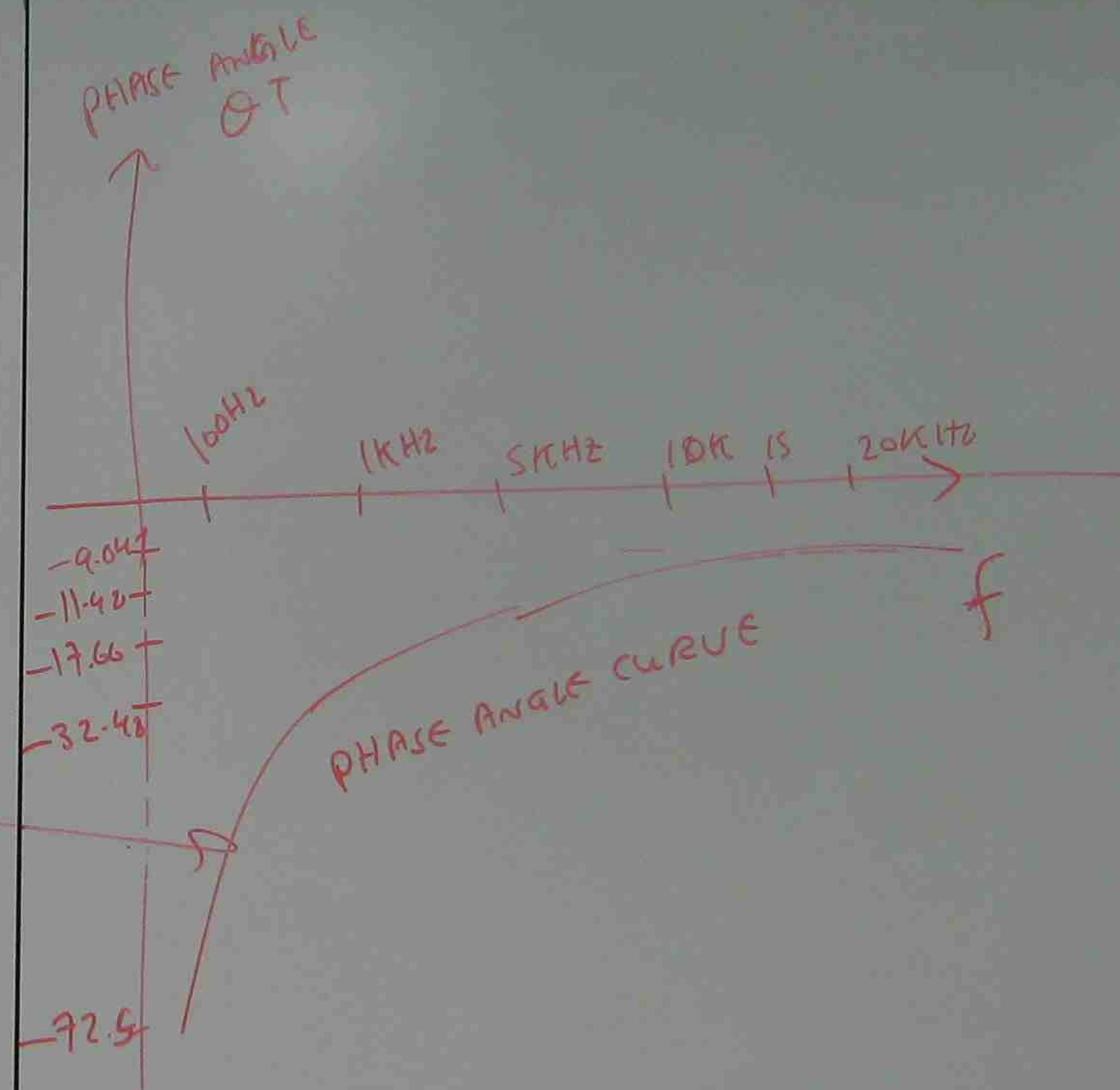


$\overline{\quad 0.01 \times 10^{-6}} = 15.92\ k\Omega$

$= 16.69\ k\Omega$

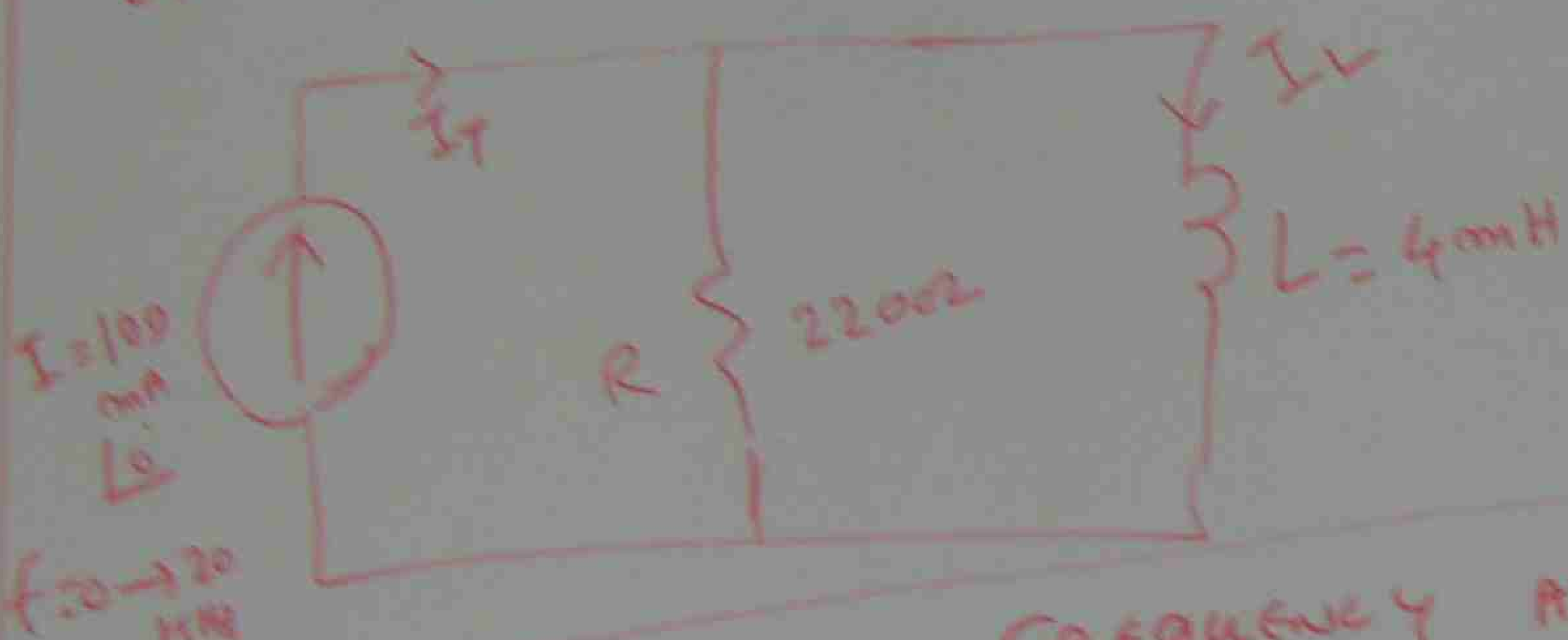
$\tan^{-1} \frac{15.92}{5} = -72.54^{\circ}$





FREQUENCY RESPONSE OF PARALLEL R-L NETWORK

Q) DETERMINE THE FREQUENCY RESPONSE OF IMPEDANCE, PHASE ANGLE AND CURRENT OF THE FOLLOWING PARALLEL R-L NETWORK



V_o ↓ 1kHz, 5kHz, 10kHz, 15kHz, 20kHz

8.75kHz

CALCULATE RESONANT FREQUENCY AT WHICH CIRCUIT RESISTANCE AND INDUCTIVE REACTANCE ARE EQUAL

$X_L = 2\pi f L$, R

$f_r = ? \Rightarrow R = X_L$

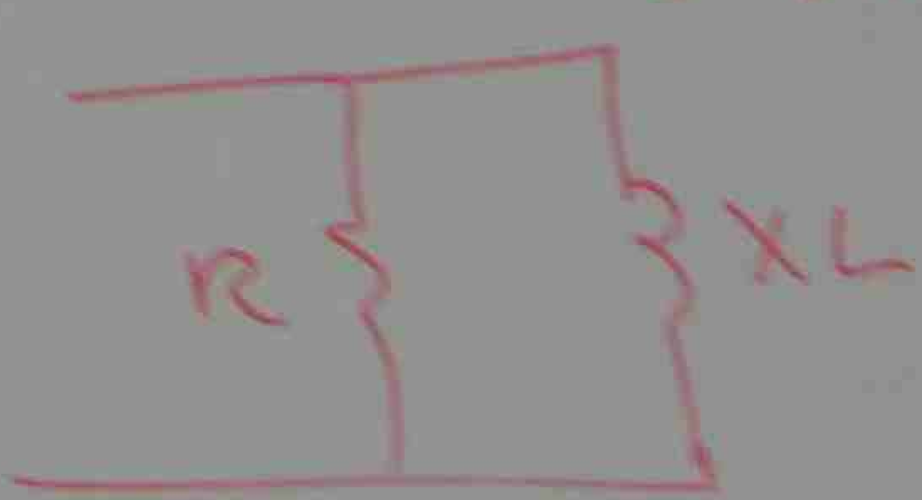
$220 = 2 \times 3.1416\ f \times 4 \times 10^{-3}$

$f = \dfrac{220}{2 \times 3.1416 \times 4 \times 10^{-3}} = 8.75\ kHz$

1 kHz

$X_L = 2\pi f L = 2 \times 3.1416 \times 1 \times 10^{3} \times 4 \times 10^{-3}$

$= 25.12\Omega$



$\dfrac{1}{Z_T} = \dfrac{1}{R} + \dfrac{1}{X_L}$

$\dfrac{1}{Z_T} = \dfrac{R + X_L}{R \cdot X_L}$

$Z_T = \dfrac{R(jX_L)}{R + jX_L} = \dfrac{220 \times j25.12}{220 + j25.12}$

CURRENT

kHz

kHz, 15 kHz, 20 kHz

$= 2 \times 3.1416 \times 1 \times 10^{3} \times 4 \times 10^{-3}$

$\frac{1}{Z_T} = \frac{1}{R} + \frac{1}{X_L}$

$\frac{1}{Z_T} = \frac{R + X_L}{R \cdot X_L}$

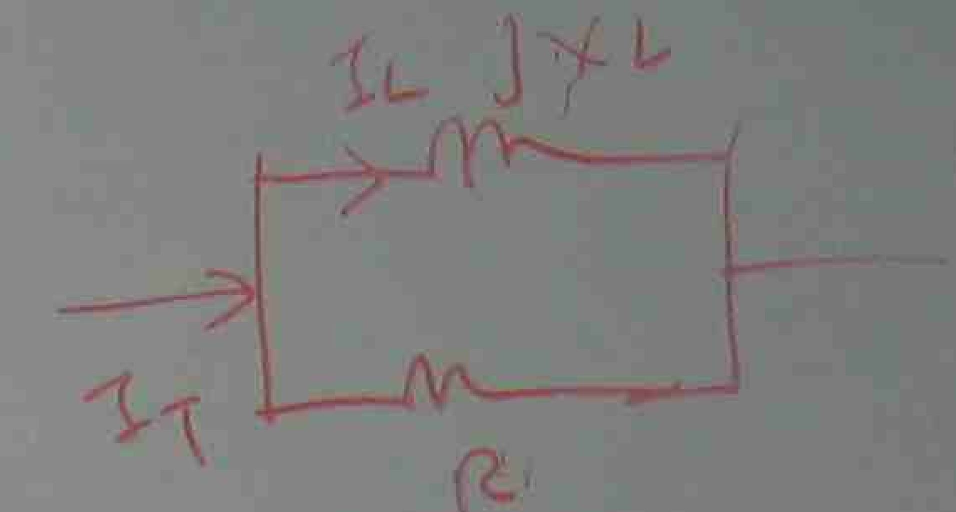
$= \frac{220 \times j25.12}{220 + j25.12}$

$$Z_T = \frac{220\angle 0 \times 25.12 \angle 90}{\sqrt{220^2 + 25.12^2} \angle \tan^{-1}\frac{25.12}{220}}$$

$$= \frac{220 \times 25.12}{\sqrt{220^2 + 25.12}} \frac{\angle 90}{\angle 8.76}$$

$$= 24.96 \angle 90 - 8.76$$

$$Z_T = 24.96 \angle 83.49$$



$$I_L = I_T \times \frac{R}{R + jX_L}$$

1kHz

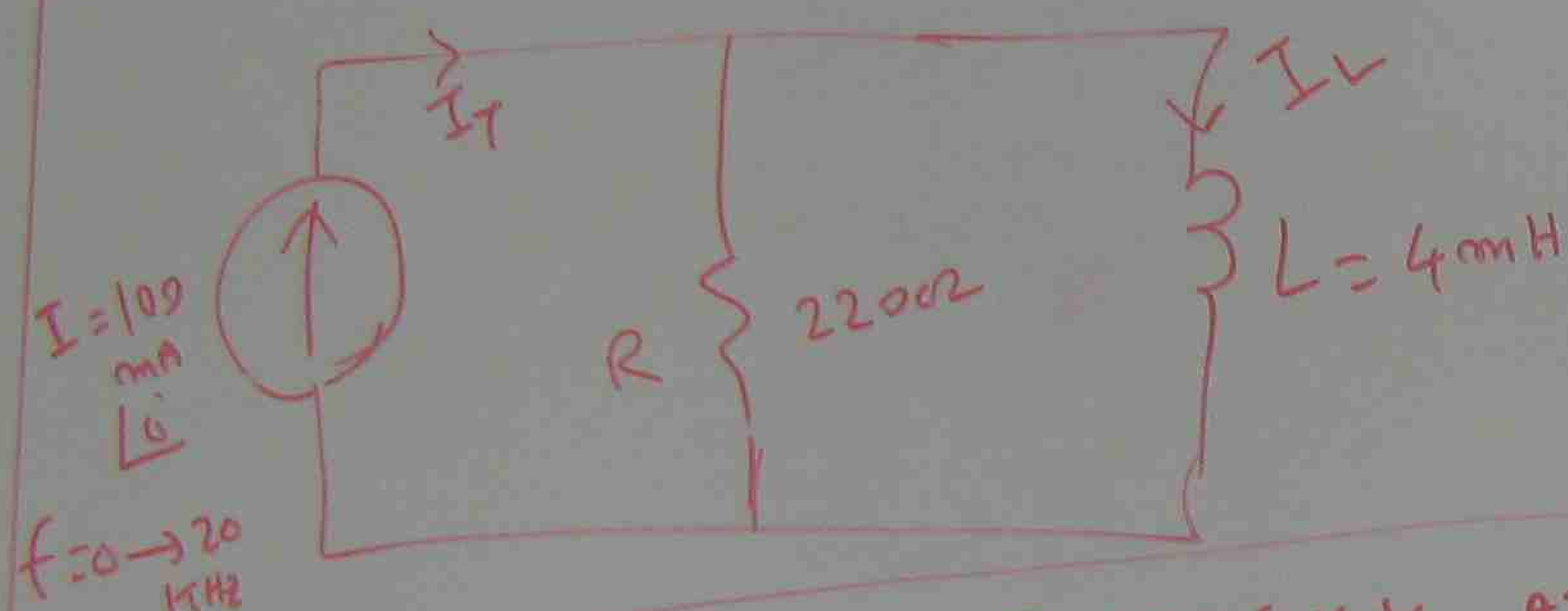
$$= 100\,mA \times \frac{220}{220 + j25.12}$$

$$= 100 \times \frac{220}{\sqrt{220^2 + 25.12^2} \angle \tan^{-1}\frac{25.12}{220}} = 99.5 \angle -6.5$$

f	Z_T	θ_T	I	θ
1kHz	24.96	83.49	99.35	-6.5
5	109.1	60.23	86.84	-29.76
10	165.5	41.21	65.83	-48.79
15	189.99	30.28	50.43	-59.72
20	201.83	23.66	40.11	-73.73

FREQUENCY RESPONSE OF PARALLEL R-L NETWORK

pb DETERMINE THE FREQUENCY RESPONSE OF IMPEDANCE, PHASE ANGLE AND CURRENT OF THE FOLLOWING PARALLEL R-L NETWORK



$\downarrow$ 1/8

8.75KHz

1KHz 5KHz, 10KHz, 15KHz 20KHz

CALCULATE RESONANT FREQUENCY AT WHICH CIRCUIT RESISTANCE AND INDUCTIVE REACTANCE ARE EQUAL

$X_L = 2\pi f L$, R

$f_r = ? \Rightarrow R = X_L$

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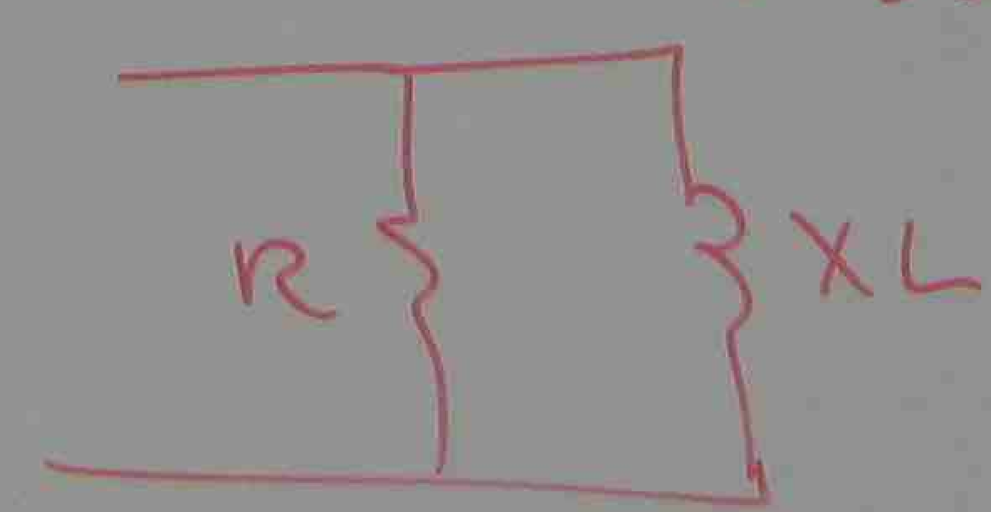
1KHz

$X_L = 2\pi f L = 2 \times 3.1416 \times 1 \times 10^{3} \times 4 \times 10^{-3}$

$= 25.12\Omega$



$\frac{1}{Z_T} = \frac{1}{R} + \frac{1}{X_L}$

$\frac{1}{Z_T} = \frac{R + X_L}{R \cdot X_L}$

$Z_T = \frac{R(jX_L)}{R + jX_L} = \frac{220 \times j25.12}{220 + j25.12}$

URRENT

kHz

5 kHz, 15 kHz 20 kHz

$= 2\times 3.1416\times 1\times 10^{3}\times 4\times 10^{-3}$

$\frac{1}{Z_T} = \frac{1}{R} + \frac{1}{X_L}$

$= \frac{R+X_L}{R\cdot X_L}$

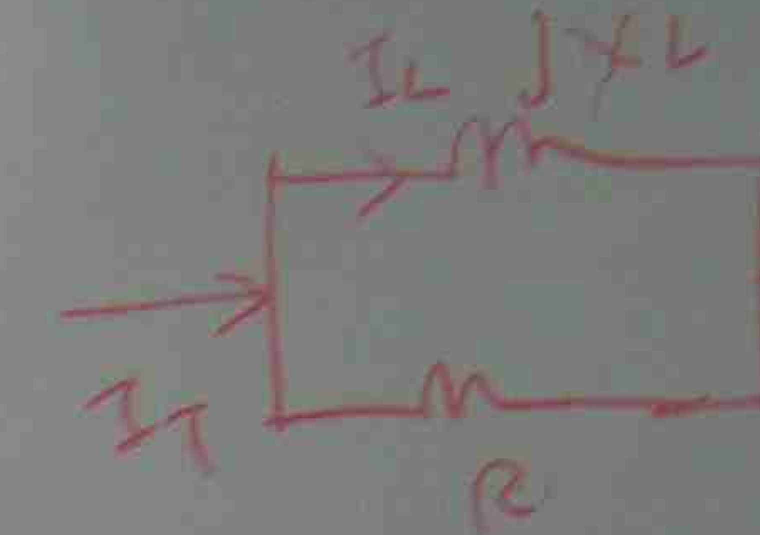
$= \frac{220\times j25.12}{220+j25.12}$

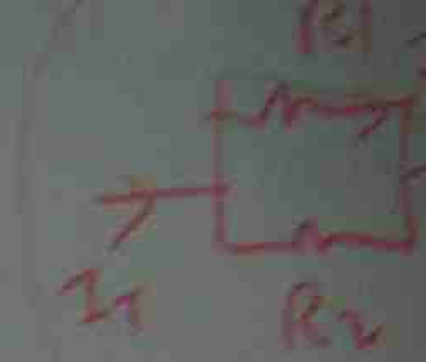
$$Z_T = \frac{220\angle 0 \times 25.12\angle 90}{\sqrt{220^2+25.12^2}\ \angle \tan^{-1}\frac{25.12}{220}}$$

$$= \frac{220\times 25.12}{\sqrt{220^2+25.12}}\ \frac{\angle 90}{\angle 8.76}$$

$$= 24.96 \angle 90 - 8.76$$

$$Z_T = 24.96 \angle 83.49$$





$I_{R1} = I_T \times \frac{R_2}{R_1+R_2}$

$$I_L = I_T \times \frac{R}{R+jX_L}$$

1kHz

$$= 100\,mA \times \frac{220}{220+j25.12}$$

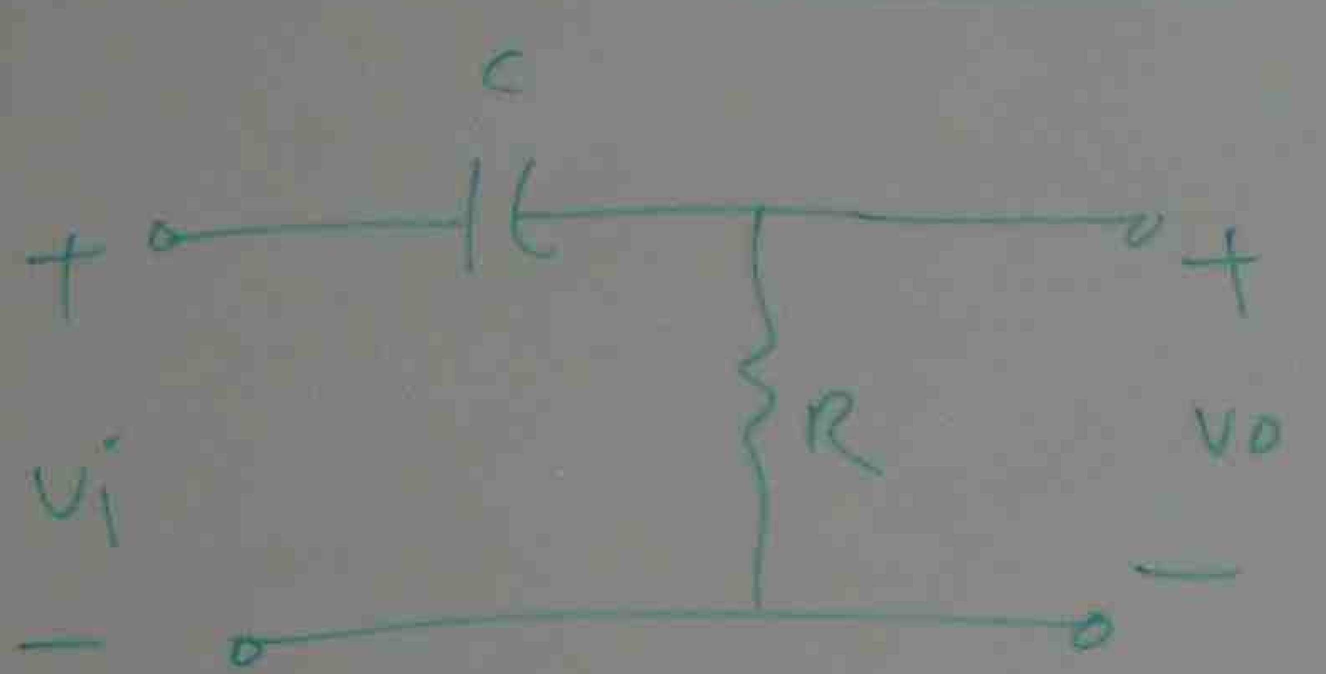
$$= 100\times \frac{220}{\sqrt{220^2+25.12^2}\ \angle \tan^{-1}\frac{25.12}{220}} = 99.5\angle -6.5$$

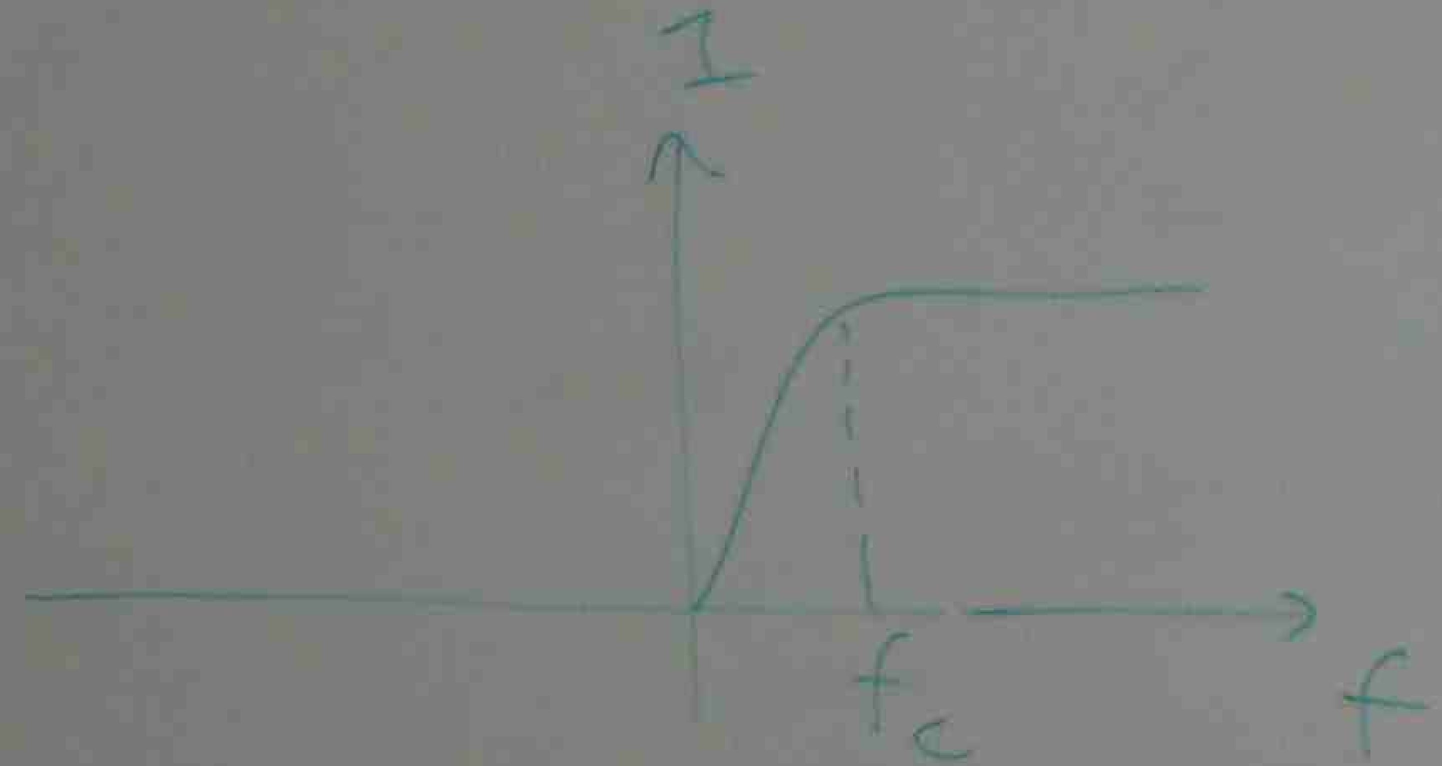
f	Z_T	θ_T	I	θ
1kHz	24.96	83.49	99.35	-6.5
5	109.1	60.23	86.84	-29.72
10	163.5	41.21	65.83	-48.79
15	189.99	30.28	50.43	-59.72
20	201.83	23.66	40.11	-73.78

ZT
201.53
189.9
165.5
109.1
24.46
1KHz
5
8.75
10
15
20
f
IL
99.35
86.84
65.28
50.43
40.11
1KHz
5KHz
10K
15
20K
f
θT
83.49
60.23
41.21
30.26
1k
5k
10k
15
20
f
θL
1K
5KHz
10K
15K
20K
f
-8.5
-24.92
-48.94
-54.92
-66.35

PLOTTING FREQUENCY RESPONSE CURVE FOR LOW PASS AND HIGH PASS FILTERS

HIGH PASS FILTER





BODE PLOT

FREQUENCY GAIN (dB) $= -20 \log_{10} \frac{f_c}{f}$

FREQUENCY GAIN

f_c = CRITICAL FREQUENCY

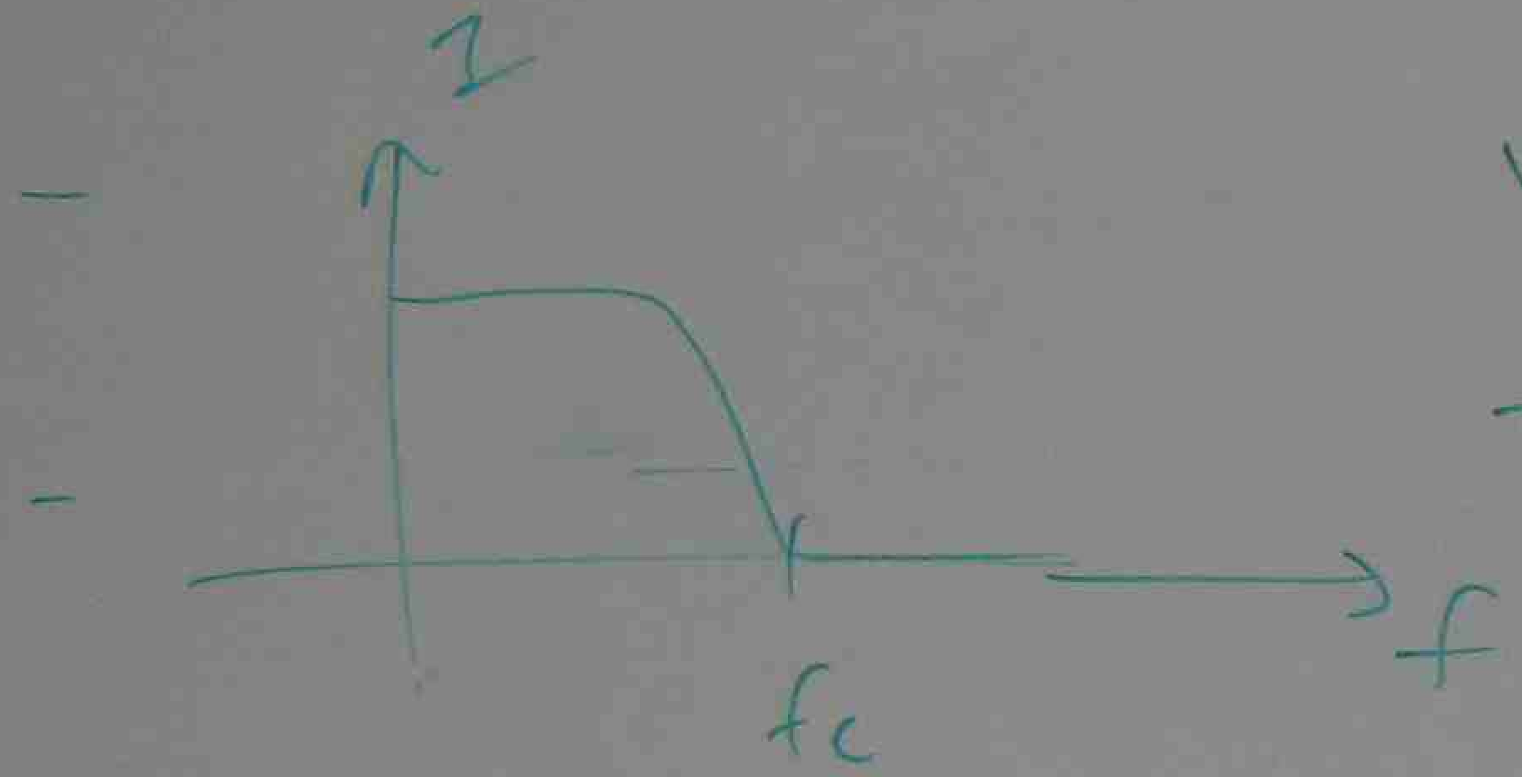
(CUT-OFF FREQUENCY)

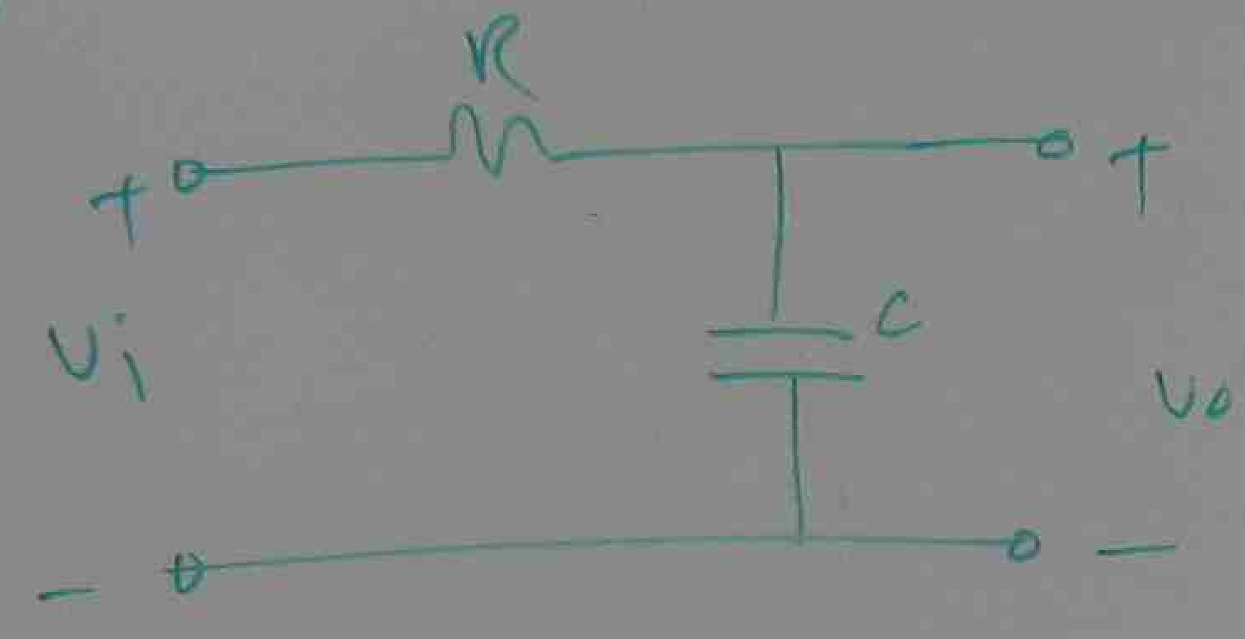
VOLTAGE GAIN

$$|A_{vdB}| = 20 \log_{10} \frac{1}{\sqrt{1+\left(\frac{f_c}{f}\right)^2}}$$

PHASE ANGLE $\theta = \tan^{-1} \frac{f_c}{f}$

LOW PASS FILTER (RC)





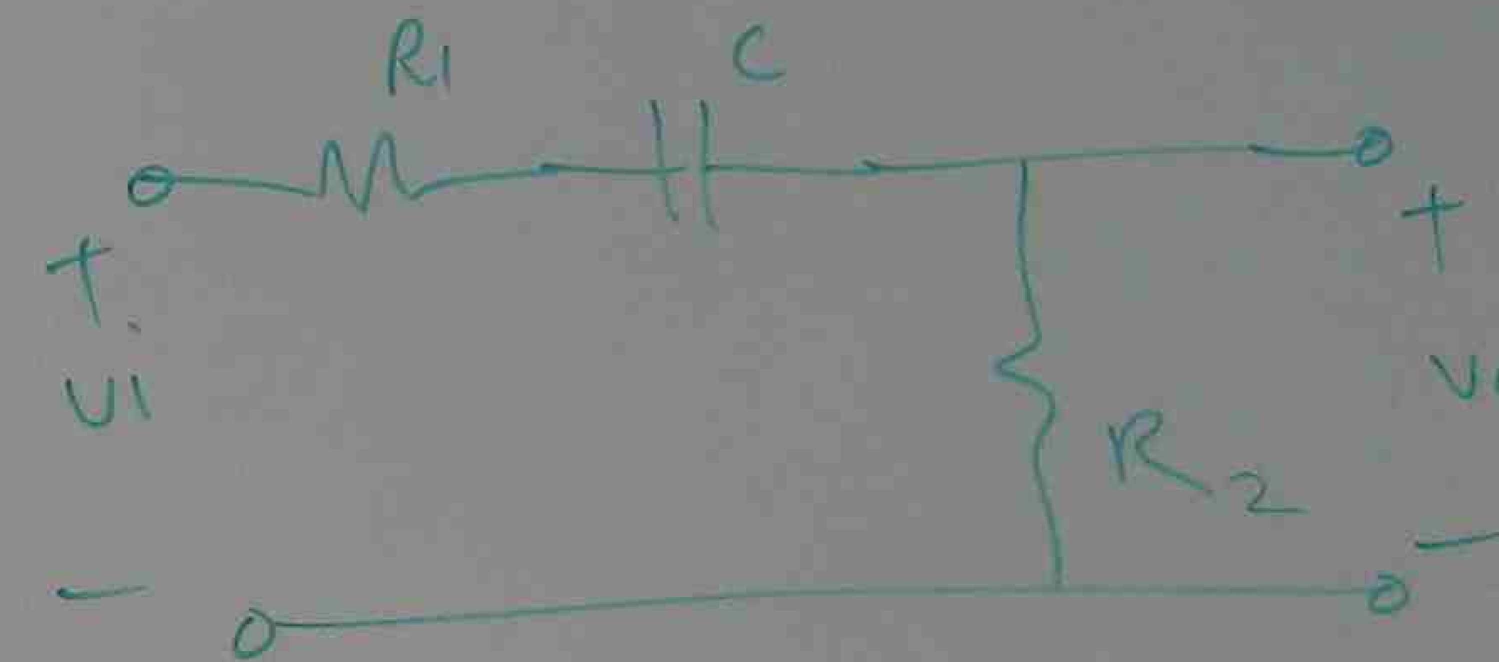
FREQUENCY GAIN $dB = -20 \log_{10} \frac{f}{f_c}$

VOLTAGE GAIN

$$|A_{V\,dB}| = 20 \log_{10} \frac{1}{\sqrt{1+\left(\frac{f}{f_c}\right)^2}}$$

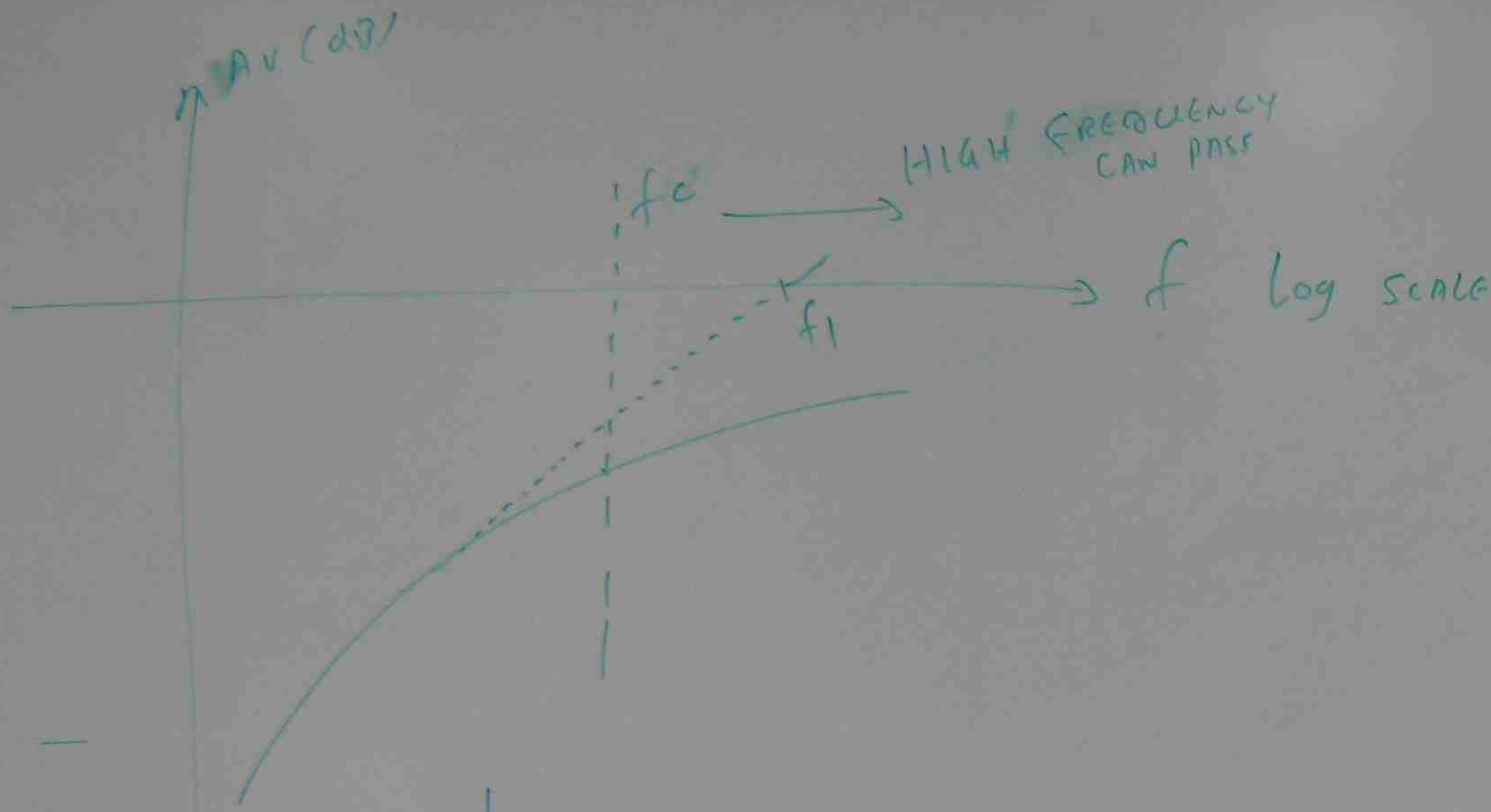
PHASE ANGLE $\theta = \tan^{-1} \frac{f}{f_c}$

HIGH PASS FILTER WITH ADDITIONAL RESISTOR (HIGH PASS FILTER WITH ATTENUATED OUTPUT)



$$A_v = \frac{V_o}{V_i} = \frac{R_2}{R_1+R_2}\left[\frac{1}{1-j\frac{f_c}{f}}\right]$$

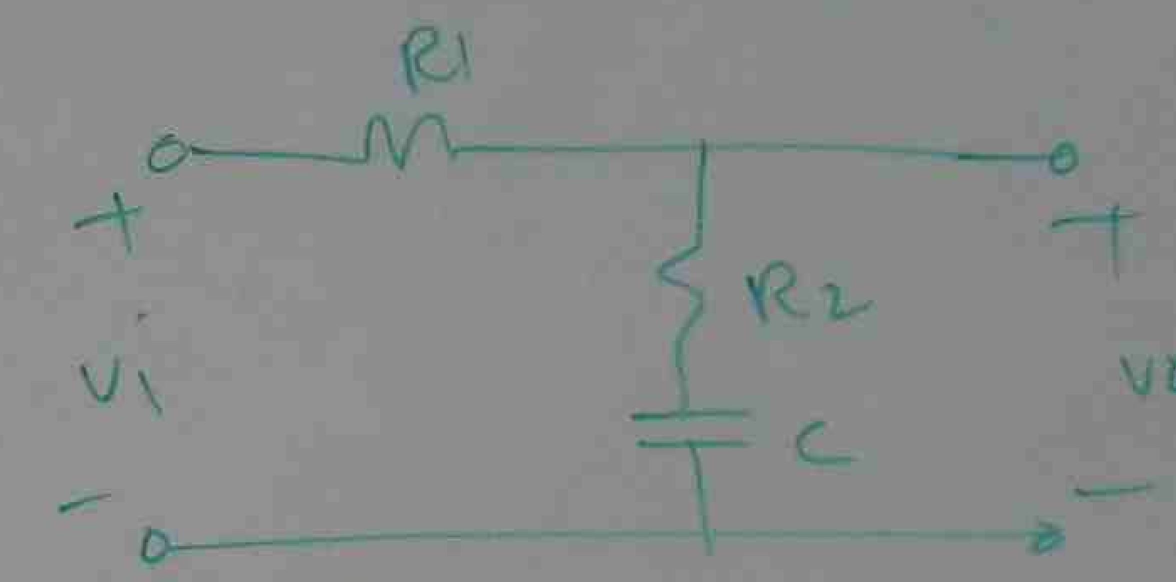
$$|A_{v\,dB}| = -20 \log_{10} \frac{R_1+R_2}{R_2}$$



$$f_1 = \frac{1}{2\pi R_2 C}$$

$$f_c = \frac{1}{2\pi (R_1 + R_2) C}$$

LOW PASS FILTER WITH LIMITED ATTENUATION

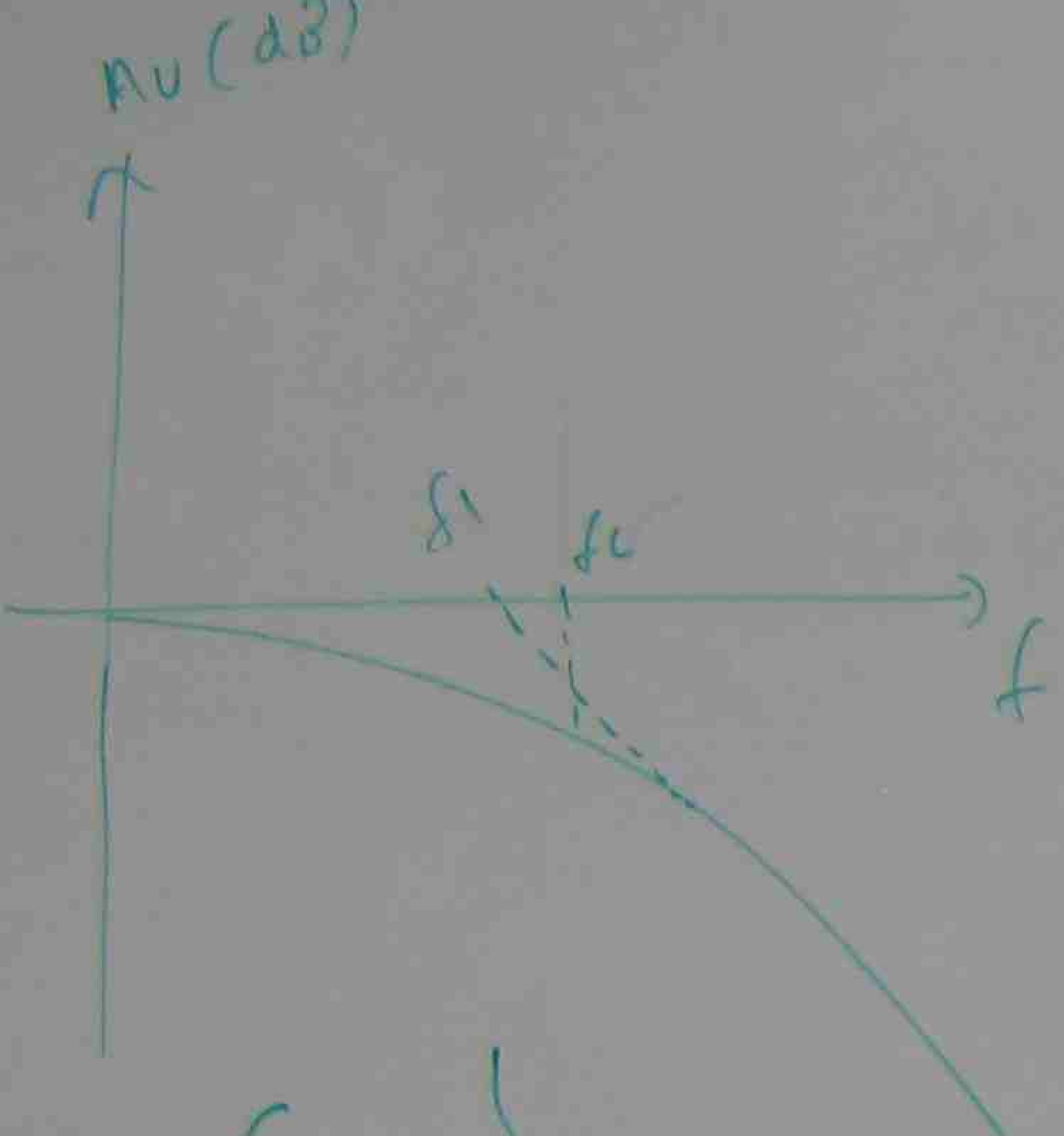


BY INSERTING R_2, THE ATTENUATION LEVEL OF HIGH FREQUENCY IS LIMITED

$$V_o = \frac{R_2}{R_1 + R_2} V_i$$

$$A_v(dB) = -20 \log_{10} \frac{R_1 + R_2}{R_2}$$

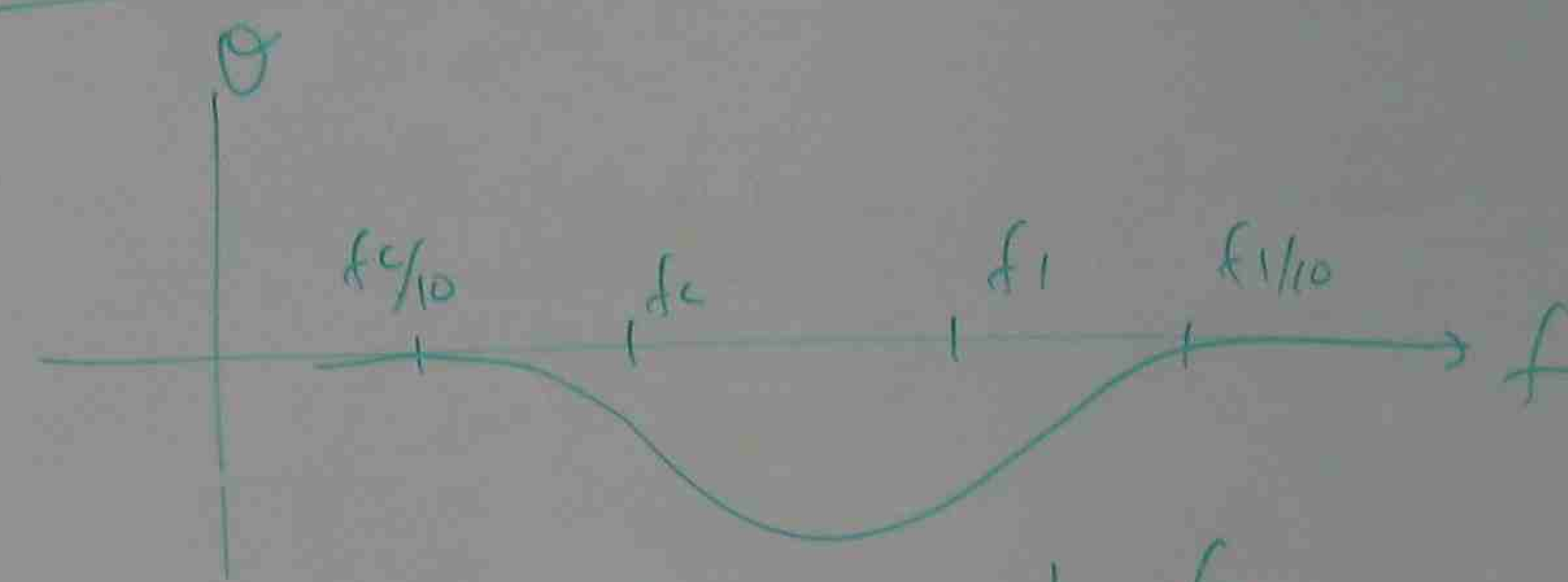
$$A_v = \frac{1 + j\frac{f}{f_1}}{1 + j\frac{f}{f_c}}$$



$$f_1 = \frac{1}{2\pi R_2 C}$$

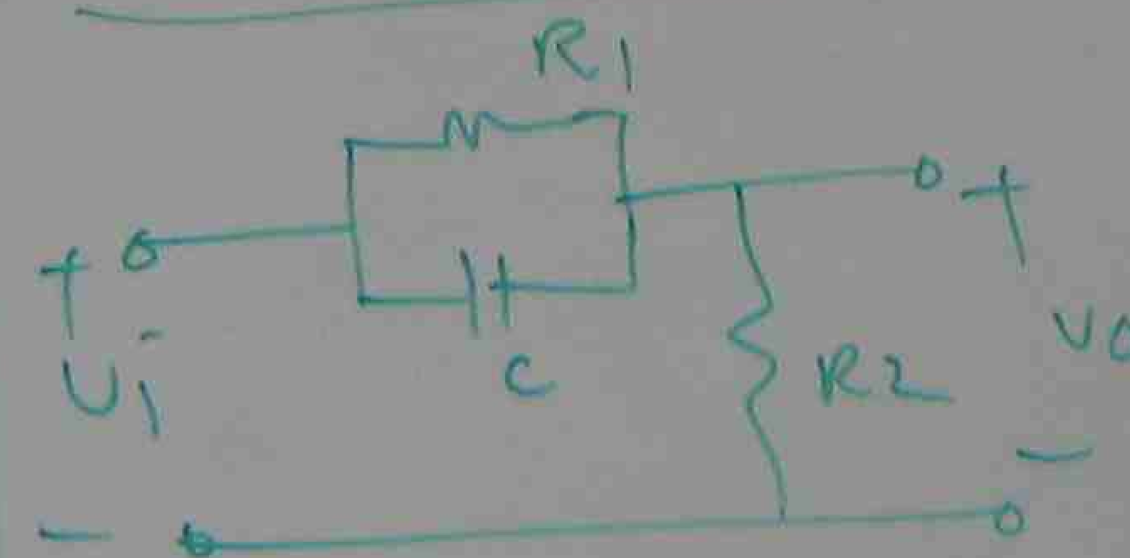
$$f_c = \frac{1}{2\pi (R_1 + R_2) C}$$

PHASE ANGLE PLOT



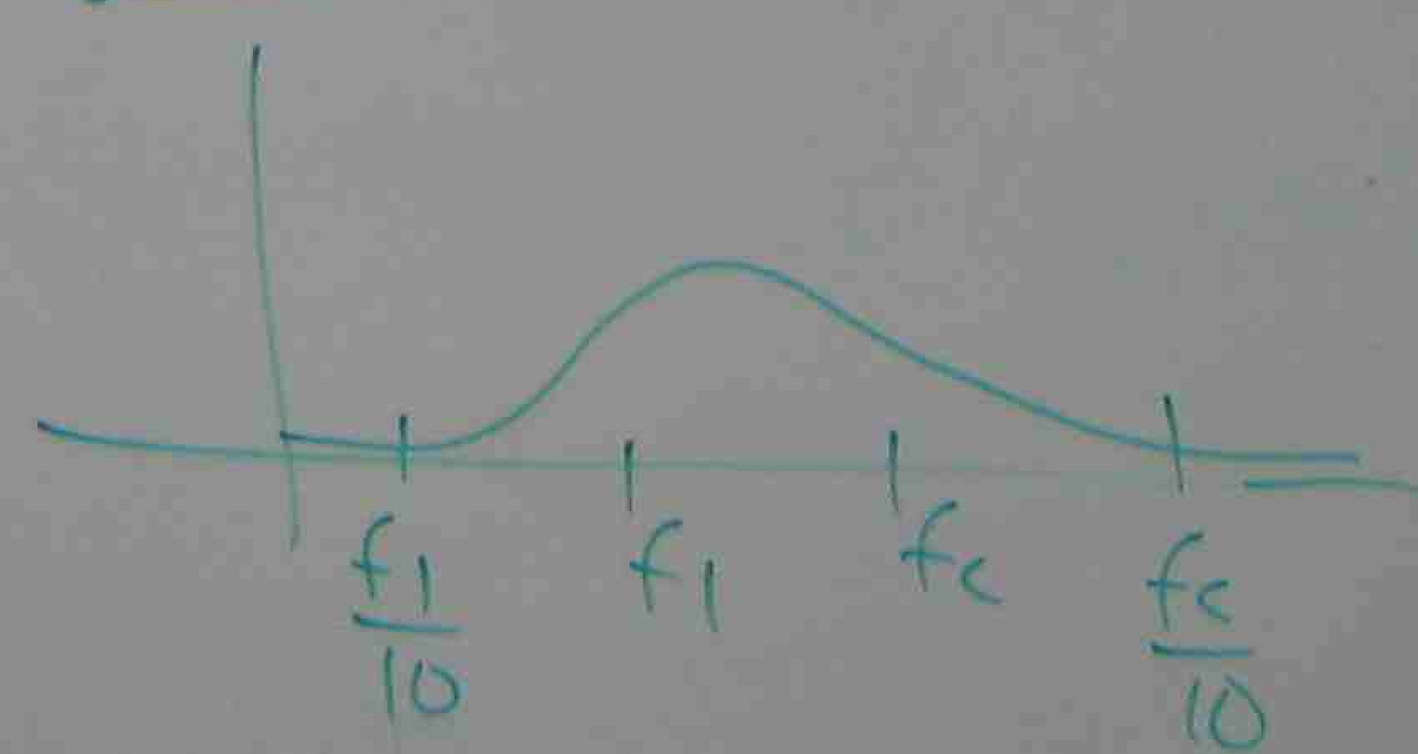
$$\theta = \tan^{-1}\frac{f}{f_1} - \tan^{-1}\frac{f}{f_c}$$

HIGH PASS FILTER WITH LIMITED ATTENUATION



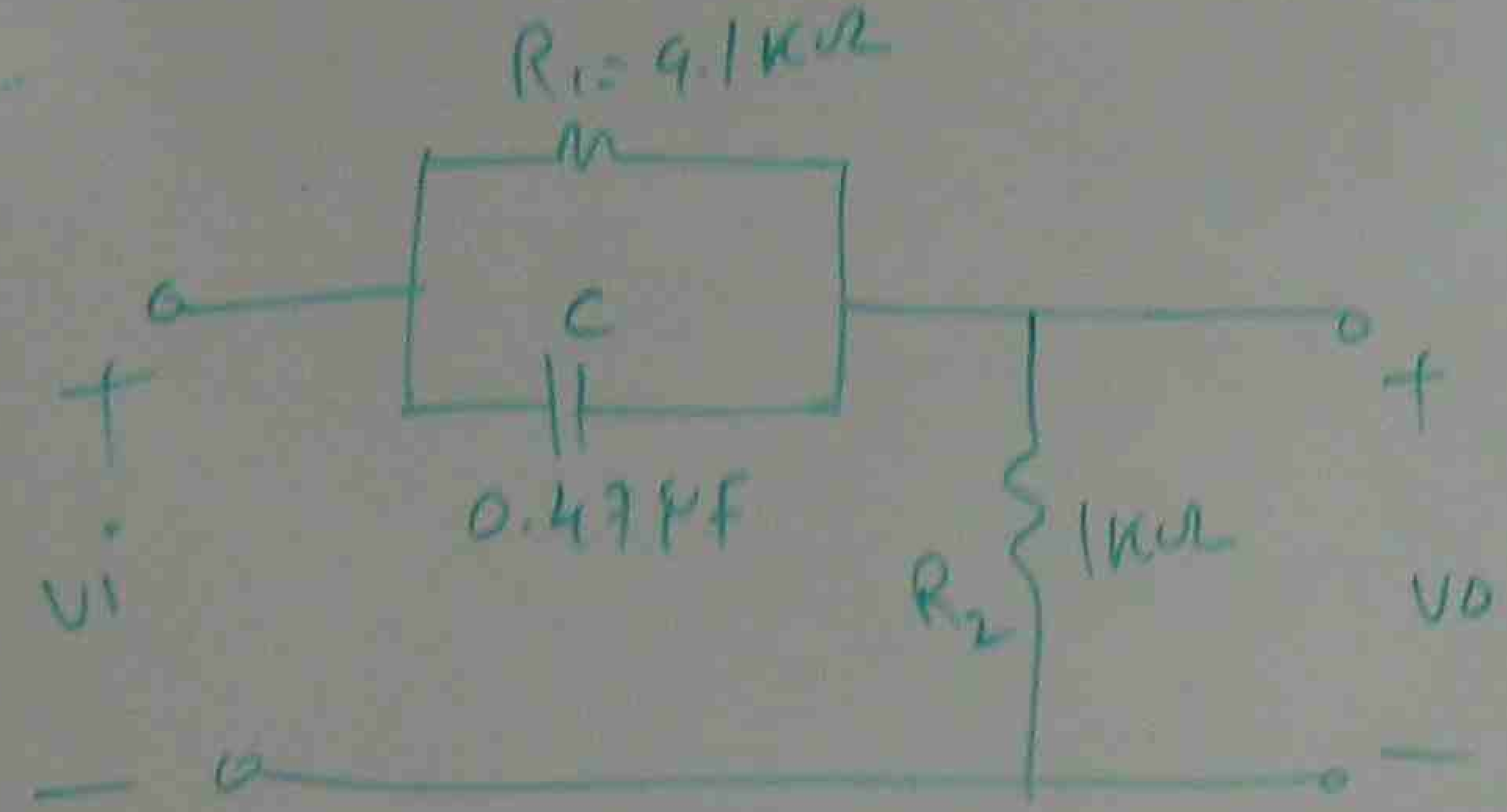
$$A_v = \frac{V_o}{V_i} = \frac{1 - j\,f_1/f}{1 - j\,f_c/f}$$

$$f_1 = \frac{1}{2\pi R_1 C}, \quad f_c = \frac{1}{2\pi (R_1 \| R_2) C}$$



$$\theta = -\tan^{-1}\frac{f_1}{f} + \tan^{-1}\frac{f_c}{f}$$

ph



FOR THE ABOVE CIRCUIT,

(A) SKETCH A_{vdB} vs f USING LOG SCALE

(B) SKETCH θ vs f USING LOG SCALE

HIGH PASS FILTER WITH LIMITED ATTENUATION

BREAK FREQUENCIES

$$f_1 = \frac{1}{2\pi R_1 C}$$

$$= \frac{1}{2 \times 3.1416 \times 9.1 \times \ldots}$$

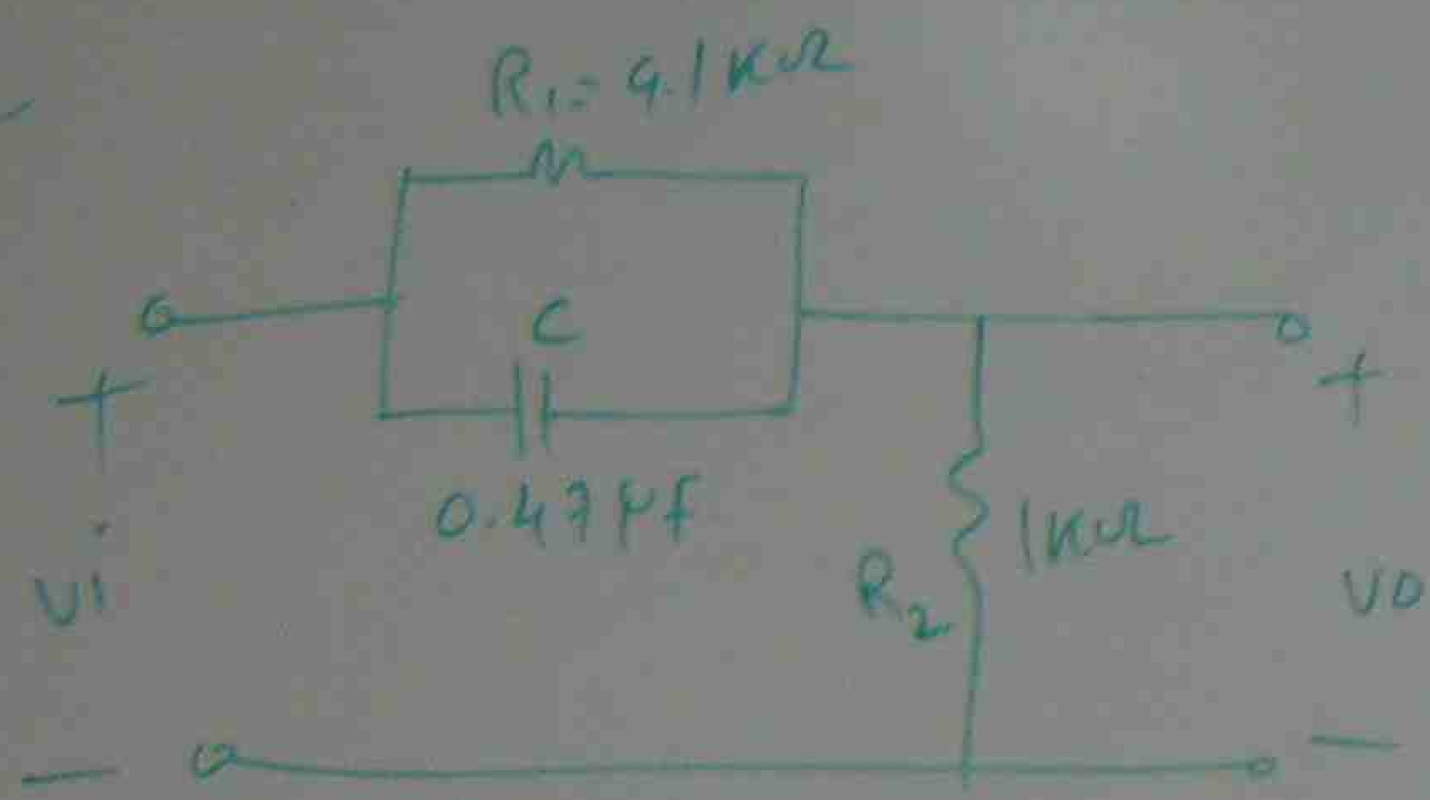
$$= 37.2\ HZ$$

$$f_c = \frac{1}{2\pi \frac{R_1 R_2}{R_1 + R_2} \ldots}$$

$$= \frac{1}{2 \times 3.1416 \times \frac{9.1 \times 10 \ldots}{9. \ldots}}$$

$$f_c = 376.25\ HZ$$

ph



FOR THE ABOVE CIRCUIT,

(A) SKETCH A_{vdB} vs f USING LOG SCALE

(B) SKETCH θ vs f USING LOG SCALE

HIGH PASS FILTER WITH LIMITED ATTENUATION

BREAK FREQUENCIES

$$f_1 = \frac{1}{2\pi R_1 C}$$

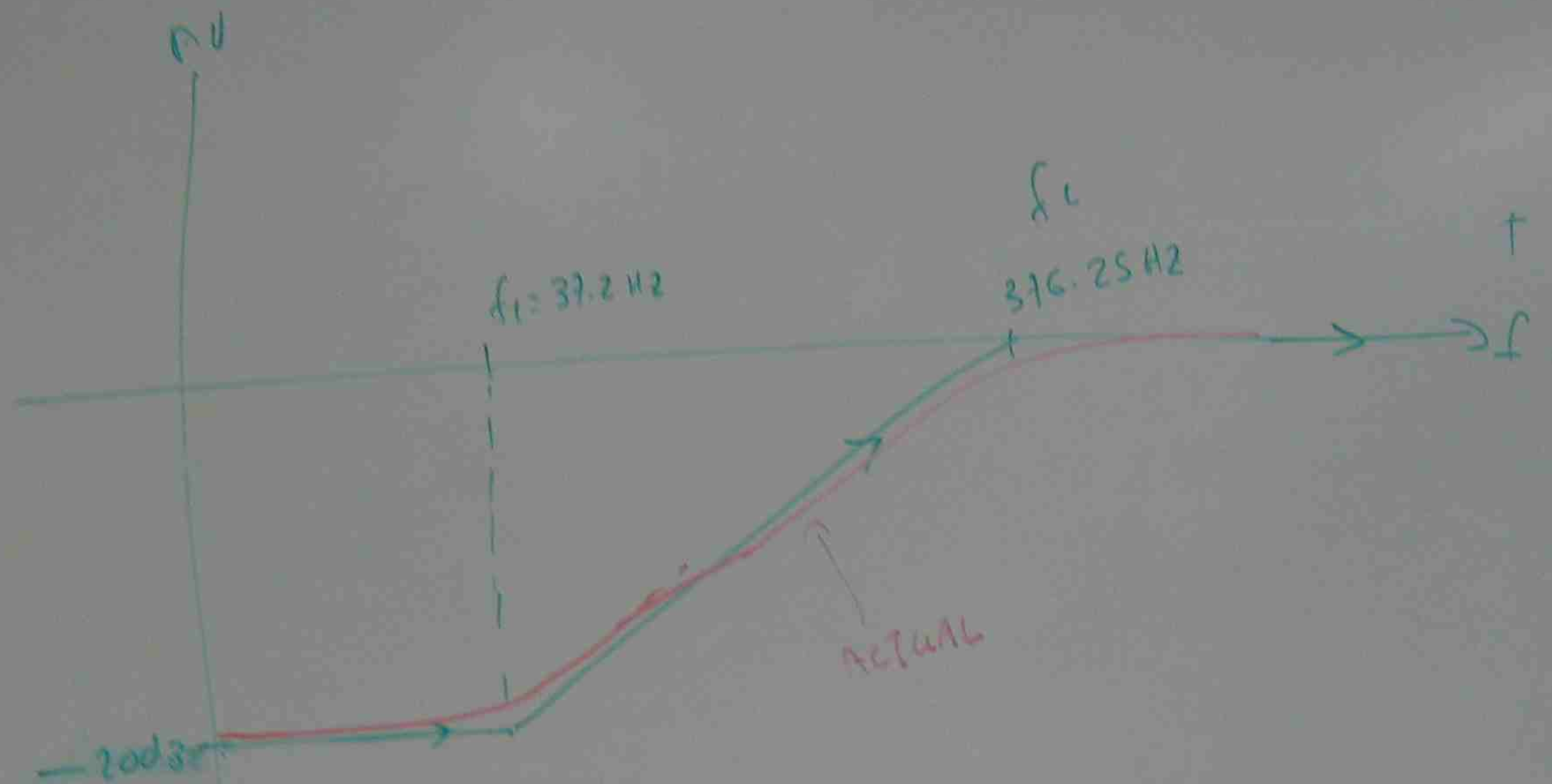
$$= \frac{1}{2 \times 3.1416 \times 9.1 \times 10^3 \times 0.47 \times 10^{-6}}$$

$$= 37.2\ HZ$$

$$f_c = \frac{1}{2\pi \frac{R_1 R_2}{R_1 + R_2} C}$$

$$= \frac{1}{2 \times 3.1416 \times \frac{9.1 \times 10^3 \times 1 \times 10^3}{9.1 \times 10^3 + 1 \times 10^3} \times 0.47 \times 10^{-6}}$$

$$f_c = 376.25\ HZ$$



MAXIMUM LEVEL ATTENUATION =

$$A_{V}\,dB = -20\log_{10}\frac{R_1+R_2}{R_2}$$

$$= -20\log_{10}\frac{9.1+1}{1}$$

$$= -20.09\ dB$$

$\times 10^3 \times 0.47\times10^{-6}$

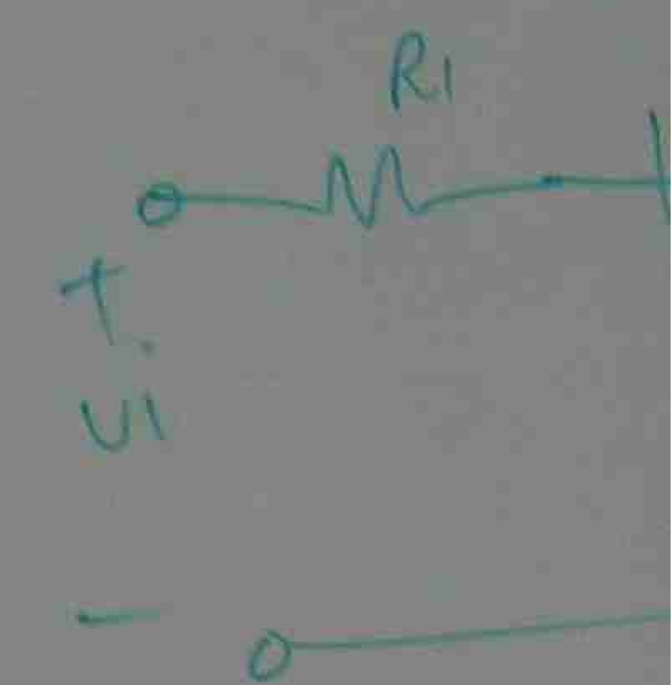
C

$\frac{10^3 \times 1\times10^3}{1\times10^3+1\times10^3} \times 0.47\times10^{-6}$

HIGH PAS

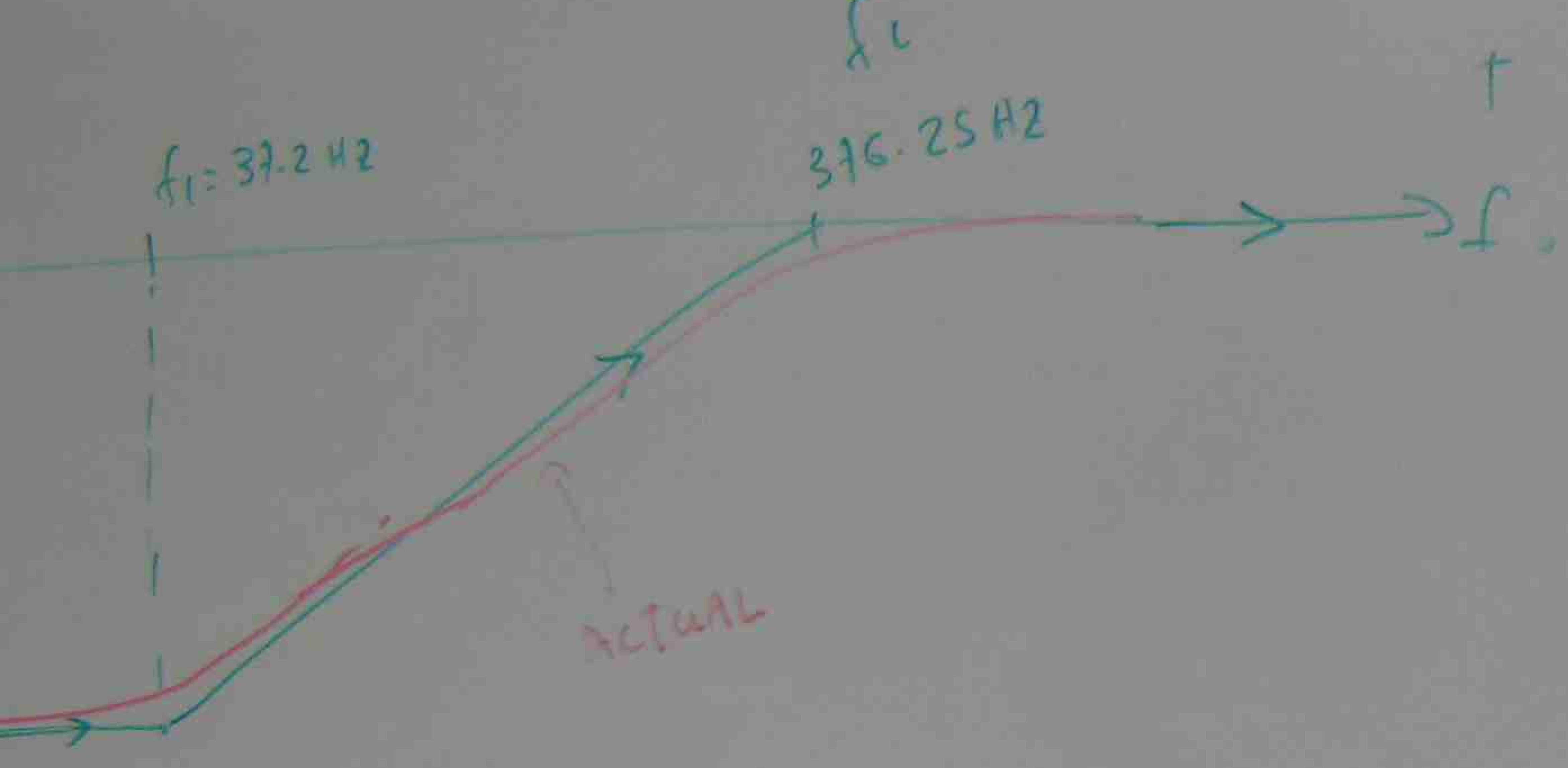
RESISTOR

ATTENUA



$$A_V = \frac{V_o}{V_i}$$

$$[A_V dB] = -$$



...mum level

...nuation =

$$A_{V\,dB} = -20\log_{10}\frac{R_1+R_2}{R_2}$$

$$= -20\log_{10}\frac{9.1+1}{1}$$

$$= -20.09\ dB$$

(b)

$$\theta = -\tan^{-1}\frac{f_1}{f} + \tan^{-1}\frac{f_c}{f}$$

$f = 37.2\ Hz$

$$\theta = -\tan^{-1}\frac{37.2}{37.2} + \tan^{-1}\frac{376.25}{37.2}$$

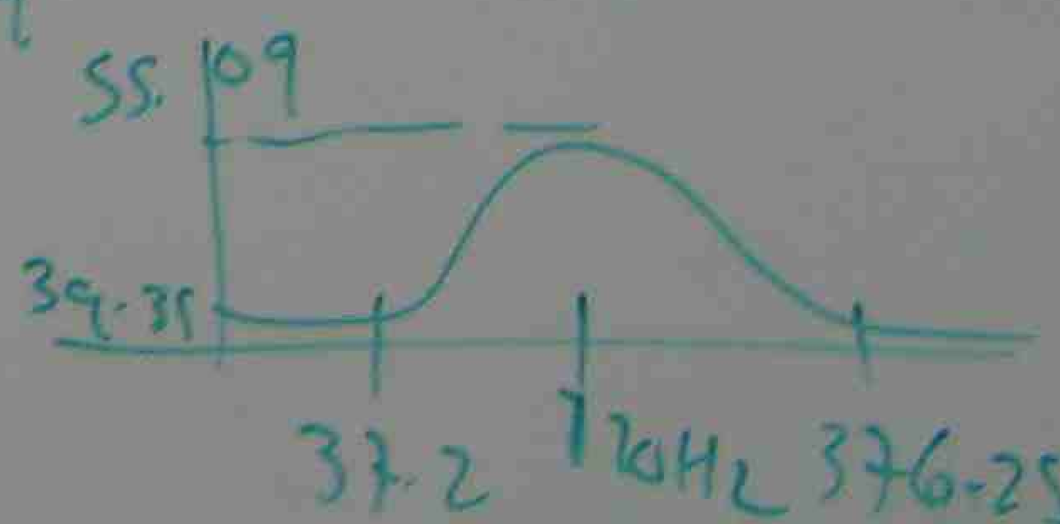
$$= 39.35^\circ$$

SELECT FREQUENCY BETWEEN f_1 & f_c

IF WE SELECT 120 HZ

$$\theta = -\tan^{-1}\frac{37.2}{120} + \tan^{-1}\frac{376.25}{120}$$

$$= 55.09^\circ$$



(b)

$$\theta = -\tan^{-1}\frac{f_1}{f} + \tan^{-1}\frac{f_c}{f}$$

$f = 37.2\ HZ$

$$\theta = -\tan^{-1}\frac{37.2}{37.2} + \tan^{-1}\frac{376.25}{37.2}$$

$$= 39.35^\circ$$

SELECT FREQUENCY BETWEEN f_1 & f_c

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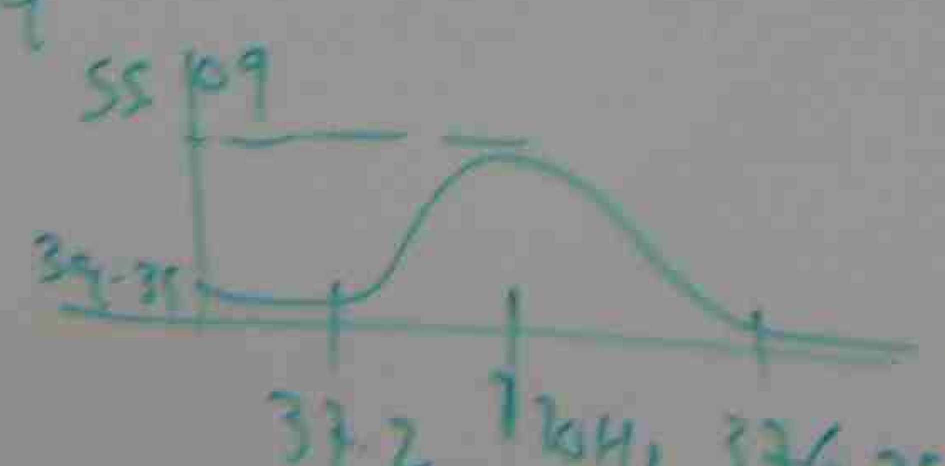
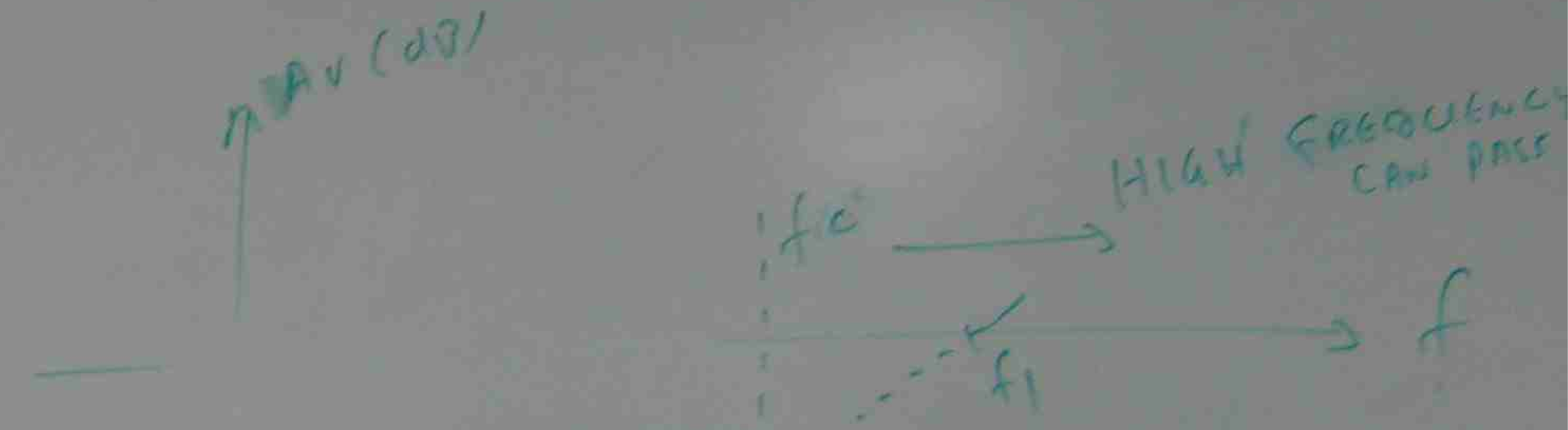




$f = 376.25$

$$\theta = -\tan^{-1}\frac{37.2}{37.2} + \tan^{-1}\frac{376.25}{37.2}$$

$$= 39.35$$

f_c

$376.25\,Hz$

(b)

$$\theta = -\tan^{-1}\frac{f_1}{f} + \tan^{-1}\frac{f_c}{f}$$

$f = 37.2\,Hz$

$$\theta = -\tan^{-1}\frac{37.2}{37.2} + \tan^{-1}\frac{376.25}{37.2}$$

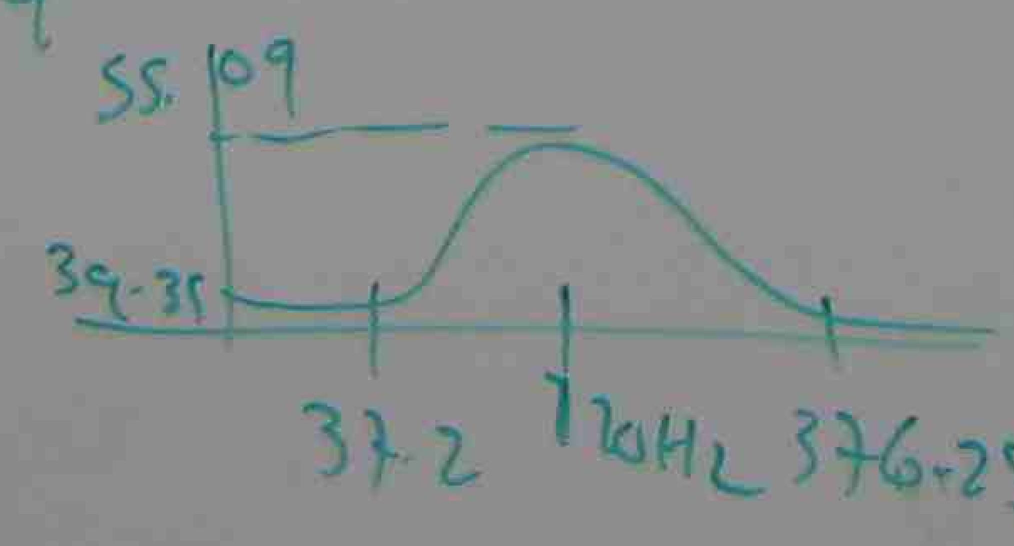
$$= 39.35^\circ$$

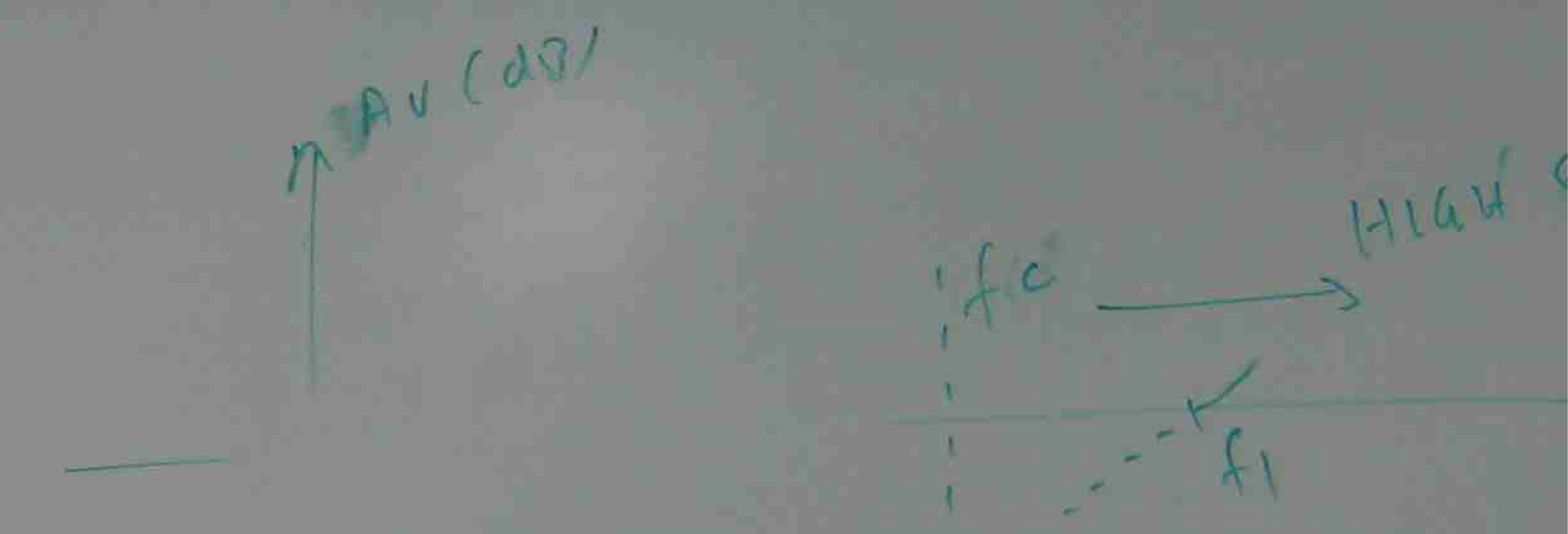
SELECT FREQUENCY BETWEEN f_1 & f_c

IF WE SELECT 120 HZ

$$\theta = -\tan^{-1}\frac{37.2}{120} + \tan^{-1}\frac{376.25}{120}$$

$$= 55.09^\circ$$





$f = 376.25$

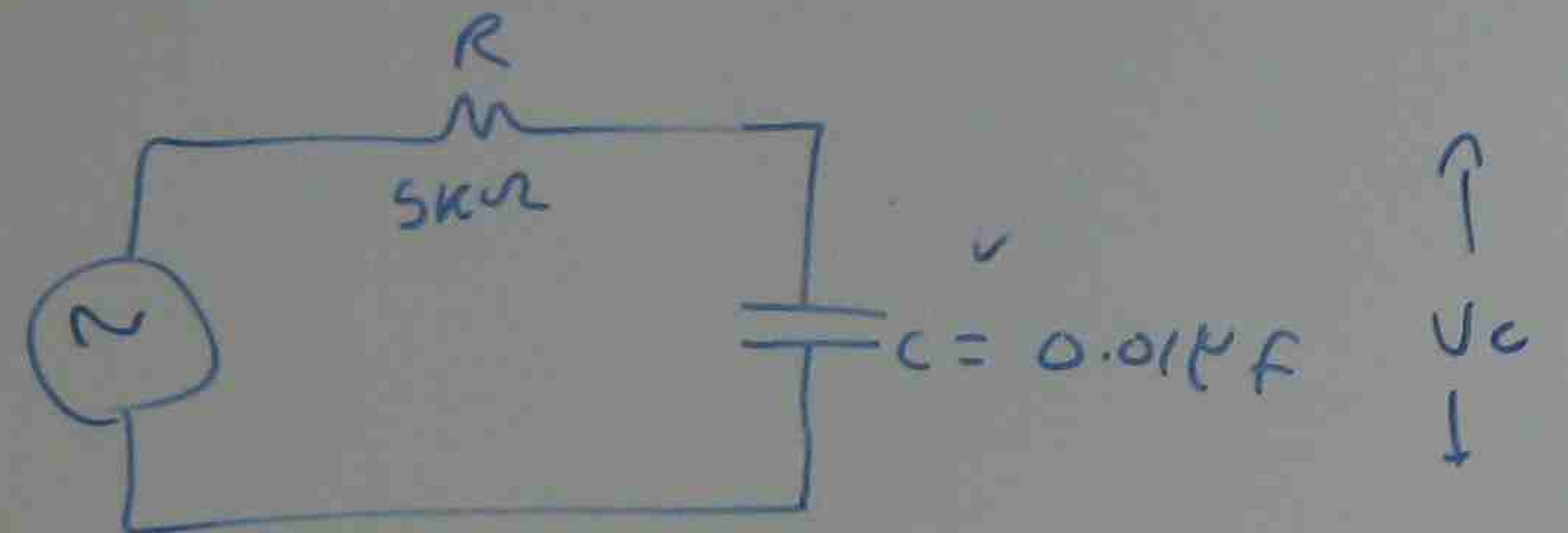
$$\theta = -\tan^{-1}\frac{37.2}{376.25} + \tan^{-1}\frac{376.25}{376.25}$$

$$= 39.35$$

FREQUENCY RESPONSE OF RC CIRCUIT

$E = 10\angle 0\,V$

$f = 0 \rightarrow 20\,kHz$



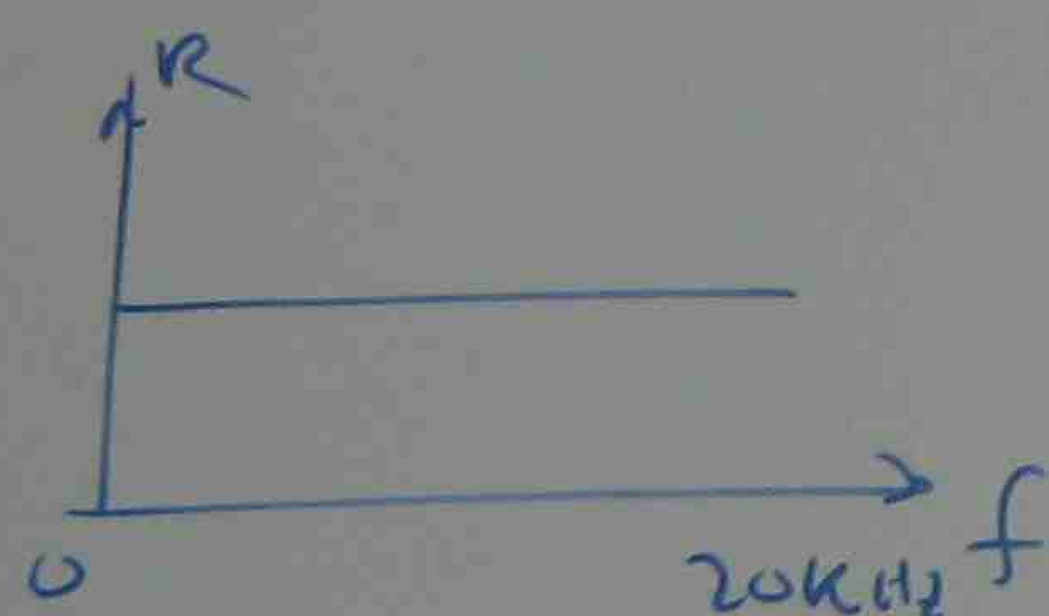
$$V_c = E \times \frac{X_C}{R + X_C}$$

$$= E \times \frac{-jX_C}{R + (-jX_C)}$$

$$= \frac{E \times (-jX_C)}{R - jX_C}$$

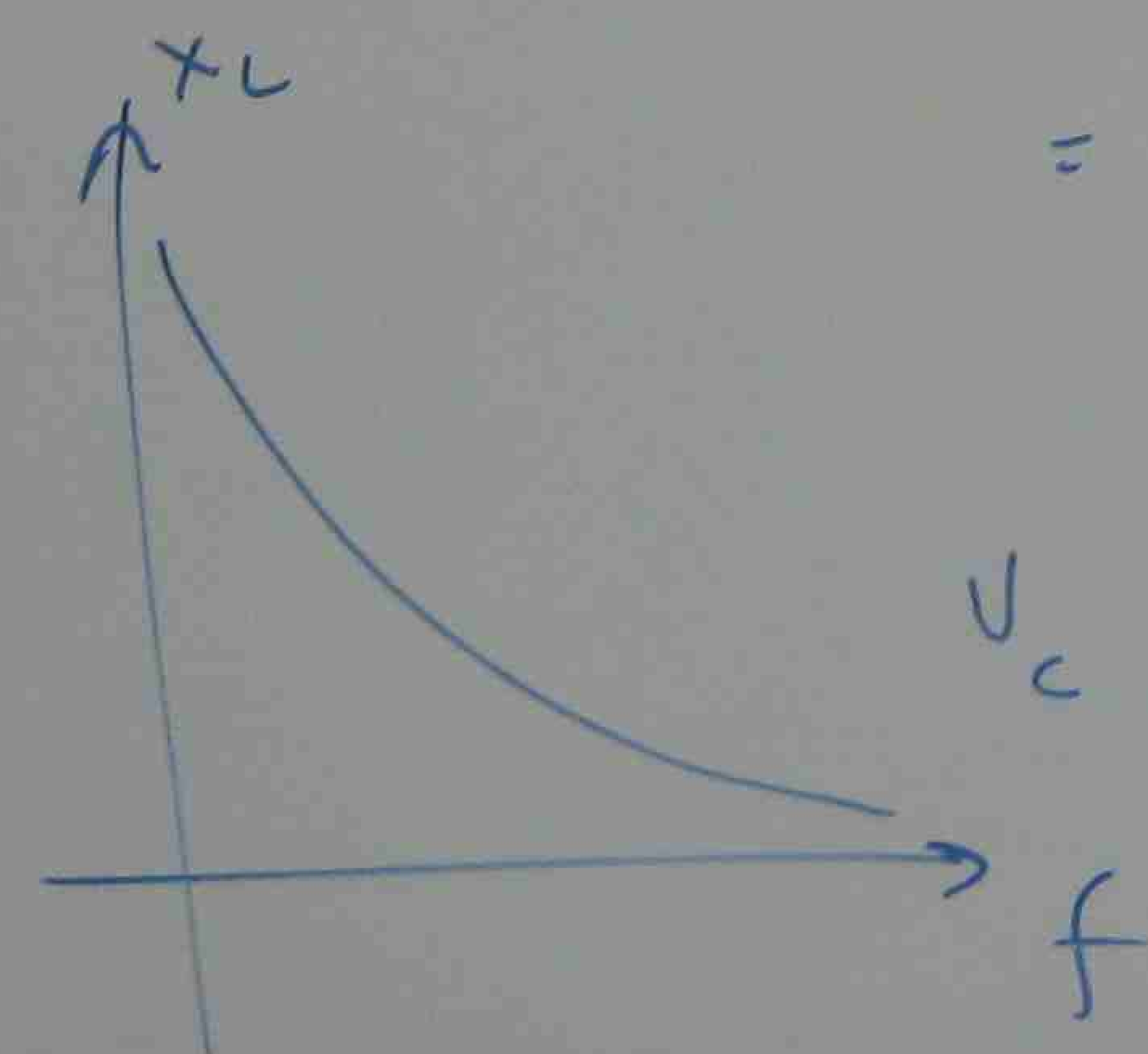
$$V_c = \frac{E \times X_C\angle -90}{\sqrt{R^2 + X_C^2}\ \angle -\tan^{-1}\frac{X_C}{R}}$$

$$\theta = -\tan^{-1}\frac{X_C}{R}$$

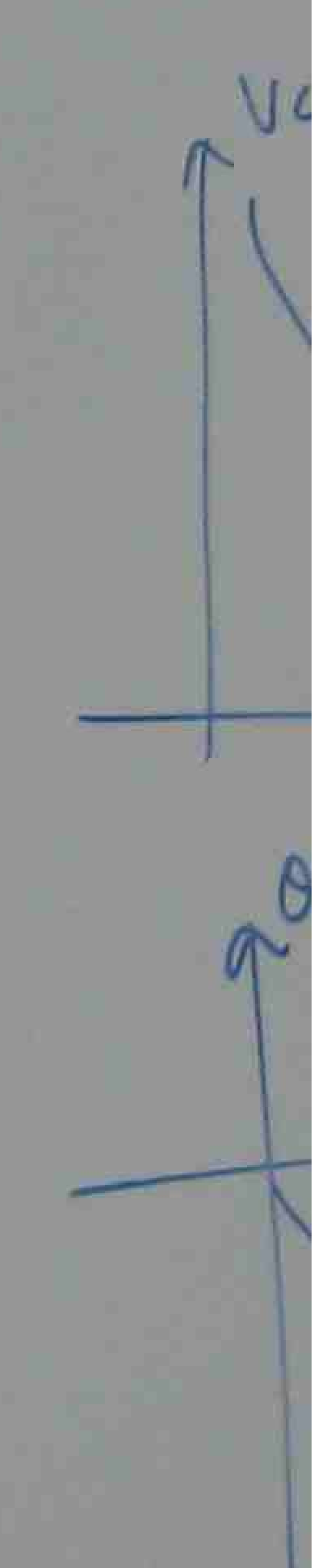


$$X_C = \frac{1}{2\pi f C}$$

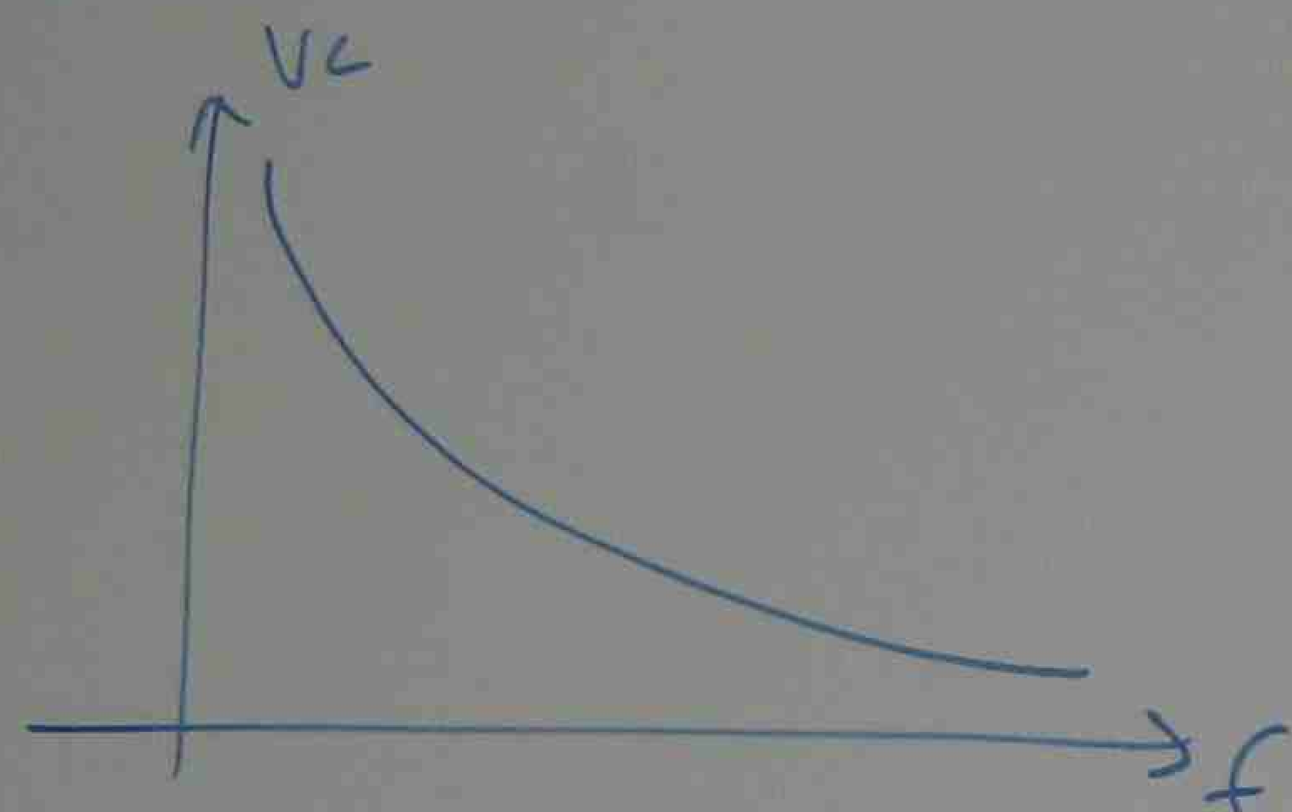
$f\uparrow \quad X_C\downarrow$

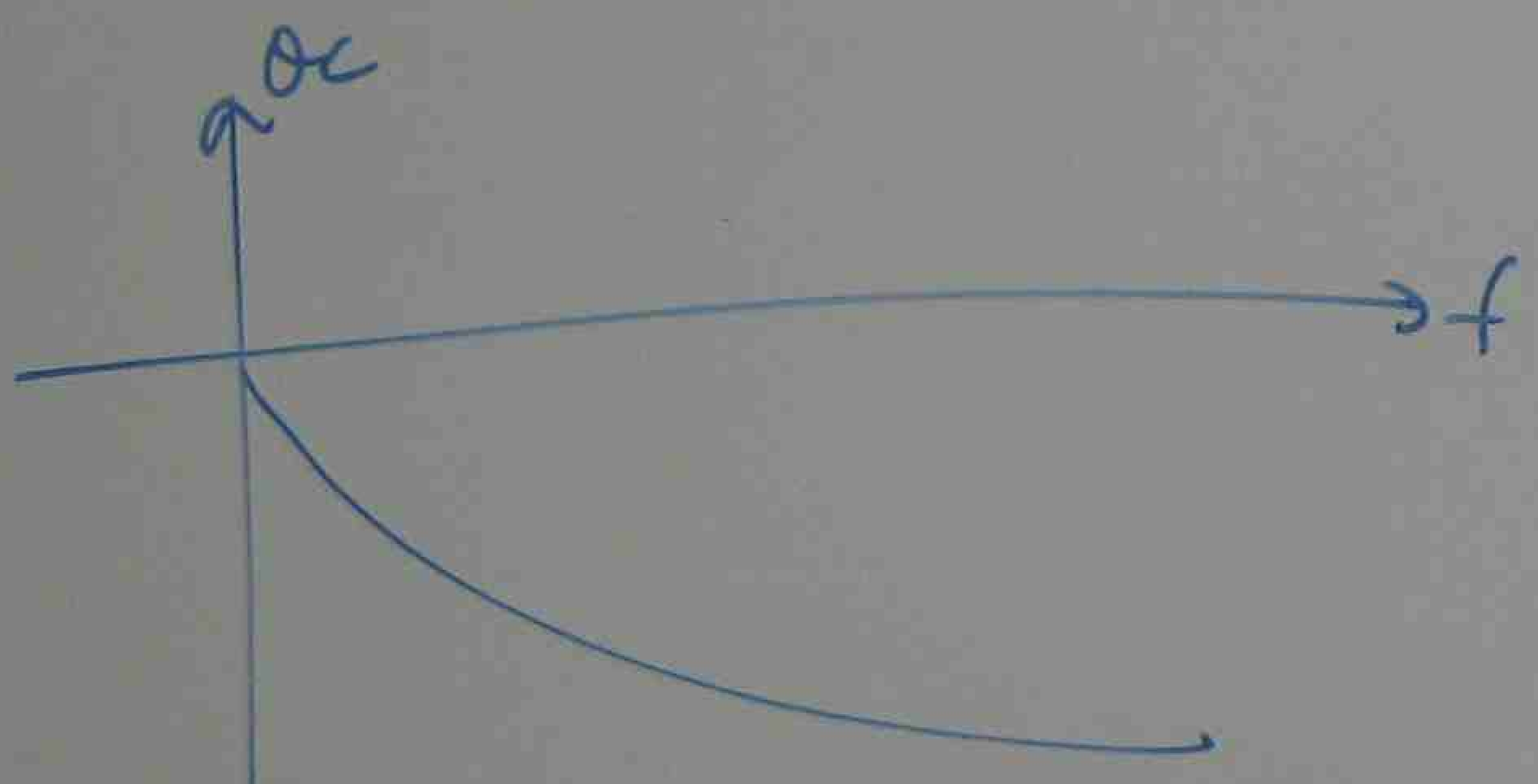


BY CHANG

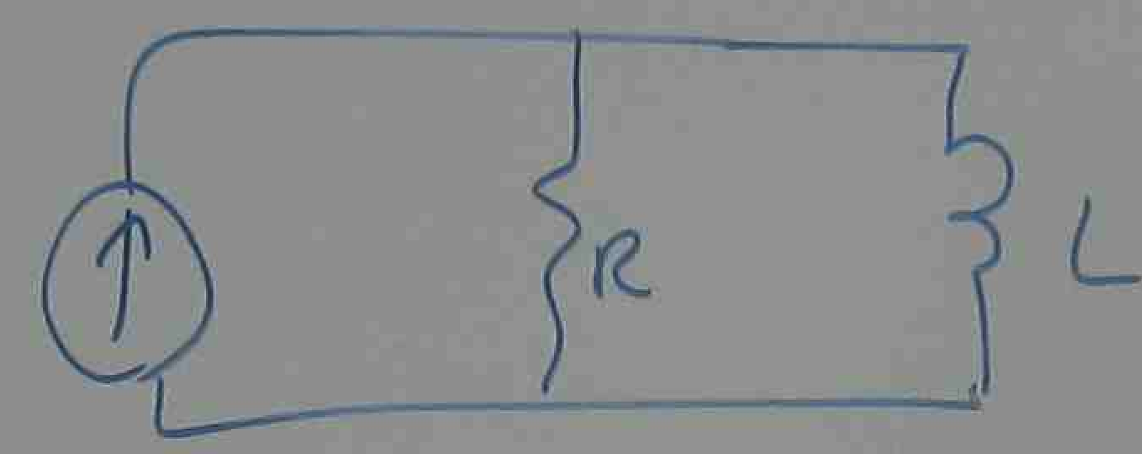


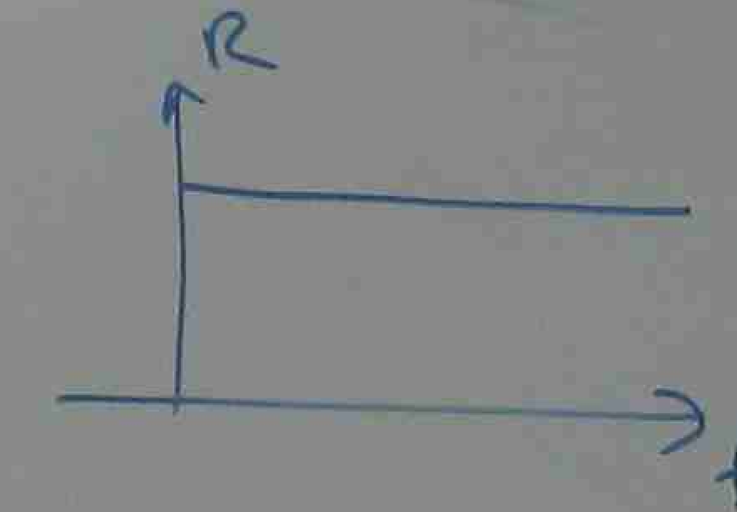
BY CHANGING "f", θ & V_C ALSO CHANGE

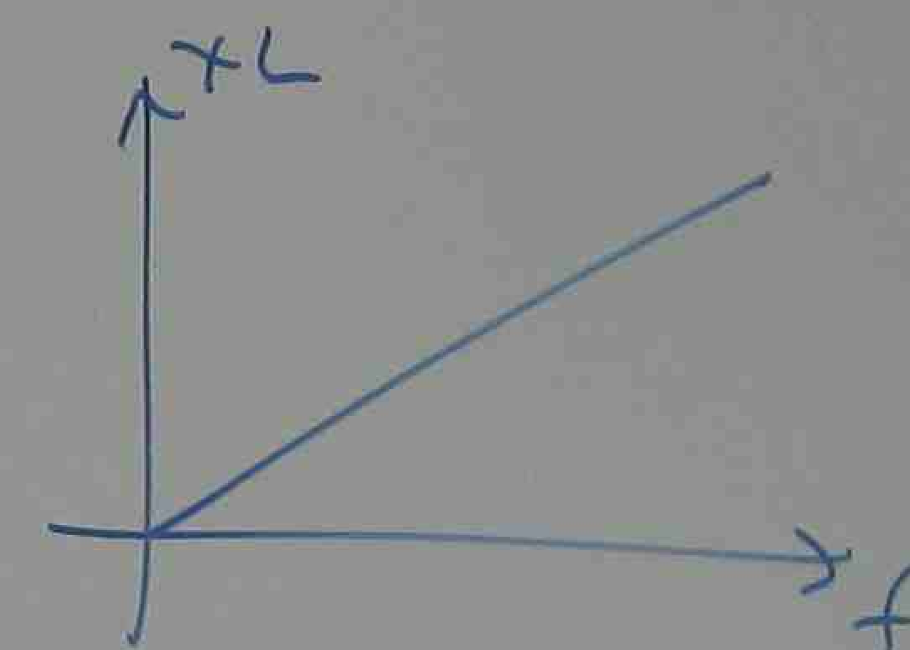




FREQUENCY RESPONSE of PARALLEL R-L NETWORK

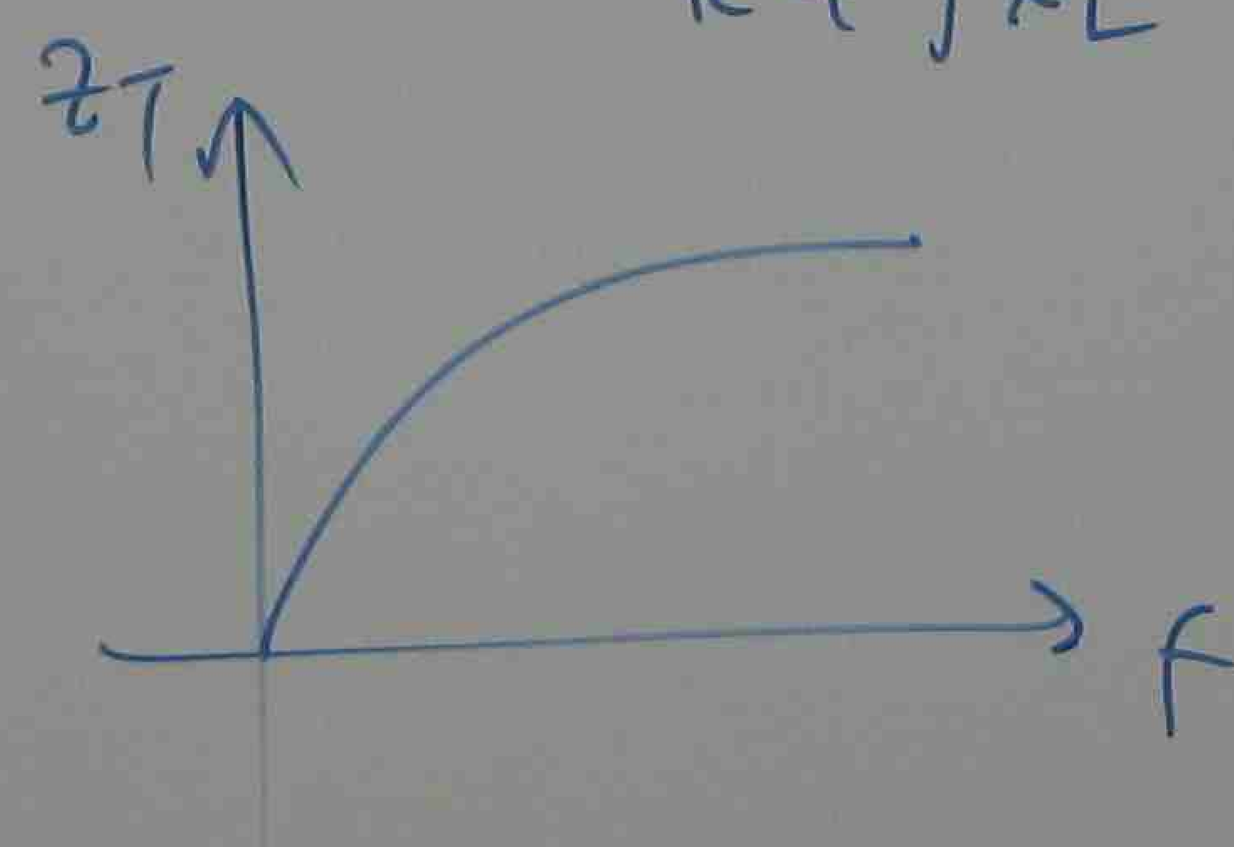


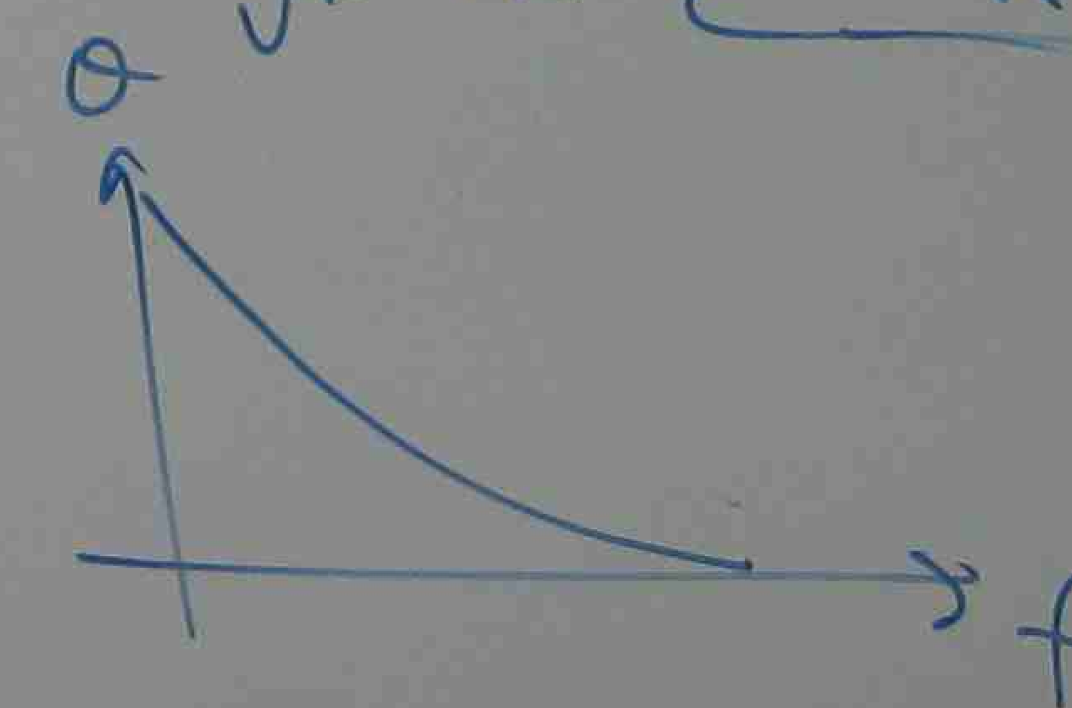




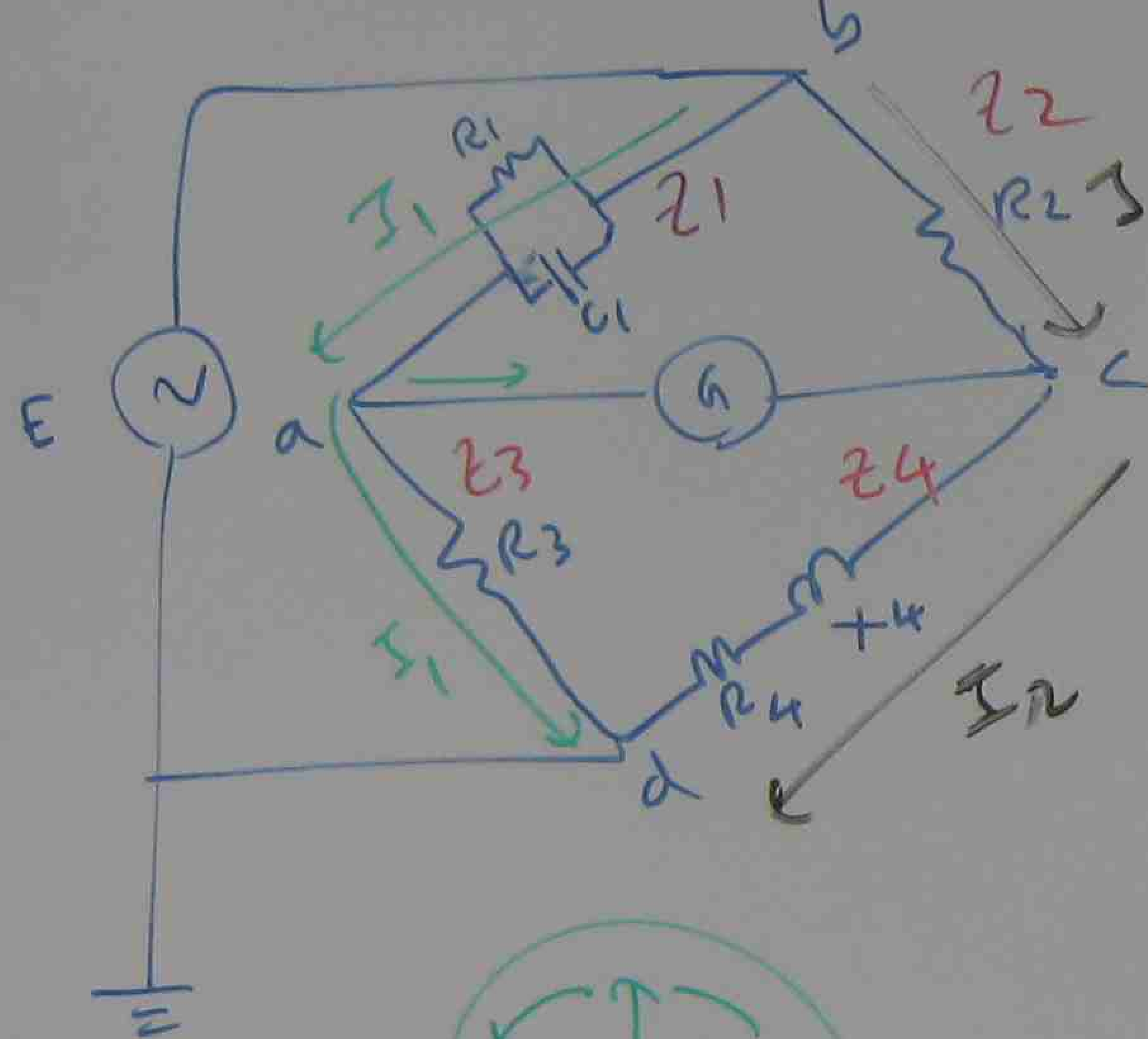
$X_L = 2\pi f L$

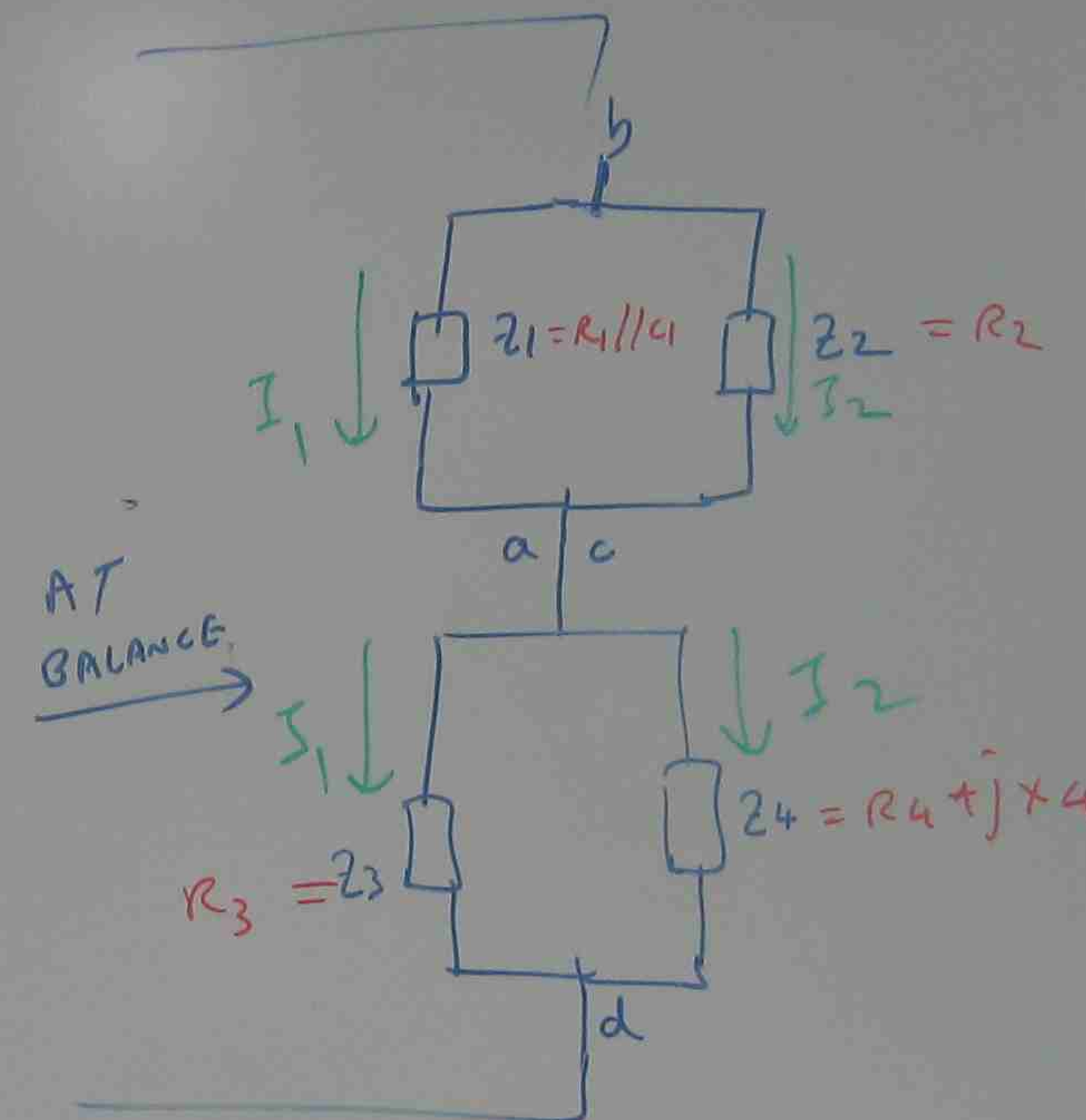
$$Z_T = \frac{R \times jX_L}{R + jX_L} = \frac{R \times X_L \angle +90}{\sqrt{R^2 + X_L^2} \angle \tan^{-1} \frac{X_L}{R}}$$





BRIDGE NETWORK (AC)





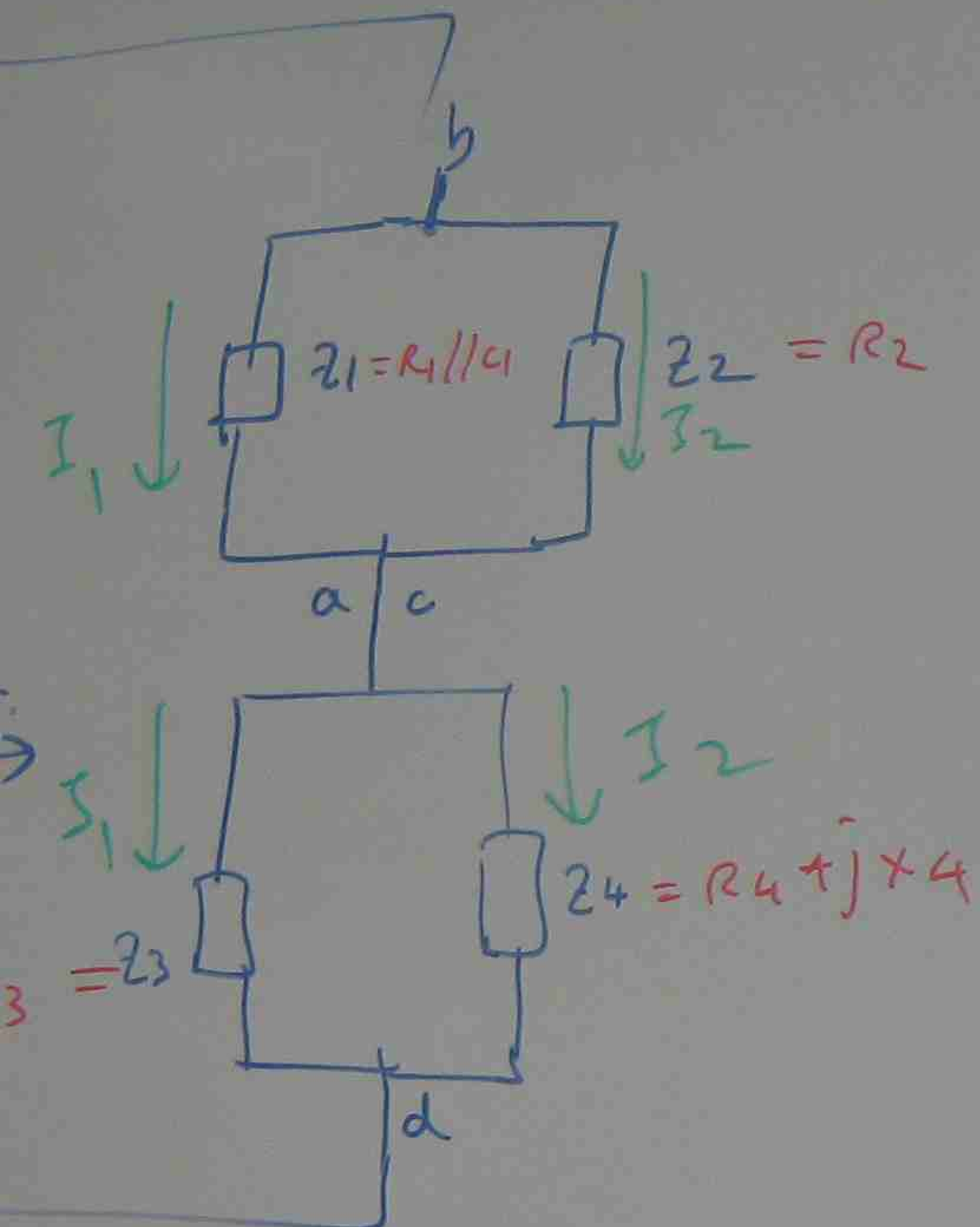
$$I_1 Z_1 = I_2 Z_2 \quad \text{--- (1)}$$

$$I_1 Z_3 = I_2 Z_4 \quad \text{--- (2)}$$

AT BALANCE

$$I_{ba} = I_{ad} = I_1$$

$$I_{bc} = I_{cd} = I_2$$



$I_1 Z_1 = I_2 Z_2$ — (1)

$I_1 Z_3 = I_2 Z_4$ — (2)

(1) ÷ (2) ⇒

$$\frac{I_1 Z_1}{I_1 Z_3} = \frac{I_2 Z_2}{I_2 Z_4}$$

$$\frac{Z_1}{Z_3} = \frac{Z_2}{Z_4}$$

$$Z_1 Z_4 = Z_2 Z_3$$

$$\frac{R_1 \times (-jX_{c1})}{R_1 + (-jX_{c1})} \times (R_4 + jX_4) = R_2 \times R_3$$

$$\frac{-jR_1 X_{c1}}{R_1 - jX_{c1}} (R_4 + jX_4) = R_2 \times R_3$$

$j = \sqrt{-1}$, $j^2 = -1$

$$\frac{-jR_1 X_{c1} R_4 + j^2 R_1 X}{R_1 - jX_{c1}}$$

$$\frac{-jR_1 R_4 X_{c1} + R_1}{R_1 - jX_{c1}}$$

$$\frac{R_1 X_{c1} X_4 - jR}{R_1 - jX_{c1}}$$

$$\frac{(R_1 X_{c1} X_4 - jR_1 R}{(R_1 - jX_{c1}}$$

$$\frac{R_1^2 X_{c1} X_4 - j}{R_1^2 + X}$$

$j=\sqrt{-1}$, $j^2=-1$

$$\frac{-jR_1 X_{c1} R_4 + j^2 R_1 X_{c1} X_4}{R_1 - jX_{c1}} = R_2 R_3$$

$$\frac{-jR_1 R_4 X_{c1} + R_1 X_{c1} X_4}{R_1 - jX_{c1}} = R_2 R_3$$

$$\frac{R_1 X_{c1} X_4 - jR_1 R_4 X_{c1}}{R_1 - jX_{c1}} = R_2 R_3$$

$$\frac{(R_1 X_{c1} X_4 - jR_1 R_4 X_{c1})(R_1 + jX_{c1})}{(R_1 - jX_{c1})(R_1 + jX_{c1})} = R_2 R_3$$

$$\frac{R_1^2 X_{c1} X_4 - jR_1^2 R_4 X_{c1} + jR_1 X_{c1}^2 X_4 + R_1 R_4 X_{c1}^2}{R_1^2 + X_{c1}^2} = R_2 R_3$$

$$\frac{R_1^2 X_{c1} X_4 + R_1 R_4 X_{c1}^2}{R_1^2 + X_{c1}^2} + j\frac{R_1 X_{c1}^2 X_4 - R_1^2 R_4 X_{c1}}{R_1^2 + X_{c1}^2} = R_2 R_3$$

$$\frac{R_1^2 X_{c1} X_4 + R_1 R_4 X_{c1}^2}{R_1^2 + X_{c1}^2} = R_2 R_3$$

$$\frac{R_1 X_{c1}^2 X_4 - R_1^2 R_4 X_{c1}}{R_1^2 + X_{c1}^2} = 0$$

$\times R_3$

$j=\sqrt{-1}\ ,\ j^2=-1$

$$\frac{-jR_1x_{c_1}R_4+j^2R_1x_{c_1}x_4}{R_1-jx_4}=R_2R_3$$

$$\frac{-jR_1R_4x_{c_1}+R_1x_{c_1}x_4}{R_1-jx_4}=R_2R_3$$

$$\frac{R_1x_{c_1}x_4-jR_1R_4x_{c_1}}{R_1-jx_{c_1}}=R_2R_3$$

$$\frac{(R_1x_{c_1}x_4-jR_1R_4x_{c_1})(R_1+jx_{c_1})}{(R_1-jx_{c_1})(R_1+jx_{c_1})}=R_2R_3$$

$$\frac{R_1^2x_{c_1}x_4-jR_1^2R_4x_{c_1}+jR_1x_{c_1}^2x_4+R_1R_4x_{c_1}^2}{R_1^2+x_{c_1}^2}=R_2R_3$$

$$\frac{R_1^2x_{c_1}x_4+R_1R_4x_{c_1}^2}{R_1^2+x_{c_1}^2}+j\frac{R_1x_{c_1}^2x_4-R_1^2R_4x_{c_1}}{R_1^2+x_{c_1}^2}=R_2R_3$$

$$\frac{R_1^2x_{c_1}x_4+R_1R_4x_{c_1}^2}{R_1^2+x_{c_1}^2}=R_2R_3$$

$$\frac{R_1x_{c_1}^2x_4-R_1^2R_4x_{c_1}}{R_1^2+x_{c_1}^2}=0$$

$R_1x_{c_1}^2x_4-R_1^2R_4x_{c_1}=0$

$R_1x_{c_1}^2x_4=R_1^2R_4x_{c_1}$

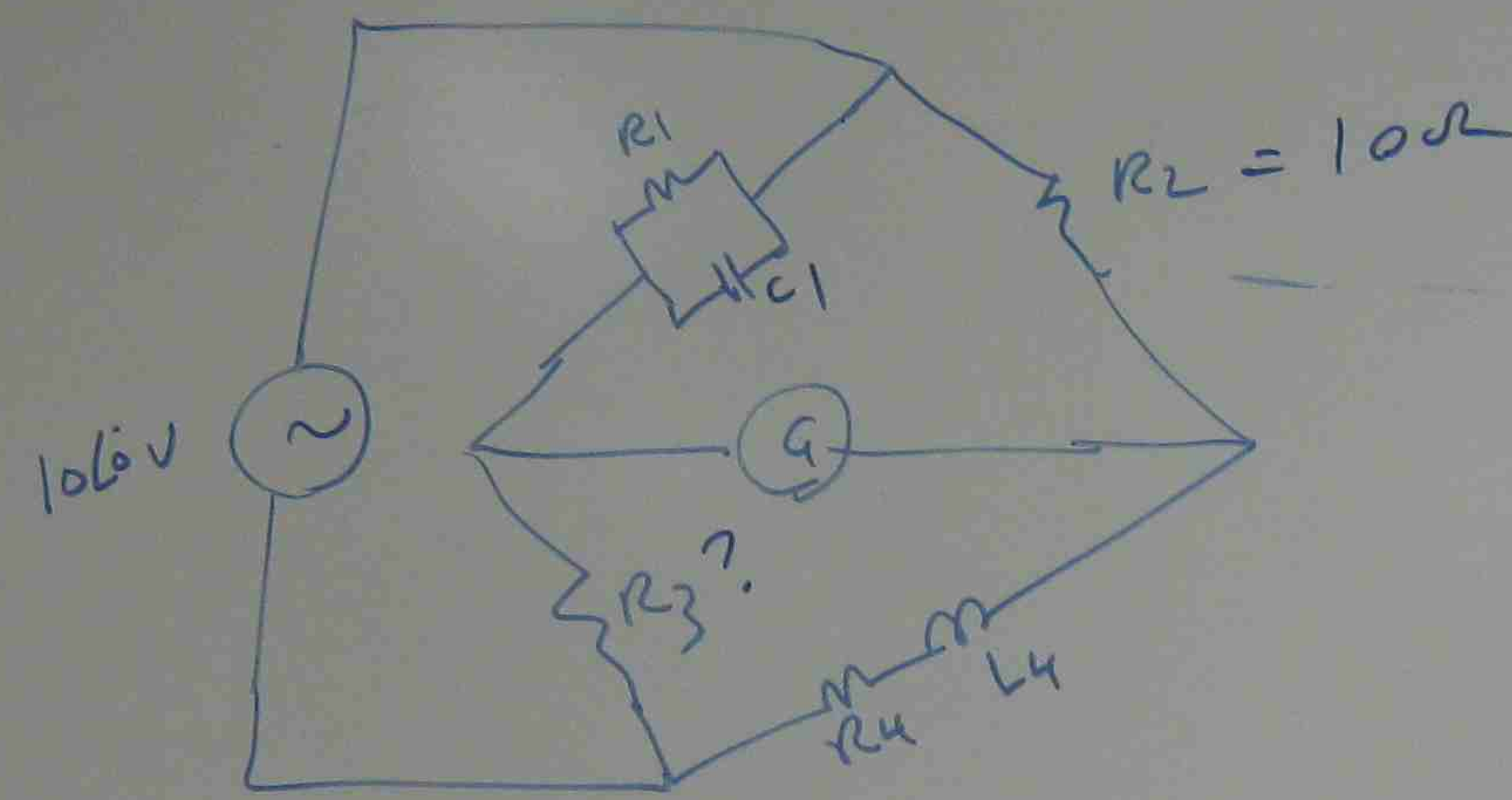
$x_{c_1}x_4=R_1R_4$

#

$\ldots x R_3$

$=R_2 \times R_3$

(b)



IF THE ABOVE CIRCUIT IS BALANCED

& $R_1 = 3\Omega$, $R_4 = 2\Omega$

$X_4 = j5\Omega$ FIND X_{C1}

ALSO FIND R_3

BALANCED

$X_{C1} \times X$

$X_{C1} \times j5$

$X_{C1} \times j5 =$

$X_{C1} = \frac{}{j}$

$R_1^2 X_{C1} X_4$

R_1^2

$3^2 \times 1.2$

3

$(9 \times 1.$

$= 10\Omega$

IS BALANCED

$= 2\Omega$

D X_{C1}

BALANCED

$X_{C1} \times X_4 = R_1 \times R_4$

$X_{C1} \times j5 = 3 \times 2$

$X_{C1} \times j5 = 6$

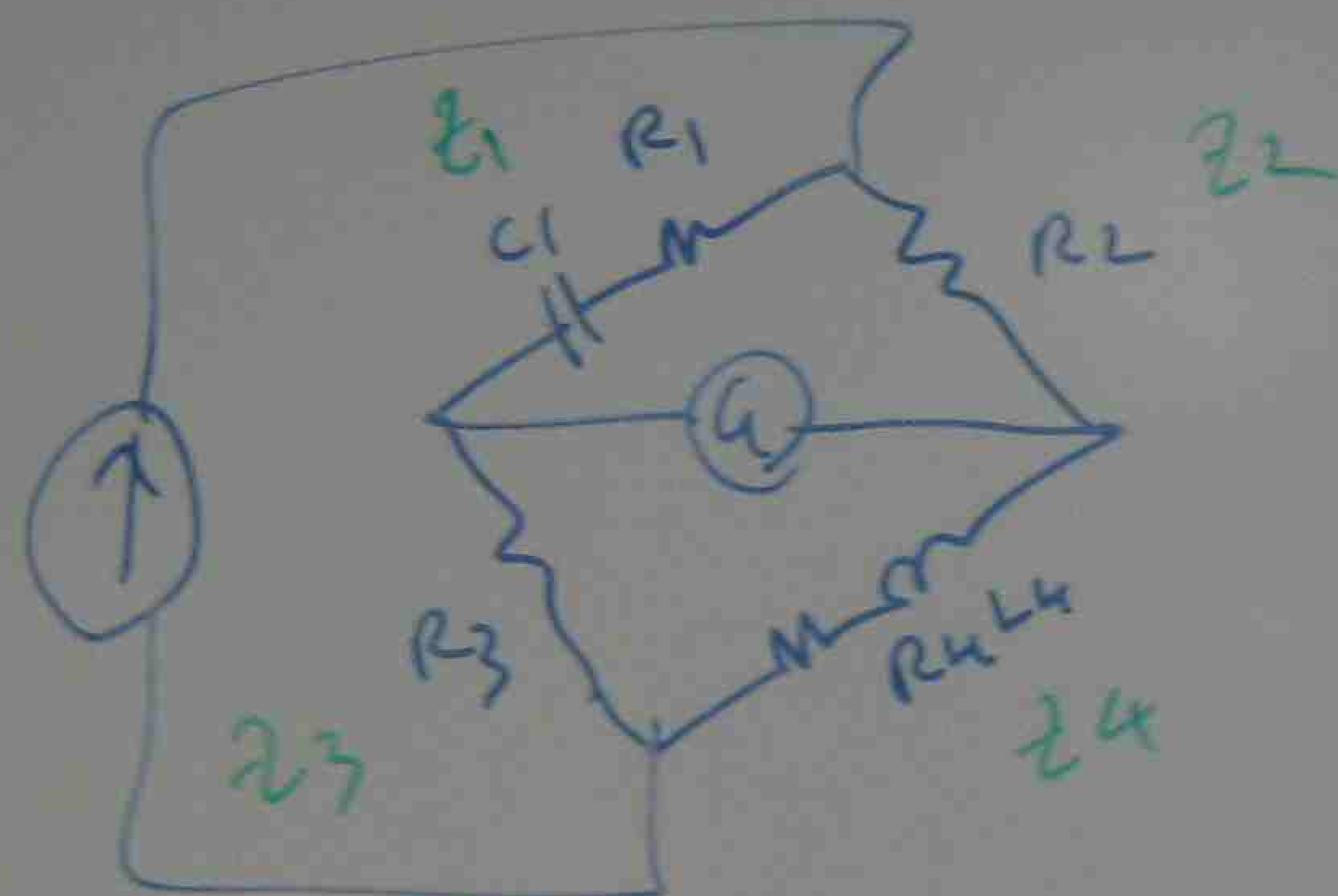
$X_{C1} = \frac{6}{j5} = -j1.2\Omega$

$$\frac{R_1^2 X_{C1} X_4 + R_1 R_4 X_{C1}^2}{R_1^2 + X_{C1}^2} = R_2 R_3$$

$$\frac{3^2 \times 1.2 \times 5 + 3 \times 2 \times 1.2^2}{3^2 + (1.2)^2} = 10 \times R_3$$

$$\left(\frac{9 \times 1.2 \times 5 + 3 \times 2 \times 1.44}{9 + 1.44}\right) \times \frac{1}{10} = R_3$$

$R_3 = 0.6\Omega$



FIND THE EQUATIONS FOR ABOVE BALANCED BRIDGE

$$Z_1 = R_1 - jX_{C1}$$

$$Z_2 = R_2$$

$$Z_3 = R_3$$

$$Z_4 = R_4 + jX_{L4}$$

$$Z_1 Z_4 = Z_2 Z_3$$

$$(R_1 - jX_{C1})(R_4 + jX_{L4}) = R_2 R_3$$

$$R_1R_4 - jX_{C1}R_4 + jR_1X_{L4} + X_{C1}X_{L4} = R_2R_3$$

$$R_1R_4 + X_{C1}X_{L4} + j(R_1X_{L4} - R_4X_{C1}) = R_2R_3$$

EQUATE REAL & J TERMS

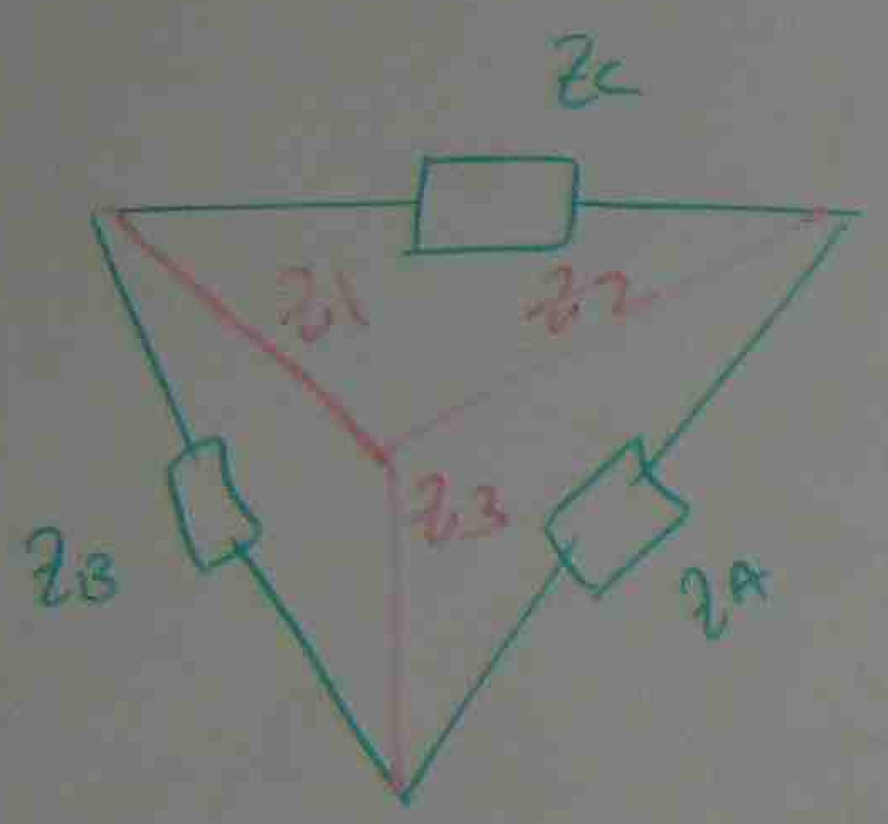
$$R_1R_4 + X_{C1}X_{L4} = R_2R_3 \quad \text{— } 1$$

$$j(R_1X_{L4} - R_4X_{C1}) = 0$$

$$R_1X_{L4} - R_4X_{C1} = 0$$

$$R_1X_{L4} = R_4X_{C1} \quad \text{— } 2$$

STAR / DELTA & DELTA / STAR CONVERSION



$\Delta \longrightarrow \curlyvee$

$$Z_1 = \frac{Z_B \; Z_C}{Z_A + Z_B + Z_C}$$

$$Z_2 = \frac{Z_A \; Z_C}{Z_A + Z_B + Z_C}$$

$$Z_3 = \frac{Z_A \; Z_B}{Z_A + Z_B + Z_C}$$

$\curlyvee \longrightarrow \Delta$

$$Z_A = \frac{Z_1 Z_2 + Z_2 Z_3 + Z_3 Z_1}{Z_1}$$

$$Z_B = \frac{Z_1 Z_2 + Z_2 Z_3 + Z_3 Z_1}{Z_2}$$

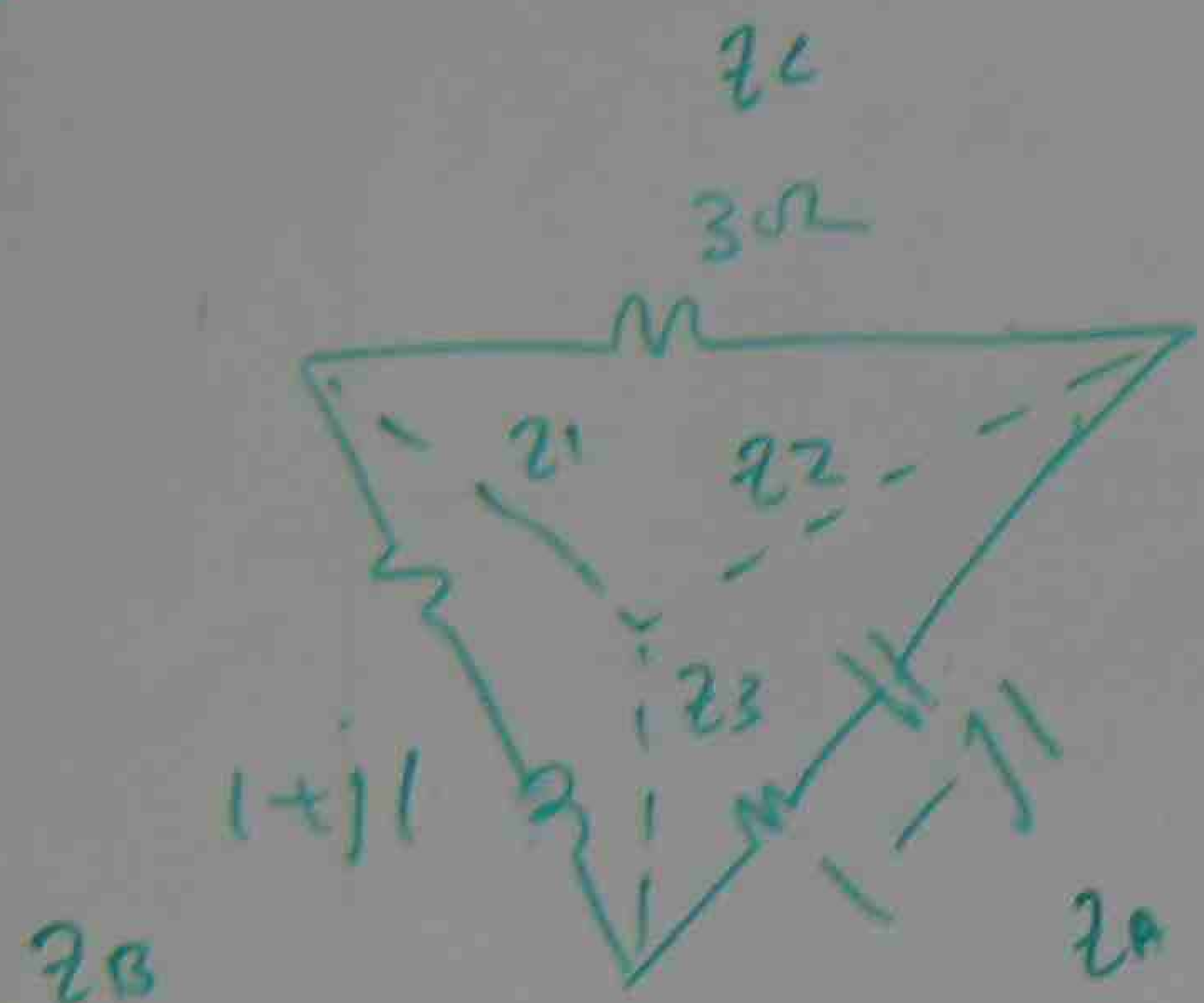
$$Z_C = \frac{Z_1 Z_2 + Z_2 Z_3 + Z_3 Z_1}{Z_3}$$

Z_1

Z_1

$3 Z_1$

P) CONVERT Δ TO λ FOR GIVEN CIRCUIT



$$Z_1 = \frac{Z_B Z_C}{Z_A + Z_B + Z_C} = \frac{(1+j1) \times 3}{1-j1+1+j1+3} = \frac{3+j3}{5}$$

$$= 0.6 + j0.6$$

$$Z_2 = \frac{Z_A Z_C}{Z_A + Z_B + Z_C} = \frac{(1-j1)\ 3}{1-j1+1+j1+3} = \frac{3-j3}{5}$$

$$= 0.6 - j0.$$

$$Z_3 = \frac{Z_A Z_B}{Z_A + Z_B + Z_C} = \frac{(1-j1)(1+j1)}{1-j1+1+j1+3}$$

$$= \frac{1 - j1 + j1 \times 1 - j1 \times j1}{5}$$

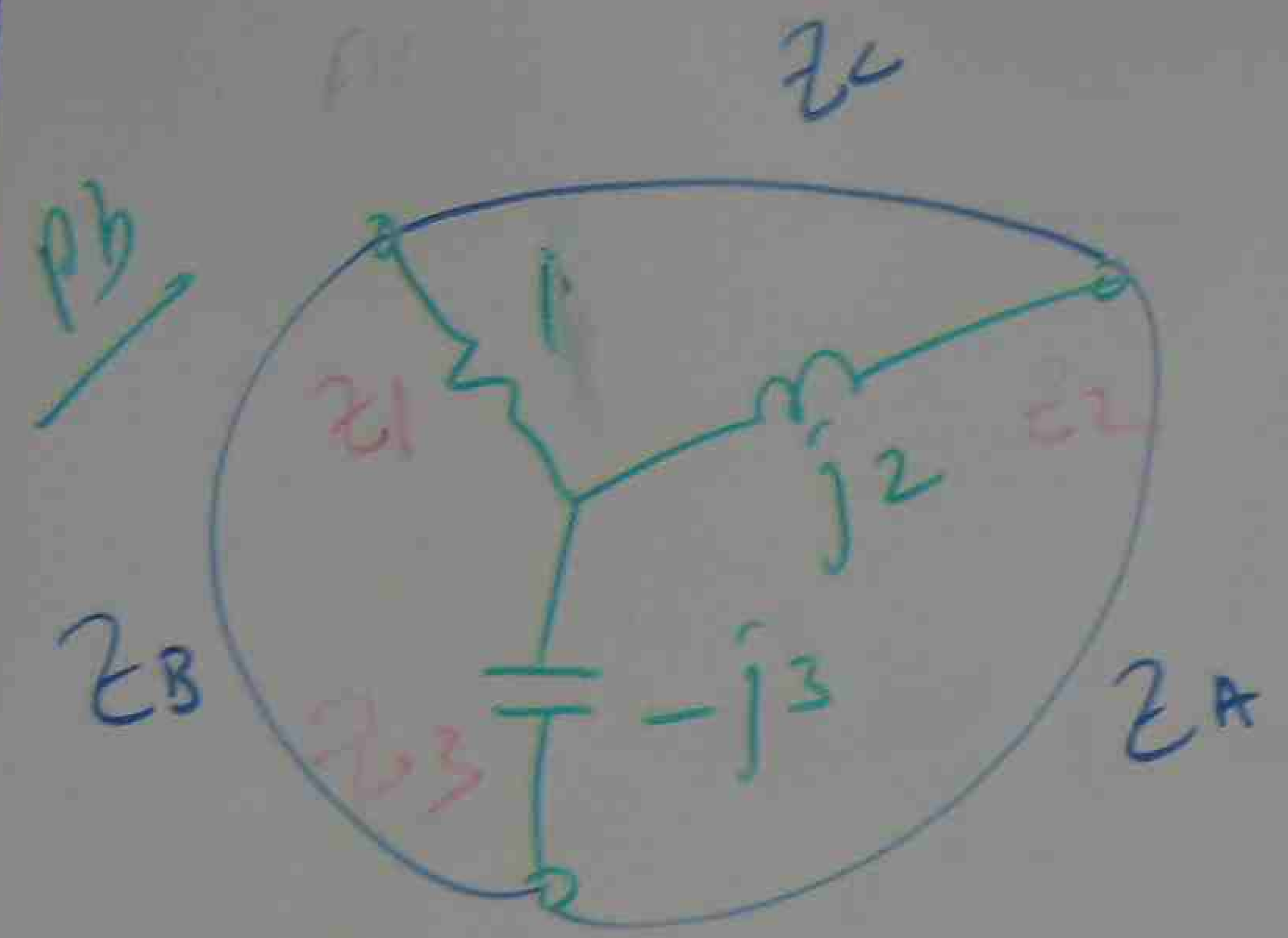
$$= \frac{1 - j1 + j1 - (-1)}{5}$$

$$= \frac{1+1}{5} = \frac{2}{5} = 0.4\Omega$$

$j = \sqrt{-1}$

$j \times j = \sqrt{-1} \times \sqrt{-1}$

$= -1$



FIND Δ EQUIVALENT OF ABOVE CIRCUIT

$$Z_A = \frac{Z_1 Z_2 + Z_2 Z_3 + Z_3 Z_1}{Z_1}$$

$$= \frac{1 \times j2 + j2 \times (-j3) + (-j3) \times 1}{1}$$

$$= \frac{j2 - (-1)6 - j3}{}$$

$$= j2 + 6 - j3$$

$$= 6 - j1$$

$$Z_B = \frac{Z_1 Z_2 + Z_2 Z_3 + Z_3 Z_1}{Z_2}$$

$$= \frac{1 \times j2 + j2(-j3) + (-j3) \times 1}{j2}$$

$$= \frac{6 - j1}{j2}$$

$$= \frac{6}{j2} - \frac{j1}{j2}$$

$$= \frac{6}{j2} \times \frac{j}{j} - \frac{1}{2}$$

$$= \frac{j6}{-2} - \frac{1}{2}$$

$$= -j3 - \frac{1}{2} = -\frac{1}{2} - j3$$

Z

$$Z_B = \frac{z_1 z_2 + z_2 z_3 + z_3 z_1}{z_2}$$

$$= \frac{1 \times j2 + j2(-j3) + (-j3) \times 1}{j2}$$

$$= \frac{6 - j1}{j2}$$

$$= \frac{6}{j2} - \frac{j1}{j2}$$

$$= \frac{6}{j2} \times \frac{j}{j} - \frac{1}{2}$$

$$= \frac{j6}{-2} - \frac{1}{2}$$

$$= -j3 - \frac{1}{2} = -\frac{1}{2} - j3$$

$$Z_C = \frac{z_1 z_2 + z_2 z_3 + z_3 z_1}{z_3}$$

$$= \frac{6 - j1}{-j3}$$

$$= \frac{6}{-j3} - \frac{j1}{-j3}$$

$$= -\frac{2}{j} + \frac{1}{3}$$

$$= -\frac{2}{j} \times \frac{j}{j} + \frac{1}{3}$$

$$= \frac{-j2}{-1} + \frac{1}{3}$$

$$= j2 + \frac{1}{3}$$

$$= \frac{1}{3} + j2$$

SYSTEM ANALYSIS

TWO PORTS NETWORKS

IMPEDANCE PARAMETER

Z - PARAMETER

ADMITTANCE PARAMETER

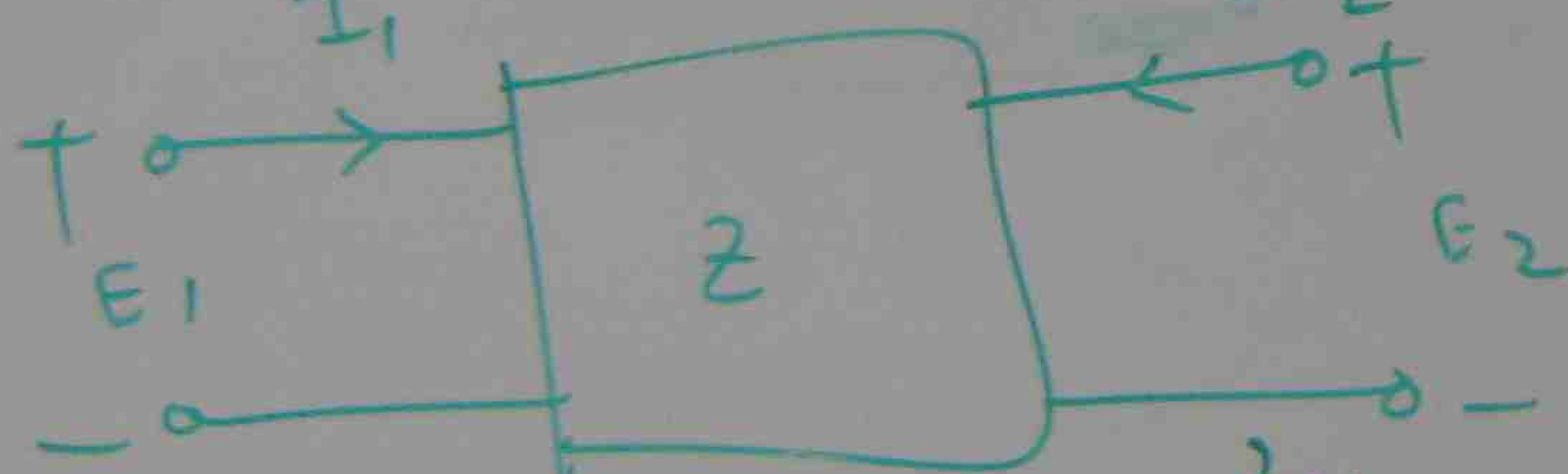
Y - PARAMETER

COMBINED IMPEDANCE & ADMITTANCE PARAMETER

HYBRID PARAMETER

H - PARAMETER

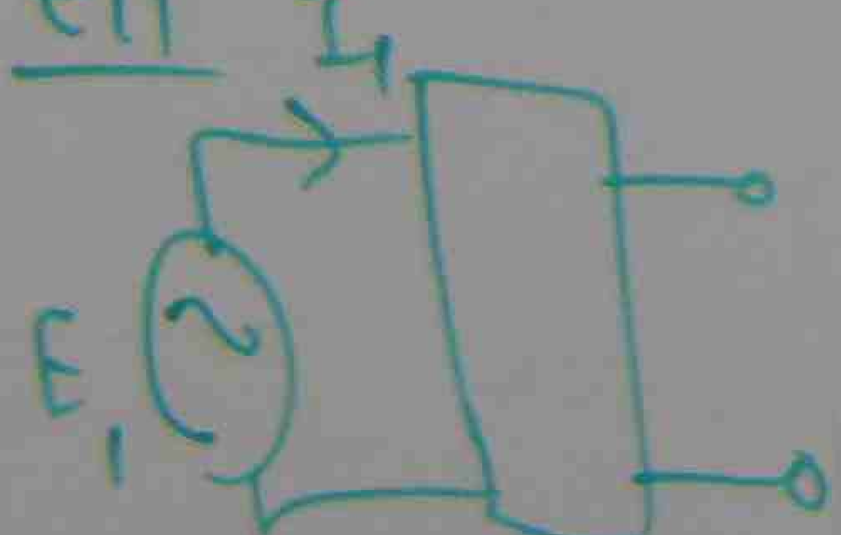
IMPEDANCE PARAMETER (Z)



$$E_1 = Z_{11} I_1 + Z_{12} I_2$$

$$E_2 = Z_{21} I_1 + Z_{22} I_2$$

Z_{11}



$$Z_{11} = \frac{E_1}{I_1}$$

Z_{12}

$$Z_{12} = \frac{E_1}{I_2}$$

Z_{21}

$$Z_{21} = \frac{E_2}{I_1}$$

Z_{22}

$$Z_{22} = \frac{E_2}{I_2}$$

$_3 Z_1$

$\frac{j1}{-j3}$

$\frac{1}{3}$

$+\frac{1}{3}$

$+\frac{1}{3}$

3

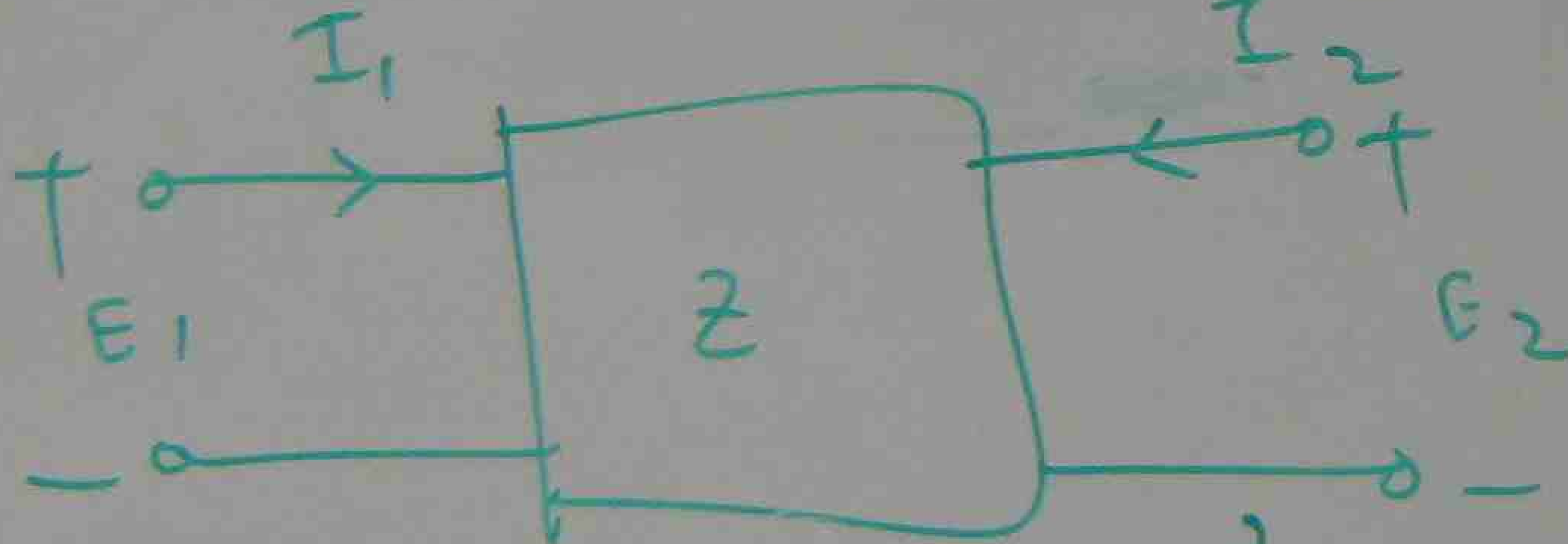
K

SYSTEM ANALYSIS

TWO PORTS NETWORKS

- IMPEDANCE PARAMETER
  Z - PARAMETER
- ADMITTANCE PARAMETER
  Y - PARAMETER
- COMBINED IMPEDANCE & ADMITTANCE PARAMETER
  HYBRID PARAMETER
  H - PARAMETER

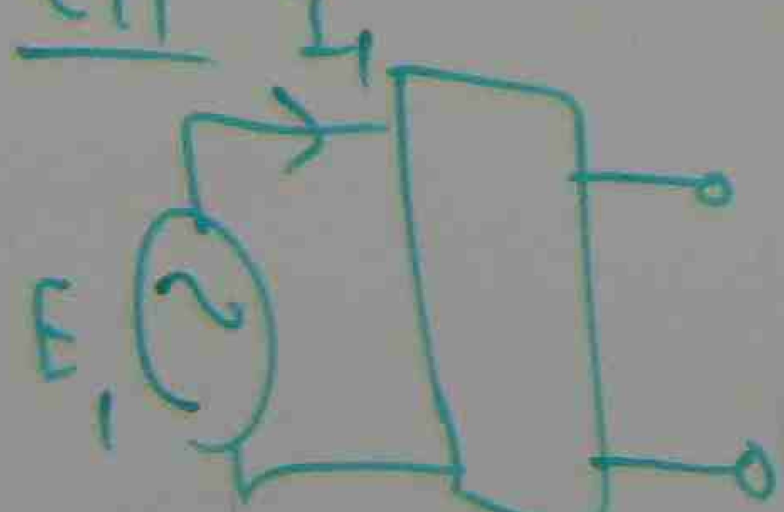
IMPEDANCE PARAMETER (Z)



$$E_1 = Z_{11} I_1 + Z_{12} I_2$$

$$E_2 = Z_{21} I_1 + Z_{22} I_2$$

Z_{11}

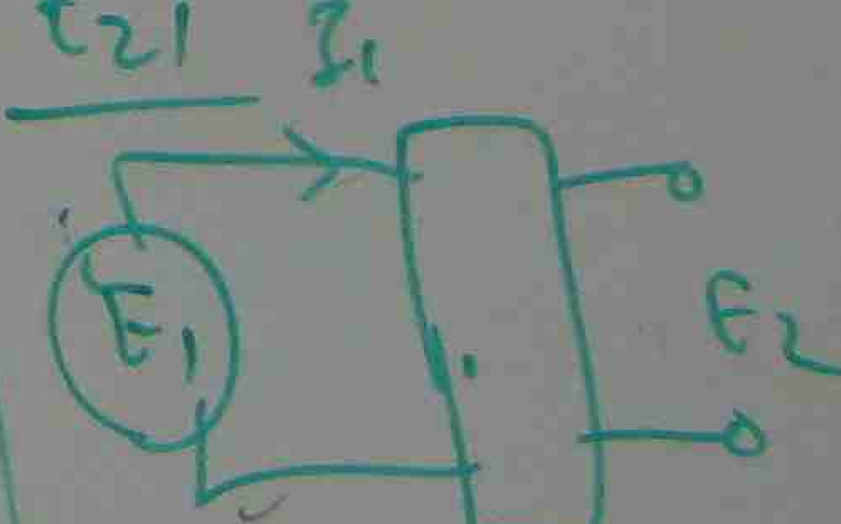


$$Z_{11} = \frac{E_1}{I_1}$$

Z_{12}

$$Z_{12} = \frac{E_1}{I_2}$$

Z_{21}

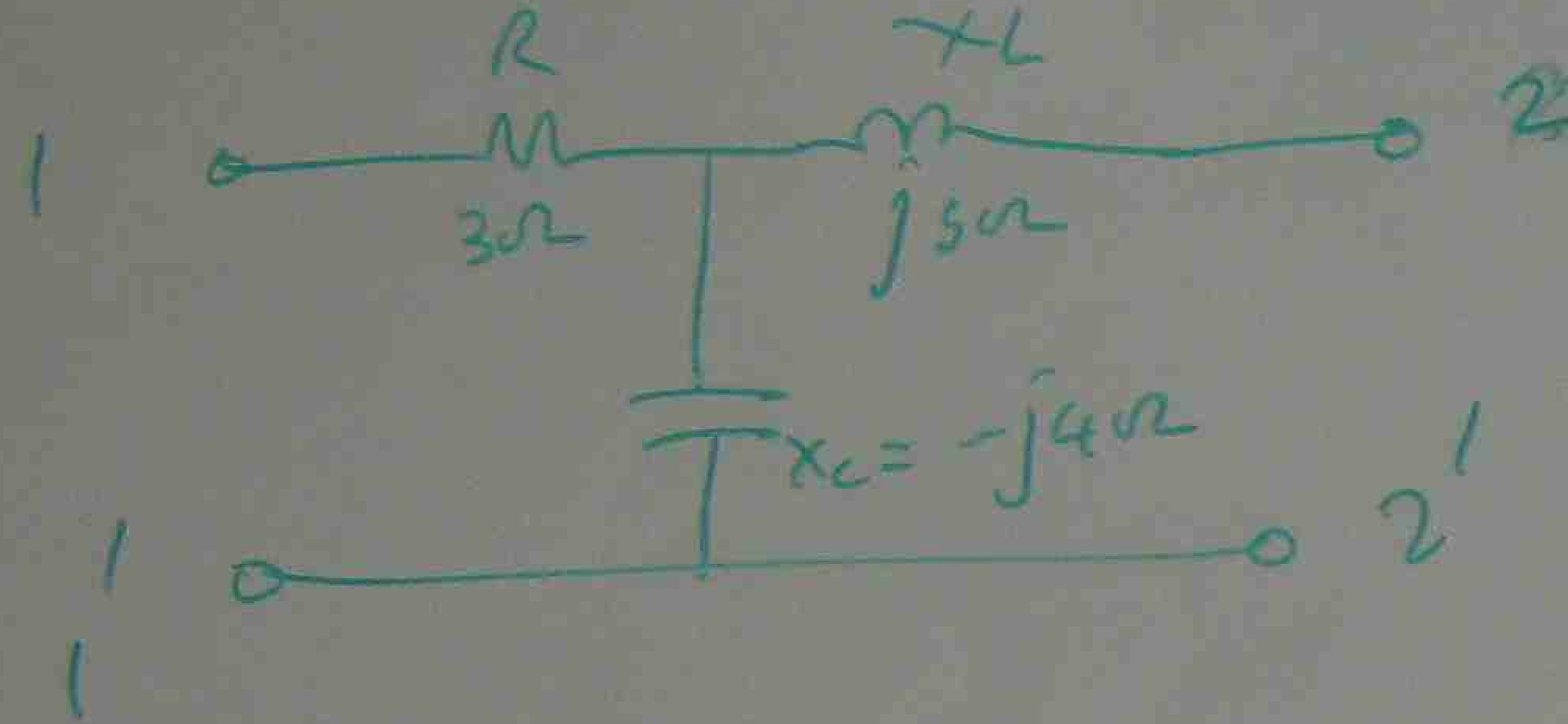


$$Z_{21} = \frac{E_2}{I_1}$$

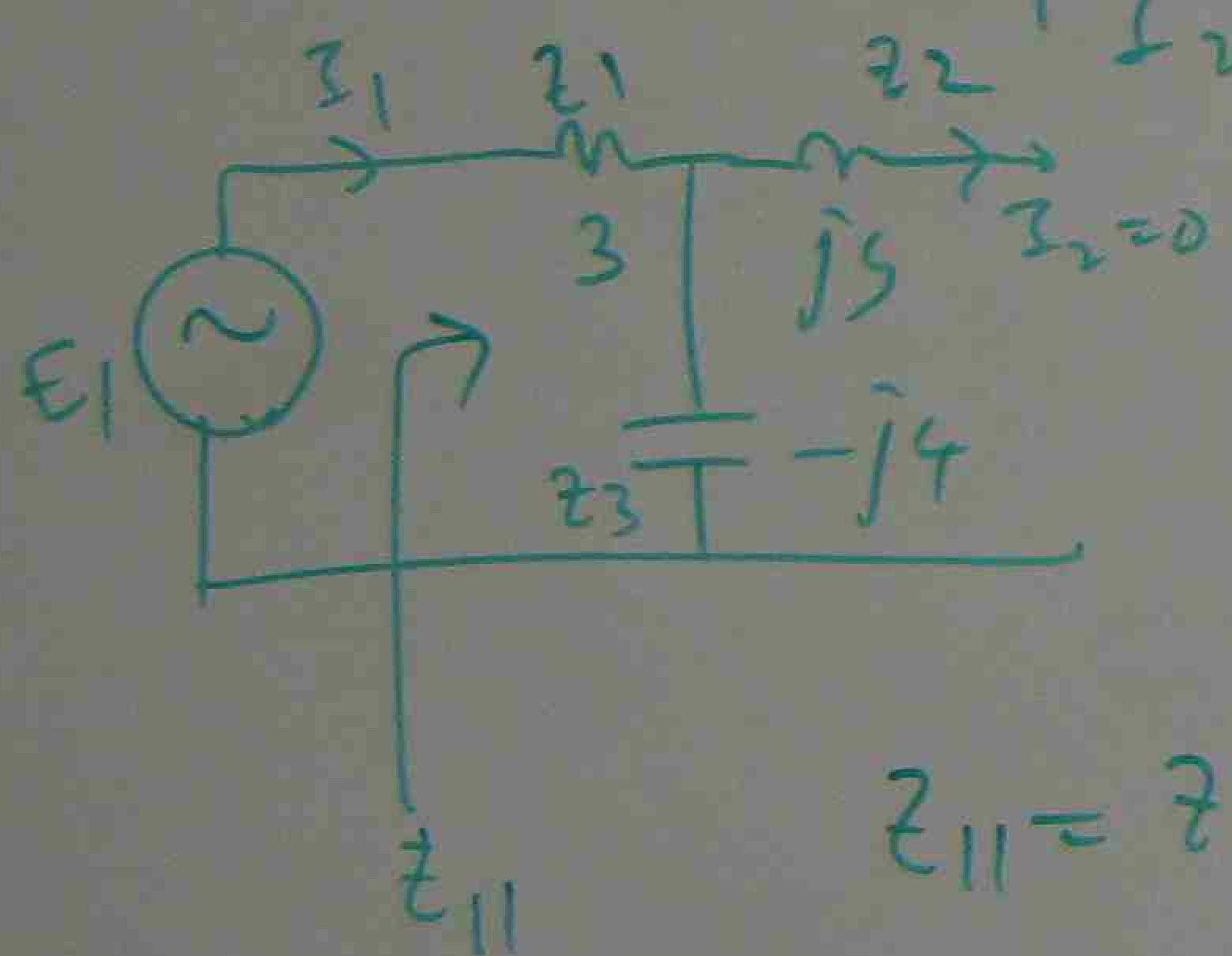
Z_{22}

$$Z_{22} = \frac{E_2}{I_2}$$

ph DETERMINE IMPEDANCE (Z) PARAMETER FOR THE GIVEN CIRCUIT



$$Z_{11} = \left.\frac{E_1}{I_1}\right|_{I_2=0}$$



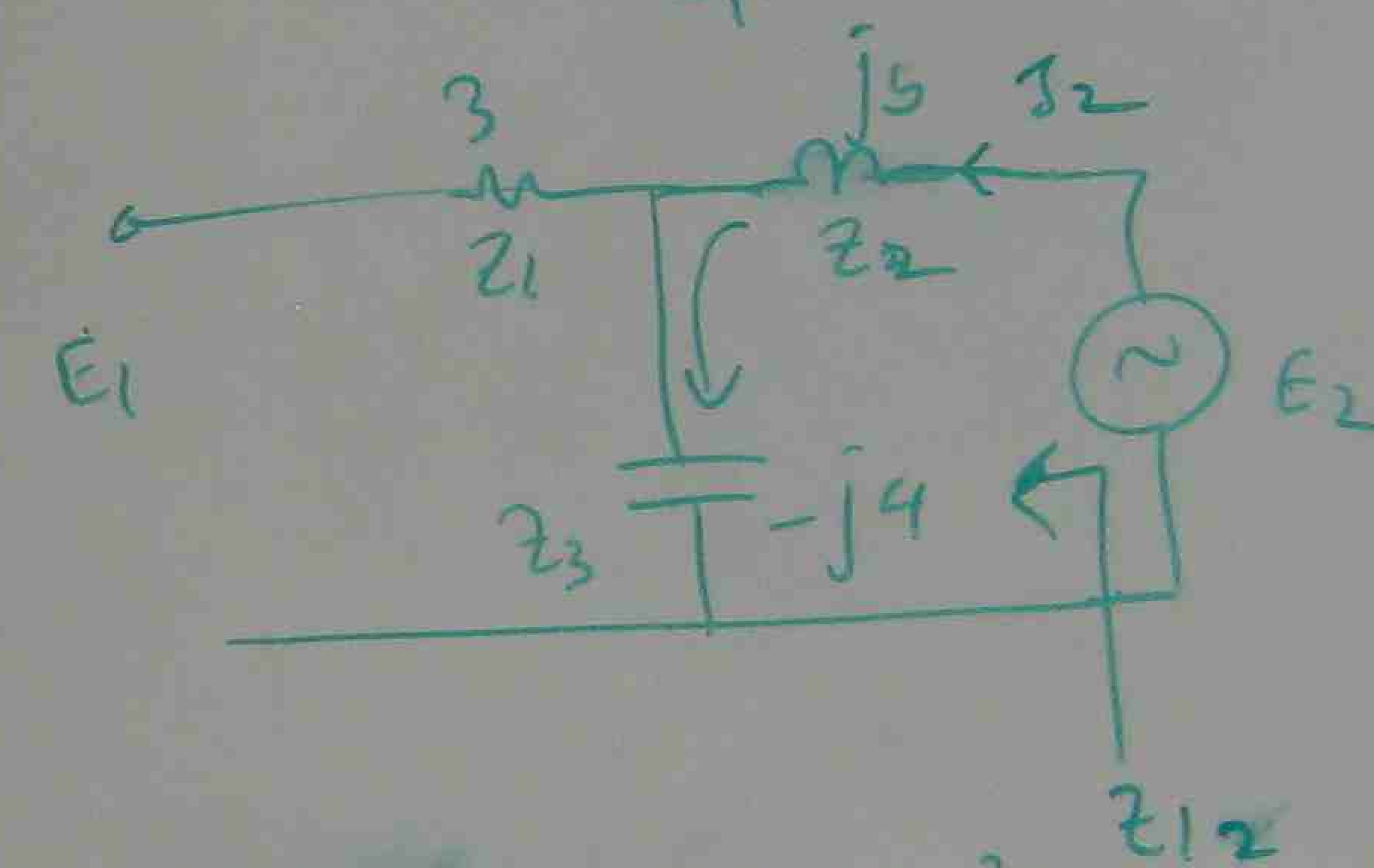
$$I_1 = \frac{E_1}{Z_1 + Z_3}$$

$$\therefore \frac{E_1}{I_1} = Z_1 + Z_3$$

$$Z_{11} = Z_1 + Z_3$$

$$Z_{11} = Z_1 + Z_3$$
$$= 3 + (-j4)$$
$$= 3 - j4\Omega$$

$$Z_{12} = \left.\frac{E_1}{I_2}\right|_{I_1=0}$$

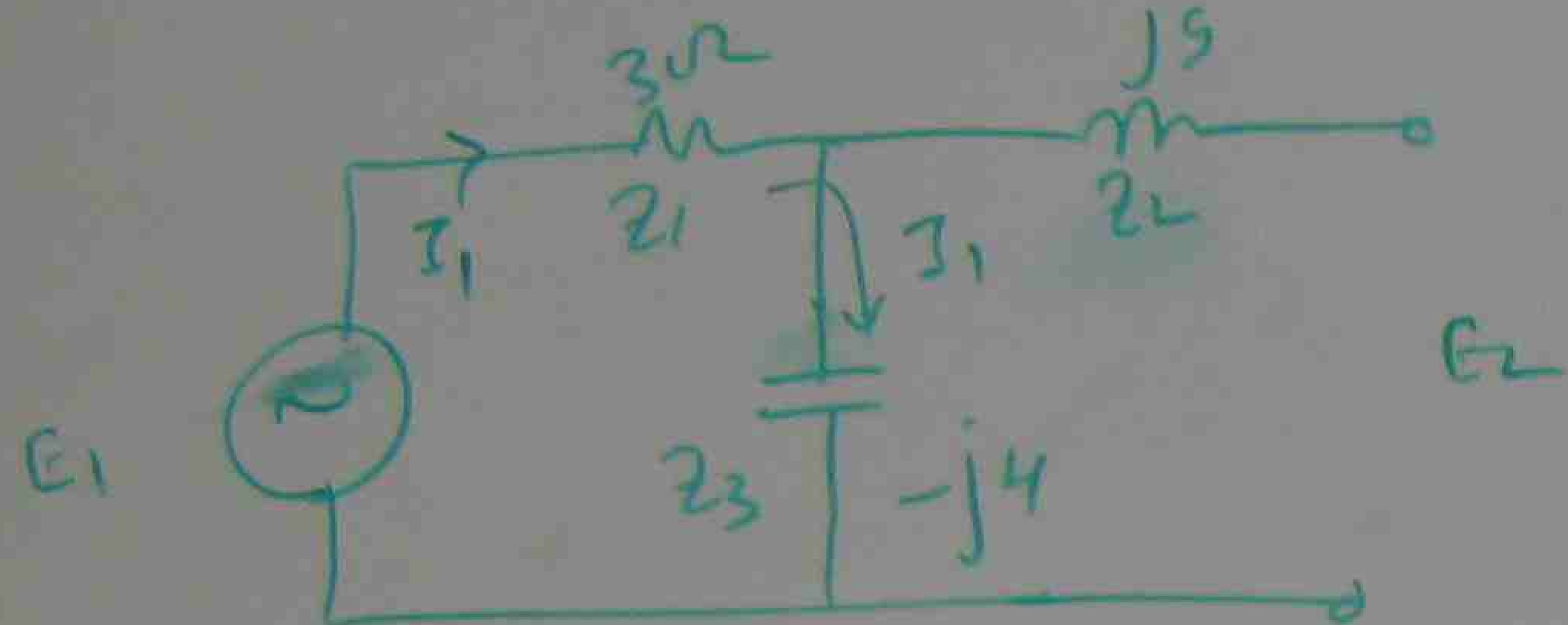


NO VOLTAGE DROP IN Z_1

$$\therefore I_2 Z_3 = E_1$$

$$Z_{12} = \frac{E_1}{I_2} = \frac{I_2 Z_3}{I_2} = Z_3 = -j4\Omega$$

$$Z_{21} = \frac{E_2}{I_1}\Bigg|_{I_2=0}$$

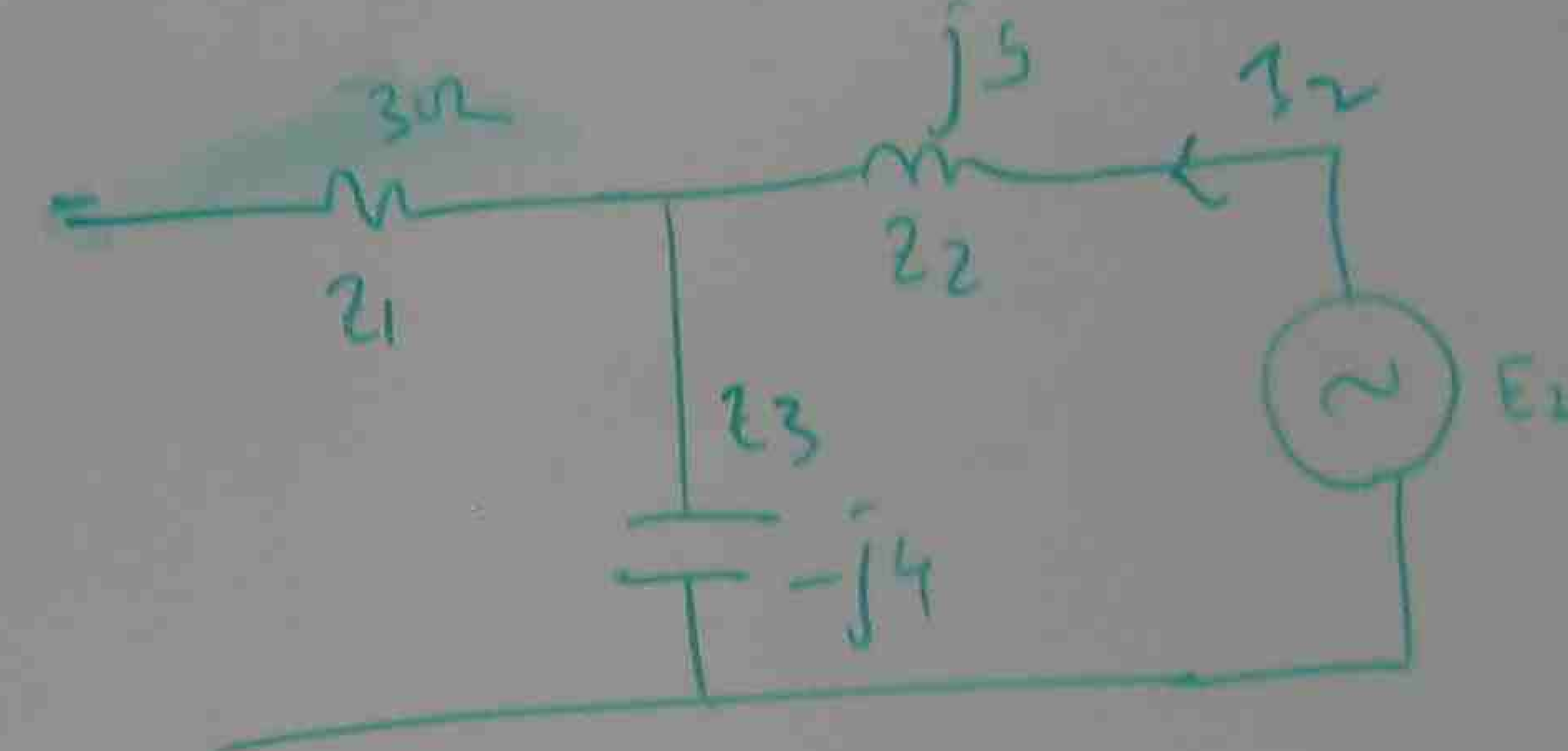


$$E_2 = I_1 Z_3$$

$$Z_{21} = \frac{E_2}{I_1} = \frac{I_1 Z_3}{I_1} = Z_3$$

$$Z_{21} = Z_3 = -j4$$

$$Z_{22} = \frac{E_2}{I_2}\Bigg|_{I_1=0}$$



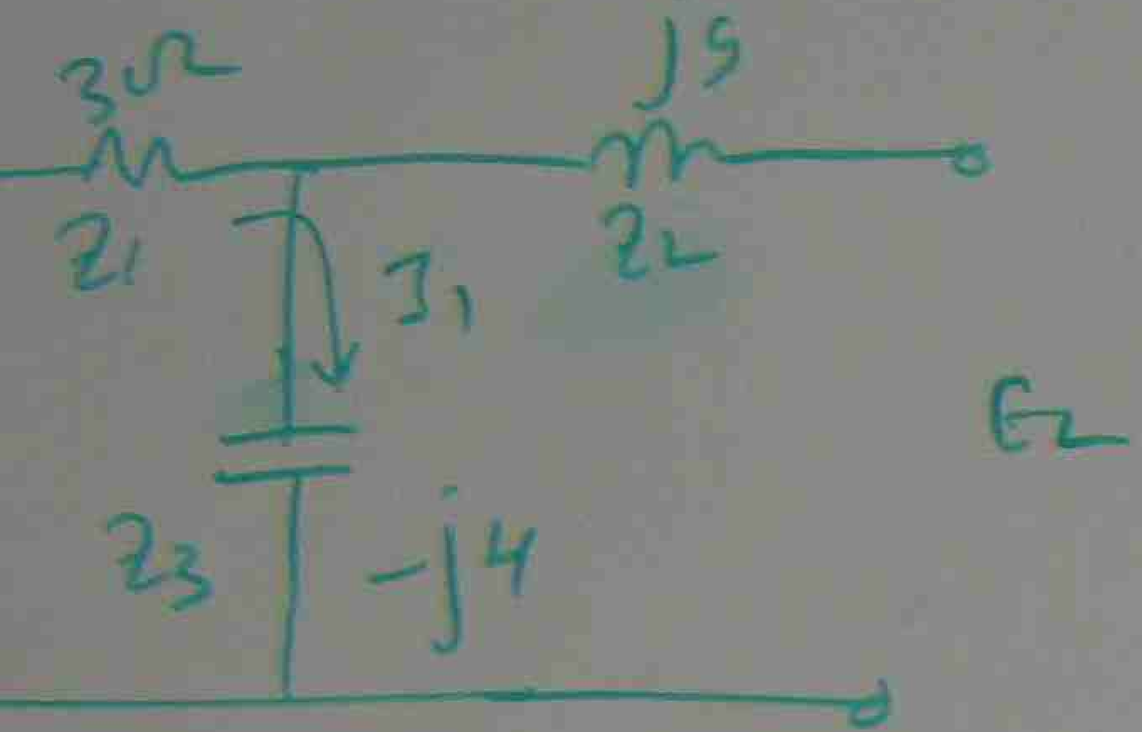
$$I_2 = \frac{E_2}{Z_2+Z_3}$$

$$I_2(Z_2+Z_3) = E_2$$

$$Z_2+Z_3 = \frac{E_2}{I_2} = Z_{22}$$

$$Z_{22} = Z_2+Z_3 = j5+(-j1) = j1\Omega$$

$\frac{E_2}{I_1}\Big|_{I_2=0}$

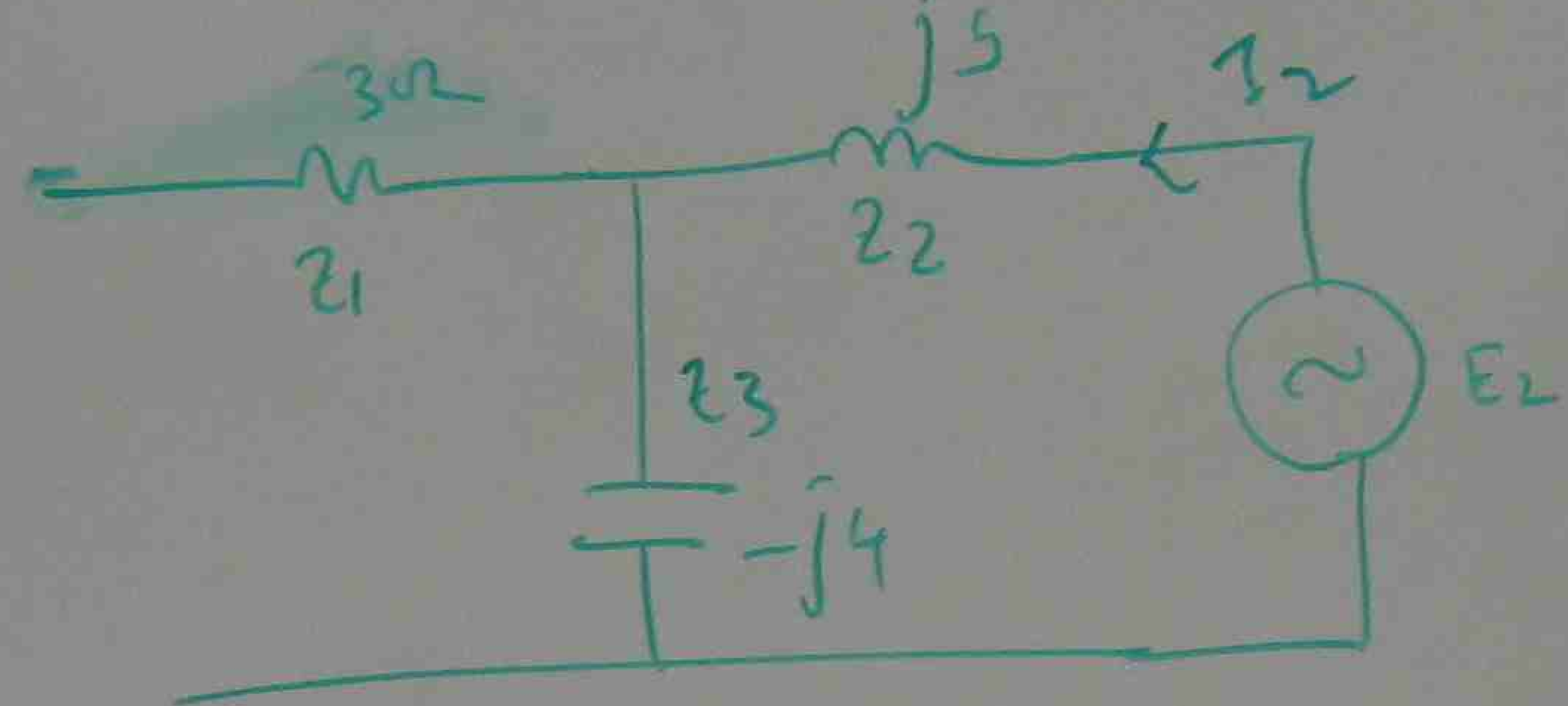


Z_3

$= \frac{I_1 Z_3}{I_1} = Z_3$

$Z_3 = -j4$

$$Z_{22} = \frac{E_2}{I_2}\Big|_{I_1=0}$$



$$I_2 = \frac{E_2}{Z_2+Z_3}$$

$$I_2(Z_2+Z_3) = E_2$$

$$Z_2+Z_3 = \frac{E_2}{I_2} = Z_{22}$$

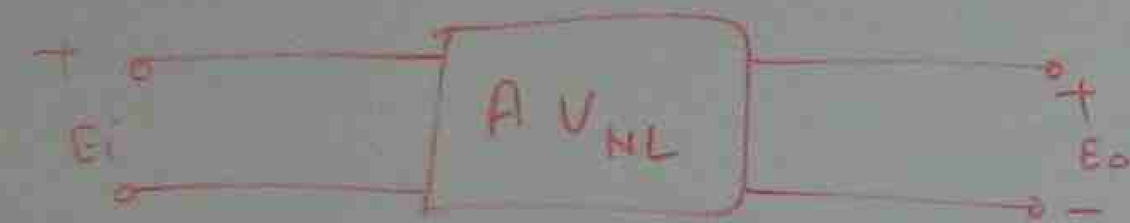
$$Z_{22} = Z_2+Z_3 = j5+(-j4) = j1\,\Omega$$

pb

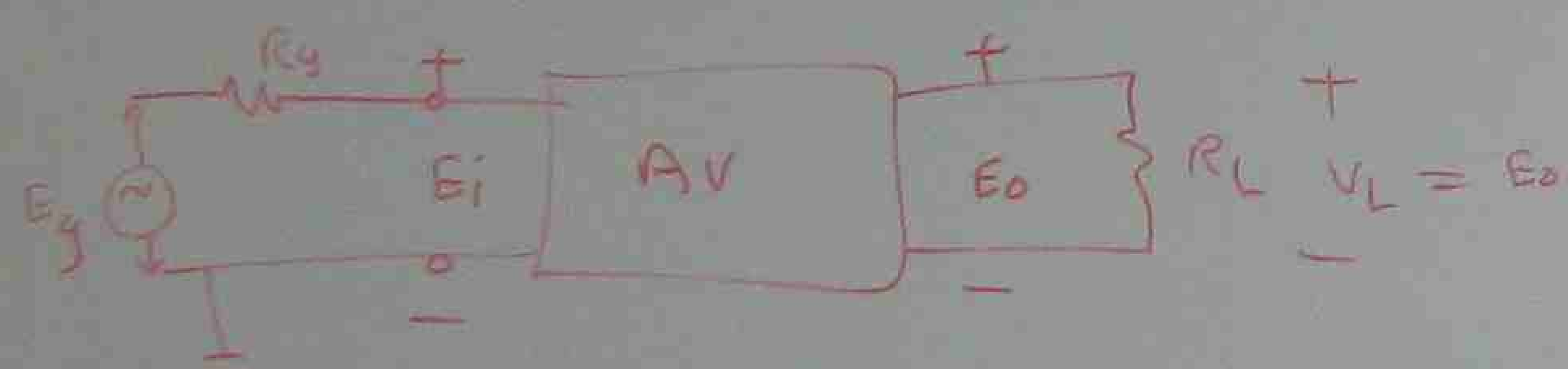
Z_B

Z_A

NO LOAD VOLTAGE GAIN ($A_{V_{NL}}$), LOADED VOLTAGE GAIN (A_{V_L}), TOTAL VOLTAGE GAIN (A_{V_T})



$$A_{V_{NL}} = \frac{E_o}{E_i}$$



$$A_V = \frac{E_o}{E_i}$$

WITH R_L

$$A_{V_T} = \frac{E_o}{E_g}$$

$$A_{V_T} = A_V \times \frac{Z_i}{Z_i + R_g}$$

$$A_{V_T} = A_{V_{NL}} \times \frac{Z_i}{Z_i + R_g}$$

$$A_V = A_{V_{NL}} \times \frac{R_L}{R_L + R_o}$$

$$R_o = R_L \left(\frac{A_{V_{NL}}}{A_V} - 1 \right)$$

pb FOR THE FOLLOWING

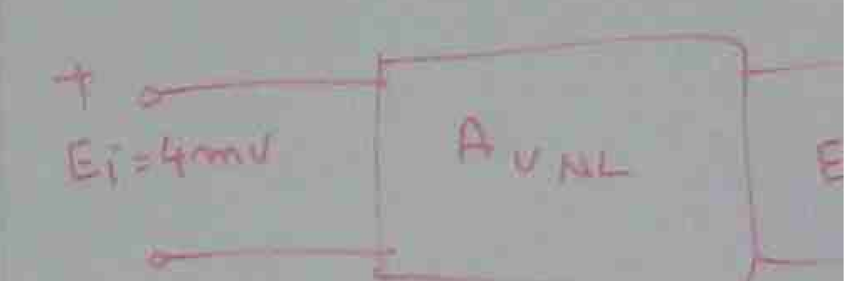
AMPLIFIER

(a) DETERMINE THE

(b) FIND THE LOADED

(c) CALCULATE TOTAL

(d) DETERMINE R_o



(a) (a)

$$A_{V_{NL}} = \frac{E_o}{E_i} = \frac{-20}{4 \times 10^{-}}$$

(b) $A_V = A_{V_{NL}} \times \frac{R_L}{R_L}$

$= (-5000) \times$

...TAGE GAIN (Av_T)

$= Av \times \frac{Z_i}{Z_i + R_g}$

$= Av_{NL} \times \frac{Z_i}{Z_i + R_g}$

$Av_{NL} \times \frac{R_L}{R_L + R_o}$

$R_L \left(\frac{Av_{NL}}{Av} - 1 \right)$

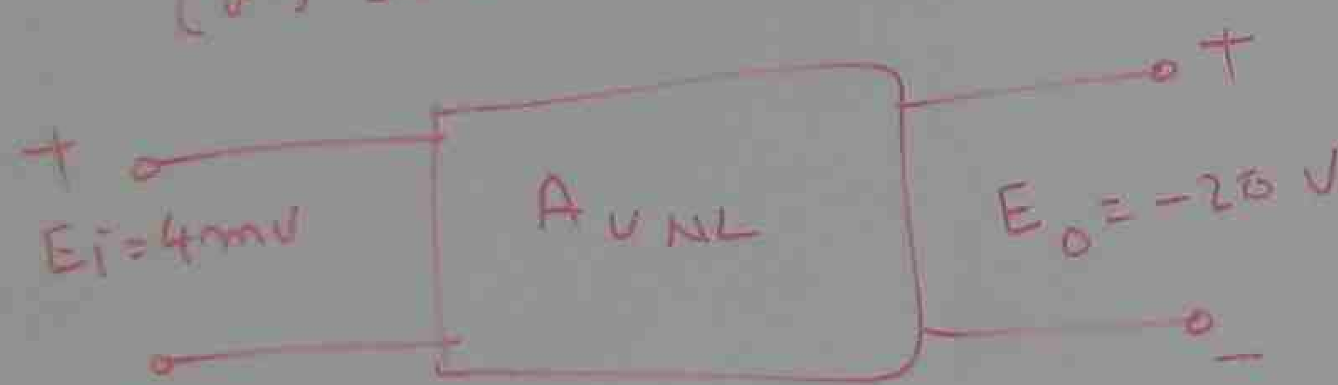
pb FOR THE Following SYSTEM EMPLOYED IN THE LOADED AMPLIFIER

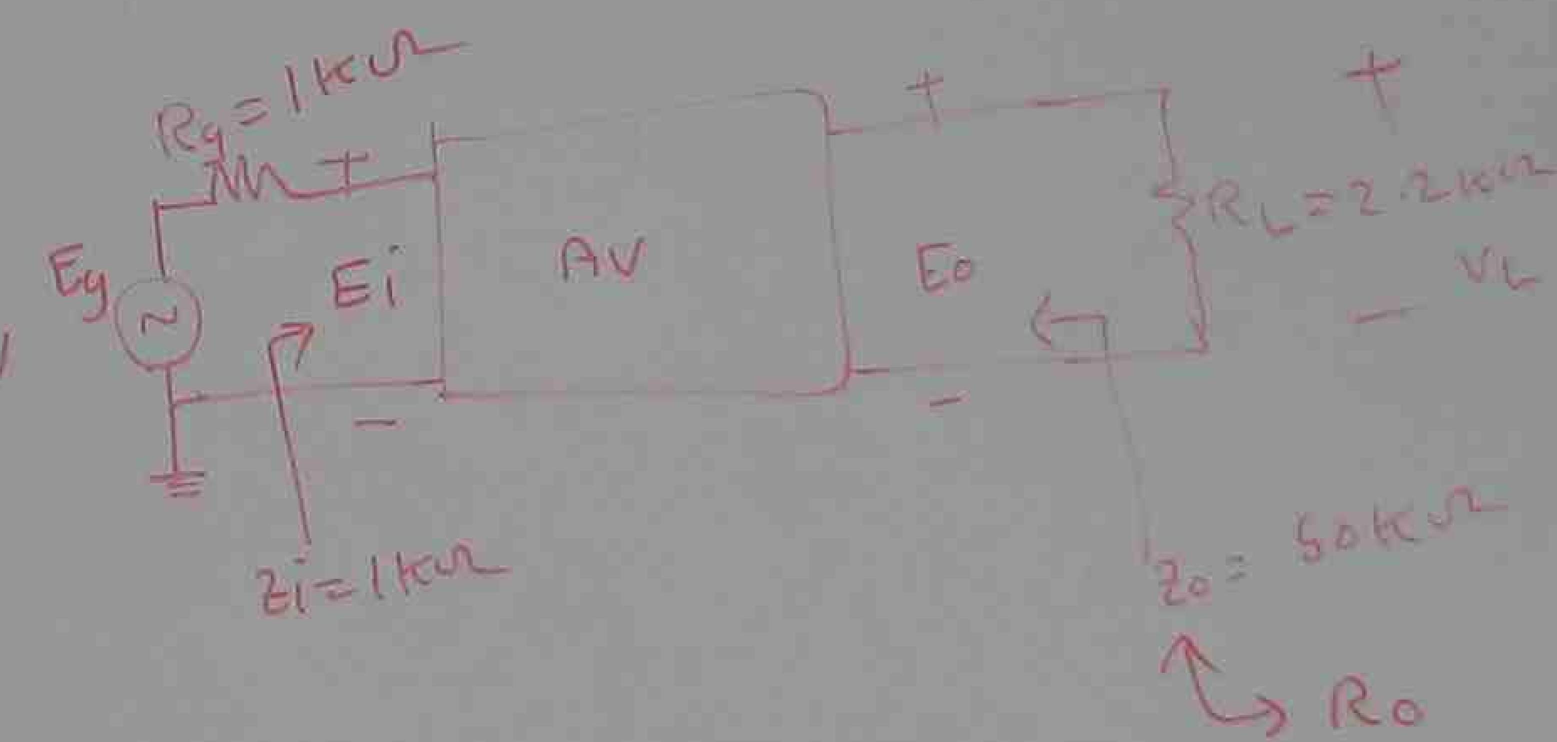
(a) DETERMINE THE NO LOAD VOLTAGE GAIN Av_{NL}

(b) FIND THE LOADED VOLTAGE GAIN Av

(c) CALCULATE TOTAL LOADED VOLTAGE GAIN Av_T

(d) DETERMINE R_o





(a)

$$A_{VNL} = \frac{E_o}{E_i} = \frac{-20}{4 \times 10^{-3}} = -5000$$

(b) $$A_V = A_{VNL} \times \frac{R_L}{R_L + R_o}$$

$$= (-5000) \times \frac{2.2 \times 10^3}{2.2 \times 10^3 + 50 \times 10^3} = -210.73$$

(c) $$Av_T = Av \times \frac{Z_i}{Z_i + R_g}$$

$$= (-210.73) \times \frac{1k\Omega}{1k\Omega + 1k\Omega}$$

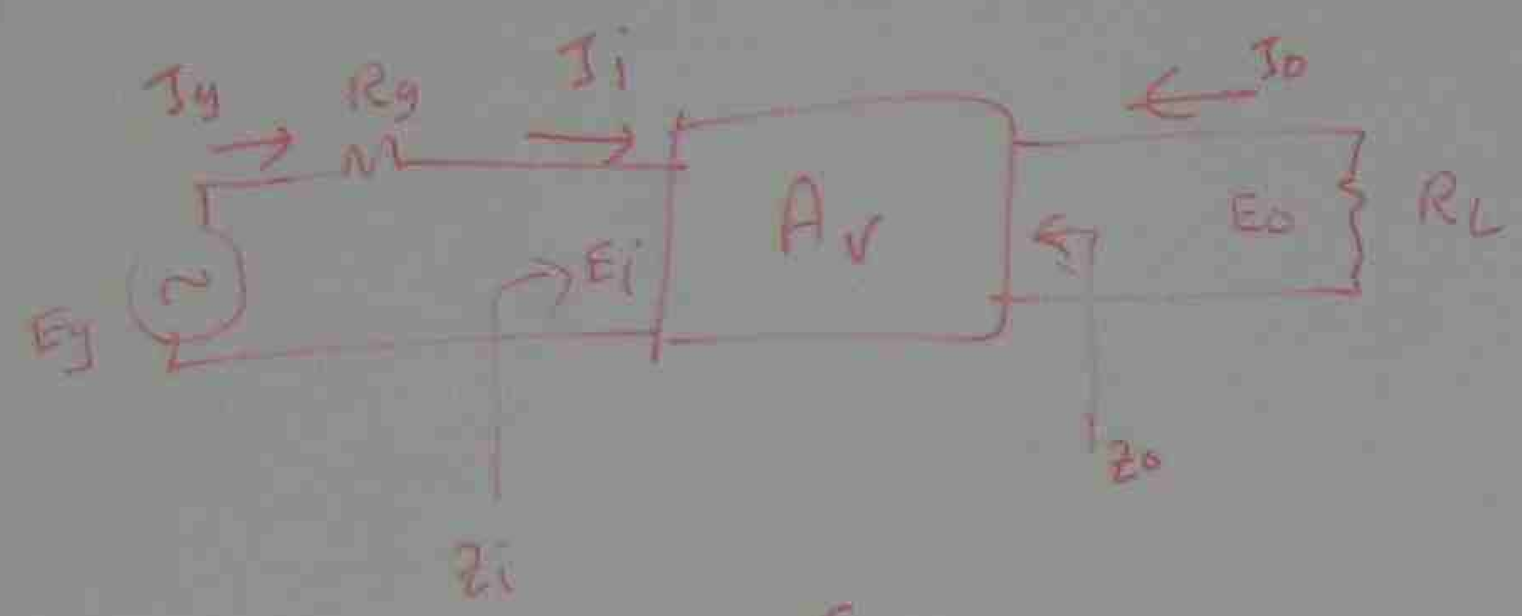
$$= -105.36$$

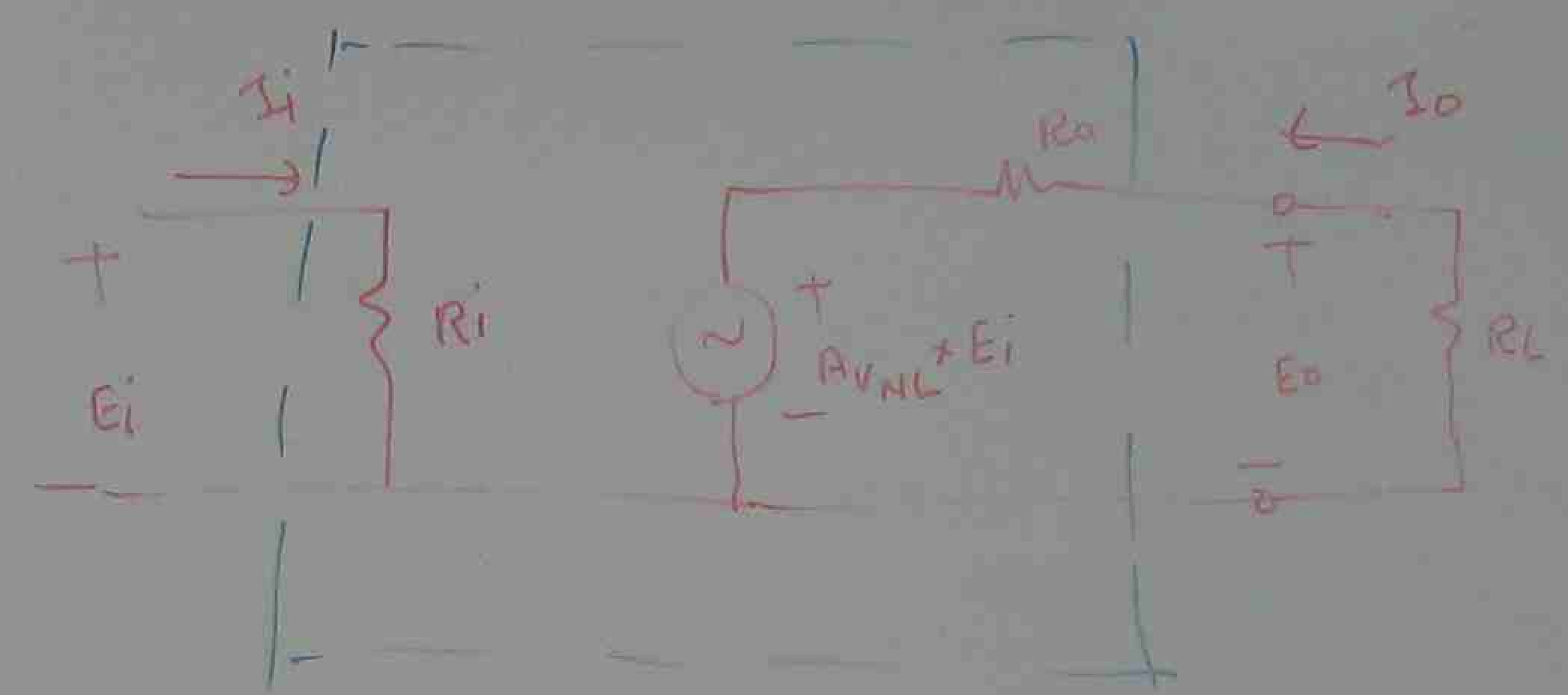
(d) $$R_o = R_L \left(\frac{Av_{NL}}{Av} - 1 \right)$$

$$= 2.2K \left(\frac{-5000}{-210.73} - 1 \right)$$

$$= 50k\Omega$$

CURRENT GAIN A_I, A_{I_T} AND POWER GAIN A_G





$$I_o = -\frac{E_o}{R_L}$$

$$I_i = \frac{E_i}{Z_i}$$

$$A_i = -A_v \times \frac{Z_i}{R_L}$$

TOTAL LOADED CURRENT GAIN

$$A_{I_T} = -A_{v_T}\left(\frac{R_g + Z_i}{R_L}\right)$$

$$I_o = -\frac{A_{vNL}\,E_i}{R_L + R_o}$$

$$E_i = I_i R_i$$

$$I_o = -\frac{A_{vNL}\,(I_i R_i)}{R_L + R_o}$$

$$A_I = \frac{I_o}{I_i} = -A_{vNL} \times \frac{R_I}{R_L + R_o}$$

A_G = POWER GAIN

$$A_G = A_v^2 \times \frac{R_I}{R_L}$$

$$A_G = A_v \times (-A_I)$$

$$A_{G_T} = -A_{v_T} \times A_{I_T}$$

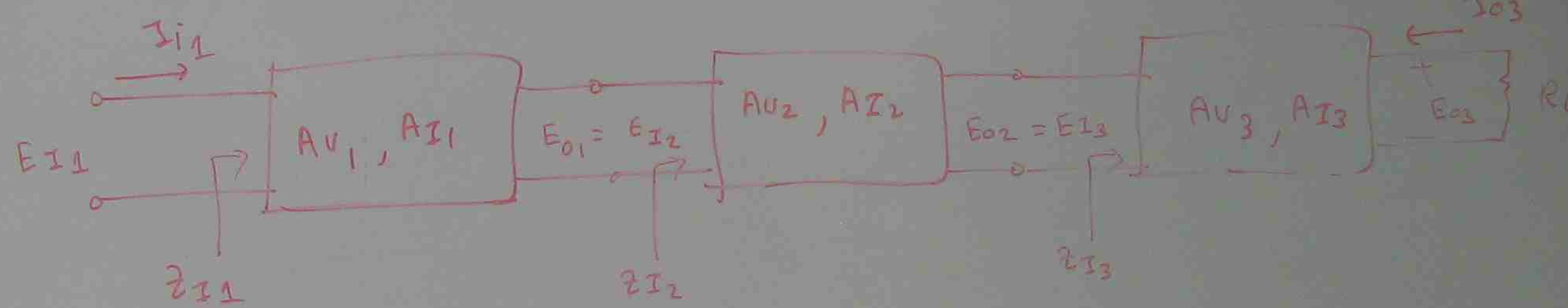
A_G = POWER GAIN

$$A_G = A_v^2 \times \frac{R_I}{R_L}$$

$$A_G = A_v \times (-A_I)$$

$$A_{G_T} = -A_{v_T} \times A_{I_T}$$

CASCADED SYSTEM



$$A_{v_T} = A_{v_1} \times A_{v_2} \times A_{v_3}$$

$$A_{I_T} = A_{I_1} \times A_{I_2} \times A_{I_3}$$

$$A_I = A_v \times \frac{Z_I}{R_L}$$

$$A_{G_T} = A_{v_T} \times A_{I_T}$$

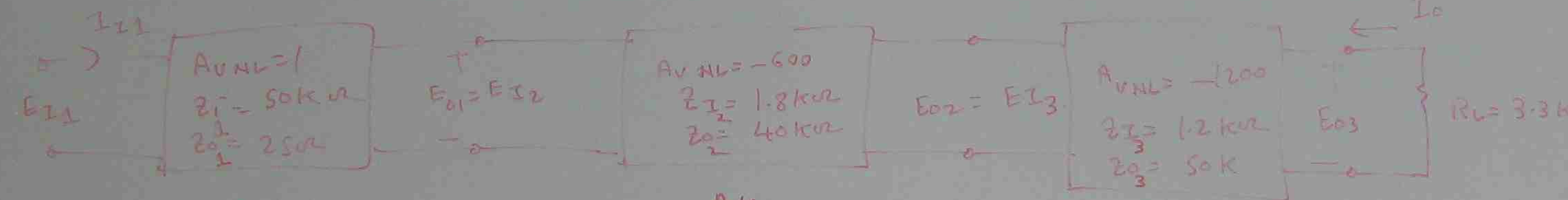
pb

FOR THE GIVEN CASCADED SYSTEM,

(a) DETERMINE THE LOADED VOLTAGE AND CURRENT GAIN FOR EACH STAGE

(b) CALCULATE TOTAL VOLTAGE AND CURRENT GAIN

(c) FIND TOTAL POWER GAIN.



A_{v_1} $\quad$ A_{v_2} $\quad$ A_{v_3}

A_{I_1} $\quad$ A_{I_2} $\quad$ A_{I_3}

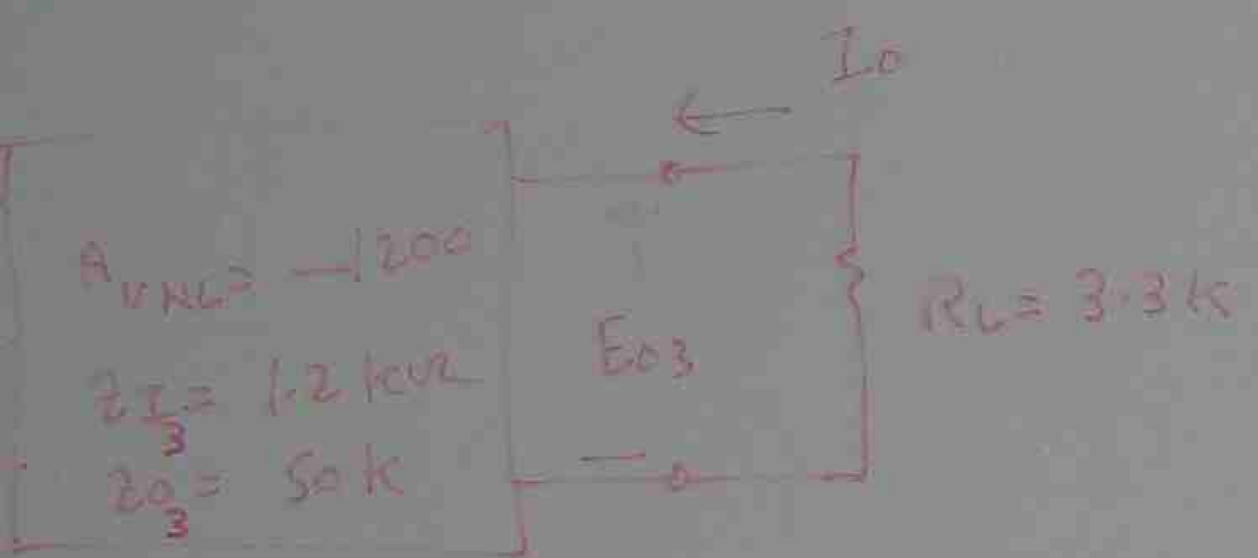
(a)

$$A_{v_1} = A_{v_{NL1}} \times \frac{Z_{I_2}}{Z_{I_2} + Z_{o_1}} = 1 \times \frac{1.8}{1.8 + 25\times10^{-3}} = 0.986$$

$$A_{v_2} = A_{v_{NL_2}} \times \frac{Z_{I_3}}{Z_{I_3} + Z_{o_2}} = (-600) \times \frac{1.2}{1.2 + 40} = -17.476$$

$$A_{v_3} = A_{v_{NL_3}} \times \frac{R_L}{R_L + Z_{o_3}} = (-1200) \times \frac{3.3}{3.3 + 5\ldots} = -74.296$$

$$AI_1 = -Av_{NL_1} \times \frac{Z_{I_1}}{Z_{I_2} + Z_{o_1}} = -1 \times \frac{50K}{18K + 26\times10^{-3}} = -27.397$$



$$AI_2 = -Av_{NL_2} \times \frac{Z_{I_2}}{Z_{I_3} + Z_{o_2}} = -(-600) \times \frac{1.8K}{1.2K + 40} = 26.214$$

Av_3

AI_3

$$AI_3 = -Av_{NL_3} \times \frac{Z_{I_3}}{R_L + Z_{o_3}} = -(-1200) \times \frac{1.2K}{3.3K + 50K}$$

$$= 27.017$$

3

$+Z_{o2}$

.2

$2+40$

$$Av_3 = Av_{NL_3} \times \frac{R_L}{R_L + Z_{o_3}}$$

$$= (-1200) \times \frac{3.3}{3.3 + 50}$$

$$= -74.296$$

(b) $Av_T = Av_1 \times Av_2 \times Av_3 = (0.486) \times (-17.476) \times (-74.296)$

$= 1280.22$

$AI_T = AI_1 \times AI_2 \times AI_3 = (-27.397) \times (26.214) \times (27.017)$

$= -19403.20$ Amp.

(c) $A_{GT} = -Av_T \times AI_T$

$= -1280.22 \times (-19403.2) = 24.84 \times 10^6$