1\. 18'

(a) Reflect the load to the middle circuit.

$$\mathbf{Z_L}' = 8 - j20 + (18 + j45)/3^2 = 10 - j15$$ 4'

We now reflect this to the primary circuit so that

$\mathbf{Z_{in}} = 6 + j4 + (10 - j15)/n^2 = 7.6 + j1.6 = 7.767\angle 11.89°$, where $n = 5/2 = 2.5$

$$\mathbf{I_1} = 40/\mathbf{Z_{in}} = 40/7.767\angle 11.89° = 5.15\angle -11.89°$$ 4'

$$\mathbf{S} = \mathbf{v_s I_1^*} = (40\angle 0°)(5.15\angle 11.89°) = \mathbf{206\angle 11.89°\ VA}$$ 2'

$= 201.58 + 42.44j$ VA

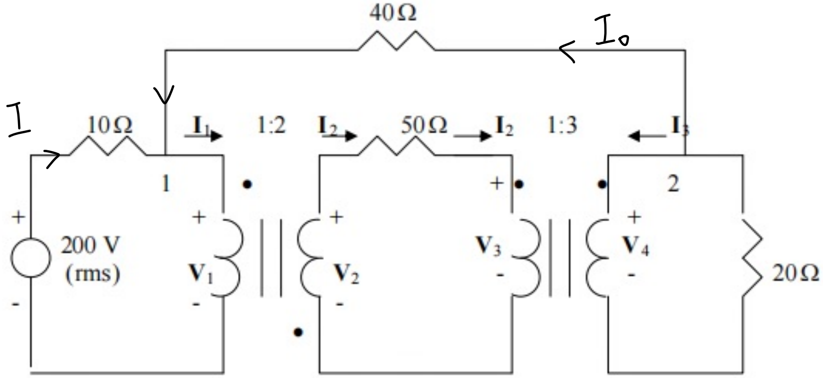
(b) $\mathbf{I_2} = -\mathbf{I_1}/n, \quad n = 2.5$

$\mathbf{I_3} = -\mathbf{I_2}/n', \quad n = 3$ 6'

$$\mathbf{I_3} = \mathbf{I_1}/(nn') = 5.15\angle -11.89°/(2.5x3) = 0.6867\angle -11.89°$$

$$p = |\mathbf{I_2}|^2(18) = 18(0.6867)^2 = \mathbf{8.488\ watts}$$ 2'

2、 26'



At node 1,

$$\frac{200-V_1}{10}=\frac{V_1-V_4}{40}+I_1 \longrightarrow 200=1.25V_1-0.25V_4+10I_1 \qquad (1)$$ 2'

At node 2,

$$\frac{V_1-V_4}{40}=\frac{V_4}{20}+I_3 \longrightarrow V_1=3V_4+40I_3 \qquad (2)$$ 2'

At the terminals of the first transformer,

$$\frac{V_2}{V_1}=-2 \longrightarrow V_2=-2V_1 \qquad (3)$$ 2'

$$\frac{I_2}{I_1}=-1/2 \longrightarrow I_1=-2I_2 \qquad (4)$$ 2'

For the middle loop,

$$-V_2+50I_2+V_3=0 \longrightarrow V_3=V_2-50I_2 \qquad (5)$$ 2'

At the terminals of the second transformer,

$$\frac{V_4}{V_3}=3 \longrightarrow V_4=3V_3 \qquad (6)$$ 2'

$$\frac{I_3}{I_2} = -1/3 \longrightarrow I_2 = -3I_3 \qquad (7)$$ 2'

We have seven equations and seven unknowns. Combining (1) and (2) leads to

$$200 = 3.5V_4 + 10I_1 + 50I_3$$

But from (4) and (7), $I_1 = -2I_2 = -2(-3I_3) = 6I_3$. Hence

$$200 = 3.5V_4 + 110I_3 \qquad (8)$$ 2'

From (5), (6), (3), and (7),

$$V_4 = 3(V_2 - 50I_2) = 3V_2 - 150I_2 = -6V_1 + 450I_3$$

Substituting for V_1 in (2) gives

$$V_4 = -6(3V_4 + 40I_3) + 450I_3 \longrightarrow I_3 = \frac{19}{210}V_4 \qquad (9)$$ 2'

Substituting (9) into (8) yields

$$200 = 13.452V_4 \longrightarrow V_4 = 14.87$$

$$\boldsymbol{P = \frac{V^2{}_4}{20} = \underline{11.05\ \mathrm{W}}}$$

$I_3 = \frac{19}{210}V_4 = 1.345$ A $\qquad V_3 = \frac{1}{3}V_4 = 4.957$ V

$I_2 = -3I_3 = -4.036$ A $\qquad V_2 = V_3 + 50I_2 = -196.843$ V

$I_1 = -2I_2 = 8.072$ A $\qquad V_1 = 3V_4 + 40I_3 = 98.41$ V

$I = \frac{200 - V_1}{10} = 10.16$ A 2'

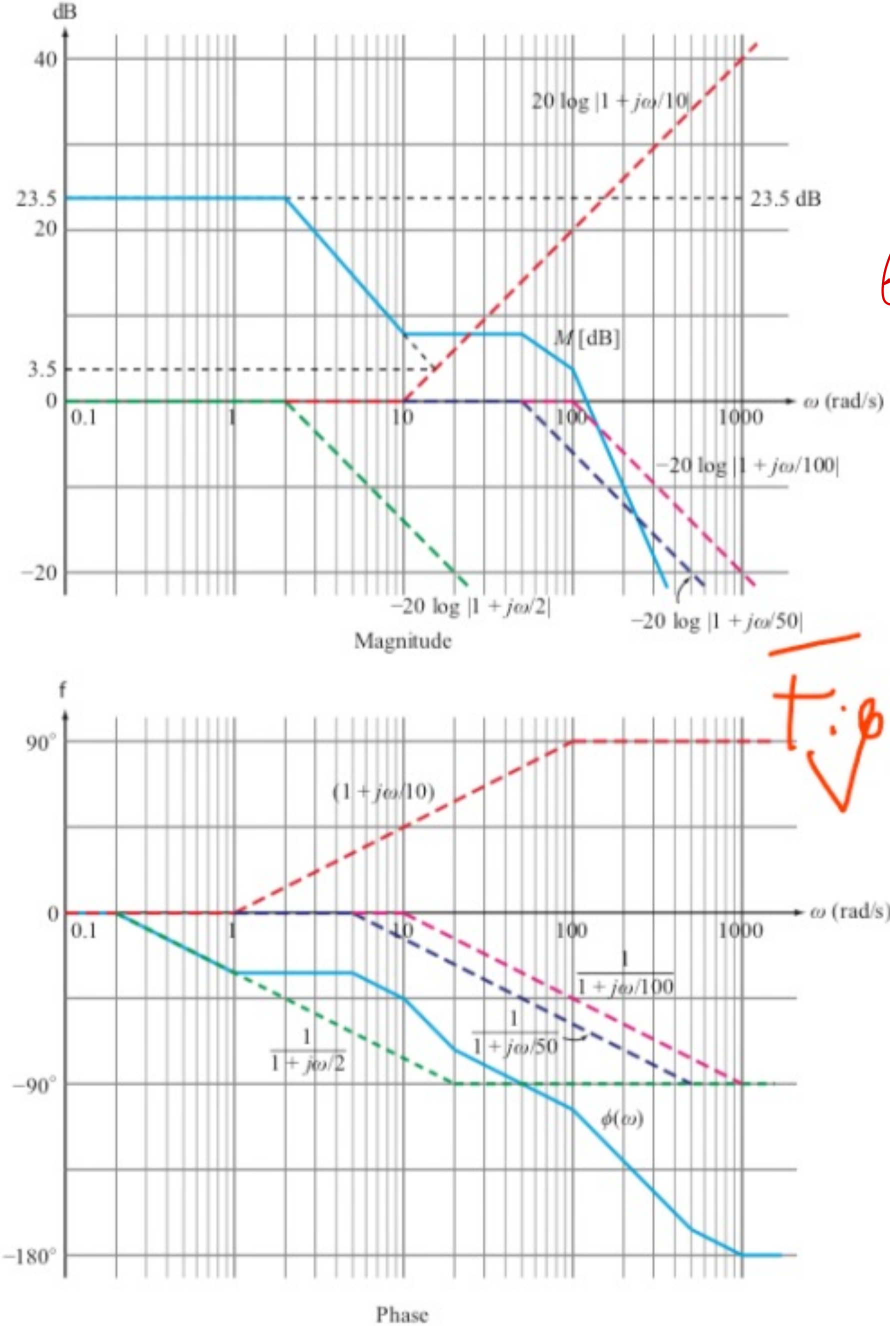
(1) $\tilde{S} = V \cdot I^* = 2031.8$ VA 2'

(2) $P = \frac{V_4^2}{20} = 11.05$ W 2' (3) $I_0 = I_1 - I = -2.09$ A

2'

3. 30'

(1)



dB
40
23.5
20
3.5
0
−20
0.1
1
10
100
1000
ω (rad/s)
20 log |1 + jω/10|
23.5 dB
M [dB]
−20 log |1 + jω/100|
−20 log |1 + jω/2|
−20 log |1 + jω/50|
Magnitude
f
90°
0
−90°
−180°
(1 + jω/10)
1 / (1 + jω/100)
1 / (1 + jω/50)
1 / (1 + jω/2)
φ(ω)
Phase

6'

t:0.1 ✓

5'

(2)

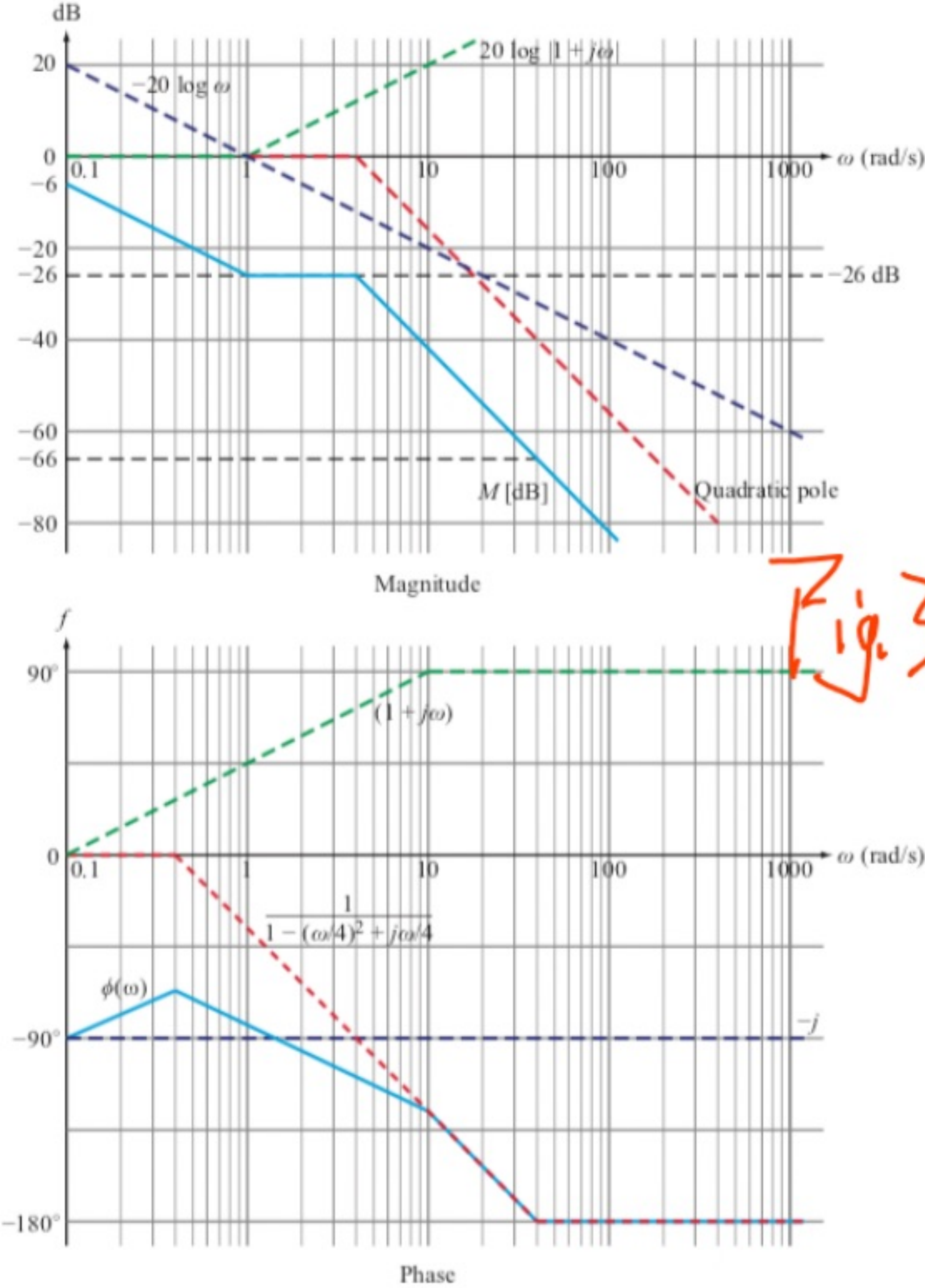
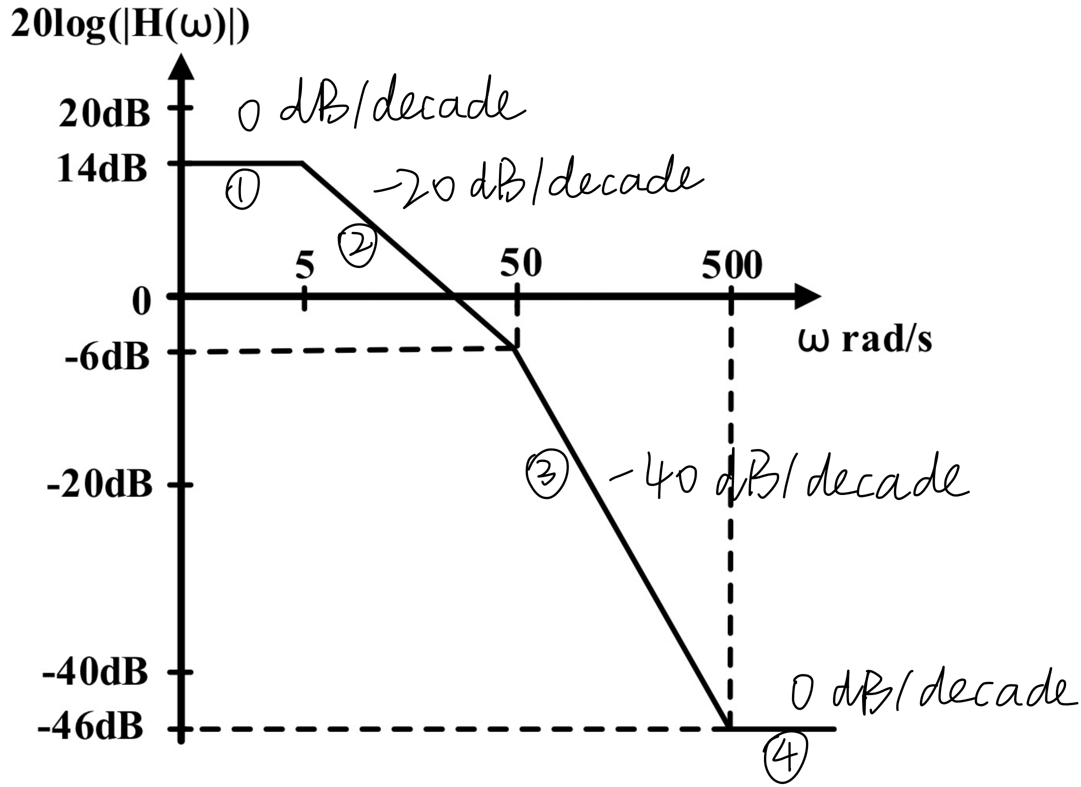

dB
20
0
−6
−20
−26
−40
−60
−66
−80
0.1
1
10
100
1000
ω (rad/s)
20 log |1 + jω|
−20 log ω
−26 dB
M [dB]
Quadratic pole
Magnitude
f
90°
(1 + jω)
0
0.1
1
10
100
1000
ω (rad/s)
$\frac{1}{1 - (\omega/4)^2 + j\omega/4}$
φ(ω)
−90°
−j
−180°
Phase

Fig. 3

5'

4'

(3)



2' ① $20\log K = 14 \Rightarrow K = 10^{0.7}$

2' ② slope $= -20$ dB/decade, $p_1 = 5 \Rightarrow \dfrac{1}{1+\frac{j\omega}{5}}$

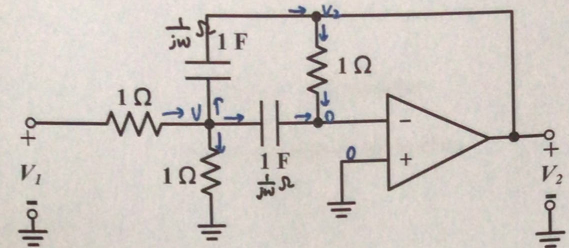
2' ③ slope $= -20-20$ dB/decade, $p_2 = 50 \Rightarrow \dfrac{1}{1+\frac{j\omega}{50}}$

2' ④ slope $= -20-20+40$ dB/decade, $p_3 = 500 \Rightarrow \left(1+\frac{j\omega}{500}\right)^2$

2' $$H(\omega) = \frac{10^{0.7}\left(1+\frac{j\omega}{500}\right)^2}{\left(1+\frac{j\omega}{5}\right)\left(1+\frac{j\omega}{50}\right)}$$

26'

4. For the circuit below, please find the transfer function H(ω)=V_2/V_1, **Also** sketch the magnitude and phase frequency relation of bode plot.



$1F \rightarrow \frac{1}{j\omega C} = \frac{1}{j\omega}\ \Omega$ 2'

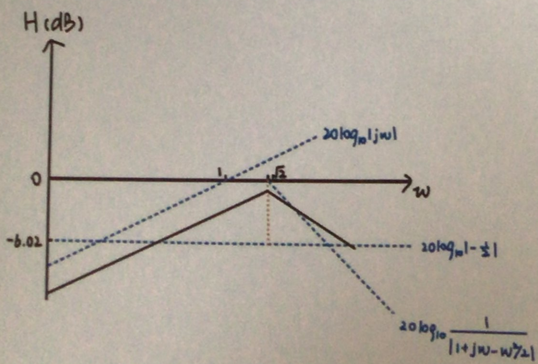
① $\frac{\dot V_1 - \dot V}{1\Omega} = \frac{\dot V - 0}{1\Omega} + \frac{\dot V - 0}{1/j\omega} + \frac{\dot V - \dot V_2}{1/j\omega}$

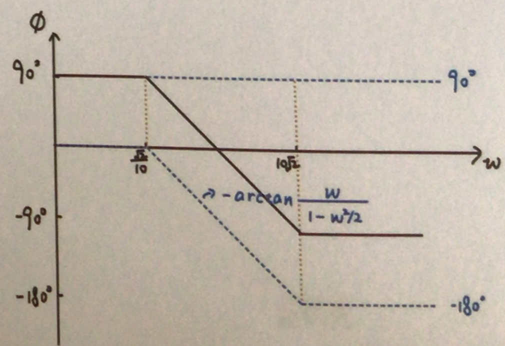
② $\frac{\dot V - 0}{1/j\omega} + \frac{\dot V_2 - 0}{1\Omega} = 0 \quad \Rightarrow \quad \dot V = -V_2 \cdot \frac{1}{j\omega} = -\frac{1}{j\omega}\dot V_2$ 8'

$\Rightarrow \dot V_1 = -\left(\frac{2}{j\omega} + 2 + j\omega\right)\dot V_2$ 2'

$\Rightarrow H(\omega) = \frac{\dot V_2}{\dot V_1} = -\frac{j\omega}{2+2j\omega-\omega^2} = \frac{-0.5\,j\omega}{1+j\omega+\left(\frac{j\omega}{\sqrt2}\right)^2}$

$H(\omega) = \frac{-\frac{1}{2}\cdot j\omega}{1+\frac{2j\omega\cdot 1/\sqrt2}{\sqrt2}+\left(\frac{j\omega}{\sqrt2}\right)^2}$. $20\log_{10}|\frac{1}{2}| \approx -6.02\ dB$





8' 6'