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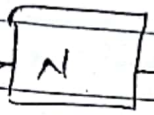
Frequency Response



V_i → N → output (V_2)

constant voltage

variable frequency

gain $= \left(\frac{V_2}{V_i}\right)$

gain in db $= 20 \log_{10}\left(\frac{V_2}{V_i}\right)$

plot of magnitude (in db) vs frequency and phase angle & phase angle in (degree) vs frequency

graph use → semilog graph.

* Bode plot

Plot of asymptotic plot or Bode plot for the following given transfer function.

$$G(s) = \frac{(s+10)(s+1)}{s(s+50)}$$

sol:

step - 1. convert all the factors in the $\left(1 + \frac{s}{\ldots}\right)$ form.

$$G(s) = \frac{10\left(1+\frac{s}{10}\right) \times 1\left(1+\frac{s}{1}\right)}{s \times 50\left(1+\frac{s}{50}\right)}$$

$$= \frac{0.2\left(1+\frac{s}{10}\right)\left(1+\frac{s}{1}\right)}{s\left(1+\frac{s}{50}\right)}$$

step - 2. put $s = j\omega$

(Note: Constant has 0 db/decade or straight line)

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$$G(jw) = \frac{0.2\left(1+\frac{jw}{10}\right)\left(1+\frac{jw}{1}\right)}{jw\left(1+\frac{jw}{50}\right)}$$

Step-3. convert into decibels

$$20\log_{10}(G(jw)) = 20\log_{10}\left(\frac{0.2\left(1+\frac{jw}{10}\right)\left(1+\frac{jw}{1}\right)}{jw\left(1+\frac{jw}{50}\right)}\right)$$

[$\log(mn) = \log m + \log n$
$\log(m/n) = \log m - \log n$.] ~~Note~~

$$20\log_{10}[G(jw)] = 20\log_{10}(0.2) + 20\log_{10}\left(1+\frac{jw}{10}\right) + 20\log_{10}\left(1+\frac{jw}{1}\right) - 20\log_{10}(jw) - 20\log_{10}\left(1+\frac{jw}{50}\right)$$

Step-2 Table.

S.N	Component	Corner frequency	slope (20db/decade)	overall slope
1.	$20\log_{10}\left(\frac{0.2}{jw}\right)$	none	-20 db/decade	-20 db/decade
2.	$20\log_{10}\left(1+\frac{jw}{1}\right)$	1	+20 db/decade	0 db/decade (straight line)
3.	$20\log_{10}\left(1+\frac{jw}{10}\right)$	10	+20 db/decade	20 db/decade
4.	$20\log_{10}\left(1+\frac{jw}{50}\right)$	50	-20 db/decade	0 db/decade (straight line)
starting point →	$20\log_{10}\left(\frac{0.2}{jw}\right)$			

starting point: $20 \log_{10} \left(\frac{0.2}{j\omega} \right)$

mod(j) = 1

$= 20 \log_{10} \left(\frac{0.2}{0.1} \right) = 6.02\,db$, $\omega = 0.1$, starting line नै assumed corner frequency.

corner frequency मानेर first line assume गर्न पाइदैन ।

2017 Fall
4. (b)

Sketch the Bode plot for the following transfer function.

$$\frac{2s^2}{(1+0.25s)(1+0.025s)}$$

step 1. $G(s) = \dfrac{2s^2}{\left(1+\frac{s}{4}\right)\left(1+\frac{s}{40}\right)}$

step-2. put $s = j\omega$

$$G(j\omega) = \frac{2(j\omega)^2}{\left(1+\frac{j\omega}{4}\right)\left(1+\frac{j\omega}{40}\right)}$$

step-3 converting into decibels

$$= 20\log_{10}\left(2(j\omega)^2\right) - 20\log_{10}\left(1+\frac{j\omega}{4}\right) - 20\log\left(1+\frac{j\omega}{40}\right)$$

$$= 20\log_{10}(2) + 40\log_{10}(j\omega) - 20\log_{10}\left(1+\frac{j\omega}{4}\right) - 20\log\left(1+\frac{j\omega}{40}\right)$$

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Step 4 Table.

S/N.	component	corner freq.	db/decade slope	overall slope
1.	$20\log_{10}(2(j\omega)^2)$	none	40 db/decade	40 db/decade
2.	$20\log_{10}\left(1+\frac{j\omega}{4}\right)$	4	-20 db/decade	20 db/decade
3.	$20\log_{10}\left(1+\frac{j\omega}{40}\right)$	40	-20 db/decade	0 db/decade

starting point.

$$20\log_{10}(2(j\omega)^2)$$

$$= 20\log_{10}(2\times 0.1^2)$$

$$= -33.979 \text{ db.}$$

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phase angle plot:

$$H(s) = \frac{(s+10)(s+1)}{s(s+50)}$$

step 1, 2, 3 — same as magnitude plot

$$= +20\log_{10}(0.2) + 20\log_{10}\left(1+\frac{j\omega}{10}\right) + 20\log_{10}\left(1+\frac{j\omega}{1}\right) - 20\log_{10}(j\omega) - 20\log_{10}\left(1+\frac{j\omega}{50}\right)$$

Ignore constant value in phase.

$-\tan^{-1}\left(\frac{\omega}{0}\right) = 90°$

Then

$$\phi = -90° - \tan^{-1}\left(\frac{\omega}{50}\right) + \tan^{-1}\left(\frac{\omega}{10}\right) + \tan^{-1}\left(\frac{\omega}{1}\right)$$

phase angle ϕ vs ω.

ω	0.1	0.2	0.3	0.8	1	2	6	8
ϕ	-83.83	-77.77	-71.92	-97.68	-90.93	-17.59	14.65	22.94

10	20
27.97	38.77

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Q. $H(s) = \dfrac{300(s+4)}{5(4s+1)(3s^2+11s+12)(s+10)}$

Magnitude plot

step-1. convert into $\left(1+\frac{s}{\quad}\right)$

$$= \frac{60 * 4\left(1+\frac{s}{4}\right)}{\left(1+\frac{s}{0.5}\right) * 10\left(1+\frac{s}{10}\right) * 12\left(1+\frac{11}{12}s+\frac{3s^2}{12}\right)}$$

$$= \frac{s\left(1+\frac{s}{4}\right)}{\left(1+\frac{s}{0.5}\right)\left(1+\frac{s}{10}\right)\left(1+\frac{11}{12}s+\frac{s^2}{4}\right)}$$

step-2. put $s = j\omega$

$$H(j) = \frac{2\left(1+\frac{j\omega}{4}\right)}{\left(1+\frac{j\omega}{0.5}\right)\left(1+\frac{j\omega}{10}\right)\left(1+\frac{11}{12}j\omega+\left(\frac{j\omega}{2}\right)^2\right)}$$

step-3. convert into db

$$= 20\log_{10}(2) + 20\log_{10}\left(1+\frac{j\omega}{4}\right) - 20\log_{10}\left(1+\frac{j\omega}{0.5}\right) - 20\log_{10}\left(1+\frac{j\omega}{10}\right) - 40\log_{10}\left(1+\frac{11}{12}j\omega+\left(\frac{j\omega}{2}\right)^2\right)$$

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Table

S.N.	Component	corner freq.	slope	overall slope
1.	$20\log_{10}(2)$	none	0 db/ decade	0 db/decade
2.	$20\log_{10}\left(1+\frac{j\omega}{0.5}\right)$	0.5	-20 db/decade	-20 db/decade
3.	$20\log_{10}\left(1+\frac{11}{12}j\omega+\left(\frac{j\omega}{2}\right)^2\right)$	2	-40 db/decade	-60 db/decade
4.	$20\log_{10}\left(1+\frac{j\omega}{4}\right)$	4	20 db/decade	-40 db/decade
5.	$20\log_{10}\left(1+\frac{j\omega}{10}\right)$	10	-20 db/decade	-60 db/decade

starting point $\Rightarrow$ $20\log_{10}(2) = 6.02$.

Phase angle plot:

$$\phi = \tan^{-1}\left(\frac{\omega}{4}\right) - \tan^{-1}\left(\frac{\omega}{0.5}\right) - \tan^{-1}\left(\frac{\omega}{10}\right) - \tan^{-1}\left(\frac{11\omega}{12-\omega^2}\right)$$

ω	0.1	0.2	0.4	0.8	1	2	4	6	8	10	20
ϕ	-15.69	-30.5	-55.62	-89.02	-100.11	-130.72	-95.12	-10.12	-2.22	-12.59	-43.76