

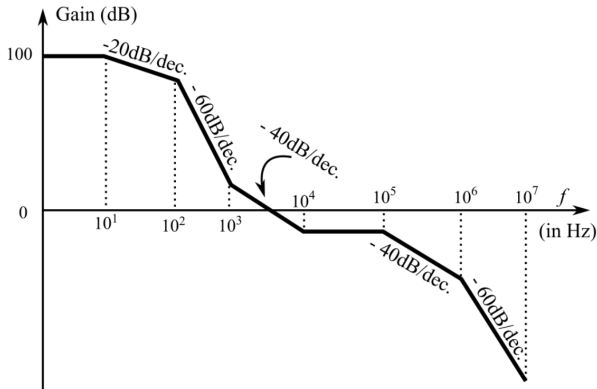
# Gate Problem on Control Systems

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# Gate 2019 EC Problem

Q.6 - For an LTI system, the Bode plot for its gain is as illustrated in the figure shown. The number of system poles  $N_p$  and number of system zeros  $N_z$  in the frequency range  $1 \text{ Hz} \leq f \leq 10^7 \text{ Hz}$  is



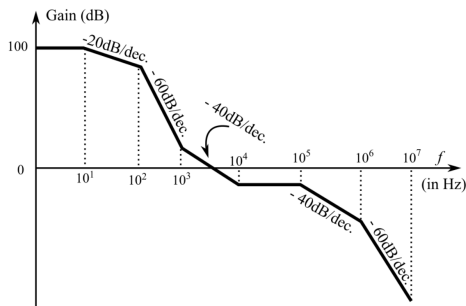
Let us consider a generalized transfer gain

$$H(s) = k \frac{(s-z_1)(s-z_2)\dots(s-z_{m-1})(s-z_m)}{(s-p_1)(s-p_2)\dots(s-p_{n-1})(s-p_n)}$$

$$\text{Gain} = 20\log|H(s)| = 20\log|k| + 20\log|s - z_1| + 20\log|s - z_2| + \dots + 20\log|s - z_m| - 20\log|s - p_1| - 20\log|s - p_2| - \dots - 20\log|s - p_n|$$

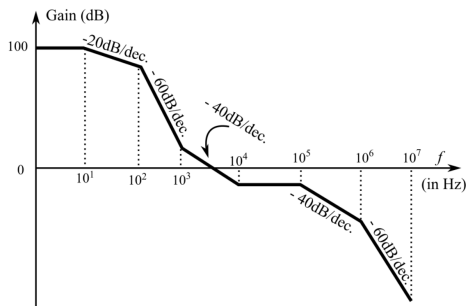
- When a pole is encountered the slope always decreases by -20 dB/decade
- When a zero is encountered the slope always increases by +20 dB/decade

# Solution



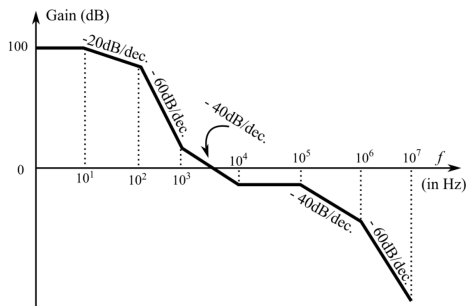
- At  $f = 10$  Hz , change in slope =  $-20\text{dB/sec}$ , Hence we have 1 pole here
- At  $f = 10^2$  Hz, Change in slope =  $-40\text{dB/sec}$ , Hence we have 2 poles here

# Solution



- At  $f = 10^3$  Hz, Change in slope =  $+20\text{dB/sec}$ , Hence we have 1 zero here
- At  $f = 10^4$  Hz, Change in slope =  $+40\text{dB/sec}$ , Hence we have 2 zeros here

# Solution



- At  $f = 10^5$  Hz, Change in slope =  $-40\text{dB/sec}$ , Hence we have 2 poles here
- At  $f = 10^6$  Hz, Change in slope =  $-20\text{dB/sec}$ , Hence we have 1 pole here

$$N_p = 6$$

$$N_z = 3$$