20 dB/dec = 6 dB/oitava

1 Rad/sec ⇒ 1 Zero: $\left(1 + \frac{j\omega}{1}\right)$

2 Rad/sec ⇒ 1 Pole: $\frac{1}{\left(1 + \frac{j\omega}{2}\right)}$

5 Rad/sec ⇒ 1 Pole: $\frac{1}{\left(1 + \frac{j\omega}{5}\right)}$

20 Rad/sec ⇒ 1 Pole: $\frac{1}{\left(1 + \frac{j\omega}{20}\right)}$

$$G(j\omega) = \frac{\left(1 + \frac{j\omega}{1}\right)}{\left(1 + \frac{j\omega}{2}\right) \cdot \left(1 + \frac{j\omega}{5}\right) \cdot \left(1 + \frac{j\omega}{20}\right)}$$

a) Add a pole in origin: $\left(\frac{1}{j\omega}\right)$

$$G(j\omega) = \frac{(1 + j\omega)}{(j\omega)\left(1 + \frac{j\omega}{2}\right) \cdot \left(1 + \frac{j\omega}{5}\right)\left(1 + \frac{j\omega}{20}\right)}$$

check the Bode Diagram in the solution

b) Gain Margin (GM) - Indicates how much the gain can be raised until the system becomes in the verge of instability.

Phase Margin (PM) - Is the amount of additioned phase lag at the gain crossover frequency required to bring the system to the verge of instability

MF=90,63
MG=15,82

Gain crossover frequency - Is the frequency at which $|G(j\omega)|$, the magnitude of the open loop transfer function is unity

check the Bode Graph in the solutions

c) Will have an impact on the magnitude of the Gain by a +15dB.

GM and PM decreases in the situation.

continuacao

d) Gain dB:

$$20 \log K = 15\ dB$$

$$K = 5,6 = 10^{\frac{15}{20}}$$

Note:

$y = \log_a K$

$K = a^y$

$$G(j\omega) = \frac{(1+j\omega)}{j\omega\left(1+\frac{j\omega}{2}\right)\left(1+\frac{j\omega}{5}\right)\left(1+\frac{j\omega}{20}\right)}$$

$$G(j\omega) = \frac{5,6\cdot(1+j\omega)}{j\omega\left(1+\frac{j\omega}{2}\right)\cdot\left(1+\frac{j\omega}{5}\right)\cdot\left(1+\frac{j\omega}{20}\right)} \quad \text{[add Gain]} \quad 21:06$$

$$G(s) = \frac{5,6\ (1+s)}{s\cdot\frac{1}{2}(2+s)\cdot\frac{1}{5}(5+s)\cdot\frac{1}{20}(20+s)}$$

$$= \frac{200\cdot 5,6\cdot(s+1)}{s\cdot(s+2)(s+5)\cdot(s+20)}$$

$$= \frac{1120\cdot(s+1)}{s\cdot(s+2)\cdot(s+5)\cdot(s+20)}$$