Bode 图绘制

① 化成标准形式：

如 $H(s)=\dfrac{25(0.1s+1)}{s^2(0.2s+1)}$

此时有比例环节（1个）：25（k）

积分环节（2个）：$\dfrac{1}{s^2}$

导前环节（1个）：$0.1s+1$

惯性环节（1个）：$0.2s+1$

⇒ 低频部分会过 $(1,\ 20\lg k)$ → 此处 $(1,\ 20\lg 25)$

比例环节：$G(s)=k$

积分环节：$G(s)=\dfrac{1}{s}$

微分环节：$G(s)=s$

惯性环节：$G(s)=\dfrac{1}{Ts+1}$

导前环节：$G(s)=Ts+1$

确定了第一条线

Ⅱ型系统（有n个积分环节就是n型系统）

⇓

$V=2$ ⇒ 低频部分斜率为 $-20\ dB/dec \cdot V=-40\ dB/dec$

此处

② 求频率特性（把 s 变为 jw）

$$H(jw)=\frac{25(j0.1w+1)}{(jw)^2(j0.2w+1)}$$

对导前环节 $j0.1w+1$，$w_2=\dfrac{1}{0.1}=10\ s^{-1}$

对惯性环节 $j0.2w+1$，$w_1=\dfrac{1}{0.2}=5\ s^{-1}$

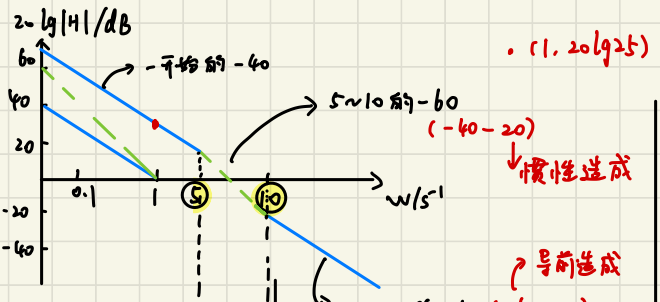
（小的标1）

对导前环节 w_2 开始斜率上升 $20\ dB/dec$

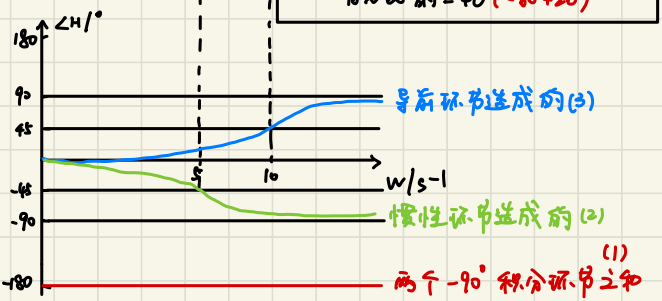
对惯性环节 w_2 开始斜率下降 $20\ dB/dec$

③ 画图

幅频图 →

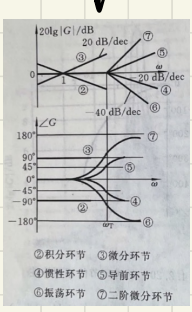


相频图 →



把(1)(2)(3)加起来即可得到结果

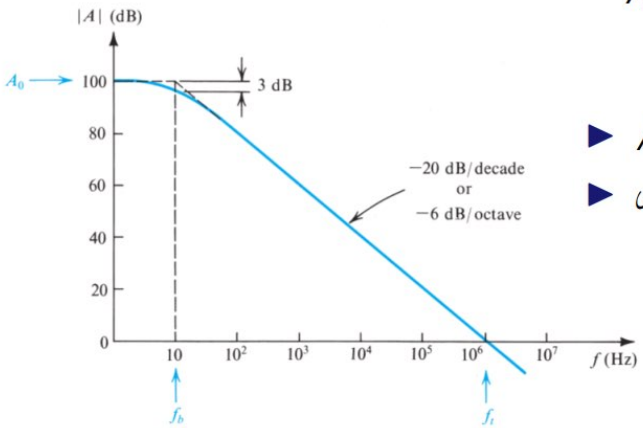
不用管比例环节



Pole-zero representation

- Bode plot (magnitude)
  - Zero contributes 20dB/decade slope if $s > s_z$
  - Pole contributes -20dB/decade slope if $s > s_p$
  - Complex conjugate zeros contributes 40dB/decade slope if $s > \mid s_z \mid$
  - Complex conjugate poles contributes -40dB/decade slope if $s > \mid s_p \mid$
- Bode plot (phase)
  - 90° if $s_z = 0$
  - -90° if $s_p = 0$
  - Increase by 90° and passes though the midpoint of 45° at the break point $s = s_z \neq 0$
  - Decrease by 90° and passes though the midpoint of -45° at the break point $s = s_p \neq 0$

Finite op amp bandwidth



$$A(j\omega) = \frac{A_0}{1 + j\omega/\omega_b} \qquad (8)$$

- A_0: dc gain
- ω_b: 3-dB frequency

Finite op amp bandwidth

- Magnitude:

$$| A(j\omega) | = \frac{A_0 \omega_b}{\omega} \tag{9}$$

- Unity gain:

$$A(j\omega_t) = 1 \tag{10}$$

- unity-gain bandwidth (gain–bandwidth product)

$$f_t = \frac{\omega_t}{2\pi} = \frac{A_0 \omega_b}{2\pi} \tag{11}$$