Tuesday, April 3, 2018 10:21 AM

join.me/asodemann

1)

$20 \frac{mm}{rev} \times \frac{1 rev}{360^\circ} \times \frac{1 step}{0.1 mm} = 0.55 \frac{steps}{^\circ}$

$\frac{^\circ}{step}$

$\leq 1.8 \frac{^\circ}{step}$

$\leq 0.1 \frac{mm}{step}$

$1.8 \frac{^\circ}{step} \times \frac{1 rev}{360^\circ} \times \frac{1 s}{10 mm} \times \frac{20 mm}{rev} \times \frac{1000 ms}{1 s}$ $\frac{ms}{step}$

$= 10 \frac{ms}{step}$

$10 \frac{mm}{s}$

---

2)

DC motor

less accurate, because can't do feedback control

↓

washing machine
→ don't need position control, just need speed

servo

more accurate; have feedback

↓

claw.
→ need feedback to control not only position but force, etc.

stepper

more accurate positioning than DC, but less accurate than servo

↓

car window
→ position control is needed, but precision not that important. Has limit switches

4) too much overshoot

too much SSE

5) $OS = e^{\frac{-\pi \zeta}{\sqrt{1-\zeta^2}}}$

$\frac{15}{\ldots} = 0.33$ or 33%

$OS = 45$

$$0.33 = e^{\frac{-\pi \zeta}{\sqrt{1-\zeta^2}}}$$

$$-1.0986 = \frac{-\pi \zeta}{\sqrt{1-\zeta^2}}$$

$$1.2069 = \frac{\pi^2 \zeta^2}{1-\zeta^2}$$

$$t_p = \frac{\pi}{\omega_n \sqrt{1-\zeta^2}}$$

$$0.009 = \frac{\pi}{\omega_n \sqrt{1-(0.33)^2}}$$

$$349.0655 = \omega_n \sqrt{1-(0.33)^2}$$

$$\boxed{\omega_n = 370.2 \ \frac{rad}{s}}$$

$$1.2069 - 1.2069\zeta^2 = \pi^2 \zeta^2$$

$$1.2069 = 11.076\zeta^2$$

$$\zeta^2 = 0.1089$$

$$\boxed{\zeta = 0.33}$$

---

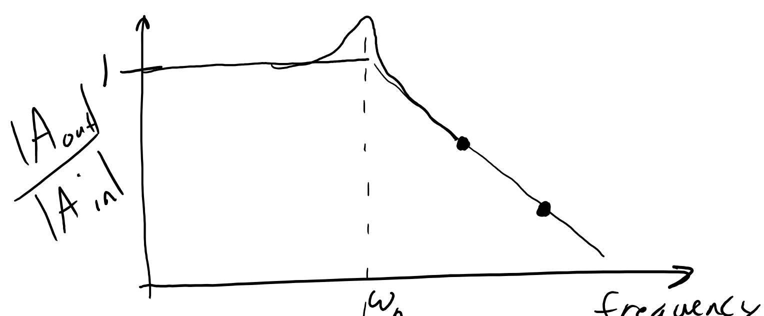
6) $$\ddot{x}(t) + 2(0.33)(370.2)\dot{x}(t) + (370.2)^2 x(t) = (370.2)^2 u(t)$$

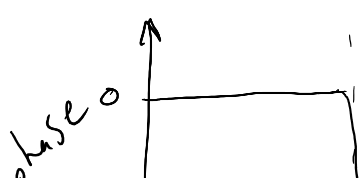
$$\ddot{x}(t) + 244.332\dot{x}(t) + 137048.04\, x(t) = 137048.04\, u(t)$$

$$s^2 X(s) + 244.332\, s X(s) + 137048.04\, X(s) = 137048.04\, U(s)$$

$$\frac{X(s)}{U(s)} = \frac{137048.04}{s^2 + 244.332 s + 137048.04}$$

7)





8) I would give a sine wave input at a particular frequency and I would measure the amplitude of the output. If the output amplitude is the same as the input amplitude, I know that the tested frequency is below the natural frequency.

9)

$$\frac{X(s)}{U(s)} = \frac{137048.04}{s^2 + 244.332s + 137048.04} = \frac{K_pH(s)}{1+K_pH(s)}$$

$$137048.04 + 137048.04H(s) = (s^2 + 244.332s + 137048.04)H(s)$$

$$137048.04 = (s^2 + 244.332s)H(s)$$

$$H(s) = \frac{137048.04}{s^2 + 244.332s}$$

$$\frac{K_pH(s)}{1+K_pH(s)} = \frac{\frac{K_p137048.04}{s^2+244.332s}}{1 + \frac{K_p137048.04}{s^2+244.332s}}$$

$K_p 137048.04$

$$\frac{K_p\, 137048.04}{\bigcirc s^2 + (244.332)s + (K_p\, 137048.04)}$$

244.332 → $2\zeta\omega_n$; $K_p\, 137048.04$ → ω_n^2

$244.332 = 2\zeta\omega_n$

$\omega_n = 122.16 \frac{rad}{s}$

$K_p\, 137048.04 = (122.16)^2$

$\boxed{K_p = 0.1}$

---

10) $$\frac{137048.04}{s^2 + 244.332s + 137048.04} = \frac{2H(s)}{1 + 2H(s)}$$

$$137048.04 + \boxed{274096.08\, H(s)} = (2s^2 + 488.664s + \boxed{274096.08})H(s)$$

$$137048.04 = (2s^2 + 488.664s)H(s)$$

$$H(s) = \frac{137048.04}{2s^2 + 488.664s}$$

$$\frac{K_p H(s)}{1 + K_p H(s)} = \frac{\frac{137048.04 K_p}{2s^2 + 488.664s}}{1 + \frac{137048.04 K_p}{2s^2 + 488.664s}}$$

$$\frac{\cancel{(2)}\; 68524.02 K_p}{\cancel{(2)}(s^2 + 244.332s + 68524.02 K_p)}$$

$244.332 = 2\zeta\omega_n$ (ζ = 0.7)

$$244.332 = 25\omega_n \cdot 0.1$$

$$\omega_n = 174.522$$

$$\omega_n^2 = 68524.02K_p$$

$$30458.227 = 68524.02K_p$$

$$K_p = 0.4$$