SRV02 Modeling

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Contents

1 Pre-Lab

All values of the form x.x.x are references to the student workbook [1]

1.1

Taking equation 1.1.26:

$$(\frac{d}{dt}\omega_l(t))J_{eq} + B_{eq,v}\omega_l(t) = A_m V_m(t)$$

Applying the Laplace transform:

$$J_{eq} S\Omega_l(s) + B_{eq,v}\Omega_l(s) = A_m V_m(s)$$

Rearranging into the transfer function:

$$\frac{\Omega_l(s)}{V_m(s)} = \frac{A_m}{J_{eq}s + B_{eq,v}}$$

1.2

We know from equation 1.1.1 that the transfer function takes the form:

$$\frac{\Omega_l(s)}{V_m(s)} = \frac{K}{\tau s + 1}$$

Therefore fitting the answer form question 1 to this form we get:

$$\tau = \frac{J_{eq}}{B_{eq,v}}$$

$$K = \frac{A_m}{B_{eq,v}}$$

1.3

Using equations 1.1.26 and 1.1.27 along with the specifications from the user manual [2] we get the values:

$$B_{eq,v} = 0.0844 Nms/rad$$

$$A_m = 0.129 Nm/V$$

1.4

Both J_{tach} and $J_{m,rotor}$ are given in the user manual [2] hence we can simply determine J_m with:

$$J_m = J_{tach} + J_{m,rotor} = 4.606 * 10^{-7} kgm^2$$

1.5

Using the approximation of each gear as a disc we can use the specifications outlined in [2] to calculate the moment of inertia of each gear.

$$J_{disc} = \frac{mr^2}{2}$$

For the 24 tooth gear:

$$J_{24} = 1.008 * 10^{-7} kgm^2$$

For the 72 tooth gear:

$$J_{72} = 5.415 * 10^{-6} kgm^2$$

For the 120 tooth gear:

$$J_{120} = 4.24 * 10^{-5} kgm^2$$

Using the "High Gear" configuration from the user manual [2] we can see that the 120 and 72 tooth gears are on the same shaft while the 24 tooth gear drives the 120 tooth gear hence the total inertia J_g is given by:

$$J_g = J_{72} + J_{120} + J_{24}\frac{120}{24}$$

$$J_g = 4.8319 * 10^{-5} kgm^2$$

1.6

We know $J_l = J_g + J_{l,ext}$ and from the values in the user manual [2] $J_{l,ext} = 5 * 10^{-5} kgm^2$ therefore:

$$J_l = 9.24 * 10^{-5} kgm^2$$

1.7

Using the load inertia found in the previous question motor inertia found in question 4 and substituting values from the user manual [2] into equation 1.1.18 we get:

$$J_{eq} = 0.002046 kgm^2$$

1.8

We have values for $B_{eq,v}$, A_m and J_{eq} hence using the equations from Question 2 we get:

$$K = 1.528 rad/Vs$$

$$\tau = 0.0243 s$$

1.9

From section 1.1.2.1 we know the gain is $\frac{1}{\sqrt{2}}$ of the maximum gain:

$$|G_{wl,v}(\omega_c)| = \frac{\sqrt{2}}{2}|G_{wk,v}0)|$$

Hence using equation 1.1.31:

$$\frac{\sqrt{2}}{2}|G_{wk,v}0)| = \frac{|G_{wl,v}(0)|}{1 + \tau_{e,f}^2 \omega_c^2}$$

Rearranging to solve for the time constant:

$$\tau_{e,f} = \frac{1}{|w_c|}$$

1.10

Knowing $\omega_{l,ss} = lim_{t \to \infty} \omega_l(t)$ and taking the limit of the servo step response from 1.1.40:

$$\omega_{l,ss} = KA_v + \omega_l(t_0)$$

Rearranging for K:

$$K = \frac{\omega_{l,ss} - \omega_l(t_0)}{A_v}$$

Which is consistent with the relationship given in 1.1.34.

1.11

Substituting $t = t_0 + \tau$ into equation 1.1.40 gives us:

$$\omega_l(t_0 + \tau) = KA_v(1 - e^{-1}) + \omega_l(t_0)$$

Which is consistent with equation 1.1.34 through the example given of $y(t_1)$ in 1.1.35.

References

[1] J. Apkarian, M. Lvis, and H. Gurocak, "Srv02 - student workbook," 2011.

[2] J. Apkarian, M. Lvis, and H. Gurocak, "Srv02 rotary servo base unit - set up and configuration," 2011.