RIS Lab Report 4

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Task 1.17

1.A) $T_L(s) = 0$, $r(t) = k u(t)$

$$E(s) = \frac{1}{1+H_{wv}(s)G(s)} R(s) + \frac{H_{wL}(s)}{1+H_{wv}(s)G(s)} T_L(s)$$

we have, $T_L(s) = 0$

$$\mathcal{L}\{k u(t)\} = \frac{k}{s}$$

$$H_{wv}(s) = \frac{k_t}{D(s)} = \frac{k_t}{(R_a+L_a s)(Js+b)+k_t k_e}$$

$$G(s) = K_p + K_I \frac{1}{s} + K_D s$$

$$H_{wv}(s)G(s) = \frac{k_t}{(R_a+L_a s)(Js+b)+k_t k_e} \cdot \left(K_p + K_I \frac{1}{s} + K_D s\right)$$

$$= \frac{(K_p s + K_I + K_D s^2)\, k_t}{s(R_a+L_a s)(Js+b) k_t k_e}$$

$$1+H_{wv}(s)G(s) = 1 + \frac{(K_p s + K_I + K_D s^2)k_t}{s(R_a+L_a s)(Js+b)+k_t k_e}$$

$$= \frac{s(R_a+L_a s)(Js+b) k_t k_e + (K_p s + K_I + K_D s^2)\, k_t}{s(R_a+L_a s)(Js+b)+k_t k_e}$$

$$E(s) = \frac{\cancel{s}(R_a+L_a s)(Js+b)k_t k_e}{s(R_a+L_a s)(Js+b)k_t k_e + (K_p s + K_I + K_D s^2)\, k_t} \cdot \frac{k}{\cancel{s}}$$

$$\lim_{s\to 0} sE(s) = \frac{s(R_a+L_a s)(Js+b)\, k_t k_e}{s(R_a+L_a s)(Js+b)k_t k_e + (K_p s + K_I + K_D s^2)\, k_t} = 0$$

Task 1.18

Task 1-18)

$r(t) = k u(t)$, and $T_L(t) = l u(t)$

$$E(s) = \frac{1}{1+H_{wv}(s)G(s)} R(s) + \frac{H_{we}(s)}{1+H_{wv}(s)G(s)} T_L(s)$$

We know,

$$\lim_{s\to 0} s E(s) \cancel{\text{for}} \frac{1}{1+H_{wv}(s)G(s)} R(s) = 0$$

for $R(s) = \frac{k}{s}$

$$\cancel{E(s)} \frac{H_{we}(s)}{1+H_{wv}(s)G(s)} T_L(s) \quad \text{, We know } H_{we}(s) = \frac{R_a + L_a s}{D(s)}$$

$$H_{wv}(s) = \frac{k_t}{(R_a+L_a s)(Js+b) + k_t K_e}$$

$$\lim_{s\to 0} \frac{s H_{we}(s)}{1+H_{wv}(s)G(s)} T_L(s)$$

$$= \cancel{\lim_{s\to 0} s \cdot \lim_{s\to 0} H_{we}(s) \cdot \lim_{s\to 0} \frac{l}{s}}$$

$$\lim_{s\to 0} \frac{\frac{s(R_a+L_a s)}{D(s)} \cdot \frac{l}{s}}{1 + \frac{k_t G(s)}{(R_a+L_a s)(Js+b)+K_t K_e}}$$

$$\lim_{s\to 0} \frac{\frac{\cancel{s}(R_a+L_a s)}{\cancel{(R_a+L_a s)(Js+b)+K_e K_t}} \cdot \frac{l}{\cancel{s}}}{\frac{(R_a+L_a s)(Js+b)+K_t K_e + K_t G(s)}{\cancel{(R_a+L_a s)(Js+b)+K_e K_t}}}$$

$$= \frac{(R_a+L_a s)\cdot l}{(R_a+L_a s)(Js+b) + K_e K_t + K_t G(s)}$$

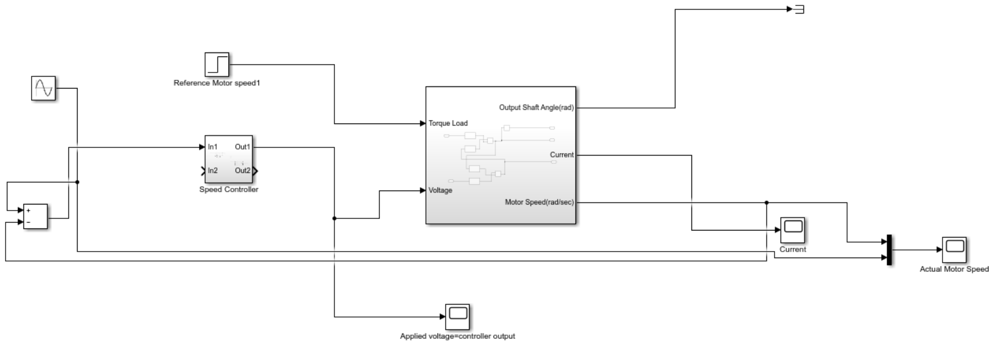
$$= \frac{(R_a+L_a s)\cdot l}{(R_a+L_a s)(Js+b) + K_e K_t + K_t \cdot (K_p + K_I \frac{1}{s} + K_D s)}$$

$$= \frac{(R_a+L_a s)\cdot l}{(R_a+L_a s)(Js+b) + K_e K_t + K_t \cdot \frac{sK_p + K_I + K_D s^2}{s}}$$

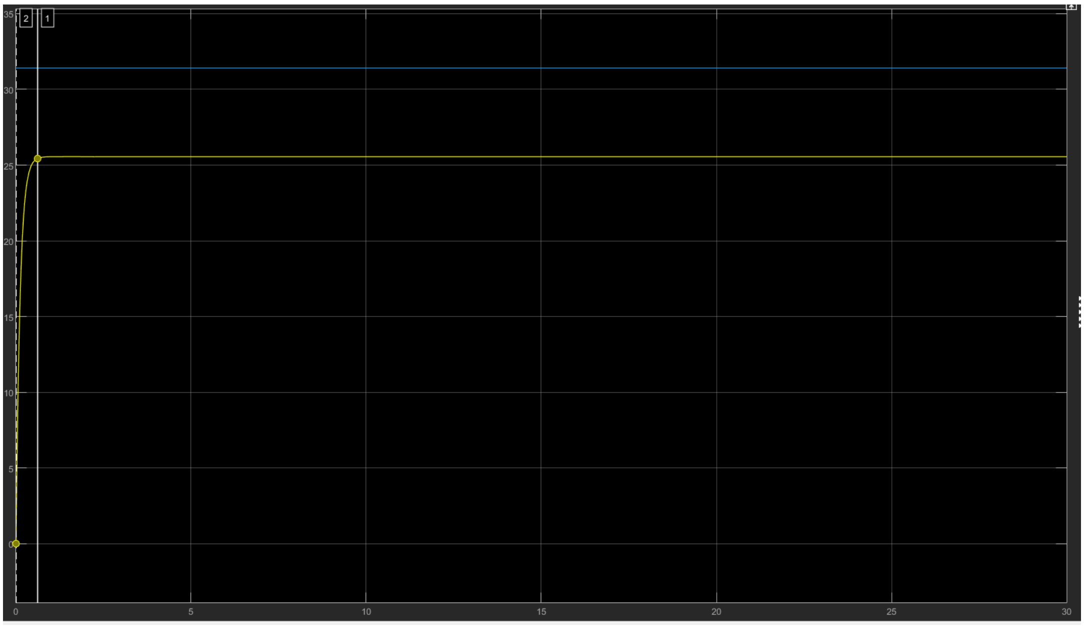
$$= \frac{(R_a+L_a s)\cdot l s}{s\{(R_a+L_a s)(Js+b) + K_e K_t\} + K_t \cdot sK_p + K_I + K_D s^2} = E(s)$$

$$\lim_{s\to 0} s E(s) = 0$$

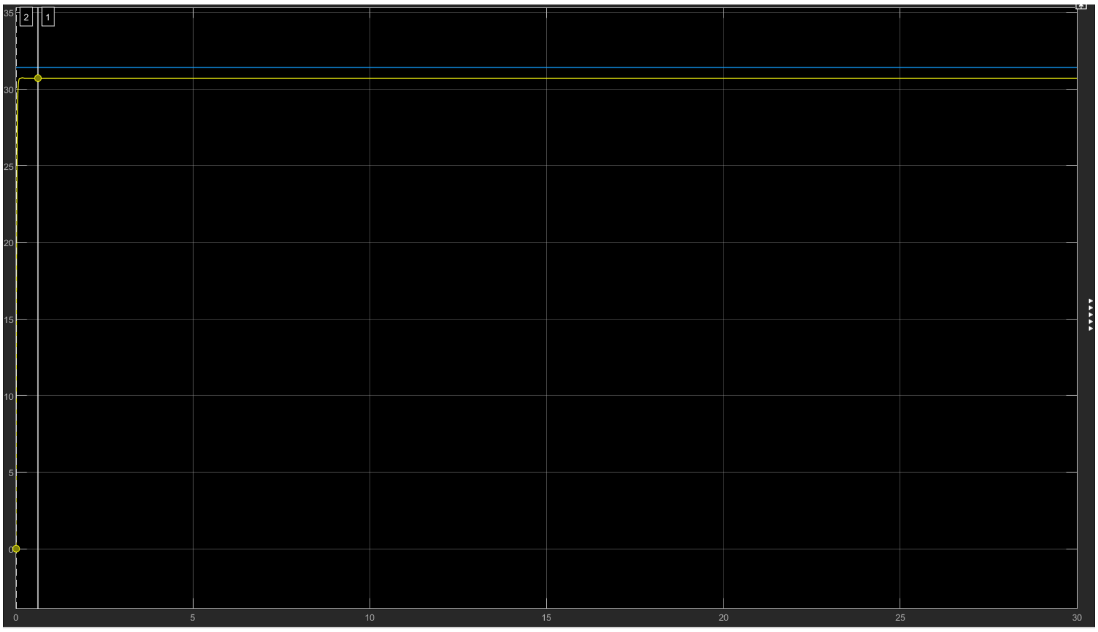
Task 1.19



Task 1.20



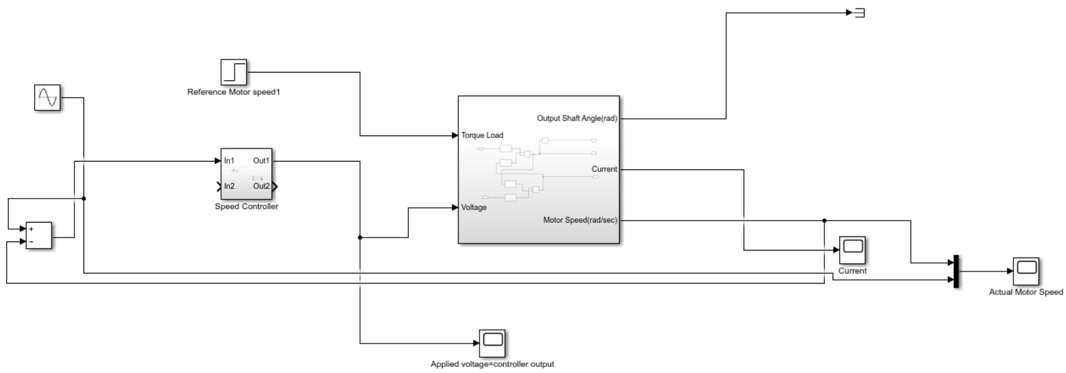
R(T) with Kp=1



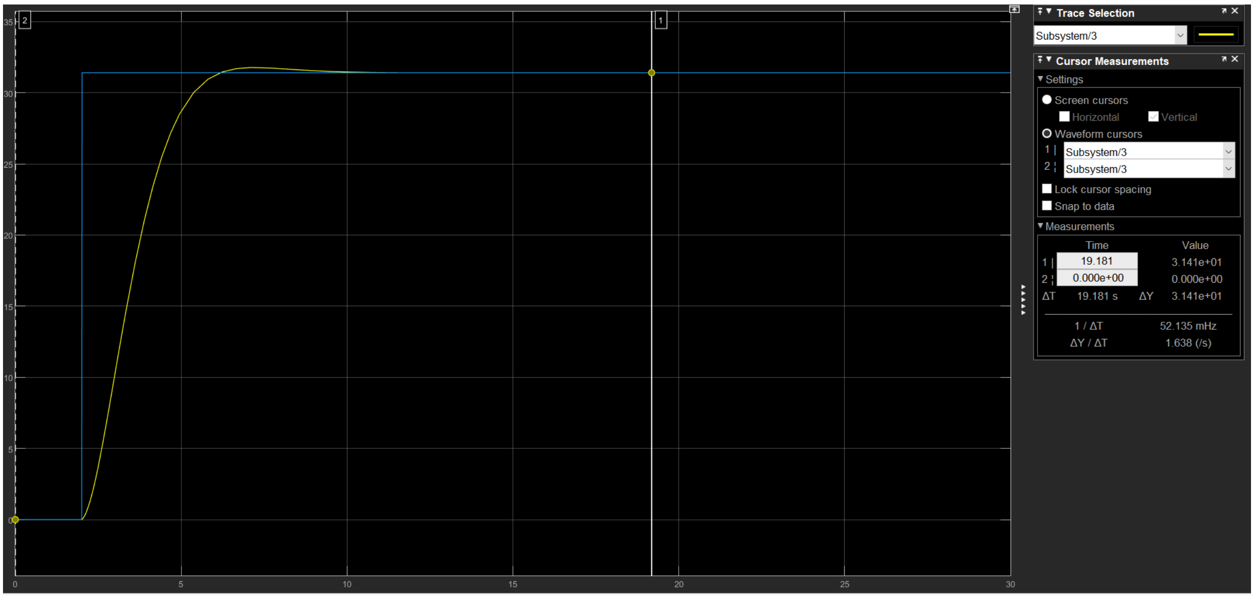
R(T) with Kp=10

From the graph we can see that w(t) did not reach r(t) and the error is the blue line (Actual) – yellow line (Reference). For kp=1 the error is 32-26=6 radians per second.

Task 1.21



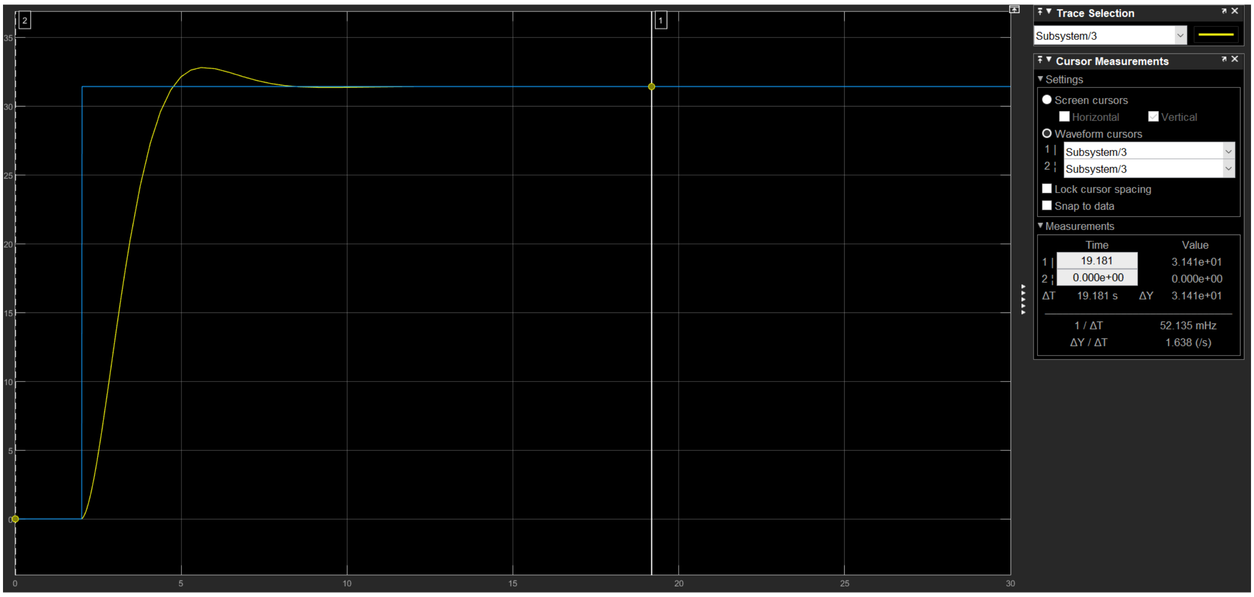
1)



R(T) with kp=0.0084 and ki=0.15

There is no steady state error as when the system reaches a steady state (the reference speed and the actual speed overlap) and the discriminant is near to 0 when ki=0.15.

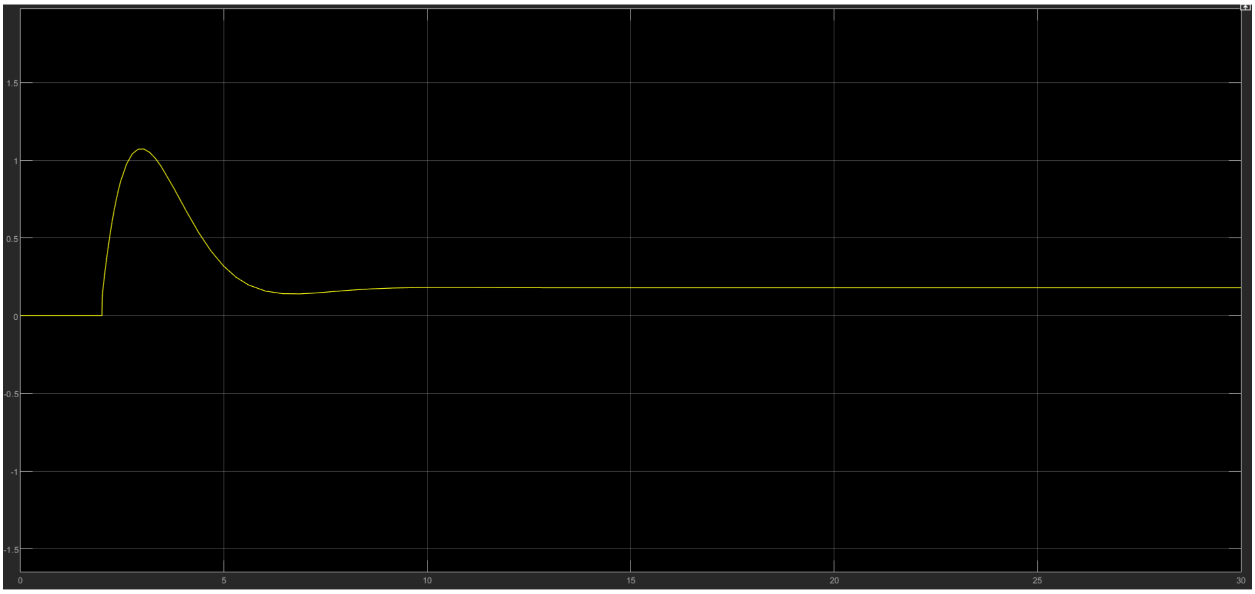
2)



R(T) with kp=0.0084 and ki=0.2

Yes, a small ripple can be seen in the graph before the system settles down.

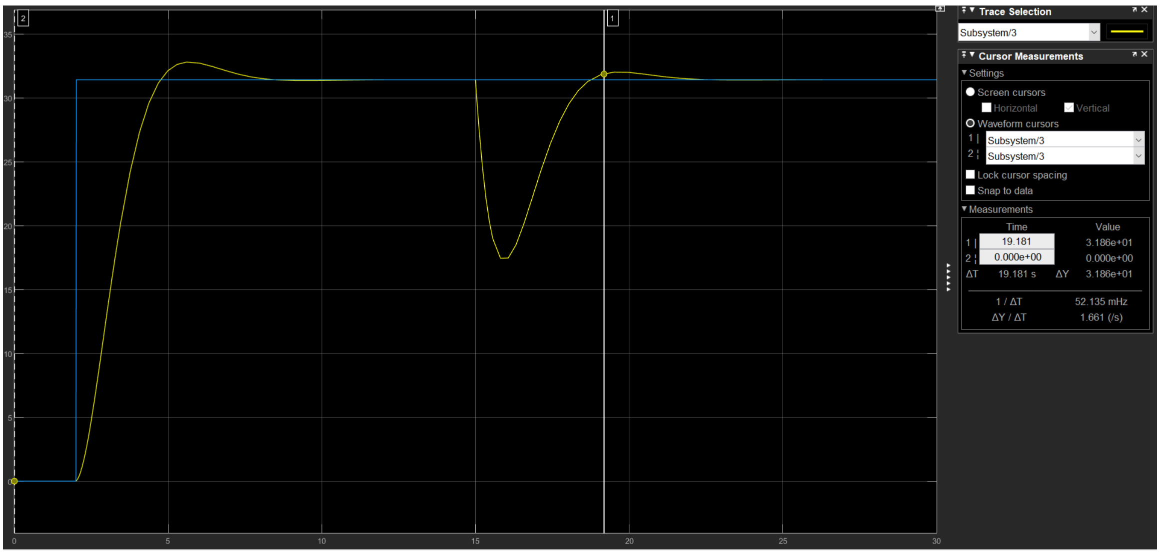
3)



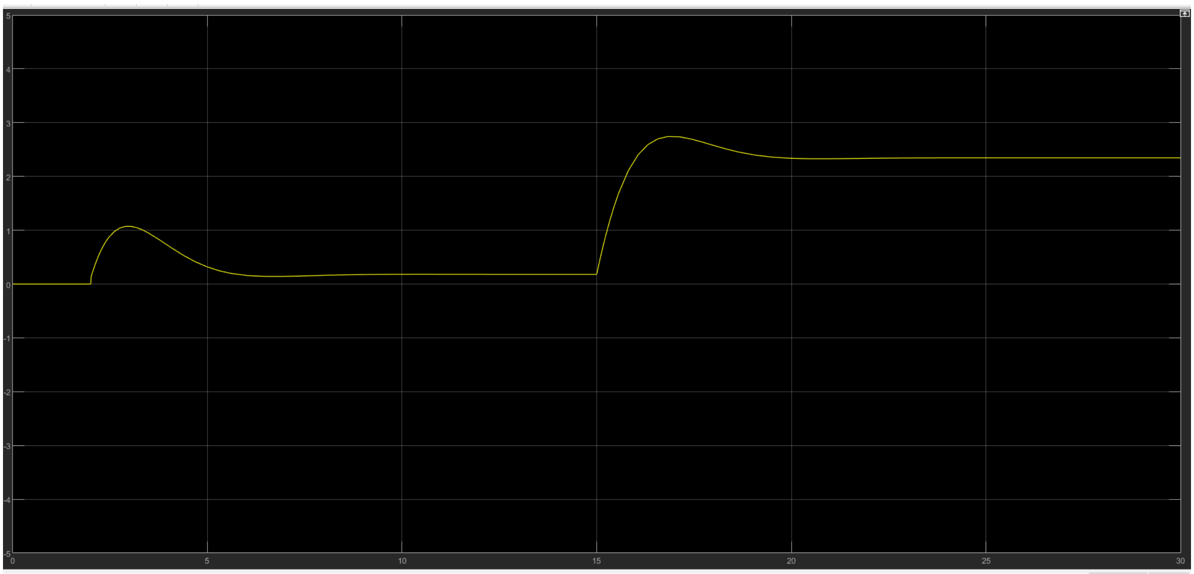
Current-time Graph

They are in safe range as the value is below 5 Amperes. (Stall Current)

4)



R(t) with half of the stall torque at t=15

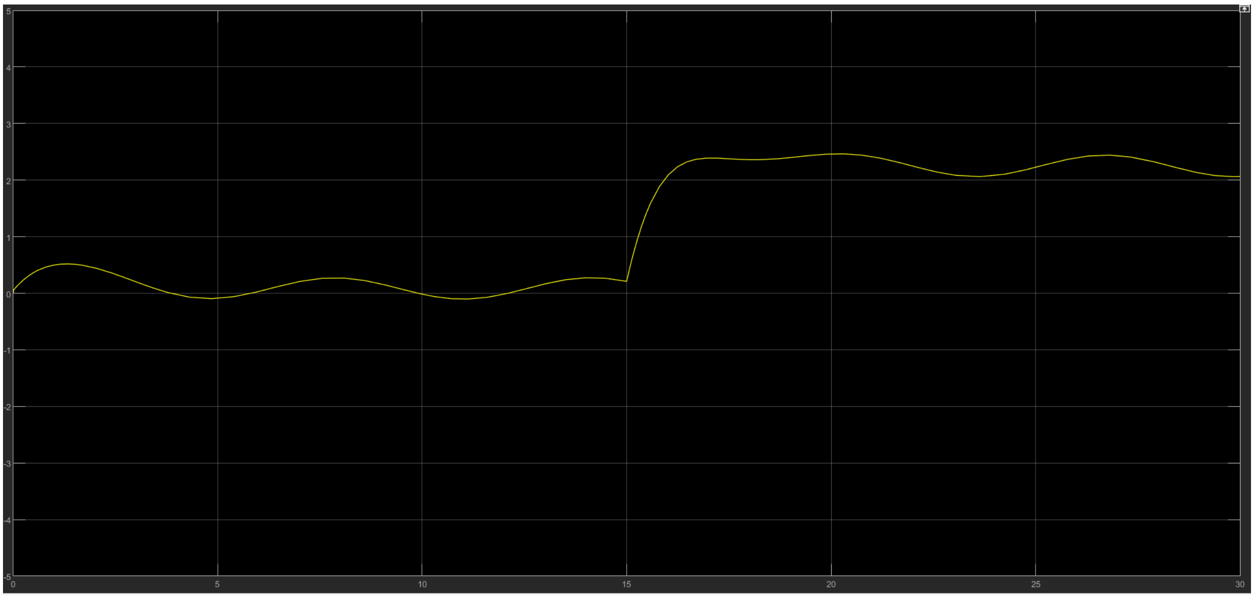


Current-time graph

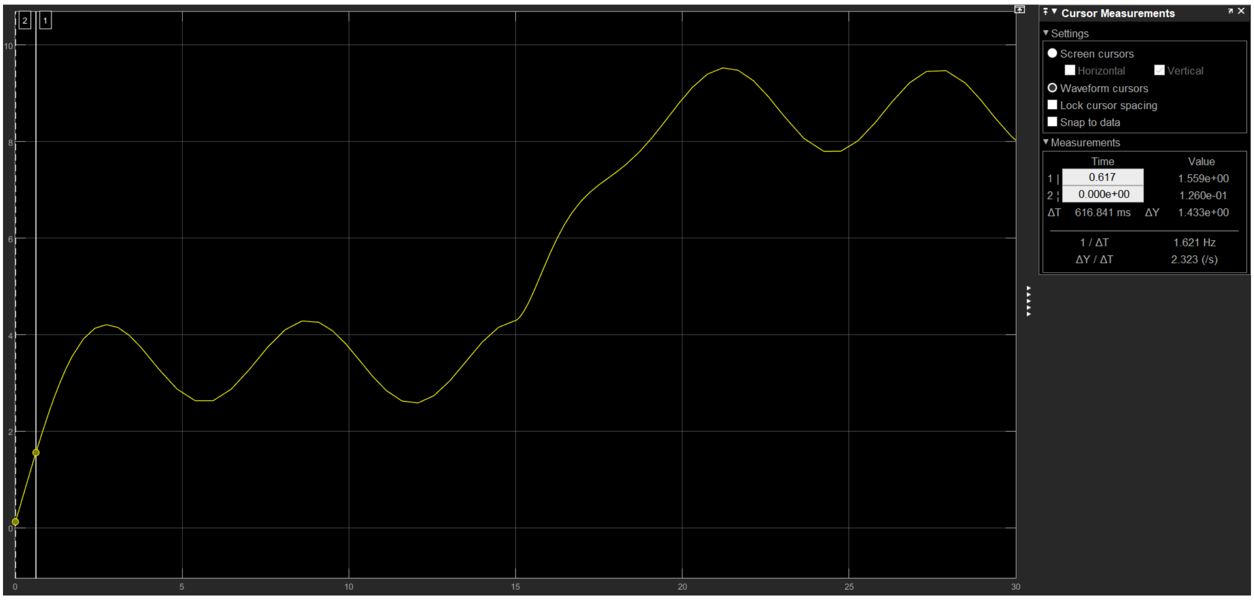
The steady state error is zero, as we can see that the two lines of the curve eventually overlap.

All values are within the limits because, from the current graph, we can see that it is below 5A as it approaches steady state.

5)



Current-Time Graph



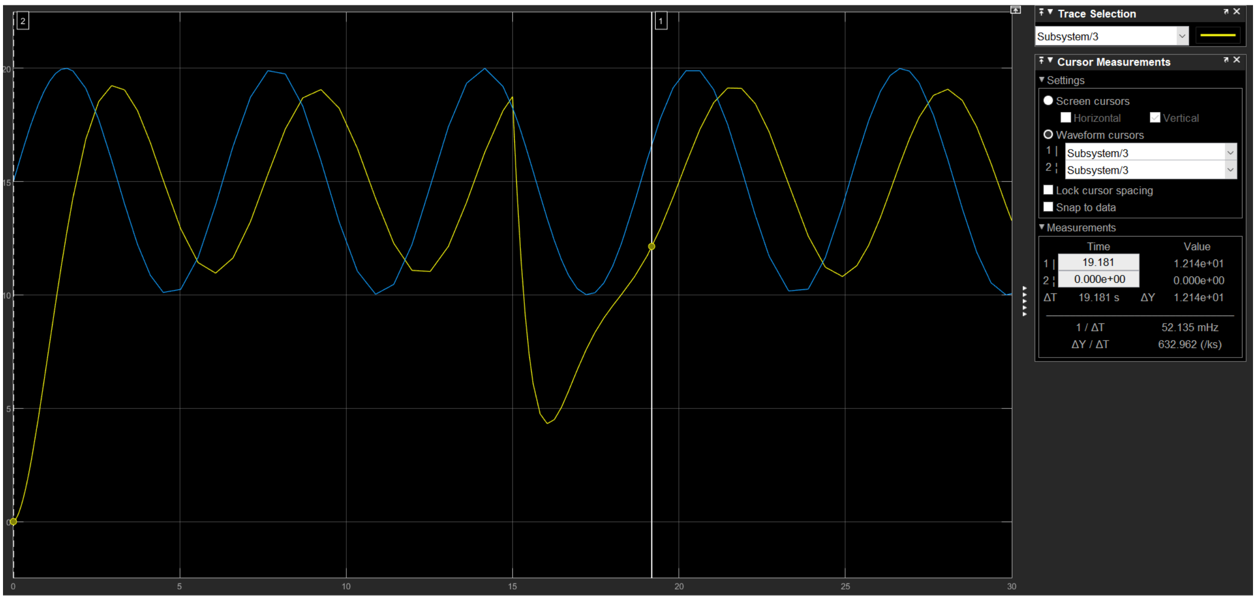
Voltage-Time Graph

Yes, as the current is under 5 amperes and the voltage is also below 12 V, they are both in limit.

6)

You will have to plot the Bode plot of the error E(s) to get the result that is expected.

Task 1.22



From the graph,

Amplitude of the reference = 19.95 − 15.085
= 4.865

Amplitude of the obtained speed = 4.1

~~Magnitud~~ Amplitude difference = 4.865 − 4.1
= 0.765

For Phase Difference :-

Reference value at a peak = 28.053 (x-axis)
Obtained speed value at a peak = ~~26.07~~ 26.702 (axis-axis)

Phase Diff = 26.702 − 28.053
= −1.353

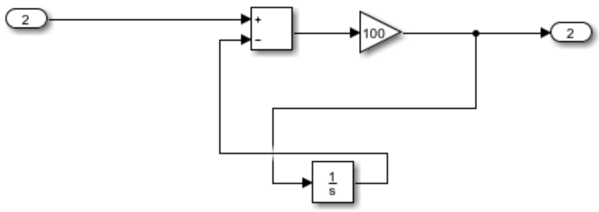
In degrees, Phase Diff = −77.40 degrees.

0.765 ≈ 0.632 and −77.40 ≈ −84.8112,
we can see that the obtained values are relatively close.

We can confirm these value selections by checking our Matlab calculations which is close to the one we got

```
  6.968e-10 s^4 + 1.674e-05 s^3 + 0.0003257 s^2

                                    + 0.0004827 s

  -----------------------------------------------

  4.9e-13 s^6 + 2.352e-08 s^5 + 0.0002823 s^4

         + 0.0009291 s^3 + 0.001063 s^2

                                    + 0.0004827 s


Continuous-time transfer function.

>> bode(T)
>> grid on;
>> w=1;
>> [mag,phase]=bode(T,w)

mag =

    0.6321


phase =

  -84.8112
```

Task 1.23



Task 1.23)

Input = I(s)

Output = O(s).

$$100 \times \left[I(s) - \left(O(s) \times \frac{1}{s} \right) \right] = O(s).$$

$$100\, I(s) - \frac{100 . O(s)}{s} = O(s)$$

$$100\, I(s) = \frac{s . O(s) + 100 . O(s)}{s}$$

$$100 . s . I(s) = O(s) \ (s + 100$$

$$\cancel{to}\ \frac{O(s)}{I(s)} = \frac{100 . s}{s + 100} \quad //.$$