Part ① ASS - 4

③ $G(s) = \frac{4}{s+2}$

$R(s) = \frac{1}{s}$

$y_{ss} = \lim_{s \to 0} s \cdot G(s) \cdot \frac{1}{s} = 2$

Matlab FVT value = 2

∴ Both are same

Q.2

$G(s) = \frac{10}{s(s+5)}$

① no. of poles at $s=0$,

$G(s) = \frac{10}{s(s+5)}$; no. of integrator = 1

$\boxed{\text{System Type} = 1}$

② $e_{ss} = \lim_{s \to 0} s \left(\underbrace{\frac{1}{s} - G(s)\frac{1}{s}}_{E(s)} \right)$

$\lim_{s \to 0} s \left(\frac{1}{s} - \frac{10}{s(s+5)} \cdot \frac{1}{s} \right)$

$\to -\infty$

unbounds input are not in steady state.

Q.3 $t_s < 1.2\,sec$, $e_{ss} = 0.1$

① $t_s = \frac{4}{a}$, $e_{ss} = \frac{1}{1+K}$

$\frac{4}{a} < 1.2$

$a > \frac{4}{1.2} \approx 3.3$

$\boxed{a > 3.\overline{33}}$

$0.1 = \frac{1}{1+K}$

$\boxed{K = 9}$

② $G_{new}(s) = K/s+a$

$= \frac{9}{s+4}$

Q.4

① $G(s) = \frac{3}{s+1}$, $C(s) = K/(s+z)$

$t_s < 2$, $M_p < 10$, $y_{ss} = 0.8$

$M_p = e^{\left(-\frac{\zeta\pi}{\sqrt{1-\zeta^2}}\right)}$, $t_p = \frac{\pi}{\zeta\omega_n}$

ζ

$$\frac{\xi\pi}{\sqrt{1-\xi^2}} > -\log(10)$$

$$\boxed{\xi \simeq 0.7}$$

(8) $\omega_n = \frac{4}{1.4} = 2.86$

$$\boxed{\omega_n \simeq 3}$$

$$s = -0.7 \times 3 \pm j\, 3\sqrt{1-0.49}$$

$$\simeq -2.1 \pm j\, 2.14$$

$$\boxed{z = 2}$$

$$T(s) = \frac{C(s)\,G(s)}{1 + C(s)\,G(s)}$$

$$T(0) = y_{ss} = \frac{Kz \cdot 3}{1 + 3Kz}$$

$$\frac{8}{10} = \frac{4}{1+4}$$

$$\cancel{3} \cdot 2 \cdot \frac{(3Kz)}{\cancel{2}} = 8$$

$$Kz = \cancel{4}\ 3$$

$\boxed{\zeta = 0.7, \quad \omega_n = 3, \quad z = 2, \quad K = \frac{2}{3}}$

② $C(s)G(s) = \frac{3K(s+z)}{s+1}$

$$T(s) = \frac{C(s)G(s)}{1+\ \ } = \frac{3K(s+z)}{(s+1)+3K(s+z)}$$

$$= \frac{2(s+2)}{(s+1)+2(s+2)}$$

$$\frac{2(s+2)}{3s+5}$$

③

① LHP zero may reduce t_r but increase overshoot, as zero in left-halfplane

→ adding 0 ↑ overshoot

② $y_{ss} = K_p/1+K_p$

↑ K_p ↑ y_{ss}.

③ (gain↑ response↑ + LHP + zero adding)

⇒ close loop response will be faster than original plant.

Q.5 ~~for~~ $\boxed{\text{without controller}}$ $G(s) = \frac{3}{s+1}$

① system Type = 0

② $\boxed{\text{Type 0: infinite}}$

③ FVT

$$e_{ss}^{ramp} = \lim_{s \to 0} s\left(\frac{1}{s^2} - T(s)\frac{1}{s^2}\right)$$

$$\lim_{s \to 0} s\left(\frac{1}{s^2} - \frac{3}{s+4}\frac{1}{s^2}\right)$$

$$= \infty$$

$\boxed{\text{with controller}}$

$$C(s)G(s) = \frac{3K(s+z)}{s+1}$$

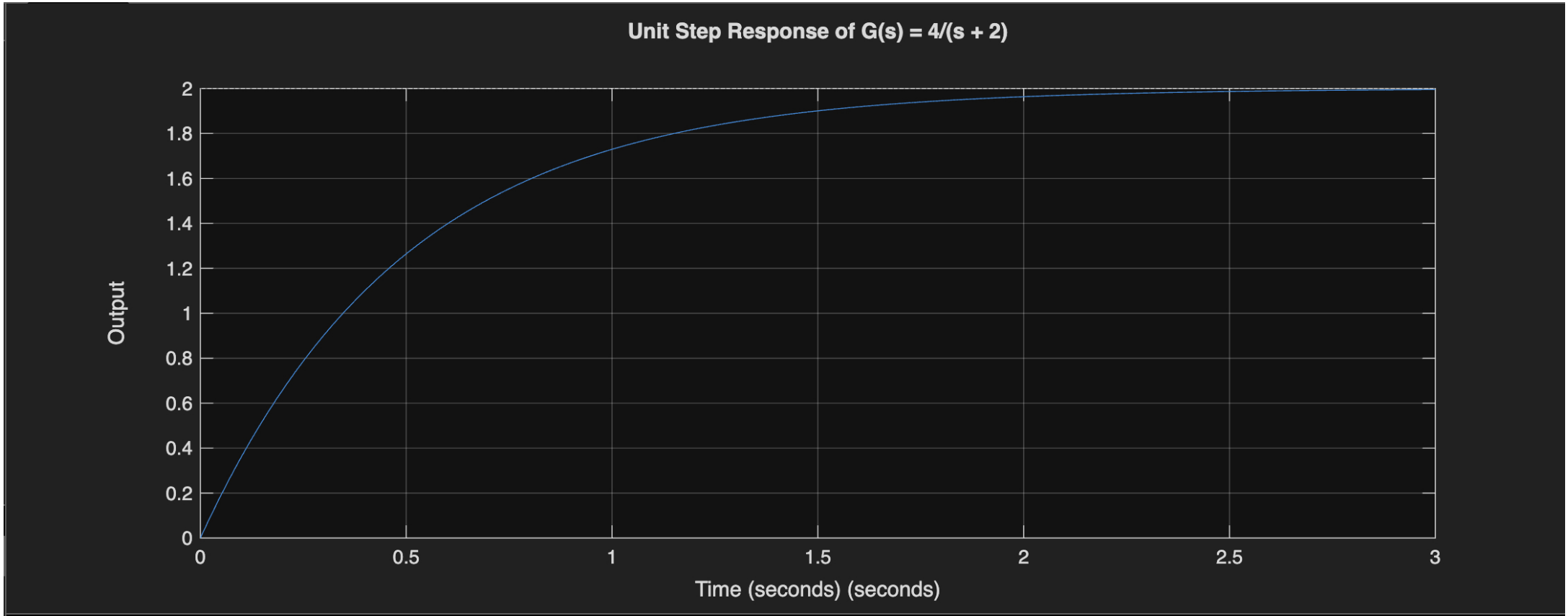
① System Type = 0

② $e_{ss}^{ramp} = \infty$ $\quad T(0) = \frac{3Kz}{1+3Kz}$

③ $e_{ss}^{ramp} = \lim_{s \to 0} \frac{1}{s}\left(1 - T(s)\right)$

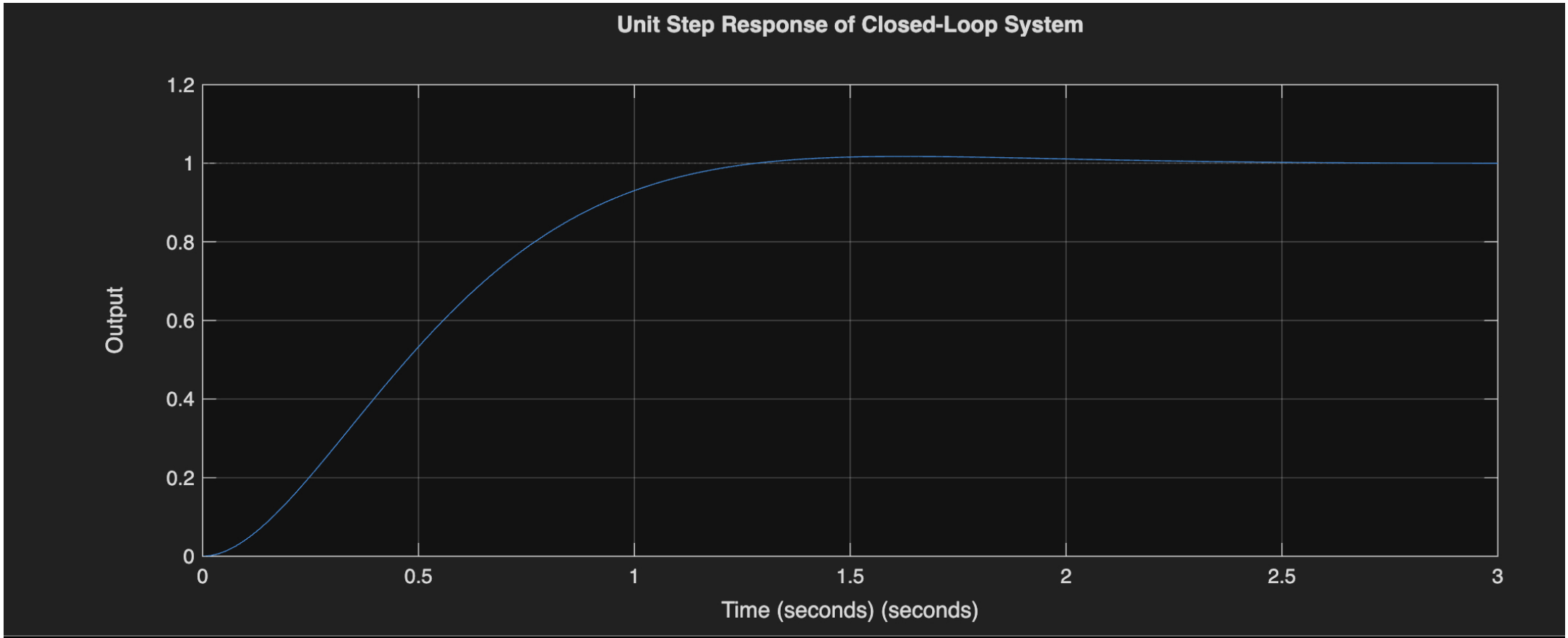
$$\frac{1 - T(0)}{T(0)} = \infty$$

④ adding zero do not help ramp tracking



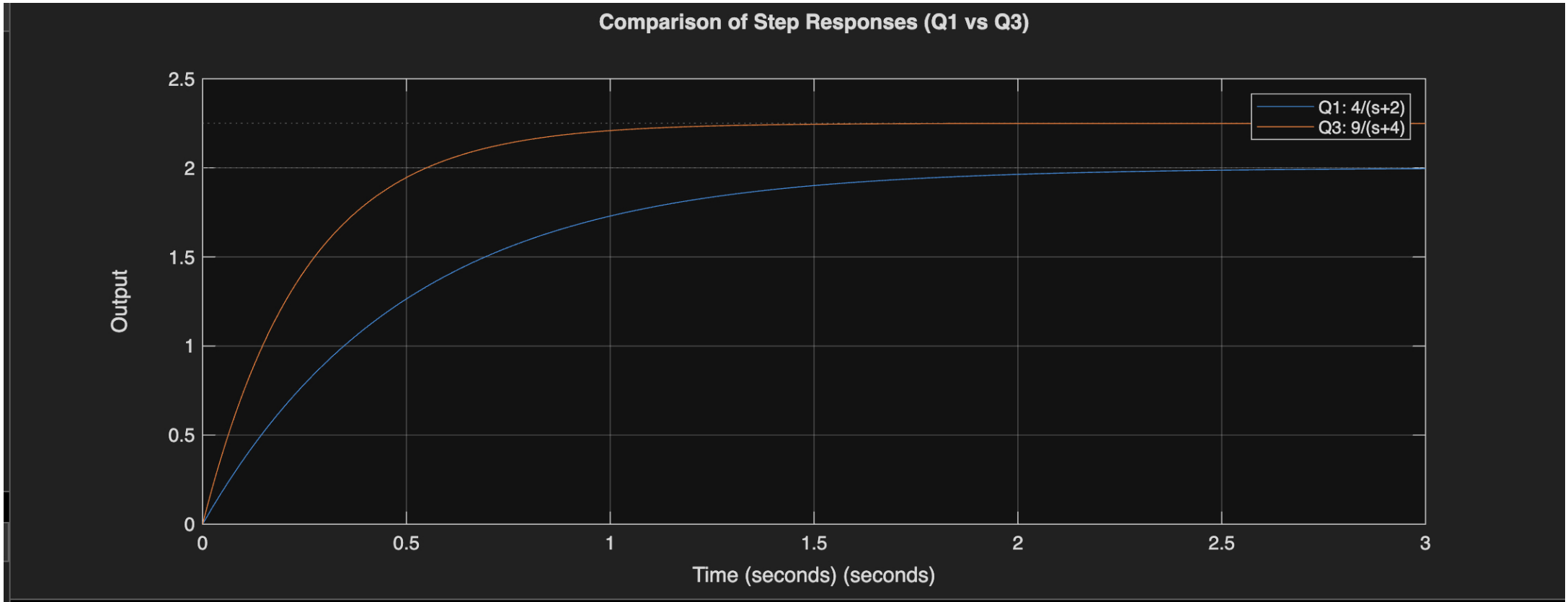
Command Window

```
Step Response Information from MATLAB:
         RiseTime: 1.0985
    TransientTime: 1.9560
     SettlingTime: 1.9560
      SettlingMin: 1.8090
      SettlingMax: 1.9987
        Overshoot: 0
       Undershoot: 0
             Peak: 1.9987
         PeakTime: 3.6611


Theoretical Calculations:
Time Constant (tau)       = 0.50 seconds
Rise Time (tr)            = 1.10 seconds
Settling Time (ts)        = 2.00 seconds
Final Value (y_ss)        = 2.00
Steady-State Error (e_ss) = -1.00

Final Value Theorem Check:
Final Value from FVT = 2.00
```



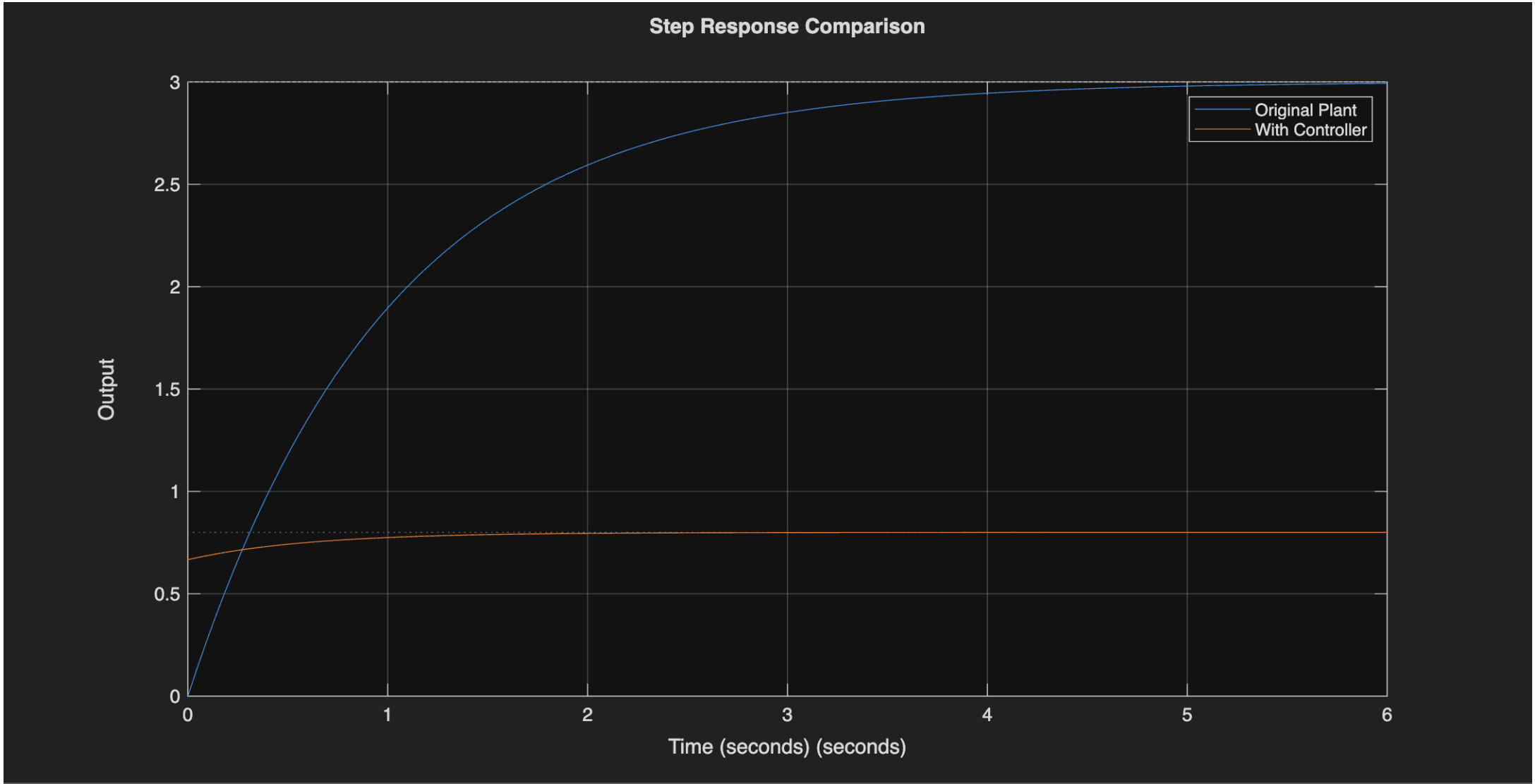
Command Window

```
Step Response Information:
         RiseTime: 0.7693
    TransientTime: 1.1648
     SettlingTime: 1.1648
      SettlingMin: 0.9040
      SettlingMax: 1.0173
        Overshoot: 1.7322
       Undershoot: 0
             Peak: 1.0173
         PeakTime: 1.6210

Steady-State Value = 1.00
>>
```



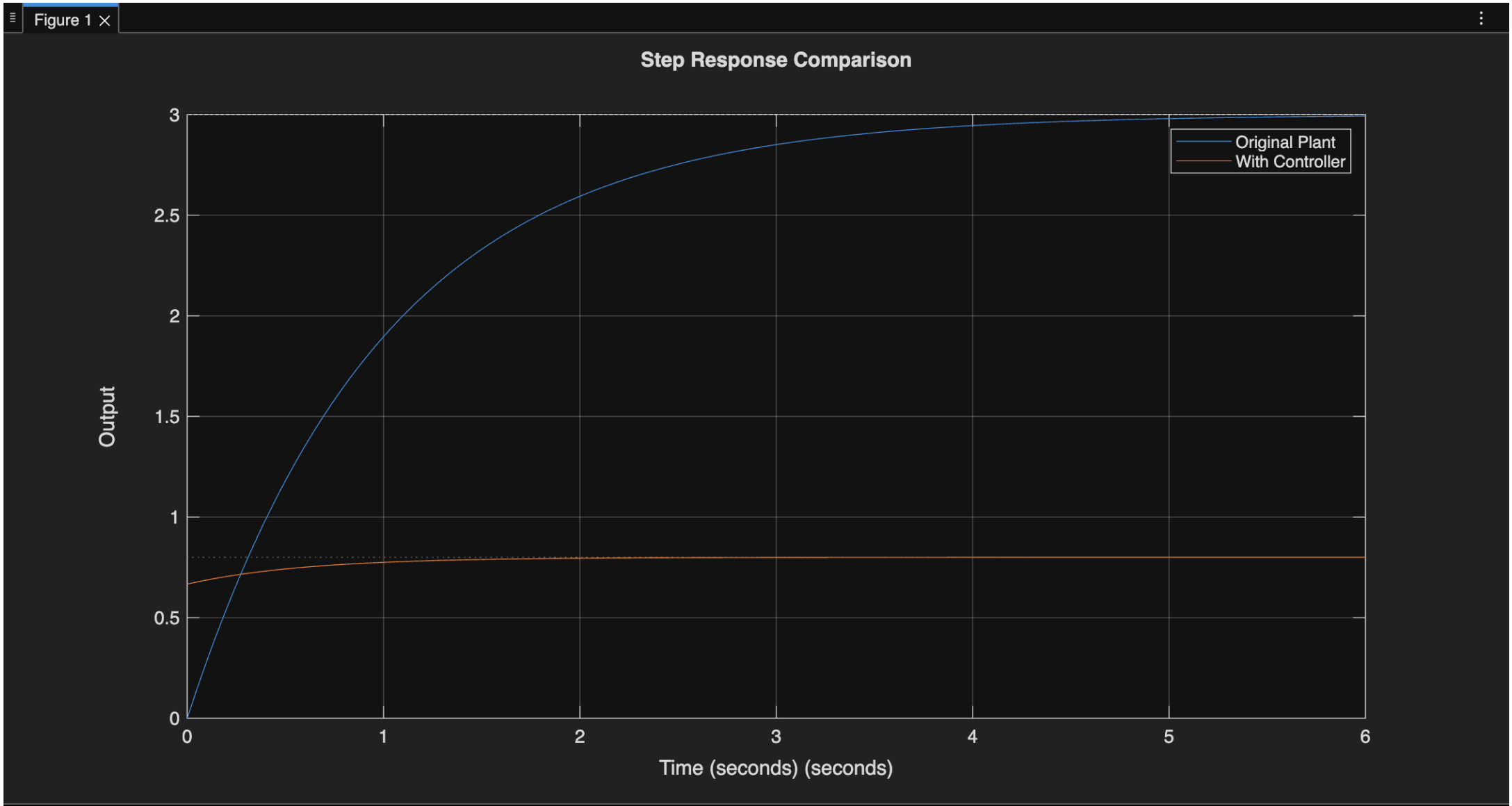
Command Window

```
===== Q3 PART 3: PREDICTIONS & VERIFICATION =====
• The modified system is FASTER than Q1.
• The final value of Q3 is HIGHER than Q1.
• Both systems are first-order → response is smooth with NO overshoot.

Numerical Comparison:
Q1 Settling Time  = 2.00 s
Q3 Settling Time  = 1.00 s
Q1 Final Value    = 2.00
Q3 Final Value    = 2.25
>>
```



Command Window

```
===== MATLAB VERIFICATION =====
Settling Time (ts) = 1.27 s
Overshoot (Mp)     = 0.00 %
Steady-State Value = 0.80

===== FINAL CONCLUSION =====
✔ Settling time requirement satisfied.
✔ Overshoot requirement satisfied.
✔ Steady-state value requirement satisfied.
>>
```



Command Window

```
  -------
  3 s + 5

Continuous-time transfer function.
Model Properties

PART 3: QUALITATIVE PREDICTIONS
• Adding a LHP zero reduces rise time but may increase overshoot.
• Increasing gain K increases steady-state value y_ss.
• Controller adds speed → response will be faster than original plant.
```