ELC 3252 : Control Engineering
Section 3

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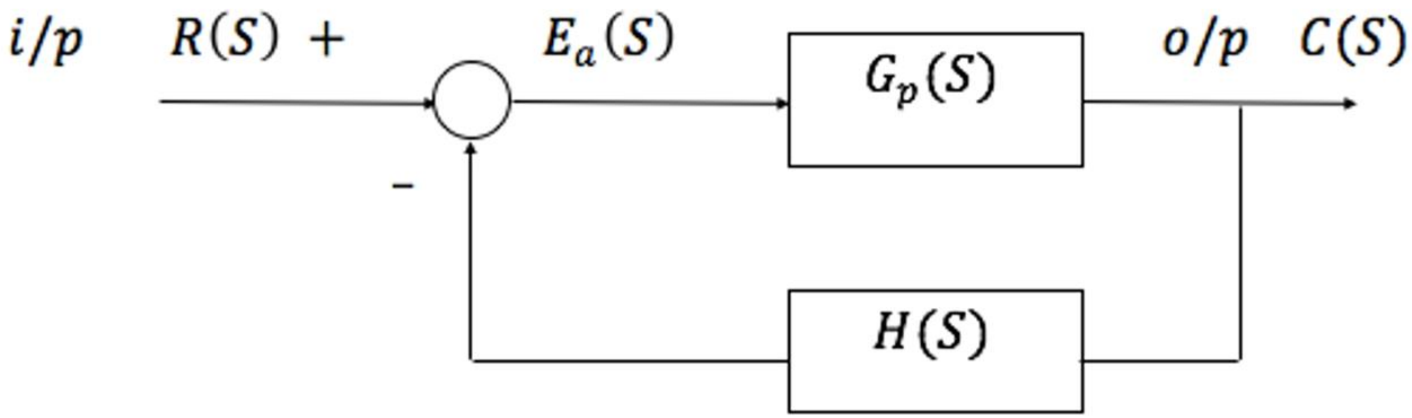
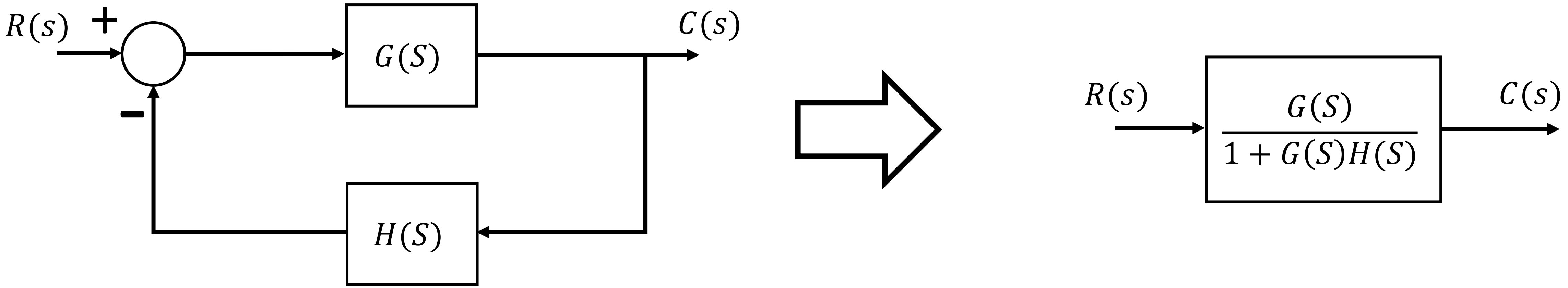
Steady State Error Summary

- Stability : characteristic equation (closed loop)
  - $C/C: 1 + GH(s)$

- Steady state error : open loop TF
  - $GH(s)$



Steady State Error Summary



Steady State Error Summary

Input / Type	Step $r(t) = M\,u(t)$	Ramp $r(t) = M\,t$	Parabola $r(t) = M\dfrac{t^2}{2}$
Type 0	$\boxed{\dfrac{M}{1+K_p}}, K_p = \lim_{S\to 0} GH(s)$	∞	∞
Type 1	0	$\boxed{\dfrac{M}{K_v}}, K_v = \lim_{S\to 0} S\,GH(s)$	∞
Type 2	0	0	$\boxed{\dfrac{M}{K_a}}, K_a = \lim_{S\to 0} S^2\,GH(s)$

- $E(s) = R(s) - C(s)H(s)$

Sheet 3 – Q2

2. A unity feedback system has a forward transfer function of:

$$G(s) = \frac{12\,(s+4)}{s\,(s+1)\,(s+3)\,(s^2+2s+10)}$$

a) Determine the static error coefficients for this system.
b) Determine the steady state error and the steady state output for a reference input r (t) =16+2t and for r (t) =$5t^2$.
c) Is the closed loop system stable?

Sheet 3 – Q3

3. A unity feedback control system has the forward transfer function:

$$G(s)=\frac{k_v}{s(4s+1)(s+1)}$$

a) The steady state value of the error is desired to be less than or equal to 0.1 for a reference input r (t) = 1+t. Determine the minimum value of k_v that satisfies this requirement.

b) Check the stability of the system for the value k_v of obtained in part (a) and comment on your result.

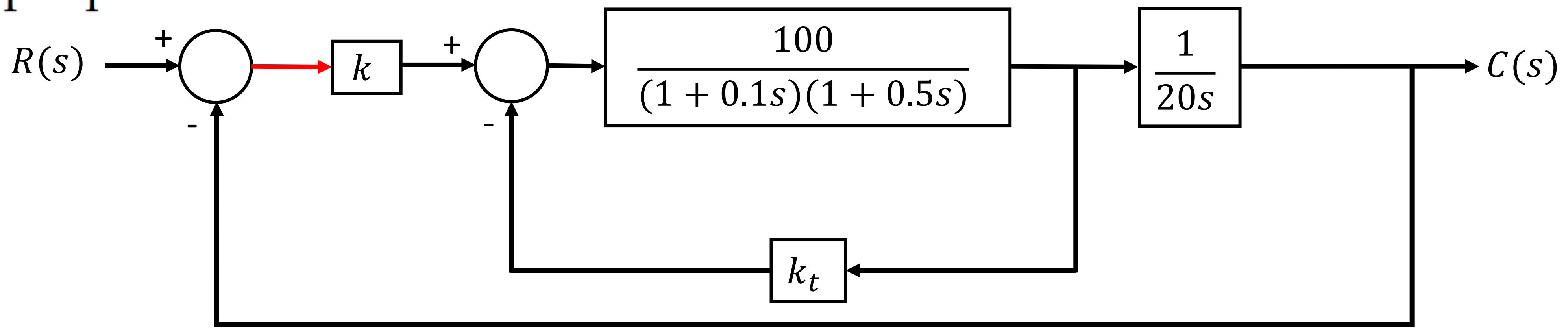
Sheet 3 – Q4

4. The block diagram of a control system is shown the following figure. Find the step, ramp and parabolic error constants. The error signal is defined to be e (t). Find the steady state errors of the system in terms of k and k_t, when the following inputs are applied:

a) r (t) =6+8t

b) r(t) =2t+7 t^2

What constraint must be made on the values of k and k_t so that the answers are valid? Determine the minimum steady state error that can be achieved with a unit ramp input.



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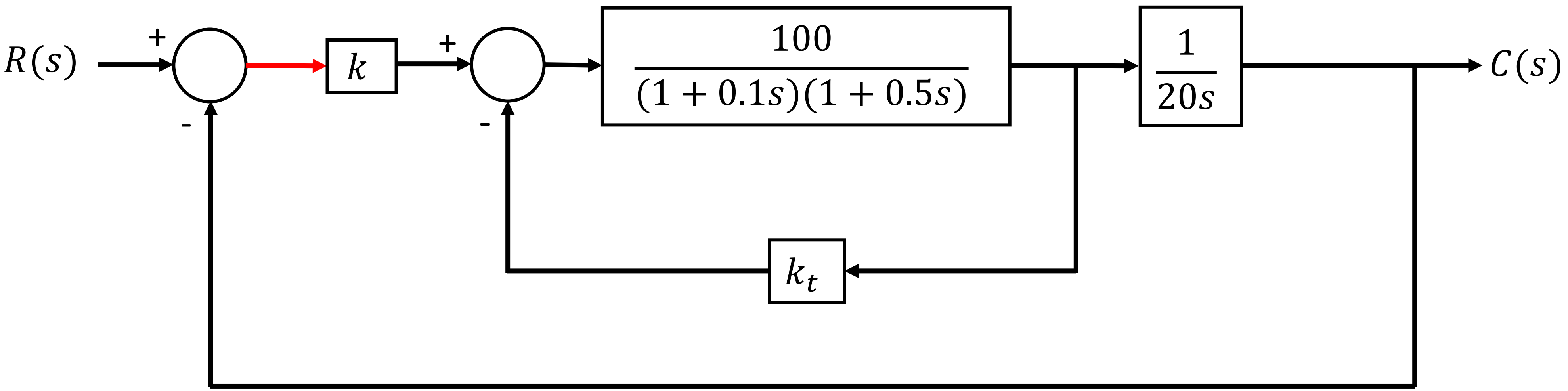

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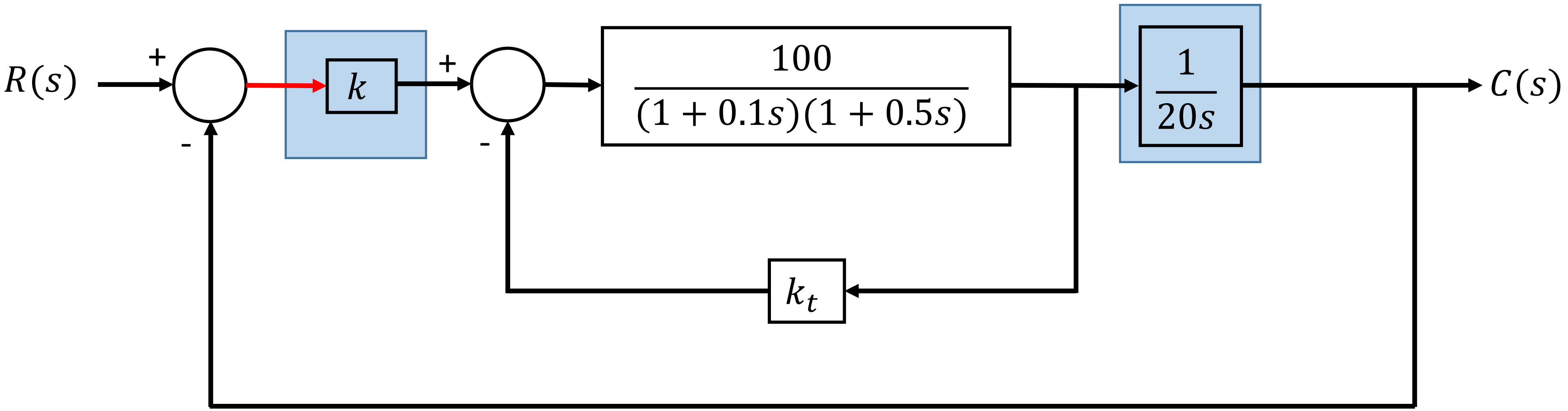

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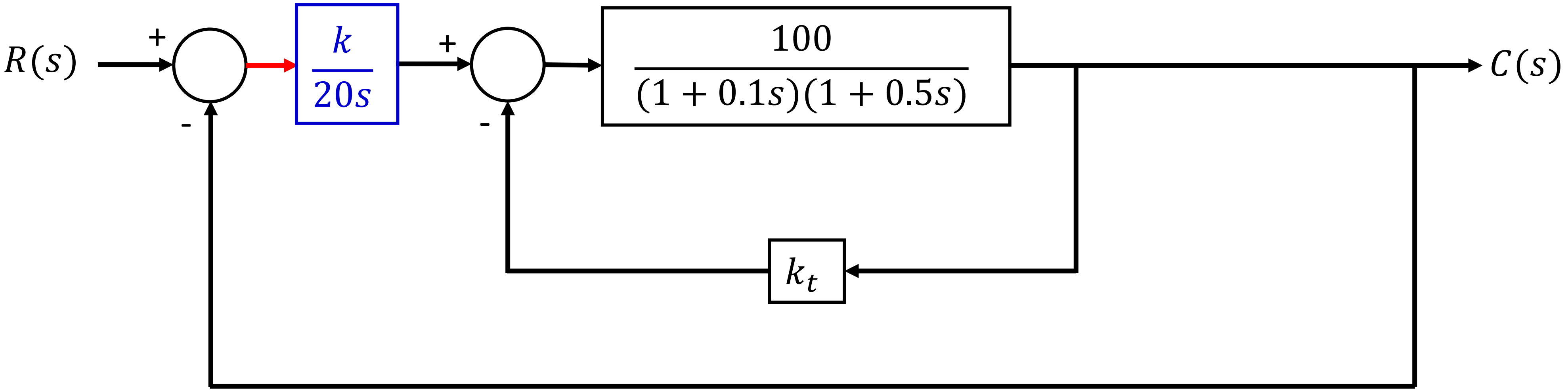

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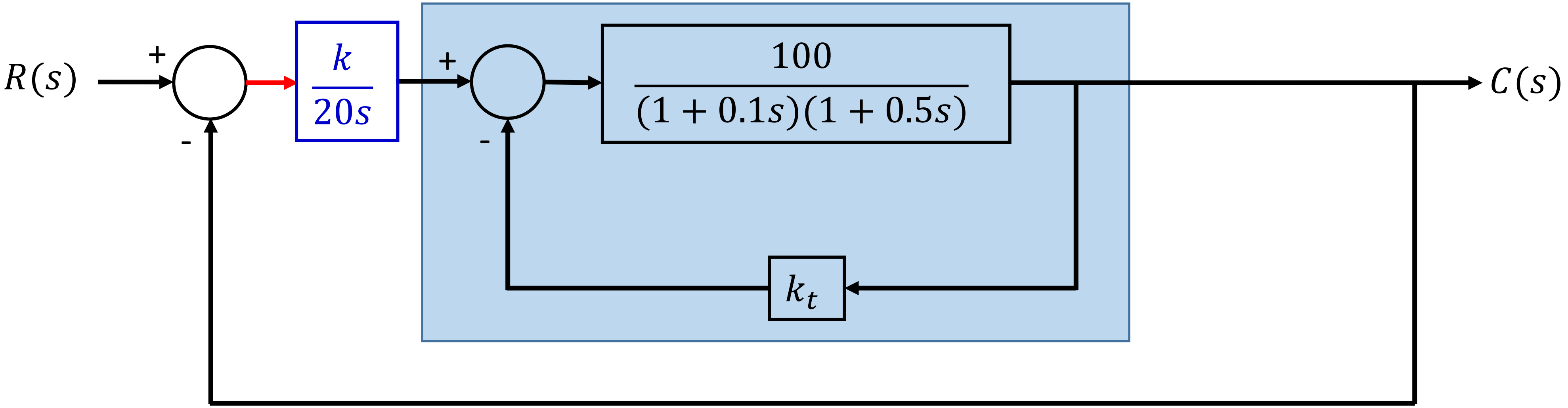

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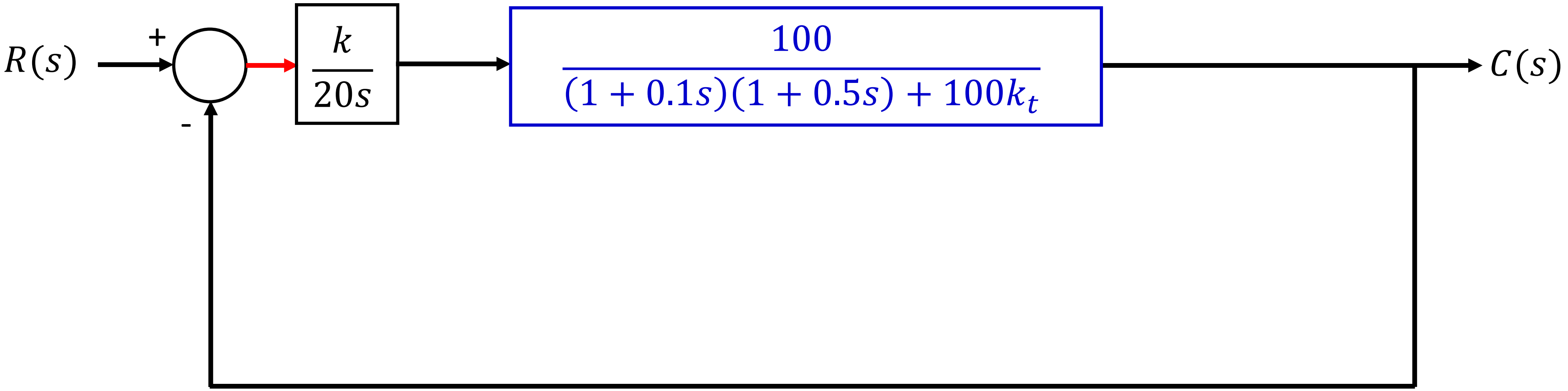

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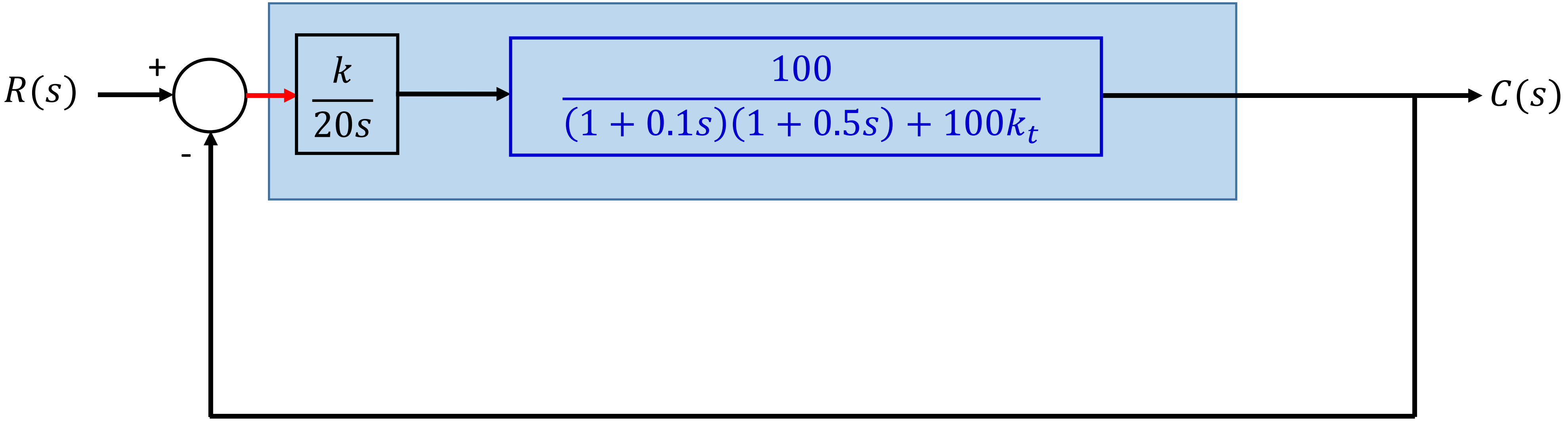

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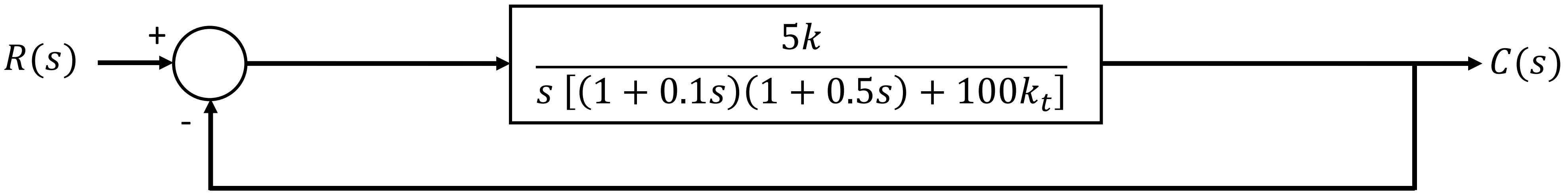

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4. The block diagram of a control system is shown the following figure. Find the step, ramp and parabolic error constants. The error signal is defined to be e (t). Find the steady state errors of the system in terms of k and k_t, when the following inputs are applied:

a) r (t) =6+8t

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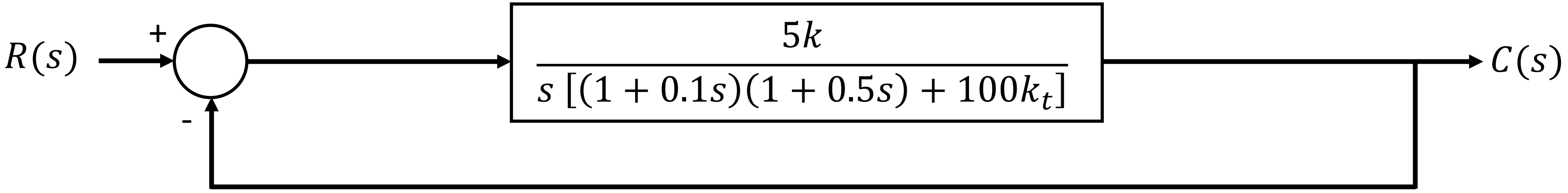
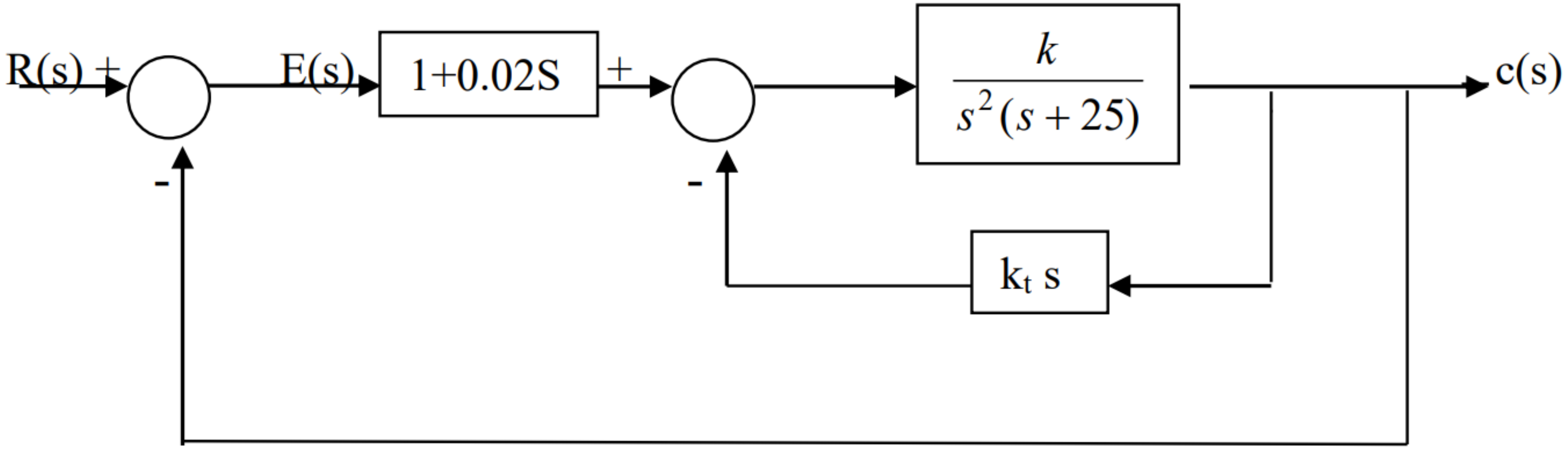
What constraint must be made on the values of k and k_t so that the answers are valid? Determine the minimum steady state error that can be achieved with a unit ramp input.



Sheet 3 – Q5

5. The block diagram of a feedback control system is shown in the figure. The error signal is defined to be e (t).

a) Find the steady state error of the system in terms of k and k_t when the input is a unit ramp function. Give the constraints on the values of k and k_t so that the answer is valid.



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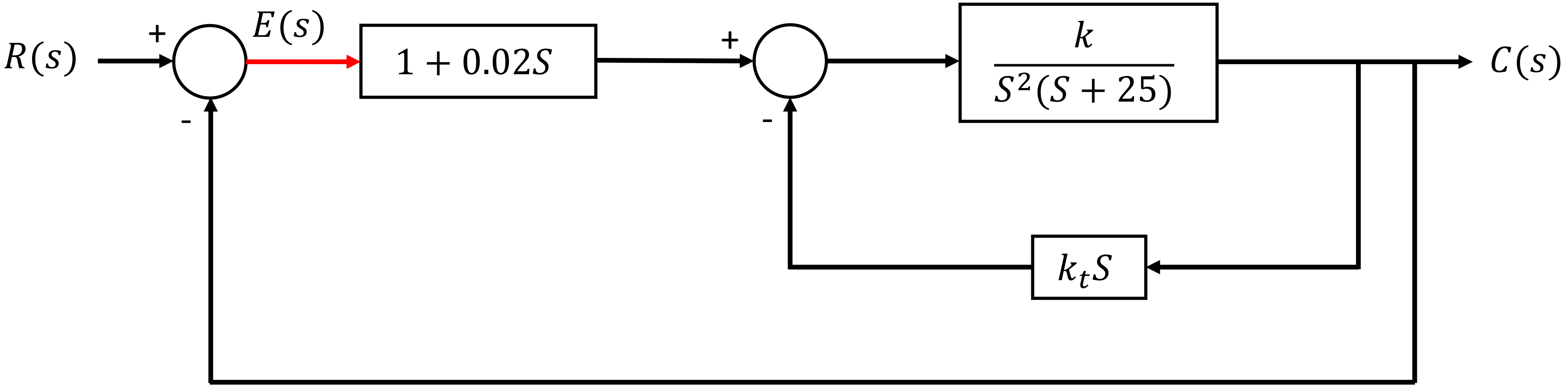

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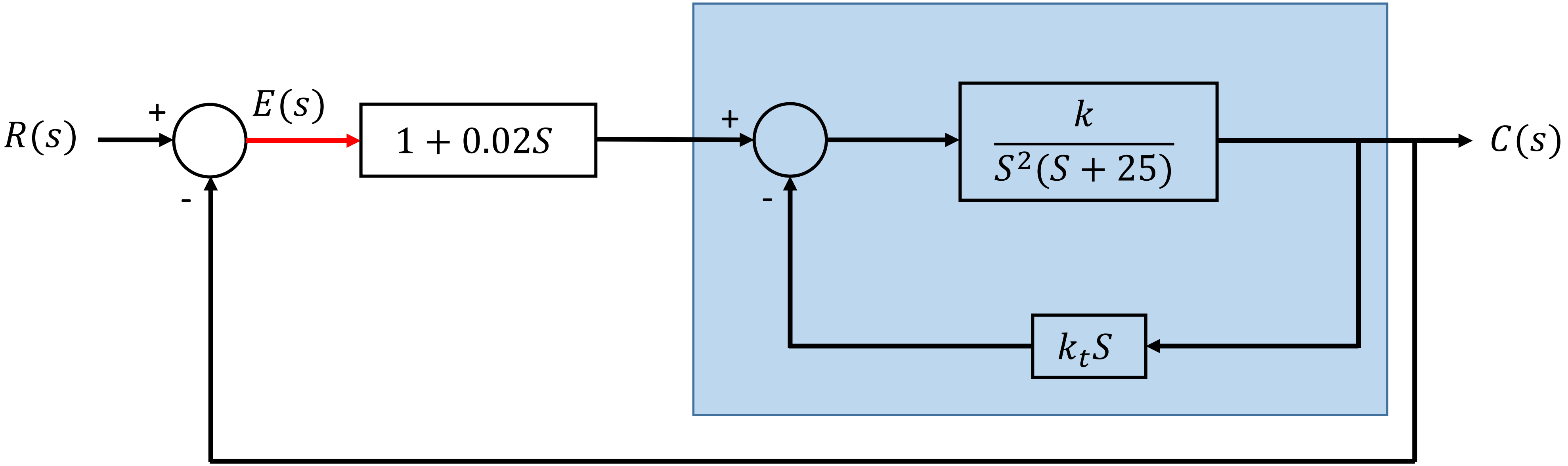

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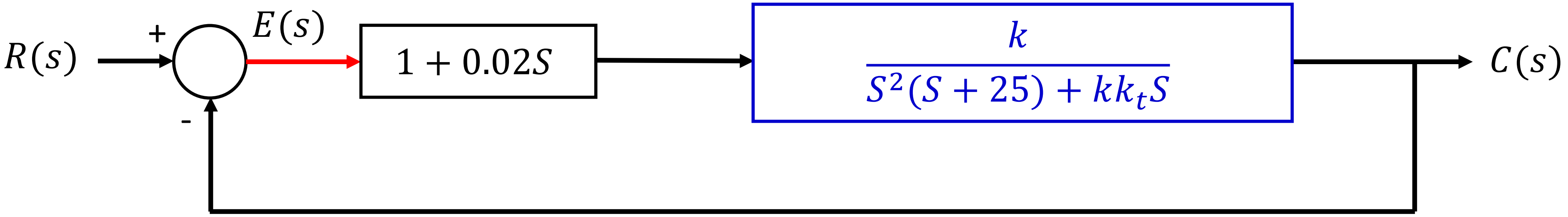

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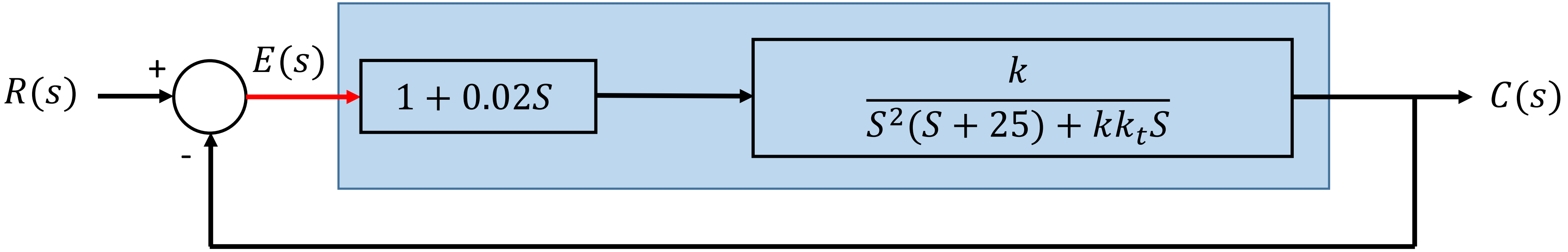

$$GH(s) = \frac{k(1 + 0.02S)}{S^2(S+25) + kk_t S}$$

Sheet 3 – Q5

$$GH(s) = \frac{k(1 + 0.02S)}{S(S^2 + 25S + kk_t)}$$

- Type 1, Order 3

- $K_v = \lim_{S \to 0} S\,GH(s) = \frac{1}{k_t}$

- $ess|_{ramp} = \frac{1}{K_v} = k_t$