



IIT ROORKEE



NPTEL ONLINE
CERTIFICATION COURSE

DESIGN VIA ROOT LOCUS AND COMPENSATION TECHNIQUES

PI CONTROLLER DESIGN

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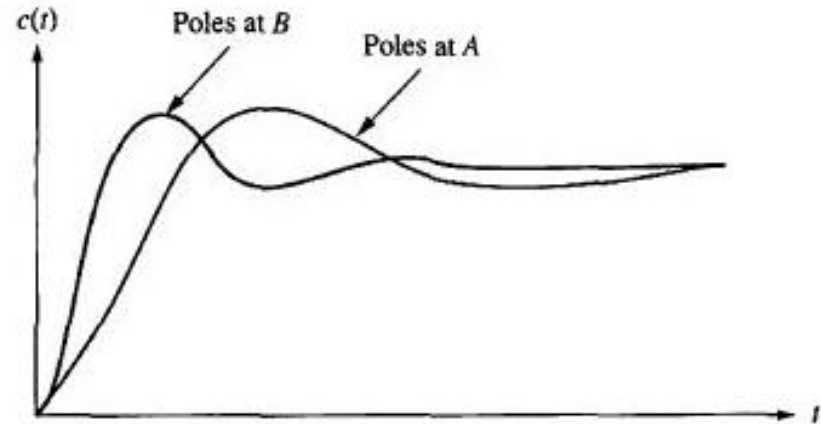
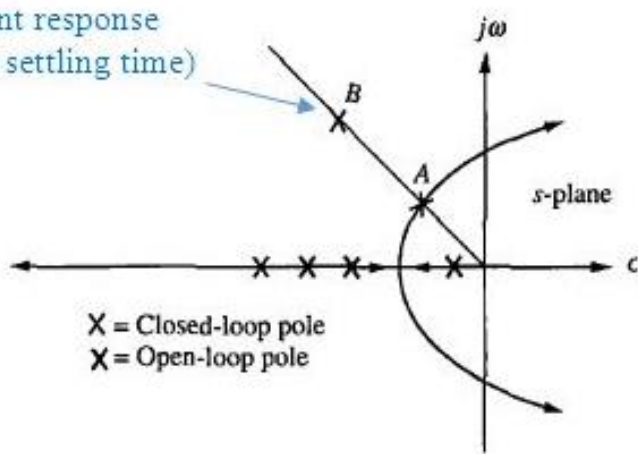
DESIGN VIA ROOT LOCUS

- Root locus (RL) graphically displays both transient response (TR) and stability information
- RL can be sketched quickly to get a general idea of the changes in TR generated by changes in gain
- Specific points on the RL also can be found accurately to give quantitative design information
- The RL typically allows us to choose the proper loop gain to meet a TR specification
- We are limited to those responses that exist along the root locus



DESIGN VIA GAIN ADJUSTMENT- LIMITATION

Desired transient response
(overshoot and settling time)

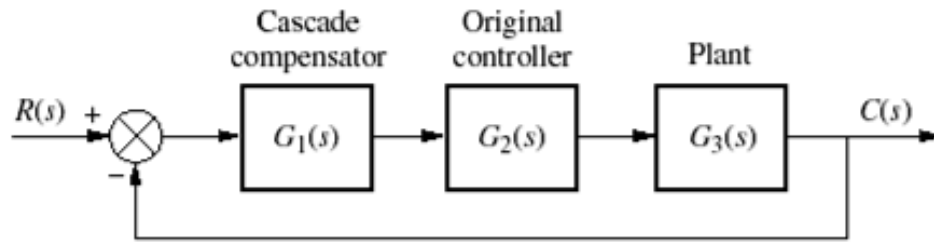


Ref: N. S. Nise: Control Systems Engineering, 6th Ed., Wiley, 2013

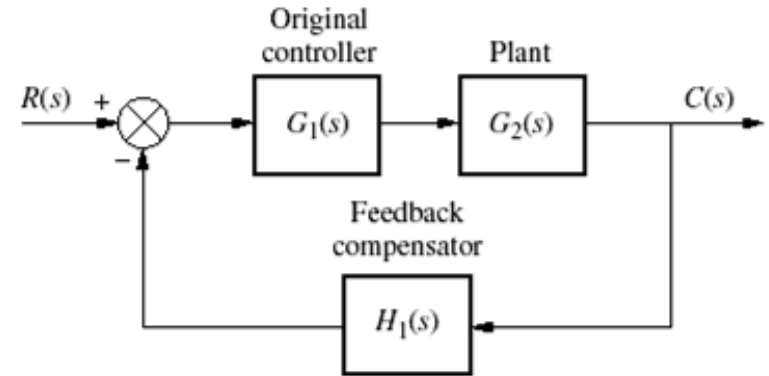
DESIGN VIA ROOT LOCUS

- Replace the existing system with a system whose root locus intersects the desired design point B
- Unfortunately this change is expensive and counter productive
- Most of the systems are chosen for characteristics other than TR, e.g. a motor is chosen for speed and power
- Rather changing the existing system we augment or compensate the system with additional poles and zeros, so that the compensated system has a RL that goes through the desired pole location for some value of gain
- Additional poles and zeros can be added at the low-power end of the system before the plant.
- It does not interfere with the power output requirements of the system or present additional load or design problems

COMPENSATION TECHNIQUES



CASCADE



FEEDBACK

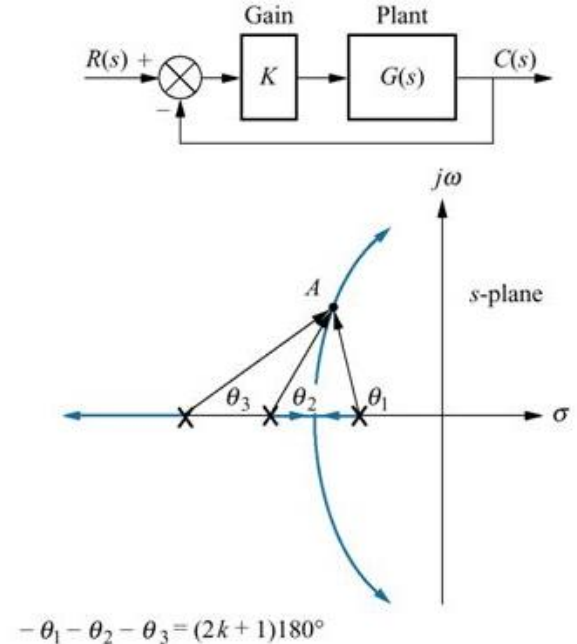
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BASIC ELEMENTS OF IDEAL COMPENSATORS

- Proportional Controller: feed scaled error to the plant. $G_1(s) = K.$
- Integral Controller: feed integrated error to the plant. $G_1(s) = \frac{K}{s}$
- Derivative Controller: feed differentiated error to the plant. $G_1(s) = Ks.$
- Proportional-plus-Integrator (PI): feed scaled+integrated error to the plant $G_1(s) = K(a + \frac{1}{s}).$

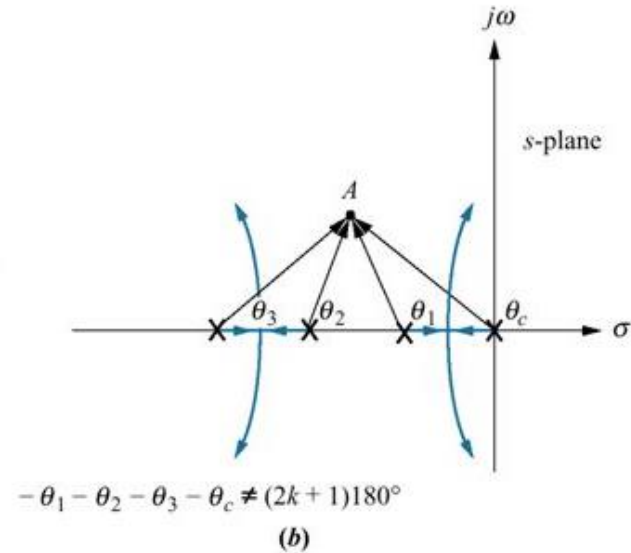
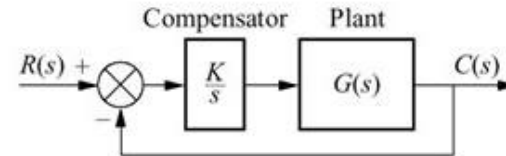
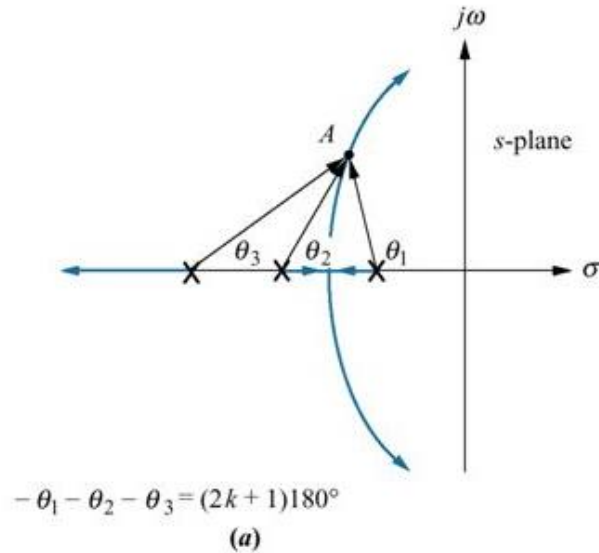
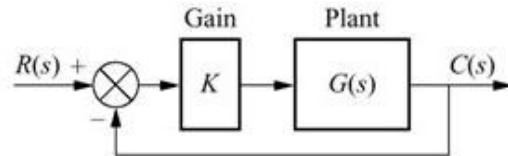
IDEAL INTEGRAL COMPENSATION (PI)

- Improve SS error without affecting the TR of the system
- A compensator with a pole at origin and zero close to the pole
- Steady state error can be improved by placing an open-loop pole at the origin because this increases the system type by one



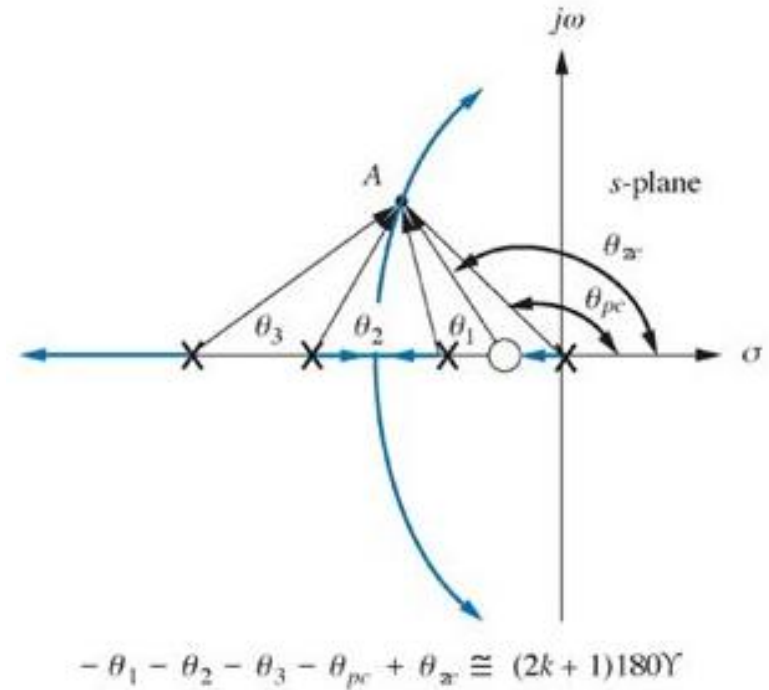
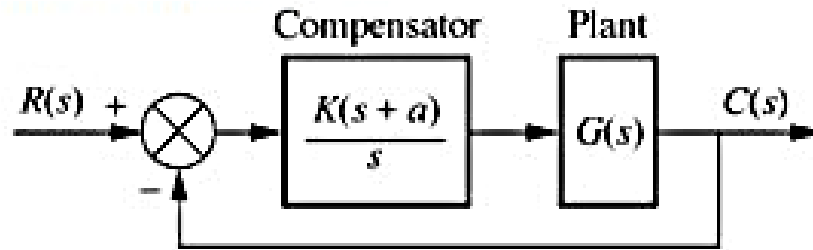
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IDEAL INTEGRAL COMPENSATION (PI)



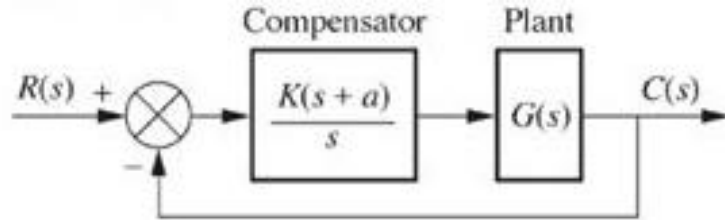
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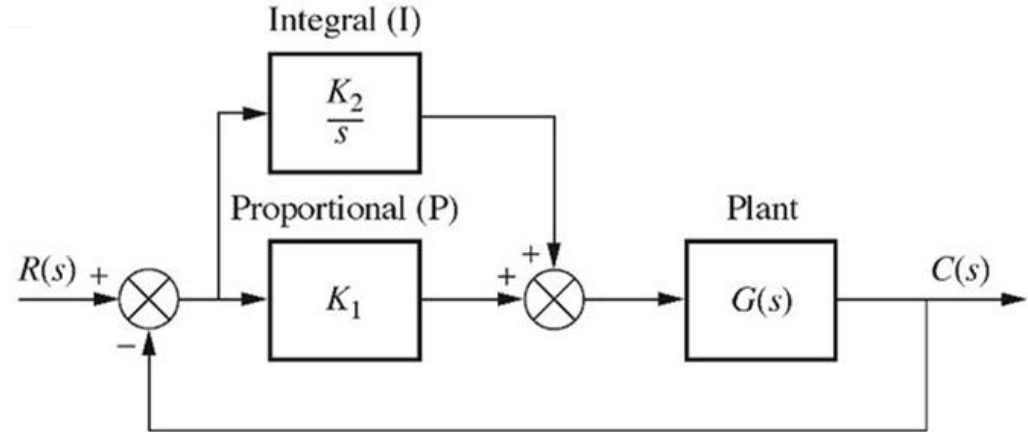


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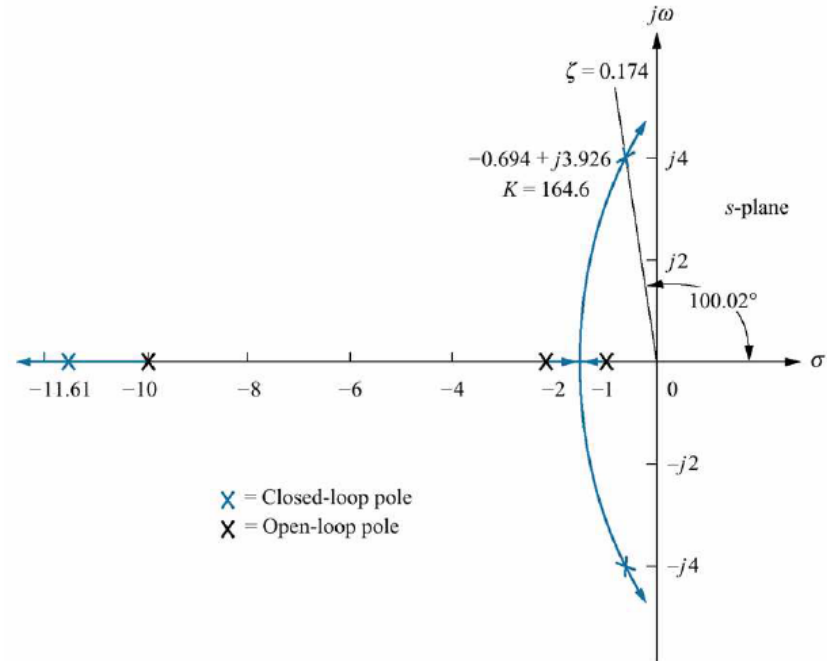
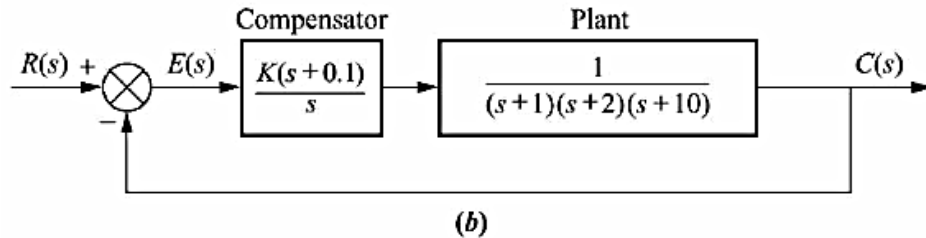
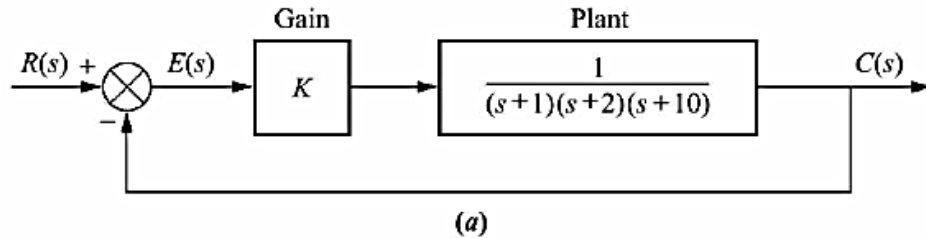


$$G_c(s) = K_1 + \frac{K_2}{s} = K_1 \frac{(s + \frac{K_2}{K_1})}{s}$$



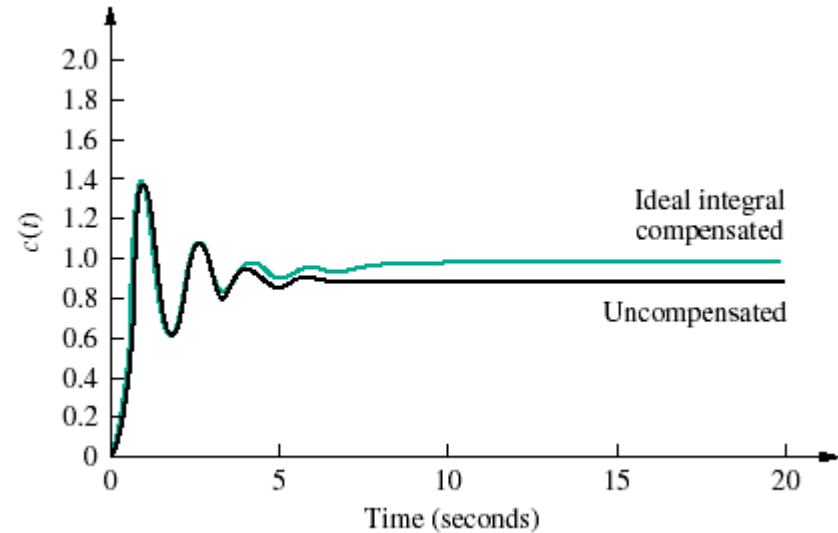
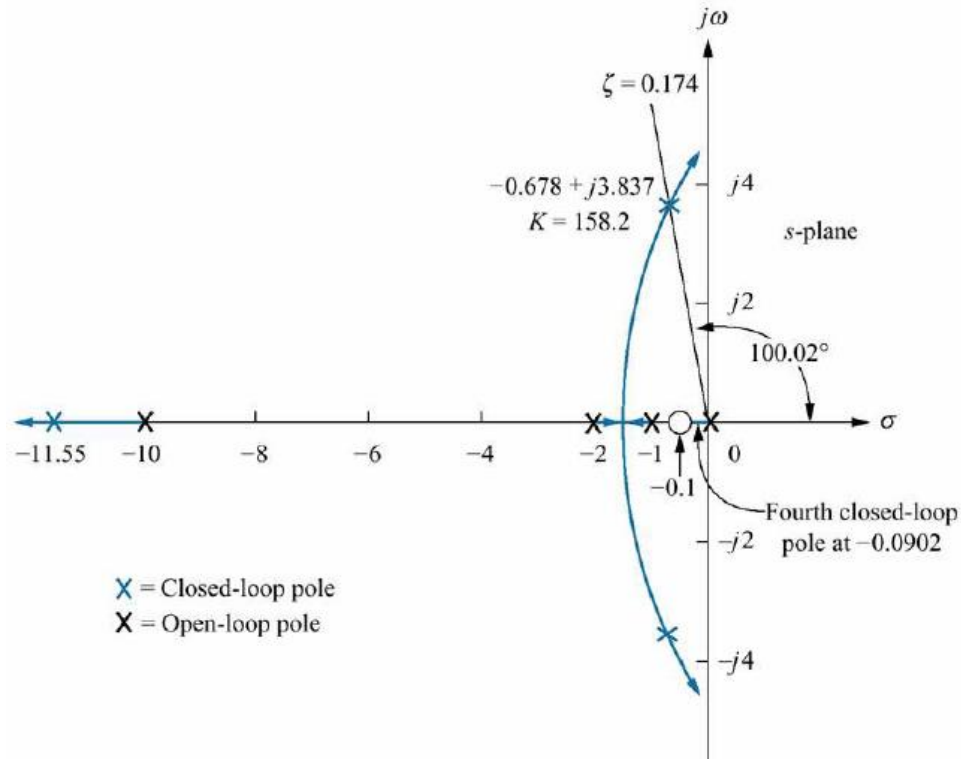
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IDEAL INTEGRAL COMPENSATION (PI): EXAMPLE



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REFERENCE BOOKS

- Norman S. Nise, Control Systems Engineering, Wiley, 2013
- Katsuhiko Ogata, Modern Control Engineering, Prentice Hall, 2010.

