



# CONTROL I

ELEN3016

---

## Closed-Loop Control Systems

(Lecture 10)

# Overview

---

- First Things First!
- Case Study
- Tutorial Exercises & Homework
- **Next Attraction!**

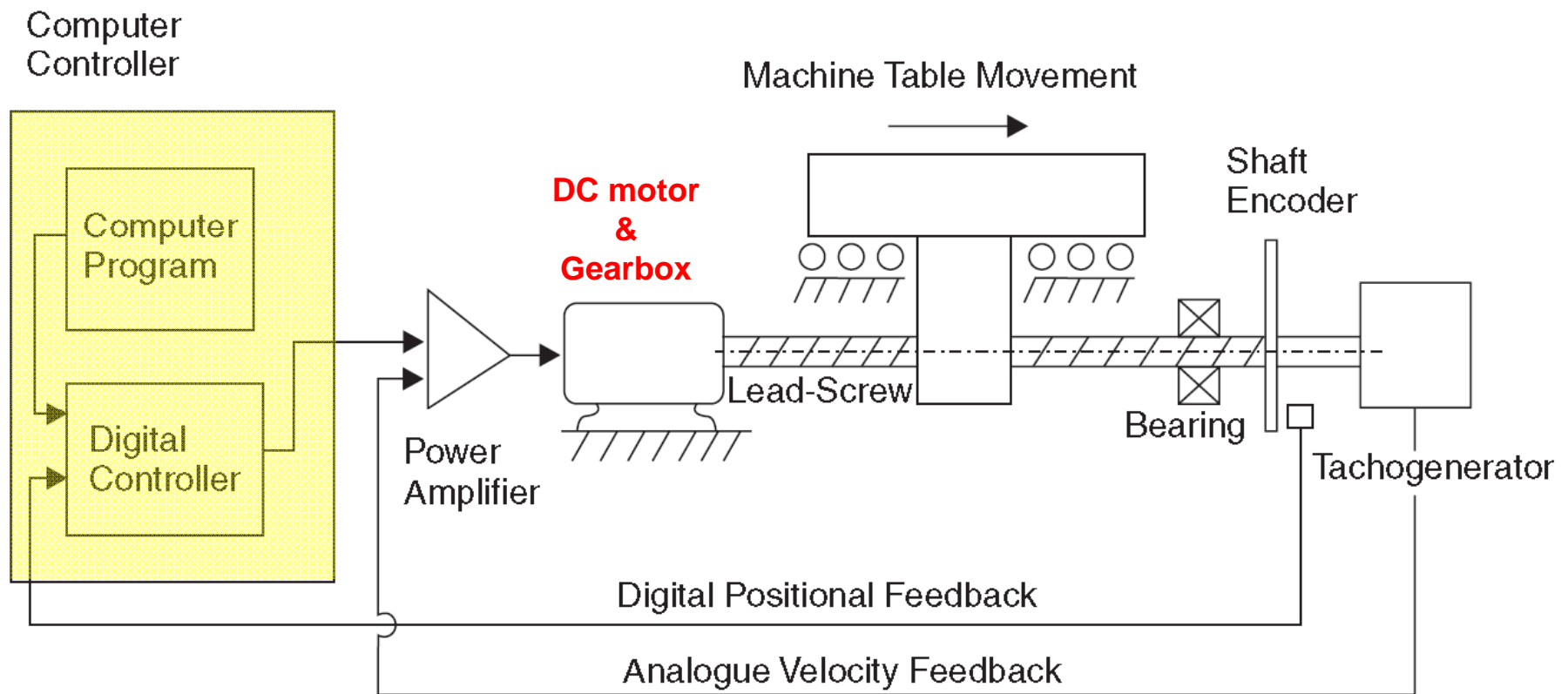
# First Things First!

---

- Miss prints & corrections
  - Unit in Eq. (4.95) should be  $[V/V]$  and not  $[V/m]$ .
  - Figure 4.31, machine table transfer function.
  - Still in the process of upgrading the list!
- Excellent physics paper!
  - G.B. Schmid, "An Up-To-Date Approach to Physics," Am. J. Phys. 52(9), 794-799, September 1984.

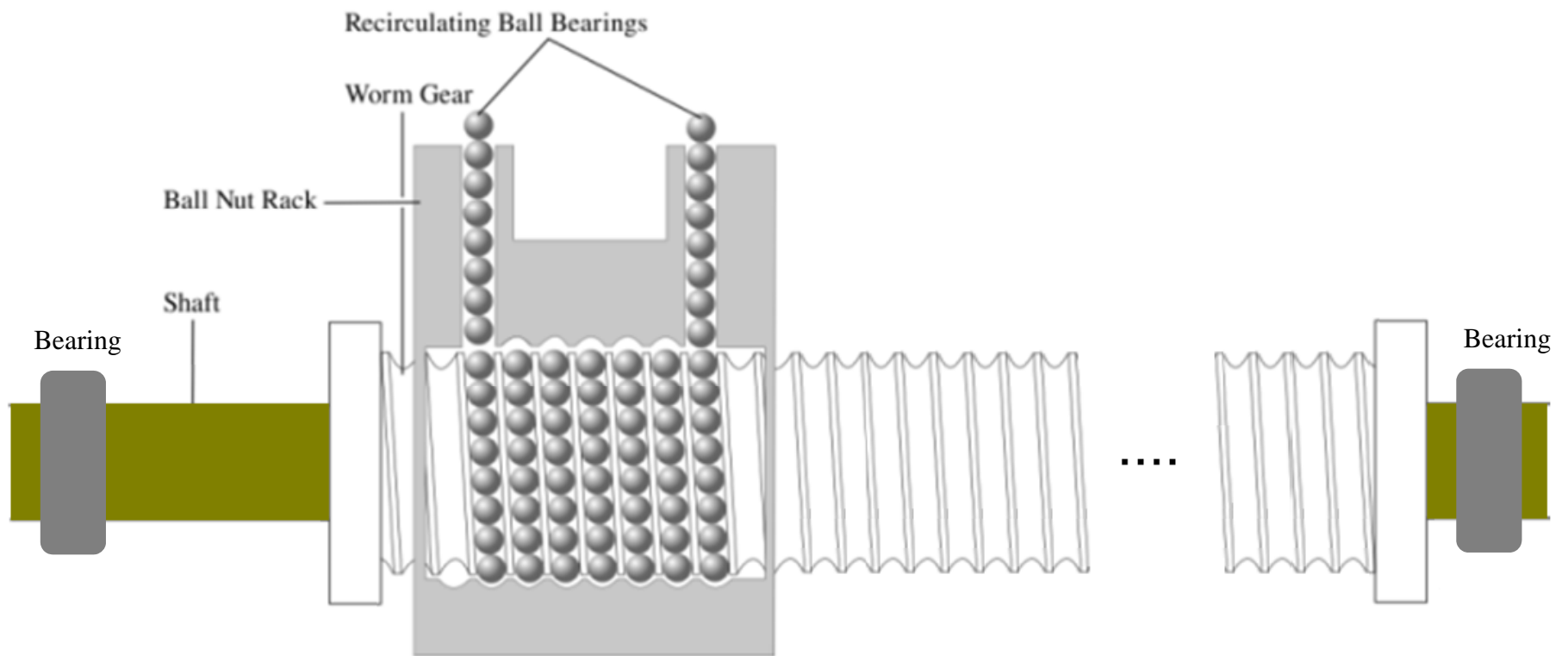
# Case Study – CNC Machine

- Electromechanical configuration



# Case Study – CNC Machine

- Re-circulating ball-bearings



# Case Study – CNC Machine

---

- Taper Roller Bearing



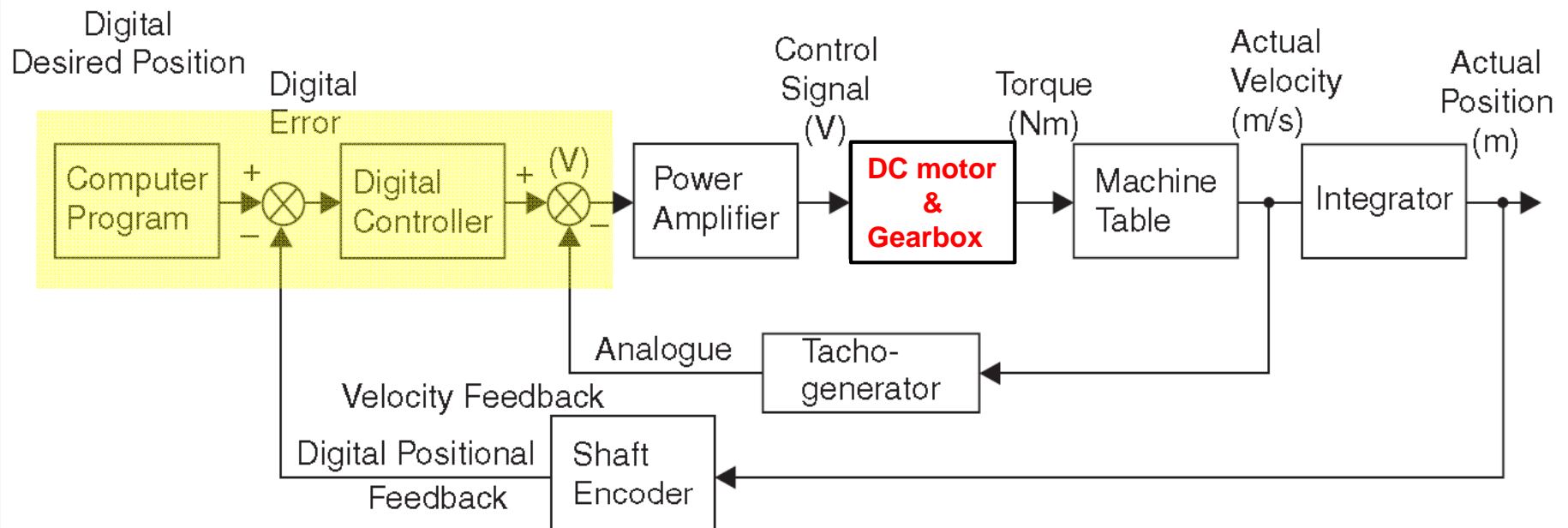
# Case Study – CNC Machine

- Ball Bearing



# Case Study – CNC Machine

- Block diagram





# Case Study – CNC Machine

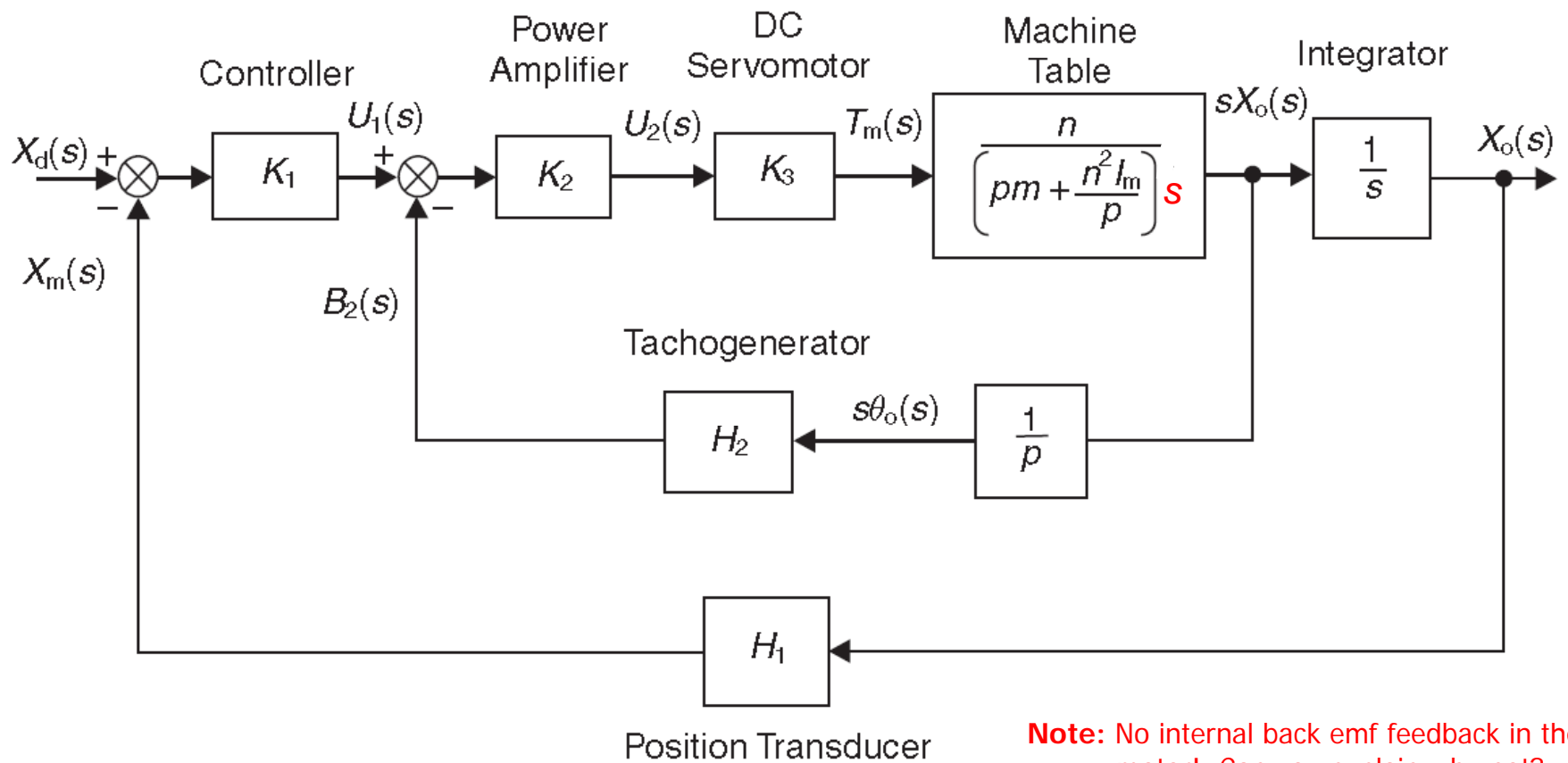
- System properties required
  - The lead-screw, using re-circulating ball-bearings, is virtually frictionless.
  - To avoid overshoot the closed-loop damping ratio must be greater than 1. (Why?)
- Possible solutions
  - Mechanical damping – dashpot attached to the lead-screw
    - > Defeats the object of using a virtually frictionless system.
    - > Wastes energy – dissipated energy lost as heat.

# Case Study – CNC Machine

- Possible solutions (cont'd)
  - PD control
    - > No modification of the machine needed.
    - > Practical realisation requires additional filtering to reduce the effects of high frequency noise – e.g. a lead-lag compensator.
  - Speed feedback – sensor that measures either rotational speed of the lead-screw or the translational speed of the machine table.
    - > Generally requires installation & integration of a speed sensor into the existing CNC machine – modification.
    - > This will be the approach we take!

# Case Study – CNC Machine

- Modelling block diagram



**Note:** No internal back emf feedback in the motor! Can you explain why not?

# Tutorial Exercises & Homework

---

- Tutorial Exercise

- Derive the machine table's transfer function for the case study discussed.

- Homework

- Example 4.6.3 (Burns, p. 100)

# Conclusion


---

- Case Study: Example 4.6.1 (p. 92)
- Example 4.6.2 (p. 97) (**Discard!**)
- Example 4.6.3 (p. 100) (**Self-study!**)
- Tutorial Exercises & Homework

# Next Attraction! – Miss It & You'll Miss Out!

- Stability of Dynamical Systems

...



**Thank you!**  
**Any Questions?**