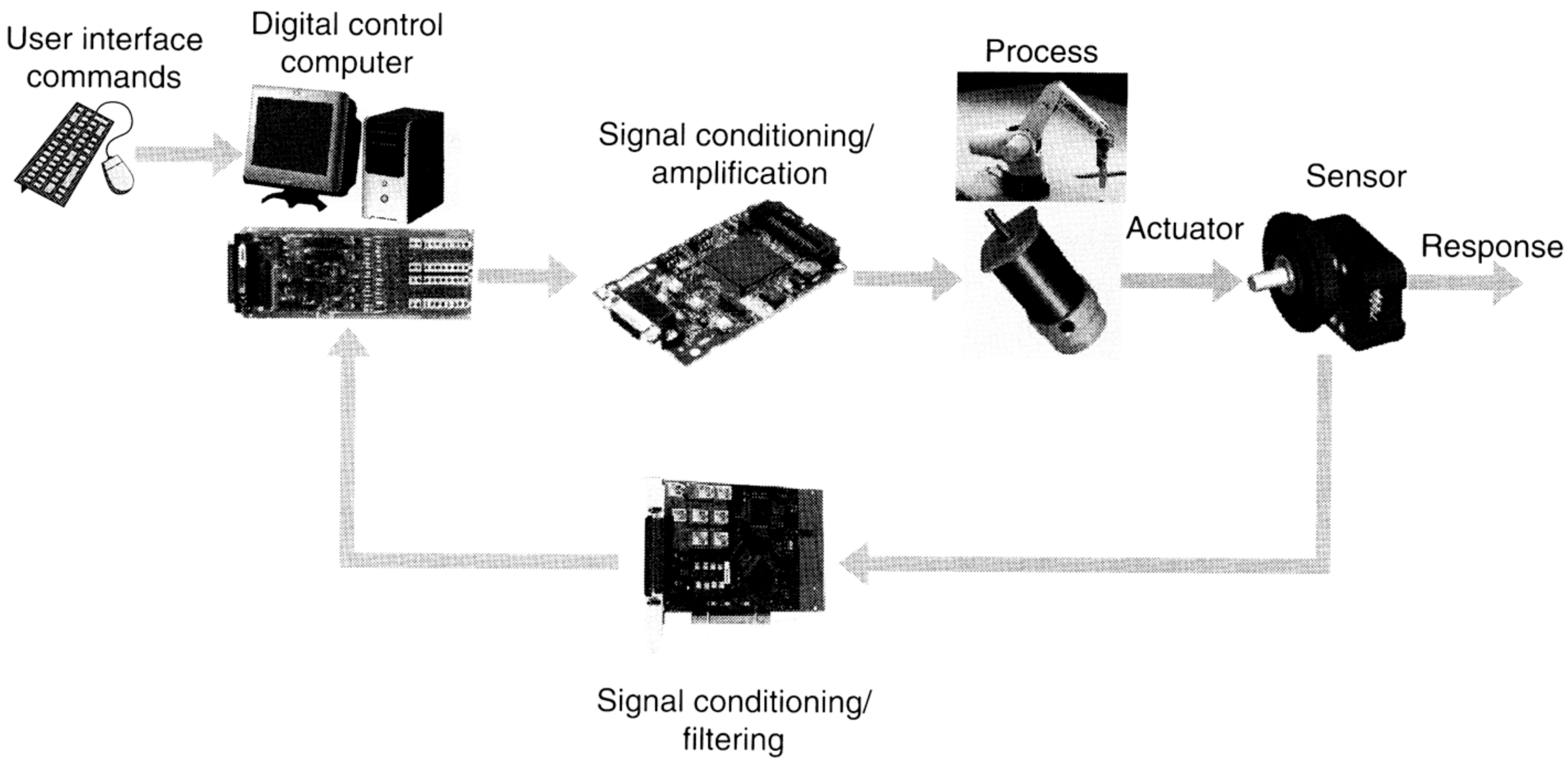
Instrumentation of an Engineering System

Chapter 1

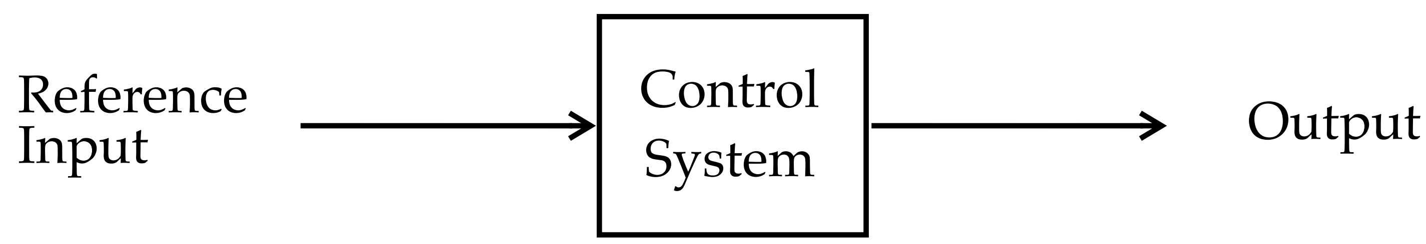
Professor Fuller

What is the need for mechatronics?



- Mechatronics are multi-domain (i.e. real) systems involving electrical, mechanical, computational, and control theory components:
    - actuators, sensors, controllers, signal conditioners, power sources, mechanical structure, user interface
- A mechatronic approach considers *all* of the systems, and in particular, how they will be interconnected.
    - Components designed separately may behave differently when interconnected.

Control System Fundamentals



Goal: Cause the output to follow, or “track”, the reference Input.

Examples:

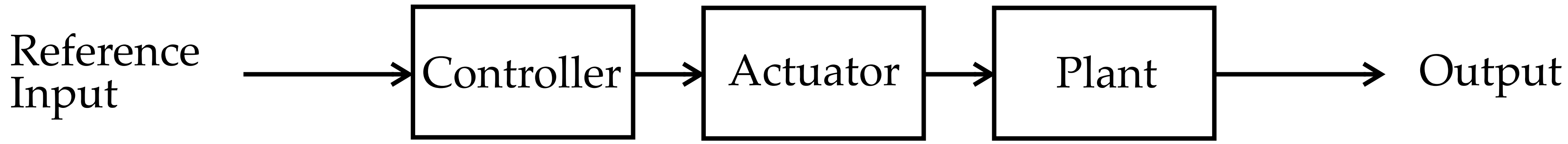
- Cruise control system for a car
- Autopilot for an airplane
- Oven thermostat

Control system types:

- Open-loop (“feed-forward”)
- Closed-loop (“feedback”)

Open-Loop Control System

(ME593)

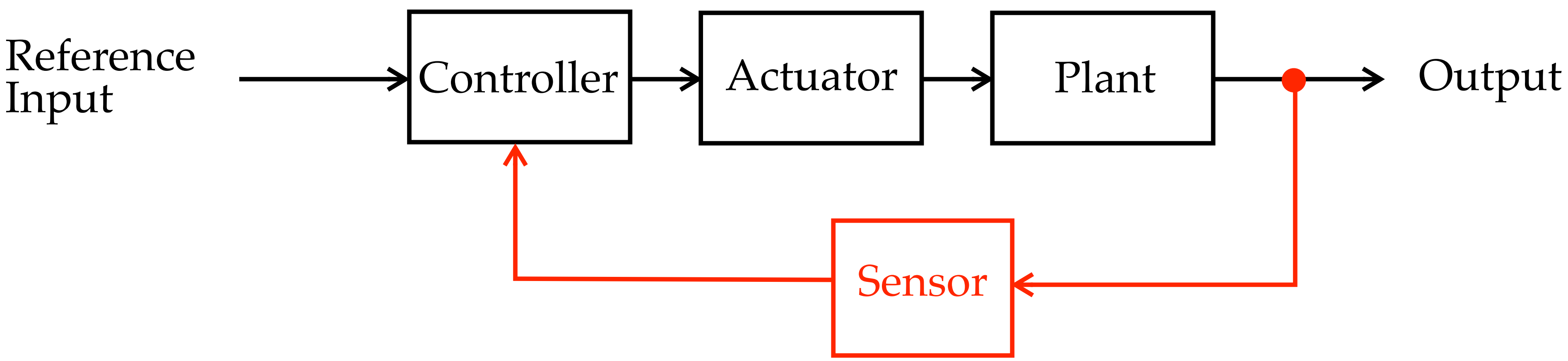


Goal: Cause the output to follow, or “track”, the reference Input.

Advantage: Simple, low-cost configuration

Disadvantage: Controller has no knowledge of the output

Closed-Loop Control System



Goal: Cause the output to follow, or "track", the reference Input.

Advantage: Controller has a *measurement* of the output

- Reject disturbances
- Good performance even without an accurate model

Disadvantages:

- Comparatively complex, costly configuration
- Possibility of instability, or even self destruction if there is a sensor failure

A well-designed mechatronic feedback system

- is stable:
  - response to an initial condition asymptotically decays to a steady state
  - a bounded input leads to a bounded output (BIBO stability)
- responds quickly to a control signal (is high-bandwidth)
- is not significantly affected by sensor noise and disturbances
- is robust to small changes in the characteristics of the plant
- low error

These specifications are often in conflict, e.g. a fast response requires high feedback gain, which can drive the system to instability

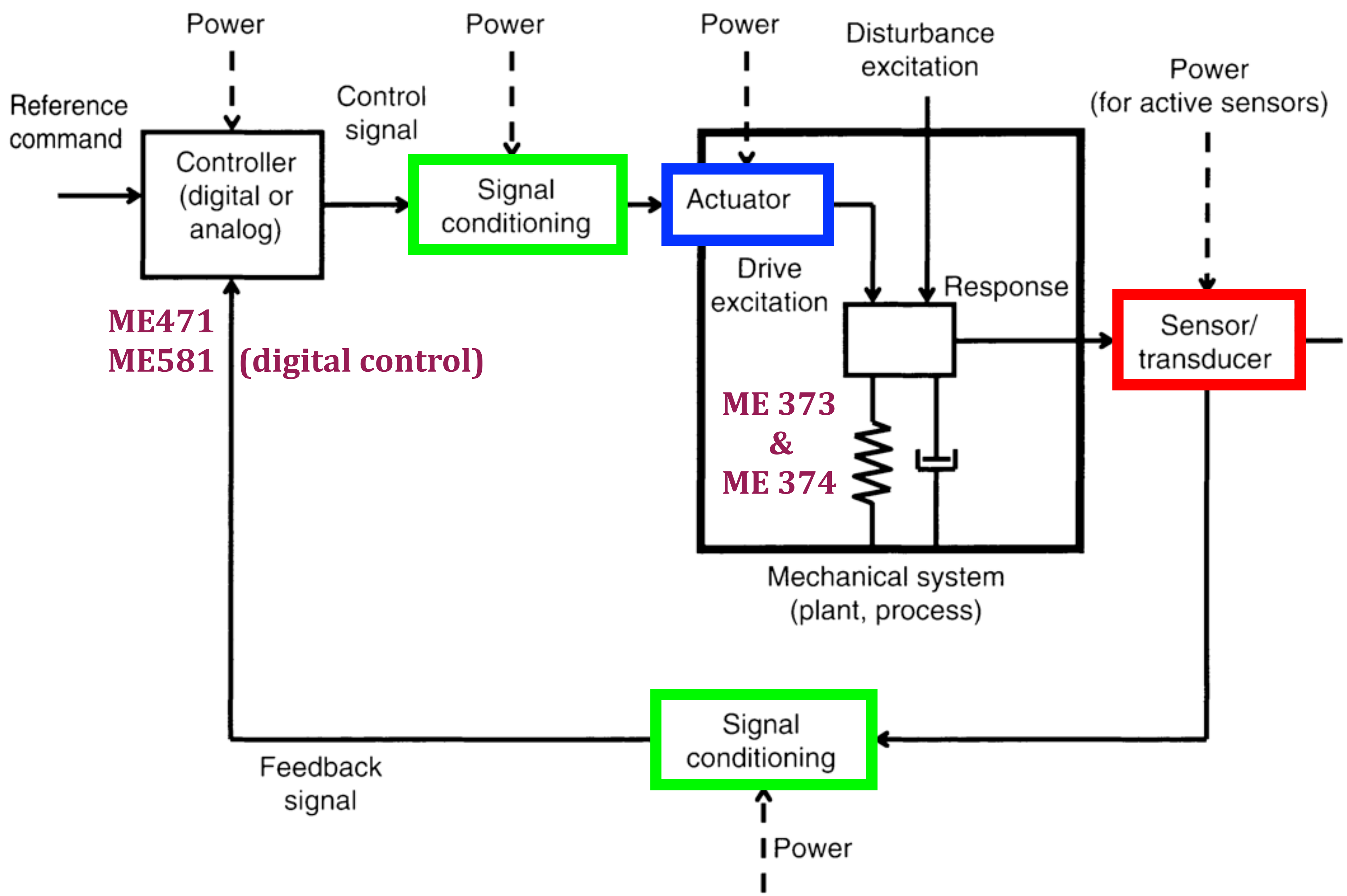
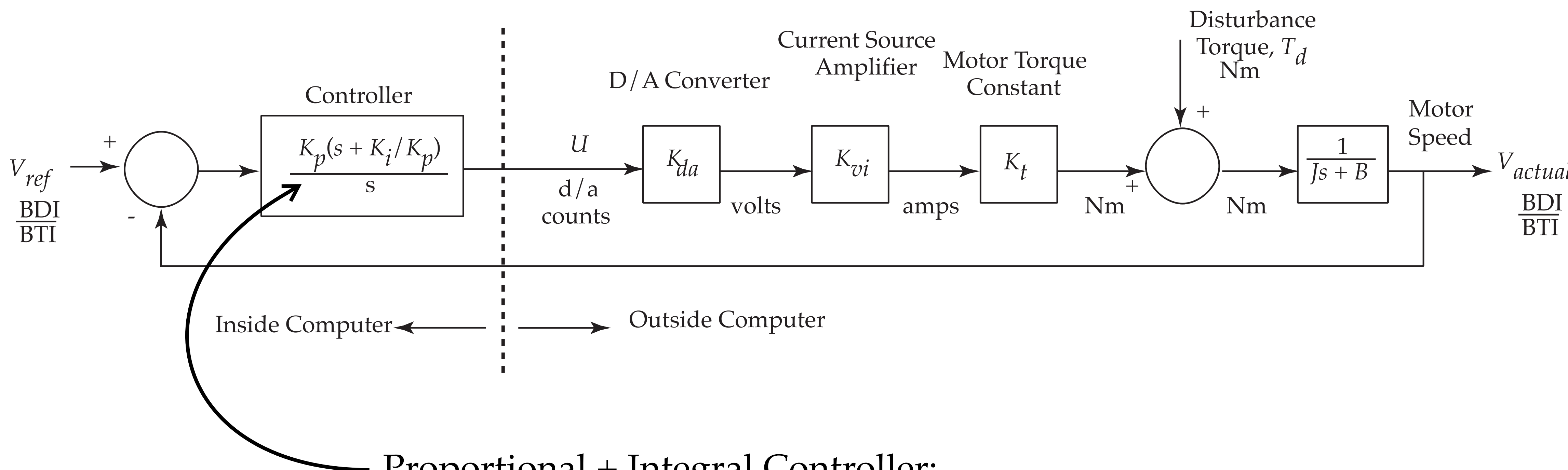


Figure 1.6 Key components of a feedback control system.

ME 477 Lab 8: Control of Angular Velocity of DC Motor



Proportional + Integral Controller:

$$u(t) = K_p\left[v_{ref}(t) - v_{actual}(t)\right] + K_i \int_0^t \left[v_{ref}(\lambda) - v_{actual}(\lambda)\right] d\lambda$$