Control System Training

Module 10 – Open / Closed Loop Control Concepts

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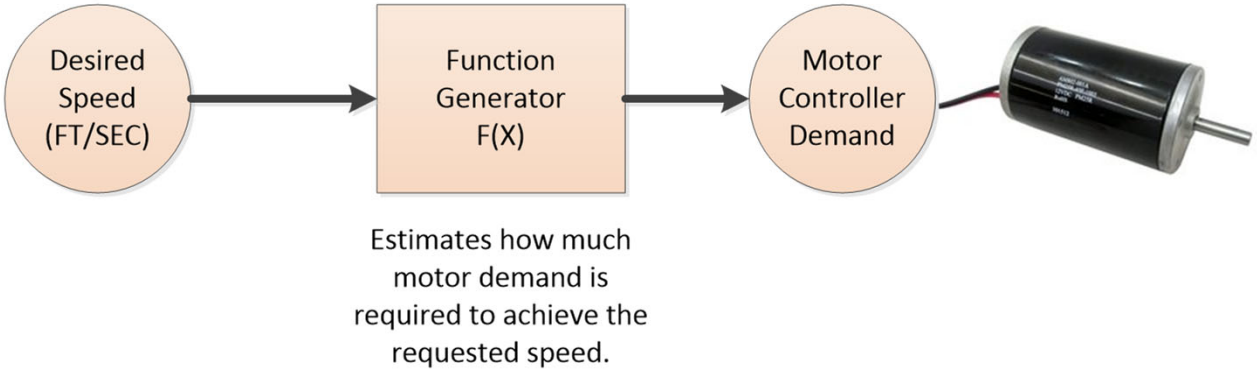
What is “Control”

- **The actions taken to achieve a specific result**
- **I want the car to go 55 MPH.**
  - Driver pushes the gas pedal
- **I want the robot to go 13 FT/SEC.**
  - Driver moves the joy stick

Open Loop Control

- **Action taken to achieve the result with any feedback of what the result is.**
  - Blindfolded driver pushes the gas pedal based on memory of where to push the pedal to achieve 55 MPH.
  - Robot driver, without seeing robot or dashboard, sets joystick based on memory of what has worked in the past to achieve 13 FT/SEC.
- **Response is potentially fast, but can be inaccurate**
  - Response is “anticipated”
  - Memory was based on a fresh battery.
  - Memory didn’t account for rough terrain or the ramp.

Open Loop Control

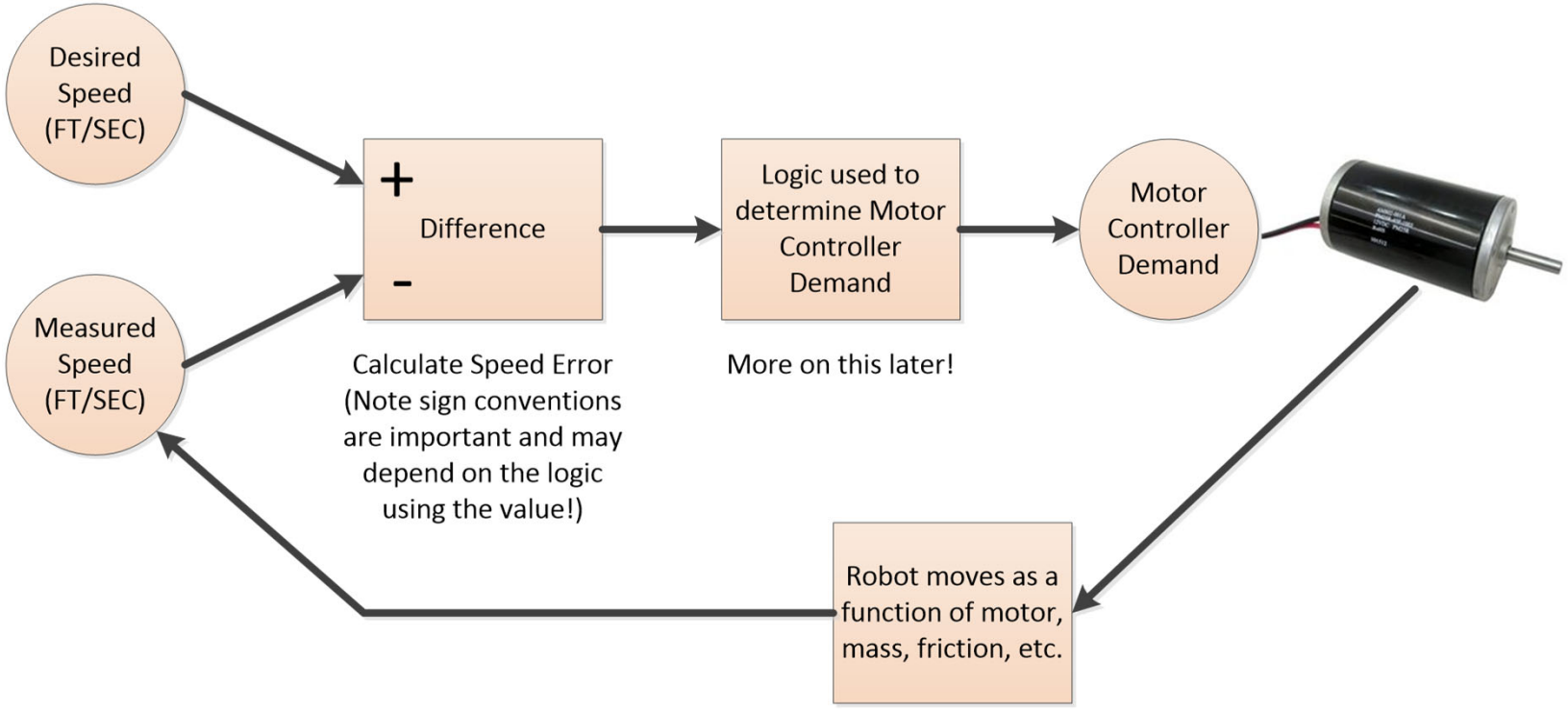


- **Motor Demand = F(Desired Speed)**

Closed Loop Control

- **Action taken to achieve the result is based on continuously watching the result and adjusting.**
  - Driver pushes the gas pedal while watching the speedometer to achieve 55 MPH.
  - Robot driver, while watching the dashboard speed and robot, sets joystick to achieve 13 FT/SEC.
- **Control depends on using the actual speed as feedback**
  - Output is adjusted based on the error between the actual speed and desired speed
  - Desired speed is achieved, but this could take some time as driver adjusts pedal or joystick.

Closed Loop Control

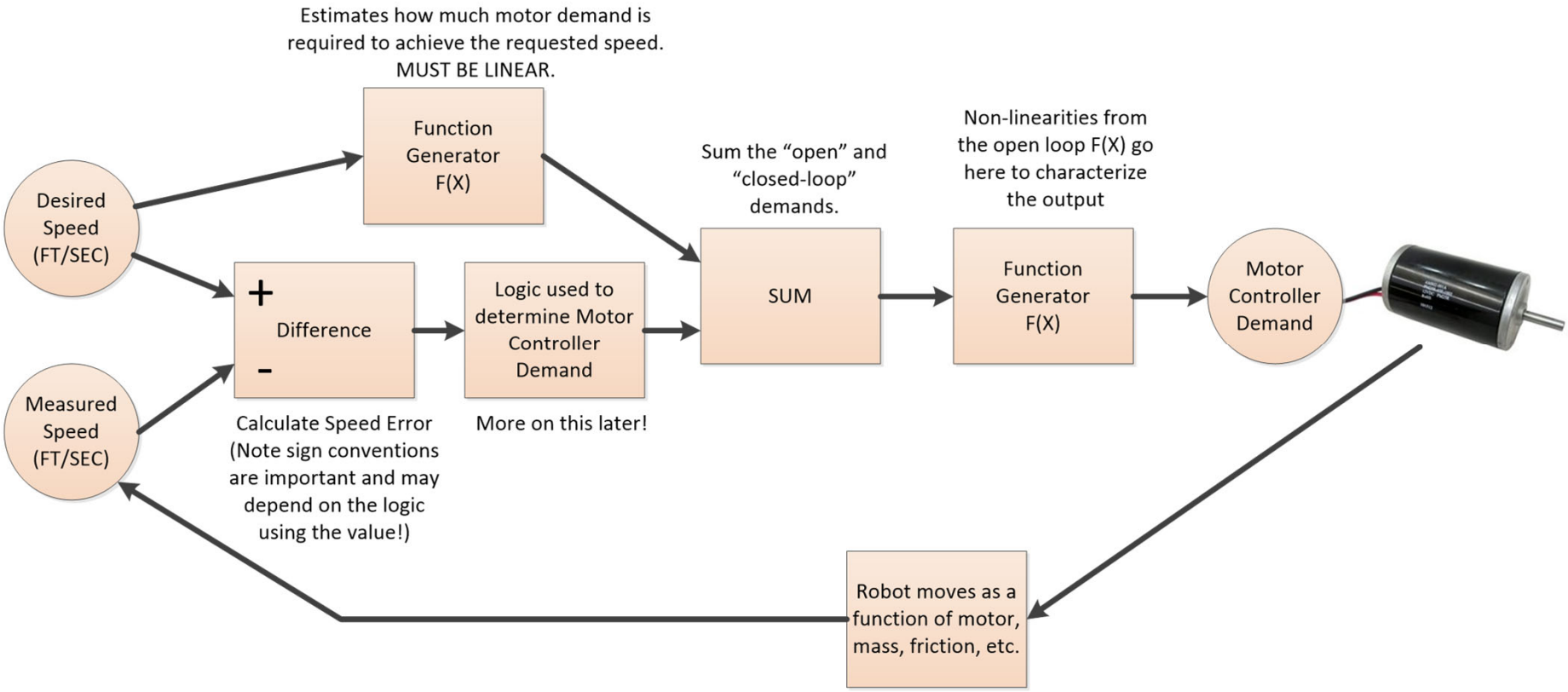


- **Motor Demand = F(Desired Speed – Actual Speed)**
  - More on the "Function" later

Closed Loop Control with Feedforward

- **Used both open loop (feedforward) memory and closed loop together.**
  - Driver pushes the gas pedal based on memory and adjusts while watching the speedometer to achieve 55 MPH.
  - Robot driver, sets joystick based and memory and adjusts while watching the dashboard speed and robot to achieve 13 FT/SEC.

Closed Loop Control with Feedforward

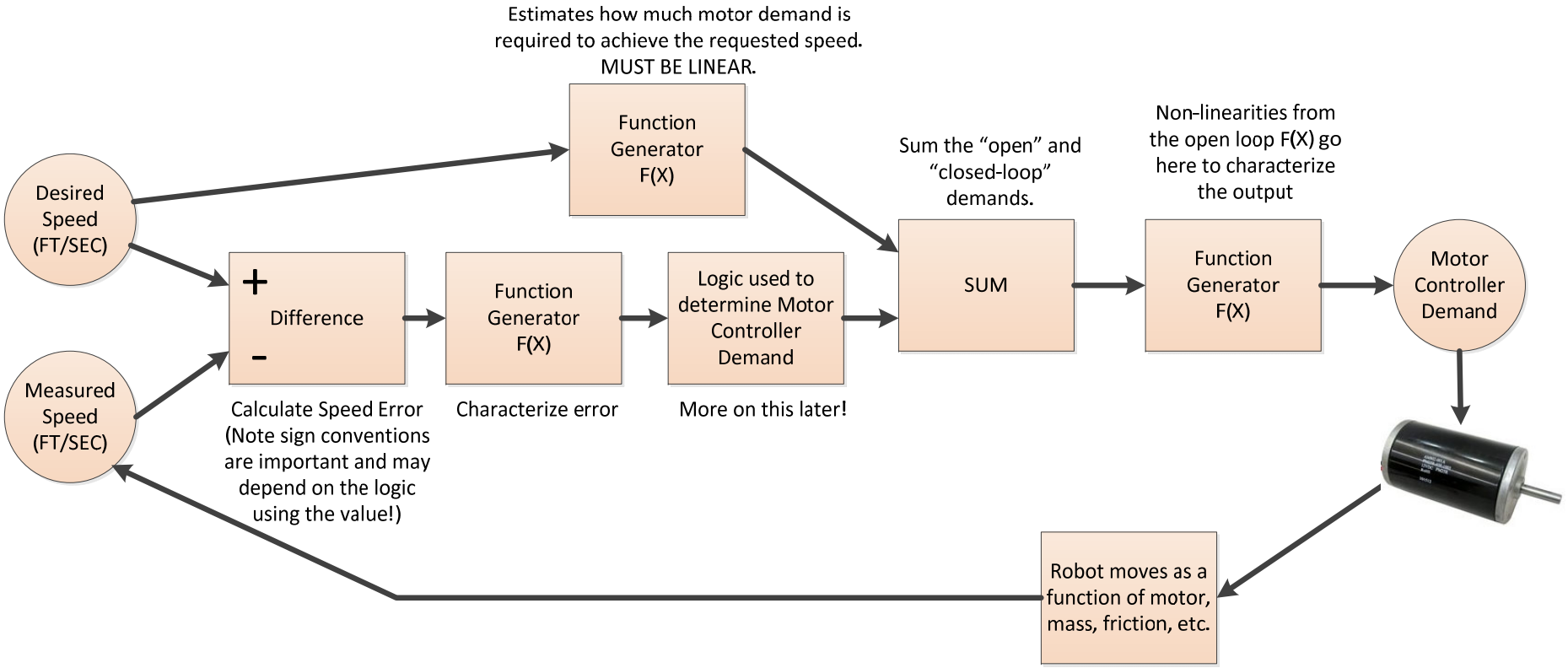


- **Motor Demand = F(F(Desired Speed) + F(Speed Error))**

Analog Control Terms

- **Target**
  - Eventual desired setpoint, prior to high / low limiting, rate limiting or other pre-processing. This is not a “universal” term.
- **Demand**
  - Desired setpoint after pre-processing has been performed. This is not a “universal” term.
- **Setpoint**
  - What the desired outcome is. Example: Desired car speed.
- **Process Variable**
  - Current value to compare with Setpoint. Example: Car speedometer.
- **Process Error**
  - Difference between setpoint and process variable
- **Control Output**
  - Action that the control system takes to try and the process error closer to zero. Example: How far to push the car’s gas pedal.

Extra Credit :) … Complete PID with FF



- **Added error characterization F(x)**