

Feedforward Speed Control

Course 1, Module 5, Lesson 3



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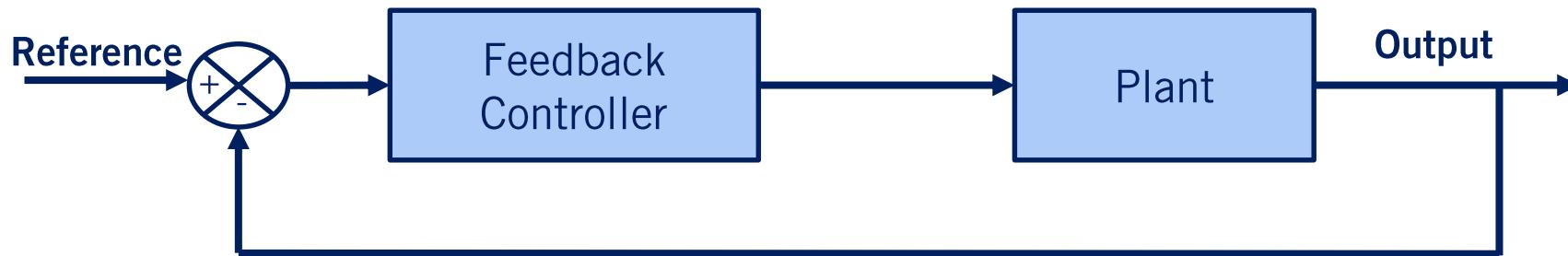
Learning Objectives

In this video, you will ...

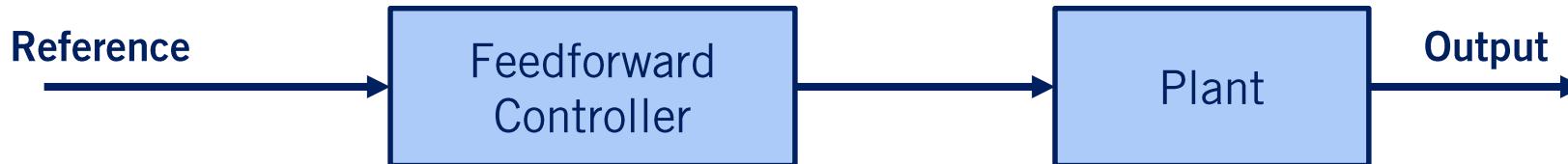
- Integrate both feedforward and feedback control into a combined control architecture
- Apply this architecture to longitudinal vehicle control

Feedback vs. Feedforward Control

Feedback - Closed Loop

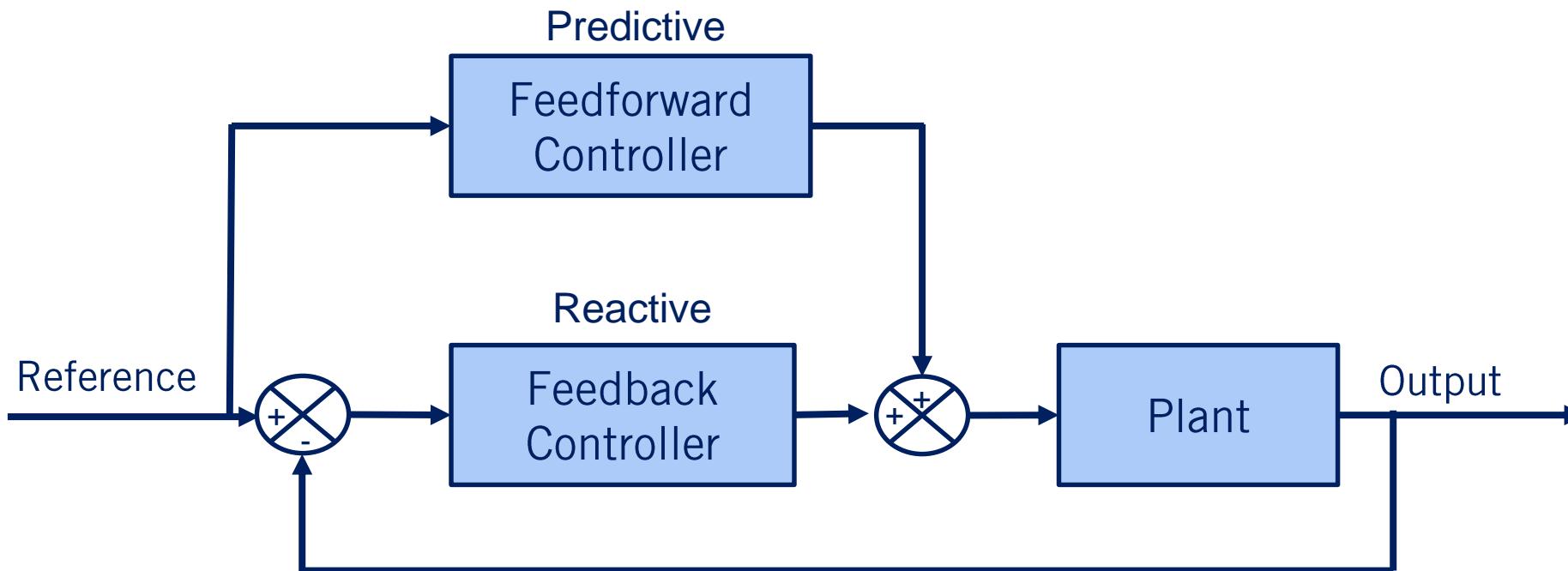


Feedforward - Open Loop



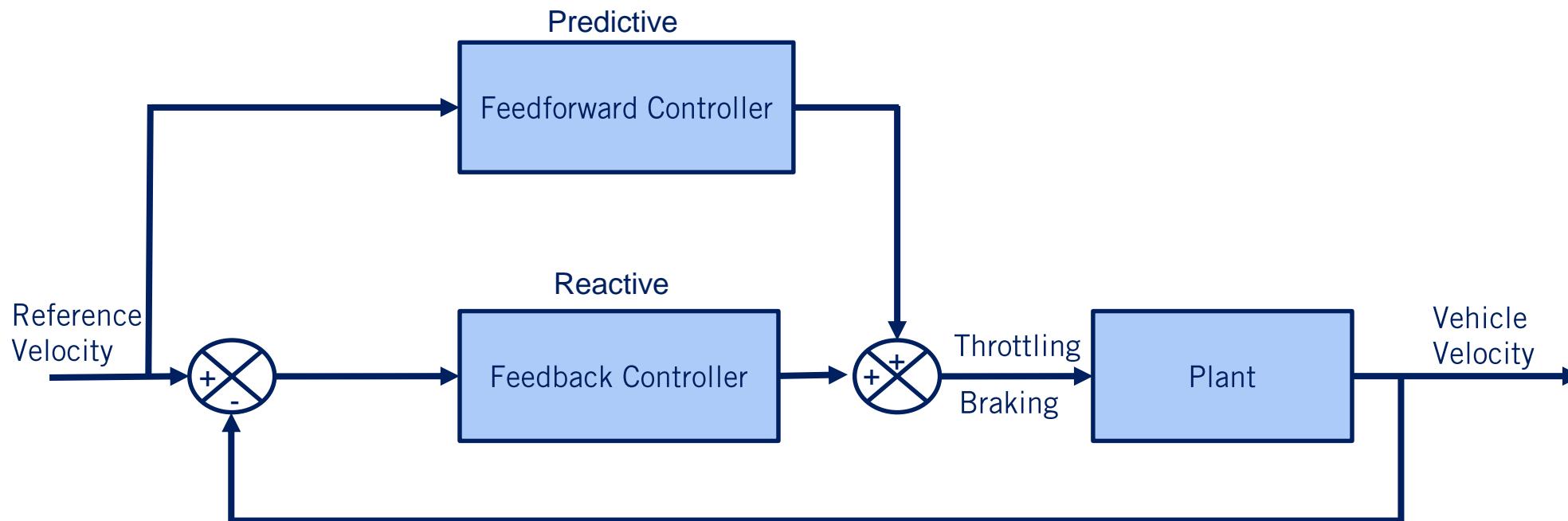
Combined Feedforward and Feedback Control

- Feedforward and feedback are often used together:
 - Feedforward controller provides predictive response, non-zero offset
 - Feedback controller corrects the response, compensating for disturbances and errors in the model



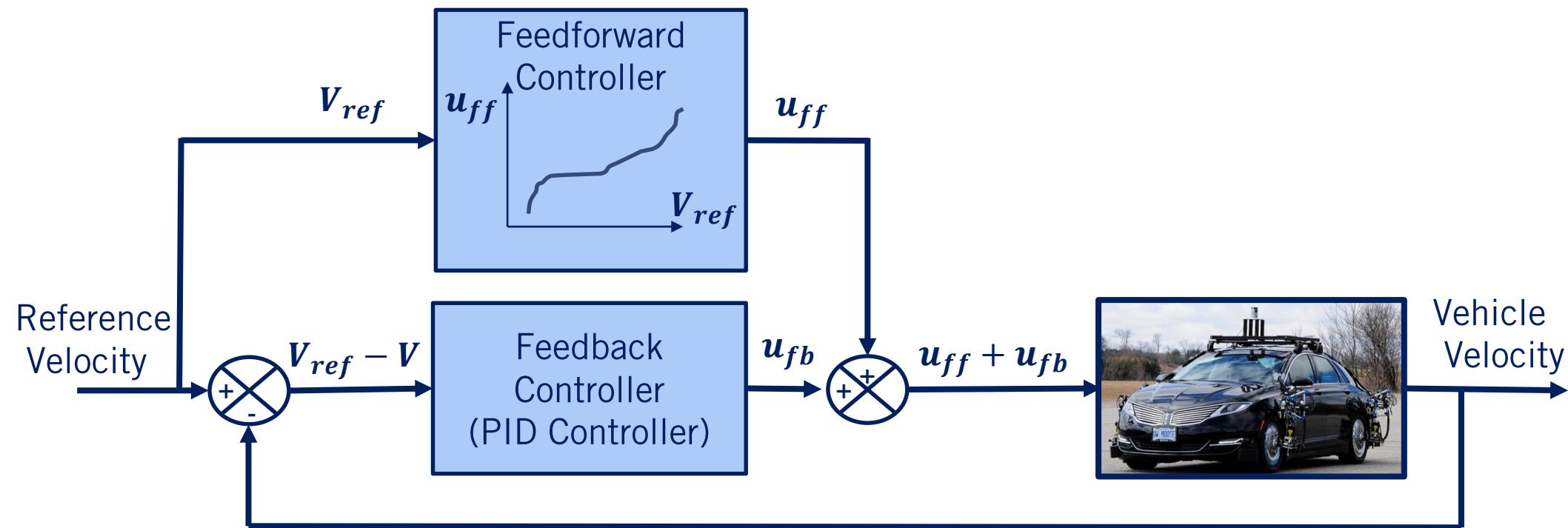
Vehicle Speed Control

- Throttling & Braking:
 - The output of the feedforward and feedback control blocks are the throttling or braking signals to accelerate or decelerate the vehicle (plant) to keep the vehicle velocity close to the reference velocity.



Controller Actuators

- Actuators (throttle angle):
 - The feedforward controller generates the actuator signal (u_{ff}) based on the predefined table and the feedback controller generates the actuator signal (u_{fb}) based on the velocity error.



Feedforward Table

Reference Velocity

Wheel Angular Speed

$$V_{ref} = r_{eff} \omega_w \rightarrow \omega_w = \frac{V_{ref}}{r_{eff}}$$

Engine Angular Speed

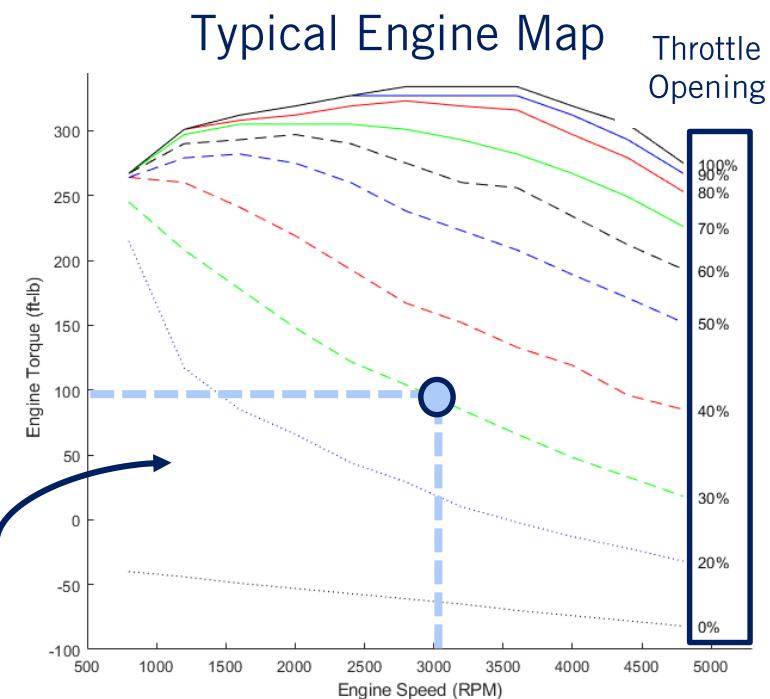
$$\omega_w = GR \omega_e \rightarrow \omega_e = \frac{\omega_w}{GR}$$

Engine Torque

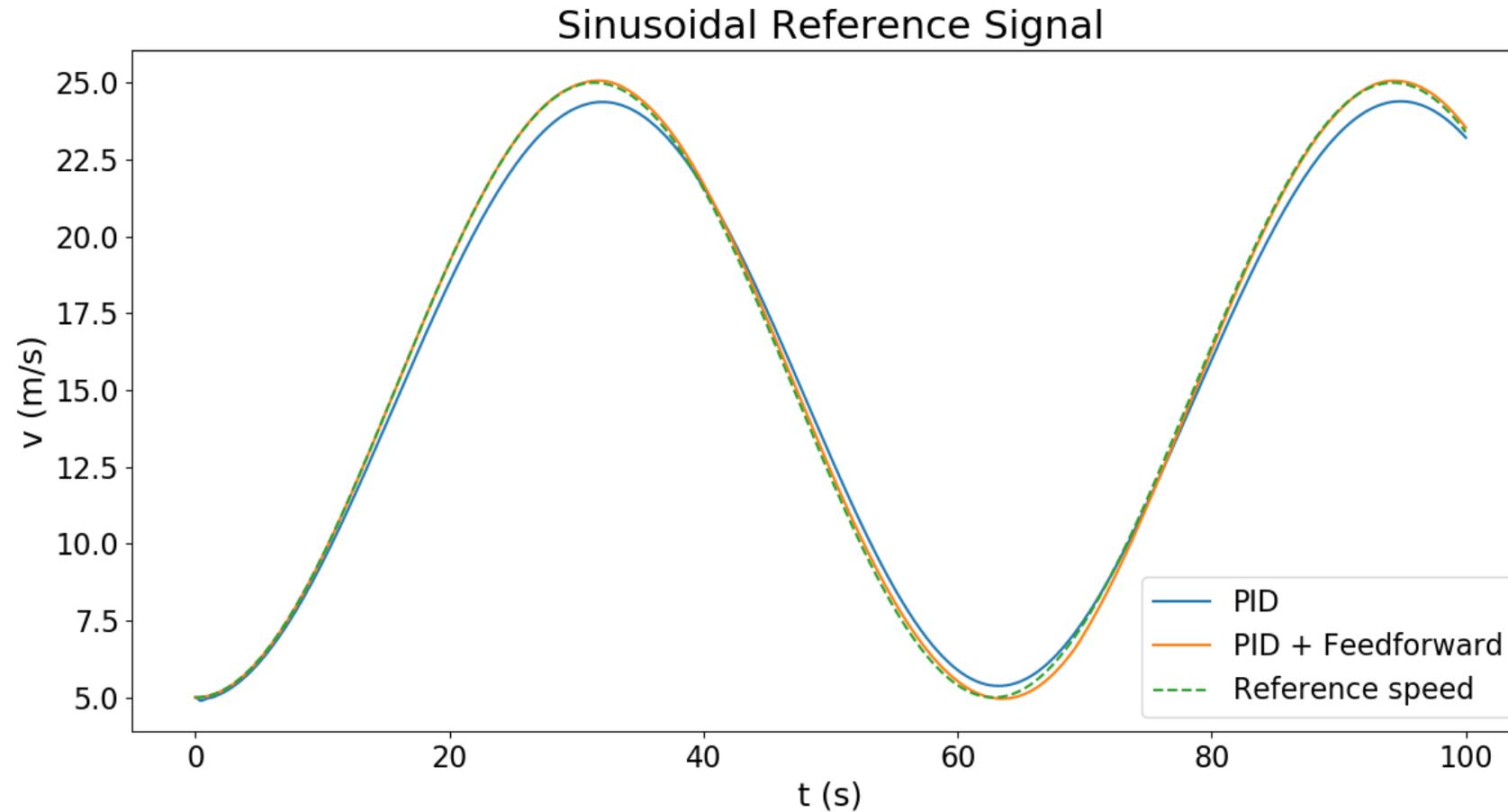
$$T_{Engine} = T_{Load}$$

Throttle Angle

$$\omega_e \quad \left. \right\} \rightarrow \Theta_{throttle}$$
$$T_{Eng}$$



Feedforward Simulation Results



Summary

What we have learned from this lesson:

- Add feedforward control for improved reference tracking
- Apply feedback and feedforward loops for autonomous vehicle speed control

Summary

What we have learned from this module:

- Reviewed the concepts of classical control, and defined the PID controller
- Built a PID controller for longitudinal control of a car
- Applied feedforward control to improve reference speed tracking

What is next?

- In the next module, we will study lateral vehicle control