# Example for PID controller

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## 1 PID controller

A Proportional Integral Derivative (PID) controller is a is a control loop which automatically adjusts a control output based on the difference between a set point (SP) and a measured process variable (PV). The overall control function $u(t)$ (a value of the controller output) is fed into the system as the manipulated variable input as

$$u(t) = u_{bias} + K_p e(t) + K_i \int_0^t e(t)dt + K_d \frac{d\,e(t)}{dt} \tag{1}$$

where $u_{bias}$ is bias (steady-state) value. $K_p, K_i$ and $K_d$ are denoted as the coefficients for the proportional, integral, and derivative terms respectively. $e(t) = SP - PV$ is an error signal. The equation (1) can be written in term of an integration time ($\tau_I$) and a derivative time ($\tau_D$) as

$$u(t) = u_{bias} + K_p \left( e(t) + \frac{1}{\tau_I} \int_0^t e(t)dt + \tau_D \frac{de(t)}{dt} \right). \tag{2}$$

### 1.1 Vehicle Velocity Control

The following example shows how to use a PI control to control a velocity of vehicle. The equation of motion of vehicle can be model as

$$m\frac{dv(t)}{dt} = F_p u(t) - \frac{1}{2}\rho A C_d v(t)^2 \tag{3}$$

where $u(t)$ is assigned as a gas pedal position (% pedal), $v(t)$ is velocity, $m$ as the mass of the vehicle, $F_p$ is a thrust parameter (N/ %pedal), $\rho$ is the air density, $A$ is a vehicle cross-sectional area, and $C_d$ is the drag coefficient [1, 2].

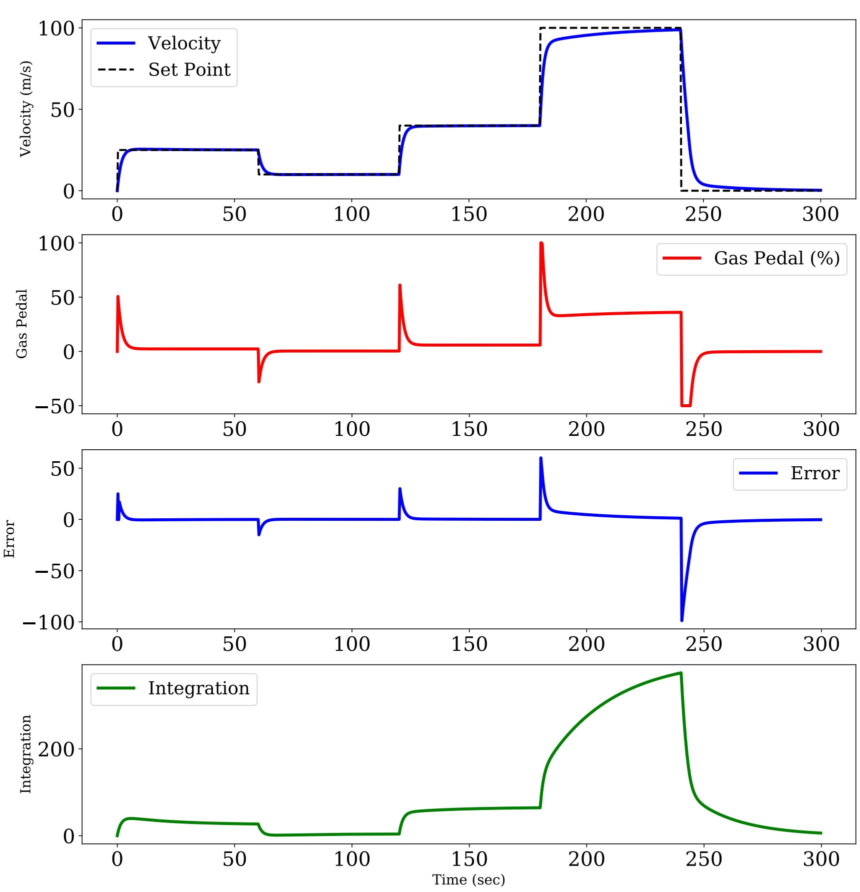


**Figure 1.** Vehicle velocity control using PI controller

## References

[1] J. Hedengren. (2018) PID velocity control in python. [Online]. Available: https://youtu.be/k46nCvOBllA

[2] ——. (2021) Process control introduction. [Online]. Available: http://apmonitor.com/pdc/index.php/Main/FeedbackControl