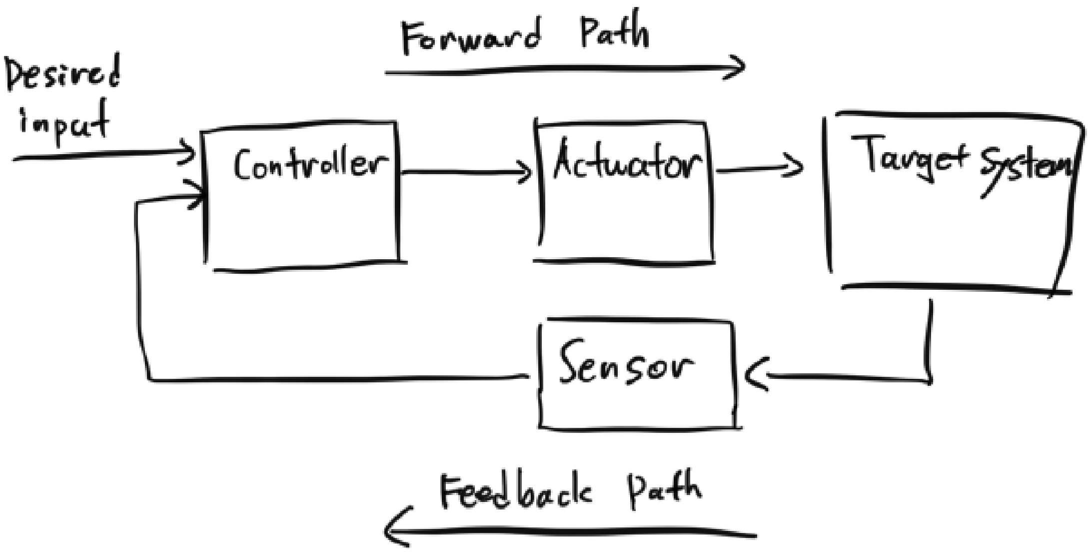
PID Control Basics

Closed Loop Control System

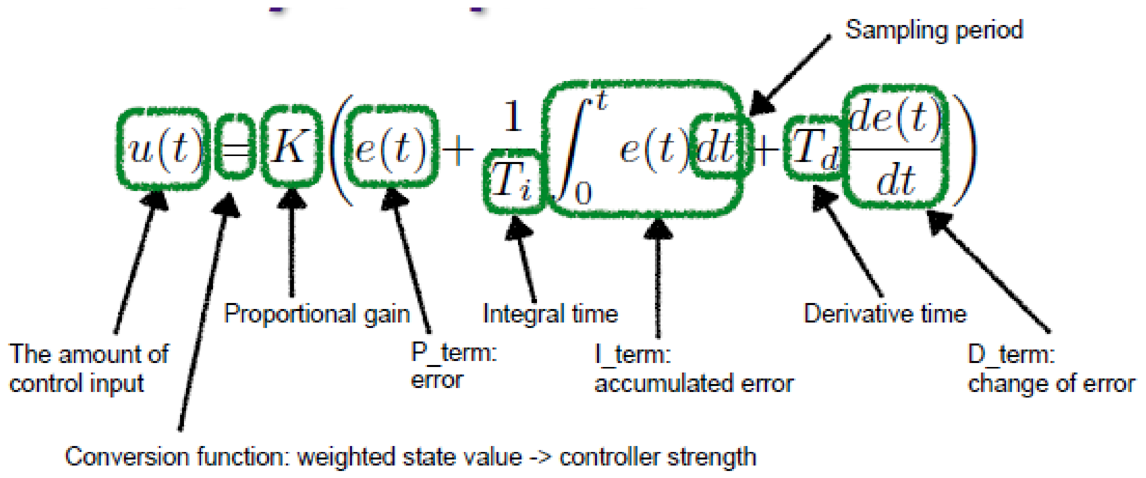


- Target system examples

PID Control

- 목표
  - 붕뜨고 반응이 느린 타깃 시스템에 대해 안정적이고 빠른 제어 방법론
- Means
  - P : Proportional gain, present(현재의 상태)
  - I : Integral gain, past(누적, accumulation)
  - D : Derivative gain, future, future(바로 직전과 지금의 차이)

Anatomy of Equation




```
// Pseudo code
while(1) {
    state_curr = sensor_read();
    P_term = state_desired - state_curr; // error
    I_term += P_term * dT;
    D_term = (error - error_prev) / dT;
    output_control = K * ( P_term + I_term / T_i + T_d * D_term);
    sleep(dT);
}
```

- Pros
  - Applicable to **many systems without knowing their accurate model**
- Cons
  - Does not guarantee the **optimal control of the target system**

Parameter Tuning

- Hard to find a systematic way to determine optimal values
- Trial & error / empirical methods
- Known / applicable heuristics
  - Ziegler-Nichols method
  - Twiddle algorithm
- Commercial tools
  - CEMTool / MATLAB & Simulink

Integrator Windup

- Actuators have **limitations**
  - Saturation : the control variable reaches the **actuator limit**
  - Accumulated error can be **too large** when saturation continues
- Windup may cause oscillation
  - The integral term still remains high when the target system reaches to the desired state
- Solutions
  - Initialize the integral term to a predefined one, or reset to zero
  - Moderately increase the desired state value
  - Disable the integral term for a while
  - Limit the min-max range of the integral term

- Back-calculate the integral term such that the control variable does not exceed a certain bound