Texas Instruments Robotics System Learning Kit
Module 17
Activity: Control Systems
Activity: Control Systems

Question 1
In this activity you will design multiple digital controllers. Assume the desired speed is $S^*$ and the estimated speed can be obtained by calling the function with the following prototype

```c
uint16_t Speed(void);
```

Both estimated and desired speed are unsigned 16-bit integers in RPM. The time constant of the motor is 10ms. The actuator is a PWM circuit with a duty cycle range of 0 (0%) to 250 (100%). Software sets the duty cycle by calling the function with the following prototype

```c
void PWM_Duty(uint16_t duty);
```

At what rate should the controller run? Let $\Delta t$ be the time between executions of the controller.

Question 2
Using the hardware, `Speed()`, and `PWM_Duty()` functions described in Q1 show the C code that implements an incremental controller. Make sure to limit the actuator output to between 0 and 250.

Question 3
Using the hardware, `Speed()`, and `PWM_Duty()` functions described in Q1 implement a proportional controller.

$$U(t) = 0.1256 \cdot e(t)$$
$$0 \leq U(t) \leq 250$$

Question 4
Using the hardware, `Speed()`, and `PWM_Duty()` functions described in Q1 implement an integral controller.

$$U(t) = U(t) + 12.52 \cdot e(t) \cdot \Delta t$$
$$0 \leq U(t) \leq 250$$

where $\Delta t$ was determined in Q1.

Question 5
Using the hardware, `Speed()`, and `PWM_Duty()` functions described in Q1 implement a proportional-integral controller.

$$U_p(t) = 0.3451 \cdot e(t)$$
$$U(t) = U(t) + 125.1 \cdot e(t) \cdot \Delta t$$
$$0 \leq U(t) \leq 250$$

where $\Delta t$ was determined in Q1.

Question 6
Using the hardware, `Speed()`, and `PWM_Duty()` functions described in Q1 implement a proportional-integral-derivative controller.

$$U_p(t) = 0.024 \cdot e(t)$$
$$U_d(t) = 0.000012 \cdot e(t) / \Delta t$$
$$U(t) = U(t) + 256.7 \cdot e(t) \cdot \Delta t$$
$$0 \leq U(t) \leq 250$$

where $\Delta t$ was determined in Q1.
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