



Module 17

Activity: Control Systems



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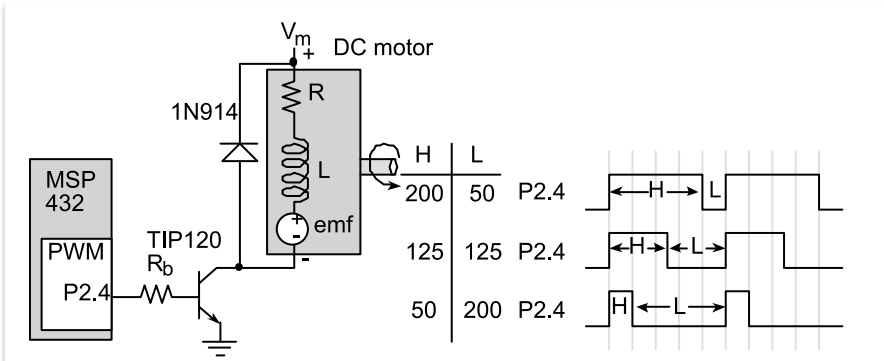
Question 1

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

`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

`void PWM_Duty(uint16_t duty);`



At what rate should the controller run? Let Δt 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.

$$U(t) = 0.1256 * e(t)$$

$$0 \leq U(t) \leq 250$$

Question 4

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

$$U(t) = U(t) + 12.52 * e(t) * \Delta t$$

$$0 \leq U(t) \leq 250$$

where Δt was determined in Q1.

Question 5

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

$$U_p(t) = 0.3451 * e(t)$$

$$U_i(t) = U_i(t) + 125.1 * e(t) * \Delta t$$

$$0 \leq U_i(t) \leq 250$$

$$U(t) = U_i(t) + U_p(t)$$

$$0 \leq U(t) \leq 250$$

where Δt was determined in Q1.

Question 6

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

$$U_p(t) = 0.024 * e(t)$$

$$U_d(t) = 0.000012 * e(t) / \Delta t$$

$$U_i(t) = U_i(t) + 256.7 * e(t) * \Delta t$$

$$0 \leq U_i(t) \leq 250$$

$$U(t) = U_i(t) + U_p(t) + U_d(t)$$

$$0 \leq U(t) \leq 250$$

where Δt was determined in Q1

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