CENG4480 Homework 2

Q1 Given the following system as shown in Fig. 1. Q_1 is so-call NPN bipolar device, which has following voltage-current characteristic:

$$I_C = I_S \cdot e^{\frac{kV_X}{T}}, \tag{1}$$

where T is temperature, k and I_S is constant. Suppose R_2 is a temperature-sensitive resister and has resistor value of $R_{2,0}$ at temperature T_0, determine the R_2 in terms of T, so that V_Y is stable as temperature changes.
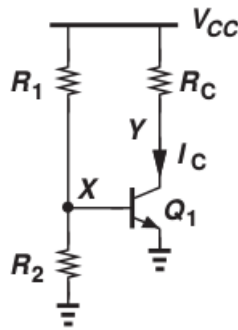

Figure 1: Resistive Divider Biased System

Q2 A simple Infra-Red Sensor system to detect passing human is presented as in Fig. 2. A and B are IR Sensors which will generate different output voltages for different infra-red intensity, and higher voltage level corresponds to high light intensity.

(1) Explain how this system works for counting passing pedestrians.

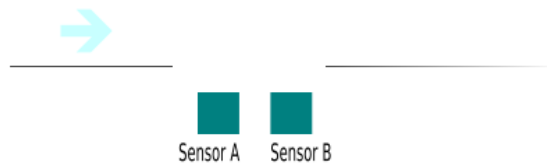(2) To increase counting accuracy, usually B is covered with materials that can reflect infra-red light. Explain why.

Figure 2: IR-System

Q3 Considering the 4-bit DAC in Fig. 3, calculate the output scope of v_a, and the minimum voltage change it can generate.

Q4 Design a fully paralleled ADC, please provide ADC details. ADC should satisfy: (1) Detect input range 0–3V and (2) Generate 4-bit digital output.

Q5 For the 4-bit R-2R DAC, calculate V_0 in terms of $V_{b,0} - V_{b,4}$ if V_{ref} is grounded (Fig. 4).
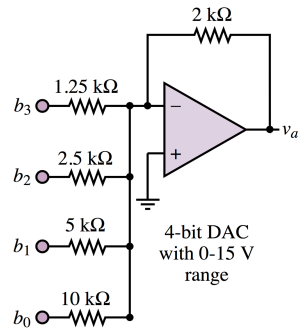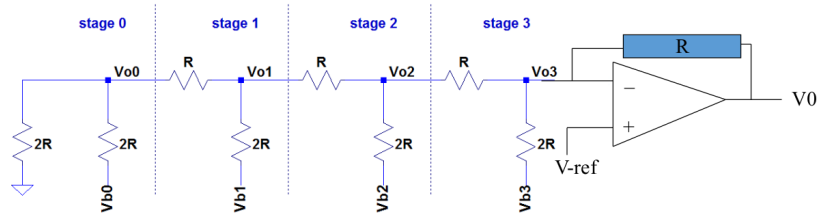
Figure 3: 4-bit DAC

Figure 4: R-2R DAC

Q6 Briefly describe how PID affects motor control.

Q7 Elaborate motion sensors you know.

Q8 Describe how Sample and Hold Amp works.