AMERICAN INTERNATIONAL UNIVERSITY – BANGLADESH (AIUB)
Faculty of Engineering
Department of Electrical and Electronic Engineering

Course/Lab Name: EEE4103 Microprocessor and Embedded Systems				
Semester: Fall 2023-23	**Term**: Mid	**Quiz**: 03M	**Total Marks**: 10	**Time**: 20 Minutes

Question Mapping with Course Outcomes:

Item	COs	POIs	K	P	A	Marks	Obtained Marks
Q1-2	CO1	P.a.4.C.3	K4			2×5	
					Total:	**10**	

Student Information:

Student Name:	Solve Sheet		**Section:**	**B**
Student ID #:	Solve Sheet	**Date:** 16.10.2023	**Department:**	

1. A TV remote controller is to be designed with the channel selection buttons to be debounced. It was observed that the switches exhibit bounce times well under 20 ms and the duty cycle is 50%. Design a circuit using the 74AHC14 Schmitt trigger IC along with the resistance and capacitance. The worst-case positive-going threshold, V_{th+} of this IC for a signal when going high is 3.15 V, and that of the negative-going threshold, V_{th-} when going low is 1.35 V. Consider that the CMOS device leakage current is 50 µA and the gate's best-case switching point is 0.1 V. Compute the hysteresis voltage. V_{CC} = 5 V. **[5]**

Answer:

While falling the signal, we choose a value of capacitance, C = 1 µF and use $v_c = v_{th+} = V_{final}e^{-t/RC}$. After rearranging the equation, we get $R = -\frac{t}{Cln\frac{V_{th+}}{V_{final}}}$, and then putting the values, we find-

$$R_2 = \frac{-20 \times 10^{-3}}{1 \times 10^{-6} ln \frac{3.15}{5}} = 43.29\ \text{k}\Omega\ \cong 44\ \text{k}\Omega$$

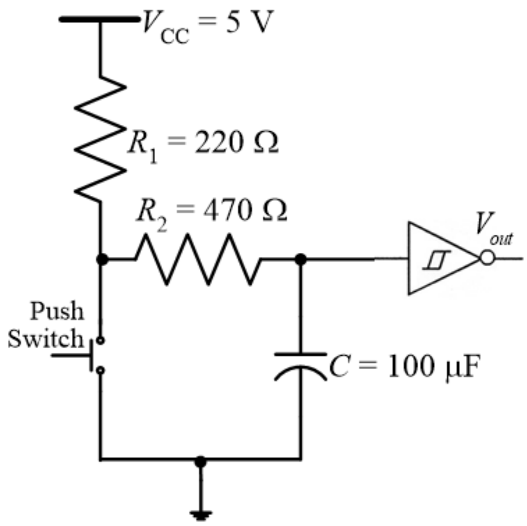
For TTL IC family, we usually choose supply voltage, V_{CC} = 5 V.

If we choose this value, therefore, during discharging, due to the leakage current of 50 µA, a voltage drops of $V = IR = 50 \times 10^{-6} \times 44 \times 10^3 = 2.2$ V would occur, and it is uncomfortably over the gate's best-case switching point of 0.1 V. Therefore, we can increase this capacitor's capacitance to 100 µF so that the resistance of discharging path becomes 440 Ω and as such the voltage drop becomes 0.022 V.

Again, during rising the signal, we choose this capacitance value, that is, C = 100 µF and use capacitor's charging equation, $V_c = v_{th-} = V_{final}(1 - e^{-t/RC})$. After rearranging the equation, we get $R = -\frac{t}{Cln\left(1-\frac{V_{th-}}{V_{final}}\right)}$, and then putting the values, we find-

$$R_1 + R_2 = \frac{-20 \times 10^{-3}}{100 \times 10^{-6} ln\left(1 - \frac{1.35}{5}\right)} = 635.5\ \Omega\ \cong 640\ \Omega$$

Since, already we have calculated R_2 = 440 Ω, hence, R_1 = 640 – 440 = 200 Ω. But these values are not available, therefore we will use 220 Ω for R_1 and 470 Ω for R_2. Therefore, the final designed circuit is given as in the next page-



The hysteresis voltage is given by-

$$V_H = V_{th+} - V_{th-} = 3.15 - 1.35 = 1.8\ V$$

2. For example, we are using a debounce program for the above problem as follows: **[5]**

```
int inPin = 5;          // the pin number of the input pin
int outPin = 12;        // the pin number of the output pin

int counter = 0;        // how many times we have seen the new value
int reading;            // the current value read from the input pin
int current_state = HIGH;    // the debounced input value

long time = 0;          // the last time the output pin was sampled
int debounce_count = 40; // number of millisecond/samples to consider before declaring a debounced input

void setup()
{
 pinMode(inPin, INPUT);
 pinMode(outPin, OUTPUT);
 digitalWrite(outPin, current_state); // setup the Output LED for initial state

void loop()
{
 if(millis() != time)
 {
  reading = digitalRead(inPin);

  if(reading == current_state && counter > 0)
  {
   counter--;
  }
  if(reading != current_state)
  {
    counter++;
  }
  if(counter >= debounce_count)
  {
   counter = 0;
   current_state = reading;
   digitalWrite(outPin, current_state);
  }
  time = millis();
 }
}
```

What should be the state of the LED connected to pin # 12 if pin # 5 reads a LOW from the switch connected to it after 20 ms, 30 ms, and 50 ms? Why do you think so?

Answer:

Since switch is debounced by the software program and the debounce_count value is 40; that is, the number of millisecond/samples to consider before declaring a debounced input is 40 and millis() function gives 1 ms time for each count, therefore we get a debounced switch after 40 ms. Input pin (5) reads a LOW signal, therefore after 10 ms and 30 ms, LOW signal will not go to the output pin (12), so the LED will remain turned ON as the current state is HIGH and the setup function writes this signal to the output pin (12) where the LED is connected. But after 50 ms, LOW signal will go to the output pin (12) because by this time the switch is debounced, so the LED will be turned OFF.