EE 200 **Problem Set 4 Cover Sheet** **Spring 2014**

Last Name (Print): _____

First Name (Print): _____

ID number (Last 4 digits): _____

Section: ____

Submission deadlines:

- Demonstrate completion of problems 13 and 14 during evening laboratory sessions on either Monday February 10, or Tuesday February 11, from 6:30 pm to 8:30 pm in 302 EE West. You must sign up for a ten minute slot on either Monday or Tuesday using SignUpGenius. You will receive an email message via your Penn State email address when the sign up sheet is available online at SignUpGenius. Slots are filled on a first-come, first-served basis.
- Turn in the written solutions for problems 15 through 16 by 4:00 pm Tuesday February 11 in the homework slot outside 121 EE East.
- Upload the Multisim file for problem 15 no later than midnight Wednesday February 12.

Problem	Weight	Score
13	25	
14	25	
15	25	
16	25	
Total	100	

Problem 13: (25 points)

Verify the operation of the finite state machine for robot navigation realized in Problem Set 3 Problem 10 using Multisim. Implement the circuit using a 4012BD_5V dual four-input NAND gate, a CD4023BD_5V triple three-input NAND gate gate, and a 40175BD_5V quad D-type flip-flop. Allow the user to interactively generate the input signals S_L and S_R with generic single-pole single-throw (SPST) switches. Include a third input S_B, also set by an interactive SPST switch, that asynchronously resets the system to state S1. Pull the signals S_L, S_R, and S_B either low or high using a 27kΩ resistors. Activate the switches for the signals S_L, S_R, and S_B using the keys L, R, and B, respectively. Indicate the output signals M_L, and M_R using red and green LEDs, respectively. Use a 330Ω resistor in series with each LED to limit current. Generate a clock signal using the specifications provided on page 12 of the Laboratory 4 handout. During your grading window, a grader will verify that that your Multisim model correctly simulates the operation of the finite state machine.

Problem 14: (25 points)

Each EE 200 student must realize the finite state machine considered in problems 10 and 13, and demonstrate their circuit to the the laboratory instructor during their grading session on either Monday or Tuesday evening. **To insure this requirement, after you demonstrate your circuit to the instructor, your circuit will be held in a secure location and returned to you during your first laboratory section after Tuesday evening.** Implement the circuit using the components in Table 1 that are available in the EE 200 component kit. Component specifications sheets are provided along with this problem set.

Manufacturer Part Number	**Description**	**Quantity**
CD4012BE	Dual 4-input NAND gate	1
CD4023BE	Triple 3-input NAND gate	1
CD40175BE	Quad D-Type flip-flop	1
CD4541BE	Programmable Timer	1
SSL-LX25731D	Red LED	1
SSL-LX2573GD	Green LED	1
SSL-LX2573YD	Yellow LED	1
MULTICOMP MCF	330Ω 0.25 W carbon film resistor	3
MULTICOMP MCF	27kΩ 0.25 W carbon film resistor	1
MULTICOMP MCF	56kΩ 0.25 W carbon film resistor	1
KEMET C315C103K5R5TA	$0.01\mu F$ ceramic capacitor	1

Table 1: FSM Components.

Adhere to the following guidelines.

1. Generate a clock signal of approximately 0.2 Hz using the CD4541BE programmable timer using the design from problem 11, part 2. Set the values of R_{TC}, C_{TC}, and R_S to 27kΩ, $0.01\mu F$, and 56kΩ, respectively. Use the yellow LED to display the state of the clock signal.

2. Use the two tactile switches to generate the inputs S_L and S_R. Pressing a button should send the corresponding input to the logic-high state. Use a 27kΩ pull down resistor between the CMOS input and V_{SS} to make sure that the gate input sees a logic-low state when the button is not pressed.

3. As the clear input for the CD40175BE quad D-Type flip-flop is active low, pressing the tactile switch representing S_B must drive the clear input low on the CD40175BE. For this reason, tie the clear input to V_{DD} through a 27kΩ pull up resistor, and wire the tactile switch representing S_B between the clear input and V_{SS}.

4. Clearly label the tactile switches that represent the control signals S_L, S_R, and S_B, and the LEDs that represent the motor control signals M_L, and M_R.

5. Use red and green LEDs to indicate the motor output signals M_L, and M_R, where a lit LED indicates a logic-high signal.

6. For each LED, limit current using a 330Ω series resistor.

7. Measure the maximum current drawn by your circuit using the myDAQ as this information is need for a future problem assignment.

8. In order to verify the operation of your circuit with the EE 200 mouse, leave room on your protoboard for the 16-pin DIP in Figure 2. Note that the EE 200 mouse returns the signal $\overline{S_B}$ for the common clear input on the CD40175BE quad D-Type flip-flop.

Each student has approximately five minutes to demonstrate their circuit, and points are awarded as follows:

1. (5 points) Each tactile switch and LED must be labeled with the corresponding signal, S_L, S_R, S_B, M_L, and M_R. Use a post-it note or, alternatively, tape a piece of paper to the wiring connecting the switch or LED with the appropriate signal label.

2. (5 points) Demonstrate that the programmable timer produces the desired clock signal using the yellow LED.

3. (5 points) Demonstrate that pressing the asynchronous reset button immediately returns the system to state S1, regardless of the clock signal state.

4. (10 points) Demonstrate that system responds correctly to the inputs S_L, and S_R.

Pin	Function	Symbol
1	left sensor signal input	S_L
2	right sensor signal input	S_R
3	back sensor signal input	S_B
4,5,6	ground	DGND
7	left motor output	M_L
8	right motor output	M_R

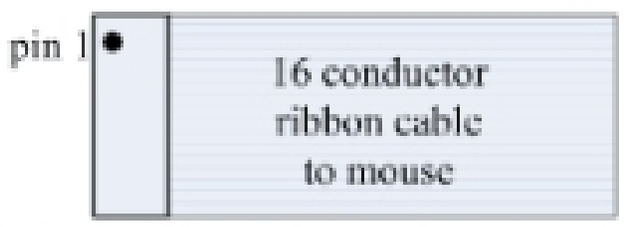

Figure 1: Umbilical cord connector.