Hardware Switch Debouncer/Counter

In this project, we will design a hardware switch debouncer to reliably produce a signal that can be counted by a 4-bit counter circuit. The basic ingredients for this project were covered in Experiment 7: a monostable multivibrator built with a 555 timer and a counter circuit. It is a good idea to leave the very last configuration you built in Experiment 7, your 555 astable multivibrator and counter circuits as a starting point for this project.

**Goal:** Design, model, implement and test a circuit that reliably counts the number of times a pushbutton switch is pressed by eliminating switch bounce. The only new components you will need for this are some resistors and capacitors and a pushbutton switch. The switch should be returned at the end of the project. You can keep the capacitors and resistors. The requirements for the report are simple: collect and present information necessary to demonstrate that your design meets the requirements.

**Note:** In Embedded Control (aka LITEC), switch debouncing is done in software. Here we use hardware. Both are viable solutions to a significant problem. Engineers must almost always choose between hardware and software solutions (or a combination of hardware and software) to the design problems they face on the job. The approach chosen is based on what ends up making the most money for the company.

For background, please do a web search on ‘555 timer switch debouncer’ and you will find many different options, most of which look about the same. (There are many different ways to debounce a switch, but we will only use designs based on the 555.) Choose a particular configuration and model it in PSpice. To model a pushbutton switch, we suggest using two switches, one that opens and one that closes, something like the figure below.

Note that this switch closes with a delay. This is because the 555 timer should be allowed to find its natural state before pushing the switch. PSpice seems to get confused otherwise. Also, most of the designs you will see include a pullup resistor (R3) that keeps pin 2 on the 555 high until the switch is closed. This seems to be the most reliable way to trigger the 555 (pin 2 is called the trigger).

A secondary goal (also to be achieved for this project), is to select parameters so that your circuit uses the minimum possible power. There are limits to how big or small components can be to produce a working circuit. You should choose them to meet this goal. Whatever you choose, you will have to demonstrate that the circuit counts reliably. It is not necessary to find the optimum choice of circuit parameters. Rather, you should provide two or three designs, show that your circuits work reliably and that one of your designs uses less average power than the others. In your report, you should include your analysis for power use and plots (both from PSpice and the Mobile Studio) that demonstrate performance. Be sure to discuss the information in the plots and why your data show a successful design. Also remember that it is the power used by the entire circuit that must be assessed. Sometimes this process is called a power or energy inventory, but, like many other good engineering terms, the expression has been adopted by too many other disciplines to be all that useful anymore.
Generate PSpice plots of the voltages that change in the 555 circuit (pin 2, pin 6, pin 7, pin 3). Once you have built the circuit and demonstrated that it works, also measure the same voltages that you simulated with PSpice and verify that your simulation and experimental measurements are consistent. Get all data signed (or create a signature sheet to be signed) and also have a TA sign a statement that the circuit works.

Just as in the experiments, you must collect information from three sources: ideal theory, simulation and experiment. List the three types of information separately and then compare and contrast what they tell us about how your system should work and does work.

Extra Credit – Use the circuit to count events for some simple mechanical system. For example, you can count swings of a pendulum or rotations of a wheel (please choose something that interests you). Points will be given for simplicity, difficulty and creativity.

Examples of switch bounce are shown below:

http://lapierre.jammys.net/
http://carlitoscontraptions.com/
http://www.labbookpages.co.uk/electronics/debounce.html

Figure 24: Electrical Representation of a Pedometer Step
Your Group Report (80 points)

The following should be included in your written report. Everything should be clearly labeled and easy to find. Partial credit will be deducted for poor labeling or unclear presentation.

Introduction (5 points)
State the purpose of the project and describe the process used to demonstrate that the purpose has been achieved.

Theory (15 points)
Describe the basic theory and analyze the expected performance of your design.

Simulation (15 points)
Describe the simulations you have performed (PSpice, Matlab, etc). Present and discuss the results you obtain.

Experimentation (20 points)
Describe the experiments you have performed. Present and discuss the results you obtain.

System Design (10 points)
Compare and contrast the three types of information you have obtained and then describe the final design of your system including all practical considerations for successful performance. Include the simplest possible explanation of your design and the simplest approach to designing something similar, should someone wish to use your information in their own application.

Personal Responsibilities (5 points)
How as the responsibility for the tasks divided between group members?

References
No points are assigned to references, but no report will be accepted without clear and complete reference to all information used. Online information is acceptable even though that is not generally the case with journals, books, etc. References will be checked by the grader.

Appendices
Include any additional information you think adds to your study, but be sure that whatever you include actually helps make your case.

Extra Credit (? points)
The extra credit task is described above.

Your grade will also include a general assessment of project understanding and quality worth up to 10 points.

Total: 70 points for project report
+10 points general assessment
+20 points attendance
100 points

Attendance (20 possible points)
3 classes (20 points), 2 classes (10 points), 1 class (0 points)
Minus 5 for each late
No attendance at all = No grade for project