ESE 366: Design using Programmable Mixed-Signal Systems-on-Chip
Instructor: Dr. Alex Doboli

Project Assignment 1

Due Date: Posted on Blackboard

A. Description

Project Title: Sound Controlled Stopwatch

Functionality description:

1. A microphone is connected to a PSoC chip that implements a stopwatch functionality by starting and stopping the timer at consecutive whistle blows (sound measurement mode timer).
2. Alternatively, the system can be also used as a traditional stopwatch with pushbutton control only (pushbutton controlled only measurement mode).
3. The system incorporates a memory function that saves the last x timing readings (display the last x recorded samples with statistics).
4. The accuracy of the stopwatch timer can be selected by the user: available resolutions are 1 second, 1/2 seconds, 1/10 seconds (accuracy setting mode).
5. Microphone sensitivity setting: this functionality allows the user to select the trigger level for the microphone for use in sound mode. Also, the trigger window is selected. (microphone sensitivity setting mode).

Requirements:

1. All software is to be implemented in assembly language.
2. The main system is controlled by a finite state machine, where each state implements one of the functionalities at a time. The memory function is performed at runtime and in the memory mode the recorded time measurements are only displayed.
3. The stopwatch has only one pushbutton available which is used in various ways to control the device: toggle between modes and different actions within each mode.
4. In sound mode, the stopwatch is immune to background noise and starts/stops only at the person's whistle blows. In addition, in sound mode, the stopwatch can also be started by the whistle sound and stopped by the button press.
5. The LCD is used for displaying information and LEDs are used to indicate the systems current state.
6. In measurement modes, information is displayed as HRS:MIN:SEC:(selected resolution) in real-time (updated with the selected resolution). In measurement modes, after the timer is stopped, the system displays the final result for y seconds. During this time it is idle and does not accept any inputs (pushbutton or sound). Only after the y seconds, can a new measurement be performed by resetting the measurement mode or can be the state changed.
7. In memory mode, the system also computes the average, longest, and shortest times from the x stored samples. These values are displayed accordingly.
8. In microphone sensitivity setting mode, the user will use the background noise to calibrate the trigger threshold for when the sound mode is used. Basically, the system records the current "noise" level and when used in stopwatch mode, it will only start recording for levels which are much higher than this value (e.g. twice the threshold).

The calibration mechanism works by recording sample for some time and then considering the average value as the threshold.

OPTIONAL: In this mode, the user can also set the trigger window: this functionality provides further noise immunity. When making measurements, once the trigger level is reached, the timer is started and an additional down counter is started (trigger period). If when the down counter reaches zero the sound is still above the trigger level, the timer is stopped (condition occurs at start) or no action is taken (if running, like at the end). This situation is also considered as noise since the high level sound is present for more than the set trigger period.

9. Thoroughly investigate your implementation's accuracy. Determine any software delays (if any) that may limit the system's precision in the different measurement modes by analyzing their impact on performance.
10. All timing constraints of the system must be implemented using PSoC available blocks and not through software delays. In extreme circumstances (i.e. all blocks are utilized), non crucial timing functions can be implemented through software.
11. LCD display: information texts should be displayed in ASCII mode. Numbers can be displayed in hex, but decimal representations are preferred (this exception is only valid for this ASM project).
12. Toggling between modes (e.g. sound mode to traditional mode) is implementing by long button presses (e.g. more than 1 second). Within each mode, different functionalities (e.g. start timer) are selected by short button presses (e.g. less than 0.5 seconds).
13. The microphone interfacing blocks from PSoC are provided. You will only be required to read data from the front-end and process it in the corresponding modes.

B. What to hand in

You should submit a report describing your complete design, debugging and testing procedures, and related experiments, including the following:

1. Present the overall algorithm, the structure of your routines, and the selected data structures.
2. Explain the reasons that motivate all the above decisions.
3. Discuss the interfacing signals for your circuit.
4. Present your estimations of the hardware resources that are used in the design, including I/O pins, flash memory, and RAM memory.
5. Estimate the number of clock cycles required to execute the routines. Discuss the computational complexity of the routines and their required program & data memory.
6. Present the testing and debugging procedure. Explain what kinds of tests were run to verify the correctness of the implementation.
7. Propose a procedure that guarantees that your design is correct for any possible situation.
8. Provide sufficient waveform plots to justify the correctness of the design.
9. Discuss any possibilities to improve the performance and cost of your design.

The project reports should not exceed eight pages. Please submit your reports by email to adoboli@ece.sunysb.edu as PDF files. Submit only one report per group.

In addition, you will do a demo of the project to the TA during the lab hours.