**McGill University**

**ECSE-426 Winter 2015**

**Microprocessor Systems**

Teaching Assistants Instructor

**Omar Abdelfattah Zeljko Zilic**

**Ali Gorji**

**Lab 2: Sensor Data, Acquisition, Filtering and Digital I/O**

AUTHORS:

Name of Authors: **Simon Ho | Xavier Sit | Kai-Cheng Wang**

Student Numbers: **260479710 | 260481340 | 26082635**

**Group 8**

Date: **February 22th, 2015**

Table of Contents

[1. Abstract 2](#_Toc412042069)

[2. Problem Statement 2](#_Toc412042070)

[3. Theory and hypothesis 3](#_Toc412042071)

# Abstract

The goal of this experiment is to construct a system based on embedded temperature sensors using sensor data acquisition, signal conditioning and a Kalman low-pass filter to remove noise. The STM Discovery F4 microcontroller board will change the LED outputs when the internal temperature sensor detects a change in temperature. One LED will turn on for every 2°C increment/decrement and will rotate clockwise and counterclockwise respectively. The second function of our device is an overheating alarm that will have its four LEDs pulsate using PMW (pulse-width modulation) within a chosen temperature threshold. The alarm stops when the temperature goes back into safe range. By processing the inputs through a filter of the peripheral on the Discovery board, we are able to obtain a functioning temperature detector and LED PMW effect.

# Problem Statement

Our program implemented in the microcontroller is ran on a timer in order to poll the sensor periodically for each tick. When the sensor polls too fast, the ADC doesn’t have time to acquire new values and repeated values are obtained. The STM32F4 microcontroller’s SysTick function is used at 50 Hz to prevent this. The architecture of the program must be adapted to respond to SysTick ticks.

For the temperature display operation, we must consider how the temperature sensor outputs analog into digital information. The data has to go through an ADC (analog-to-digital converter) before program process it. The values returned by the ADC must also be converted to degrees Celcius using a specific mathematical function.

The temperature sensor is analog and is likely to have errors associated to it. The variation in the values returned by the ADC makes the results unpredictable and consequently, a Kalman filter is used to minimize the error of the temperature sensor. This filter has been previously used in the first experiment and is altered for this sensor to maximize computational performance and reduce the error margin for the filtration process.

The LED are controlled and manipulated to gradually fade in and fade out their brightness to create a pulsating effect. The program will have a built in software delay mechanism that uses the PWM (pulse-width modulation).

# Theory and hypothesis

## SysTick Timer

The SysTick timer is a hardware timer that can be set to tick at a particular frequency. For each ticks, an interrupt is created to execute an interrupt handler routine. It counts down from the reload value to zero, reloads, that is wraps to, the value in the SYST\_RVR register on the next clock edge, then counts down on subsequent clocks (ARM website). This allows an OS to carry out context switching to support multiple tasking. For applications that do not require an OS like this temperature sensor, the SysTick can be used for time keeping, time measurement, or as an interrupt source for tasks that need to be executed regularly (Keil website). In general, the SysTick interrupt handler has to be as short as possible. In the case where the processor gets a critical interrupt while a non-critical instructions ticks in the interrupt handler, the processor won’t respond to the critical interrupt and can cause a failure in the operation of the microcontroller.

## Kalman Filter