ECE 445
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Sound controlled smoke detector

Mock Design Review

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Introduction

Statement of Purpose

Almost all of us encounters false fire alarms at some point in our life. Although many modern fire alarms have the ability to mute temporarily with a push of button, the physical location of the smoke detector does not always make it easy to do so. At the same time, voice controlled products are entering markets and gaining popularity in recent days. These products, such as Android phones and Amazon Echo, can be activated by keyword such as “OK Google”, ”Alexa” or “Amazon”.

Therefore, we propose a sound controlled fire alarm that allows users to easily turn the alarm off by shouting the keyword "cooking" when false alarm happens (in addition to a push button). In specific, we plan to use many different human version of “cooking” as the training data. Then the processor will find and store the Mel-Frequency Cepstral Coefficients (MFCCs) for the training word. Then once the alarm is triggered, the core will be turned on and actively listens for the keyword, finding the MFCCs for what it hears, and comparing with the stored MFCCs. If the mean square error is below a threshold, the core will stop the alarm. In additional, we may also look into Dynamic Time Warping (DTW) to improve our detection accuracy.

Objectives

Goals and benefits:

- Allow false fire alarms to be safely turned off by shouting the keyword "cooking"
- Prevent unnecessary interruption to everyday activities such as cooking
- Maintain sufficient warning against possible fire hazard.

Functions and features:

- Sense environment condition relating to fire, specifically, Carbon Monoxide concentration.
- Activate alarm and power on Digital Signal Processor (DSP) if fire hazard is detected.
- Capture human voice if alarm is triggered
- Implement an algorithm to recognize keyword by feature extraction using Mel-Frequency Cepstral Coefficients
- Process audio data in real time using our algorithm and check if there is a match to the keyword
- Interpret CO sensor data to calculate ppm
- Pause the alarm if keyword is matched and if it is safe to do so

Design

Block Diagram

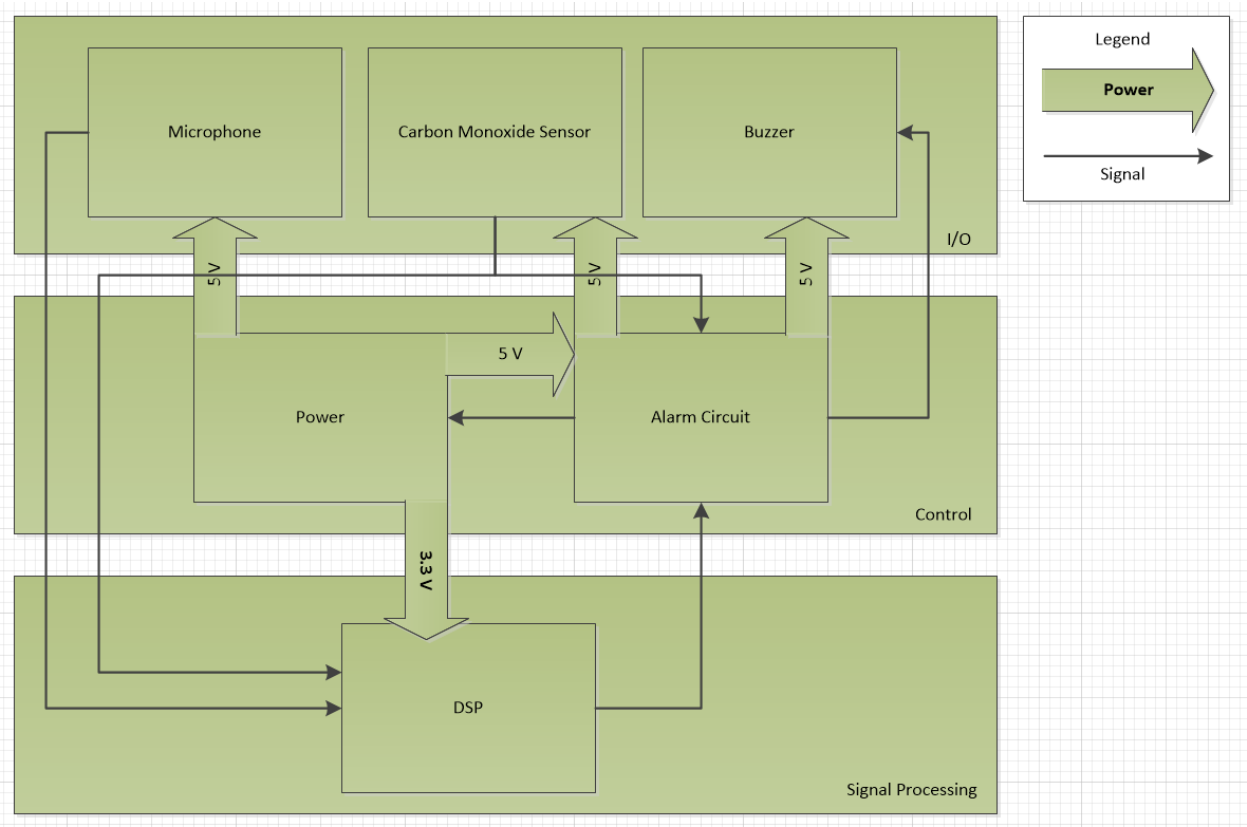
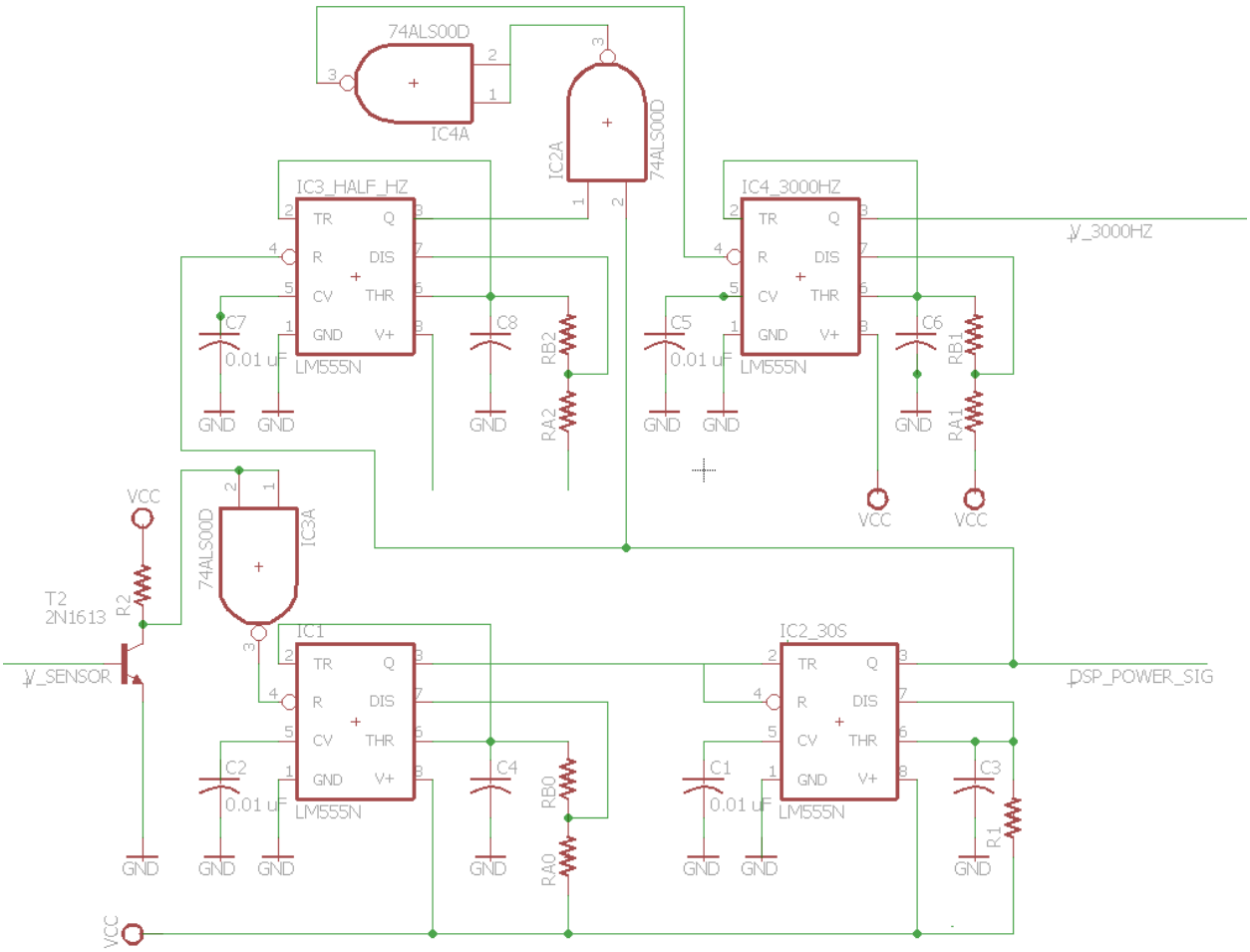


Figure 1: Block Diagram

Block Descriptions

Alarm Circuit



Input: Sensor output, test signal, pause signal

Output: 3000 Hz voltage to speaker, dsp power on signal to power

If the sensor detects CO concentration above active threshold, this circuit will trigger the alarm at 3 kHz. The circuit should also be capable of pausing the alarm when told to do so by outside signal.Test switch and pause switch should be provided in this circuit, where test switch simulates the sensor input, and pause switch simulates the DSP input.

Each of the ICs are responsible for the following:

IC1: This sub circuit take in the analog input from sensor, and oscillates at a constant frequency to trigger IC2 if the input is considered active.

IC2: This sub circuit is triggered and re-triggered on every falling edge of the IC1 signal. After each trigger, the circuit output will stay high for 30 seconds. This output indicates that the alarm should be on.

IC3: This sub circuit oscillates at 0.5 Hz if the alarm is on to produce the pauses during alarms.

IC4: This sub circuit oscillates at 3000 Hz if the alarm is on, and IC3 output is high. This effectively produces the alarm sound.

Calculation

The LM555 timer can be configured in two modes, and IC2 uses monostable mode, IC1, IC3, and IC4 uses astable mode.

IC2:

In monostable mode, the time delay t = 1.1 * R1 * C3 seconds.

To get around 30 seconds of delay, and choosing from the standard RC values, R1 = 3 MΩ, C3 = 10 uF.

Or, we can use a smaller resistor value and a larger capacitor value, R1 = 620 kΩ, C3 = 47 uF

IC4:

In astable mode, the frequency is given as f = 1/T = 1.44 / ((Ra+2Rb)*C)

The duty cycle is given as D = Rb/(Ra+2Rb)

We want to achieve around 3000 Hz, and let C = 0.1 uF.

Then Ra+2Rb = 4.8 kΩ. We can choose Ra = 0.82 kΩ, Rb = 2 kΩ

Or if we use a even smaller capacitor, C = 0.001 uF, we can have Ra = 82 kΩ, Rb = 200 kΩ

Both of the above combinations will give us f = 2.994 kHz, and D = 42%

IC3:

Similar to IC4, we want IC3 to oscillate at 0.5 Hz, and let C = 10 uF.

Then Ra+2Rb = 2880 kΩ. We can choose Ra = 82 kΩ, Rb = 100 kΩ

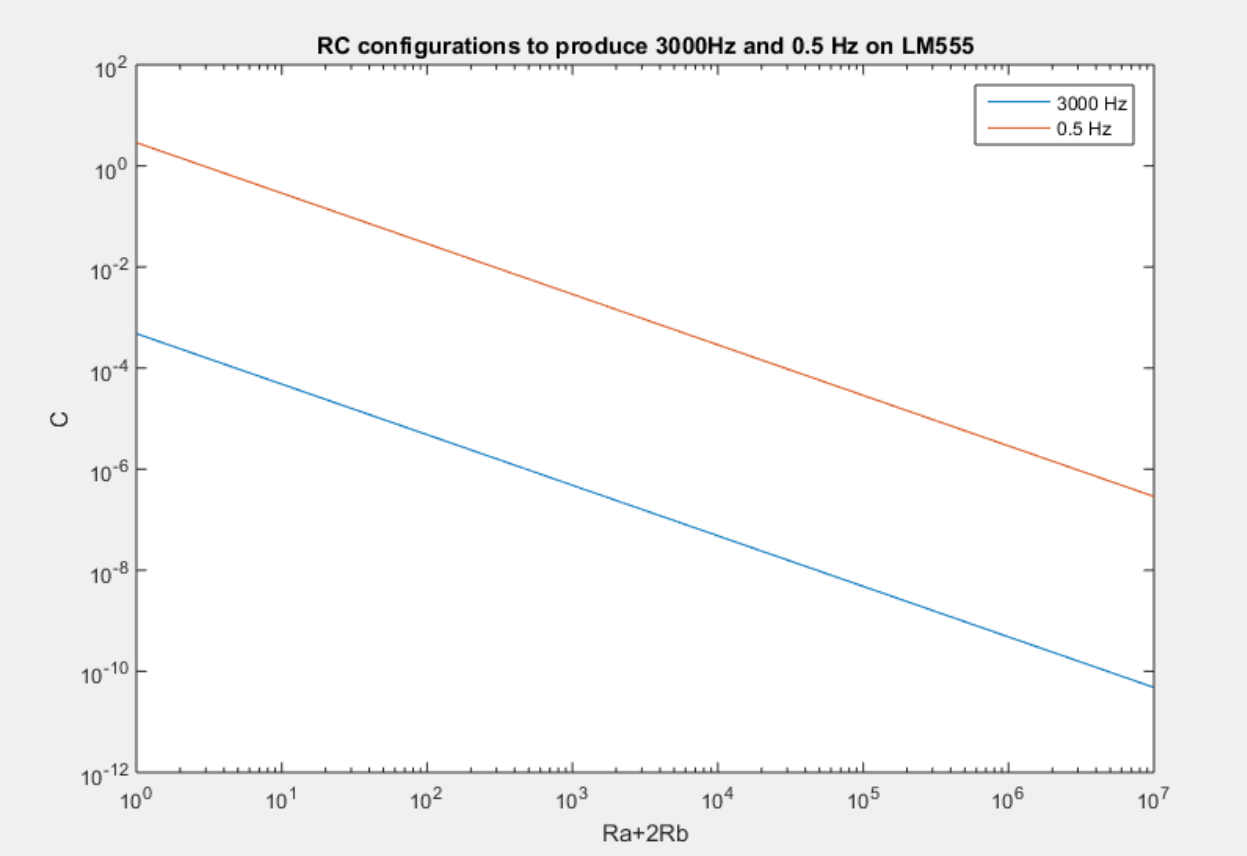
And if we choose C = 100 uF, we can have Ra = 8.2 kΩ, Rb = 10 kΩ

Both of the above combination will give us f = 0.512 Hz, and D = 36%

IC1:

IC1 can be of any arbitrary frequency that is higher than 1/60 Hz, and we will use IC3's configuration here.

Plots:



This is a simulation of different R and C values that can produce 3 kHz and 0.5 Hz on the LM555 timer.

Requirements and Verification

Table of Requirements and Verification:

Name	Requirements	Verification
Alarm Circuit	a. Able to trigger alarm b. Able to pause alarm c. Trigger alarm when there's fire	A) 1. Make sure power is on 2. Attach oscilloscope at the timer chip output 3. Press test button on alarm circuit to force an alarm 4. Timer should oscillate near 3 kHz B) 1. Make sure power is on 2. Attach oscilloscope at the timer chip output 3. Press test button on alarm circuit to force an alarm 4. Timer should oscillate at 3 kHz

		5. Use pause button on alarm circuit to pause alarm 6. Timer should stop oscillation C) 1. Go outside 2. Make sure power is on 3. Light up a cigarette 4. Bring cigarette close to smoke sensor 5. The alarm should start

Safety Statement:

Testing of a fire alarm will involve fire at some point, and this poses a safety issue in the lab. As such, all the testing that involves fire must be done outside in an open space with no explosives around, and the use of matches to start a fire are limited to lighting up cigarettes. We will then use the cigarette to test if our alarm behaves correctly.

For laboratory testing, we are implementing a test switch that allows us to trigger the alarm without actually starting a fire. All the testing in lab should use this test button to test the functionality of our circuit.

In addition, members should complete the lab safety training to protect themselves with other common lab safety factors such as electricity.

Citation:

"LM555 Timer", Texas Instruments, Dallas, Texas. 2015. Available: www.ti.com/lit/ds/symlink/lm555.pdf. [Accessed 16 February 2016]

Adhar Labs, "RETRIGGERABLE 555 TIMING CIRCUIT: AN INTERESTING FIND", 2013. Available: http://m8051.blogspot.com/2013/02/retriggerable-555-timing-circuit.html. [Accessed 16 February 2016]