# CALIFORNIA STATE SCIENCE FAIR
# 2015 PROJECT SUMMARY

**Name(s)**

Rajiv Movva

**Project Number**

35746

**Project Title**

## A Novel Use of RC Circuits to Build a Low-Cost and Non-Invasive Respiratory Monitor

**Abstract**

**Objectives/Goals**

The field of biotechnology is advancing quickly today - new devices that fit new use cases are developed all the time, but some firmly established medical tools are being left behind. In this project we apply modern technology to advance breathing monitoring, which is vital in hospitals and humans alike, especially for those 18 million Americans who suffer from sleep apnea and whose lives depend on accurate respiratory monitoring. In particular our goal is to apply capacitive sensing to build a cheap, touchless monitor that will bring utility to many.

**Methods/Materials**

Two charged conductive plates form a capacitor - an electrical component that stores energy in an electric field. Since humans are good conductors, a capacitor following the parallel plate model is formed between a conductive plate and a human. In our setup we have a plate under a human's chest - since capacitance can be modeled geometrically using the equation $C = E*A/d$, where E is a constant, A is the plate area, and d is the distance, we know that capacitance varies as the human's chest geometry varies. So we correlate changes in capacitance of the human-plate system to breaths. To measure capacitance we use a resistor-capacitor circuit and calculate C by applying properties of the RC time constant. However, there is lots of noise in our capacitance vs. time signal. Thus we use a fast fourier transform to break down the signal to its constituent waveforms and then apply a distance clustering algorithm to identify the frequency band which corresponds to breathing. If there is no activity where expected, our system raises an alert.

**Results**

We tested our device for accuracy (3000 breaths at 20 bpm) and fault detection time (30 tests) in four sleeping conditions: prone, supine, side, and half plate cover. A plethysmography belt, which works by translating abdomen displacement to breaths, was our benchmark monitor. Our worst use case of half plate cover had 72% accuracy and 13.7s fault detection time on average.

**Conclusions/Discussion**

Our breathing monitor achieved the goals we designed it for - our worst fault detection time of 13.7 seconds still leaves ample time before hypoxic damage, and our monitor is low-cost and zero-contact. Our next steps would be to bring our device to clinical testing and optimize for more realistic sleeping conditions using other pattern recognition algorithms. Our design was successful as a proof-of-concept.

**Summary Statement**

In this project, we built a completely touchless and cheap breathing monitor, targeted to be used in diagnosis of sleep disorders and for monitoring of sleep apnea patients.

**Help Received**

My project mentor, Mr. Spenner, gave useful advice; Brother helped me learn about circuits and provided science fair tips; Father provided presentation advice; Mother helped build my board.