Stress Detection and Management System

ECE 445: Senior Design (Design Review)

10/07/2012

Team#30

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1. Introduction

1.1Statement of purpose

Some scientists say accumulated stress is a possible reason for all kinds of disease. Certain amount of stress is necessary for our lives, but too much stress brings negative consequence. Also, it is difficult for people to relieve and be aware of stress. Most people do not know when and what situations they get stress from. Therefore, we are designing a system that can daily record a person's stress level and time. On the market, there are smart phones apps where people can hold a finger to the camera, which will then detect slight changes in color related to blood flow. With these apps, users can purchase other apps that direct the user towards stress reduction techniques. These solutions, however, do not continuously record stress level. If a person able to recognize when they get stress and what they get stress from, it will be helpful for them to find ways to relive it.

It is our intention to address these gaps in the market and create a system that will be of benefits to a great many patients and health care practitioners by better assisting them by taking control of an elevated physiological response that has many negative health consequence.

1.2Objectives

Our goal is to create and combine a continuous monitoring device and stress management device into one system. Our continuous monitoring device will be responsible for monitoring the user's stress level, so that the user will be able to concentrate on his/her tasks throughout the day and be assured that stress levels are accounted for. Stress dots are a method for detecting stress. When a user gets stress, stress dot will change the color and LED light will magnify the changing of color of stress dots. Each color has different voltage, so photodiode will send output voltage to microcontroller (Arduino). A microcontroller will activate the assisted stress management device, when elevated levels of stress are detected. It will record a specific time and stress level inside the memory in microcontroller, and let user knows by sensory stimulus and vibration. When this device is activated the user will simply follow the guide of the device to reduce his momentary stress.

1.2.1 Features

- This device will record user’s stress level and data
- Battery operated for portability (Lithium battery)
- Sensory stimulus and vibration for continuous notification of stress to user
- User can control the vibration and alarm sounds
- User can transport recorded data from device to computer (using USB)

1.2.2 Benefits

- Small and portable size
- User can recognize when, where, and what they get stress from
- Assistance in alleviating stress.

2. Design

2.1 Block Diagram

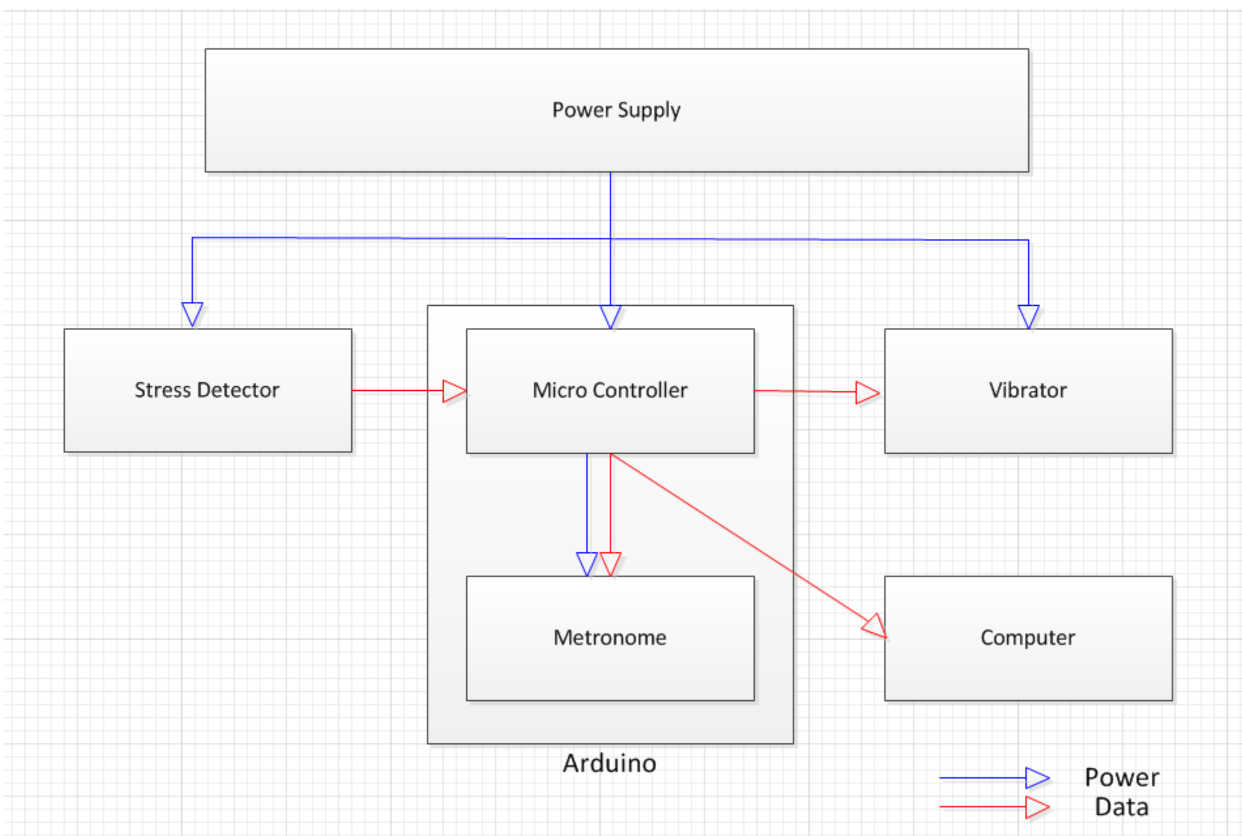


Figure 1: Block diagram

2.2 Block Diagram Descriptions

Power Supply

For our design, we are going to use alkaline battery, which supplies 9V. Since Arduino's input voltage range is 7~12V, we decided that 9V alkaline battery is most reasonable choice. Other hardware components have smaller input voltage than Arduino such as stress detector circuit needs 5V and vibration motor needs 2.5 ~ 3.8V. We will use voltage regulator to control the voltages going through other components.

Stress Detecting Circuits

Stress detecting circuit includes stress dots, LED, and photodiode. When user get stressed, stress dot will change color (green = relaxed, red = stressed). We will magnify the intensity of color by LED, so photodiode can detect changing color. Red has wavelength about 650nm with 0.225 V and green has about 450nm with 0.164V (Results from color detection test). Photodiode has breakdown voltage 120V, but it is too big, so we do not have to worry about it. Photodiode analog output send signal to microcontroller's analog input. Since each analog input of Arduino has 1024 steps from 0 to 5V, both color voltage can be handled. Amount of voltage needs to operate photodiode is 5V. However, power supply provides 9V. Therefore, we are going to use +5V voltage regulator (LM7805) to regulate the voltage. Amount of voltage needs to operate LED is 3.4V. Therefore, we are going to use LM317 to regulate the voltage going through LED. LM317 determine output voltage by two of resistor values connected series to pin 2 and 3.

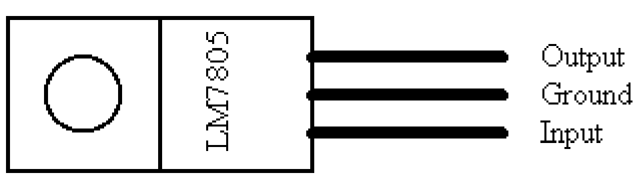


Figure 2: +5V Voltage Regulator

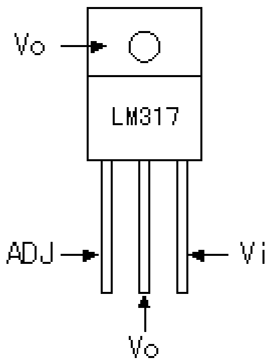


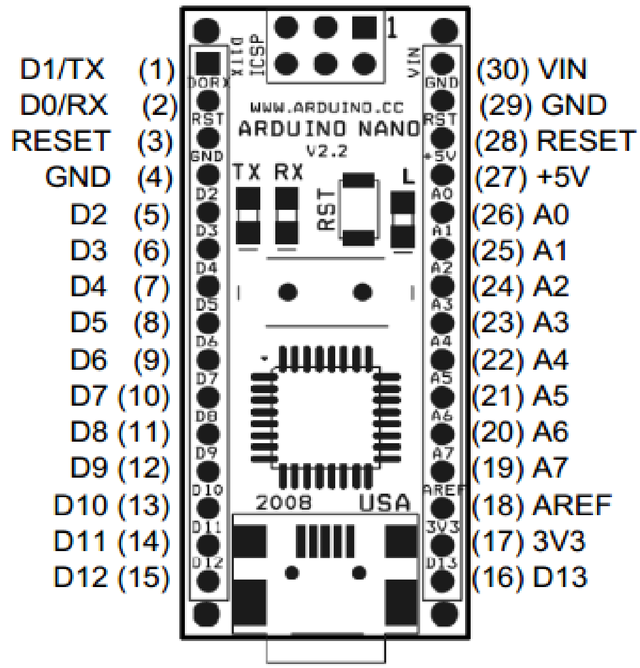
Figure 3: Adjustable Voltage Regulator

Arduino

a) Microcontroller

We are going to use Arduino nano for the microcontroller. It has operation voltage of 5V and input voltage 7~12V. There are total 14 digital input and output pins and six of them provide PWM (pulse width modulation) output. It has 8 analog input pins, but do not have any analog output pins. It has 40mA of DC current per input and output pins. It also has 32KB of flash memory with 2KB of SRAM and 1KB EEPROM, which we can read and write with the EEPROM library. It has clock speed of 16MHZ. When photodiode detects color change of stress dots, each color has different wavelength and voltage. According to our color detection test, red has about 0.225V and green has 0.164V. When it gets analog signals from photodiode, we need PWM digital outputs send signal to BJT (bipolar junction transistor) Since Arduino does not have analog outputs. At the same time, micro controller receives a voltage signal from the stress detector block and outputs data to the EEPROM.

Arduino Nano Pin Layout



Pin No.	Name	Type	Description
1-2, 5-16	D0-D13	I/O	Digital input/output port 0 to 13
3, 28	RESET	Input	Reset (active low)
4, 29	GND	PWR	Supply ground
17	3V3	Output	+3.3V output (from FTDI)
18	AREF	Input	ADC reference
19-26	A7-A0	Input	Analog input channel 0 to 7
27	+5V	Output or Input	+5V output (from on-board regulator) or +5V (input from external power supply)
30	VIN	PWR	Supply voltage

Figure 4: Arduino Pin Lay out

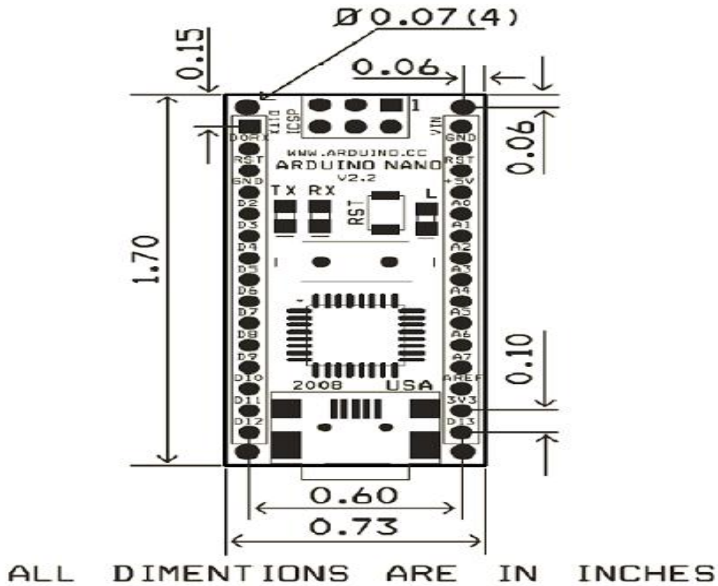


Figure 5: Arduino Nano Mechanical Drawing

b) Metronome

Metronome will be a program, which is a part of Arduino. We will output audio signal to speaker. If we use pulse wave, it will be a long sound with different amplitude. Therefore, we are going to use square waves to make 60bits/minutes, so it can have one bit per seconds.

Vibrator

Vibrator motor needs operation input voltage 2.5~3.8V. When microcontroller gets input signals from photodiode, it needs PWM digital outputs wend signals to BJT, so currents can flow to motor and generate voltage. When there is no signal to BJT, it makes open circuit, so currents do not flow to motor and do not generate voltage. However, when motor runs and stops, coil inside motor still running and generates voltage. It is possible that this voltage is too big for entire circuits and burns them. Therefore, we will use register and protection diode (also called as safety diode), which is protecting circuits from reverse voltage and currents, so it can get rids off voltage from motor instead of let it flows to the circuits. Vibrator requires 3V and we will use adjustable voltage regulator (LM317) again to regulate the voltage.

2.3 Flow Charts

2.3.1 Main Program

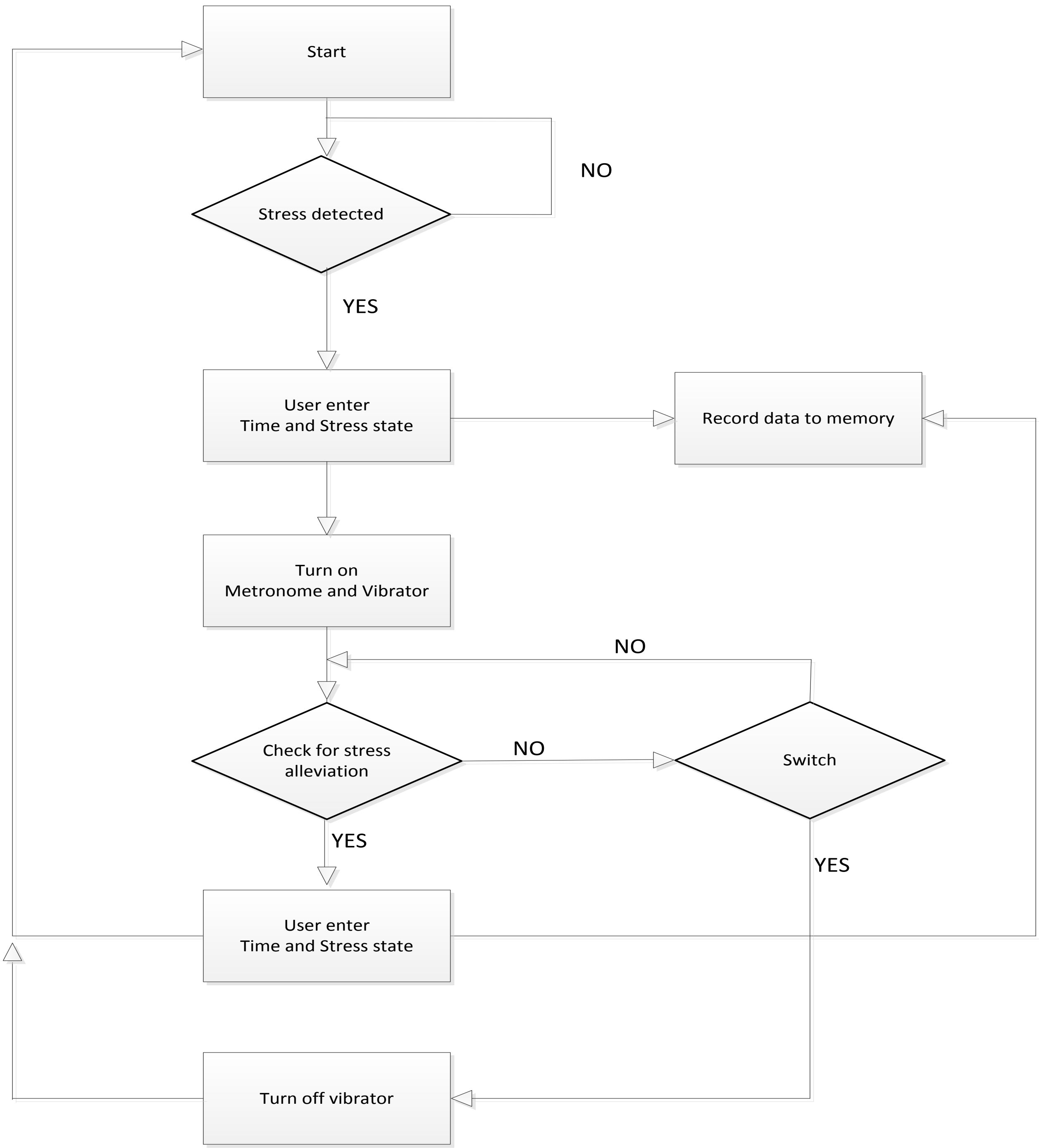


Figure 6: Flow Chart

2.4 Schematics

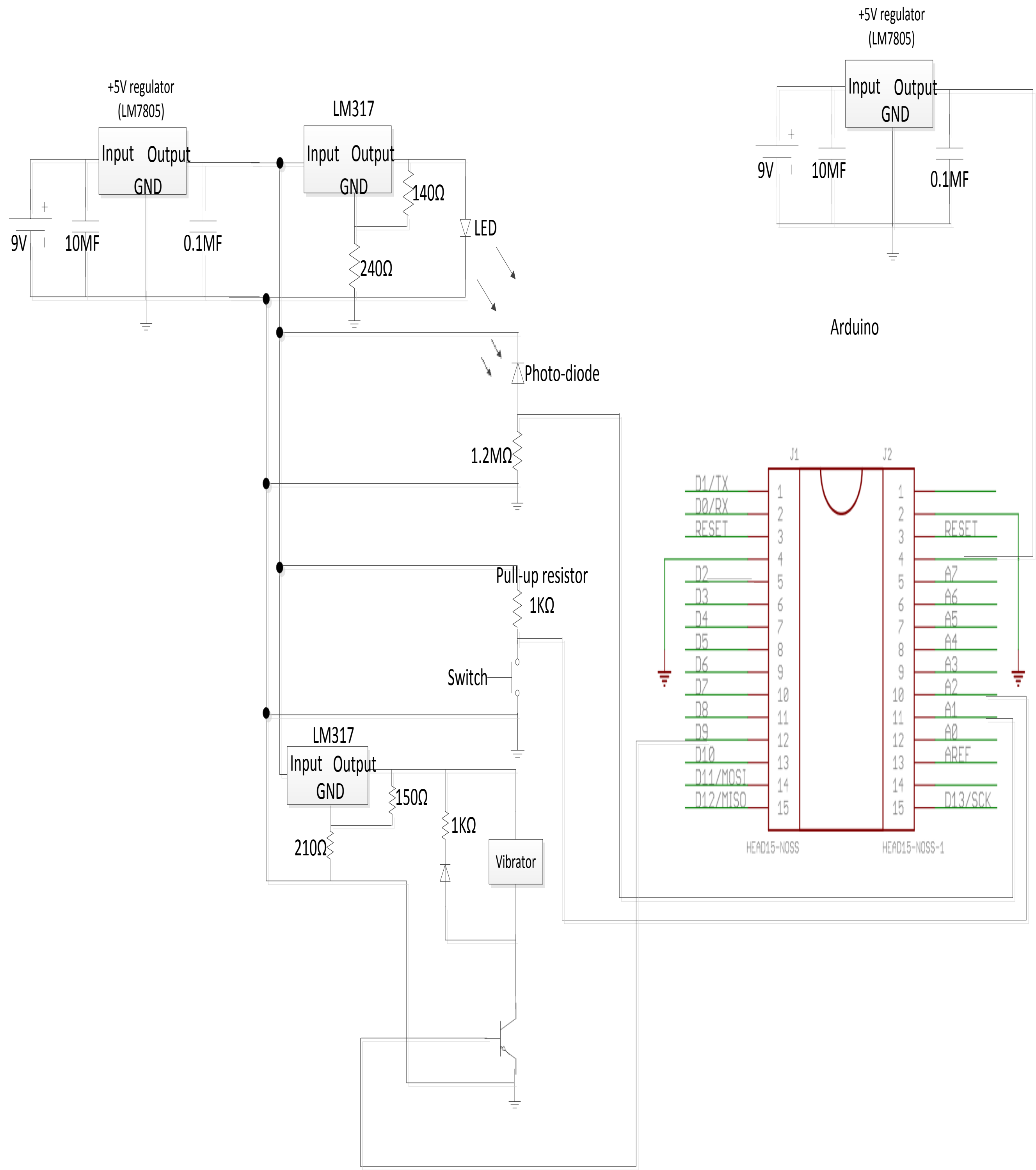


Figure 7: schematic

2.4.1 Data

Color Detection Test

This is the test described in the tolerance analysis and the second verification of the photo-detector module done for 5 trials. A 1.2Mohm resistor was placed in series with the photodiode and a DMM was used to measure the voltage across the resistor. A color being detected by the photodiode causes a current through the resistor and a corresponding voltage increase.

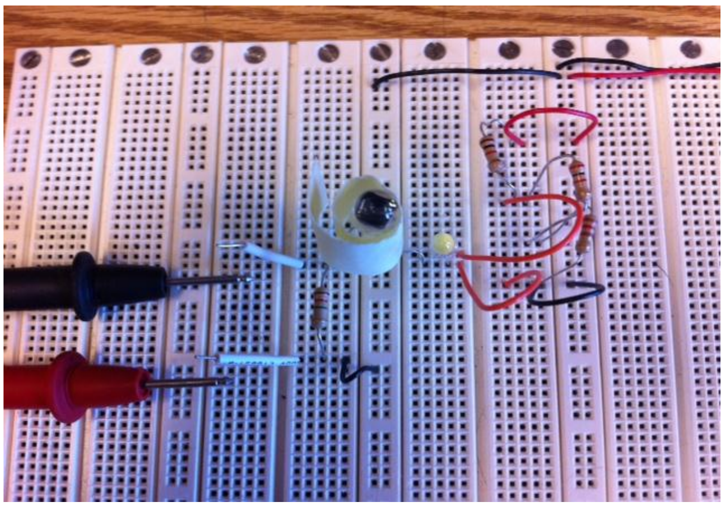


Figure 8: color detection test picture

Trial	Green	Red	Difference
1	0.161V	0.229V	0.068V
2	0.168V	0.225V	0.057V
3	0.164V	0.226V	0.062V
4	0.165V	0.228V	0.063V
5	0.168V	0.227V	0.059V

Figure 9: data from color detection test.

Avg Difference = (0.068+0.057+0.062+0.063+0.059)/5 = 0.0618V

2.4.2 Calculations

It is calculations that show what values of registers, voltage, and currents are required for our schematic design.

a) LM317 Voltage calculation

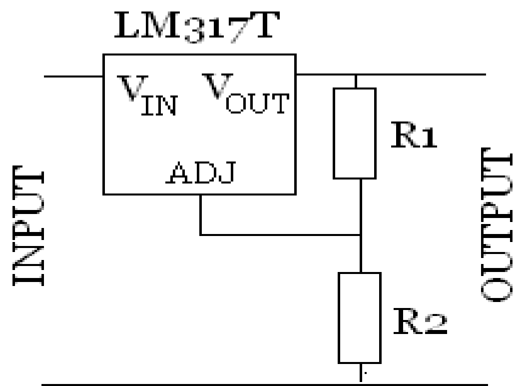


Figure 10: LM317 Voltage Regulator

$$V_{out} = 1.25 * (1 + \frac{R_2}{R_1})$$

Alkaline battery supplies 9V, however stress detectors, photodiodes, and vibrators require less than 5V. Therefore, we used voltage regulator to supply voltage to each hardware components.

Voltage and Current for LED

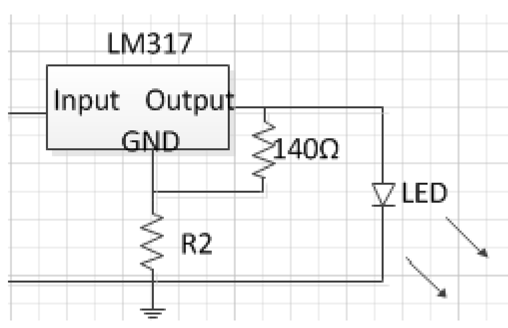


Figure 11: LED circuit

$We\ set\ V_{LED} = 3.4V, because\ Foward\ voltage\ is\ 3.4V\ from\ data\ sheet.$

$$3.4V = 1.25 * (1 + \frac{R_2}{R_1})$$

Also, we assume that $R_1 = 140\Omega$

$$\frac{3.4V}{1.25} = 1 + R_2/140\Omega$$

$R_2 = 240\Omega$

This is a stress detecting circuits that includes LED and photodiodes. Amount of voltage that diode can handle is about 3.4V. By using voltage regulator, we could find out amount of register value that need across the diodes, and it was 240Ω.

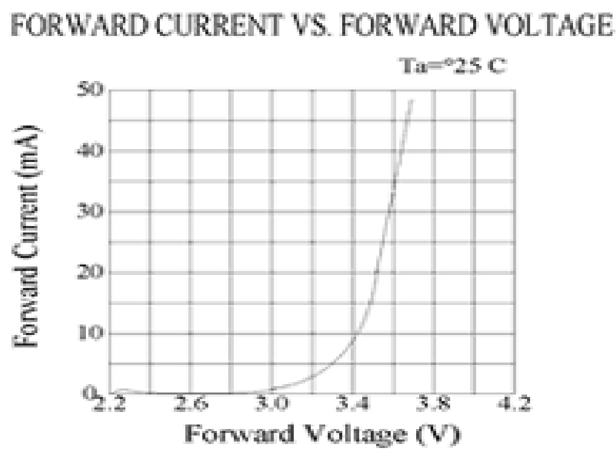


Figure 22: V-I Graph for LED

$V_{LED} = 3.4V$

$I_{LED} = 10mA$

$P_{LED} = 0.0339W$

Since we know voltage and currents flows on LED light, we could find amount of power that LED has by using P = IV. It has 0.0339W.

b) Calculate power on vibrator

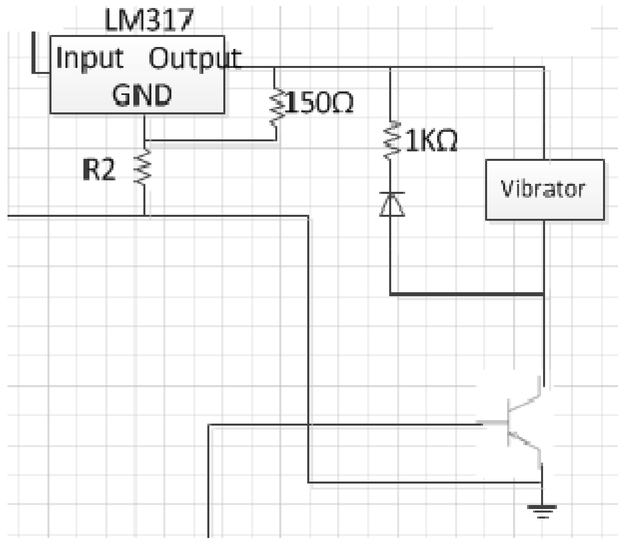


Figure 13: Vibrator circuit

$V_{Vibrator} = 3V$

$3V = 1.25 * (1 + \frac{R_2}{150\Omega})$

$R_2 = 210\Omega$

$Rated\ Current = 75mA$

$P_{Vibrator} = 0.2250W$

We know that current flows on vibrator are about 75mA (given). Therefore, we could get amount of power that vibrator has by using P = IV, since already know that vibrator has 3V. By using voltage divider rule again, we can approximate amount of register value require for R2, which is 210Ω.

3. Requirement and Verifications

Module Requirement	Testing and Verification
Power Supply I. The power supply provides a 5V source for a current range from 5mA to 50mA. II. The power supply provides a 3.4V source for a current range from 10mA to 50mA. III. The power supply provides a 3V source for a current range from 10mA to 50mA.	I. Supply 9V from a power supply to the input pin of the LM7805 and connect a 100 ohm resistor from the output pin to ground. Use a DMM to measure the voltage across the resistor. Increase the resistance in 100 ohm intervals to a maximum of 1kohms. The voltage should stay at 5V while the current varies from 5mA to 50mA. II. Supply 5V from a power supply to the input pin of the LM317 and connect a 70 ohm resistor in parallel with the 140+240 ohm series resistor combination. Increase the resistance in 100ohm intervals to a maximum of 340ohms. Use a DMM to measure the voltage across the resistor. The voltage should stay at 3.4V while the current varies from 10mA to 50mA. III. Supply 5V from a power supply to the input pin of the LM317 and connect a 60 ohm resistor in parallel with the 150+210ohm series resistor combination. Increase the resistance to 300 ohms in 100 ohm intervals. Use a DMM to measure the voltage across the resistor. The voltage should stay at 3V while the current varies from 10mA to 50mA.

Photo-detector Circuit I. LED emits white light while power is supplied at 3.4V. II. Photodiode generates more current when it detects the color Red, from the stress dot, than when it detects Green. III. The photo-diode circuit outputs a voltage for one color that differs from the second color by at least 0.01 V, with a tolerance of 5%.	The photo-detector circuit will be tested with a green object and red object (not the stress dots). In a dark room the color objects will be held at a fixed height of 1cm from the lit LED and photodiode. Verification II explains the measurements that will be recorded. This test will be done for ten trials. We will then do the same test with the stress dots. The stress dots will be attached to a glass containing temperature controlled water. The water temperature will be adjusted by placing the glass on a hotplate. The changing temperature of the water will cause the color of the stress dot to change, and the colors detected will include red and green. Once we see either red or green, verification II will be followed to record data. I. Connect the anode of the LED to a power supply supplying 3.4V. Observe illuminated LED while power supply is providing forward current. II. Reverse bias the photodiode with 3.4 V from a power supply to the cathode. Place a 1.2Mohm resistor in series with the photodiode. Hold a green and then a red object 1mm away from the photodiode for the first test and a stress dot 1mm away from the photodiode for the second test. Measure the voltage across the resistor for both colors. A higher photo-current generated by the photodiode will correspond to a higher

	voltage across the resistor. A higher voltage across the resistor should be observed for the color red. III. The measurements observed in verification II will be analyzed (by calculating the difference between the voltage levels of each trial) to ensure requirement III is met.
Arduino I. Differentiates between stressed state voltage and relaxed state voltage. II. Stores time and state of user III. Outputs PWM signal to vibrator module and a square audio signal at 1Hz to a speaker when stress is detected. Subsequently turns off both signals when user enters sleep mode or relaxed state is detected.	I. Write a test program that gives voltage inputs differentiated by 0.01 V and send the stress state as an output stream to the monitor. Observe the monitor to check for the correct stress state output. II. Use the write() function to write a sample time and stress level to EEPROM and use read() function to read from memory and send the data to the monitor through an output stream. Observe whether the correct time and stress state are observed. III. Write a test program that provides a voltage level input that corresponds to a stressed state and then a relaxed state voltage level input after ten seconds. The output pins of the Arduino that would be connected to the vibrator and speaker will be connected to an oscilloscope. The requirement will be verified if the correct PWM signal is outputted to the scope from the output pin to the

	vibrator and a 1Hz square wave from the output pin to the speaker.
Vibrator I. Vibrator module turns on when current is supplied to the transistor and turns off when the transistor is open circuited.	II. Supply the vibrator input with 3V from a power supply. The transistor base will be connected to a 5V supply through a 1k ohm resistor. This should result in a short circuit allowing current to pass through the vibrator. Observe that the vibrator turns on. Remove the resistor to create an open circuit and check if the vibrator turns off. III.

4. Tolerance analysis

It is important to know the voltage levels that correspond with different colors detected by the photo-detector. The Arduino inputs have 10 bit resolution for 0 to 5 V. For our design to work correctly, we will require a voltage difference of at least 0.01 V between the stress state voltage level output and relax state voltage level output of the photo-detector circuit. The tolerance for the difference in voltage levels should be 5%, this will provide at least a 0.005V difference, which is within the required resolution (5V/2^10 = 0.00488V) of the Arduino input.

For testing this tolerance, our photo-detector has a 1.2Mohm resistor in series with our photodiode. A rise in current due to a color being detected will cause a photo-current through the diode. This current will cause a voltage drop across the resistor, which we will measure with a DMM. Our simulation results above include the test results of such a test, and it can be seen that the difference is on average 0.0618V, which is well within the 0.01V difference required.

5. Costs and Schedule

5.1 Costs

5.1.1 Labors

Name	Hourly Rate	Total work hours	Salary
Yong Ho Kwon	$20	100hr	5,000
Udara Cabraal	$20	100hr	5,000
Hong Lee	$20	100hr	5,000
Total	$60	300hr	15,000

5.1.2 Parts

Name	Price	Quantity	Model #	Cost
Micro-controller (Arduino Nano 3.0)	$65	1	ATMEGA328	$65
LED (white)	$0.63	1	LED-156	$0.63
Photodiode	$2.14	1	VTP1188SH	$2.14
Stress Dots	$0.16	10	BC208	$1.6
Internal speaker	$20.3	1	PSP 2000	$15
Vibrator	$4.99	1	ROB-08449	$4.99
PCB	$33	1		$33
Op-Amps	$1.10	1	CA31302	$1.10
Voltage Regulator	$6.8	4	LM7805, LM317	$27.2
BJT's	$0.08	1	2N3904G	$0.08
Push Button Switch	$5.99	2	IM206	$11.98
Mini B-USB cable	$2.29	1	GO27005	$2.29
Resistors (100 Ω)	$1.07	1	20J100	$1.07
Resistors (250 Ω)	$1.08	2	20J250E	$1.08
Capacitors	$0.15	6	P5178-ND	$0.9
TOTAL	$144.78			$168.06

5.1.3 Grand Total

	Cost
Labor	$15,000
Parts	$168.06
Total	$15,168.06

5.2 Schedules

Week	Task	Group Member
10/1	Finishing Design Review	Cabraal
	Complete purchasing parts (op-amps, photodiodes)	Kwon
	Build circuits for stress detectors	Lee
	Color detection test	Cabraal
10/8	Revise Design Review	Lee
	Purchase speaker and vibrator	Cabraal
	Design and Connect vibrator circuits to microcontroller	Kwon
10/15	Design metronome program and test the program	Lee
	Individual progress reports	Cabraal
	Design vibrator program and test the program	Lee
10/29	Design stress detecting program	Kwon
	Complete programming and compile inside microcontroller	Lee
	Memory test, checking microcontroller can store the data successfully translate data to PC with Mini B-	Cabraal

	USB cable.	
11/5	Prepare mock up demos	Cabraal
	Fixing any programming issues	Lee
11/12	Prepare mock up presentation	Kwon
	Get together all the hardware components on the proto- board including stress detecting circuits, microcontrollers, vibrator, and speaker	Lee
	Program and run PCB	Cabraal
11/19	THANKSGIVING BREAK.	
11/26	Getting volunteers for running stress detecting test	Kwon
	Running stress detecting test on human	Lee
	Fixing any issues including circuits and programs.	Cabraal
12/3	Prepare Demos	Lee
	Prepare Presentation	Cabraal
	Prepare Final Paper	Lee
12/10	Presentation	Kwon
	Finishing Lab notebook	Lee
	Check Out	Cabraal
12/17	Exam Week	

6. Ethics Considerations

Our group will adhere to the IEEE Code of Ethics. Upon consideration, the device designed in this system will not harm others in any: all voltages are low level voltages (less than 12 V) and all components, besides the stress dot, will be shielded from the user. The device will safely store all personal information and any personal information stored will not be disclosed for unauthorized use.

7. Reference

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