Judo Sensor Vest

ECE 445 Spring 2017

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What is Judo?

Judo is a grappling based martial art

To win the practitioner must either:

Submit (Choke/Joint Lock)

Pin (One Shoulder)

Or Throw the opponent

Famous People Who Have Practiced Judo

Source: Google Images

Sydney Olympics 2000
Source: vippudeyare [YouTube]

Introduction

Competitive judo has had a couple of run-ins with poor decisions and controversy. Controversy stems from human errors and limitations in viewing angles and perspective. The addition of video recording has helped but the cameras cannot cover every angle.

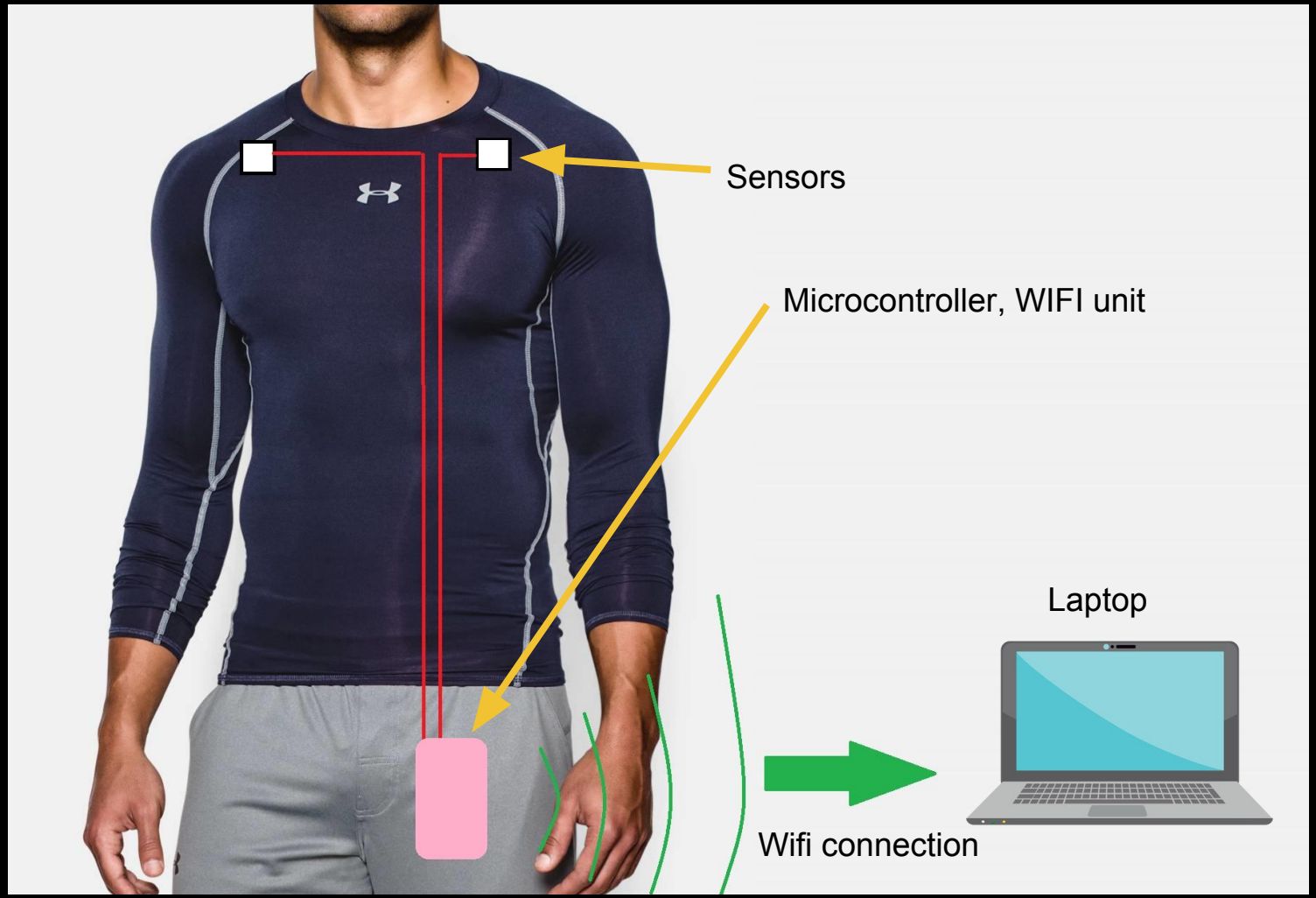
Our Solution:

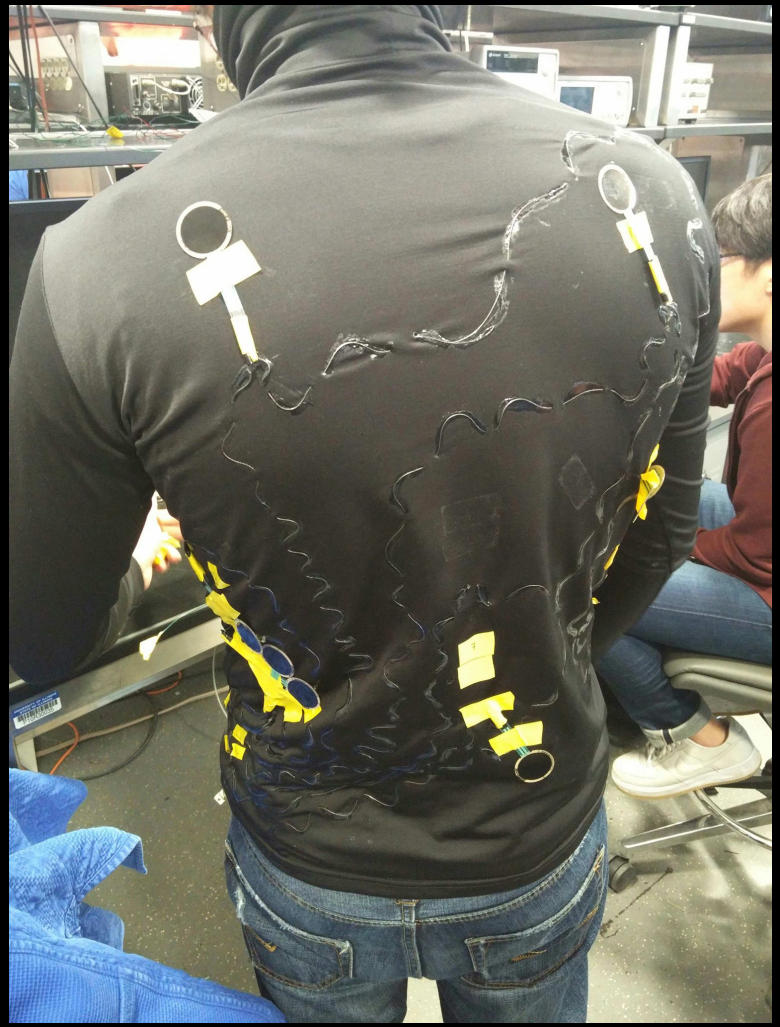
A vest to be worn by judo practitioners during matches which is able to detect moves executed on the user and transmit this data to the judges and referees.

Objectives

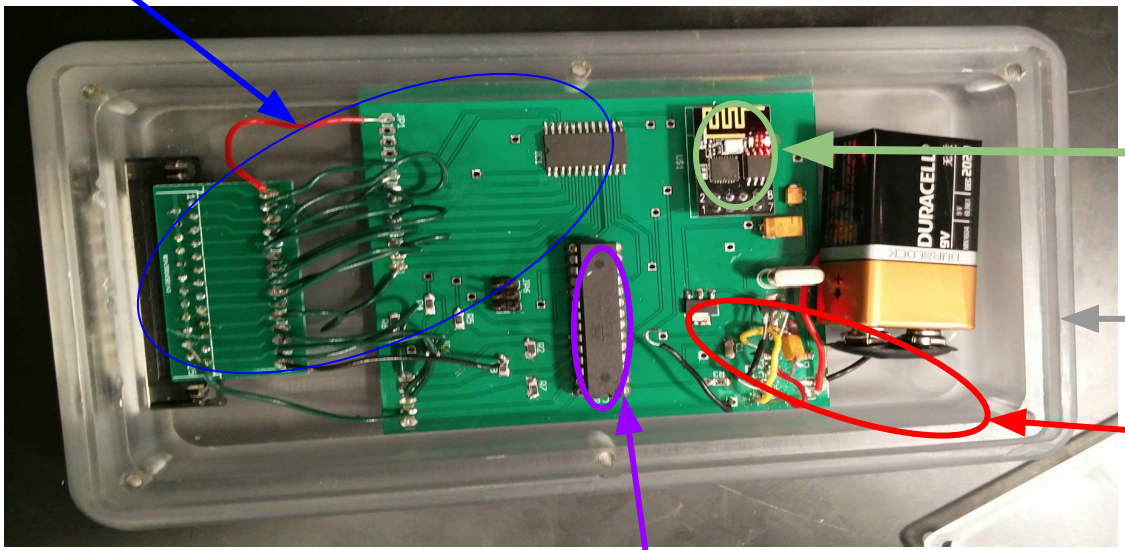
- The vest must detect different moves like throws and pins.
- The vest must be able to transmit this information wirelessly to a pc.

The overall objective is to provide supplementary data during a match from sensors on the vest to judges and referees to help them make more informed decisions.

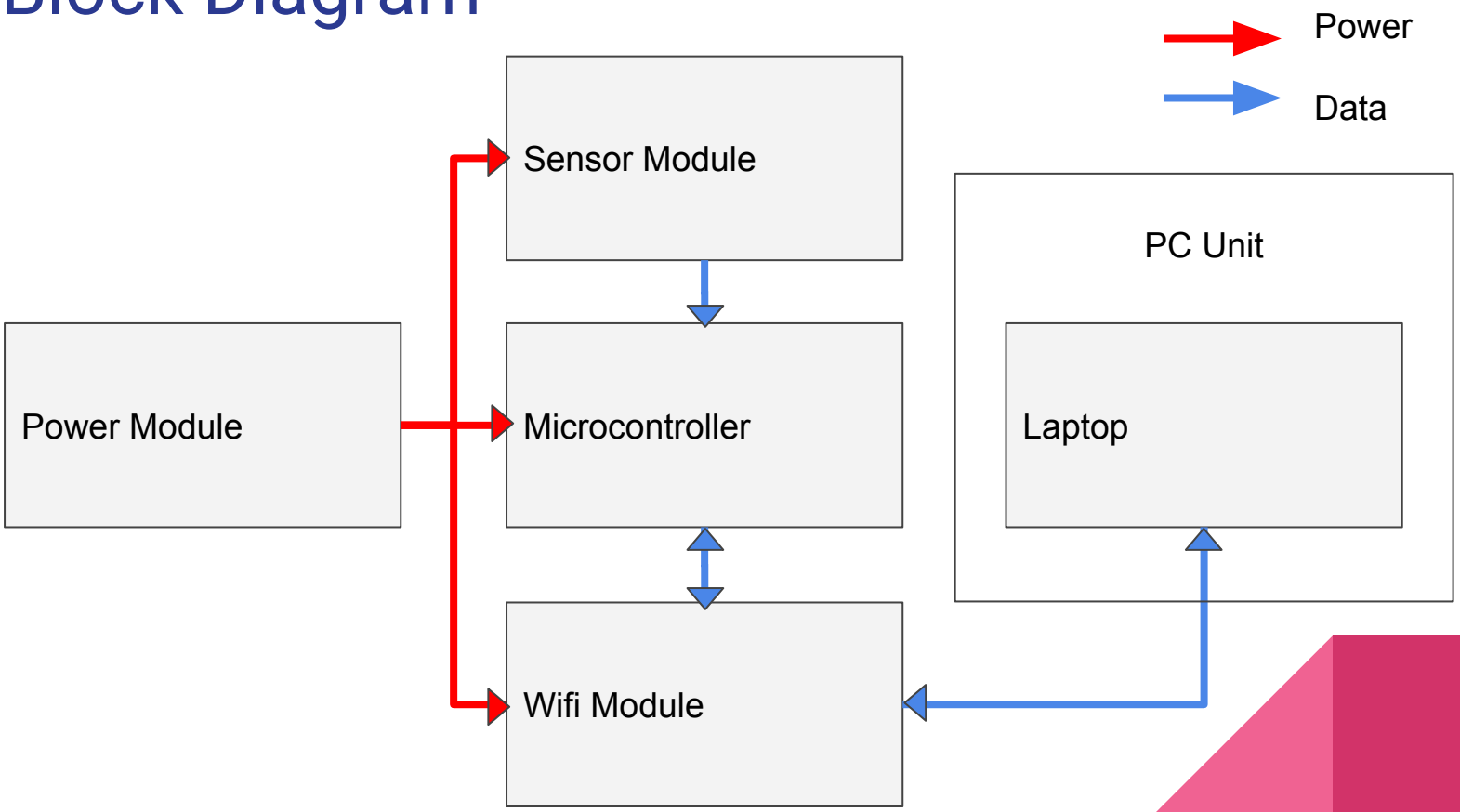

Sensors
Microcontroller, WIFI unit
Laptop
Wifi connection



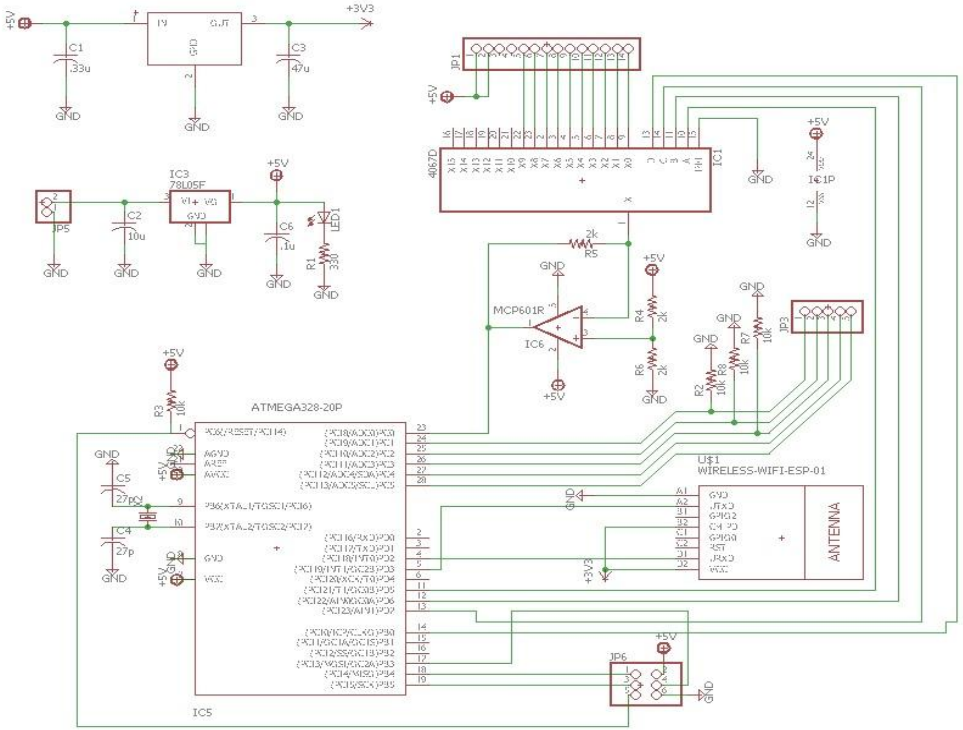
Physical Design



Block Diagram



Circuit Schematic



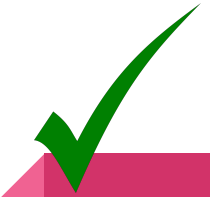
Wifi Module

ESP8266 ESP01 unit

The module communicates with the microcontroller via AT commands. The wifi unit is configured to required specifications by a sketch running on microcontroller on startup.

AT commands are instructions used to configure and control modems. AT stands for ‘Attention’.

Wifi Module: Requirements and Verification

Requirement	Verification	Result
Should be configured as a wifi station and be able to connect to a wireless access point.	Connect to wireless network and check connections list of the access point to make sure that the wifi unit is connected.	
Should be able to open a UDP connection with an existing UDP receiver on specified port and IP address.	Connect to UDP receiver and send initial handshake packets to confirm connection and data transfer.	
Should be able to send packets over UDP connection.		

PC Module

A Linux laptop runs the PC Module. A UDP receiver client prints moves and timestamps to a terminal window for judges and referees to inspect.

The client receives UDP packets containing sensor information. Some processing is done to verify judo pin timings to ensure a full or half duration legal pin.

Timestamps, specific move names and scoring recommendations are then printed to the terminal.

PC Module (cont.)

```
Waiting for Vest Response on port: 21234
Wed May  3 11:14:16 2017 Judo Sensor Vest: PINNED - WAZARI
Wed May  3 11:14:21 2017 Judo Sensor Vest: PINNED - IPPON
Wed May  3 11:14:37 2017 Judo Sensor Vest: THROW-LEFT
Wed May  3 11:14:42 2017 Judo Sensor Vest: THROW-RIGHT
Wed May  3 11:14:48 2017 Judo Sensor Vest: THROW-CENTER
Wed May  3 11:14:57 2017 Judo Sensor Vest: CHOKE OCCURING
Wed May  3 11:15:07 2017 Judo Sensor Vest: TAPOUT-MATCH END
```

PC Module: Requirements and Verification

Requirement	Verification	Result
Should be configured as a UDP receiver and on standby waiting to receive packets.	Start UDP receiver and check if client is listening on specified port and IP address.	
Should display information received in packets from vest to user.	Send data packets and confirm output of receiver and check if it matches the action on the vest.	

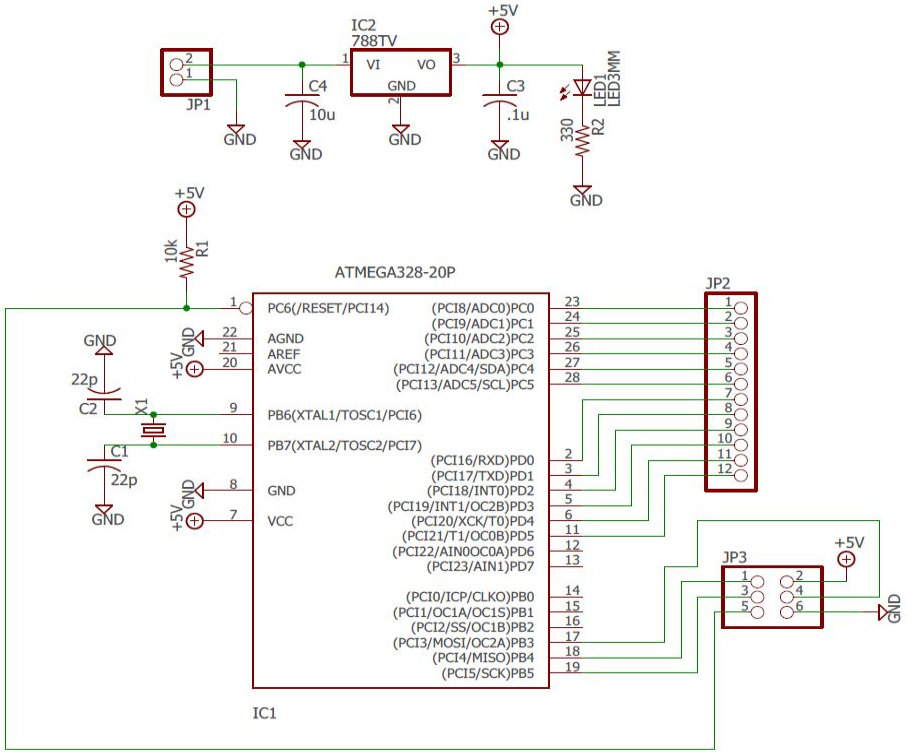
Control Module

ATMega328p microcontroller

A DIY Arduino that controls the entire project: Handles inputs from sensors and sends commands to the ESP8266 to wirelessly broadcast scoring data.

Runs an Arduino sketch that processes inputs and commands the wifi module.

Control Module: Schematic



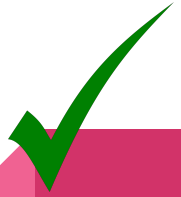
Control Module: Arduino Sketch

- Setup and configure WIFI module according to requirements
- Cycle through multiplexer to query each sensor on the vest
- Pass sensor array information to decision tree to determine which move was executed
- Construct UDP data packet based on move determined.
- Send data packet through UDP connection.

Control Module: Requirements and Verification

Requirement	Verification	Result
PCB should be able to run arduino sketches.	Run sample sketch to on board to test functionality.	
Microcontroller should be able to communicate with wifi module with AT commands.	Run sketch on microcontroller to connect wifi module with wireless access point.	

Control Module: R&V Cont.

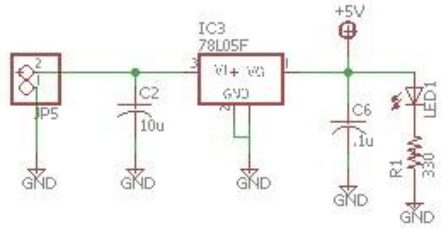
Requirement	Verification	Result
PCB should be able to take inputs from a large sensor array through a mux and get sensor inputs depending on select bits provided by microcontroller.	Activate individual sensors and test response generated to confirm that the right sensor was recognized.	
Should be able to construct packet depending on sensor inputs to send to wifi module.	Feed sample sensor values to microcontroller and run code to check whether the data packet was correctly constructed.	

Power Module

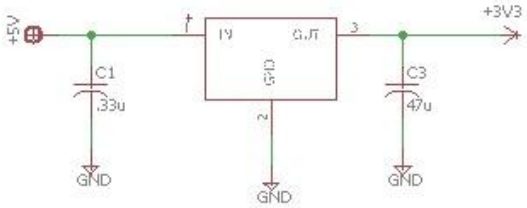
Takes 9V from a battery

Uses voltage regulators to deliver 5V to the circuit at large and 3.3V to the wifi module.

5 V regulator circuit



3.3 V regulator circuit



Power Module: Requirements and Verification

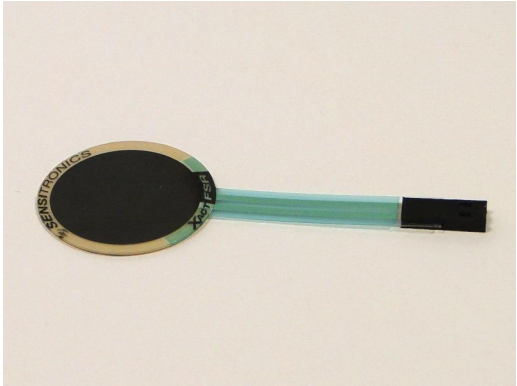
Requirement	Verification	Result
Provide a constant 5 V ±5% to microcontroller, mux, op-amp and sensors	Use multimeter to measure voltage between points of interest and circuit ground	
Provide a constant 3.3 V ±5% to the wifi module	Use multimeter to measure voltage between points of interest and circuit ground	

Sensor Module

Sensitronics 1 Inch Shunt Mode FSR

Able to handle up to 45 kg (440N) or 125 PSI

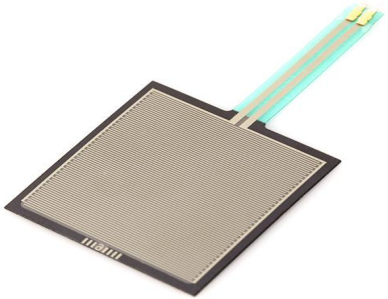
Used for throws and pins.



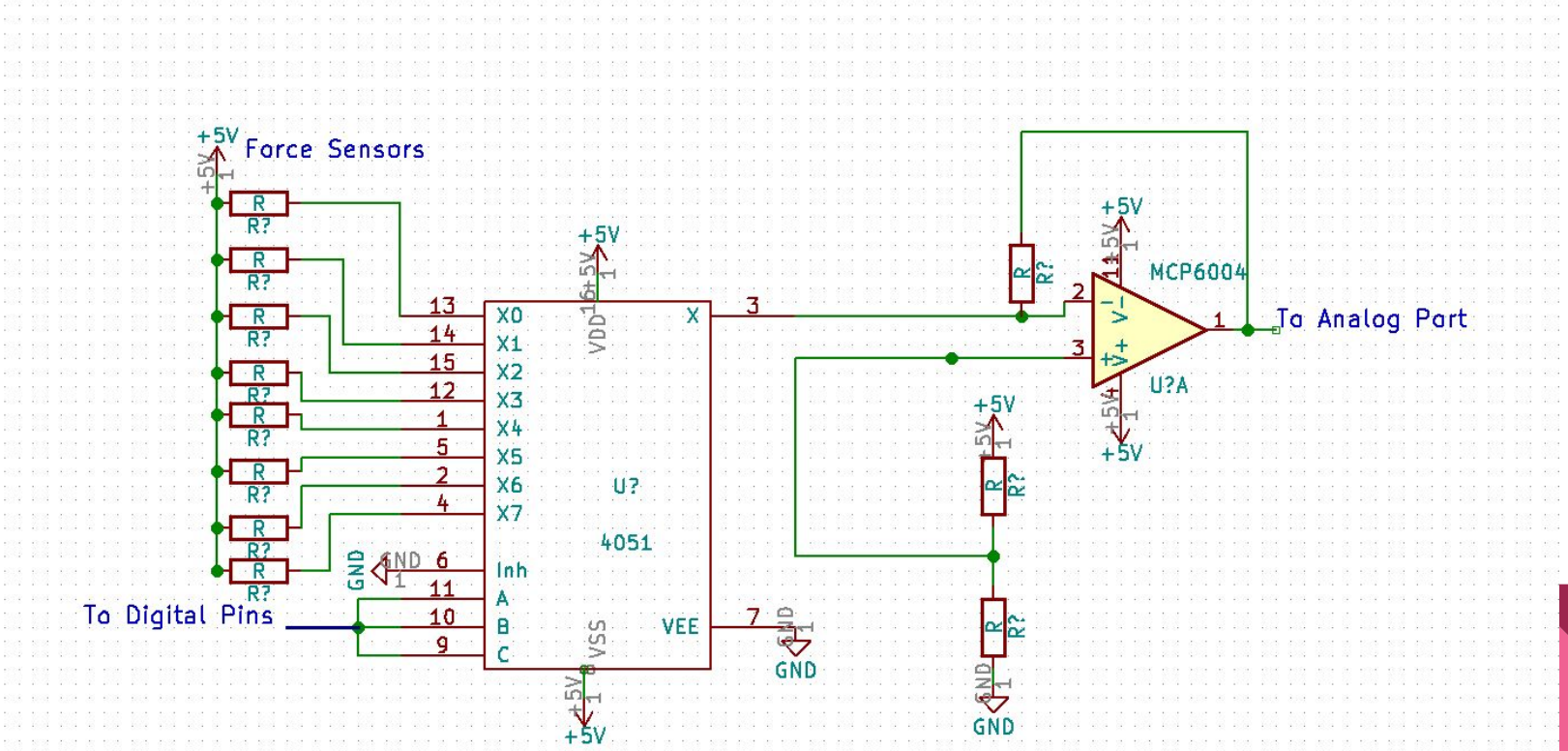
SEN-09376

Able to handle up to 10kg (100 N)

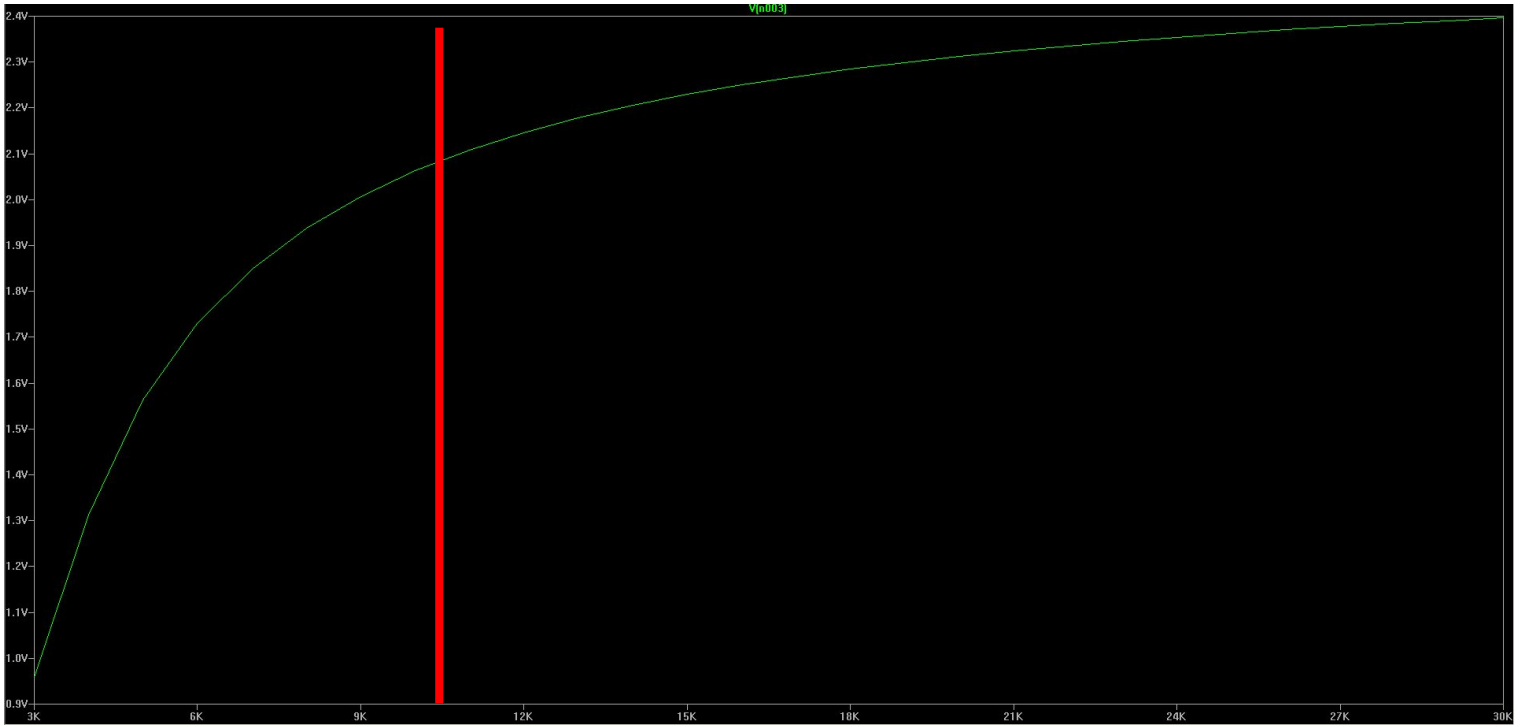
Sensors used for tapping out



Sensor Module: Schematic



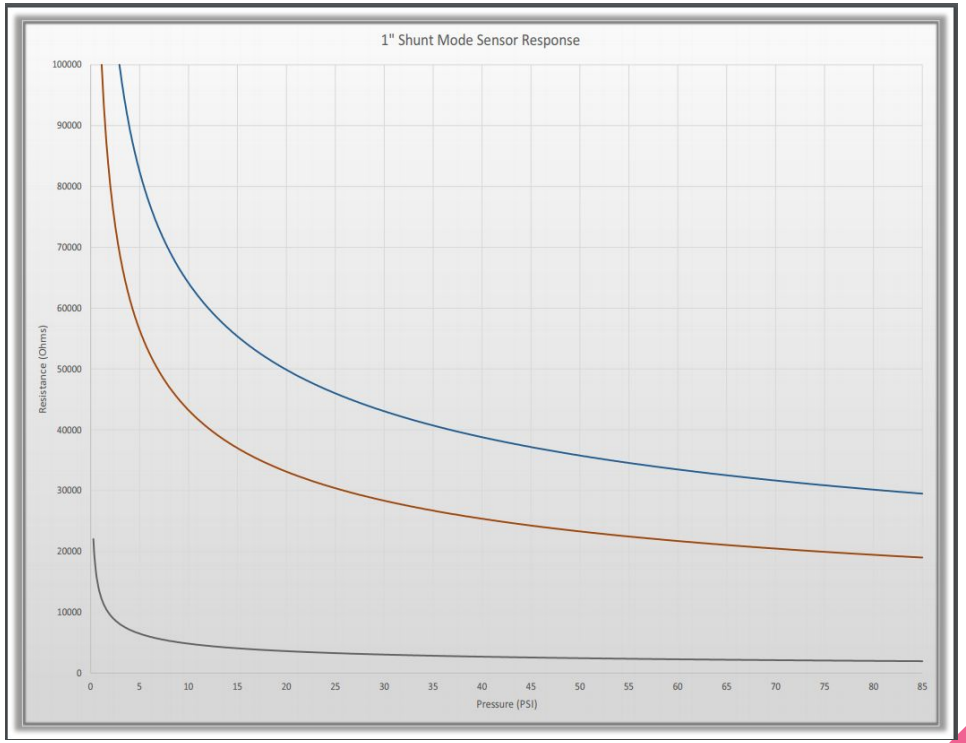
Simulation



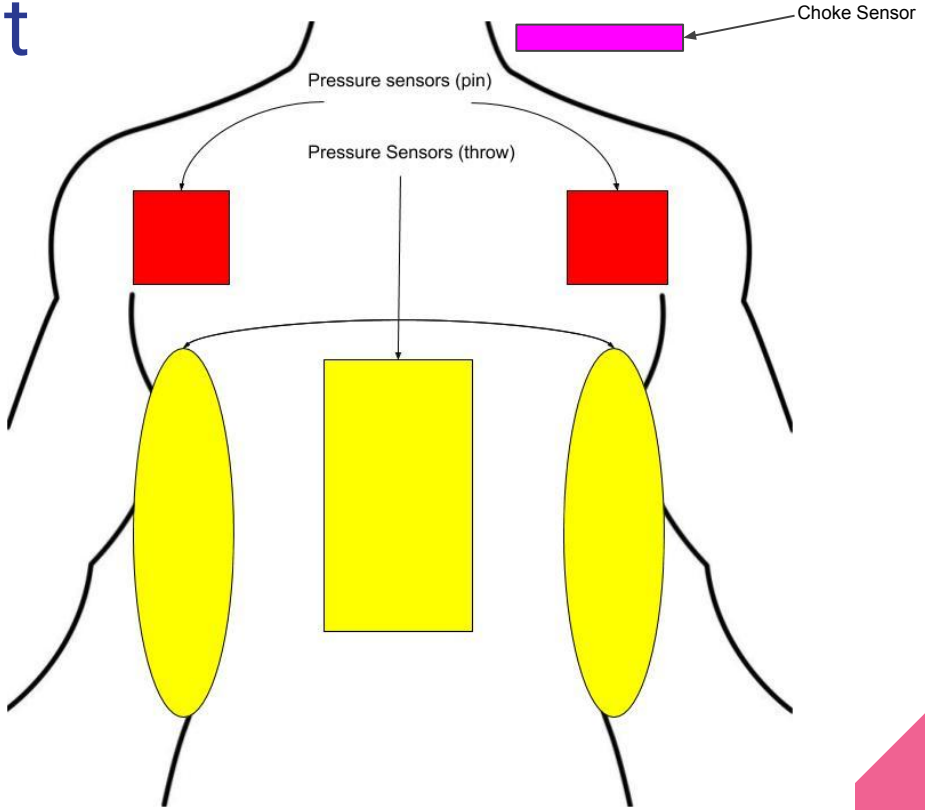
Voltage

Resistance

Sensor Module (cont.)



Sensor Layout



Sensor Module: Requirements and Verification

Requirement	Verification	Result
Able to withstand forces greater than 125 PSI	Verified using weights and humans to see maximum resistance reading across FSR	
Detect changes on user's back in case of throw or pin	Apply pressure to sensors to approximate a throw or a pin	

Functional Tests

- Individual tests for modules. -Power Supply, Wifi Module, Sensors, Microcontroller
- Individual area test on vest: connectivity of sensor array on vest
- Combined test: Applied pressure on vest and waited for response on terminal
- Live test: Conducted a real throw on Max

Courtesy of Sam Sagan

Challenges in Verification

- Resistance in conductive threads was higher than we expected.
- Difficulty in insulating conductive threads. Led to shorts.
- Difficulty in accurately measuring forces applied on sensors.
- Sensors were lower resistance rating than we had requested. Sensitivity was much higher than we required.

Conclusion

The modules worked as specified and they integrated well into the final design. The design worked as intended.

The vest was able to recognize throws and pins on the body and transmit that information to a PC.

Future Work

Work on making circuitry more compact and integrating the force sensors more thoroughly.

Some alternative uses include being used as a training vest in other martial arts (Karate, Muay Thai, Brazilian Jiu Jitsu)

We also believe the sensor array could be used as a teaching aide to the elderly falling.

Thank you!

- Sam Sagan
- Karl Reinhard
- Skot Wiedmann
- Mark Smart
- Scott McDonald
- Skee Aldrich
- Zikang Tong
- Jamie Norton
- Dr. Manuel Hernandez

Questions?