Team 47 - Pressure Sensing Piezoelectric Insole

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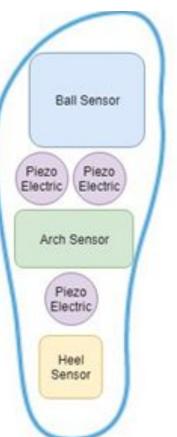




Introduction

 Dynamic pressure sensing insole with mobile app interface

 Gathers foot pressure data as a user walks



	Ball Sensor	
	Piezo Electric Electric	
V	Arch Sensor	
	Piezo Electric	
	Heel Sensor	

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Objective

Deaths from DFU or DFU related Amputation Equal or exceed deaths from Prostate cancer, Breast cancer and Hodgkin lymphoma combined



Every 30 seconds a Leg is lost to Diabetes somewhere in the world



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[1] DFU: Diabetic foot ulcer

Provide health information to detect physiological foot complications Long lasting, low power, real time solution





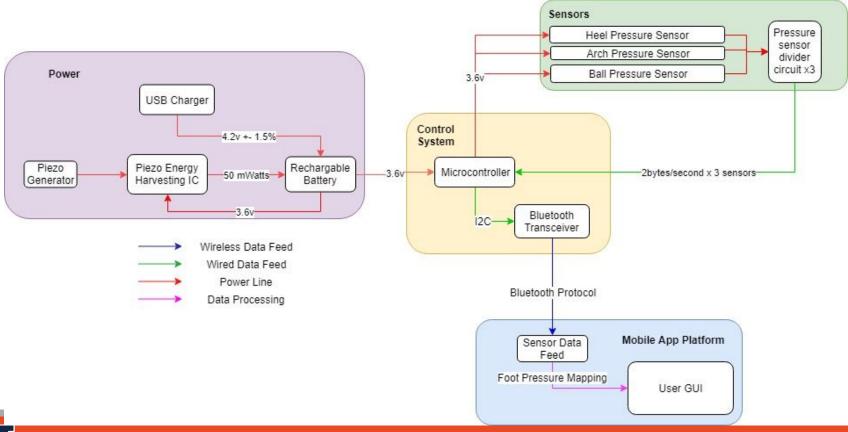
Original Design Features

- Rechargeable via USB and piezoelectrics
- App compatible with any Android device
- Data feed with color coded sensor GUI
- 3 pressure sensing pads
- Lasts for up to 8 hours at maximum use

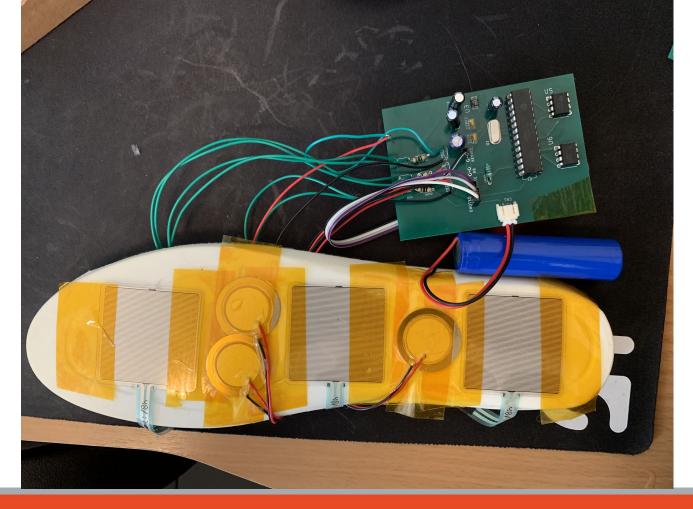




Block Diagram



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Requirements for Power Block

 Battery must last at least 8 hours from full charge during operation

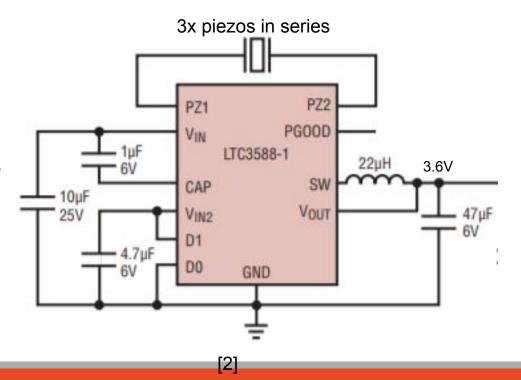
 Within 1 hour of walking piezos must output 50 mW (2-5% savings)





Power Block Schematics

- LTC3588-1
 - Full-wave
 bridge rectifier
 - Buck converter
 - Pin selectable output voltage

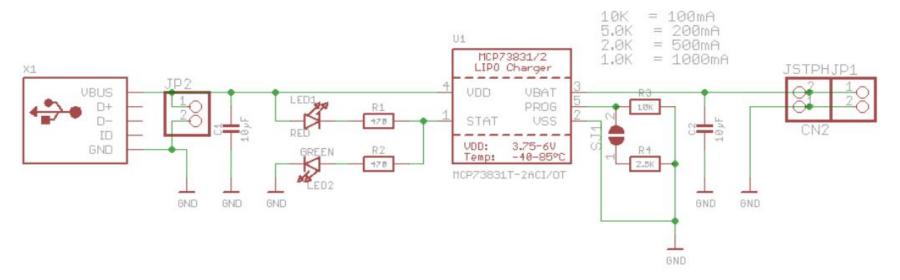


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Power Block Schematics

[3] - Adafruit Battery Charger







Verifications for Power Block

- Current draw:
 - Range of 54 mA with no pressure to 170 mA at full pressure saturation
 - 2200 mAh / 170 mA = **12.9 hours** at maximum use
- We could not verify that our piezos provided 2-5% energy savings, possible explanations:
 - Replacement piezo elements
 - Output plenty of voltage, not enough current
 - IC consuming more power than generated

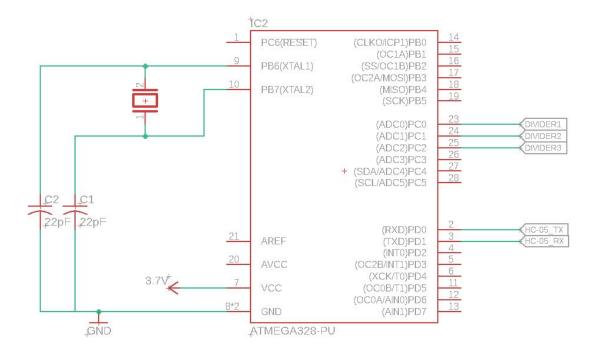


Requirements for Control Block

- Microcontroller must have at least 3 sensor analog inputs
- Microcontroller must be Bluetooth compatible
- Bluetooth must send data losslessly within 30 feet



Control Block Schematic







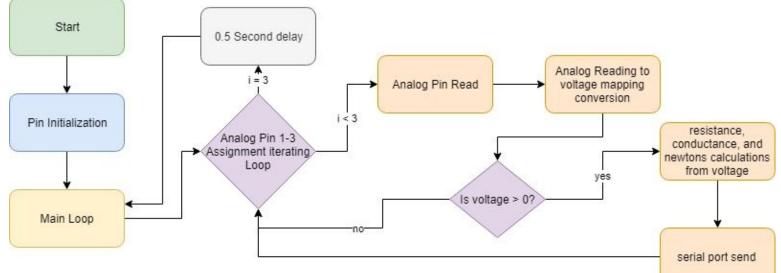
Verifications for Control Block

- AT Mega 328P has 5 Analog inputs, and RX TX pins.
- HC-05 operates within 9 meter range(30 ft)
 - Bluetooth V2.0 Serial Port Profile
 - Baud Rate of 9600
 - Serial feed of all sensors every 0.5 seconds





Microcontroller Software Flowchart



- Voltage = Vcc * R / (R + FSR)
- FSR = ((Vcc V) * R) / V
- R = 10 and Vcc = 3.7V





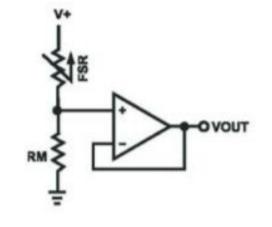
Requirements for Sensor Block

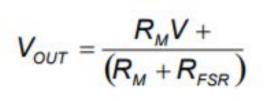
- Sensors must react by changing resistance to increasing and decreasing amounts of pressure
- Voltage divider must be able to output voltage 0.01V per kPa for up to 120 kPa at a chosen Rm value
 - MinPressure = $120*1000 \text{ N/m}^2 = 120,000 \text{ N/m}^2$
 - Area_{FSR} = $3.8*10^{-3}$ m²
 - MinForce = MinPressure * Area_{FSR} = 456 N per sensor, +/-10mV per +/-3.8 N



FSR Voltage Divider Schematic

- Increasing force leads to increasing Vout
- Rm determines sensitivity to applied force



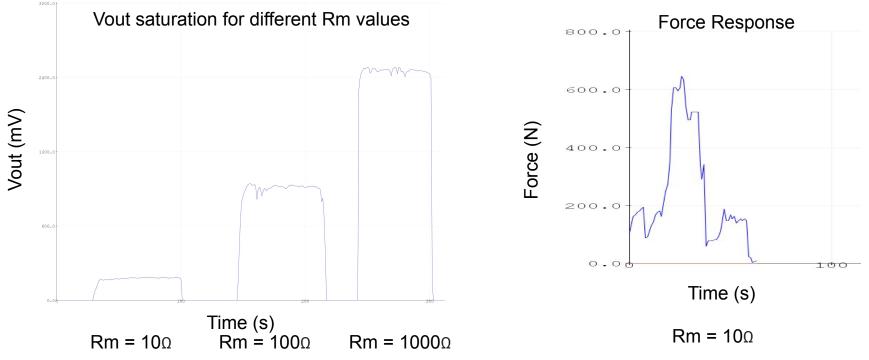


[4]





Verifications for Sensor Block



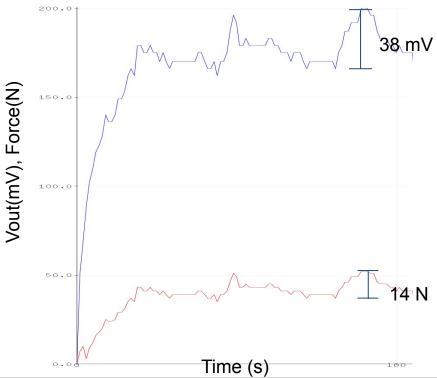


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Verifications for Sensor Block

- Orange Force
- Blue Voltage

- 38mV/14N = 2.71
 mV/N
- Requirement: 2.63 mV/N



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Requirements for Mobile App Block

 Must receive dynamic data feed from device

 Data feed must be mapped to color coded pressure pads on the GUI





Verifications for Mobile App Block

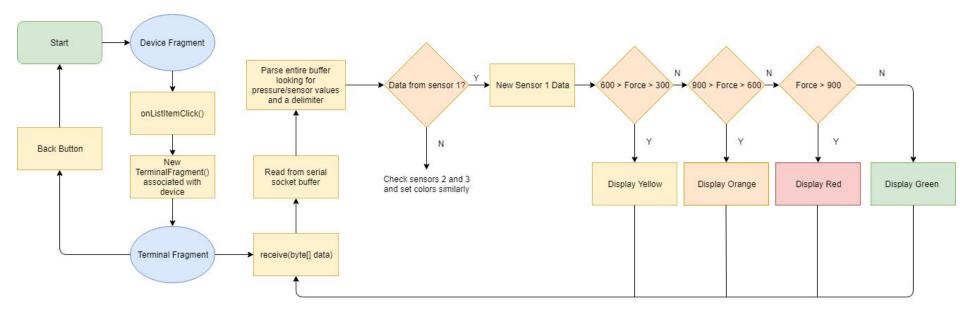
Data feed

- Bluetooth V2.0 Serial Port Profile
- Baud Rate of 9600
- Serial feed of all sensors every 0.5 seconds
- Color coded GUI
 - Color coding dependent on sensor input within certain ranges





Mobile App Software Flowchart







Successes

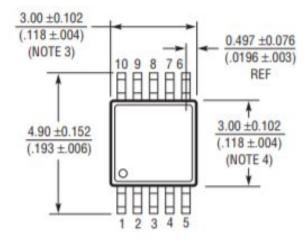
- FSR sensitivity calibration
- Microcontroller data intake
- Bluetooth connection
- Mobile app feed and GUI
- Reliable power supply





Challenges

- Choosing proper parts
 - Microcontroller
 - Piezos
 - Piezo Harvesting IC
 - Bluetooth module
- PCB soldering with small IC's
- Piezo energy harvesting margin



[2] - units in mm





Piezo Harvesting Error Root Cause

- IC optimized for different piezo model that is not sold anymore
- Number of piezos insufficient
- IC damage while soldering
- IC operational voltage unprovided by source



Conclusion

- Accomplished:
 - Sensors and piezo charging
 - Insole well constructed
 - Circuit fully PCB soldered
 - Foot pressure mapping on mobile app
 - Dynamic data feed from device to phone





Conclusion Cont.

- For the future:
 - Scale up number of sensors
 - Finer visuals of foot pressure mapping
 - Optimize piezoelectrics for harvesting
 - Simultaneous device connection on BTE 2.1
 - Shrink PCB



Questions?







Works Cited

- [1] The Diabetes Council, 'diabetes-and-amputation-everything-you-need-to-know-to-avoid-amputation'. [Online]. Available: <u>https://www.thediabetescouncil.com/diabetes-and-amputation-everything-you-need-to-know-to-avoid-amputation/</u>. [Accessed: 2/18/2019].
- [2] Linear Technology, 'Nanopower Energy Harvesting Power Supply'. [Online]. Available: <u>https://www.analog.com/media/en/technical-documentation/data-sheets/35881fc.pdf</u>. [Accessed 4/29/2019].
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