EquiPack

Team 02


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Advisor: Prof. Salthouse

Overview: The Problem

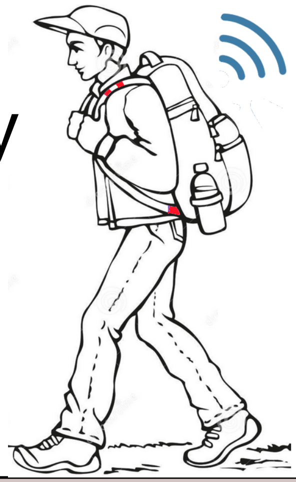
- Backpacks are frequently misused
  - Most people don’t know how to use the current features
  - Many people overload their bags to a dangerous weight
- How familiar does this look?

http://www.euclidchiropracticinc.com/causes-of-forward-head-posture-fhp-124

http://www.newvision.co.ug/mobile/Detail.aspx?NewsID=635397&CatID=6

What makes Equi**Pack**: hardware

- Intelligent backpack with an integrated array of 8 pressure and 1 integrated strain sensor
- Embedded bluetooth and computational hardware used to relay data to user's BLE equipped Android device
- All embedded components are powered by 4 standard replaceable AA batteries



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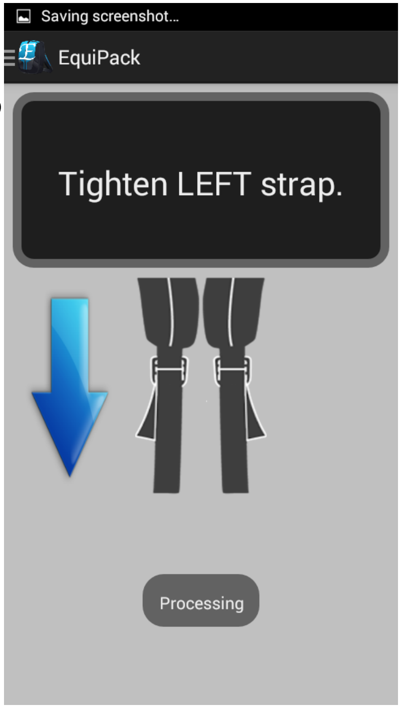
What makes Equi**Pack**: software

- Software running on Android device estimates backpack's position and outputs data which can be interpolated to reduce health risks
- "EquiPack" Android application displays output of analytics in a meaningful and graphical manner
  - One (i.e. parent) can intervene when the backpack is abusing the wearer
  - SMS to a subscriber



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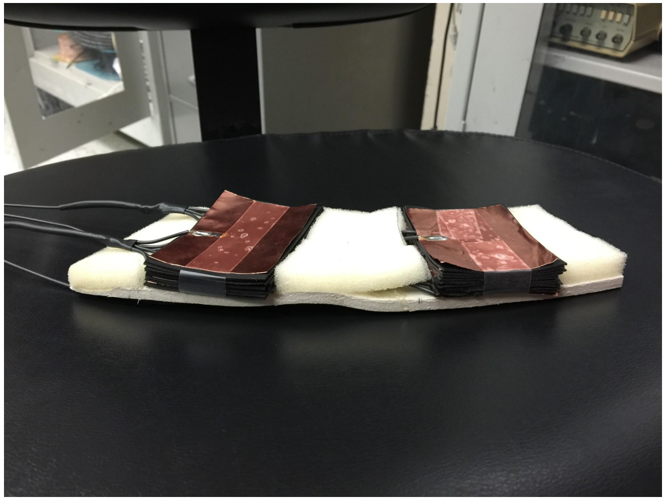
Outline of Demonstration

- Demonstration of foam sensor outside the EquiPack to show data collection method
- Demonstration of fully integrated system:
  - User-initiated microcontroller data collection
  - Bluetooth communication
  - Data is presented graphically to user via App



What's not working:

- Total Weight Sensor (blown power converter, replacement never received)
- Weight pressure sensor normalization
- Gradient plane model integrity handling
- Lower left Strap pressure sensor has shorted out
- Microcontroller is not fitted into enclosure

What's working: Why 9 sensors?

4 Back pressure sensors.

- Pressures across flat surfaces can be measured as a gradient plane.
- In order to characterize a flat plane, we require three orthogonal points.
- a fourth sensor is added to verify the accuracy of the flat plane model.
- These points allow us to determine symmetry of the bag and the distance of the contents in the bag.

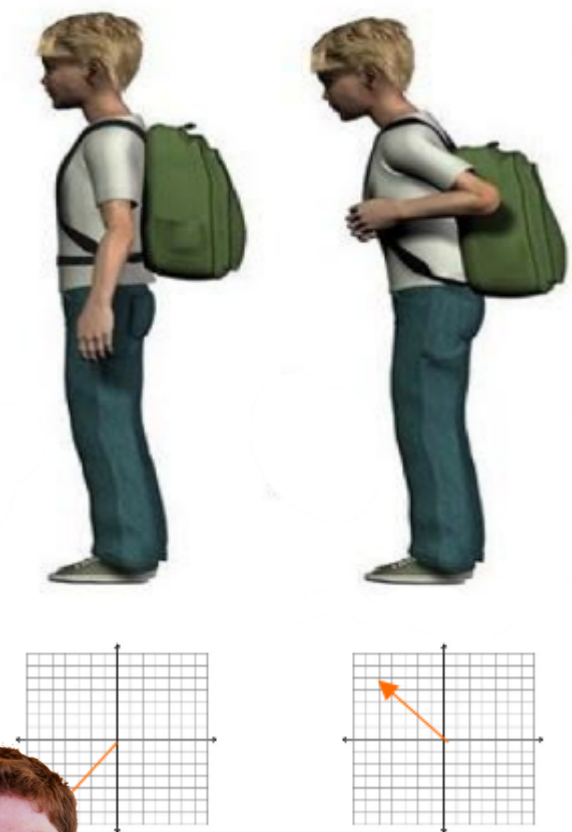
What's working: Why 9 sensors? cont.

4 Shoulder Sensors

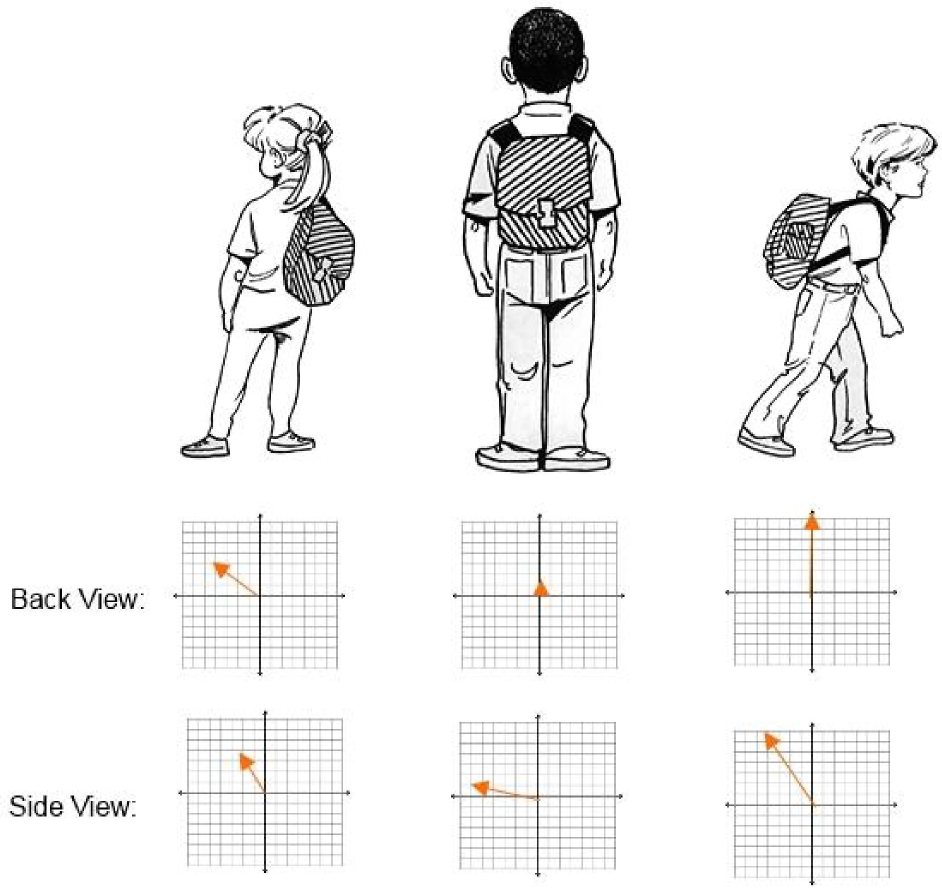
- once again the shoulder sensors provide a characterization of the gradient plane along the shoulders.
- we require three sensors for a complete characterization of the gradient plane and a fourth is added to ensure accuracy of the model.
- Shoulder sensors again sense symmetry provide for shoulder plane back plane optimization and approximate the initial location of the straps

1 Load sensor

- The load sensor provides a direct calculation of the total weight of the bag without requiring a complex model



houlder Pressure Gradient Vectors



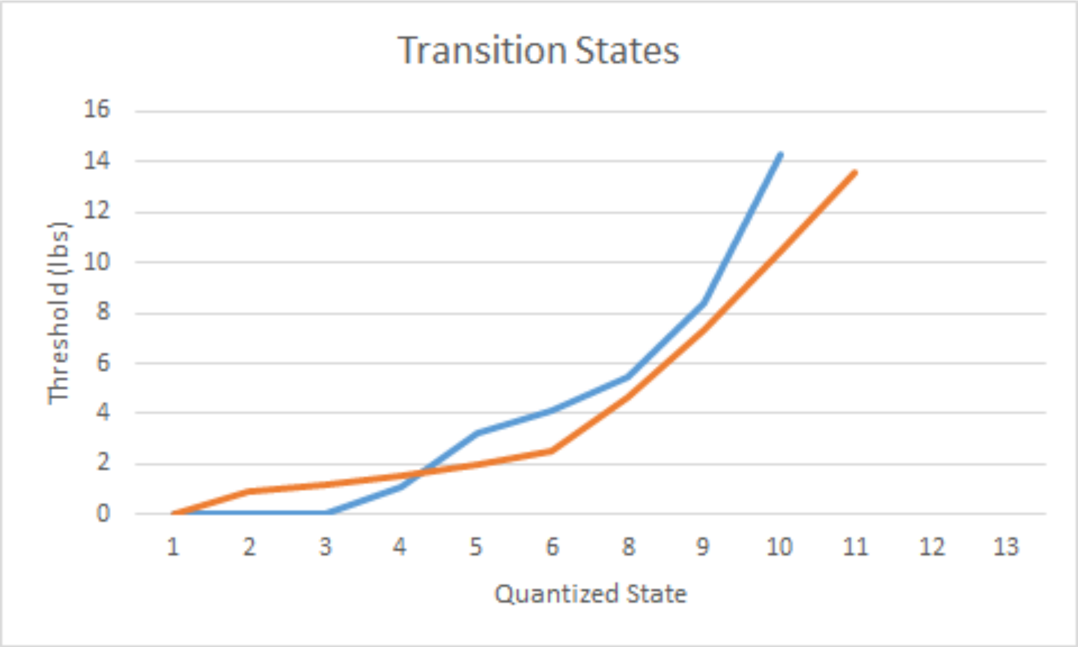
Back Pressure Gradient Vectors

UMassAmherst

What's Working

- Weight Sensors Subsystem:
  - Capacitive Foam Sensors
  - Sensing Circuitry
- Subsystem on a PCB:
  - µController - LPC824M0
  - Mux/Demux of ADCs
  - Two-Way Bluetooth Communication
- Power Systems:
  - 4 AA batteries, converted to 5V with switching regulator

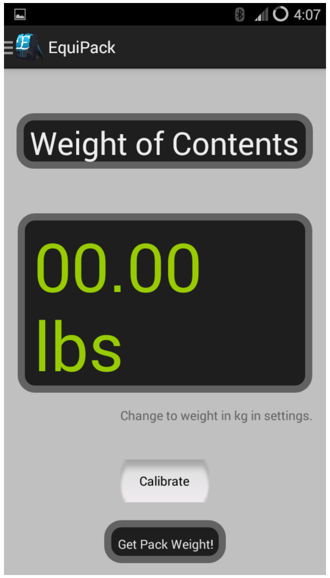
What's Working



Sensor Characterization

What's Working, Continued

- Android Application Subsystem
  - Graphic display of:
    - Raw sensor data
    - User suggestions (simulated)
  - Persistent user preferences



- Weight Analytics Subsystem
  - Simulated Left/ Right Symmetry adjustment
  - Simulated Up/Down height adjustment.
  - Slope based algorithm error correction (obsolete)

How do our analytics work?

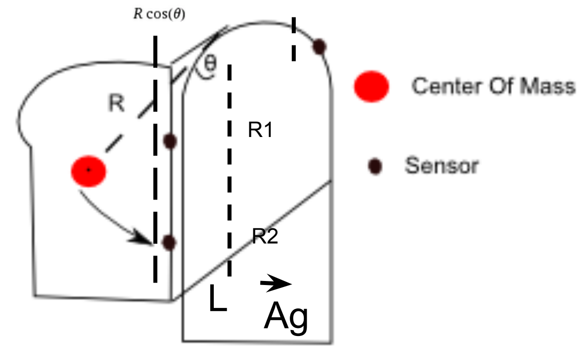
- Left/Right Symmetry Adjustment
  - Goal: even weight distribution on both sides of body
  - Process:
    - Average values of both shoulder and back sensors on each side.
    - compare difference to threshold value
    - If below, threshold move to next function
    - If above, send user adjustments and repeat process
  - Failure Cases
    - The adjustments briefly become symmetric because of system noise (eg. rustling of the backpack)
    - Symmetry of individual sensors are severely uncorrelated

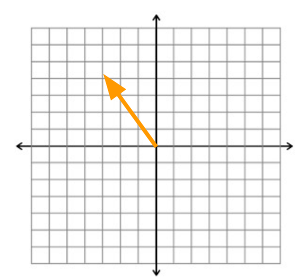
How do our analytics work?

- Center of Mass Calculation
  - Goal: determine if objects are too far back in backpack
  - Process:
    - Run center of mass equation
    - provide information to user for manual adjustments.
  - Failure Cases:
    - Back does not create flat interface with back.
    - Backpack has a widely dispersed load, invalidating the point mass assumption.

Center of Mass Equation:

$$\frac{L^3}{2\,m\,g}\left(\frac{p_1}{r_1^2}+\frac{p_2}{r_2^2}\right)+A$$





y height correlates to center of mass

How do our analytics work?

- Up/Down Optimization
  - Goal: Minimize load on shoulders
  - Process:
    - Determine initial position using shoulder pressure gradient vector location.
    - Adjust towards center until back pressure decreases and shoulder pressure increases
  - Failure Cases:
    - Significant quantization error in sensors leads to zero valued slopes.
    - noise in system causes brief changes of increases in shoulder pressure.
    - Backpack is already close to max point at start of algorithm

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How do our analytics work?

- Error Handling features
  - Fourth sensor on each plane checks for consistency to model
  - linear regression formula provides slope measurements to only check for static values. (Currently Unused due to heavy quantization error from Microcontroller sampling rate.)
  -

Overall Specifications

- Low cost (< $25 mass production)
- Passive or low power (< 50mW)
- Light-weight (under 12oz additional weight)
- Solution should be applicable to both frameless and framed packs
- Solution provides User with feedback

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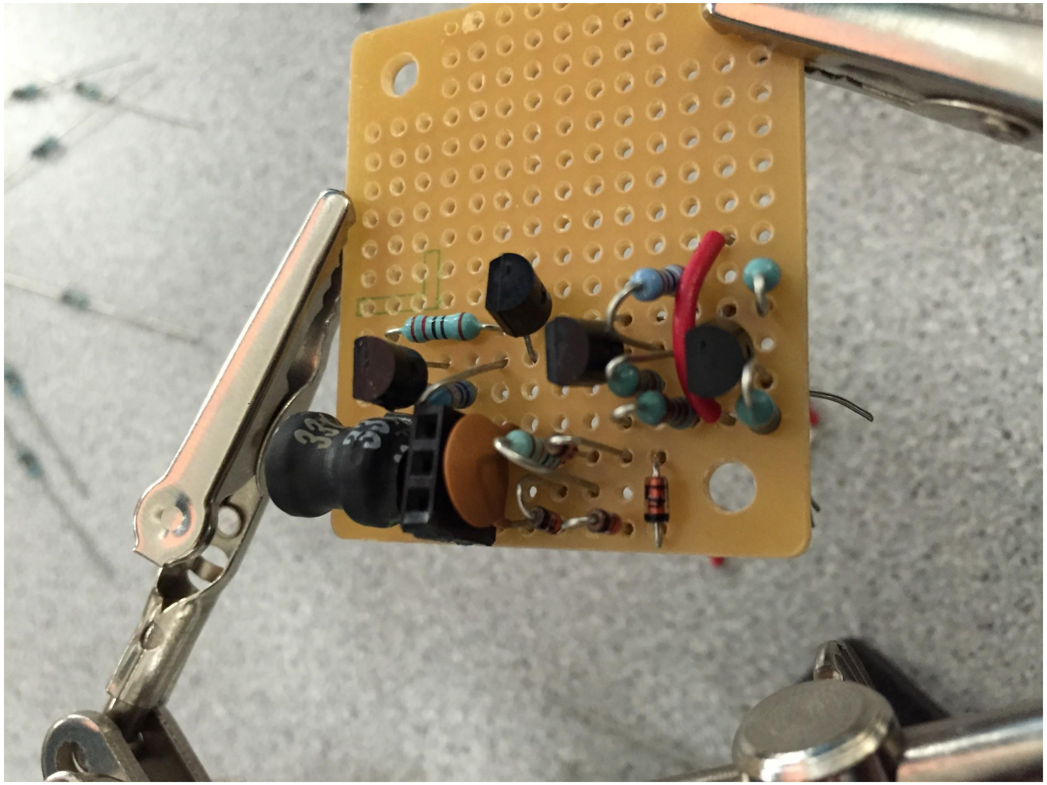
Demonstration

Changes made to pressure sensors

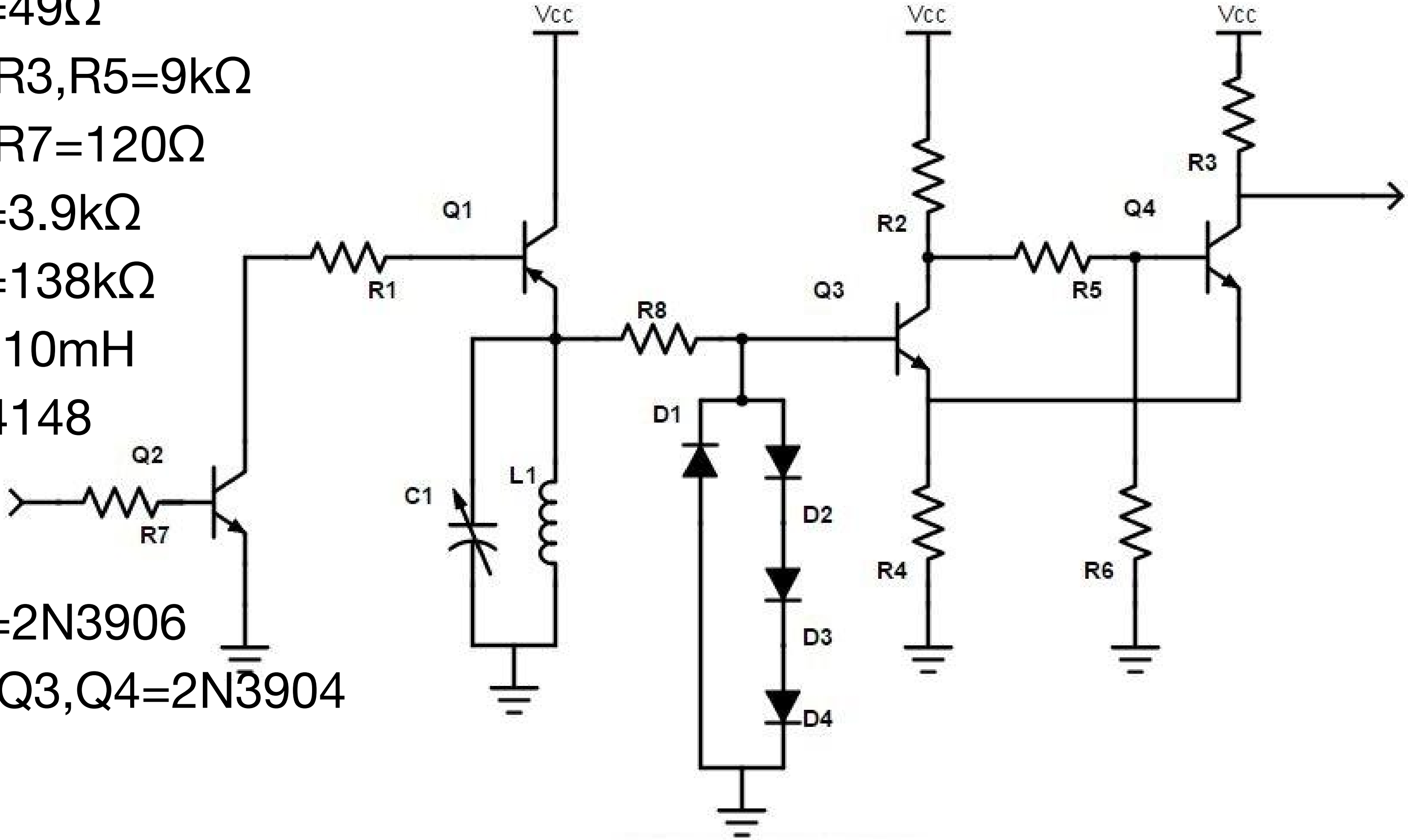


- Relay was removed in favor of a transistor
- Diode stack was added to up the circuit Q
- Removed Schmitt Trigger IC in favor of discrete components

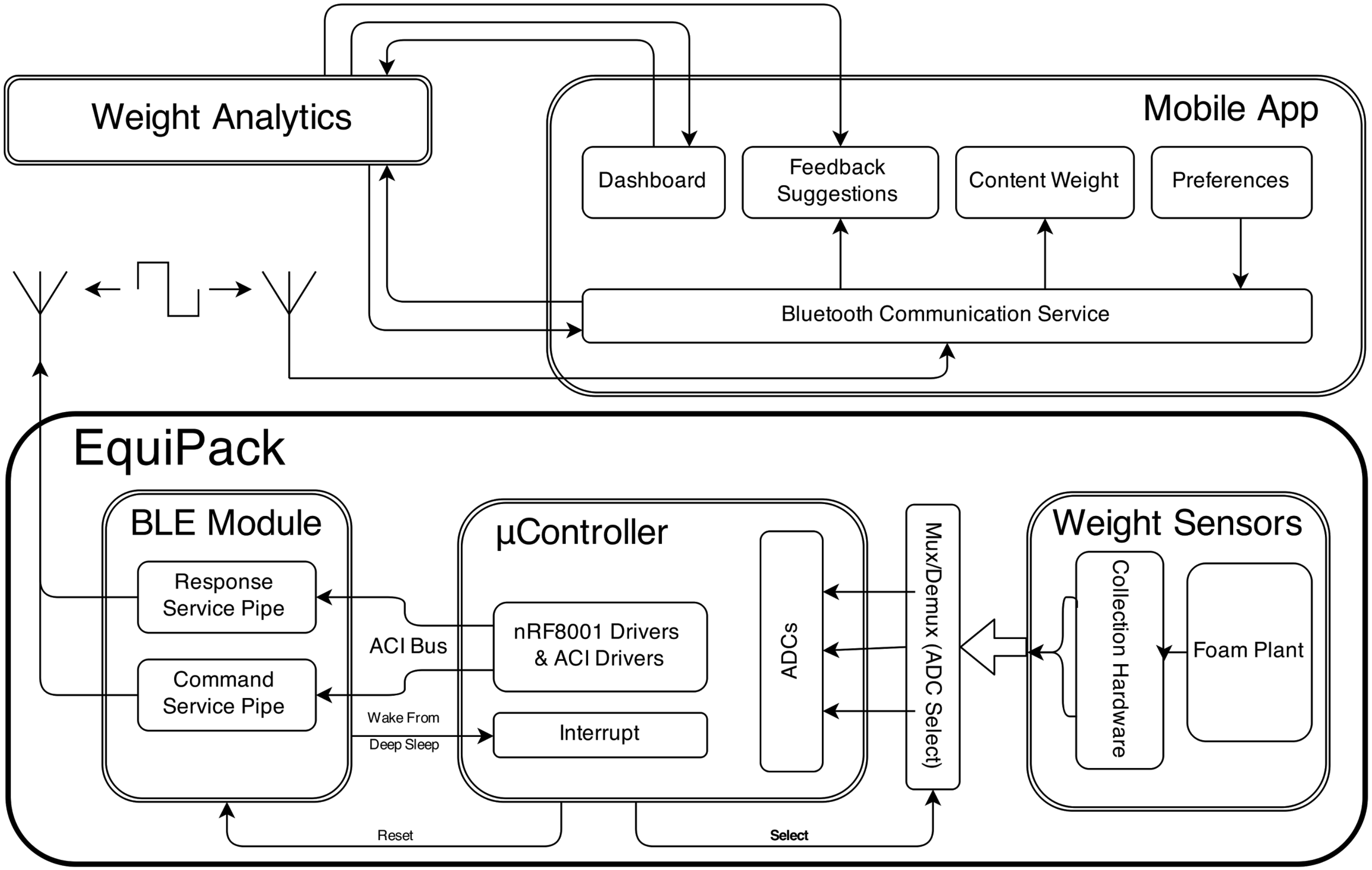
Current Schematic

R1=49Ω
R2,R3,R5=9kΩ
R4,R7=120Ω
R6=3.9kΩ
R8=138kΩ
L1=10mH
D=4148

Q1=2N3906
Q2,Q3,Q4=2N3904



Block Diagram



EquiPack's user stories

- "As a **parent**, I want **an intelligent backpack** for my child so that they can **learn to prevent long term injury**."
- "As a **parent**, I want **to be alerted** (regardless of distance) when my child's **bag contains an unhealthy amount of weight** so that appropriate measures can be taken"
- "As a **primary school student**, I want an **intelligent backpack** so that I can **be "cool" without risking my health.**"
- "As an **active person**, I want to be able to **learn from, control and configure** my smart backpack system **while wearing the backpack**"