Display/Electronics

The bike will be utilizing several different components to add some audio and some visual feedback to the bicycle. The concept is to use the previous design's inclinometer and speakers, along with new parts, primarily a microcontroller.

How it Works

The inclinometer will be mounted near the base of the bike. The inclinometer gives an analog linearly scaled voltage response to its angle with respect to gravity. When it is level, it yields 2.5V. At +- 30 degrees, it will give 0 and 5 volts. This signal will be given to the microcontroller through one of its analog input pins. A software program will be written to implement the actual display for the bike, as well as the hit counter. The program will divide the range of -5 degrees to 5 degrees into 15 equal sections, with each section being assigned a number. When a section is chosen and its correlated LED will need to light up, the binary representation of that number will be sent to a demultiplexer, which will then select the correct LED in the array. Each different section will light up a different LED, with 0 degrees representing the center green LED. Furthermore, the sections that light up the furthest red LED, (-5 to -4.3 degrees and 4.3 to 5 degrees) will also add one to an internal counter, and activate the speakers signaling a fall. A separate section of the program will be written to encode this counter's value into a 16 bit signal that represents a two digit decimal number on a seven segment display. This signal will be sent through sixteen separate outputs directly to the seven segment display. There will also be a button mounted next to the hit counter's display that will function as a reset button. This will be a pull up button, and will input into the microcontroller, where the software will recognize that signal as a command to reset the internal counter to zero. The old tachometer will no longer have anywhere to be mounted on the bicycle. However, the pedal resistance mechanism we are purchasing comes with a multifunction display mounted on top. This display will be relocated, either to the handlebars of the bicycle for easier access, or be mounted in the same display box as all of the rest of the electronic parts.

Advantages

- Increased control over all of the displays.
- Reuses some of the previous bike’s hardware.
- Moves parts of design from hardware to software, removing any physical decay problems.
- Software shift also allows refining of product much later in product development.
- Fully completed breadboard increases safety and stability of the display box.
- Allows for intuitive, large, easy to read display
- Takes advantage of display from magnetic brake system

Disadvantages

- Software shift will likely require a robust program.
- Increased complexity compared to other designs.
- More expensive than originally thought
- No control over or interaction with multifunction display from pedal system

Customer Needs

Need	Section	Requirement	Importance
Need 4.1	Tilt Sensor	Improve accuracy	3
Need 4.2	Tilt Sensor	Larger display	1
Need 5.1	Fall Counter	Count the number of times the patient hits the maximum tilt angle	3
Need 5.2	Fall Counter	Audio feedback	1
Need 5.3	Fall Counter	Incorporate variable tilt angles	3
Need 5.4	Fall Counter	Be able to reset	3
Need 6.2	Bike Frame	Conceal loose wires	1
Need 6.3	Bike Frame	Stabilize part in display	9

- LED array will be accurate enough to give a good resolution of the patients current tilt angle, and large and bright enough to give good visibility.
- Hit Counter will be implemented in this design.
- Every time a fall is measured the speakers will momentarily turn on.
- The hit counter will have a switch attached to allow an input into the microcontroller. This will either set it to 5 degree mode or 10 degree mode.
- Reset button mounted on box next to hit counter.
- Only wires outside of box will be belonging to the inclinometer and the multifunction display from the pedals. Both of these will either be covered in a wire sheath, or routed through the frame itself.
- Entire PC Board will be mountable inside the box. Speakers, displays etc. will all be mounted on the surface of the box.

Applicable Engineering Specs

Corresponding Need	Metric	Importance	Marginal Value	Ideal Value	Units
4.1	Difference Between Actual and Measured Angle on Tilt Sensor	3	1	0	Degrees
4.2	Display Size	1	3	4	Inches
5.1	Counts Falls	3	TRUE	TRUE	Integer
5.2	Audio Feedback	1	60	75	Decibels
5.3	Tilt Angles	3	2	2	Quantity
5.4	Reset Unit	3	TRUE	TRUE	Binary
6.2	Concealed Wires	1	TRUE	TRUE	Binary
6.3	Display Stability Improved	9	TRUE	TRUE	Binary

- Inclinometer accurate to 0.5% of value, microcontroller input accurate to ten binary bits (1024 values)
- LED Display >= 6 inches
- Speaker output levels variable

Bill of Materials

Part	Model	Price (Amount)	Total Cost	Ordering From
Microcontroller	Arduino Mega 2560	$60.00	60	Arduino or affiliate
Inclinometer	Rieker H4A1-30	Free	0	
Seven Segment Display	Lumex LDD-A814RI	$3.29 (x2)	6.58	Mouser
LED resistors (1k)	½ watt resistors	Free (x16)	0	
Red LEDs	Lumex SSL-LX100133YD	$0.33 (x8)	2.64	Mouser
Yellow LEDs	Lumex SSL-LX100133SYD	$0.77 (x8)	6.16	Mouser
Green LEDs	Lumex SSL-LX100133SGC	$0.33 (x14)	4.62	Mouser
Demultiplexer	Texas Instruments CD4514BM96E4	$0.58 (x2)	1.16	Mouser
PC Board Manufacturing	Express PCB Manufacturing	$50-$100	51	Express PCB
			132.16	

Individual Parts

- Inclinometer
  - Reiker H4A1-30
  - Reused from last years model
  - 8-30V Input 0-5V Output
  - Mounted at base of handlebars as in previous design
  - Power and output wires will be run either wound together in a larger wire sheath, or routed through the inside of the frame.
- Microcontroller
  - Arduino Mega 2560
  - Popular prototyping board
  - 7-12V Power, 5V Digital I/O voltage, 0-5V Analog input voltage
  - Includes enough digital I/O pins, and analog input pins as required for this device
  - Mounted above PC Board, and attached inside of box
  - Current size of box unknown, as until the PC Board is designed I don't know the size specs.
  - Goal is to fit all devices on 3.8” X 2.5” board to take advantage of cheapest price from ExpressPCB
  - Communicates with computer through external USB port
  - Programmed in C/C++ from computer
  - Program Flowchart shown in figure one
- Seven Segment Display
  - Lumex LDD-A814RI
  - Two digit seven segment display array
  - Sixteen inputs come directly from microcontroller
  - Mounted on PC Board, through surface of box
  - Seven segment display truth table shown in figure two
- LED's
  - Lumex SSL-LX100133 series

- Large and bright enough to be easily visible, but not stunning or painfully bright
- Three different colors representing different ranges of tilt
- Array of fifteen mounted on board, through surface of box, controlled through the demultiplexer

- Demultiplexer
  - Texas Instruments CD4514BM96E4
  - Uses four input binary selection data to choose between sixteen outputs
  - Data line simply tied to power
  - Fifteen outputs tied directly to a single LED, one unused.
  - Demultiplexer simulation results shown in figure three
- PC Board
  - Manufactured by Express PCB
  - Designed using their free software
  - Mounted directly to the inside of the surface of the box, so that all displays are visible
  - Mounting holes for Arduino board to be mounted directly 'below' it
  - Communications between two boards likely done with ribbon cables and headers

Reference Material

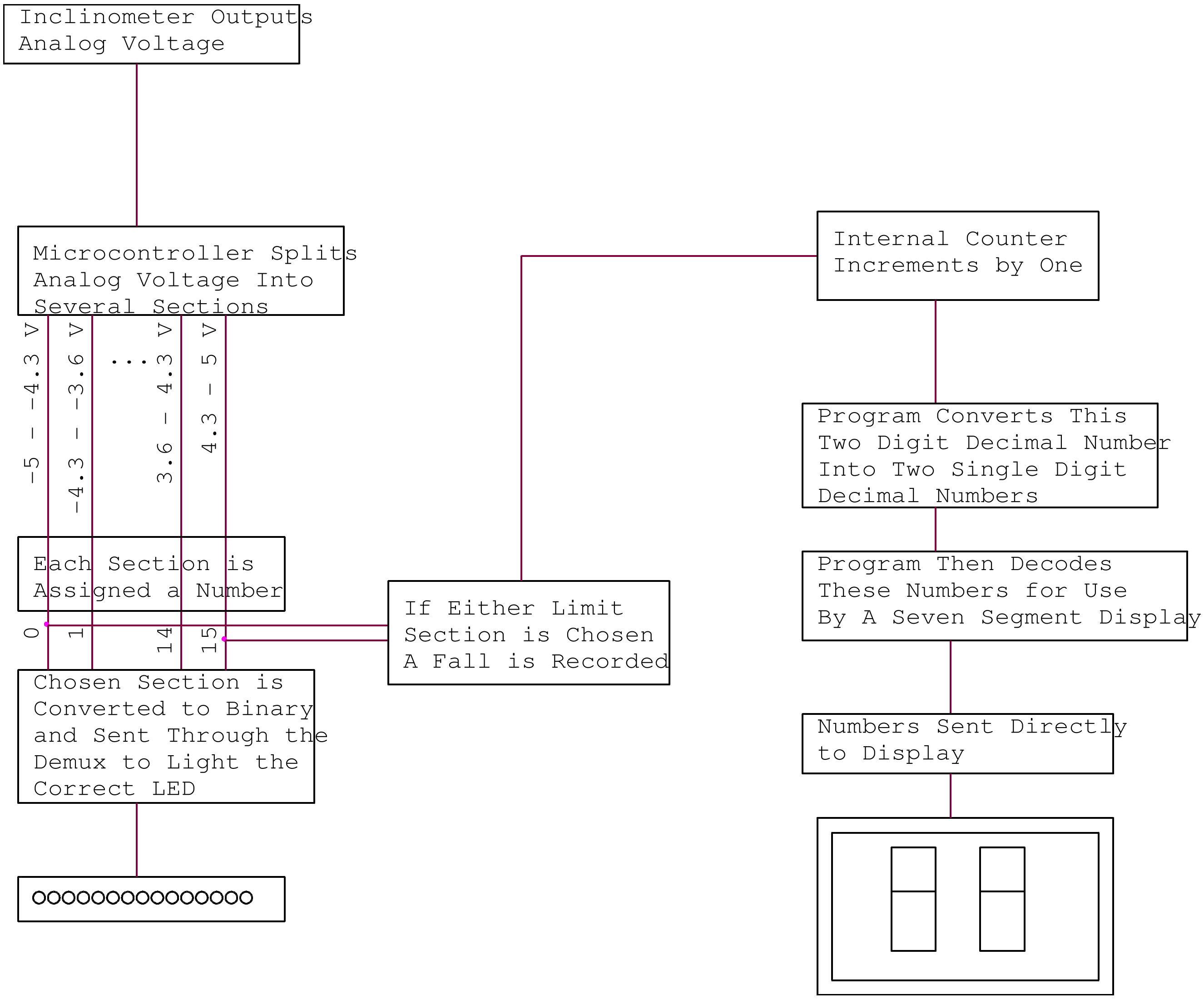

Figure One: Flowchart of programming commands for microcontroller

Decimal Number	**Inputs**				**Outputs**						
	D	**C**	**B**	**A**	**a**	**b**	**c**	**d**	**e**	**f**	**g**
0	0	0	0	0	1	1	1	1	1	1	0
1	0	0	0	1	0	1	1	0	0	0	0
2	0	0	1	0	1	1	0	1	1	0	1
3	0	0	1	1	1	1	1	1	0	0	1
4	0	1	0	0	0	1	1	0	0	1	1
5	0	1	0	1	1	0	1	1	0	1	1
6	0	1	1	0	1	0	1	1	1	1	1
7	0	1	1	1	1	1	1	0	0	0	0
8	1	0	0	0	1	1	1	1	1	1	1
9	1	0	0	1	1	1	1	1	0	1	1

Figure Two: Truth Table for Seven Segment Display

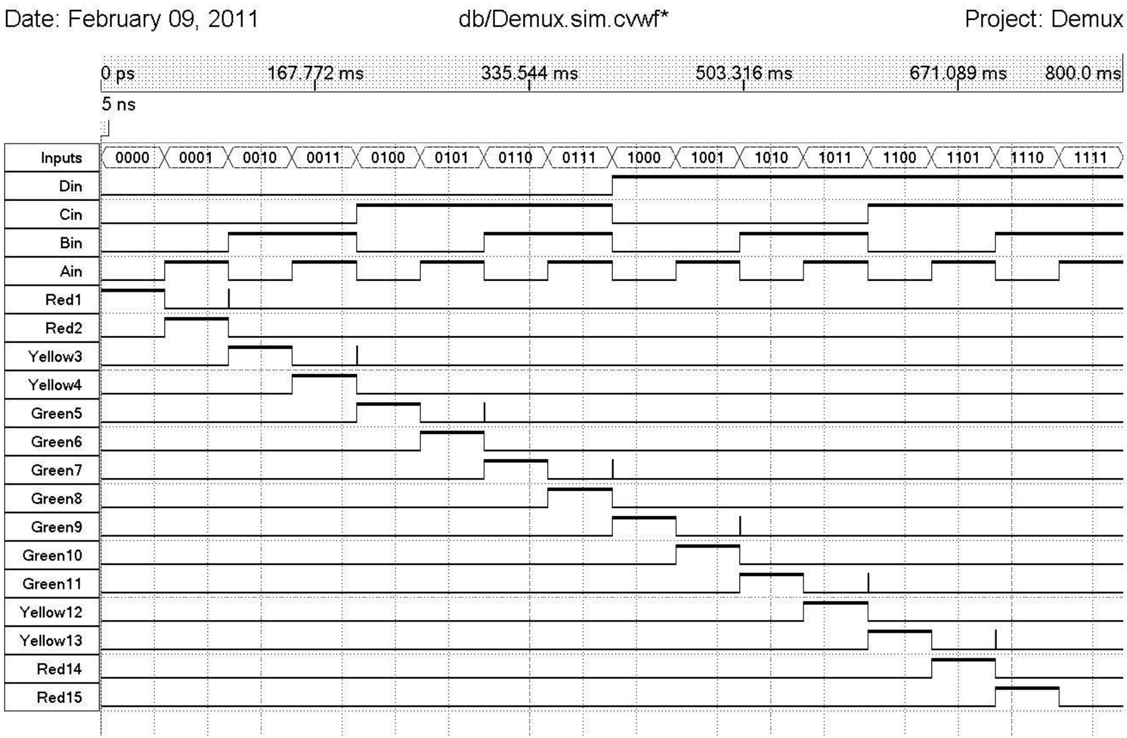

Figure Three: Simulation of Demultiplexer, and LED selection