Commuter Tracking Sensor Network

High-Risk Component Investigation: *Windbelt Technology*

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Overview

* Windbelt
  * Power to Lithium-Polymer battery
  * Risks associated
  * Signal conditioning necessary
  * Adequate?
  * Reliable?
  * Sustainable?

Risk Specification

Item	Need / Requirement
1	Modules will detect commuters and the path they are taking.
2	Modules will determine the mode of transportation used by the commuter.
3	Modules will mesh network with one another.
4	A gateway module will allow the network to interface with the internet.

- Risks are not related directly
- Providing power to battery
- Battery powers MCU and peripherals
- Need to do this for long periods of time

Risk Specification

Item	Engineering Specification	Related Need(s)
1.a.i.1	An image sensor must be able to resolve the image so that CV can be performed.	1,2
1.a.i.2	An image sensor must be able to perform in a variety of light conditions.	1,2
2.a.i.1	A processor on the module must be able to capture image from sensor and perform the needed CV algos on the captured image.	1,2
3.a.i.1	A radio on the module must operate on a band that is open by the FCC.	3
3.a.i.2	A radio on the module must be able to implement a mesh protocol.	3
4.a.i.1	A radio on the gateway module must be able to interface with an existing internet entryway.	4

Risk Investigation

Item	Component	System	Relation to High-Risk Component
1	OV10633 Image Sensor	Commuter Detection	532mW to 480uW of power required to operate for active and standby modes.
2	CV2201 Image Processor	Commuter Detection	250mW of power typically required to operate in image processing applications.
3	XBee-Pro Radio Module	Module Networking	215mA to 2.5uA of current required to operate for transmit and sleep modes.
4	Half-Wave Rectifier w/ Cap.	Signal Conditioning	Converts the AC signal provided by the Windbelt to DC and capacitor increases fall time.
5	TI bq25504 Boost Converter	Signal Conditioning	Conditions the signal provided by the Windbelt and rectifier, readying it for the Li-Po battery.
6	Lithium Polymer Battery	Signal Conditioning	Maintains the charge generated by the Windbelt signal and provides power MCU and peripherals.

Risk Investigation

Alternatives	Design 1 Windbelt	Design 2 Solar	Design 3 Turbine	Design 4 None
Efficient	5	5	3	1
Unique	5	3	3	1
Adequate	3	5	4	1
Low-Profile	5	3	1	5
Cost	5	3	1	5
Sum	23	19	12	13

- Pugh Chart
- Designs rated 1 to 5
- Windbelt was the clear winner

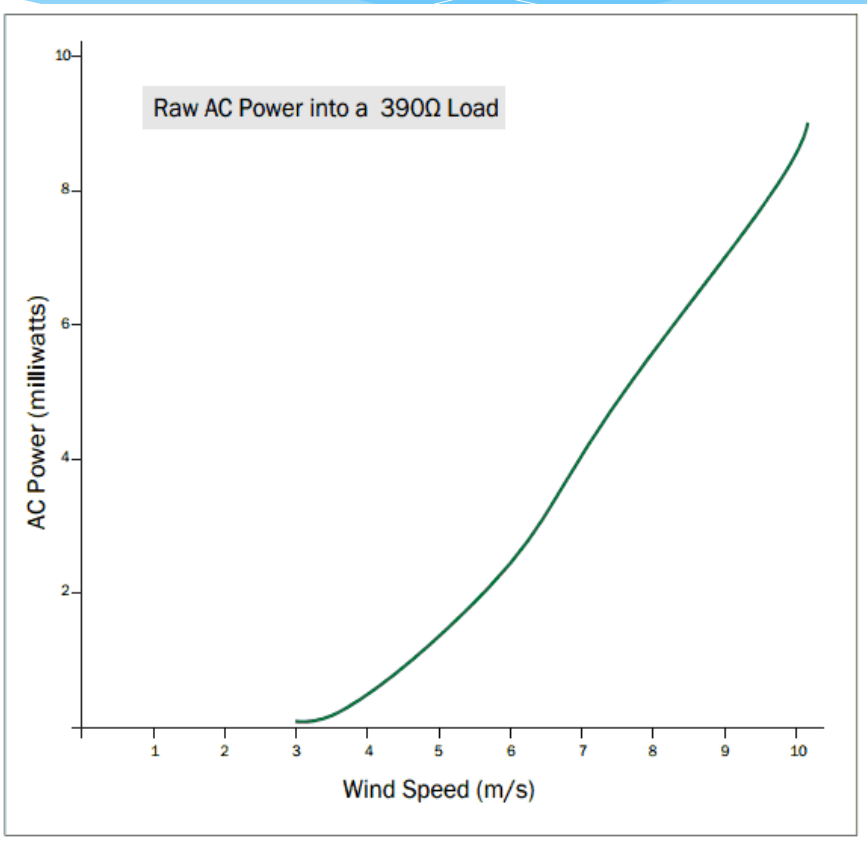
Windbelt Technology

- Shawn Fraye – Innovator
  - US 20080129254 A1

- Aeroelastic flutter effect
  - Sine wave kind – bad!
  - Half-period oscillating – good!

- Small AC current produced
- Windspeed dependent
  - As low as 2 m/s
  - 10mW to 100mW

- Different frequencies
  - 0.5m works with 70-100Hz
  - 1m works with 20-50Hz

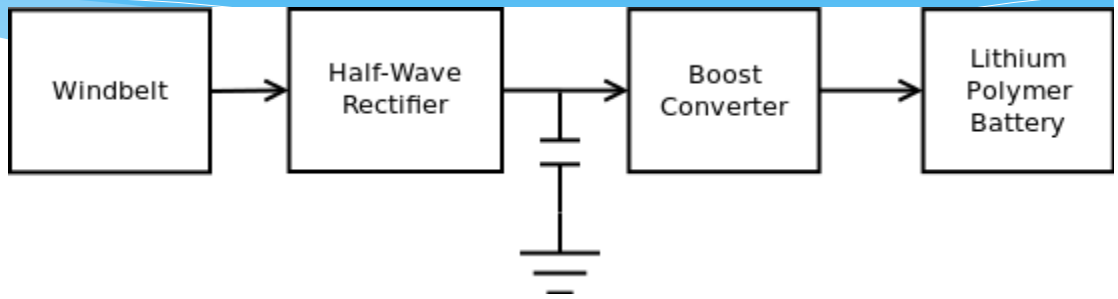


µicroBelt

* Fraye – Humdinger LLC
* 13cm x 3cm x 2.5cm
* Made for MCU!

* 0.2mW at 3.5 m/s
* 2.0mW at 5.5 m/s
* 5.0mW at 7.5 m/s
* All at 70 Hz

Risk Mitigation Design



PROS

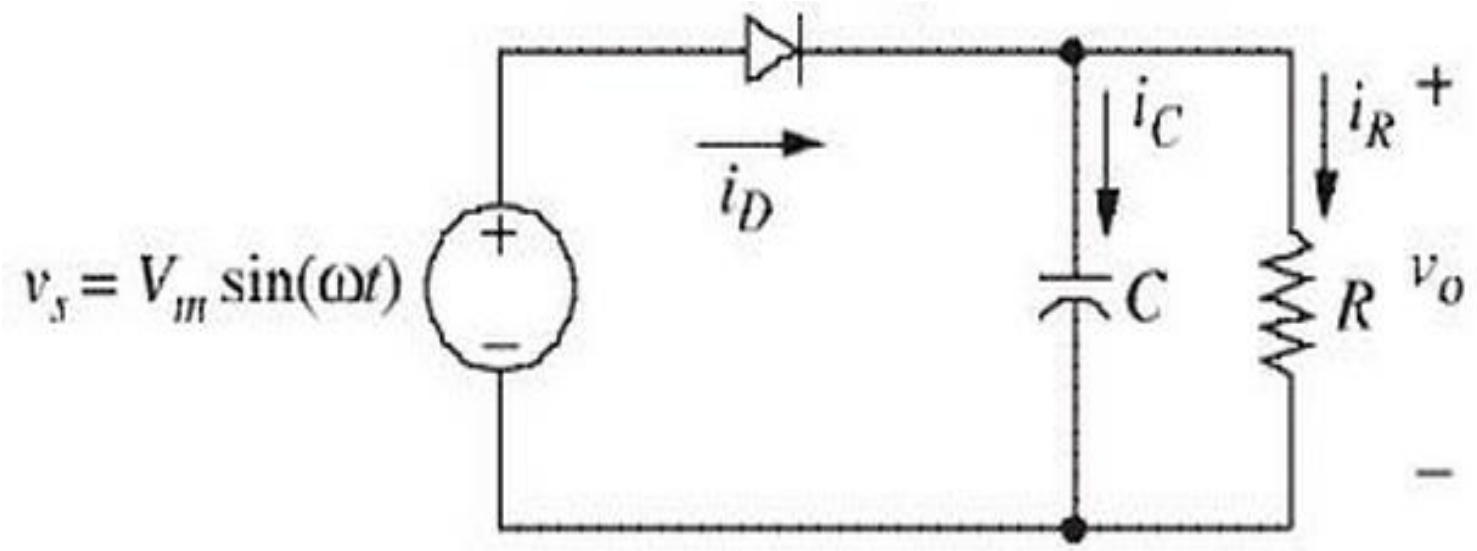
- Maintain Li-Po battery charge
- Sustainable energy
- Risk associated
- Li-Po battery needs
  - Certain current
- Low-Profile
- Minimal cost – a few quarters
- Innovative!

CONS

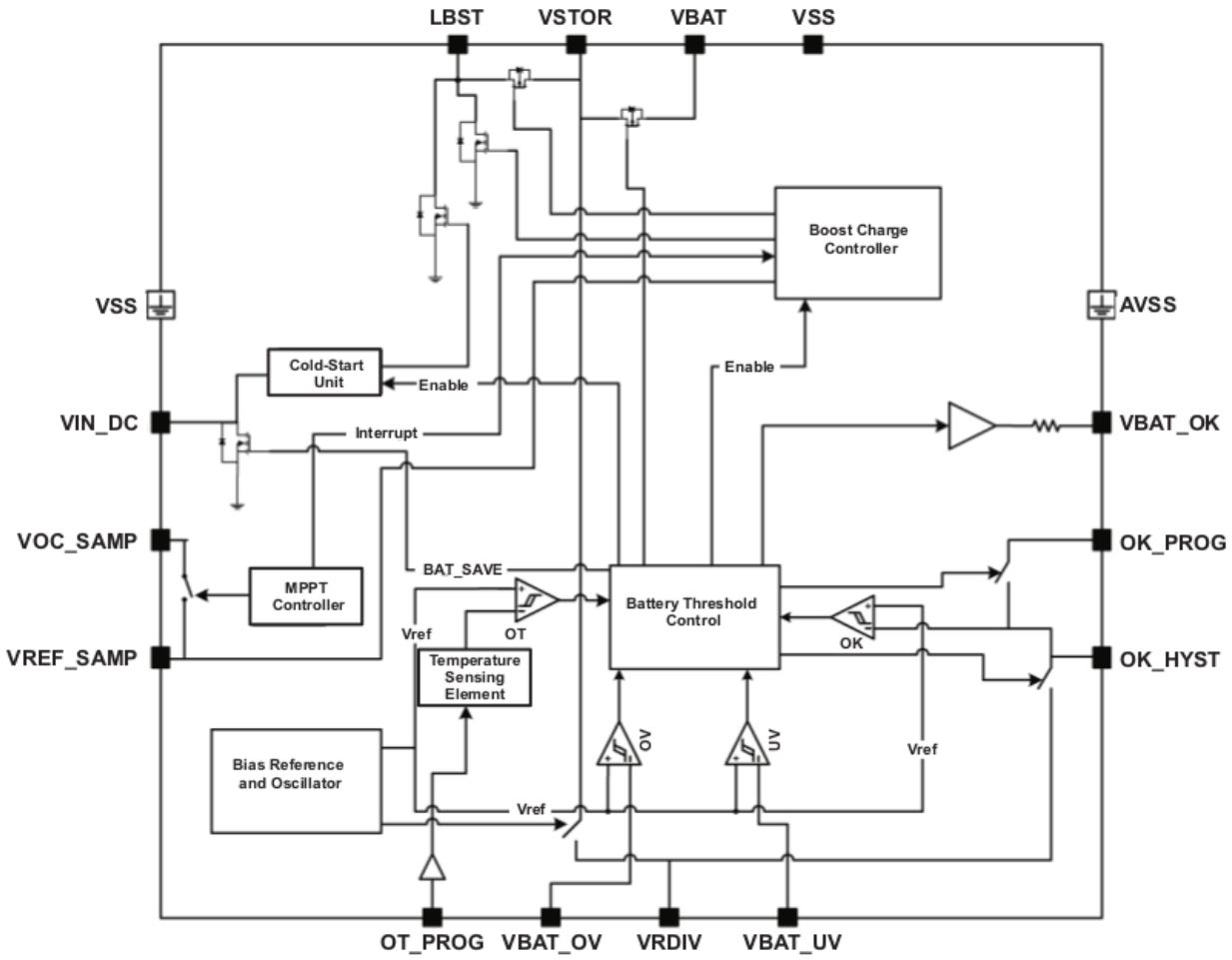
- Things could catch fire
- Parts could be damaged
- Cost of time and money
- More… much more… could be damaged

Risk Mitigation Design

Quick quiz: Name that circuit.



Risk Mitigation Design



- TI bq25504
- Boost Converter
- Low Voltage Cold-Start
- MPPT
- Battery Threshold Ctrl
- Temp Sensing
- Boost Control
- Programmable over and under-voltage protection
- TI ensures cell chemistry compatible

Parts List

Part Description	Cost(unit)	Effective Cost	Qty	Availability
Windbelt Case	$10	May be $0	15	RIT 3D Printing Facilities. Requires a CAD design.
Windbelt Band	$1	May be $0	15	Ribbon acquired for use
Windbelt Magnet	$1	May be $0	15	Reuse hard drive magnets
Windbelt Transformer	$4	May be $0	15	Hand coiled with available wire
Half-Wave Rectifier Schottky Diodes	$0.15	$2.25	15	CE Department or order through Sparkfun. In stock.
Half-Wave Rectifier Resistors/Capacitors	$0.10	$3.00	30	CE Department or order through Sparkfun. In stock.
TI Boost Converter	$5.51	$82.65	15	Order through Digi-Key. In stock
Li-Po Battery	$10.00	$150	15	Order through MCM Electronics. In stock.

Testing Strategy

* Early testing – vary length, fan speed, distance from fan, angle the belt is to source.
  Focus on – compactness of design, max AC
* Intermediate I– continue with optimal design.
  Connect to rectifier and test
  Focus on – adequate smoothing levels
* Intermediate II – boost converter. MCU connected to non-battery power source
  Focus on – provide safe levels at output

Testing Strategy

* Advanced I – connect battery. Stress test.
  Connect MCU and stress test
  Focus on – duration and level of charge

* Advanced II (Final) – deployment of single node.
  Stress test for as long as Windbelt allows.
  Focus on – operation in outdoor environment

Uncertainties

* Theft
  * How to mitigate?
  * Post node at an elevated position.
* Weather
  * How to mitigate?
  * Enclosure? Wind belt must be exposed!
* Fire
  * How to mitigate?
  * Boost converter