Development of a Low-Cost Ground Magnetometer Station

Power Generation and Signal Processing

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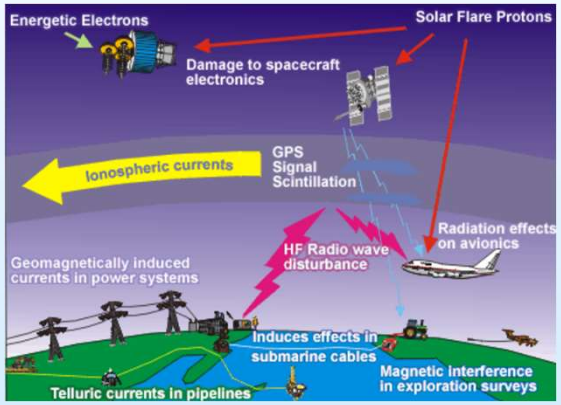
Introduction

- Earth's magnetic field experiences changes due to ejections from the sun
- Changes in magnetic fields results in currents being induced in electrical systems
- Significant spikes can cause system failures that can have devastating impacts
- Previous Magnetometers have considerable cost and maintenance and consequently are sparsely located
- New system aims at being low cost, low maintenance, and increasing density to achieve better data models



Measuring the Signal

- Previous system was not able to obtain a clear signal of Earth's magnetic variances
  - Analyze the application and settings of the selected sensor
  - Develop a filter system allows for the digital sampling of the signal
  - Establish an appropriate noise floor that will allow for accurate data
  - Signal Characteristics:
    - Frequency Range: 0-40Hz
    - Magnetic Field: (0-500nT)

Filtering

- Analog filtering used to reduce unwanted signals outside of the desired frequency band
  - 6^{th} order Butterworth LPF, 40Hz
  - 60 Hz notch Filter
- Sampling Rate was selected at 128 samples per second
  - Allows for the digital filtering of 60 Hz signals
  - Reduces expense of analog filter
- Noise floor was reduced to 16 mv $\sim 2nT$
  - Allows for the capture of substorms

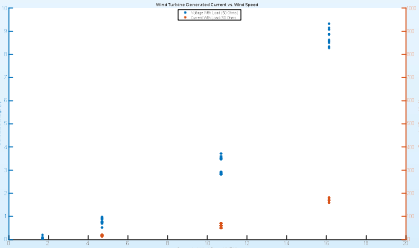
Power Problem

- Researching Low-Cost Autonomous Magnetometer Stations Charging Solution
  - Current System : Solar
    - Couldn't reliably charge battery for long time periods
  - Supplementary System : Wind
- Purposed solution for testing
  - 50W Wind Turbine Generator (AMG Power Solutions)
  - Voltage and Current Sensor (Arduino UNO and Adafruit INA260)
  - Turbine Control Circuit (PIKASOLA Controller)
  - Blade Assembly
    Savonius Blade for Higher Torque at Low Wind Speeds

Testing

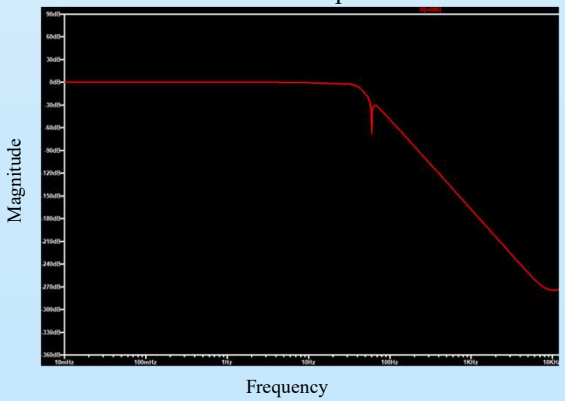
- Testing was Conducted in the UNH Wind Tunnel
  - 2 multimeters (Voltage & Current), 1 Anemometer (Wind Speed)

MPH	feet per minute (+-40 ft/minute	Voltage	Current
1.7	174	0.2	0
1.7	174	0.05	0
1.7	174	0.1	0
1.7	174	0.07	0
1.7	174	0.03	0
4.7	415	0.94	0.0151
4.7	415	0.89	0.0193
4.7	415	0.75	0.0198
4.7	415	0.73	0.0208
4.7	415	0.88	0.0195
4.7	415	0.75	0.0191
4.7	415	0.52	0.015
4.7	415	0.79	0.0152
4.7	415	0.98	0.0183
4.7	415	0.69	0.0153
10.69	940	3.51	0.07
10.69	940	3.72	0.07
10.69	940	3.53	0.06
10.69	940	3.6	0.07
10.69	940	3.47	0.06
10.69	940	2.93	0.05
10.69	940	2.83	0.05
10.69	940	2.82	0.05
10.69	940	2.9	0.06
10.69	940	2.84	0.06
16.13	1420	9.14	0.18
16.13	1420	8.87	0.17
16.13	1420	9.07	0.18
16.13	1420	8.62	0.17
16.13	1420	8.28	0.16
16.13	1420	8.33	0.16
16.13	1420	8.5	0.17
16.13	1420	8.56	0.17
16.13	1420	8.87	0.17
16.13	1420	9.32	0.18

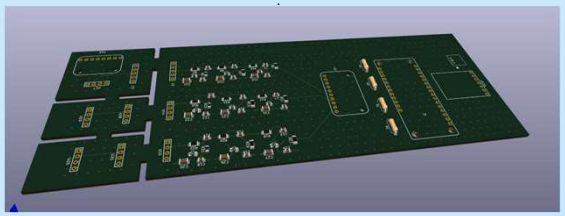


System Realization

Filter Response



PCB Implementation



Future Work / Final Thoughts

- Wind Turbine with Higher wattage
- Combined Solar and Wind Turbine
- Using Commercial Solution for more reliability
  - Comes with higher cost for reliable solutions
- Final Wind Tunnel Test With Controller Circuit
  - Proof of Concept and Final Testing