Electronic Instrumentation Design to Measure Electrical Currents in Space using a Rogowski Coil

Team: Brian Gannon, Ryan Taylor Advisors: Dr. Wayne Smith, Dr. Matthew Argall, Dr. Dean Sullivan

Department of Electrical Engineering, University of New Hampshire, Durham, NH 03824

Introduction

Space weather is the result of activity on the sun's surface that causes charged particles and electromagnetic radiation to be emitted into regions close to earth.

Goal: Design and construct an analog filter with the use of a Rogowski Coil to directly measure electrical currents.

Problem/Motivation: Directly measuring the events of space weather via. electrical currents will help us better prepare for solar storms and coronal mass ejections (CME) which can damage power grids, satellites, and general electronics.

System Block Diagram

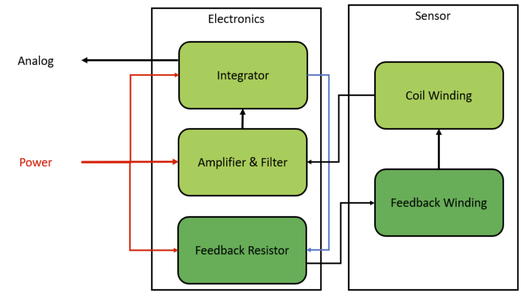

Figure 1: RC Block Diagram

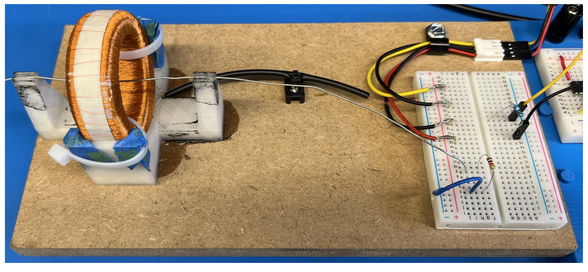

Figure 2: Benchtop Version of Rogowski Coil

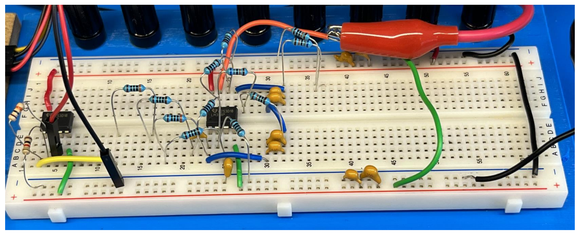

Figure 3: Constructed Cascaded Filter

Benefits of Utilizing a Rogowski Coil

- Compact, durable, and simplistic design
- Toroidal winding of copper wrapped 7500 times around a ferrite core, acting as a current transformer
- High permeability which serves to amplify the signal by enhancing the induced magnetic field produced by the windings

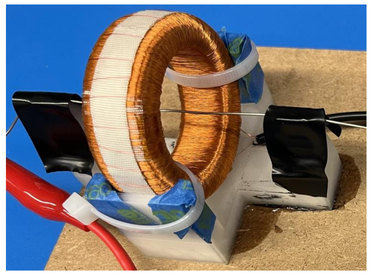

Figure 4: Rogowski Coil

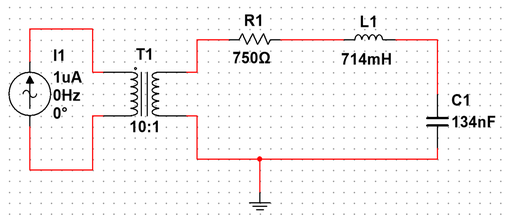

Figure 5: Multisim Schematic of Rogowski Coil

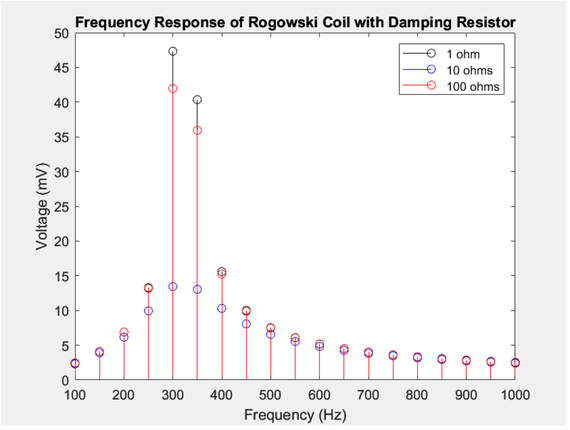

Figure 6: Frequency Response of Rogowski Coil with Current of 1mA and Damping Resistors of 1Ω , 10Ω and 100Ω

Analog Filter Circuit Design

The circuit is designed to filter and amplify the signal received from the Rogowski Coil which was accomplished by designing a bandpass filter.

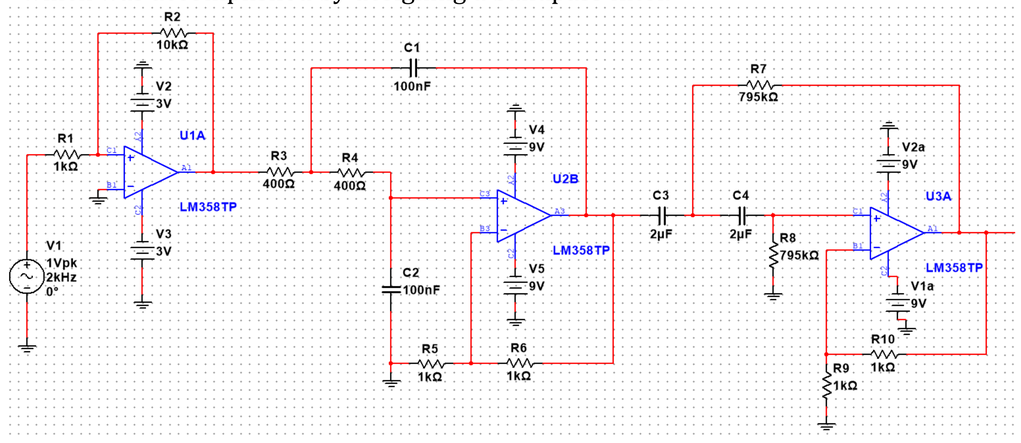

Figure 7: Multisim Schematic of Cascaded Filter

First Stage:
- Amplification Stage
- Gain of 10

Second Stage:
- Low Pass Filter
- Cutoff Frequency of 4kHz

Third Stage:
- High Pass Filter
- Cutoff Frequency of 0.1Hz

Results

- Compacted filter design from 9 to 3 op-amps
- Reduced noise and voltage consumption while idle
- Achieved a measured range of frequencies from 0.1Hz to 4kHz
- Achieved a measured range of current from 1mA to 100mA
- Achieved a measured voltage down to 200mV AC while idle

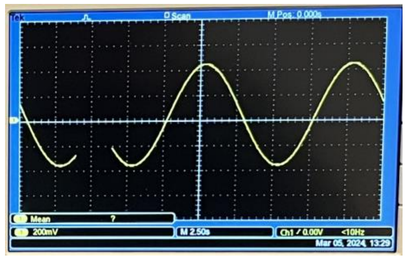

Figure 8: Cutoff Frequency at 0.1Hz

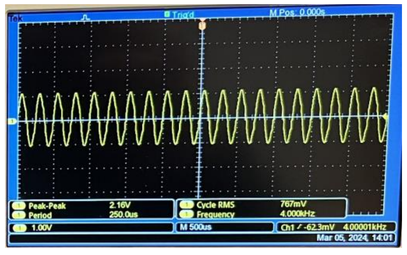

Figure 9: Cutoff Frequency at 4kHz

Conclusions

The redesigned filter with the given coil specifications allowed us to successfully measure current through a wire using the Rogowski Coil. We encountered various design and testing issues that we plan to improve upon:

Challenges:
- External magnetic interference with coil
- Constructing the filter with low noise and power consumption while idle
- Time constraints during testing phase

Future Improvements:
- Plan to utilize an IC with lower quiescent current, lower noise voltage density, and lower voltage consumption than the LM358
- Print electronic components onto PCB
- Digitize and packetize the receiving data
- Implementation of NASA telemetry methods