

# Assessment of a Low-Cost Magneto-Inductive Magnetometer for Personal Space Weather Stations

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## Abstract

Low-cost ground-based magnetometers are an important component of Personal Space Weather Station (PSWS) efforts, yet their performance in urban residential environments remains poorly constrained. This work investigates how nearby homes and urban electromagnetic interference influence the noise floor of the RM3100 magneto-inductive magnetometer. Four short-duration measurements were conducted at two locations within a residential property to examine this question. At each location, magnetic field data were collected using a pipe-based apparatus and within a shielded cage, resulting in four experimental configurations. Each measurement spanned approximately one week, producing a total of four weeks of data. Noise characteristics and signal stability are compared across locations and shielding conditions to evaluate the hypothesis that shielding reduces environmental interference and that RM3100-based systems deployed in urban settings can provide data suitable for PSWS applications. By characterizing the limitations and practical considerations of residential magnetometer deployments, this work supports the use of low-cost instrumentation in citizen science, amateur radio-driven space weather studies, and distributed ground-based monitoring networks relevant to both community participants and the broader space physics community.

## Introduction

The Personal Space Weather Station (PSWS) project, promoted by HamSCI and funded by the National Science Foundation (NSF), develops low-cost ground-based magnetometers for citizen science networks. When deployed in arrays, these instruments provide system-level measurements that complement other PSWS sensors [4]. This study evaluates the RM3100 magnetometer, a PSWS module recognized by HamSCI that offers high resolution at a cost of about \$20 [1]. The effects of suburban magnetic interference and mu-metal shielding on measurement precision are investigated.

## Method/Experimental Setup

- Four week-long experiments conducted at two locations: (CLOSE) and (FAR), selected for expected differences in magnetic noise.
- RM3100 buried vertically, with ~10 in. above ground.
- Connected by 100-ft Ethernet to a shed containing the PSWS data system and Raspberry Pi hat (Fig 1), following the configuration in [2].
- Shielding tests: magnetometer placed in a mu-metal enclosure (six cylinders with cardboard and foam insulation).
- Enclosure placed on stone pavers and covered to protect from moisture (Fig 3).



Fig 1 (PSWS) Magnetometer housing apparatus connected to the raspberry pi via raspberry pi hat



Fig 3.(SFAR) Apparatus inside Mu Metal enclosure with top trash bag removed

## Experiments and Data Analysis

The magnetometer noise floor was determined by examining the noise density at 0.1 Hz using Welch's method from the SciPy Python library, following the approach used in [3]. Unlike [3], which sampled at 40 Hz and evaluated the noise floor at 1 Hz, this experiment sampled at 1 Hz and evaluated the noise floor at 0.1 Hz. Additionally, instead of ten 1-hour measurements, a total of around ~170 one-hour measurements were collected.

- Week 1 (FAR): Magnetometer buried vertically at location FAR for one week. Mean Noise Floor @ 0.1 Hz: 3.23 nT/VHz
- Week 2 (Buried / Unshielded – CLOSE): Same procedure repeated at location CLOSE. Mean Noise Floor @ 0.1 Hz: 5.74 nT/VHz
- Week 3 (Mu-Metal Shielded – SFAR): Magnetometer placed vertically inside the mu-metal enclosure. Mean Noise Floor @ 0.1 Hz: 4.11 nT/VHz (27.2% increase from FAR)
- Week 4 (Mu-Metal Shielded – SCLOSE): Shielded experiment repeated at location CLOSE. Mean Noise Floor @ 0.1 Hz: 3.26 nT/VHz (43.2% decrease from CLOSE)

## Conclusion

This experiment determined the noise floor of the RM3100 magnetometer using the Power Spectral Line Density method described in [3]. The high variance in SFAR results makes it difficult to confirm that magnetic shielding improves measurement accuracy, likely due to interference from the unshielded X direction since shielding only covered the Y-Z plane. In practice, proximity to residential structures appears to be the primary factor affecting the noise floor. The results are consistent with estimates in [2], indicating a field resolution of about 10 nT, and show that typical residential environments can influence the instrument's effective resolution.

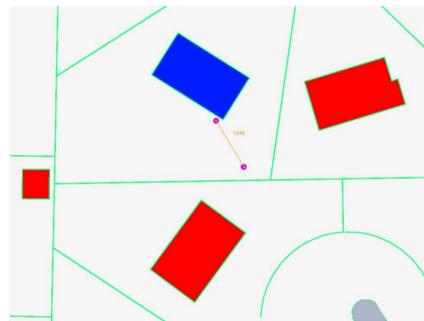


Fig 2.(LOCATION) The residence testing the magnetometer (Blue), at FAR and CLOSE (Purple), with homes nearby (Red), Separated by 154ft (Orange) about property lines (Green)

EXPERIMENT	NOISE FLOOR @ 0.1Hz	Std. DEV
FAR	3.23 nT/VHz	0.76
CLOSE	5.74 nT/VHz	1.78
SFAR	4.11 nT/VHz	1.70
SCLOSE	3.26 nT/VHz	1.06

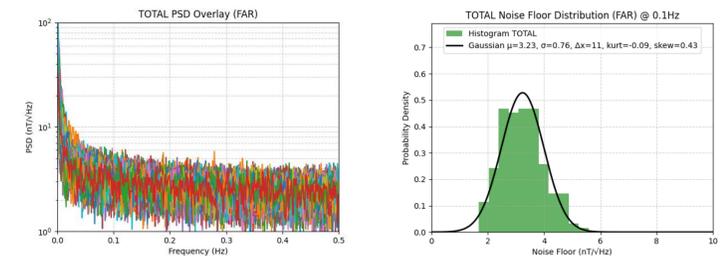


Fig 4 Power Spectral Line and Distribution Function (FAR)

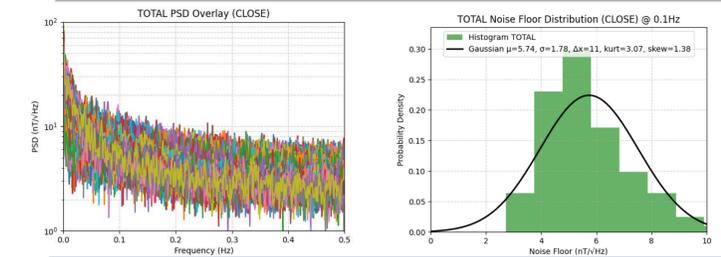


Fig 5 Power Spectral Line and Distribution Function (CLOSE)

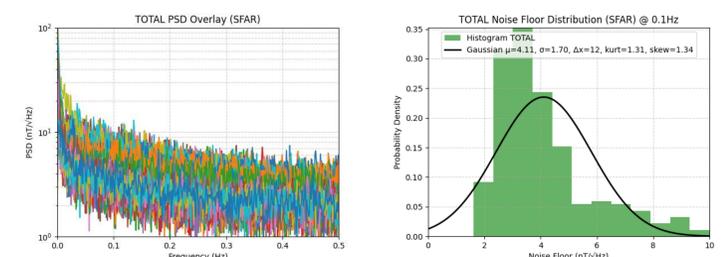


Fig 6 Power Spectral Line and Distribution Function (SFAR)

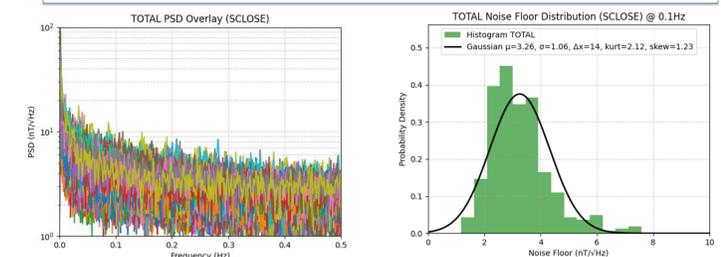


Fig 7 Power Spectral Line and Distribution Function (SCLOSE)

## References

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