

## ***Interactive comment on “A Hybrid Fluxgate and Search Coil Magnetometer Concept Using a Racetrack Core” by David M. Miles et al.***

### **Anonymous Referee #2**

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#### General comments:

The authors argue to provide a proof-of-concept of a hybrid magnetometer design which is meant to be a fluxgate and a search coil sensor at the same time. The work performed is certainly interesting to the community but strictly speaking, the proof-of-concept has not been accomplished. This must be made clear in the abstract and the conclusion. The lack of a feedback circuit, which is essential for a highly linear and stable fluxgate magnetometer, combined with the fact that the search coil mode is just 6 dB better than an air core based sensor make this concept useless even for cubesat applications as long as a science case is missing which could provide the rationale for the acceptance of the poor performance (“Search coil reconstruction provides superior gain and noise only above 1kHz”).

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Specific comments to slicing, filtering and non-linearity:

Slicing is equivalent to decimation of sampled data to sample streams with identical core saturation. This decimation happens without ant-aliasing. Consequently, the resulting 4 data streams (slices) are subject to spectral folding from the original 20 kHz spectrum down to the new sampling frequency of 5 kHz. All distortion, harmonics and noise in the frequency band from 2.5 to 10 kHz is therefore folded into the used spectrum of each of the sliced data sets. This is only somewhat reduced by the first order analog input filter with a cut-off frequency of 5 kHz.

Both, sliced and “all” data sets are subject to different magnetic gains within the core. These gains are time dependent on excitation. If “magnetic data” was directly sampled at the core, one could try to just use the slices that are not subject to saturation to avoid the resulting nonlinearity. Unfortunately, the signal crosses sensor output (RLC network), input amplifier, analog low pass and sampling stage before the digitiser. All of these stages have transfer functions that mix up data from different saturation states unless their combined phase delay is below half a sample. The resulting transfer function has to be considered as nonlinear system with fading memory and cannot be handled easily, if at all.

At the same time, averaging multiple slices means to mix up different gain states which will result in nonlinearity.

Specific comments to feedback-less operation:

The fluxgate does not include a feedback circuit, but regular operation will presumably require it. Feedback reduces the non-linearity of the fluxgate and a trade-off is required between fluxgate linearity and feedback bandwidth. This means that the fluxgate feedback will certainly have an impact on the search-coil action. A digital compensation by modelling will be needed which drives the complexity of the instrument.

Specific comments on noise scales:

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The initial assumption is that the core is more or less free of excitation between the pulses. However, Figure 7 shows that the noise floor is much higher for the excitation-free slice “C”. This is counter-intuitive and requires explanation.

The noise floor and sensitivity of the search-coil part are only slightly better than the fluxgate part. In principle one could assume that operating the fluxgate sensor up to 3 kHz (page 3, line 11) could deliver comparable results with only a minor loss in sensitivity. The importance of this loss needs to be discussed in the context of potential scientific requirements.

Editorial:

It would be of advantage to use the same colour code for the slices in Figure 10 and 11.

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