Introduction

This document provides preliminary review guidance for magnetometer integration into design proposals. The goal of this review is to quickly identify reasonable layout positions and locations for the magnetometer and to eliminate magnetic field sources which cause non-optimal performance for magnetometer-based applications.

This preliminary check does not eliminate the need for more precise magneto-static research in the final design; but it helps guide technical selections in early phases of design. An early integration check is good practice for magnetometers since typically dropping the magnetometer component into a design in the late design phase can result in poor application performance.

The review topics contained in this document are a collection of simplified and generalized ”rules of thumb” to enable a quick first check of integration design candidates. Because there is a wide variety of magnetic field sources, estimates in this review are done using extreme values in order to simulate the full population of magnetic field sources. This preliminary check works well when there are only a few different disturbing magnetic field sources. This review divides the design volume (3D) into four regions to simplify and classify the decisions needed for individual magnetic field sources relative to the magnetometer.

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Preliminary Review

Before any integration design review, the performance targets of the application must be clear. This means setting limits for the cumulative magnetic field properties as measured at the **magnetometer**:

- Design limit for the total maximum static offset (remanence)
  - typically in the range of 200 to 600µT
- Design limit for the static offset attributed to a single magnetic field source
  - typically in the range of 1/15 - 1/8 of the total maximum static offset design limit value
- Design limit for the maximum magnetic field noise variation
  - typically < 2µT

The values of the design limit targets will define the overall application performance level in normal use case circumstances.

Using this "Early Check" method, the magnetic field source's remanence and distance to magnetometer must be first estimated. Careful collection of the magnetic field environment information is recommended before this review.

Basis

This magneto-static review is based on a cumulated static and noise magnetic field properties estimation. Because distance is the only practical cure for avoiding the effects of magnetic field disturbances, the first check is a review of the distance between the magnetometer and the magnetic field sources.

For this preliminary review, magnetic field sources are categorized into four zones according magnetometer component placement. Sources of magnetic fields are:

- Mechanical Constructions
- Electrical components
- PWB layout

The result of this review is a list of magnetic field sources which exceed defined warning zone limits.

Warning zones

Warning zones are predefined guidance setup for integration help. Zone limits are very simplified and are only for guidance. Warning zones dimensions are 3 dimensional.

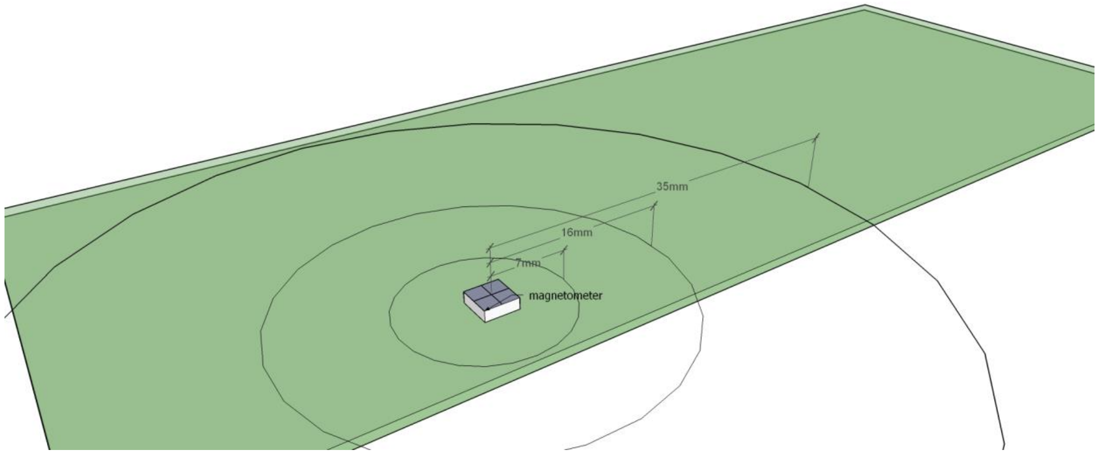

Figure 1. Warning zone guidance

Constructions

For mechanical construction near the magnetometer component, guidance is simple and clear, but hard to implement because low coercive ferromagnetic materials are widely used in designs for their mechanical strength.

Typical mechanical constructions are:

- Cover mechanics
- Frame mechanics
- Moving mechanisms like hinges or slides
- BB and RF shielding cans in PWB
- Screws, nuts, and housing blocks

Structures to avoid placing near the magnetometer:

- Ferromagnetic materials (μr >1.03 and coercive force >100A/m)
- Unknown ferromagnetic materials
- Moving ferromagnetic constructions
- Ferromagnetic parts which have been cut, punched, welded or bent

Warning zone definitions for construction related magnetic field sources:

1. beyond 3rd warning zone: > 35 mm distance – big volume and heavy Carbon Steel parts
2. 3rd warning zone: between 16mm to 35mm distance – only for moderate capacity magnetic field sources (Smaller Carbon Steel material parts and other Stainless Steel material are okay.)
3. 2nd warning zone: between 7mm to 16mm distance – only low capacity and smaller volume magnetic field sources (SUS304, SUS305, German Silver level structures are okay.)
4. 1st warning zone: closer than 7mm to magnetometer – no ferromagnetic constructions at all

Placement of components

Some (electrical and mechanical) components act as disturbing magnetic field sources. The design must place all of these components far enough away from the magnetometer.

Typical disturbing electrical components are:

- Speakers (earpiece, IHF)
- Vibrator (cylinder or coil types)
- Motors and actuators like position motors, voice coil motors etc.
- DC/DC coils (for SMPS)
- RF sources (big current RF power amplifier)
- Battery connectors and the battery poles collector structures
- Wireless chargers
- NFC antennas

Typical disturbing mechanical components are:

- Latch magnets
- Position magnets and their opposite attaching parts

Components to avoid near the magnetometer:

- Permanent magnets
- Moving parts with permanent magnets
- RF sources

Warning zone definitions for component placement related magnetic field sources:

1. Beyond 3rd warning zone: Speakers and other big permanent magnets are okay.
2. Within 3rd warning zone: Moderate capacity magnetic field sources (like coils and very small permanent magnets) are okay.
3. Within 2nd warning zone: No permanent magnetic field sources permitted at all. Smaller coils are okay
4. Within 1st warning zone: None of these components at all.

PWB layout

Magnetometer placement on the PWB is a compromise between the other components' functionality and the magnetometer's magnetic field disturbance issues. Practically speaking, there is not much freedom for the magnetometer's placement. Typically, the best place for a magnetometer is on or near the edge of the design integration area.

The PWB has current carrying traces. Currents (DC/AC) greater than >8mA must be routed around the magnetometer by a distance of greater than >7mm. Even the return path current flow must be prevented from flowing under the magnetometer in all PWB layers. Because the ground plane in one PWB layer can also be a return current route, **no ground plane should pass under the magnetometer**.

Typical low energy digital signals (data, address and control busses) do not harm magnetometer measurement signals. Therefore, those can be routed under the magnetometer in any PWB layer.

Typical sources of magnetic field disturbances which are generated from currents are:

- battery current
- RF PA current
- return path current
- layout openings under the sensor

Other disturbing elements in PWB:

- The nickel (Ni) layer under the gold (Au) plating area in the PWB under the magnetometer
- Large areas of nickel-gold (NiAu) plating near the magnetometer

Warning zone definitions for PWB related magnetic field sources:

1. Beyond 2nd warning zone: Current traces over 0.2A are okay.
2. Within 2nd warning zone: Current traces under 0.2A are okay. No large areas of NiAu plating.
3. Within 1st warning zone: Only high impedance digital and analog signals (data, address and control busses) under magnetometer are allowed. Return path current flow (i.e. ground plane) should be prevented. No NiAu plating areas at all are allowed. Only traces with currents <8mA are allowed, but not directly under the magnetometer.

Results analysis

If more than one magnetic field source is within the zone limits, then there will be a higher risk for poor magnetometer application performance.

Because cumulative effects are not taken into account, this simple check is not good for designs where there are many (>10) magnetic field sources within the warning zones. Magneto-static simulations for the design integration are recommended in such cases where many different magnetic field sources exist within a design.

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- A partnership approach that begins with early development and extends way beyond the purchase order, culminating in our customer's delivery of their product to market.
- World-class manufacturing capacity and capability that enables us to meet volume production on stringent deadlines.

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Kionix utilizes a deep-silicon, proprietary MEMS technology known as plasma micromachining for its high-volume production. This technology enables Kionix to produce MEMS products that are unmatched in performance and manufacturing cost. As such, the Company holds an extensive portfolio of licensed and internally-developed intellectual property.

Kionix was acquired by ROHM Co., Ltd. of Japan on November 16, 2009. Kionix is able to leverage ROHM's resources as a leading semiconductor company in order to advance its technology, sustain its growth while reducing costs, and expand its global reach through an established and thriving international customer base. The Company continues to operate as Kionix and its products continue to be produced primarily at its headquarters in Ithaca, New York, USA. Kionix's commitment to customers in sales, development support, integration expertise, and pricing remains paramount.

Today, Kionix continues to respond to growing market demand for increased product applications, while creating new product opportunities in industries as diverse as automotive, consumer electronics, biotechnology, wireless communications, and pharmaceutical research.

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