Magnetoresistive sensors for a Magnetometer

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Technology Survey

- Induction sensors
- Magnetic sensors
- Anisotropic Magnetoresistors (AMR)
- Super Conducting Quantum Interference Devices
- Fluxgate Magnetometers
- Anisotropic Magnetoresistors (AMR)

AMR Concept Justification

CONCEPT 1 - Fluxgate
Power Consumption: < 900 mW
Mass: 450 gr
Size: 11 cm x 6cm x 4.5 cm
(Mass x Width x Height)
Most widely used in space MTM

CONCEPT 2 - AMR
Power Consumption: < 600 mW
Mass: 195 gr
Size: 8 cm x 6cm x 3.2 cm
(Mass x Width x Height)
Microchip Technology

Comparison

Concept Technology Comparison Table

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<tr>
<th>Specifications</th>
<th>AMR Concept</th>
<th>Fluxgate Concept</th>
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<tr>
<td>Mass</td>
<td>Lighter</td>
<td>Heavier</td>
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<tr>
<td>Dimensions</td>
<td>Smaller</td>
<td>Bigger</td>
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<tr>
<td>Power</td>
<td>Lower Power</td>
<td>Higher power consumption</td>
</tr>
<tr>
<td>Calibration</td>
<td>Easy to calibrate</td>
<td>Not so easy to calibrate</td>
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<tr>
<td>Orthogonality</td>
<td>Lower Orthogonality between (x,y) plane and z axis</td>
<td>Better Orthogonality</td>
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<tr>
<td>Reliability</td>
<td>No accurate data. (AMR sensors from earth need to be calibrated)</td>
<td>Good (Mission life time)</td>
</tr>
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</table>

Low Cost AMR Magnetometer
Analogue AMR Sensor Element Description

- 3-axis AMR sensor
- Differential output (out+ / out-), varies with the magnetic field
- Output typically (5 to 10 mV)

Principles of Operation

- **Power Converter**
- **Set / Reset**
- **Signal Conditioning Module**
- **Test Connector / Health Check**

**Low Cost AMR Magnetometer**

**Block Diagram**

- **SET / RESET**
  - Restores magnetization vector
  - Performed by built-in circuit straps
  - Maintain repeatability
  - Maintain low noise output

**Low Cost AMR Magnetometer**

**Test Connector**

- Uses built-in straps to create a magnetic field

**Low Cost AMR Magnetometer**
Achieved Parameters with AMR Concept

- Power Consumption: < 600 mW
- Linearity: better than 1%
- Noise: <40 nT
- Resolution: 100 nT
- Offset: < 300 nT (without calibration)
- Mass: 195 gr
- Size: 8 cm x 6 cm x 3.2 cm (Length x Width x Height)

AMR magnetometer Exploded Diagram

- Length x width x Height: 8 cm x 6 cm x 3.2 cm
- AMR Sensor: Not Actual Size
  Actual: 8 x 4 x 3.81 mm

Preliminary Tests Already Performed

- Radiation tests
  Performed at Estec (Holland)
- Thermal cycling
  Performed at Chipidea (Portugal)

Preliminary Tests Already Performed

- Radiation Tests
  (Performed at Estec)

- Two brands of sensors were tested:
  - 2-axes AMR sensor
  - 3-axes AMR sensor
Preliminary Tests Already Performed

Thermal Cycling
(Performed at Chipidea)

Test performed according with MIL-STD-883E

- Two brands of sensors were tested:
  - 2-axes AMR sensor
  - 3-axes AMR sensor
- No effect on sensor’s performance detected

Low Cost AMR Magnetometer

Thermal Cycling
Test description

- Ten cycles
- Max temp: +100ºC
- Min temp: -55ºC

Conclusions

AMR Magnetometer Performances

- Simple
- Small
- Light
- Low Power

Suitable for AOCS purposes

Future work

- AMR Qualification (End 2003)
- Magnetometer Qualification (2004)
- Possible First flight (2004-2005)

Aknowledgments

Financial Support from ESA/ESTEC

Contract “Low Cost Magnetometer Feasibility Study”

Facilities Support from ESA/ESTEC

Radiation Testing

Low Cost AMR Magnetometer