Features and Benefits

- **3-axis** magnetometer device suitable for position sensors applications Triaxis® (Hall Technology)
- Suitable for space constrained applications (only 2 x 2.5 x 0.4mm)
- Compatible with I2C FM+
- Low power application – Idle mode current of 7nA
- Supply voltage from 1.7V to 3.6V
- Ambient temperature range from -40°C to 105°C
- Digital Output
  - 16-bit Magnetic (XYZ)
  - 16-bit Temperature
- At runtime selectable modes
  - Magnetic axis selection
  - Single Measurement
  - Continuous Mode up to 1.4kHz (XYZ)
- RoHS Compliant & Green Package

Application Examples

- Battery powered applications
- Power tools - Screwdriver trigger
- Home security - door/ window opening detection
- Knobs for White goods
- PC peripheral – Mouse roller
- Gaming pads
- Joystick with back-bias magnet
- Industrial Pneumatic cylinder

Description

The device, especially designed for micropower battery powered applications, measures magnetic fields along the 3 axis X, Y and Z (Y being in a plane parallel to the surface of the die, Z being perpendicular to the surface). Those measurements and the IC temperature are converted into 16-bit words which are transferred upon request over I2C communication channel. The device transmits compensated raw measurement data of the selected Bx, By, Bz or a combination.

The MLX90397 is designed for position sensor applications with a +/-50mT range and an adaptive range on Bz of +/-200mT.
1. Ordering information

<table>
<thead>
<tr>
<th>Ordering Code</th>
<th>Temperature</th>
<th>Package</th>
<th>Type</th>
<th>Output</th>
<th>Packing</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>MLX90397RLQ-AAA-000-RE</td>
<td>-40°C to 105°C</td>
<td>UTDFN-8 2x2.5</td>
<td>+/-50mT</td>
<td>I2C</td>
<td>Reel</td>
<td>I2C address = 0x0D</td>
</tr>
</tbody>
</table>

*Table 1 – Ordering codes*

**Legend:**

- MLX90397RLQ-AAA-000-RE
  - Packing delivery form
  - Option code for variant
  - Silicon & firmware version
  - Package code
  - Temperature code
  - Product name
2. Contents

FEATURES AND BENEFITS ............................................................................................................. 1
APPLICATION EXAMPLES ............................................................................................................. 1
DESCRIPTION .................................................................................................................................. 1
1. ORDERING INFORMATION ......................................................................................................... 2
2. CONTENTS .................................................................................................................................... 3
3. GLOSSARY OF TERMS ................................................................................................................ 5
4. PINS DESCRIPTION AND BLOCK DIAGRAM ........................................................................... 6
   4.1. Pins description ..................................................................................................................... 6
   4.2. Block diagram ....................................................................................................................... 6
5. CONDITIONS AND SPECIFICATIONS ....................................................................................... 7
   5.1. Absolute Maximum Ratings (AMR) ....................................................................................... 7
   5.2. Operating Conditions ............................................................................................................ 8
      5.2.1. General Operating Conditions ...................................................................................... 8
      5.2.2. Electrical Operating Conditions .................................................................................... 8
      5.2.3. Magnetic Operating Conditions .................................................................................... 8
   5.3. Electrical Specifications ........................................................................................................ 9
   5.4. Magnetic Specifications ....................................................................................................... 13
   5.5. Timing Specifications .......................................................................................................... 14
   5.6. Accuracy Specifications ....................................................................................................... 17
6. FUNCTIONAL DESCRIPTION & INTERFACES ......................................................................... 17
   6.1. Operating Modes .................................................................................................................. 17
      6.1.1. Single measurement mode .............................................................................................. 18
      6.1.2. Continuous measurement Mode .................................................................................... 19
      6.1.3. Idle mode ...................................................................................................................... 23
   6.2. Measurement axis selection ................................................................................................. 23
   6.3. Magnetic range selection .................................................................................................... 24
   6.4. Output protocol (I2C) description ......................................................................................... 24
      Command implementation ....................................................................................................... 24
   6.5. Memory items description .................................................................................................... 27
      6.5.1. Memory Structure ........................................................................................................ 27
      6.5.2. I/O registers description ............................................................................................... 28
   6.6. Flowchart ............................................................................................................................. 34
   6.7. Noise Performance Graphs ................................................................................................ 35
      Without temperature compensation ...................................................................................... 35
      With temperature compensation .......................................................................................... 37
   6.8. Temperature compensation ............................................................................................... 39
7. APPLICATION INFORMATION ................................................................................................... 39
   Recommended application diagram .......................................................................................... 39
8. PACKAGE AND MANUFACTURABILITY INFORMATION ......................................................... 39
   8.1. ESD precaution .................................................................................................................... 39
   8.2. Package information – UTDFN8 ........................................................................................ 40
      8.2.1. Dimensions .................................................................................................................. 40
      8.2.2. Sensing element placement .......................................................................................... 41
      8.2.3. Marking ....................................................................................................................... 42
   8.3. Standard information on soldering processes ..................................................................... 43
      8.3.1. Storage and handling of plastic encapsulated ICs ............................................................ 43
      8.3.2. Assembly of encapsulated ICs ....................................................................................... 43
      8.3.3. Environment and sustainability .................................................................................... 43
9. TABLES ........................................................................................................................................ 44
10. FIGURES .................................................................................................................................... 44
11. REVISION HISTORY .................................................................................................................. 45
## 3. Glossary of terms

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NC</td>
<td>Not Connected</td>
</tr>
<tr>
<td>ADC</td>
<td>Analog-to-digital converter</td>
</tr>
<tr>
<td>LSB</td>
<td>Least significant bit</td>
</tr>
<tr>
<td>MSB</td>
<td>Most significant bit</td>
</tr>
<tr>
<td>Gauss (G)</td>
<td>Units for magnetic flux density – 1mT = 10G</td>
</tr>
<tr>
<td>RMS</td>
<td>Root mean square</td>
</tr>
<tr>
<td>DSP</td>
<td>Digital signal processing</td>
</tr>
</tbody>
</table>

*Table 2 – Glossary of terms*
4. Pins Description and Block diagram

4.1. Pins description

<table>
<thead>
<tr>
<th>Pin #</th>
<th>Name (I^2C)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SCL</td>
<td>[I] Bus clock</td>
</tr>
<tr>
<td>2</td>
<td>Not used</td>
<td>Not Connected</td>
</tr>
<tr>
<td>3</td>
<td>VSS</td>
<td>[S] Ground</td>
</tr>
<tr>
<td>4</td>
<td>SDA</td>
<td>[I/O] Bus Data</td>
</tr>
<tr>
<td>5</td>
<td>Not used</td>
<td>Not connected</td>
</tr>
<tr>
<td>6</td>
<td>VDD</td>
<td>[S] Supply</td>
</tr>
<tr>
<td>7</td>
<td>RESB</td>
<td>[I] Reset</td>
</tr>
<tr>
<td>8</td>
<td>VDD_I^2C</td>
<td>[S] I/O supply</td>
</tr>
</tbody>
</table>

Table 3 – Pin description

4.2. Block diagram

Figure 1 – Block diagram
5. Conditions and Specifications

5.1. Absolute Maximum Ratings (AMR)

Operating Characteristics, $T_A = -40^\circ$C to $105^\circ$C (unless otherwise specified)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Voltage</td>
<td>$V_{DD}$</td>
<td>4</td>
<td></td>
<td></td>
<td>V</td>
<td>&lt;48h</td>
</tr>
<tr>
<td>Reverse supply voltage protection</td>
<td>$V_{DDREV}$</td>
<td>-0.3</td>
<td></td>
<td></td>
<td>V</td>
<td>Room temp, &lt;48h</td>
</tr>
<tr>
<td>Supply voltage I2C</td>
<td>$V_{DD,I2C}$</td>
<td>4</td>
<td></td>
<td></td>
<td>V</td>
<td>&lt;48h</td>
</tr>
<tr>
<td>Reverse I2C supply voltage protection</td>
<td>$V_{DDREV}$</td>
<td>-0.3</td>
<td></td>
<td></td>
<td>V</td>
<td>Room temp, &lt;48h</td>
</tr>
<tr>
<td>Output voltage</td>
<td>$V_{SDA}$</td>
<td>4</td>
<td></td>
<td></td>
<td>V</td>
<td>&lt;48h</td>
</tr>
<tr>
<td>Reverse output voltage</td>
<td>$V_{SDAREV}$</td>
<td>-0.3</td>
<td></td>
<td></td>
<td>V</td>
<td>Room temp, &lt;48h</td>
</tr>
<tr>
<td>Input voltage</td>
<td>$V_{RESB}, V_{SCL}$</td>
<td>4</td>
<td></td>
<td></td>
<td>V</td>
<td>&lt;48h</td>
</tr>
<tr>
<td>Reverse input voltage</td>
<td>$V_{RESBREV}, V_{SCLREV}$</td>
<td>-0.3</td>
<td></td>
<td></td>
<td>V</td>
<td>typical Vdd operating range, room temp, &lt;48h</td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>$T_A$</td>
<td>-40</td>
<td></td>
<td>+105</td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td>Junction Temperature</td>
<td>$T_{JUNC}$</td>
<td></td>
<td></td>
<td>+105</td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td>Storage Temperature</td>
<td>$T_{storage}$</td>
<td>-40</td>
<td></td>
<td>150</td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td>Thermal resistance</td>
<td>$R_{thja}$</td>
<td>230</td>
<td>40</td>
<td></td>
<td>K/W</td>
<td>Junction to ambient 150p board</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>K/W</td>
<td>Junction to ambient multi layered pcb</td>
</tr>
<tr>
<td></td>
<td>$R_{thjc}$</td>
<td>3.4</td>
<td></td>
<td></td>
<td>K/W</td>
<td>Junction to case</td>
</tr>
<tr>
<td>Magnetic Flux density</td>
<td></td>
<td>-1</td>
<td></td>
<td>1</td>
<td>T</td>
<td></td>
</tr>
</tbody>
</table>

Exceeding the absolute maximum ratings may cause permanent damage. Exposure to absolute maximum-rated conditions for extended periods may affect device reliability.
5.2. Operating Conditions

5.2.1. General Operating Conditions

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Temperature</td>
<td>$T_A$</td>
<td>-40</td>
<td>+105</td>
<td>°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storage Temperature</td>
<td>$T_{\text{storage}}$</td>
<td>-40</td>
<td>150</td>
<td>°C</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5 – General operating conditions

5.2.2. Electrical Operating Conditions

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Voltage</td>
<td>$V_{\text{DD}}$</td>
<td>1.7</td>
<td>1.8</td>
<td>3.6</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>I/O supply voltage</td>
<td>$V_{\text{DD,I2C}}$</td>
<td>1.7</td>
<td>1.8</td>
<td>3.6</td>
<td>V</td>
<td></td>
</tr>
</tbody>
</table>

Table 6 – Electrical Operating conditions

5.2.3. Magnetic Operating Conditions

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Min.</th>
<th>Typ. (1)</th>
<th>Max. (2)</th>
<th>Unit</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnetic Flux density</td>
<td>$B_{xy}$</td>
<td>-50</td>
<td>50</td>
<td>-200</td>
<td>mT</td>
<td>$B_{xy} = \sqrt{B_x^2 + B_y^2}$</td>
</tr>
<tr>
<td>Magnetic Flux density</td>
<td>$B_z$</td>
<td>-200</td>
<td>200</td>
<td></td>
<td>mT</td>
<td>$B_z$</td>
</tr>
</tbody>
</table>

Table 7 – Magnetic Operating conditions

---

1. Above this value, the sensor starts saturating resulting in an increase of the linearity error.
2. For magnetic ranges above 50mT, Melexis only guarantees the performance by design.
5.3. Electrical Specifications

Operating Characteristics, $T_A = -40^\circ\text{C}$ to $105^\circ\text{C}$ (unless otherwise specified)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>RESB high threshold</td>
<td>$I_{DD,RESB}$</td>
<td>49</td>
<td>61</td>
<td>67</td>
<td>%$V_{DD}$</td>
<td>$V_{DD} \leq 1.8V$</td>
</tr>
<tr>
<td>RESB low threshold</td>
<td>$I_{DD,RESB}$</td>
<td>41</td>
<td>50</td>
<td>51</td>
<td>%$V_{DD}$</td>
<td>$V_{DD} &gt; 1.8V$</td>
</tr>
<tr>
<td>RESB hysteresis</td>
<td>$I_{DD,RESB}$</td>
<td>5</td>
<td>11</td>
<td>17</td>
<td>%$V_{DD}$</td>
<td>$+/3\text{sigma}$</td>
</tr>
<tr>
<td>RESB pull down resistance</td>
<td>$R_{PD}$</td>
<td>5</td>
<td>Kohms</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DSP Current</td>
<td>$I_{DD,DSP}$</td>
<td>0.7</td>
<td>1</td>
<td>1.2</td>
<td>mA</td>
<td>$V_{DD} \leq 1.8V$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>mA</td>
<td>$V_{DD} &gt; 1.8V$</td>
</tr>
<tr>
<td>Conversion Current</td>
<td>$I_{DD,CONVXY}$</td>
<td>2.4</td>
<td>2.9</td>
<td>3.5</td>
<td>mA</td>
<td>$XY \text{ axis, } V_{DD} \leq 1.8V$</td>
</tr>
<tr>
<td></td>
<td>$I_{DD,CONVZ}$</td>
<td>2.8</td>
<td>3.4</td>
<td>4.5</td>
<td>mA</td>
<td>$XY \text{ axis, } V_{DD} &gt; 1.8V$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>3.8</td>
<td>5</td>
<td>mA</td>
<td>$Z \text{ axis, } V_{DD} \leq 1.8V$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3.4</td>
<td>4.4</td>
<td>6</td>
<td>mA</td>
</tr>
<tr>
<td>Conversion current</td>
<td>$I_{DD,CONVT}$</td>
<td>0.7</td>
<td>0.9</td>
<td>1</td>
<td>mA</td>
<td>Temperature, $V_{DD} \leq 1.8V$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.1</td>
<td>1.4</td>
<td>1.85</td>
<td>mA</td>
<td>Temperature, $V_{DD} &gt; 1.8V$</td>
</tr>
<tr>
<td>Counting state current</td>
<td>$I_{DD,CNT}$</td>
<td>11</td>
<td>13</td>
<td>15</td>
<td>µA</td>
<td>$V_{DD} \leq 1.8V$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12</td>
<td>20</td>
<td>25</td>
<td>µA</td>
<td>$V_{DD} &gt; 1.8V$</td>
</tr>
<tr>
<td>Idle current</td>
<td>$I_{DD,IDLE}$</td>
<td>7</td>
<td>30</td>
<td></td>
<td>nA</td>
<td>$V_{DD} = 1.8V, T_A = 35^\circ\text{C}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>400</td>
<td>1000</td>
<td></td>
<td>nA</td>
<td>$V_{DD} = 1.8V, T_A = 105^\circ\text{C}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>600</td>
<td>100</td>
<td></td>
<td>nA</td>
<td>$V_{DD} = 3.6V, T_A = 35^\circ\text{C}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2000</td>
<td></td>
<td>nA</td>
<td>$V_{DD} = 3.6V, T_A = 105^\circ\text{C}$</td>
</tr>
<tr>
<td>Temperature sensor resolution</td>
<td>$T_{RES}$</td>
<td>48</td>
<td>50</td>
<td>52</td>
<td>LSB16/°C</td>
<td></td>
</tr>
<tr>
<td>Temperature sensor accuracy</td>
<td>$T_{LIN}$</td>
<td>-3</td>
<td>3</td>
<td>°C</td>
<td>+/-3sigma</td>
<td></td>
</tr>
<tr>
<td>Input Level High</td>
<td>$V_{IH}$</td>
<td>53</td>
<td>65</td>
<td>71</td>
<td>%$V_{DD}$</td>
<td>SDA, SCL</td>
</tr>
<tr>
<td>Input Level Low</td>
<td>$V_{IL}$</td>
<td>37</td>
<td>49</td>
<td>54</td>
<td>%$V_{DD}$</td>
<td>SDA, SCL</td>
</tr>
<tr>
<td>Input Level Hysteresis</td>
<td>$V_{IHYST}$</td>
<td>9</td>
<td>16</td>
<td>21</td>
<td>%$V_{DD}$</td>
<td>SDA, SCL</td>
</tr>
<tr>
<td>Input Capacitance</td>
<td>$C_{in}$</td>
<td>8</td>
<td>15</td>
<td>pF</td>
<td></td>
<td>SDA, SCL</td>
</tr>
<tr>
<td>Output Level Low</td>
<td>$V_{OL}$</td>
<td>2</td>
<td>4</td>
<td>6</td>
<td>mV</td>
<td>SDA (Static, 1mA load)</td>
</tr>
<tr>
<td>Output on resistance</td>
<td>$R_{DSON}$</td>
<td>2</td>
<td>4</td>
<td>6</td>
<td>ohms</td>
<td>+/-3sigma</td>
</tr>
<tr>
<td>Output leakage current</td>
<td></td>
<td>0.1</td>
<td>0.3</td>
<td>µA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ESD HBM</td>
<td></td>
<td>1</td>
<td>kV</td>
<td></td>
<td>All pins</td>
<td></td>
</tr>
<tr>
<td>ESD CDM</td>
<td></td>
<td>0.5</td>
<td>kV</td>
<td></td>
<td>All pins</td>
<td></td>
</tr>
</tbody>
</table>

3 The data format is 2’s complement with 0 LSB16 corresponding to 0°C
4 This specification relates to the sensor and not the I2C bus
### Average current

**100Hz refresh**
- **Symbol**: IDD_AVG100-1
- **Conditions**: Continuous mode TXYZ, OSR_HALL=1, DIG_FILTXY=2, DIG_FILTZ=3, DIG_FILT_TEMP=1, OSR_TEMP=1, Temp Comp enabled, Tconv = 2.76ms
- **Conditions**: VDD ≤ 1.8V, VDD > 1.8V
- **Min.**: 0.6 mA
- **Typ.**: 0.8 mA
- **Max.**: 1.3 mA

**125Hz refresh**
- **Min.**: 170 µA
- **Typ.**: 270 µA
- **Max.**: 340 µA
- **Conditions**: Continuous mode XZ or YZ measured only, OSR_HALL=1, DIG_FILTXY=0, DIG_FILTZ=1, Temp Comp disabled, Tconv = 707µs
- **Conditions**: VDD ≤ 1.8V, VDD > 1.8V
- **Min.**: 220 µA
- **Typ.**: 320 µA
- **Max.**: 390 µA
- **Conditions**: Continuous mode TXZ or TYZ measured only, OSR_HALL=1, DIG_FILTXY=0, DIG_FILTZ=1, DIG_FILT_TEMP=1, OSR_TEMP=1, Temp Comp enabled, Tconv = 1.18ms
- **Conditions**: VDD ≤ 1.8V, VDD > 1.8V

**125Hz refresh**
- **Min.**: 160 µA
- **Typ.**: 200 µA
- **Max.**: 250 µA
- **Conditions**: Continuous mode XY measured only, OSR_HALL=1, DIG_FILTXY=0, Temp Comp disabled, Tconv = 600µs
- **Conditions**: VDD ≤ 1.8V, VDD > 1.8V

### Table 8—Electrical Specifications
Average consumption

**Figure 2:** Average Consumption vs Filtering – Continuous measurement mode - Temperature compensation on

**Figure 3:** Average Consumption vs Filtering – Continuous measurement at all possible speeds – Temp compensation off
Figure 4: Average consumption vs Filtering – Continuous measurements at 10Hz – Temperature compensation off

Average current consumption calculation

\[ T_{DGp} = f(T_{COMP\_EN}, Number\_Enabled\_Magnetic\_Axes) \]

\[ T_{refresh} = \frac{1}{\text{refresh}} \]

\[ T_{CNT} = T_{refresh} \cdot (T_{COMP\_EN} + T_{CONV\_T} + T_{EN} + T_{CONV\_XY} + T_{EN} + T_{CONV\_Z} + T_{DSP}) \]

\[ I_{DD\_AVG} = \frac{T_{COMP\_EN} + T_{CONV\_T} + T_{DD\_CONV\_T} + T_{EN} + T_{CONV\_XY} + T_{DD\_CONV\_XY} + T_{EN} + T_{CONV\_Z} + T_{DD\_CONV\_Z} + T_{DSP} + T_{DD\_DSP} + T_{CNT} + T_{DD\_CNT}}{T_{refresh}} \]
5.4. Magnetic Specifications

Operating Characteristics, $T_A = -40°C$ to $105°C$ (unless otherwise specified)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
<th>Conditions</th>
</tr>
</thead>
</table>
| XY Magnetic sensitivity | SENSXY_25  
SENSXY_50 | 0.675  
1.35 | 0.75  
1.5 | 0.825  
1.65 | µT/LSB16  
µT/LSB16 | room temperature, 25mT range  
50mT range |
| Z Magnetic Sensitivity | SENSZ_25  
SENSZ_50  
SENSZ_100  
SENSZ_200 | 0.675  
1.35  
2.7  
5.4 | 0.75  
1.5  
3  
6 | 0.825  
1.65  
3.3  
6.6 | µT/LSB16  
µT/LSB16  
µT/LSB16  
µT/LSB16 | room temperature, 25mT range  
50mT range  
100mT range  
200mT range |
| Magnetic measurement range XY | BRANGE_XY_25  
BRANGE_XY_50 | ±22,107  
±44,215 | ±24,564  
±49,128 | ±27,020  
±54,041 | µT  
µT | room temperature, 25mT range  
50mT range |
| Magnetic measurement range Z | BRANGE_Z_25  
BRANGE_Z_50  
BRANGE_Z_100  
BRANGE_Z_200 | ±22,107  
±44,215  
±88,430  
±176,860 | ±24,564  
±49,128  
±98,256  
±196,512 | ±27,020  
±54,041  
±108,082  
±216,163 | µT  
µT  
µT  
µT | room temperature, 25mT range  
50mT range  
100mT range  
200mT range |
| RMS Noise | $N_{XYZ}$ | 1.90  
2.40 | 2.20  
2.80 | | µTrms  
µTrms | without temperature compensation  
5ms conv time  
DIG_FILTXY=3  
DIG_FILTZ=4  
OSR_HALL=1,  
room temperature  
25mT range  
50mT range |
| RMS Noise | $N_{XYZ}$ | 2.00  
2.90 | 2.30  
3.50 | | µTrms  
µTrms | with temperature compensation  
5ms conv time  
(DIG_FILTXY=3  
DIG_FILTZ=4,  
OSR_HALL=1),  
room temperature  
25mT range  
50mT range |
| Sensitivity drift vs TA = 35°C | SENS_THD | -5  
-8 | 5  
8 | | %  
% | With temperature compensation  
Without temperature compensation |
| Hysteresis | $B_h$ | 200 | | | | µT |

Table 9– Magnetic Specifications

5 Not validated by any production test, only verified by characterization
### 5.5. Timing Specifications

Operating Characteristics, $T_A = -40^\circ$C to $105^\circ$C (unless otherwise specified)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output refresh rate $^{(6)}$</td>
<td>Fr1</td>
<td>10</td>
<td>100</td>
<td>700</td>
<td>Hz</td>
<td>With temperature measurement $^{(7)}$</td>
</tr>
<tr>
<td></td>
<td>Fr2</td>
<td></td>
<td></td>
<td>1400</td>
<td>Hz</td>
<td>Without temperature measurement $^{(6)}$</td>
</tr>
<tr>
<td>Oscillator trimming accuracy</td>
<td>TOSC_TRIM</td>
<td>-5</td>
<td>0</td>
<td>5</td>
<td>%</td>
<td>room temperature</td>
</tr>
<tr>
<td>Oscillator Thermal drift</td>
<td>TOSC_THD</td>
<td>-5</td>
<td>0</td>
<td>5</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>Magnetic axis/Temperature conversion time $^{(8)}$</td>
<td>$T_{CONV}$</td>
<td>105.8</td>
<td>113.3</td>
<td>121.9</td>
<td>$\mu$s</td>
<td>Time per axis DIG_FILT=0, OSR=0</td>
</tr>
<tr>
<td></td>
<td>$T_{CONV}$</td>
<td>205.5</td>
<td>220.0</td>
<td>236.7</td>
<td>$\mu$s</td>
<td>Time per axis DIG_FILT=0, OSR=1</td>
</tr>
<tr>
<td></td>
<td>$T_{CONV}$</td>
<td>902.8</td>
<td>966.7</td>
<td>1040.2</td>
<td>$\mu$s</td>
<td>Time per axis DIG_FILT=3, OSR=1</td>
</tr>
<tr>
<td></td>
<td>$T_{CONV}$</td>
<td>12857.5</td>
<td>13766.7</td>
<td>14814.2</td>
<td>$\mu$s</td>
<td>Time per axis DIG_FILT=7, OSR=1</td>
</tr>
<tr>
<td>Start up time</td>
<td>$T_{Startup}$</td>
<td>0.15</td>
<td>1.2</td>
<td></td>
<td>ms</td>
<td>Reset to idle mode</td>
</tr>
<tr>
<td>Manual reset</td>
<td>$T_{RES}$</td>
<td>3</td>
<td>5</td>
<td></td>
<td>$\mu$s</td>
<td>Minimum time to trigger a reset Vdd&gt;1.7V</td>
</tr>
<tr>
<td>DSP Time</td>
<td>$T_{DSP}$</td>
<td>359.9</td>
<td>385.4</td>
<td>414.7</td>
<td>$\mu$s</td>
<td>XYZ enabled $^{(6)}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>223.0</td>
<td>238.8</td>
<td>256.9</td>
<td>$\mu$s</td>
<td></td>
</tr>
</tbody>
</table>

$^6$ Fr1 and Fr2 are defined as the period between two set of measurements. It is relevant for the Continuous measurement mode and is defined by the parameter MODE[3:0]. TREFRESH is adjustable with the following settings: 10Hz, 20Hz, 50Hz, 100Hz, 125Hz, 200Hz, 500Hz, 700Hz, 1000Hz, and 1.4kHz. The default value in the non-volatile memory is 100Hz.

$^7$ The temperature compensation can be enabled or disabled by the user.

$^8$ This conversion time is defined as the time to acquire a single axis of the magnetic flux density. When measuring XYZ, they are obtained through time-multiplexing. The conversion time is programmable through DIG_FILT for magnetic and temperature conversion. The total conversion time is obtained by summing up the magnetic & temperature conversion time.
5.5.1.1. Magnetic Axis/ Temperature Conversion time

The above graph can be expressed with the following formula:

\[ T_{\text{conv}}(\text{DIG\_FILT}) = \frac{16}{F_{\text{clk}}} + \frac{\text{OSR}}{F_{\text{clk}}} \cdot \left( \frac{1}{2^{\text{DIG\_FILT}}+2} + 4 \right) \]

\[ F_{\text{clk}} = 2.4\text{MHz} \quad \text{typical} \]
5.5.1.2. **DSP Time**

![DSP Time vs nb of enabled magnetic axes](image)

*Figure 6: DSP time vs. number of enabled magnetic axes at typical Fclk = 2.4MHz.*

5.5.1.3. **Reset sequence**

The MLX90397 does not embark a Power on Reset. The reset should be performed by the user using the RESB external pin. Melexis recommends to follow the below timings:

![Reset sequence](image)

*Figure 3: Reset sequence*
5.6. Accuracy Specifications

Operating Characteristics, $T_A = -40^\circ C$ to $105^\circ C$ (unless otherwise specified). All specifications in this chapter are given with +/- 3 sigma.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resolution</td>
<td>$O_{FSX}$</td>
<td>-200</td>
<td>16</td>
<td>200</td>
<td>bits</td>
<td>XYZ</td>
</tr>
<tr>
<td>Offset</td>
<td>$O_{FFSY}$</td>
<td>-200</td>
<td></td>
<td>200</td>
<td>$\mu T$</td>
<td>at 0 Gauss, Room temperature, Ranges 25mT and 50mT</td>
</tr>
<tr>
<td></td>
<td>$O_{FFSZ}$</td>
<td>-200</td>
<td></td>
<td>200</td>
<td>$\mu T$</td>
<td></td>
</tr>
<tr>
<td>Offset thermal drift X-axis</td>
<td>$S_{MSMXY}$</td>
<td>-1.5</td>
<td>2.1</td>
<td>5.7</td>
<td>%</td>
<td>vs. $T_A = 35^\circ C$</td>
</tr>
<tr>
<td>Offset thermal drift Y-axis</td>
<td>$S_{MSMXY}$</td>
<td>-3</td>
<td>1.7</td>
<td>6.4</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>Offset thermal drift Z-axis</td>
<td>$S_{MSMZ}$</td>
<td>-5.1</td>
<td>-0.8</td>
<td>3.5</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>Sensitivity mismatch</td>
<td>$S_{XMXY}$</td>
<td>-1.5</td>
<td>2.1</td>
<td>5.7</td>
<td>%</td>
<td>verified by characterization / not by final testing</td>
</tr>
<tr>
<td></td>
<td>$S_{XMXZ}$</td>
<td>-3</td>
<td>1.7</td>
<td>6.4</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$S_{XMZY}$</td>
<td>-5.1</td>
<td>-0.8</td>
<td>3.5</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>Thermal drift of sensitivity mismatch</td>
<td>$S_{XYi}$</td>
<td>-0.3</td>
<td>0.3</td>
<td>4.4</td>
<td>%</td>
<td>DIG_FILT = 7. Best fit method</td>
</tr>
<tr>
<td></td>
<td>$S_{YXi}$</td>
<td>-0.1</td>
<td>0.1</td>
<td>5.1</td>
<td>%</td>
<td>Verified by characterization only.</td>
</tr>
<tr>
<td></td>
<td>$S_{XZi}$</td>
<td>-0.4</td>
<td>0.4</td>
<td>2.1</td>
<td>%</td>
<td>XY, range 25mT</td>
</tr>
<tr>
<td></td>
<td>$S_{ZXi}$</td>
<td>-0.2</td>
<td>0.2</td>
<td>5.2</td>
<td>%</td>
<td>Z, range 25mT</td>
</tr>
<tr>
<td></td>
<td>$S_{YZi}$</td>
<td>-0.3</td>
<td>0.3</td>
<td>4.4</td>
<td>%</td>
<td>XY, range 50mT</td>
</tr>
<tr>
<td></td>
<td>$S_{ZYi}$</td>
<td>-0.1</td>
<td>0.1</td>
<td>5.1</td>
<td>%</td>
<td>Z, range 50mT</td>
</tr>
</tbody>
</table>

Table 11– Accuracy specifications

6. Functional Description & Interfaces

6.1. Operating Modes

MLX90397 has the following Application modes

1. Idle mode
2. Single measurement mode
3. Continuous measurement mode (10Hz, 20Hz, 50Hz, 100Hz, 125Hz, 200Hz, 500Hz, 700Hz, 1000Hz, and 1.4kHz)

---

9 The data format is 2’s complement, further explanation can be found on Table 14– Magnetic data format
10 Value of measurement data register on shipment test without applying magnetic field on purpose. These values are guaranteed in the operating magnetic field range.
11 The cross axis sensitivity is measured by applying a force field on one axis and measured on another axis. For instance, $S_{XYi}$ means that a field was applied along X axis and measured along Y axis.
6.1.1. Single measurement mode

When the Single measurement mode is set, a magnetic measurement is started. After a measurement and when the signal processing is finished, the measurement data is stored to the data registers (X, Y and Z). After this, the sensor will go to the Idle mode automatically.

While going to the Idle mode, MODE[3:0] bits turn to 0. At the same time, DRDY bit (Data Ready) in STAT1 register turns to High.

When any of measurement data register (X, Y and Z) is read, DRDY bit turns to Low. It remains High when switching from Idle mode to another mode.

When the sensor is measuring, the data registers (X, Y and Z) keep the previous data. Therefore, it is possible to read out data even during measurement periods.
6.1.2. Continuous measurement Mode

When the "Continuous measurement" mode is set, the measurement starts periodically. After measurement and signal processing is finished, the measurement data is stored to the data registers (X, Y, and Z). Almost all internal blocks are disabled ("Counting" power state).

After a measurement period, the device wakes up automatically from "Counting" power state and starts a new measurement.

The Continuous measurement mode ends when "Idle" mode (MODE[3:0] bits = 0) is set. If the measurement period is changed while the device is already configured in "Continuous measurement" mode, a new measurement starts.

STAT1 and measurement data registers (X, Y and Z) will not be initialized by this.

6.1.2.1. Data Ready

When the measurement data is stored and ready to be read, the DRDY bit (Data ready) in STAT register is set to High. When a measurement is performed correctly, the device sets the Data Ready bit before going back to "Counting" power state.

6.1.2.2. Normal Read Sequence

The stored measurement data is protected during the data reading. There is no update of the data during this time. Consequently, the following sequence should be followed:

1. **Check if the Data is Ready or not** by polling DRDY bit of STAT1 register
   a. DRDY: Data Ready. The Data is ready when set High.
2. Reading of the STAT1 register will not trigger the protection.
3. **Read measurement data** - When any of the measurement data register (X, Y, or Z) is read, the device enables the protection as soon as the register is copied into the I2C sending register. When data reading starts, DRDY (Data ready) bit turns Low.
4. **Read STAT2 register** (required for data consistency - provides information on overflow and data skip)

When this read sequence is followed and there is no attempted I2C read during measurement, reading of STAT2 sets the DOR bit to low (see I/O registers description for reference).
6.1.2.3. **Data Read Start during Measurement**

When the sensor is measuring, the measurement data registers (X, Y and Z) keep the previous data. Therefore, it is possible to read out data even in measurement period.
6.1.2.4. Timings considerations

The device offers many options for different axis configurations depending on the tradeoff between:

- noise-measurement time
- current consumption
- temperature compensation
- axis selection

Whichever settings are chosen depending on the application specific requirements, the following timing consideration should be always considered during design in order to ensure proper continuous measurement mode operation:

\[ T_{\text{CONV\_TEMP}} + T_{\text{CONV\_X}} + T_{\text{CONV\_Y}} + T_{\text{CONV\_Z}} + T_{\text{DSP}} + 66\mu s < 1/F_r \]

Example 1:
The lowest possible noise and temperature compensation of XYZ magnetic sensitivities at refresh rate of 100Hz (10,000 µs period) result in the following settings:

- \( \text{OSR\_HALL} = \text{OSR\_TEMP} = 1b, \text{DIG\_FILT\_XY} = 6d, \text{DIG\_FILT\_TEMP} = 1d \)
- Temperature compensation enabled, \( \text{DIG\_FILT\_Z} = 7d \)
- X, Y, Z enabled, \( \text{MODE}[3:0] = 5h \) (100Hz)

Referring to the timing specifications and the inequality, for the selected settings follows:

\[ 326.7\mu s + 6,940.0\mu s + 6,940.0\mu s + 13,766.7\mu s + 385.4\mu s + 66\mu s < 10,000\mu s \rightarrow \text{The criterion is not satisfied} \]
because the selected refresh rate is not slow enough.

Example 2:
The lowest possible noise and temperature compensation of XYZ magnetic sensitivities at refresh rate of 20Hz (50,000 µs period) result in the following settings:

- \( \text{OSR\_HALL} = \text{OSR\_TEMP} = 1b, \text{DIG\_FILT\_XY} = 6d, \text{DIG\_FILT\_TEMP} = 1d \)
- Temperature compensation enabled, \( \text{DIG\_FILT\_Z} = 7d \)
- X, Y, Z enabled, \( \text{MODE}[3:0] = 3h \) (20Hz)

Referring to the timing specifications and the inequality for the selected settings follows:

\[ 326.7\mu s + 6940.0\mu s + 6940.0\mu s + 13766.7\mu s + 385.4\mu s + 66\mu s < 50,000\mu s \rightarrow \text{The criterion is satisfied} \]

<table>
<thead>
<tr>
<th>Refresh rate</th>
<th>10Hz</th>
<th>20Hz</th>
<th>50Hz</th>
<th>100Hz</th>
<th>125Hz</th>
<th>200Hz</th>
<th>500Hz</th>
<th>700Hz</th>
<th>1KHz</th>
<th>1.4KHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measurements</td>
<td>TXYZ</td>
<td>TXYZ</td>
<td>TXYZ</td>
<td>TXYZ</td>
<td>TXYZ</td>
<td>TXYZ</td>
<td>TXYZ</td>
<td>TXYZ</td>
<td>XY</td>
<td>XY</td>
</tr>
<tr>
<td>( T_{\text{COMP_EN}} ) (binary)</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>( \text{OSR_HALL} ) (binary)</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>( \text{OSR_TEMP} ) (binary)</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>( \text{DIG_FILT_TEMP} ) (decimal)</td>
<td>6</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>( \text{DIG_FILT_HALL_XY} ) (decimal)</td>
<td>6</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>( \text{DIG_FILT_HALL_Z} ) (decimal)</td>
<td>7</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Table 13 – Example of settings satisfying the timing consideration for proper operation in continuous measurement mode
6.1.2.5. **Data Skip**

If the available data is not read before a new measurement ends, the DRDY bit (Data Ready) remains High. However, a new set of measurement data will replace the previous one.

![Figure 12: Data Skip: When data is not read](image)

If the available data is read while a new measurement is being performed, this set of data will be protected. This is also the case even if the reading procedure finishes after the measurement. Consequently, this new set of data is skipped.

![Figure 13: Data Skip: When data read has not been finished before the next measurement end](image)
6.1.2.6. **End Operation**

Set the Idle mode (MODE[3:0] bits = 0) to end the Continuous measurement mode.

6.1.2.7. **Magnetic Sensor Overflow**

The device has two separate limitations for measurement range. Combined for X and Y axes and another one for Z axis. The absolute values of X and Y axis should be smaller than 25mT or 50mT depending on the selected range.

Along Z axis, the absolute value should be smaller than 25mT, 50mT, 100mT or 200mT depending on the selected range.

<table>
<thead>
<tr>
<th>X, Y, Z (2's complement)</th>
<th>X, Y, Z (HEX)</th>
<th>Range = 25mT [µT]</th>
<th>Range = 50mT [µT]</th>
<th>Range = 100mT [µT]</th>
<th>Range = 200mT [µT]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0111 1111 1111 0000</td>
<td>7FF0</td>
<td>24,564</td>
<td>49,128</td>
<td>98,256</td>
<td>196,512</td>
</tr>
<tr>
<td>0000 0000 0000 0001</td>
<td>0001</td>
<td>0.75</td>
<td>1.50</td>
<td>3.00</td>
<td>6.00</td>
</tr>
<tr>
<td>0000 0000 0000 0000</td>
<td>0000</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1111 1111 1111 1111</td>
<td>FFFF</td>
<td>-0.75</td>
<td>-1.50</td>
<td>-3.00</td>
<td>-6.00</td>
</tr>
<tr>
<td>1000 0000 0001 0000</td>
<td>8010</td>
<td>-32,752</td>
<td>-24,564</td>
<td>-49,128</td>
<td>-98,256</td>
</tr>
</tbody>
</table>

*Table 14– Magnetic data format*

When the magnetic field exceeds the limitation, data stored at measurement data are not correct. This is called Magnetic Sensor Overflow.

For X axis overflow flag condition is: |X| > 32,752

When the condition is performed, HOFL_X bit turns to “1”.

For Y axis overflow flag condition is: |Y| > 32,752

When the condition is performed, HOFL_Y bit turns to “1”.

For Z axis overflow check is: |Z| > 32,752 If the condition is fulfilled, the HOFL_Z bit turns to “1”.

When measurement data register (X, Y and Z) is updated, HOFL_X, HOFL_Y and HOFL_Z bits are updated, too.

6.1.3. **Idle mode**

In Idle mode, the device is in minimal power consumption state. All internal blocks are disabled. Only the communication over the I2C interface is maintained. The digital handling of the communication is clocked by the I2C master clock. All registers remain accessible and the data stored in read/write registers remains.

6.2. **Measurement axis selection**

Each measurement axis (i.e X, Y or Z) can be selected and then measured individually or through a combination of 2 or 3 axis.

This is user configurable through the CTRL register. See chapter 0 for more details.
6.3. Magnetic range selection

The magnetic range is controlled through the RANGE_SEL parameter.

<table>
<thead>
<tr>
<th>RANGE_SEL[2:0]</th>
<th>X &amp; Y ranges [mT]</th>
<th>Z range [mT]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>1</td>
<td>50</td>
<td>25</td>
</tr>
<tr>
<td>2</td>
<td>25</td>
<td>50</td>
</tr>
<tr>
<td>3</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>4(12)</td>
<td>25</td>
<td>100</td>
</tr>
<tr>
<td>5(12)</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>6(12)</td>
<td>25</td>
<td>200</td>
</tr>
<tr>
<td>7(12)</td>
<td>50</td>
<td>200</td>
</tr>
</tbody>
</table>

*Table 15– XY and Z magnetic range selection*

6.4. Output protocol (I2C) description

The 7-bit I2C address is pre-programmed to a fixed value of 0x0D. This value cannot be changed by the user. Please contact Melexis in case a specific address is needed.

<table>
<thead>
<tr>
<th>Description</th>
<th>7-bits I2C address</th>
<th>R/W bit</th>
</tr>
</thead>
<tbody>
<tr>
<td>bits</td>
<td>7-1</td>
<td>0</td>
</tr>
<tr>
<td>Value</td>
<td>0x0D or 0b0001101</td>
<td>0 for I2C write 1 for I2C read</td>
</tr>
</tbody>
</table>

*Table 16– 8-bits Addressing register*

Command implementation

The following I2C commands are implemented:

- **MEM_DIRECT_READ**: reads data from memory space, starting from the default address 0x00
- **MEM_READ**: the start address will be specified in the command and the address will be incremented for continuous reading until an I2C stop is detected.
- **MEM_WRITE**: the start address will be specified followed by the data to be stored at addresses starting from the given start address and incremented until an I2C stop is detected.
- **ADDRESSED_RESET**: reset of the device, based on the I2C Slave Address (reset of addressed devices on the I2C bus only)

In the next sections, the format of the different I2C commands is explained. The following legend is used:

---

12 For magnetic ranges above 50mT, Melexis only guarantees the performance by design
6.4.1.1. **Read Commands**

There are two read commands that are implemented:

- **MEM_DIRECT_READ**: reads data from memory space, starting from the default address 0x00
- **MEM_READ**: the start address will be specified in the command and the address will be incremented for continuous reading until an I2C stop is detected.

### 6.4.1.1.1. **MEM_DIRECT_READ** (direct read) Command

**MEM_DIRECT_READ**: reads data from memory space, starting from the default address 0x00

![Figure 14: I2C - MEM_DIRECT_READ (direct read) Command](image)

**NOTES:**

- Incremental readout – return 0x00 when address out of valid space
- **NAK is needed from master** to allow going to STOP

### 6.4.1.1.2. **MEM_READ** (addressed read)

**MEM_READ**: the start address will be specified in the command and the address will be incremented for continuous reading until an I2C stop (P) is detected.

Incremental read-out starting at a given address (Register Start Address).

Normally it will read 1x register only, but the slave will continue to transmit data of sequential register addresses until the master terminates the communication.

![Figure 15: I2C - MEM_READ (addressed read)](image)

**Important! A repeated START is required to perform an “addressed read”. Without repeated START, the command will be seen as a “direct read”.

As soon as incremental addressing leaves the address space, the slave will respond with all 0x00.

**NOTES:**

- Incremental readout – return 0x00 when address out of valid space
- **NAK is needed from master** to allow going to STOP

### 6.4.1.2. **MEM_WRITE** (addressed write) Command

**MEM_WRITE**: the start address will be specified followed by the data to be stored at addresses starting from the given start address and incremented until an I2C stop (P) is detected.
Incremental write starting at a given address (Register Start Address). Normally you write 1x register only, but optionally the master can continue to transmit data of sequential register addresses to reduce the communication time when a lot of registers should be written.

![Figure 16: I2C - MEM_WRITE (addressed write) Command](image)

The slave is sending AK/NAK based on the fact whether it was able to write data. The slave will automatically increment the address of the read out byte, independent if it gave an AK or a NAK to the master. It is up to the master to re-write the byte afterwards. When the device is busy with the write operation, new write commands will be ignored. A read operation will return invalid data.

### 6.4.1.3. **ADDRESSED_RESET: Addressed reset**

![I2C addr [W] A 0x11 A 0x06 A P](image)

The addressed reset command brings the device back into a state like it was after power-on. The I2C Slave Address is used, which means that only the addressed devices on the I2C bus will be reset.
6.5. Memory items description

6.5.1. Memory Structure

The MLX90397 has registers (ports) of 16 addresses. Each address consists of 8 bits data. Data is transferred to or received from the external CPU via the I2C interface.

<table>
<thead>
<tr>
<th>Address</th>
<th>Name</th>
<th>Description</th>
<th>R/W</th>
<th>7</th>
<th>6</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x00</td>
<td>STAT1</td>
<td>Status Register 1</td>
<td>R</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0x01</td>
<td>X[7:0]</td>
<td>X-axis Measurement Magnetic Data [7:0]</td>
<td>R</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0x03</td>
<td>Y[7:0]</td>
<td>Y-axis Measurement Magnetic Data [7:0]</td>
<td>R</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0x05</td>
<td>Z[7:0]</td>
<td>Z-axis Measurement Magnetic Data [7:0]</td>
<td>R</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0x07</td>
<td>STAT2</td>
<td>Status Register 2</td>
<td>R</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0x08</td>
<td>T[7:0]</td>
<td>Temperature Measurement Data Lower 8-bit</td>
<td>R</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0x09</td>
<td>T[15:8]</td>
<td>Temperature Measurement Data Higher 8-bit</td>
<td>R</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0x0A</td>
<td>CID</td>
<td>Company ID [7:0]</td>
<td>R</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0x0B</td>
<td>DID</td>
<td>Device ID [7:0]</td>
<td>R</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0x0C</td>
<td></td>
<td>Not used</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0x0D</td>
<td></td>
<td>Not used</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0x0E</td>
<td>CTRL</td>
<td>Control Register (Application Mode)</td>
<td>R/W</td>
<td></td>
<td></td>
<td>Z.EN</td>
<td>Y.EN</td>
<td>X.EN</td>
<td>MODE[1:0]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0x0F</td>
<td>CUST_CTRL2</td>
<td>Second Control Register (Application Mode)</td>
<td>R/W</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>RANGE_SEL[2:0]</td>
</tr>
<tr>
<td>0x10</td>
<td></td>
<td>Not used</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0x11</td>
<td>RST</td>
<td>Reset = 0x06</td>
<td>R/W</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0x12</td>
<td></td>
<td>Not used</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0x13</td>
<td></td>
<td>Not used</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0x14</td>
<td>OSR_DIG_FILT</td>
<td>OSR DIG Filt[7:0]</td>
<td>R/W</td>
<td></td>
<td>OSR_HALL</td>
<td>OSR_TEMP</td>
<td>DIG_FILT_HALL_XY[2:0]</td>
<td>DIG_FILT_TEMP[2:0]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0x15</td>
<td>T_EN_DIG_FILT</td>
<td>T.EN DIG Filt[7:0]</td>
<td>R/W</td>
<td></td>
<td>DNC=1</td>
<td>DNC=0</td>
<td>T.COMP_EN</td>
<td>DNC=1</td>
<td></td>
<td>DIG_FILT_HALL[Z[2:0]]</td>
<td></td>
</tr>
</tbody>
</table>

Table 17 – Memory map

**DNC=Do Not Change**

The STAT1 register is mapped on address 0x00, since it is the default address of **MEM_DIRECT_READ** (direct read) command.

The idea is that first the user has to read the status bits **DRDY** to check if there is new data and if there is new data, to continue the command to read the registers X, Y and Z.
6.5.2. I/O registers description

1. Address 0x00. STAT1[7:0]

<table>
<thead>
<tr>
<th>Bit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Reserved (Not used)</td>
</tr>
<tr>
<td>6</td>
<td>Reserved (Not used)</td>
</tr>
<tr>
<td>5</td>
<td>Reserved (Not used)</td>
</tr>
<tr>
<td>4</td>
<td>Reserved (Not used)</td>
</tr>
<tr>
<td>3</td>
<td>RT. The device is reset</td>
</tr>
<tr>
<td>2</td>
<td>STAT1[2:1]. Reserved (Not used)</td>
</tr>
<tr>
<td>1</td>
<td>DRDY. Data Ready</td>
</tr>
<tr>
<td>0</td>
<td>DRDY bit turns to “1” when data is ready in &quot;Single measurement&quot; mode, &quot;Continuous measurement&quot; mode or &quot;Self-test&quot; mode.</td>
</tr>
</tbody>
</table>

Bit 7 – 4 STAT1[7:4]. Reserved (Not used)

Bit 3

- RT. The device is reset
  - 0 – The device was not reset
  - 1 – The device was reset and this is the first reading. Automatically set to 0 when the first reading of STAT register is done

Bit 2 – 1 STAT1[2:1]. Reserved (Not used)

Bit 0

- DRDY. Data Ready.
  - It returns to “0” when any one the measurement data register (X, Y or Z) is read
  - 0 – Normal
  - 1 – Data is Ready

2. Addresses 0x01 - 0x06. XYZ[15:0]

<table>
<thead>
<tr>
<th>Bit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>X[7:0]. LS byte of X axis</td>
</tr>
<tr>
<td>15</td>
<td>X[15:8]. MS byte of X axis</td>
</tr>
<tr>
<td>7</td>
<td>Y[7:0]. LS byte of Y axis</td>
</tr>
<tr>
<td>15</td>
<td>Y[15:8]. MS byte of Y axis</td>
</tr>
<tr>
<td>7</td>
<td>Z[7:0]. LS byte of Z axis</td>
</tr>
<tr>
<td>15</td>
<td>Z[15:8]. MS byte of Z axis</td>
</tr>
</tbody>
</table>
3. Address 0x07. STAT2[7:0]

<table>
<thead>
<tr>
<th>Bit 7 – 4</th>
<th>STAT2[7:4]</th>
<th>Reserved (Not used)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bit 3</td>
<td>DOR</td>
<td>Data Overrun</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DOR bit turns to “1” when data has been skipped in &quot;Continuous measurement&quot; mode. It returns to “0” when the data registers (X, Y, Z) are read.</td>
</tr>
<tr>
<td>Bit 2</td>
<td>HOVF_Z</td>
<td>Z axis Magnetic Sensor Overflow</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 – Normal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 – Magnetic Sensor Overflow occurred</td>
</tr>
<tr>
<td>Bit 1</td>
<td>HOVF_Y</td>
<td>Y axis Magnetic Sensor Overflow</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 – Normal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 – Magnetic Sensor Overflow occurred</td>
</tr>
<tr>
<td>Bit 0</td>
<td>HOVF_X</td>
<td>X axis Magnetic Sensor Overflow</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 – Normal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 – Magnetic Sensor Overflow occurred</td>
</tr>
</tbody>
</table>

NOTE: R=Read access; W=Write access; value following dash (-) = value after reset

STAT2 register contains the following bits:

In "Single measurement" mode, "Continuous measurement" mode, the magnetic sensor may overflow even though the measurement data register is not saturated. In this case, measurement data is not correct and HOVF bit turns to “1”. When the measurement data register is updated, HOVF bit is updated.
4. Addresses 0x08-0x09. T[15:0]

Bit 7 – 0   T[7:0]. LSB byte of Temperature
Bit 15 – 8  T[15:8]. MSB byte of Temperature

5. Addresses 0x0A. CID[7:0]

Bit 7 – 0   CID[7:0]. Company ID

6. Addresses 0x0B. DID[7:0]

Bit 7 – 0   DID[7:0]. Device ID

7. Addresses 0x10. CTRL[7:0]

<table>
<thead>
<tr>
<th></th>
<th>7</th>
<th>6</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Z_EN</td>
<td>Y_EN</td>
<td>X_EN</td>
<td>MODE3</td>
<td>MODE2</td>
<td>MODE1</td>
<td>MODE0</td>
<td></td>
</tr>
<tr>
<td>RW-0</td>
<td>RW-0</td>
<td>RW-0</td>
<td>RW-0</td>
<td>RW-0</td>
<td>RW-0</td>
<td>RW-0</td>
<td>RW-0</td>
<td></td>
</tr>
</tbody>
</table>

NOTE: R=Read access; W=Write access; value following dash (-) = value after reset

Bit 7   CTRL[7]. Reserved (Not used)

Z_EN. Enable Z axis magnetic measurement
Bit 6   0 – Disable
        1 – Enable

Y_EN. Enable Y axis magnetic measurement
Bit 5   0 – Disable
        1 – Enable

X_EN. Enable X axis magnetic measurement
Bit 4   0 – Disable
        1 – Enable
**MODE[3:0]**. Application Mode

- 0 – Idle mode
- 1 – Single Measurement mode
- 2 – Continuous measurement mode 10Hz
- 3 – Continuous measurement mode 20Hz
- 4 – Continuous measurement mode 50Hz
- 5 – Continuous measurement mode 100Hz
- 6 – Continuous measurement mode 125Hz

Bit 3 - 0
- 7 – Not used
- 8 – Idle mode (same as 0)
- 9 – Single Measurement mode (same as 1)
- 10 – Continuous measurement mode 200Hz
- 11 – Continuous measurement mode 500Hz
- 12 – Continuous measurement mode 700Hz
- 13 – Continuous measurement mode 1.0kHz
- 14 – Continuous measurement mode 1.4kHz
- 15 – Idle mode (same as 0)

8. Addresses 0x0F. CUST_CTRL2[7:0]

<table>
<thead>
<tr>
<th>Bit 7</th>
<th>Bit 6</th>
<th>Bit 5</th>
<th>Bit 4</th>
<th>Bit 3</th>
<th>Bit 2</th>
<th>Bit 1</th>
<th>Bit 0</th>
</tr>
</thead>
<tbody>
<tr>
<td>CUST_CTRL2_7</td>
<td>CUST_CTRL2_6</td>
<td>CUST_CTRL2_5</td>
<td>CUST_CTRL2_4</td>
<td>CUST_CTRL2_3</td>
<td>RANGE_SEL_2</td>
<td>RANGE_SEL_1</td>
<td>RANGE_SEL_0</td>
</tr>
<tr>
<td>RW-0</td>
<td>RW-0</td>
<td>RW-0</td>
<td>RW-0</td>
<td>RW-0</td>
<td>RW-0</td>
<td>RW-0</td>
<td>RW-0</td>
</tr>
</tbody>
</table>

Bit 7 – 3 **CUST_CTRL2[7:3]**. Reserved (Not used)

**RANGE_SEL[3:0]**. Select Magnetic Range

- 0 – X and Y axes = 25mT, Z axis = 25mT
- 1 – X and Y axes = 50mT, Z axis = 25mT
- 2 – X and Y axes = 25mT, Z axis = 50mT
- 3 – X and Y axes = 50mT, Z axis = 50mT
- 4 – X and Y axes = 25mT, Z axis = 100mT
- 5 – X and Y axes = 50mT, Z axis = 100mT
- 6 – X and Y axes = 25mT, Z axis = 200mT
- 7 – X and Y axes = 50mT, Z axis = 200mT

9. Addresses 0x11. RST[7:0]

Bit 7 – 0 **RST[7:0]**. Addressed RESET when users sends an I2C_ADDRESSED_RESET command
10. Addresses 0x12-0x13. Not used

11. Addresses 0x14. OSR_DIG_FILT[7:0]

Bit 7
0 -> OSR = 32
1 -> OSR = 64

OSR_HALL. Over Sampling Ratio setting for the magnetic measurements

Bit 6
0 -> OSR = 32
1 -> OSR = 64

OSR_TEMP. Over Sampling Ratio setting for the temperature measurement

Bits 5 - 3
0 - 0.113ms @ OSR_HALL = 0; 0.220ms @ OSR_HALL = 1
1 - 0.167ms @ OSR_HALL = 0; 0.327ms @ OSR_HALL = 1
2 - 0.273ms @ OSR_HALL = 0; 0.540ms @ OSR_HALL = 1
3 - 0.487ms @ OSR_HALL = 0; 0.967ms @ OSR_HALL = 1
4 - 0.913ms @ OSR_HALL = 0; 1.820ms @ OSR_HALL = 1
5 - 1.767ms @ OSR_HALL = 0; 3.527ms @ OSR_HALL = 1
6 - 3.473ms @ OSR_HALL = 0; 6.940ms @ OSR_HALL = 1
7 - 6.887ms @ OSR_HALL = 0; 13.767ms @ OSR_HALL = 1

Bits 2 - 0
0 - 0.113ms @ OSR_TEMP = 0; 0.220ms @ OSR_TEMP = 1
1 - 0.167ms @ OSR_TEMP = 0; 0.327ms @ OSR_TEMP = 1
2 - 0.273ms @ OSR_TEMP = 0; 0.540ms @ OSR_TEMP = 1
3 - 0.487ms @ OSR_TEMP = 0; 0.967ms @ OSR_TEMP = 1
4 - 0.913ms @ OSR_TEMP = 0; 1.820ms @ OSR_TEMP = 1
5 - 1.767ms @ OSR_TEMP = 0; 3.527ms @ OSR_TEMP = 1
6 - 3.473ms @ OSR_TEMP = 0; 6.940ms @ OSR_TEMP = 1
7 - 6.887ms @ OSR_TEMP = 0; 13.767ms @ OSR_TEMP = 1

12. Addresses 0x15. CUST_CTRL[7:0]

Bit 7
DNC = 1

DNC = 0

T_COMP_EN

DNC = 1

CUST_CTRL3

DNC = 1

DIG_FILT_HA LL_XY2

DIG_FILT_HA LL_XY1

DIG_FILT_HA LL_XYO

DIG_FILT_TE MP2

DIG_FILT_TE MP1

DIG_FILT_TE MP0

NOTE: R=Read access; W=Write access; value following dash (-) = value after reset
<table>
<thead>
<tr>
<th>Bit 7</th>
<th>DNC=1. Value is preloaded from OTP with 0b1. Do not change it</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bit 6</td>
<td>DNC=0. Value is preloaded from OTP with 0b0. Do not change it</td>
</tr>
<tr>
<td></td>
<td><strong>T_COMP_EN. Enable or disable the temperature measurement and compensation</strong></td>
</tr>
<tr>
<td>Bit 5</td>
<td>0 - Disabled</td>
</tr>
<tr>
<td></td>
<td>1 - Enabled</td>
</tr>
<tr>
<td>Bit 4</td>
<td>DNC=1. Value is preloaded from OTP with 0b1. Do not change it</td>
</tr>
<tr>
<td>Bit 3</td>
<td><strong>CUST_CTRL3. Reserved. Not used</strong></td>
</tr>
</tbody>
</table>

**DIG_FILT_HALL_Z[2:0]. DIG_FILT setting for Z magnetic measurements**

| Bit 2 - 0 | 0 - 0.113ms @ OSR_HALL = 0; 0.220ms @ OSR_HALL = 1 |
|           | 1 - 0.167ms @ OSR_HALL = 0; 0.327ms @ OSR_HALL = 1 |
|           | 2 - 0.273ms @ OSR_HALL = 0; 0.540ms @ OSR_HALL = 1 |
|           | 3 - 0.487ms @ OSR_HALL = 0; 0.967ms @ OSR_HALL = 1 |
|           | 4 - 0.913ms @ OSR_HALL = 0; 1.820ms @ OSR_HALL = 1 |
|           | 5 - 1.767ms @ OSR_HALL = 0; 3.527ms @ OSR_HALL = 1 |
|           | 6 - 3.473ms @ OSR_HALL = 0; 6.940ms @ OSR_HALL = 1 |
|           | 7 - 6.887ms @ OSR_HALL = 0; 13.767ms @ OSR_HALL = 1 |
6.6. Flowchart

![Flowchart Image]

Figure 17: Sequence flowchart
6.7. Noise Performance Graphs

Without temperature compensation

**Figure 18:** XY axis RMS noise (typ) without temperature compensation and 25mT range selected

**Figure 19:** Z axis RMS noise (typ) without temperature compensation and 25mT range selected
Figure 20: XY axis RMS noise (typ) without temperature compensation and 50mT range selected

Figure 21: Z axis RMS noise (typ) without temperature compensation and 50mT range selected
With temperature compensation

**Figure 22:** XY axis RMS noise (typ) with temperature compensation and 25mT range selected

**Figure 23:** Z axis RMS noise (typ) with temperature compensation and 25mT range selected
Figure 24: XY axis RMS noise (typ) with temperature compensation and 50mT range selected

Figure 25: Z axis RMS noise (typ) with temperature compensation and 50mT range selected
6.8. Temperature compensation

The MLX90397 has a built-in temperature compensation, which is done by a piecewise linear approximation of the temperature coefficient of the Hall plates. A reference temperature is chosen (TREF=35°C), where the result at any temperature higher than TREF is adjusted by a gain $\text{SENS}_{\text{TC,HT}}$ and if the temperature is lower than TREF - by $\text{SENS}_{\text{TC,LT}}$. These two coefficients are calibrated at Melexis and are lumped into the parameter name $\text{SENS}_{\text{TC}}$ in the equation below.

$$XYZ_{18,0} = XYZ_{\text{RAW,18,0}} \left[ 1 + \frac{\text{SENS}_{\text{TC,HT}} \left( \text{TEMP}_{15,0} - \text{TREF}_{15,0} \right)}{2 \text{SENS}_{\text{TC,LT}} \cdot 0^{18}} \right]$$

$\text{SENS}_{\text{TC,N}}$ is a scaling factor needed for the fixed-point calculations. It is determined and written at Melexis during the production test.

In case the temperature compensation is not needed, bit 5 in T_EN_DIG_FILT_Z register is set to 0. This also disables the temperature measurement and the term in the square brackets of the formula above is equal to 1.

The operation is executed on the 19 bits raw magnetic data which is consequently truncated to 16 bit and loaded into the results registers.

7. Application information

Recommended application diagram

![Recommended application diagram](image)

Figure 26: Recommended application diagram

The MLX90397 package features an exposed pad. Considering the low self-heating of the component, no recommendation is given whether or not to connect this pad to ground.

Note: $R_{\text{SDA}}$ and $R_{\text{SCL}}$ are part of the bus specifications. Please refer to it.

8. Package and Manufacturability information

8.1. ESD precaution

Electronic semiconductor products are sensitive to Electro Static Discharge (ESD). Always observe Electro Static Discharge control procedures whenever handling semiconductor products.
### 8.2. Package information – UTDFN8

#### 8.2.1. Dimensions

UTDFN 2x2.5mm

![UTDFN 2x2.5mm](image)

**NOTE:**
1. ALL DIMENSIONS IN MILLIMETERS (mm).
2. EXPOSED TIE BAR SHOULD BE KEPT FREE FROM SOLDER.

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>MINIMUM</th>
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<tr>
<td>A</td>
<td>0.31</td>
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<td>A1</td>
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<td>0.05</td>
</tr>
<tr>
<td>A3</td>
<td>0.12 REF</td>
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<tr>
<td>L</td>
<td>0.25</td>
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</tr>
<tr>
<td>k</td>
<td>0.20</td>
<td>---</td>
</tr>
<tr>
<td>b</td>
<td>0.16</td>
<td>0.24</td>
</tr>
<tr>
<td>e</td>
<td>0.40 BSC</td>
<td></td>
</tr>
</tbody>
</table>
8.2.2. Sensing element placement

**Magnetic sweet spot**

![Diagram showing magnetic sweet spot with dimensions]

Figure 27: Field convention (Top view of the package with pin 1 at the bottom left)
8.2.3. Marking

1. Top mark

![Diagram of top mark with marking details](image)

- **Line 1**: Fixed Characters
- **Line 2**: WWY
- **Line 3**: dot = pin 1 position

Assembly date:
- WW = calendar week
- Y = last digit of the year

2. Bottom mark

![Diagram of bottom mark](image)

Line 1

Line 2

Line 3
8.3.  Standard information on soldering processes

8.3.1. Storage and handling of plastic encapsulated ICs

Plastic encapsulated ICs shall be stored and handled according to their MSL categorization level (specified in the packing label) as per J-STD-033.

Electronic semiconductor products are sensitive to Electro Static Discharge (ESD). The component assembly shall be handled in EPA (Electrostatic Protected Area) as per ANSI S20.20

For more information refer to Melexis Guidelines for storage and handling of plastic encapsulated ICs

8.3.2. Assembly of encapsulated ICs

For Surface Mounted Devices (SMD, as defined according to JEDEC norms), the only applicable soldering method is reflow.

For Through Hole Devices (THD), the applicable soldering methods are reflow, wave, selective wave and robot point-to-point. THD lead pre-forming (cutting and/or bending) is applicable under strict compliance with Melexis Guidelines for lead forming of SIP Hall Sensors.

Melexis products soldering on PCB should be conducted according to the requirements of IPC/JEDEC and J-STD-001. Solder quality acceptance should follow the requirements of IPC-A-610.

For PCB-less assembly refer to the relevant application notes or contact Melexis.

Electrical resistance welding or laser welding can be applied to Melexis products in THD and specific PCB-less packages following the Guidelines for welding of PCB-less devices.

Environmental protection of customer assembly with Melexis products for harsh media application, is applicable by means of coating, potting or overmolding considering restrictions listed in the relevant application notes

For other specific process, contact Melexis via www.melexis.com/technical-inquiry

8.3.3. Environment and sustainability

Melexis is contributing to global environmental conservation by promoting non-hazardous solutions. For more information on our environmental policy and declarations (RoHS, REACH...) visit www.melexis.com/environmental-forms-and-declarations

13 www.melexis.com/ic-handling-and-assembly
9. Tables

Table 1 – Ordering codes .................................................................................................................................. 2
Table 2 – Glossary of terms ........................................................................................................................... 5
Table 3 – Pin description .................................................................................................................................. 6
Table 4 – Absolute Maximum Ratings ........................................................................................................ 7
Table 5 – General operating conditions ...................................................................................................... 8
Table 6 – Electrical Operating conditions .................................................................................................. 8
Table 7 – Magnetic Operating conditions ..................................................................................................... 8
Table 8 – Electrical Specifications ................................................................................................................ 10
Table 9 – Magnetic Specifications ................................................................................................................ 13
Table 10 – Timing specifications ................................................................................................................... 14
Table 11 – Accuracy specifications ............................................................................................................... 17
Table 12 – Operating modes .......................................................................................................................... 18
Table 13 – Example of settings satisfying the timing consideration for proper operation in continuous
measurement mode........................................................................................................................................ 21
Table 14 – Magnetic data format ................................................................................................................ 23
Table 15 – XY and Z magnetic range selection ........................................................................................... 24
Table 16 – 8-bits Addressing register ........................................................................................................ 24
Table 17 – Memory map................................................................................................................................ 27
Table 18 – Revisions...................................................................................................................................... 45

10. Figures

Figure 1 – Block diagram ................................................................................................................................. 6
Figure 2: Average Consumption vs Filtering – Continuous measurement mode - Temperature compensation
on .................................................................................................................................................................. 11
Figure 3: Average Consumption vs Filtering – Continuous measurement at all possible speeds – Temp
compensation off .......................................................................................................................................... 11
Figure 4: Average consumption vs Filtering – Continuous measurements at 10Hz – Temperature
compensation off ......................................................................................................................................... 12
Figure 5: Conversion time vs. digital filtering (DIG_FILT) at typical Fclk = 2.4MHz ..................................... 15
Figure 6: DSP time vs. number of enabled magnetic axes at typical Fclk = 2.4MHz ................................. 16
Figure 7: Single measurement mode when data is read out of measurement period .................................. 18
Figure 8: Single measurement mode when data read started during measurement period ....................... 18
Figure 9: Continuous measurement mode .................................................................................................... 19
Figure 10: Normal read sequence ................................................................................................................ 20
Figure 11: Data read start during measurement ........................................................................................... 20
Figure 12: Data Skip: When data is not read ............................................................................................... 22
Figure 13: Data Skip: When data read has not been finished before the next measurement end .................. 22
Figure 14: I2C - MEM_DIRECT_READ (direct read) Command ............................................................... 25
Figure 15: I2C - MEM_READ (addressed read) .......................................................................................... 25
Figure 16: I2C - MEM_WRITE (addressed write) Command ................................................................. 26
Figure 17: Sequence flowchart .................................................................................................................... 34
Figure 18: XY axis RMS noise (typ) without temperature compensation and 25mT range selected ......... 35
Figure 19: Z axis RMS noise (typ) without temperature compensation and 25mT range selected .......... 35
Figure 20: XY axis RMS noise (typ) without temperature compensation and 50mT range selected ....... 36
Figure 21: Z axis RMS noise (typ) without temperature compensation and 50mT range selected .......... 36
Figure 22: XY axis RMS noise (typ) with temperature compensation and 25mT range selected .......... 37
Figure 23: Z axis RMS noise (typ) with temperature compensation and 25mT range selected .......... 37
Figure 24: XY axis RMS noise (typ) with temperature compensation and 50mT range selected ........... 38
Figure 25: Z axis RMS noise (typ) with temperature compensation and 50mT range selected .......... 38
Figure 26: Recommended application diagram .......................................................................................... 39
Figure 27: Field convention (Top view of the package with pin 1 at the bottom left) ................................. 41
11. Revision history

<table>
<thead>
<tr>
<th>Revision</th>
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<tr>
<td>001</td>
<td>14-March-2022</td>
<td>First datasheet</td>
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*Table 18 – Revisions*
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