

## Features and Benefits

- ☐ Triaxis® Magnetometer (BX, BY, BZ)
- ☐ On Chip Signal Processing for Robust Position Sensing
- ☐ High Speed Serial Interface (SPI compatible – Full Duplex)
- ☐ Enhanced Self-Diagnostics Features
- ☐ 5V and 3V3 Application Compatible
- ☐ 14 bit Output Resolution
- ☐ 48 bit ID Number
- ☐ Single Die – SO8 Package RoHS Compliant
- ☐ Dual Die (Full Redundant) – TSSOP16 Package RoHS Compliant



## Applications

- ☐ Absolute Contactless Position Sensor

## Ordering Code

| Product Code | Temperature Code | Package Code | Option Code | Packing Form Code |
|--------------|------------------|--------------|-------------|-------------------|
| MLX90363     | K                | DC           | ABB-000     | RE                |
| MLX90363     | K                | DC           | ABB-000     | TU                |
| MLX90363     | K                | GO           | ABB-000     | RE                |
| MLX90363     | K                | GO           | ABB-000     | TU                |
| MLX90363     | E                | DC           | ABB-000     | RE                |
| MLX90363     | E                | DC           | ABB-000     | TU                |
| MLX90363     | E                | GO           | ABB-000     | RE                |
| MLX90363     | E                | GO           | ABB-000     | TU                |
| MLX90363     | L                | DC           | ABB-000     | RE                |
| MLX90363     | L                | DC           | ABB-000     | TU                |
| MLX90363     | L                | GO           | ABB-000     | RE                |
| MLX90363     | L                | GO           | ABB-000     | TU                |

### Legend:

Temperature Code: L for Temperature Range - 40°C to 150°C,  
K for Temperature Range - 40°C to 125°C,  
E for Temperature Range - 40°C to 85°C.

Package Code: DC for SOIC-8, GO for TSSOP-16.

Option Code: xxx-000: Standard version

Packing Form: RE for Reel  
TU for Tube

Ordering example: MLX90363LGO-ABB-000-TU

## 1. Functional Diagram

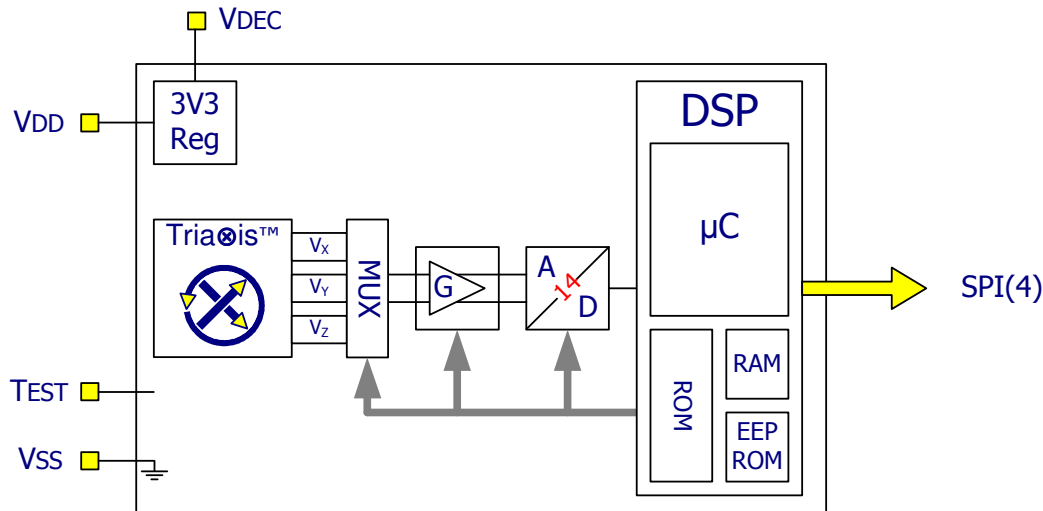


Figure 1 – Block Diagram

## 2. Description

The MLX90363 is a monolithic magnetic sensor IC featuring the Triaxis® Hall technology. Conventional planar Hall technology is only sensitive to the flux density applied orthogonally to the IC surface. The Triaxis® Hall sensor is also sensitive to the flux density applied parallel to the IC surface. This is obtained through an Integrated Magneto-Concentrator (IMC®) which is deposited on the CMOS die .

The MLX90363 is sensitive to the three (3) components of the flux density applied to the IC (i.e. Bx, By and Bz). This allows the MLX90363 to sense any magnet moving in its surrounding and decode its position through an appropriate signal processing.

Using its Serial Interface the MLX90363 can transmit a digital output (SP – 64 bits per frame).

The MLX90363 is intended for Embedded Position Sensor applications (vs. Stand-Alone “Remote” Sensor) for which the output is directly provided to a microcontroller (Master) close to the magnetometer IC MLX90363 (Slave). The SPI protocol confirms this intent.

The MLX90363 is using full duplex SPI protocol and requires therefore the separated SPI signal lines: MOSI, MISO, /SS and SLCK<sup>1</sup>.

<sup>1</sup> The MLX90316 multiplexes the MOSI/MISO lines. The application diagrams of the MLX90363 and MLX90316 are therefore not compatible.

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### 3. Glossary of Terms – Abbreviations – Acronyms

- Gauss (G), Tesla (T): Units for the magnetic flux density – 1 mT = 10 G
- TC: **T**emperature **C**oefficient (in ppm/Deg.C.)
- NC: **N**ot **C**onnected
- Byte: 8 bits
- Word: 16 bits (= 2 bytes)
- ADC: **A**nalog-to-**D**igital **C**onverter
- LSB: **L**east **S**ignificant **B**it
- MSB: **M**ost **S**ignificant **B**it
- DNL: **D**ifferential **N**on-**L**inearity
- INL: **I**ntegral **N**on-**L**inearity
- RISC: **R**educed **I**nstruction **S**et **C**omputer
- ASP: **A**nalog **S**ignal **P**rocessing
- DSP: **D**igital **S**ignal **P**rocessing
- ATAN: trigonometric function: arctangent (or inverse tangent)
- IMC: **I**ntegrated **M**agneto-**C**oncentrator (IMC®)
- CoRDIC: **C**oordinate **R**otation **D**igital **C**omputer (i.e. iterative rectangular-to-polar transform)
- EMC: **E**lectro-**M**agnetic **C**ompatibility
- FE: **F**alling **E**dge
- RE: **R**ising **E**dge
- MSC: **M**essage **S**equen**C**h
- FW: **F**irm**w**are
- HW: **H**ard**w**are

### 4. Pinout

| Pin # | SOIC-8       | TSSOP-16                                |
|-------|--------------|-----------------------------------------|
| 1     | VDD          | VDEC <sub>1</sub>                       |
| 2     | MISO         | VSS <sub>1</sub> (Ground <sub>1</sub> ) |
| 3     | Test         | VDD <sub>1</sub>                        |
| 4     | SCLK         | MISO <sub>1</sub>                       |
| 5     | /SS          | Test <sub>2</sub>                       |
| 6     | MOSI         | SCLK <sub>2</sub>                       |
| 7     | VDEC         | /SS <sub>2</sub>                        |
| 8     | VSS (Ground) | MOSI <sub>2</sub>                       |
| 9     |              | VDEC <sub>2</sub>                       |
| 10    |              | VSS <sub>2</sub> (Ground <sub>2</sub> ) |
| 11    |              | VDD <sub>2</sub>                        |
| 12    |              | MISO <sub>2</sub>                       |
| 13    |              | Test <sub>1</sub>                       |
| 14    |              | SCLK <sub>1</sub>                       |
| 15    |              | /SS <sub>1</sub>                        |
| 16    |              | MOSI <sub>1</sub>                       |

For optimal EMC behavior, it is recommended to connect the unused pins (Test) to the Ground (see section 19).

## 5. Pin Description

| Name         | Direction | Type    | Function / Description                                                                                         |
|--------------|-----------|---------|----------------------------------------------------------------------------------------------------------------|
| VDD          | VDD       | Analog  | Supply (5V and 3V3 application diagrams)                                                                       |
| MISO         | OUT       | Digital | Master In Slave Out                                                                                            |
| Test         | I/O       | Both    | Test Pin                                                                                                       |
| SCLK         | IN        | Digital | Clock                                                                                                          |
| /SS          | IN        | Digital | Slave Select                                                                                                   |
| MOSI         | IN        | Digital | Master Out Slave IN                                                                                            |
| VDEC         | I/O       | Analog  | <u>5V Application Diagrams</u><br>Decoupling Pin<br><u>3V3 Application Diagrams</u><br>Supply (Shorted to VDD) |
| VSS (Ground) | GND       | Analog  | Ground                                                                                                         |

## 6. Absolute Maximum Ratings

| Parameter                                           | Value              |
|-----------------------------------------------------|--------------------|
| Supply Voltage, VDD <sup>2</sup>                    | + 18 V             |
| Reverse VDD Voltage                                 | – 0.3 V            |
| Supply Voltage, VDEC                                | + 3.6 V            |
| Reverse VDEC Voltage                                | – 0.3 V            |
| Positive Input Voltage                              | + 11 V             |
| Reverse Input Voltage                               | – 11 V             |
| Positive Output Voltage                             | VDD + 0.3 V        |
| Reverse Output Voltage                              | – 0.3 V            |
| Operating Ambient Temperature Range, T <sub>A</sub> | – 40°C ... + 150°C |
| Storage Temperature Range, T <sub>S</sub>           | – 40°C ... + 150°C |
| Magnetic Flux Density                               | ± 700 mT           |

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

<sup>2</sup> Maximum rise time: 10µs. Rise time faster than 10µs might induce an extra current consumption.

## 7. Detailed Description

The three components of the applied flux density are measured through the Tria<sup>®</sup>is front end:

$$\begin{aligned} V_X &\propto B_X \\ V_Y &\propto B_Y \\ V_Z &\propto B_Z \end{aligned}$$

Those three (3) Hall voltages corresponding to the three (3) components of the applied flux density are provided to the ADC (Analog-to-Digital Converter). The Hall signals are processed through a fully differential analog chain featuring the classic offset cancellation technique (Hall plate 2-Phases spinning and chopper-stabilized amplifier).

The amplitude of  $V_Z$  is smaller than the two (2) components  $V_X$  and  $V_Y$  due to the fact that the magnetic gain of the IMC only affects the components parallel to the IC surface.

The conditioned analog signals are converted through a 14 bit ADC and provided to a DSP block for further processing. The DSP stage is based on a 16 bit RISC micro-controller whose primary function is the extraction of the position information (magnetic angle(s)) from the raw signals (after front-end compensation steps) through one the following operations:

$$\alpha = ATAN\left(\frac{k \cdot V_1}{V_2}\right)$$

where  $V_1 = V_X$  or  $V_Y$  or  $V_Z$ ,  $V_2 = V_X$  or  $V_Y$  or  $V_Z$  and  $k$  (or SMISM) is a programmable factor to match the amplitude of  $k V_1$  and  $V_2$ .

$$\alpha = ATAN\left(\frac{\sqrt{(k_\alpha V_3)^2 + (k_t V_2)^2}}{V_1}\right) \text{ and } \beta = ATAN\left(\frac{\sqrt{(k_\beta V_3)^2 + (k_t V_1)^2}}{V_2}\right)$$

where  $V_1 = V_X$  or  $V_Y$  or  $V_Z$ ,  $V_2 = V_X$  or  $V_Y$  or  $V_Z$ ,  $V_3 = V_X$  or  $V_Y$  or  $V_Z$  and  $k_\alpha$ ,  $k_\beta$  and  $k_t$  are programmable parameters.

The DSP functionality is governed by the micro-code (firmware – FW) of the micro-controller which is stored into the ROM (mask programmable). In addition to the “ATAN” (“Arctangent”) function, the FW controls the whole analog chain, the programming/calibration and also the self-diagnostic modes.

Due to the fact that the “ATAN” operation is performed on the ratios “ $V_1/V_2$ ”, “ $V_3/V_1$ ” and “ $V_3/V_2$ ”, the output is intrinsically self-compensated vs. flux density variations (due to airgap change, thermal or ageing effects) affecting both signals. This feature allows an improved thermal accuracy compared to a conventional linear Hall sensor.

The end-user programmable parameters are stored in EEPROM featuring a Hamming Error Correction Coding (ECC).

The programming steps do not require dedicated pins or programming tool. The operation is performed through the Master and the Serial Protocol using a dedicated and protected function<sup>(3)</sup>.

<sup>3</sup> For debug/demo purpose, Melexis can provide the Melexis Programming Unit PTC-04 with the SPI daughterboard (PTC-04-DB-SPI) and software library (PSF – Product Specific Functions).

## 8. MLX90363 Electrical Specification

DC Operating Parameters at VDD = 5V (5V Application Diagram) or VDD = 3.3V (3V3 Application Diagram) and for T<sub>A</sub> as specified by the Temperature suffix (E, K and L).

| Parameter                         | Symbol    | Test Conditions                             | Min     | Typ     | Max     | Units |
|-----------------------------------|-----------|---------------------------------------------|---------|---------|---------|-------|
| Nominal Supply Voltage            | VDD5      | 5V Application Diagram                      | 4.5     | 5       | 5.5     | V     |
| Nominal Supply Voltage            | VDD33     | 3V3 Application Diagram                     | 3.15    | 3.3     | 3.45    | V     |
| Supply Current <sup>(4)</sup>     | IDD       |                                             |         | 12.5    | 15.5    | mA    |
| Standby Current                   | ISTANDBY  |                                             |         | 3.5     | 4.5     | mA    |
| Supply Current at VDD MAX         | IDDMAX    | VDD = 18V                                   |         |         | 18      | mA    |
| POR Rising Level                  | POR LH    | Voltage referred to VDEC                    | 2.6     | 2.8     | 3.1     | V     |
| POR Falling Level                 | POR HL    | Voltage referred to VDEC                    | 2.5     | 2.7     | 2.9     | V     |
| POR Hysteresis                    | POR Hyst  | Voltage referred to VDEC                    |         | 0.1     |         | V     |
| MISO Switch Off Rising Level      | MT8V LH   | VDD level for disabling MISO <sup>(5)</sup> | 7.5     |         | 9.5     | V     |
| MISO Switch Off Falling Level     | MT8V HL   | VDD level for disabling MISO <sup>(5)</sup> | 6       |         | 7.5     | V     |
| MISO Switch Off Hysteresis        | MT8V Hyst | VDD level for disabling MISO <sup>(5)</sup> | 1       |         | 2       | V     |
| Input High Voltage Level          | VIH       |                                             | 65%*VDD | -       | -       | V     |
| Input Low Voltage Level           | VIL       |                                             | -       | -       | 35%*VDD | V     |
| Input Hysteresis                  | VHYS      |                                             |         | 20%*VDD |         | V     |
| Input Capacitance                 | CIN       | Referred to GND                             |         | 20      |         | pF    |
| Output High Voltage Level         | VOH       | Current Drive IOH = 0.5 mA                  | VDD-0.4 |         |         | V     |
| Output Low Voltage Level          | VOL       | Current Drive IOH = 0.5 mA                  |         |         | 0.4     | V     |
| Output High Short Circuit Current | IshortH   | VOUT forced to 0V                           |         | 20      | 30      | mA    |
| Output Low Short Circuit Current  | IshortL   | VOUT forced to VDD                          |         | 25      | 30      | mA    |

## 9. MLX90363 Isolation Specification

Only valid for the package code GO i.e. dual die version.

| Parameter            | Symbol | Test Conditions | Min | Typ | Max | Units |
|----------------------|--------|-----------------|-----|-----|-----|-------|
| Isolation Resistance |        | Between 2 dies  | 4   |     |     | MΩ    |

<sup>4</sup> For the dual version, the supply current is multiplied by 2

<sup>5</sup> Above the MT8V threshold, no SPI communication is possible.

## 10. MLX90363 Timing Specification

### 10.1. Timing Specification for 5V Application Diagram

DC Operating Parameters at VDD = 5V and for T<sub>A</sub> as specified by the Temperature suffix (E, K)<sup>6</sup>.

| Parameter                                                  | Symbol   | Test Conditions                                                                                                           | Min  | Typ  | Max             | Units                              |
|------------------------------------------------------------|----------|---------------------------------------------------------------------------------------------------------------------------|------|------|-----------------|------------------------------------|
| Main Clock Frequency                                       | Ck       |                                                                                                                           | 15.2 |      | 18.8            | MHz                                |
| Frame Rate                                                 | FR       | Trigger Mode 1 (Trg. Mod. 1),<br>Markers 0&2, SCI 2MHz<br>All other modes, markers and SCI<br>Frequencies                 |      |      | 1000<br>500     | s <sup>-1</sup><br>s <sup>-1</sup> |
| Watchdog time-out                                          | Wd       | See Section 18                                                                                                            | 15.3 | 18.8 | 20              | ms                                 |
| Power On to First SC/ message<br>(Start-up Time)           | tStartUp | See Section 14.20                                                                                                         | 20   |      |                 | ms                                 |
| SCI protocol: Slave-select rising-<br>edge to falling-edge | tShort   |                                                                                                                           | 120  |      |                 | us                                 |
| SCI protocol: EEPROMWrite Time                             | teewrite | Trimmed oscillator                                                                                                        | 32   |      |                 | ms                                 |
| Diagnostic Loop Time                                       | tDiag    | FR = 1000 s <sup>-1</sup> , Trg.Mod.1, Mark 0&2<br>FR = 500 s <sup>-1</sup><br>FR = 200 s <sup>-1</sup>                   |      |      | 40<br>20<br>10  | ms<br>ms<br>ms                     |
| Internal 1MHz signal                                       | t1us     | Ck = 19MHz                                                                                                                |      | 1    |                 | us                                 |
| MISO Rise Time                                             |          | C <sub>L</sub> = 30pF, R <sub>L</sub> = 10 kΩ                                                                             |      | 35   | 60              | ns                                 |
| MISO Fall Time                                             |          | C <sub>L</sub> = 30pF, R <sub>L</sub> = 10 kΩ                                                                             |      | 35   | 60              | ns                                 |
| Magnetic Flux Density Frequency                            |          | Sinewave Flux Density <sup>(7)</sup><br>FR = 1000 s <sup>-1</sup><br>FR = 500 s <sup>-1</sup><br>FR = 100 s <sup>-1</sup> |      |      | 4<br>8<br>18    | Hz<br>Hz<br>Hz                     |
|                                                            |          | FR = 1000 s <sup>-1(8)</sup><br>FR = 500 s <sup>-1(8)</sup><br>FR = 200 s <sup>-1(8)</sup>                                |      |      | 28<br>14<br>5.6 | Hz<br>Hz<br>Hz                     |

<sup>6</sup> Timing specification for "L" Temperature suffix available in 2012

<sup>7</sup> Sensitivity monitors enable (See section 18). Beyond that frequency, the Sensitivity monitor should be disabled.

<sup>8</sup> Limitation linked to the Automatic Gain Control. Beyond that frequency, there is a reduced immunity to norm change (like vibration). See also Section 19.4.

## 10.2. Timing Specification for 3V3 Application Diagram

DC Operating Parameters at  $V_{DD} = 3.3V$  and for  $T_A$  as specified by the Temperature suffix (E, K)<sup>9</sup>.

| Parameter                                                  | Symbol   | Test Conditions                                                                                           | Min  | Typ | Max                  | Units                              |
|------------------------------------------------------------|----------|-----------------------------------------------------------------------------------------------------------|------|-----|----------------------|------------------------------------|
| Main Clock Frequency                                       | Ck       |                                                                                                           | 13.1 |     | 18.8                 | MHz                                |
| Frame Rate                                                 | FR       | Trigger Mode 1 (Trg. Mod. 1),<br>Markers 0&2, SCI 2MHz<br>All other modes, markers and SCI<br>Frequencies |      |     | 862<br>430           | s <sup>-1</sup><br>s <sup>-1</sup> |
| Watchdog time-out                                          | Wd       | See Section 18                                                                                            | 15.3 |     | 23.2                 | ms                                 |
| Power On to First SCI message<br>(Start-up Time)           | tStartUp | See Section 14.20                                                                                         | 23.2 |     |                      | ms                                 |
| SCI protocol: Slave-select rising-<br>edge to falling-edge | tShort   |                                                                                                           | 139  |     |                      | us                                 |
| SCI protocol: EEPROMWrite Time                             | teewrite | 3.3V Trimmed oscillator                                                                                   | 37   |     |                      | ms                                 |
| Diagnostic Loop Time                                       | tDiag    | FR = 862 s <sup>-1</sup> , Trg.Mod.1, Mark 0&2<br>FR = 430 s <sup>-1</sup><br>FR = 215 s <sup>-1</sup>    |      |     | 46.4<br>23.2<br>11.6 | ms<br>ms<br>ms                     |
| Internal 1MHz signal                                       | t1us     | Ck = 19MHz                                                                                                |      | 1   |                      | us                                 |
| MISO Rise Time                                             |          | C <sub>L</sub> = 30pF, R <sub>L</sub> = 10 kΩ                                                             |      | 35  | 60                   | ns                                 |
| MISO Fall Time                                             |          | C <sub>L</sub> = 30pF, R <sub>L</sub> = 10 kΩ                                                             |      | 35  | 60                   | ns                                 |
| Magnetic Flux Density Frequency                            |          | FR = 862 s <sup>-1(10)</sup><br>FR = 430 s <sup>-1(10)</sup><br>FR = 215 s <sup>-1(10)</sup>              |      |     | 24<br>12<br>4.8      | Hz<br>Hz<br>Hz                     |

<sup>9</sup> Timing specification for "L" Temperature suffix available in 2012

<sup>10</sup> Limitation linked to the Automatic Gain Control. Beyond that frequency, there is a reduced immunity to norm change (like vibration). See also Section 19.4.

## 11. MLX90363 Accuracy Specification

DC Operating Parameters at VDD = 5V (5V Application Diagram) or VDD = 3.3V (3V3 Application Diagram) and for T<sub>A</sub> as specified by the Temperature suffix (E, K and L).

| Parameter                                    | Symbol     | Test Conditions                                                                       | Min       | Typ      | Max     | Units             |
|----------------------------------------------|------------|---------------------------------------------------------------------------------------|-----------|----------|---------|-------------------|
| ADC Resolution on the raw signals X, Y and Z | RADC       |                                                                                       |           | 14       |         | bit               |
| Serial Interface Resolution                  | RSI        | On the angle value<br>On the X,Y,Z values                                             |           | 14<br>12 |         | bit<br>bit        |
| Offset on the Raw Signals X, Y and Z         | X0, Y0, Z0 | TA = 25°C                                                                             | -30       |          | +30     | LSB <sub>14</sub> |
| Mismatch on the Raw Signals X, Y and Z       | SMISMxy    | TA = 25°C<br>Between X and Y                                                          | -1        |          | 1       | %                 |
|                                              | SMISMxz    | Between X and Z <sup>(11)</sup>                                                       | -30       |          | +30     | %                 |
|                                              | SMISMyz    | Between Y and Z <sup>(11)</sup>                                                       | -30       |          | +30     | %                 |
| Magnetic Angle Phase Error                   | ORTHxy     | TA = 25°C<br>Between X and Y                                                          | -0.3      |          | 0.3     | Deg               |
|                                              | ORTHxz     | Between X and Z <sup>(12)</sup>                                                       | -10       |          | 10      | Deg               |
|                                              | ORTHyz     | Between Y and Z <sup>(12)</sup>                                                       | -10       |          | 10      | Deg               |
| Intrinsic Linearity Error <sup>(13)</sup>    | Le         | TA = 25°C,<br>Magnetic Angle ∠XY<br>Magnetic Angle ∠XZ, ∠YZ <sup>(14)</sup>           | -1<br>-20 |          | 1<br>20 | Deg<br>Deg        |
| Supply Dependency                            |            | 5V Application Diagram<br>VDD = 4.5 ... 5.5V                                          | -0.1      |          | 0.1     | Deg               |
|                                              |            | 3V3 Application Diagram<br>VDD = 3.20 ... 3.40V<br>Temperature suffix E and K<br>20mT | -0.8      |          | 0.8     | Deg               |
|                                              |            | 50mT                                                                                  | -0.4      |          | 0.4     | Deg               |
|                                              |            | Temperature suffix L<br>20mT                                                          | -1        |          | 1       | Deg               |
|                                              |            | 50mT                                                                                  | -0.6      |          | 0.6     | Deg               |
|                                              |            |                                                                                       |           |          |         |                   |
| MLX90363 Accuracy Specification continues... |            |                                                                                       |           |          |         |                   |

<sup>11</sup> The Mismatch between X or Y and Z can be reduced through the calibration of the SMISM (or k) factor in the end application. See section 17.3.2 for more information

<sup>12</sup> The Magnetic Angle Phase error X or Y and Z can be reduced through the calibration of the ORTH\_B1B2 factor in the end application. See section 17.3.2 for more information

<sup>13</sup> The Intrinsic Linearity Error is a consolidation of the IC errors (offset, sensitivity mismatch, phase error) taking into account an ideal rotating field. Once associated to a practical magnetic construction and the associated mechanical and magnetic tolerances, the output linearity error increases.

<sup>14</sup> The Intrinsic Linearity Error for Magnetic Angle ∠XZ, ∠YZ can be reduced through the programming of the SMISM (or k) factor and ORTH\_B1B2. By applying the correct compensation, a non linearity error of +/-1 deg can be reached. See section 17.3.2 for more information

| ... MLX90363 Accuracy Specification                   |  |                            |       |  |       |                   |
|-------------------------------------------------------|--|----------------------------|-------|--|-------|-------------------|
| Thermal Offset Drift <sup>(15)</sup>                  |  | Temperature suffix E and K | -30   |  | +30   | LSB <sub>14</sub> |
|                                                       |  | Temperature suffix L       | -45   |  | +45   | LSB <sub>14</sub> |
| Thermal Drift of Sensitivity Mismatch <sup>(16)</sup> |  | XY axis, XZ axis, YZ axis  |       |  |       |                   |
|                                                       |  | Temperature suffix E and K | - 0.5 |  | + 0.5 | %                 |
|                                                       |  | Temperature suffix L       | - 0.7 |  | + 0.7 | %                 |
| Thermal Drift of Magnetic Angle Phase Error           |  | XY axis, XZ axis, YZ axis  | 0.1   |  | 0.1   | Deg               |
| Magnetic Angle Noise <sup>(17)</sup>                  |  | Temperature suffix E and K |       |  |       |                   |
|                                                       |  | 20mT, No Filter            |       |  | 0.20  | Deg               |
|                                                       |  | 50mT, No Filter            |       |  | 0.10  | Deg               |
|                                                       |  | 50mT, FILTER=1             |       |  | 0.07  | Deg               |
|                                                       |  | Temperature suffix L       |       |  |       |                   |
|                                                       |  | 20mT, No Filter            |       |  | 0.25  | Deg               |
|                                                       |  | 50mT, No Filter            |       |  | 0.12  | Deg               |
|                                                       |  | 50mT, FILTER=1             |       |  | 0.08  | Deg               |
| Raw signals X, Y, Z Noise <sup>(17)</sup>             |  | Temperature suffix E and K |       |  |       |                   |
|                                                       |  | 20mT, No Filter            |       |  | 12    | LSB <sub>14</sub> |
|                                                       |  | 50mT, No Filter            |       |  | 6     | LSB <sub>14</sub> |
|                                                       |  | 50mT, FILTER_TYPE =1       |       |  | 4     | LSB <sub>14</sub> |
|                                                       |  | Temperature suffix L       |       |  |       |                   |
|                                                       |  | 20mT, No Filter            |       |  | 14    | LSB <sub>14</sub> |
|                                                       |  | 50mT, No Filter            |       |  | 7     | LSB <sub>14</sub> |
|                                                       |  | 50mT, FILTER=1             |       |  | 4     | LSB <sub>14</sub> |

<sup>15</sup> For instance, Thermal Offset Drift equal  $\pm 30\text{LSB}_{14}$  yields to max.  $\pm 0.32$  Deg. error. This is only valid if the Virtual Gain is not fixed (See Section 17.6). See Front End Application Note for more details.

<sup>16</sup> For instance, Thermal Drift of Sensitivity Mismatch equal  $\pm 0.4\%$  yields to max.  $\pm 0.1$  Deg. error. See Front End Application Note for more details.

<sup>17</sup> Noise is defined by  $\pm 3 \sigma$  for 1000 successive acquisitions. The application diagram used is described in the recommended wiring (Section 20). For detailed information, refer to section Filter in application mode (Section 17.5).

## 12. MLX90363 Magnetic Specification

DC Operating Parameters at  $V_{DD} = 5V$  (5V Application Diagram) or  $V_{DD} = 3.3V$  (3V3 Application Diagram) and for  $T_A$  as specified by the Temperature suffix (E, K and L).

| Parameter                       | Symbol          | Test Conditions | Min   | Typ | Max                | Units  |
|---------------------------------|-----------------|-----------------|-------|-----|--------------------|--------|
| Magnetic Flux Density in X or Y | $B_{XY}^{(18)}$ |                 | 20    | 50  | 70 <sup>(19)</sup> | mT     |
| Magnetic Flux Density in Z      | $B_Z^{(18)}$    |                 | 24    | 75  | 126                | mT     |
| Magnet Temperature Coefficient  | TCm             |                 | -2400 |     | 0                  | ppm/°C |
| IMC Gain <sup>(20)</sup>        | GainIMC         |                 | 1.2   | 1.4 | 1.8                |        |

## 13. MLX90363 CPU & Memory Specification

The digital signal processing is based on a 16 bit RISC  $\mu$ Controller featuring

- ROM & RAM
- EEPROM with hamming codes (ECC)
- Watchdog
- C Compiler

| Parameter | Symbol | Test Conditions | Min | Typ | Max | Units |
|-----------|--------|-----------------|-----|-----|-----|-------|
| ROM       |        |                 |     | 14  |     | kByte |
| RAM       |        |                 |     | 256 |     | Byte  |
| EEPROM    |        |                 |     | 64  |     | Byte  |
| CPU MIPS  |        | Ck = 15 MHz     |     | 3.5 |     | MIPS  |

<sup>18</sup> The condition must be fulfilled for at least one field  $B_x$ ,  $B_y$  or  $B_z$ .

<sup>19</sup> Above 70 mT, the IMC starts saturating yielding an increase of the linearity error.

<sup>20</sup> This is the magnetic gain linked to the Integrated Magneto Concentrator structure. It applies to  $B_x$  and  $B_y$  and not to  $B_z$ . This is the overall variation. Within one lot, the part to part variation is typically  $\pm 10\%$  versus the average value of the IMC gain of that lot.

## 14. MLX90363 Serial Interface

The MLX90363 serial interface allows a master device to operate the position sensor. The MLX90363 interface allows multi-slave applications and synchronous start of the data acquisition among the slaves. The interface offers 2 Mbps data transfer bit rate and is full duplex. The interface accepts messages of 64 bits wide only, making the interfacing robust.

In this document, the words *message*, *frame* and *packet* refer to the same concept.

### 14.1. Electrical Layer and Timing Specification

Message transmissions start necessarily at a falling edge on /SS and end necessarily at a rising edge on the /SS signal. This defines a message. The serial interface counts the number of transmitted bits and declares the incoming message invalid when the bit count differs from 64. The master must therefore ensure the flow described below:

1. Set pin /SS Low
2. Send and receive 8 bytes or four (4x) 16 bit words
3. Set pin /SS High

The *MISO* and *MOSI* signals change on *SCLK* rising edge and are captured on *SCLK* falling edge. The most-significant-bit of the transmitted byte or word comes first <sup>(21)</sup>.

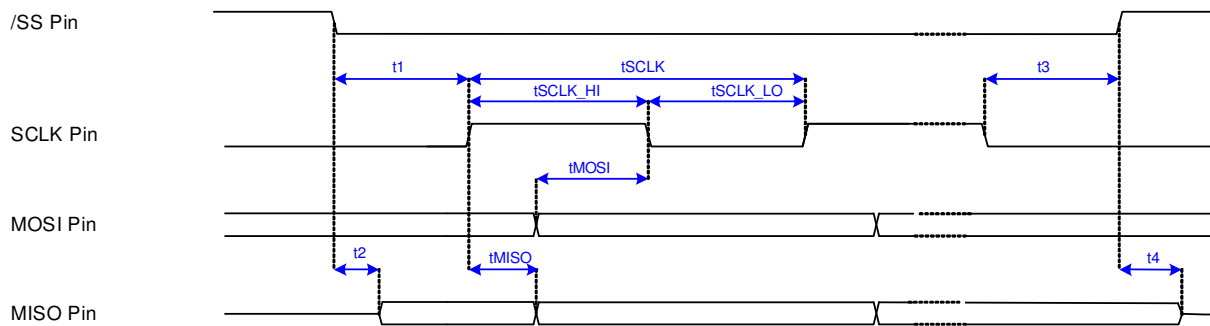


Figure 2 – Serial Interface Timing Diagram

The interface is sensitive, in Trigger mode 2 (see section 14.6), to *Sync* pulses. A *Sync* pulse is negative pulse on /SS, while *SCLK* is kept quiet.

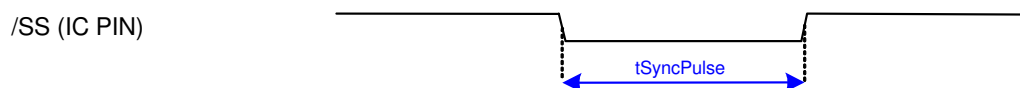


Figure 3 – Sync Pulse Timing Diagram

<sup>21</sup> For instance, for master compatible w/ the Motorola SPI protocol, the configuration bits must be *CPHA*=1, *CPOL*=0, *LSBFE*=0.

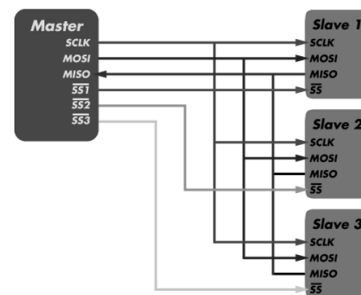
| Parameter                     | Symbol     | Test Conditions                | Min  | Typ  | Max   | Units |
|-------------------------------|------------|--------------------------------|------|------|-------|-------|
| Clock Period                  | tSCLK      | EE_PINFILTER = 1               | 450  | 500  |       | ns    |
|                               |            | EE_PINFILTER = 2               | 900  | 1000 |       | ns    |
|                               |            | EE_PINFILTER = 3               | 1800 | 2000 |       | ns    |
| Clock Low Level               | tSCLK_HI   | EE_PINFILTER = 1               | 225  |      |       | ns    |
|                               |            | EE_PINFILTER = 2               | 450  |      |       | ns    |
|                               |            | EE_PINFILTER = 3               | 900  |      |       | ns    |
| Clock High Level              | tSCLK_LO   | EE_PINFILTER = 1               | 225  |      |       | ns    |
|                               |            | EE_PINFILTER = 2               | 450  |      |       | ns    |
|                               |            | EE_PINFILTER = 3               | 900  |      |       | ns    |
| Clock to Data Delay           | tMISO      | EE_PINFILTER = 1, Cload = 30pF |      |      | 210   | ns    |
|                               |            | EE_PINFILTER = 2, Cload = 30pF |      |      | 300   | ns    |
|                               |            | EE_PINFILTER = 3, Cload = 30pF |      |      | 510   | ns    |
| Data Capture Setup Time       | tMOSI      |                                | 30   |      |       | ns    |
| /SS FE to SCLK RE             | t1         | EE_PINFILTER = 1               | 225  |      |       | ns    |
|                               |            | EE_PINFILTER = 2               | 450  |      |       | ns    |
|                               |            | EE_PINFILTER = 3               | 900  |      |       | ns    |
| /SS FE to MISO Low Impedance  | t2         | EE_PINFILTER = 1               |      | 90   | 120   | ns    |
|                               |            | EE_PINFILTER = 2               |      | 180  | 210   | ns    |
|                               |            | EE_PINFILTER = 3               |      | 370  | 420   | ns    |
| SCLK FE to /SS RE             | t3         |                                | 225  |      |       | ns    |
| /SS RE to MISO High Impedance | t4         | EE_PINFILTER = 1               |      | 90   | 120   | ns    |
|                               |            | EE_PINFILTER = 2               |      | 180  | 210   | ns    |
|                               |            | EE_PINFILTER = 3               |      | 370  | 420   | ns    |
| Sync Pulse Duration           | tSyncPulse | EE_PINFILTER = 1               | 520  |      | 10000 | ns    |
|                               |            | EE_PINFILTER = 2               | 610  |      | 10000 | ns    |
|                               |            | EE_PINFILTER = 3               | 820  |      | 10000 | ns    |

Table 1 - Serial Interface Timing Specifications

Melexis recommends using the multi-slave application diagram as shown on the right.

The *SCLK*, *MISO* and *MOSI* wires interconnect the slaves with the master. A slave is selected by its dedicated */SS* input. A slave *MISO* output is in high-impedance state when the slave is not selected.

Slaves can be triggered synchronously by sending *Sync* pulses on the different */SS*. The pulses must not overlap to avoid electrical short-circuits on the *MISO* bus.



## 14.2. Serial Protocol

The serial protocol of MLX90363 allows the SPI master device to request the following information:

- Position (magnetic angle Alpha)
- Raw field components (X,Y and Z)
- Self-Diagnostic data

It allows customizing the calibration of the sensor, when needed, at the end-of-line, through EEPROM programming.

The serial protocol offers a transfer rate of 1000 messages/sec. A regular message holds position and diagnostic information. The data acquisition start and processing is fully under the control of the SPI master. The user configuration bits, stored in EEPROM, are programmable with this protocol.

Data integrity is guaranteed in both directions by an 8 bit CRC covering the content of the incoming and outgoing messages. In a dual sensors application, a *Sync* pulse allows a synchronous start of the raw signals acquisition.

## 14.3. Message General Structure

A message has a unique *Opcode*. The general structure of a message consists of 8 bytes (byte #0, transmitted first, to byte #7 transmitted last).

Byte #7 (the last byte transmitted) holds an 8 bit CRC. The byte #6 holds a *Marker* plus either an *Opcode* or a *rolling counter*.

| # | 7   | 6 | 5 | 4 | 3 | 2 | 1 | 0   | # | 7      | 6 | 5                      | 4 | 3 | 2 | 1 | 0   |
|---|-----|---|---|---|---|---|---|-----|---|--------|---|------------------------|---|---|---|---|-----|
| 1 | (4) |   |   |   |   |   |   | (3) | 0 | (2)    |   |                        |   |   |   |   | (1) |
| 3 |     |   |   |   |   |   |   |     | 2 |        |   |                        |   |   |   |   | (5) |
| 5 |     |   |   |   |   |   |   |     | 4 |        |   |                        |   |   |   |   |     |
| 7 | CRC |   |   |   |   |   |   |     | 6 | Marker |   | Opcode or Roll Counter |   |   |   |   |     |

Table 2 – General Structure of a message and bit naming convention

- (1) This bit is named Byte0[0]      (2) This bit is named Byte0[7]  
 (3) This bit is named Byte1[0]      (4) This bit is named Byte1[7]  
 (5) This bit is named Byte2[0]

A blank cell refers necessarily to a bit 0.

In a byte, the most-significant-bit is transmitted first (for instance, Byte0[7] is transmitted first, Byte0[0] transmitted last).

Parameter *CRC*[7:0] is Byte7[7:0], Parameter *Marker*[1:0] is Byte6[7:6],  
 Parameter *Opcode*[5:0] (or *Roll Counter*[5:0]) is Byte6[5:0]

CRCs are encoded and decoded according the following algorithm (language-C):

```

crc = 0xFF;
crc = cba_256_TAB[ Byte0 ^ crc ];
crc = cba_256_TAB[ Byte1 ^ crc ];
crc = cba_256_TAB[ Byte2 ^ crc ];
crc = cba_256_TAB[ Byte3 ^ crc ];
crc = cba_256_TAB[ Byte4 ^ crc ];
crc = cba_256_TAB[ Byte5 ^ crc ];
crc = cba_256_TAB[ Byte6 ^ crc ];
crc = ~crc;
```

The Table 3 corresponds to the CRC-8 polynomial “0xC2”.

| cba_256_TAB | 0    | 1    | 2    | 3    | 4    | 5    | 6    | 7    |
|-------------|------|------|------|------|------|------|------|------|
| 0           | 0x00 | 0x2f | 0x5e | 0x71 | 0xbc | 0x93 | 0xe2 | 0xcd |
| 1           | 0x57 | 0x78 | 0x09 | 0x26 | 0xeb | 0xc4 | 0xb5 | 0x9a |
| 2           | 0xae | 0x81 | 0xf0 | 0xdf | 0x12 | 0x3d | 0x4c | 0x63 |
| 3           | 0xf9 | 0xd6 | 0xa7 | 0x88 | 0x45 | 0x6a | 0x1b | 0x34 |
| 4           | 0x73 | 0x5c | 0x2d | 0x02 | 0xcf | 0xe0 | 0x91 | 0xbe |
| 5           | 0x24 | 0x0b | 0x7a | 0x55 | 0x98 | 0xb7 | 0xc6 | 0xe9 |
| 6           | 0xdd | 0xf2 | 0x83 | 0xac | 0x61 | 0x4e | 0x3f | 0x10 |
| 7           | 0x8a | 0xa5 | 0xd4 | 0xfb | 0x36 | 0x19 | 0x68 | 0x47 |
| 8           | 0xe6 | 0xc9 | 0xb8 | 0x97 | 0x5a | 0x75 | 0x04 | 0x2b |
| 9           | 0xb1 | 0x9e | 0xef | 0xc0 | 0x0d | 0x22 | 0x53 | 0x7c |
| 10          | 0x48 | 0x67 | 0x16 | 0x39 | 0xf4 | 0xdb | 0xaa | 0x85 |
| 11          | 0x1f | 0x30 | 0x41 | 0x6e | 0xa3 | 0x8c | 0xfd | 0xd2 |
| 12          | 0x95 | 0xba | 0xcb | 0xe4 | 0x29 | 0x06 | 0x77 | 0x58 |
| 13          | 0xc2 | 0xed | 0x9c | 0xb3 | 0x7e | 0x51 | 0x20 | 0x0f |
| 14          | 0x3b | 0x14 | 0x65 | 0x4a | 0x87 | 0xa8 | 0xd9 | 0xf6 |
| 15          | 0x6c | 0x43 | 0x32 | 0x1d | 0xd0 | 0xff | 0x8e | 0xa1 |
| 16          | 0xe3 | 0xcc | 0xbd | 0x92 | 0x5f | 0x70 | 0x01 | 0x2e |
| 17          | 0xb4 | 0x9b | 0xea | 0xc5 | 0x08 | 0x27 | 0x56 | 0x79 |
| 18          | 0x4d | 0x62 | 0x13 | 0x3c | 0xf1 | 0xde | 0xaf | 0x80 |
| 19          | 0x1a | 0x35 | 0x44 | 0x6b | 0xa6 | 0x89 | 0xf8 | 0xd7 |
| 20          | 0x90 | 0xbf | 0xce | 0xe1 | 0x2c | 0x03 | 0x72 | 0x5d |
| 21          | 0xc7 | 0xe8 | 0x99 | 0xb6 | 0x7b | 0x54 | 0x25 | 0x0a |
| 22          | 0x3e | 0x11 | 0x60 | 0x4f | 0x82 | 0xad | 0xdc | 0xf3 |
| 23          | 0x69 | 0x46 | 0x37 | 0x18 | 0xd5 | 0xfa | 0x8b | 0xa4 |
| 24          | 0x05 | 0x2a | 0x5b | 0x74 | 0xb9 | 0x96 | 0xe7 | 0xc8 |
| 25          | 0x52 | 0x7d | 0x0c | 0x23 | 0xee | 0xc1 | 0xb0 | 0x9f |
| 26          | 0xab | 0x84 | 0xf5 | 0xda | 0x17 | 0x38 | 0x49 | 0x66 |
| 27          | 0xfc | 0xd3 | 0xa2 | 0x8d | 0x40 | 0x6f | 0x1e | 0x31 |
| 28          | 0x76 | 0x59 | 0x28 | 0x07 | 0xca | 0xe5 | 0x94 | 0xbb |
| 29          | 0x21 | 0x0e | 0x7f | 0x50 | 0x9d | 0xb2 | 0xc3 | 0xec |
| 30          | 0xd8 | 0xf7 | 0x86 | 0xa9 | 0x64 | 0x4b | 0x3a | 0x15 |
| 31          | 0x8f | 0xa0 | 0xd1 | 0xfe | 0x33 | 0x1c | 0x6d | 0x42 |

Table 3 – cba\_256\_TAB Look-up table Polynomial “C2”

| # | 7    | 6 | 5 | 4 | 3 | 2 | 1 | 0 | # | 7    | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|------|---|---|---|---|---|---|---|---|------|---|---|---|---|---|---|---|
| 1 | 0xFF |   |   |   |   |   |   |   | 0 | 0xC1 |   |   |   |   |   |   |   |
| 3 | 0xFF |   |   |   |   |   |   |   | 2 | 0x16 |   |   |   |   |   |   |   |
| 5 | 0xFF |   |   |   |   |   |   |   | 4 | 0xD4 |   |   |   |   |   |   |   |
| 7 | 0x23 |   |   |   |   |   |   |   | 6 | 0x86 |   |   |   |   |   |   |   |

Table 4 – Example of valid CRC

## 14.4. Regular Messages

The MLX90363 offers three types of regular messages:

- “ $\alpha$ ” – diagnostic
- “ $\alpha - \beta$ ” – diagnostic
- X – Y – Z – diagnostic

| # | 7   | 6  | 5            | 4 | 3 | 2 | 1 | 0 | # | 7           | 6 | 5    | 4 | 3 | 2 | 1 | 0 |
|---|-----|----|--------------|---|---|---|---|---|---|-------------|---|------|---|---|---|---|---|
| 1 | E1  | E0 | ALPHA [13:8] |   |   |   |   |   | 0 | ALPHA [7:0] |   |      |   |   |   |   |   |
| 3 | 0   |    |              |   |   |   |   |   | 2 | 0           |   |      |   |   |   |   |   |
| 5 | 0   |    |              |   |   |   |   |   | 4 | VG[7:0]     |   |      |   |   |   |   |   |
| 7 | CRC |    |              |   |   |   |   |   | 6 | 0           | 0 | ROLL |   |   |   |   |   |

Table 5 – “ $\alpha$ ” message

| # | 7   | 6  | 5            | 4 | 3 | 2 | 1 | 0 | # | 7           | 6 | 5    | 4 | 3 | 2 | 1 | 0 |
|---|-----|----|--------------|---|---|---|---|---|---|-------------|---|------|---|---|---|---|---|
| 1 | E1  | E0 | ALPHA [13:8] |   |   |   |   |   | 0 | ALPHA [7:0] |   |      |   |   |   |   |   |
| 3 |     |    | BETA [13:8]  |   |   |   |   |   | 2 | BETA [7:0]  |   |      |   |   |   |   |   |
| 5 | 0   |    |              |   |   |   |   |   | 4 | VG[7:0]     |   |      |   |   |   |   |   |
| 7 | CRC |    |              |   |   |   |   |   | 6 | 0           | 1 | ROLL |   |   |   |   |   |

Table 6 – “ $\alpha - \beta$ ” message

| # | 7   | 6  | 5                  | 4 | 3 | 2 | 1 | 0 | # | 7                 | 6 | 5    | 4 | 3 | 2 | 1 | 0 |
|---|-----|----|--------------------|---|---|---|---|---|---|-------------------|---|------|---|---|---|---|---|
| 1 | E1  | E0 | X COMPONENT [13:8] |   |   |   |   |   | 0 | X COMPONENT [7:0] |   |      |   |   |   |   |   |
| 3 |     |    | Y COMPONENT [13:8] |   |   |   |   |   | 2 | Y COMPONENT [7:0] |   |      |   |   |   |   |   |
| 5 |     |    | Z COMPONENT [13:8] |   |   |   |   |   | 4 | Z COMPONENT [7:0] |   |      |   |   |   |   |   |
| 7 | CRC |    |                    |   |   |   |   |   | 6 | 1                 | 0 | ROLL |   |   |   |   |   |

Table 7 – “X – Y – Z” message

The bits byte6[7] and byte6[6] are markers. They allow the master to recognize the type of regular message (00b, 01b, 10b). The marker is present in all messages (incoming and outgoing). The marker of any message which is not a regular message is equal to 11b.

The bits E1 and E0 report the status of the diagnostics (4 possibilities) as described in the Table 8 – See section 18 for more details.

| E1 | E0 | Description                                 |
|----|----|---------------------------------------------|
| 0  | 0  | First Diagnostics Sequence Not Yet Finished |
| 0  | 1  | Diagnostic Fail                             |
| 1  | 0  | Diagnostic Pass (Previous cycle)            |
| 1  | 1  | Diagnostic Pass – New Cycle Completed       |

Table 8 - Diagnostics Status Bits

### 14.4.1. Note for the regular message “X – Y – Z – diagnostic” (Marker = 2)

In the case of marker = 2, the X,Y,Z components are given after offset compensation and filtering (see signal processing in section 19.2). These components are gain dependent (see also section 17.6).

The sensitivity in the X and Y direction is always higher than the Z direction by the IMC Gain factor (see parameter GainIMC in section 12). Melexis therefore recommends multiplying the Z component by the GainIMC factor inside the master in order to use the MLX90363 as a 3D magnetometer.

### 14.5. Trigger Mode 1

The master sends a GET1 command to initiate the magnetic field acquisition and post-processing. It waits  $t_{SSREFE}$ , issues the next GET1 and receives at the same time the regular message resulting from the previous GET.

The field sensing, acquisition and post-processing is starting on /SS rising edge events.

Although GET1 commands are preferably followed by another GET1 command or a NOP command, any other commands are accepted by the slave.

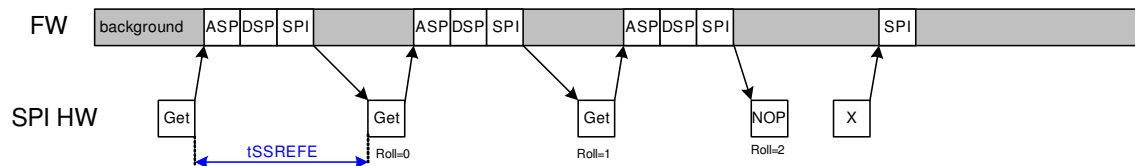


Figure 4 – Trigger mode 1

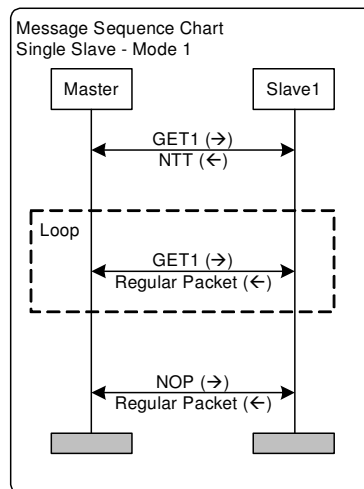


Figure 5 – Trigger Mode 1 Message Sequence Chart

| # | 7          | 6 | 5 | 4 | 3 | 2 | 1 | 0   | # | 7      | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|------------|---|---|---|---|---|---|-----|---|--------|---|---|---|---|---|---|---|
| 1 |            |   |   |   |   |   |   | RST | 0 |        |   |   |   |   |   |   |   |
| 3 | Time – Out |   |   |   |   |   |   |     | 2 | Value  |   |   |   |   |   |   |   |
| 5 |            |   |   |   |   |   |   |     | 4 |        |   |   |   |   |   |   |   |
| 7 | CRC        |   |   |   |   |   |   |     | 6 | Marker | 0 | 1 | 0 | 0 | 1 | 1 |   |

Table 9 – GET1 MOSI Message (Opcode = 19)

Note: The NOP message is described at section “14.11”

- The parameter *Marker* defines the regular data packet type expected by the master:

Marker = 0 refers to frame type “ALPHA + Diagnostic”.

Marker = 1 refers to frame type “ALPHA + BETA + Diagnostic”.

Marker = 2 refers to frame type “Components X + Y + Z +Diagnostic”.

- The parameter *Rst* (Byte1[0] ) when set, resets the rolling counter attached to the regular data packets.
- The parameter *TimeOutValue* tells the maximum life time of the Regular Data Message. The time step is  $t_{1us}$  (See table in Section 10), the maximum time-out is  $65535 * t_{1us}$ . The time-out timer starts when the message is ready, and stops on the SS rising edge of the next message.

On time-out occurrence, there are two possible scenarios:

- Scenario 1. SS is high, there is no message exchange. In this case, a NTT message replaces the regular message in the SCI buffer.
- Scenario 2. SS is low, the regular packet is being sent out. In this case, the timeout violation is reported on the next message, this later being an NTT message.

## 14.6. Trigger Mode 2

The Trigger Mode 1 works without *Sync* pulses, as the GET1 command plays the role of a sync pulse. When a delay between the regular message readback and the start of acquisition is needed, or when two or more slaves should be triggered synchronously, the use of a sync pulse is required, and this is the meaning of the Trigger Mode 2.

**Principle:** The master first enables the trigger mode 2 by issuing a GET2 command. The master then sends a *Sync Pulse*, at the appropriate time, to initiate the magnetic field acquisition and post-processing. Finally the master reads the response message with a NOP or a GET2. The GET2 command re-initiates a sync pulse triggered acquisition, whereas the NOP command would just allow the master to receive the latest packet.

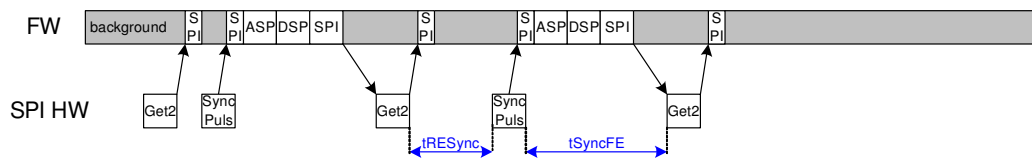


Figure 6 – Trigger Mode 2 – Single Slave Approach

A timing constraint between GET2 and the sync pulse ( $t_{RESync}$ ) should be met.

When this timing is smaller than the constraint, the sync pulse might not be taken in account, causing the next GET2 to return a NTT packet.

GET1 and GET2/SyncPulse can be interlaced.

**Multi-slave approach:** The way of working described below fits the multi-slave applications where synchronous acquisitions are important. GET2 commands are sent one after the other to the slaves. Then the Sync Pulses are sent almost synchronously (very shortly one after the other).

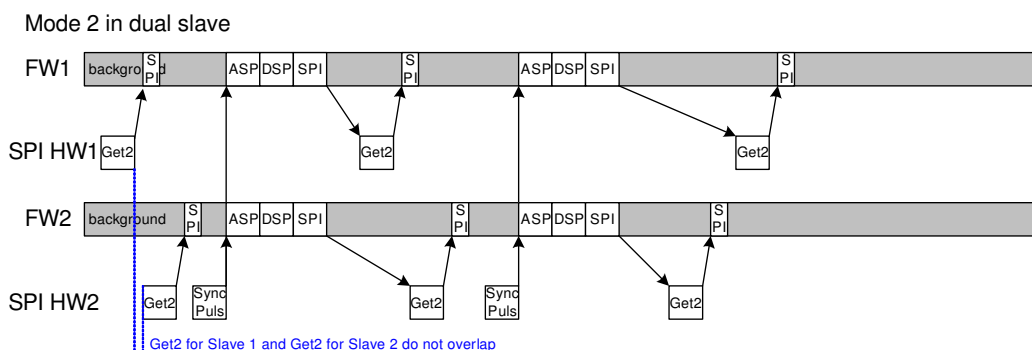


Figure 7 – Trigger mode 2 - Multi-slave approach, example for two slaves

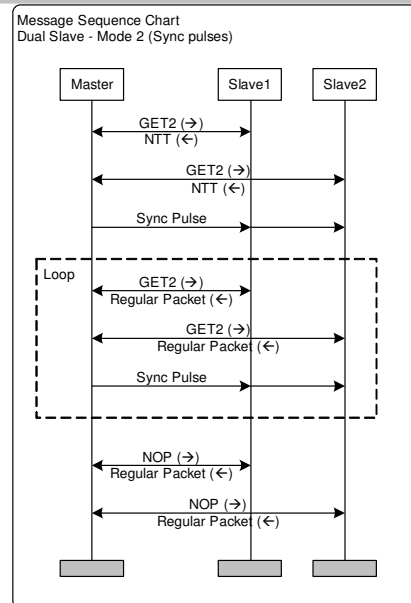


Figure 8 – Trigger mode 2 Message Sequence Chart

| # | 7          | 6 | 5 | 4 | 3 | 2 | 1 | 0   | # | 7      | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|------------|---|---|---|---|---|---|-----|---|--------|---|---|---|---|---|---|---|
| 1 |            |   |   |   |   |   |   | RST | 0 |        |   |   |   |   |   |   |   |
| 3 | Time - Out |   |   |   |   |   |   |     | 2 | Value  |   |   |   |   |   |   |   |
| 5 |            |   |   |   |   |   |   |     | 4 |        |   |   |   |   |   |   |   |
| 7 | CRC        |   |   |   |   |   |   |     | 6 | Marker | 0 | 1 | 0 | 1 | 0 | 0 |   |

Table 10 – GET2 MOSI Message (Opcode = 20)

Parameter definition: See GET1 (Section 14.5).

### 14.7. Trigger Mode 3

**Principle:** The acquisition sequences are triggered by a GET message, but unlike the Mode 1, the resulting data (position ...) is buffered. The slave-out messages contain the buffered data of the previous GET message, and not the newly computed values corresponding to the current GET slave-in request. The buffering releases constraints on the SCI clock frequency (*SCLK*). The Mode 3 offers frame rates as high as Mode 1, if not higher, with slower *SCLK* frequencies. When the clock frequency is limited (400 kbps or less), and when it matters to reach a certain frame rate, Mode 3 is preferred over Mode 1. In any other cases, for instance when the shortest response time represents the main design criteria, Mode 1 is preferred.

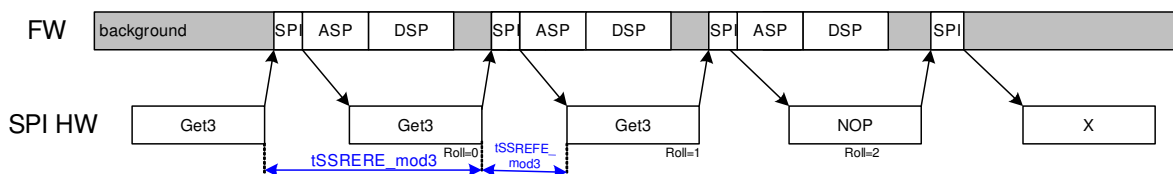


Figure 9 – Trigger mode 3

GET3 sequences must end with a NOP.

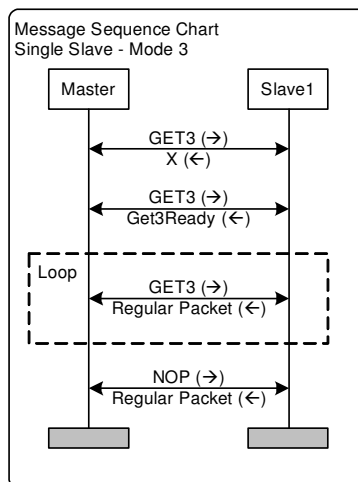


Figure 10 – Trigger mode 3 Message Sequence Chart

| # | 7          | 6 | 5 | 4 | 3 | 2 | 1 | 0   | # | 7      | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|------------|---|---|---|---|---|---|-----|---|--------|---|---|---|---|---|---|---|
| 1 |            |   |   |   |   |   |   | RST | 0 |        |   |   |   |   |   |   |   |
| 3 | Time – Out |   |   |   |   |   |   |     | 2 | Value  |   |   |   |   |   |   |   |
| 5 |            |   |   |   |   |   |   |     | 4 |        |   |   |   |   |   |   |   |
| 7 | CRC        |   |   |   |   |   |   |     | 6 | Marker | 0 | 1 | 0 | 1 | 0 | 1 |   |

Table 11 – GET3 MOSI Message (Opcode = 21)

Parameter definition: See GET1 (Section 14.5)

| # | 7   | 6 | 5 | 4 | 3 | 2 | 1 | 0 | # | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|-----|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 |     |   |   |   |   |   |   |   | 0 |   |   |   |   |   |   |   |   |
| 3 |     |   |   |   |   |   |   |   | 2 |   |   |   |   |   |   |   |   |
| 5 |     |   |   |   |   |   |   |   | 4 |   |   |   |   |   |   |   |   |
| 7 | CRC |   |   |   |   |   |   |   | 6 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 |

Table 12 – Get3Ready Slave-Out Message (Opcode = 45)

## 14.8. Trigger Modes Timing Specifications

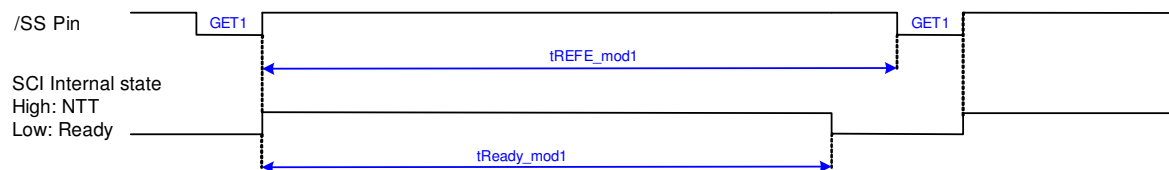


Figure 11 – Trigger mode 1 timing diagram

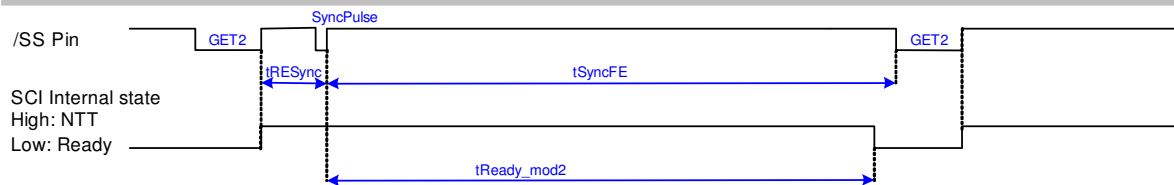


Figure 12 – Trigger mode 2 timing diagram

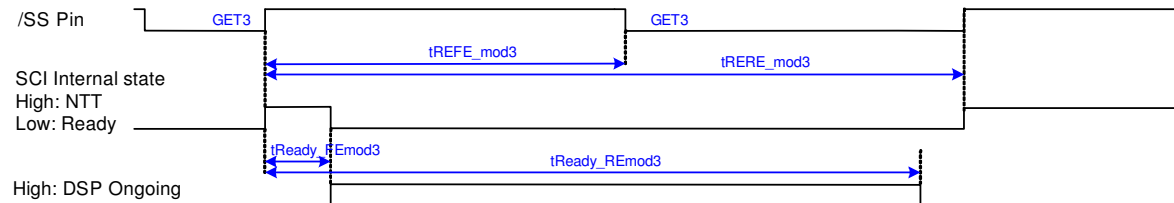


Figure 13 – Trigger mode 3 timing diagram

#### 5V Application Diagram

| Items             | Definition                                       | Marker | Min  | Typ | Max  | Unit    |
|-------------------|--------------------------------------------------|--------|------|-----|------|---------|
| $t_{REFE\_mod1}$  | Get1 SS Rising Edge to next Get1 SS Falling Edge | 0      | 920  |     |      | $\mu s$ |
|                   |                                                  | 1      | 1050 |     |      | $\mu s$ |
|                   |                                                  | 2      | 920  |     |      | $\mu s$ |
| $t_{Ready\_mod1}$ | Get1 SSRE to SO Answer ReadyToTransmit           | 0      |      |     | 920  | $\mu s$ |
|                   |                                                  | 1      |      |     | 1050 | $\mu s$ |
|                   |                                                  | 2      |      |     | 920  | $\mu s$ |

Table 13 – Trigger Modes Timing Specification (Mode 1, VDD=5V)

| Items             | Definition                                   | Marker | Min  | Typ | Max  | Unit    |
|-------------------|----------------------------------------------|--------|------|-----|------|---------|
| $t_{SyncFE}$      | Sync Pulse (RE) to Get2 Falling Edge         | 0      | 874  |     |      | $\mu s$ |
|                   |                                              | 1      | 1004 |     |      | $\mu s$ |
|                   |                                              | 2      | 874  |     |      | $\mu s$ |
| $t_{Ready\_mod2}$ | Sync Pulse (RE) to SO Answer ReadyToTransmit | 0      |      |     | 874  | $\mu s$ |
|                   |                                              | 1      |      |     | 1004 | $\mu s$ |
|                   |                                              | 2      |      |     | 874  | $\mu s$ |
| $t_{RESync}$      | Get2 SS Rising Edge to Sync Pulse (RE)       |        | 80   |     |      | $\mu s$ |

Table 14 – Trigger Modes Timing Specification (Mode 2, VDD=5V)

| Items               | Definition                              | Marker | Min  | Typ | Max  | Unit    |
|---------------------|-----------------------------------------|--------|------|-----|------|---------|
| $t_{RERE\_mod3}$    | Get3 SS RE to RE                        | 0      | 950  |     |      | $\mu s$ |
|                     |                                         | 1      | 1080 |     |      | $\mu s$ |
|                     |                                         | 2      | 950  |     |      | $\mu s$ |
| $t_{ReadyRE\_mod3}$ | Get3 SS RE to DSP Completion            | 0      |      |     | 950  | $\mu s$ |
|                     |                                         | 1      |      |     | 1080 | $\mu s$ |
|                     |                                         | 2      |      |     | 950  | $\mu s$ |
| $t_{REFE\_mod3}$    | Get3 SS Rising to Falling               |        | 90   |     |      | $\mu s$ |
| $t_{ReadyFE\_mod3}$ | Get3 SS RE to SO Answer ReadyToTransmit |        |      |     | 90   | $\mu s$ |

Table 15 – Trigger Modes Timing Specification (Mode 3, VDD=5V)

## 3V3 Application Diagram

| Items              | Definition                                       | Marker | Min  | Typ | Max  | Unit |
|--------------------|--------------------------------------------------|--------|------|-----|------|------|
| <i>tREFE_mod1</i>  | Get1 SS Rising Edge to next Get1 SS Falling Edge | 0      | 1067 |     |      | µs   |
|                    |                                                  | 1      | 1218 |     |      | µs   |
|                    |                                                  | 2      | 1067 |     |      | µs   |
| <i>tReady_mod1</i> | Get1 SSRE to SO Answer ReadyToTransmit           | 0      |      |     | 1067 | µs   |
|                    |                                                  | 1      |      |     | 1218 | µs   |
|                    |                                                  | 2      |      |     | 1067 | µs   |

Table 16 – Trigger Modes Timing Specification (Mode 1, VDD = 3.3V)

| Items              | Definition                                   | Marker | Min  | Typ | Max  | Unit |
|--------------------|----------------------------------------------|--------|------|-----|------|------|
| <i>tSyncFE</i>     | Sync Pulse (RE) to Get2 Falling Edge         | 0      | 1014 |     |      | µs   |
|                    |                                              | 1      | 1165 |     |      | µs   |
|                    |                                              | 2      | 1014 |     |      | µs   |
| <i>tReady_mod2</i> | Sync Pulse (RE) to SO Answer ReadyToTransmit | 0      |      |     | 1014 | µs   |
|                    |                                              | 1      |      |     | 1165 | µs   |
|                    |                                              | 2      |      |     | 1014 | µs   |
| <i>tRESync</i>     | Get2 SS Rising Edge to Sync Pulse (RE)       |        | 93   |     |      | µs   |

Table 17 – Trigger Modes Timing Specification (Mode 2, VDD = 3.3V)

| Items                | Definition                              | Marker | Min  | Typ | Max  | Unit |
|----------------------|-----------------------------------------|--------|------|-----|------|------|
| <i>tRERE_mod3</i>    | Get3 SS RE to RE                        | 0      | 1102 |     |      | µs   |
|                      |                                         | 1      | 1253 |     |      | µs   |
|                      |                                         | 2      | 1102 |     |      | µs   |
| <i>tReadyRE_mod3</i> | Get3 SS RE to DSP Completion            | 0      |      |     | 1102 | µs   |
|                      |                                         | 1      |      |     | 1253 | µs   |
|                      |                                         | 2      |      |     | 1102 | µs   |
| <i>tREFE_mod3</i>    | Get3 SS Rising to Falling               |        | 105  |     |      | µs   |
| <i>tReadyFE_mod3</i> | Get3 SS RE to SO Answer ReadyToTransmit |        |      |     | 105  | µs   |

Table 18 – Trigger Modes Timing Specification (Mode 3, VDD = 3.3V)

## 14.9. Opcode Table

| Opcode | MOSI Message | Opcode            | MISO Message                       |
|--------|--------------|-------------------|------------------------------------|
| 19d    | 0x13         | GET1              | n/a                                |
| 20d    | 0x14         | GET2              | Regular Data Packet                |
| 21d    | 0x15         | GET3              | 45d                                |
| 1d     | 0x01         | MemoryRead        | 0x2D                               |
| 3d     | 0x03         | EEPROMWrite       | 2d                                 |
| 5d     | 0x05         | EEChallengeAns    | 0x02                               |
| 15d    | 0x0F         | EEReadChallenge   | 4d                                 |
| 16d    | 0x10         | NOP / Challenge   | 0x04                               |
| 22d    | 0x16         | DiagnosticDetails | EEReadAnswer                       |
| 24d    | 0x18         | OscCounterStart   | 40d                                |
| 26d    | 0x1A         | OscCounterStop    | 0x28                               |
| 47d    | 0x2F         | Reboot            | 14d                                |
| 49d    | 0x31         | Standby           | 0x0E                               |
|        |              |                   | EEPROMWrite Status                 |
|        |              |                   | 17d                                |
|        |              |                   | 0x11                               |
|        |              |                   | Challenge/NOP MISO Packet          |
|        |              |                   | 23d                                |
|        |              |                   | 0x17                               |
|        |              |                   | Diagnostics Answer                 |
|        |              |                   | 25d                                |
|        |              |                   | 0x19                               |
|        |              |                   | OscCounterStart Acknowledge        |
|        |              |                   | 27d                                |
|        |              |                   | 0x1B                               |
|        |              |                   | OscCounterStopAck+CounterValue     |
|        |              |                   | 50d                                |
|        |              |                   | 0x32                               |
|        |              |                   | StandbyAck                         |
|        |              |                   | 61d                                |
|        |              |                   | 0x3D                               |
|        |              |                   | Error frame                        |
|        |              |                   | 62d                                |
|        |              |                   | 0x3E                               |
|        |              |                   | NothingToTransmit (NTT)            |
|        |              |                   | 44d                                |
|        |              |                   | 0x2C                               |
|        |              |                   | Ready Message (first SO after POR) |

Table 19 – Opcode Table

## 14.10. Timing specifications per Opcode, and next allowed messages

For each slave-in message, the timing between the slave-select-rising-edge event and the slave-select-falling event, as depicted below, is specified.



Figure 14 – Timing diagram

| Op | MOSI Message          | tREFE      | Next allowed slave-in message      |
|----|-----------------------|------------|------------------------------------|
| 19 | GET1                  | tREFE_mod1 | GET1, MemoryRead, DiagDetails, NOP |
| 20 | GET2 followed by Sync | tSyncFE    | GET2, MemoryRead, DiagDetails, NOP |
| 21 | GET3                  | tREFE_mod3 | GET3, MemoryRead, DiagDetails, NOP |
| 1  | MemoryRead            | tShort     | MemoryRead, DiagDetails, NOP       |
| 3  | EEPROMWrite           | tShort     | EEReadChallenge                    |
| 5  | EEChallengeAns        | teewrite   | NOP                                |
| 15 | EEReadChallenge       | tShort     | EEChallengeAns                     |
| 16 | NOP / Challenge       | tShort     | All commands                       |
| 22 | DiagnosticDetails     | tShort     | All commands                       |
| 24 | OscCounterStart       | tShort     | OscCounterStop                     |
| 26 | OscCounterStop        | tShort     | NOP                                |
| 47 | Reboot                | tStartup   | See Startup Sequence               |
| 49 | Standby               | tShort     | All commands                       |

Table 20 – Response time and Next allowed slave-in messages

#### 14.11. NOP Command and NOP Answer

| # | 7          | 6 | 5 | 4 | 3 | 2 | 1 | 0 | # | 7         | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|------------|---|---|---|---|---|---|---|---|-----------|---|---|---|---|---|---|---|
| 1 |            |   |   |   |   |   |   |   | 0 |           |   |   |   |   |   |   |   |
| 3 | KEY [15:8] |   |   |   |   |   |   |   | 2 | KEY [7:0] |   |   |   |   |   |   |   |
| 5 |            |   |   |   |   |   |   |   | 4 |           |   |   |   |   |   |   |   |
| 7 | CRC        |   |   |   |   |   |   |   | 6 | 1         | 1 | 0 | 1 | 0 | 0 | 0 | 0 |

Table 21 – NOP(Challenge) MOSI Message (Opcode = 16)

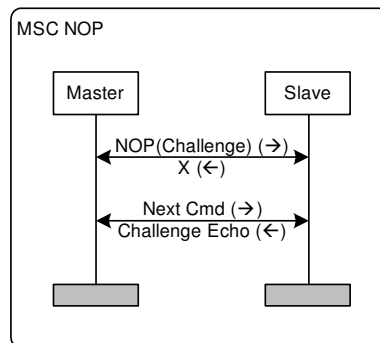


Figure 15 – NOP Message Sequence Chart

Note: the message X means “unspecified valid answer” and typically contains the answer of the previous command.

- Parameter *Key* : any 16 bit number

| # | 7                        | 6 | 5 | 4 | 3 | 2 | 1 | 0 | # | 7                       | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|--------------------------|---|---|---|---|---|---|---|---|-------------------------|---|---|---|---|---|---|---|
| 1 |                          |   |   |   |   |   |   |   | 0 |                         |   |   |   |   |   |   |   |
| 3 | KEY_ECHO [15:8]          |   |   |   |   |   |   |   | 2 | KEY_ECHO [7:0]          |   |   |   |   |   |   |   |
| 5 | INVERTED KEY_ECHO [15:8] |   |   |   |   |   |   |   | 4 | INVERTED KEY_ECHO [7:0] |   |   |   |   |   |   |   |
| 7 | CRC                      |   |   |   |   |   |   |   | 6 | 1                       | 1 | 0 | 1 | 0 | 0 | 0 | 1 |

Table 22 - Challenge Echo MISO Message (Opcode = 17)

- Parameter *Key\_Echo* = *Key*
- Parameter *InvertedKey\_Echo* = 65535 - *Key* (meaning bit reversal).

#### 14.12. OscCounterStart and OscCounterStop Commands

The SCI Master can evaluate the slave’s internal oscillator frequency by the use of the *OscCounterStart* and *OscCounterStop* commands. This first command enables in the MLX90363 a software counter whereas the second command stops it and returns the counter value.

| # | 7   | 6 | 5 | 4 | 3 | 2 | 1 | 0 | # | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|-----|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 |     |   |   |   |   |   |   |   | 0 |   |   |   |   |   |   |   |   |
| 3 |     |   |   |   |   |   |   |   | 2 |   |   |   |   |   |   |   |   |
| 5 |     |   |   |   |   |   |   |   | 4 |   |   |   |   |   |   |   |   |
| 7 | CRC |   |   |   |   |   |   |   | 6 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 |

Table 23 – OscCounterStart Slave-In message (opcode 24)

| # | 7   | 6 | 5 | 4 | 3 | 2 | 1 | 0 | # | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|-----|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 |     |   |   |   |   |   |   |   | 0 |   |   |   |   |   |   |   |   |
| 3 |     |   |   |   |   |   |   |   | 2 |   |   |   |   |   |   |   |   |
| 5 |     |   |   |   |   |   |   |   | 4 |   |   |   |   |   |   |   |   |
| 7 | CRC |   |   |   |   |   |   |   | 6 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 |

Table 24 – OscCounterStart Acknowledge Slave-Out message (opcode 25)

| # | 7   | 6 | 5 | 4 | 3 | 2 | 1 | 0 | # | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|-----|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 |     |   |   |   |   |   |   |   | 0 |   |   |   |   |   |   |   |   |
| 3 |     |   |   |   |   |   |   |   | 2 |   |   |   |   |   |   |   |   |
| 5 |     |   |   |   |   |   |   |   | 4 |   |   |   |   |   |   |   |   |
| 7 | CRC |   |   |   |   |   |   |   | 6 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 0 |

Table 25 – OscCounterStop Slave-In message (opcode 26)

| # | 7                  | 6 | 5 | 4 | 3 | 2 | 1 | 0 | # | 7                 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|--------------------|---|---|---|---|---|---|---|---|-------------------|---|---|---|---|---|---|---|
| 1 |                    |   |   |   |   |   |   |   | 0 |                   |   |   |   |   |   |   |   |
| 3 | CounterValue[14:8] |   |   |   |   |   |   |   | 2 | CounterValue[7:0] |   |   |   |   |   |   |   |
| 5 |                    |   |   |   |   |   |   |   | 4 |                   |   |   |   |   |   |   |   |
| 7 | CRC                |   |   |   |   |   |   |   | 6 | 1                 | 1 | 0 | 1 | 1 | 0 | 1 | 1 |

Table 26 – OscCounter Slave-Out message (opcode 27)

- Parameter *CounterValue* represents the time between the two events OscCounterStart Slave Select Rising Edge and OscCounterStop Slave Select Rising Edge, in microsecond, and for an oscillator frequency equal to 19MHz exactly.

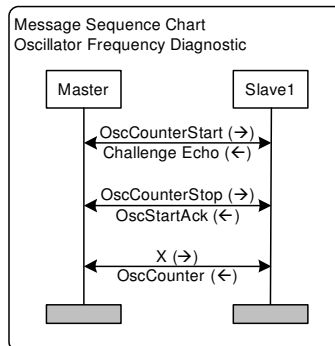


Figure 16 – Oscillator Frequency Diagnostic Message Sequence Chart

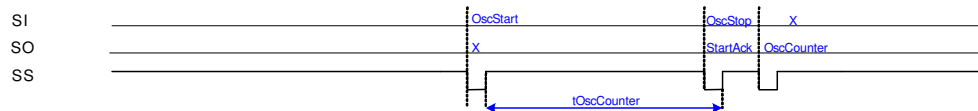


Figure 17 – Oscillator Frequency Diagnostic Timing Diagram (SCI)

| Parameter | Symbol           | Test Conditions | Min | Typ  | Max   | Units |
|-----------|------------------|-----------------|-----|------|-------|-------|
|           | $t_{OscCounter}$ |                 | 500 | 1000 | 30000 | us    |

## 14.13. Protocol Errors Handling

| Error Item                             | Error definition                         | Condition      | Detection                                                             | Slave Actions                                        | MISO Message                                                                              |
|----------------------------------------|------------------------------------------|----------------|-----------------------------------------------------------------------|------------------------------------------------------|-------------------------------------------------------------------------------------------|
| IncorrectBitCount                      | Slave In Message bit count $\neq 64$     | all modes      | FW reads the HW bit counter                                           | Ignore Message + Re-init Protocol                    | Error Message (incorrect bitcount = 1)                                                    |
| IncorrectCRC                           | Slave In Message has a CRC Error         | all modes      | FW computes CRC                                                       | Ignore Message + Re-init Protocol                    | Error Message (incorrect crc = 1)                                                         |
| IncorrectOpcode                        | Invalid Slave in Message                 | all modes      | FW                                                                    | Ignore Message + Re-init Protocol                    | Error Message (incorrect opcode = 1)                                                      |
| $t_{REFE} < t_{Ready\_mod1}$           | Regular Message Readback occurs to early | Trigger mode 1 | Interrupt occurring to early + Fw reads HW bit + Protection interrupt | Ignore Frame + Re-init Protocol                      | NTT message                                                                               |
| $t_{SyncFE} < t_{Ready\_mod2}$         | Regular Message Readback occurs to early | Trigger mode 2 | Interrupt occurring to early + Fw reads HW bit + Protection interrupt | Ignore Frame + Re-init Protocol                      | NTT message                                                                               |
| $t_{RESync} \text{ Violation}$         | Sync Pulse occurring to early            | Trigger mode 2 | none. The Sync pulse is pending internally.                           | none (but the sync pulse is not treated immediately) | Valid message. Note: This violation can cause a $t_{SyncFE} < t_{Ready\_mod2}$ violation. |
| $t_{RERE\_mod3} < t_{Ready\_mod3}$     | Regular Message Readback occurs to early | Trigger mode 3 | Protection interrupt                                                  | Re-init Protocol                                     | NTT message                                                                               |
| $t_{REFE\_mod3} < t_{Ready\_FE\_mod3}$ | Regular Message Readback occurs to early | Trigger mode 3 | Protection interrupt                                                  | Re-init Protocol                                     | NTT message                                                                               |
| TimeOut                                | Regular Message Readback occurs to late  | all modes      | Timer Interrupt                                                       | MISO Frame = NTT + Re-init Protocol                  | NTT message                                                                               |

Table 27 – Protocol Errors Handling (Slave standpoint)

| Error Items/Events                                | Associated Slave Event | Master recommended actions               | Associated Slave Actions   | Next MISO message                   |
|---------------------------------------------------|------------------------|------------------------------------------|----------------------------|-------------------------------------|
| Receive NTT                                       | Receive NTT            | Protocol re-initialization               | Protocol re-initialization | Error Message * (TimeViolation = 1) |
| Receive Incorrect CRC<br>Receive Incorrect Opcode | undetected event       | Protocol re-initialization               | none                       | Normal message                      |
| Receive Error Message                             | Send Error Message     | Protocol re-initialization               | none                       | Normal message                      |
| Receive an unexpected <i>DiagDetails</i> message  | Run in fail-safe mode  | Protocol re-initialization + Slave reset | none                       | <i>DiagDetails</i> message          |

Table 28 – Protocol Errors Handling (Master standpoint)

Note 1: On NTT or Error messages, master should consider that the last command is ignored by the slave, and it should therefore, either resend the command, or more generally re-initialize the protocol.

Note 2: After protocol re-initialization, master can diagnose the communication with a NOP command.

Note 3: A slave-out error message implicitly means that the slave has re-initialized the communication and is therefore ready to receive any commands.

## 14.14. Ready, Error and NTT Messages

After power-on-reset, the first slave-out message is a *Ready* message.

| # | 7               | 6 | 5 | 4 | 3 | 2 | 1 | 0 | # | 7              | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|-----------------|---|---|---|---|---|---|---|---|----------------|---|---|---|---|---|---|---|
| 1 | FWVersion[15:8] |   |   |   |   |   |   |   | 0 | HWVersion[7:0] |   |   |   |   |   |   |   |
| 3 |                 |   |   |   |   |   |   |   | 2 |                |   |   |   |   |   |   |   |
| 5 |                 |   |   |   |   |   |   |   | 4 |                |   |   |   |   |   |   |   |
| 7 | CRC             |   |   |   |   |   |   |   | 6 | 1              | 1 | 1 | 0 | 1 | 1 | 0 | 0 |

Table 29 - *Ready* Slave-out Message (Opcode = 44)

The MLX90363 reports protocol errors using the *Error* message defined below. Diagnostics Errors (as opposed to protocol errors) are reported with the bits E1 and E0 of the regular message.

| # | 7   | 6 | 5 | 4 | 3 | 2 | 1 | 0 | # | 7          | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|-----|---|---|---|---|---|---|---|---|------------|---|---|---|---|---|---|---|
| 1 |     |   |   |   |   |   |   |   | 0 | ERROR CODE |   |   |   |   |   |   |   |
| 3 |     |   |   |   |   |   |   |   | 2 |            |   |   |   |   |   |   |   |
| 5 |     |   |   |   |   |   |   |   | 4 |            |   |   |   |   |   |   |   |
| 7 | CRC |   |   |   |   |   |   |   | 6 | 1          | 1 | 1 | 1 | 1 | 1 | 0 | 1 |

Table 30 - *Error* Message MISO (Opcode = 61)

The description of the parameter *ErrorCode* is given in the table below.

| Code | Description of Error CODE                                                |
|------|--------------------------------------------------------------------------|
| 1    | Incorrect BitCount                                                       |
| 2    | Incorrect CRC                                                            |
| 3    | Answer = NTT message<br>Two reasons: Answer Time-Out or Answer not Ready |
| 4    | OPCODE not valid                                                         |

In most of the timing violations, the slave answers with a NTT message. A NTT message is stored in the slave's ROM (as opposed to the slave's RAM). NTT messages are typically seen in case of timing violation: either the firmware is still currently processing the previous SCI command, or a time-out occurred (see GET). In normal operation, NTT messages are not supposed to be observed: the Master is supposed to respect the protocol timings defined.

| # | 7   | 6 | 5 | 4 | 3 | 2 | 1 | 0 | # | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|-----|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 |     |   | 1 |   |   |   | 1 |   | 0 |   |   |   | 1 |   |   |   | 1 |
| 3 |     | 1 |   |   |   | 1 |   |   | 2 |   |   | 1 | 1 |   |   | 1 | 1 |
| 5 |     | 1 | 1 |   |   | 1 | 1 |   | 4 |   | 1 |   | 1 |   | 1 |   | 1 |
| 7 | CRC |   |   |   |   |   |   |   | 6 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |

Table 31 – *NTT* (Nothing To Transmit) Message (Opcode = 62)

## 14.15. DiagnosticsDetails commands

This is the only function that can be combined with a regular message.

| # | 7   | 6 | 5 | 4 | 3 | 2 | 1 | 0 | # | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|-----|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 |     |   |   |   |   |   |   |   | 0 |   |   |   |   |   |   |   |   |
| 3 |     |   |   |   |   |   |   |   | 2 |   |   |   |   |   |   |   |   |
| 5 |     |   |   |   |   |   |   |   | 4 |   |   |   |   |   |   |   |   |
| 7 | CRC |   |   |   |   |   |   |   | 6 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 0 |

Table 32 – *DiagnosticsDetails* Slave In Command (opcode =22)

Use *DiagnosticDetails* to get a detailed analysis of the diagnostics.

| # | 7      | 6   | 5   | 4   | 3          | 2   | 1  | 0  | # | 7   | 6   | 5   | 4   | 3   | 2   | 1   | 0   |
|---|--------|-----|-----|-----|------------|-----|----|----|---|-----|-----|-----|-----|-----|-----|-----|-----|
| 1 | D15    | D14 | D13 | D12 | D11        | D10 | D9 | D8 | 0 | D7  | D6  | D5  | D4  | D3  | D2  | D1  | D0  |
| 3 | FSMERC |     |     |     | ANADIAGCNT |     |    |    | 2 | D23 | D22 | D21 | D20 | D19 | D18 | D17 | D16 |
| 5 |        |     |     |     |            |     |    |    | 4 |     |     |     |     |     |     |     |     |
| 7 | CRC    |     |     |     |            |     |    |    | 6 | 1   | 1   | 0   | 1   | 0   | 1   | 1   | 1   |

Table 33 - Diagnostics *DiagnosticDetails* Master In message (Opcode = 23)

- Diagnostic bit  $Dx$  : see Section 18
- Parameter *DIGDIAGCNT* is a sequence loop counter referring to the digital-class diagnostics (B2, B3, B4, B5 )
- Parameter *ANADIAGCNT* is a sequence loop counter referring to the analog-class diagnostics (all others).

If *FSMERC* = 3, *ANADIAGCNT* takes another meaning:

193 protection error interruption happened  
194 invalid address error interruption happened  
195 program error interruption happened  
196 exchange error interruption happened  
197 not connected error interruption happened  
198 Stack Interrupt  
199 Flow Control Error

- Parameter *FSMERC* reports the root-cause of entry in fail-safe mode
  - FSMERC* = 0 : the chip is not in fail safe mode
  - FSMERC* = 1 : BIST error happened and the chip is in fail safe mode
  - FSMERC* = 2 : digital diagnostic error happened and the chip is in fail safe mode
  - FSMERC* = 3 : one of the 5 error interruptions listed above happened and the chip is in fail safe mode

#### 14.16. MemoryRead message

| # | 7          | 6 | 5 | 4 | 3 | 2 | 1 | 0 | # | 7         | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|------------|---|---|---|---|---|---|---|---|-----------|---|---|---|---|---|---|---|
| 1 | ADD0[15:8] |   |   |   |   |   |   |   | 0 | ADD0[7:0] |   |   |   |   |   |   |   |
| 3 | ADD1[15:8] |   |   |   |   |   |   |   | 2 | ADD1[7:0] |   |   |   |   |   |   |   |
| 5 |            |   |   |   |   |   |   |   | 4 |           |   |   |   |   |   |   |   |
| 7 | CRC        |   |   |   |   |   |   |   | 6 | 1         | 1 | 0 | 0 | 0 | 0 | 0 | 1 |

Table 34 – MemoryRead Master-Out Slave-In Message (Opcode = 1)

MemoryRead returns two EEPROM or RAM words respectively pointed by the parameters *ADDR0*, *ADDR1*.

- The parameter *ADDRx* has three valid ranges: 0...254 for RAM access, 0x1000...0x103E for EEPROM access, and 0x4000...0x5FFE for ROM access

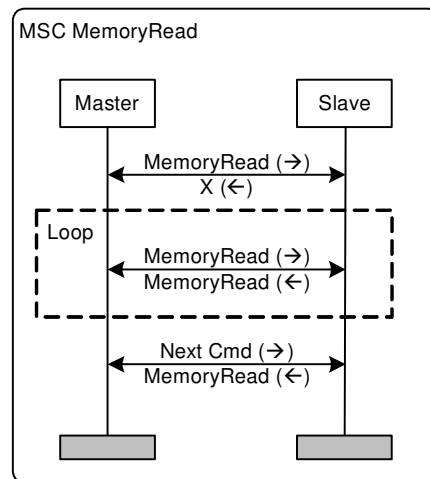


Figure 18 – MSC for RAM/ROM/EEPROM Memory Read

Note: Enter the loop for complete memory dumps.

#### MemoryRead Master-In Message (opcode 0x02)

The address *Addr* may be valid or not:

Case of validity: MemoryRead returns normally the data word pointed by *Addr*

Case of invalidity: MemoryRead returns *DataWord* = 0.

Note: FW makes sure that invalid addresses do not cause memory access violation

| # | 7                  | 6 | 5 | 4 | 3 | 2 | 1 | 0 | # | 7                 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|--------------------|---|---|---|---|---|---|---|---|-------------------|---|---|---|---|---|---|---|
| 1 | DATA[15:8] AT ADD0 |   |   |   |   |   |   |   | 0 | DATA[7:0] AT ADD0 |   |   |   |   |   |   |   |
| 3 | DATA[15:8] AT ADD1 |   |   |   |   |   |   |   | 2 | DATA[7:0] AT ADD1 |   |   |   |   |   |   |   |
| 5 |                    |   |   |   |   |   |   |   | 4 |                   |   |   |   |   |   |   |   |
| 7 | CRC                |   |   |   |   |   |   |   | 6 | 1                 | 1 | 0 | 0 | 0 | 0 | 1 | 0 |

Table 35 – MemoryRead MISO Packet (Opcode = 2)

## 14.17. EepromWrite Message

| # | 7               | 6 | 5                            | 4 | 3 | 2 | 1 | 0 | # | 7              | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|-----------------|---|------------------------------|---|---|---|---|---|---|----------------|---|---|---|---|---|---|---|
| 1 | 0               | 0 | ADDRESS[5:0] <sup>(22)</sup> |   |   |   |   |   | 0 |                |   |   |   |   |   |   |   |
| 3 | KEY[15:8]       |   |                              |   |   |   |   |   | 2 | KEY[7:0]       |   |   |   |   |   |   |   |
| 5 | DATA WORD[15:8] |   |                              |   |   |   |   |   | 4 | DATA WORD[7:0] |   |   |   |   |   |   |   |
| 7 | CRC             |   |                              |   |   |   |   |   | 6 | 1              | 1 | 0 | 0 | 0 | 0 | 1 | 1 |

Table 36 – *EEPROMWrite* MOSI Message (Opcode = 3)

The EEPROM data consistency is guaranteed through two protection mechanisms: A and B.

Protection A: The parameter *ADDRESS* should match the parameter *KEY*.

The key associated to each address is public. Protection against erroneous write (in the field) is guaranteed as long as the keys are not stored in the master (ECU), but in the calibration system, which is typically a CAN or LIN Master.

Protection B: Slave challenges the Master with a randomly generated *ChallengeKey*, expects back this key exclusive-or with 0x1234

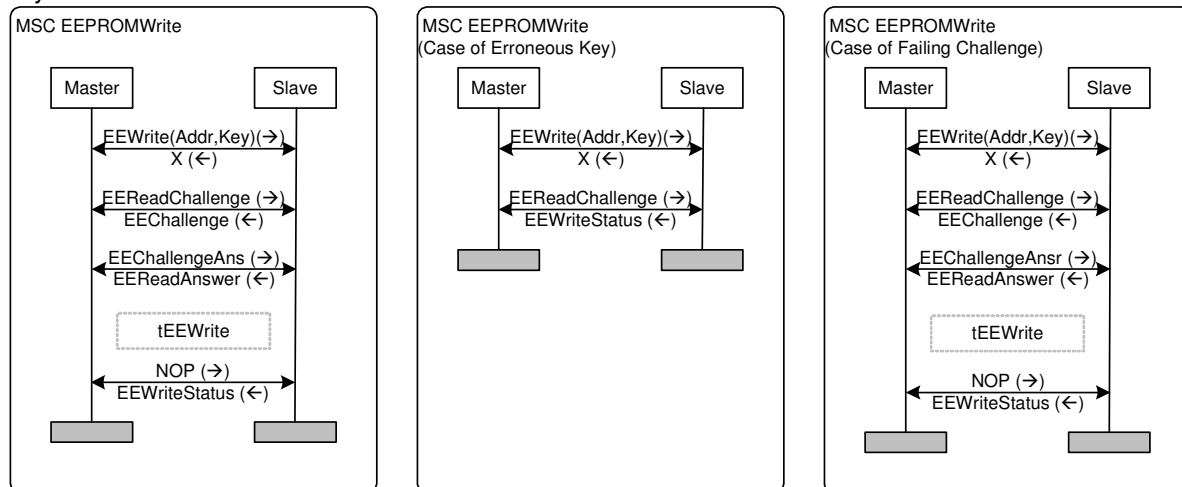


Figure 19 – MSCs *EEPROMWrite*

| ADDRESS[5:4] | 0     | 1     | 2     | 3     | 4     | 5     | 6     | 7     |
|--------------|-------|-------|-------|-------|-------|-------|-------|-------|
| 0            | 17485 | 31053 | 57190 | 57724 | 7899  | 53543 | 26763 | 12528 |
| 1            | 38105 | 51302 | 16209 | 24847 | 13134 | 52339 | 14530 | 18350 |
| 2            | 55636 | 64477 | 40905 | 45498 | 24411 | 36677 | 4213  | 48843 |
| 3            | 6368  | 5907  | 31384 | 63325 | 3562  | 19816 | 6995  | 3147  |

Table 37 – EEPROM Write Public Keys

| # | 7   | 6 | 5 | 4 | 3 | 2 | 1 | 0 | # | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|-----|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 |     |   |   |   |   |   |   |   | 0 |   |   |   |   |   |   |   |   |
| 3 |     |   |   |   |   |   |   |   | 2 |   |   |   |   |   |   |   |   |
| 5 |     |   |   |   |   |   |   |   | 4 |   |   |   |   |   |   |   |   |
| 7 | CRC |   |   |   |   |   |   |   | 6 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 |

Table 38 – *EEPROMWrite* ReadChallenge Slave-In Message (Opcode = 15)

<sup>22</sup> The value of the ADDRESS[5:0] shall be even.

| # | 7                    | 6 | 5 | 4 | 3 | 2 | 1 | 0 | # | 7                   | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|----------------------|---|---|---|---|---|---|---|---|---------------------|---|---|---|---|---|---|---|
| 1 |                      |   |   |   |   |   |   |   | 0 |                     |   |   |   |   |   |   |   |
| 3 | CHALLENGE KEY [15:8] |   |   |   |   |   |   |   | 2 | CHALLENGE KEY [7:0] |   |   |   |   |   |   |   |
| 5 |                      |   |   |   |   |   |   |   | 4 |                     |   |   |   |   |   |   |   |
| 7 | CRC                  |   |   |   |   |   |   |   | 6 | 1                   | 1 | 0 | 0 | 0 | 1 | 0 | 0 |

Table 39 – EEPROMWrite EEChallenge Slave-Out Message (Opcode = 4)

- The parameter *ChallengeKey* is randomly generated by the sensor, and should be echoed because of the next command

| # | 7                        | 6 | 5 | 4 | 3 | 2 | 1 | 0 | # | 7                       | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|--------------------------|---|---|---|---|---|---|---|---|-------------------------|---|---|---|---|---|---|---|
| 1 |                          |   |   |   |   |   |   |   | 0 |                         |   |   |   |   |   |   |   |
| 3 | KEY ECHO [15:8]          |   |   |   |   |   |   |   | 2 | KEY ECHO [7:0]          |   |   |   |   |   |   |   |
| 5 | INVERTED KEY ECHO [15:8] |   |   |   |   |   |   |   | 4 | INVERTED KEY ECHO [7:0] |   |   |   |   |   |   |   |
| 7 | CRC                      |   |   |   |   |   |   |   | 6 | 1                       | 1 | 0 | 0 | 0 | 1 | 0 | 1 |

Table 40 – EEPROMWrite ChallengeAns Slave-In Message (Opcode = 5)

- The parameter *KeyEcho* should match *ChallengeKey* exor'ed with 0x1234.
- The parameter *InvertedKeyEcho* should match *KeyEcho* after bit reversal.

| # | 7   | 6 | 5 | 4 | 3 | 2 | 1 | 0 | # | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|-----|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 |     |   |   |   |   |   |   |   | 0 |   |   |   |   |   |   |   |   |
| 3 |     |   |   |   |   |   |   |   | 2 |   |   |   |   |   |   |   |   |
| 4 |     |   |   |   |   |   |   |   | 4 |   |   |   |   |   |   |   |   |
| 7 | CRC |   |   |   |   |   |   |   | 6 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 |

Table 41 – EEReadAnswer Slave-Out Message (Opcode = 40)

| # | 7   | 6 | 5 | 4 | 3 | 2 | 1 | 0 | # | 7 | 6 | 5 | 4 | 3    | 2 | 1 | 0 |
|---|-----|---|---|---|---|---|---|---|---|---|---|---|---|------|---|---|---|
| 1 |     |   |   |   |   |   |   |   | 0 |   |   |   |   | CODE |   |   |   |
| 3 |     |   |   |   |   |   |   |   | 2 |   |   |   |   |      |   |   |   |
| 4 |     |   |   |   |   |   |   |   | 4 |   |   |   |   |      |   |   |   |
| 7 | CRC |   |   |   |   |   |   |   | 6 | 1 | 1 | 0 | 0 | 1    | 1 | 1 | 0 |

Table 42 – EEPROMWriteStatus Slave-Out Message (Opcode = 14)

- The parameter *Code* details the exact cause of EEPROM write failure

| Code | Description of EEPROM Write Failure |
|------|-------------------------------------|
| 1    | Success                             |
| 2    | Erase/Write Fail                    |
| 4    | EEPROM CRC Erase/Write Fail         |
| 6    | Key Invalid                         |
| 7    | Challenge Fail                      |
| 8    | Odd Address                         |

The command *Reboot* must be sent after a series of EEPROM writes, to make sure that the new EEPROM parameters are taken into account.

## 14.18. Reboot

*Reboot* is a valid command in the following three cases.

1. After an EEPROM write
2. In fail-safe mode
3. In standby mode

In normal mode, *Reboot* reports wrong opcode.

*Reboot* causes a system reset identical to a true power-on reset. Start-up timings and sequences are applicable for the *reboot* message.

### Reboot, after EEPROM programming

It is meant to force the FW to refresh the EEPROM cache and IO space after a series of EEPROM write commands. It forces the FW to take into account all the changes (modes enabling, disabling...) including those that are not cached.

### Reboot, in fail-safe mode

ECU can issue a *reboot* message to exit the fail-safe mode before the watchdog time-out, for a fast recovery.

| # | 7   | 6 | 5 | 4 | 3 | 2 | 1 | 0 | # | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|-----|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 |     |   |   |   |   |   |   |   | 0 |   |   |   |   |   |   |   |   |
| 3 |     |   |   |   |   |   |   |   | 2 |   |   |   |   |   |   |   |   |
| 4 |     |   |   |   |   |   |   |   | 4 |   |   |   |   |   |   |   |   |
| 7 | CRC |   |   |   |   |   |   |   | 6 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 |

Table 43 – Reboot (Opcode = 47)

## 14.19. Standby

*Standby* sets the sensor in Standby mode: the digital clock is stopped and some analog blocks are switched off. The SCI clock remains active, allowing the sensor to be responsive to SCI messages.

The first SCI message received while in Standby wakes up the sensor. The standby mode is precisely exited on the SS rising edge. The first message following a *Standby* message is normally interpreted by the sensor. It can be NOP, a GET or anything else.

| # | 7   | 6 | 5 | 4 | 3 | 2 | 1 | 0 | # | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|-----|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 |     |   |   |   |   |   |   |   | 0 |   |   |   |   |   |   |   |   |
| 3 |     |   |   |   |   |   |   |   | 2 |   |   |   |   |   |   |   |   |
| 4 |     |   |   |   |   |   |   |   | 4 |   |   |   |   |   |   |   |   |
| 7 | CRC |   |   |   |   |   |   |   | 6 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 |

Table 44 – Standby (Opcode = 49)

The sensor answer to *Standby* is *StandbyAck* (opcode 50).

After resuming, the (E1, E0) error bits of the 6 following *GET* messages shall be ignored.

## 14.20. Start-up Sequence (Serial Communication)

The MLX90363 serial interface is enabled after the internal start-up initializations and start-up checks. Note: The start-up sequence of the MLX90363 firmware is described at chapter 19.1. The recommended *SCI* start-up sequences (Master – Slave) are depicted in the following message sequence charts, and timing diagrams. It usually starts with a NOP SI message. *Ready* is the first SO message.

For safety critical applications, Melexis recommends performing two extra checks prior to the request of the first regular data: oscillator frequency check and a readback of the diagnostic details (ROM, RAM, ADC Monitor...)

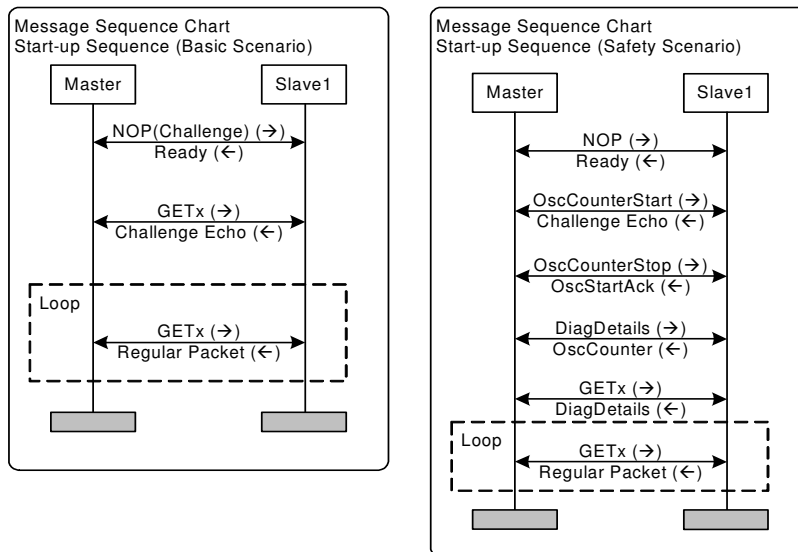


Figure 20 – MSCs Start-up sequence examples (basic and safety critical scenario)

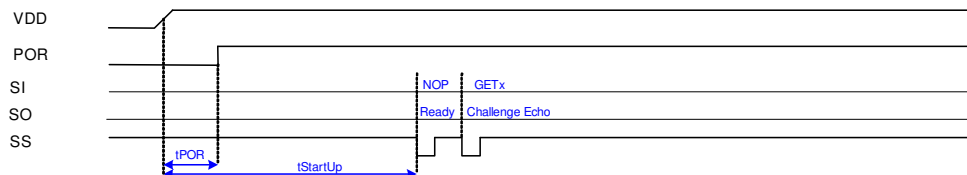


Figure 21 – Start-up sequence, basic scenario, timing diagram

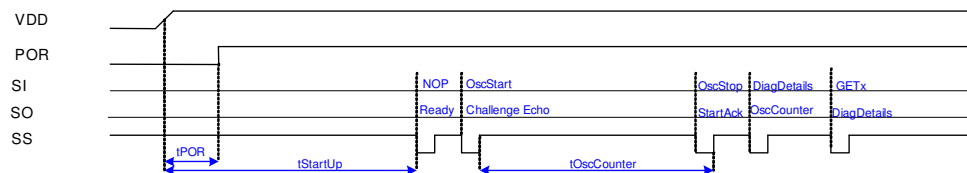


Figure 22 – Start-up sequence, safety critical scenario, timing diagram

### Notes:

- The timing  $t_{StartUp}$  is specified at chapter Timing Specifications (Section 10)
- The slave answers with *NTT* in case the first SI message occurs prior the end of the initial checks.
- The NOP - Challenge Echo is meant to diagnose the SCI link.

### 14.21. Allowed sequences

Only the message sequences described in this datasheet are accepted by the sensor.

A few more are described below; they combine GET1 or GET2 with MemoryRead or DiagDetails. The particular timings associated to these sequences do not overrule the general timing specifications.

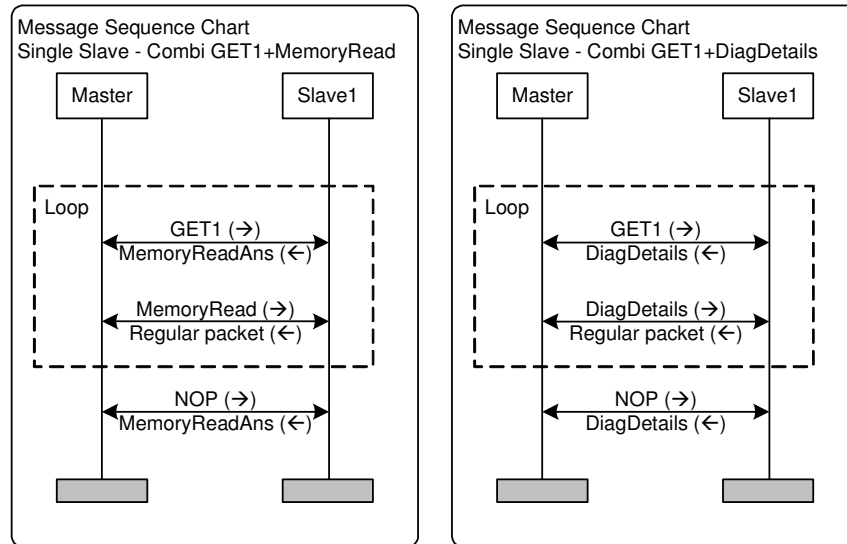


Figure 23 – MSCs Combi sequences GET1+MemoryRead and GET1+DiagDetails

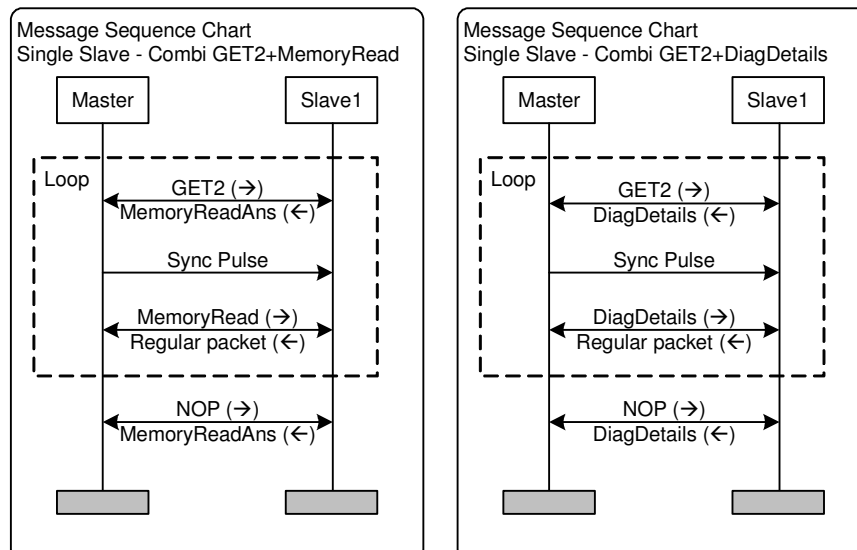


Figure 24 – MSCs Combi sequences GET2+MemoryRead and GET2+DiagDetails

## 15. MLX90363 Traceability Information

Every device contains a unique ID that is stored in the EEPROM. Melexis strongly recommends storing this value during the EOL (end-of-line) programming to ensure full traceability of the product.

These parameters shall never be erased during the EOL programming.

| Parameter | Comments                 | Address                                | Default Values | Parameter |
|-----------|--------------------------|----------------------------------------|----------------|-----------|
|           |                          | (Hexa)                                 | -              | # bit     |
| MLXID     | Traceability Information | 1012[15:0]<br>1014[15:0]<br>1016[15:0] | MLX            | 48        |

## 16. MLX90363 End-User Programmable Items

The list below describes the parameters that are available to the customer during EOL programming. The parameters will be programmed through the *EepromWrite* Message (section 14.17).

It must be noted that the data type of *Eepromwrite* Message is a word, and therefore it is mandatory to first readback the complete contents of the word before changing only the bits corresponding to the parameter.

| Parameter         | Comments                              | Address                                            | Default Values | Parameter |
|-------------------|---------------------------------------|----------------------------------------------------|----------------|-----------|
|                   |                                       | (Hexa)                                             | -              | # bit     |
| MAPXYZ            | XYZ Coordinates mapping               | 102A[2:0]                                          | 0              | 3         |
| 3D                | Enabling of 3D formula (Joystick)     | 102A[3]                                            | 0              | 1         |
| FILTER            | Enabling of Signal Filter             | 102A[5:4]                                          | 0              | 2         |
| VIRTUALGAINMAX    | Electrical Gain Code Max              | 102E[15:8]                                         | 41             | 8         |
| VIRTUALGAINMIN    | Electrical Gain Code Min              | 102E[7:0]                                          | 0              | 8         |
| KALPHA            | Magnetic Angle Formula Parameter      | 1022[15:0]                                         | 0              | 16        |
| KBETA             | Magnetic Angle Formula Parameter      | 1024[15:0]                                         | 1.6            | 16        |
| SMISM + SEL_SMISM | Magnetic Angle Formula Parameter      | 1032[15:0]                                         | 1              | 16        |
| ORTH_B1B2         | Magnetic Angle Formula Parameter      | 1026[7:0]                                          | 0              | 8         |
| KT                | Magnetic Angle Formula Parameter      | 1030[15:0]                                         | 1              | 16        |
| FHYST             | Hysteresis Value (Alpha + Beta )      | 1028[15:8]                                         | MLX            | 8         |
| PINFILTER         | SCI Input Pins: EMC: Filter Bandwidth | 1001[1:0]                                          | 1              | 2         |
| USERID            | User Identification                   | 103A[15:0]                                         | 0001           | 16        |
|                   |                                       | 103C[15:0]                                         | 0003           | 16        |
| FREE              | Freely usable by user                 | 1018[15:0]<br>1026[15:8]<br>1028[7:0]<br>103E[7:0] | 0              | 40        |

Melexis strongly recommends checking the User Identification data (Parameters USERID) during EOL calibration.

## 17. MLX90363 Description of End-User Programmable Items

### 17.1. User Configuration: Device Orientation

| MAPXYZ | Assignment             | Note               |
|--------|------------------------|--------------------|
| 0      | B1 = X, B2 = Y, B3 = Z |                    |
| 1      | B1 = X, B2 = Z, B3 = Y |                    |
| 2      | B1 = Y, B2 = Z, B3 = X |                    |
| 3      | B1 = Y, B2 = X, B3 = Z | Use mode 0 instead |
| 4      | B1 = Z, B2 = X, B3 = Y |                    |
| 5      | B1 = Z, B2 = Y, B3 = X |                    |

The values B1, B2 and B3 are inputs to the 2D/3D formula (see section 17.2).

The field coordinates X, Y, Z are relative to the device (See Section 23.3 and 23.6). The parameter MAPXYZ selects the application-dependent mapping of (X, Y, Z) to (B1, B2, B3).

### 17.2. User Configuration: Magnetic Angle Formula

| Parameter 3D | Formula                                                                                                                                                                          | Note                                           |
|--------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------|
| 0            | $Alpha = \arctan\left(\frac{B2}{B1}\right)$                                                                                                                                      | extended to the full circle                    |
| 1            | $Alpha = \arctan\left(\frac{\sqrt{(KALPHA \times B3)^2 + (KT \times B2)^2}}{B1}\right)$<br>$Beta = \arctan\left(\frac{\sqrt{(KBETA \times B3)^2 + (KT \times B1)^2}}{B2}\right)$ | extended across<br>B1=0 and B2=0<br>max 180deg |

### 17.3. User Configuration: 3D=0 formula trimming parameters SMISM and ORTH\_B1B2

#### 17.3.1. Magnetic Angle ∠XY

| Parameter        | Address (hex) | Value          |
|------------------|---------------|----------------|
| SMISM + SEL_MISM | 1032[15:0]    | Trimmed by MLX |
| ORTH             | 1038[7:0]     | Trimmed by MLX |
| ORTH_SEL         | 102C[8]       | 0              |
| MAPXYZ           | 102A[2:0]     | 0              |

This is the default condition as programmed by MLX. In such case, no front-end calibration is needed from the customer.

## 17.3.2. Magnetic Angle $\angle XZ$ and $\angle YZ$

| Parameter | Address (hex) | Range        | Value        |
|-----------|---------------|--------------|--------------|
| SEL_SMISM | 1032[15]      | 0 or 1       | 0 or 1       |
| SMISM     | 1032[14:0]    | [0..2]       | TYP = 1.4    |
| ORTH_SEL  | 102C[8]       | 0 or 1       | 1            |
| ORTH_B1B2 | 1026[7:0]     | [0..2]       | TYP = 0      |
| MAPXYZ    | 102A[2:0]     | 1, 2, 4 or 5 | 1, 2, 4 or 5 |

If the magnetic angle  $\angle XZ$  or  $\angle YZ$  is read, Melexis strongly recommends calibrating the front-end parameters<sup>(23)</sup> in order to reduce the magnetic accuracy error (see Section 11):

### 1) Phase Error

$$B2 = B1 - B2 * ORTH\_B1B2 / 1024$$

Where ORTH\_B1B2 is the phase mismatch between the B1 and B2 signals.

### 2) Sensitivity Mismatch between B1 and B2

The parameter SMISM is selected in such a way that:

- i. Case  $|B1| > |B2| \rightarrow \text{SEL\_SMISM} = 0$

$B1 * \text{SMISM}[14:0] / 2^{15}$  and B2 have the same amplitude.

- ii. Case  $|B2| < |B1| \rightarrow \text{SEL\_SMISM} = 1$

B1 and  $B2 * \text{SMISM}[14:0] / 2^{15}$  have the same amplitude.

## 17.4. User Configuration: 3D=1 formula trimming parameters KALPHA, KBETA, KT

The values KAPLHA, KBETA and KT are inputs to the 3D formula (see section 17.2) and allow a targeted reduction of the linearity error through a normalization of the raw signals and a correction prior to the ATAN function.

| Parameter | Value            | Range  | Typ. |
|-----------|------------------|--------|------|
| KAPLHA    | 0 ... $2^{16}-1$ | [0..2] | 1.4  |
| KBETA     | 0 ... $2^{16}-1$ | [0..2] | 1.4  |
| KT        | 0 ... $2^{16}-1$ | [0..2] | 1    |

Note: when not trimmed by the customer, the values per default of KALPHA and KBETA must be programmed to the TYP. value of 1.4.

<sup>23</sup> See AN Front End Calibration of MLX90363 in XZ and YZ Mode – Application note to be created in 2012.

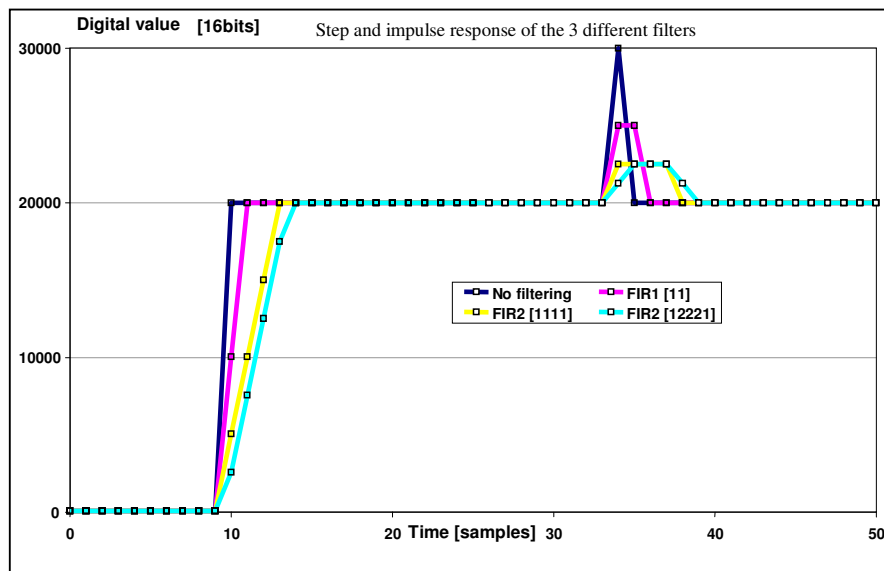
### 17.5. User Configuration: Filter

The MLX90363 features 3 FIR filter modes controlled with Filter = 1...3. The transfer function is described below:

$$y_n = \frac{1}{\sum_{i=0}^j a_i} \sum_{i=0}^j a_i x_{n-i}$$

The characteristics of the filters No. 0 to 3 is given in the following table.

| Filter No. (j)               | 0         | 1                       | 2     | 3      |
|------------------------------|-----------|-------------------------|-------|--------|
| Type                         | Disable   | Finite Impulse Response |       |        |
| Coefficients $a_0 \dots a_5$ | N/A       | 11                      | 1111  | 12221  |
| Title                        | No Filter | Extra Light             | Light | Medium |
| 99% Response Time            | 1         | 2                       | 4     | 5      |
| Efficiency RMS (dB)          | 0         | 3.0                     | 6.0   | 6.6    |



### 17.6. Virtual Gain Min and Max Parameters

The MLX90363 automatic gain control (AGC) loop selects the electrical gain code within the user-defined range VIRTUALGAINMIN...VIRTUALGAINMAX. Setting VIRTUALGAINMIN=VIRTUALGAINMAX means setting a fixed gain. The min and max virtual gain codes influence directly the sensitivity of the diagnostics D17-“Field Magnitude Too High” and D18-“Field Magnitude Too Low”.

## 17.7. Hysteresis FILTER

| Parameter | Value     | Note              |
|-----------|-----------|-------------------|
| FHYST     | 0 ... 255 | 1 LSB = 0.044 deg |

The FHYST parameter is a hysteresis filter. The output value of the IC is not updated when the digital step is smaller than the programmed FHYST parameter value. The output value is modified when the increment is bigger than the hysteresis. The hysteresis filter reduces the resolution to a level compatible with the internal noise of the IC. The hysteresis must be programmed to a value close to the noise level.

## 17.8. EMC Filter on SCI Pins

The EEPROM parameter PINFILTER selects the level of filtering on the serial protocol input pins.

| SCI clock frequency | PINFILTER<br>Recommended value<br>for higher EM Immunity |
|---------------------|----------------------------------------------------------|
| 2MHz                | 1                                                        |
| 1MHz                | 2                                                        |
| 500kHz              | 3                                                        |

## 17.9. Identification & FREE bytes

| Parameter | Value             | Unit |
|-----------|-------------------|------|
| USERID    | 0..( $2^{31}-1$ ) |      |
| FREE      | 0..( $2^{39}-1$ ) |      |

Identification number: 32 bits freely useable by Customer for traceability purpose.  
 The FREE bytes can also be used for identification or any other purposes.

## 17.10. Lock

The calibration parameters of the MLX90363 are locked.  
 To unlock the write, one must follow the write procedure described in section 14.17.

## 18. MLX90363 Self Diagnostic

The MLX90363 provides numerous self-diagnostic features which increase the safety integrity level of the IC, by diagnosing and reporting as many as 18 internal and external failure cases.

| Diagnostic Item                                                                | Action                                  | Bit | Notes                                                             |
|--------------------------------------------------------------------------------|-----------------------------------------|-----|-------------------------------------------------------------------|
| RAM March C- 10N Test                                                          | Fail-safe mode                          | D0  | At Startup only                                                   |
| Watchdog BIST                                                                  | Fail-safe mode                          | D1  | At Startup only                                                   |
| ROM 16 bit Checksum                                                            | Fail-safe mode                          | D2  |                                                                   |
| RAM Test (continuous)                                                          | Fail-safe mode                          | D3  |                                                                   |
| CPU Register Functional Test                                                   | Fail-safe mode                          | D4  |                                                                   |
| EEPROM Calibration parameters (8 bit CRC)                                      | Fail-safe mode                          | D5  |                                                                   |
| EEPROM Hamming Code DED (Dual Error Detection)                                 | Fail-safe mode                          | D6  |                                                                   |
| EEPROM RAM Cache Error                                                         | Report <sup>(24)</sup>                  | D7  |                                                                   |
| ADC Block                                                                      | Report                                  | D8  | Reference Voltage Unit (VCM)<br>+ 11 Input Levels                 |
| Bz sensitivity monitor <sup>(26)</sup>                                         | Report<br>(Optional)                    | D12 | See Magnetic Frequency Spec.                                      |
| Bx sensitivity monitor <sup>(26)</sup>                                         | Report                                  | D13 | See Magnetic Frequency Spec.                                      |
| By sensitivity monitor <sup>(26)</sup>                                         | Report                                  | D14 | See Magnetic Frequency Spec.                                      |
| Temperature sensor monitoring (based on redundancy)                            | Report, temp.<br>value set to<br>EE_T35 | D15 |                                                                   |
| Temperature > 190 deg ( $\pm 20$ deg)<br>Temperature < -80 deg ( $\pm 20$ deg) | Report, saturate<br>temp. value         | D16 | External failure                                                  |
| Field magnitude too high ( $Norm > 99\%$ ADC Span) <sup>(25)</sup>             | Report                                  | D17 | External failure, given that<br>AGC keeps <i>Norm</i> below 63.5% |
| Field magnitude too low ( $Norm < 20\%$ ADC Span)                              | Report                                  | D18 | External failure, given that<br>AGC keeps <i>Norm</i> above 47%   |
| ADC clipping (X, Y, Z, two phases each)                                        | Report                                  | D19 | External failure                                                  |
| Supply voltage monitor (VDD) and Regulator monitor<br>(VDEC) <sup>(26)</sup>   | Report<br>(Optional)                    | D20 | External failure                                                  |
| Firmware Flow monitoring                                                       | Fail-safe mode                          | n/a |                                                                   |
| Read/Write Access out of physical memory                                       | Fail-safe mode                          | n/a |                                                                   |
| Stack Overflow                                                                 | Fail-safe mode                          | n/a |                                                                   |
| Write Access to protected area (IO and RAM Words)                              | Fail-safe mode                          | n/a |                                                                   |
| Unauthorized entry in "SYSTEM" Mode                                            | Fail-safe mode                          | n/a |                                                                   |
| Serial Interface Protection Error                                              | NTT<br>Message <sup>(27)</sup>          | n/a |                                                                   |
| Watchdog Timeout                                                               | Reset <sup>(28)</sup>                   | n/a |                                                                   |
| Oscillator Frequency (Dedicated SCI Command)                                   | n/a                                     | n/a | Diagnostic performed by master                                    |
| VDD > MT8V                                                                     | MISO is HiZ                             | n/a | 100% Hardware detection.<br>No communication possible.            |

Figure 25 – Diagnostics List

<sup>24</sup> Reporting is done through the bits E0 and E1 of the regular messages or the bits Dx of the DiagnosticDetails message. See Table 8 for more details.

<sup>25</sup>  $Norm = \max(\text{abs}(X), \text{abs}(Y), \text{abs}(Z))$

<sup>26</sup> Diagnostic to be disabled in the 3V3 application diagram (VDD = VDEC).

<sup>27</sup> The NTT Message is followed by an Error Message.

<sup>28</sup> Resetting has the same effects as a POR: the next SO message is therefore Ready.

## 19. MLX90363 Firmware Flowcharts

### 19.1. Start-up sequence

The entry in operation mode is preceded by a startup phase or startup sequence, performing the built-in self tests (performed only once), the automatic analog gain adjustment, the temperature acquisition and a first execution of the built-in self diagnostics (also performed continuously afterwards). The start-up sequence ends with the enabling of the serial interface.

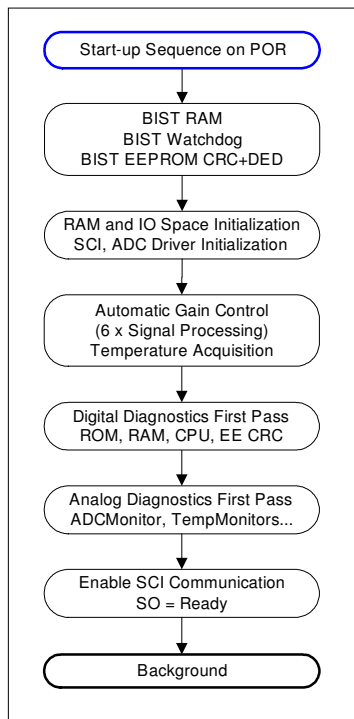
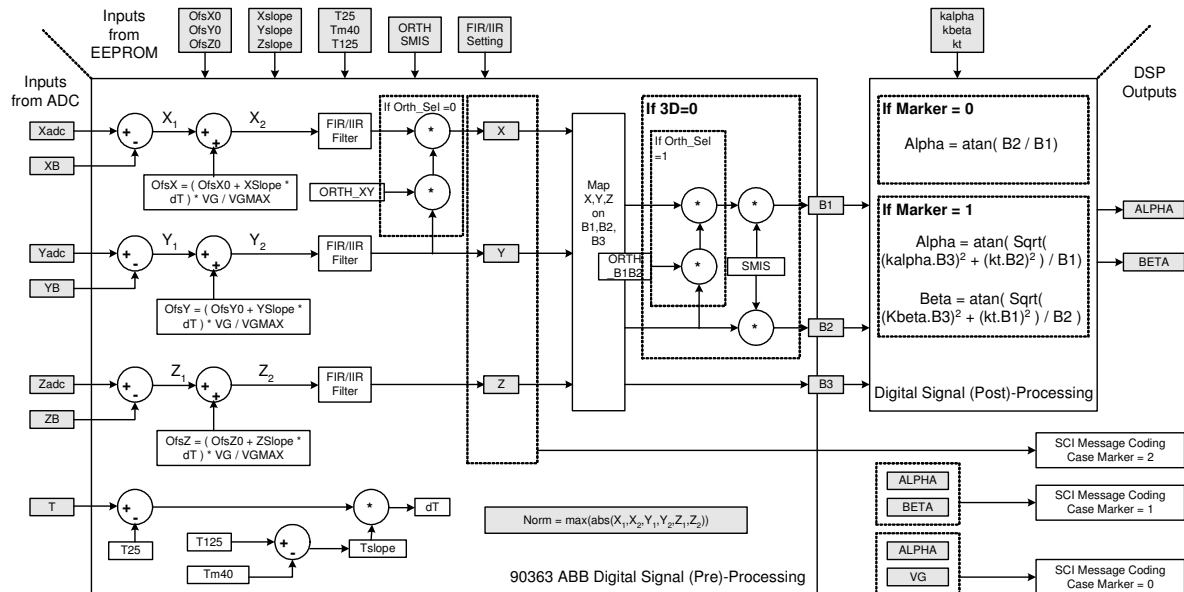


Figure 26 – Firmware start-up sequence

## 19.2. Signal Processing (GETx)

The digital signal processing performed by the firmware is depicted by the following diagram.



## 19.3. Fail-safe Mode

The purpose of fail-safe mode is dual:

1. To increase the safety integrity, by blocking any position calculation and position reporting whenever a critical error (WD error, ROM Checksum, Firmware flow error...) is detected
2. To report the root cause of the failure

In fail-safe mode,

- The analog is [set] inactive
- The sensor waits for the master to initiate a reset
- Autonomous reset by watchdog after 100ms, i.e. watchdog running but will not be acknowledged
- Only SPI driver and communication handler is active. The only supported MOSI commands is
  - sciREBOOT
- Upon all SPI MOSI commands, the MISO message SPI\_ERROR (= DiagDetailAnswer) is sent
- Diagnostics (analog and digital) and background are not running

### Fail-safe mode – entry conditions

The fail-safe mode is entered upon:

- Critical error during initialization (RAM BIST, WD BIST, ROM Checksum, EEPROM CRC)
- Critical error during background/digital diagnostics (RAM continuous test, ROM test, EEPROM CRC)
- Exception, i.e. system level interrupts (Stack-overflow, invalid address, protection error, program error)
- FW flow error

#### **19.4. Automatic Gain Control**

The Virtual Gain code is updated at every *GET* message. The new code value is based on the field strength (Norm) of every raw component (X, Y, Z).

The Automatic Gain Control (AGC) makes sure that Norm is between 47% and 63.5%, by controlling the gain code within the range (VIRTUALGAINMIN, VIRTUALGAINMAX).

The algorithm gives a limitation in term flux density frequency, see Section 10 for specification.

It is not recommended to interrupt the GET message sequence, because AGC iterations are triggered by *GET* messages. If a pause cannot be avoided, the (E1, E0) error bits of the 6 following *GET* messages shall be ignored.

## 20. Recommended Application Diagrams

### 20.1. MLX90363 in SOIC-8 Package and 5V Application Diagrams

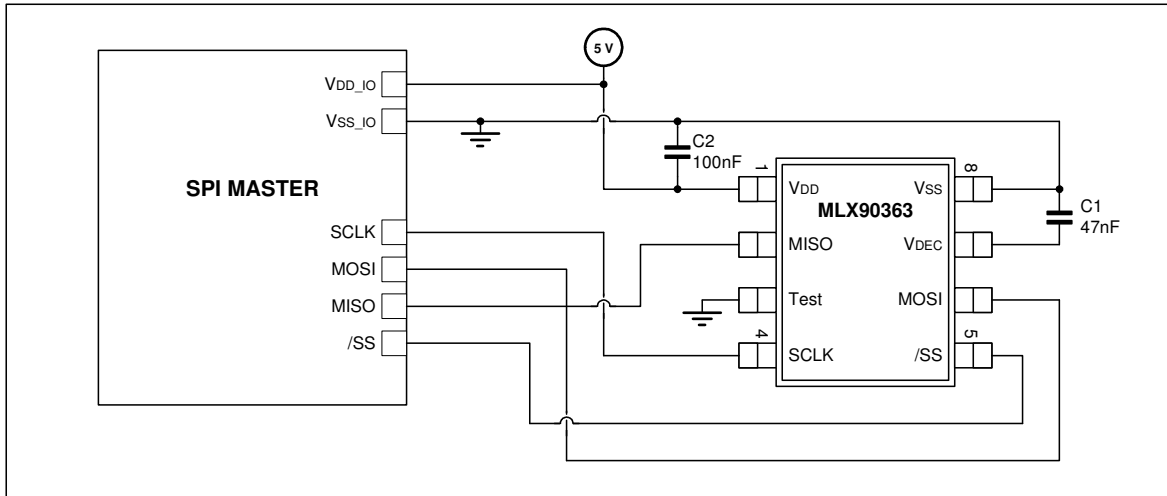


Figure 28 – Recommended wiring<sup>(29)</sup> for the MLX90363 in SOIC8 package and 5V Application Diagrams.

### 20.2. MLX90363 in SOIC-8 Package and 3V3 Application Diagrams

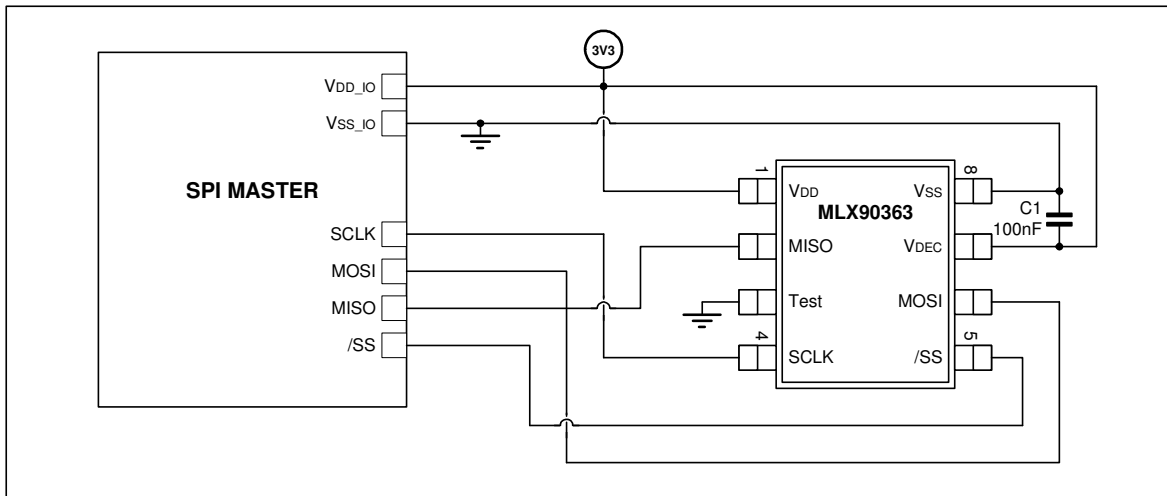


Figure 29 – Recommended wiring<sup>(29)</sup> for the MLX90363 in SOIC8 package and 3V3 Application Diagrams.

<sup>29</sup> Wiring of the SCl signals must be kept short on the PCB. In other cases, Melexis advises to add 100Ω serial resistor on the SCLK, MOSI, MISO and /SS lines. Melexis also recommends doubling the C1 decoupling capacitor.

### 20.3. MLX90363 in TSSOP-16 Package and 5V Application Diagrams

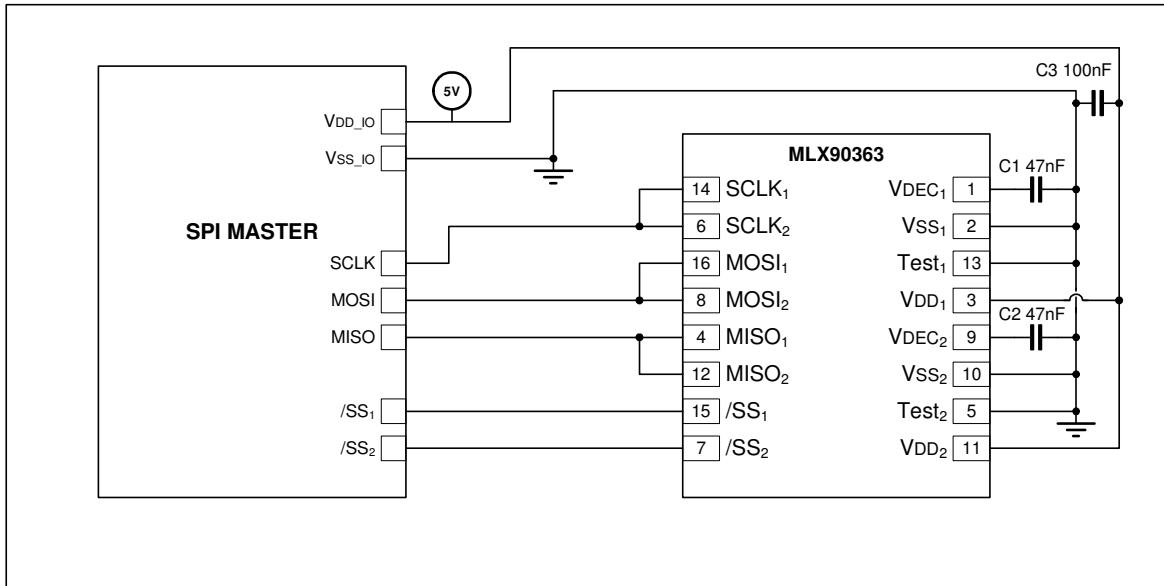


Figure 30 – Recommended<sup>(30)</sup> wiring for the MLX90363 in TSSOP16 package (dual die) and 5V Application Diagrams.

<sup>30</sup> Wiring of the SCl signals must be kept short on the PCB. In other cases, Melexis advises to add 100Ω serial resistor on the SCLK, MOSI, MISO and /SS lines. Melexis also recommends to double the C1,C2 decoupling capacitors.

#### 20.4. MLX90363 in TSSOP-16 Package and 3V3 Application Diagrams

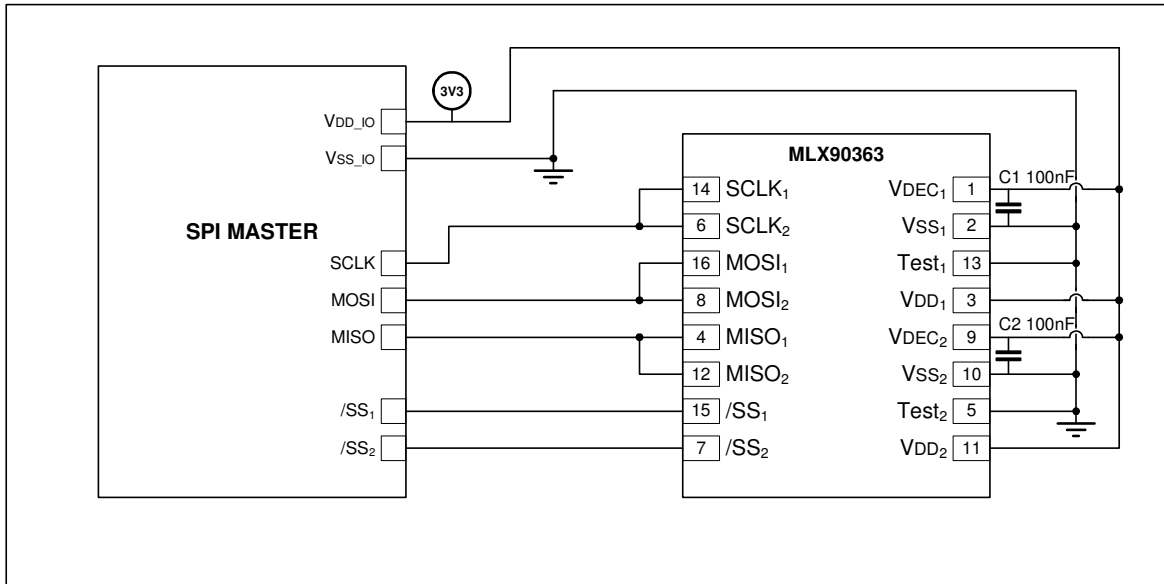


Figure 31 – Recommended<sup>(30)</sup> wiring for the MLX90363 in TSSOP16 package (dual die) and 3V3 Application Diagrams

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## **21. Standard information regarding manufacturability of Melexis products with different soldering processes**

Our products are classified and qualified regarding soldering technology, solderability and moisture sensitivity level according to following test methods:

### **Reflow Soldering SMD's (Surface Mount Device)s**

- IPC/JEDEC J-STD-020  
Moisture/Reflow Sensitivity Classification for Nonhermetic Solid State Surface Mount Devices (classification reflow profiles according to table 5-2)
- EIA/JEDEC JESD22-A113  
Preconditioning of Nonhermetic Surface Mount Devices Prior to Reliability Testing (reflow profiles according to table 2)

### **Wave Soldering SMD's (Surface Mount Device)s and THD's (Through Hole Device)s**

- EN60749-20  
Resistance of plastic- encapsulated SMD's to combined effect of moisture and soldering heat
- EIA/JEDEC JESD22-B106 and EN60749-15  
Resistance to soldering temperature for through-hole mounted devices

### **Iron Soldering THD's (Through Hole Device)s**

- EN60749-15  
Resistance to soldering temperature for through-hole mounted devices

### **Solderability SMD's (Surface Mount Device)s and THD's (Through Hole Device)s**

- EIA/JEDEC JESD22-B102 and EN60749-21  
Solderability

For all soldering technologies deviating from above mentioned standard conditions (regarding peak temperature, temperature gradient, temperature profile etc) additional classification and qualification tests have to be agreed upon with Melexis.

The application of Wave Soldering for SMD's is allowed only after consulting Melexis regarding assurance of adhesive strength between device and board.

Melexis is contributing to global environmental conservation by promoting **lead free** solutions. For more information on qualifications of **RoHS** compliant products (RoHS = European directive on the Restriction Of the use of certain Hazardous Substances) please visit the quality page on our website:

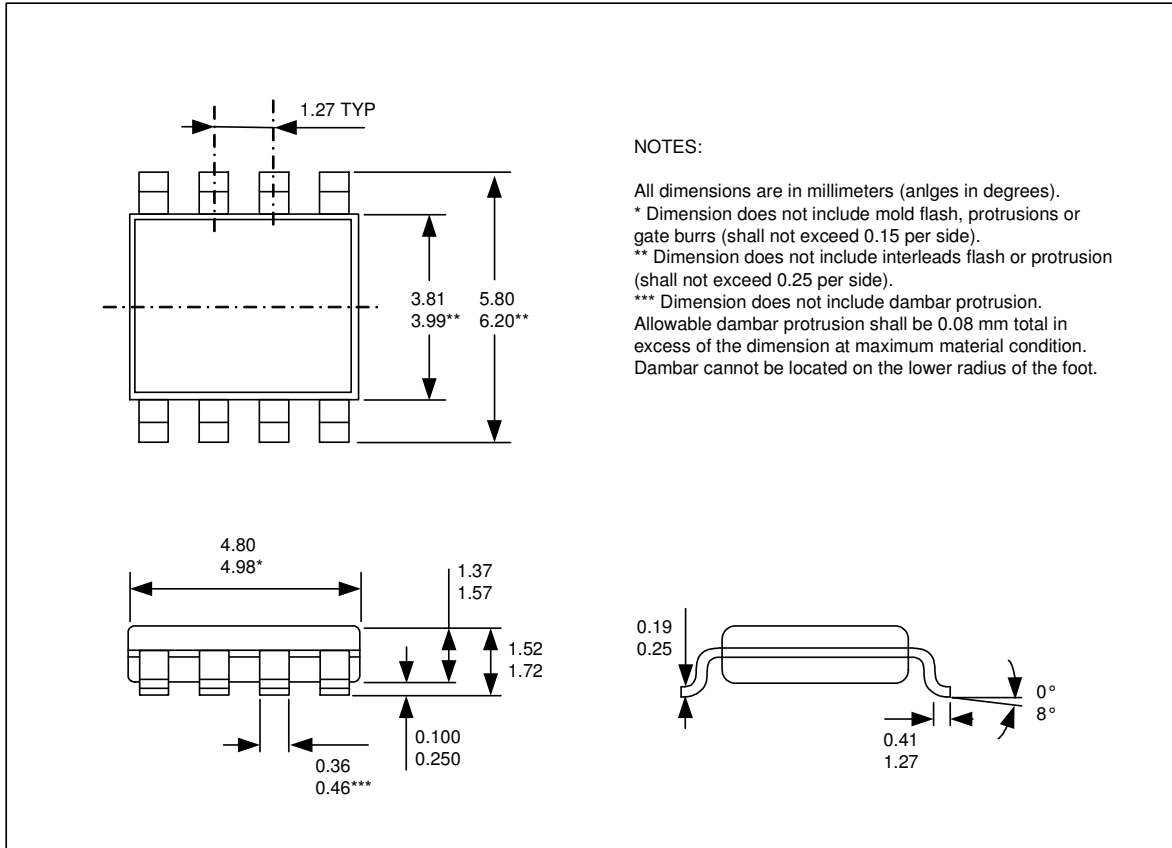
<http://www.melexis.com/quality.aspx>

## **22. ESD Precautions**

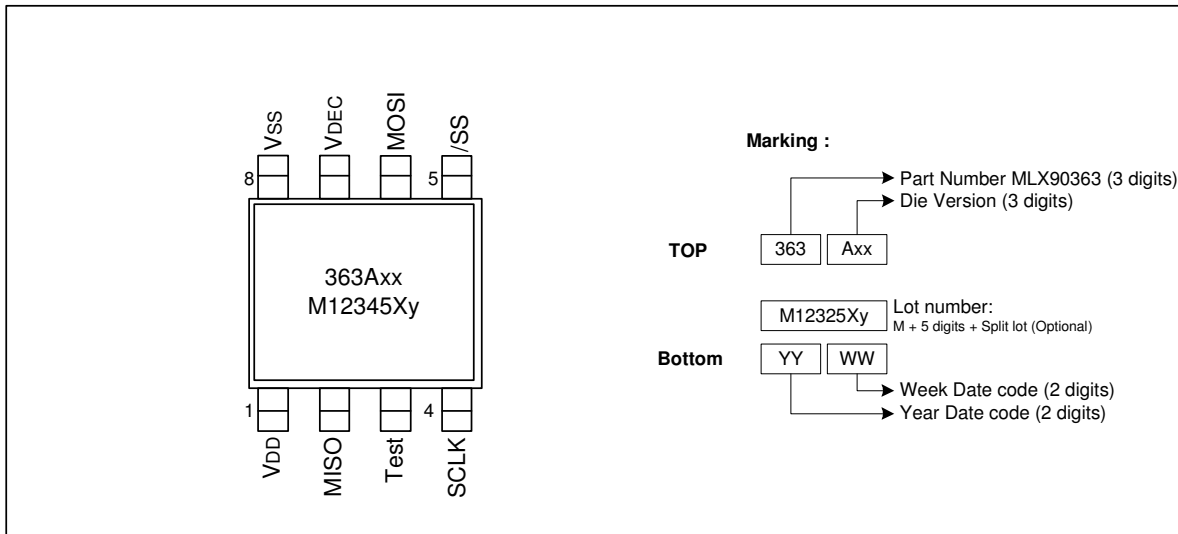
Electronic semiconductor products are sensitive to Electro Static Discharge (ESD). Always observe Electro Static Discharge control procedures whenever handling semiconductor products.

## 23. Package Information

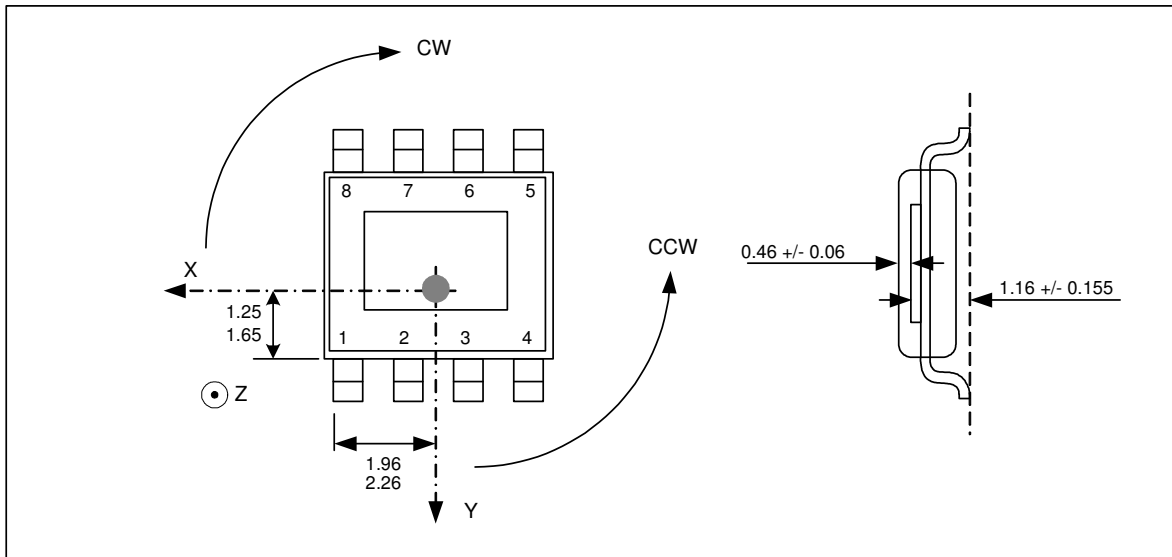
### 23.1. SOIC8 – Package Dimensions



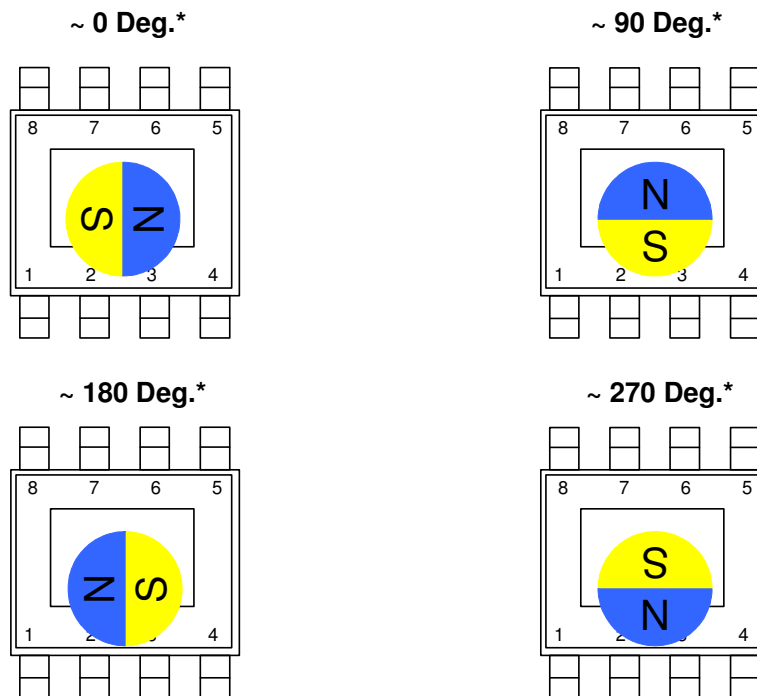
## 23.2. SOIC8 – Pinout and Marking



### 23.3. SOIC8 – IMC Positioning



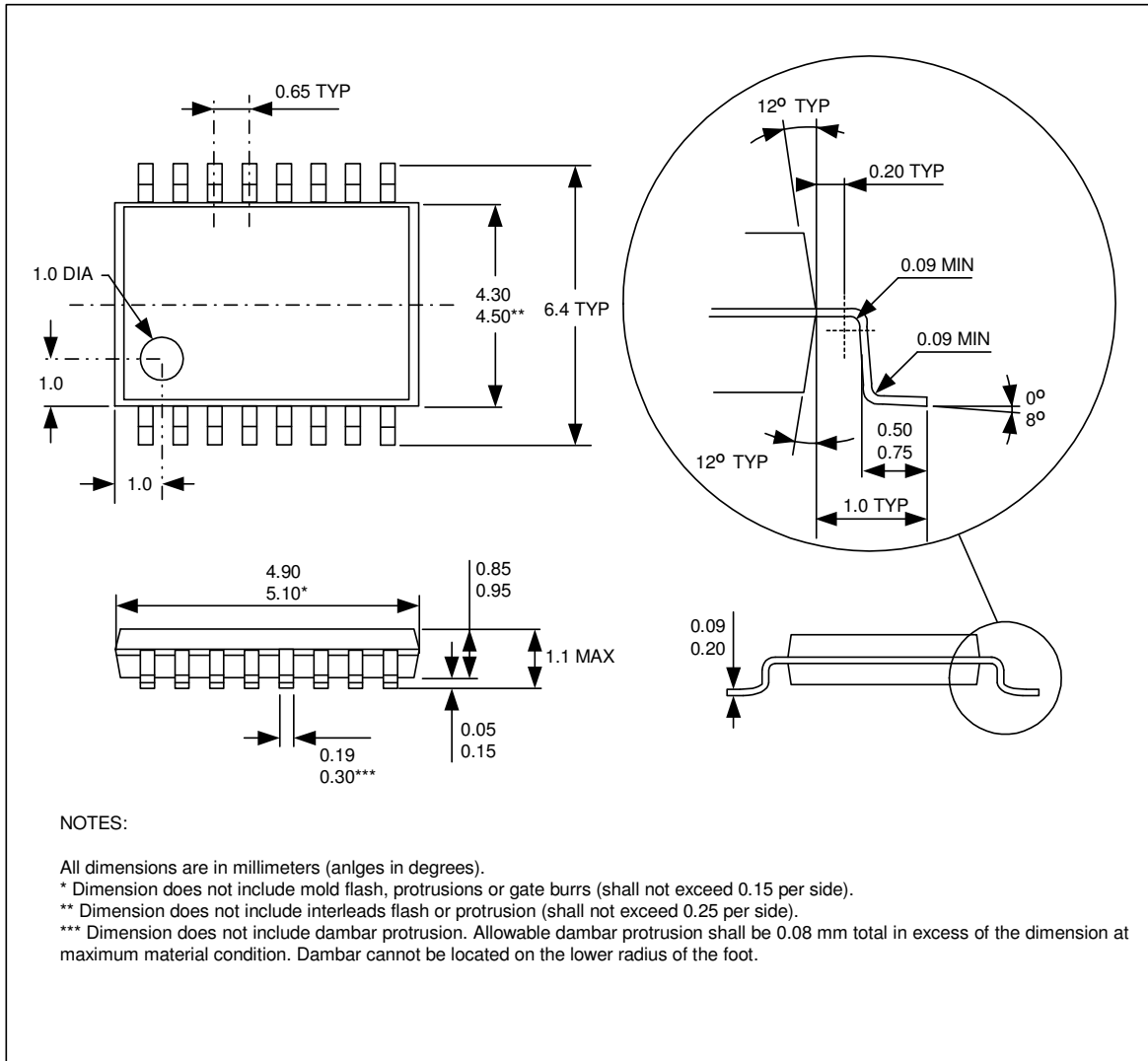
#### Angle detection MLX90363 SOIC8



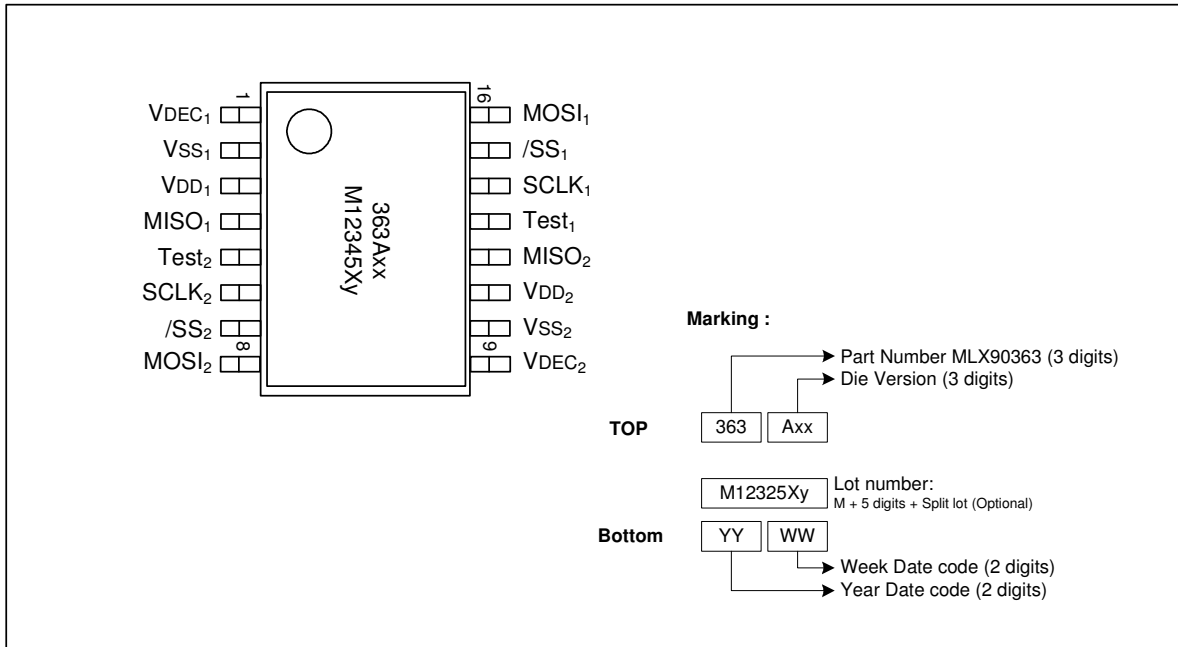
\* No absolute reference for the angular information.

The MLX90363 is an absolute angular position sensor but the linearity error (Le – See Section 11) does not include the error linked to the absolute reference 0 Deg.

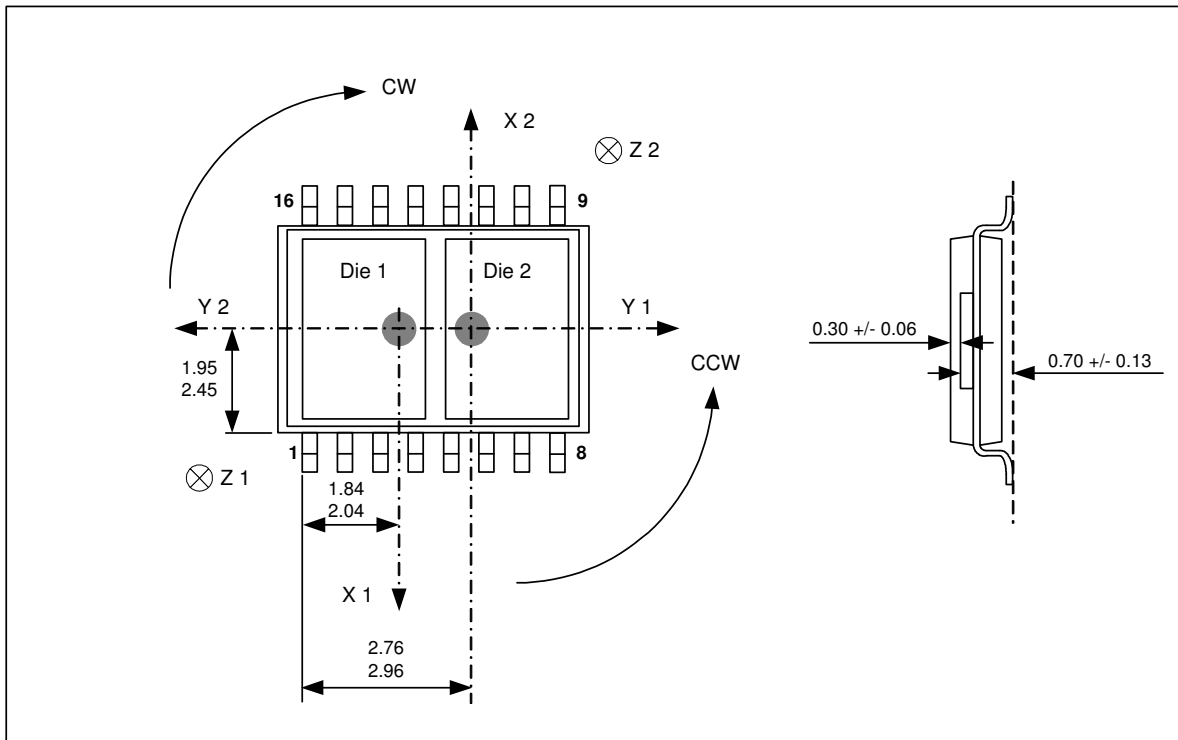
## 23.4. TSSOP16 – Package Dimensions



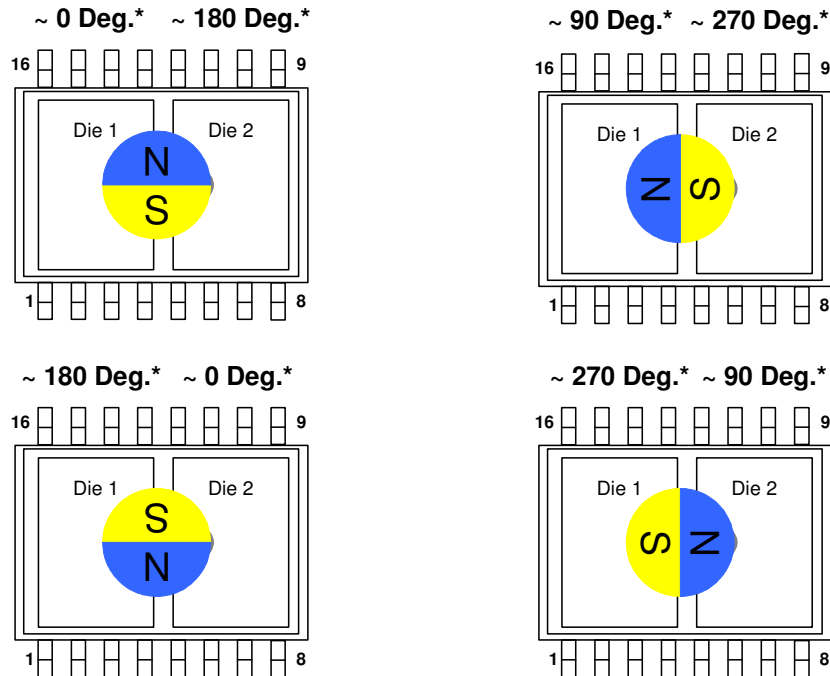
### 23.5. TSSOP16 – Pinout and Marking



### 23.6. TSSOP16 – IMC Positioning



**Angle detection MLX90363 TSSOP16**



\* No absolute reference for the angular information.

The MLX90363 is an absolute angular position sensor but the linearity error (Le – See Section 11) does not include the error linked to the absolute reference 0 Deg.

---

## **24. Disclaimer**

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|--------------------------------------------------------------------------------|--------------------------------------------------------------------------|
| <b>Europe, Africa, Asia:</b>                                                   | <b>America:</b>                                                          |
| Phone: +32 1367 0495                                                           | Phone: +1 248 306 5400                                                   |
| E-mail: <a href="mailto:sales_europe@melexis.com">sales_europe@melexis.com</a> | E-mail: <a href="mailto:sales_usa@melexis.com">sales_usa@melexis.com</a> |

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#### Как с нами связаться

**Телефон:** 8 (812) 309 58 32 (многоканальный)

**Факс:** 8 (812) 320-02-42

**Электронная почта:** [org@eplast1.ru](mailto:org@eplast1.ru)

**Адрес:** 198099, г. Санкт-Петербург, ул. Калинина, дом 2, корпус 4, литера А.