

# MLX90367 Triaxis® Position Sensor IC

## Datasheet

### Features and Benefits

- Triaxis® Hall Technology **Triaxis®**
- On Chip Signal Processing for Robust Absolute Position Sensing
- Simple Magnetic Design
- Programmable Measurement Range
- Programmable Linear Transfer Characteristic (Multi-points)
- SENT output (according to SAE J2716-2010)
- 12 bit Resolution - 10 bit Thermal Accuracy
- 48 bit ID Number option
- Single Die – SOIC-8 Package RoHS Compliant
- Dual Die (Full Redundant) – TSSOP-16 Package RoHS Compliant
- Output Thermal Offset correction



### Applications

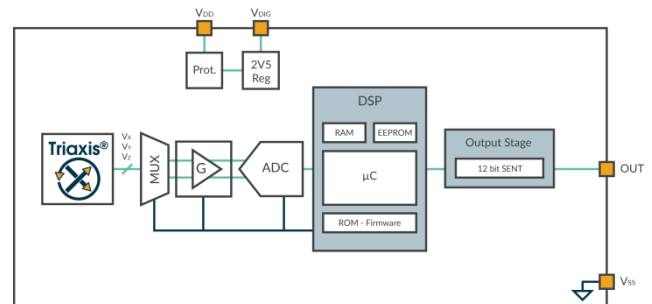
- Absolute Rotary Position Sensor
- Absolute Linear Position Sensor
- Pedal Position Sensor
- Steering Wheel Position Sensor
- Throttle Position Sensor
- Float-Level Sensor
- Ride Height Position Sensor
- Non-Contacting Potentiometer

### Description

The MLX90367 is a monolithic sensor IC sensitive to the flux density applied orthogonally and parallel to the IC surface.

The MLX90367 is sensitive to the three components of the flux density applied to the IC (i.e.  $B_x$ ,  $B_y$  and  $B_z$ ). This allows the MLX90367 with the correct magnetic circuit to decode the absolute position of any moving magnet (e.g. rotary position from 0 to 360 Degrees or linear displacement, stroke). It enables the design of novel generation of non-contacting position sensors that are frequently required for both automotive and industrial applications.

MLX90367 provides SENT Frames encoded according the Throttle sensor format or Secure Sensor format. The circuit delivers enhanced serial messages providing error codes, and user-defined values.



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# 1. Ordering Information

| Product Code | Temperature Code | Package Code | Option Code | Packing Form Code | Comment                        |
|--------------|------------------|--------------|-------------|-------------------|--------------------------------|
| MLX90367     | E                | DC           | ABU-000     | RE                | Not recommended for new design |
| MLX90367     | K                | DC           | ABU-000     | RE                | Not recommended for new design |
| MLX90367     | L                | DC           | ABU-000     | RE                | Not recommended for new design |
| MLX90367     | E                | GO           | ABU-000     | RE                | Not recommended for new design |
| MLX90367     | K                | GO           | ABU-000     | RE                | Not recommended for new design |
| MLX90367     | L                | GO           | ABU-000     | RE                | Not recommended for new design |
| MLX90367     | L                | DC           | ABV-000     | RE                | Not recommended for new design |
| MLX90367     | L                | GO           | ABV-000     | RE                | Not recommended for new design |
| MLX90367     | L                | DC           | ABX-000     | RE                | Not recommended for new design |
| MLX90367     | L                | GO           | ABX-000     | RE                | Not recommended for new design |
| MLX90367     | E                | DC           | ACU-000     | RE                |                                |
| MLX90367     | K                | DC           | ACU-000     | RE                |                                |
| MLX90367     | L                | DC           | ACU-000     | RE                |                                |
| MLX90367     | E                | GO           | ACU-000     | RE                |                                |
| MLX90367     | K                | GO           | ACU-000     | RE                |                                |
| MLX90367     | L                | GO           | ACU-000     | RE                |                                |
| MLX90367     | L                | DC           | ACV-000     | RE                |                                |
| MLX90367     | L                | GO           | ACV-000     | RE                |                                |
| MLX90367     | L                | DC           | ACX-000     | RE                |                                |
| MLX90367     | L                | GO           | ACX-000     | RE                |                                |

## Legend:

|                   |                                                                                                                                                                                                                                                                                                    |
|-------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Temperature Code: | E: from -40 Deg.C to 85 Deg.C<br>K: from -40 Deg.C to 125 Deg.C<br>L: from -40 Deg.C to 150 Deg.C                                                                                                                                                                                                  |
| Package Code:     | “DC” for SOIC-8 package<br>“GO” for TSSOP-16 package (dual die)                                                                                                                                                                                                                                    |
| Option Code:      | Axx-xxx: Die version<br>ABx-xxx: Not recommended for new design<br>ACU-xxx: Standard version (3-pts LNR Parameters)<br>ACV-xxx: Standard version with 17-Pts LNR Parameters<br>ACX-xxx: Standard version with 17-Pts LNR Parameters and Thermal Output Offset correction<br><br>xxx-000 – Standard |
| Packing Form:     | “RE” for Reel                                                                                                                                                                                                                                                                                      |
| Ordering Example: | MLX90367LGO-ACX-000-RE                                                                                                                                                                                                                                                                             |

Table 1 – Legend

## 2. Functional Diagram

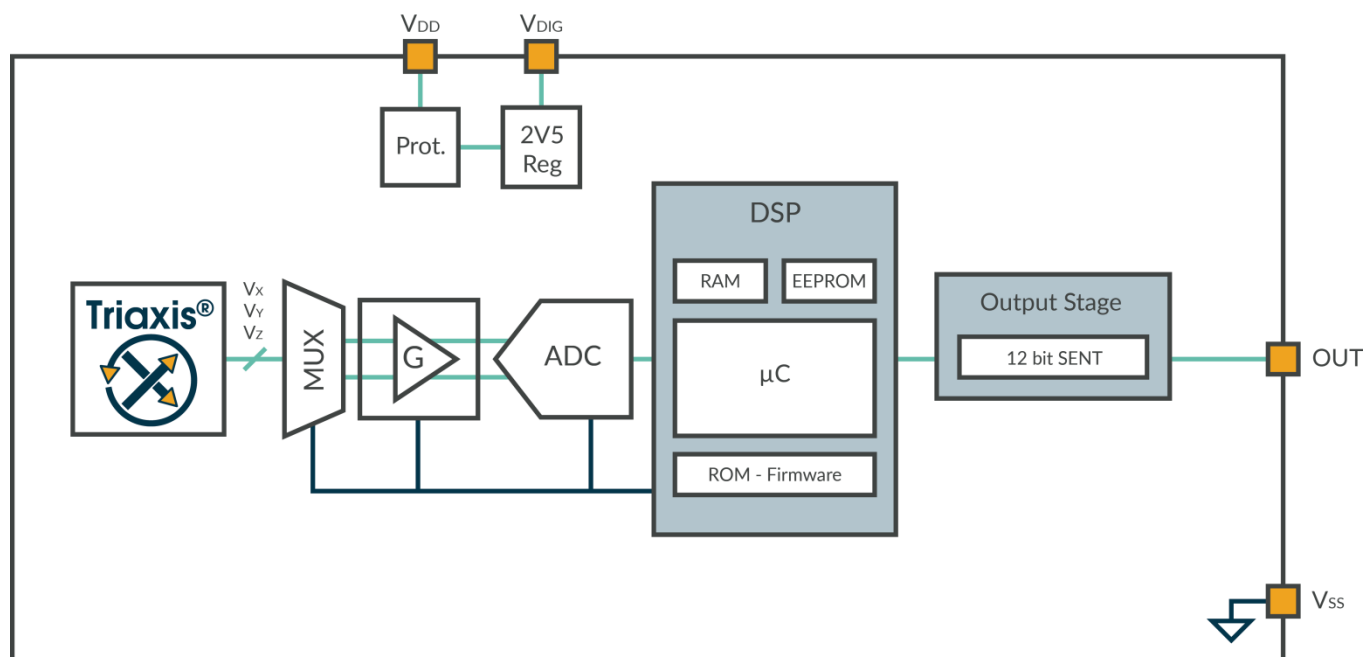


Figure 1 – Block Diagram

## 3. Glossary of Terms

|                      |                                                   |
|----------------------|---------------------------------------------------|
| Gauss (G), Tesla (T) | Units for the magnetic flux density - 1 mT = 10 G |
| TC                   | Temperature Coefficient (in ppm/Deg.C.)           |
| NC                   | Not Connected                                     |
| SENT                 | Single Edge Nibble Transmission                   |
| PWM                  | Pulse Width Modulation                            |
| ADC                  | Analog-to-Digital Converter                       |
| DAC                  | Digital to Analog Converter                       |
| LSB                  | Least Significant Bit                             |
| MSB                  | Most Significant Bit                              |
| DNL                  | Differential Non-Linearity                        |
| INL                  | Integral Non-Linearity                            |
| RISC                 | Reduced Instruction Set Computer                  |
| ASP                  | Analog Signal Processing                          |
| DSP                  | Digital Signal Processing                         |

|        |                                                                                      |
|--------|--------------------------------------------------------------------------------------|
| ATAN   | Trigonometric function: arctangent (or inverse tangent)                              |
| IMC    | Integrated Magneto-Concentrator (IMC®)                                               |
| CoRDIC | Coordinate Rotation Digital Computer (i.e. iterative rectangular-to-polar transform) |
| EMC    | Electro-Magnetic Compatibility                                                       |
| FE     | Falling Edge                                                                         |
| RE     | Rising Edge                                                                          |
| FW     | Firmware                                                                             |
| HW     | Hardware                                                                             |
| MT3V   | More than 3V Condition                                                               |
| MT4V   | More than 4V Condition                                                               |
| LSD    | Low Side Driver = Open drain N                                                       |
| PP     | Push-Pull                                                                            |

Table 2 – Glossary of Terms

## 4. Pinout

| PIN | SOIC-8                   | TSSOP-16                                |
|-----|--------------------------|-----------------------------------------|
| 1   | VDD                      | V <sub>DIG1</sub>                       |
| 2   | Test 0                   | V <sub>SS1</sub> (Ground <sub>1</sub> ) |
| 3   | Test 2                   | VDD <sub>1</sub>                        |
| 4   | Not Used                 | Test 0 <sub>1</sub>                     |
| 5   | OUT                      | Test 2 <sub>2</sub>                     |
| 6   | Test 1                   | OUT <sub>2</sub>                        |
| 7   | V <sub>DIG</sub>         | Not Used <sub>2</sub>                   |
| 8   | V <sub>SS</sub> (Ground) | Test 1 <sub>2</sub>                     |
| 9   |                          | V <sub>DIG2</sub>                       |
| 10  |                          | V <sub>SS2</sub> (Ground <sub>2</sub> ) |
| 11  |                          | VDD <sub>2</sub>                        |
| 12  |                          | Test 0 <sub>2</sub>                     |
| 13  |                          | Test 2 <sub>1</sub>                     |
| 14  |                          | Not Used <sub>1</sub>                   |
| 15  |                          | OUT <sub>1</sub>                        |
| 16  |                          | Test 1 <sub>1</sub>                     |

For optimal EMC behavior, it is recommended to connect the unused pins (Test) to the Ground (see section 17).

## 5. Absolute Maximum Ratings

| Parameter                                           | Value                       |
|-----------------------------------------------------|-----------------------------|
| Supply Voltage, VDD (overvoltage)                   | + 24 V                      |
| Reverse Voltage Protection                          | – 12 V (breakdown at -14 V) |
| Positive Output Voltage                             | + 18 V (breakdown at 24 V)  |
| Output Current (I <sub>OUT</sub> )                  | + 30 mA (in breakdown)      |
| Reverse Output Voltage                              | – 0.3 V                     |
| Reverse Output Current                              | – 50 mA (in breakdown)      |
| Operating Ambient Temperature Range, T <sub>A</sub> | – 40 ... + 150 Deg.C        |
| Storage Temperature Range, T <sub>S</sub>           | – 40 ... + 150 Deg.C        |
| Magnetic Flux Density                               | ± 1 T                       |

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

## 6. Electrical Specification

DC Operating Parameters at Nominal Supply Voltage (unless otherwise specified) and for  $T_A$  as specified by the Temperature suffix (E, K or L).

| Parameter                                                                      | Symbol                | Test Conditions                                                                                             | Min        | Typ        | Max                     | Units                    |
|--------------------------------------------------------------------------------|-----------------------|-------------------------------------------------------------------------------------------------------------|------------|------------|-------------------------|--------------------------|
| Nominal Supply Voltage                                                         | VDD                   |                                                                                                             | 4.5        | 5          | 5.5                     | V                        |
| Supply Current <sup>(1)</sup>                                                  | IDD                   | Power saving Enabled, all modes<br>For Outmode=1                                                            |            | 6          | 10 <sup>(2)</sup><br>10 | mA                       |
| Isurge Current <sup>(3)</sup>                                                  | Isurge                |                                                                                                             |            |            | 20                      | mA                       |
| Power-On reset (rising)                                                        | HPOR_LH               | Refer to internal voltage Vdig                                                                              | 2          | 2.25       | 2.5                     | V                        |
| Power-On reset Hysteresis                                                      | HPOR_Hyst             |                                                                                                             | 50         |            | 200                     | mV                       |
| Start-up Level (rising)                                                        | MT4V_LH               |                                                                                                             | 3.8        | 4.0        | 4.2                     | V                        |
| Start-up Hysteresis                                                            | MT4V_Hyst             |                                                                                                             | 50         |            | 200                     | mV                       |
| PTC Entry Level (rising)                                                       | MT7V_LH               |                                                                                                             | 5.8        | 6.2        | 6.6                     | V                        |
| PTC Entry Level Hysteresis                                                     | MT7V_Hyst             |                                                                                                             | 50         |            | 200                     | mV                       |
| Output Short Circuit Current                                                   | ISHORT                | Vout = 0 V<br>Vout = 5 V<br>Vout = 18 V ( $T_A = 25 \text{ Deg.C}$ )                                        |            |            | 15<br>15<br>18          | mA<br>mA<br>mA           |
| Output Load                                                                    | RL                    | Pull-down to Ground<br>Pull-up to 5V                                                                        | 1<br>1     | 10<br>10   | $\infty$<br>$\infty$    | k $\Omega$<br>k $\Omega$ |
| Active Diagnostic Output Level                                                 | Dsat_lo               | Pull-up load $R_L \geq 10 \text{ k}\Omega$ to 5 V<br>Pull-up load $R_L \geq 5 \text{ k}\Omega$ to 18V       |            | 0.5<br>2   | 2<br>3                  | %VDD                     |
| Digital Saturation Output Level                                                | Dsat_hi               | Pull-down load $R_L \geq 5 \text{ k}\Omega$<br>Pull-down load $R_L \geq 10 \text{ k}\Omega$                 | 95<br>97.5 | 97<br>98.5 |                         | %VDD                     |
| Passive Diagnostic Output Level<br>(Broken Track Diagnostic)<br><sup>(4)</sup> | BVssPD <sup>(5)</sup> | Broken Vss &<br>Pull-down load $R_L \geq 5 \text{ k}\Omega$<br>Pull-down load $R_L \geq 10 \text{ k}\Omega$ | 95<br>97.5 |            |                         | %VDD                     |
|                                                                                | BVssPU                | Broken Vss &<br>Pull-up load $R_L \geq 4.7 \text{ k}\Omega$                                                 | 99.5       | 100        |                         | %VDD                     |
|                                                                                | BVDDPD                | Broken VDD &<br>Pull-down load $R_L \geq 4.7 \text{ k}\Omega$                                               |            | 0          | 0.5                     | %VDD                     |
|                                                                                | BVDDPU                | Broken VDD &<br>Pull-up load $R_L \geq 5 \text{ k}\Omega$                                                   |            |            | 2                       | %VDD                     |
| Digital output Ron                                                             | Ron                   | Diag_low<br>Diag_hi                                                                                         | 15<br>120  |            | 30<br>300               | $\Omega$                 |

<sup>1</sup> Averaged current consumption, for the dual version, the supply current is multiplied by 2.

<sup>2</sup> To reach 10mA, the power saving option is enabled. This option switches off and on internal blocks dynamically. It can be disabled in case of extreme emission requirements; the maximum supply current consumption is then increased up to 12mA.

<sup>3</sup> The specified value is valid during early start-up time only; the current might dynamically exceed the specified value, shortly, during the Start-up phase.

<sup>4</sup> The SENT output signal will no longer be reported. For detailed information, see also section 0

<sup>5</sup> In case the dual-die variant is used BVssPD level can be influenced. Refer to Technical note MLX90365\_Broken\_Vss\_DualDie

## 7. Isolation Specification

DC Operating Parameters at Nominal Supply Voltage (unless otherwise specified) and for  $T_A$  as specified by the Temperature suffix (E, K or L). Only valid for the package code GO i.e. dual die version.

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

## 8. Timing Specification

DC Operating Parameters at Nominal Supply Voltage (unless otherwise specified) and for  $T_A$  as specified by the Temperature suffix (E, K or L).

| Parameter                                      | Symbol          | Test Conditions                                                                                   | Min   | Typ    | Max       | Units             |
|------------------------------------------------|-----------------|---------------------------------------------------------------------------------------------------|-------|--------|-----------|-------------------|
| Main Clock Frequency                           | Ck              | All contributors (trimming accuracy, supply voltage, thermal and ageing)                          | 12.6  | 13.3   | 14        | MHz               |
| Main Clock Frequency Thermal Drift             | $\Delta T_{Ck}$ |                                                                                                   |       |        | $\pm 3\%$ | Ck <sub>NOM</sub> |
| Tick time                                      |                 | Default EEPROM setting                                                                            |       | 3      |           | μs                |
| Low pulse tick count                           |                 |                                                                                                   | 4     | 5      |           | ticks             |
| SENT Frame Period                              | tframe          |                                                                                                   |       | 882    |           | μs                |
| Internal Angle Measurement Period              | tper            |                                                                                                   |       | 441    |           | μs                |
| First Angle Measurement to Sync Pulse latency  | ta1             | Exact value for Ck = 13.3 MHz<br>The typical value will be affected by any variation of the clock |       | 1084   |           | μs                |
| Second Angle Measurement to Sync Pulse latency | ta2             |                                                                                                   |       | 643    |           | μs                |
| Field Change to SENT Data: Average Latency     | Latency         | FILTER = 1 (recommended)<br>SENT Transmission Included                                            | 1745  |        | 1745      | μs                |
| SENT Frame Tick Count                          |                 | Default EEPROM setting                                                                            | 294   |        | 294       |                   |
| Watchdog                                       | Twd             |                                                                                                   | 114.5 | 118    | 121.5     | ms                |
| Start-up Time (up to first sync pulse)         | Tsu1            |                                                                                                   |       | 1.8    |           | ms                |
| Start-up Time (up to first data received)      | Tsu2            | Last pause pulse not included                                                                     |       | 5.9    | 6.3       | ms                |
| Serial Message                                 |                 | Extended sequence (40 frames)                                                                     |       | 635.04 |           | ms                |
|                                                |                 | Short sequence (24 frames)                                                                        |       | 381.02 |           |                   |
| Rise Time @ Cable                              |                 | Thresholds: 0.5V and 4.5V<br>See section 9.2                                                      | 2.97  |        | 5.31      | μs                |
| Rise Time @ Receiver                           |                 |                                                                                                   | 5.07  |        | 6.84      | μs                |
| Fall Time @ Cable                              |                 |                                                                                                   | 2.65  |        | 2.82      | μs                |
| Fall Time @ Receiver                           |                 |                                                                                                   | 4.84  |        | 4.9       | μs                |

## 8.1. Timing diagrams

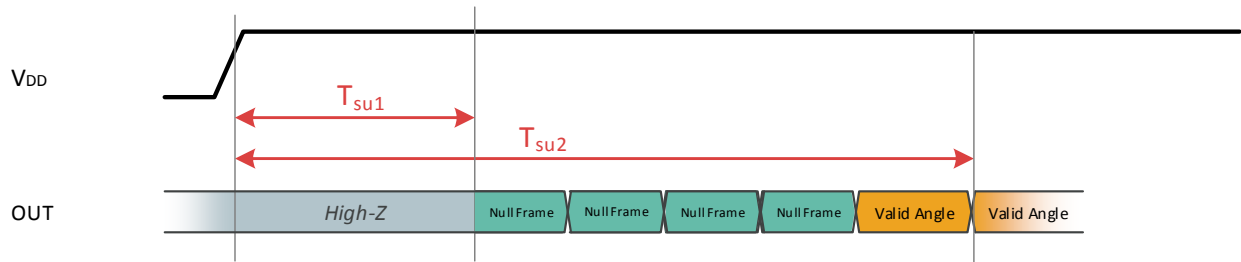


Figure 2 - Start-up phase timings

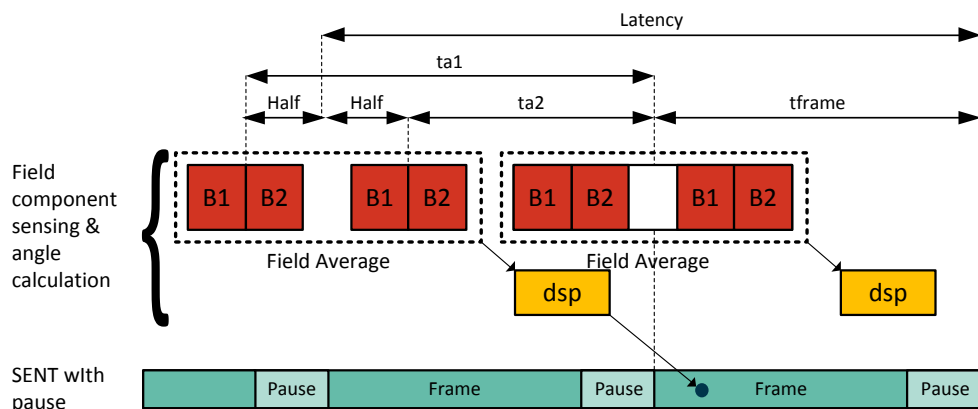


Figure 3 - Latencies (acquisition to output delays) – FILTER = 1 (recommended)

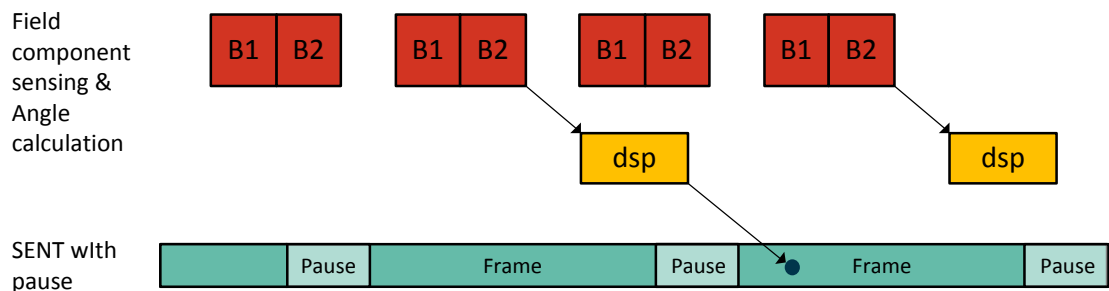


Figure 4 - Latency - Case FILTER = 0 (not recommended)

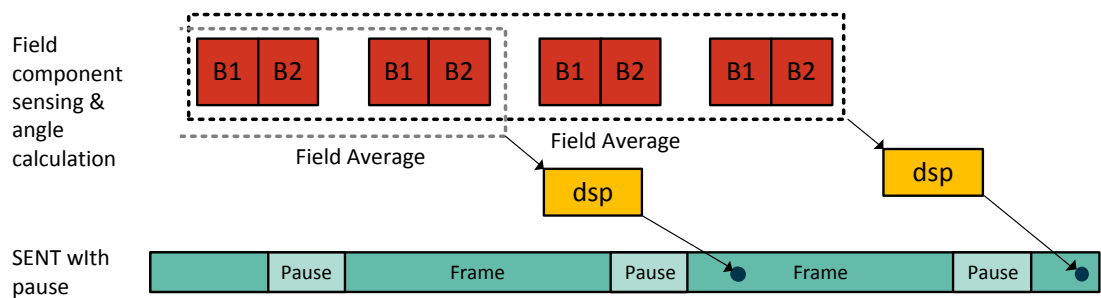


Figure 5 - Latency - Case FILTER = 2

## 8.2. Application diagram used for rise and fall time measurement

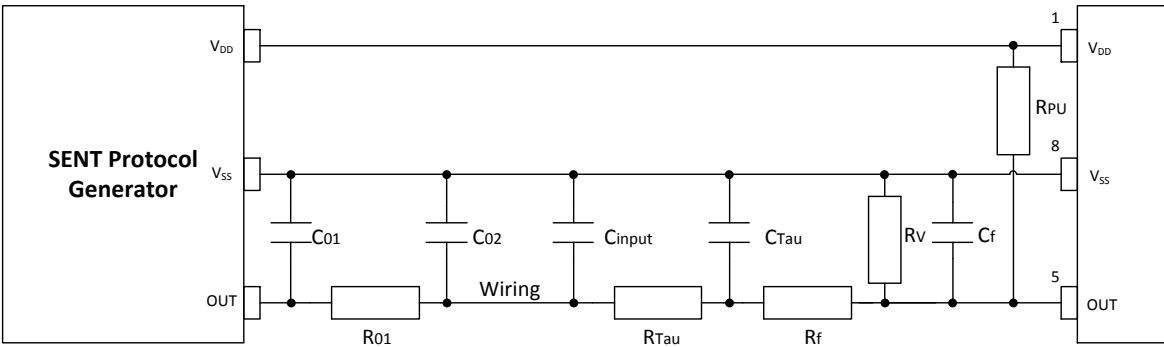


Figure 6 - Schematic used for rise and fall time measurements (ref: J2716 Rev Jan 2010 Fig. 6.3.4)

| Component | Value       | Unit |
|-----------|-------------|------|
| C01       | 10 ± 25%    | nF   |
| C02       | not mounted | nF   |
| R01       | not mounted | Ω    |
| Cinput    | 68          | pF   |
| CTau      | 2.2         | nF   |
| Cf        | 100         | pF   |
| RTau      | 568         | Ω    |
| Rf        | 10          | kΩ   |
| RPU       | 14.7        | kΩ   |
| Rv        | not mounted | Ω    |

Component values used for rise and fall time measurements (ref: J2716 Rev Jan 2010 Fig. 6.3.4)

## 9. Accuracy Specification

DC Operating Parameters at Nominal Supply Voltage (unless otherwise specified) and for  $T_A$  as specified by the Temperature suffix (E, K or L).

| Parameter                                                                            | Symbol | Test Conditions                                                                                                                | Min                      | Typ                  | Max                      | Units |
|--------------------------------------------------------------------------------------|--------|--------------------------------------------------------------------------------------------------------------------------------|--------------------------|----------------------|--------------------------|-------|
| ADC Resolution on the raw signals sine and cosine <sup>(6)</sup>                     | RADC   |                                                                                                                                |                          | 15                   |                          | bits  |
| Thermal Offset Drift #1 <sup>(7)</sup> at the DSP input (excl. DAC and output stage) |        | Temperature suffix E<br>Temperature suffix K<br>Temperature suffix L                                                           | -60<br>-60<br>-90        |                      | +60<br>+60<br>+90        | LSB15 |
| Thermal Drift of Sensitivity Mismatch <sup>(8)</sup>                                 |        | XY axis – Temp. suffix E<br>XY axis – Temp. suffix K & L<br>XZ (YZ) axis – Temp. suffix E<br>XZ (YZ) axis – Temp. suffix K & L | -0.3<br>-0.5<br>-1<br>-1 |                      | +0.3<br>+0.5<br>+1<br>+1 | %     |
| Magnetic Angle phase error                                                           |        | $T_A = 25\text{Deg.C}$ – XY axis<br>$T_A = 25\text{Deg.C}$ – XZ axis<br>$T_A = 25\text{Deg.C}$ – YZ axis                       | -0.3<br>-2<br>-2         |                      | 0.3<br>2<br>2            | Deg.  |
| Thermal Drift of Magnetic Angle phase error                                          |        | XY axis, XZ (YZ) axis                                                                                                          |                          | 0.01                 |                          | Deg.  |
| XY – Intrinsic Linearity Error <sup>(9)</sup>                                        | Le     | $T_A = 25\text{Deg.C}$ – factory trim. “SMISM”                                                                                 | -1                       |                      | 1                        | Deg.  |
| XZ - Intrinsic Linearity Error <sup>(9)</sup>                                        | Le     | $T_A = 25\text{Deg.C}$ – “k” trimmed for XZ                                                                                    | -2.5                     | $\pm 1.25$           | +2.5                     | Deg.  |
| YZ - Intrinsic Linearity Error <sup>(9)</sup>                                        | Le     | $T_A = 25\text{Deg.C}$ – “k” trimmed for YZ                                                                                    | -2.5                     | $\pm 1.25$           | +2.5                     | Deg.  |
| Noise pk-pk <sup>(10)</sup>                                                          |        | Filter = 0; 40mT<br>Filter = 1 (recommended); 30mT<br>Filter = 2; 20mT                                                         |                          | 0.10<br>0.10<br>0.10 | 0.2<br>0.2<br>0.2        | Deg.  |

<sup>6</sup> 16 bits corresponds to 15 bits + sign. Internal computation is performed using 16 bits.

<sup>7</sup> For instance, in case of a rotary position sensor application, Thermal Offset Drift #1 equal  $\pm 60\text{LSB15}$  yields to max.  $\pm 0.3$  Deg. angular error for the computed angular information (output of the DSP). This is only valid if  $k = 1$ .

<sup>8</sup> For instance, in case of a rotary position sensor application, Thermal Drift of Sensitivity Mismatch equal  $\pm 0.5\%$  yields to max.  $\pm 0.15$  Deg. angular error for the computed angular information (output of the DSP).

<sup>9</sup> The Intrinsic Linearity Error refers to the IC itself (offset, sensitivity mismatch, orthogonality) taking into account an ideal rotating field for  $B_X$  and  $B_Y$ . Once associated to a practical magnetic construction and the associated mechanical and magnetic tolerances, the output linearity error increases. However, it can be improved with the multi-point end-user calibration. The intrinsic Linearity Error for Magnetic angle  $\angle XZ$  and  $\angle YZ$  can be reduced through the programming of the  $k$  factor.

<sup>10</sup> Noise pk-pk (peak-to-peak) is here intended as 6 times the Noise standard Deviation. The application diagram used is described in the recommended wiring. For detailed information, refer to section Filter in application mode (Section 15.5).

## 10. Magnetic Specification

DC Operating Parameters at Nominal Supply Voltage (unless otherwise specified) and for TA as specified by the Temperature suffix (E, K or L).

| Parameter                           | Symbol                | Test Conditions                              | Min                | Typ | Max                | Units     |
|-------------------------------------|-----------------------|----------------------------------------------|--------------------|-----|--------------------|-----------|
| Magnetic Flux Density               | $B_x, B_y^{(11)}$     | $\sqrt{B_x^2 + B_y^2}$                       |                    |     | 70 <sup>(12)</sup> | mT        |
| Magnetic Flux Density               | $B_z$                 |                                              |                    |     | 126                | mT        |
| Magnetic Flux Norm                  | Norm                  | $\sqrt{B_x^2 + B_y^2 + (B_z/1.2)^2}$         | 20 <sup>(13)</sup> |     |                    | mT        |
| IMC Gain in X and Y <sup>(14)</sup> | GainIMC <sub>XY</sub> |                                              | 1.2                | 1.4 | 1.8                |           |
| IMC Gain in Z                       | GainIMC <sub>Z</sub>  |                                              | 1.1                |     | 1.3                |           |
| k factor                            | k                     | GainIMC <sub>XY</sub> / GainIMC <sub>Z</sub> | 1                  | 1.2 | 1.5                |           |
| Magnet Temperature Coefficient      | TCm                   |                                              | -2400              |     | 0                  | ppm/Deg.C |

## 11. CPU & Memory Specification

The DSP is based on a 16 bit RISC  $\mu$ Controller. This CPU provides 2.5 MIPS while running at 10 MHz.

| Parameter | Symbol | Test Conditions | Min | Typ | Max | Units |
|-----------|--------|-----------------|-----|-----|-----|-------|
| ROM       |        |                 |     | 10  |     | KB    |
| RAM       |        |                 |     | 384 |     | B     |
| EEPROM    |        |                 |     | 128 |     | B     |

## 12. Traceability Information

Every device contains a unique ID that is programmed by Melexis in the EEPROM. Melexis strongly recommends storing this value during the EOL (End-Of-Line) programming to ensure full traceability of the final product. These parameters shall never be erased during the EOL programming.

| Parameter  | Comments                         | Default Values | Parameter # bit |
|------------|----------------------------------|----------------|-----------------|
| MELEXISID1 | Melexis identification reference | MLX            | 16              |
| MELEXISID2 | Melexis identification reference | MLX            | 16              |
| MELEXISID3 | Melexis identification reference | MLX            | 16              |

<sup>11</sup> The condition must be fulfilled for at least one field  $B_x$  or  $B_y$ .

<sup>12</sup> Above 70 mT, the IMC starts saturating yielding to an increase of the linearity error.

<sup>13</sup> Below 20 mT, the performances slightly degrade due to a reduction of the signal-to-noise ratio, signal-to-offset ratio.

<sup>14</sup> This is the magnetic gain linked to the Integrated Magneto Concentrator structure. 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.

## 13. End-User Programmable Items

| Parameter      | Comments                                  | AxU-xxx |        | AxV-xxx |        | AxX-xxx |        |
|----------------|-------------------------------------------|---------|--------|---------|--------|---------|--------|
|                |                                           | #bit    | Std    | #bit    | Std    | #bit    | Std    |
| MAPXYZ         | Mapping fields for output angle           | 2       | 0x0    | 2       | 0x0    | 2       | 0x0    |
| CLAMPHIGH      | Clamping High                             | 16      | 0xFF80 | 16      | 0xFFFF | 16      | 0xFF80 |
| CLAMPLOW       | Clamping Low                              | 16      | 0x0010 | 16      | 0x0000 | 16      | 0x0010 |
| SMISM          | Sensitivity mismatch factor X, Y          | 15      | MLX    | 15      | MLX    | 15      | MLX    |
| K              | Sensitivity mismatch factor X (Y), Z      | 15      | MLX    | 15      | MLX    | 15      | MLX    |
| SELK           | Location for K – correction               | 1       | 0x0    | 1       | 0x0    | 1       | 0x0    |
| GAINMIN        | Low threshold for virtual gain            | 8       | 0x00   | 8       | 0x00   | 8       | 0x01   |
| GAINMAX        | High threshold for virtual gain           | 8       | 0x28   | 8       | 0x28   | 8       | 0x28   |
| GAINSATURATION | Gain Saturates on GAINMIX and GAINMAX     | 1       | 0x0    | 1       | 0x0    | 1       | 0x0    |
| DP             | Discontinuity point                       | 15      | 0x0000 | 15      | 0x0000 | 15      | 0x0000 |
| CW             | Clock Wise                                | 1       | 0x0    | 1       | 0x0    | 1       | 0x0    |
| LNR50          | 3pts – Initial Slope                      | 16      | 0x0000 |         | N/A    |         | N/A    |
| LNRAX          | 3pts – AX Coordinate                      | 16      | 0x0000 |         | N/A    |         | N/A    |
| LNRAY          | 3pts – AY Coordinate                      | 16      | 0x0010 |         | N/A    |         | N/A    |
| LNRAS          | 3pts – AS Coordinate                      | 16      | 0x1FF0 |         | N/A    |         | N/A    |
| LNRBX          | 3pts – BX Coordinate                      | 16      | 0xFFFF |         | N/A    |         | N/A    |
| LNRBY          | 3pts – BY Coordinate                      | 16      | 0xFFFF |         | N/A    |         | N/A    |
| LNRBS          | 3pts – BS Coordinate                      | 16      | 0x0000 |         | N/A    |         | N/A    |
| LNRCX          | 3pts – CX Coordinate                      | 16      | 0xFFFF |         | N/A    |         | N/A    |
| LNRCY          | 3pts – CY Coordinate                      | 16      | 0xFFFF |         | N/A    |         | N/A    |
| LNRC5          | 3pts – CS Coordinate                      | 16      | 0x0000 |         | N/A    |         | N/A    |
| DIAGSETTINGS   | 16 Bit Diagnostics enabling               | 16      | 0x4080 | 16      | 0x4080 | 16      | 0x4080 |
| CRCDISABLE     | Enable EEPROM CRC check (0x0000=enabled)  | 16      | 0x0000 | 8       | 0x00   | 8       | 0x00   |
| SERIALERROR    | Diagnostic reporting through fast channel | 3       | 0x0    | 3       | 0x0    | 3       | 0x0    |
| FILTER         | FIR Filter                                | 2       | 0x0    | 2       | 0x0    | 2       | 0x0    |
| SENTSERIAL     | Serial Message                            | 8       | 0x80   | 8       | 0x80   | 8       | 0x80   |
| SERIAL_OEM1    | Serial Message (12 lsb are used)          | 16      | 0x0000 | 12      | 0x000  | 12      | 0x000  |
| SERIAL_OEM2    | Serial Message (12 lsb are used)          | 16      | 0x0000 | 12      | 0x000  | 12      | 0x000  |

| Parameter         | Comments                                                                                                                                                      | AxU-xxx |        | AxV-xxx |        | AxX-xxx |        |
|-------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|--------|---------|--------|---------|--------|
|                   |                                                                                                                                                               | #bit    | Std    | #bit    | Std    | #bit    | Std    |
| SERIAL_OEM3       | Serial Message (12 lsb are used)                                                                                                                              | 16      | 0x0000 | 12      | 0x000  | 12      | 0x000  |
| SERIAL_OEM4       | Serial Message (12 lsb are used)                                                                                                                              | 16      | 0x0000 | 12      | 0x000  | 12      | 0x000  |
| SERIAL_OEM5       | Serial Message (12 lsb are used)                                                                                                                              | 16      | 0x0000 |         | N/A    |         | N/A    |
| SERIAL_OEM6       | Serial Message (12 lsb are used)                                                                                                                              | 16      | 0x0000 |         | N/A    |         | N/A    |
| SERIAL_OEM7       | Serial Message (12 lsb are used)                                                                                                                              | 16      | 0x0000 |         | N/A    |         | N/A    |
| SERIAL_OEM8       | Serial Message (12 lsb are used)                                                                                                                              | 16      | 0x0000 |         | N/A    |         | N/A    |
| SERIAL_MANCODE    | Serial Message (12 lsb are used)                                                                                                                              | 16      | 0x0000 | 16      | 0x0000 | 16      | 0x0000 |
| SERIAL_SensorType | Serial Message                                                                                                                                                | 12      | 0x000  | 12      | 0x000  | 12      | 0x000  |
| SERIAL_SENTREV    | Serial Message                                                                                                                                                | 4       | 0x3    | 4       | 0x3    | 4       | 0x3    |
| USERID1           | Cust identification reference: Default = Bin1<br>Can be used as incoming inspection, only set when final test was PASS.                                       | 16      | 0x0001 |         | N/A    |         | N/A    |
| USERID2           | Cust identification reference: Default Rev nr                                                                                                                 | 16      | 0x0305 |         | N/A    |         | N/A    |
| USERID3           | Cust identification reference: Default Sens.                                                                                                                  | 16      | MLX    |         | N/A    |         | N/A    |
| SERIAL_ID1        | Serial data for serial 29 (12 lsb are used)                                                                                                                   | 16      | 0x0000 | 12      | 0x000  | 12      | 0x000  |
| SERIAL_ID2        | Serial data for serial 2A (12 lsb are used)                                                                                                                   | 16      | 0x0000 | 12      | 0x000  | 12      | 0x000  |
| SERIAL_ID3        | Serial data for serial 2B (12 lsb are used)                                                                                                                   | 16      | 0x0000 | 12      | 0x000  | 12      | 0x000  |
| SERIAL_ID4        | Serial data for serial 2C (12 lsb are used)                                                                                                                   | 16      | 0x0000 | 12      | 0x000  | 12      | 0x000  |
| SERIALID1         | ID of user serial message #1                                                                                                                                  |         | N/A    |         | N/A    |         | N/A    |
| SERIALID2         | ID of user serial message #2                                                                                                                                  |         | N/A    |         | N/A    |         | N/A    |
| SERIALID3         | ID of user serial message #3                                                                                                                                  |         | N/A    |         | N/A    |         | N/A    |
| SERIALID4         | ID of user serial message #4                                                                                                                                  |         | N/A    |         | N/A    |         | N/A    |
| SLOW_MESSAGE      | Enable or disable the serial message                                                                                                                          | 1       | 0x1    | 1       | 0x1    | 1       | 0x1    |
| PAUSEPULSE        | Enable or disable the pause pulse                                                                                                                             | 1       | 0x1    | 1       | 0x1    | 1       | 0x1    |
| CRC2010           | CRC according 2010 or 2007 standard                                                                                                                           | 1       | 0x1    | 1       | 0x1    | 1       | 0x1    |
| MEMLOCK           | EEPROM memory lock                                                                                                                                            | 2       | 0x0    | 2       | 0x0    | 2       | 0x0    |
| SERIALDATA1       | Data of user serial message #1 (12 lsb used)<br>Not available to USER until MemLock performed. For more details, see:<br>EEPROM_MLX90366_default_settings.doc |         | N/A    |         | N/A    |         | N/A    |
| SERIALDATA2       | Data of user serial message #2 (12 lsb used)                                                                                                                  |         | N/A    |         | N/A    |         | N/A    |
| SERIALDATA3       | Data of user serial message #3 (12 lsb used)                                                                                                                  |         | N/A    |         | N/A    |         | N/A    |
| SERIALDATA4       | Data of user serial message #4 (12 lsb used)                                                                                                                  |         | N/A    |         | N/A    |         | N/A    |

| Parameter         | Comments                                            | AxU-xxx |        | AxV-xxx |        | AxX-xxx |        |
|-------------------|-----------------------------------------------------|---------|--------|---------|--------|---------|--------|
|                   |                                                     | #bit    | Std    | #bit    | Std    | #bit    | Std    |
| SERIAL_X1         | Serial Message (12 lsb used)                        | 16      | 0x0000 | 12      | 0x000  | 12      | 0x000  |
| SERIAL_X2         | Serial Message (12 lsb used)                        | 16      | 0x0000 | 12      | 0x000  | 12      | 0x000  |
| SERIAL_Y1         | Serial Message (12 lsb used)                        | 16      | 0x0000 | 12      | 0x000  | 12      | 0x000  |
| SERIAL_Y2         | Serial Message (12 lsb used)                        | 16      | 0x0000 | 12      | 0x000  | 12      | 0x000  |
| W                 | 17pts – Output angle range                          |         | N/A    | 4       | 0x0    | 4       | 0x0    |
| LNRY0             | Y coordinate point 0/16                             |         | N/A    | 16      | 0x4001 | 16      | 0x4009 |
| LNRY1             | Y coordinate point 1/16                             |         | N/A    | 16      | 0x4801 | 16      | 0x4804 |
| LNRY2             | Y coordinate point 2/16                             |         | N/A    | 16      | 0x5001 | 16      | 0x5000 |
| LNRY3             | Y coordinate point 3/16                             |         | N/A    | 16      | 0x5801 | 16      | 0x57FC |
| LNRY4             | Y coordinate point 4/16                             |         | N/A    | 16      | 0x6001 | 16      | 0x5FF8 |
| LNRY5             | Y coordinate point 5/16                             |         | N/A    | 16      | 0x6801 | 16      | 0x67F4 |
| LNRY6             | Y coordinate point 6/16                             |         | N/A    | 16      | 0x7001 | 16      | 0x6FF0 |
| LNRY7             | Y coordinate point 7/16                             |         | N/A    | 16      | 0x7801 | 16      | 0x77EC |
| LNRY8             | Y coordinate point 8/16                             |         | N/A    | 16      | 0x8001 | 16      | 0x7FE8 |
| LNRY9             | Y coordinate point 9/16                             |         | N/A    | 16      | 0x8801 | 16      | 0x87E4 |
| LNRY10            | Y coordinate point 10/16                            |         | N/A    | 16      | 0x9001 | 16      | 0x8FE0 |
| LNRY11            | Y coordinate point 11/16                            |         | N/A    | 16      | 0x9801 | 16      | 0x97DC |
| LNRY12            | Y coordinate point 12/16                            |         | N/A    | 16      | 0xA001 | 16      | 0x8FD8 |
| LNRY13            | Y coordinate point 13/16                            |         | N/A    | 16      | 0xA801 | 16      | 0xA7D4 |
| LNRY14            | Y coordinate point 14/16                            |         | N/A    | 16      | 0xB001 | 16      | 0xAFD0 |
| LNRY15            | Y coordinate point 15/16                            |         | N/A    | 16      | 0xB801 | 16      | 0xB7CC |
| LNRY16            | Y coordinate point 16/16                            |         | N/A    | 16      | 0xC001 | 16      | 0xBF8C |
| ANGLEOFSSLOPECOLD | Temperature coefficient offset at cold temperatures |         | N/A    |         | N/A    | 8       | 0x0    |
| ANGLEOFSSLOPEHOT  | Temperature coefficient offset at hot temperatures  |         | N/A    |         | N/A    | 8       | 0x0    |

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

## 14. SENT output Protocol

### 14.1. Generality

The MLX90367 complies with the sub-set of the norm J2716 Revised **JAN2010**, “A.1 A.1 Throttle Position” or “A.3 Single Secure Sensors”

### 14.2. Throttle position / Single Secure Fast Channel

The MLX90367 delivers SENT frames according the Throttle position or Single Secure format. This format is explicitly described in this section.

#### 14.2.1. Frame Content

The MLX90367 SENT frames have 6 data nibbles and are formatted according the below tables.

| Single Secure       |                                                    |          |          |             |          |          |          |          |                |
|---------------------|----------------------------------------------------|----------|----------|-------------|----------|----------|----------|----------|----------------|
|                     | Nibble 0                                           | Nibble 1 | Nibble 2 | Nibble 3    | Nibble 4 | Nibble 5 | Nibble 6 | Nibble 7 |                |
| <b>SENT Frame :</b> | Status                                             | CH1-MSN  | CH1-MidN | CH1-LSN     | RC-MSN   | RC-LSN   | CCH1-MSN | CRC      | Optional Pause |
| optional error code |                                                    | F        | F        | 8+EE_REPORT |          |          | 0        |          |                |
| Status[0]           | Channel 1 indicator ( "1" = error, "0" otherwise ) |          |          |             |          |          |          |          |                |
| Status[1]           | 0                                                  |          |          |             |          |          |          |          |                |
| Status[2]           | Enhanced Serial Message ( dissable option)         |          |          |             |          |          |          |          |                |
| Status[3]           | Enhanced Serial Message ( dissable option)         |          |          |             |          |          |          |          |                |
| CRC                 | Enhanced CRC (the legacy CRC is optional)          |          |          |             |          |          |          |          |                |
| Ch1                 | 12 bit angle                                       |          |          |             |          |          |          |          |                |
| RC                  | 8 bit rolling counter                              |          |          |             |          |          |          |          |                |
| CCH1                | Inverted Copy Ch1                                  |          |          |             |          |          |          |          |                |

| Throttle position   |                                                               |          |          |             |          |          |             |          |                |
|---------------------|---------------------------------------------------------------|----------|----------|-------------|----------|----------|-------------|----------|----------------|
|                     | Nibble 0                                                      | Nibble 1 | Nibble 2 | Nibble 3    | Nibble 4 | Nibble 5 | Nibble 6    | Nibble 7 |                |
| <b>SENT Frame :</b> | Status                                                        | CH1-MSN  | CH1-MidN | CH1-LSN     | CH2-LSN  | CH2-MidN | CH2-MSN     | CRC      | Optional Pause |
| optional error code |                                                               | F        | F        | 8+EE_REPORT | F        | F        | 8+EE_REPORT |          |                |
| Status[0]           | Channel 1 indicator ( "1" = error, "0" otherwise )            |          |          |             |          |          |             |          |                |
| Status[1]           | Channel 2 indicator ( "1" = error, "0" otherwise )            |          |          |             |          |          |             |          |                |
| Status[2]           | Enhanced Serial Message ( dissable option)                    |          |          |             |          |          |             |          |                |
| Status[3]           | Enhanced Serial Message ( dissable option)                    |          |          |             |          |          |             |          |                |
| CRC                 | Enhanced CRC (the legacy CRC is optional)                     |          |          |             |          |          |             |          |                |
| Ch1                 | 12 bit angle                                                  |          |          |             |          |          |             |          |                |
| Ch2                 | 12 bit angle = Inverted CH1 ( optional : FFF-CH1 or FF9-CH1 ) |          |          |             |          |          |             |          |                |

#### 14.2.2. Diagnostic Reporting through the fast channel

##### Diagnostic Reporting, bit Status[0]

The bit Status[0] is high whenever the three following conditions are met:

1. A diagnostic (analog/environmental) detects an error<sup>(15)</sup>
2. The reporting of the above error is enabled<sup>(16)</sup>
3. The debouncing time has elapsed.

## Diagnostic Reporting, Channel 1

The diagnostic can be reported through the 12 bit payload of channel 1, and not only through the status bit Status[0]. The EEPROM parameters SERIALERROR controls the diagnostic reporting through channel 1 as follow:

If SERIALERROR =0, the channel 1 reports the angle, and not the diagnostic, as if no diagnostic.

The error is reported only thanks to the Status bits.

If SERIALERROR >0, the channel 1 payload contains the value Channel1 = (4088 + SERIALERROR)]

## Diagnostic Reporting Time

The Diagnostic Reporting Time is programmable (defined as multiple of a macro-cycle unit time).

A macro-cycle is a sequence of 20 angle acquisitions and has duration of approximately 6ms.

## Diagnostic Debouncing

The Diagnostic Reporting is debounced. The debouncing parameters are user-programmable, by steps of approximately 6 ms.

## Pause pulse

A pause pulse, as defined by the standard, is present at the end of every frame. The pause pulse mode can be disabled. Please contact our Direct Sales team to obtain the complete procedure for deactivating the pause pulse mode. The pause pulse length is adjusted by the circuit so that the frame period is constant.

The field sensing and the frame synchronization pulse are in sync.

## Fast Channel CRC

The MLX90367 features the new recommended implementation and optional the legacy implementation

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<sup>15</sup> A diagnostic of type digital cause the circuit to switch in fail-safe-mode

<sup>16</sup> See EEPROM bits EE\_DIAG\_SETTINGS

## 14.3. Slow Channel

### 14.3.1. Enhanced Serial Message

The circuit encodes the slow messages according the Enhanced Serial Message Format as specified at Chapter 5.2.4.3 of the SENT norm, except for the following restriction:

The configuration bit is always 0, meaning that the payload consists in 12-bit data and 8-bit message ID.

### 14.3.2. Serial Message sequence

The circuit complies with the following sub-set specifications of the norm for pressure sensors

(The norm for the angular sensor case does not specify the serial message format)

| ID | Item                      | 12 bit data | Comment                   | AxU |               | AxV & AxX |               |
|----|---------------------------|-------------|---------------------------|-----|---------------|-----------|---------------|
|    |                           |             |                           | #   | Optional part | #         | Optional part |
| 1  | Diagnostic error codes    | RAM         | cf section 14.3.4         | 1   |               | 1         |               |
| 6  | SENT standard revision    | Prog.       | EEPROM: SERIAL_SENTREV    | 2   |               | 2         |               |
| 1  | Diagnostic error codes    | RAM         |                           | 3   |               | 3         |               |
| 5  | Manufacturer code         | Prog.       | EEPROM: SERIAL_MANCODE    | 4   |               | 4         |               |
| 1  | Diagnostic error codes    | RAM         |                           | 5   |               | 5         |               |
| 3  | Channel 1 / 2 sensor type | Prog.       | EEPROM: SERIAL_SensorType | 6   |               | 6         |               |
| 1  | Diagnostic error codes    | RAM         |                           | 7   |               | 7         |               |
| 7  | Fast channel 1 - X1       | Prog.       | EEPROM: SERIAL_X1         | 8   |               | 8         |               |
| 1  | Diagnostic error codes    | RAM         |                           | 9   |               | 9         |               |
| 8  | Fast channel 1 - X2       | Prog.       | EEPROM: SERIAL_X2         | 10  |               | 10        |               |
| 1  | Diagnostic error codes    | RAM         |                           | 11  |               | 11        |               |
| 9  | Fast channel 1 - Y1       | Prog.       | EEPROM: SERIAL_Y1         | 12  |               | 12        |               |
| 1  | Diagnostic error codes    | RAM         |                           | 13  |               | 13        |               |
| A  | Fast channel 1 - Y2       | Prog.       | EEPROM: SERIAL_Y2         | 14  |               | 14        |               |
| 1  | Diagnostic error codes    | RAM         |                           | 15  |               | 15        |               |
| 23 | Temperature sensor        | Prog.       |                           | 16  |               | 16        |               |
| 1  | Diagnostic error codes    | RAM         |                           | 17  |               | 17        |               |
| 29 | Sensor ID #1              | Prog.       | EEPROM: SERIAL_ID1        | 18  |               | 18        |               |
| 1  | Diagnostic error codes    | RAM         |                           | 19  |               | 19        |               |
| 2A | Sensor ID #2              | Prog.       | EEPROM: SERIAL_ID2        | 20  |               | 20        |               |
| 1  | Diagnostic error codes    | RAM         |                           | 21  |               | 21        |               |
| 2B | Sensor ID #3              | Prog.       | EEPROM: SERIAL_ID3        | 22  |               | 22        |               |
| 1  | Diagnostic error codes    | RAM         |                           | 23  |               | 23        |               |
| 2C | Sensor ID #4              | Prog.       | EEPROM: SERIAL_ID4        | 24  |               | 24        |               |
| 1  | Diagnostic error codes    | RAM         |                           | 25  | X             | 25        | X             |
| 90 | OEM Code #1               | Prog.       | EEPROM: SERIAL_OEM1       | 26  | X             | 26        | X             |
| 1  | Diagnostic error codes    | RAM         |                           | 27  | X             | 27        | X             |
| 91 | OEM Code #2               | Prog.       | EEPROM: SERIAL_OEM2       | 28  | X             | 28        | X             |
| 1  | Diagnostic error codes    | RAM         |                           | 29  | X             | 29        | X             |

| ID | Item                   | 12 bit data | Comment             | AxU |               | AxV & AxX |               |
|----|------------------------|-------------|---------------------|-----|---------------|-----------|---------------|
|    |                        |             |                     | #   | Optional part | #         | Optional part |
| 92 | OEM Code #3            | Prog.       | EEPROM: SERIAL_OEM3 | 30  | X             | 30        | X             |
| 1  | Diagnostic error codes | RAM         |                     | 31  | X             | 31        | X             |
| 93 | OEM Code #4            | Prog.       | EEPROM: SERIAL_OEM4 | 32  | X             | 32        | X             |
| 1  | Diagnostic error codes | RAM         |                     | 33  | X             | NA        |               |
| 94 | OEM Code #5            | Prog.       | EEPROM: SERIAL_OEM5 | 34  | X             | NA        |               |
| 1  | Diagnostic error codes | RAM         |                     | 35  | X             | NA        |               |
| 95 | OEM Code #6            | Prog.       | EEPROM: SERIAL_OEM6 | 36  | X             | NA        |               |
| 1  | Diagnostic error codes | RAM         |                     | 37  | X             | NA        |               |
| 96 | OEM Code #7            | Prog.       | EEPROM: SERIAL_OEM7 | 38  | X             | NA        |               |
| 1  | Diagnostic error codes | RAM         |                     | 39  | X             | NA        |               |
| 97 | OEM Code #8            | Prog.       | EEPROM: SERIAL_OEM8 | 40  | X             | NA        |               |

Table 3 - Serial Message Sequence

The first part (positions 1 to 24) provides the Error Code and the Sensor ID alternatively.

The second part (positions 25 to 40) is optional and enabled with EEPROM bit( EE\_ExtendedSequence=1).. This second part consists of the error code (8 occurrences), and 8 OEM -defined Code

The temperature can be derived from SENT ID 23, TEMP sensor, with the following equation:

$$\text{SENT@ ID 23} = 8 * (T[C] - 35[C]) + 865 \text{ LSB}_{12}$$

The accuracy of the actual Temperature is around  $\pm 10$  Deg.C.

### 14.3.3. Serial message sequence period

| Sequence Length (serial message count) | Sequence Length (frame count) | Sequence Period (ms, typical) |
|----------------------------------------|-------------------------------|-------------------------------|
| 8                                      | 144                           | 127                           |
| 24                                     | 432                           | 381                           |
| 32                                     | 576                           | 509                           |
| 40                                     | 720                           | 636                           |

### Error Code Rate

The Error Code are on purpose transmitted every second message, to maximize the rate, which equals then 36 SENT frames.

#### 14.3.4. Serial Message Error Code

The list of error and status messages transmitted in the 12-bit Enhanced Serial Message data field when Enhance Serial Message ID is \$01 is given in the following Table.

| 12 Bit Data | Diagnostic   | Comments                                            |
|-------------|--------------|-----------------------------------------------------|
| \$000       | No error     |                                                     |
| \$801       | GainOOS      | Front-end Gain code Out-of-spec (too low, too high) |
| \$808       | ADCSatura    | Diag                                                |
| \$810       | ADCMonitor   | ADC monitor                                         |
| \$820       | VanaMoni     | Analog Internal Supply Too Low                      |
| \$840       | VddMoni      | External Supply Too Low                             |
| \$880       | Rough Offset | Front-end Rough Offset too low, too high            |
| \$900       | TempMonitor  | Temperature Sensor monitor                          |

In case multiple errors occur, then the resulting 12 bit enhanced serial message data will be the OR-operation of the individual data values. Example \$809 = GainOOS + ADCsatura

#### 14.4. Start-up

During the chip initialization, the output remains high until the circuit emits four initialization frames (all 6 data nibbles are zero). The fifth frame is not an initialization frame but a valid frame containing a measured angle. See also section 8 “Timing Specification”. The first four frames conform to the SENT specification and include a valid CRC.

#### 14.5. Field sensing (A2D conversions) and the frame Synchro pulse

By default setting of the Timer period and Filter =1, the digital angle (fast channel payload) results of the average of two angles. These angles are themselves computed from 4 ADCs values.

The time between the ADCs and the frame synchronization pulse is constant.

As a result, the phase delay between the magnetic field angle and the SENT synchronization pulse is constant, allowing filtering at the ECU side.

See also section 8 “Timing Specification”

## 15. Description of End-User Programmable Items

### 15.1. Output Transfer Characteristic

To define the transfer function (LNR):

| Parameter                  | Comments                              | Value                                 | Unit            |
|----------------------------|---------------------------------------|---------------------------------------|-----------------|
| CW                         | For all versions                      | 0 : CounterClockWise<br>1 : ClockWise | LSB             |
| DP                         | For all versions                      | 0...359.9999                          | Deg.            |
| CLAMPLOW                   | For all versions                      | 0 ... 100                             | %               |
| CLAMPHIGH                  | For all versions                      | 0 ... 100                             | %               |
| LNRAX, LNRBX, LNRXC        | 3pts LNR only                         | 0 ... 359.9999                        | Deg.            |
| LNRAY, LNRBY, LNRCY        | 3pts LNR only                         | 0 ... 100                             | %               |
| LNR50, LNRAS, LNRBS, LNRCS | 3pts LNR only                         | -17... 0 ... 17                       | %/Deg.          |
| LNR0...LNR16               | 17pts LNR only                        | -50 ...+150                           | %               |
| ANGLEOFSSLOPECOLD          | Thermal Output Offset correction only | 0..255                                | LSB In %/ Deg.C |
| ANGLEOFSSLOPEHOT           | Thermal Output Offset correction only | 0..255                                | LSB In %/ Deg.C |

#### 15.1.1. CLOCKWISE Parameter

The CLOCKWISE parameter defines the magnet rotation direction.

- CCW is defined by the 1-4-5-8 pin order direction for the SOIC-8 package and 1-8-9-16 pin order direction for the TSSOP-16 package.
- CW is defined by the reverse direction: 8-5-4-1 pin order direction for the SOIC-8 and 16-9-8-1 pin order direction for the TSSOP-16 package.

Refer to the drawing in the sensitive spot positioning sections (Section 20.3 and 20.6).

#### 15.1.2. Discontinuity Point (DP or Zero Degree Point)

The Discontinuity Point defines the 0Deg. point on the circle. The discontinuity point places the origin at any location of the trigonometric circle. The DP is used as reference for all the angular measurements.

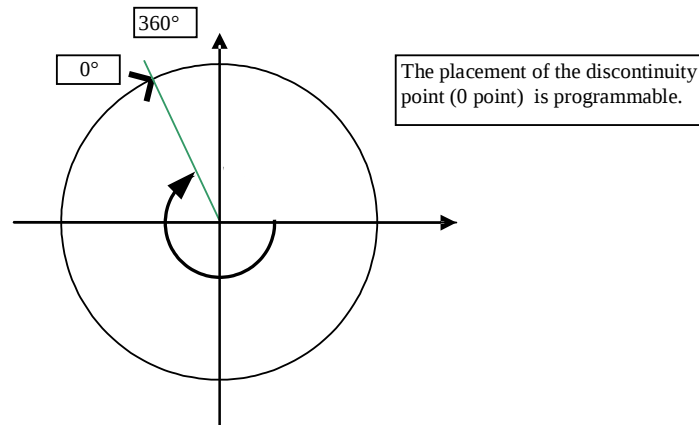


Figure 7 - Discontinuity Point Positioning

### 15.1.3. 3-Pts LNR Parameters (AxU version only)

The LNR parameters, together with the clamping values, fully define the relation (the transfer function) between the digital angle and the output signal.

The shape of the MLX90367 transfer function from the digital angle value to the output voltage is described by the drawing below. Six segments can be programmed but the clamping levels are necessarily flat.

Two, three, or even five calibration points are then available, reducing the overall non-linearity of the IC by almost an order of magnitude each time. Three or five point calibration will be preferred by customers looking for excellent non-linearity figures. Two-point calibrations will be preferred by customers looking for a cheaper calibration set-up and shorter calibration time.

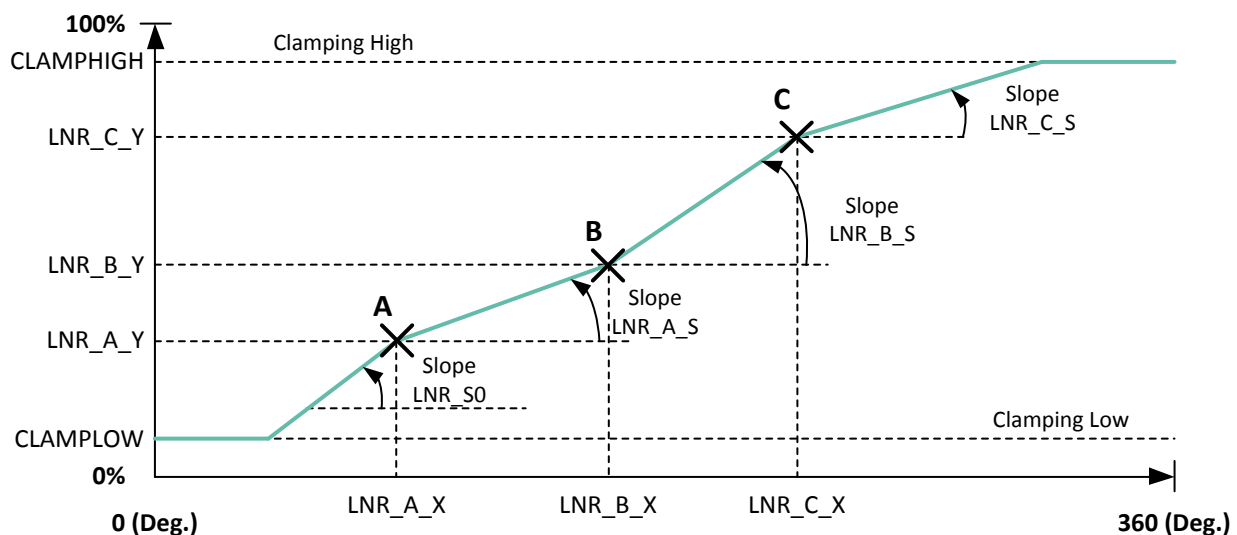


Figure 8 - 3-Pts LNR Parameters

### 15.1.4. 17-Pts LNR Parameters (AxV and AxX versions only)

The LNR parameters, together with the clamping values, fully define the relation (the transfer function) between the digital angle and the output signal.

The shape of the MLX90367 transfer function from the digital angle value to the output voltage is described by the drawing below. In the 17-Pts mode, the output transfer characteristic is Piece-Wise-Linear (PWL).

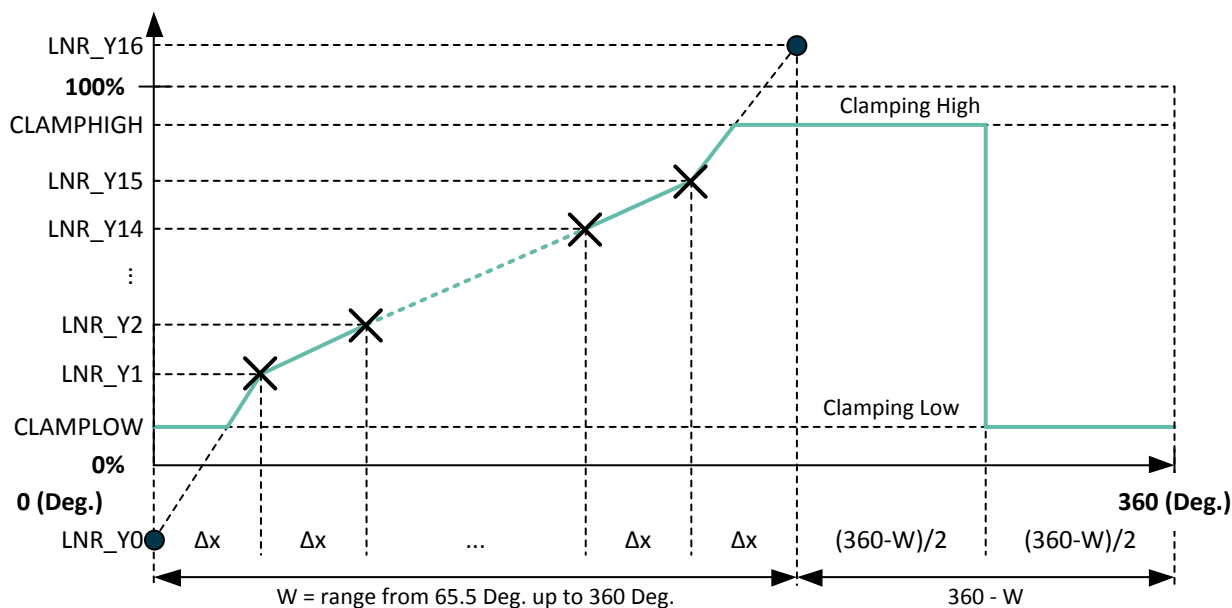


Figure 9 - Input range from 65.5Deg. up to 360Deg.

All the Y-coordinates can be programmed from -50% up to +150% to allow clamping in the middle of one segment (like on the Figure 9), but the output value is limited to CLAMPLOW and CLAMPHIGH values.

Between two consecutive points, the output characteristic is interpolated.

The parameter W determines the input range on which the 17 points (16 segments) are uniformly spread:

| W         | Range     | $\Delta x$ |
|-----------|-----------|------------|
| 0 (0000b) | 360.0Deg. | 22.5Deg.   |
| 1         | 320.0Deg. | 20.0Deg.   |
| 2         | 288.0Deg. | 18.0Deg.   |
| 3         | 261.8Deg. | 16.4Deg.   |
| 4         | 240.0Deg. | 15.0Deg.   |
| 5         | 221.5Deg. | 13.8Deg.   |
| 6         | 205.7Deg. | 12.9Deg.   |
| 7         | 192.0Deg. | 12.0Deg.   |

| W          | Range     | $\Delta x$ |
|------------|-----------|------------|
| 8          | 180.0Deg. | 11.3Deg.   |
| 9          | 144.0Deg. | 9.0Deg.    |
| 10         | 120.0Deg. | 7.5Deg.    |
| 11         | 102.9Deg. | 6.4Deg.    |
| 12         | 90.0Deg.  | 5.6Deg.    |
| 13         | 80.0Deg.  | 5.0Deg.    |
| 14         | 72.0Deg.  | 4.5Deg.    |
| 15 (1111b) | 65.5Deg.  | 4.1Deg.    |

Outside of the selected range, the output will remain in clamping levels.

### 15.1.5. CLAMPING Parameters

The clamping levels are two independent values to limit the output voltage range. The CLAMPLOW parameter adjusts the minimum output voltage level. The CLAMPHIGH parameter sets the maximum output voltage level. Both parameters have 16 bits of adjustment and are available for both LNR modes.

### 15.1.6. Thermal Output Offset correction (AxX version only)

On the AxX version, the two parameters ANGLEOFSSLOPEHOT and ANGLEOFSSLOPECOLD, defined in the section End-User Programmable Parameters, enable adding an offset to the output dependent on the measured temperature (see the Figure 10).

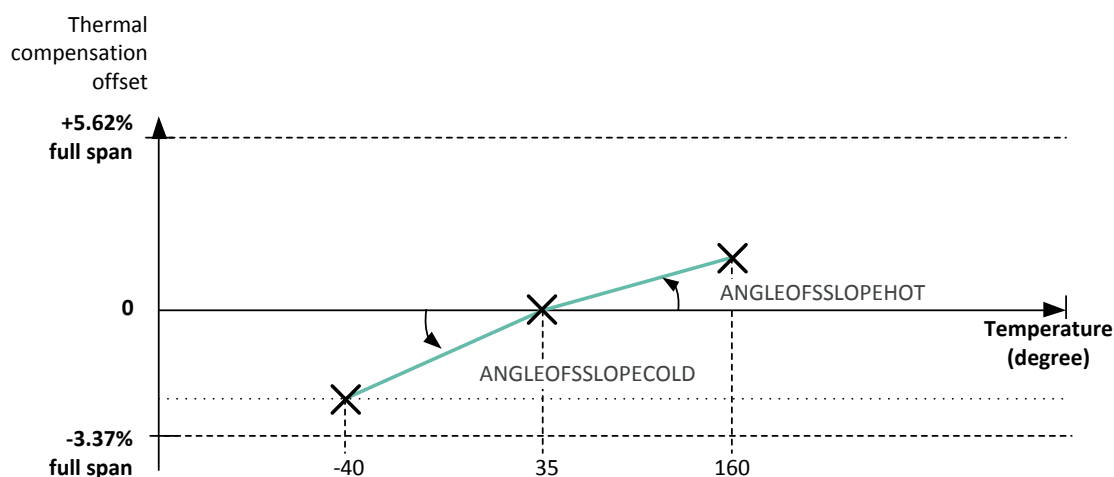


Figure 10 - Input range from -40Deg.C up to 160 Deg.C

The thermal offset is added before the clamping (see section 15.1.5). The span of this offset is +5.62/-3.37% of the full output scale. The added thermal offset varies with temperature see the equation below and the thermal coefficient is defined separately before (used coefficient ANGLEOFSSLOPECOLD) and after 35Deg.C (used coefficient ANGLEOFSSLOPEHOT).

If the temperature is higher than 35 Deg.C then:  $\text{output} \leq \text{output} - \Delta T * \text{ANGLEOFSSLOPEHOT}$

If the temperature is lower than 35 Deg.C then:  $\text{output} \leq \text{output} - \Delta T * \text{ANGLEOFSSLOPECOLD}$

Where output is the calculated output adjusted by the thermal correction offset  $\Delta T * \text{ANGLEOFSSLOPECOLD}$ . Where  $\Delta T$  is the difference between the current temperature and the reference temperature 35Deg.C. The output correction capability at hot and room (extreme temperature and maximum value of ANGLEOFSSLOPEHOT and ANGLEOFSSLOPECOLD) are given in the table below.

| Parameter                                | Min    | Typ    | Max | Unit         |
|------------------------------------------|--------|--------|-----|--------------|
| Output correction capability at 160Deg.C | 5%     | 5.62%  |     | of Full span |
| Output correction capability at -40Deg.C | -3.09% | -3.37% |     | of Full span |

## 15.2. Identification

| Parameter | Comments                 | Value     |
|-----------|--------------------------|-----------|
| USERID1   | For AxU-xxx version only | 0...65535 |
| USERID2   |                          | 0...65535 |
| USERID3   |                          | 0...65535 |

Identification number: 48 bits (3 words) freely useable by Customer for traceability purpose.

## 15.3. Lock

The MEMLOCK write protects all the EEPROM parameters set by the Melexis and user. Once the lock is enabled, it is not possible to change the EEPROM values anymore.

Note that the Memlock bits should be set by the solver function "MemLock".

## 15.4. Sensor Front-End

| Parameter      | Value       |
|----------------|-------------|
| MAPXYZ         | 0 ... 3     |
| SMISM          | 0 ... 32768 |
| k              | 0 ... 32768 |
| SEL_k          | 0 or 1      |
| GAINMIN        | 0 ... 41    |
| GAINMAX        | 0 ... 41    |
| GAINSATURATION | 0 ... 1     |

### 15.4.1. MAPXYZ

The MAPXYZ parameter defines which fields are used to calculate the angle. The different possibilities are described in the tables below.

This 2 bit value selects the first (B1) and second (B2) field components according the table below.

| MAPXYZ  | B1 | B2 | Angular  |
|---------|----|----|----------|
| 0 – 00b | X  | Y  | XY mode  |
| 1 – 01b | Zx | X  | XZx mode |
| 2 – 10b | Y  | Zx | YZx mode |

Note: MAPXYZ = 3 is not recommended.

## 15.4.2. SMISM, k and SEL\_k Parameters

### (i) SMISM

When the mapping (B1=X, B2=Y) is selected, SMISM defines the sensitivity mismatch factor that is applied on B1 or B2; When another B1, B2 mapping is selected, this parameter is “don’t care”.

This parameter is trimmed at factory; Melexis strongly recommends TO NOT overwrite it for optimal performances.

### (ii) K

When the mapping (B1=X, B2=Y) is **NOT** selected, k defines the sensitivity mismatch factor that is applied on B1 or B2 (according to parameter SELK – see below). When the mapping (B1=X, B2=Y) is selected, this parameter is “don’t care”.

This parameter is trimmed at factory for mapping (B1=Z, B2=X). Melexis recommends to fine trim it when a smaller linearity error (Le) is required and a different mapping than (B1=X, B2=Y) is selected.

### (iii) SELK

When the mapping (B1=X, B2=Y) is **NOT** selected, SELK defines the component on which the sensitivity mismatch factor k (see above): SELK = 0 means  $B1 \rightarrow k \cdot B1$  and SELK = 1 means  $B2 \rightarrow k \cdot B2$ .

## 15.4.3. GAINMIN and GAINMAX Parameters

GAINMIN and GAINMAX define the thresholds on the gain code outside which the fault “GAIN out of Spec.” is set.

If GAINSATURATION is set, then the virtual gain code is saturated at GAINMIN and GAINMAX, and no Diagnostic fault is set since the saturations applies before the diagnostic check.

## 15.5. Filter

| Parameter | Value |
|-----------|-------|
| FILTER    | 0...2 |

The MLX90367 features a filter that is enabled when FILTER = 1 or 2. Filter = 0 corresponds to no filtering. 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 filters characteristic is given in the following table:

| Filter              | 0         | 1                       | 2     |
|---------------------|-----------|-------------------------|-------|
| J No                | 0         | 1                       | 3     |
| Type                | Disable   | Finite Impulse Response |       |
| Coefficients ai     | 1         | 11                      | 1111  |
| Title               | No filter | ExtraLight              | Light |
| 99% Response Time   | 1         | 2                       | 4     |
| Efficiency RMS (dB) | 0         | 3.0                     | 6.0   |

## 15.6. Diagnostic Features

It is recommended to enable the diagnostic features for safety critical applications.

Refer to Application\_note\_Diagnostic\_Behavior\_90367 for EE\_CRC\_Enable function description and for Diagnostic features which can be enabled by user.

## 15.7. EEPROM endurance

Although the EEPROM is used for Calibration Data Storage (similarly to an OTPROM), the MLX90367 embedded EEPROM is qualified to guarantee a minimum endurance of 1000 write cycles at 125°C for (engineering/calibration purpose).

## 16. Self Diagnostic

The MLX90367 provides numerous self-diagnostic features. Those features increase the robustness of the IC functionality as it will prevent the IC to provide erroneous output signal in case of internal or external failure modes ("fail-safe").

| Diagnostic Item                                                    | Action                                          | Effect on Outputs                         | Type             | Monitoring Rate                  | Reporting Rate                                                                          |
|--------------------------------------------------------------------|-------------------------------------------------|-------------------------------------------|------------------|----------------------------------|-----------------------------------------------------------------------------------------|
| <b>Start-up phase Diagnostics</b>                                  |                                                 |                                           |                  |                                  |                                                                                         |
| RAM March C-10N Test                                               | Fail-safe mode **<br>** CPU reset after 120ms   | Diagnostic low/ high Reporting (optional) | Digi HW          | n/applicable (start-up only)     | n/applicable (start-up only)                                                            |
| Watchdog BIST                                                      | Fail-safe mode **<br>** CPU reset after 120ms   | Diagnostic low/ high Reporting (optional) | Digi HW          | n/applicable (start-up only)     | n/applicable (start-up only)                                                            |
| Under Voltage Monitoring<br><i>SUPPLYMONI = (MT3VB) OR (MT4VB)</i> | Start-up on Hold **<br>** CPU reset after 120ms | Diagnostic low/high                       | Environ & Analog | n/applicable (start-up only)     | n/applicable (start-up only)                                                            |
| Over Voltage Monitoring<br><i>MT7V</i>                             | PTC entry                                       | Output in High-Impedance                  | Environ          | n/applicable (start-up only)     | n/applicable (start-up only)                                                            |
| <b>Back-Ground Loop Diagnostics</b>                                |                                                 |                                           |                  |                                  |                                                                                         |
| ROM 16bit checksum<br>( continuous )                               | Fail-safe mode **<br>** CPU reset after 120ms   | Diagnostic low//high Reporting (optional) | Digi HW          | 800ms                            | 800ms                                                                                   |
| EEPROM 8 bit CRC Check<br>(continuous)                             | Fail-safe mode **<br>** CPU reset after 120ms   | Diagnostic low/high Reporting (optional)  | Digi HW          | 10ms                             | 10ms                                                                                    |
| Watchdog<br>( continuous )                                         | CPU reset                                       | --                                        | Digi HW          | 120ms                            | n/a                                                                                     |
| <b>DSP Loop Diagnostics</b>                                        |                                                 |                                           |                  |                                  |                                                                                         |
| ADC Clipping<br>ADCCLIP                                            | Debouncing<br>(programmable)                    | SENT Status bit0 = 1<br>(optional)        | Environ & Analog | 5/DSP                            | $\frac{6\text{ms} \times \text{Diag\_Debounce\_Thresh}}{\text{Diag\_Debounce\_Stepup}}$ |
| Virtual Gain Code Out-of-spec<br>GAINOOS                           | Debouncing<br>(programmable)                    | SENT Status bit0 = 1<br>(optional)        | Environ & Analog | 1/DSP                            | $\frac{6\text{ms} \times \text{Diag\_Debounce\_Thresh}}{\text{Diag\_Debounce\_Stepup}}$ |
| Virtual Gain Code Saturation<br>[GAINMIN..GAINMAX]                 | Saturation<br>(optional)                        | Gain Saturated @ GAINMIN-GAINMAX          | Environ & Analog | n/applicable<br>Not a diagnostic | N/A<br>Not a diagnostic                                                                 |

| Diagnostic Item                                                                   | Action                                                                      | Effect on Outputs                                                    | Type               | Monitoring Rate             | Reporting Rate                                                                          |
|-----------------------------------------------------------------------------------|-----------------------------------------------------------------------------|----------------------------------------------------------------------|--------------------|-----------------------------|-----------------------------------------------------------------------------------------|
| ADC Monitor<br>(Analog to Digital Converter)<br><i>ADCMONI</i>                    | Debouncing<br>(programmable)                                                | SENT Status bit0 = 1<br>(optional)                                   | Analog<br>HW       | 1/DSP                       | $\frac{6\text{ms} \times \text{Diag\_Debounce\_Thresh}}{\text{Diag\_Debounce\_Stepup}}$ |
| Under Voltage Monitoring<br><i>SUPPLYMONI = (MT3VB) OR (MT4VB)</i>                | Supply Debouncing<br>(programmable)                                         | SENT Status bit0 = 1<br>(optional)                                   | Environ<br>&Analog | 1/DSP                       | $\frac{6\text{ms} \times \text{Diag\_Debounce\_Thresh}}{\text{Diag\_Debounce\_Stepup}}$ |
| Over Voltage Monitoring<br><i>MT7V</i>                                            | PTC entry after PTC<br>Debouncing                                           | Output in High-Impedance                                             | Environ            | 2ms                         | 2ms                                                                                     |
| Temperature Sensor Monitor<br><i>TEMPMONI</i>                                     | Debouncing<br>(programmable)                                                | SENT Status bit0 = 1<br>(optional)                                   | Analog             | 1/DSP                       | $\frac{6\text{ms} \times \text{Diag\_Debounce\_Thresh}}{\text{Diag\_Debounce\_Stepup}}$ |
| Temperature > 170 Deg.C (± 20)<br>Temperature < - 60 Deg.C (± 20)                 | Saturate value used for the compensations to - 40Deg.C and +150 Deg.C resp. | No effect                                                            | Environ<br>&Analog | N/A<br>Not a diagnostic     | N/A<br>Not a diagnostic                                                                 |
| <b>Hardware Diagnostics ( continuously checked by dedicated Logic )</b>           |                                                                             |                                                                      |                    |                             |                                                                                         |
| Read/Write Access out of physical memory                                          | Fail-safe mode **<br>** CPU reset after 120ms                               | Diagnostic Low/High                                                  | Digi HW            | N/A<br>Immediate Diag       | N/A<br>Immediate diagnostic                                                             |
| Write Access to protected area (IO and RAM Words)                                 | Fail-safe mode **<br>** CPU reset after 120ms                               | Diagnostic low/high                                                  | Digi HW            | N/A<br>Immediate Diag.      | N/A<br>immediate Diagnostic                                                             |
| Unauthorized Mode Entry                                                           | Fail-safe mode **<br>** CPU reset after 120ms                               | Diagnostic low/high                                                  | Digi HW            | N/A<br>Immediate diagnostic | N/A<br>Immediate diagnostic                                                             |
| EEPROM Error Correcting Code ( Hamming correction )                               | (Transparent) Error Correction                                              | No effect                                                            | Digi HW            | N/A                         | N/A                                                                                     |
| <b>Hardware Diagnostics ( continuously checked by dedicated Analog circuits )</b> |                                                                             |                                                                      |                    |                             |                                                                                         |
| Broken VSS                                                                        | CPU Reset on recovery                                                       | Pull down load => Diagnostic High<br>Pull up load => Diagnostic High | Environ            | N/A<br>Immediate diagnostic | N/A<br>Immediate diagnostic                                                             |
| Broken VDD                                                                        | CPU Reset on recovery                                                       | Pull down load => Diagnostic Low<br>Pull up load => Diagnostic Low   | Environ            | N/A<br>Immediate diagnostic | N/A<br>Immediate diagnostic                                                             |
| Resistive Cable Test                                                              | Start-up on Hold                                                            | Diagnostic low/high                                                  | Environ            | N/A<br>Immediate diagnostic | N/A<br>Immediate diagnostic                                                             |

# 17. Recommended Application Diagrams

## 17.1. MLX90367 in SOIC-8 Package

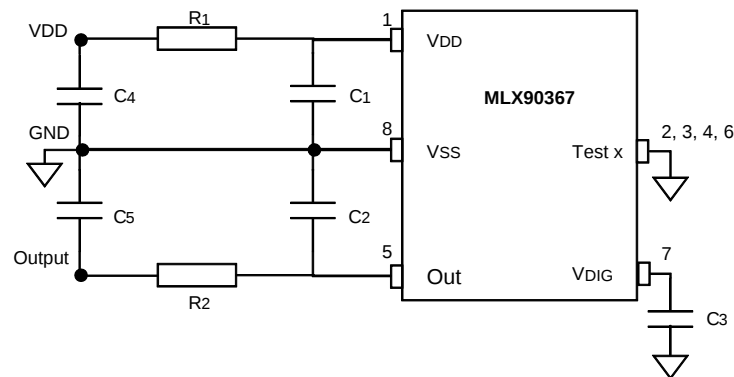


Figure 11 - Recommended wiring for the MLX90367 in SOIC-8 package

| Output | Compact PCB routing |        |        | EMC robust PCB routing |        |        | Remarks                        |
|--------|---------------------|--------|--------|------------------------|--------|--------|--------------------------------|
| SENT   | Min                 | Typ.   | Max    | Min                    | Typ.   | Max    |                                |
| C1     | 100 nF              | 100 nF | 1 uF   | 47 nF                  | 100 nF | 1 uF   | Close to the pin               |
| C2     | 2.2 nF              | 4.7 nF | 22 nF  | 2.2 nF                 | 4.7 nF | 22 nF  | Close to the pin               |
| C3     | 47 nF               | 100 nF | 220 nF | 47 nF                  | 100 nF | 220 nF | Close to the pin               |
| C4     | -                   | -      | -      | 500 pF                 | 1 nF   | 10 nF  | Connector Side                 |
| C5     | -                   | -      | -      | 500 pF                 | 1 nF   | 2.2 nF | Connector Side                 |
| R1     | -                   | -      | -      | 0 Ω                    | 10 Ω   | 33 Ω   | Impacts the Voltage on VDD pin |
| R2     | -                   | -      | -      | 10 Ω                   | 50 Ω   | 100 Ω  |                                |

## 17.2. MLX90367 in TSSOP-16 Package

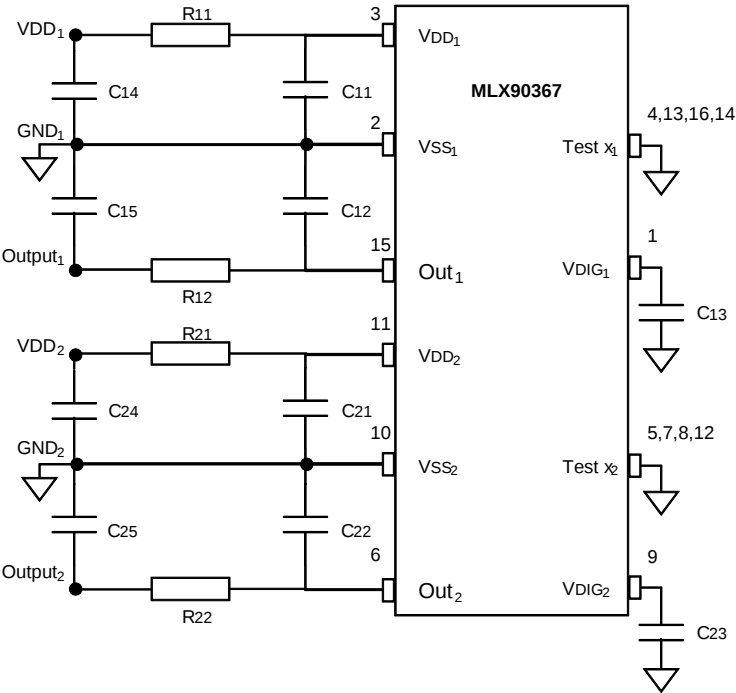


Figure 12 – Recommended wiring for the MLX90367 in TSSOP-16 package

| Output      | Compact PCB routing |        |        | EMC robust PCB routing |        |        | Remarks                        |
|-------------|---------------------|--------|--------|------------------------|--------|--------|--------------------------------|
| SENT Output | Min                 | Typ.   | Max    | Min                    | Typ.   | Max    |                                |
| C11, C21    | 100 nF              | 100 nF | 1 uF   | 47 nF                  | 100 nF | 1 uF   | Close to the pin               |
| C12, C22    | 2.2 nF              | 4.7 nF | 22 nF  | 2.2 nF                 | 4.7 nF | 22 nF  | Close to the pin               |
| C13, C23    | 47 nF               | 100 nF | 220 nF | 47 nF                  | 100 nF | 220 nF | Close to the pin               |
| C14, C24    | -                   | -      | -      | 500 pF                 | 1 nF   | 10 nF  | Connector Side                 |
| C15, C25    | -                   | -      | -      | 500 pF                 | 1 nF   | 2.2 nF | Connector Side                 |
| R11, R21    | -                   | -      | -      | 0 Ω                    | 10 Ω   | 33 Ω   | Impacts the Voltage on VDD pin |
| R12, R22    | -                   | -      | -      | 10 Ω                   | 50 Ω   | 100 Ω  |                                |

## 18. 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 standards in place in Semiconductor industry.

For further details about test method references and for compliance verification of selected soldering method for product integration, Melexis recommends reviewing on our web site the General Guidelines soldering recommendation (<http://www.melexis.com/en/quality-environment/soldering>).

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

For package technology embedding trim and form post-delivery capability, Melexis recommends consulting the dedicated trim&forming recommendation application note: lead trimming and forming recommendations (<http://www.melexis.com/en/documents/documentation/application-notes/lead-trimming-and-forming-recommendations>).

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/en/quality-environment>.

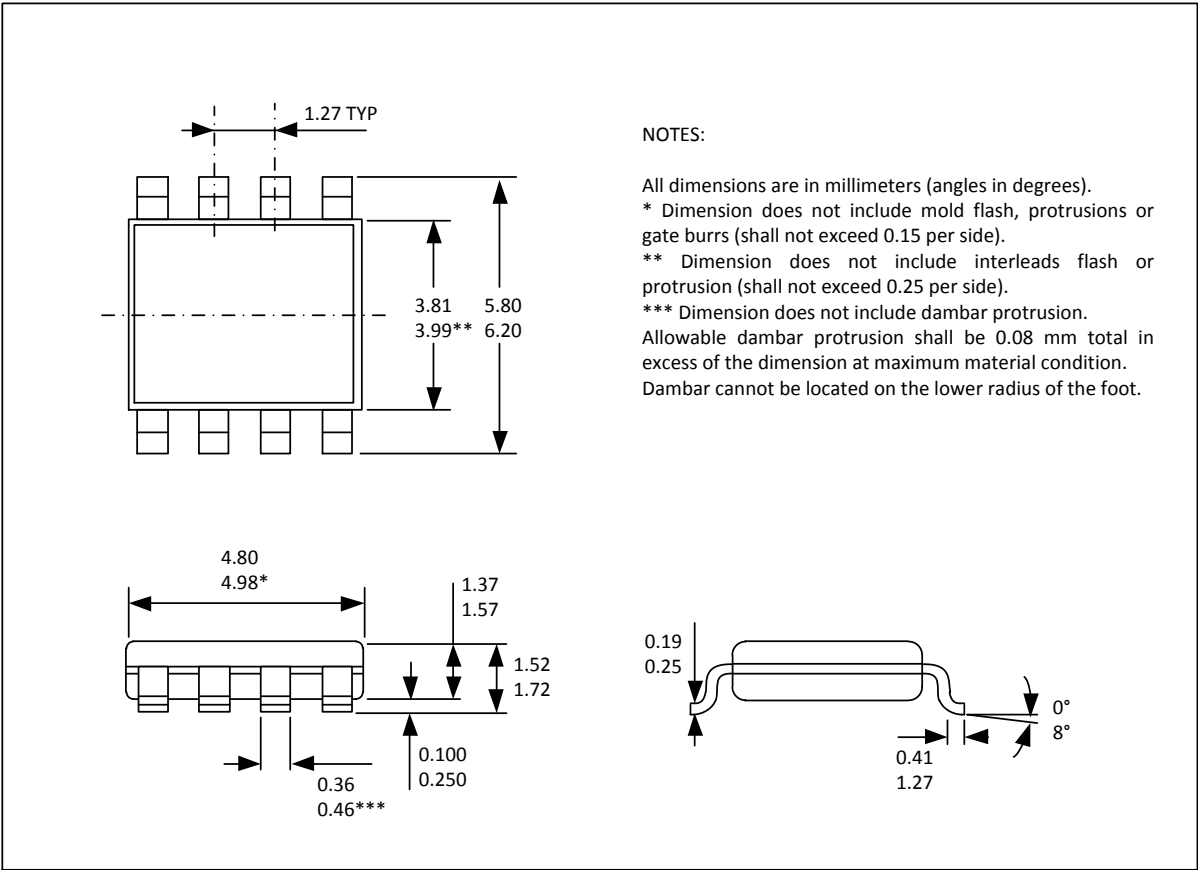
## 19. ESD Precautions

Electronic semiconductor products are sensitive to Electro Static Discharge (ESD).

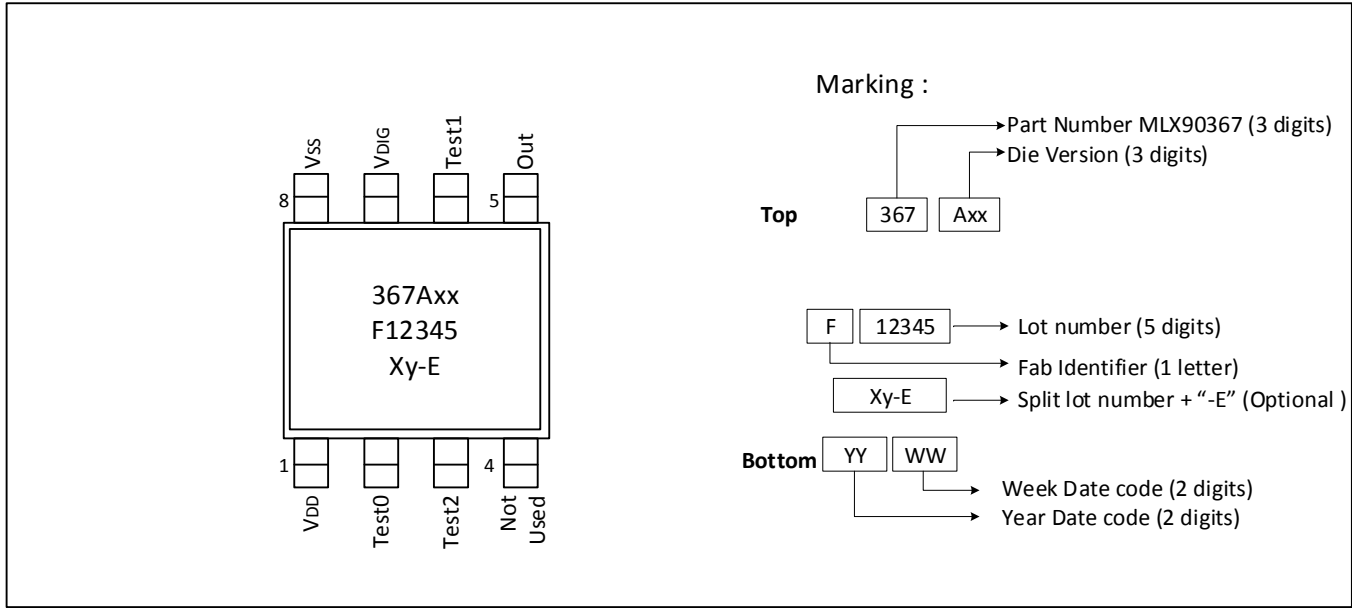
Always observe Electro Static Discharge control procedures whenever handling semiconductor products.

# 20. Package Information

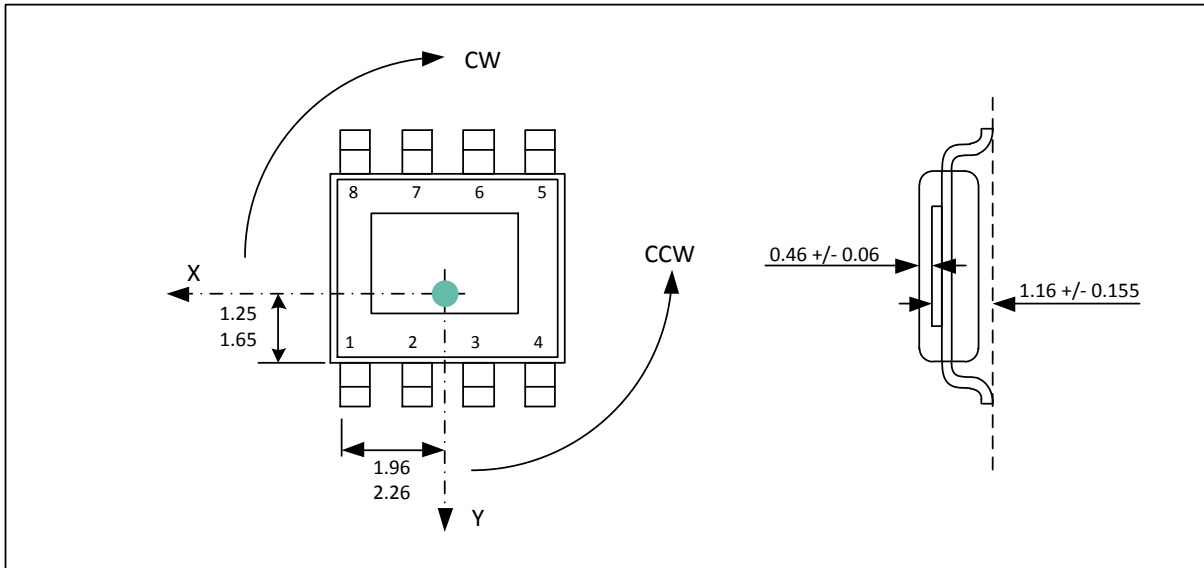
## 20.1. SOIC-8 - Package Dimensions

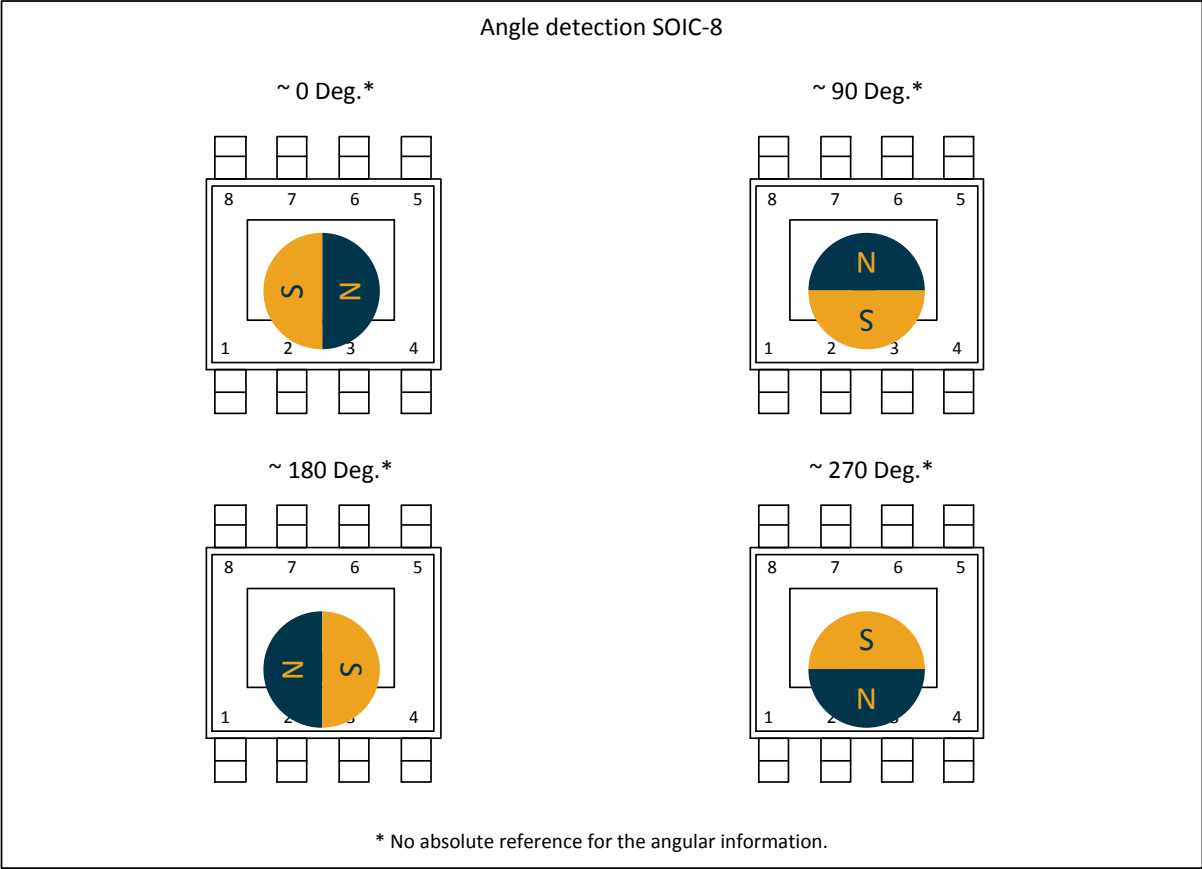


## 20.2. SOIC-8 - Pinout and Marking



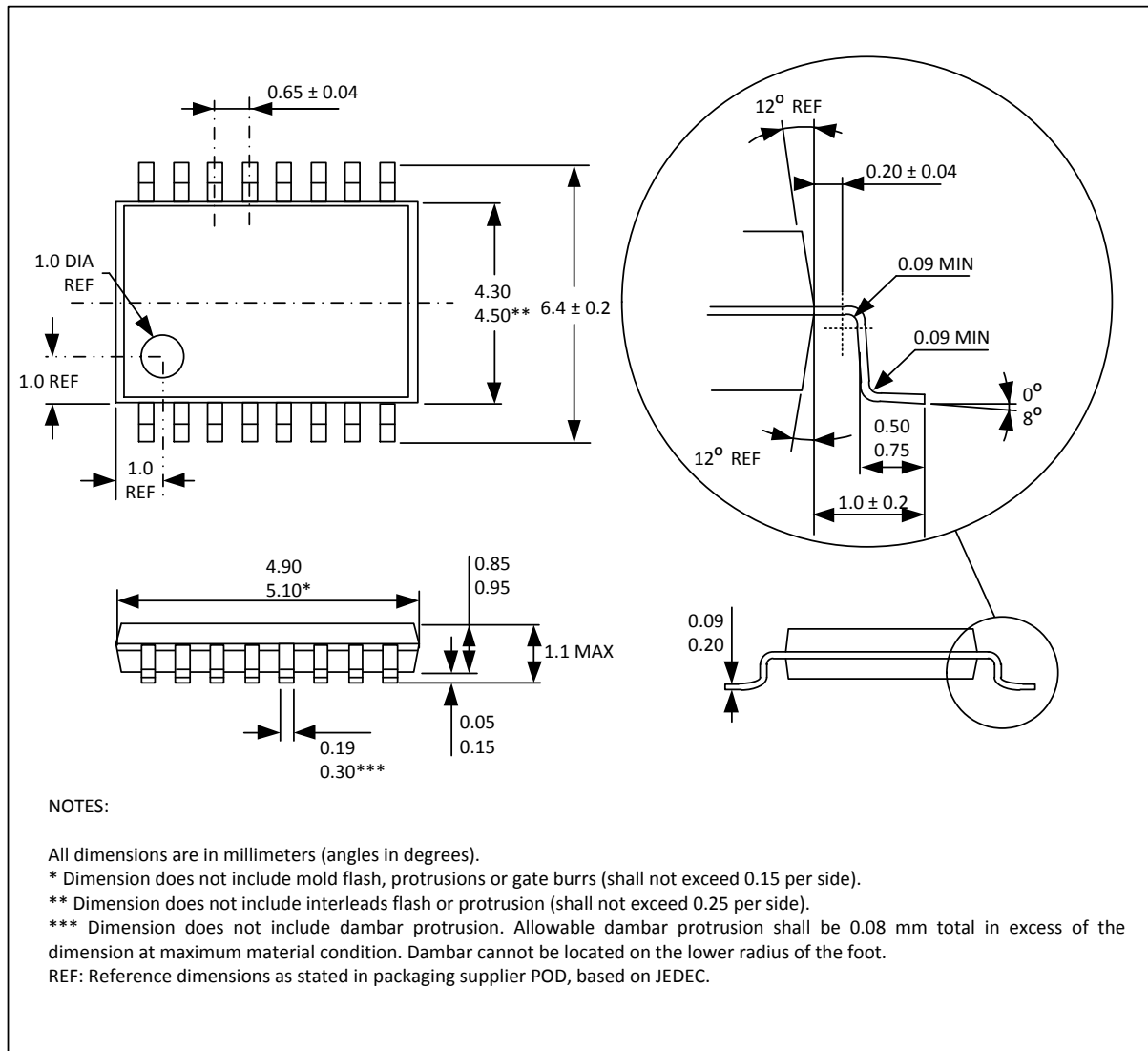
## 20.3. SOIC-8 - Sensitive spot positioning



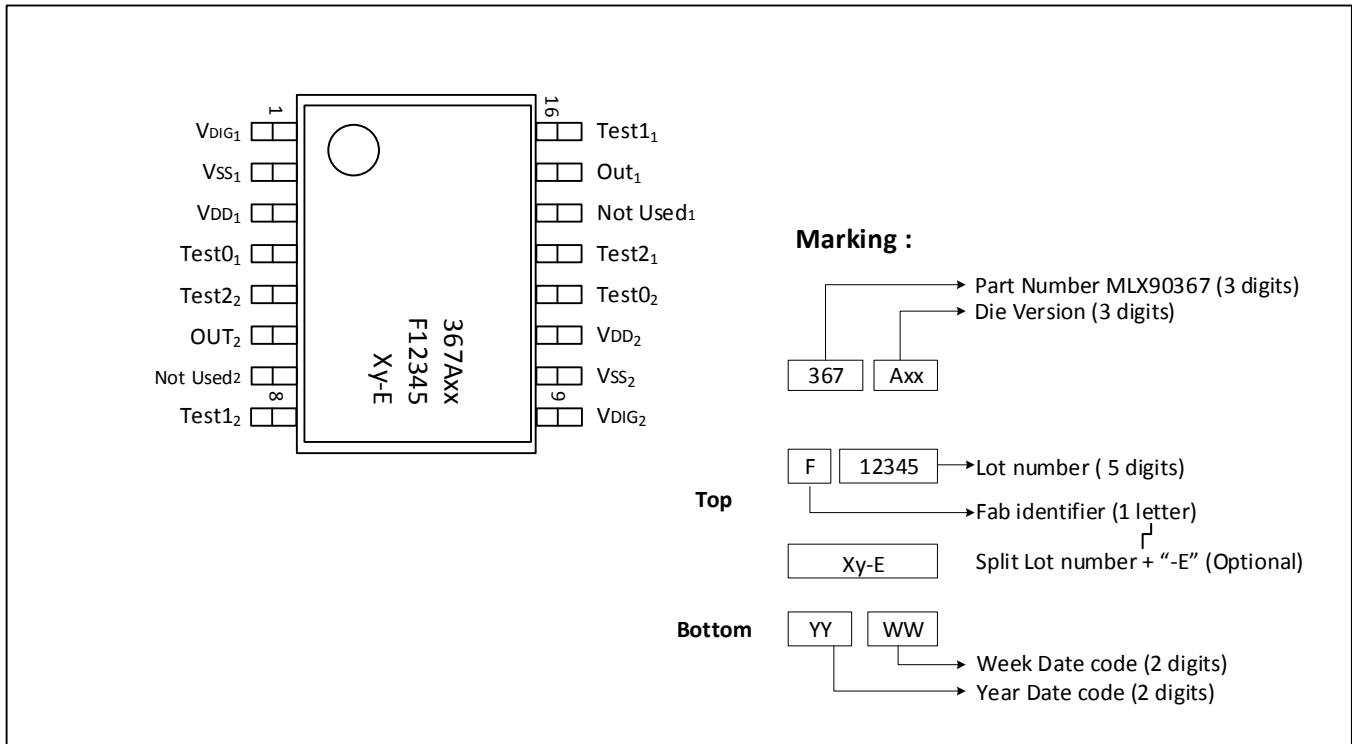


The MLX90367 is an absolute angular position sensor but the linearity error (Le – See section 9) does not include the error linked to the absolute reference 0 Deg.

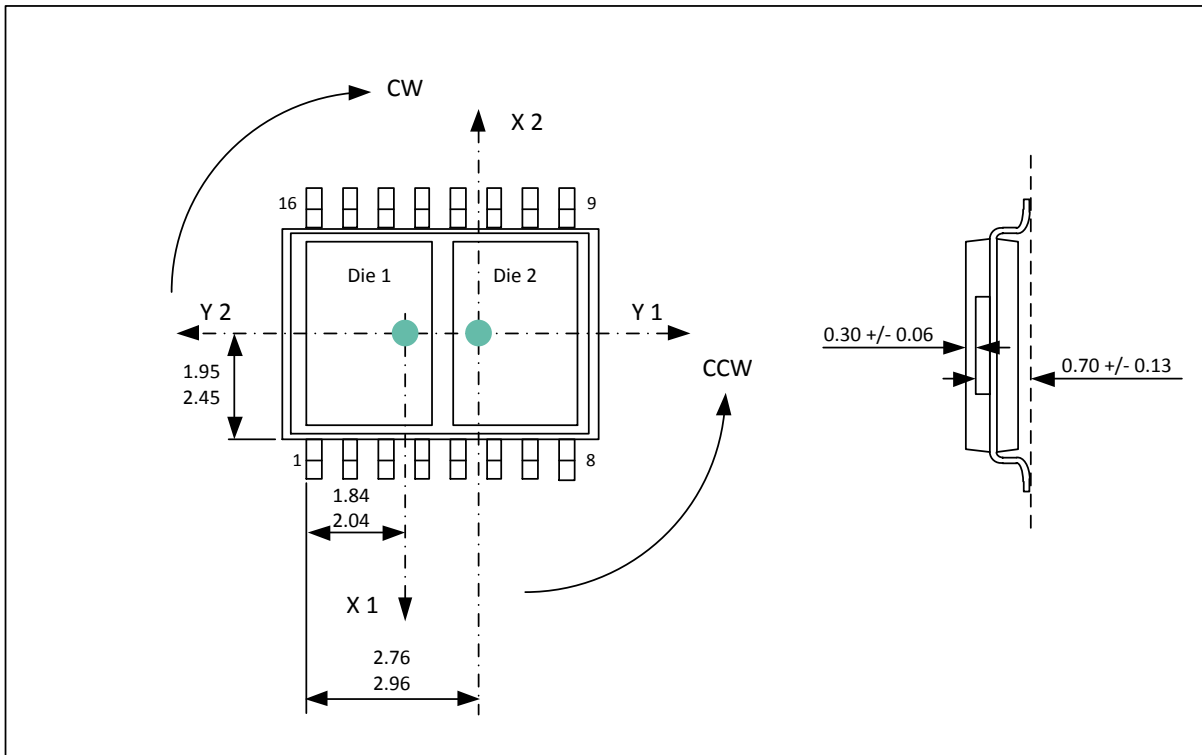
## 20.4. TSSOP-16 - Package Dimensions

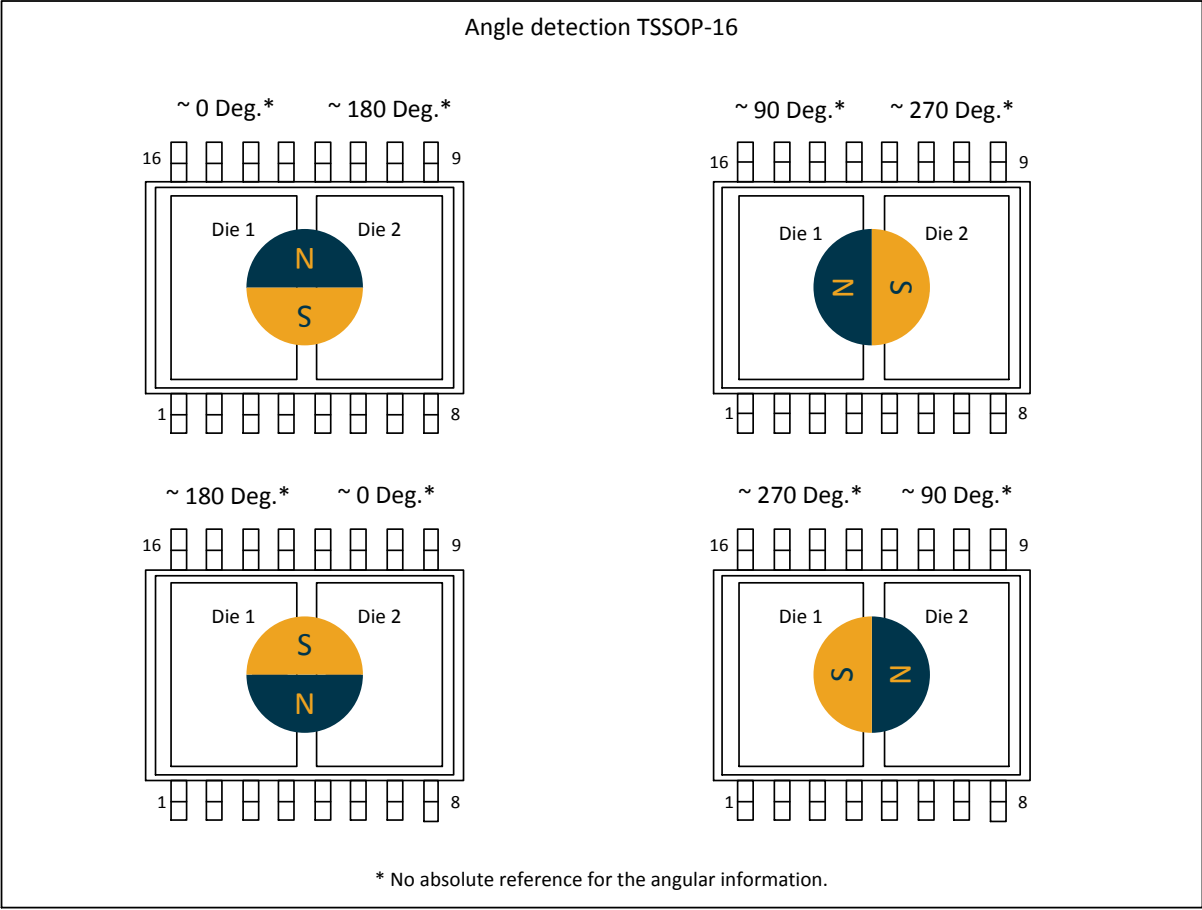


## 20.5. TSSOP-16 - Pinout and Marking



## 20.6. TSSOP-16 - Sensitive spot positioning





The MLX90367 is an absolute angular position sensor but the linearity error (Le – See section 9) does not include the error linked to the absolute reference 0 Deg.

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