## Features and Benefits

- 16-bit Digital Output for magnetic and temperature data
- Individually selectable magnetic axes
- Three Wake-up on change / Interrupt modes
- Data Ready output for µC synchronization
- Built-in chip temperature compensation
- Runtime selectable modes (on-the-fly)
- Three user selectable configurations (Low Current, Low Noise, High Range)
- Two selectable I²C slave addresses in one device
- Integrated configurable digital filter
- Average consumption of 3µA for X or Y and 4.3µA for Z at 10Hz in single measurement mode
- Average consumption of 10µA for X, Y and Z at 10Hz in single measurement mode
- Power Down mode 0.7µA
- Magnetic Ranges ±5mT (0.15µT/LSB) and ±50mT[1] (1.5µT/LSB)
- Wide supply voltage from 1.7V to 3.6V
- I²C compatible with 0.1MHz, 0.4MHz & 1.0MHz
- Ambient temperature range from -40°C to 105°C
- UTDFN-6 (LD) package: RoHS, Green and Halogen free compliant (2mm x 1.5mm x 0.4mm)

## Application Examples

- PC peripheral – Mouse roller
- Gaming – Joystick, D-pads & Trigger buttons
- Wearables – Smart watch digital crown & bezel
- Battery powered tools – Hairdryer & drill trigger
- White goods – Smart knob & liquid levels
- Industrial – Linear & pneumatic actuators
- Smart home – HMI thermostat & electronic lock
- Home security – Door/window opening detection

## Description

MLX90394 is a 3-axis magnetometer suitable for a myriad of position sensors applications using Triaxis® Hall Technology. The device, especially designed for micropower applications, measures magnetic fields along the 3-axis (X, Y & Z). Those measurements and the IC temperature are converted into 16-bit words which are transferred over an I²C communication channel. Measurements can be made upon request or continuously with selectable refresh rates.

MLX90394 offers superb noise performance despite its small 6-pin package. It does all that while keeping current consumption low for multiple settings and configurations.

MLX90394's wake-up modes allow the user to put their entire system in deep sleep, until the IC detects a magnetic field change on the selected axes either versus an initial measurement (Static Delta), or previous measurement (Dynamic Delta), or a predefined absolute threshold (Absolute). In this way both busy as well as slowly drifting magnetic fields can be registered, while the device automatically toggles between active and sleep mode.

The MLX90394 has synchronization options through an interrupt pin and 2x I²C addresses (per device) by clever wiring. Furthermore, its available in 2 versions, to offer more variety in I²C address options. In total 4x pre-programmed MLX90394 can be placed on a single I²C bus.

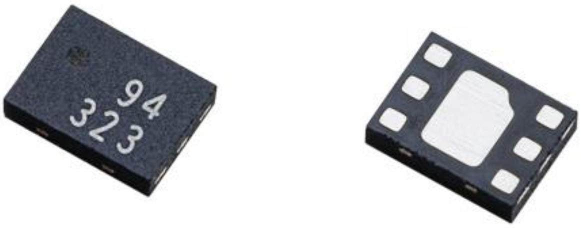

*Figure 1 UTDFN-6*

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[1] ±200mT in Z direction available on specific request

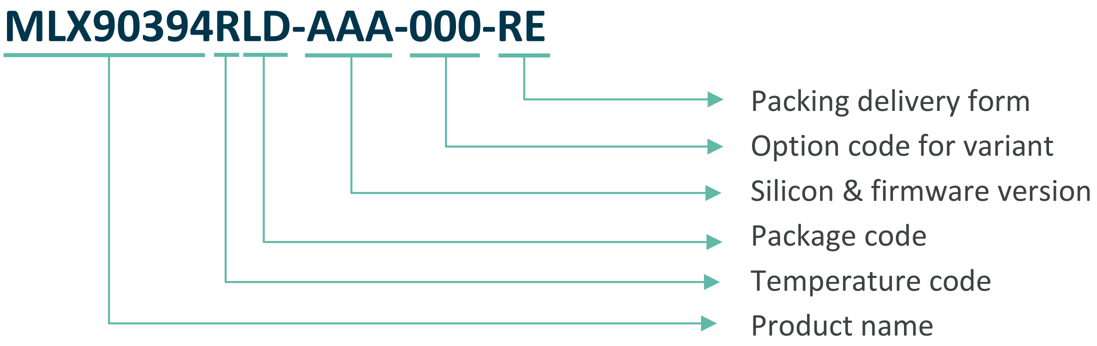
# Contents

# 1. Ordering information

| Ordering Code | Temperature | Package | Range | Output | Packing |
|---|---|---|---|---|---|
| MLX90394RLD-AAA-000-RE | -40°C to 105°C | UTDFN-6 1.5x2 | ±5mT, ±50mT | $I^2C$ (0x10 / 0x11) | Reel |
| MLX90394RLD-AAA-001-RE | -40°C to 105°C | UTDFN-6 1.5x2 | ±5mT, ±50mT | $I^2C$ (0x60 / 0x61) | Reel |

*Table 1 – Ordering codes*

***Legend:***



# 2. Glossary of terms

| Term | Description |
|---|---|
| NC | Not Connected |
| ADC | Analog-to-digital converter |
| LSB | Least significant bit |
| MSB | Most significant bit |
| Gauss (G) | Units for magnetic flux density – 1mT = 10G |
| RMS | Root mean square |
| POR | Power On reset |
| NV | Non-volatile |
| DSP | Digital signal processing |
| WOC | Wake-up On Change |

# 3. Pins Description and Block diagram

## 3.1. Pins description

| Pin # | Pin Name | Pin Description | Function |
|---|---|---|---|
| 1 | SDA | Digital Input/Output | $I^2C$ Bus Data Input/Output, WOC Interrupt Output, Synchronization Output |
| 2 | SCL | Digital Input / Output | $I^2C$ Bus Clock |
| 3 | Not used | Ground | Sense GND internally connected to pin #4 through the die pad[2] |
| 4 | GND | Ground | Ground |
| 5 | VDD | Supply | Supply |
| 6 | INTB | Digital Input/Output | $I^2C$ Bus Data Input/Output, WOC Interrupt Output, Synchronization Output |

*Table 2 – Pin description*

## 3.2. Block Diagram

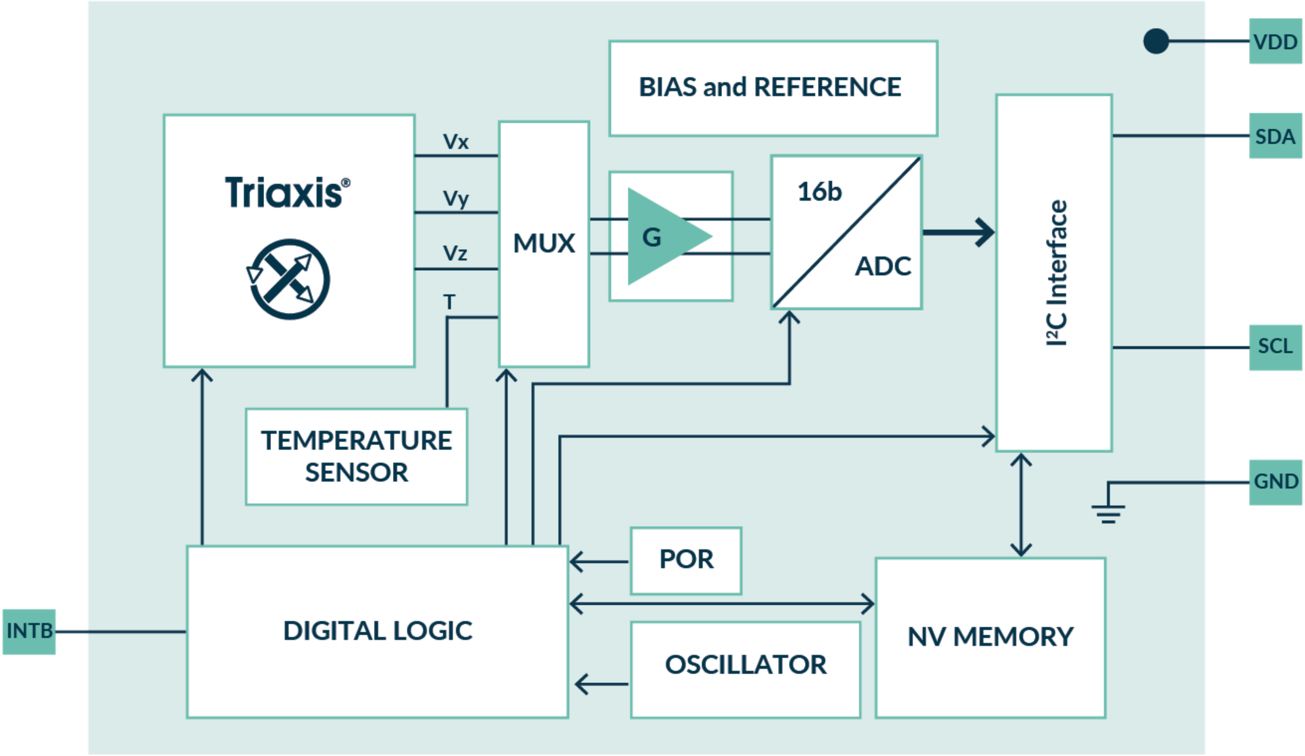


*Figure 2: IC block diagram*

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[2] This pin has to be treated as having GND potential and must be either left floating or connected to pin #4

# 4. Conditions and Specifications

## 4.1. Absolute Maximum Ratings (AMR)

| Parameter | Symbol | Min. | Typ. | Max. | Unit | Conditions |
|---|---|---|---|---|---|---|
| Supply Voltage | $V_{DD}$ | -0.3 | - | 4 | V | Room temp, <48h |
| Output voltage | $V_{SDA}$, $V_{SCL}$, $V_{INTB}$ | -0.3 | - | 4 | V | Room temp, <48h |
| ESD HBM (all pins) | | -2 | - | 2 | kV | AEC-Q100-002 |
| ESD CDM (all pins) | | -500 | - | 500 | V | AEC-Q100-011 |
| Junction Temperature | $T_{JUNC}$ | - | - | 125 | °C | |

*Table 3– Absolute Maximum Ratings*

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

## 4.2. Operating Conditions

### 4.2.1. General Operating Conditions

| Parameter | Symbol | Min. | Typ. | Max. | Unit | Conditions |
|---|---|---|---|---|---|---|
| Operating Temperature | $T_A$ | -40 | | 105 | °C | |
| Storage Temperature | $T_{storage}$ | -40 | | 150 | °C | |

*Table 4 – General operating conditions*

### 4.2.2. Electrical Operating Conditions

| Parameter | Symbol | Min. | Typ. | Max. | Unit | Conditions |
|---|---|---|---|---|---|---|
| Supply Voltage | VDD | 1.7 | - | 3.6 | V | |

*Table 5 – Electrical Operating conditions*

### 4.2.3. Thermal Characteristics

| Parameter | Symbol | Typ. | Unit | Conditions |
|---|---|---|---|---|
| Thermal resistance | $R_{thja}$ | 230 | K/W | Junction to ambient 1s0p board |
| | | 40 | K/W | Junction to ambient multi layered pcb |
| Thermal resistance | $R_{thjc}$ | 3.4 | K/W | Junction to case |

*Table 6 – Thermal Characteristics*

### 4.2.4. Magnetic Operating Conditions[3]

| Parameter | Symbol | Min. | Typ. | Max. | Unit | Conditions |
|---|---|---|---|---|---|---|
| Magnetic Flux density | $B_Z$ | -50 | - | 50 | mT | |
| Magnetic Flux density[4] | $B_{XY}$ | -50 | - | 50 | mT | $B_{XY} = \sqrt{B_X^2 + B_Y^2}$ |
| Magnetic Flux density | $B_Z$ | -5 | - | 5 | mT | |
| Magnetic Flux density[5] | $B_{XY}$ | -5 | - | 5 | mT | $B_{XY} = \sqrt{B_X^2 + B_Y^2}$ |

*Table 7 – Magnetic Operating conditions*

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[3] In case higher fields are required for Z axis (up to 200mT), it is possible to factory program the range accordingly.

[4] The vector sum of X and Y magnetic flux densities should not exceed ±50mT, CONFIG=0,1

[5] The vector sum of X and Y magnetic flux densities should not exceed ±5mT, CONFIG=2

## 4.3. Electrical Specifications

Operating Conditions, $V_{DD}$=1.7V to 3.6V, $T_A$ = -40°C to 105°C (unless otherwise specified)

| Parameter | Symbol | Min. | Typ.[6] | Max. | Unit | Conditions |
|---|---|---|---|---|---|---|
| Power On Reset (rising edge) | $V_{POR\_LH}$ | 1.44 | 1.5 | 1.6 | V | |
| Power On Reset (falling edge) | $V_{POR\_HL}$ | 1.35 | 1.4 | 1.45 | V | |
| Magnetic axes conversion current | $I_{DD,CONVXY0}$ | - | 2 | 2.9 | mA | XY axis CONFIG=0 |
| | $I_{DD,CONVZ0}$ | - | 3 | 4.5 | mA | Z axis CONFIG=0 |
| | $I_{DD,CONVXY12}$ | - | 2.9 | 3.8 | mA | XY axis CONFIG=1,2 |
| | $I_{DD,CONVZ12}$ | - | 3.9 | 5.3 | mA | Z axis CONFIG=1,2 |
| Temperature conversion current | $I_{DD,CONVT}$ | - | 0.89 | 1.1 | mA | |
| Counting state current | $I_{DD,CNT}$ | - | 9.5 | 15 | µA | |
| Digital Signal Processing Current | $I_{DD,DSP}$ | | 450 | 610 | µA | T_EN=0 |
| | | - | 500 | 660 | | T_EN=1 |
| Power Down current | $I_{DD,PD}$ | - | 0.7 | 2.5 | µA | |
| Average current consumption at 15Hz refresh rate[7] | $I_{DD,AVG1}$ | - | 29 | 40 | µA | OSR_HALL=0 |
| | | - | 43 | 60 | µA | OSR_HALL=1 |
| | | | | | | CONFIG=0 |
| Average current consumption at 15Hz polling rate[8] | $I_{DD,AVG2}$ | - | 15 | 23 | µA | OSR_HALL=0 |
| | | - | 29 | 40 | µA | OSR_HALL=1 |
| | | | | | | CONFIG=0 |
| Average current consumption at 100Hz refresh rate[7] | $I_{DD,AVG3}$ | - | 142 | 200 | µA | OSR_HALL=0 |
| | | - | 238 | 320 | µA | OSR_HALL=1 |
| | | | | | | CONFIG=0 |
| Average current consumption at 100Hz refresh rate[7] | $I_{DD,AVG4}$ | - | 175 | 230 | µA | OSR_HALL=0 |
| | | - | 300 | 400 | µA | OSR_HALL=1 |
| | | | | | | CONFIG=1,2 |
| Average current consumption at 10Hz polling rate[8] | $I_{DD,AVG5}$ | - | 10 | 15 | µA | OSR_HALL=0 |
| | | - | 19 | 27 | µA | OSR_HALL=1 |
| | | | | | | CONFIG=0 |
| Average current consumption at 10Hz polling rate[9] | $I_{DD,AVG6}$ | - | 3 | 6 | µA | OSR_HALL=0<br>CONFIG=0 |
| Average current consumption at 10Hz polling rate[10] | $I_{DD,AVG7}$ | - | 4.3 | 7.8 | µA | OSR_HALL=0<br>CONFIG=0 |

*Table 8 Electrical specification*

The average current consumption in Continuous measurement mode can be calculated using the following formula:

$$IDD = \frac{T_{Temp} \cdot I_{DD,CONVT} + 2 \cdot T_{XY} \cdot I_{DD,CONVXY} + T_Z \cdot I_{DD,CONVZ} + T_{DSP} \cdot IDD_{DSP} + T_{Counting} \cdot IDD,CNT}{T_{refresh}}$$

Where $T_{Temp}$, $T_{XY}$ and $T_Z$ are controlled by DIG_FILT_HALL_XY, DIG_FILT_HALL_Z, DIG_FILT_TEMP, OSR_TEMP, OSR_HALL and T_EN. $T_{DSP}$ can be set according to the timing specification in *Table 13*. $T_{Counting}$ is defined as

$$T_{Counting} = T_{refresh} - \left(T_{Temp} + 2 \cdot T_{XY} + T_Z + T_{DSP}\right)$$

In case an axis is not selected for conversion, its respective measurement time is set to 0s. In case the temperature measurement is not enabled (T_EN=0), then $T_{Temp}$ is set to 0s. $T_{refresh}$ is the refresh period set by the user.

---

[6] VDD=2.2V, $T_A$=35°C

[7] Refresh rate in Continuous measurement mode XYZT, DIG_FILT_HALL_XY=0, DIG_FILT_HALL_Z=1, DIG_FILT_TEMP=1, OSR_TEMP=1, T_EN=1

[8] Polling rate in Single measurement mode XYZ, DIG_FILT_HALL_XY=0, DIG_FILT_HALL_Z=1, T_EN=0

[9] Polling rate in Single measurement mode X or Y, DIG_FILT_HALL_XY=0, T_EN=0

[10] Polling rate in Single measurement mode Z, DIG_FILT_HALL_Z=0, T_EN=0

| Parameter | Symbol | Min. | Typ. | Max. | Unit | Conditions |
|---|---|---|---|---|---|---|
| Temperature sensor resolution[11] | TRES | - | 50 | - | LSB16/°C | |
| Temperature sensor accuracy | TLIN | -3 | - | 3 | °C | +/-3sigma with respect to 35°C |

*Table 9 Temperature sensor specification*

| Parameter[12] | Symbol | Min. | Typ. | Max. | Unit | Conditions |
|---|---|---|---|---|---|---|
| Input Level High | VIH | 53 | 65 | 71 | %VDD | SDA (INTB), SCL |
| Input Level Low | VIL | 37 | 49 | 54 | %VDD | SDA (INTB), SCL |
| Input Level Hysteresis | VIHYST | 9 | 16 | 21 | %VDD | SDA (INTB), SCL |
| Output on resistance | Rdson | -<br>- | 7.6<br>4 | 15<br>7 | Ω | SCL<br>SDA (INTB)<br>+/-3sigma |
| Output leakage current | | - | - | 0.1 | µA | SCL, SDA, INTB |

*Table 10 I²C DC Characteristics*

| Parameter | Symbol | Min. | Typ. | Max. | Unit | Conditions |
|---|---|---|---|---|---|---|
| SDA pull up resistance | $R_{SDA}$ | 1 | - | - | kΩ | When not using SDA pin |
| INTB pull up resistance | $R_{INTB}$ | 1 | - | - | kΩ | When not using INTB pin |

*Table 11 I²C bus and external connection requirements*

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[11] The data format is 2's complement with 0 LSB corresponding to 0degC

[12] This specification refers to the sensor and not to the I2C bus

## 4.4. Magnetic Specifications

Operating Conditions, $V_{DD}$=1.7V to 3.6V, $T_A$ = -40°C to 105°C, (T)XYZ measurement (unless otherwise specified). All specifications in this chapter are given with +/- 3 sigma.

| Parameter | Symbol | Min. | Typ. | Max. | Unit | Conditions |
|---|---|---|---|---|---|---|
| Magnetic sensor measurement range | $B_{RANGE}$ | ±43.6 | ±49.13 | ±54.7 | mT | room temperature CONFIG=0,1 |
| Magnetic sensor measurement range | $B_{RANGE}$ | ±4.36 | ±4.91 | ±5.47 | mT | room temperature CONFIG=2 |
| Resolution(13) | | - | 16 | - | bits | XYZT |
| Magnetic sensitivity | $SENS_{XYZ}$ | 1.33 | 1.5 | 1.67 | µT/LSB | room temperature, CONFIG=0,1 |
| Magnetic sensitivity | $SENS_{XYZ}$ | 0.133 | 0.15 | 0.167 | µT/LSB | room temperature, CONFIG=2 |
| Sensitivity thermal drift | $SENS_{THD}$ | -8 | - | 8 | % | vs. Ta=35°C |
| Offset [14] | $B_{OFFSX}$ | -550 | - | 550 | µT | |
| | $B_{OFFSY}$ | -550 | - | 550 | | |
| | $B_{OFFSZ}$ | -260 | - | 260 | | |
| Offset thermal drift X-axis[12] | | -100 | - | 100 | µT | vs. 35°C |
| Offset thermal drift Y-axis | | -100 | - | 100 | | |
| Offset thermal drift Z-axis | | -100 | - | 100 | | |
| RMS Noise[15] | $N_X$,$N_Y$,$N_Z$ | - | 40 | - | µTrms | OSR_HALL=0, CONFIG=0 |
| RMS Noise[15] | $N_X$,$N_Y$,$N_Z$ | - | 28 | - | µTrms | OSR_HALL=1, CONFIG=0 |
| RMS Noise[15] | $N_X$,$N_Y$,$N_Z$ | - | 11 | - | µTrms | OSR_HALL=0, CONFIG=1 |
| RMS Noise[15] | $N_X$,$N_Y$,$N_Z$ | - | 6.5 | - | µTrms | OSR_HALL=1, CONFIG=1 |
| RMS Noise[15] | $N_X$,$N_Y$,$N_Z$ | - | 5.1 | - | µTrms | OSR_HALL=0, CONFIG=2 |
| RMS Noise[15] | $N_X$,$N_Y$,$N_Z$ | - | 3.5 | - | µTrms | OSR_HALL=1, CONFIG=2 |
| RMS Noise[16] | $N_X$,$N_Y$,$N_Z$ | - | 0.7 | - | µTrms | OSR_HALL=0, CONFIG=2 |
| RMS Noise[16] | $N_X$,$N_Y$,$N_Z$ | - | 0.5 | - | µTrms | OSR_HALL=1, CONFIG=2 |

*Table 12 Magnetic Specifications*

Note: The RMS noise values for OSR=1 are approximately $\sqrt{2}$ smaller than at setting OSR=0 for the same configuration and DIG_FILT_HALL_XY and DIG_FILT_HALL_Z settings

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[13] The data format is 2's complement

[14] No external magnetic field applied. Verified with device characterization tests in the operating magnetic field range

[15] Room temperature, DIG_FILT_HALL_XY=0, DIG_FILT_HALL_Z=1, DIG_FILT_TEMP=1, OSR_TEMP=1

[16] Room temperature, DIG_FILT_HALL_XY=6, DIG_FILT_HALL_Z=7, DIG_FILT_TEMP=1, OSR_TEMP=1

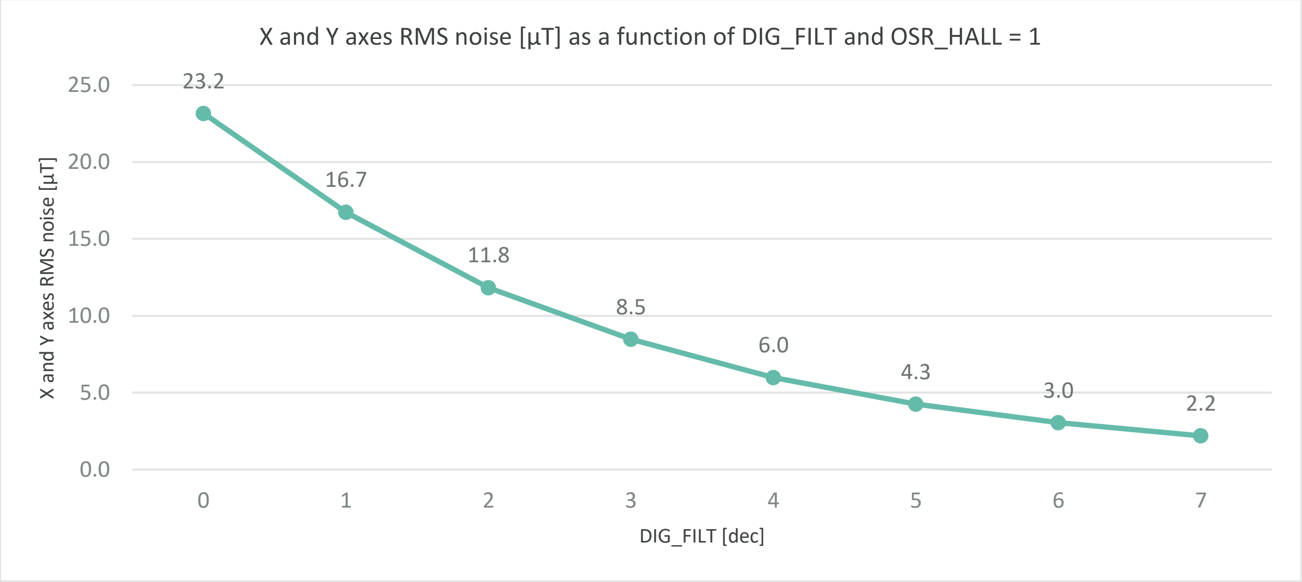

*Figure 3 XY axes noise as a function of DIG_FILT_HALL_XY. CONFIG=0*

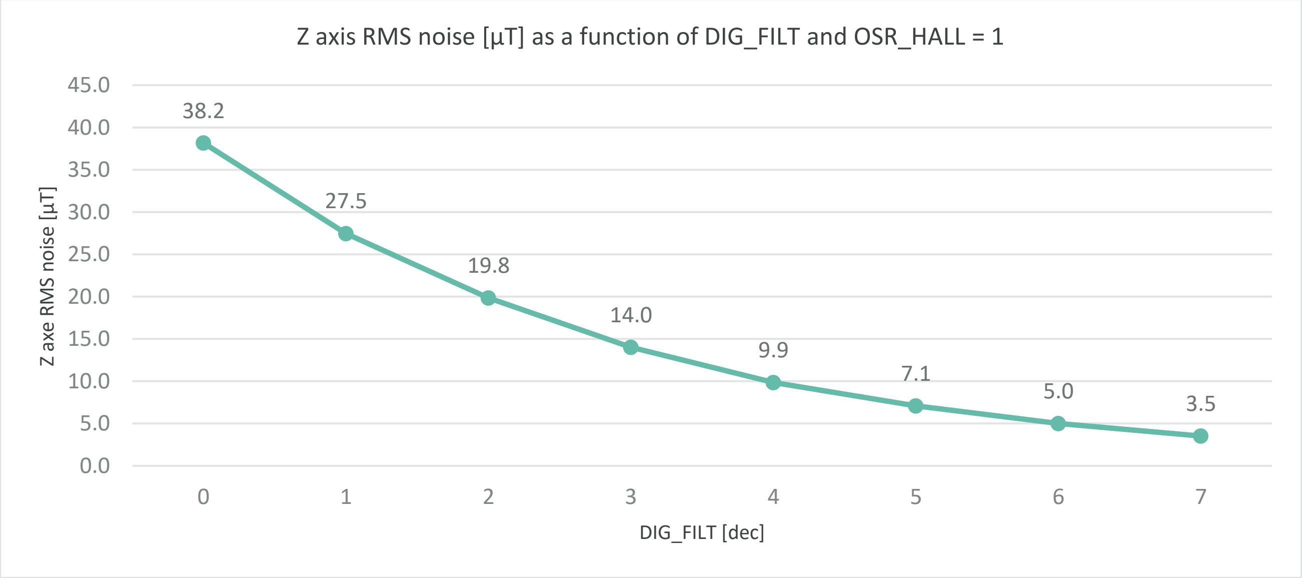

*Figure 4 Z axis noise as a function of DIG_FILT_HALL_Z. CONFIG=0*

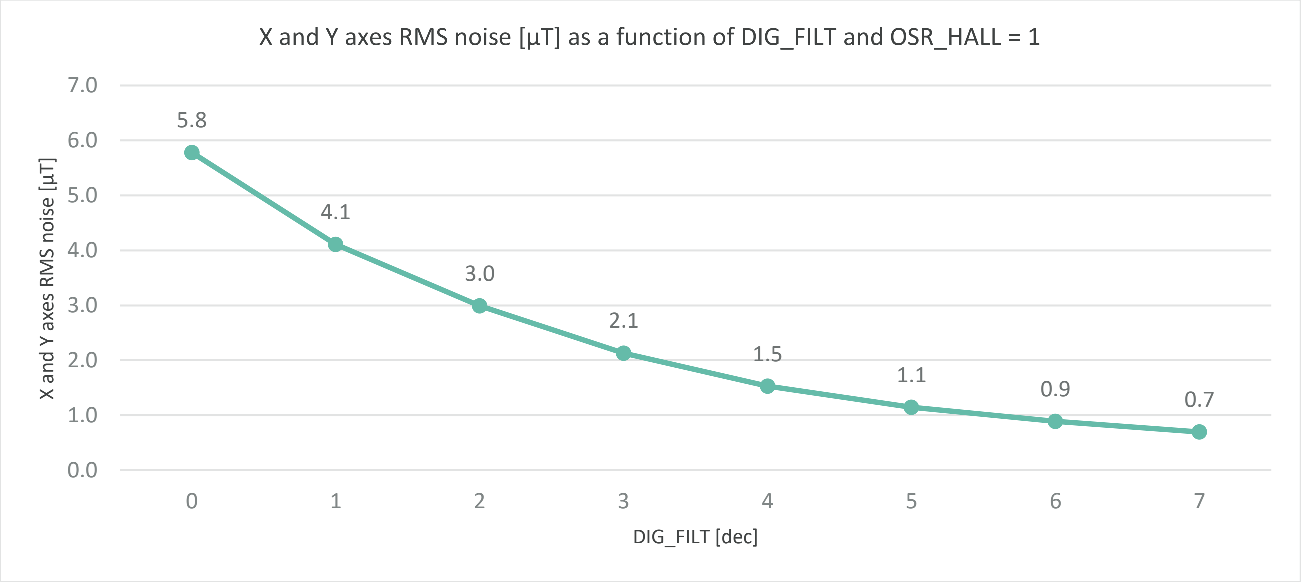

*Figure 5 XY axes noise as a function of DIG_FILT_HALL_XY. CONFIG=1*

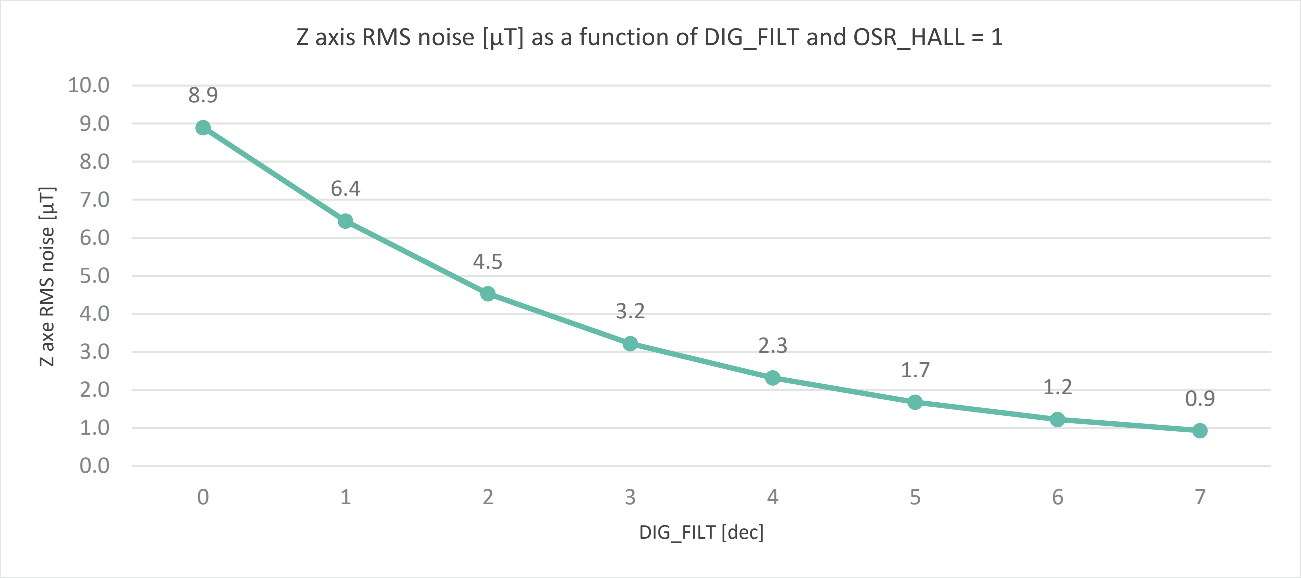

*Figure 6 Z axis noise as a function of DIG_FILT_HALL_Z. CONFIG=1*

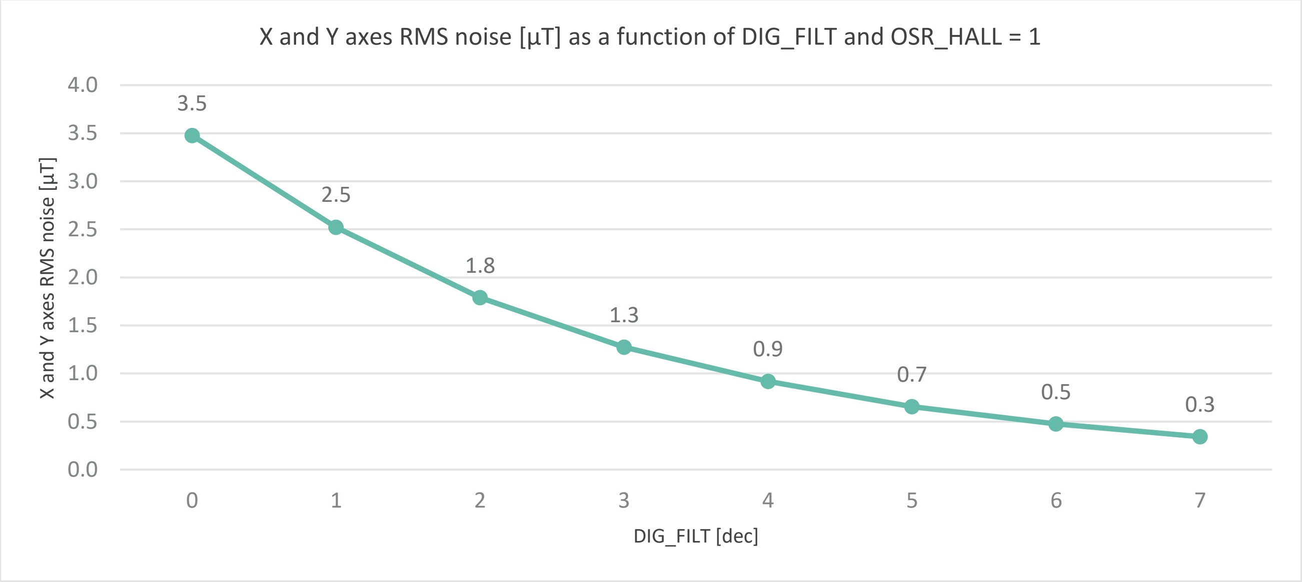

*Figure 7 XY axes noise as a function of DIG_FILT_HALL_XY. CONFIG=2*

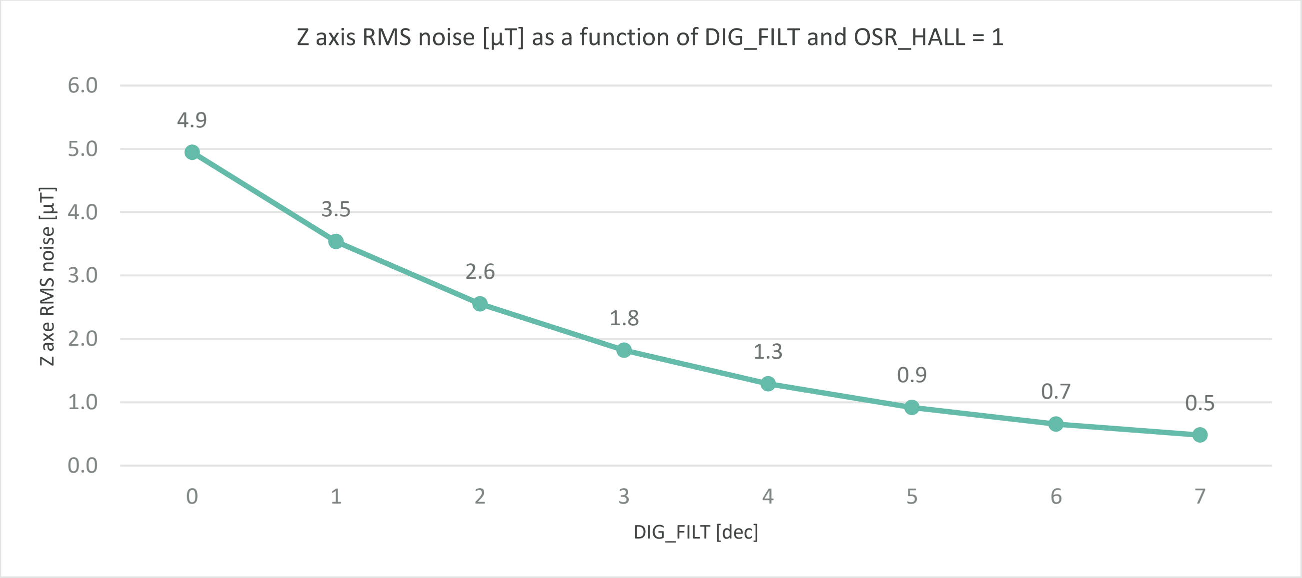

*Figure 8 Z axis noise as a function of DIG_FILT_HALL_Z. CONFIG=2*

## 4.5. Timing Specifications

Operating Conditions, $V_{DD}$=1.8V to 3.6V , $T_A$ = -40°C to 105°C, (T)XYZ measurement (unless otherwise specified)

| Parameter | Symbol | Min. | Typ. | Max. | Unit | Conditions |
|---|---|---|---|---|---|---|
| Output refresh rate[17] | FR[18] | 5 | 100 | 1400 | Hz | |
| Oscillator trimming accuracy | TOSC_TRIM | -5 | 0 | 5 | % | |
| Oscillator Thermal drift | TOSC_THD | -5 | 0 | 5 | % | |
| WOC pulse on SCL | $WOC_{PULSE}$ | 14.4 | 16 | 17.6 | µs | Default configuration |
| Magnetic axis conversion time[19] | $T_{CONVM}$ | 108 | 113 | 119 | µs | Time per axis DIG_FILT=0, OSR=0 |
| | $T_{CONVM}$ | 210 | 220 | 232 | µs | Time per axis DIG_FILT=0, OSR=1 |
| | $T_{CONVM}$ | 1733 | 1820 | 1916 | µs | Time per axis DIG_FILT=4, OSR=1 |
| | $T_{CONVM}$ | 13.1 | 13.8 | 14.5 | ms | Time per axis DIG_FILT=7, OSR=1 |
| DSP time single axis | $T_{DSP1}$ | 25.6 | 27 | 28.4 | µs | |
| DSP time two axes | $T_{DSP2}$ | 47.5 | 50 | 52.5 | µs | |
| DSP time three axes | $T_{DSP3}$ | 69.3 | 73 | 76.7 | µs | |
| DSP time single axis and temperature | $T_{DSP1T}$ | 59.8 | 63 | 66.2 | µs | |
| DSP time two axes and temperature | $T_{DSP2T}$ | 81.7 | 86 | 90.3 | µs | |
| DSP time three axes and temperature | $T_{DSP3T}$ | 104.5 | 110 | 115.3 | µs | |
| DSP time temperature | $T_{DSPT}$ | 19 | 20 | 21 | µs | |
| Start-up time | $T_{Startup}$ | - | 0.15 | 0.4 | ms | From initial reset to Power Down mode. No toggling on INTB pin during Power-up |

*Table 13 – Timing specifications*

---

[17] FR is defined as the inverse of the period between two sets of measurements. It is relevant for the Continuous measurement and WOC modes and is defined by the parameter MODE[3:0]. FR is adjustable with the following settings: 5Hz, 10Hz, 15Hz, 50Hz, 100Hz, 200Hz, 500Hz, 700Hz 1000Hz, 1400Hz. The default value in the non-volatile memory is 100Hz.

[18] It is up to the user to make sure that the FR setting corresponds to the time needed to measure the selected axes with their respective filter settings, together with the DSP time, which depends on whether T_EN is set or reset.

[19] This conversion time is defined as the time to acquire a single axis of the magnetic flux density. When measuring XYZ, they are obtained through time-multiplexing. The conversion time is programmable through DIG_FILT_HALL_XY, DIG_FILT_HALL_Z for magnetic and DIG_FILT_TEMP for temperature conversion. The total conversion time is obtained by summing up the magnetic & temperature conversion time.

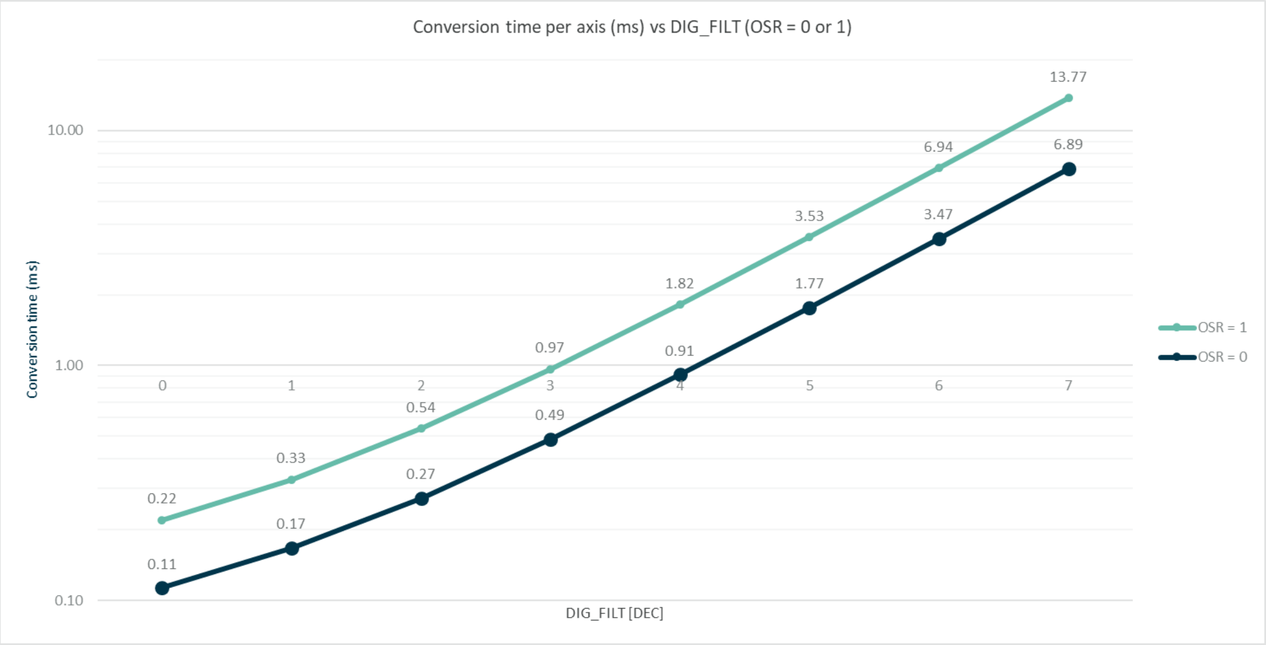

*Figure 9: Conversion time*

The above graph can be expressed with the following formula:

$$T_{conv}(DIG\_FILT) = \frac{16 + 2^{(OSR+5)} \cdot \left[2^{(DIG\_FILT+2)} + 4\right]}{F_{clk}}$$

$$F_{clk} = 2.4\text{MHz} \quad \text{(typ)}$$

# 5. Functional Description

## 5.1. Device Configuration for Magnetic measurements

MLX90394 has three configurations for magnetic measurements selectable by the user:

- Low Current High Range (CONFIG = 0)
- Low Noise High Range (CONFIG = 1)
- Low Noise High Sensitivity (CONFIG = 2)

The current consumption specification can be found in Section 4.3. The noise specification can be found in Section 4.4. The magnetic range specification can be found in Section 5.3.5.

## 5.2. Configuration of SDA and INTB pin function

SDA and INTB pins can both be used interchangeably as I$^2$C bus data input/output. Which pin will be used for data communication is automatically configured upon start of communication. It is required that the pin not used for communication is held HIGH and tied to VDD always through a pull-up resistor. It is recommended to connect a pull-up resistance to VDD in order to avoid accidental short circuit current due to pin misuse – accidental wrong configuration by the user.

| Pin # | Pin Name | Connected to | I$^2$C Slave Address | Function |
|---|---|---|---|---|
| 1 | SDA | SDA bus line | 0x10h | I$^2$C Bus Data Input/Output |
| 6 | INTB | Tied to VDD through a pull-up resistor | 0x10h | WOC Interrupt Output, Synchronization Output or not used |

*Table 14 MLX90394RLD-AAA-000-RE interface with SDA pin connected to the SDA bus line*

| Pin # | Pin Name | Connected to | I$^2$C Slave Address | Function |
|---|---|---|---|---|
| 1 | SDA | Tied to VDD through a pull-up resistor | 0x11h | WOC Interrupt Output, Synchronization Output or not used |
| 6 | INTB | SDA bus line | 0x11h | I$^2$C Bus Data Input/Output |

*Table 15 MLX90394RLD-AAA-000-RE interface with INTB pin connected to the SDA bus line*

| Pin # | Pin Name | Connected to | I$^2$C Slave Address | Function |
|---|---|---|---|---|
| 1 | SDA | SDA bus line | 0x60h | I$^2$C Bus Data Input/Output |
| 6 | INTB | Tied to VDD through a pull-up resistor | 0x60h | WOC Interrupt Output, Synchronization Output or not used |

*Table 16 MLX90394RLD-AAA-001-RE interface with SDA pin connected to the SDA bus line*

| Pin # | Pin Name | Connected to | I2C Slave Address | Function |
|---|---|---|---|---|
| 1 | SDA | Tied to VDD through a pull-up resistor | 0x61h | WOC Interrupt Output, Synchronization Output or not used |
| 6 | INTB | SDA bus line | 0x61h | I$^2$C Bus Data Input/Output |

*Table 17 MLX90394RLD-AAA-001-RE interface with INTB pin connected to the SDA bus line*

MLX90394 has a predefined default I$^2$C address 0x10h (MLX90394RLD-AAA-000-RE). This address can be changed to 0x11h if SDA and INTB pins are swapped. This enables the coexistence of two identical MLX90394 devices on the same I$^2$C bus. Similarly, MLX90394RLD-AAA-001-RE features I$^2$C slave addresses 0x60 and 0x61.

## 5.3. Operating Modes

MLX90394 has the following Application modes

1. Power Down mode (Deep Sleep)
2. Single measurement mode
3. Continuous measurement mode (5Hz, 10Hz, 15Hz, 50Hz, 100Hz, 200Hz, 500Hz, 700Hz, 1000Hz, 1400Hz)
4. Wake-up on change (5Hz, 10Hz, 15Hz, 50Hz, 100Hz, 200Hz, 500Hz, 700Hz, 1000Hz, 1400Hz)

Both Continuous and Wake-up on change modes measure periodically the magnetic field and (or) the temperature with a duty cycle defined by OSR_HALL, OSR_TEMP, DIG_FILT_HALL_XY, DIG_FILT_HALL_Z and DIG_FILT_TEMP.

### 5.3.1. Single measurement mode

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

While going to the *Power Down mode*, **MODE[3:0]** bits turns to 0. At the same time, **DRDY** bit (Data Ready) in **STAT1** register turns to High.
When any of measurement data register (**X**, **Y** and **Z**) is read, **DRDY** bit turns to Low. It remains High when switching from *Power Down mode* to another mode.

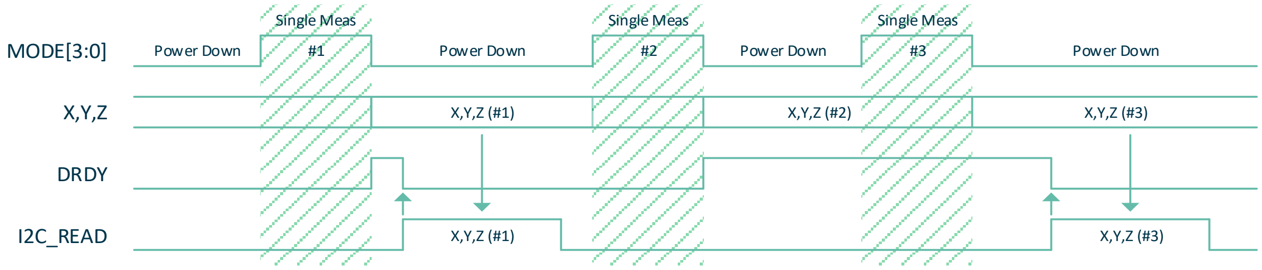

Figure 10: Single measurement mode when data is read out of measurement period

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

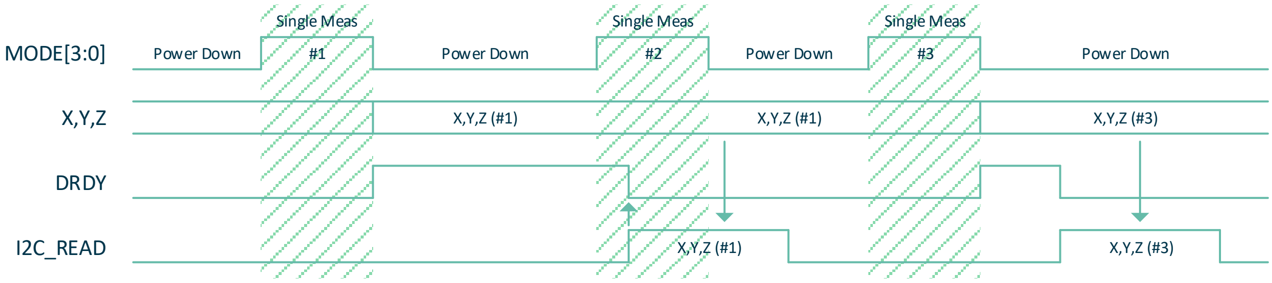

Figure 11: Single measurement mode when data read started during measurement period

## 5.3.2. Continuous measurement Mode

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

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

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

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

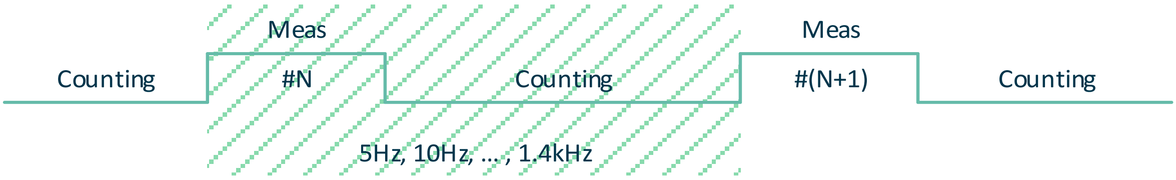

*Figure 12: Continuous measurement mode*

### 5.3.2.1. *Data Ready*

When the measurement data is stored and ready to be read, the **DRDY** bit (Data Ready) in STAT1 register is set to High. When a measurement is performed correctly, the device sets the Data Ready bit before going back to "*Counting*" or "*Wake-up on Change*" power state.

### 5.3.2.2. *Normal Read Sequence*

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

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

When this read sequence is followed and there is no attempted $I^2C$ read during measurement, reading of STAT2 sets the DOR (Data Overrun) bit to low (see I/O registers description for reference).

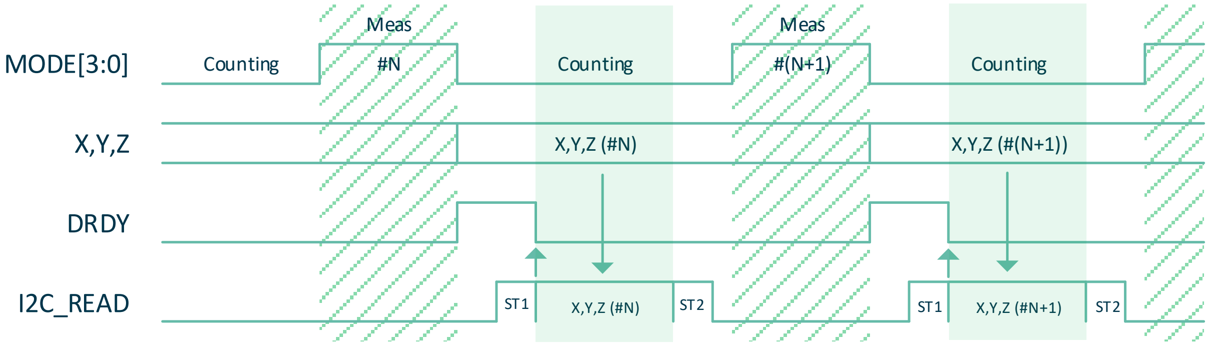

*Figure 13: Normal read sequence*

### 5.3.2.3. *Data Read Start during Measurement*

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

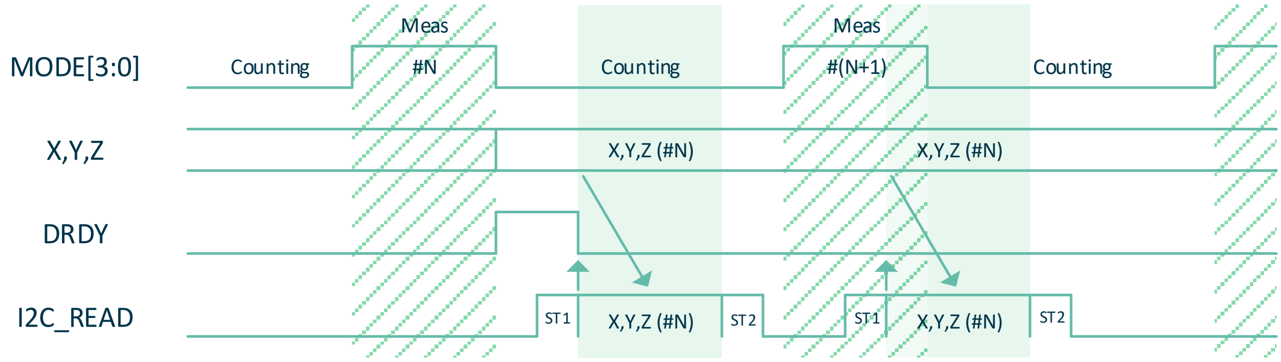

Figure 14: Data read start during measurement

### 5.3.2.4. *Data Skip*

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

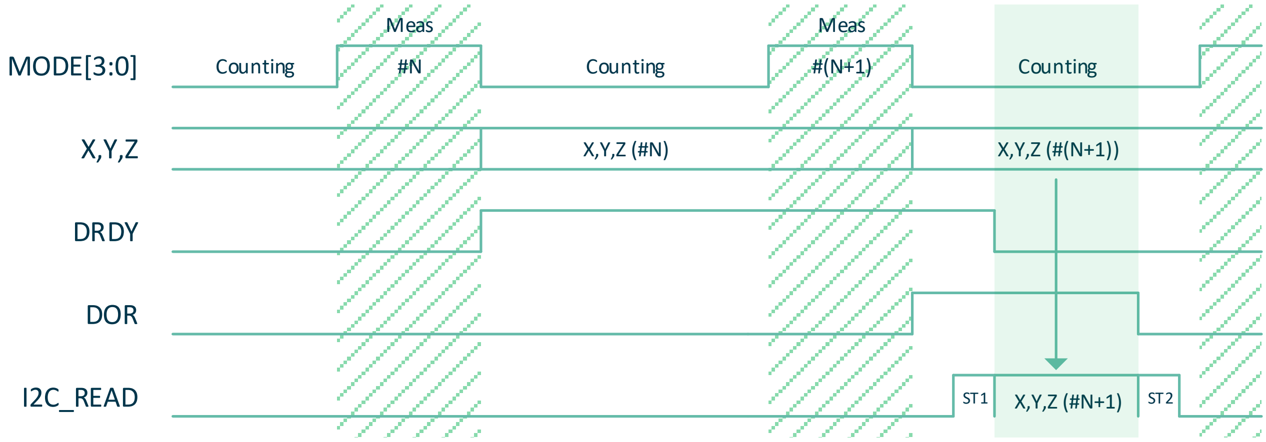

Figure 15: Data Skip: When data is not read

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

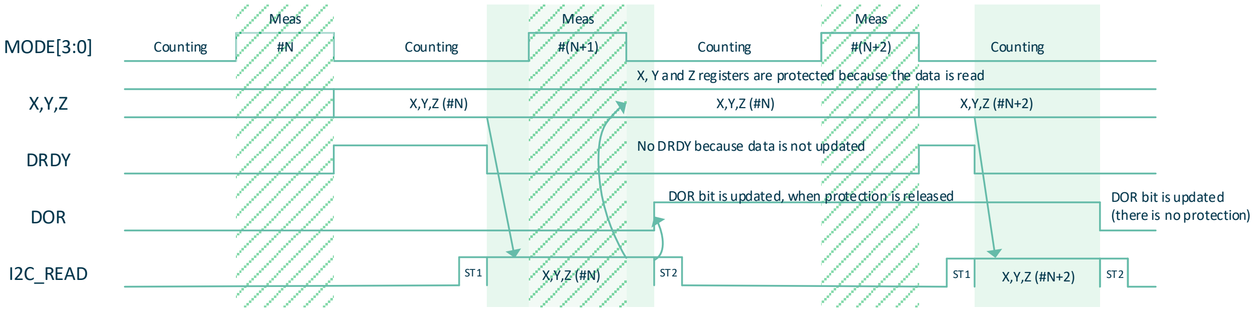

Figure 16: Data Skip: When data read has not been finished before the next measurement end

### 5.3.2.5. *End Operation*

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

## 5.3.3. Wake-up On Change Mode

This mode of operation can be enabled when setting the **SWOC** bit. As in Continuous measurement mode, the device wakes up periodically and measures the enabled axes and the temperature if enabled. When the current reading, the difference or the differential of the reading of any of the enabled axes exceeds a predefined threshold defined by the user, MLX90394 issues an interrupt. The interrupt can be configured to be signaled in two ways through INTB_SCL_B bit:

1. Pulling the SCL line low for 16 µs. The duration of the pulse is configurable → 8µs, 16µs, 32µs, 64µs by changing the INTDUR[1:0] bits
2. Latching low of INTB or SDA pin, depending on the connection to the I$^2$C bus

The condition for interrupt can be Static Delta, Dynamic Delta or Absolute Thresholds:

1. Static Delta → the measured field is greater in magnitude **with a predefined threshold than** the **first** read value after WOC enter. The threshold is interpreted as an unsigned 15-bit value. Set X(Y/Z)_THR[15]=0[20].
2. Dynamic Delta → the measured field is greater in magnitude **with a predefined threshold than** the **previous** read value. The threshold is interpreted as an unsigned 15-bit value. Set X(Y/Z)_THR[15]=0[20].
3. Absolute Thresholds→ the measured field is greater **than a predefined threshold**. The threshold is interpreted as a signed 2's complement 16-bit value.

Which condition is used in the application is controlled by WOC_MODE[1:0] in the user address space.

When an interrupt condition occurs, the INT flag is set in the STAT1 register. It is cleared upon reading STAT1 register. The figures below describe the behavior of the interrupt.

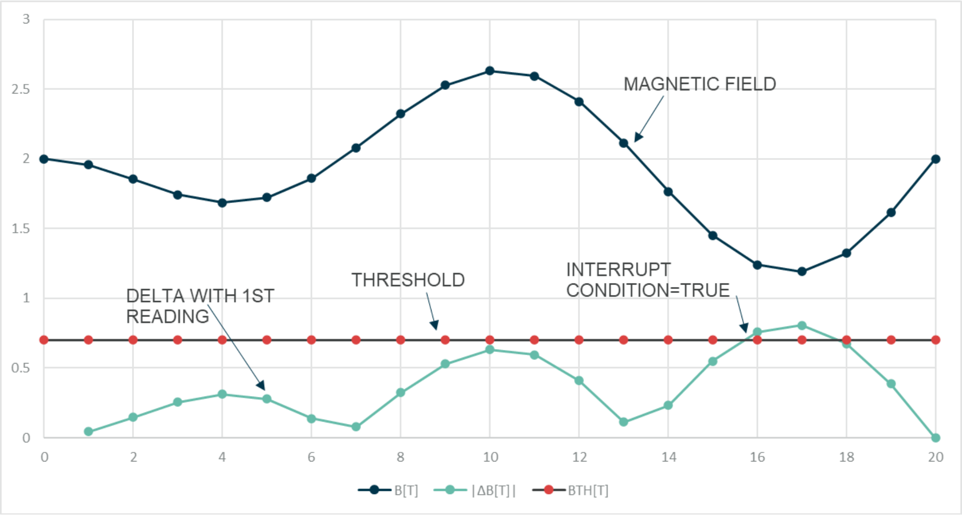

*Figure 17 Conceptual representation of Static Delta WOC behavior*

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[20] In case Set X(Y/Z)_THR[15]=1, MLX90394 will not issue an interrupt, irrespective of the threshold value

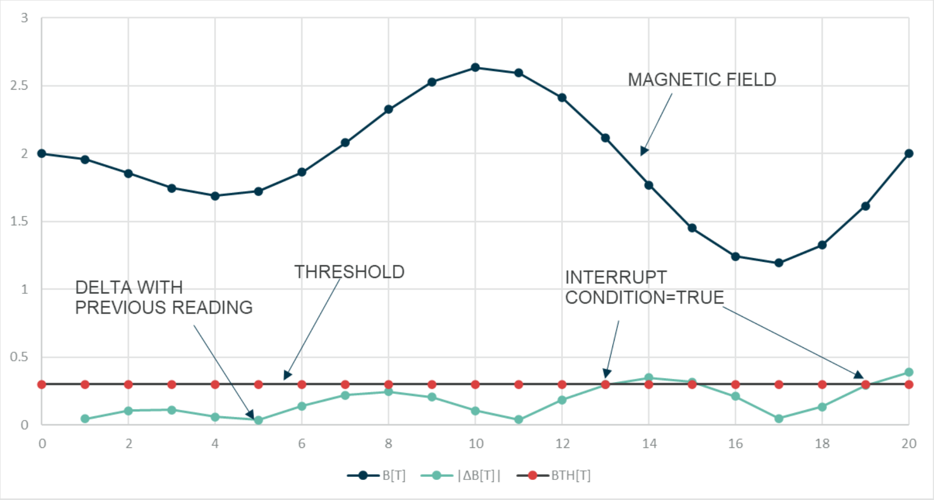


*Figure 18 Conceptual representation of Dynamic Delta WOC behavior*

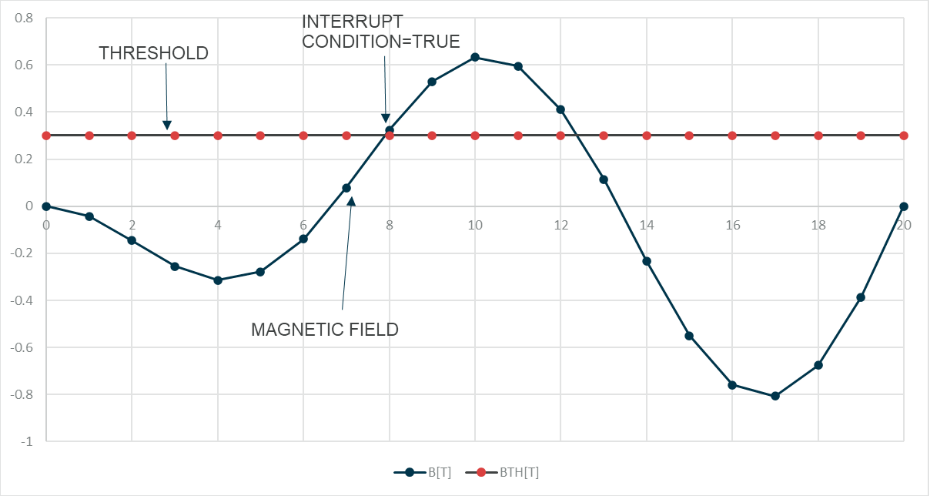


*Figure 19 Conceptual representation of Absolute positive WOC behavior*

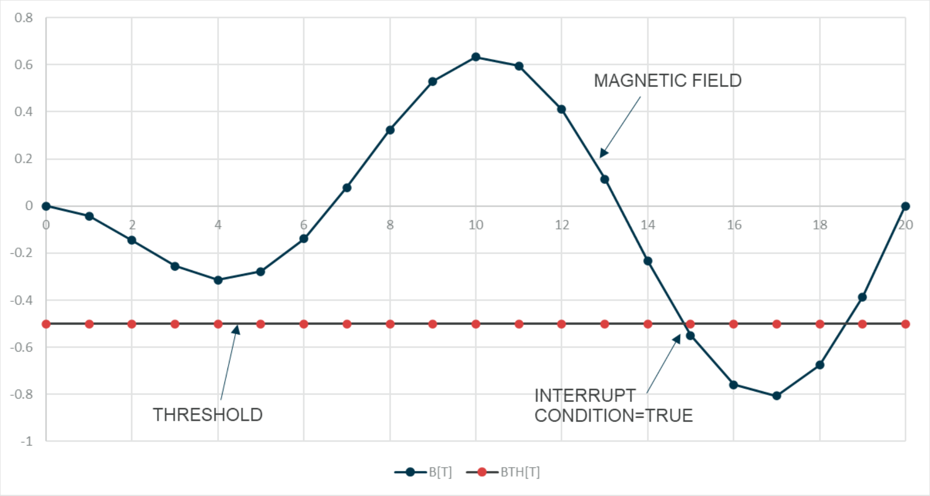


*Figure 20 Conceptual representation of Absolute negative WOC behavior*

The wake-up on change (WOC) interrupt can be configured (INTREPB=0 (default)) so that it keeps repeating until WOC mode is exit, regardless of whether STAT1 was read or not, once an interrupt condition is detected. Reading STAT1 will clear the interrupt until the next measurement only.
If INTREPB=1, then the interrupt will stop repeating when STAT1 register is read even though WOC mode was not exit.

Condition X: if X_EN = 1'b1, |X (#N+n) - X(#N)| > X(THR) -> TRUE/FALSE
or
Condition Y: If Y_EN = 1'b1, |Y (#N+n) - Y(#N)| > Y(THR) -> TRUE/FALSE
or
Condition Z: If Z_EN = 1'b1, |Z (#N+n) - Z(#N)| > Z(THR) -> TRUE/FALSE

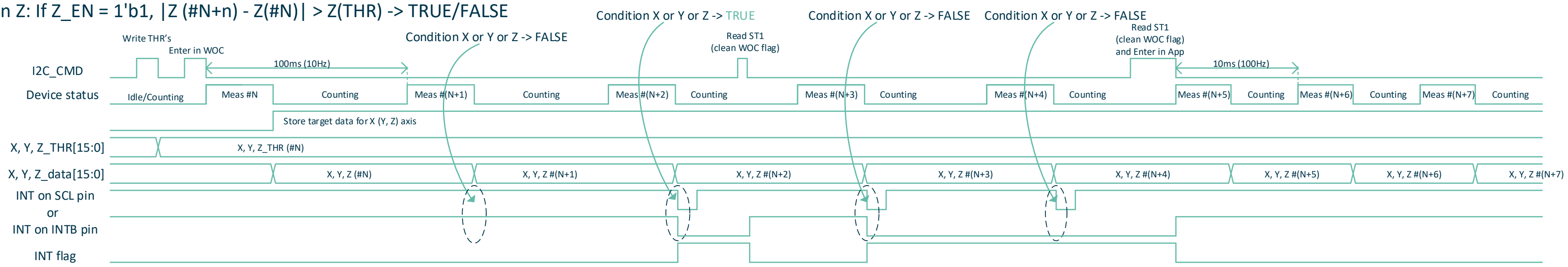


*Figure 21 Static Delta WOC example with 1st measurement after WOC enter. Repetitive interrupt*

Condition X: if X_EN = 1'b1, |X (#N+n) - X(#N+n-1)| > X(THR) -> TRUE/FALSE
or
Condition Y: If Y_EN = 1'b1, |Y (#N+n) - Y(#N+n-1)| > Y(THR) -> TRUE/FALSE
or
Condition Z: If Z_EN = 1'b1, |Z (#N+n) - Z(#N+n-1)| > Z(THR) -> TRUE/FALSE

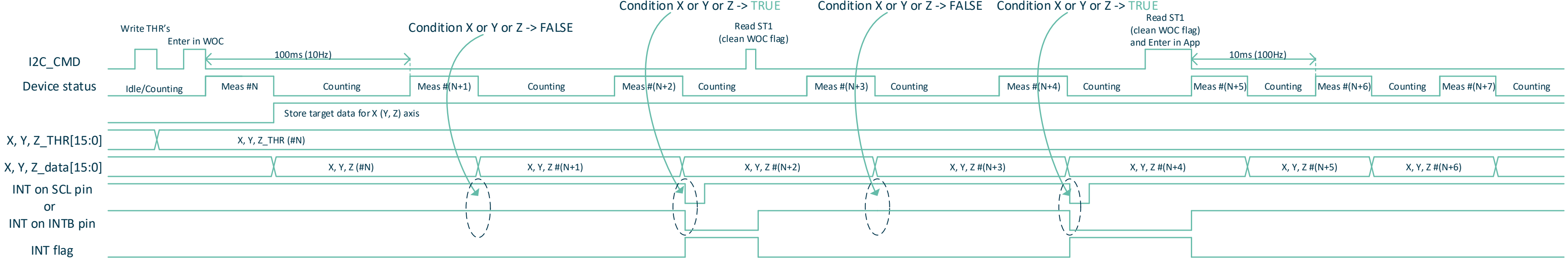


*Figure 22 Dynamic Delta WOC example. Comparison of each measurement with the threshold after WOC enter, Single interrupt*

### 5.3.4. Power Down (Deep Sleep)

In Power Down mode, the device is in minimal power consumption state. All internal blocks including the oscillator are disabled except the POR circuit. Only the communication over the I$^2$C interface is maintained. The digital handling of the communication is clocked by the I$^2$C master clock. All registers remain accessible and the data stored in read/write registers remains.

### 5.3.5. Magnetic Sensor Overflow

The device has a built in overflow detection

| 2's complement | Hex | Dec | Magnetic flux density [µT] CONFIG = 0,1 | Magnetic flux density [µT] CONFIG = 2 |
|---|---|---|---|---|
| 0111_1111_1111_0000 | 7FF0 | 32752 | 49 128 | 4912.8 |
| \| | \| | \| | \| | \| |
| 0000_0000_0000_0001 | 0001 | 1 | 1.5 | 0.15 |
| 0000_0000_0000_0000 | 0000 | 0 | 0 | 0 |
| 1111_1111_1111_1111 | FFFF | -1 | -1.5 | -0.15 |
| \| | \| | \| | \| | \| |
| 1000_0000_0001_0000 | 8010 | -32752 | -49 128 | -4912.8 |

*Table 18 - Measurement magnetic data format*

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

For X axis overflow flag condition is: |X| > 32,752
When the condition is fulfilled, HOFL_X bit turns to “1”.

For Y axis overflow flag condition is: |Y| > 32,752
When the condition is fulfilled, HOFL_Y bit turns to “1”.

For Z axis overflow check is: |Z| > 32,752 If the condition is fulfilled, the HOFL_Z bit turns to “1”.
When measurement data register (X, Y and Z) is updated, HOFL_X, HOFL_Y and HOFL_Z bits are updated, too.

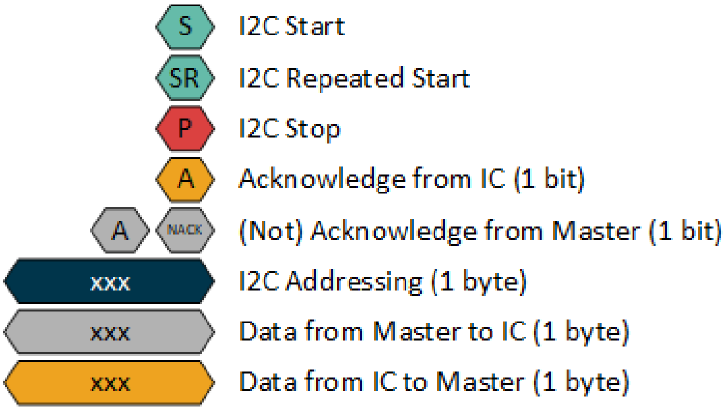
## 5.4. Output protocol (I$^2$C) description

### 5.4.1. Command implementation

The following I$^2$C commands are implemented:

- **MEM_DIRECT_READ**: reads data from memory space, starting from the default address 0x00
- **MEM_READ**: the start address will be specified in the command and the address will be incremented for continuous reading until an I$^2$C stop is detected.
- **MEM_WRITE**: the start address will be specified followed by the data to be stored at addresses starting from the given start address and incremented until an I$^2$C stop is detected.
- **ADDRESSED_RESET**: reset of the device, based on the I$^2$C Slave Address (reset of addressed devices on the I$^2$C bus only)

In the next sections, the format of the different I$^2$C commands is explained.
The following legend is used:



### 5.4.1.1. *Read Commands*

There are two read commands that are implemented

- **MEM_DIRECT_READ**: reads data from memory space, starting from the default address 0x00
- **MEM_READ**: the start address will be specified in the command and the address will be incremented for continuous reading until an I$^2$C stop is detected.

#### 5.4.1.1.1. MEM_DIRECT_READ (direct read) Command

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

*Figure 23: I$^2$C - MEM_DIRECT_READ (direct read) Command*

**NOTES:**

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

#### 5.4.1.1.2. MEM_READ (addressed read)

**MEM_READ:** the start address will be specified in the command and the address will be incremented for continuous reading until an I$^2$C stop (P) is detected.
Incremental read-out starting at a given address (Register Start Address).
Normally it will read 1x register only, but the slave will continue to transmit data of sequential register addresses until the master terminates the communication.

*Figure 11: I$^2$C - MEM_READ (addressed read)*

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

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

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

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

**MEM_WRITE:** the start address will be specified followed by the data to be stored at addresses starting from the given start address and incremented until an I$^2$C stop (P) is detected.
Incremental write starting at a given address (Register Start Address).
Normally you write 1x register only, but optionally the master can continue to transmit data of sequential register addresses to reduce the communication time when a lot of registers should be written.

*Figure 24: I²C - MEM_WRITE (addressed write) Command*

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

### 5.4.1.3. ***ADDRESSED_RESET: Addressed reset***

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

# 5.5. Memory items description

## 5.5.1. Memory Structure

The MLX90394 has registers (ports) of 16 addresses. Each address consists of 8 bits data.
Data is transferred to or received from the external CPU via the I²C interface.

| Address | Name | Description | R/W | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0x00 | STAT1 | Status Register 1 | R | - | - | - | INT | RT | - | - | DRDY |
| 0x01 | X[7:0] | X-axis Measurement Magnetic Data low byte | R | - | - | - | - | - | - | - | - |
| 0x02 | X[15:8] | X-axis Measurement Magnetic Data high byte | R | - | - | - | - | - | - | - | - |
| 0x03 | Y[7:0] | Y-axis Measurement Magnetic Data low byte | R | - | - | - | - | - | - | - | - |
| 0x04 | Y[15:8] | Y-axis Measurement Magnetic Data high byte | R | - | - | - | - | - | - | - | - |
| 0x05 | Z[7:0] | Z-axis Measurement Magnetic Data low byte | R | - | - | - | - | - | - | - | - |
| 0x06 | Z[15:8] | Z-axis Measurement Magnetic Data high byte | R | - | - | - | - | - | - | - | - |
| 0x07 | STAT2 | Status Register 2 | R | - | - | - | - | DOR | HOVF_Z | HOVF_Y | HOVF_X |
| 0x08 | T[7:0] | Temperature Measurement Data low byte | R | - | - | - | - | - | - | - | - |
| 0x09 | T[15:8] | Temperature Measurement Data high byte | R | - | - | - | - | - | - | - | - |
| 0x0A | CID | Company ID [7:0] | R | - | - | - | - | - | - | - | - |
| 0x0B | DID | Device ID [7:0] | R | - | - | - | - | - | - | - | - |
| 0x0C |  | Reserved |  | - | - | - | - | - | - | - | - |
| 0x0D |  | Reserved |  | - | - | - | - | - | - | - | - |
| 0x0E | CTRL1 | Control Register 1 | R/W | SWOC | Z_EN | Y_EN | X_EN | MODE[3:0] |  |  |  |
| 0x0F | CTRL2 | Control Register 2 | R/W | CONFIG[1:0] |  | INTDUR[1:0] |  | INTB_SCL_B | INTREPB | WOC_MODE[1:0] |  |
| 0x10 |  | Reserved |  | - | - | - | - | - | - | - | - |
| 0x11 | RST | Reset = 0x06 | R/W | - | - | - | - | - | - | - | - |
| 0x12 |  | Reserved |  | - | - | - | - | - | - | - | - |
| 0x13 |  | Reserved |  | - | - | - | - | - | - | - | - |
| 0x14 | CTRL3 | Control Register 3 | R/W | OSR_HALL | OSR_TEMP | DIG_FILT_HALL_XY[2:0] |  |  | DIG_FILT_TEMP[2:0] |  |  |
| 0x15 | CTRL4 | Control Register 4 | R/W | DNC=1 | DNC=0 | T_EN | DNC=1 | DRDY_EN | DIG_FILT_HALL_Z[2:0] |  |  |
| ..... |  |  |  |  |  |  |  |  |  |  |  |
| 0x58 | X_THR[7:0] | X axis WOC threshold low byte | R/W | X_THR[7:0] |  |  |  |  |  |  |  |
| 0x59 | X_THR[15:8] | X axis WOC threshold high byte | R/W | X_THR[15:8] |  |  |  |  |  |  |  |
| 0x5A | Y_THR[7:0] | Y axis WOC threshold low byte | R/W | Y_THR[7:0] |  |  |  |  |  |  |  |
| 0x5B | Y_THR[15:8] | Y axis WOC threshold high byte | R/W | Y_THR[15:8] |  |  |  |  |  |  |  |
| 0x5C | Z_THR[7:0] | Z axis WOC threshold low byte | R/W | Z_THR[7:0] |  |  |  |  |  |  |  |
| 0x5D | Z_THR[15:8] | Z axis WOC threshold high byte | R/W | Z_THR[15:8] |  |  |  |  |  |  |  |

*Table 19 – Memory map*

DNC = Do Not Change

The **STAT1** register is mapped on address **0x00**, since it is the default address of **MEM_DIRECT_READ** (direct read) command.
The idea is that first the user has to read the status bits **DRDY** to check if there is new data and if there is new data, to continue the command to read the registers **X**, **Y** and **Z**.

### 5.5.2. I/O registers description

**Address 0x00**

| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|
| STAT1_7 | STAT1_6 | STAT1_5 | INT | RT | STAT1_2 | STAT1_1 | DRDY |
| RW-0 | RW-0 | RW-0 | RW-0 | RW-1 | RW-0 | RW-0 | RW-0 |

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

| | |
|---|---|
| **Bit 7 – 5** | **STAT1[7:5].** Reserved (Not used) |
| **Bit 4** | **INT**. Interrupt bit turns to "1" when the interrupt condition is satisfied during WOC. It returns to "0" when the STAT1 register is read. It is reset to “0” upon power on reset and upon entering WOC mode<br>**0** – The Interrupt is not active<br>**1** – The Interrupt is active |
| **Bit 3** | **RT**. The device is reset<br>**0** – The device was not reset<br>**1** – The device was reset and this is the first reading. Automatically set to 0 when the first reading of STAT1 register is done |
| **Bit 2 – 1** | **STAT1[2:1].** Reserved (Not used) |
| **Bit 0** | **DRDY**. Data Ready.<br>DRDY bit turns to “1” when data is ready in "*Single measurement*" mode (1, 9), "*Continuous measurement*" mode (2, 3, 4, 5, 6, 10, 11, 12, 13, 14) or "*Self-test*" mode (7).<br>It returns to “0” when any of the measurement data registers (X, Y or Z ) is read<br>**0** – Normal<br>**1** – Data is ReaDY |

**Addresses 0x01 – 0x06**

Magnetic measurement data for X, Y and Z axes

**Address 0x07**

| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|
| STAT2_7 | STAT2_6 | STAT2_5 | STAT2_4 | DOR | HOVF_Z | HOVF_Y | HOVF_X |
| RW-0 | RW-0 | RW-0 | RW-0 | RW-0 | RW-0 | RW-0 | RW-0 |

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

| | |
|---|---|
| **Bit 7 – 4** | **STAT2[7:4].** Reserved (Not used) |
| **Bit 3** | **DOR**. Data Overrun<br>DOR bit turns to “1” when data has been skipped in "*Continuous measurement*" mode (2, 3, 4, 5, 6, 10, 11, 12, 13, 14).<br>It returns to “0” when any of the measurement data registers (X, Y or Z) is read.<br>**0** – Normal<br>**1** – Data OverRun |
| **Bit 2** | **HOVF_Z.** Magnetic Sensor OverFlow for Z axis measurement<br>**0** – Normal<br>**1** – Magnetic Sensor OverFlow for Z axis occurred |
| **Bit 1** | **HOVF_Y.** Magnetic Sensor OverFlow for Y axis measurement<br>**0** – Normal<br>**1** – Magnetic Sensor OverFlow for Y axis occurred |
| **Bit 0** | **HOVF_X**. Magnetic Sensor OverFLow for X axis measurements<br>**0** – Normal<br>**1** – Magnetic Sensor OverFlow for X axis occurred |

**Addresses 0x08 – 0x09**

Temperature measurement data

## Addresses 0x0A

Company ID

## Addresses 0x0B

Device ID

## Address 0x0E – CTRL1 Register

| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|
| SWOC | Z_EN | Y_EN | X_EN | MODE3 | MDOE2 | MODE1 | MODE0 |
| RW-0 | RW-1 | RW-1 | RW-1 | RW-0 | RW-0 | RW-0 | RW-0 |

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

**Bit 7** **SWOC**. Start Wake-up On Change mode

- **0** – Disable
- **1** – Enable

**Bit 6** **Z_EN**. Control magnetic measurement at Z axis

- **0** – Disable
- **1** – Enable

**Bit 5** **Y_EN.** Control magnetic measurement at Y axis

- **0** – Disable
- **1** – Enable

**Bit 4** **X_EN.** Control magnetic measurement at X axis

- **0** – Disable
- **1** – Enable

**Bit 3 – 0** **MODE[3:0].** Application Mode

- **0** – Power-down mode
- **1** – Single Measurements mode
- **2** – Continuous measurement mode 5Hz
- **3** – Continuous measurement mode 10Hz
- **4** – Continuous measurement mode 15Hz
- **5** – Continuous measurement mode 50Hz
- **6** – Continuous measurement mode 100Hz
- **7** – Self-test mode
- **8** – Power-down mode
- **9** – Single Measurements mode
- **10** – Continuous measurement mode 200Hz
- **11** – Continuous measurement mode 500Hz
- **12** – Continuous measurement mode 700Hz
- **13** – Continuous measurement mode 1.0kHz
- **14** – Continuous measurement mode 1.4kHz
- **15** – Power-down mode

**NOTE:** The user needs to take care for correct configuration of OSR and DIG_FILT according to the datasheet when selecting a certain refresh rate

### Address 0x0F – CTRL2 Register

| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|
| CONFIG1 | CONFIG0 | INTDUR1 | INTDUR0 | INTB_SCL_B | INTREPB | WOC_MODE1 | WOC_MODE0 |
| RW-0 | RW-0 | RW-0 | RW-0 | RW-1 | RW-0 | RW-0 | RW-0 |

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

**Bit 7 - 6** **CONFIG[1:0].** Range Configuration
- **0** – Configuration 0
- **1** – Configuration 1
- **2** – Configuration 2
- **3** – Configuration 0

**Bit 5 - 4** **INTDUR[1:0].** Configuration of interrupt pulse duration on SCL pin
- **0** – 4 x OSC_SLOW clocks = 16us
- **1** – 8 x OSC_SLOW clocks = 32us
- **2** – 1 x OSC_SLOW clocks = 4us
- **3** – 2 x OSC_SLOW clocks = 8us

**Bit 3** **INTB_SCL_B.** Select interrupt function on SCL pin or INTB pin
- **0** – Interrupt on SCL pin
- **1** – Interrupt on INTB pin

**Bit 2** **INTREPB.** Interrupt repetition configuration
- **0** – interrupt repeat after first time when condition is TRUE till WOC exit
- **1** – interrupt repeat only if condition is TRUE

**Bit 1 - 0** **WOC_MODE[1:0**]. WOC mode configurations
- **0** – Difference than 1st measurement in WOC
- **1** – Difference than previous measurement in WOC
- **2** – Absolute mode
- **3** – Not used

### Address 0x11 – RESET Register

Writing 0x06 in this register resets the IC

### Address 0x14 – CTRL3 Register

| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|
| OSR_ HALL | OSR_ TEMP | DIG_FILT_ HALL_XY2 | DIG_FILT_ HALL_XY1 | DIG_FILT_ HALL_XY0 | DIG_FILT_ TEMP2 | DIG_FILT_ TEMP1 | DIG_FILT_ TEMP0 |
| RW-1 | RW-1 | RW-1 | RW-0 | RW-0 | RW-0 | RW-0 | RW-1 |

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

**Bit 7** **OSR_HALL.** OSR setting for Hall Measurement
**Bit 6** **OSR_TEMP.** OSR setting for Temperature Measurement
**Bit 5 – 3** **DIG_FILT_HALL_XY[2:0].** Digital filter setting for X and Y Hall Measurements
**Bit 2 – 0** **DIG_FILT_TEMP[2:0].** Digital filter setting for Temperature Measurement

### Address 0x15 – CTRL4 Register

| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|
| CTRL4_7 | CTRL4_6 | T_EN | CTRL4_4 | DRDY_EN | DIG_FILT_HALL_Z2 | DIG_FILT_HALL_Z1 | DIG_FILT_HALL_Z0 |
| RW-1 | RW-0 | RW-0 | RW-1 | RW-0 | RW-1 | RW-0 | RW-1 |

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

| | |
|---|---|
| **Bit 7** | **CTRL4_7**. Reserved (keep set to 1 for proper operation) |
| **Bit 6** | **CTRL4_6**. Reserved (keep set to 0 for proper operation) |
| **Bit 5** | **T_EN.** Enable Temperature Measurement |
| **Bit 4** | **CTRL4_4**. Reserved (keep set to 1 for proper operation) |
| **Bit 3** | **DRDY_EN.** Enables DRDY flag on INTB or SDA pin (depending on the connection interface)<br>· **0** – DRDY flag output disabled<br>· **1** – DRDY flag output enabled. If used, **INTB_SCL_B** must be set |
| **Bit 2 – 0** | **DIG_FILT_HALL_Z[2:0].** Digital filter setting for Z Hall Measurement |

### Addresses 0x58 – 0x59

X axis WOC threshold low (0x58) and high (0x59) byte

### Addresses 0x5A – 0x5B

Y axis WOC threshold low (0x58) and high (0x59) byte

### Addresses 0x5C – 0x5D

Z axis WOC threshold low (0x58) and high (0x59) byte

These registers are initialized at 0 and are to be set by the user.

## 5.6. Flowchart

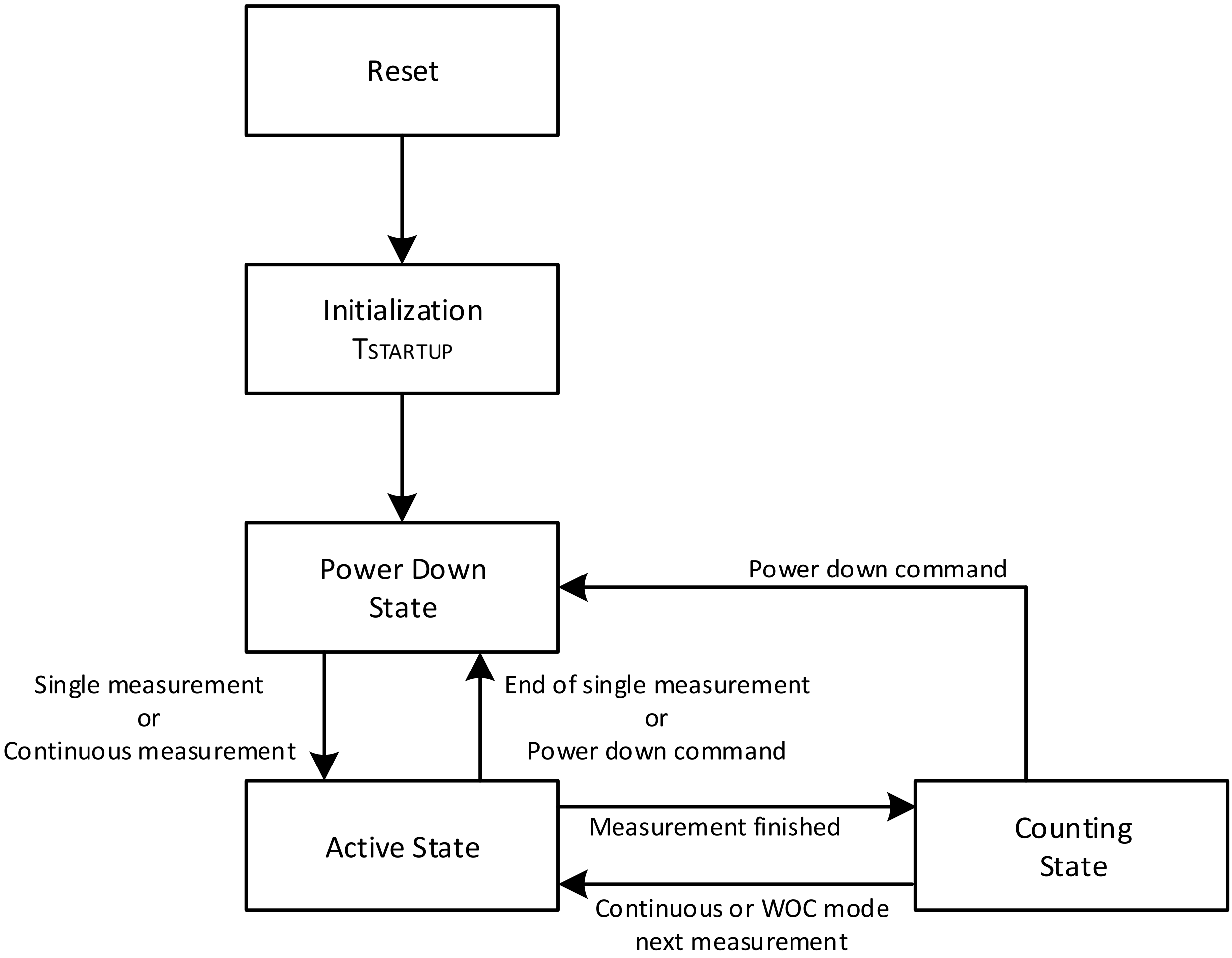


*Figure 25: State Sequence flowchart*

# 6. Application Information

## 6.1. Recommended Application Diagram

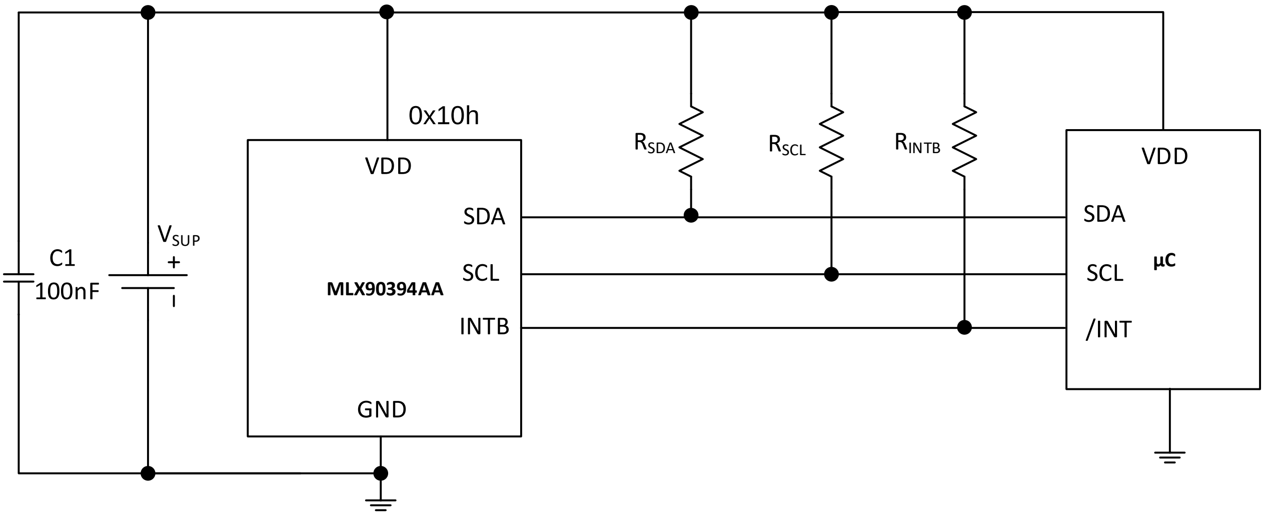


*Figure 26: Recommended application diagram*

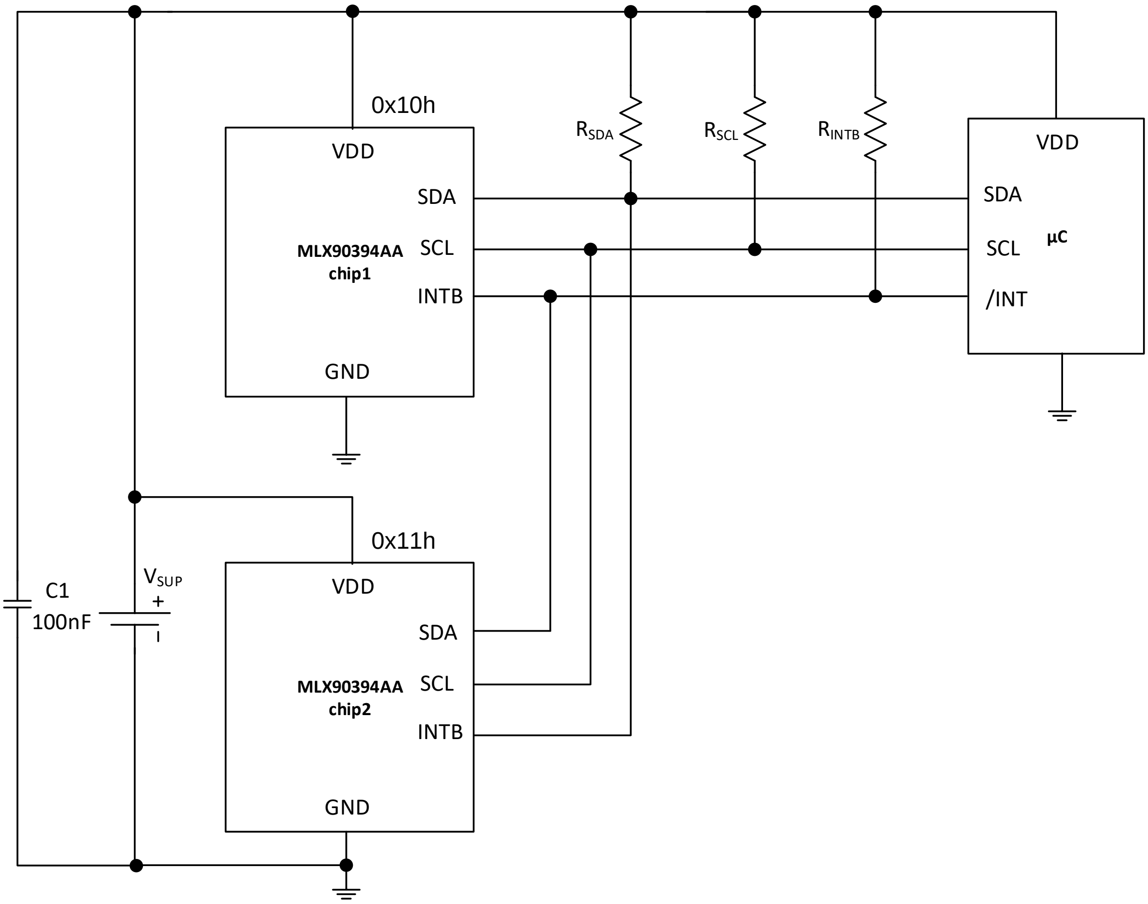


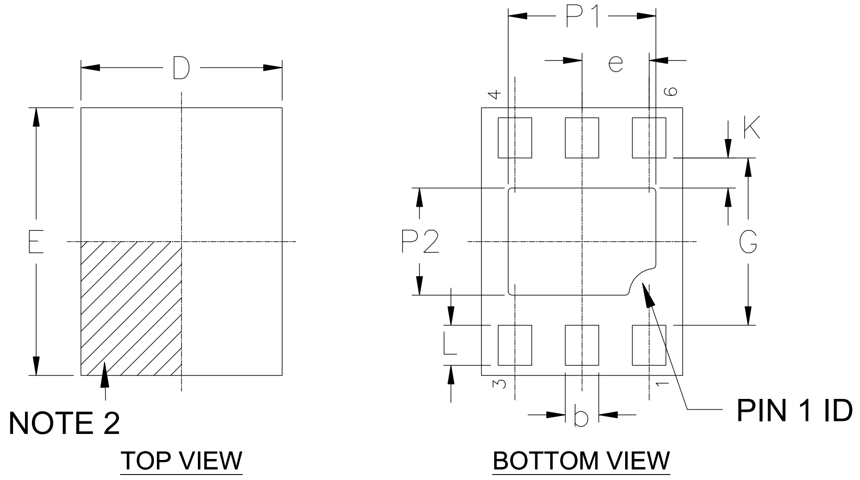
*Figure 27 Application diagram with two MLX90394AA*

# 7. Package, IC handling and assembly

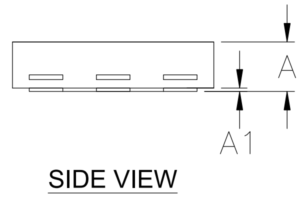
## 7.1. Package information

### 7.1.1. Dimensions

UTDFN6 1.5mm x 2mm



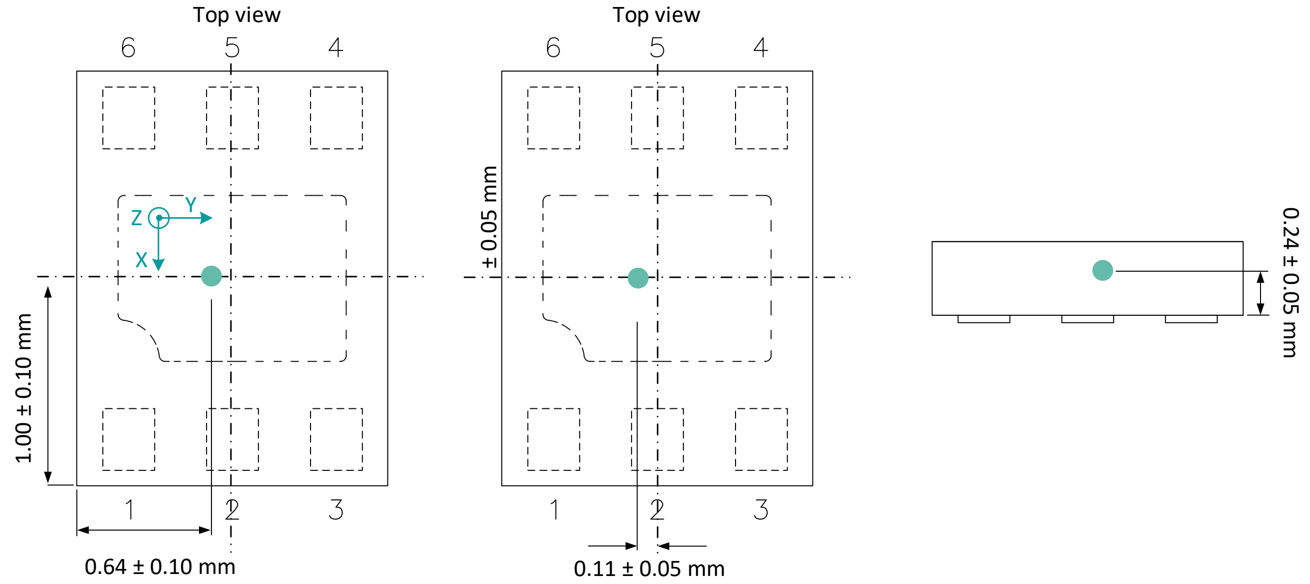
| SYMBOL | MINIMUM | MAXIMUM |
|---|---|---|
| A | 0.31 | 0.40 |
| A1 | 0.00 | 0.05 |
| D | 1.40 | 1.60 |
| E | 1.90 | 2.10 |
| P1 | 1.00 | 1.20 |
| P2 | 0.70 | 0.90 |
| G | 1.20 | 1.30 |
| L | 0.225 | 0.325 |
| K | 0.20 | --- |
| b | 0.20 | 0.30 |
| e | 0.50 BSC | |



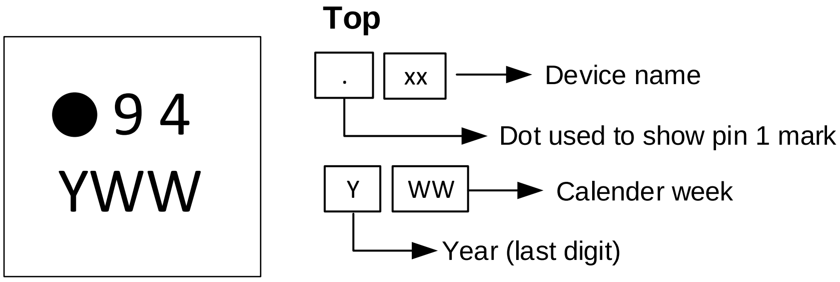
NOTE :
1. ALL DIMENSIONS IN MILLIMETERS (mm).
2. TERMINAL #1 IDENTIFIER AND TERMINAL NUMBERING CONVENTION SHALL CONFORM JEDEC PUBLICATION 95 SPP-002. DETAILS OF TERMINAL #1 IDENTIFIER ARE OPTIONAL, BUT MUST BE LOCATED WITHIN THE ZONE IDENTICATED. THE TERMINAL #1 IDENTIFIER MAY BE MARKED FEATURE.
3. EXPOSED TIE BAR SHOULD BE KEPT FREE FROM SOLDER.

*Figure 28 Preliminary Package Outline Drawing*

### 7.1.2. Sensing element location and field direction



### 7.1.3. UTDFN6 Package Marking



## 7.2. Storage and handling of plastic encapsulated ICs

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

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

For more information refer to Melexis *Guidelines for storage and handling of plastic encapsulated ICs* [21]

## 7.3. Assembly of encapsulated ICs

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

For Through Hole Devices (THD), the applicable soldering methods are reflow, wave, selective wave and robot point-to-point. THD lead pre-forming (cutting and/or bending) is applicable under strict compliance with Melexis *Guidelines for lead forming of SIP Hall Sensors* [21].

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

For PCB-less assembly refer to the relevant application notes [21] or contact Melexis.

Electrical resistance welding or laser welding can be applied to Melexis products in THD and specific PCB-less packages following the *Guidelines for welding of PCB-less devices* [21].

Environmental protection of customer assembly with Melexis products for harsh media application, is applicable by means of coating, potting or overmolding considering restrictions listed in the relevant application notes [21]

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

## 7.4. Environment and sustainability

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

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[21] www.melexis.com/ic-handling-and-assembly

# 8. References

## 8.1. List of figures

## 8.2. List of tables

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