

MLX90818

Absolute Pressure Sensor

1. Features and Benefits

- High accuracy absolute pressure sensor $\pm 0.5\%$ to $\pm 0.75\%$ for extended life operation at 150°C
- Digital SENT output with available compensated $\pm 1^{\circ}\text{C}$ accurate NTC temperature information
- System in a package: MEMS, analog front end circuitry, 16 bit microcontroller, voltage regulators, SENT driver
- Large automotive temperature range (-40°C to 150°C)
- Excellent harsh media compliance
- Automotive qualified and automotive diagnostic features (clamping levels, multiple internal fault diagnostics)
- Factory calibrated or fully programmable through the connector for customized calibration curves at customers
- Assembled in a rugged easy to use 4x5mm DFN package

2. Application Examples

- Automotive applications with absolute pressure from 1bar to 5.5bar
- Manifold and Turbo Manifold Air Pressure
- Manifold and Turbo Manifold Air Pressure combined with Temperature

3. Ordering information

| Product Code | Temperature Code | Package Code | Option Code | Packing Form Code |
|--------------|------------------|--------------|-------------|-------------------|
| MLX90818 | L | XE | BBG-015 | RE |
| MLX90818 | L | XE | BBG-016 | RE |
| MLX90818 | L | XE | BBG-017 | RE |

Legend:

Temperature Code: L (-40°C to 150°C)

Package Code: XE = DFN14

Option Code: BBG-015 = 0.1 to 4bar absolute pressure / 193 to 3896LSB SENT output / no NTC

BBG-016 = 0.1 to 3bar absolute pressure / 193 to 3896LSB SENT output / NTC

BBG-017 = 0.1 to 4bar absolute pressure / 193 to 3896LSB SENT output / NTC

Packing Form: RE = Reel

Ordering example: MLX90818LXE-BBG-015-RE

4. Functional Diagram

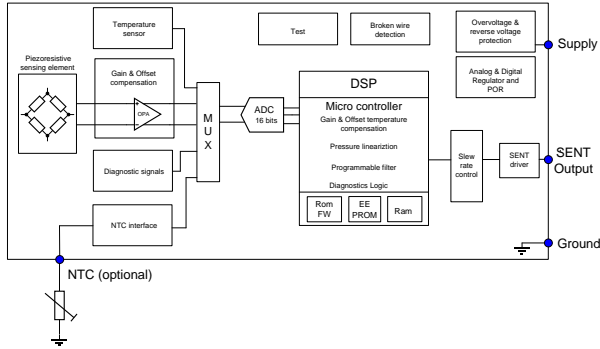


Figure 1: Functional block diagram

5. General Description

The MLX90818 is a packaged, factory calibrated, absolute pressure sensor delivering a digital output signal using the SENT protocol.

Use of an optimized architecture and a high density CMOS technology imparts the MLX90818 with best in class automotive EMC performance. A DSP based architecture using a 16bit microcontroller provides outstanding performance in terms of initial accuracy.

A smart package and die assembly concept suits applications with stringent automotive temperature and stress conditions needing small drift over life.

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6. Glossary of Terms

- Bar: Pressure unit (1bar = 100kPa)
- POR: Power-on Reset
- ADC: Analog to Digital Converter
- DSP: Digital Signal Processor
- EMC: Electro Magnetic Compatibility
- SENT: Single Edge Nibble Transmission
- OV: Over Voltage
- UV: Under Voltage
- FC: SENT Fast Channel
- FC1: SENT Fast Channel 1
- FC2: SENT Fast Channel 2

7. Absolute Maximum Ratings

| Parameter | Value | Units |
|-----------------------------------|------------|-------|
| Supply Voltage (overvoltage) | 18 | V |
| Reverse Voltage Protection | -18 | V |
| Positive output voltage | 18 | V |
| Reverse output voltage | -18 | V |
| Operating Temperature Range | -40 to 150 | °C |
| Storage Temperature Range | -40 to 150 | °C |
| Programming Temperature Range | -40 to 125 | °C |
| Burst pressure (Room Temperature) | 15 | Bar |

Table 1: 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.

8. Pin Definitions and Descriptions

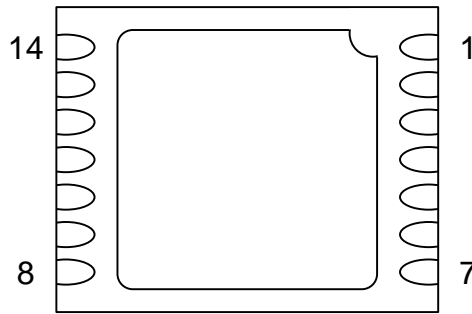


Figure 2: Package pinout (bottom view)

| Pin number | Description | Pin number | Description |
|------------|---------------|------------|---------------|
| 1 | Test pin | 14 | Ground |
| 2 | Not Connected | 13 | Not Connected |
| 3 | SENT output | 12 | NTC input |
| 4 | Not Connected | 11 | Not Connected |
| 5 | Test pin | 10 | Ground |
| 6 | Not Connected | 9 | Not Connected |
| 7 | Supply input | 8 | NTC input |

Table 2: Pinout definitions and descriptions

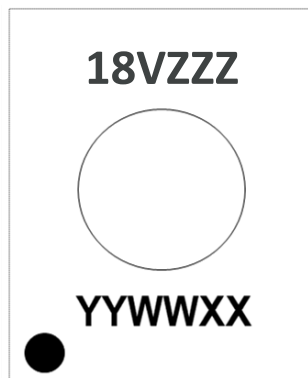


Figure 3: Package marking (top view)

| Symbol | Function / Description |
|--------|---|
| V | MEMS and ASIC traceability letter |
| ZZZ | Last 3 digits of ASIC lot number |
| YY | Year of assembly |
| WW | Calendar week of assembly |
| XX | Last 2 digits of the sensor wafer lot # |

Table 3: Package marking definition

9. General Electrical Specifications

DC Operating Parameters $T_A = -40^{\circ}\text{C}$ to 150°C

| Parameter | Symbol | Remarks | Min | Typ ⁽¹⁾ | Max | Units |
|--------------------------------|---------|--|------|----------------------|----------------------|-------------|
| Nominal supply voltage | Vdd | | 4.5 | 5 | 5.5 | V |
| Nominal supply current | Idd | No output load, no NTC connected | | 8.3 | 9.5 | mA |
| Decoupling capacitor on supply | | | | 100 | | nF |
| Supply series resistor | | Not mandatory but recommended for optimal EMC performance | 0 | 10 | 27 | Ohm |
| Capacitive load on output | | Pure capacitive load | | 2.2 | 10 | nF |
| | | CRC load circuit (C close to device + Series R + C close to connector) | | 1.1nF + 100Ω + 1.1nF | 2.2nF + 220Ω + 2.2nF | |
| Resistive load on output | | Pull-up to Vdd at receiver ⁽²⁾ | 10 | | 55 | kOhm |
| Supply programming entry level | Vdd_com | Threshold to enter communication mode | 6.2 | 7 | 7.8 | V |
| Analog POR level (rising) | | | 3.1 | 3.5 | 3.9 | V |
| Analog POR hysteresis | | | 100 | | 500 | mV |
| Digital POR level (rising) | | | 2.05 | 2.3 | 2.7 | V |
| Digital POR hysteresis | | | 10 | | 200 | mV |
| Power up time | | Time from reaching minimum allowed supply voltage of 4.5V till the first falling edge of the first SENT frame | | | 1.1 | msec |
| Response time ⁽³⁾ | | Using default filter setting PFLT = 0 and SSF = 1. Tick time = 3us and Pause Pulse enabled. For other configurations refer to Table 8 in chapter 12. | | | 3 | SENT frames |
| Pressure output noise | | Default configuration BBG-015, BBG-016 and BBG-017. Other configurations in Table 9. | | | 3 | LSB pk-pk |
| Sensing element supply voltage | VDDA | | -9% | 3.5 | +9% | V |
| Sensing element sensitivity | | | | 9 | | mV/V/bar |
| On chip temperature accuracy | | On chip PTAT temperature | -10 | | +10 | °C |
| ADC resolution | | | | 16 | | Bit |
| Input voltage range on NTC pin | | | 0 | | 3.5 | V |

¹ Typical values are defined at $T_A = +25^{\circ}\text{C}$ and $V_{DD} = 5\text{V}$.

² As specified in the SENT standard

³ Number of SENT frames between pressure step and settled output (last frame containing stable pressure data)

| Parameter | Symbol | Remarks | Min | Typ ⁽¹⁾ | Max | Units |
|-------------------------------|--------|---------|-----|--------------------|-----|-----------|
| NTC Temperature Output noise | | | | | 1 | LSB pk-pk |
| NTC Temperature range | | | -55 | | 200 | °C |
| NTC Temperature response time | | | | | 100 | msec |

Table 4: Electrical specifications

10. Detailed General Description

The MLX90818 contains a pressure sensing element which consists of a diaphragm realized in the silicon chip by wafer bonding on an etched cavity with built in reference vacuum. The diaphragm reacts to a change in absolute pressure. The internal strain increases, in particular at the border of the diaphragm. Here, the piezo-resistive elements have been implanted into the silicon diaphragm forming a Wheatstone bridge, which act as a transducer.

The electronics front end amplifies the signal from the bridge, performs a coarse offset compensation and an ADC conversion. The DSP performs the compensations over temperature. Furthermore, the digital circuit provides some filtering, the possibility to linearize the pressure signal and also implements the clamping function. This chip delivers a SENT output compliant with SAE J2716 spec dated April 2016. On one of the fast channels of the SENT message it is possible to select to transmit linearized and calibrated temperature information measured by an external NTC thermistor. An analog interface is available for the external thermistor and the 16bits DSP performs the calibration and linearization of the measured thermistor temperature.

Extensive protection of the supply lines allows the MLX90818 to handle extreme overvoltage conditions and is immune to severe external disturbances. Several diagnostic functions (over-voltage, under-voltage, overpressure, under pressure detections) have been implemented on the 90818 and can be enabled by programming EEPROM settings. Figure 4 describes MLX90818 block diagram.

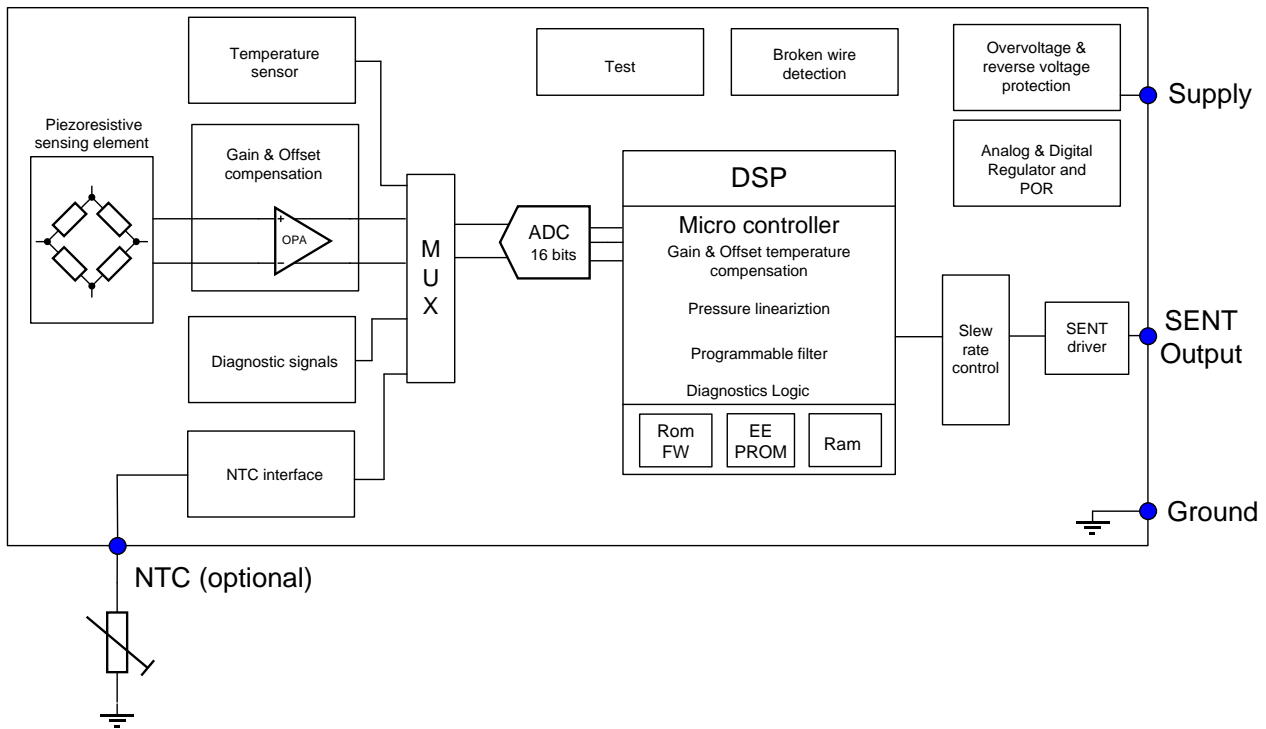


Figure 4: MLX90818 block diagram

11. Default programmed settings

The MLX90818 is calibrated at the final manufacturing test steps. During the calibration, settings are stored in the on chip EEPROM to define the pressure transfer curve. Besides pressure, the internal temperature and optionally the NTC temperature calibrations are performed. The default temperature characteristic can be found in the graph of Figure 5. The SENT parameters and the IC filter values are also configured.

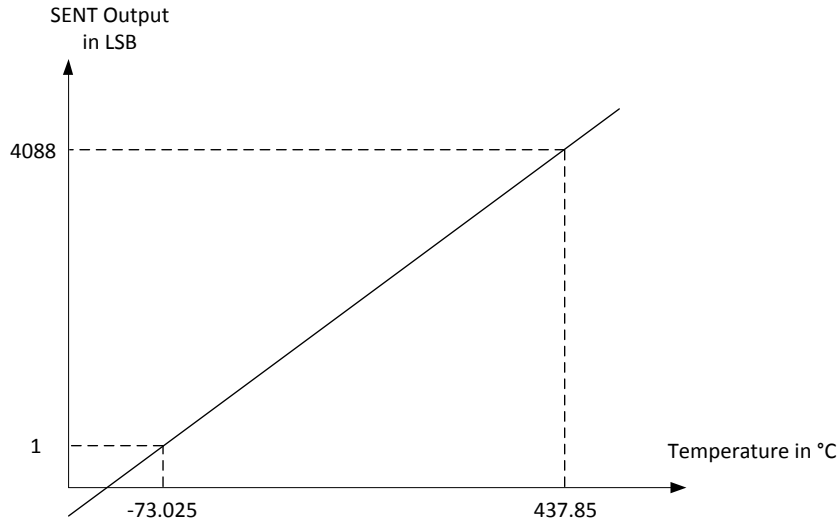


Figure 5: NTC and internal temperature transfer function

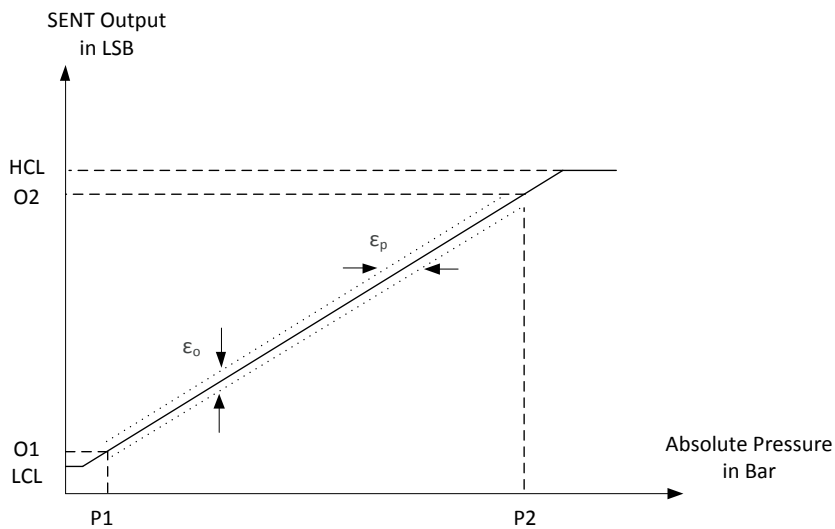


Figure 6: Pressure transfer function description at room temperature

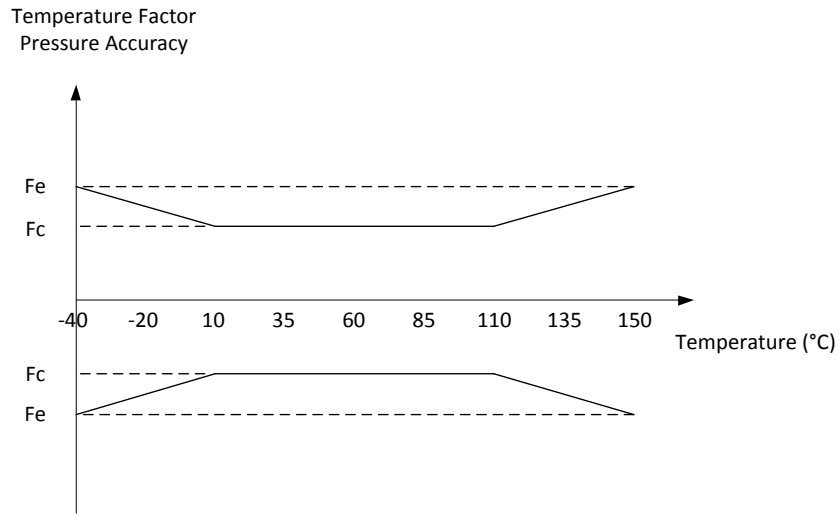


Figure 7: Pressure accuracy temperature factor

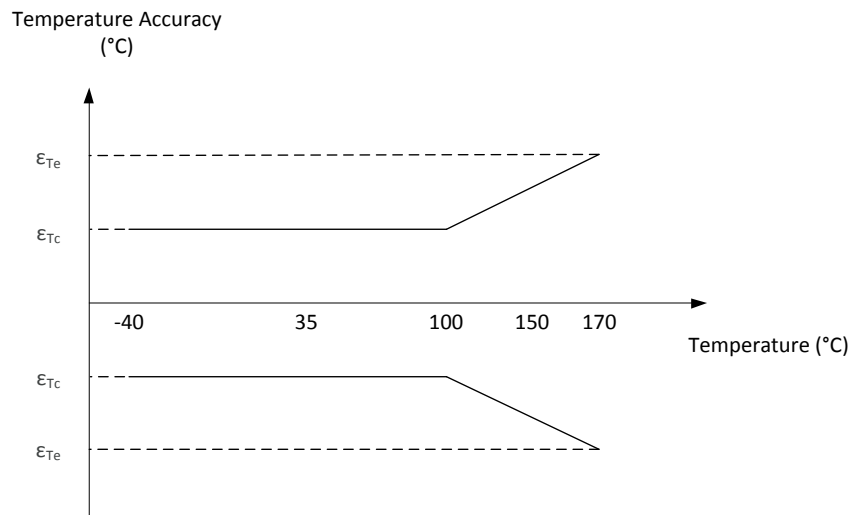


Figure 8: NTC temperature accuracy

11.1. MLX90818LXE-BBG-015

| Transfer Curve Parameter | Symbol | Remarks | Value | | | Unit |
|--------------------------------------|--------------|--|-------------|-----|-----------|------------|
| Pressure 1 | P1 | See Figure 6: Pressure transfer function description at room temperature | 0.1 | | | Bar |
| Pressure 2 | P2 | | 4 | | | Bar |
| Output 1 | O1 | | 193 | | | LSB |
| Output 2 | O2 | | 3896 | | | LSB |
| Low clamping level | LCL | | 1 | | | LSB |
| High clamping level | HCL | | 4088 | | | LSB |
| Pressure Accuracy Parameter | Symbol | Remarks | Min | Typ | Max | Unit |
| Output accuracy | ϵ_o | Overall accuracy expressed as output value (FS range from 193 to 3896) | -19 -0.5 | | 19 0.5 | LSB %FS |
| Pressure accuracy | ϵ_p | Overall accuracy expressed as pressure value | -20 | | 20 | mBar |
| Center temperature accuracy factor | Fc | See Figure 7: Pressure accuracy temperature factor | | | 1 | |
| Extended temperature accuracy factor | Fe | | | | 1.5 | |

Table 5: BBG-015 Default configuration

11.2. MLX90818LXE-BBG-016

| Transfer Curve Parameter | Symbol | Remarks | Value | | | Unit |
|--------------------------------------|-----------------|---|-------------|-----|-----------|------------|
| Pressure 1 | P1 | See Figure 6: Pressure transfer function description at room temperature | 0.1 | | | Bar |
| Pressure 2 | P2 | | 3 | | | Bar |
| Output 1 | O1 | | 193 | | | LSB |
| Output 2 | O2 | | 3896 | | | LSB |
| Low clamping level | LCL | | 1 | | | LSB |
| High clamping level | HCL | | 4088 | | | LSB |
| Pressure Accuracy Parameter | Symbol | Remarks | Min | Typ | Max | Unit |
| Output accuracy | ϵ_o | Overall accuracy expressed as output value (FS range from 193 to 3896) | -19 -0.5 | | 19 0.5 | LSB %FS |
| Pressure accuracy | ϵ_p | Overall accuracy expressed as pressure value | -15 | | 15 | mBar |
| Center temperature accuracy factor | Fc | See Figure 7: Pressure accuracy temperature factor | | | 1 | |
| Extended temperature accuracy factor | Fe | | | | 1.5 | |
| NTC Accuracy Parameter | Symbol | Remarks | Min | Typ | Max | Unit |
| Center NTC temperature accuracy | ϵ_{Tc} | Overall accuracy using the default NTC as described in Table 12 See Figure 8: NTC temperature accuracy | -1 | | 1 | °C |
| Extended NTC temperature accuracy | ϵ_{Te} | | -2 | | 2 | °C |

Table 6: BBG-016 Default Configuration

11.3. MLX90818LXE-BBG-017

| Transfer Curve Parameter | Symbol | Remarks | Value | | | Unit |
|--------------------------------------|-----------------|---|-------------|-----|-----------|------------|
| Pressure 1 | P1 | See Figure 6: Pressure transfer function description at room temperature | 0.1 | | | Bar |
| Pressure 2 | P2 | | 4 | | | Bar |
| Output 1 | O1 | | 193 | | | LSB |
| Output 2 | O2 | | 3896 | | | LSB |
| Low clamping level | LCL | | 1 | | | LSB |
| High clamping level | HCL | | 4088 | | | LSB |
| Pressure Accuracy Parameter | Symbol | Remarks | Min | Typ | Max | Unit |
| Output accuracy | ϵ_o | Overall accuracy expressed as output value (FS range from 193 to 3896) | -19 -0.5 | | 19 0.5 | LSB %FS |
| Pressure accuracy | ϵ_p | Overall accuracy expressed as pressure value | -20 | | 20 | mBar |
| Center temperature accuracy factor | Fc | See Figure 7: Pressure accuracy temperature factor | | | 1 | |
| Extended temperature accuracy factor | Fe | | | | 1.5 | |
| NTC Accuracy Parameter | Symbol | Remarks | Min | Typ | Max | Unit |
| Center NTC temperature accuracy | ϵ_{Tc} | Overall accuracy using the default NTC as described in Table 12 See Figure 8: NTC temperature accuracy | -1 | | 1 | °C |
| Extended NTC temperature accuracy | ϵ_{Te} | | -2 | | 2 | °C |

Table 7: BBG-017 Default Configuration

12. Filters

There are two filters available to filter the pressure signal. The first filter is a Small Signal Filter which can be disabled or enabled. The second filter is a first order low pass filter for the pressure signal which has a programmable depth.

An overview of the noise levels using different filter and gain combinations can be found in Table 9.

12.1. PFLT

PFLT is a programmable first order low pass filter. The depth of this filter can be selected. This filter can be configured to select the optimal trade-off between response time and output noise.

The low pass filter is implemented according to the following formula:

$$Filter_{output}(k) = \frac{Filter_{input}(k) - Filter_{output}(k - 1)}{2^{PFLT}} + Filter_{output}(k - 1)$$

The PFLT parameter in the formula is set in EEPROM and can have a value between 0 and 9. An overview of typical response times when applying a step on the input using different PFLT filter settings can be found in Table 8. The number of SENT frames indicated in the table includes the last frame which contains stable pressure data. Filter setting 0 disables the PFLT.

| PFLT setting | Response time in SENT frames ⁽⁴⁾ |
|--------------|---|
| 0 | 3 |
| 1 | 3 |
| 2 | 4 |
| 3 | 7 |
| 4 | 13 |
| 5 | 23 |
| 6 | 45 |
| 7 | 88 |
| 8 | 173 |
| 9 | 346 |

Table 8: Filter settings with corresponding typical response times

12.2. SSF

The SSF (Small Signal Filter) is a digital filter which is designed not to have an impact on the response time of a fast changing pressure signal like a pressure step. When a large signal change at the input is present, the filter is bypassed and not filtering the signal. For small signal changes, which are in most cases noise, the filter is used and filtering the pressure signal.

⁴ Tick time is set to 3µs and Pause Pulse is enabled.

The Small Signal Filter can be enabled or disabled in EEPROM. It is advised not to use the SSF in combination with the PFLT enabled.

| Analog front end gain (CG) | Digital gain (G0) | PFLT setting | SSF | Noise (LSB pk-pk) |
|----------------------------|-------------------|--------------|-----|-------------------|
| 0 | 10000 | 0 | 1 | 2 |
| 0 | 10000 | 1 | 0 | 2 |
| 0 | 10000 | 4 | 0 | 1 |
| 0 | 10000 | 9 | 0 | 1 |
| 0 | 17000 | 0 | 1 | 2 |
| 0 | 17000 | 1 | 0 | 2 |
| 0 | 17000 | 4 | 0 | 1 |
| 0 | 17000 | 9 | 0 | 0 |
| 0 | 30000 | 0 | 1 | 4 |
| 0 | 30000 | 1 | 0 | 3 |
| 0 | 30000 | 4 | 0 | 2 |
| 0 | 30000 | 9 | 0 | 1 |
| 10 | 10000 | 0 | 1 | 3 |
| 10 | 10000 | 1 | 0 | 2 |
| 10 | 10000 | 4 | 0 | 1 |
| 10 | 10000 | 9 | 0 | 0 |
| 10 | 17000 | 0 | 1 | 4 |
| 10 | 17000 | 1 | 0 | 4 |
| 10 | 17000 | 4 | 0 | 2 |
| 10 | 17000 | 9 | 0 | 1 |
| 10 | 30000 | 0 | 1 | 5 |
| 10 | 30000 | 1 | 0 | 5 |
| 10 | 30000 | 4 | 0 | 3 |
| 10 | 30000 | 9 | 0 | 1 |
| 31 | 10000 | 0 | 1 | 8 |
| 31 | 10000 | 1 | 0 | 8 |
| 31 | 10000 | 4 | 0 | 6 |
| 31 | 10000 | 9 | 0 | 3 |
| 31 | 17000 | 0 | 1 | 12 |
| 31 | 17000 | 1 | 0 | 11 |
| 31 | 17000 | 4 | 0 | 10 |
| 31 | 17000 | 9 | 0 | 4 |
| 31 | 30000 | 0 | 1 | 41 |
| 31 | 30000 | 1 | 0 | 38 |
| 31 | 30000 | 4 | 0 | 15 |
| 31 | 30000 | 9 | 0 | 8 |

Table 9: Filter settings and gain combinations with corresponding pressure noise values

13. Analog Front End

The analog front end of the MLX90818 consists of a chopping stage and 3 amplification stages as can be seen in Figure 9. There are also several input diagnostics integrated into this front end to be able to detect a broken InP or InN connection or an input which is out of range. This diagnostic information is transferred to the microcontroller to handle further action for example flagging a diagnostic message.

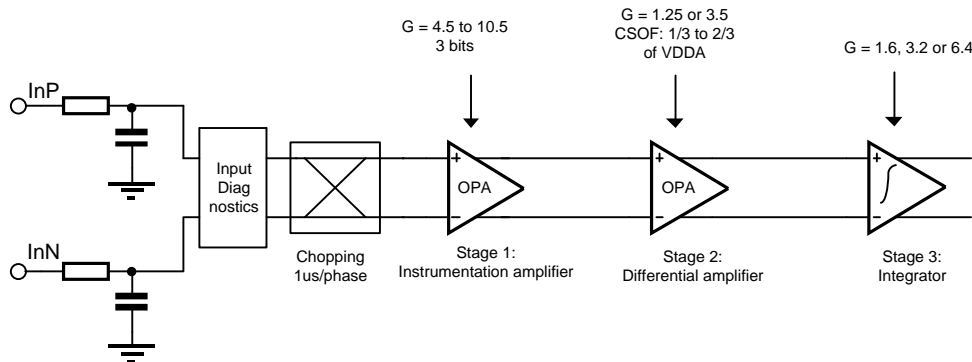


Figure 9: Analog front end block diagram

The first stage is an instrumentation amplifier of which the gain can be programmed using 3 bits to cover a gain range between 4.5 and 10.6.

Transfer equation:

$$\text{OUTP1} - \text{OUTN1} = \text{Gst1} * (\text{InP} - \text{InN}) \text{ in phase 1}$$

$$\text{OUTP1} - \text{OUTN1} = \text{Gst1} * (\text{InN} - \text{InP}) \text{ in phase 2}$$

The second stage is a fully differential amplifier. The gain of the amplifier can be calibrated using 1 bit.

Transfer equation:

$$\text{OUTP2} - \text{OUTN2} = -\text{Gst2} * (\text{OUTP1} - \text{OUTN1}) - \text{Gst2} * (\text{CSOF1} - \text{CSOF2}) \text{ in phase 1}$$

$$\text{OUTP2} - \text{OUTN2} = -\text{Gst2} * (\text{OUTN1} - \text{OUTP1}) - \text{Gst2} * (\text{CSOF2} - \text{CSOF1}) \text{ in phase 2}$$

The CSOF1 and CSOF2 signals are generated by the coarse offset DAC with the following transfer functions:

$$\text{CSOF1} = \frac{\text{VDDA}}{2} + (-1)^{\text{CO7}} * \left(\frac{2}{3} - \frac{1}{3} \right) * \frac{\text{VDDA}}{2} * \frac{\text{CO}[6:0]}{127}$$

$$\text{CSOF2} = \frac{\text{VDDA}}{2} - (-1)^{\text{CO7}} * \left(\frac{2}{3} - \frac{1}{3} \right) * \frac{\text{VDDA}}{2} * \frac{\text{CO}[6:0]}{127}$$

CO[6:0] fixes the DAC output. CO7 is used for the polarity.

The third stage is an integrator which is controlled using 2 bits to set a gain between 1.6 and 6.4

Transfer equation at the outputs of the amplifier:

$$\text{OUTP3} - \text{OUTN3} = -N * (\text{C1}/\text{C2}) * (\text{OUTP2} - \text{OUTN2})$$

$$\text{OUTP3_common_mode} \text{ and } \text{OUTN3_common_mode} = \text{VCM} = \text{VDDA}/2$$

In this equation N represents the number of integration cycles which is a fixed value of N = 40.

C2 is a fixed feedback capacitor of approximately 5pF. C1 can have 3 different values: 0.2pF, 0.4pF or 0.8pF.

Transfer equation after the ADC:

$$\text{Pressure_ADC} = ((\text{OUTN3} - \text{OUTP3}) * 2^{16} / \text{VDDA}) + 32768$$

An overview of all possible values for Gst1, Gst2 and Gst3 can be found in Table 10 below.
The input stage is designed to work with an input common-mode voltage range between 42%Vbrg and 58%Vbrg.

| Gain setting [-] | Gst1 [V/V] | Gst2 [V/V] | Gst3 [V/V] | Total gain [V/V] | FS Differential Input Signal [mV] |
|---------------------|---------------|---------------|---------------|---------------------|--------------------------------------|
| 0 | 4.49 | -1.25 | 1.6 | -9.0 | ± 195 |
| 1 | 5.06 | -1.25 | 1.6 | -10.1 | ± 173 |
| 2 | 5.8 | -1.25 | 1.6 | -11.6 | ± 151 |
| 3 | 6.52 | -1.25 | 1.6 | -13.0 | ± 134 |
| 4 | 7.43 | -1.25 | 1.6 | -14.9 | ± 118 |
| 5 | 8.37 | -1.25 | 1.6 | -16.7 | ± 105 |
| 6 | 9.35 | -1.25 | 1.6 | -18.7 | ± 94 |
| 7 | 10.6 | -1.25 | 1.6 | -21.2 | ± 83 |
| 8 | 4.49 | -3.5 | 1.6 | -25.1 | ± 70 |
| 9 | 5.06 | -3.5 | 1.6 | -28.3 | ± 62 |
| 10 | 5.8 | -3.5 | 1.6 | -32.5 | ± 54 |
| 11 | 6.52 | -3.5 | 1.6 | -36.5 | ± 48 |
| 12 | 7.43 | -3.5 | 1.6 | -41.6 | ± 42 |
| 13 | 8.37 | -3.5 | 1.6 | -46.9 | ± 37 |
| 14 | 9.35 | -3.5 | 1.6 | -52.4 | ± 33 |
| 15 | 10.6 | -3.5 | 1.6 | -59.4 | ± 29 |
| 16 | 4.49 | -3.5 | 3.2 | -50.3 | ± 35 |
| 17 | 5.06 | -3.5 | 3.2 | -56.7 | ± 31 |
| 18 | 5.8 | -3.5 | 3.2 | -65.0 | ± 27 |
| 19 | 6.52 | -3.5 | 3.2 | -73.0 | ± 24 |
| 20 | 7.43 | -3.5 | 3.2 | -83.2 | ± 21 |
| 21 | 8.37 | -3.5 | 3.2 | -93.7 | ± 19 |
| 22 | 9.35 | -3.5 | 3.2 | -104.7 | ± 17 |
| 23 | 10.6 | -3.5 | 3.2 | -118.7 | ± 15 |
| 24 | 4.49 | -3.5 | 6.4 | -100.6 | ± 17 |
| 25 | 5.06 | -3.5 | 6.4 | -113.3 | ± 15 |
| 26 | 5.8 | -3.5 | 6.4 | -129.9 | ± 13 |
| 27 | 6.52 | -3.5 | 6.4 | -146.0 | ± 12 |
| 28 | 7.43 | -3.5 | 6.4 | -166.4 | ± 11 |
| 29 | 8.37 | -3.5 | 6.4 | -187.5 | ± 9 |
| 30 | 9.35 | -3.5 | 6.4 | -209.4 | ± 8 |
| 31 | 10.6 | -3.5 | 6.4 | -237.4 | ± 7 |

Table 10: Gain and input signal range of the analog front end

14. ADC

The 16 bit differential ADC has a range from $-VDDA/2$ to $+VDDA/2$.

There are 7 different ADC channels. Channel 0 is not used. Table 11 below describes all the channels.

| ADC | Signal | Remarks |
|----------|---------|--|
| SIN[2:0] | | |
| 0 | - | Nothing connected |
| 1 | P | Pressure |
| 2 | Tint | Internal Temperature |
| 3 | Vsup | External Supply |
| 4 | InP/InN | Multiplexing between Positive/Negative Sensor Output |
| 5 | Vdig | Digital Regulator |
| 6 | Tntc | NTC Output |
| 7 | VBE | Internal Voltage |

Table 11: ADC channels

The different channels are converted in a constantly repeating sequence at a rate of $50\mu\text{sec}$ for each individual conversion. The order is shown in Figure 10 below.

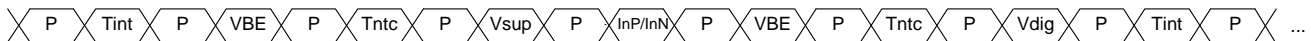


Figure 10: ADC sequence

15. Digital

The digital is built around a 16-bit microcontroller. It contains besides the processor also ROM, RAM and EEPROM and a set of user and system IO registers.

Temperature compensation of the pressure signal and pressure linearization is handled by the microcontroller. For the pressure compensation there are EEPROM parameters allocated to be able to cover a large variety of calibration approaches.

Both for gain and offset of the pressure signal, there is a separate temperature dependency programmable ranging from a temperature independence to a first order, second order and finally a third order compensation. This is reflected in EEPROM parameters for the offset (O0, O1, O2 and O3) and for the gain (G0, G1, G2 and G3). If required, the linearity of the pressure signal can also be compensated without a temperature dependency or with a first order temperature dependency through EEPROM parameters L0 and L1.

Linearization of the NTC temperature is also covered partially by the microcontroller. More information in this topic can be found in chapter 16.

16. NTC Temperature Linearization

The linearization of the NTC temperature signal is split up in several stages. A schematic overview of these steps can be seen in Figure 11.

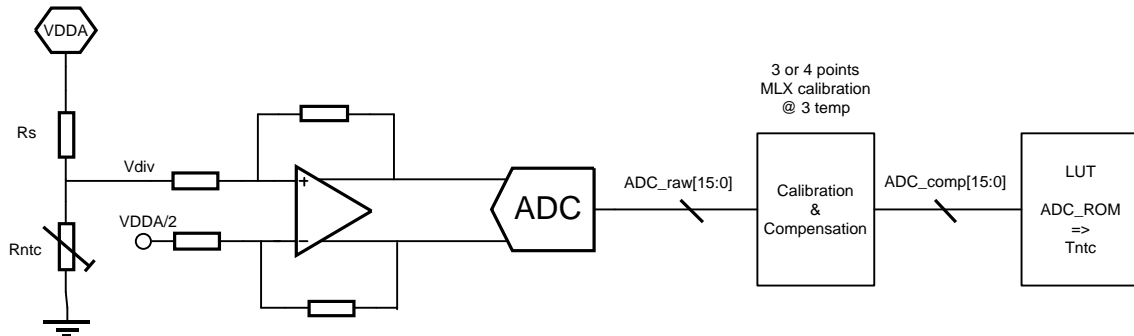


Figure 11: Block diagram NTC linearization

The complete system can be divided into 5 separate stages.

1. A resistor divider with internal resistor R_s is used to linearize R_{ntc} into a voltage.
2. A fully differential amplifier with unity gain is used to drive the ADC.
3. The 16-bit ADC is being used to convert the analog resistor divider output voltage into a digital signal called ADC_raw .
4. With the help of calibration data saved in EEPROM the microcontroller will perform a first compensation on ADC_raw converting in to ADC_comp . This new value is targeted to be as close as possible to the value ADC_ROM .
5. Finally a look up table (LUT) will be used to convert the ADC_ROM values into the T_{ntc} value which is the desired linearized NTC temperature.

The default NTC characteristic which is calibrated on option codes BBG-016 and BBG-017 can be found in Table 12. When using an NTC which does not match the coefficients described above, it is advised to contact Melexis.

The EEPROM coefficients which are used for the conversion from ADC_raw to ADC_comp are N_0 to N_3 , $N_0_Diff_Low$ to $N_3_Diff_Low$, $N_0_Diff_High$ to $N_3_Diff_High$ and $TEMP1$ to $TEMP3$.

| T (°C) | R _T /R ₂₅ | R (Ω) | T (°C) | R _T /R ₂₅ | R (Ω) |
|--------|---------------------------------|---------|--------|---------------------------------|---------|
| -55 | 53.68 | 268400 | 75 | 0.18779 | 938.95 |
| -50 | 39.112 | 195560 | 80 | 0.16261 | 813.05 |
| -45 | 28.817 | 144085 | 85 | 0.14131 | 706.55 |
| -40 | 21.459 | 107295 | 90 | 0.12324 | 616.2 |
| -35 | 16.142 | 80710 | 95 | 0.10783 | 539.15 |
| -30 | 12.259 | 61295 | 100 | 0.094663 | 473.315 |
| -25 | 9.3959 | 46979.5 | 105 | 0.083361 | 416.805 |
| -20 | 7.2644 | 36322 | 110 | 0.073638 | 368.19 |
| -15 | 5.6633 | 28316.5 | 115 | 0.06524 | 326.2 |
| -10 | 4.4503 | 22251.5 | 120 | 0.057964 | 289.82 |
| -5 | 3.5236 | 17618 | 125 | 0.05164 | 258.2 |
| 0 | 2.8102 | 14051 | 130 | 0.046128 | 230.64 |
| 5 | 2.2567 | 11283.5 | 135 | 0.041309 | 206.545 |
| 10 | 1.8243 | 9121.5 | 140 | 0.037085 | 185.425 |
| 15 | 1.4841 | 7420.5 | 145 | 0.033373 | 166.865 |
| 20 | 1.2147 | 6073.5 | 150 | 0.030102 | 150.51 |
| 25 | 1 | 5000 | 155 | 0.027213 | 136.065 |
| 30 | 0.82785 | 4139.25 | 160 | 0.024654 | 123.27 |
| 35 | 0.689 | 3445 | 165 | 0.022384 | 111.92 |
| 40 | 0.57639 | 2881.95 | 170 | 0.020364 | 101.82 |
| 45 | 0.48457 | 2422.85 | 175 | 0.018564 | 92.82 |
| 50 | 0.40931 | 2046.55 | 180 | 0.016955 | 84.775 |
| 55 | 0.34731 | 1736.55 | 185 | 0.015515 | 77.575 |
| 60 | 0.29599 | 1479.95 | 190 | 0.014223 | 71.115 |
| 65 | 0.25332 | 1266.6 | 195 | 0.013063 | 65.315 |
| 70 | 0.21768 | 1088.4 | 200 | 0.012017 | 60.085 |

Table 12: Default NTC characteristic

17. SENT Configuration

The SENT output is designed to be compliant with the SAE J2716 rev. Apr 2016 SENT standard. The tick time is configurable in EEPROM using parameter TICK_DIV. The available tick time settings are 3us, 4us, 6us, 10us, 12us and 16us. A pause pulse can also be enabled to have a fixed frame length of 282 ticks. This can be done using parameter PAUSE.

In the default configuration a tick time of 3us is selected and the pause pulse is enabled.

17.1. Fast Channel Configuration

On the fast channel, 8 different options are available to configure channel 1 and channel 2. An overview of these different options and how to configure them can be found in Table 13.

| # | FC_CFG setting | Fast Channel 1 | Fast Channel 2 | Remark | Default Configuration ⁽⁵⁾ |
|---|----------------|--|--|---|--------------------------------------|
| 1 | 0 | Pressure (3x 4 bit) | Inverse of Pressure (3x 4 bit) | | |
| 2 | 1 | Pressure (3x 4 bit) | Rolling counter (2x 4 bit) and inverse of MSN of Pressure (1x 4 bit) | | BBG-015 |
| 3 | 2 | Pressure (3x 4 bit) | Medium temperature (3x 4 bit) | NTC temperature | BBG-016, BBG-017 |
| 4 | 3 | Pressure (3x 4 bit) | Internal temperature (3x 4 bit) | PTAT temperature | |
| 5 | 4 | Pressure only (3x 4 bit) | / | | |
| 6 | 5 | Pressure only (4x 3 bit) | / | | |
| 7 | 6 | Data indicated by pointer 1 (3x 4 bit) | Data indicated by pointer 2 (3x 4 bit) | In this mode no diagnostics are available. FC configuration only used by Melexis. | |
| 8 | 7 | Pressure (3x 4 bit) | 0 (3x 4 bit) | | |

Table 13: Fast channel configuration options

The selection of the fast channel output mode can be done by changing the parameter 'FC_CFG' in the EEPROM.

17.2. Slow Channel Configuration

The Slow Serial Channel is implemented according to the Enhanced Serial Message Format using 12 bit data and 8 bit message ID as described in the reference SENT protocol standard SAE J2716 rev. Apr 2016.

An overview of the different slow channel messages which are available in the MLX90818 can be found in Table 14. From this table 16 messages can be configured completely in EEPROM. The 12 bit data content of these messages can be configured freely. The ID of programmable message PR0, PR1, PR2 and PR3 is copied from EEPROM (2x 4 bit). The ID of PR5 is 1 bit higher than of PR4. The same is valid for the other pairs: PR6-7, PR8-9, ..., PR14-15. This programmable ID is indicated in Table 14 as 0xYZ.

All programmable messages can also be enabled and disabled, but not all independently of each other:

- PR0, PR1, PR2 and PR3 can be each independently enabled or disabled
- PR4 and PR5 are together enabled or disabled
- PR6 and PR7 are together enabled or disabled
- PR8, PR9, PR10 and PR11 are together enabled or disabled
- PR12, PR13, PR14 and PR15 are together enabled or disabled

⁵ MLX90818 Option Code default configuration

| # | Type | ID | Description | Data | Rep |
|----|--------|------|-------------------------------------|---|-----|
| 0 | RAM | 0x01 | Diagnostic codes | Error_flags (See chapter 0 Diagnostics) | Y |
| 1 | EEPROM | 0x03 | Sensor Type | Configurable 0 to 15 | N |
| 2 | EEPROM | 0x04 | Configuration code | Configurable 0 to 4095 | N |
| 3 | EEPROM | 0x05 | Manufacturer Code | Configurable 0 to 4095 | N |
| 4 | RAM | 0x06 | SENT revision | Selectable by bit in EEPROM Data = 3 or 4 | N |
| 5 | RAM | 0x07 | Fast channel 1 Characteristic X1 | Fast channel 1 Characteristic Configuration Enable / disable shared with MID08 | N |
| 6 | RAM | 0x08 | Fast channel 1 Characteristic X2 | Fast channel 1 Characteristic Configuration Enable / disable shared with MID07 | N |
| 7 | EEPROM | 0xYZ | Fully Programmable message 0 | Programmable ID: 8 bit Programmable Data: 12 bit | N |
| 8 | RAM | 0x23 | Internal Temperature | According to default linear temperature transfer characteristic in SAE J2716 standard | Y |
| 9 | RAM | 0x09 | Fast channel 1 Characteristic Y1 | Fast channel 1 Characteristic Configuration Enable / disable shared with MID0A | N |
| 10 | RAM | 0x0A | Fast channel 1 Characteristic Y2 | Fast channel 1 Characteristic Configuration Enable / disable shared with MID09 | N |
| 11 | ROM | 0x0B | Fast channel 2 Characteristic X1 | If FC2 is pressure (FC_CFG = 0): ID0B = ID07 If FC2 is temperature (FC_CFG = 2 or 3): Default temperature Characteristic X1: Fixed value: 233 Enable / disable shared with MID0C / 0D / 0E | N |
| 12 | ROM | 0x0C | Fast channel 2 Characteristic X2 | If FC2 is pressure (FC_CFG = 0): ID0C = ID08 If FC2 is temperature (FC_CFG = 2 or 3): Default temperature Characteristic X2: Fixed value: 423 Enable / disable shared with MID0B / 0D / 0E | N |
| 13 | ROM | 0x0D | Fast channel 2 Characteristic Y1 | If FC2 is pressure (FC_CFG = 0): ID0D = ID09 If FC2 is temperature (FC_CFG = 2 or 3): Default temperature Characteristic Y1: Fixed value: 264 Enable / disable shared with MID0B / 0C / 0E | N |
| 14 | ROM | 0x0E | Fast channel 2 Characteristic Y2 | If FC2 is pressure (FC_CFG = 0): ID0E = ID0A If FC2 is temperature (FC_CFG = 2 or 3): Default temperature Characteristic Y2: Fixed value: 1784 Enable / disable shared with MID0B / 0C / 0D | N |
| 15 | EEPROM | 0x29 | Sensor ID #1 | Programmable Data: 12 bit Enable / disable shared with MID2A / 2B / 2C | N |
| 16 | EEPROM | 0xYZ | Fully Programmable message 1 | Programmable ID: 8 bit Programmable Data: 12 bit | N |

| # | Type | ID | Description | Data | Rep |
|----|--------|------|------------------------------|---|-----|
| 17 | EEPROM | 0x2A | Sensor ID #2 | Programmable Data: 12 bit Enable / disable shared with MID29 / 2B / 2C | N |
| 18 | EEPROM | 0x2B | Sensor ID #3 | Programmable Data: 12 bit Enable / disable shared with MID29 / 2A / 2C | N |
| 19 | EEPROM | 0x2C | Sensor ID #4 | Programmable Data: 12 bit Enable / disable shared with MID29 / 2A / 2B | N |
| 20 | EEPROM | 0xYZ | Fully Programmable message 2 | Programmable ID: 8 bit Programmable Data: 12 bit | N |
| 21 | EEPROM | 0xYZ | Fully Programmable message 3 | Programmable ID: 8 bit Programmable Data: 12 bit | N |
| 22 | EEPROM | 0xYZ | Programmable message 4 | Programmable ID: 8 bit Programmable Data: 12 bit Enable / disable shared with programmable message 5 | N |
| 23 | EEPROM | 0xYZ | Programmable message 5 | Message ID = ID programmable message 4 + 1 Programmable Data: 12 bit Enable / disable shared with programmable message 4 | N |
| 24 | EEPROM | 0xYZ | Programmable message 6 | Programmable ID: 8 bit Programmable Data: 12 bit Enable / disable shared with programmable message 7 | N |
| 25 | EEPROM | 0xYZ | Programmable message 7 | Message ID = ID programmable message 6 + 1 Programmable Data: 12 bit Enable / disable shared with programmable message 6 | N |
| 26 | EEPROM | 0xYZ | Programmable message 8 | Programmable ID: 8 bit Programmable Data: 12 bit Enable / disable shared with programmable messages 9 / 10 / 11 | N |
| 27 | EEPROM | 0xYZ | Programmable message 9 | Message ID = ID programmable message 8 + 1 Programmable Data: 12 bit Enable / disable shared with programmable messages 8 / 10 / 11 | N |
| 28 | EEPROM | 0xYZ | Programmable message 10 | Programmable ID: 8 bit Programmable Data: 12 bit Enable / disable shared with programmable messages 8 / 9 / 11 | N |
| 29 | EEPROM | 0xYZ | Programmable message 11 | Message ID = ID programmable message 10 + 1 Programmable Data: 12 bit Enable / disable shared with programmable messages 8 / 9 / 10 | N |

| # | Type | ID | Description | Data | Rep |
|----|--------|------|-------------------------|---|-----|
| 30 | EEPROM | 0xYZ | Programmable message 12 | Programmable ID: 8 bit Programmable Data: 12 bit Enable / disable shared with programmable messages 13 / 14 / 15 | N |
| 31 | EEPROM | 0xYZ | Programmable message 13 | Message ID = ID programmable message 12 + 1 Programmable Data: 12 bit Enable / disable shared with programmable messages 12 / 14 / 15 | N |
| 32 | EEPROM | 0xYZ | Programmable message 14 | Programmable ID: 8 bit Programmable Data: 12 bit Enable / disable shared with programmable messages 12 / 13 / 15 | N |
| 33 | EEPROM | 0xYZ | Programmable message 15 | Message ID = ID programmable message 14 + 1 Programmable Data: 12 bit Enable / disable shared with programmable messages 12 / 13 / 14 | N |
| 34 | RAM | 0x10 | Medium Temperature | According to default linear temperature transfer characteristic in SAE J2716 standard | Y |
| 35 | RAM | 0xE1 | Device start-up check | Start-up self-check result data | N |

Table 14: Slow channel messages

Messages which have a “Y” in the column Rep of Table 14 can be selected to have a higher occurrence in the slow channel message sequence. Their repetition rate can be configured as indicated in Table 15. The repeatable messages MID01h, MID10h and MID23h can be configured individually to have their own repetition rate. The repetition factor setting can be done in respectively “SENT_REP_FACT_ID_01”, “SENT_REP_FACT_ID_10” and “SENT_REP_FACT_ID_23”.

| Repetition Factor Setting | Real Repetition Factor |
|---------------------------|----------------------------------|
| 0 | Message repetition disabled |
| 1 | Message repeat every 2 messages |
| 2 | Message repeat every 3 messages |
| 3 | Message repeat every 4 messages |
| 4 | Message repeat every 5 messages |
| 5 | Message repeat every 6 messages |
| 6 | Message repeat every 7 messages |
| 7 | Message repeat every 8 messages |
| 8 | Message repeat every 9 messages |
| 9 | Message repeat every 10 messages |
| 10 | Message repeat every 12 messages |
| 11 | Message repeat every 16 messages |
| 12 | Message repeat every 20 messages |
| 13 | Message repeat every 24 messages |
| 14 | Message repeat every 28 messages |
| 15 | Message repeat every 30 messages |

Table 15: Repetition rate settings

Absolute Pressure Sensor

Once a message is configured to be repeatable, it will automatically have the highest priority. Therefore it will appear first in the slow message sequence.

The priority order between MID01, MID10 and MID23 can also be configured using EEPROM parameter “SC_R_O”:

- SC_R_O = 0: Priority order: ID01h > ID10h > ID23h (default setting)
- SC_R_O = 1: Priority order: ID10h > ID23h > ID01h

An overview of the default slow channel configurations for our different option codes can be found in Table 16.

| Option code | Info | 0 0x01 | 1 0x03 | 2 0x04 | 3 0x05 | 4 0x06 | 5 0x07 | 6 0x08 | 7 0xYZ | 8 0x23 | 9 0x09 | 10 0x0A | 11 0x0B |
|-------------|---------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|------------|------------|
| BBG-015 | Enabled | Rep 6 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ |
| | ID | 0x01 | 0x03 | 0x04 | 0x05 | 0x06 | 0x07 | 0x08 | 0x81 | 0x23 | 0x09 | 0x0A | |
| | Data | Diag. | 0x004 | 0x000 | 0x006 | 0x004 | 0x053 | 0x144 | 0x000 | Temp. | 0x0C1 | 0xF38 | |
| BBG-016 | Enabled | Rep 6 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ |
| | ID | 0x01 | 0x03 | 0x04 | 0x05 | 0x06 | 0x07 | 0x08 | 0x81 | 0x23 | 0x09 | 0x0A | |
| | Data | Diag. | 0x007 | 0x000 | 0x006 | 0x004 | 0x053 | 0x0F4 | 0x000 | Temp. | 0x0C1 | 0xF38 | |
| BBG-017 | Enabled | Rep 6 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ |
| | ID | 0x01 | 0x03 | 0x04 | 0x05 | 0x06 | 0x07 | 0x08 | 0x81 | 0x23 | 0x09 | 0x0A | |
| | Data | Diag. | 0x007 | 0x000 | 0x006 | 0x004 | 0x053 | 0x144 | 0x000 | Temp. | 0x0C1 | 0xF38 | |

| Option code | Info | 12 0x0C | 13 0x0D | 14 0x0E | 15 0x29 | 16 0xYZ | 17 0x2A | 18 0x2B | 19 0x2C | 20 0xYZ | 21 0xYZ | 22 0xYZ | 23 0xYZ |
|-------------|---------|------------|------------|------------|-------------------|------------|-------------------|-------------------|-------------------|------------|------------|------------|------------|
| BBG-015 | Enabled | ✗ | ✗ | ✗ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✓ | ✓ |
| | ID | | | | 0x29 | 0x80 | 0x2A | 0x2B | 0x2C | 0x81 | | 0x90 | 0x91 |
| | Data | | | | ID ⁽⁶⁾ | 0x000 | ID ⁽⁶⁾ | ID ⁽⁶⁾ | ID ⁽⁶⁾ | 0x000 | | 0x000 | 0x000 |
| BBG-016 | Enabled | ✗ | ✗ | ✗ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✓ | ✓ |
| | ID | | | | 0x29 | 0x80 | 0x2A | 0x2B | 0x2C | 0x81 | | 0x90 | 0x91 |
| | Data | | | | ID ⁽⁶⁾ | 0x000 | ID ⁽⁶⁾ | ID ⁽⁶⁾ | ID ⁽⁶⁾ | 0x000 | | 0x000 | 0x000 |
| BBG-017 | Enabled | ✗ | ✗ | ✗ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✓ | ✓ |
| | ID | | | | 0x29 | 0x80 | 0x2A | 0x2B | 0x2C | 0x81 | | 0x90 | 0x91 |
| | Data | | | | ID ⁽⁶⁾ | 0x000 | ID ⁽⁶⁾ | ID ⁽⁶⁾ | ID ⁽⁶⁾ | 0x000 | | 0x000 | 0x000 |

| Option code | Info | 24 0xYZ | 25 0xYZ | 26 0xYZ | 27 0xYZ | 28 0xYZ | 29 0xYZ | 30 0xYZ | 31 0xYZ | 32 0xYZ | 33 0xYZ | 34 0x10 | 35 0xE1 |
|-------------|---------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
| BBG-015 | Enabled | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ |
| | ID | 0x92 | 0x93 | 0x94 | 0x95 | 0x96 | 0x97 | | | | | | |
| | Data | 0x000 | 0x000 | 0x000 | 0x000 | 0x000 | 0x000 | | | | | | |
| BBG-016 | Enabled | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ |
| | ID | 0x92 | 0x93 | 0x94 | 0x95 | 0x96 | 0x97 | | | | | | |
| | Data | 0x000 | 0x000 | 0x000 | 0x000 | 0x000 | 0x000 | | | | | | |
| BBG-017 | Enabled | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ |
| | ID | 0x92 | 0x93 | 0x94 | 0x95 | 0x96 | 0x97 | | | | | | |
| | Data | 0x000 | 0x000 | 0x000 | 0x000 | 0x000 | 0x000 | | | | | | |

Table 16: Default configuration slow channel messages

⁶ The ID available in the data of slow channel messages 0x29 – 0x2C is a unique sensor ID

18. Wrong Connections Overview

Table 17 provides an overview of the behavior of the MLX90818 when different combinations of connections to GND, VDD and OUT are made.

| GND | VDD | SENT out | Effect on output | Action after wrong connection |
|--------------|--------------|---------------------------|------------------------|-------------------------------|
| 0V | 5V | SAE Standard Load Circuit | Normal operation | Normal operation |
| Disconnected | 5V | SAE Standard Load Circuit | No communication | Normal operation |
| 0V | Disconnected | SAE Standard Load Circuit | No communication | Normal operation |
| 0V | 5V | Disconnected | No communication | Normal operation |
| 0V | 5V | 0V | 0V – No communication | Normal operation |
| 0V | 5V | 5V | 5V – No communication | Normal operation |
| 0V | 5V | 18V | 18V – No communication | Normal operation |
| 0V | 0V | SAE Standard Load Circuit | No communication | Normal operation |
| 0V | 18V | SAE Standard Load Circuit | No communication | Normal operation |
| 5V | 5V | SAE Standard Load Circuit | No communication | Normal operation |
| 5V | 0V | SAE Standard Load Circuit | No communication | Normal operation |

Table 17: Wrong connections overview

19. Diagnostics

19.1. Input Diagnostics

An overview of the different sensing element diagnostics conditions and their corresponding fast channel mapping and diagnostic bit information in slow channel can be found in Table 18.

| Condition | Fast Channel Code | Error ⁽⁷⁾ |
|--|-------------------|----------------------|
| Sensing element supply disconnected | 4090 | ERROR_SPSN |
| Sensing element GND disconnected | 4090 | ERROR_SPSN |
| Sensing element P output disconnected | 4090 | ERROR_PRESS_BROKEN_W |
| Sensing element N output disconnected | 4090 | ERROR_PRESS_BROKEN_W |
| Sensing element supply shorted to GND | 4090 | ERROR_SPSN |
| Sensing element P output shorted to GND | 4090 | ERROR_SPSN |
| Sensing element N output shorted to GND | 4090 | ERROR_SPSN |
| Sensing element P output shorted to Vbrg | 4090 | ERROR_SPSN |
| Sensing element N output shorted to Vbrg | 4090 | ERROR_SPSN |

Table 18: Input diagnostics

19.2. Diagnostic Sources

The MLX90818 product has several internal checks which monitor the status of device. These checks or diagnostic sources can be enabled or disabled based on the sensor module requirements. An overview of the different diagnostic sources, their enable/disable parameter and the explanation of their functionality can be found below in table Table 19.

| Bit | Parameter | Error condition |
|-----|--------------|---|
| 10 | ERR_EN_TINT | The Internal temperature could not be measured/calculated |
| 9 | ERR_EN_IO | RAM configuration error |
| 8 | ERR_EN_SPSN | SP or SN pin voltage out of range |
| 7 | ERR_EN_PV | The pressure value could not be measured/calculated |
| 6 | ERR_EN_PP | Pressure parameter error |
| 5 | ERR_EN_BW | A broken wire is detected in the pressure sensor path |
| 4 | ERR_EN_TMED | The Medium temperature could not be measured/calculated |
| 3 | ERR_EN_VDIG | The digital voltage is out of range |
| 2 | ERR_EN_VSUPH | The supply voltage is too high |
| 1 | ERR_EN_VSUPL | The supply voltage is too low |
| 0 | ERR_EN_TCHIP | The chip temperature out of range |

Table 19: Diagnostic sources

⁷ See tables 21 to 23 for more information on the errors

19.3. Fast and Slow Channel Diagnostics

There are two values reserved to show an error diagnostic mode in the fast channel. These values are 4090 and 4091. According to the type of diagnostic flag, one of the values will be transmitted if enabled. Internal errors like for example PRESS_BROKEN_W or PRESS_PAR use 4090 to indicate an error condition on the fast channel.

Errors conditions which can be linked to external influences can be configured to either transmit 4090 or 4091. These errors are VSUP_HIGH, VSUP_LOW, T_CHIP and VDIG.

For both VSUP_HIGH and VSUP_LOW fast channel overwriting using an error message can even be disabled. This allows you to still decode properly the pressure or optionally temperature information in case of an over voltage or under voltage condition. The OV or UV condition can still be monitored using the status bits for FC1 and FC2 and the slow channel diagnostic message MID01.

An overview of the fast channel error configuration can be found in Table 20. The EEPROM parameters V_ERR, FCE_VSUP, FCE_VDIG and FCE_TCHIP handle this configuration.

| Fast Channel | Parameter | | Fast Channel | Parameter | Fast Channel | Parameter |
|--------------|-----------|----------------|--------------|-----------|--------------|-----------|
| ERR_VSUP | V_ERR | FCE_VSUP | ERR_VDIG | FCE_VDIG | ERR_TCH | FCE_TCHIP |
| No change | 0 | Not applicable | 4091 | 0 | 4091 | 0 |
| 4091 | 1 | 0 | 4090 | 1 | 4090 | 1 |
| 4090 | 1 | 1 | | | | |

Table 20: Fast channel error configuration

The diagnostic slow channel message (MID 1) can be enabled or disabled independent of the other slow channel messages and it has an adjustable repetition factor (2, 4, ..., 30).

More information on the different diagnostics shown in SENT, their fast channel, slow channel and status bit mapping can be found in the tables below.

| ERROR_ENABLE parameter | ERROR | FC_CFG = 0 | | | | FC_CFG = 1 | | | | FC_CFG = 2 | | | | FC_CFG = 3 | | | |
|------------------------|----------------------|------------|-----------|-------|-------|------------|---------------|-------|-------|------------|-----------|-------|-------|------------|-----------|-------|-------|
| | | FC1 | FC2 | St[0] | St[1] | FC1 | FC2 | St[0] | St[1] | FC1 | FC2 | St[0] | St[1] | FC1 | FC2 | St[0] | St[1] |
| N.A. | no error | P | ~P | 0 | 0 | P | cnt & ~MSN(P) | 0 | 0 | P | Tmed | 0 | 0 | P | Tint | 0 | 0 |
| - | not calibrated | 4095 | 4095 | 1 | 1 | 4095 | nc | 1 | nc | 4095 | 4095 | 1 | 1 | 4095 | 4095 | 1 | 1 |
| DIAG_INT | initialization error | 4090 | 4090 | 1 | 1 | 4090 | nc | 1 | nc | 4090 | 4090 | 1 | 1 | 4090 | 4090 | 1 | 1 |
| ERR_EN_TINT | T_INT | nc | nc | nc | nc | nc | nc | nc | nc | nc | nc | nc | nc | nc | 4090 | nc | 1 |
| ERR_EN_IO | RAM_IO_CFG | 4090 | 4090 | 1 | 1 | 4090 | nc | 1 | nc | 4090 | 4090 | 1 | 1 | 4090 | 4090 | 1 | 1 |
| ERR_EN_SPSN | SPSN | 4090 | 4090 | 1 | 1 | 4090 | nc | 1 | nc | 4090 | nc | 1 | nc | 4090 | nc | 1 | nc |
| ERR_EN_PV | PRESS | 4090 | 4090 | 1 | 1 | 4090 | nc | 1 | nc | 4090 | nc | 1 | nc | 4090 | nc | 1 | nc |
| ERR_EN_PP | PRESS_PAR | 4090 | 4090 | 1 | 1 | 4090 | nc | 1 | nc | 4090 | nc | 1 | nc | 4090 | nc | 1 | nc |
| ERR_EN_BW | PRESS_BROKEN_W | 4090 | 4090 | 1 | 1 | 4090 | nc | 1 | nc | 4090 | nc | 1 | nc | 4090 | nc | 1 | Nc |
| ERR_EN_TMED | T_MED | nc | nc | nc | nc | nc | nc | nc | nc | nc | 4090 | nc | 1 | nc | nc | nc | Nc |
| ERR_EN_VDIG | VDIG | ERR_VDIG | ERR_VDIG | 1 | 1 | ERR_VDIG | nc | 1 | nc | ERR_VDIG | ERR_VDIG | 1 | 1 | ERR_VDIG | ERR_VDIG | 1 | 1 |
| ERR_EN_TCHIP | T_CHIP | ERR_TCHIP | ERR_TCHIP | 1 | 1 | ERR_TCHIP | nc | 1 | nc | ERR_TCHIP | ERR_TCHIP | 1 | 1 | ERR_TCHIP | ERR_TCHIP | 1 | 1 |
| ERR_EN_VSUPH | VSUP_HIGH | ERR_VSUP | ERR_VSUP | 1 | 1 | ERR_VSUP | nc | 1 | nc | ERR_VSUP | ERR_VSUP | 1 | 1 | ERR_VSUP | ERR_VSUP | 1 | 1 |
| ERR_EN_VSUPL | VSUP_LOW | ERR_VSUP | ERR_VSUP | 1 | 1 | ERR_VSUP | nc | 1 | nc | ERR_VSUP | ERR_VSUP | 1 | 1 | ERR_VSUP | ERR_VSUP | 1 | 1 |
| DIAG_P1 | P @ FC1 = | 1 | nc | 1 | nc | 1 | nc | 1 | nc | 1 | nc | 1 | nc | 1 | nc | 1 | Nc |
| DIAG_P1 | P @ FC1 = | 4088 | nc | 1 | nc | 4088 | nc | 1 | nc | 4088 | nc | 1 | nc | 4088 | nc | 1 | Nc |
| DIAG_P2 | P @ FC1 = | < Y1 | nc | nc | nc | < Y1 | nc | nc | nc | < Y1 | nc | nc | nc | < Y1 | nc | nc | Nc |
| DIAG_P2 | P @ FC1 = | >Y2 | nc | nc | nc | >Y2 | nc | nc | nc | >Y2 | nc | nc | nc | >Y2 | nc | nc | Nc |
| DIAG_T1 | T @ FC2 = | | | | | | | | | nc | 1 | nc | 1 | nc | 1 | nc | 1 |
| DIAG_T1 | T @ FC2 = | | | | | | | | | nc | 4088 | nc | 1 | nc | 4088 | nc | 1 |
| DIAG_T2 | T @ FC2 = | | | | | | | | | nc | <=186 | nc | 1 | nc | <=186 | nc | 1 |
| DIAG_T2 | T @ FC2 = | | | | | | | | | nc | >=2266 | nc | 1 | nc | >=2266 | nc | 1 |

Table 21: Diagnostics in fast channel configuration 0 - 3

MLX90818

Absolute Pressure Sensor



| ERROR_ENABLE parameter | ERROR | FC_CFG = 4 | | FC_CFG = 5 | | FC_CFG = 6 | | | | FC_CFG = 7 | | | |
|------------------------|----------------------|------------|-------|------------|-------|------------|-----------|-------|-------|------------|-----|-------|-------|
| | | FC1 | St[0] | FC1 | St[0] | FC1 | FC2 | St[0] | St[1] | FC1 | FC2 | St[0] | St[1] |
| N.A. | no error | P (3x 4b) | 0 | P (4x 3b) | 0 | [fc0_ptr] | [fc1_ptr] | 0 | 0 | P | 0 | 0 | 0 |
| - | not calibrated | 4095 | 1 | 4095 | 1 | nc | nc | nc | nc | 4095 | nc | 1 | nc |
| DIAG_INT | initialization error | 4090 | 1 | 4090 | 1 | nc | nc | nc | nc | 4090 | nc | 1 | nc |
| ERR_EN_TINT | T_INT | nc | nc | nc | nc | nc | nc | nc | nc | nc | nc | nc | nc |
| ERR_EN_IO | RAM_IO_CFG | 4090 | 1 | 4090 | 1 | nc | nc | nc | nc | 4090 | nc | 1 | nc |
| ERR_EN_SPSN | SPSN | 4090 | 1 | 4090 | 1 | nc | nc | nc | nc | 4090 | nc | 1 | nc |
| ERR_EN_PV | PRESS | 4090 | 1 | 4090 | 1 | nc | nc | nc | nc | 4090 | nc | 1 | nc |
| ERR_EN_PP | PRESS_PAR | 4090 | 1 | 4090 | 1 | nc | nc | nc | nc | 4090 | nc | 1 | nc |
| ERR_EN_BW | PRESS_BROKEN_W | 4090 | 1 | 4090 | 1 | nc | nc | nc | nc | 4090 | nc | 1 | nc |
| ERR_EN_TMED | T_MED | nc | nc | nc | nc | nc | nc | nc | nc | nc | nc | nc | nc |
| ERR_EN_VDIG | VDIG | ERR_VDIG | 1 | ERR_VDIG | 1 | nc | nc | nc | nc | ERR_VDIG | nc | 1 | nc |
| ERR_EN_TCHIP | T_CHIP | ERR_TCHIP | 1 | ERR_TCHIP | 1 | nc | nc | nc | nc | ERR_TCHIP | nc | 1 | nc |
| ERR_EN_VSUPH | VSUP_HIGH | ERR_VSUP | 1 | ERR_VSUP | 1 | nc | nc | nc | nc | ERR_VSUP | nc | 1 | nc |
| ERR_EN_VSUPL | VSUP_LOW | ERR_VSUP | 1 | ERR_VSUP | 1 | nc | nc | nc | nc | ERR_VSUP | nc | 1 | nc |
| DIAG_P1 | P @ FC1 = | 1 | 1 | 1 | 1 | nc | nc | 1 | nc | 1 | nc | 1 | nc |
| DIAG_P1 | P @ FC1 = | 4088 | 1 | 4088 | 1 | nc | nc | 1 | nc | 4088 | nc | 1 | nc |
| DIAG_P2 | P @ FC1 = | < Y1 | nc | < Y1 | nc | nc | nc | nc | nc | < Y1 | nc | nc | nc |
| DIAG_P2 | P @ FC1 = | >Y2 | nc | >Y2 | nc | nc | nc | nc | nc | >Y2 | nc | nc | nc |
| DIAG_T1 | T @ FC2 = | | | | | nc | nc | nc | nc | | | | |
| DIAG_T1 | T @ FC2 = | | | | | nc | nc | nc | nc | | | | |
| DIAG_T2 | T @ FC2 = | | | | | nc | nc | nc | nc | | | | |
| DIAG_T2 | T @ FC2 = | | | | | nc | nc | nc | nc | | | | |

Table 22: Diagnostics in fast channel configuration 4 - 7

| ERROR_ENABLE parameter | ERROR | Slow channel diagnostic |
|------------------------|----------------------|---|
| N.A. | no error | 000h |
| - | not calibrated | nc = no change |
| DIAG_INT | initialization error | 003h (only once when reinit passes after reset) (Remark: in contrary to the other errors, DIAG_INT is used here to enable/disable the complete check and not only the customized slow channel error reporting) |
| ERR_EN_TINT | T_INT | A05h if DIAG_INT=1, else set bit 11 & 10 |
| ERR_EN_IO | RAM_IO_CFG | A05h if DIAG_INT=1, else set bit 11 & 9 |
| ERR_EN_SPSN | SPSN | A05h if DIAG_INT=1, else set bit 11 & 8 |
| ERR_EN_PV | PRESS | A05h if DIAG_INT=1, else set bit 11 & 7 |
| ERR_EN_PP | PRESS_PAR | A05h if DIAG_INT=1, else set bit 11 & 6 |
| ERR_EN_BW | PRESS_BROKEN_W | A05h if DIAG_INT=1, else set bit 11 & 5 |
| ERR_EN_TMED | T_MED | A05h if DIAG_INT=1, else set bit 11 & 4 |
| ERR_EN_VDIG | VDIG | A05h if DIAG_INT=1, else set bit 11 & 3 |
| ERR_EN_TCHIP | T_CHIP | A05h if DIAG_INT=1, else set bit 11 & 0 |
| ERR_EN_VSUPH | VSUP_HIGH | 021h / 901h if DIAG_VSUP = 0 / 1, but set bit 11 & 2 if also other errors are reported in the fast channel and if DIAG_INT=0 (if DIAG_INT=1 and other errors, then A05h) |
| ERR_EN_VSUPL | VSUP_LOW | 020h / 900h if DIAG_VSUP = 0 / 1, but set bit 11 & 1 if also other errors are reported in the fast channel and if DIAG_INT=0 (if DIAG_INT=1 and other errors, then A05h) |
| DIAG_P1 | P @ FC1 = | 002h if DIAG_PCL = 0 / 812h if DIAG_PCL = 1 |
| DIAG_P1 | P @ FC1 = | 001h if DIAG_PCL = 0 / 811h if DIAG_PCL = 1 |
| DIAG_P2 | P @ FC1 = | 002h |
| DIAG_P2 | P @ FC1 = | 001h |
| DIAG_T1 | T @ FC2 = | 005h |
| DIAG_T1 | T @ FC2 = | 004h |
| DIAG_T2 | T @ FC2 = | 805h (Remark: value 186 matches with -50 degC) |
| DIAG_T2 | T @ FC2 = | 804h (Remark: value 2266 matches with +210 degC) |

Table 23: Diagnostics in slow channel

Multiple diagnostic errors can be flagged in the range 8xxh – FFFh in case parameter DIAG_INT is set to 0.

The level of the over and under voltage diagnostics can be configured according to the ranges described in Table 24.

| Parameter | Min | Max | Units | Comment |
|---|------|------|-------|--|
| Under voltage detection threshold range | 3.25 | 5.74 | V | Optional and Programmable with 8 bits in parameter VSUP_LOW |
| Overvoltage detection threshold range | 4.25 | 6.74 | V | Optional and Programmable with 8 bits in parameter VSUP_HIGH |
| Over-/Under-voltage detection accuracy | | 200 | mV | |

Table 24: MLX90818 under and overvoltage detection

The default configuration for diagnostics on the different option codes can be found in Table 25 below.

| EEPROM Parameter | BBG-015 | BBG-016 | BBG-017 |
|------------------|---------|----------|----------|
| ERR_EN_TINT | 1 | 1 | 1 |
| ERR_EN_IO | 1 | 1 | 1 |
| ERR_EN_SPSN | 1 | 1 | 1 |
| ERR_EN_PV | 1 | 1 | 1 |
| ERR_EN_PP | 1 | 1 | 1 |
| ERR_EN_BW | 1 | 1 | 1 |
| ERR_EN_TMED | 0 | 1 | 1 |
| ERR_EN_VDIG | 1 | 1 | 1 |
| ERR_EN_VSUPH | 0 | 0 | 0 |
| ERR_EN_VSUPL | 1 (4V) | 1 (4.5V) | 1 (4.5V) |
| ERR_EN_TCHIP | 1 | 1 | 1 |
| FCE_VDIG | 1 | 1 | 1 |
| FCE_TCHIP | 1 | 1 | 1 |
| DIAG_PCL | 0 | 1 | 1 |
| DIAG_INT | 1 | 1 | 1 |
| V_ERR | 0 | 0 | 0 |
| FCE_VSUP | 1 | 1 | 1 |
| DIAG_VSUP | 1 | 1 | 1 |
| DIAG_P2 | 1 | 0 | 0 |
| DIAG_P1 | 1 | 1 | 1 |
| DIAG_T2 | 0 | 0 | 0 |
| DIAG_T1 | 0 | 1 | 1 |

Table 25: Default diagnostic configurations

20. Timings

| Parameter | Symbol | Comment | Min | Typ | Max | Unit |
|---|--------|---|------------|-----|---------------------------|------------------------|
| SENT frame period | tframe | Shortest message (without pause pulse) and longest message (pause pulse enabled). Example in μs calculated using a $3\mu\text{s}$ tick time. | 154 462 | | 282 846 ⁽⁸⁾ | ticks μs |
| Start-up time (to first falling edge) | tsu1 | Based on default settings. | 0.7 | 1 | 1.1 | ms |
| Start-up time (up to first data received) | tsu2 | First SENT frame contains valid pressure data. Calculation based on $3\mu\text{s}$ tick time. | | | 1.946 ⁽⁸⁾ | ms |

Table 26: Start-up timings

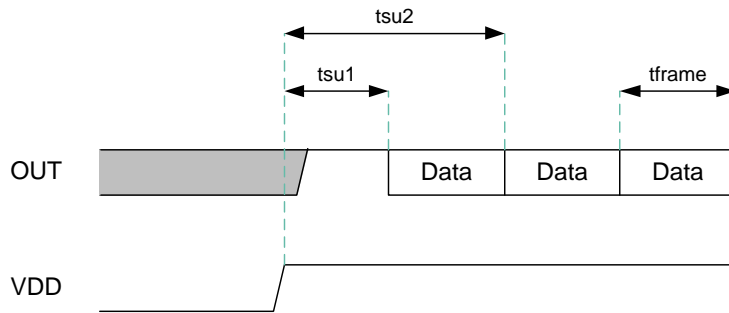


Figure 12: Start-up timings

⁸ Using nominal tick time, excluding tick time variations.

21. Application Information

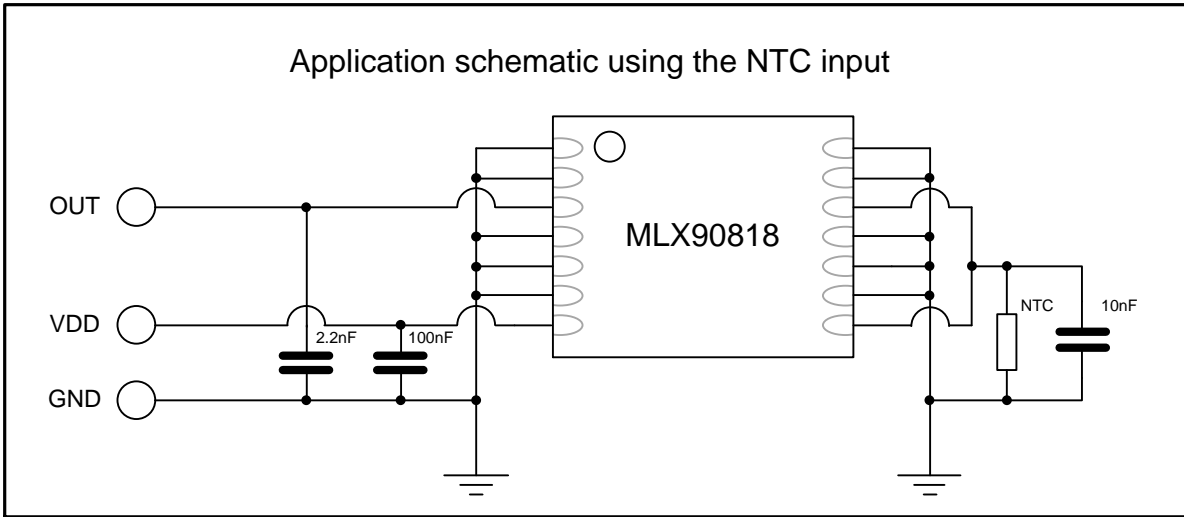


Figure 13: Basic application schematic using NTC

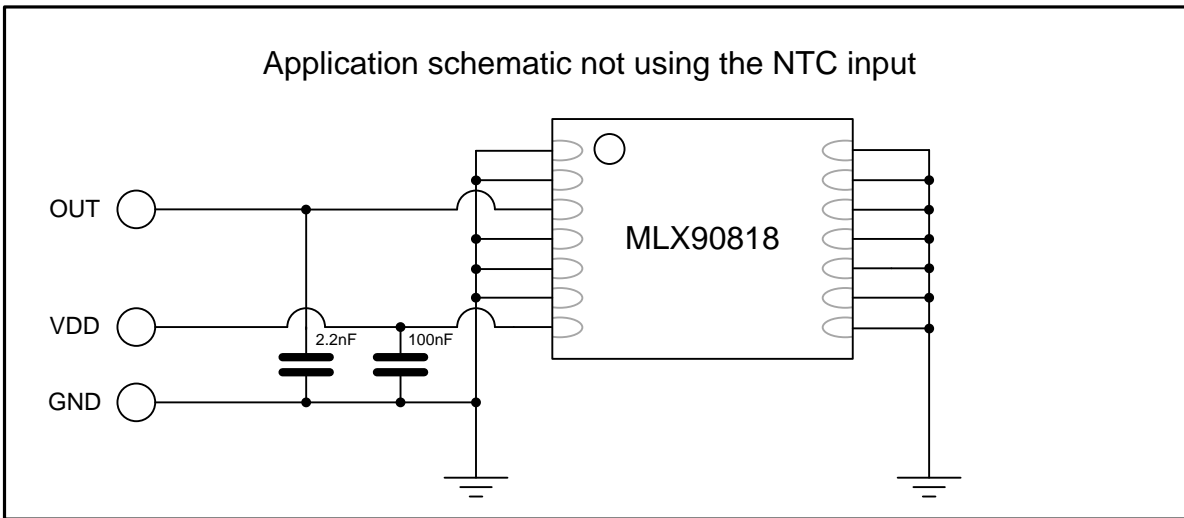


Figure 14: Basic application schematic without NTC

These recommendations for external components are only providing a basic protection. Depending on the module design and the EMC speciation requirements different configurations can be needed.

22. Standard information regarding manufacturability of Melexis products with different soldering processes

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

Reflow Soldering SMD's (Surface Mount Devices)

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

Wave Soldering SMD's (Surface Mount Devices) and THD's (Through Hole Devices)

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

Iron Soldering THD's (Through Hole Devices)

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

Solderability SMD's (Surface Mount Devices) and THD's (Through Hole Devices)

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

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

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

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

23. ESD Precautions

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

24. Package Information

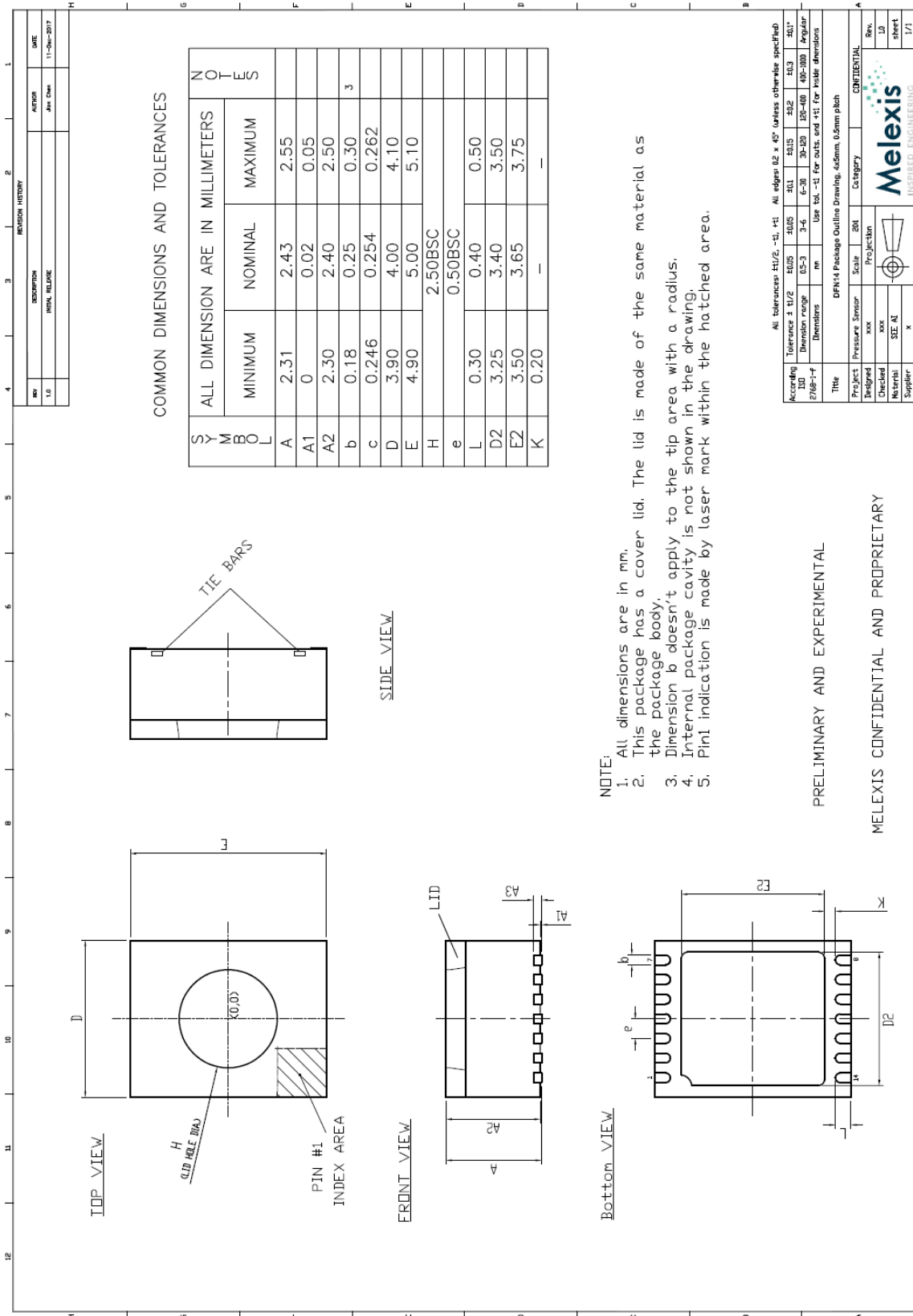
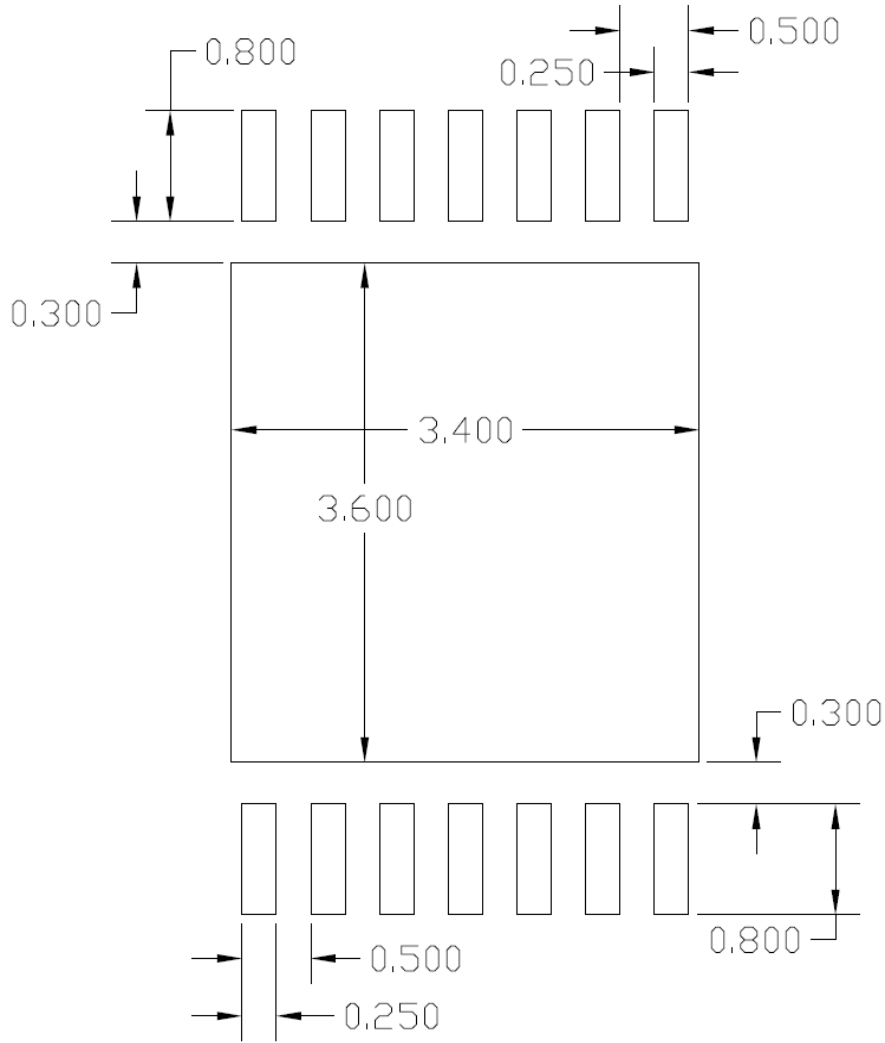


Figure 15: MLX90818 package drawing

25. PCB Land Pattern Recommendation



Unit: mm

Figure 16: PCB Land Pattern

26. Contact

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