# MLX90821

Relative Pressure Sensor IC

## 1. Features and Benefits

- High accuracy relative pressure sensor
- Ratiometric analog output or digital SENT output with optional compensated ±1°C accurate NTC temperature information
- System in a package: MEMS, analog front end circuitry, 16 bit microcontroller, analog back end circuitry, voltage regulators
- Large automotive temperature range (-40°C to 150°C)
- Automotive qualified and automotive diagnostic features (clamping levels, broken track diagnostics, multiple internal fault diagnostics)
- Factory calibrated or fully programmable or reconfigurable through the connector for customized calibration curves
- Back side exposed relative pressure sensor for higher resistance to common automotive media
- Assembled in a robust easy to seal package

## 2. Application Examples

- Fuel vapor pressure sensor
- Crankcase ventilation pressure sensor
- Pressure sensor for filter monitoring

## 3. Ordering Information

| Product Code | Temperature Code | Package Code | Option Code | Packing Form Code |
|---|---|---|---|---|
| MLX90821 | L | XG | DBA-003 | RE |
| MLX90821 | L | XG | DBA-005 | RE |
| MLX90821 | L | XG | DBA-006 | RE |
| MLX90821 | L | XG | DBA-007 | RE |
| MLX90821 | V | XG | DBA-008 | RE |
| MLX90821 | L | XG | DBA-100 | RE |

Legend:

Temperature Code: L = -40°C to 150°C
V = -40°C to 115°C

Package Code: XG = SOIC16 WB cavity package

Option Code: DBA-003 = -0.06 to 0.26bar relative pressure / 0.5V to 4.5V analog output
DBA-005 = -0.05 to 0.05bar relative pressure / 0.5V to 4.5V analog output
DBA-006 = -0.2 to 0.5bar relative pressure / 4.5V to 0.5V analog output
DBA-007 = -0.1 to 0.1bar relative pressure / 0.5V to 4.5V analog output
DBA-008 = -0.0375 to 0.0125 bar relative pressure / 4.5 V to 0.5 V analog output
DBA-100 = -0.06 to 0.26bar relative pressure / 193 to 3896LSB SENT output

Packing Form: RE = Reel

Ordering example: MLX90821LXG-DBA-003-RE

## 4. Functional Diagram

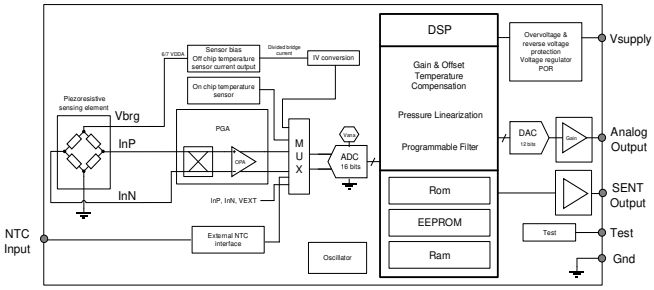



*Figure 1: Functional block diagram*

## 5. General Description

The MLX90821 is a packaged, factory calibrated, relative pressure sensor delivering a ratiometric analog output or a digital signal using the SENT protocol.

Using a best in class MEMS sensor enables reliably and accurately measuring very low pressures of a few tenths of millibars. An optimized architecture and a high density CMOS technology imparts the MLX90821 with best in class automotive EMC performance. A DSP based architecture using a 16bit microcontroller provides outstanding performance in terms of initial accuracy of both pressure and optionally external NTC temperature.

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
DAC: Digital to Analog Converter
DSP: Digital Signal Processor
EMC: Electro Magnetic Compatibility
Vbrg: Sensor bridge supply
InP: Positive sensing element input
InN: Negative sensing element input
OV: Over Voltage
UV: Under Voltage
SENT: Single Edge Nibble Transmission
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 | -14 | V |
| Positive output voltage | 18 | V |
| Reverse output voltage | -0.5 | 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) | 3.75 | 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

| Pin number | Description | Pin number | Description |
|---|---|---|---|
| 1 | Not Connected | 16 | Not Connected |
| 2 | Not Connected | 15 | Not Connected |
| 3 | Not Connected | 14 | Not Connected |
| 4 | Not Connected | 13 | Not Connected |
| 5 | Ground | 12 | Test pin |
| 6 | NTC input | 11 | SENT output |
| 7 | Ground | 10 | Test pin |
| 8 | Analog output | 9 | Supply input |

*Table 2: Pin out definitions and descriptions*

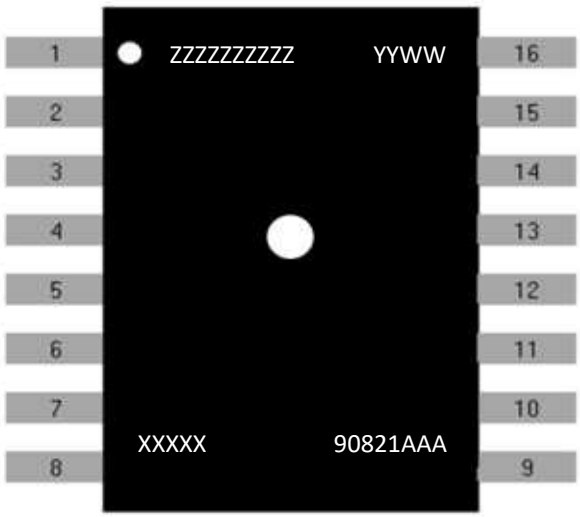



*Figure 2: Package marking (top view)*

| Symbol | Function / Description |
|---|---|
| ZZZZZZZZZZ | Assembly lot number |
| YY | Year of assembly |
| WW | Calendar week of assembly |
| XXXXX | Sensor lot number |
| AAA | MEMS and ASIC traceability letter |

*Table 3: Package marking definition*

## 9. General Electrical Specifications

DC Operating Parameters $T_A$ = -40°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 connected, no NTC connected[2] | | 8.5 | 11 | mA |
| Decoupling capacitor on supply | | | 47 | 100 | | nF |
| Capacitive load on analog output | Cload | | 47 | 100 | 470 | nF |
| Resistive load on analog output | Rload | Pull up or Pull down | 4.7 | | | kOhm |
| Capacitive load on SENT output | Cload | Pure capacitive load | | | 2.2 | nF |
| | | CRC load circuit (C close to device + Series R + C close to connector) | | | 1.1nF + 220Ω + 1.1nF | |
| Resistive load on SENT output | | Pull-up to Vdd at receiver[3] | 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 |
| Analog regulator | VDDA | | -9% | 3.5 | +9% | V |
| Nominal bridge supply voltage | Vbrg | | -9% | 3 | +9% | V |
| Sensing element sensitivity | | | | 55 | | mV/V/bar |
| ADC resolution | | | | 16 | | Bits |
| Diagnostic limits | Diag low | Pull-up ≥ 4.7kΩ<br>Pull-down ≥ 4.7kΩ | | | 3<br>3 | %Vdd |
| | Diag high | Pull-up ≥ 4.7kΩ<br>Pull-down ≥ 8kΩ | 96<br>96 | | | %Vdd |
| Clamping levels analog output | Clamp low | Programmable range with 7 bit resolution for the low clamping level, 9 for the high | 0 | | 12.5 | %Vdd |
| | Clamp high | | 50 | | 100 | %Vdd |

*[1] Typical values are defined at $T_A$ = +25°C and $V_{DD}$ = 5V.*

*[2] Only applicable for SENT output and combination with NTC option.*

*[3] As specified in the SENT standard*

| Parameter | Symbol | Remarks | Min | Typ[1] | Max | Units |
|---|---|---|---|---|---|---|
| Analog saturation output level | Vsat high | Pull-up ≥ 4.7kΩ<br>Pull-down ≥ 4.7kΩ<br>Pull-down ≥ 10kΩ | 97<br>96<br>97 | | 100<br>100<br>100 | %Vdd |
| | Vsat low | Pull-up ≥ 4.7kΩ<br>Pull-down ≥ 4.7kΩ | 0<br>0 | | 3<br>3 | %Vdd |
| Power up time analog | | Time from reaching minimum allowed supply voltage of 4.5V till having the output within specification | | | 1.3 | ms |
| Power up time SENT | | Time from reaching minimum allowed supply voltage of 4.5V till the first falling edge of the first SENT frame | | | 1.1 | ms |
| Pressure response time analog | | Time needed for the output to change from an input pressure step to 90% of its final value. Capacitive load 100nF.<br>Using default filter settings PFLT=0 and SSF=1.<br>For response times using different filter settings see Table 11. | | | 1 | ms |
| Pressure response time SENT[4] | | Default filter setting PFLT = 0 and SSF = 1.<br>Tick time = 3us and Pause Pulse enabled.<br>For other configurations refer to Table 11 in chapter 12.1. | | | 3 | SENT frames |
| InP InN digital diagnostic levels | | Diagnostic thresholds of 25% of VDDA (low) and 75% of VDDA (high) | -16384 | | 16384 | lsb |
| Pressure output noise analog | | BW limited to 50kHz. | | | 2 | mVrms |
| Input voltage range on NTC pin | | | 0 | | 3.5 | V |

*Table 4: Electrical specifications*

## 10. Detailed General Description

The MLX90821 contains a pressure sensing element which consists of a square diaphragm realized in the silicon chip by backside etching. The diaphragm reacts to a pressure difference between the top and bottom side of the diaphragm. The internal strain increases, in particular at the border of the diaphragm. Here, the piezoresistive elements have been implanted into the silicon diaphragm, which act as a transducer.

The sensor interface containing the readout circuit is integrated in the same package as the sensing element. 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. The analog back end consists of a 12 bit DAC and an output driver. This chip delivers an analog output proportional to the pressure or a SENT output compliant with the rev 4 from April 2016 of the SAE J2716 specification. An accurate factory calibrated external NTC temperature is also available on the SENT output.

[4] *Number of SENT frames between pressure step and settled output (last frame containing stable pressure data)*

A broken wire detection block allows actively driving the output to one of the rails in case of a broken supply or ground connection. Extensive protection of the supply lines allows the MLX90821 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 90821 and can be enabled by programming EEPROM settings. Figure 3 describes MLX90821 block diagram.

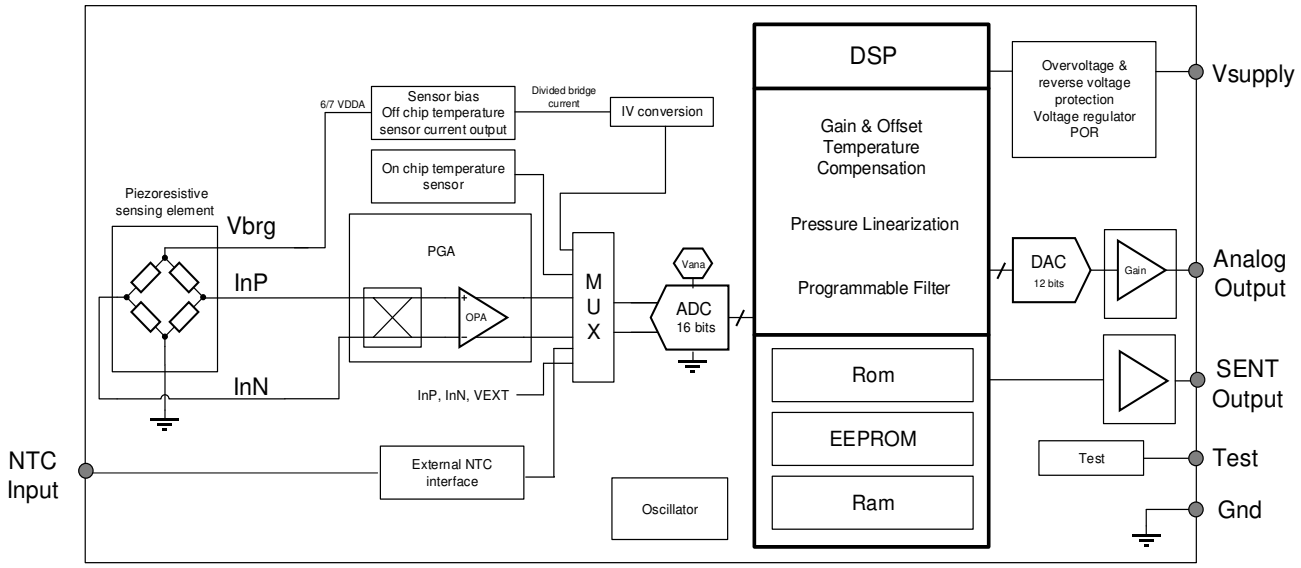



*Figure 3: MLX90821 block diagram*

## 11. Default programmed settings

The MLX90821 is calibrated at the final manufacturing test step. During the calibration, settings are stored in the on chip EEPROM to define the pressure transfer curve as well as the output clamping levels. On MLX90821 devices using the SENT output, besides pressure, the internal temperature and optionally the NTC temperature calibrations are performed. Together with the transfer functions, the IC filter values are set.

The analog output transfer curves as described below are valid assuming a supply voltage of 5V for the IC, the analog output scales in a ratiometric way to the supply voltage.

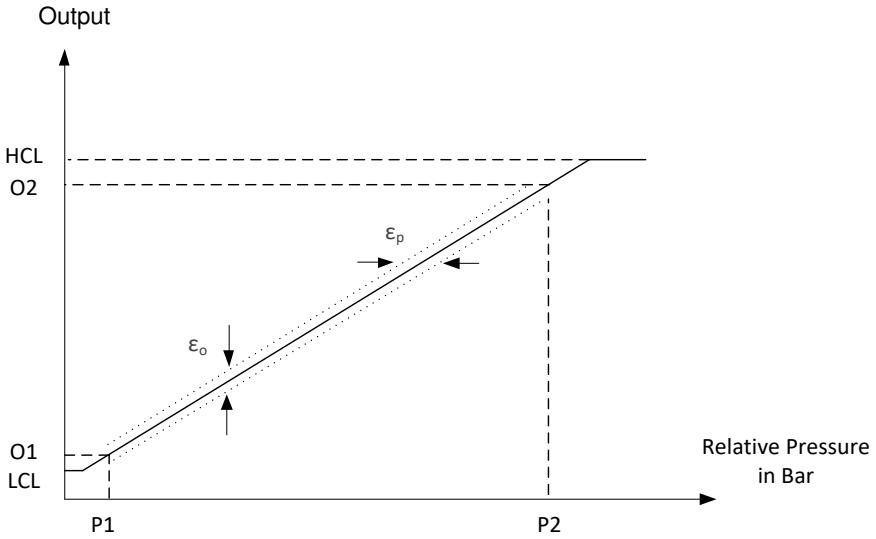



*Figure 4: Pressure transfer function description at room temperature*

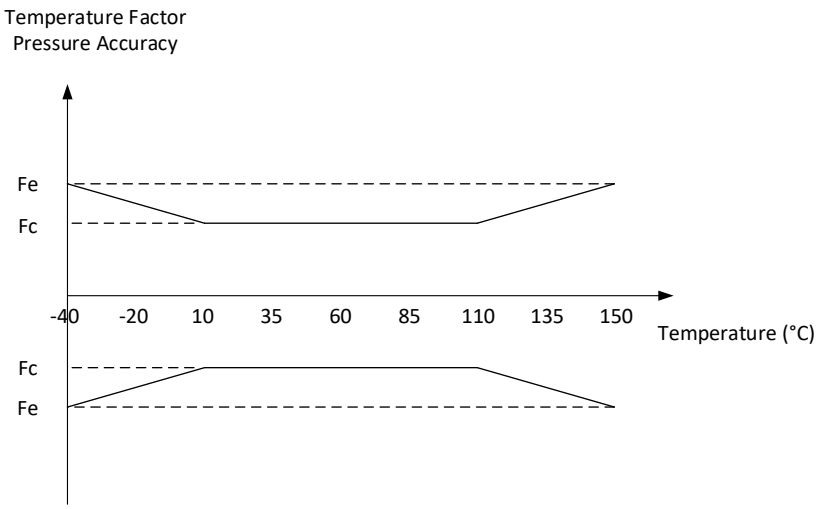



*Figure 5: Pressure accuracy temperature factor (temperature code L)*

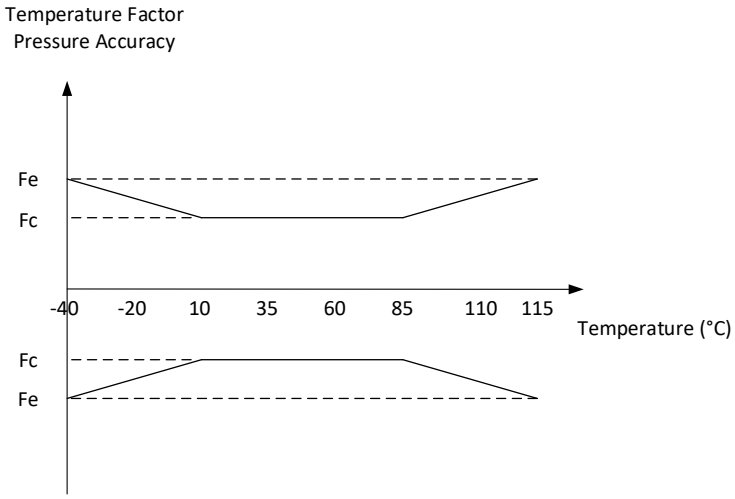



*Figure 6: Pressure accuracy temperature factor (temperature code V)*

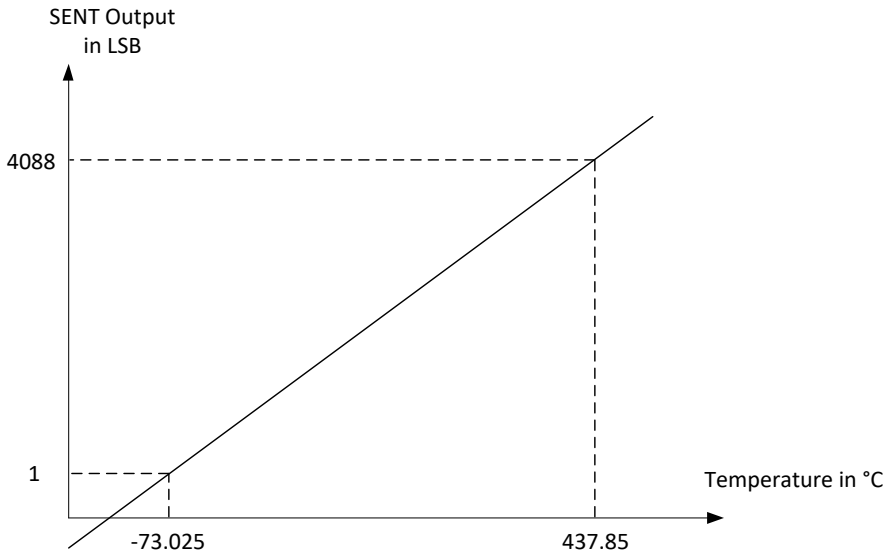



*Figure 7: NTC and internal temperature transfer function*

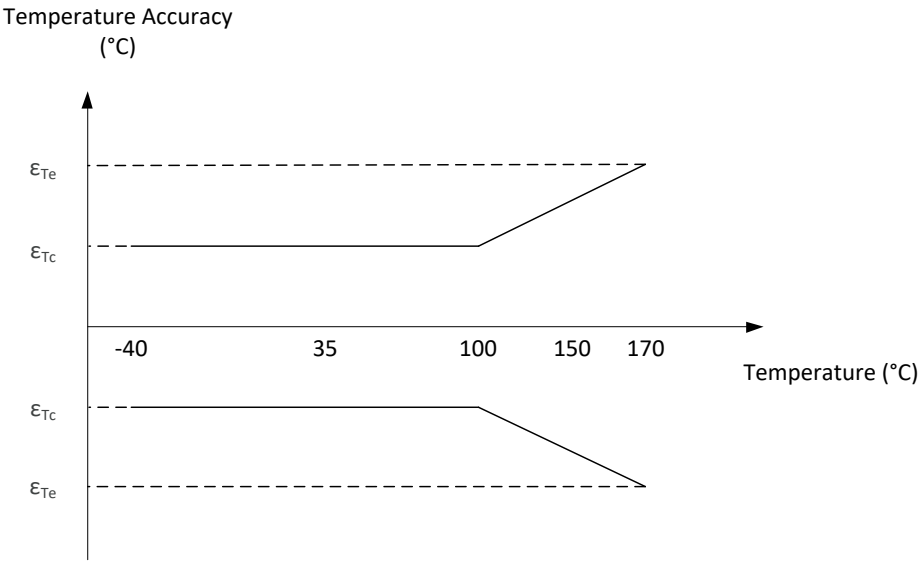



*Figure 8: NTC temperature accuracy*

## 11.1. Default Characteristics DBA-003

| Transfer Curve Parameter | Symbol | Remarks | Value | | | Unit |
|---|---|---|---|---|---|---|
| Pressure 1 | P1 | See Figure 4: Pressure transfer function description at room temperature | -0.06 | | | Bar |
| Pressure 2 | P2 | | 0.26 | | | Bar |
| Output 1 | O1 | | 0.5 | | | V |
| Output 2 | O2 | | 4.5 | | | V |
| Low clamping level | LCL | | 0.25 | | | V |
| High clamping level | HCL | | 4.75 | | | V |
| **Pressure Accuracy Parameter** | **Symbol** | **Remarks** | **Min** | **Typ** | **Max** | **Unit** |
| Output accuracy | $\varepsilon_o$ | Overall accuracy expressed as output value (FS range from 0.5V to 4.5V) | -60<br>-1.5 | | 60<br>1.5 | mV<br>%FS |
| Pressure accuracy | $\varepsilon_p$ | Overall accuracy expressed as pressure value | -4.8 | | 4.8 | mBar |
| Center temperature accuracy factor | Fc | See Figure 5: Pressure accuracy temperature factor | | | 1 | |
| Extended temperature accuracy factor | Fe | | | | 1.5 | |

*Table 5: DBA-003 Default configuration*

## 11.2. Default Characteristics DBA-005

| Transfer Curve Parameter | Symbol | Remarks | Value | | | Unit |
|---|---|---|---|---|---|---|
| Pressure 1 | P1 | See Figure 4: Pressure transfer function description at room temperature | -0.05 | | | Bar |
| Pressure 2 | P2 | | 0.05 | | | Bar |
| Output 1 | O1 | | 0.5 | | | V |
| Output 2 | O2 | | 4.5 | | | V |
| Low clamping level | LCL | | 0.5 | | | V |
| High clamping level | HCL | | 4.5 | | | V |
| **Pressure Accuracy Parameter** | **Symbol** | **Remarks** | **Min** | **Typ** | **Max** | **Unit** |
| Output accuracy | $\varepsilon_o$ | Overall accuracy expressed as output value (FS range from 0.5V to 4.5V) | -100<br>-2.5 | | 100<br>2.5 | mV<br>%FS |
| Pressure accuracy | $\varepsilon_p$ | Overall accuracy expressed as pressure value | -2.5 | | 2.5 | mBar |
| Center temperature accuracy factor | Fc | See Figure 5: Pressure accuracy temperature factor | | | 1 | |
| Extended temperature accuracy factor | Fe | | | | 1.5 | |

*Table 6: DBA-005 Default configuration*

## 11.3. Default Characteristics DBA-006

| Transfer Curve Parameter | Symbol | Remarks | Value | | | Unit |
|---|---|---|---|---|---|---|
| Pressure 1 | P1 | See Figure 4: Pressure transfer function description at room temperature | -0.2 | | | Bar |
| Pressure 2 | P2 | | 0.5 | | | Bar |
| Output 1 | O1 | | 4.5 | | | V |
| Output 2 | O2 | | 0.5 | | | V |
| Low clamping level | LCL | | 0.3 | | | V |
| High clamping level | HCL | | 4.7 | | | V |
| **Pressure Accuracy Parameter** | **Symbol** | **Remarks** | **Min** | **Typ** | **Max** | **Unit** |
| Output accuracy | $\varepsilon_o$ | Overall accuracy expressed as output value (FS range from 0.5V to 4.5V) | -40<br>-1 | | 40<br>1 | mV<br>%FS |
| Pressure accuracy | $\varepsilon_p$ | Overall accuracy expressed as pressure value | -7 | | 7 | mBar |
| Center temperature accuracy factor | Fc | See Figure 5: Pressure accuracy temperature factor | | | 1 | |
| Extended temperature accuracy factor | Fe | | | | 1.5 | |

*Table 7: DBA-006 Default configuration*

## 11.4. Default Characteristics DBA-007

| Transfer Curve Parameter | Symbol | Remarks | Value | | | Unit |
|---|---|---|---|---|---|---|
| Pressure 1 | P1 | See Figure 4: Pressure transfer function description at room temperature | -0.1 | | | Bar |
| Pressure 2 | P2 | | 0.1 | | | Bar |
| Output 1 | O1 | | 0.5 | | | V |
| Output 2 | O2 | | 4.5 | | | V |
| Low clamping level | LCL | | 0.475 | | | V |
| High clamping level | HCL | | 4.8 | | | V |
| **Pressure Accuracy Parameter** | **Symbol** | **Remarks** | **Min** | **Typ** | **Max** | **Unit** |
| Output accuracy | $\varepsilon_o$ | Overall accuracy expressed as output value (FS range from 0.5V to 4.5V) | -90<br>-2.25 | | 90<br>2.25 | mV<br>%FS |
| Pressure accuracy | $\varepsilon_p$ | Overall accuracy expressed as pressure value | -4.5 | | 4.5 | mBar |
| SCenter temperature accuracy factor | Fc | See Figure 5: Pressure accuracy temperature factor | | | 1 | |
| Extended temperature accuracy factor | Fe | | | | 1.5 | |

*Table 8: DBA-007 Default configuration*

## 11.5. Default Characteristics DBA-008

| Transfer Curve Parameter | Symbol | Remarks | Value | | | Unit |
|---|---|---|---|---|---|---|
| Pressure 1 | P1 | See Figure 4: Pressure transfer function description at room temperature | -0.0375 | | | Bar |
| Pressure 2 | P2 | | 0.0125 | | | Bar |
| Output 1 | O1 | | 4.5 | | | V |
| Output 2 | O2 | | 0.5 | | | V |
| Low clamping level | LCL | | 0.3 | | | V |
| High clamping level | HCL | | 4.7 | | | V |
| **Pressure Accuracy Parameter** | **Symbol** | **Remarks** | **Min** | **Typ** | **Max** | **Unit** |
| Output accuracy | $\varepsilon_o$ | Overall accuracy expressed as output value (FS range from 0.5V to 4.5V) | -160<br>-4 | | 160<br>4 | mV<br>%FS |
| Pressure accuracy | $\varepsilon_p$ | Overall accuracy expressed as pressure value | -2 | | 2 | mBar |
| Center temperature accuracy factor | Fc | See Figure 6: Pressure accuracy temperature factor (temperature code V) | | | 1 | |
| Extended temperature accuracy factor | Fe | | | | 1.5 | |

*Table 9: DBA-008 Default configuration*

## 11.6. Default Characteristics DBA-100

| Transfer Curve Parameter | Symbol | Remarks | Value | | | Unit |
|---|---|---|---|---|---|---|
| Pressure 1 | P1 | See Figure 4: Pressure transfer function description at room temperature | -0.06 | | | Bar |
| Pressure 2 | P2 | | 0.26 | | | 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 | $\varepsilon_o$ | Overall accuracy expressed as output value (FS range from 193 to 3896) | -55<br>-1.5 | | 55<br>1.5 | LSB<br>%FS |
| Pressure accuracy | $\varepsilon_p$ | Overall accuracy expressed as pressure value | -4.8 | | 4.8 | mBar |
| Center temperature accuracy factor | Fc | See Figure 5: Pressure accuracy temperature factor | | | 1 | |
| Extended temperature accuracy factor | Fe | | | | 1.5 | |

*Table 10: DBA-100 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.

## 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 11. Filter setting 0 disables the PFLT.

| PFLT setting | Analog output Response time in ms[5] | SENT output Response time in SENT frames[6] |
|---|---|---|
| 0 | 0.93 | 3 |
| 1 | 1.25 | 3 |
| 2 | 2 | 5 |
| 3 | 3.7 | 8 |
| 4 | 7.1 | 13 |
| 5 | 13.7 | 24 |
| 6 | 27.0 | 45 |
| 7 | 53.8 | 88 |
| 8 | 106.8 | 176 |
| 9 | 203.8 | 350 |

*Table 11: Filter settings and 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.

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.

[5] *Time needed for the output to change from an input pressure step to 90% of its final value.*
[6] *Tick time is set to 3us and Pause Pulse is enabled.*

## 13. Analog Front End

The analog front end of the MLX90821 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.

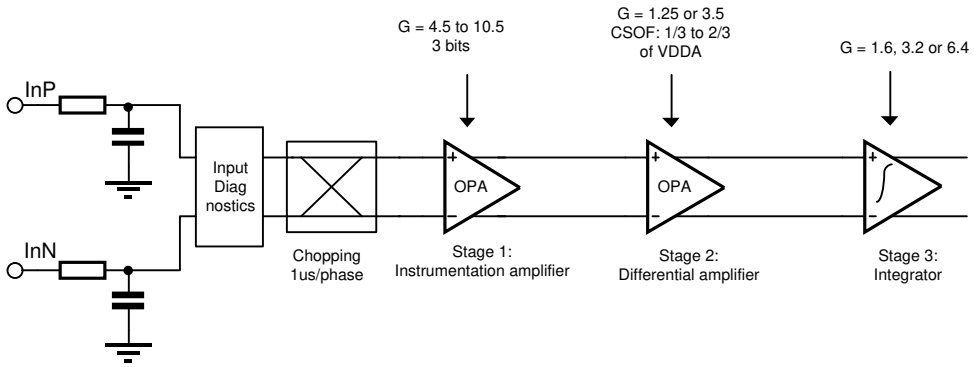



*Figure 9: Analog front end block diagram*

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:
OUTP1 – OUTN1 = Gst1*(InP – InN) in phase 1
OUTP1 – OUTN1 = Gst1*(InN – InP) in phase 2

The second stage is a fully differential amplifier. The gain of the amplifier can be calibrated using 1 bit.
Transfer equation:
OUTP2 – OUTN2 = -Gst2*(OUTP1 – OUTN1) – Gst2*(CSOF1 – CSOF2) in phase 1
OUTP2 – OUTN2 = -Gst2*(OUTN1 – OUTP1) – Gst2*(CSOF2 – CSOF1) in phase 2

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

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

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

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:
OUTP3 – OUTN3 = -N*(C1/C2)*(OUTP2 – OUTN2)
OUTP3_common_mode and OUTN3_common_mode = VCM = 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:
Pressure_ADC = ((OUTN3 – OUTP3)*$2^{16}$/VDDA) + 32768

An overview of all possible values for Gst1, Gst2 and Gst3 can be found in Table 12 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 12: 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 13 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 | Text | External Temperature |

*Table 13: ADC channels*

The different channels are converted in a constantly repeating sequence. A new ADC conversion is done every 50us following the sequence shown below in Figure 10. This is resulting in an updated pressure output value every 200us.




*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.

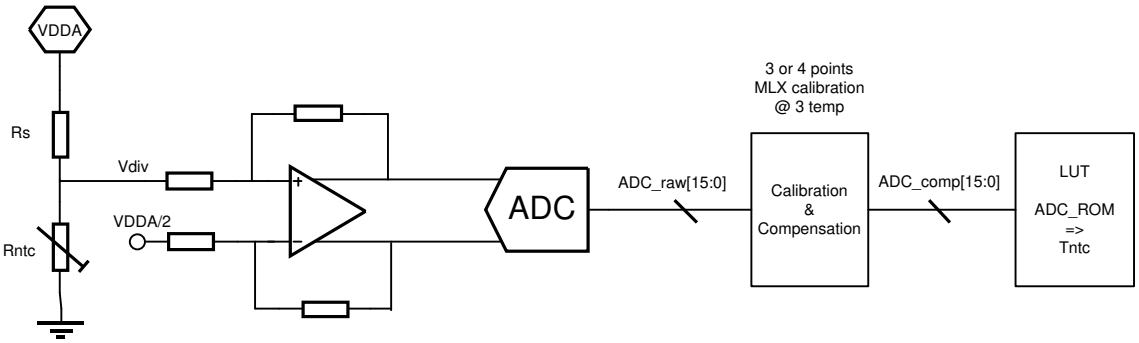



*Figure 11: Block diagram NTC linearization*

The complete system can be divided into 5 separate stages.

1. A resistor divider with internal resistor Rs is used to linearize Rntc 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 Tntc value which is the desired linearized NTC temperature.

The default optional NTC characteristic can be found in Table 14. 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 N0 to N3, N0_Diff_Low to N3_Diff_Low, N0_Diff_High to N3_Diff_High and TEMP1 to TEMP3.

| T (°C) | $R_T/R_{25}$ | R (Ω) |
|---|---|---|
| -55 | 53.68 | 268400 |
| -50 | 39.112 | 195560 |
| -45 | 28.817 | 144085 |
| -40 | 21.459 | 107295 |
| -35 | 16.142 | 80710 |
| -30 | 12.259 | 61295 |
| -25 | 9.3959 | 46979.5 |
| -20 | 7.2644 | 36322 |
| -15 | 5.6633 | 28316.5 |
| -10 | 4.4503 | 22251.5 |
| -5 | 3.5236 | 17618 |
| 0 | 2.8102 | 14051 |
| 5 | 2.2567 | 11283.5 |
| 10 | 1.8243 | 9121.5 |
| 15 | 1.4841 | 7420.5 |
| 20 | 1.2147 | 6073.5 |
| 25 | 1 | 5000 |
| 30 | 0.82785 | 4139.25 |
| 35 | 0.689 | 3445 |
| 40 | 0.57639 | 2881.95 |
| 45 | 0.48457 | 2422.85 |
| 50 | 0.40931 | 2046.55 |
| 55 | 0.34731 | 1736.55 |
| 60 | 0.29599 | 1479.95 |
| 65 | 0.25332 | 1266.6 |
| 70 | 0.21768 | 1088.4 |

| T (°C) | $R_T/R_{25}$ | R (Ω) |
|---|---|---|
| 75 | 0.18779 | 938.95 |
| 80 | 0.16261 | 813.05 |
| 85 | 0.14131 | 706.55 |
| 90 | 0.12324 | 616.2 |
| 95 | 0.10783 | 539.15 |
| 100 | 0.094663 | 473.315 |
| 105 | 0.083361 | 416.805 |
| 110 | 0.073638 | 368.19 |
| 115 | 0.06524 | 326.2 |
| 120 | 0.057964 | 289.82 |
| 125 | 0.05164 | 258.2 |
| 130 | 0.046128 | 230.64 |
| 135 | 0.041309 | 206.545 |
| 140 | 0.037085 | 185.425 |
| 145 | 0.033373 | 166.865 |
| 150 | 0.030102 | 150.51 |
| 155 | 0.027213 | 136.065 |
| 160 | 0.024654 | 123.27 |
| 165 | 0.022384 | 111.92 |
| 170 | 0.020364 | 101.82 |
| 175 | 0.018564 | 92.82 |
| 180 | 0.016955 | 84.775 |
| 185 | 0.015515 | 77.575 |
| 190 | 0.014223 | 71.115 |
| 195 | 0.013063 | 65.315 |
| 200 | 0.012017 | 60.085 |

*Table 14: 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. The default configuration for option code DBA-100 is 3us tick time and pause pulse 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 15.

| # | FC_CFG setting | Fast Channel 1 | Fast Channel 2 | Remark |
|---|---|---|---|---|
| 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) | Default for option code DBA-100. |
| 3 | 2 | Pressure (3x 4 bit) | Medium temperature (3x 4 bit) | Media temperature can either be NTC or sensing element temperature. (Tmedium_Select). |
| 4 | 3 | Pressure (3x 4 bit) | Internal temperature (3x 4 bit) | Internal temperature can either be PTAT or sensing element temperature (Tinternal_Select). |
| 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 15: Fast channel configuration options*

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

In case Medium temperature is selected to be available on fast channel 2, the type of media can be defined in EEPROM using parameter 'Tmedium_Select'. When selecting 0, linearized NTC temperature will be available. Selecting 1 enables sensing element temperature. Sensing element temperature is not calibrated by default.

For Internal temperature, also two options are available defined in EEPROM parameter 'Tinternal_Select' where 0 corresponds to on chip factory calibrated PTAT temperature and 1 corresponds to sensing element temperature. The same comment regarding the calibration of the sensing element temperature calibration as made above applies here.

## 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 MLX90821 can be found in Table 16. 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 16 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

| # | Type | ID | Description | Data | Rep |
|---|---|---|---|---|---|
| 0 | RAM | 0x01 | Diagnostic codes | Error_flags (See chapter 20 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<br>Data = 3 or 4 | N |
| 5 | RAM | 0x07 | Fast channel 1 Characteristic X1 | Fast channel 1 Characteristic Configuration<br>Enable / disable shared with MID08 | N |
| 6 | RAM | 0x08 | Fast channel 1 Characteristic X2 | Fast channel 1 Characteristic Configuration<br>Enable / disable shared with MID07 | N |
| 7 | EEPROM | 0xYZ | Fully Programmable message 0 | Programmable ID:<br>8 bit<br>Programmable Data:<br>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<br>Enable / disable shared with MID0A | N |
| 10 | RAM | 0x0A | Fast channel 1 Characteristic Y2 | Fast channel 1 Characteristic Configuration<br>Enable / disable shared with MID09 | N |
| 11 | ROM | 0x0B | Fast channel 2 Characteristic X1 | If FC2 is pressure (FC_CFG = 0): ID0B = ID07<br>If FC2is temperature (FC_CFG = 2 or 3):<br>Default temperature Characteristic X1: Fixed value: 233<br>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<br>If FC2is temperature (FC_CFG = 2 or 3):<br>Default temperature Characteristic X2: Fixed value: 423<br>Enable / disable shared with MID0B / 0D / 0E | N |

| # | Type | ID | Description | Data | Rep |
|---|---|---|---|---|---|
| 13 | ROM | 0x0D | Fast channel 2 Characteristic Y1 | If FC2 is pressure (FC_CFG = 0): ID0D = ID09<br>If FC2is temperature (FC_CFG = 2 or 3):<br>Default temperature Characteristic Y1: Fixed value: 264<br>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<br>If FC2is temperature (FC_CFG = 2 or 3):<br>Default temperature Characteristic Y2: Fixed value: 1784<br>Enable / disable shared with MID0B / 0C / 0D | N |
| 15 | EEPROM | 0x29 | Sensor ID #1 | Programmable Data: 12 bit<br>Enable / disable shared with MID2A / 2B / 2C | N |
| 16 | EEPROM | 0xYZ | Fully Programmable message 1 | Programmable ID: 8 bit<br>Programmable Data: 12 bit | N |
| 17 | EEPROM | 0x2A | Sensor ID #2 | Programmable Data: 12 bit<br>Enable / disable shared with MID29 / 2B / 2C | N |
| 18 | EEPROM | 0x2B | Sensor ID #3 | Programmable Data: 12 bit<br>Enable / disable shared with MID29 / 2A / 2C | N |
| 19 | EEPROM | 0x2C | Sensor ID #4 | Programmable Data: 12 bit<br>Enable / disable shared with MID29 / 2A / 2B | N |
| 20 | EEPROM | 0xYZ | Fully Programmable message 2 | Programmable ID: 8 bit<br>Programmable Data: 12 bit | N |
| 21 | EEPROM | 0xYZ | Fully Programmable message 3 | Programmable ID: 8 bit<br>Programmable Data: 12 bit | N |
| 22 | EEPROM | 0xYZ | Programmable message 4 | Programmable ID: 8 bit<br>Programmable Data: 12 bit<br>Enable / disable shared with programmable message 5 | N |
| 23 | EEPROM | 0xYZ | Programmable message 5 | Message ID = ID programmable message 4 + 1<br>Programmable Data: 12 bit<br>Enable / disable shared with programmable message 4 | N |
| 24 | EEPROM | 0xYZ | Programmable message 6 | Programmable ID: 8 bit<br>Programmable Data: 12 bit<br>Enable / disable shared with programmable message 7 | N |
| 25 | EEPROM | 0xYZ | Programmable message 7 | Message ID = ID programmable message 6 + 1<br>Programmable Data: 12 bit<br>Enable / disable shared with programmable message 6 | N |

| # | Type | ID | Description | Data | Rep |
|---|---|---|---|---|---|
| 26 | EEPROM | 0xYZ | Programmable message 8 | Programmable ID: 8 bit<br>Programmable Data: 12 bit<br>Enable / disable shared with programmable messages 9 / 10 / 11 | N |
| 27 | EEPROM | 0xYZ | Programmable message 9 | Message ID = ID programmable message 8 + 1<br>Programmable Data: 12 bit<br>Enable / disable shared with programmable messages 8 / 10 / 11 | N |
| 28 | EEPROM | 0xYZ | Programmable message 10 | Programmable ID: 8 bit<br>Programmable Data: 12 bit<br>Enable / disable shared with programmable messages 8 / 9 / 11 | N |
| 29 | EEPROM | 0xYZ | Programmable message 11 | Message ID = ID programmable message 10 + 1<br>Programmable Data: 12 bit<br>Enable / disable shared with programmable messages 8 / 9 / 10 | N |
| 30 | EEPROM | 0xYZ | Programmable message 12 | Programmable ID: 8 bit<br>Programmable Data: 12 bit<br>Enable / disable shared with programmable messages 13 / 14 / 15 | N |
| 31 | EEPROM | 0xYZ | Programmable message 13 | Message ID = ID programmable message 12 + 1<br>Programmable Data: 12 bit<br>Enable / disable shared with programmable messages 12 / 14 / 15 | N |
| 32 | EEPROM | 0xYZ | Programmable message 14 | Programmable ID: 8 bit<br>Programmable Data: 12 bit<br>Enable / disable shared with programmable messages 12 / 13 / 15 | N |
| 33 | EEPROM | 0xYZ | Programmable message 15 | Message ID = ID programmable message 14 + 1<br>Programmable Data: 12 bit<br>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 16: Slow channel messages*

Messages which have a "Y" in the column Rep of Table 16 can be selected to have a higher occurrence in the slow channel message sequence. Their repetition rate can be configured as indicated in Table 17.

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 17: Repetition rate settings*

Once a message is configured to be repeatable, it will automatically have the highest priority. Therefore it will appear first in the slow message sequences.
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
- SC_R_O = 1: Priority order: ID10h > ID23h > ID01h

## 18. Wrong Connections Overview Analog Output

Table 18 provides an overview of the behavior of the MLX90821 when different combinations of connections to GND, VDD and OUT are made.

| GND | VDD | Analog out | Effect on output | Action after wrong connection |
|---|---|---|---|---|
| 0V | 5V | Pull-down or Pull-up | Normal operation | Normal operation |
| Disconnected | 5V | Pull-down or Pull-up | High Fault Band | Normal operation |
| 0V | Disconnected | Pull-down or Pull-up | Low Fault Band | Normal operation |
| 0V | 5V | Disconnected | Low Fault Band for Pull-down<br>High Fault Band for Pull-up | Normal operation |
| 0V | 5V | 0V | Low Fault Band | Normal operation |
| 0V | 5V | 5V | High Fault Band | Normal operation |
| 0V | 5V | 18V | 18V | Normal operation |
| 0V | 0V | Pull-down or Pull-up | Low Fault Band | Normal operation |
| 0V | 18V | Pull-down or Pull-up | Low Fault Band for Pull-down<br>High Fault Band for Pull-up | Normal operation |
| 5V | 5V | Pull-down or Pull-up | High Fault Band | Normal operation |
| 5V | 0V | Pull-down or Pull-up | | Normal operation |

*Table 18: Wrong connections overview*

## 19. Wrong Connections Overview SENT Output

Table 19 provides an overview of the behavior of the MLX90821 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 19: Wrong connections overview*

# 20. Diagnostics

## 20.1. Input Diagnostics

An overview of the different input diagnostics conditions and their corresponding fault band and diagnostic source can be found in Table 20.

| Condition | Analog Output Fault Band | SENT Output Fast Channel Code | Diagnostic Source[7] |
|---|---|---|---|
| Vbrg disconnected | Low | 4090 | ERR_EN_SPSN |
| GND (sensor) disconnected | Low | 4090 | ERR_EN_SPSN |
| InP disconnected | Low | 4090 | ERR_EN_BW |
| InN disconnected | Low | 4090 | ERR_EN_BW |
| Vbrg shorted to GND | Low | 4090 | ERR_EN_SPSN |
| InP shorted to GND | Low | 4090 | ERR_EN_SPSN |
| InN shorted to GND | Low | 4090 | ERR_EN_SPSN |
| InP shorted to Vbrg | Low | 4090 | ERR_EN_SPSN |
| InN shorted to Vbrg | Low | 4090 | ERR_EN_SPSN |

*Table 20: Input diagnostics*

## 20.2. Diagnostic Sources

The MLX90821 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 21. The default diagnostic configuration for the different option codes can be found in Table 22.

| 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 |
| 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 21: Diagnostic sources*

[7] *See tables 22 to 24 for more information on the errors*

| Parameter | DBA-003 | DBA-005 | DBA-006 | DBA-007 | DBA-008 | DBA-100 |
|---|---|---|---|---|---|---|
| ERR_EN_TINT | ✖ | ✖ | ✖ | ✖ | ✖ | ✖ |
| ERR_EN_IO | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| ERR_EN_SPSN | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| ERR_EN_PV | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| ERR_EN_PP | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| ERR_EN_BW | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| ERR_EN_TMED | ✖ | ✖ | ✖ | ✖ | ✖ | ✖ |
| ERR_EN_VSUPH | ✖ | ✖ | ✖ | ✖ | ✖ | ✖ |
| ERR_EN_VSUPL | ✖ | ✖ | ✖ | ✖ | ✖ | ✖ |
| ERR_EN_TCHIP | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

*Table 22: Default diagnostic configuration*

The level of the over and under voltage diagnostics can be configured according to the ranges described in Table 23.

| 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 23: MLX90821 under and overvoltage detection*

## 20.3. Sent Output 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 and T_CHIP.
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 24. The EEPROM parameters V_ERR, FCE_VSUP and FCE_TCHIP handle this configuration.

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

| Fast Channel | Parameter |
|---|---|
| ERR_TCH | FCE_TCHIP |
| 4091 | 0 |
| 4090 | 1 |

*Table 24: 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.

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

| 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_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 25: Diagnostics in fast channel configuration 0 - 3*

| 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_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 26: 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)<br>(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_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 27: Diagnostics in slow channel*

## 21. SENT 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 3µs tick time. | 154<br>462 | | 282<br>846[8] | ticks<br>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 3µs tick time. | | | 1.946[8] | ms |

*Table 28: Start-up timings*

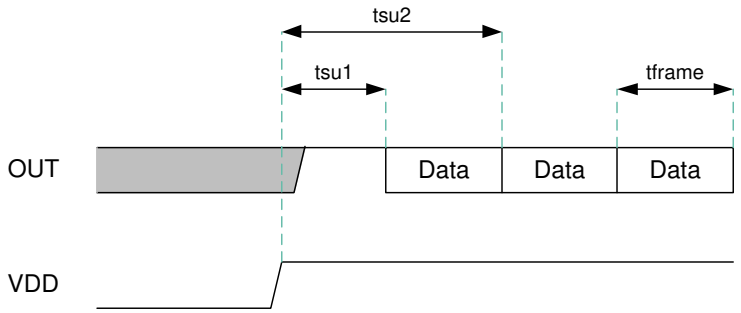



*Figure 12: Start-up timings*

[8] *Using nominal tick time, excluding tick time variations.*

## 22. Application Information

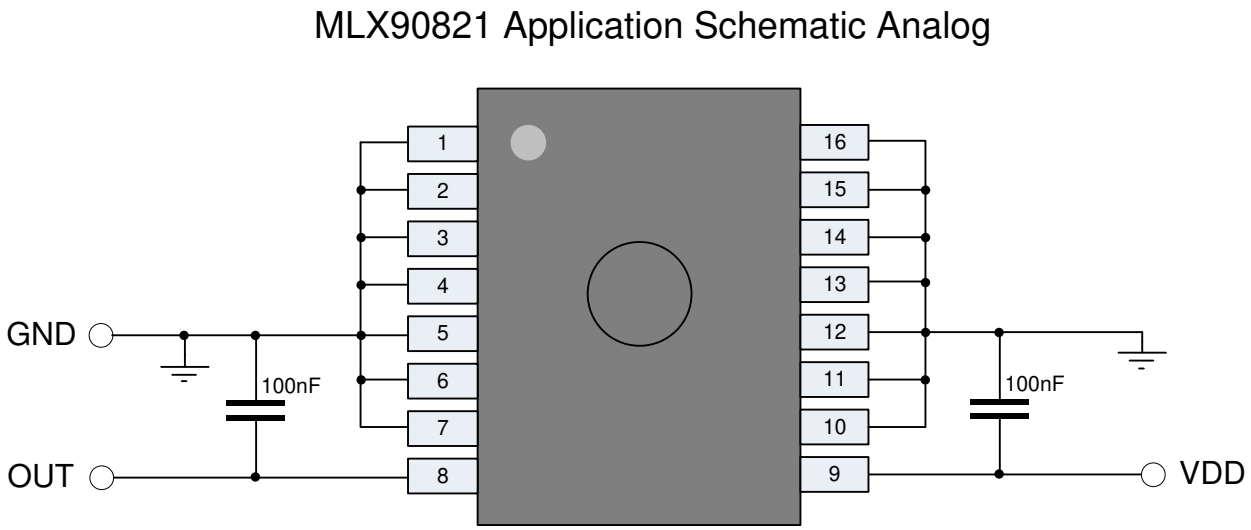



*Figure 13: Basic application schematic analog output*

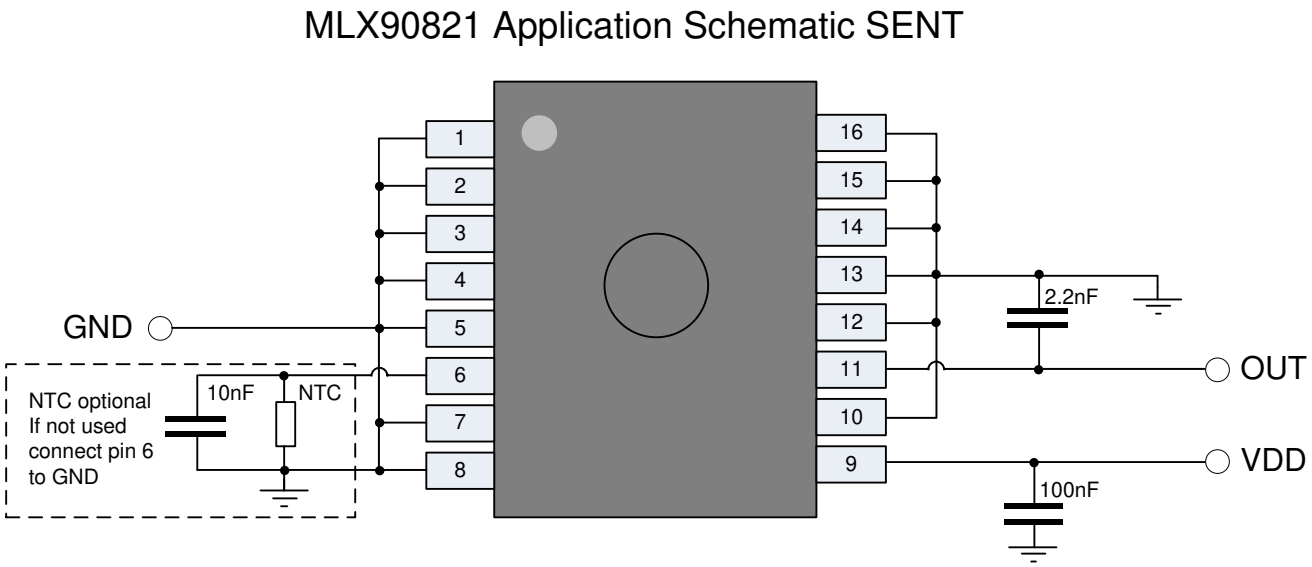



*Figure 14: Basic application schematic SENT output*

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.

The pressure sensor side facing the PCB shall be exposed only to clean dry air, it should be protected against excessive moisture or any source of corrosion in the application.

## 23. 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

## 24. ESD Precautions

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

## 25. Package Information

COMMON DIMENSIONS AND TOLERANCES

| SYMBOL | ALL DIMENSION ARE IN MILLIMETERS | | | NOTES |
|---|---|---|---|---|
| | MINIMUM | NOMINAL | MAXIMUM | |
| A | 2.207 | 2.307 | 2.407 | |
| A1 | −0.025 | 0.025 | 0.075 | |
| A2 | 2.182 | 2.282 | 2.382 | |
| b | 0.326 | 0.406 | 0.486 | 5 |
| c | 0.246 | 0.254 | 0.262 | 4 |
| D | 10.128 | 10.198 | 10.268 | 2,3 |
| E | 7.422 | 7.492 | 7.562 | 2,3 |
| H | 10.01 | 10.31 | 10.62 | 2,3 |
| e | | 1.27BSC | | |
| L | 0.74 | 0.86 | 0.99 | |
| L1 | | 0.25BSC | | |
| θ1 | 2° | – | 8° | |
| θ2 | 15° | 18° | 21° | |
| θ3 | 6.3° | 9.3° | 12.3° | |
| θ4 | 0° | – | 7° | |
| T1 | 0.983 | 1.033 | 1.083 | |
| T2 | 0.920 | 1.000 | 1.080 | |

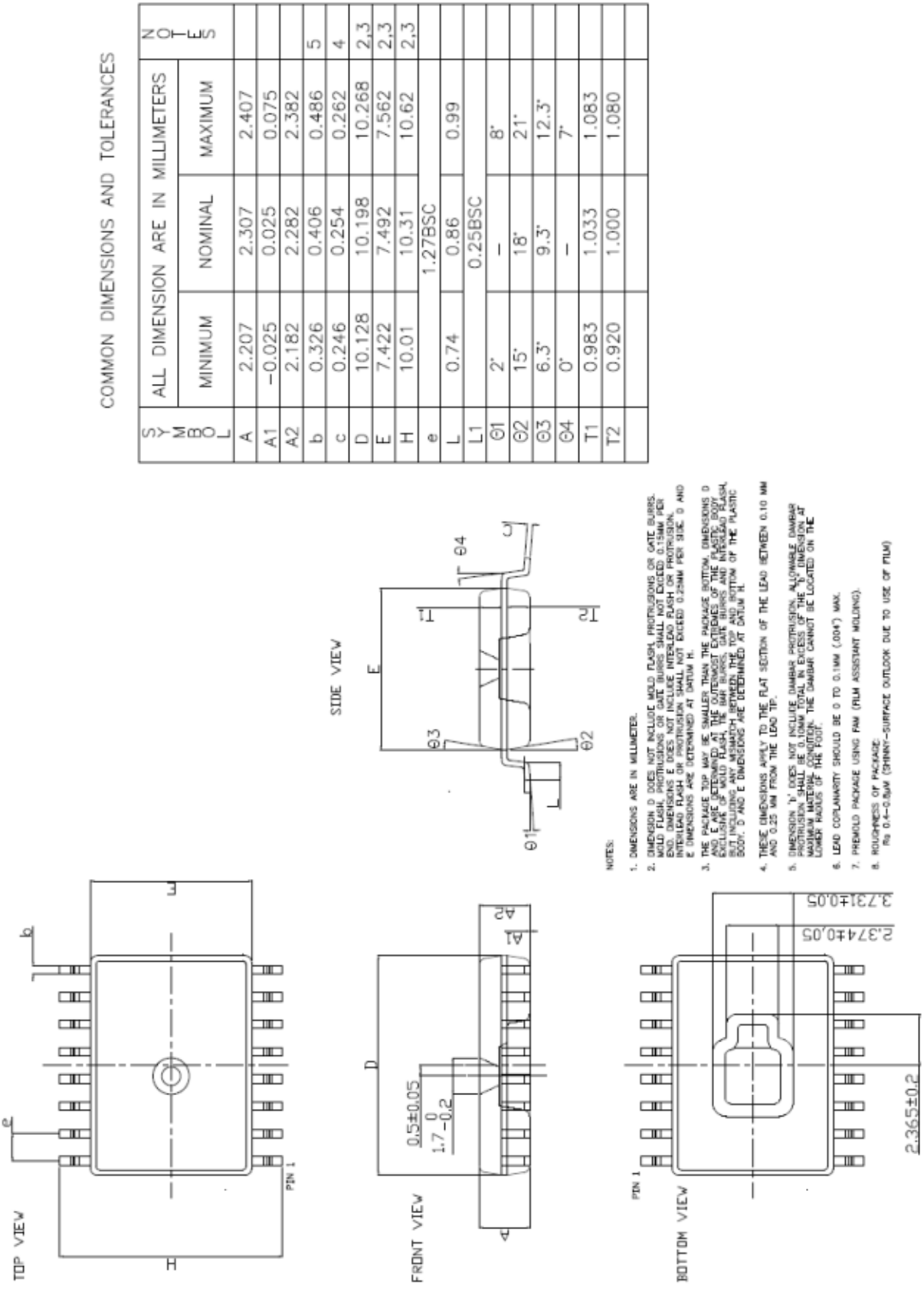



*Figure 15: MLX90821 package drawing*

## 26. Contact

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| | |
|---|---|
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