1. Features and Benefits

- Sensor interface IC for use in harsh automotive environments
- High EMC robustness
- Possibilities to achieve outstanding overall sensor performances
- SENT output with option for pressure, calibrated on chip or external NTC temperature information
- Outstanding accuracy for factory calibrated NTC within ±1°C

2. Application Examples

- Piezoresistive automotive pressure sensors interface
- Sensors based on Wheatstone bridge resistors

3. Ordering information

Product Code	Temperature Code	Package Code	Option Code	Packing Form Code
MLX90329	L	DC	DBA-000	RE

Legend:
Temperature Code: L (-40°C to 150°C)
Package Code: DC = SOIC-8 Plastic Small Outline, 150 mil
Option Code: DBA-000
Packing Form: RE = Reel
Ordering example: MLX90329LDC-DBA-000-RE

4. Functional Diagram

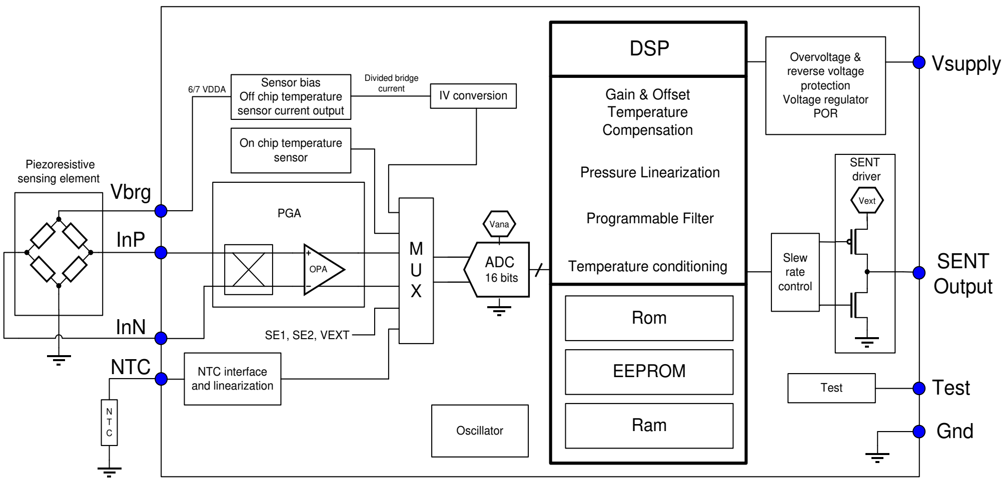

Figure 1: Functional block diagram

5. General Description

The MLX90329 covers the most typical resistive type of Wheatstone bridge applications for use in an automotive environment. It is a mixed signal sensor interface IC that converts small changes in resistors, configured in a full Wheatstone bridge on a sensing element, to large output voltage variations.

The signal conditioning includes gain adjustment, offset control as well as temperature compensation in order to accommodate variations of the different resistive sensing elements. Compensation values are stored in EEPROM and can be reprogrammed with a Melexis tool including the necessary software. The MLX90329 is programmed with a single wire serial interface through the output pin.

The user can specify SENT fast channel configuration, slow channel messages and enable several diagnostic settings. By intercepting these various fault modes, the MLX90329 is able to inform about the reliability of its output signal.

Contents

6. Glossary of Terms

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	-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

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 SOIC8	Description
1	Vbrg: bridge supply voltage
2	InP: positive bridge output
3	Test: pin used for testing purposes only
4	InN: negative bridge output
5	Out: SENT output
6	Vsupply: IC supply
7	NTC: NTC input
8	Gnd: Ground

Table 2: Pin out definitions and descriptions

Package side	Line number	Description
Top	1	Product number
Top	2	Lot number
Top	3	Sublot number (optional)
Bottom	1	Year and calendar week (yyww)

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	Sensing element current consumption, SENT interface current and NTC current excluded		8	10	mA
Decoupling capacitor on supply				100		nF
Supply series resistor		Not mandatory but recommended for optimal EMC performance	0		10	Ohm
Capacitive load on output		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 output		Pull-up to Vdd at receiver	10		55	kOhm
Supply programming entry level	Vdd_com	Threshold to enter communication mode	6.2		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
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
Pressure response time[2]		Filter setting PFLT = 0 and SSF = 1. Tick time = 3us and Pause Pulse enabled. For other configurations refer to Table 5 in chapter 10.			3	SENT frames

[1] *Typical values are defined at T_A = +25°C and V_{DD} = 5V.*
[2] *Number of SENT frames between pressure step and settled output (last frame containing stable pressure data)*

Parameter	Symbol	Remarks	Min	Typ[1]	Max	Units
Wheastone Bridge sensitivity range at 25°C[3]			2		55	mV/V
Wheastone Bridge resistance range			2			kOhm
InP InN digital diagnostic levels		Diagnostic thresholds of 25% of VDDA (low) and 75% of VDDA (high)	-16384		16384	lsb
Pressure sensor signal chain accuracy		Initial errors compensated by calibration of the pressure sensor at minimum two temperatures. Only drift over life remaining in error budget. Worst case for maximum gain setting.			0.2	%FSO
Wheastone Bridge[4] offset range			-20		20	mV/V
External Wheatstone Bridge Temperature accuracy		For typical Wheatstone bridges. Application specific.	-3		+3	°C
Input voltage range on NTC pin			0		3.5	V
ADC resolution				16		Bits
NTC Temperature Output noise					1	LSB pk-pk
NTC Temperature Range			-55		200	°C
Temperature response time					100	msec

Table 4: Electrical specifications

10. 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 6.

10.1. 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.

[3] *A maximum performance can be obtained with this sensor sensitivity range. A programmable gain with 5 bits from a gain of 9 to 237 is used in the analog front end circuitry to adapt the sensor range to the on chip ADC input range. Half of the ADC input range (= 1.75V) is foreseen to be used during the sensor calibration at the first temperature. The rest of the ADC input range is left for the compensation of the sensor temperature effects. A coarse offset compensation is available to calibrate large sensor offsets.*
A more detailed overview of the gains in the analog frontend can be found in Table 7.
[4] *Please contact Melexis for assistance in evaluating the match between the sensing element and the MLX90329 interface if needed.*

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 5. 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[5]
0	3
1	3
2	5
3	8
4	13
5	24
6	45
7	88
8	176
9	350

Table 5: Filter settings with corresponding typical response times

10.2. 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] *Tick time is set to 3us and Pause Pulse is 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	0
0	17000	0	1	2
0	17000	1	0	2
0	17000	4	0	1
0	17000	9	0	1
0	30000	0	1	4
0	30000	1	0	3
0	30000	4	0	2
0	30000	9	0	0
10	10000	0	1	2
10	10000	1	0	1
10	10000	4	0	1
10	10000	9	0	0
10	17000	0	1	3
10	17000	1	0	2
10	17000	4	0	1
10	17000	9	0	0
10	30000	0	1	4
10	30000	1	0	4
10	30000	4	0	2
10	30000	9	0	0
31	10000	0	1	3
31	10000	1	0	3
31	10000	4	0	2
31	10000	9	0	1
31	17000	0	1	4
31	17000	1	0	4
31	17000	4	0	2
31	17000	9	0	1
31	30000	0	1	7
31	30000	1	0	7
31	30000	4	0	4
31	30000	9	0	1

Table 6: Filter settings and gain combinations with corresponding pressure noise values

11. Analog Front End

The analog front end of the MLX90329 consists of a chopping stage and 3 amplification stages as can be seen in Figure 2. 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.

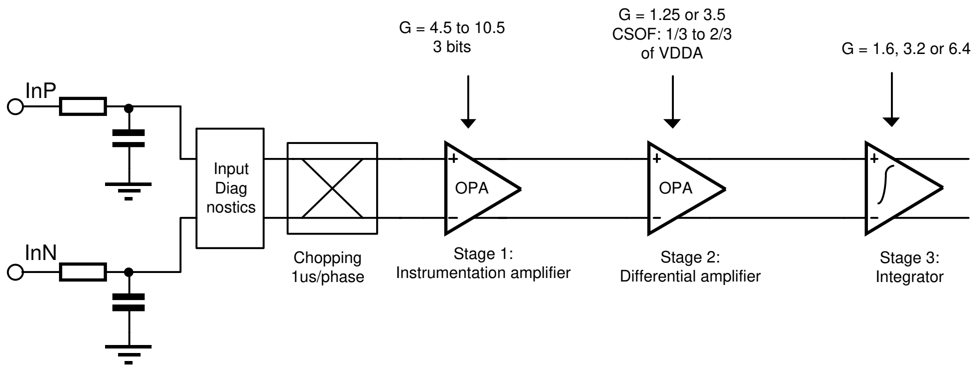

Figure 2: Analog front end block diagram

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 7 below.
The input stage is designed to work with an input common-mode voltage range between 42%Vbrg and 58%Vbrg.

Gain setting	Gst1	Gst2	Gst3	Total gain	FS Differential Input Signal
[-]	[V/V]	[V/V]	[V/V]	[V/V]	[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 7: Gain and input signal range of the analog front end

12. 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 8 below describes all the channels.

ADC SIN[2:0]	Signal	Remarks
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 8: ADC channels

The different channels are converted in a constantly repeating sequence at a rate of 50µsec for each individual conversion. The order is shown in Figure 3 below.

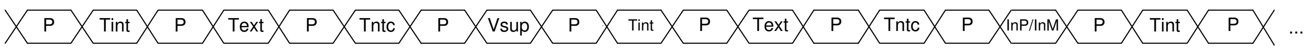

Figure 3: ADC sequence

13. 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.

For the temperature compensation of the pressure signal both the internal on-chip PTAT temperature as the temperature measured using the sensor bridge resistance can be used. The selection between both can be set in EEPROM using the ‘Tpress_Select’ parameter. Tpress_Select = 0 corresponds to sensing element temperature reference and Tpress_Select = 1 is on-chip PTAT temperature. When using the sensing element bridge resistance temperature measurement, a selection of a 2K, 4K, 8K or a 32K bridge resistance can be done using EEPROM parameter 'BRIDGE_SEL'[6], see Table 9.

BRIDGE_SEL	Resistance selection
0	2K
1	4K
2	8K
3	32K

Table 9: Bridge resistance selection for temperature reference

Linearization of the NTC temperature is also covered partially by the microcontroller. More information in this topic can be found in chapter 14.

14. 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 4.

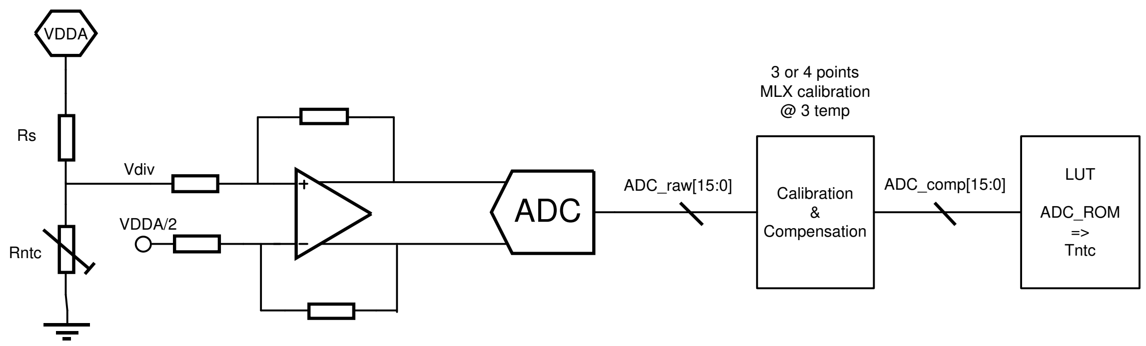

Figure 4: Block diagram NTC linearization

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.

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[6] *It is not mandatory to have a bridge resistance identical to the resistance selection setting. In this case it is advised to select the setting closest to the actual value. In case support is needed please contact Melexis.*

The default NTC characteristic which is calibrated can be found in Table 10. 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)	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 10: Default NTC characteristic

The overall accuracy of the default NTC can be found in Table 11. The default temperature characteristic of the NTC and the internal temperature signal can be found in the graph of Figure 6.

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 10. See Figure 5: NTC temperature accuracy.	-1		1	°C
Extended NTC temperature accuracy	ε_{Te}		-2		2	°C

Table 11: NTC accuracy

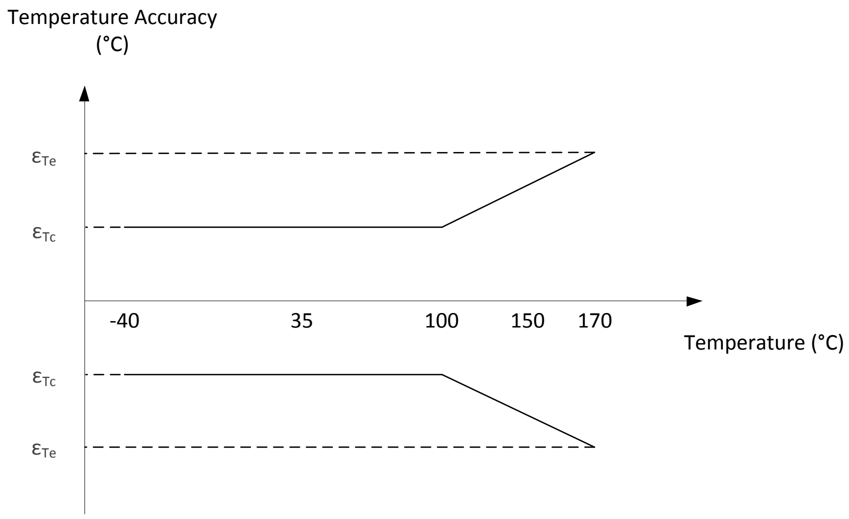

Figure 5: NTC temperature accuracy

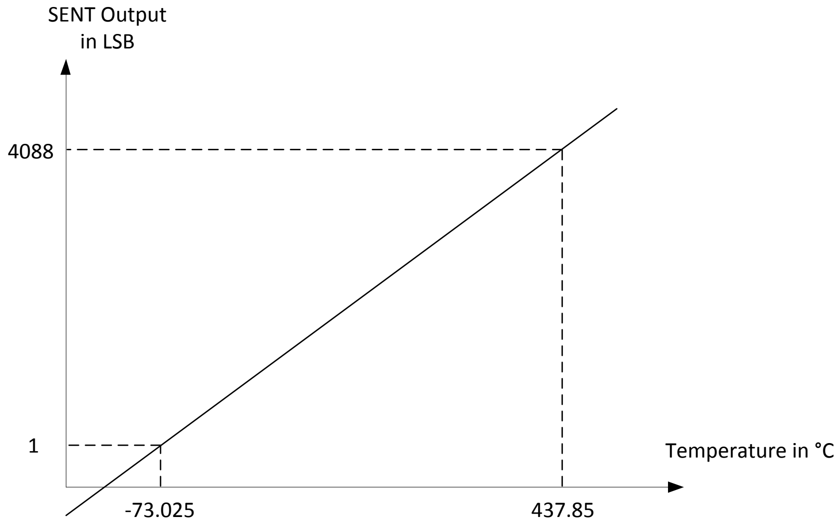

Figure 6: NTC and internal temperature transfer function

15. 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.

15.1. 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 12.

#	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)	
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 12: 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 should 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 needs to be calibrated after connecting the sensing element to the MLX90329 and is not calibrated by Melexis[(7)].

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.

[7] *Contact Melexis for assistance if required.*

15.2. 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 MLX90329 can be found in Table 13. 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 13 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 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 FC2is temperature (FC_CFG = 2 or 3): Default temperature Characteristic X1: Fixed value: 233 Enable / disable shared with MID0C / 0D / 0E	N

#	Type	ID	Description	Data	Rep
12	ROM	0x0C	Fast channel 2 Characteristic X2	If FC2 is pressure (FC_CFG = 0): ID0C = ID08 If FC2is 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 FC2is 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 FC2is 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
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

#	Type	ID	Description	Data	Rep
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
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 13: Slow channel messages

Messages which have a "Y" in the column Rep of Table 13 can be selected to have a higher occurrence in the slow channel message sequence. Their repetition rate can be configured as indicated in Table 14.

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 14: 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

16. Wrong Connections Overview

Table 15 provides an overview of the behavior of the MLX90329 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 15: Wrong connections overview

17. Diagnostics

17.1. Input Diagnostics

An overview of the different input diagnostics conditions and their corresponding fast channel mapping and diagnostic bit information in slow channel can be found in Table 16.

Condition	Fast Channel Code	Error[8]
Vbrg disconnected	4090	ERROR_SPSN
GND (sensor) disconnected	4090	ERROR_SPSN
InP disconnected	4090	ERROR_PRESS_BROKEN_W
InN disconnected	4090	ERROR_PRESS_BROKEN_W
Vbrg shorted to GND	4090	ERROR_SPSN
InP shorted to GND	4090	ERROR_SPSN
InN shorted to GND	4090	ERROR_SPSN
InP shorted to Vbrg	4090	ERROR_SPSN
InN shorted to Vbrg	4090	ERROR_SPSN

Table 16: Input diagnostics

17.2. Diagnostic Sources

The MLX90329 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 17.

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 17: Diagnostic sources

[8] *See tables 17 to 19 for more information on the errors*

17.3. 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 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 18. 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 18: 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_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 19: 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 20: 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_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 21: 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 22.

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 22: MLX90818 under and overvoltage detection

18. 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.	154 462		282 846[9]	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 3µs tick time.			1.946[9]	ms

Table 23: Start-up timings

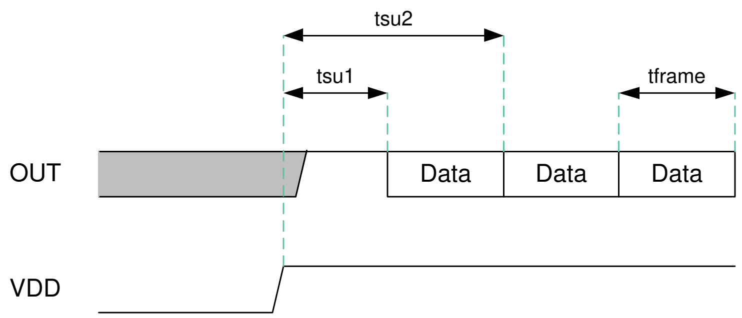

Figure 7: Start-up timings

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

19. Unique features

Thanks to its state of the art mixed signal chain, the MLX90329 offers the possibility to calibrate several types of resistive Wheatstone bridge technologies allowing the MLX90329 users to reach an outstanding overall sensor accuracy. The MLX90329 is robust for harsh automotive environments like large temperature range, overvoltage conditions and external EMC disturbances.
The MLX90329 allows the compensation of sensor nonlinear variations over temperature as well as compensates for the sensor pressure signal non linearity. Several parameters can be programmed through the application pins in the MLX90329 to set clamping levels or filter settings to choose for the best trade-off between signal chain noise and speed. The MLX90329 can also diagnose several error conditions like sensor connections errors.

The sensor bias Vbrg which is supplying the external pressure sensor is generated using a regulator. The target sensor supply is 6/7VDDA or typically 3V. The current through the bridge resistance is mirrored and divided so that it can be fed to an IV convertor. This IV converted signal is a measure for the external temperature so that it can be used for the calibration of the pressure sensor.

MLX90329 can interface an external NTC and provide the linearized temperature information together with the pressure signal on the SENT output. This NTC is factory calibrated by Melexis.

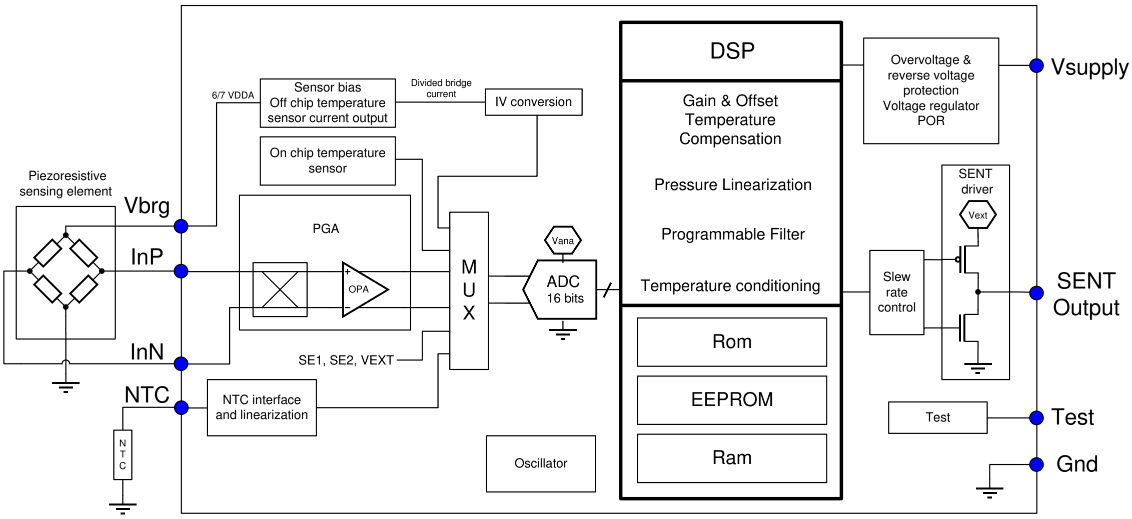

Figure 8: MLX90329 Block Diagram

20. Application Information

The MLX90329 only needs 2 capacitors in the application. A 100nF decoupling capacitor connected between the supply line and the ground a 2.2nF load between the SENT output pin and the ground.
Optionally an NTC can be connected to pin 7. It is recommended to place a 10nF capacitor in parallel with the NTC to improve EMC performance. In case no NTC is used, pin 7 has to be connected to GND.

MLX90329 has built in EMC protection for the sensor supply and sensing element input pins. Therefore it is advised not to place any external capacitors between the sensing element and the interface. Capacitors on the sensor supply or the inputs can even disturb the normal operation of the interface.

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

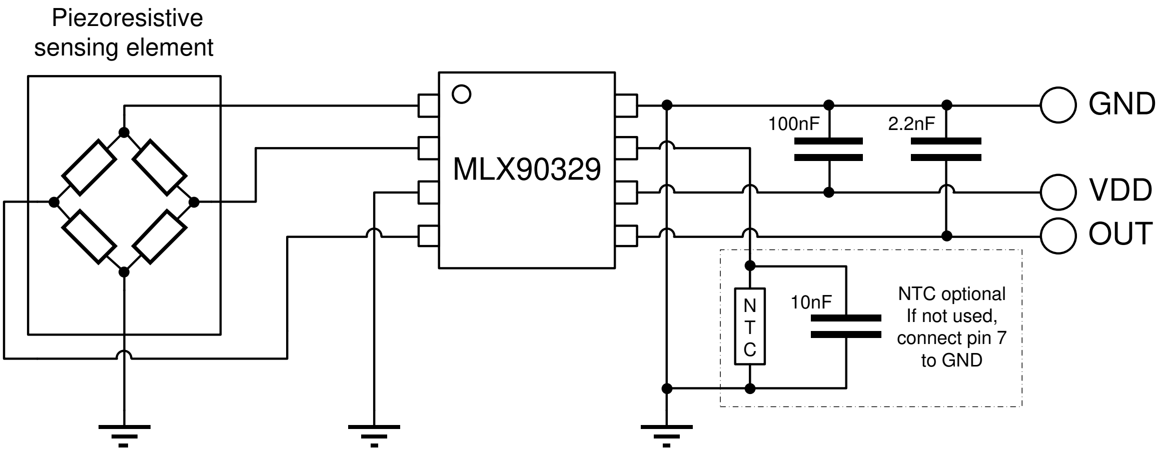

Figure 9: MLX90329 basic application schematic

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

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

Reflow Soldering SMD's (Surface Mount 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

22. ESD Precautions

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

23. Package Information

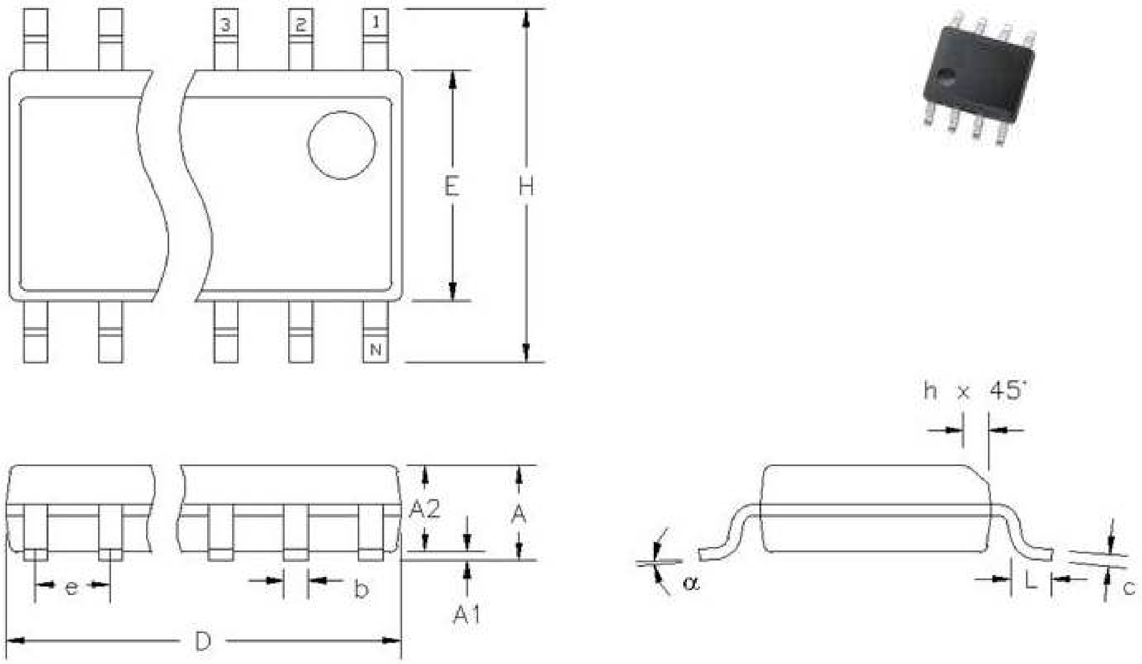

Figure 10: Package drawing

Package dimensions in mm

N		A	A1	A2	D	E	H	L	b	c	e	h	α
8	min	1.52	0.10	1.37	4.80	3.91	5.80	0.41	0.35	0.19	1.27 BSC	0.25	0°
	max	1.73	0.25	1.57	4.98	3.99	6.20	1.27	0.49	0.25		0.50	8°

Package dimensions in inch

N		A	A1	A2	D	E	H	L	b	c	e	h	α
8	min	.060	.004	.054	.189	.150	.228	.016	.014	.008	.050 BSC	.010	0°
	max	.068	.010	.062	.196	.157	.244	.050	.019	.010		.020	8°

Table 24: Package dimensions in mm and inch

24. Contact

For the latest version of this document, go to our website at www.melexis.com.

For additional information, please contact our Direct Sales team and get help for your specific needs:

Europe, Africa	Telephone: +32 13 67 04 95
	Email : sales_europe@melexis.com
Americas	Telephone: +1 603 223 2362
	Email : sales_usa@melexis.com
Asia	Email : sales_asia@melexis.com

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