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### Features and Benefits

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

### Applications

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

### Ordering Information<sup>1</sup>

Part No.	Temperature Suffix	Package Code	Die Revision	Option code	Packing
MLX90366	L (- 40 °C to + 150 °C)	VS	ADU	250	RE
MLX90366	L (- 40 °C to + 150 °C)	VS	ADU	250	RX
MLX90366	L (- 40 °C to + 150 °C)	VS	ADU	250	SP
MLX90366	L (- 40 °C to + 150 °C)	VS	ADU	251	RE
MLX90366	L (- 40 °C to + 125 °C)	VS	ADU	251	RX
MLX90366	L (- 40 °C to + 150 °C)	VS	ADU	251	SP
MLX90366	L (- 40 °C to + 150 °C)	VS	ADU	253	RE
MLX90366	L (- 40 °C to + 150 °C)	VS	ADU	253	RX
MLX90366	L (- 40 °C to + 150 °C)	VS	ADU	253	SP

#### Legend:

Temperature Code: E for Temperature Range -40°C to 85°C  
 K for Temperature Range -40°C to 125°C  
 L for Temperature Range -40°C to 150°C

Package Code: VS for DMP-4 Package

Option Code: AAA-123:  
 AAA: die version  
 1: IMC placement  
 23: Trim and form option:  
 • 50: Standard (straight leads) see section 20.1  
 • 51: Trim and Form STD1 2.54 see section 20.2  
 • 53: Trim and Form STD2 2.54 see section 20.3

Packing Form: RE for Reel (face-up)  
 RX for Reel (face-down)  
 SP for sample pack

Ordering example: MLX90366LVS-ADU-250-RE

<sup>1</sup> See your sales representative for more details.

**1. Functional Diagram**

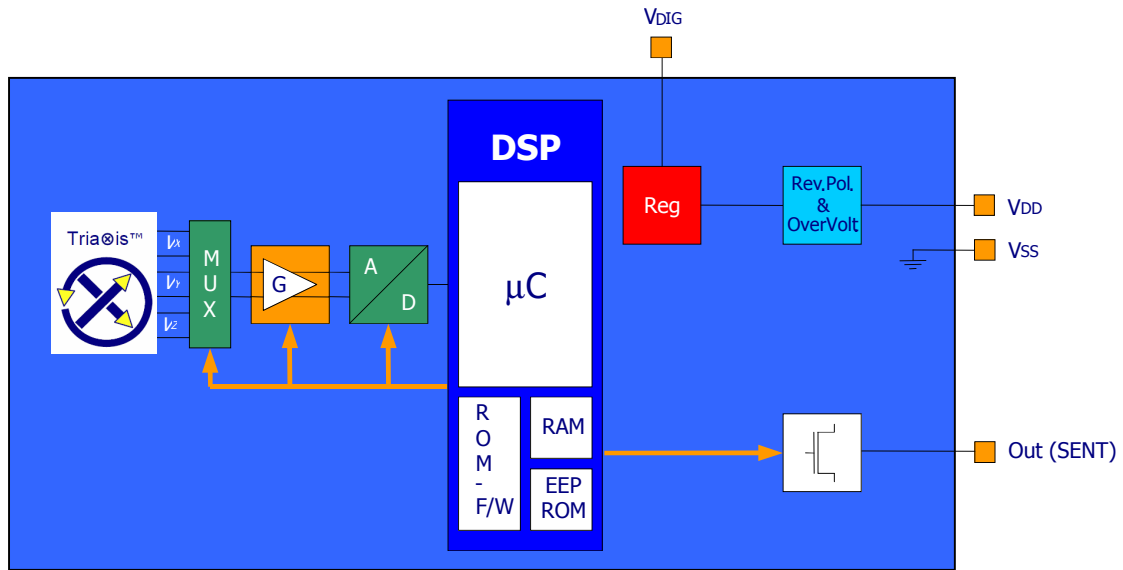


Figure 1 - MLX 90366 Block Diagram



## 2. Description

The MLX90366 Triaxis® Position Sensor Assembly is a high accuracy linear and angular position sensor which eliminates need for inclusion of a printed circuit board (PCB) within sensing modules.

This device is based on a Dual Mold Package (DMP) construction, which integrates a Triaxis position sensing die together with the decoupling capacitors necessary to meet the strenuous ESD and EMC requirements. No PCB is needed.

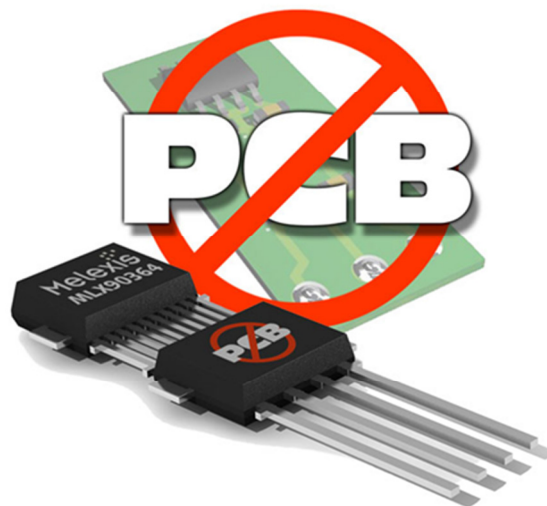
The Triaxis position sensing die is nothing but the one used for the MLX90367 in conventional surface-mount packages (SOIC-8 – single die & TSSOP-16 – dual die).

The decoupling capacitors are X8R capacitors well suited for package integration and the target operating temperature range.

The MLX90366 is sensitive to the three components of the flux density applied to the IC (i.e.  $B_x$ ,  $B_y$  and  $B_z$ ). This allows the MLX90366 with the correct magnetic circuit to decode the absolute position of any moving magnet (e.g. rotary position from 0 to 360 Degrees or linear displacement, stroke - Figure 2). It enables the design of novel generation of non-contacting position sensors that are frequently required for both automotive and industrial applications.

MLX90366 provides SENT Frames encoded according the Secure Sensor format.  
The circuit delivers enhanced serial messages providing error codes, and user-defined values.

MLX90366 Triaxis® Position Sensor Assembly enables the realization of position sensor modules for which a PCB is no longer needed: this yield to an increase of the electrical, mechanical and environmental robustness of the final application.



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### 3. Glossary of Terms – Abbreviations – Acronyms

- Gauss (G), Tesla (T): Units for the magnetic flux density – 1 mT = 10 G
- TC: **T**emperature **C**oefficient (in ppm/Deg.C.)
- NC: **N**ot **C**onnected
- SENT: **S**ingle **E**dge **N**ibble **T**ransmission
- ADC: **A**nalog-to-**D**igital **C**onverter
- LSB: **L**east **S**ignificant **B**it
- MSB: **M**ost **S**ignificant **B**it
- DNL: **D**ifferential **N**on-**L**inearity
- INL: **I**ntegral **N**on-**L**inearity
- RISC: **R**educed **I**nstruction **S**et **C**omputer
- ASP: **A**nalog **S**ignal **P**rocessing
- DSP: **D**igital **S**ignal **P**rocessing
- CoRDIC: **C**oordinate **R**otation **D**igital **C**omputer (i.e. iterative rectangular-to-polar transform)
- EMC: **E**lectro-**M**agnetic **C**ompatibility

### 4. Pinout

Pin #	
1	VSS (Ground)
2	VDD
3	OUT
4	VSS (Ground)

### 5. Absolute Maximum Ratings

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

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

## 6. Description

As described on the block diagram the three vector components of the magnetic flux density ( $B_x$ ,  $B_y$  and  $B_z$ ) applied to the IC are sensed through the sensor front-end. The respective Hall signals ( $V_x$ ,  $V_y$  and  $V_z$ ) are generated at the Hall plates and amplified.

The analog signal processing is based on a fully differential analog chain featuring the classic offset cancellation technique (Hall plate 2-Phases spinning and chopper-stabilized amplifier).

The conditioned analog signals are converted through an ADC (15 bits) and provided to a DSP block for further processing. The DSP stage is based on a 16 bit RISC micro-controller whose primary function is the extraction of the position from two (out of three) raw signals (after so-called front-end compensation steps) through the following function:

$$\alpha = \angle(V_1, k \cdot V_2)$$

where alpha is the magnetic angle  $\angle(B_1, B_2)$ ,  $V_1 = V_x$  or  $V_y$  or  $V_z$ ,  $V_2 = V_x$  or  $V_y$  or  $V_z$  and k is a programmable factor to match the amplitude of  $V_1$  and  $k \cdot V_2$ .

The DSP functionality is governed by the micro-code (firmware – F/W) of the micro-controller which is stored into the ROM (mask programmable). In addition to the magnetic angle extraction, the F/W controls the whole analog chain, the output transfer characteristic, the output protocol, the programming/calibration and also the self-diagnostic modes.

The magnetic angular information is intrinsically self-compensated vs. flux density variations. This feature allows therefore an improved thermal accuracy vs position sensor based on conventional linear Hall sensors.

In addition to the improved thermal accuracy, the realized position sensor features excellent linearity performances taking into account typical manufacturing tolerances (e.g. relative placement between the Hall IC and the magnet).

Once the position (angular or linear stroke) information is computed, it is further conditioned (mapped) vs. the target transfer characteristic and it is provided at the output(s) as SENT output.

The linear part of the transfer curve can be adjusted through a multi-point calibration:

This back-end step consists in a Piece-Wise-Linear (PWL) output transfer characteristics – 3 reference points & 4 slopes w/ programmable origin.

The calibration parameters are stored in EEPROM featuring a Hamming Error Correction Coding (ECC).

The programming steps do not require any dedicated pins. The operation is done using the supply and output nodes of the IC. The programming of the MLX90366 is handled at both engineering lab and production line levels by the Melexis Programming Unit PTC-04 with the dedicated MLX90366 daughterboard and MLX90366 software tools (DLL – User Interface).



## 7. MLX90366 Electrical Specification

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

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
Nominal Supply Voltage	VDD		4.5	5	5.5	V
Supply Current <sup>1</sup>	I <sub>dd</sub>				10	mA
Isurge Current <sup>2</sup>	I <sub>surge</sub>				20	mA
Power-On reset ( rising )	HPOR_LH	Refer to internal voltage V <sub>dig</sub>	2	2.25	2.5	V
Power-On reset Hysteresis	HPOR_Hyst		50		200	mV
Start-up Level ( rising )	MT4V_LH		3.8	4.0	4.2	V
Start-up Hysteresis	MT4V_Hyst		50		200	mV
PTC Entry Level ( rising )	MT7V_LH		5.8	6.2	6.6	V
PTC Entry Level Hysteresis	MT7V_Hyst		50		200	mV
Output Short Circuit Current	I <sub>short</sub>	V <sub>out</sub> = 0 V			15	mA
		V <sub>out</sub> = 5 V			15	mA
		V <sub>out</sub> = 18 V (T <sub>A</sub> = 25°C)			18	mA
Output Load	R <sub>L</sub>	Pull-down to Ground	4.7	10	∞	kΩ
		Pull-up to 5V	4.7	10	∞	kΩ
Active Diagnostic Output Level Digital Saturation Output Level	D <sub>sat_lo</sub>	Pull-up load R <sub>L</sub> ≥ 10 kΩ to 5 V Pull-up load R <sub>L</sub> ≥ 5 kΩ to 18V		0.5 2	2 3	%VDD
	D <sub>sat_hi</sub>	Pull-down load R <sub>L</sub> ≥ 5 kΩ Pull-down load R <sub>L</sub> ≥ 10 kΩ	95 97.5	97 98.5		%VDD
Passive Diagnostic Output Level (Broken Track Diagnostic) <sup>3</sup>	BV <sub>SSPD</sub>	Broken V <sub>SS</sub> & Pull-down load R <sub>L</sub> ≥ 10 kΩ	97.5			%VDD
	BV <sub>SSPU</sub>	Broken V <sub>SS</sub> & Pull-up load R <sub>L</sub> ≥ 4.7kΩ	99.5	100		%VDD
	BV <sub>DDPD</sub>	Broken V <sub>DD</sub> & Pull-down load R <sub>L</sub> ≥ 4.7kΩ		0	0.5	%VDD
	BV <sub>DDPU</sub>	Broken V <sub>DD</sub> & Pull-up load R <sub>L</sub> ≥ 5kΩ			2	%VDD
Digital output Ron	Ron	Diag_low	15		30	Ohms
		Diag_hi	120		300	

<sup>2</sup> The specified value is valid during early start-up time only; the current might dynamically exceed the specified value, shortly, during the Start-up phase.

<sup>3</sup> The SENT output signal will no longer be reported. For detailed information, see also section 15.

## 8. MLX90366 Timing Specification

DC Operating Parameters at Nominal supply voltage (unless otherwise specified) and for T<sub>A</sub> as specified by the Temperature suffix (L).

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
Main Clock Frequency	Ck	All contributors (trimming accuracy, supply voltage, thermal and ageing)	12.6	13.3	14	MHz
Main Clock Frequency Thermal Drift	$\Delta^T Ck$				$\pm 3\%$	Ck <sub>NOM</sub>
Tick time		Default EEPROM setting		3		$\mu s$
Low pulse tick count		Exact value for Ck = 13.3 MHz The typical value will be affected by any variation of the clock	4	5		ticks
SENT Frame Period	tframe			882		$\mu s$
Internal Angle Measurement Period	tper			441		$\mu s$
First Angle Measurement to Sync Pulse latency	ta1			1084		$\mu s$
Second Angle Measurement to Sync Pulse latency	ta2			643		$\mu s$
Field Change to SENT Data : Average Latency	Latency		FILTER = 1 (recommended) SENT Transmission Included	1745		1745
SENT Frame Tick Count		Default EEPROM setting	294		294	
Watchdog	twd		114.5	118	121.5	ms
Start-up Time (up to first sync pulse)	tsu1			1.8		ms
Start-up Time (up to first data received)	tsu2	Last pause pulse not included		5.9	6.3	ms
Serial Message		Extended sequence ( 40 frames ) Short sequence ( 24 frames )		35.28 21.168		ms
Rise Time @ Cable		Thresholds : 0.5V and 4.5V See section 9.2	2.97		5.31	$\mu s$
Rise Time @ Receiver			5.07		6.84	$\mu s$
Fall Time @ Cable			2.65		2.82	$\mu s$
Fall Time @ Receiver			4.84		4.9	$\mu s$

## 8.1. Timing diagrams

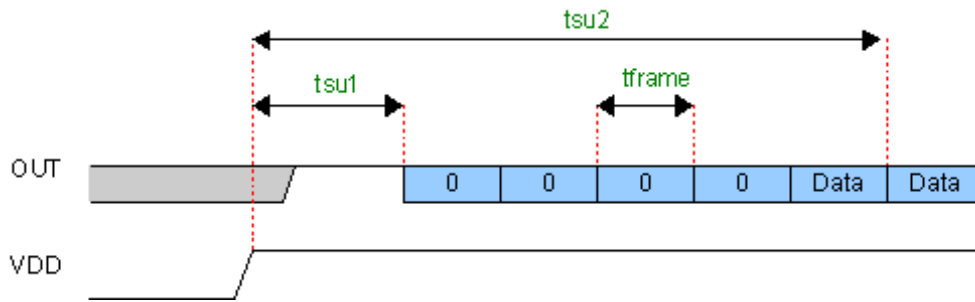


Figure 7 – Start-up phase timings

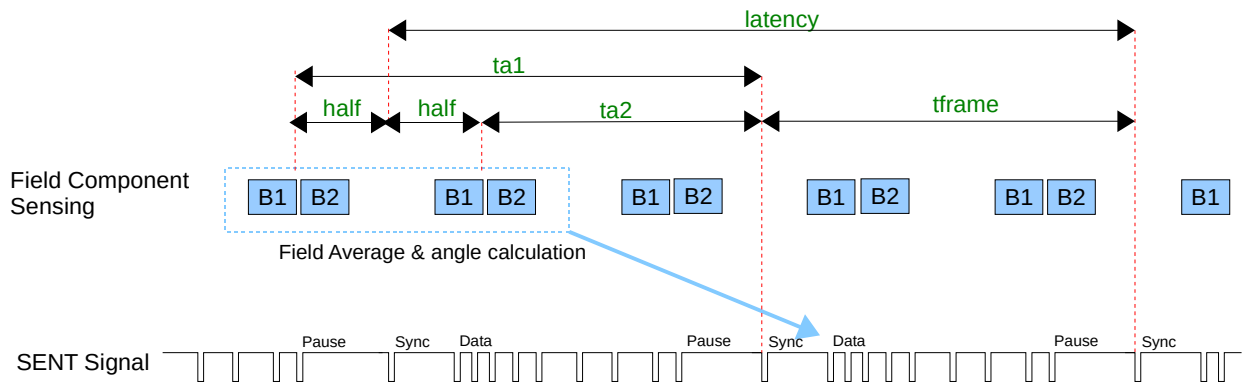


Figure 8a – Latencies (acquisition to output delays) – FILTER = 1 (recommended)

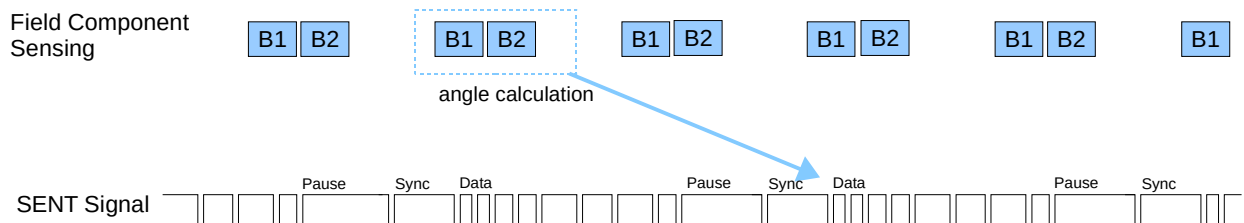


Figure 8b – Latency - Case FILTER = 0 (not recommended)

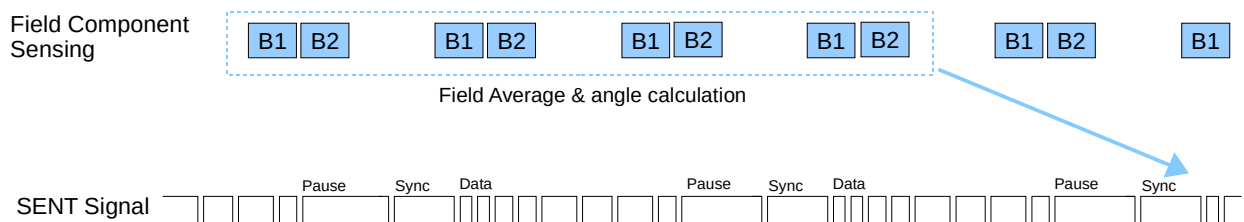


Figure 8c – Latency - Case FILTER = 2

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

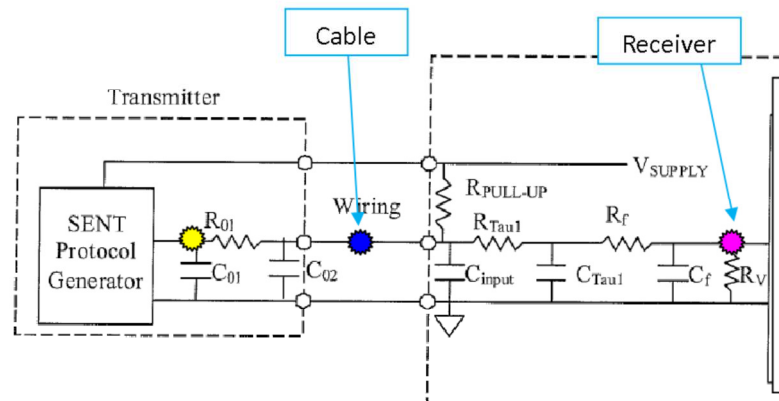


Figure 9 –Schematic used for rise and fall time measurements (ref: J2716 Rev Jan 2010 Fig. 6.3.4)

Component	Value	Unit
C01	10 ± 25% (internal in DMP)	nF
C02	not mounted	nF
R01	not mounted	Ohms
Cinput	68	pF
CTau	2.2	nF
Cf	100	pF
RTau	568	Ohms
Rf	10	kOhms
RPU	14.7	kOhms
RV	not mounted	Ohms

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

## 9. MLX90366 Accuracy Specification

DC Operating Parameters at VDD = 5V (unless otherwise specified) and for T<sub>A</sub> as specified by the Temperature suffix (E or K or L).

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
ADC Resolution on the raw signals sine and cosine <sup>(4)</sup>	R <sub>ADC</sub>			15		bits
Thermal Offset Drift #1 <sup>(5)</sup> at the DSP input (excl. DAC and output stage)		Temperature suffix E Temperature suffix K Temperature suffix L	-60 -60 -90		+60 +60 +90	LSB <sub>15</sub>
Thermal Drift of Sensitivity Mismatch <sup>(6)</sup>		XY axis – Temp. suffix E XY axis – Temp. suffix K & L XZ (YZ) axis – Temp. suffix E XZ (YZ) axis – Temp. suffix K & L	-0.3 -0.5 -1 -1		+0.3 +0.5 +1 +1	%
Magnetic Angle phase error		T <sub>A</sub> = 25°C – XY axis T <sub>A</sub> = 25°C – XZ axis T <sub>A</sub> = 25°C – YZ axis	-0.3 -2 -2		0.3 2 2	Deg.
Thermal Drift of Magnetic Angle phase error		Y axis, XZ (YZ) axis		0.01		Deg.
XY – Intrinsic Linearity Error <sup>(7)</sup>	Le	T <sub>A</sub> = 25°C – factory trim. “SMISM”	-1		1	Deg
XZ - Intrinsic Lin. Error <sup>(11)</sup>	Le	T <sub>A</sub> = 25°C – “k” trimmed for XZ	-2.5	±1.25	2.5	Deg
YZ - Intrinsic Lin. Error <sup>(11)</sup>	Le	T <sub>A</sub> = 25°C – “k” trimmed for YZ	-2.5	±1.25	2.5	Deg
Noise pk-pk <sup>(8)</sup>		FILTER = 0, 40mT FILTER = 1 (recommended) , 30mT FILTER = 2, 20mT		0.10 0.10 0.1	0.2 0.2 0.2	Deg

<sup>4</sup> 16 bits corresponds to 15 bits + sign. Internal computation is performed using 16 bits.

<sup>5</sup> For instance, in case of a rotary position sensor application, Thermal Offset Drift #1 equal ± 60LSB<sub>15</sub> yields to max. ± 0.3 Deg. angular error for the computed angular information (output of the DSP). This is only valid if k = 1. “MLX90365 Front-End Application Note” will be released for more details.

<sup>6</sup> For instance, in case of a rotary position sensor application, Thermal Drift of Sensitivity Mismatch equal ± 0.5% yields to max. ± 0.15 Deg. angular error for the computed angular information (output of the DSP). See “MLX90365 Front-End Application Note” for more details.

<sup>7</sup> The Intrinsic Linearity Error refers to the IC itself (offset, sensitivity mismatch, orthogonality) taking into account an ideal rotating field for B<sub>x</sub> and B<sub>y</sub>. Once associated to a practical magnetic construction and the associated mechanical and magnetic tolerances, the output linearity error increases. However, it can be improved with the multi-point end-user calibration. The intrinsic Linearity Error for Magnetic angle ∠XZ and ∠YZ can be reduced through the programming of the k factor.

<sup>8</sup> Noise pk-pk (peak-to-peak) is here intended as 6 times the Noise standard Deviation. The application diagram used is described in the recommended wiring. For detailed information, refer to section Filter in application mode (Section 14.4).



## 10. MLX90366 Magnetic Specification

DC Operating Parameters at VDD = 5V (unless otherwise specified) and for TA as specified by the Temperature suffix (E or K or L).

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
Magnetic Flux Density	B <sub>x</sub> , B <sub>y</sub> <sup>(9)</sup>	$\sqrt{B_x^2 + B_y^2}$			70(10)	mT
Magnetic Flux Density	B <sub>Z</sub> <sup>(11)</sup>				126	mT
Magnetic Flux Norm	Norm	$\sqrt{B_x^2 + B_y^2 + (B_z/1.2)^2}$	20 <sup>(12)</sup>			mT
IMC Gain <sup>(12)</sup>	GainIMC		1.15	1.3	1.4	
Magnet Temperature Coefficient	TCm		-2400		0	ppm/°C

## 11. MLX90366 CPU & Memory Specification

The DSP is based on a 16 bit RISC µController. This CPU provides 2.5 Mips while running at 10 MHz.

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
ROM				10		kB
RAM				384		B
EEPROM				128		B

<sup>9</sup> The condition must be fulfilled for at least one field BX or BY.

<sup>10</sup> Above 70 mT, the IMC starts saturating yielding to an increase of the linearity error.

<sup>11</sup> Below 20 mT, the performances slightly degrade due to a reduction of the signal-to-noise ratio, signal-to-offset ratio.

<sup>12</sup> This is the magnetic gain linked to the Integrated Magneto Concentrator (IMC) structure. It applies to BX and BY and not to BZ. This is the overall variation. Within one lot, the part to part variation is typically ± 10% versus the average value of the IMC gain of that lot

### 12. MLX90366 End-User Programmable Items

Parameter	Comments	Standard	Comments
MAPXYZ	Mapping fields for output angle	0	2
CLAMP_HIGH	Clamping High (50%)	0%	16
CLAMP_LOW	Clamping Low (50%)	100%	16
SMISM	Sensitivity mismatch factor X,Y	MLX	15
K	Sensitivity mismatch factor X (Y) , Z	MLX	15
Sel_K	Location for for K – correction	0	1
GAINMIN	Low threshold for virtual gain	00h	8
GAINMAX	High threshold for virtual gain	28h	8
GAINSATURATION	Gain Saturates on GAINMIX and GAINMAX	0h	1
DP	Discontinuity point	0h	15
CW	Clock Wise	0h	1
MELEXISID1	Melexis identification reference	MLX	16
MELEXISID2	Melexis identification reference	MLX	16
MELEXISID3	Melexis identification reference	MLX	16
LNR_Ax, LNR_Ay, LNR_As	Coordinate For point A	Tbd	16
LNR_Bx, LNR_By, LNR_Bs	Coordinate For point B	Tbd	16
LNR_Cx, LNR_Cy, LNR-Cs	Coordinate For point C	Tbd	16
DIAG Settings	16 Bit Diagnostics enabling	FDFh	16
CRC_DISABLE	Enable EEPROM CRC check ( 3131h= disable)	0h	16
SERIALERROR	Diagnostic reporting through fast channel	0	2
FILTER	FIR Filter	0	2
SERIAL_X1	Serial Message	0	12
SERIAL_X2	Serial Message	0	12
SERIAL_Y1	Serial Message	0	12
SERIAL_Y2	Serial Message	0	12
EE_SENT_SERIAL	Serial Message	0	12
EE_SERIAL_OEM#1	Serial Message	0	12
EE_SERIAL_OEM#2	Serial Message	0	12
EE_SERIAL_OEM#8	Serial Message	0	12
EE_SENT Man Code	Serial Message	0	12
EE_SENT Sensor Type	Serial Message	0	12
EE_User ID1	Cust identification reference : Default = Bin1	1	16
EE_User ID2	Cust identification reference : Default Rev nr	305h	16
EE_User ID3	Cust identification reference ; Default Sens.	MLX	16
EE_SENSOR ID#1	Serial Message	0	12
EE_SENSOR ID#2	Serial Message	0	12
EE_SENSOR ID#3	Serial Message	0	12
EE_SENSOR ID#4	Serial Message	0	12
SENT_Dis_Serialmessage	Disable Serial message	0	1
SENT_Dis_PausePulse	Disable pause pulse	0	1
SENT_CRC2007	Enable CRC calculation according SAE2007	0	1
SENT_DATA MODE	Select SENT DATA Channel nibble order	0	1
Memlock	EEProm memory lock		2

## 13. SENT output Protocol

### 13.1. Generality

The MLX90366 complies with the sub-set of the norm J2716 Revised **JAN2010**, “A.1 A.1 Throttle Position” or “A.3 Single Secure Sensors”

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

MLX90366 delivers SENT frames according the Throttle position or Single Secure format. This format is explicitly described in this section.

#### 13.2.1. Frame Content

The 90366 SENT frames have 6 data nibbles, and are formatted according the below table

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

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

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

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

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

1. A diagnostic (analog/environmental) detects an error \*
2. The reporting of the above error is enabled \*\*
3. The debouncing time has elapsed.

\* A diagnostic of type digital cause the circuit to switch in fail-safe-mode

\*\* See EEPROM bits EE\_DIAG\_SETTINGS

#### 13.2.2.2. Diagnostic Reporting, Channel 1

The diagnostic can be reported through the 12 bit payload of channel 1, and not only through the status bit Status[0].

The EEPROM parameters SERIALERROR controls the diagnostic reporting through channel 1 as follow:

If SERIALERROR =0, the channel 1 reports the angle, and not the diagnostic, as if no diagnostic.  
The error is reported only thanks to the Status bits.

If SERIALERROR >0, the channel1 payload contains the value Channel1 = (4088 + SERIALERROR]

#### 13.2.2.3. Diagnostic Reporting Time

The Diagnostic **Reporting Time** is programmable (defined as multiple of a macro-cycle unit time).  
A macro-cycle is a sequence of 20 angle acquisitions, and has a duration of approximately 6 ms.

#### 13.2.2.4. Diagnostic Debouncing

The Diagnostic Reporting is **Debounced**. The debouncing paramater are user-programmable, by steps of approximately 6 ms.

#### 13.2.3. Pause pulse

A pause pulse, as defined by the standard, is present at the end of every frame.  
The pause pulse mode can be disabled.

The pause pulse lenght is adjusted by the circuit so that the frame period is constant.  
The field sensing and the frame synchro pulse are in sync.

#### 13.2.4. Fast Channel CRC

The 90366 features the new recommended implementation and optional the legacy implementation

### 13.3. Slow Channel

#### 13.3.1. Enhanced Serial Message

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

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

### 13.3.2. Serial Message Sequence

The circuit complies with the following sub-set specifications of the norm for pressure sensors (The norm for the angular sensor case does not specify the serial message format)

#	8bit ID	Item	12 bit data	Comments
1	0 1	Diagnostic Error Codes	RAM	Described at next chapter
2	0 6	SENT standard revision	Prog.	EE_SENT rev
3	0 1	Diagnostic Error Codes	RAM	
4	0 5	Manufacturer code	Prog.	EE_SENT Man Code
5	0 1	Diagnostic Error Codes	RAM	
6	0 3	Channel 1 / 2 Sensor type	Prog.	EE_SENT Sensor type
7	0 1	Diagnostic Error Codes	RAM	
8	0 7	Fast channel 1 -X1	Prog.	EE_SENTChannel X1
9	0 1	Diagnostic Error Codes	RAM	
10	0 8	Fast channel 1 -X2	Prog.	EE_SENTChannel X2
11	0 1	Diagnostic Error Codes	RAM	
12	0 9	Fast channel 1 -Y1	Prog.	EE_SENTChannel Y1
13	0 1	Diagnostic Error Codes	RAM	
14	0A	Fast channel 1 -Y2	Prog.	EE_SENTChannel Y2
15	0 1	Diagnostic Error Codes	RAM	
16	2 3	TEMP Sensor	RAM	
17	0 1	Diagnostic Error Codes	RAM	
18	2 9	Sensor ID #1	Prog.	EE_SENT Sensor ID1
19	0 1	Diagnostic Error Codes	RAM	
20	2A	Sensor ID #2	Prog.	EE_SENT Sensor ID2
21	0 1	Diagnostic Error Codes	RAM	
22	2 B	Sensor ID #3	Prog.	EE_SENT Sensor ID3
23	0 1	Diagnostic Error Codes	RAM	
24	2 C	Sensor ID #4	Prog.	EE_SENT Sensor ID4
Optional Part ( EE_ExtendedSequence = 1 )				
25	0 1	Diagnostic Error Codes	RAM	Described at next chapter
26	90	OEM Code #1	Prog.	EE_SENT OEM CODE1
27	0 1	Diagnostic Error Codes	RAM	
28	91	OEM Code #2	Prog.	EE_SENT OEM CODE2
29	0 1	Diagnostic Error Codes	RAM	
30	92	OEM Code #3	Prog.	EE_SENT OEM CODE3
31	0 1	Diagnostic Error Codes	RAM	
32	93	OEM Code #4	Prog.	EE_SENT OEM CODE4
33	0 1	Diagnostic Error Codes	RAM	
34	94	OEM Code #5	Prog.	EE_SENT OEM CODE5
35	0 1	Diagnostic Error Codes	RAM	
36	95	OEM Code #6	Prog.	EE_SENT OEM CODE6
37	0 1	Diagnostic Error Codes	RAM	
38	96	OEM Code #7	Prog.	EE_SENT OEM CODE7
39	0 1	Diagnostic Error Codes	RAM	
40	97	OEM Code #8	Prog.	EE_SENT OEM CODE8

Table. Serial Message Sequence



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

The second part (positions 24 to 40) is optional as a whole enabled with EEPROM bit EE\_ExtendedSequence.

This second part consists of the error code (8 occurrences), 8 OEM -defined Code

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

$$\text{SENT@ ID 23} = 8 * (T[C] - 35[C]) + 865 \text{ lsb12}$$

The accuracy of the actual Temperature is = ± 10 DegC.

### 13.3.3. Serial message sequence period

Sequence Length (serial message count)	Sequence Length (frame count)	Sequence Period (ms, typical)
24	432	381
40	720	635

#### 13.3.3.1. Error Code Rate

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

### 13.3.4. Serial Message Error Code

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

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

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

### **13.4. Start-up**

During the chip initialization, the output remains high until the circuit emits four initialization frames (all 6 data nibble zero). The fifth frame is not an initialization frame but a valid frame containing a measured angle. See also section 9 “Timing specifications”.

### **13.5. Field sensing (A2D conversions) and the frame Synchronization pulse**

By default setting of the Timer period and Filter =1 , the digital angle (fast channel payload) results of the average of two angles.

These angles are themselves computed from 4 ADCs values.

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

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

See also section 8 “Timing specifications”.

## 14. Description of End-User Programmable Items

### 14.1. Output Transfer Characteristic

To define the transfer function (LNR):

Parameter	Value	Unit
CLOCKWISE	0 → CounterClockWise 1 → ClockWise	LSB
DP	0 ... 359.9999	deg
LNR_A_X LNR_B_X LNR_C_X	0 ... 359.9999	deg
LNR_A_Y LNR_B_Y LNR_C_Y	0 ... 100	%
LNR_S0 LNR_A_S LNR_B_S LNR_C_S	-17... 0 ... 17	%/deg
CLAMP_LOW	0 ... 100	%
CLAMP_HIGH	0 ... 100	%

#### 14.1.1. CLOCKWISE Parameter

The CLOCKWISE parameter defines the magnet rotation direction.

- CCW is defined by the 1-4-5-8 pin order direction for the SOIC8 package and 1-8-9-16 pin order direction for the TSSOP16 package.
- CW is defined by the reverse direction: 8-5-4-1 pin order direction for the SOIC8 and 16-9-8-1 pin order direction for the TSSOP16 package.

Refer to the drawing in the sensitive spot positioning sections (Section 19.5)

### 14.1.2. Discontinuity Point (or Zero Degree Point)

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

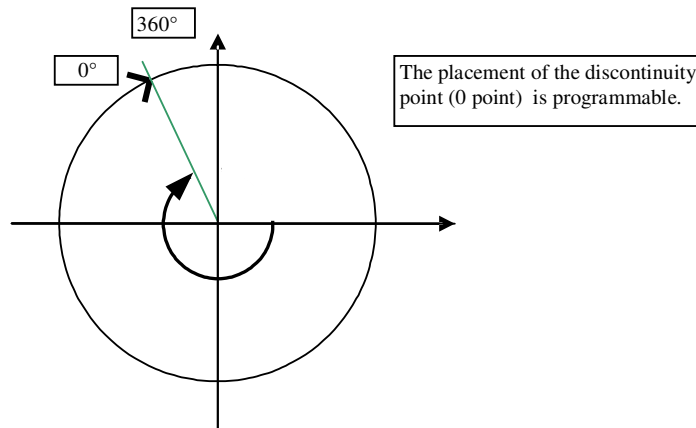


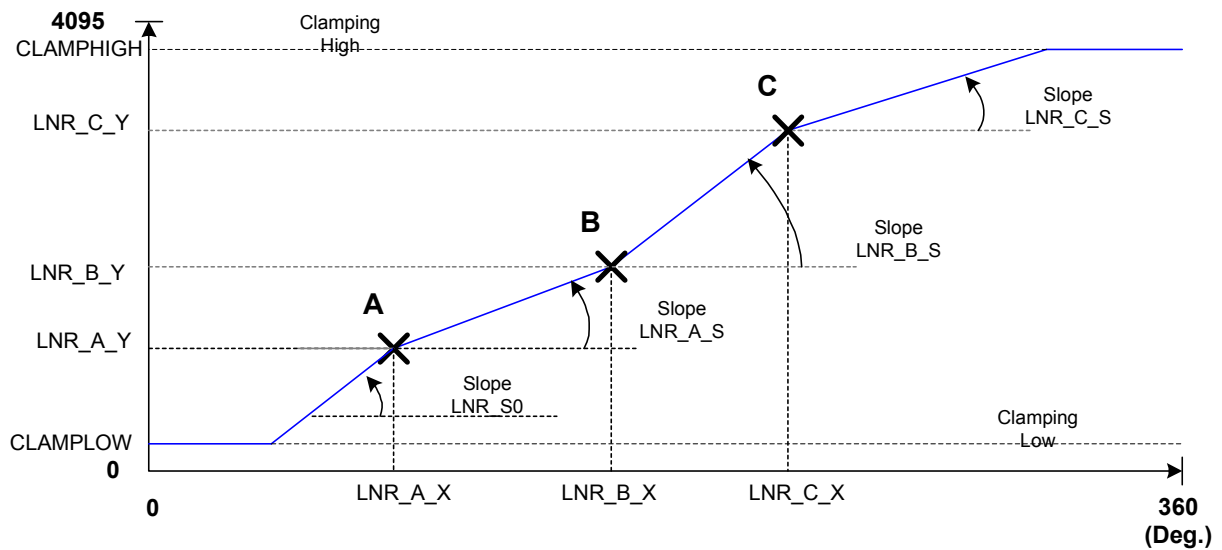
Figure 10 - Discontinuity Point Positioning

### 14.1.3. 3-Pts LNR Parameters

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

The shape of the MLX90366 transfer function from the digital angle value to the output voltage is described by the drawing below. Six segments can be programmed but the clamping levels are necessarily flat.

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



#### 14.1.4. CLAMPING Parameters

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

#### 14.2. Identification

Parameter	Value
MELEXISID1	0 ... 65535
MELEXISID2	0 ... 65535
MELEXISID3	0 ... 65535
CUSTOMERID1	0 ... 65535
CUSTOMERID2	0 ... 65535
CUSTOMERID3	0 ... 65535

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

#### 14.3. Sensor Front-End

Parameter	Value
MAPXYZ	0 .. 3
SMISM	0 .. 32768
K	0 .. 32768
SEL_k	0 or 1
GAINMIN	0 ... 41
GAINMAX	0 ... 41
GAINSATURATION	0.. 1

##### 14.3.1. MAPXYZ

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

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

MAPXYZ	B1	B2	Angular
0 – 00b	X	Y	XY mode
1 – 01b	Zx	X	XZx mode
2 – 10b	Y	Zx	YZx mode
3 – 11b	Y	Zy	YZy mode

MAPXYZ = 3 is not recommended.



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

(i) SMISM

When the mapping (B1=X, B2=Y) is selected, SMISM defines the sensitivity mismatch factor that is applied on B1, B2; When another B1, B2 mapping is selected, this parameter is “don’t care”. This parameter is trimmed at factory; Melexis strongly recommends TO NOT overwrite it for optimal performances.

(ii) k

When the mapping (B1=X, B2=Y) is **NOT** selected, k defines the sensitivity mismatch factor that is applied on B1 or B2 (according to parameter SEL\_k – see below). When the mapping (B1=X, B2=Y) is selected, this parameter is “don’t care”. This parameter is trimmed at factory for mapping (B1=Z, B2=X). Melexis recommends to fine trim it when a smaller linearity error (Le) is required and a different mapping than (B1=X, B2=Y) is selected.

(iii) SEL\_k

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

### 14.3.3. GAINMIN and GAINMAX Parameters

GAINMIN and GAINMAX define the thresholds on the gain code outside which the fault “GAIN out of Spec.” is set; If GAINSATURATION is set, then the virtual gain code is saturated at GAINMIN and GAINMAX, and no Diagnostic fault is set since the saturations applies before the Diag. check.

#### 14.4. Filter

Parameter	Value
FILTER	0, 1, 2

The MLX90366 features a filter that is enabled when FILTER = 1 or 2.

The filter is of type “moving average”. It averages the two most recent **internal** angle values in case FILTER=1 and the four most recent **internal** angle values in case FILTER=2. When the filter is enabled, the SENT data holds the average of the two or 4 most recent **internal** angles.

We recommend to enable the filter, in order to benefit from a noise reduction of 30% compared to the case FILTER = 0. Given that two angle values are computed per each SENT frame, the latency increases in this case only marginally.

Filter = 0 corresponds to no filtering, and may be selected to optimize the latency (by about 10%), whenever the latter is system-critical (e.g. stability of a close-loop system).

#### 14.5. Diagnostic Features

Refer to Application\_note\_Diagnostic\_Behavior\_90366 for EE\_CRC\_Enable function description and for Diagnostic features which can be enabled at user.

#### 14.6. EEPROM endurance

Although the EEPROM is used for Calibration Data Storage (similarly to an OTPROM), the MLX90366 embedded EEPROM is qualified to guarantee an endurance of minimum 1000 write cycles at 125°C for (engineering/calibration purpose).

### 15. MLX90366 Self Diagnostic

The MLX90366 provides numerous self-diagnostic features. Those features increase potentially the functional safety of safety-related systems as it reduces the risk of erroneous angle reporting in case of internal or external failure modes (“fail-safe”).

Diagnostic Item	Action	Effect on Output	Type	Monitoring Rate	Reporting Rate
<b>Start-up phase Diagnostics</b>					
RAM March C- 10N Test	Fail-safe mode ** ** CPU reset after 120ms	Diagnostic low/ high Reporting (optional)	Digi HW	n/applicable (start-up only)	n/applicable (start-up only)
Watchdog BIST	Fail-safe mode ** ** CPU reset after 120ms	Diagnostic low/ high Reporting (optional)	Digi HW	n/applicable (start-up only)	n/applicable (start-up only)
Under Voltage Monitoring SUPPLYMONI = (MT3VB) OR (MT4VB)	Start-up on Hold ** ** CPU reset after 120ms	Diagnostic low/high	Environ &Analog	n/applicable (start-up only)	n/applicable (start-up only)
Over Voltage Monitoring MT7V	PTC entry	Output in High-Impedance	Environ	n/applicable (start-up only)	n/applicable (start-up only)
<b>BG Loop Diagnostics</b>					
ROM 16bit checksum (continuous)	Fail-safe mode ** ** CPU reset after 120ms	Diagnostic low/high Reporting (optional)	Digi HW	800ms	800ms
EEPROM 8 bit CRC Check (continuous)	Fail-safe mode ** ** CPU reset after 120ms	Diagnostic low/high Reporting (optional)	Digi HW	10ms	10ms
Watchdog (continuous)	CPU reset	--	Digi HW	120ms	n/a
<b>DSP Loop Diagnostics</b>					
ADC Clipping ADCCIP	Debouncing (programmable)	SENT Status bit0 = 1 (optional)	Environ &Analog	5/DSP	6ms x $\frac{\text{Diag\_Debounce\_Thresh}}{\text{Diag\_Debounce\_Stepup}}$
Virtual Gain Code Out-of-spec GAINOOS	Debouncing (programmable)	SENT Status bit0 = 1 (optional)	Environ &Analog	1/DSP	6ms x $\frac{\text{Diag\_Debounce\_Thresh}}{\text{Diag\_Debounce\_Stepup}}$
Virtual Gain Code Saturation [GAINMIN..GAINMAX]	Saturation (optional)	Gain Saturated @ GAINMIN-GAINMAX	Environ &Analog	n/applicable Not a diagnostic	n/applicable Not a diagnostic
ADC Monitor (Analog to Digital Converter) ADCMONI	Debouncing (programmable)	SENT Status bit0 = 1 (optional)	Analog HW	1/DSP	6ms x $\frac{\text{Diag\_Debounce\_Thresh}}{\text{Diag\_Debounce\_Stepup}}$
Under Voltage Monitoring SUPPLYMONI = (MT3VB) OR (MT4VB)	Supply Debouncing (programmable)	SENT Status bit0 = 1 (optional)	Environ &Analog	1/DSP	6ms x $\frac{\text{Diag\_Debounce\_Thresh}}{\text{Diag\_Debounce\_Stepup}}$
Over Voltage Monitoring MT7V	PTC entry after PTC Debouncing	Output in High-Impedance	Environ	2ms	2ms
Temperature Sensor Monitor TEMPMONI	Debouncing (programmable)	SENT Status bit0 = 1 (optional)	Analog	1/DSP	6ms x $\frac{\text{Diag\_Debounce\_Thresh}}{\text{Diag\_Debounce\_Stepup}}$
Temperature > 170degC (± 20) Temperature < -60degC (± 20)	Saturate value used for the compensation to -40degC and +150degC resp.	No effect	Environ &Analog		n/applicable Not a diagnostic
<b>Hardware Diagnostics (continuously checked by dedicated Logic)</b>					
Read/Write Access out of physical memory	Fail-safe mode ** ** CPU reset after 120ms	Diagnostic Low/High	Digi HW	n/a immediate Diagnostic	n/a immediate Diagnostic
Write Access to protected area (IO and RAM Words)	Fail-safe mode ** ** CPU reset after 120ms	Diagnostic low/high	Digi HW	n/a immediate Diagnostic	n/a immediate Diagnostic
Unauthorized Mode Entry	Fail-safe mode ** ** CPU reset after 120ms	Diagnostic low/high	Digi HW	n/a immediate Diagnostic	n/a immediate Diagnostic
EEPROM Error Correcting Code (Hamming correction)	(Transparent) Error Correction	no effect	Digi HW	n/a.	n/a