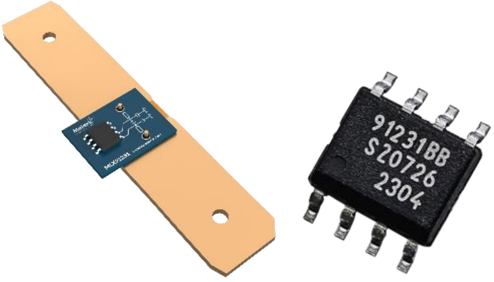
MLX91231

Smart IVT Sensor IC
Datasheet

1. Features and Benefits

- IVT battery measurements:
  - Shunt based current sensor
  - Voltage measurement
    - Internal dividers for 12V or 24V/48V batteries
    - External divider required for HV batteries
  - Internal (PTAT) temperature sensor
- 16-bit MCU with 32 KB Flash, 128 B Flash CS, 20 KB ROM, 2 KB RAM and 512 B EEPROM Memory
- LIN/UART communication interfaces
  - LIN Physical Layer compliant to ISO17987-4 and SAE J2602
  - UART as CAN MCU bridge
  - Wake-up on LIN and UART or on internal timer
- Overcurrent detection functionality (<500µs)
- Sensing range of 256mV
- Possible Automatic Gain Control (AGC) for higher dynamic range
- Low level SW libraries provided by Melexis
- User programmable transfer characteristic
- Supply voltage: 4.5 to 18V (5V regulated supply or 12V battery supply capability)
- Low current consumption (<21mA), programmable duty cycled sleep mode (RAM content maintained at <100µA)
- Ambient temperature from -40°C to 125°C
- ASIL compliant SEooC (Safety Element out of Context) according to ISO26262
- AEC-Q100 Grade 1 automotive qualified
- RoHS compliant package SOIC8 (DC)



2. Application Examples

- Battery Terminal Sensor 12V/ 24V
  Battery Management System 48V/ HV
  - Primary current measurement
  - Redundant current measurement (homogenous or heterogenous sensing technology)
  - Diagnosable Overcurrent Detection
- SoC/ SoH/ SoF + R_{int} (pre)calculations
- Smart Battery Disconnect Unit, Junction Box or Power Relay Assembly
- Smart Pyrofuses, HV relays or contactors
- HV DC FastCharge current sensor
- Zone controller
- DC/DC converter
- Power Distribution Unit

3. Description

The MLX91231 is the first Melexis smart Shunt-based current sensor and is part of Gen3 portfolio. With a measurement capability of three physical quantities: Current, Voltage and Temperature, Overcurrent detection alongside a dedicated 32 KB Flash memory on a single IC, this ASIL-compliant chip is ideal for safety applications. With its diagnostics, the MLX91231 is removing an important part of the burden from the integrator in developing all the safety mechanisms. The MLX91231 comes with 0.25% accuracy over temperature (-40°C to 125°C) and over lifetime all-in, hence boosting the accuracy of Shunt DC current sensing. The IC's MCU enables automatic gain control to cover higher dynamic ranges, and its on-board flash memory supports custom software, extensive compensation of system imperfections and low power modes. Supplied with a regulated 5V or directly connected to the 12V battery, the MLX91231 outputs measurements and diagnostics either on LIN bus or via UART.

Contents

4. Ordering Information

Product Code	Package	Sensing Technology	Sensing range
MLX91231KDC – BBA – 000 – RE	SOIC8	Shunt	[-100mV; 256mV]
MLX91231KDC – BBC – 000 – RE	SOIC8	Shunt	[-100mV; 256mV]

Table 1 - Ordering code

Legend:

Temperature Code	**K**: from -40°C to 125°C ambient temperature
Package Code	**DC**: for SOIC-8 package
Option Code	**BBC**-xxx: **BB:** die version **C:** ASIL Level (A is for ASIL.B and C is for ASIL.C) **xxx**-123: accuracy variant / version customization/ different programmed features (OCD, VBAT, …)
Packing Form	**RE**: for Reel
Ordering Example	**"MLX91231KDC-BBA-000-RE"** For a Shunt variant with default trimming in SOIC8 package.

Table 2 – Legend

Melexis is continuously expanding its product portfolio by adding new option codes to better meet the needs of our customer's applications. This table is being updated frequently; please go to the Melexis website to download the latest version of this datasheet.

5. Functional Diagram

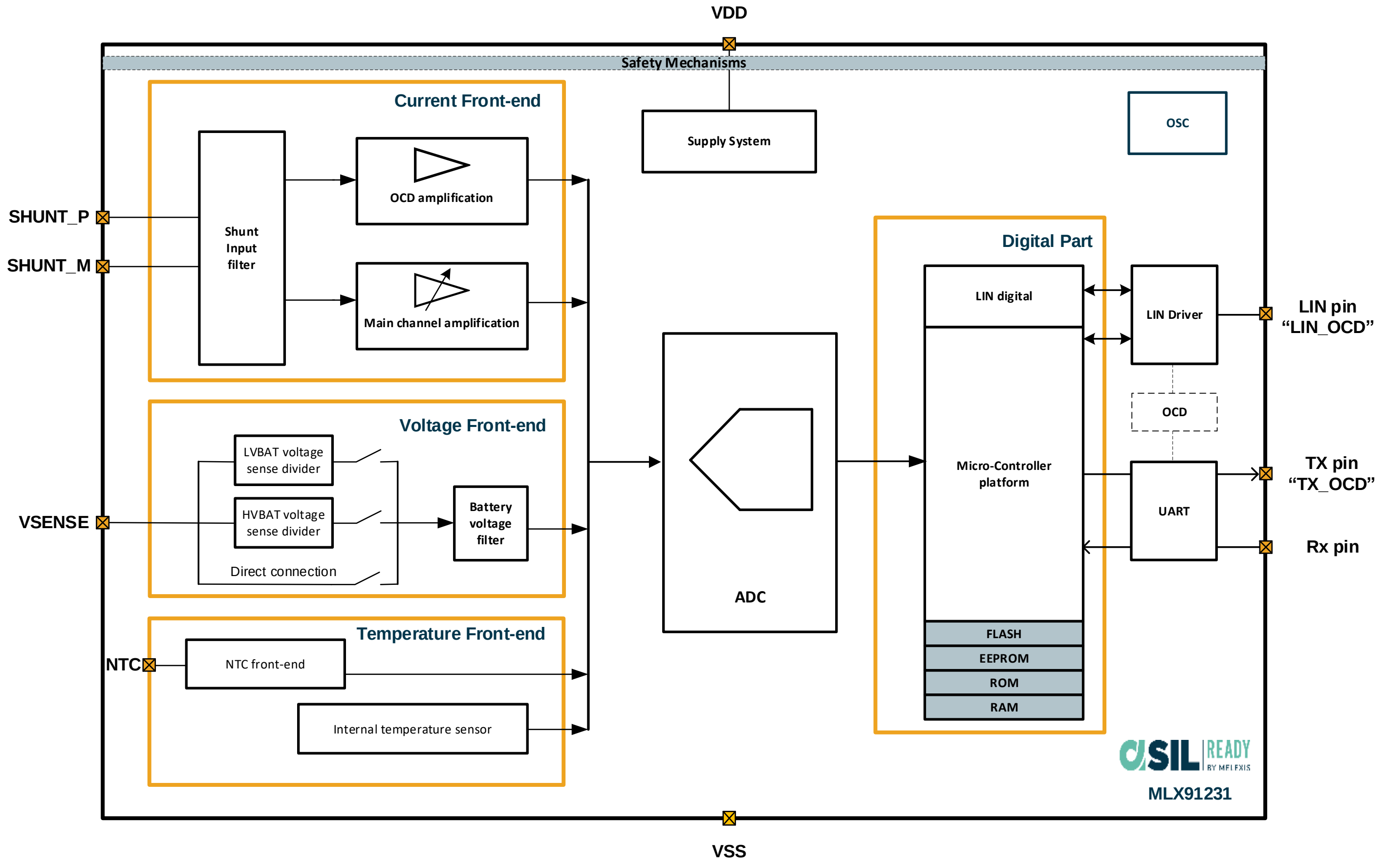


Figure 1- Detailed Block Diagram[1]

6. Functional Safety

The MLX91231 is an ASIL-compliant IC, developed as SEooC following ISO26262. The safety concept is described in the "MLX91231 Safety Manual", and defines safety requirements for the IVT signals (current, internal temperature and voltage measurement) as well as for the OCD function. Please contact Melexis for obtaining this document, which is only shared under NDA.

7. References

Melexis makes other documentation available to support the present datasheet. The **customer user manual**, several Application Notes as well as software tools and libraries can be found under http://softdist.melexis.com/. For login credentials, please contact Melexis in order to gain access to this platform and the MLX91231 directory in particular.

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[1] *NTC pad not bonded – please contact Melexis in case NTC functionality is needed*

8. Glossary of Terms

Term	Explanation
ADC	Analog-to-Digital Converter
AFE	Analog Front End
AGC	Automatic Gain Control
DC	Duty Cycle
DSP	Digital Signal Processing
ECU	Electronic Control Unit
EMC	Electro-Magnetic Compatibility
IVT	Current – Voltage – Temperature
LIN	Local Interconnect Network
LVBAT/ HV	Low Voltage Battery/ High Voltage (>60V)
MCU	Microcontroller Unit
OCD	Over Current Detection
PCB	Printed Circuit Board
PWM	Pulse Width Modulation
SoC/ SoH/ SoF	State of Charge/ State of Health/ State of Function
UART	Universal Asynchronous Receiver-Transmitter

Table 3 – Glossary of terms

9. Pin description, Pin Definitions and Pinout

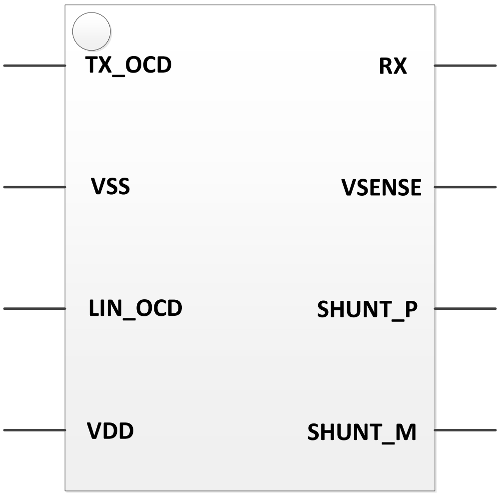
Pin #	Name	Description	Pinout
1	TX_OCD	UART communication pin OR Overcurrent detection pin	
2	VSS	Ground pin	
3	LIN_OCD	LIN communication pin OR Overcurrent detection pin	
4	VDD	Supply pin	
5	SHUNT_M	Shunt minus input pin	
6	SHUNT_P	Shunt plus input pin	
7	VSENSE	Voltage measurement input pin	
8	RX	UART communication pin	

Table 4 – Pin description, definitions and pinout

10. Absolute Maximum Ratings

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Operating Ambient Temperature Range	Ta	-40		+125	°C	
Storage Temperature Range	Ts	-55		+165	°C	
Junction Temperature Range	Tj	-40		+150	°C	
Maximum Supply Voltage	VDD_MAX	-0.3		36	V	Referred to VSS
Shunt pins absolute voltage	SHUNT_ABS_MAX	-0.5		1	V	SHUNTP or SHUNTM referred to VSS

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Shunt pins differential voltage	SHUNT_DIFF _MAX	-1		1	V	SHUNTP-SHUNTM Pin to pin (differential input)
Maximum Voltage Sensing Channel	VSENSEMAX	-14		36	V	12V input mode 400ms max for 36V referred to VSS
		-60		70	V	48V input mode 200ms max for 70V (only for LV148 E48-02 short test) referred to VSS
		-0.3		5.5	V	Direct (HV) input mode referred to VSS
LIN pin voltage	VLIN_MAX	-27		40	V	Conformance test according to ISO 17987-7
RX pin voltage	RX_MAX	-0.3		5.5	V	
TX OCD pin voltage	TXOCD_MAX _PP	-14		18	V	TX OCD configured as push-pull driver
TX OCD pin voltage	TXOCD_MA X_OD	-0.3		18	V	TX OCD configured as low side open drain driver
ESD – Human Body Model Protection	HBM_LINTX	8			kV	Test method: AEC-Q100-002 LIN_OCD and TX_OCD pin
	HBM_VDD	6			kV	Test method: AEC-Q100-002 VDD pin
	HBM_OTHER	2			kV	Test method: AEC-Q100-002 Other pins
ESD Charged Device Model Protection	CDM_ALL	500			V	Test method: AEC-Q100-011 Corner pins (1,4,5,8) 750V

Table 5 – Absolute Maximum Ratings

Attention: exceeding the absolute maximum ratings may cause permanent damage. Exposure to absolute maximum-rated conditions for extended periods of time may affect device reliability.

11. Operating Ranges

The IC comprises a Standby and a KeyOn mode:

- **Standby mode**: the IC is programmed to wake up at regular time intervals, make IVT measurements and go back into low power mode afterwards. In Standby mode, the RAM content is maintained.

- **KeyOn mode**: the IC is active all the time, performing continuous measurements of IVT and transmitting measurements via LIN or UART.

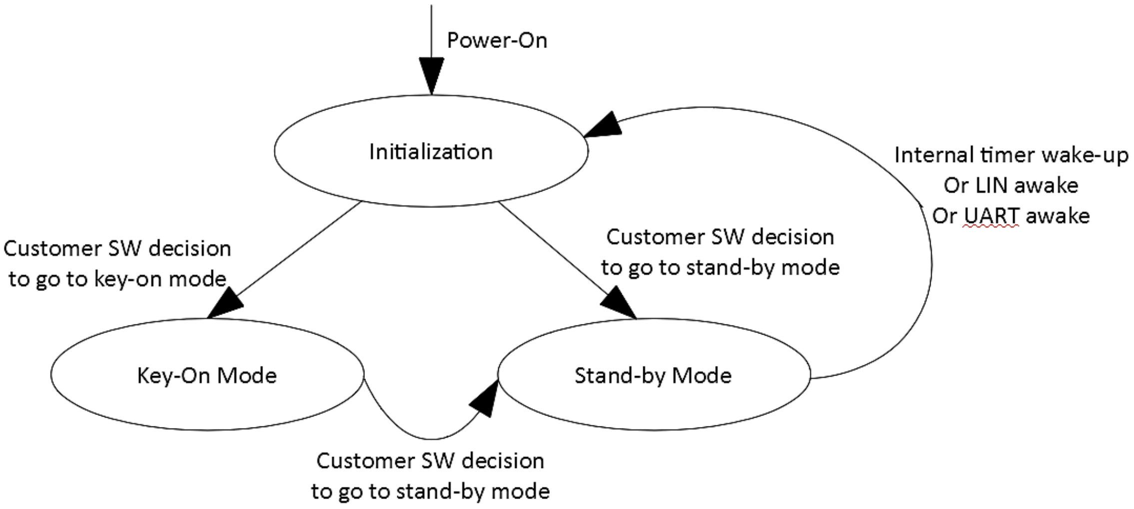


Figure 2- State Diagram

Electrical Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Supply Voltage	VDD	4.5	12	18	V	
Voltage Sensing Channel	VSENSE	3		18	V	LVBAT (12V)
		20		60	V	HVBAT (24V/ 48V)
		0.3		1.1	V	Direct connection, external divider
Current consumption	IDD_KEY			21	mA	KeyOn mode, without external load circuitry
	IDD_STBY			0.1	mA	Standby mode (averaged over 1 hour operation)

Table 6 – Operating conditions

Range number	BiPol	NegPol	PosPol	Unit
Range 1	[-2…2]	[-2…0]	[0…2]	mV
Range 2	[-8…8]	[-8…0]	[0…8]	mV
Range 3	[-32…32]	[-32…0]	[0…32]	mV
Range 4	[-100…128]	[-100…0]	[0…128]	mV
Range 5	[-100…256]	[-100…0]	[0…256]	mV

Table 7 – Typical shunt differential voltage ranges

12. General Timing Specification

The timing specification is built around the sequential measurement of Vbat (battery voltage measured on VSENSE pin) and Ibat (the battery current measured through the Shunt pins). With a single ADC resource, these Vbat and Ibat measurements are alternated, together with internal temperature ADCs, diagnostic ADCs and other ADC tasks. The IC can only start measuring after a start-up time called $T_{initialization}$.

Parameter	Value	Unit	Remarks
$T_{initialization}$	20	ms	Maximum value
$T_{acquisition}$	477	µs	Clock has a tolerance of ±3%
T_{synch}	123	µs	Clock has a tolerance of ±3%

Table 8 – Timing synchronization

The figure below shows the synchronization between the current and the voltage measurement based on the timing values in Table 9 above. These values are supported by the standard SW library delivered by Melexis. If different timings are needed, they can be adjusted through the FLASH SW based on a technical discussion with Melexis. Some applications may not require a voltage measurement that exists abundantly through other sensors, which could then speed up the MLX91231 Ibat acquisitions or improve the OCD response time which is more important for PyroFuse applications.

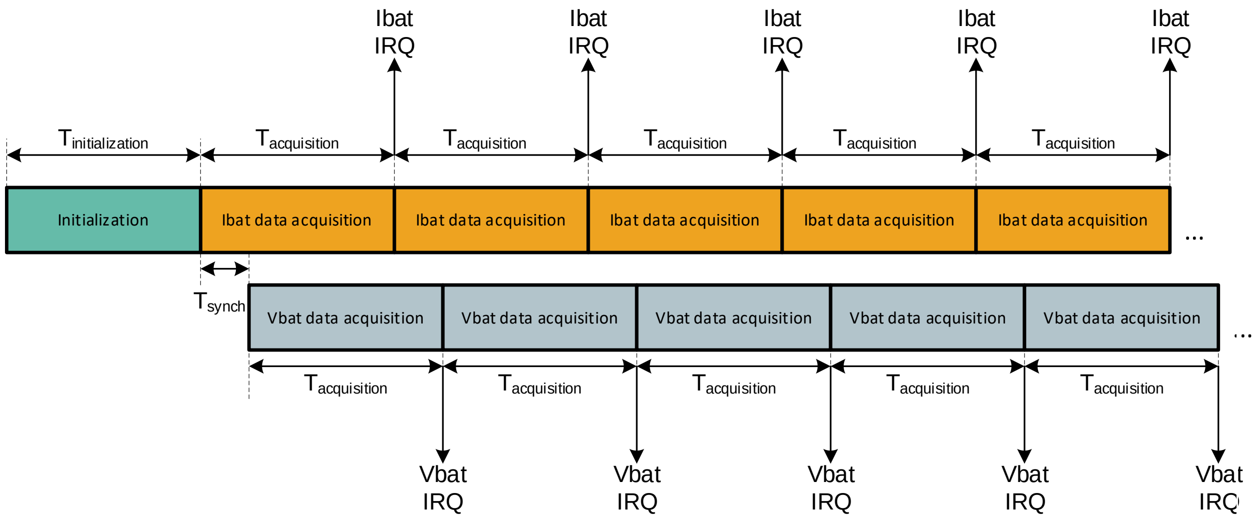


Figure 3 – Standard timing synchronization (programmable)

13. Analog Front End

13.1. Shunt current measurement

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Sensing differential voltage range	$Vshunt_{range}$	-100		256	mV	SHUNTP or SHUNTM vs. ground[2]
Resolution	R		20		nV	
Gain error between ranges[3]	$\Delta^{G}R$	-0.2		0.2	%	Full VDD range, shunt ranges 1-3 BiPol, 4-5 PosPol
Peak to peak noise	$Vshunt_{N,PTP}$		9	14	µV	Update rate of 500µs; Shunt Range 1
RMS noise	N_{RMS}		1.4	1.8	µV	Update rate of 500µs; Shunt Range 1

Table 9 – Shunt specifications

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[2] *One of the shunt pins should be at the same potential as the VSS pin, taking routing/layout precautions (for reference see Chapter 15)*

[3] *Calculated for two consecutive ranges with the same input voltage and VDD value*

Table 10 – Key Shunt specifications

Parameter	Symbol	Absolute Min.[4]	Min -3σ	Typ.	Max +3σ	Absolute Max.[4]	Unit	Condition
Sensitivity total drift[5, 6]	$\Delta^{T}S$	-0.25 -2	-0.18 -1.3		0.18 1.3	0.25 2	%	Full VDD range, shunt ranges 1-3 BiPol, 4-5 PosPol Full VDD range, shunt range 4 NegPol
Offset thermal drift[7] referred to 25°C	$\Delta^{T}O$	-1 -1.2 -1.5	-0.8 -0.9 -1.1		0.8 0.9 1.1	-1 -1.2 -1.5	µV	VDD = 5V VDD = 12V VDD = 18V

13.2. Automatic gain control

The Analog Front End (AFE) for the current measurement is factory trimmed for different amplifications. For MLX91231 five different gain settings are used to cover the following ranges: ±2mV, ±8mV, ±32mV, ±128mV and ± 256mV. The customer application firmware is responsible for the transition from one range to the other.

When a gain change is requested, following behavior of the IC is expected. Please contact Melexis for more detailed specifications linked to particular programmed settings.

Timeline	Time before the next sample	Condition
Normal processing	500us	Starting condition before the range change is requested
From range change till the first DSP update	9.5 ms	AGC (Automatic Gain Control) and AOC (Automatic Offset Correction) are completely settled
Normal processing	500us	Once the first DSP value is obtained, the refresh rate is 2kHz

Table 11 – Timing for AGC

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[4] *Absolute Max/ Min values are calculated to achieve ppk>1.67*

[5] *This specification includes non-linearity and is based on the recommended application diagram of Chapter 15*

[6] *Total drift data are built on a dataset of 3 lots of 77pcs each, indicating the difference between the measured variable after 1000h HTOL at T_{amb}=125°C (AEC-Q100 Grade1) and the measured value after MSL3 preconditioning readout at 25°C.*

[7] *Parameter guaranteed by design and characterization; not tested during manufacturing*

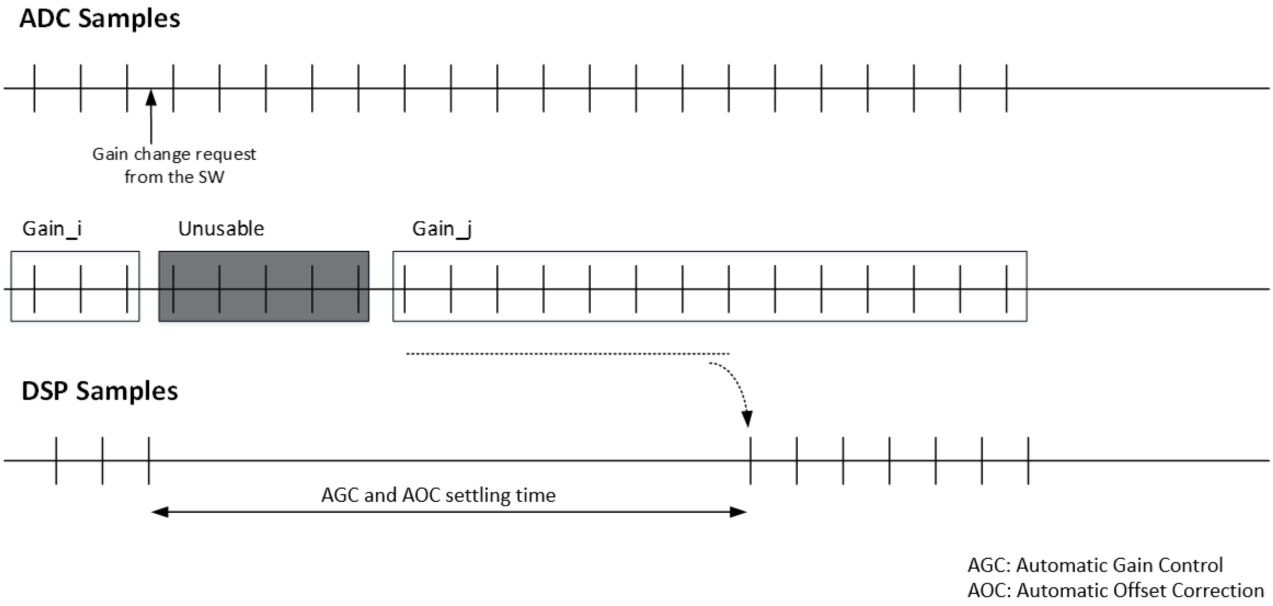

Figure 4 - Automatic Gain Control (AGC)

13.3. Overcurrent detection

The MLX91231 provides an overcurrent signal that can be put out on the LIN pin or TX pin when detecting an overcurrent event. The IC has two analog amplification channels, a slower and more precise one for the linear current measurement (supporting AGC) and a faster one (fixed gain) for the overcurrent detection. The ADC is also used for the OCD function, with the aim of bringing higher levels of accuracy and programmability in the DSP.

This feature allows detecting overcurrent outside of a defined (programmable) range that can even be set asymmetrically (negative current thresholds at lower magnitude than positive current thresholds), often linked to different requirements for charging (overcharge) and discharging (short-circuit). It can be enabled or disabled in the software. The rising threshold can be set at a higher magnitude than the falling threshold to introduce some hysteresis avoiding chattering of the OCD signal. If the OCD is set on the LIN pin, it uses the open drain LIN driver. If it is set on the TX pin, a push-pull or an open drain output can be set. Open-drain outputs are typically slower because of the passive pull-up.

There are 3 possible OCD modes[8] as mentioned in the following table:

- **Level-based readout:**

  The OCD information is encoded in the voltage level mapped to either the LIN pin or the TX pin. In case of an OCD event, the output transitions from low level to high level (active high signal) if OCD is on TX_OCD pin and from high to low level (active low signal) if on LIN_OCD pin. An external MCU detects the transitions and triggers the necessary actions or the signal can be used to (pre-)drive some event-handling transistor or switch. Diagnostic capabilities are limited since no distinction exists between stuck-at errors and active/inactive levels.
- **PWM digital readout:**

  The OCD output has a fixed PWM duty cycle (DC) in absence of an OCD event, but transitions to another fixed PWM DC in case of an OCD detection. The external MCU requires timer resources to monitor the OCD state (encoded in the DC) and continuously diagnose anomalies through signal plausibility checks (PWM period & allowed duty cycle) for safety purposes.
- **PWM analog readout:**

  Having an output which is the same as the PWM digital readout, this time the PWM signal is then low-pass filtered before being interpreted by the external MCU giving rise again to a level-based information that is very EMC-robust. For functional safety purposes, (another) MCU still has to perform the signal plausibility checks employing timer resources, but the OCD state is now again level-based and can therefore be interpreted using a voltage comparator versus one or more threshold(s). Note that the MCU has to monitor the PWM signal before the RC filter for functional safety purposes.

OCD modes	OCD event IC output	OCD event decoding	OCD diagnostics decoding

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[8] *The MLX91230/31 Safety Manual is built around PWM diagnosis capabilities. Level-based thresholds are not well diagnosable and as such do not reach the targeted safety goals described in the Safety Manual.*

Level - based	Voltage level change (active high on TX_OCD, active low on LIN_OCD)	Voltage Level Change (IC output)	N/A
PWM digital	PWM Dutycycle Change	PWM Dutycycle Change	PWM Allowed Dutycycle Tolerance PWM Period
PWM analog	PWM Dutycycle Change	Voltage Level Change (RC-filtered PWM signal)	PWM Allowed Dutycycle Tolerance PWM Period

Table 12 – OCD modes and decoding information

OCD response time [µs]		**OCD on TX_OCD pin**		**OCD on LIN_OCD pin**	
OCD mode	**Symbol**	**Typ.**	**Max.**	**Typ.**	**Max.**
Level - based	$T_{OCD,LEVEL}$	300	417.5	300	417.5
PWM digital	$T_{OCD,PWM-DIG}$	325	506.6	350	619.5
PWM analog	$T_{OCD,PWM-ANA}$	370	553.6	450	723

Table 13 – OCD response times on TX pin or LIN pin, per OCD mode

13.3.1. PWM digital OCD on TX_OCD pin

Category	Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
General	Upper voltage[9]	$V_{OH,TX-OCD}$	3.9	4.5	4.95	V	VDD ≥ 6V 1mA sourcing current
			3.8	4.3	4.95	V	4.5V < VDD < 6V 1mA sourcing current
	Lower voltage[9]	$V_{OL,TX-OCD}$	0	0.1	0.2	V	1mA sinking current
OCD programmable threshold	S_OCD threshold	$B_{OCD-THRES}$	-100 25		25 256	mV	Negative input differential signal Positive input differential signal
PWM output	TX-OCD output signal frequency	$F_{PWM,TX-OCD}$	20	22	24	kHz	22kHz is set by default 1kHz steps
	No OCD detected – TX duty cycle [9, 10]	$DC_{OFF,TX-OCD}$	16	20	24	%	
	OCD detected - TX duty cycle [9, 10]	$DC_{ON,TX-OCD}$	76	80	84	%	
Slew rate	Rising slew rate	SR_{TXrise}		1		V/µs	
	Falling slew rate	SR_{TXfall}		-1		V/µs	
Accuracy	OCD threshold accuracy TX	ACC_{TX-OCD}	-10	±5	10	%	Relative to programmed OCD threshold at 25°C
Timings	TX OCD Input debounce time [11]	$T_{DEB,TX-OCD}$	70			µs	OCD event duration needed for detection
	TX OCD Output latch time	$T_{HOLD,TX-OCD}$		90		µs	OCD event lasts minimum 2 PWM periods

Table 14 – OCD specifications on the TX_OCD pin

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[9] *With reference to the recommended application diagram in Chapter 15*

[10] *Duty cycle measured with trigger level between 2V and 3.3V*

[11] *The OCD will not be triggered for over-current event having a lower duration than the minimum value*

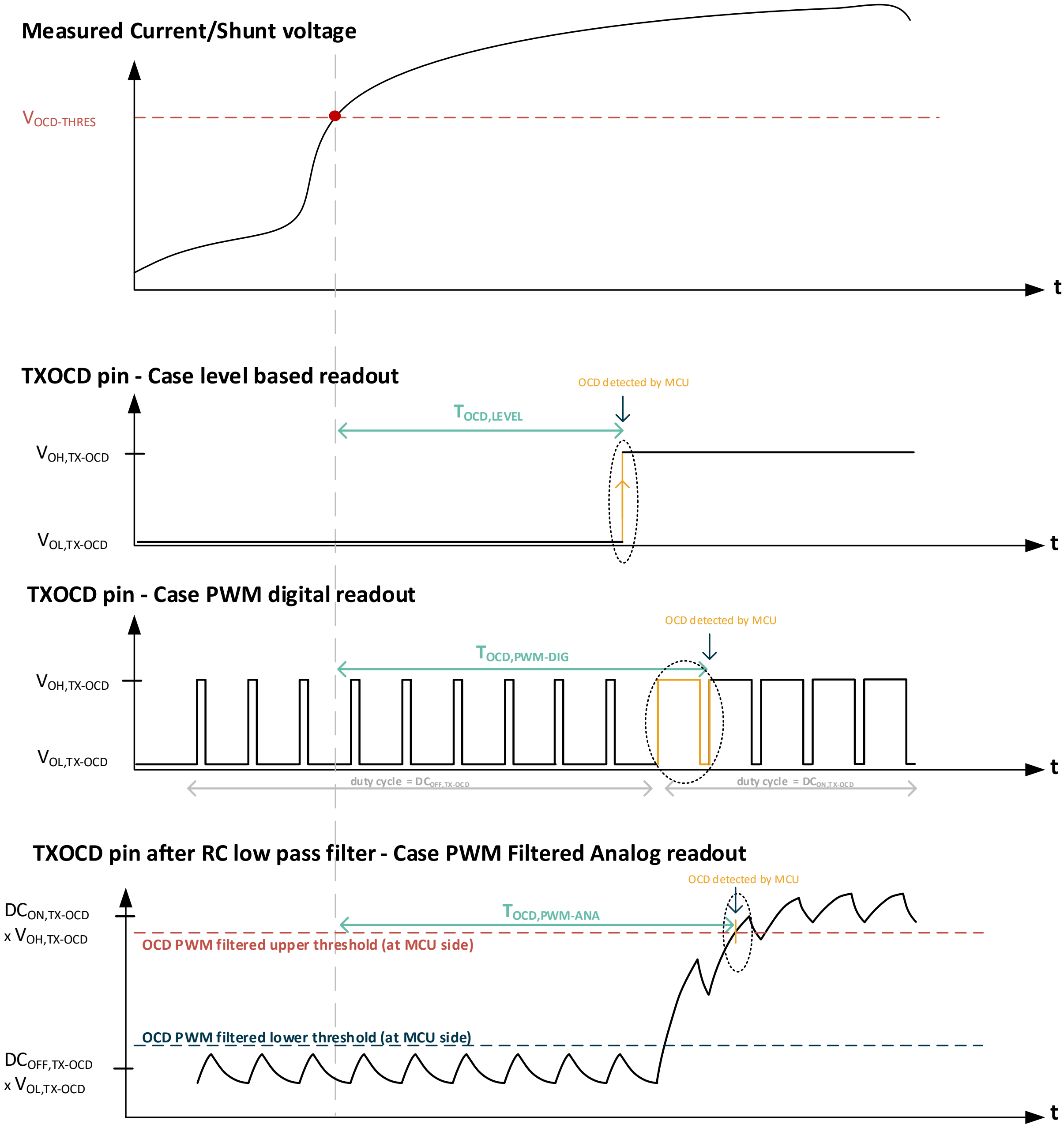

Figure 5 – Example of an overcurrent detection on TX_OCD pin and timing overview per readout (LIN_OCD using timings and voltages of the table in Chapter 13.3.2)

13.3.2. PWM digital OCD on LIN_OCD pin

Category	Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
General	Supply Voltage OCD use	$VDD_{LIN-OCD}$	4.5	5	5.5	V	
	Pull-up voltage[12]	$V_{PU,LIN}$	4.5	5	5.5	V	
	Upper voltage[12]	$V_{OH,LIN-OCD}$	$V_{PU,LIN}$ - 0.1	-	$V_{PU,LIN}$	V	
	Lower voltage[12]	$V_{OL,LIN-OCD}$	0.55	0.9	1.1	V	R_{PU} = 2.2kΩ pull-up resistance $V_{PU,LIN}$ (refer to the recommended application diagram – chapter 15)
OCD programmable threshold	S_OCD threshold	$Vshunt_{OCD-THRES}$	-100 25		25 256	mV	Negative input differential signal Positive input differential signal
PWM output	LIN-OCD output signal frequency	$F_{PWM,LIN-OCD}$			10	kHz	10kHz is set by default
	No OCD detected – LIN duty cycle [12, 13]	$DC_{OFF,LIN-OCD}$	70	75	91	%	
	OCD detected - LIN duty cycle[12, 13]	$DC_{ON,LIN-OCD}$	15	25	32	%	
Accuracy	OCD threshold accuracy LIN	$ACC_{LIN-OCD}$	-10	±5	10	%	Relative to programmed OCD threshold at 25°C
Timings	LIN OCD Input debounce time[14]	$T_{DEB,LIN-OCD}$	70			µs	OCD event duration needed for detection
	LIN OCD Output latch time	$T_{HOLD,LIN-OCD}$		200		µs	OCD event lasts minimum 2 PWM periods

Table 15 – OCD specifications on the LIN_OCD pin

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[12] *With reference to the recommended application diagram in Chapter 15*

[13] *Duty cycle measured with trigger level between 2V and 3.3V*

[14] *The OCD will not be triggered for over-current event having a lower duration than the minimum value*

13.4. VSENSE voltage measurement

13.4.1. LVBAT (12V) measurement

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Sensing range	$V_{R,LVBAT}$	3		18	V	
Input current	I_{LVBAT}			30	µA	Due to internal voltage division
Resolution	R_{LVBAT}		0.5		mV	1 LSB representation
Integral non-linearity error	INL		±0.015		%	
Error Drift	LVBat_err	-0.2 -0.25 -0.5		0.2 0.25 0.5	%	Relative to 25°C Range = [12…13]V, Standby mode, temperature in [5…45]°C Range = [8…16]V, KeyOn mode, temperature in [-40…125]°C Range = [3…8] and [16…18]V, KeyOn mode, temperature in [-40…125]°C
Peak-to-Peak Noise	$V_{N,PTP}$		±0.01 ±0.02		%Full Scale Range	Standby mode KeyOn mode (averaged over 100ms)

Table 16 – LVBAT (12V) analog front-end specifications

13.4.2. HVBAT (24V/48V) measurement

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Sensing range	$V_{R,HVBAT}$	20		60	V	
Input current	I_{HVBAT}			110	µA	Due to internal voltage division
Resolution	R_{HVBAT}		2		mV	1 LSB representation
Integral non-linearity error	INL		±0.015		%	
Error Drift	HVBat_err	-0.2		0.2	%	Relative to 25°C Range = [36…52]V, Standby mode, temperature in [5…45]°C.

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
		-0.25 -0.5		0.25 0.5		Range = [36…52]V, KeyOn mode, temperature in [-40…125]°C. Range = [20…36] and [52…60]V, KeyOn mode, temperature in [-40…125]°C.
Peak-to-Peak Noise	$V_{N,PTP}$		±0.01 ±0.02		%Full Scale Range	Standby mode KeyOn mode (averaged over 100ms)

Table 17 – HVBAT (24V/48V) analog front-end specifications

13.4.3. Direct voltage (HV) measurement

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Sensing range	$V_{R,DIRECT}$	0.3		1.1	V	The external HV battery should be stepped down to this range by using an external resistive divider
Input current	I_{DIRECT}		0		µA	No internal resistive divider
Resolution	R_{DIRECT}		33.33		uV	
Integral non-linearity error	INL		±0.015		%	
Error Drift	DVBat_err	-0.3 -0.5		0.3 0.5	%	Range=[0.6…1.1]V Range=[0.3…1.1]V
Peak-to-Peak Noise	$V_{N,PTP}$		±0.01 ±0.02		%Full Scale Range	Standby mode KeyOn mode (averaged over 100ms)

Table 18 – Direct voltage analog front-end specification

13.5. Internal die Temperature measurement

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition

Sensing range	$T_{INT,RANGE}$	-40		150	°C	
Accuracy	ACC_{TINT}	-5 -2		+5 +2	°C	KeyOn mode Operating range in -10 to 45°C, KeyOn mode
Resolution	R_{TINT}		1/16		°C	
Sampling rate	F_{TINT}		250		Hz	Standard MLX SW library

Table 19 – Internal die temperature sensing specification

13.6. VDD voltage measurement

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Sensing range	VDD_{RANGE}	7		17	V	
Accuracy	ACC_{VDD}		±1		%	KeyOn mode
Resolution	R_{VDD}	50			mV	
Peak-to-Peak Noise	$VDD_{N,PTP}$		±90		mV	KeyOn mode, averaged over 100ms
Sampling rate	F_{VDD}		250		Hz	Standard MLX SW library

Table 20 – Internal supply voltage measurement specification

14. Electrical specifications

14.1. LIN

Note that the electrical specification of the LIN transceiver is developed in compliance to LIN2.2, ISO17987-4 and SAE J2602. For details, please refer to the Customer user manual where LIN transceiver's description, static and dynamic values are described in the "Communication protocols" chapter.

14.2. UART

For more details about the UART interface, please refer to the product customer user manual" in "Communication protocols" chapter.

14.2.1. RX

Parameter	Symbol	Min.	Typ.	Max.	Unit
RX input voltage threshold - high	VTH_RX_IO	2.6			V
RX input voltage threshold - low	VTL_RX_IO			0.5	V
RX input voltage threshold - hysteresis	VHY_RX_IO	0.7		1.7	V
RX pin input pull-down resistance	RPD_RX_IO	40	100	240	kΩ

Table 21 – RX electrical specifications

14.2.2. TX

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Upper voltage	VOH_TX	3.9	4.5	4.85	V	VDD>6V, 1mA sourcing current
		3.8	4.3	4.85	V	4.5V< VDD <6V, 1mA sourcing current
Lower voltage	VOL_TX	0	0.1	0.2	V	1mA sinking current

Table 22 – TX electrical specifications

14.3. Supply system

Parameter	Symbol	Min.	Typ.	Max.	Unit
VDD under-voltage detection threshold	VDD_UV_thres	3.9	4.05	4.5	V
VDD over-voltage detection threshold	VDD_ OV_thres	20	22	24	V

Table 23 – Electrical specifications: VDD over- and under-voltage detection

14.4. Internal Clock Generation

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
30MHz Oscillator	Fosc_trim		30		MHz	Factory Trimmed
30MHz Oscillator frequency error (target 100% or 75% of the trimmed frequency)	Fosc_error	-3.5	0	+3.5	%	Trimmed oscillator, over temperature and over VDDD
30MHz Oscillator frequency error (target 50% or 25% of the trimmed frequency)	Fosc_error	-5	0	+5	%	Trimmed oscillator, over temperature and over VDDD
1MHz Oscillator	Fosc_1M	0.95	1	1.05	MHz	Trimmed, Nominal VDD
10kHz Oscillator	Fosc_10K	5	10	20	kHz	Non-trimmable

Table 24 – Internal clock electrical specifications

15. Recommended Application Diagrams

15.1. Application diagram for LIN and UART communications

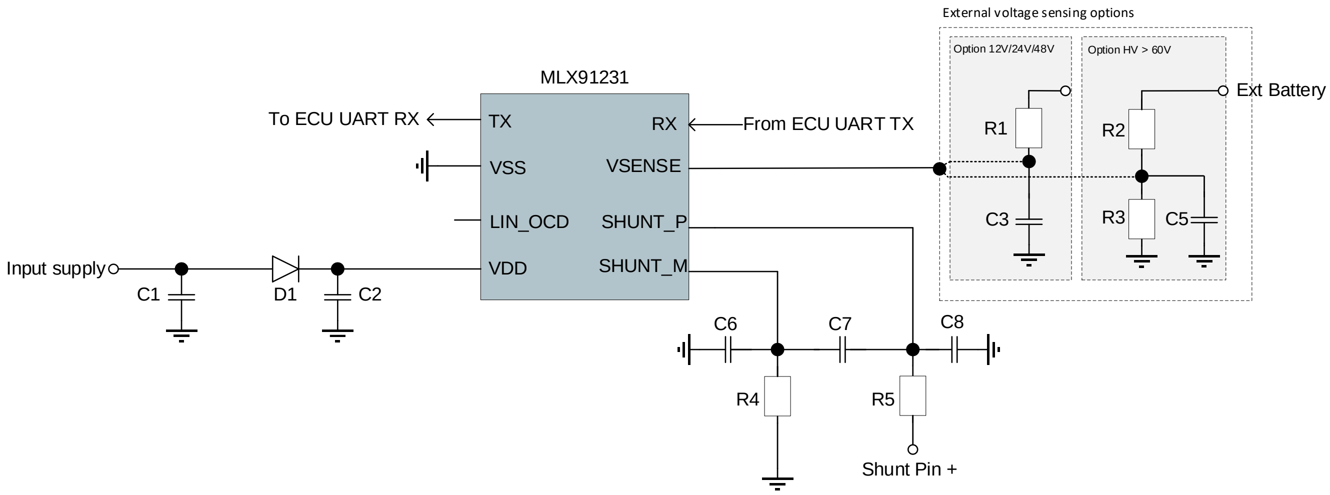

Figure 6 – Application block diagram with UART communication –possible to read OCD on LIN (Chapter 13.3.2)

For UART usage at lower voltages than those defined in the datasheet or activation of the open-drain mode instead of default push-pull mode, please contact Melexis for support. TX_OCD functionality below is only recommended in this default push-pull mode.

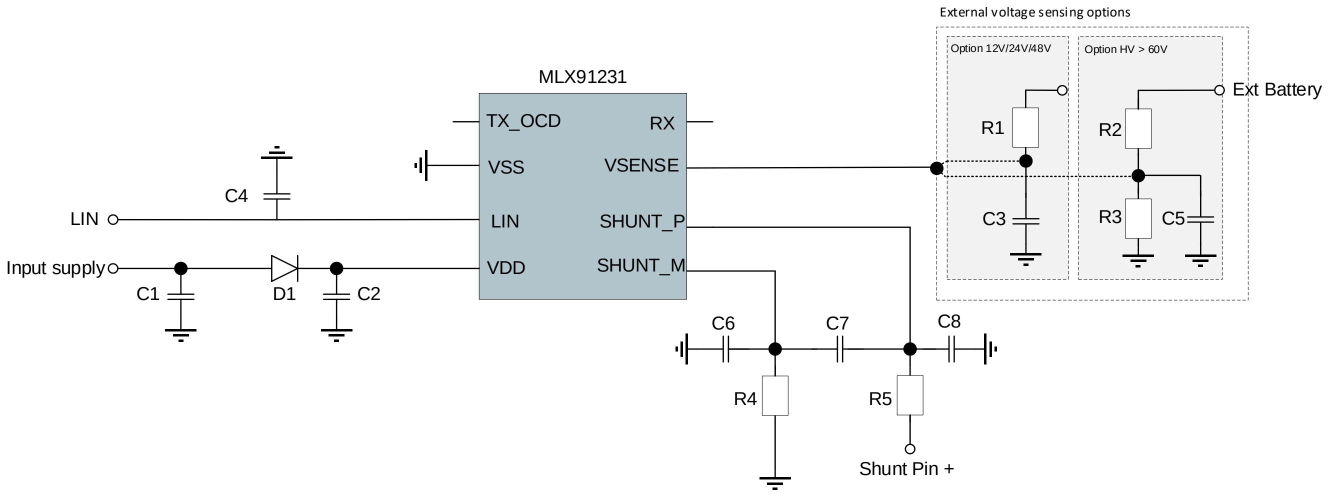

Figure 7 - Application block diagram with LIN communication – possible to read OCD on TX (Chapter 13.3.1)

Component	Description	Value	Unit

C1	Battery supply capacitance, before diode	10	nF
C2	Battery supply capacitance, after diode type: Ceramic SMD Murata X7R 4.7uF +-10% 50V GCM31CC71H475KA03	4.7	uF
C3	12/24/48V (LVBAT/HVBAT) voltage sense capacitor	1	nF
C4	LIN pin capacitor	0.18	nF
C5	Direct voltage sense capacitor	1	nF
R1	12/48V voltage sense resistance	2.2	kΩ
R2	Direct voltage sense resistive division – high side	Voltage divider to stay in the VSENSE operating range – customer to manage voltage isolation if applicable	kΩ
R3	Direct voltage sense resistive division – low side		kΩ
R4, R5	Shunt RC filter	0.1	kΩ
C6	Shunt RC filter	22	nF
C7	Shunt RC filter	33	nF
C8	Shunt RC filter	22	nF

Table 25 – Resistor and Capacitor Values for Recommended Application Diagrams in Figure 6 and Figure 7

15.2. OCD external circuit example (PWM)

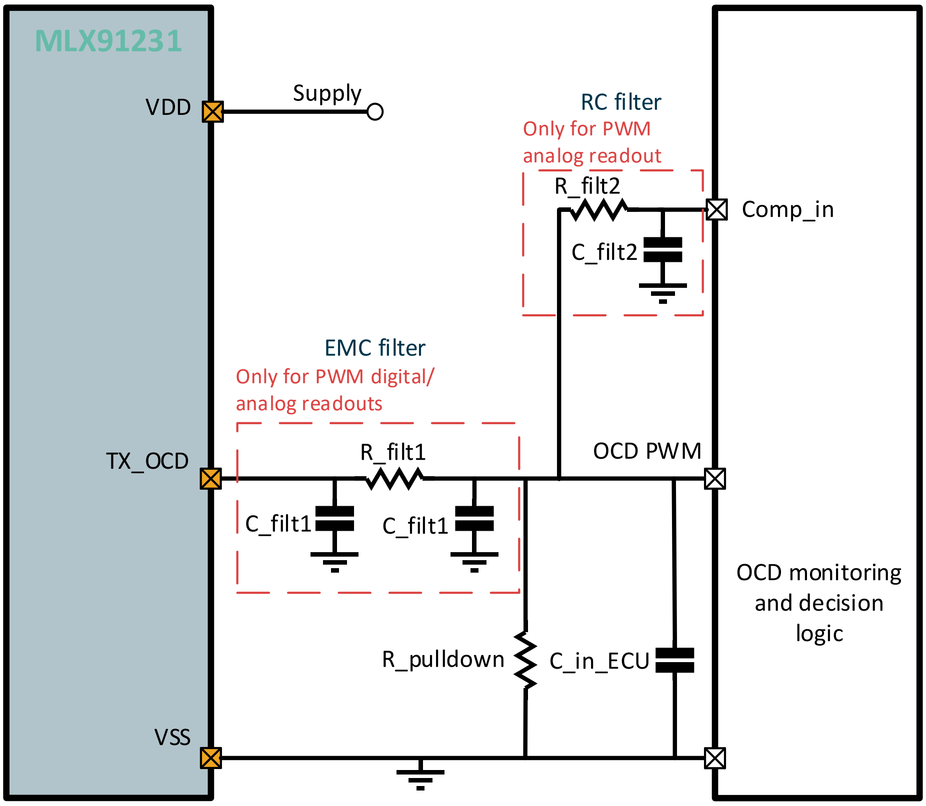

Figure 8 – OCD application diagram example for OCD on TX[15]

Part	Description	Value	Unit
C_filt1	EMC filter capacitor	100	pF
R_filt1	EMC filter resistor	220	Ω
C_filt2	OCD PWM filter capacitor	470	pF
R_filt2	OCD PWM filter resistor	100	kΩ
R_pulldown	Pull down resistor at ECU side	51	kΩ
C_in_ECU	Input capacitor at ECU side	4.7	nF

Table 26 – Resistor and Capacitor Values for TX OCD Application Diagram example

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[15] *For OCD on LIN pin, contact Melexis for support with application diagram.*

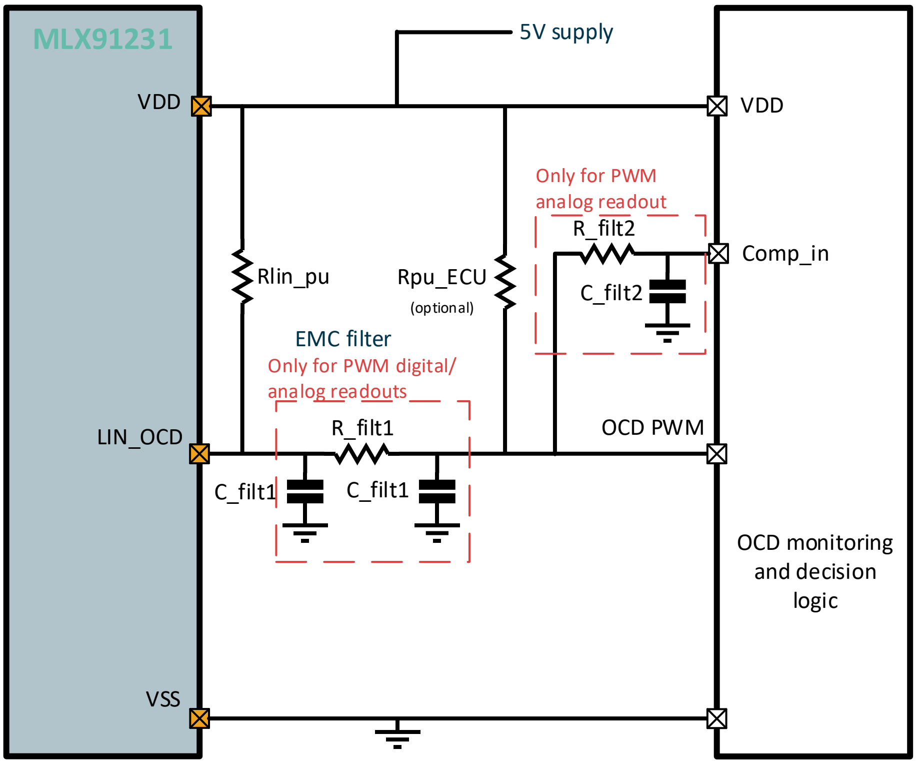


Figure 9 – OCD application diagram example for OCD on LIN (Recommended 5V operation)

Part	Description	Value	Unit
Rlin_pu	Pull up resistance (high side driver on the LIN pin)	2.2	kΩ
Cfilt_1	EMC filter capacitance	470	pF
Rfilt_1	EMC filter resistance	220	Ω
Cfilt_2	PWM filtering capacitance	1	nF
Rfilt_2	PWM filtering resistor	100	kΩ
Rpu_ECU	Pull up resistance at the ECU/ MCU side (not required if the ECU/ MCU is on the same PCB)	82	kΩ

Table 27 – Resistor and Capacitor Values for LIN OCD Application Diagram example

16. Package, IC handling and assembly

16.1. Package information

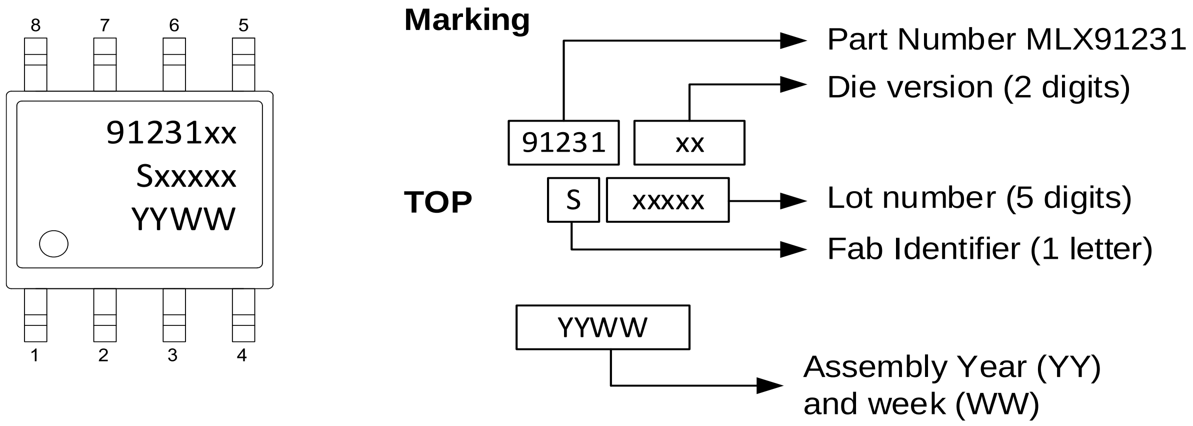
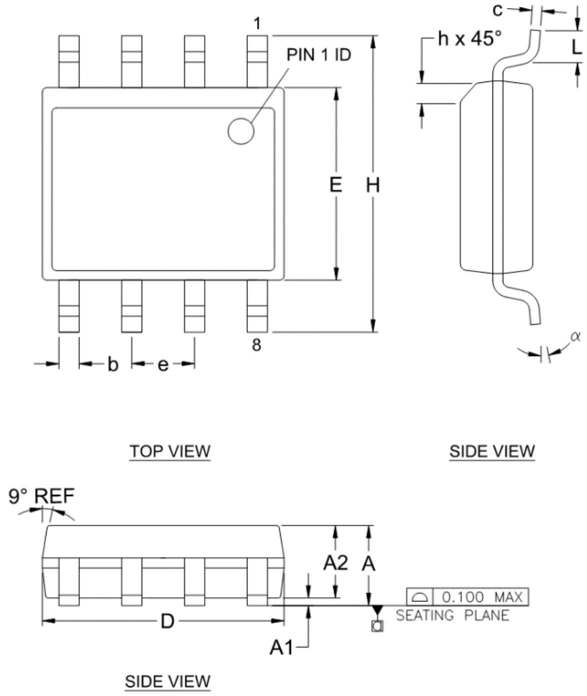


Figure 10 – Package marking



SYMBOL	MINIMUM	MAXIMUM
A	1.52	1.73
A1	0.10	0.25
A2	1.37	1.57
D	4.80	4.98
E	3.81	3.99
H	5.80	6.20
L	0.41	1.27
b	0.35	0.49
c	0.19	0.25
h	0.25	0.50
e	1.27 BSC	
α	0°	8°

NOTE :

1. ALL DIMENSIONS IN MILLIMETERS (mm) UNLESS OTHERWISE STATED.
2. DIMENSION D DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS OF MAX 0.15 mm PER SIDE.
3. DIMENSION E DOES NOT INCLUDE INTERLEADS FLASH OR PROTRUSIONS OF MAX 0.25 mm PER SIDE.
4. DIMENSION b DOES NOT INCLUDE DAMBAR PROTRUSION OF MAX 0.08 mm.
5. LEAD COPLANARITY SHALL BE 0.1 mm MAX.

Figure 11 – SOIC8 package information

16.2. Storage and handling of plastic encapsulated ICs

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

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

For more information refer to Melexis *Guidelines for storage and handling of plastic encapsulated ICs*[16]

16.3. Assembly of encapsulated ICs

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

For Through Hole Devices (THD), the applicable soldering methods are reflow, wave, selective wave and robot point-to-point. THD lead pre-forming (cutting and/or bending) is applicable under strict compliance with Melexis *Guidelines for lead forming of SIP Hall Sensors*[16]

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

For PCB-less assembly refer to the relevant application notes[16] or contact Melexis.

Electrical resistance welding or laser welding can be applied to Melexis products in THD and specific PCB-less packages following the *Guidelines for welding of PCB-less devices*[16]

Environmental protection of customer assembly with Melexis products for harsh media application, is applicable by means of coating, potting or overmolding considering restrictions listed in the relevant application notes[16]. For other specific process, contact Melexis via www.melexis.com/technical-inquiry

16.4. Environment and sustainability

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

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[16] *All documents can be found on* www.melexis.com/ic-handling-and-assembly

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