

1. Features and Benefits

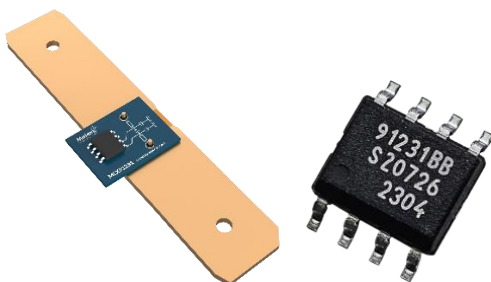
- IVT battery measurements:
 - Shunt based current sensor
 - Voltage measurement
 - Internal dividers for 12V or 24V/48V batteries
 - External divider required for HV batteries
 - Internal (PTAT) temperature sensor
- 16-bit MCU with 32 KB Flash, 128 B Flash CS, 20 KB ROM, 2 KB RAM and 512 B EEPROM Memory
- 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 (<500 μ s)
- 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 <100 μ A)
- 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.



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4. Ordering Information

| Product Code | Package | Sensing Technology | Sensing range |
|------------------------------|---------|--------------------|-----------------|
| MLX91231KDC – BBA – 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 | BBA-xxx: die version 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

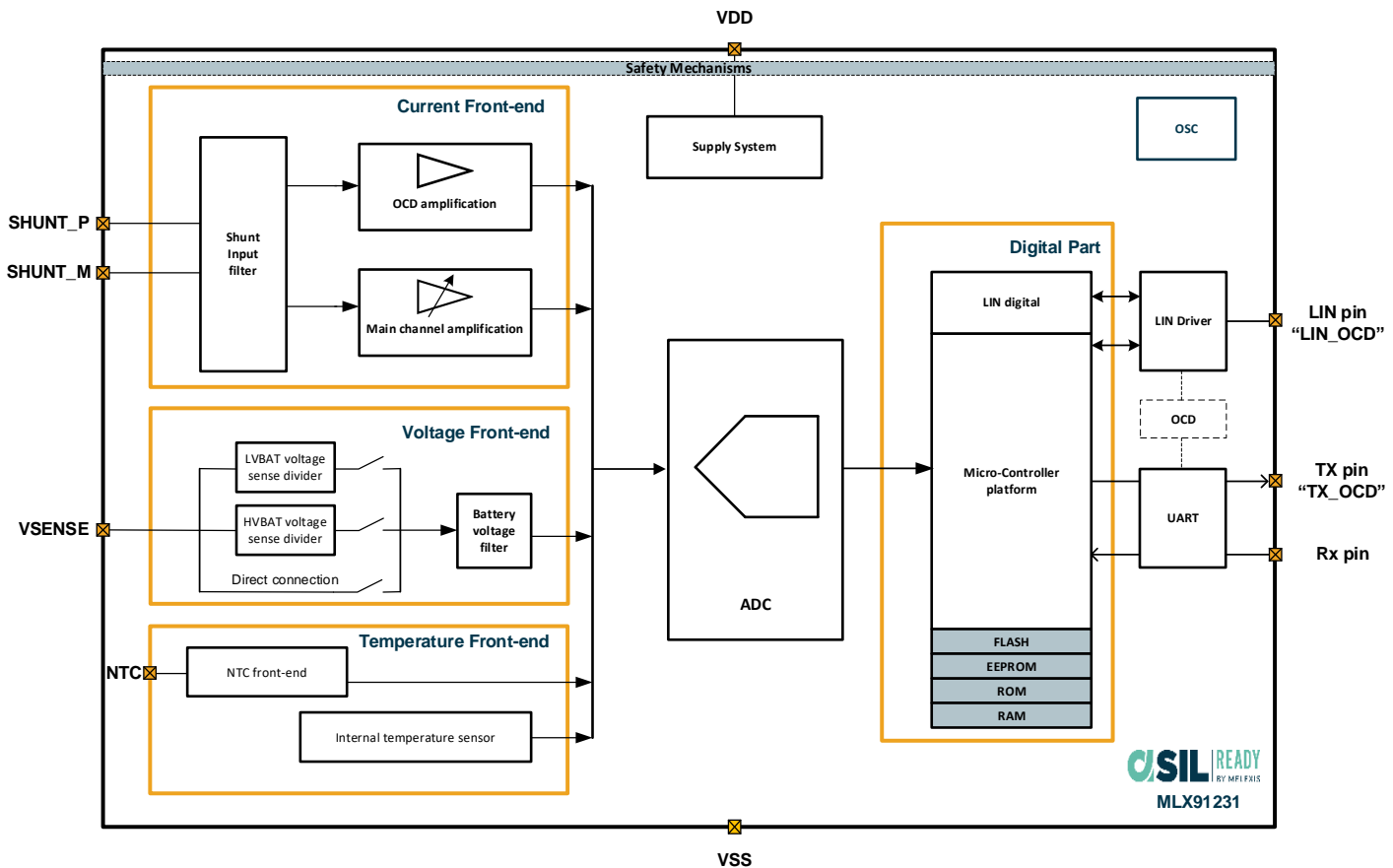


Figure 1- Detailed Block Diagram
 (NTC pad not bonded – please contact Melexis in case NTC functionality is needed)

6. Functional Safety

The MLX91231 is an ASIL-compliant IC, developed as SEoC 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 “MLX9123x 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.

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

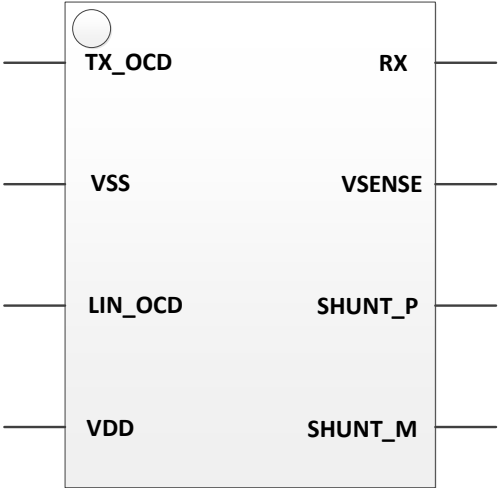
| Pin # | Name | Description | Pinout |
|-------|---------|---|---|
| 1 | TX_OCD | UART communication pin <u>OR</u> Overcurrent detection pin |  |
| 2 | VSS | Ground pin | |
| 3 | LIN_OCD | LIN communication pin <u>OR</u> Overcurrent detection pin | |
| 4 | VDD | Supply pin | |
| 5 | SHUNT_M | Shunt 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. 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 | -0.5 | | 1 | V | SHUNTP or SHUNTM referred to VSS |

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| Parameter | Symbol | Min. | Typ. | Max. | Unit | Condition |
|-------------------------------------|------------|------|------|------|------|---|
| Shunt pins differential voltage | SHUNT_DIFF | -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_DC | -27 | | 40 | V | Conformance test according to ISO 17987-7 |
| RX pin voltage | TX/RX_MAX | -0.3 | | 5.5 | V | |
| TX OCD pin voltage | OCD_MAX | -14 | | 18 | V | |
| 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.

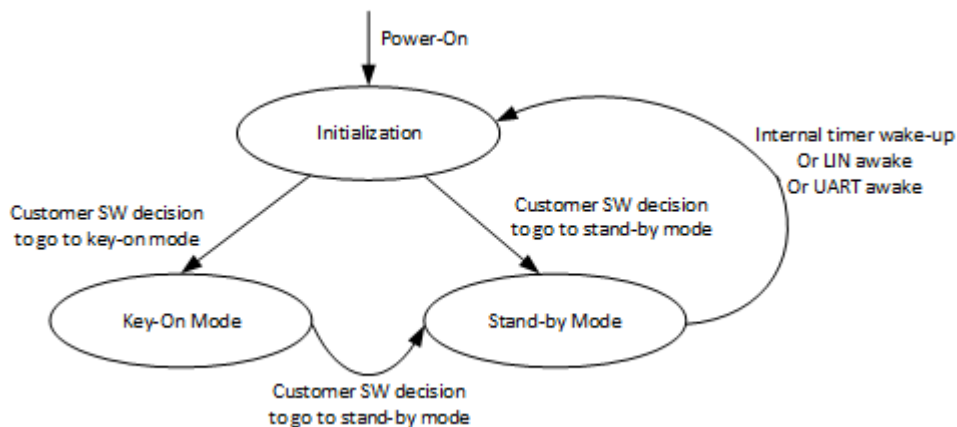


Figure 2- State Diagram

| 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 $T_{\text{initialization}}$.

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

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 MLX91230 Ibat acquisitions or improve the OCD response time which is more important for PyroFuse applications.

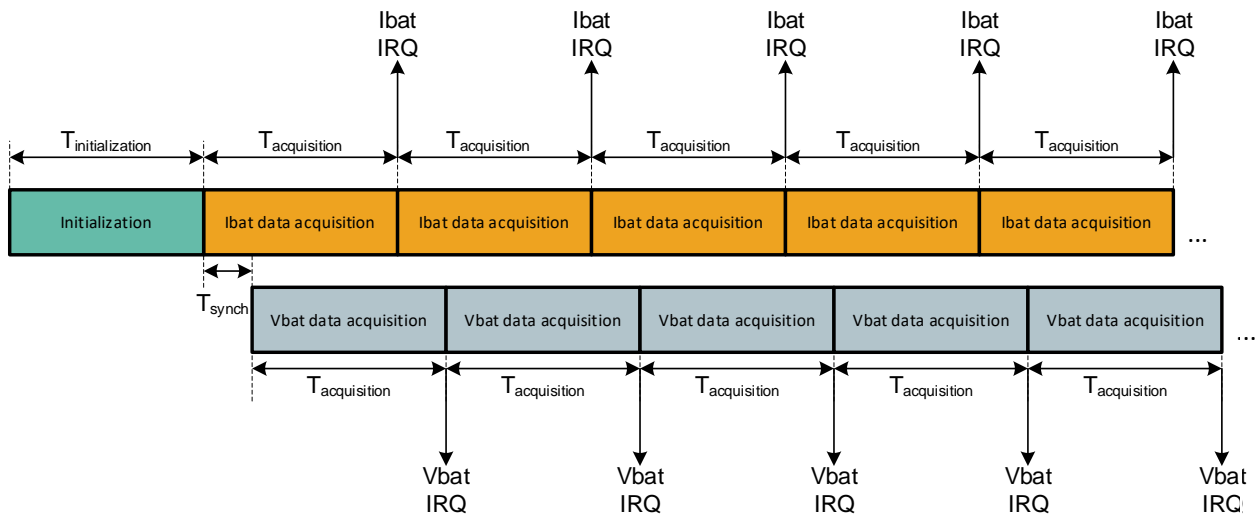


Figure 3 – Standard timing synchronization (programmable)

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 | |
| Total sensitivity thermal drift ³ | ΔT_S | -0.3 | | 0.3 | % | Full VDD range, shunt ranges 1-3 BiPol, 4-5 PosPol |
| | | -3 | | 3 | | Full VDD range, shunt range 4 NegPol |
| | | -0.25 | | 0.25 | | VDD ≤ 5.5V, shunt ranges 1-3 BiPol, 4-5 PosPol |
| | | -2 | | 2 | | VDD ≤ 5.5V, shunt range 4 NegPol |

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

| Parameter | Symbol | Min. | Typ. | Max. | Unit | Condition |
|--|---------------------|--------------------|------|-----------------|---------|--|
| Gain error between ranges | Δ^GR | -0.1 | | 0.1 | % | Full VDD range, shunt ranges 1-3 BiPol, 4-5 PosPol |
| Peak to peak noise | $V_{shunt_{N,PTP}}$ | | 9 | 14 | μV | Update rate of 500 μs ; Shunt Range 1 |
| RMS noise | N_{RMS} | | 1.4 | 1.8 | μV | Update rate of 500 μs ; Shunt Range 1 |
| Offset thermal drift ⁵ referred to 25°C | Δ^TO | -1 -1.2 -1.5 | | 1 1.2 1.5 | μV | VDD = 5V VDD = 12V VDD = 18V |

Table 9 – Shunt specifications

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: $\pm 2mV$, $\pm 8mV$, $\pm 32mV$, $\pm 128mV$ and $\pm 256mV$. 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 | 21.5 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 10 – Timing for AGC

⁵Parameter guaranteed by design and characterization; not tested during manufacturing

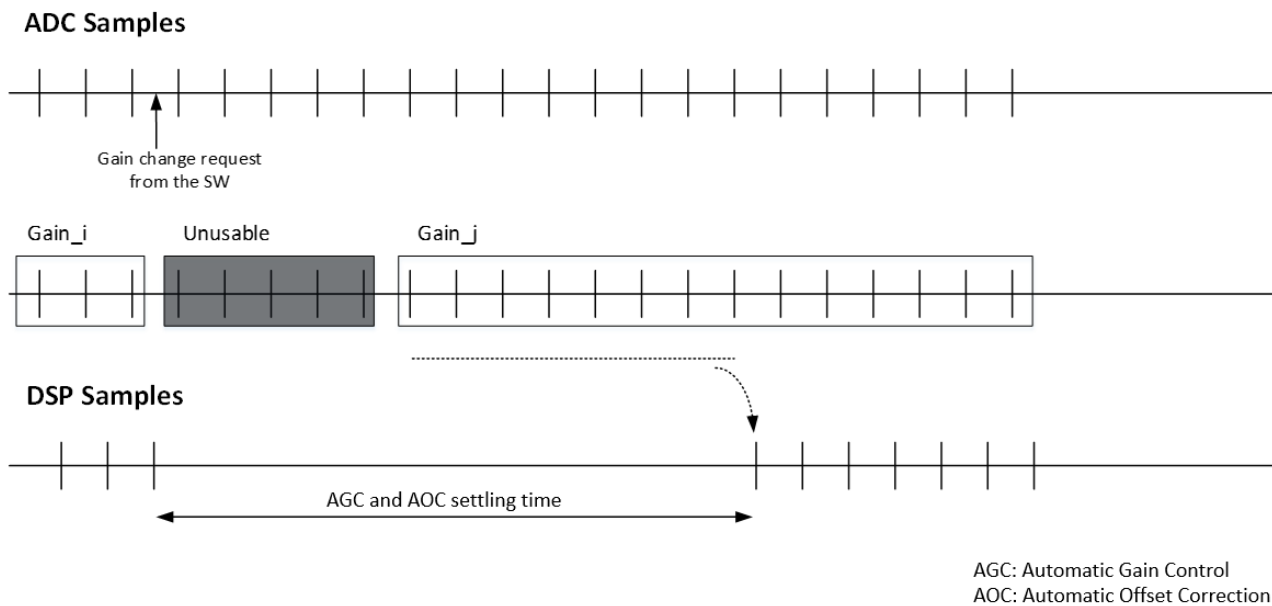


Figure 4 - Automatic Gain Control (AGC)

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 modes⁶ 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.

⁶ *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.*

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| OCD modes | OCD event IC output | OCD event decoding | OCD diagnostics decoding |
|---------------|---|--|---|
| 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 11 – 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 12 – 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 | $V_{OH,TX-OCD}$ | 3.9 | 4.5 | 4.95 | V | $V_{DD} \geq 6V$ 1mA sourcing current |
| | | | 3.8 | 4.3 | 4.95 | V | $4.5V < V_{DD} < 6V$ 1mA sourcing current |
| | Lower voltage | $V_{OL,TX-OCD}$ | 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 | $DC_{OFF,TX-OCD}$ | 16 | 20 | 24 | % | |
| | OCD detected - TX duty cycle | $DC_{ON,TX-OCD}$ | 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 ⁷ | $T_{DEB,TX-OCD}$ | 70 | | | μs | |
| | TX OCD Output latch time | $T_{HOLD,TX-OCD}$ | | 90 | | μs | OCD event lasts minimum 2 PWM periods |

Table 13 – OCD specifications on the TX_OCD pin

⁷ The OCD will not be triggered for over-current event having a lower duration than the minimum value

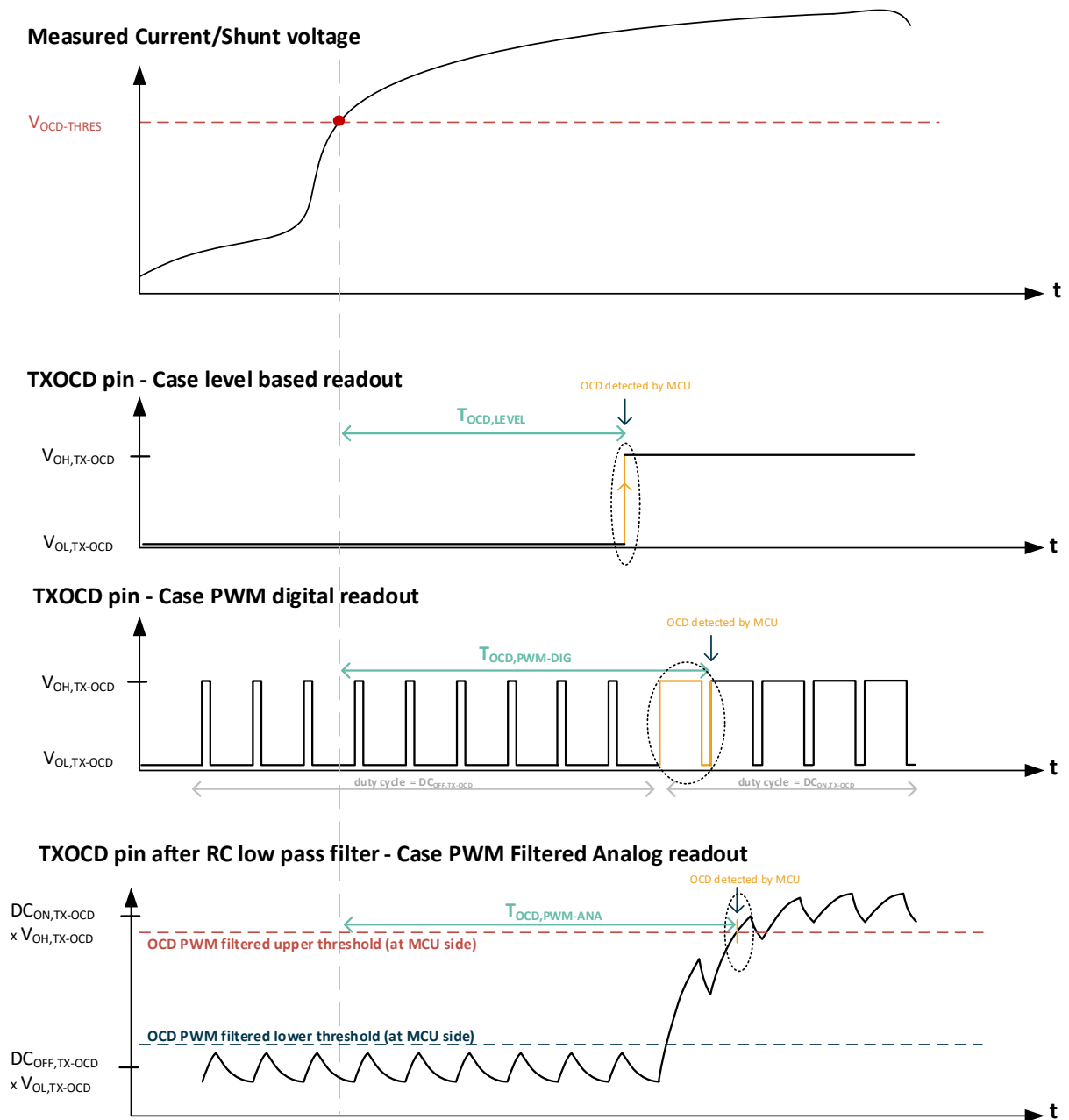


Figure 5 – Example of an overcurrent detection on TX_OCD pin and timing overview per readout (LIN_OCD using timings and voltages of the table in Chapter 13.3.2)

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 ⁸ | V _{PU,LIN} | 4.5 | 5 | 5.5 | V | |
| | Upper voltage ⁸ | V _{OH,LIN-OCD} | V _{PU,LIN} - 0.1 | - | V _{PU,LIN} | V | |
| | Lower voltage | 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 | V _{shuntOCD- 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 | DC _{OFF,LIN- OCD} | 70 | 75 | 91 | % | |
| | OCD detected - LIN duty cycle | DC _{ON,LIN- OCD} | 12 | 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 ⁹ | T _{DEB,LIN-OCD} | 70 | | | μs | |
| | LIN OCD Output latch time | T _{HOLD,LIN-OCD} | | 200 | | μs | OCD event lasts minimum 2 PWM periods |

Table 14 – OCD specifications on the LIN_OCD pin

⁸ With reference to the recommended application diagram in Chapter 15

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 | | % | |
| Gain error | GE | -0.2 -0.25 -0.5 | | 0.2 0.25 0.5 | % | Range = [12...13]V, Standby mode, temperature in [5...45] $^{\circ}\text{C}$ Range = [8...16]V, KeyOn mode, temperature in [-40...125] $^{\circ}\text{C}$ Range = [3...8] and [16...18]V, KeyOn mode, temperature in [-40...125] $^{\circ}\text{C}$ |
| Peak-to-Peak Noise | $V_{N,PTP}$ | | ± 0.01 ± 0.02 | | %Full Scale Range | Standby mode KeyOn mode (averaged over 100ms) |

Table 15 – 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 | | % | |
| Gain error | GE | -0.2 | | 0.2 | % | Range = [36...52]V, Standby mode, temperature in [5...45] $^{\circ}\text{C}$. |

| Parameter | Symbol | Min. | Typ. | Max. | Unit | Condition |
|--------------------|-------------|-------|----------------|------|-------------------------|---|
| | | -0.25 | | 0.25 | | Range = [36...52]V, KeyOn mode, temperature in [-40...125]°C. |
| | | -0.5 | | 0.5 | | 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 16 – 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 | | μV | |
| Integral non-linearity error | INL | | ±0.015 | | % | |
| Gain error | GE | -0.2 -0.5 | | 0.2 0.5 | % | Range=[0.3...1.1]V, Standby mode, temperature in [5...45]°C Range=[0.3...1.1]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 – 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 18 – 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 19 – Internal supply voltage measurement specification

14. Electrical specifications

14.1. LIN

For details, please refer to the “MLX9123x 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 “MLX9123x 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 20 – 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 21 – 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 22 – 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 23 – Internal clock electrical specifications

15. Recommended Application Diagrams

15.1. Application diagram for LIN and UART communications

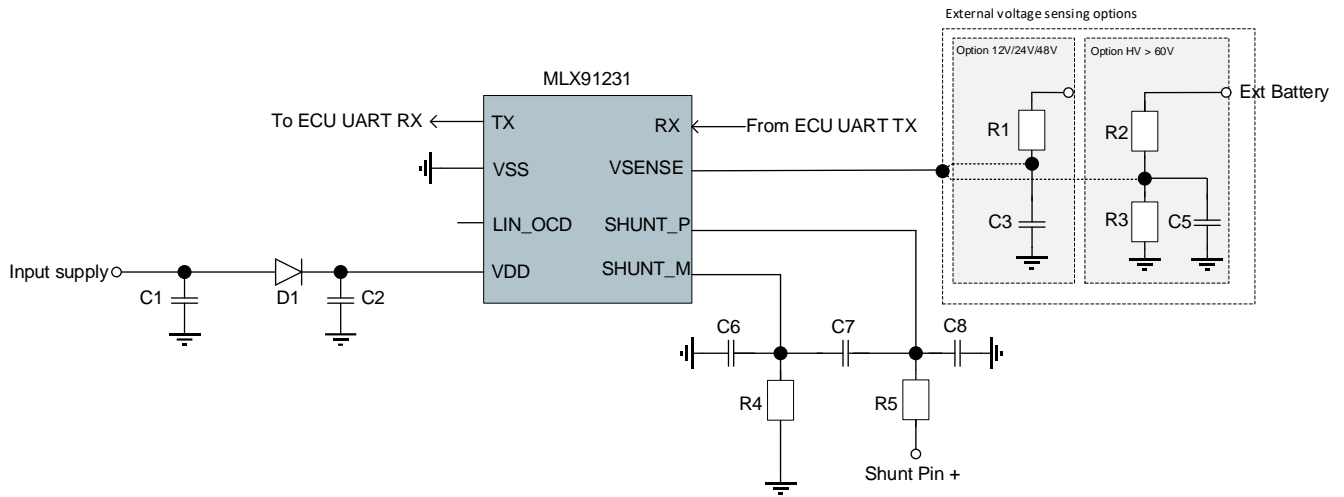


Figure 6 – Application block diagram with UART communication –possible to read OCD on LIN (Chapter 13.3.2)

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.

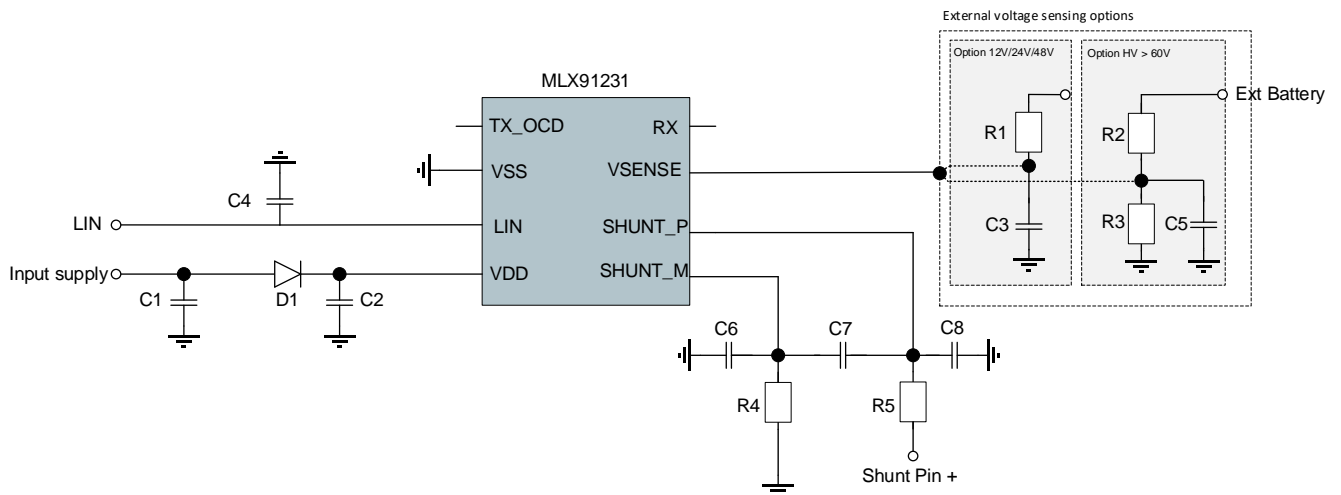


Figure 7 - Application block diagram with LIN communication – possible to read OCD on TX (Chapter 13.3.1)

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| 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, C7, C8 | Shunt RC filter | C6 = C8 = 22 | nF |
| | | C7 = 33 | nF |

Table 24 – Resistor and Capacitor Values for Recommended Application Diagrams in Figure 6 and Figure 7

15.2. OCD external circuit example (PWM)

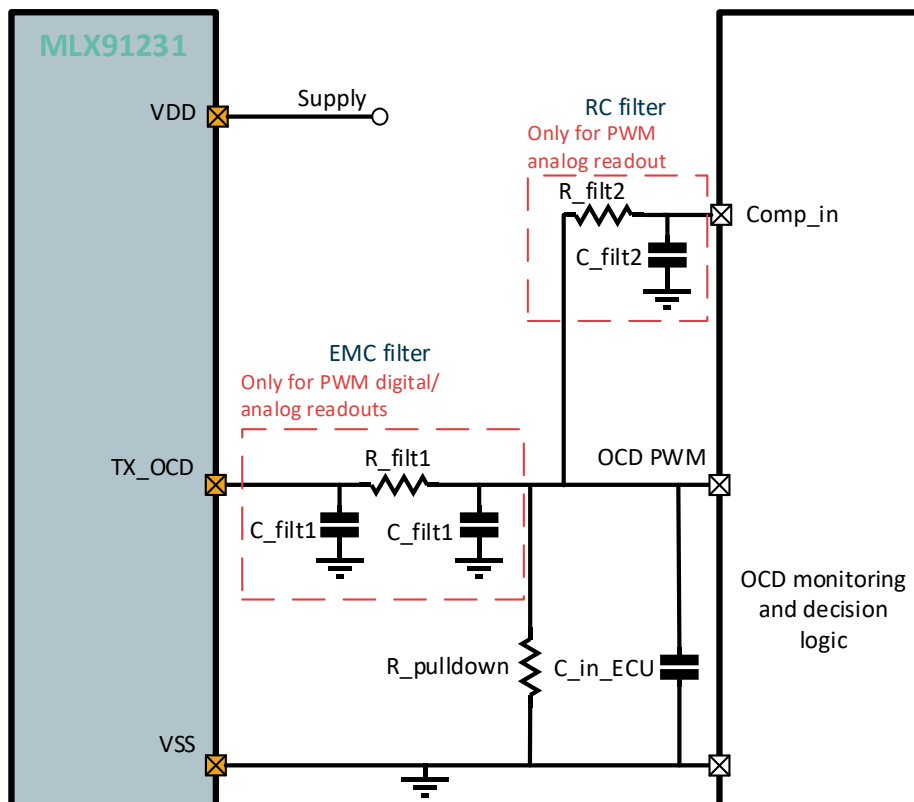


Figure 8 – OCD application diagram example for OCD on TX³

| 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 | k Ω |
| R_pulldown | Pull down resistor at ECU side | 51 | k Ω |
| C_in_ECU | Input capacitor at ECU side | 4.7 | nF |

Table 25 – Resistor and Capacitor Values for TX OCD Application Diagram example

³ For OCD on LIN pin, contact Melexis for support with application diagram.

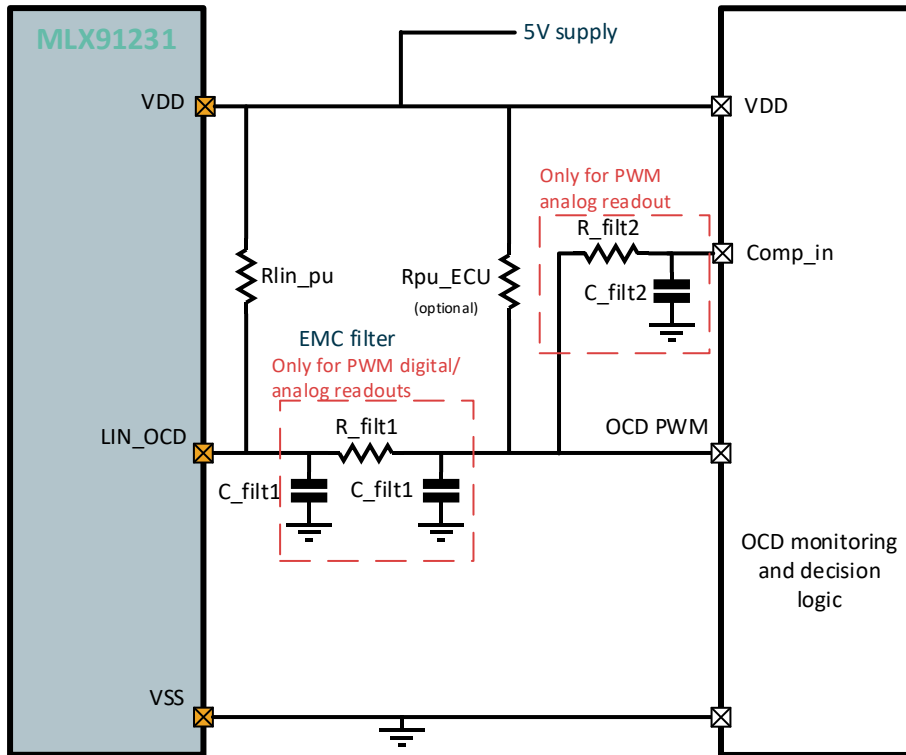


Figure 9 – OCD application diagram example for OCD on LIN (Recommended 5V operation)

| 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 26 – Resistor and Capacitor Values for LIN OCD Application Diagram example

16. Package, IC handling and assembly

16.1. Package information

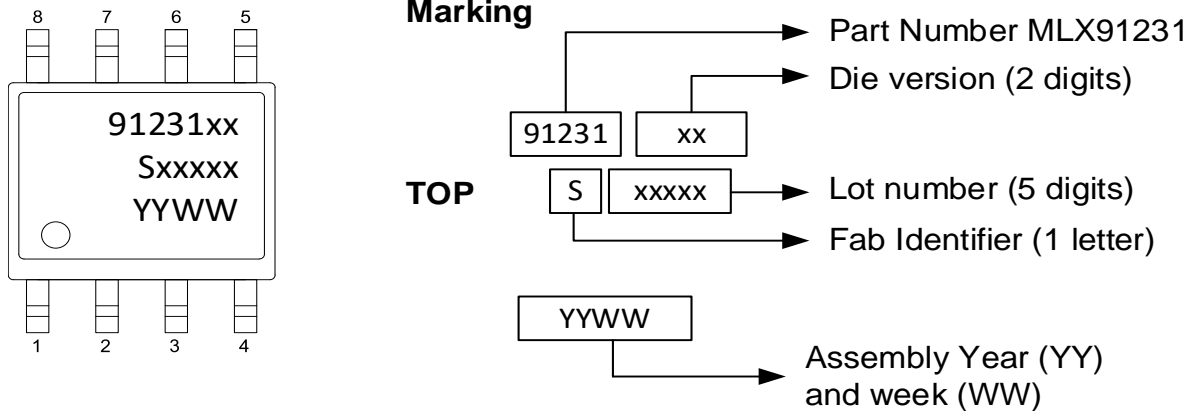
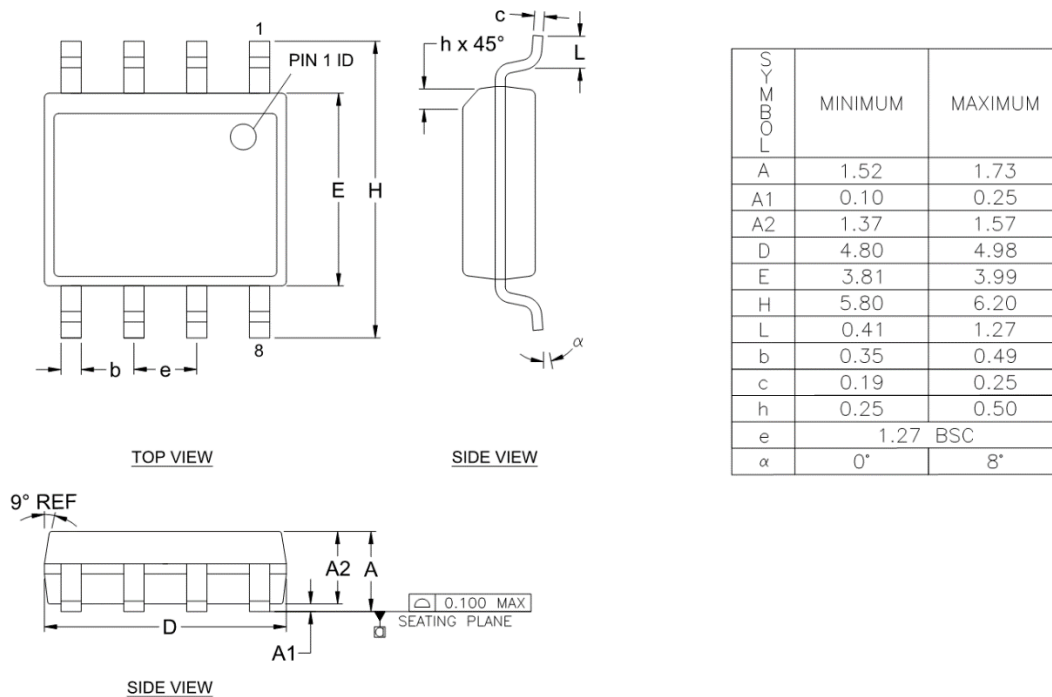


Figure 10 – Package marking



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

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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 ICs⁴](#)

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 Sensors⁴](#)

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 notes⁴ 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 devices⁴](#)

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 notes⁴. 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

⁴ All documents can be found on www.melexis.com/ic-handling-and-assembly

17. Revision History Table

| Version | Date | Author | Description |
|---------|-------------|--------|-------------------------------|
| Rev 1.0 | 07-Dec-2023 | YVT | Release of official datasheet |

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