



ICD-SERIES // HIGH PRECISION MEASUREMENT

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## 1. Introduction

The ICD series is a highly compact precision current measurement system

The system uses shunt-based current measurement technology for maximum accuracy. It consists of a 16Bit ADC for measurement acquisition and a microcontroller for processing and communication purposes. The current measurement value is available within a 24Bit range. An internal sampling rate of 1 kHz is used and a moving averaging filter can be programmed.

The communication is based on CANbus 2.0a/b with a data rate up to 1Mbit/s. A CANbus data base container (DBC) is available to support fast system integration.

The ICD series is covered with a molded housing to resist a wide range of environmental influences. With the highly compact design it can easily be integrated where installation space is limited.

## 2. Applications

The ICD series is designed for a wide range of DC applications.

For example:

- UPS systems
- Energy storage systems
- Battery applications
- automotive and industrial application

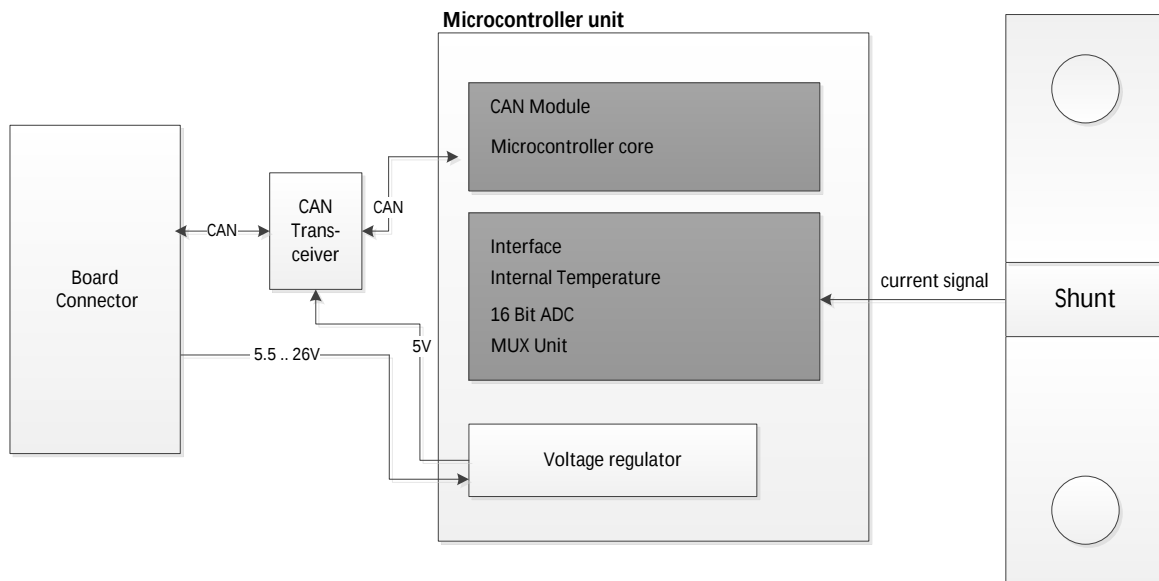
## 3. Additional features

Sleep mode:

During the sleep mode the own current consumption is very low. The current measurement and the ampere-hour meter runs in the background. It's possible to realize the wake up over different functions (timer, rest, current threshold...)

The ICD can measure its own current consumption.

## 4. Block Diagram



### 4.1. Ranges

The ICD product family offers three different, customers selectable current measurement ranges. The selection of a required measurement range determines the shunt resistance.

Every shunt value has unique characteristics (see chapter "technical data"). One limitation characteristic is the maximum load of the shunt resistor. The limitation is based on the internal thermal resistance and a maximum tolerable heating of 20 Kelvin.

Note:

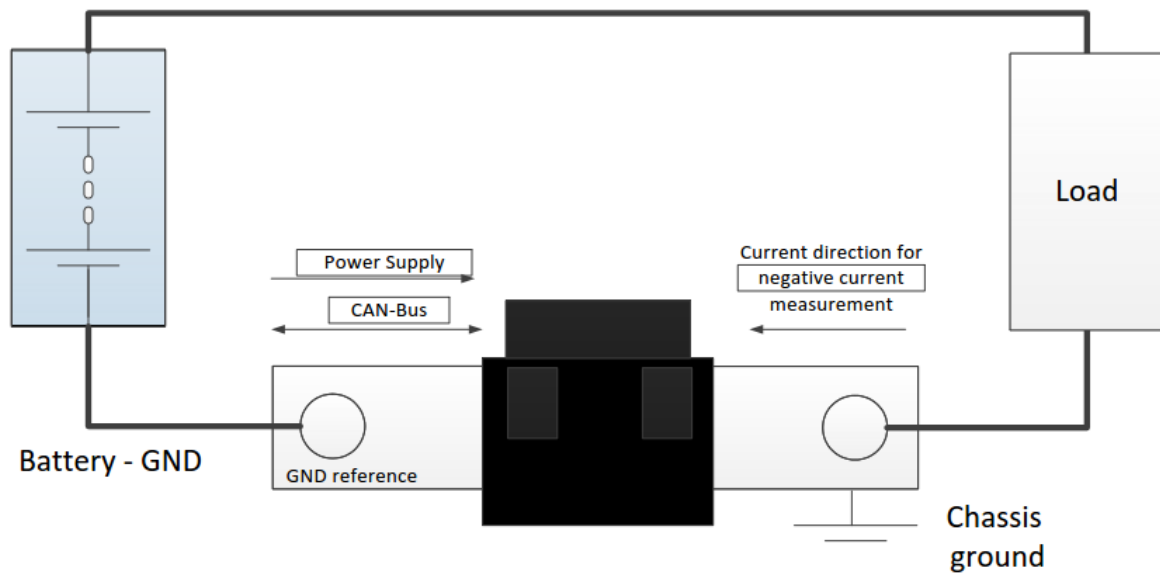
To ensure that the measurement limits are in the specified range, care has to be taken to the thermal connection between shunt and busbar. In case of an inadequate shunt to busbar connection the sensor can possibly overheat due to the internal power dissipation.

### 4.2. Communication interface

The ICD series use the standard CAN 2.0 a/b protocol.

CANbus termination: The standard configuration is without 120  $\Omega$  CANbus termination on board. It is possible to order the sensor with internal CANbus termination.

### 4.3. System integration



#### Important note:

Don't connect PIN 3 ( $V_{SS}$ ) with the Battery GND. It's usable as reference point for laboratory application. Otherwise with a bad connection between Battery and Shunt GND the current would flow through PIN 3, which can damage the sensor!

## 5. Technical Data

### 5.1. Maximum ratings

| Parameter           | Min |   | max  | Unit |
|---------------------|-----|---|------|------|
| Storage temperature | -40 | - | +125 | °C   |
| Supply voltage      | -36 | - | +38  | V    |

| Parameter                 | 100   | 300   | 500   |   |
|---------------------------|-------|-------|-------|---|
| Extended load (max. time) |       |       |       |   |
| 5min                      | ±120  | ±320  | ±730  | A |
| 30s                       | ±200  | ±430  | ±860  | A |
| 10s                       | ±300  | ±600  | ±1000 | A |
| 1s                        | ±900  | ±1600 | ±2700 | A |
| 200ms                     | ±2000 | ±3600 | ±6000 | A |

### 5.2. Operation conditions

| Parameter                            | min. | typ.  | Max.  | Unit |
|--------------------------------------|------|-------|-------|------|
| Operating temperature                | -40  |       | +105  | °C   |
| Storage temperature                  | -40  |       | +125  | °C   |
| Supply voltage                       | 5.5  | 12    | 26    | V    |
|                                      |      |       |       |      |
| Current consumption                  | < 15 | < 30  | < 50  | mA   |
| Current consumption<br>In sleep mode |      | < 100 | < 250 | µA   |
| Re-/ Startup time                    |      | 250   |       | ms   |
| Waiting time power on/off            | 2    |       |       | ms   |

### 5.3. Current measurement

| Parameter                                         |       |       |       | Unit                  |
|---------------------------------------------------|-------|-------|-------|-----------------------|
| Nominal measurement range<br>(depending on shunt) | ±100  | ±300  | ±500  | A                     |
| Power loss                                        | < 3   | < 9   | < 9   | W                     |
| Overcurrent measurement<br>range                  | ±500  | ±1500 | ±2500 | A                     |
| Initial accuracy                                  |       | ±0.1  |       | % of rdg <sup>1</sup> |
| Total accuracy (-25°C ... 85°C)                   |       | ±0.5  |       | % of rdg <sup>1</sup> |
| Total accuracy (-40°C ... 105°C)                  |       | ±0.8  |       | % of rdg <sup>1</sup> |
| Offset                                            | < ±10 | < ±35 | < ±60 | mA                    |
| Noise <sup>2</sup>                                | < ±8  | < ±20 | < ±35 | mA (RMS)              |
| Linearity <sup>3</sup>                            |       | 0.1   |       | % of range            |
| Resolution                                        |       | 1     |       | mA                    |

<sup>1</sup> Failure of reading

<sup>2</sup> Without averaging

<sup>3</sup> In nominal measurement range

#### 5.4. Supply voltage measurement

| Parameter         | Min  |      | Max | Unit     |
|-------------------|------|------|-----|----------|
| Measurement range | +5.5 |      | +26 | V        |
| Initial accuracy  |      | ±0.1 |     | % of rdg |
| Total accuracy    |      | ±0.8 |     | % of rdg |
| Offset            |      | ±35  |     | mV       |
| Noise             |      | ±60  |     | mV (rms) |
| Resolution        |      | 0.5  |     | mV       |

#### 5.5. Temperature measurement (on-chip)

| Parameter         | Min |     | Max  | Unit |
|-------------------|-----|-----|------|------|
| Measurement range | -40 |     | +125 | °C   |
| Initial accuracy  |     | ± 3 |      | °C   |
| Total accuracy    |     | ± 5 |      | °C   |
| Resolution        |     | 0.1 |      | °C   |

#### 5.6. Communication

| Interface | Specification | Speed                          | Max. number of Unit |
|-----------|---------------|--------------------------------|---------------------|
| CANbus    | 2.0 a/b       | 250kbit/s; 500kbits/s; 1Mbit/s | 6                   |

| Direction                         |                                                         |          | MIN  | MAX  | UNIT |
|-----------------------------------|---------------------------------------------------------|----------|------|------|------|
| V <sub>CC</sub>                   | Supply voltage for CAN                                  |          | 4.75 | 5.25 | V    |
| V <sub>I</sub> or V <sub>IC</sub> | Voltage at any bus terminal (separately or common mode) |          | -12  | 12   | V    |
| V <sub>max</sub>                  | Voltage at any bus terminal (max. rating)               |          | -26  | 26   | V    |
| V <sub>IH</sub>                   | High-level input voltage                                | TXD,S    | 2    | 5.25 | V    |
| V <sub>IL</sub>                   | Low-level input voltage                                 | TXD,S    | 0    | 0.8  | V    |
| V <sub>ID</sub>                   | Differential input voltage                              |          | -6   | 6    | V    |
| I <sub>OH</sub>                   | High-level output current                               | Driver   | -70  |      | mA   |
|                                   |                                                         | Receiver | 2    |      | mA   |
| I <sub>OL</sub>                   | Low-level output current                                | Driver   | 70   |      | mA   |
|                                   |                                                         | Receiver | 2    |      | mA   |

#### 5.7. Connector (only suggestion)

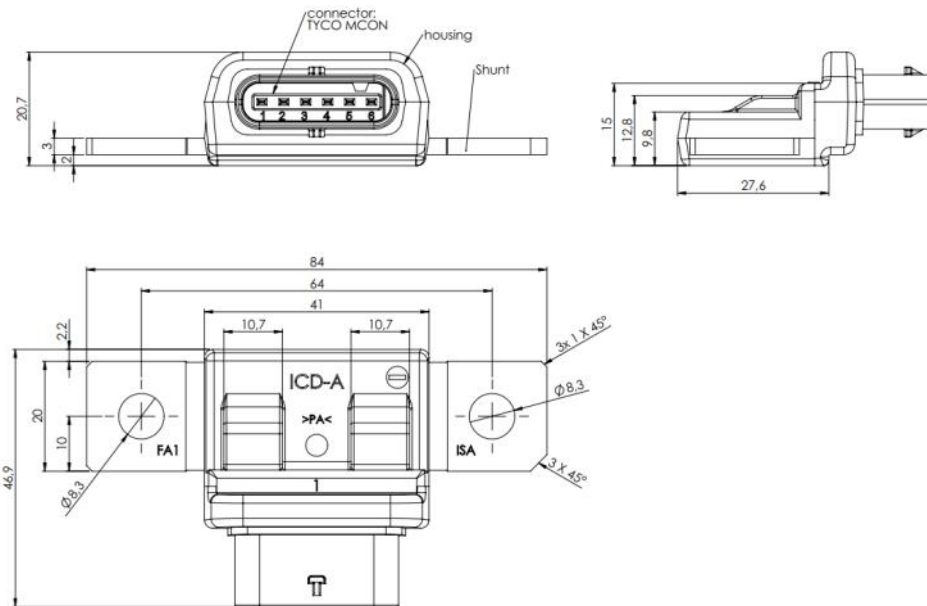
For ICD - A

|                | Manufacturer    | Type | No. of Pins | Color | Man. Part no. |
|----------------|-----------------|------|-------------|-------|---------------|
| Wire connector | TE connectivity |      | 6           | Black | 1-1718646-1   |
| Crimp contact  |                 |      |             |       | 1452671-1     |
| Sealing        |                 |      |             |       | 967067-1      |

For ICD - C

|                | Manufacturer    | Type | No. of Pins | Color | Man. Part no. |
|----------------|-----------------|------|-------------|-------|---------------|
| Wire connector | PHOENIX CONTACT |      | 6           | green | 1893724       |

## 5.8. Mechanical dimension



Product: ICD-A

*Note: These drawings show only the basic dimensions. Detailed dimensions and tolerances can be requested.*

## 5.9. Bus bar connection

The accuracy and repeatability of current measurement depends from the quality of the connection between customer's bus bar and the shunt bus bar

To ensure a good and useful connection between customer's bus bar and the shunt consider the following instructions:

- Mounting the sensor on a bus bar is highly recommended (instead of mounting a cable onto the shunt)
- Screwing the sensor on a bus bar by using all mounting holes, never use less than the available hole for screwing
- Always use screws with an outer diameter of 8 mm (M8), using smaller screws (e. g. M6 or M5) is NOT recommended
- Never use flat washers between the bus bar and the shunt!
- All screws using for mounting must be tightened with a torque as equal as possible!
- The recommended torque is **15 – 20 Nm**
- Shunt and bus bar must be clean and free of grease

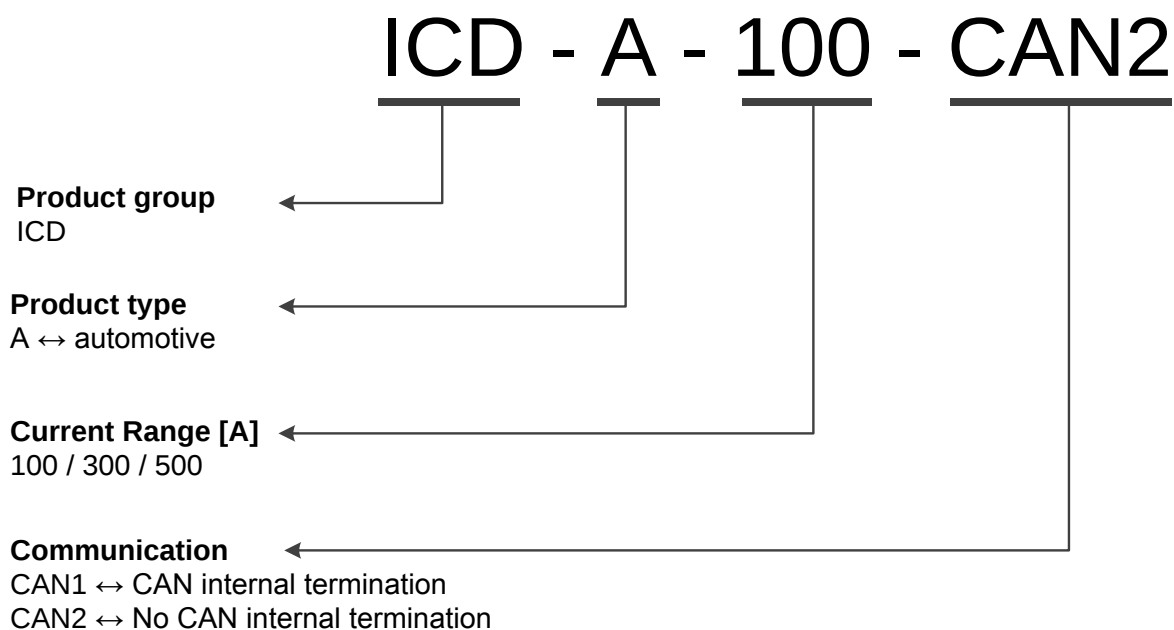
## 5.10. Pin configuration



**Figure 1 Pin configuration**

| Connector | PIN             | Description                                                               | Remark (module or basic)                |
|-----------|-----------------|---------------------------------------------------------------------------|-----------------------------------------|
| 1         | CAN-L           | CAN LOW                                                                   |                                         |
| 2         | CAN-H           | CAN HIGH                                                                  |                                         |
| 3         | V <sub>ss</sub> | (connected to Shunt GND, not needed if Shunt is connected to battery GND) | <b>Only for laboratory application!</b> |
| 4         | V <sub>cc</sub> | (Ref. to Shunt GND)                                                       |                                         |
| 5         | n/a             | Do not connect pin e or pin f to any signal source!                       |                                         |
| 6         | n/a             | Do not connect pin e or pin f to any signal source!                       |                                         |

5.11. Part description



## 6. CAN-Protocol

### 2.0 a Format (11-bit-Identifier)

| Start | Identifier | RTR   | IDE   | r0    | DLC   | DATA       | CRC    | ACK   | EOF+IFS |
|-------|------------|-------|-------|-------|-------|------------|--------|-------|---------|
| 1 Bit | 11 Bit     | 1 Bit | 1 Bit | 1 Bit | 4 Bit | 0...8 Byte | 16 Bit | 2 Bit | 10 Bit  |

### 2.0 b Format (29-bit-Identifier)

| Start | Identifier | SRR   | IDE   | Identifier | RTR   | r1    | r0    | DLC   | DATA       | CRC    | ACK   | EOF+IFS |
|-------|------------|-------|-------|------------|-------|-------|-------|-------|------------|--------|-------|---------|
| 1 Bit | 11 Bit     | 1 Bit | 1 Bit | 18 Bit     | 1 Bit | 1 Bit | 1 Bit | 4 Bit | 0...8 Byte | 16 Bit | 2 Bit | 10 Bit  |

Selectable bitrate

- 1.000.000 bit/s
- 500.000 bit/s
- 250.000 bit/s

#### Default parameters:

CAN bitrate = 500.000 bit/s

## 6.1. Message types and layout

| Description | CAN-ID Default | DLC | Time                          | Remark                                                                                    |
|-------------|----------------|-----|-------------------------------|-------------------------------------------------------------------------------------------|
| request     | 0x0500         | 8   | Triggered                     | Function commands, SET and GET commands. A command-ID.byte is included for identification |
| response    | 0x0501         | 8   | Triggered                     | Response to SET- and GET- commands from the <i>Request-message</i>                        |
| result      | 0x0502         | 8   | Cyclic 1 ms (continuous mode) | Contains the results of <i>I</i> , <i>Ubatt</i> and <i>Status</i>                         |

**Table 1: Message types and layout**

## 6.2. Request - message

The communication of the sensor is based on two CAN-frames. For getting and setting any information from/to the sensor the *cmd* (command)-Message with the ID 0x500 is required. Table 2 pictures the details of the cmd-message structure with its signals.

| CAN msg<br>cmd | D0     | D1      | D2 | D3 | D4 | D5 | D6 | D7 |
|----------------|--------|---------|----|----|----|----|----|----|
| 0x500          | MUX ID | P0...P6 |    |    |    |    |    |    |

Table 2: CAN frame

Databyte 0 (D0) is a *multiplexor-signal* which controls the type of information for get-/set frames. It's named *Multiplex ID* (MUX ID).

## 6.3. Multiplexed Request-messages (measurement)

If not otherwise mentioned blank filed are don't care.

| Message                | MUX ID | P0 | P1 | P2 | P3 | P4 | P5 | P6 |
|------------------------|--------|----|----|----|----|----|----|----|
| Trigger Result         | 0x00   |    |    |    |    |    |    |    |
| Get Result Temperature | 0x01   |    |    |    |    |    |    |    |
| Get Result Ah Counter  | 0x02   |    |    |    |    |    |    |    |

Table 3: MUX request messages

## 6.4. Multiplexed Request-messages (configuration)

| Message            | MUX ID | P0                                                                          | P1                                                                                                          | P2                                                                                                            | P3 | P4 | P5 | P6 |
|--------------------|--------|-----------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|----|----|----|----|
| Set Operation Mode | 0x10   | <b>&lt;Mode&gt;</b><br>0x00 stop<br>0x01 continuous (def)<br>0x02 triggered | <b>&lt;output rate<br/>continuous mode<br/>[ms]&gt;</b><br>Ignored in mode 0x00,<br>0x02<br>unsigned 16 bit | <b>&lt;Option as<br/>bitfield&gt;<br/>(0x00 – 0xff)</b><br>0b0000 0001 –<br>invert current<br>direction (*-1) |    |    |    |    |

Table 4: Set operation mode

| Message       | MUX ID | P0 | P1 | P2 | P3 | P4 | P5 | P6 |
|---------------|--------|----|----|----|----|----|----|----|
| Get Device ID | 0x60   |    |    |    |    |    |    |    |

Table 5: Get operation mode

| Message                              | MUX ID | P0                                                   | P1      | P2      | P3      | P4      | P5      | P6      |
|--------------------------------------|--------|------------------------------------------------------|---------|---------|---------|---------|---------|---------|
| Set Access Mode<br>(for User access) | 0x11   | <b>0x00 (def)</b><br>no configuration<br>possible    |         |         |         |         |         |         |
|                                      |        | <b>0x01</b><br>configuration<br>mode for<br>customer | 0x30(0) | 0x30(0) | 0x30(0) | 0x30(0) | 0x30(0) | 0x30(0) |

Table 6: Set access mode

| Message                             | MUX ID | P0 | P1 | P2 | P3 | P4 | P5 | P6 |
|-------------------------------------|--------|----|----|----|----|----|----|----|
| Get Access Mode<br>(of User access) | 0x61   |    |    |    |    |    |    |    |

**Table 7: Get access mode**

| Message       | MUX ID | P0                                 | P1 | P2 | P3 | P4 | P5 | P6 |
|---------------|--------|------------------------------------|----|----|----|----|----|----|
| Set Averaging | 0x20   | <Dept of averaging><br>0x00 – 0xff |    |    |    |    |    |    |

**Table 8: Set Averaging**

Set number of averaged values, within measurement result. Averaged filter implemented to response floating averaged value.

| Message       | MUX ID | P0 | P1 | P2 | P3 | P4 | P5 | P6 |
|---------------|--------|----|----|----|----|----|----|----|
| Get Averaging | 0x70   |    |    |    |    |    |    |    |

**Table 9: Get Averaging**

| Message      | MUX ID | P0                                                 | P1 | P2 | P3                                                 | P4 | P5 | P6 |
|--------------|--------|----------------------------------------------------|----|----|----------------------------------------------------|----|----|----|
| Set OC limit | 0x21   | <activation limit positive [A]><br>unsigned 24 bit |    |    | <activation limit negative [A]><br>unsigned 24 bit |    |    |    |

**Table 10: Set OC limit**

Set OC signal within status of result message.

| Message      | MUX ID | P0 | P1 | P2 | P3 | P4 | P5 | P6 |
|--------------|--------|----|----|----|----|----|----|----|
| Get OC limit | 0x71   |    |    |    |    |    |    |    |

**Table 11: Get OC limit**

| Message               | MUX ID | P0                                                                      | P1                                         | P2 | P3 | P4 | P5 | P6 |
|-----------------------|--------|-------------------------------------------------------------------------|--------------------------------------------|----|----|----|----|----|
| Set CAN configuration | 0x22   | <Baudrate><br>0x00 – 250kBaud<br>0x01 – 500kBaud (def)<br>0x02 – 1MBaud | <CAN Mode><br>0x00 – 2.0 a<br>0x01 – 2.0 b |    |    |    |    |    |

**Table 12: Set CAN configuration**

New configuration valid after restart

| Message               | MUX ID | P0 | P1 | P2 | P3 | P4 | P5 | P6 |
|-----------------------|--------|----|----|----|----|----|----|----|
| Get CAN configuration | 0x72   |    |    |    |    |    |    |    |

**Table 13: Get CAN configuration**

| Message            | MUX ID | P0            | P1            | P2            | P3           | P4           | P5           | P6           |
|--------------------|--------|---------------|---------------|---------------|--------------|--------------|--------------|--------------|
| Set CAN ID request | 0x23   | <S/N HL byte> | <S/N LH byte> | <S/N LL byte> | <ID HH byte> | <ID HL byte> | <ID LH byte> | <ID LL byte> |

**Table 14: Set CAN ID request**

Parameters including lower 3 bytes of serial number, 4 bytes new CAN-ID

| Message            | MUX ID | P0 | P1 | P2 | P3 | P4 | P5 | P6 |
|--------------------|--------|----|----|----|----|----|----|----|
| Get CAN ID request | 0x73   |    |    |    |    |    |    |    |

**Table 15: Get CAN ID request**

| Message             | MUX ID | P0            | P1            | P2            | P3           | P4           | P5           | P6           |
|---------------------|--------|---------------|---------------|---------------|--------------|--------------|--------------|--------------|
| Set CAN ID response | 0x24   | <S/N HL byte> | <S/N LH byte> | <S/N LL byte> | <ID HH byte> | <ID HL byte> | <ID LH byte> | <ID LL byte> |

**Table 16: Set CAN ID response**

Parameters including lower 3 bytes of serial number, 4 bytes new CAN-ID

| Message             | MUX ID | P0 | P1 | P2 | P3 | P4 | P5 | P6 |
|---------------------|--------|----|----|----|----|----|----|----|
| Get CAN ID response | 0x74   |    |    |    |    |    |    |    |

**Table 17: Get CAN ID response**

| Message           | MUX ID | P0            | P1            | P2            | P3           | P4           | P5           | P6           |
|-------------------|--------|---------------|---------------|---------------|--------------|--------------|--------------|--------------|
| Set CAN ID result | 0x25   | <S/N HL byte> | <S/N LH byte> | <S/N LL byte> | <ID HH byte> | <ID HL byte> | <ID LH byte> | <ID LL byte> |

**Table 18: Set CAN ID result**

Parameters including lower 3 bytes of serial number, 4 bytes new CAN-ID

| Message           | MUX ID | P0 | P1 | P2 | P3 | P4 | P5 | P6 |
|-------------------|--------|----|----|----|----|----|----|----|
| Get CAN ID result | 0x75   |    |    |    |    |    |    |    |

**Table 19: Get CAN ID result**

| Message      | MUX ID | P0                       | P1                       | P2                       | P3                       | P4                       | P5                       | P6 |
|--------------|--------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|----|
| Set user p/w | 0x26   | <new P/W><br>0x20 – 0x7e | <new P/W><br>0x20 – 0x7e | <new P/W><br>0x20 – 0x7e | <new P/W><br>0x20 – 0x7e | <new P/W><br>0x20 – 0x7e | <new P/W><br>0x20 – 0x7e |    |

**Table 20: Set user P/W**

Set password only in related user mode

| Message      | MUX ID | P0 | P1 | P2 | P3 | P4 | P5 | P6 |
|--------------|--------|----|----|----|----|----|----|----|
| Get user p/w | 0x76   |    |    |    |    |    |    |    |

**Table 21: Get user P/W**

Set password only in related user mode

## 6.5. Multiplexed Request-messages (control)

| Message | MUX ID | P0                                                                                                        | P1 | P2 | P3 | P4 | P5 | P6 |
|---------|--------|-----------------------------------------------------------------------------------------------------------|----|----|----|----|----|----|
| Reset   | 0x40   | <b>&lt;Reset option &gt;</b><br><br>0x01 – Reset all parameters to default<br><br>0x02 – Force hard reset |    |    |    |    |    |    |

Table 22: Reset

| Message    | MUX ID | P0                                                                                                                                       | P1                                                                      | P2 | P3                                                                           | P4 | P5                                                                                 | P6 |
|------------|--------|------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------|----|------------------------------------------------------------------------------|----|------------------------------------------------------------------------------------|----|
| Goto sleep | 0x41   | <b>&lt;Wakeup source as bitfield&gt;</b><br><br>0b0000 0001 – timer<br><br>0b0000 0010 – I-threshold<br><br>0b0000 0100 – Ah - threshold | <b>&lt;Timer value[1 s]&gt;</b><br><br>Unsigned 16 bit<br>0 s – 65000 s |    | <b>&lt;I – threshold [1 mA]&gt;</b><br><br>Unsigned 16 bit<br>0 mA to 250 mA |    | <b>&lt;Ah – threshold [1 mAs]&gt;</b><br><br>Unsigned 16 bit<br>0 mAs to 65000 mAs |    |

Table 23: Goto sleep

| Message          | MUX ID | P0 | P1 | P2 | P3 | P4 | P5 | P6 |
|------------------|--------|----|----|----|----|----|----|----|
| Clear Ah counter | 0x42   |    |    |    |    |    |    |    |

Table 24: Clear Ah counter

| Message           | MUX ID | P0 | P1 | P2 | P3 | P4 | P5 | P6 |
|-------------------|--------|----|----|----|----|----|----|----|
| Clear Status Bits | 0x43   |    |    |    |    |    |    |    |

Table 25: Clear Status Bits

| Message        | MUX ID | P0 | P1 | P2 | P3 | P4 | P5 | P6 |
|----------------|--------|----|----|----|----|----|----|----|
| Store settings | 0x44   |    |    |    |    |    |    |    |

Table 26: Store Settings

Storing of trigger mode, CAN configuration, averaging setting, CAN ID request, CAN ID response, CAN ID result and Result structure,

| Message             | MUX ID | P0 | P1 | P2 | P3 | P4 | P5 | P6 |
|---------------------|--------|----|----|----|----|----|----|----|
| Clear event counter | 0x45   |    |    |    |    |    |    |    |

Table 27: Clear event counter

## 6.6. Multiplexed Request-messages (information)

| Message       | MUX ID | P0 | P1 | P2 | P3 | P4 | P5 | P6 |
|---------------|--------|----|----|----|----|----|----|----|
| Get device ID | 0x50   |    |    |    |    |    |    |    |

Table 28: Get device ID

| Message         | MUX ID | P0 | P1 | P2 | P3 | P4 | P5 | P6 |
|-----------------|--------|----|----|----|----|----|----|----|
| Get SFW Version | 0x51   |    |    |    |    |    |    |    |

Table 29: Get FW version

| Message        | MUX ID | P0 | P1 | P2 | P3 | P4 | P5 | P6 |
|----------------|--------|----|----|----|----|----|----|----|
| Get Serial no. | 0x52   |    |    |    |    |    |    |    |

**Table 30: Get serial no.**

| Message        | MUX ID | P0 | P1 | P2 | P3 | P4 | P5 | P6 |
|----------------|--------|----|----|----|----|----|----|----|
| Get HW Version | 0x53   |    |    |    |    |    |    |    |

**Table 31: Get HW version**

| Message        | MUX ID | P0 | P1 | P2 | P3 | P4 | P5 | P6 |
|----------------|--------|----|----|----|----|----|----|----|
| Get article no | 0x54   |    |    |    |    |    |    |    |

**Table 32: Get article no.**

| Message      | MUX ID | P0 | P1 | P2 | P3 | P4 | P5 | P6 |
|--------------|--------|----|----|----|----|----|----|----|
| Get revision | 0x55   |    |    |    |    |    |    |    |

**Table 33: Get revision**

| Message     | MUX ID | P0 | P1 | P2 | P3 | P4 | P5 | P6 |
|-------------|--------|----|----|----|----|----|----|----|
| Get up time | 0x56   |    |    |    |    |    |    |    |

**Table 34: Get up time**

| Message              | MUX ID | P0 | P1 | P2 | P3 | P4 | P5 | P6 |
|----------------------|--------|----|----|----|----|----|----|----|
| Get lifetime counter | 0x57   |    |    |    |    |    |    |    |

**Table 35: Get lifetime counter**

| Message         | MUX ID | P0 | P1 | P2 | P3 | P4 | P5 | P6 |
|-----------------|--------|----|----|----|----|----|----|----|
| Get status bits | 0x58   |    |    |    |    |    |    |    |

**Table 36: Get status bits**

Requests bitmask of measurement status and system status

| Message      | MUX ID | P0 | P1 | P2 | P3 | P4 | P5 | P6 |
|--------------|--------|----|----|----|----|----|----|----|
| Get CRC code | 0x59   |    |    |    |    |    |    |    |

**Table 37: Get CRC Code**

| Message            | MUX ID | P0                                                                                                                                                                                                                                                                                                                                      | P1                                                                                                                                                                                                                                                                                                                                                                                                                                         | P2 | P3 | P4 | P5 | P6 |
|--------------------|--------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|----|----|----|----|
| Get Event Counters | 0x5b   | <b>&lt;Measurement status&gt;</b><br>0x01 – 0xff error counter<br><br>0x01 – adc interrupt<br>0x02 – overflow adc ch1<br>0x03 – overflow adc ch 2<br>0x04 – overflow adc ch 3<br>0x05 – open circuit I<br>0x06 – open circuit U<br>0x07 – open circuit Tchip<br>0x08 – open circuit Text<br>0x09 – calibration data<br>0x0a – OCS ative | <b>&lt;System Status&gt;</b><br>0x01 – 0xff Error Counter<br><br>0x01 – code crc<br>0x02 – calibration data crc<br>0x03 – CAN Rx<br>0x04 – CAN Tx<br>0x05 – overtemp<br>0x06 – undertemp<br>0x07 – power failure<br>0x08 – system clock<br>0x09 – system init<br>0x0a – configuration<br>0x0b – eeprom r/w<br>0x10 – power on reset<br>0x20 – low voltage reset<br>0x30 – ext. pin reset<br>0x40 – clock mon. reset<br>0x50 – COP ED reset |    |    |    |    |    |

**Table 38: Get event counters**

Request counters of measurement status and system status

## 6.7. Response - Message

Response to the get/set request messages are given in the response message. Layout and byte order correspond to the structure from response *message*, shown in the table below.

| CAN msg msg | ID    | D0              | D1 | D2 | D3 | D4 | D5 | D6 | D7 |
|-------------|-------|-----------------|----|----|----|----|----|----|----|
| Message     | 0x501 | Response MUX ID | P0 | P1 | P2 | P3 | P4 | P5 | P6 |

**Table 39: Response message – CAN frame**

## 6.8. Multiplexed Response – messages (measurement)

| Message     | Response to Message    | Response MUX ID | P0                                                          | P1 | P2                                                         | P3 | P4   | P5   | P6   |
|-------------|------------------------|-----------------|-------------------------------------------------------------|----|------------------------------------------------------------|----|------|------|------|
| Temperature | Get result temperature | 0x91            | <b>&lt;T<sub>chip</sub>&gt;</b><br>1/10 °C<br>signed 16 bit |    | <b>&lt;T<sub>ext</sub>&gt;</b><br>1/10 °C<br>signed 16 bit |    | 0x00 | 0x00 | 0x00 |

**Table 40: Temperature**

| Message    | Response to Message   | Response MUX ID | P0                                                   | P1 | P2 | P3 | P4 | P5   | P6   |
|------------|-----------------------|-----------------|------------------------------------------------------|----|----|----|----|------|------|
| Ah Counter | Get Result Ah Counter | 0x92            | <b>&lt;Ah counter [mAs]&gt;</b><br><br>signed 32 bit |    |    |    |    | 0x00 | 0x00 |
|            | Clear Ah counter      |                 |                                                      |    |    |    |    |      |      |

**Table 41: Ah counter**

## 6.9. Multiplexed Response – messages (configuration)

| Message        | Response to Message                          | Response MUX ID | P0                                                                             | P1                                                                                                                            | P2 | P3                                                                                                       | P4   | P5   | P6   |
|----------------|----------------------------------------------|-----------------|--------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|----|----------------------------------------------------------------------------------------------------------|------|------|------|
| Operation mode | Set Operation Mode<br><br>Get Operation Mode | 0xA0            | <b>&lt;Mode&gt;</b><br><br>0x00 – stop<br>0x01- continuous<br>0x02 – triggered | <b>&lt;Output rate [ms]&gt;</b><br><br>Mode 0x00 → 0x00<br>Mode 0x01 → 0x01 – 0xff<br>Mode 0x02 → 0x01<br><br>unsigned 16 bit |    | <b>&lt;Option as field&gt;</b><br><br>0x00 – 0xff<br><br>0b0000 0001<br>– invert current direction (*-1) | 0x00 | 0x00 | 0x00 |

Table 42: Operation mode

| Message     | Response to Message                    | Response MUX ID | P0                                                                              | P1   | P2   | P3   | P4   | P5   | P6   |
|-------------|----------------------------------------|-----------------|---------------------------------------------------------------------------------|------|------|------|------|------|------|
| Access mode | Set Access Mode<br><br>Get Access Mode | 0xA1            | <b>&lt;Access mode&gt;</b><br><br>0x00 – no cfg possible<br>0x01 - cfg possible | 0x00 | 0x00 | 0x00 | 0x00 | 0x00 | 0x00 |

Table 43: Access mode

| Message   | Response to Message                | Response MUX ID | P0                                                   | P1   | P2   | P3   | P4   | P5   | P6   |
|-----------|------------------------------------|-----------------|------------------------------------------------------|------|------|------|------|------|------|
| Averaging | Set Averaging<br><br>Get Averaging | 0xB0            | <b>&lt;Depth of averaging&gt;</b><br><br>0x00 – 0xff | 0x00 | 0x00 | 0x00 | 0x00 | 0x00 | 0x00 |

Table 44: Averaging

| Message  | Response to Message              | Response MUX ID | P0                                                                  | P1 | P2                                                                  | P3 | P4 | P5 | P6   |
|----------|----------------------------------|-----------------|---------------------------------------------------------------------|----|---------------------------------------------------------------------|----|----|----|------|
| OC limit | Set OC Limit<br><br>Get OC Limit | 0xB1            | <b>&lt;Activation limit positive [A]&gt;</b><br><br>unsigned 24 bit |    | <b>&lt;Activation limit negative [A]&gt;</b><br><br>unsigned 24 bit |    |    |    | 0x00 |

Table 45: OC limit

| Message           | Response to Message                                | Response MUX ID | P0                                                                                 | P1                                                          | P2 | P3   | P4   | P5   | P6   |
|-------------------|----------------------------------------------------|-----------------|------------------------------------------------------------------------------------|-------------------------------------------------------------|----|------|------|------|------|
| CAN configuration | Set CAN Configuration<br><br>Get CAN Configuration | 0xB2            | <b>&lt;Baudrate&gt;</b><br><br>0x00 – 250kBaud<br>0x01 – 500kBaud<br>0x02 – 1MBaud | <b>&lt;CAN Mode&gt;</b><br><br>0x00 – 2.0 a<br>0x01 – 2.0 b |    | 0x00 | 0x00 | 0x00 | 0x00 |

Table 46: CAN configuration

| Message        | Response to Message                          | Response MUX ID | P0                         | P1                         | P2                         | P3                        | P4                        | P5                        | P6                        |
|----------------|----------------------------------------------|-----------------|----------------------------|----------------------------|----------------------------|---------------------------|---------------------------|---------------------------|---------------------------|
| CAN ID request | Set CAN ID Request<br><br>Get CAN ID Request | 0xB3            | <b>&lt;S/N HL byte&gt;</b> | <b>&lt;S/N LH byte&gt;</b> | <b>&lt;S/N LL byte&gt;</b> | <b>&lt;ID HH byte&gt;</b> | <b>&lt;ID HL byte&gt;</b> | <b>&lt;ID LH byte&gt;</b> | <b>&lt;ID LL byte&gt;</b> |

Table 47: CAN ID request

Includes lower 3 bytes of Serial number, 4 bytes data

| Message         | Response to Message                            | Response MUX ID | P0            | P1            | P2            | P3           | P4           | P5           | P6           |
|-----------------|------------------------------------------------|-----------------|---------------|---------------|---------------|--------------|--------------|--------------|--------------|
| CAN ID response | Set CAN ID Response<br><br>Get CAN ID Response | 0xB4            | <S/N HL byte> | <S/N LH byte> | <S/N LL byte> | <ID HH byte> | <ID HL byte> | <ID LH byte> | <ID LL byte> |

**Table 48: CAN ID response**

Includes lower 3 bytes of Serial number, 4 bytes data

| Message       | Response to Message                        | Response MUX ID | P0            | P1            | P2            | P3           | P4           | P5           | P6           |
|---------------|--------------------------------------------|-----------------|---------------|---------------|---------------|--------------|--------------|--------------|--------------|
| CAN ID result | Set CAN ID Result<br><br>Get CAN ID Result | 0xB5            | <S/N HL byte> | <S/N LH byte> | <S/N LL byte> | <ID HH byte> | <ID HL byte> | <ID LH byte> | <ID LL byte> |

**Table 49: CAN ID result**

Includes lower 3 bytes of Serial number, 4 bytes data

| Message  | Response to Message              | Response MUX ID | P0                           | P1                           | P2                           | P3                           | P4                           | P5                           | P6   |
|----------|----------------------------------|-----------------|------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|------|
| User P/W | Set User P/W<br><br>Get User P/W | 0xB6            | <New P/W><br><br>0x20 – 0x7e | <New P/W><br><br>0x20 – 0x7e | <New P/W><br><br>0x20 – 0x7e | <New P/W><br><br>0x20 – 0x7e | <New P/W><br><br>0x20 – 0x7e | <New P/W><br><br>0x20 – 0x7e | 0x00 |

**Table 50: User P/W**

Only of activated mode

## 6.10. Multiplexed Response – messages (control)

| Message | Response to Message | Response MUX ID | P0                                                                                           | P1   | P2   | P3   | P4   | P5   | P6   |
|---------|---------------------|-----------------|----------------------------------------------------------------------------------------------|------|------|------|------|------|------|
| Reset   | Reset               | 0xD0            | <Reset option ><br><br>0x01 – Reset all parameters to default<br><br>0x02 – Force hard reset | 0x00 | 0x00 | 0x00 | 0x00 | 0x00 | 0x00 |

**Table 51: Reset**

Send right before reset

| Message    | Response to Message | Response MUX ID | P0                                                                                                                          | P1                                                         | P2 | P3                                                              | P4 | P5                                                                    | P6 |
|------------|---------------------|-----------------|-----------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------|----|-----------------------------------------------------------------|----|-----------------------------------------------------------------------|----|
| Goto sleep | Goto Sleep          | 0xD1            | <Wakeup source as bitfield><br><br>0b0000 0001 – timer<br><br>0b0000 0010 – I-threshold<br><br>0b0000 0100 – Ah - threshold | <Timer value[1 s]><br><br>Unsigned 16 bit<br>0 s – 65000 s |    | <I – threshold [1 mA]><br><br>Unsigned 16 bit<br>0 mA to 250 mA |    | <Ah – threshold [1 mAs]><br><br>Unsigned 16 bit<br>0 mAs to 65000 mAs |    |

**Table 52: Goto sleep**

Send right before entering sleep mode

| Message        | Response to Message | Response MUX ID | P0   | P1   | P2   | P3   | P4   | P5   | P6   |
|----------------|---------------------|-----------------|------|------|------|------|------|------|------|
| Store Settings | Store Settings      | 0xD4            | 0x00 | 0x00 | 0x00 | 0x00 | 0x00 | 0x00 | 0x00 |

**Table 53: Store Settings**

## 6.11. Multiplexed Response – messages (information)

| Message   | Response to Message | Response MUX ID | P0                                          | P1       | P2       | P3       | P4       | P5                                                       | P6   |
|-----------|---------------------|-----------------|---------------------------------------------|----------|----------|----------|----------|----------------------------------------------------------|------|
| Device ID | Get Device ID       | 0xE0            | <Message counter multiframemessage><br>0x00 | 0x49 (I) | 0x43 (C) | 0x44 (D) | 0x2D (-) | Depending on variant<br>0x41 (A)<br>0x43 (C)<br>0x52 (R) | 0x00 |

**Table 54: Device ID**

Device ID response includes 4 messages with message counter 0x00- 0x03

| Message   | Response to Message | Response MUX ID | P0                                          | P1       | P2                                                                      | P3                                                                      | P4                                                                      | P5                                                                | P6   |
|-----------|---------------------|-----------------|---------------------------------------------|----------|-------------------------------------------------------------------------|-------------------------------------------------------------------------|-------------------------------------------------------------------------|-------------------------------------------------------------------|------|
| Device ID | Get Device ID       | 0xE0            | <Message counter multiframemessage><br>0x01 | 0x2D (-) | Depending on current range<br>0x30(0100A)<br>0x30(0300A)<br>0x30(0500A) | Depending on current range<br>0x31(0100A)<br>0x33(0300A)<br>0x35(0500A) | Depending on current range<br>0x30(0100A)<br>0x30(0300A)<br>0x30(0500A) | Depending on variant<br>0x30(0100A)<br>0x30(0300A)<br>0x30(0500A) | 0x00 |

**Table 55: Device ID**

Device ID response includes 4 messages with message counter 0x00- 0x03

| Message   | Response to Message | Response MUX ID | P0                                          | P1       | P2       | P3       | P4       | P5                                                                                                                    | P6   |
|-----------|---------------------|-----------------|---------------------------------------------|----------|----------|----------|----------|-----------------------------------------------------------------------------------------------------------------------|------|
| Device ID | Get Device ID       | 0xE0            | <Message counter multiframemessage><br>0x02 | 0x2D (-) | 0x43 (C) | 0x41 (A) | 0x4E (N) | Depending on communication setup<br>0x31 (with termination)<br>0x32 (no termination)<br>0x33 (selectable termination) | 0x00 |

**Table 56: Device ID**

Device ID response includes 4 messages with message counter 0x00- 0x03

| Message   | Response to Message | Response MUX ID | P0                                          | P1       | P2                                              | P3                                              | P4   | P5   | P6   |
|-----------|---------------------|-----------------|---------------------------------------------|----------|-------------------------------------------------|-------------------------------------------------|------|------|------|
| Device ID | Get Device ID       | 0xE0            | <Message counter multiframemessage><br>0x03 | 0x2D (-) | Depending on supply voltage range<br>0x31 (12V) | Depending on supply voltage range<br>0x32 (12V) | 0x00 | 0x00 | 0x00 |

**Table 57: Device ID**

Device ID response includes 4 messages with message counter 0x00- 0x03

| Message     | Response to Message | Response MUX ID | P0                             | P1                             | P2                               | P3   | P4   | P5   | P6   |
|-------------|---------------------|-----------------|--------------------------------|--------------------------------|----------------------------------|------|------|------|------|
| F/W Version | Get FW Version      | 0xE1            | <Major Version><br>0x30 – 0x39 | <Minor Version><br>0x30 – 0x39 | <Release Version><br>0x30 – 0x39 | 0x00 | 0x00 | 0x00 | 0x00 |

Table 58: F/W Version

| Message       | Response to Message | Response MUX ID | P0                             | P1 | P2 | P3 | P4   | P5   | P6   |
|---------------|---------------------|-----------------|--------------------------------|----|----|----|------|------|------|
| Serial number | Get Serial Number   | 0xE2            | <Serial number><br>unsigned 32 |    |    |    | 0x00 | 0x00 | 0x00 |

Table 59: Serial number

| Message     | Response to Message | Response MUX ID | P0                                           | P1                     | P2                     | P3                                 | P4                                 | P5                                 | P6                          |
|-------------|---------------------|-----------------|----------------------------------------------|------------------------|------------------------|------------------------------------|------------------------------------|------------------------------------|-----------------------------|
| H/W Version | Get H/W Version     | 0xE3            | <Message counter multiframe message><br>0x00 | Identifier<br>0x49 (I) | Identifier<br>0x4D (M) | Depending on PCB no<br>0x30 – 0x39 | Depending on PCB no<br>0x30 – 0x39 | Depending on PCB no<br>0x30 – 0x39 | Depending on layout version |

Table 60: H/W version (1/2)

Device ID response includes 2 messages with message counter 0x00- 0x01

| Message     | Response to Message | Response MUX ID | P0                                           | P1       | P2       | P3                              | P4                              | P5                              | P6                              |
|-------------|---------------------|-----------------|----------------------------------------------|----------|----------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|
| H/W Version | Get H/W Version     | 0xE3            | <Message counter multiframe message><br>0x01 | 0x5F (L) | 0x41 (A) | Depending on BOM<br>0x30 – 0x39 | Depending on BOM<br>0x30 – 0x39 | Depending on BOM<br>0x30 – 0x39 | Depending on BOM<br>0x30 – 0x39 |

Table 61: H/W version (2/2)

Device ID response includes 2 messages with message counter 0x00- 0x01

| Message        | Response to Message | Response MUX ID | P0                                  | P1 | P2 | P3 | P4 | P5 | P6 |
|----------------|---------------------|-----------------|-------------------------------------|----|----|----|----|----|----|
| Article number | Get Article Number  | 0xE4            | <Article number><br>unsigned 56 bit |    |    |    |    |    |    |

Table 62: Article number

| Message  | Response to Message | Response MUX ID | P0       | P1       | P2       | P3                              | P4                              | P5                              | P6                              |
|----------|---------------------|-----------------|----------|----------|----------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|
| Revision | Get Revision        | 0xE5            | 0x52 (R) | 0x45 (E) | 0x56 (V) | Depending on BOM<br>0x30 – 0x39 | Depending on BOM<br>0x30 – 0x39 | Depending on BOM<br>0x30 – 0x39 | Depending on BOM<br>0x30 – 0x39 |

Table 63: Revision

| Message | Response to Message | Response MUX ID | P0                                    | P1 | P2 | P3 | P4   | P5   | P6   |
|---------|---------------------|-----------------|---------------------------------------|----|----|----|------|------|------|
| Up time | Get Up time         | 0xE6            | <Up Time [minute]><br>unsigned 32 bit |    |    |    | 0x00 | 0x00 | 0x00 |

Table 64: Up time // time of operation

| Message  | Response to Message | Response MUX ID | P0                                     | P1 | P2 | P3 | P4   | P5   | P6   |
|----------|---------------------|-----------------|----------------------------------------|----|----|----|------|------|------|
| Lifetime | Get Lifetime        | 0xE7            | <Lifetime [minute]><br>unsigned 32 bit |    |    |    | 0x00 | 0x00 | 0x00 |

Table 65: Lifetime

| Message | Response to Message | Response MUX ID | P0   | P1   | P2                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | P3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | P4                        | P5 | P6   |
|---------|---------------------|-----------------|------|------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------|----|------|
| Status  | Get Status          | 0xE8            | 0x00 | 0x00 | <measurement status><br>16 bit                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <system status><br>16 bit |    | 0x00 |
|         | Clear Status        |                 |      |      | 0b0000 0000 0000 0001<br>– adc interrupt<br>0b0000 0000 0000 0010<br>– overflow adc ch 1<br>0b0000 0000 0000 0100<br>– overflow adc ch 2<br>0b0000 0000 0000 1000<br>– overflow adc ch 3<br>0b0000 0000 0001 0000<br>– open circuit I<br>0b0000 0000 0010 0000<br>– open circuit U<br>0b0000 0000 0100 0000<br>– open circuit Tchip<br>0b0000 0000 1000 0000<br>– open circuit Text<br>0b0000 0001 0000 0000<br>– calibration data<br>0b0000 0010 0000 0000<br>– OCS active | 0b0000 0000 0000 0001<br>– code crc<br>0b0000 0000 0000 0010<br>– calibration data crc<br>0b0000 0000 0000 0100<br>– CAN Rx<br>0b0000 0000 0000 1000<br>– CAN Tx<br>0b0000 0000 0001 0000<br>– overtemp<br>0b0000 0000 0010 0000<br>– undertemp<br>0b0000 0000 0100 0000<br>– power failure<br>0b0000 0000 1000 0000<br>– system clock<br>0b0000 0001 0000 0000<br>– system init<br>0b0000 0010 0000 0000<br>– configuration<br>0b0000 0100 0000 0000<br>– eeprom r/w<br>0b0000 1000 0000 0000<br>– power on reset<br>0b0001 0000 0000 0000<br>– low voltage reset<br>0b0010 0000 0000 0000<br>– ext. pin reset<br>0b0100 0000 0000 0000<br>– clock mon. reset<br>0b1000 0000 0000 0000<br>– COP WD reset |                           |    |      |

Table 66: Status

| Message       | Response to Message                          | Response MUX ID | P0                                                                                                                                                                                                                                                                                                             | P1                                                                                                                                                                                                                                                                                                                                                                                                                   | P2                                                                     | P3 | P4                                                               | P5 | P6               |
|---------------|----------------------------------------------|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------|----|------------------------------------------------------------------|----|------------------|
| Event counter | Get Event Counter<br><br>Clear Event Counter | 0xEB            | <b>&lt;Measurement event counter&gt;</b><br><br>0x01 – adc interrupt<br>0x02 – overflow adc ch1<br>0x03 – overflow adc ch2<br>0x04 – overflow adc ch3<br>0x05 – open circuit I<br>0x06 – open circuit U<br>0x07 – open circuit Tchip<br>0x08 – open circuit Text<br>0x09 – calibration data<br>0x0a OCS active | <b>&lt;System event counter&gt;</b><br><br>0x01 – code crc<br>0x02 – calibration data crc<br>0x03 – CAN Rx<br>0x04 – CAN Tx<br>0x05 – overtemp<br>0x06 – undertemp<br>0x07 – power failure<br>0x08 – system clock<br>0x09 – system init<br>0x0a – configuration<br>0x0b – eeprom r/w<br>0x10 – power on reset<br>0x20 – low voltage reset<br>0x30 – ext. pin reset<br>0x40 – clock mon. reset<br>0x50 – COP WD reset | <b>&lt;Event Counter Value Measurement &gt;</b><br><br>0x0000 – 0xffff |    | <b>&lt;Event Counter Value System&gt;</b><br><br>0x0000 – 0xffff |    | 0<br>x<br>0<br>0 |

Table 67: Event counter

| Message           | Response to Message | Response MUX ID | P0   | P1   | P2   | P3   | P4   | P5   | P6   |
|-------------------|---------------------|-----------------|------|------|------|------|------|------|------|
| Non valid command |                     | 0xFF            | 0x00 | 0x00 | 0x00 | 0x00 | 0x00 | 0x00 | 0x00 |

Table 68: Non valid command

Only send if command is not valid, within MUX ID

## 6.12. Result – message

The result message includes the signal information about current ( $I$ ) and battery voltage ( $U_{bat}$ ). Layout and the specific byte order are shown in the table below.

| CAN msg result | ID    | D0                           | D1                              | D2 | D3 | D4 | D5                                   | D6 | D7   |
|----------------|-------|------------------------------|---------------------------------|----|----|----|--------------------------------------|----|------|
| Message        | 0x502 | Result values                |                                 |    |    |    |                                      |    |      |
| Result         |       | <Message counter and Status> | <Result I><br><br>signed 32 bit |    |    |    | <Result Ubat><br><br>unsigned 16 bit |    | 0x00 |

Table 69: result message – CAN frame

| Data byte | High nibble (upper 4 byte)                                                    | Low nibble (lower 4 byte)                                                                                             |
|-----------|-------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------|
| <D0>      | <b>&lt;Message counter&gt;</b><br><br>0x0 – 0xf<br>(restart at 0x0 after 0xf) | <b>&lt;Status&gt;</b><br><br>0b0000 – no issue<br>0b0001 – OCS<br>0b0010 – measurement error<br>0b0100 – system error |

Table 70: Shared byte D0 within Result Message

The signal attributes of this message are fixed in the position. There is no multiplexor byte like in the messages *cmd* and *response*.

### 6.13. Access-Mode / Storing and reset

The following Table shows in which Access-Mode the user has access to which related command. Also it can be seen which command related parameter is stored by the Store command and Reset to the default value by the Reset command.

| Message                                                                    | MUX ID | Access Mode 0x00 | Access Mode 0x01 | storing / Reset to default |
|----------------------------------------------------------------------------|--------|------------------|------------------|----------------------------|
| Trigger Result                                                             | 0x00   | x                | x                |                            |
| Get Result Temperature                                                     | 0x01   | x                | x                |                            |
| Get Result Ah Counter                                                      | 0x02   | x                | x                |                            |
| Set Operation Mode                                                         | 0x10   | x                | x                | x / x                      |
| Get Operation Mode                                                         | 0x60   | x                | x                | x / x                      |
| Set Access Mode (user access)                                              | 0x11   | x                | x                |                            |
| Set Access Mode (user access)                                              | 0x11   | x                | x                |                            |
| Set Access Mode (user access)                                              | 0x11   | x                | x                |                            |
| Get Access Mode (user access)                                              | 0x61   | x                | x                |                            |
| Set Averaging                                                              | 0x20   |                  | x                | x / x                      |
| Get Averaging                                                              | 0x70   |                  | x                | x / x                      |
| Set OC limit                                                               | 0x21   |                  | x                | x / x                      |
| Get OC limit                                                               | 0x71   |                  | x                | x / x                      |
| Set CAN configuration                                                      | 0x22   |                  | x                | x / x                      |
| Get CAN configuration                                                      | 0x72   |                  | x                | x / x                      |
| Set CAN ID request                                                         | 0x23   |                  | x                | x / x                      |
| Get CAN ID request                                                         | 0x73   |                  | x                | x / x                      |
| Set CAN ID response                                                        | 0x24   |                  | x                | x / x                      |
| Get CAN ID response                                                        | 0x74   |                  | x                | x / x                      |
| Set CAN ID result                                                          | 0x25   |                  | x                | x / x                      |
| Get CAN ID result                                                          | 0x75   |                  | x                | x / x                      |
| Set user PW only in related mode                                           | 0x26   |                  | x                | x / x                      |
| Get user PW only in related mode                                           | 0x76   |                  | x                | x / x                      |
| Reset                                                                      | 0x40   |                  | x                |                            |
| Goto Sleep                                                                 | 0x41   | x                | x                |                            |
| Clear Ah Counter                                                           | 0x42   | x                | x                |                            |
| Clear status Bits                                                          | 0x43   | x                | x                |                            |
| store setting (Trigger mode, CAN config, averaging, CAN ID, Result struct) | 0x44   |                  | x                |                            |
| Clear Event Counter                                                        | 0x45   | x                | x                |                            |
| Get Device ID                                                              | 0x50   | x                | x                |                            |
| Get FW Version                                                             | 0x51   | x                | x                |                            |
| Get Serial no.                                                             | 0x52   | x                | x                |                            |
| Get HW Version                                                             | 0x53   | x                | x                |                            |
| Get Article No.                                                            | 0x54   | x                | x                |                            |
| Get Revision                                                               | 0x55   | x                | x                |                            |
| Get up time                                                                | 0x56   | x                | x                | x / x                      |
| Get lifetime counter                                                       | 0x57   | x                | x                |                            |
| Get status Bits                                                            | 0x58   | x                | x                |                            |
| Get CRC Code                                                               | 0x59   |                  | x                |                            |
| Get CRC calibration Data                                                   | 0x5a   |                  | x                |                            |
| Get Event Counters                                                         | 0x5B   | x                | x                |                            |

Table 71: Table access mode / storing and reset

## 6.14. Default values

If using the Reset command with parameter 0x01 (reset all parameters to default) the following values are reset to its related default value.

| Message              | Parameter                                                   | Value                                              |
|----------------------|-------------------------------------------------------------|----------------------------------------------------|
| Operation Mode       | Mode<br>Output rate<br>Current direction                    | 0x01 - continues<br>0x01 - 1 ms<br>0x00 - positive |
| Result Ah Counter    | Ah-Counter value                                            | 0x00 - 0 mAs                                       |
| Averaging            | Average value                                               | 0x01 - 1                                           |
| OC limit             | Activation limit positive<br>Activation limit negative      | 0x00 00 00<br>0x00 00 00                           |
| CAN configuration    | Baudrate<br>CAN mode                                        | 0x01 - 500k Baud<br>0x00 - 2.0 a                   |
| CAN ID request       | CAN ID                                                      | 0x500                                              |
| CAN ID response      | CAN ID                                                      | 0x501                                              |
| CAN ID result        | CAN ID                                                      | 0x502                                              |
| User PW              | Mode 0x01                                                   | 0x30; 0x30; 0x30; 0x30; 0x30; 0x30                 |
| Result MSG Structure | Result MSG Structure value                                  | 0x00 - UBat                                        |
| Up time              | Up time value                                               | 0x00 00 00 00                                      |
| Status Bits          | Measurement status bits value<br>System status bits value   | 0x00 00<br>0x00 00                                 |
| Event Counter        | All measurement counter values<br>All system counter values | 0x00 00<br>0x00 00                                 |

Table 72: Default values

## 6.15. Startup Messages

During startup the sensors indicated that it is working with several messages. After sending these messages the sensor is fully functional. All Messages are send within a response message (0x501 by default), one by one.

| Message no. | Message       | MUX ID | Remark                                               |
|-------------|---------------|--------|------------------------------------------------------|
| 1           | Device ID     | 0xE0   | 4 Messages with message counter (P0)<br>0x00 to 0x03 |
| 2           | Serial Number | 0xE2   |                                                      |
| 3           | F/W Version   | 0xE1   |                                                      |

Table 73: Startup messages

## 7. Qualification

### 7.1. MBN LV 124-2, 2009-11 / DIN 40 050-9

| Mechanical tests | Description    | Profile             | Parameter |
|------------------|----------------|---------------------|-----------|
| M-01             | Free fall      |                     |           |
| M-04             | Vibration test | Vibration profile D |           |

| Climatic tests | Description       | Profile | Parameter                                                                                                                                                  |
|----------------|-------------------|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------|
| K-05           | Temperature shock |         | $\Delta T_{FIELD} = 34K$<br>$T_{MIN} = -40^{\circ}C$<br>$T_{MAX} = 125^{\circ}C$<br>Period of application = 10 years<br>Cycles for 10 years = 7300 (2*Day) |
| K-14           | Humid heat        | SG2     | $T_{FIELD} = 23^{\circ}C$<br>$RH_{FIELD} = 65\%$<br>$T_{TEST} = 65^{\circ}C$<br>$RH_{TEST} = 93\%$<br>Period of application = 10 years                     |

| Life test | Description                                 | Profile | Parameter                                                                                                                                                                               |
|-----------|---------------------------------------------|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| L-03      | Life test – temperature cycle test          |         | $\Delta T_{FIELD} = 34K$<br>$T_{MIN} = -40^{\circ}C$<br>$T_{MAX} = 105^{\circ}C$<br>Period of application = 10 years<br>Cycles for 10 years = 7300                                      |
| ---       | Storage                                     |         | $T_{TEST} = 125^{\circ}C$<br>TD according to IMC-M<br>Storage time = 10 years                                                                                                           |
| L-02      | Life test – high-temperature endurance test |         | $T_{TEST} = 105^{\circ}C$<br>TD: [-40,2],[23,20],[50,74],[80,3],[105,1]<br>Period of application = 10 years (see Storage)<br>Application within the lifetime = 20000h<br>$E_a = 0.45eV$ |

| IP Class                    | Description             | Profile | Parameter |
|-----------------------------|-------------------------|---------|-----------|
| Number 1 (DIN 40050 Part 9) | Dust-tight              | 6k      |           |
| Number 2 (DIN 40050 Part 9) | Protected against water | 0       |           |

## 7.2. ISO 16750-2:2003

| Description                                  |
|----------------------------------------------|
| Supply voltage                               |
| Overvoltage                                  |
| Superimposed alternating voltage             |
| Slow decrease and increase of supply voltage |
| Momentary drop in supply voltage             |
| Reset behaviour at voltage drop              |
| Starting profile                             |
| Open circuit tests                           |
| Reversed voltage                             |

## 7.3. ISO 7637-2:2004 (ICD-A)

| Description                 |
|-----------------------------|
| Transient Voltage emissions |
| Impulse 1                   |
| Impulse 2a / 2b             |
| Impulse 3a / 3b             |
| Impulse 4                   |
| Impulse 5a / 5b             |

## 7.4. ISO 10605:2008 (ICD-A)

| Description                             |
|-----------------------------------------|
| Contact discharge (direct and indirect) |
| Air discharge (direct and indirect)     |
| handling and packaging discharge        |

## 7.5. ISO 11452-2 (ICD-A)

| Description                                 | Range          | Parameter |
|---------------------------------------------|----------------|-----------|
| Immunity to radiated electromagnetic fields | 80 MHz – 2 GHz | 100 V/m   |

## 7.6. EN 55025 (ICD-A)

| Description                                          | Range             | Result  |
|------------------------------------------------------|-------------------|---------|
| Interference field strength                          | 150 kHz - 2,5 GHz | Class 3 |
| Interference voltage on vehicle power supply         | 150 kHz – 108 MHz | Class 3 |
| interference current on signal line and control line | 150 kHz – 108 MHz | Class 3 |

## 7.7. IEC/EN 61000-4-2 (ICD-C)

| Description                             | Parameter |
|-----------------------------------------|-----------|
| Contact discharge (direct and indirect) | 4 kV      |

## 7.8. IEC/EN 61000-6-2 (ICD-C)

| Description                                 | Range            | Parameter       |
|---------------------------------------------|------------------|-----------------|
| Immunity to radiated electromagnetic fields | 80 MHz – 2.7 GHz | 10 V/m<br>3 V/m |

## 7.9. EN 55011 (ICD-C)

| Description                                          |
|------------------------------------------------------|
| interference field strength                          |
| Interference voltage on supply voltage               |
| Interference current on signal line and control line |