# ModBus-RTU communication protocol

| Document revisions | | |
|---|---|---|
| **version** | **date** | **description** |
| A | 10/08 | - creation |
| B | 07/09 | - addition of OIML R76 settings description |
| C | 06/11 | - addition of in-flight weight limits<br>- Possibility to start a cycle even if gross weight is negative (FW ≥ 117) |

# 1 USING MODBUS-RTU COMMUNICATION PROTOCOL

## 1.1 Byte format:

*Bytes are coded in hexadecimal format*
*- Format:*
*1 start bit*
*8 data bits without parity*
*2 stop bits*
*- CRC-16:*
*CRC-16 polynomial:*

$$G(x) = x^{16} + x^{15} + x^2 + 1$$

*(cf. Appendix B: CRC-16 calculation algorithm).*

## 1.2 ModBus-RTU compatible functions

| Function | Code |
|---|---|
| read N registers* | $03_H$ / $04_H$ |
| write 1 register* | $06_H$ |
| write N registers* | $10_H$ |

** 1 register = 2 bytes*
*Maximum admitted value for N is 20.*

## 1.3 Frames structure:

- During a read or write transaction, the two bytes of a register are transmitted **MSB first then LSB.**
- If a data is coded on **4 bytes** (that means it requires two registers), **the two LSB are stored in the low address register and the two MSB are stored in the high address register.**

### 1.3.1 Function ($03_H$/$04_H$) – read N input registers (N = 20 max):

*Request command sent to the slave:*

| slave address | $03_H$ or $04_H$ | starting address | N registers | CRC16 |
|---|---|---|---|---|
| 1 byte | 1 byte | 2 bytes | 2 bytes | 2 bytes |

*Slave response:*

| slave address | $03_H$ or $04_H$ | NB * | Data 1 | … | CRC16 |
|---|---|---|---|---|---|
| 1 byte | 1 byte | 1 byte | 2 bytes | 2 bytes | 2 bytes |

* NB: number of read bytes (= N*2).

### 1.3.2 Function ($06_H$) – write a single register:

*Request command sent to the slave:*

| slave address | $06_H$ | address | data | CRC16 |
|---|---|---|---|---|
| 1 byte | 1 byte | 2 bytes | 2 bytes | 2 bytes |

*Slave response:*

| slave address | $06_H$ | address | data | CRC16 |
|---|---|---|---|---|
| 1 byte | 1 byte | 2 bytes | 2 bytes | 2 bytes |

### 1.3.3 Function ($10_H$) – preset multiple registers (N = 20 max):

*Request command sent to the slave:*

| slave address | $10_H$ | starting address | N registers | NB | Data 1 | … | CRC16 |
|---|---|---|---|---|---|---|---|
| 1 byte | 1 byte | 2 bytes | 2 bytes | 1 byte | 2 bytes | 2 bytes | 2 bytes |

*Slave response:*

| slave address | $10_H$ | starting address | N registers | CRC16 |
|---|---|---|---|---|
| 1 byte | 1 byte | 2 bytes | 2 bytes | 2 bytes |

### 1.3.4 Exception codes:

*Error frame format:*

| slave address | function code + $80_H$ | error code | CRC16 |
|---|---|---|---|
| 1 byte | 1 byte | 1 byte | 2 bytes |

*Error codes meaning:*

| Error code | Meaning | description |
|---|---|---|
| $01_H$ | illegal function | ***Modbus-RTU*** function not supported by ***eNod3-D*** |
| $02_H$ | illegal data address<br>illegal data value | - register address requested out of ***eNod3-D*** register table<br>- forbidden data values |
| $04_H$ | ***eNod3-D*** not ready | ***eNod3-D*** is not ready to answer (for example measurement request during a taring operation) |

# 2 REGISTER MAP:

See the register description in the corresponding §.

**Type :**
- Uint : unsigned integer coded on 2 bytes
- Ulong : unsigned long integer coded on 4 bytes
- Long : signed long integer coded on 4 bytes
- Float : float simple precision coded on 4 bytes

**Access :**
- R/W : read/write
- RO : read only

**Data storage * :**

- Y : the setting **must** be stored in EEPROM memory. Its new value will be taken into account next reset.
- N : The new setting value is **immediately used by the device** and has no need to be stored in EEPROM to be in use.
- the whole set of parameters except the read-only datas can be stored in EPROM. Their values are so preserved if the power supply is disconneted or if reset is requested.

| Register address (Hex) | Size in bytes (n) | Type | Name | Access | Storage * | § |
|---|---|---|---|---|---|---|
| 0000 | 2 | Uint | metrological program version | RO | | 2.2.11 |
| 0001 | 2 | Uint | A/D converter configuration | R/W | Y | 2.3.1 |
| 0002 | 4 | Ulong | calibration load 1 | R/W | N | 2.2.2 |
| 0004 | 4 | Ulong | calibration load 2 | R/W | N | 2.2.2 |
| 0006 | 4 | Ulong | calibration load 3 | R/W | N | 2.2.2 |
| 0008 | 2 | Uint | number of calibration segments | R/W | N | 2.2.1 |
| 0009 | 4 | float | scale coefficient 1 | R/W | Y | 2.2.5 |
| 000B | 4 | float | scale coefficient 2 | R/W | Y | 2.2.5 |
| 000D | 4 | float | scale coefficient 3 | R/W | Y | 2.2.5 |
| 000F | 4 | Ulong | global span adjusting coefficient | R/W | Y | 2.2.3 |
| 0011 | 4 | long | polynomial correction A coefficient | R/W | N | 2.2.4 |
| 0013 | 4 | long | polynomial correction B coefficient | R/W | N | 2.2.4 |
| 0015 | 4 | long | polynomial correction C coefficient | R/W | N | 2.2.4 |
| 0017 | 4 | Ulong | capacity | R/W | N | 2.2.6 |
| 0019 | 2 | Uint | scale interval | R/W | N | 2.2.7 |
| 001A | 4 | Ulong | sensor capacity | R/W | N | 2.2.8 |
| 001C | 4 | long | zero calibration value | R/W | Y | 2.2.9 |
| 001E | 12 | | reserved | | | |
| 0024 | 2 | Uint | legal for trade (R76) switch | R/W | O | 2.5.1 |
| 0025 | 2 | Uint | legal for trade counter | RO | | 2.5.2 |
| 0026 | 2 | Uint | legal for trade CRC-16 | RO | | 2.5.3 |
| 0027 | 2 | Uint | zero modes | R/W | Y | 2.5.4 |
| 0028 | 2 | Uint | motion and self-adaptive filter | R/W | Y | 2.3.5 |
| 0029 | 2 | Uint | firmware version | RO | | 2.1.4 |
| 002A | 2 | Uint | slave address | R/W | Y | 2.1.1 |
| 002B | 2 | Uint | communication protocol, functioning mode and treatment | R/W | Y | 2.1.2 |
| 002C | 2 | Uint | RS & bus CAN baud rates | R/W | Y | 2.1.3 |
| 002D | 2 | Uint | reserved | | | |
| 002E | 16 | Uintx 8 | text box | R/W | N | 2.7.1 |
| 0036 | 2 | Uint | logical inputs assignment | R/W | N | 2.4.1 |
| 0037 | 2 | Uint | logical outputs 1 & 2 assignment | R/W | N | 2.4.3 |
| 0038 | 4 | Uint | logical outputs 3 & 4 assignment | R/W | N | 2.4.3 |
| 0039 | 4 | long | set point 1 high value | R/W | N | 2.4.4 |
| 003B | 4 | long | set point 1 low value | R/W | N | 2.4.4 |
| 003D | 4 | long | set point 2 high value | R/W | N | 2.4.4 |
| 003F | 4 | long | set point 2 low value | R/W | N | 2.4.4 |
| 0041 | 4 | long | set point 3 high value | R/W | N | 2.4.4 |
| 0043 | 4 | long | set point 3 low value | R/W | N | 2.4.4 |
| 0045 | 4 | long | set point 4 high value | R/W | N | 2.4.4 |
| 0047 | 4 | long | set point 4 low value | R/W | N | 2.4.4 |
| 0049 | 2 | Uint | set points functioning | R/W | N | 2.4.5 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 004A | 4 | Ulong | dosing target weight | R/W | N | 2.6.1 |
| 004C | 2 | Uint | start delay | R/W | N | 2.6.2 |
| 004D | 2 | Uint | final stabilization time | R/W | N | 2.6.3 |
| 004E | 2 | Uint | coarse feed effect neutralization time | R/W | N | 2.6.4 |
| 004F | 2 | Uint | fine feed effect neutralization time | R/W | N | 2.6.5 |
| 0050 | 2 | Uint | reloading/emptying holding time | R/W | N | 2.6.6 |
| 0051 | 2 | Uint | motion time out | R/W | N | 2.6.7 |
| 0052 | 2 | Uint | automatic taring at start & cycle recovery after suspension + reloading/emptying modes | R/W | N | 2.6.8 |
| 0053 | 2 | Uint | automatic in-flight weight correction & fine feed restarting | R/W | N | 2.6.9 |
| 0054 | 4 | long | in-flight weight value | R/W | N | 2.6.10 |
| 0056 | 4 | Ulong | max empty weight | R/W | N | 2.6.11 |
| 0058 | 4 | Ulong | min empty weight / residual weight | R/W | N | 2.6.11 |
| 005A | 2 | Uint | high tolerance | R/W | N | 2.6.12 |
| 005B | 2 | Uint | low tolerance | R/W | N | 2.6.12 |
| 005C | 2 | Uint | end of cycle waiting time | R/W | N | 2.6.13 |
| 005D | 2 | Uint | feed mode | R/W | N | 2.6.14 |
| 005E | 4 | Ulong | fine feed level | R/W | N | 2.6.15 |
| 0060 | 4 | Ulong | emptying level | R/W | N | 2.6.16 |
| 0062 | 4 | Ulong | reloading max. level | R/W | N | 2.6.17 |
| 0064 | 4 | Ulong | reloading min. level | R/W | N | 2.6.18 |
| 0066 | 2 | Uint | minimal weight variation | R/W | N | 2.6.19 |
| 0067 | 2 | Uint | time interval | R/W | N | 2.6.19 |
| 0068 | 2 | | reserved | | | |
| 0069 | 2 | Uint | debounce time | R/W | N | 2.4.2 |
| 006A | 2 | Ulong | sensor sensitivity | R/W | N | 2.2.10 |
| 006C | 2 | Uint | low-pass filter order & band-stop filter activation | R/W | N | 2.3.2 |
| 006D | 4 | float | low-pass filter 1/A coefficient | R/W | N | 2.3.3 |
| 006F | 4 | float | low-pass filter B coefficient | R/W | N | 2.3.3 |
| 0071 | 4 | float | low-pass filter C coefficient | R/W | N | 2.3.3 |
| 0073 | 4 | float | low-pass filter D coefficient | R/W | N | 2.3.3 |
| 0075 | 4 | float | low-pass filter E coefficient | R/W | N | 2.3.3 |
| 0077 | 4 | float | band-stop filter X coefficient | R/W | N | 2.3.4 |
| 0079 | 4 | float | band-stop filter Y coefficient | R/W | N | 2.3.4 |
| 007B | 4 | float | band-stop filter Z coefficient | R/W | N | 2.3.4 |
| 007D | 2 | Uint | status | RO | | 2.8.1 |
| 007E | 4 | long | gross | RO | | 2.8.2 |
| 0080 | 4 | long | tare | RO | | 2.8.3 |
| 0082 | 4 | long | net | RO | | 2.8.4 |
| 0084 | 4 | long | A/D converter points | RO | | 2.8.5 |
| 0086 | 4 | long | dosing result | RO | | 2.8.6 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 0088 | 4 | long | number of complete cycles | RO | | 2.8.7 |
| 008A | 4 | long | average value | RO | | 2.8.8 |
| 008C | 4 | long | running total | RO | | 2.8.9 |
| 008E | 4 | float | standard deviation | RO | | 2.8.10 |
| 0090 | 2 | Uint | command register | R/W | N | 2.9.1 |
| 0091 | 2 | Uint | response register | RO | | 2.9.2 |
| 0092 | 2 | Uint | inputs state | RO | | 2.7.2 |
| 0093 | 2 | Uint | outputs state | RO | | 2.7.3 |
| 0094 | 2 | Uint | dosing errors report | RO | | 2.6.20 |

## 2.1 Communication settings

### 2.1.1 Slave address:

| *Address* | *N* | *Access* | *Data storage** |
|---|---|---|---|
| **$002A_H$** | **2** | **R/W** | **Y** |

*Format*: Admitted values are between $01_H$ and $F7_H$. **Default value: $01_H$**
*Description:* ***eNod3-D*** address on the network.

### 2.1.2 Protocols, functioning modes and treatment

| *Address* | *N* | *Access* | *Data storage** |
|---|---|---|---|
| **$002C_H$** | **2** | **R/W** | **Y** |

*Format*:

| **bits b0,...b15** | **Function** | |
|---|---|---|
| **bits b10, b9, b8** | **Protocol** | |
| 00 | SCMBus | communication protocol |
| 01 | ModBus-RTU | |
| 11 | SCMBus fast format | |
| **bits b2, b1, b0** | **functioning mode** | |
| 000 | transmitter | application |
| 001 | dosing by filling | |
| 010 | dosing by unloading | |
| **bit b3** | **signal processing** | |
| 0 | performed | filters activation, set points management and non-linearity correction |
| 1 | skipped | |

*Description:* this register allows selecting:
- the serial communication protocol to use
- the functioning mode
- the filters, set points management and non-linearity polynomial correction activation

### 2.1.3 Serial and bus CAN baud rates:

| *Address* | *N* | *Access* | *Data storage* |
|---|---|---|---|
| **$002C_H$** | **2** | **R/W** | **Y** |

*Format*:

| **bits b15.....b0** | **Baud rate** | |
|---|---|---|

| bits b2, b1, b0 | R485/422 or RS232 bus | |
|---|---|---|
| 001 | 9600 | default value |
| 010 | 19200 | |
| 011 | 38400 | |
| 100 | 57600 | |
| 101 | 115200 | |
| **bits b10, b9, b8** | **CAN bus** | |
| 001 | 20000 | |
| 010 | 50000 | |
| 011 | 125000 | default value |
| 100 | 250000 | |
| 101 | 500000 | |
| 110 | 800000 | |
| 111 | 1000000 | |

### 2.1.4 Firmware version:

| *Address* | *N* | *Access* | *Data storage** |
|---|---|---|---|
| **$0029_H$** | **2** | **RO** | **/** |

*Format*: value between 0 and $65\,535_d$
*Description*: identification of ***eNod3-D*** firmware and hardware versions.

## 2.2 Calibration settings

### 2.2.1 Number of calibration segments:

| *Address* | *N* | *Access* | *Data storage** |
|---|---|---|---|
| **$0008_H$** | **2** | **R/W** | **N** |

*Format*: admitted values are 1, 2 or 3.
*Description:* the number of calibration segments is limited to 3. In general one segment is sufficient, 2 or 3 can be useful in case of non-linearity problems.

### 2.2.2 Calibration loads:

| *Setting* | *Address* | *N* | *Access* | *Data storage** |
|---|---|---|---|---|
| **calibration load 1** | **$0002_H$** | **4** | **R/W** | **N** |
| **calibration load 2** | **$0004_H$** | **4** | **R/W** | **N** |
| **calibration load 3** | **$0006_H$** | **4** | **R/W** | **N** |

*Format*: admitted values are between 0 and $1\,000\,000_d$.
*Description*: each load corresponds to the termination of a calibration segment. Calibration loads are used during the physical calibration procedure.

### 2.2.3 Global span adjusting coefficient:

| *Address* | *N* | *Access* | *Data storage** |
|---|---|---|---|
| **$000F_H$** | **4** | **R/W** | **Y** |

*Format*: the unit for this setting is 1/1000000 (1E-6) that means $1000000_d$ = 1. Maximal and minimal values are $1100000_d$ and $900000_d$. It corresponds to a coefficient equal to 1.1 and 0.9.
*Description:* The calibration curve slope can be adjusted by this coefficient. It is applied on the whole curve.

### 2.2.4 Polynomial correction coefficients:

| Setting | Address | N | Access | Data storage* |
|---|---|---|---|---|
| A coefficient | $0011_H$ | 4 | R/W | N |
| B coefficient | $0013_H$ | 4 | R/W | N |
| C coefficient | $0015_H$ | 4 | R/W | N |

*Format*: each coefficient has its own unit due to their range:

- The unit for A coefficient is 1/1000000000000 (1E-12), that means 1 000 000 000 $000_d$ = 1.
- The unit for B coefficient is 1/ 1000000000 (1E-9), that means 1 000 000 $000_d$ = 1.
- C is directly express as A/D converter points.

*Description:* the coefficient determination can be achieved using ***eNodView*** software.
The correction relation is the following:

> Corrected measurement = Meas – A $(Meas)^2$ – B (Meas) – C
> where Meas = current measurement value

### 2.2.5 Scale coefficients:

| Setting | Address | N | Access | Data storage* |
|---|---|---|---|---|
| scale coefficient 1 | $0009_H$ | 4 | R/W | Y |
| scale coefficient 2 | $000B_H$ | 4 | R/W | Y |
| scale coefficient 3 | $000D_H$ | 4 | R/W | Y |

*Format*: simple precision float value.
*Description:* these coefficients are automatically calculated during one of the calibration procedures. Writing these coefficients is only valid for a copy of a previous calibration.

### 2.2.6 Capacity:

| Address | N | Access | Data storage* |
|---|---|---|---|
| $0017_H$ | 4 | R/W | N |

*Format*: admitted values are between 0 and $1000000_d$.
*Description:* when the absolute value of the gross measurement plus 9 divisions exceeds the specified capacity, bit b3 (positive overloading) or bit b2 (negative overloading) of the status register (address $0063_H$) is set to 1.

### 2.2.7 Scale interval:

| Address | N | Access | Data storage* |
|---|---|---|---|
| $0019_H$ | 2 | R/W | N |

*Format* : possible value : $1_d$, $2_d$, $5_d$, $10_d$, $20_d$, $50_d$, $100_d$.
*Description:* minimal difference between two consecutive calibrated measurements.

### 2.2.8 Sensor capacity:

| Address | N | Access | Data storage* |
|---|---|---|---|
| $001A_H$ | 4 | R/W | N |

*Format*: admitted values are between 0 and $1000000_d$
*Description:* the sensor capacity is used in association with the sensor sensitivity for a theoretical calibration (cf. §2.2.10).

### 2.2.9 Calibration zero value:

| Address | N | Access | Data storage* |
|---|---|---|---|
| $001C_H$ | 4 | R/W | Y |

*Format:* admitted values are between 0 and $\pm 10000000_d$.

*Description:* value in A/D converter points of the zero reference.
During a physical calibration, this zero value is acquired in the first step of the procedure. It can also be set for a theoretical calibration or corrected using the *'zero adjustment'* command (cf. §2.9.1).

### 2.2.10 Sensor sensitivity:

| *Address* | *N* | *Access* | *Data storage** |
|---|---|---|---|
| **$006A_H$** | **4** | **R/W** | **N** |

*Format*: admitted values are between 0 and $999999_d$.
*Description*: the unit for this variable is $10^{-5}$ mV/V that means $200000_d$ = 2mV/V (default value). The sensor sensitivity is used in association with the sensor capacity for a theoretical calibration (cf. §2.2.8).

### 2.2.11 Metrological version number

| *Address* | *N* | *Access* | *Data storage** |
|---|---|---|---|
| **$0000_H$** | **2** | **RO** | **/** |

*Format*: read-only value between 1 and $65535_d$.
*Description*: This number identifies the version of the part of the software that is dedicated to the metrology and the measurement exploitation.

## 2.3 Filtering parameters

### 2.3.1 A/D converter configuration:

| *Address* | *N* | *Access* | *Memorisation ** |
|---|---|---|---|
| **$0001_H$** | **2** | **R/W** | **Y** |

*Format/description:*

| **bits b15…..b0** | **Function** | | |
|---|---|---|---|
| **b2,b1,b0** | **Analog input signal range** | | |
| 000 | 500mV/V | | |
| 001 | 250mV/V | | |
| 010 | 124mV/V | | |
| 011 | 62mV/V | | |
| 100 | 31mV/V | | |
| 101 | 15mV/V | | |
| 110 | 7,8mV/V | | default value recommended for strain gauges load cells |
| **bit b3** | **Signal type** | | |
| 0 | bipolar | | |
| 1 | unipolar | | default configuration |
| **bit b4** | **50Hz/60Hz rejection** | | |
| 0 | 60Hz | | |
| 1 | 50Hz | | default configuration |
| **b8,b7,b6,b5** | **A/D conversion rate (meas/s)** | | |
| | 50 Hz rejection | 60 Hz rejection | |
| 0100 | 6.25 | 7.5 | |
| 0011 | 12.5 | 15 | |

| | | | |
|---|---|---|---|
| 0010 | 25 | 30 | |
| 0001 | 50 | 60 | |
| 0000 | 100 | 120 | by default |
| 1100 | 200 | 240 | |
| 1011 | 400 | 480 | |
| 1010 | 800 | 960 | |
| 1001 | 1600 | 1920 | |

### 2.3.2 Low-pass filter order and band-stop filter activation

| *Address* | *N* | *Access* | *Data storage** |
|---|---|---|---|
| **$006C_H$** | **2** | **R/W** | **N** |

*Format*:

| **bits b0,...b15**<br>**b2, b1, b0** | **Function** |
|---|---|
| 000 | low-pass digital filter inactive |
| 010 | Bessel/Butterworth 2nd order low-pass digital filter |
| 011 | Bessel/Butterworth 3rd order low-pass digital filter |
| 100 | Bessel/Butterworth 4th order low-pass digital filter |
| **bit b8** | |
| 1 | 2nd order digital band-stop filter active |
| 0 | 2nd order digital band-stop filter inactive |

*Description*: The filter recurrence relations of these filters are as follows:

- **low-pass filter :**

$$2^{nd}\text{ order : } S_n = 1/A(e_n + 2e_{n-1} + e_{n-2} - BS_{n-1} - CS_{n-2})$$
$$3^{rd}\text{ order : } S_n = 1/A(e_n + 3e_{n-1} + 3e_{n-2} + e_{n-3} - BS_{n-1} - CS_{n-2} - DS_{n-3})$$
$$4^{th}\text{ order : } S_n = 1/A(e_n + 4e_{n-1} + 6e_{n-2} + 4e_{n-3} + e_{n-4} - BS_{n-1} - CS_{n-2} - DS_{n-3} - ES_{n-4})$$

- **band-stop filter :**

$$2^{nd}\text{ order: } S_n = X\,(e_n + e_{n-2}) + Y\,(e_{n-1} - S_{n-1}) - ZS_{n-2}$$

Both filter coefficients depend on the A/D conversion rate and on cut-off frequencies. The determination of these coefficients can be easily achieved using ***eNodView*** simulation tools.

### 2.3.3 Digital low-pass filter coefficients:

| *Setting* | *Address* | *N* | *Access* | *Data storage** |
|---|---|---|---|---|
| **1/A coefficient** | **$006D_H$** | **4** | **R/W** | **N** |
| **B coefficient** | **$006F_H$** | **4** | **R/W** | **N** |
| **C coefficient** | **$0071_H$** | **4** | **R/W** | **N** |
| **D coefficient** | **$0073_H$** | **4** | **R/W** | **N** |
| **E coefficient** | **$0075_H$** | **4** | **R/W** | **N** |

*Format*: simple precision float value.

*Description:* The determination of these coefficients can be easily achieved using ***eNodView*** simulation tools.

### 2.3.4 Digital band-stop filter coefficients:

| *Setting* | *Address* | *N* | *Access* | *Data storage** |
|---|---|---|---|---|
| **X coefficient** | **$0077_H$** | **4** | **R/W** | **N** |
| **Y coefficient** | **$0079_H$** | **4** | **R/W** | **N** |
| **Z coefficient** | **$007B_H$** | **4** | **R/W** | **N** |

*Format*: simple precision float value.
*Description*: The determination of these coefficients can be easily achieved using ***eNodView*** simulation tools.

### 2.3.5 Motion and self-adaptive filter activation:

| *Address* | *N* | *Access* | *Data storage** |
|---|---|---|---|
| **$0028_H$** | **2** | **R/W** | **O** |

*Format*:

| bits b15.....b0 | Function | |
|---|---|---|
| **bits b2, b1, b0** | **Stability interval** | |
| 000 | no motion detection | |
| 001 | 0,25 d | d = scale interval |
| 010 | 0,5d | |
| 011 | 1d | |
| 100 | 2d | |
| **bit b7** | **Self-adaptive filter** | |
| 0 | inactive | |
| 1 | active | |

*Description:* Motion is indicated by the b4 bit of the status register.
Measurement is stable if X consecutive measurements following the reference measurement are included in the stability interval (see following table) else the current measurement becomes the reference measurement. X depends on the Analog to Digital (A/D) conversion rate:

| A/D conversion rate (meas/s) | | X |
|---|---|---|
| 50 Hz rejection | 60 Hz rejection | |
| 6,25 | 7,5 | 1 |
| 12,5 | 15 | 2 |
| 25 | 30 | 3 |
| 50 | 60 | 5 |
| 100 | 120 | 9 |
| 200 | 240 | 17 |
| 400 | 480 | 33 |
| 800 | 960 | 65 |
| 1600 | 1920 | 129 |

**Self-adaptive filter:** this type of filter can be set in cascade after the previous filters. It is particularly useful for static measurements, avoid using it in dynamic or dosing process. The aim of this filter is to eliminate erratic measurements and to average consistent measurements.

## 2.4 Logical inputs/outputs configuration

### 2.4.1 Logical inputs assignment:

| *Address* | *N* | *Access* | *Data storage** |
|---|---|---|---|
| **$0036_H$** | **2** | **R/W** | **N** |

*Format/description*: the MSB byte is assigned to input 2 whereas the LSB byte is assigned to input 1

| bits b0,...b15 | Functions | |
|---|---|---|
| **bits b3 and b11** | **Logic** | **b3 = input 1 ; b11 = input 2** |
| 0 | negative logic | |
| 1 | positive logic | |
| **b2, b1, b0 or b10, b9, b8** | **Assignment** | **b2, b1, b0 = input 1 / b10, b9, b8 = input 2** |
| 000 | none | inputs have no effect |
| 001 | tare | |
| 010 | zero | limited to a ±10% range of the capacity (cf. §2.2.6) |
| 101 | cancel tare/ cycle suspension | - in transmitter mode, cancels current tare<br>- in dosing mode (by filling or by unloading), suspends temporarily or stops current dosing cycle (depending on the cycle recovery option) |
| 110 | start/restart dosing cycle | in dosing mode (by filling or by unloading), starts a new cycle or restarts a previously suspended cycle |
| 111 | stop cycle | in dosing mode (by filling or by unloading), stops current cycle, inhibiting the different outputs involved |

### 2.4.2 Inputs debounce time:

| *Address* | *N* | *Access* | *Data storage** |
|---|---|---|---|
| **$0069_H$** | **2** | **R/W** | **N** |

*Format*: duration expressed in milliseconds comprised between 0 and $65\,535_d$
*Description*: debounce time corresponds to the minimum required stabilization time of the logical inputs before their activation. If the input state varies within this interval, it is ignored.

### 2.4.3 Outputs 1 & 2 and outputs 3 & 4 assignment

| *Setting* | *Address* | *N* | *Access* | *Data storage** |
|---|---|---|---|---|
| **outputs 1 & 2** | **$0037_H$** | **2** | **R/W** | **N** |
| **outputs 3 & 4** | **$0038_H$** | **2** | **R/W** | **N** |

*Format/description*: the MSB byte is assigned to output 2 (or 4) whereas the LSB byte is assigned to output 1 (or 3).

| bits b0,...b15 | Functions | |
|---|---|---|
| **bits b4 and b12** | **Logic** | **b3 assigned to output 1 (or 3)<br>b11 assigned to output 2 (or 4)** |
| 0 | negative logic | |
| 1 | positive logic | |
| **b3, b2, b1, b0<br>or<br>b11, b10, b9, b8** | **Assignment** | **b3, b2, b1, b0 = output 1 (or 3)<br>b11, b10, b9, b8 = output 2 (or 4)** |
| 0000 | set point | |
| 0001 | motion | |
| 0010 | dosing result available | |
| 0011 | cycle in progress | indicates that a dosing cycle is in progress |
| 0100 | defective measurement | cf. status register |
| 0101 | input 1 (or 2) image | regardless of the functioning mode |
| 0110 | fine feed | in dosing functioning modes |
| 0111 | coarse feed | in dosing functioning modes |
| 1000 | emptying/reloading | - in dosing by filling mode, activated during the emptying phase that follows the control of tolerances<br>- in dosing by unloading mode, activated during the reloading phase that occurs at the end or at the start of the cycle |
| 1001 | result out of tolerances | in dosing functioning modes, indicates that the result is out of the fixed tolerances |
| 1010 | flow rate failure | in dosing functioning modes, indicates that a flow rate defect has occurred |
| 1011 | dosing failure | in dosing functioning modes, indicates that a flow rate defect has occurred, **or** that the result is out of the fixed tolerances **or** that an error has occurred at the start of the cycle |

### 2.4.4 Set points 1 & 2 high/low and 3 & 4 high/low:

| *Setting* | *Address* | *N* | *Access* | *Data storage** |
|---|---|---|---|---|
| **set point 1 high** | **$0039_H$** | **4** | **R/W** | **N** |
| **set point 1 low** | **$003B_H$** | **4** | **R/W** | **N** |
| **set point 2 high** | **$003D_H$** | **4** | **R/W** | **N** |
| **set point 2 low** | **$003F_H$** | **4** | **R/W** | **N** |
| **set point 3 high** | **$0041_H$** | **4** | **R/W** | **N** |
| **set point 3 low** | **$0043_H$** | **4** | **R/W** | **N** |
| **set point 4 high** | **$0045_H$** | **4** | **R/W** | **N** |
| **set point 4 low** | **$0047_H$** | **4** | **R/W** | **N** |

*Format*: values between ± $1000000_d$
*Description*: these settings give the high and low limits for each set point. The set points state also depends on the selected commutation situated at the register address $0049_H$.
Set point 1 corresponds to output 1, set point 2 to output 2, set point 3 to output 3 and set point 4 to output 4.

### 2.4.5 Set points functions:

| *Address* | *N* | *Access* | *Data storage** |
|---|---|---|---|
| **$0049_H$** | **2** | **R/W** | **N** |

*Format/description*:

| bits b15.....b0 | Function | |
|---|---|---|
| **b0, b4, b8, b12** | **Commutation mode** | **b0 = set point 1 mode<br>b4 = set point 2 mode<br>b8 = set point 3 mode<br>b12 = set point 4 mode** |
| 0 | window | regardless of the functioning mode (cf. user's instructions document ref 165752) |
| 1 | hysteresis | |
| **b1, b5 , b9, b13** | **Comparison measurement** | **b1 = set point 1<br>b5 = set point 2<br>b9 = set point 3<br>b13 = set point 4** |
| 0 | gross value | regardless of the functioning mode (cf. user's instructions document ref 165752) |
| 1 | net value | |

## 2.5 Legal for trade

### 2.5.1 Legal for trade (R76) switch:

| *Address* | *N* | *Access* | *Data storage** |
|---|---|---|---|
| **$0024_H$** | **2** | **R/W** | **Y** |

*Format:* the activation of the settings related to the use of ***eNod3-D*** in compliance with OIML R76 recommendation is done by **setting to 1 b0 bit.**
*Description:* the activation of this switch has the following effects on the behaviour of the device:

- The legal for trade counter is incremented every time a storage in EEPROM is requested if a metrological setting has been modified (cf. § 2.5.2)
- a new legal for trade CRC-16 value is calculated every time a storage in EEPROM is requested if a metrological setting has been modified (cf. § 2.5.3)
- taring is now impossible if gross measurement is negative
- Reading a measurement during 15 seconds after power-up or a software reset is impossible (***eNod3-D*** sends the constant value –1).
- Reading the net value during tare acquisition or the gross value during zero acquisition is impossible (error frame (cf.1.3.4) with error code $04_H$).
- Zero acquisition range is reduced from 10% of the capacity to 2%.

### 2.5.2 Legal for trade counter:

| *Address* | *N* | *Access* | *Data storage** |
|---|---|---|---|
| **$0025_H$** | **2** | **RO** | ***I*** |

*Format:* read-only value between 1 and $65535_d$.
*Description* : if the legal for trade option is switched ON, the legal for trade counter is incremented every time a storage in EEPROM is requested if one (or several) of these settings has been modified :

- A/D converter configuration
- scale coefficients
- global span adjusting coefficients
- non-linearity polynomial correction coefficients
- scale interval
- sensor capacity

- maximum capacity
- zero calibration value in a/D converter points
- legal for trade switch
- initial zero setting and zero tracking
- functioning mode
- stability criterion

### 2.5.3 Legal for trade CRC-16:

| *Address* | *N* | *Access* | *Data storage** |
|---|---|---|---|
| **$0026_H$** | **2** | **RO** | **/** |

*Format:* read-only hex. Value between $0000_H$ and $FFFF_H$.
*Description* : if the legal for trade option is switched ON, a new legal for trade CRC-16 is calculated every time a storage in EEPROM is requested if one (or several) of the settings listed in § 2.5.2 has been modified.

### 2.5.4 Zero modes:

| *Address* | *N* | *Access* | *Data storage** |
|---|---|---|---|
| **$0027_H$** | **2** | **R/W** | **Y** |

*Format/description*:

| bits b15.....b0 | Function | |
|---|---|---|
| **bit b0** | **Zero tracking** | |
| 1 | zero tracking enabled | effective on ±10% range of the maximum capacity |
| 0 | zero tracking disabled | |
| **bit b1** | **Initial zero setting** | |
| 1 | initial zero setting enabled | effective on ±10% range of the maximum capacity |
| 0 | initial zero setting disabled | |

## 2.6 Dosing settings

### 2.6.1 Target weight:

| *Address* | *N* | *Access* | *Data storage** |
|---|---|---|---|
| **$004A_H$** | **4** | **R/W** | **N** |

*Format*: values between $1_d$ and $1\ 000\ 000_d$.
*Description*: In dosing by filling or by unloading functioning modes, the target weight represents the net (dosing by filling) or the gross measurement (dosing by unloading) to reach at the end of the dosing process. (See description of dosing cycles in user's instructions documentation ref. 165752)

### 2.6.2 Start delay:

| *Address* | *N* | *Access* | *Data storage** |
|---|---|---|---|
| **$004C_H$** | **2** | **R/W** | **N** |

*Format*: duration expressed in milliseconds comprised between 0 and $65535_d$
*Description:*
- **dosing by filling:** if the *'automatic taring at start'* option is enabled, this timer stands for the stabilization time that precedes the tare execution.
- **dosing by unloading:** this timer stands for the tank level stabilization time that precedes the reference weight acquisition.

### 2.6.3 Final stabilization time:

| Address | N | Access | Data storage* |
|---|---|---|---|
| $004D_H$ | 2 | R/W | N |

*Format*: duration expressed in milliseconds comprised between 0 and $65535_d$
*Description:* in dosing functioning modes (by filling or by unloading), the final stabilization time defines the duration that follows the fine feed stop and precedes the result determination

### 2.6.4 Coarse feed effect neutralization time:

| Address | N | Access | Data storage* |
|---|---|---|---|
| $004E_H$ | 2 | R/W | N |

*Format*: duration expressed in milliseconds comprised between 0 and $65535_d$
*Description*: during this delay, the flow rate control and the level monitoring are disabled so as to limit the impact of dynamic effects on the signal caused by the coarse feed activation.

### 2.6.5 Fine feed effect neutralization time:

| Address | N | Access | Data storage* |
|---|---|---|---|
| $004F_H$ | 2 | R/W | N |

*Format*: duration expressed in milliseconds comprised between 0 and $65535_d$
*Description*: during this delay, the flow rate control and the level monitoring are disabled so as to limit the impact of dynamic effects on the signal caused by the flow rate change.

### 2.6.6 Emptying/reloading holding time:

| Address | N | Access | Data storage* |
|---|---|---|---|
| $0050_H$ | 2 | R/W | N |

*Format*: duration expressed in milliseconds comprised between 0 and $65535_d$
*Description*:
**- dosing by filling :** the emptying holding time defines how long the *'emptying'* output remains active after that the gross value has become inferior to the *'emptying end level'* (cf. §2.6.14).
**- dosing by unloading :** the reloading holding time defines how long the *'reloading'* output remains active after that the gross value has become superior to the *'reloading max level'* (cf. §2.6.15).

### 2.6.7 Motion time out:

| Address | N | Access | Data storage* |
|---|---|---|---|
| $0051_H$ | 2 | R/W | N |

*Format*: duration expressed in milliseconds comprised between 0 and $65535_d$
*Description*:
**- dosing by filling:** if the *'automatic taring at start'* option is enabled, this time defines the interval during which stability is monitored for the tare acquisition. If the stability can not be found before this time out ends, the tare value is set to the current net measurement.
**- dosing by unloading:** this time defines the interval during which stability is monitored for the reference weight acquisition. If the stability can not be found before this time out ends, the reference weight value is set to the current gross measurement.
- **In both functioning modes:** the motion time out is also used when the final stabilization time ends. The dosing result is acquired as soon as no motion is detected. If the stability can not be found before this time out ends, the dosing result is set to the current net (dosing by filling) or gross (dosing by unloading) measurement.

### 2.6.8 Automatic taring at start & cycle recovery + reloading/emptying modes:

| Address | N | Access | Data storage* |
|---|---|---|---|
| $0052_H$ | 2 | R/W | N |

*Format/description*:

| bits b0,...b15 | Function | |
|---|---|---|
| **bit b0** | **Automatic taring at start** | |
| 1 | automatic taring at start enabled | see dosing by filling cycle description in user's instructions document ref. 165752 |
| 0 | automatic taring at start disabled | |
| **bit b1** | **Cycle recovery** | |
| 1 | allows cycle to be restarted after suspension | see dosing cycle descriptions in user's instructions document ref. 165752 |
| 0 | no cycle recovery allowed | cycle stopped if suspended |
| **b9, b8** | **Emptying/reloading modes** | |
| 00 | reloading/emptying not managed | |
| 01 | reloading at the end of the cycle/ emptying phase monitored | see dosing cycle descriptions in user's instructions document ref. 165752 |
| 10 | reloading at the start of the cycle | see dosing by unloading cycle description in user's instructions document ref. 165752 |

### 2.6.9 In-flight weight automatic correction & fine feed restarting:

| *Address* | *N* | *Access* | *Data storage** |
|---|---|---|---|
| **$0053_H$** | **2** | **R/W** | **N** |

*Format/description:*

| bits b0,...b15 | Function | |
|---|---|---|
| **bit b0** | **Automatic correction** | |
| 1 | in-flight weight automatic correction enabled | see dosing cycle descriptions in user's instructions document ref. 165752 |
| 0 | in-flight weight automatic correction disabled | |
| **bit b1** | **Fine feed restarting** | |
| 1 | fine feed is restarted if the dosing result is inferior to the low tolerance | see dosing cycle descriptions in user's instructions document ref. 165752 |
| 0 | fine feed is not restarted if the result is out of tolerances | |
| **bit b2** | **Correction x3** | |
| 1 | correction coefficient x3 if result out of tolerances | if the automatic correction is enabled |
| 0 | correction coefficient not modified | |
| **bit b8....b14** | | |
| from 1 up to 100% | in-flight correction coefficient | if the *'automatic correction'* option is enabled |

### 2.6.10 In-flight weight value:

| Address | N | Access | Data storage* |
|---|---|---|---|
| $0054_H$ | 4 | R/W | N |

*Format*: values comprised between 0 and ± $1000000_d$
*Description*: the in-flight value corresponds to the weight of product that carries on falling after the *'fine feed'* output disabling.
Its value can be automatically corrected thanks to the in-flight correction mechanism (cf. §2.6.9 and user' instructions documentation ref. 165752).

### 2.6.11 Min and max in-flight weight values:

| Setting | Address | N | Access | Data storage* |
|---|---|---|---|---|
| max in-flight weight value | $0095_H$ | 2 | R/W | N |
| min in-flight weight value | $0096_H$ | 2 | R/W | N |

*Format*: values comprised between 0 and $32767_d$
*Default values*: Max: 0; Min: 0
*Description*: The in-flight weight value cannot be out of these two limits. It is particularly useful if automatic in-flight weight correction is active. If both values are set to zero, test is not made.

### 2.6.12 Min and max empty weight/residual weight:

| Setting | Address | N | Access | Data storage* |
|---|---|---|---|---|
| max empty weight | $0056_H$ | 2 | R/W | N |
| min empty weight / residual weight | $0058_H$ | 2 | R/W | N |

*Format*: values comprised between 0 and $1000000_d$
*Description*:
**- dosing by filling:** Both settings define the cycle starting conditions:

- **min empty weight < gross measurement < max empty weight**
  ⇨ *empty packing presence verification*
- **min empty weight = max empty weight = 0** regardless of the gross value
  ⇨ *no verification*
- **min empty weight = 0** and **max empty weight > 0**
  ⇨ *The cycle can start if gross measurement < max empty weight. This condition is true even if gross measurement is <0.*

If none of these conditions is respected, an error is reported and the cycle can not start.
**- dosing by unloading:** the *'residual weight'* is used when ***eNod3-D*** checks if the available quantity of product is sufficient to handle a complete dosing cycle. If *Gross measurement < (target weight + residual weight)* the cycle is cancelled and an error is reported.

### 2.6.13 High and low tolerances:

| Setting | Address | N | Access | Data storage* |
|---|---|---|---|---|
| high tolerance | $005A_H$ | 2 | R/W | N |
| low tolerance | $005B_H$ | 2 | R/W | N |

*Format*: values comprised between 0 and $65535_d$.
*Description*: The tolerance settings define the acceptable range for dosing results. An output assigned to the *'out of tolerances'* function or '*dosing failure'* is set active if the dosing result is not within the range

**[target weight – (tolerance -) ; target weight + (tolerance +)]**

If the result is inferior to the default limit and if the *'restart fine feed'* (cf. §2.6.9) option is enabled, then the fine feed output is restarted.

### 2.6.14 End of cycle waiting time

| Address | N | Access | Data storage* |
|---|---|---|---|

| | | | |
|---|---|---|---|
| **$005C_H$** | **2** | **R/W** | **N** |

*Format*: duration expressed in milliseconds comprised between 0 and $65535_d$
*Description*: this delay occurs either
**- after the control of tolerances**
**- At the end of the reloading phase** in dosing by unloading functioning mode if the reloading mode is set to *'at the end of the cycle'*
**- At the end of the emptying phase** (if used) in dosing by filling functioning mode

A dosing cycle is finished as soon as this delay ends. The statistic variables (number of cycles, running total, average value and standard deviation) are then updated. If an output is assigned to the *'cycle in progress'* function it is also disabled.

### 2.6.15 Feed mode:

| *Address* | *N* | *Access* | *Data storage** |
|---|---|---|---|
| **$005D_H$** | **2** | **R/W** | **N** |

*Format:*

| b1, b0 | Function | Description |
|---|---|---|
| 00 | CF then FF | see dosing cycle descriptions in user's instructions document ref. 165752 |
| 01 | CF + FF | |
| 10 | CF only | |

*Description:* for the ***filling*** and ***dosing by unloading*** functioning modes, it is possible to select the activation order of the feed outputs:

- *coarse feed then fine feed after coarse feed stop*
- *coarse feed + fine feed at the beginning of the cycle*
- *coarse feed only, in this case an output must be assigned to the 'coarse feed' function*

### 2.6.16 Fine feed (FF) level

| *Address* | *N* | *Access* | *Data storage** |
|---|---|---|---|
| **$005E_H$** | **4** | **R/W** | **N** |

*Format*: values comprised between 0 and $1000000_d$.
*Description*: the fine feed level expressed as a subtraction of the target weight gives the level (net for filling and gross for dosing by unloading) that causes the coarse feed to be disabled and the fine feed to go on.

### 2.6.17 Emptying end level (dosing by filling):

| *Address* | *N* | *Access* | *Data storage** |
|---|---|---|---|
| **$0060_H$** | **4** | **R/W** | **N** |

*Format*: values comprised between 0 and $1000000_d$.
*Description*: during the emptying phase, the *'emptying'* output is disabled if the gross value becomes inferior to this level and if the *'emptying holding time'* has elapsed (cf. §2.6.6).

### 2.6.18 Reloading max level (dosing by unloading):

| *Address* | *N* | *Access* | *Data storage** |
|---|---|---|---|
| **$0062_H$** | **4** | **R/W** | **N** |

*Format*: values comprised between 0 and $1000000_d$.
*Description*: during the reloading phase, the *'reloading'* output is disabled if the gross value becomes superior to this level and if the *'reloading holding time'* has elapsed (cf. §2.6.6).

### 2.6.19 Reloading min level (dosing by unloading)

| *Address* | *N* | *Access* | *Data storage** |
|---|---|---|---|

| | | | |
|---|---|---|---|
| **$0064_H$** | **4** | **R/W** | **N** |

*Format*: values comprised between 0 and $1000000_d$.
*Description* : when the reloading at the end of the cycle is used, if after the control of tolerances the gross measurement is inferior to this level an output assigned to the *'reloading'* function is activated (cf. §2.6.8).

### 2.6.20 Min weight variation and time interval (flow rate control):

| *Setting* | *Address* | *N* | *Access* | *Data storage** |
|---|---|---|---|---|
| **min weight variation** | **$0066_H$** | **2** | **R/W** | **N** |
| **time interval** | **$0067_H$** | **2** | **R/W** | **N** |

*Formats*: the time interval is a duration expressed in milliseconds comprised between 0 and $65535_{d;}$ the minimal weight variation is value comprised between $_1$ and $65535_d$
*Description:* these two settings can be associated so as ***eNod3-D*** to check the flow rate.
**The flow rate control is disabled if the *'time interval'* setting is set to 0.**
If the flow rate control is active, it is monitored every dosing cycles but is inhibited during the neutralization times (cf. §2.6.4 and §2.6.5).

### 2.6.21 Dosing error report:

| *Address* | *N* | *Access* | *Data storage** |
|---|---|---|---|
| **$0094_H$** | **2** | **RO** | **/** |

*Format*:

| **bits b7...b0**<br>**b3, b2, b1, b0** | **Function** | **Note** |
|---|---|---|
| 0000 | no error | |
| 0001 | flow rate failure | cf §2.6.17 |
| 0010 | result out of tolerance + | cf §2.6.12 |
| 0100 | result out of tolerance - | cf §2.6.12 |
| 1000 | unable to start cycle | |
| **bit b15....b8** | | |
| from 0 up to 255 | dosing error counter | incremented at each error detection |

*Description:* The error report provides an identification of the last error occurred and a counter of the errors detected.

## 2.7 Other settings

### 2.7.1 Text:

| *Address* | *N* | *Access* | *Data storage** |
|---|---|---|---|
| **$002E_H$** | **16** | **R/W** | **N** |

*Format*: a 16-bytes free memory area for ASCII codes storage.
*Description:* this is a user memory space that can be used to store some information like the last calibration date.

### 2.7.2 Logical inputs state:

| *Address* | *N* | *Access* | *Data storage** |
|---|---|---|---|
| **$0092_H$** | **4** | **RO** | **/** |

*Format/description*: binary. b0 bit corresponds to input 1; b1 bit corresponds to input 2.

### 2.7.3 Logical outputs state:

| *Address* | *N* | *Access* | *Data storage** |
|---|---|---|---|
| **$0093_H$** | **4** | **RO** | **/** |

*Format/description*: binary. b0 bit corresponds to output, b1 bit corresponds to output 2, b2 bit corresponds to output 3 and b3 bit corresponds to output 4.

## 2.8 Measurements

### 2.8.1 Status register:

| *Address* | *N* | *Access* | *Data storage** |
|---|---|---|---|
| **$007D_H$** | **2** | **RO** | **/** |

*Format/description:*

| bits b15,...b0 | Function | Notes |
|---|---|---|
| **b1, b0** | | |
| XX | non-significant | |
| **b3,b2** | | |
| 00 | measurement within the admissible range | causes an output assigned to the *'defective measurement'* function to be set active |
| 01 | negative overloading | |
| 10 | positive overloading | |
| 11 | analog signal out of range | |
| **bit b4** | | |
| 0 | motion | causes an output assigned to the *'motion'* function to be set active |
| 1 | no motion | |
| **bit b5** | | |
| 0 | measurement out of the ¼ of division | |
| 1 | zero in the ¼ of division | |
| **bit b6** | | |
| 0 | EEPROM OK | |
| 1 | EEPROM failure | |
| **bit b7** | | |
| 1 | reserved | |
| **bit b8** | | |
| 0 | input 1 logical state | |
| 1 | | |
| **bit b9** | | |
| 0 | input 2 logical state | |
| 1 | | |
| **bit b10** | | |
| 0 | output 1 logical state | |
| 1 | | |
| **bit b11** | | |
| 0 | output 2 logical state | |
| 1 | | |

| bit b12 | | |
|---|---|---|
| 0 | output 3 logical state | |
| 1 | | |
| **bit b13** | | |
| 0 | output 4 logical state | |
| 1 | | |
| **bit b14** | | |
| 0 | no tare | the tare can be cancelled by an input or by a command |
| 1 | at least a tare has been processed | |
| **bit b15** | | |
| 1 | reserved | |

### 2.8.2 Gross:

| *Address* | *N* | *Access* | *Data storage** |
|---|---|---|---|
| **$007E_H$** | **4** | **RO** | **/** |

*Format*: signed hexadecimal (two's complement).
*Description*: current gross measurement value.

### 2.8.3 Tare:

| *Address* | *N* | *Access* | *Data storage** |
|---|---|---|---|
| **$0080_H$** | **4** | **RO** | **/** |

*Format*: signed hexadecimal (two's complement).
*Description*: current tare value.

### 2.8.4 Net:

| *Address* | *N* | *Access* | *Data storage** |
|---|---|---|---|
| **$0082_H$** | **4** | **RO** | **/** |

*Format*: signed hexadecimal (two's complement).
*Description*: current net measurement value.

### 2.8.5 A/D converter points:

| *Address* | *N* | *Access* | *Data storage** |
|---|---|---|---|
| **$0084_H$** | **4** | **RO** | **/** |

*Format*: signed hexadecimal (two's complement).
*Description*: current A/D converter points value. Gives a non-calibrated measurement.

### 2.8.6 Dosing result:

| *Address* | *N* | *Access* | *Data storage** |
|---|---|---|---|
| **$0086_H$** | **4** | **RO** | **/** |

*Format*: signed hexadecimal (two's complement).
*Description*: this register contains the last dosing result. It is base on net value in filling functioning mode and on gross value in dosing by unloading functioning mode.
If the result is not ready (no complete cycle or cycle in progress), it is set to $FFFFFFFF_H$. (= -1).

### 2.8.7 Number of processed cycles:

| *Address* | *N* | *Access* | *Data storage** |
|---|---|---|---|
| **$0088_H$** | **4** | **RO** | **/** |

*Format*: signed hexadecimal (two's complement).

*Description:* in dosing functioning modes, the number of complete cycles can be read through this register. This value can be reset by the *'clear'* command.

### 2.8.8 Dosing results average value:

| *Address* | *N* | *Access* | *Data storage** |
|---|---|---|---|
| **$008A_H$** | **4** | **RO** | **/** |

*Format*: signed hexadecimal (two's complement).
*Description*: In dosing functioning modes, the results average value can be read through this register. This value can be reset by the *'clear'* command.

### 2.8.9 Dosing running total:

| *Address* | *N* | *Access* | *Data storage** |
|---|---|---|---|
| **$008C_H$** | **4** | **RO** | **/** |

*Format*: signed hexadecimal (two's complement).
*Description*: In dosing functioning modes, the cumulated value of the dosing results can be read through this register. This value can be reset by the *'clear'* command.

### 2.8.10 Standard deviation:

| *Address* | *N* | *Access* | *Data storage** |
|---|---|---|---|
| **$008E_H$** | **4** | **RO** | **/** |

*Format*: simple precision float value.
*Description*: in dosing functioning modes, the standard deviation on the results is calculated after each complete cycle. This value can be reset by the *'clear'* command.

## 2.9 Functional commands

### 2.9.1 Command register:

| *Address* | *N* | *Access* | *Data storage** |
|---|---|---|---|
| **$0090_H$** | **2** | **R/W** | **/** |

*Format/description:* the command register is used to send functional commands. To accept a new command, this register must be set in idle state (by writing $00_H$), see also response register §2.9.2.

| Code | Function | Note |
|---|---|---|
| $0000_H$ | set the command register into the **IDLE** state | **Important** : must be written before any other functional command |
| $00D0_H$ | reset | similar to the power-up |
| $00D1_H$ | EEPROM storage | saves the whole settings table into the EEPROM memory |
| $00D2_H$ | restores ***eNod3-D*** default configuration | **Warning :** all the default settings are recovered including the stored calibration |
| $00D3_H$ | zero | limited to a ±10% range of the maximum capacity |
| $00D4_H$ | tare | |
| $00D6_H$ | abort calibration | allows to leave the calibration procedure |
| $00D7_H$ | sensitivity adjustment | calibration using the sensor sensitivity and the sensor capacity ; must be followed by the save calibration command ($00DE_H$) |
| $00D8_H$ | zero adjustment | calibration zero acquisition ; must be followed by the save calibration command ($00DE_H$) |

| | | |
|---|---|---|
| $00D9_H$ | put in physical calibration mode | 1st step of the physical calibration |
| $00DA_H$ | zero acquisition | 2nd step of the physical calibration |
| $00DB_H$ | calibration with load 1 | 3rd step of the physical calibration |
| $00DC_H$ | calibration with load 2 (optional) | 4th step of the physical calibration |
| $00DD_H$ | calibration with load 3 (optional) | 5th step of the physical calibration |
| $00DE_H$ | save calibration | stores the calibration into EEPROM |
| $00DF_H$ | clear | stops current cycle and resets all the calculated variables |
| $00E4_H$ | start/restart dosing cycle | in dosing functioning modes, starts a new cycle or restarts a previously suspended cycle |
| $00E5_H$ | stop/suspend dosing cycle | in dosing mode (by filling or by unloading), stops / suspend current cycle |
| $00E6_H$ | cancel tare | erases last tare value |

### 2.9.2 Response register:

| *Address* | *N* | *Access* | *Data storage** |
|---|---|---|---|
| **$0091_H$** | **2** | **RO** | **N** |

*Format/description:* indicates the functional command state.

| Code | Function | Note |
|---|---|---|
| $0000_H$ | command register in IDLE state | see command register ($0000_H$) |
| $0001_H$ | command execution in progress | |
| $0010_H$ | command execution complete | |
| $0011_H$ | error | unable to achieve requested command |

# 3 APPENDIX A: EXAMPLES

## 3.1 Physical calibration

Follow the next steps:
**1/** Configure the A/D converter (in general, the default configuration is suitable).
**2/** Make sure that the scale correction coefficient is set to 1 (default value).
**3/** Define the number of required calibration segments (1 segment by default); 2 or 3 (maximum) segments will only be used for a non-linear installation.
**4/** For each calibration segment, define the corresponding digital value (between 1 and 1000000).
**5/** Start the calibration procedure by writing the *'put in physical calibration mode'* command into the command register.
**6/** Make sure that the load cell is free then send the '*zero acquisition'* command.
This zero acquisition might take some time depending on the measurements stability and the chosen motion criterion. Do not touch the load cell during this sequence.
**7/** Read the response register to check that the zero acquisition is successful.
**8/** Put on the load cell the first calibration load then enter the *'calibration with load 1'* command. As for the zero acquisition, the execution of this command might take some time.
**9/** Read the response register to check that the load 1 acquisition is successful.
- Continue if necessary with load 2 and load 3 (steps 8 and 9).
**10/** When the calibration is over write the '*save calibration'* command into the command register.

- **Note 1:** change the stability criterion setting if the different calibration steps take too long.
- **Note 2:** for tension-compression type sensors for which bipolar operations are expected, calibration is done only with loads to the positive direction. The negative part of the calibration curve is assumed to be symmetrical.

Example: ***eNod3-D*** with address $01_H$. 3 calibration loads: 17000; 39200 and 54800. (from step 3) :

| Action | Command sent to eNod3-D | Response | Effect |
|---|---|---|---|
| calibration on 3 segments : 17000, 39200 and 54800 | 01 10 00 02 00 07 0E 00 00 42 68 00 00 99 20 00 00 D6 10 00 03 19 06 | | |
| acknowledgement | | 01 10 00 02 00 07 20 0B | writing transaction OK |
| command register set into the IDLE state | 01 06 00 90 00 00 89 E7 | | |
| acknowledgement | | 01 06 00 90 00 00 89 E7 | |
| put in physical calibration mode | 01 06 00 90 00 D9 48 7D | | |
| acknowledgement | | 01 06 00 90 00 D9 48 7D | |
| command register set into the IDLE state | 01 06 00 90 00 00 89 E7 | | |
| acknowledgement | | 01 06 00 90 00 00 89 E7 | |
| zero acquisition | 01 06 00 90 00 DA 08 7C | | |
| acknowledgement | | 01 06 00 90 00 DA 08 7C | |
| read response register | 01 03 00 91 00 01 D5 E7 | | |
| | | 01 03 02 00 01 79 84 | command execution in progress |
| read response register | 01 03 00 91 00 01 D5 E7 | | |
| | | 01 03 02 00 02 39 85 | zero acquisition complete |
| command register set into the IDLE state | 01 06 00 90 00 00 89 E7 | | |

| | | | |
|---|---|---|---|
| acknowledgement | | 01 06 00 90 00 00 89 E7 | |
| calibration with load 1 | 01 06 00 90 00 DB C9 BC | | |
| acknowledgement | | 01 06 00 90 00 DB C9 BC | |
| read response register | 01 03 00 91 00 01 D5 E7 | | |
| | | 01 03 02 00 01 79 84 | command execution in progress |
| read register response | 01 03 00 91 00 01 D5 E7 | | |
| | | 01 03 02 00 02 39 85 | load 1 acquisition complete |
| command register set into the IDLE state | 01 06 00 90 00 00 89 E7 | | |
| acknowledgement | | 01 06 00 90 00 00 89 E7 | |
| calibration with load 2 | 01 06 00 90 00 DC 88 7E | | |
| acknowledgement | | 01 06 00 90 00 DC 88 7E | |
| command register set into the IDLE state | 01 06 00 90 00 00 89 E7 | | |
| acknowledgement | | 01 06 00 90 00 00 89 E7 | |
| calibration with load 3 | 01 06 00 90 00 DD 49 BE | | |
| acknowledgement | | 01 06 00 90 00 DD 49 BE | |
| read response register | 01 03 00 91 00 01 D5 E7 | | |
| | | 01 03 02 00 01 79 84 | command execution in progress |
| read response register | 01 03 00 91 00 01 D5 E7 | | |
| | | 01 03 02 00 02 39 85 | load 3 acquisition complete |
| command register set into the IDLE state | 01 06 00 90 00 00 89 E7 | | |
| acknowledgement | | 01 06 00 90 00 00 89 E7 | |
| save calibration | 01 06 00 90 00 DE 09 BF | | |
| acknowledgement | | 01 06 00 90 00 DE 09 BF | |

- **Note:** if required, it is possible to adjust the calibration thanks to the global scale coefficient or the polynomial correction, see corresponding sections.

## 3.2 Theoretical calibration:

Example: ***eNod3-D*** with address $01_H$, associated to a 2,3450mV/V sensor for a corresponding capacity equal to 1725.

| Action | Command sent to eNod3-D | Response | Effect |
|---|---|---|---|
| capacity = 11725 | 01 10 00 1A 00 02 04 00 00 2D CD AE 19 | | |
| acknowledgement | | 01 10 00 1A 00 02 60 0F | writing transaction OK |
| sensor sensitivity = 2,3450 mV/V | 01 10 00 6A 00 02 04 00 03 94 04 EA FB | | sensor sensitivity expressed as a $10^{-5}$ number (mV/V) |
| acknowledgement | | 01 10 00 6A 00 02 61 D4 | |
| command register set into the IDLE state | 01 06 00 90 00 00 89 E7 | | |
| acknowledgement | | 01 06 00 90 00 00 89 E7 | |
| sensitivity adjustment | 01 06 00 90 00 D7 C9 B9 | | |
| acknowledgement | | 01 06 00 90 00 D7 C9 B9 | |
| command register set into the IDLE state | 01 06 00 90 00 00 89 E7 | | |
| acknowledgement | | 01 06 00 90 00 00 89 E7 | |
| zero adjustment | 01 06 00 09 00 D8 89 BD | | |
| acknowledgement | | 01 06 00 90 00 D8 89 BD | |
| command register set into the IDLE state | 01 06 00 90 00 00 89 E7 | | |
| acknowledgement | | 01 06 00 90 00 00 89 E7 | |
| save calibration | 01 06 00 90 00 DE 09 BF | | |
| acknowledgement | | 01 06 00 90 00 DE 09 BF | |

## 3.3 Initial calibration correction:

Example: ***eNod3-D*** with address $01_H$, +0,025% correction.

| Action | Command sent to eNod3-D | Response | Effect |
|---|---|---|---|
| global span adjusting coefficient = 1,0025 | 01 10 00 0F 00 02 04 0F A3 E8 23 4F | | coefficient coded as $1025000_d$ |
| acknowledgement | | 01 10 00 0F 00 02 71 CB | |
| command register set into the IDLE state | 01 06 00 90 00 00 89 E7 | | |
| acknowledgement | | 01 06 00 90 00 00 89 E7 | |
| EEPROM storage | 01 06 00 90 00 D1 49 BB | | |
| acknowledgement | | 01 06 00 09 00 81 49 BB | |

## 3.4 Transmitter mode:

Example: reading of the net measurement ***eNod3-D*** with address $01_H$.

| Action | Command sent to eNod3-D | Response | Effect |
|---|---|---|---|
| read the net value | 01 03 00 82 00 02 64 23 | | read two consecutive registers |
| | | 01 03 04 00 00 61 02 EB 56 | net measurement = +0024834 |

## 3.5 Dosing by filling mode:

Example: ***eNod3-D*** with address $01_H$.

- functioning mode set to '*dosing by filling*'
- control variables :
  - ⇨ target weight = 10000 ($2710_H$)
  - ⇨ fine feed level = 6200 ($1838_H$)
  - ⇨ emptying end level = 600 ($258_H$)
  - ⇨ min empty weight= 5 ; max empty weight = 45 ($2D_H$)
  - ⇨ tolerance + = tolerance - = 5
  - ⇨ in-flight weight value = 465 ($1D1_H$)
- cycle timings :
  - ⇨ start delay = 250 ms ($FA_H$)
  - ⇨ motion time out = 100 ms ($64_H$)
  - ⇨ coarse feed effect and fine feed neutralization times = 25 ms ($19_H$)
  - ⇨ final stabilization time = 500 ms ($1F4_H$)
  - ⇨ emptying holding time = 150 ms ($96_H$)
  - ⇨ minimal weight variation = time interval = 0 (no flow rate control)
- cycle management options :
  - ⇨ in-flight weight automatic correction enabled with a 30% correction coefficient
  - ⇨ automatic taring at start enabled
- logical outputs assignment :
  - ⇨ output1 = fine feed (positive logic)
  - ⇨ output2 = coarse feed (positive logic)
  - ⇨ output3 = emptying (positive logic)
  - ⇨ output4 = out of tolerances (negative logic)

❑ **Note**: setting eNod3-D to the 'filling' functioning mode requires storage in EEPROM followed by a reset.

| Action | Command sent to eNod3-D | Response | Effect |
|---|---|---|---|
| ModBus protocol and dosing by filling mode | 01 06 00 2B 01 01 39 92 | | |
| acknowledgement | | 01 06 00 2B 01 01 39 92 | |
| target weight = 10000 | 01 10 00 4A 00 02 04 00 00 2710 6D DC | | |
| acknowledgement | | 01 10 00 4B 00 02 F1 DE | |
| in-flight weight = 465 ; min empty weight = 5 ; max empty weight = 45 tolerances = 5 | 01 10 00 54 00 08 10 00 00 01 D1 00 00 00 2D 00 00 00 05 00 05 00 05 C4 97 | | write into 8 consecutive registers |
| acknowledgement | | 01 10 00 54 00 08 80 1F | |
| command register set into the IDLE state | 01 06 00 90 00 00 89 E7 | | |
| acknowledgement | | 01 06 00 90 00 00 89 E7 | |
| timings modification | 01 10 00 4C 00 06 0C 00 FA 01 F4 00 19 00 19 00 96 00 64 0F 3C | | write into 6 consecutive registers |
| acknowledgement | | 01 10 00 4C 00 06 81 DC | |
| fine feed level = 6200 ; emptying end level = 600 | 01 10 00 5E 00 04 08 00 00 18 38 00 00 02 58 3D EA | | write into 4 consecutive registers |
| acknowledgement | | 01 10 00 5E 00 04 A0 18 | |
| cycle management options modification | 01 10 00 52 00 02 04 00 01 1E 01 EE EA | | write into 2 consecutive registers |
| acknowledgement | | 01 10 00 52 00 02 E0 19 | |
| logical outputs assignment | 01 10 00 37 00 02 04 16 15 01 17 E5 4F | | |
| acknowledgement | | 01 10 00 37 00 02 F0 06 | |
| EEPROM storage | 01 06 00 90 00 D1 49 BB | | stores all the settings modifications |
| acknowledgement | | 01 06 00 90 00 D1 49 BB | |
| command register set into the IDLE state | 01 06 00 90 00 00 89 E7 | | |
| acknowledgement | | 01 06 00 90 00 00 89 E7 | |
| Reset | 01 06 00 90 00 D0 88 7B | | activates the dosing by filling mode |
| acknowledgement | | 01 06 00 90 00 D0 88 7B | |
| start dosing cycle | 01 06 00 90 00 EA 08 69 | | starts a dosing cycle |
| acknowledgement | | 01 06 00 90 00 EA 08 69 | |

# 4 APPENDIX B: CRC-16 CALCULATION ALGORITHM

**Note: t**he CRC-16 is calculated on the whole frame. Contrary to the bytes contained in the frame the first transmitted byte of the CRC-16 is the LSB.