eNod3-C
Digital transmitter

ModBus RTU Communication protocol

Document revisions		
version	**date**	**description**
A	01/07	- creation
B	05/07	- layout modification
C	10/07	- polynomial correction added
D	11/07	- status bits meaning correction
E	01/08	- functional commands updated - ModBus mapping updated (dynamic zero, outputs activation duration, statistical datas) - CRC16 determination appendix added
F	04/08	- new input assignement « allow new cycle » added
G	12/08	- various fixes
H	01/09	- legal for trade settings description - tare bit added in the status bytes - frame examples bugs fixed
I	07/11	- register map - Checkweigher mode dynamic acquisition and / or correction time - Checkweigher zero correction range - Checkweigher result quality

1. USING MODBUS-RTU COMMUNICATION PROTOCOL

1.1. Byte format:

Bytes are coded in hexadecimal format
- Format:
  1 start bit
  8 data bits
  No parity
  2 stop bits
- CRC 16
  CRC-16 polynomial: $G(x) = x^{16} + x^{15} + x^2 + 1$

1.2. ~~MODBUS RTU~~ModBus-RTU functions:

Function	Code
Read N registers*	03 / 04
Write 1 register	06
Write N registers*	10

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

1.3. Frames format:

~~2.1.~~1.3.1. Function codes $03/04_H$ – Read N input registers (N = 20 max) :

- Request:

slave address	function code	starting address	number of registers	CRC 16
1 byte	1 byte (03/04)	2 bytes	2 bytes	2 bytes

- Response:

slave address	function code	byte count	data 1	…	CRC 16
1 byte	1 byte (03/04)	1 byte	2 bytes	2 bytes	2 bytes

1.3.2. Function code 06_H – Write 1 register :

- Request:

slave address	function code	address	data	CRC 16
1 byte	1 byte (06)	2 bytes	2 bytes	2 bytes

- Response:

slave address	function code	address	data	CRC 16
1 byte	1 byte (06)	2 bytes	2 bytes	2 bytes

1.3.3. Function code 10_H – Preset multiple registers (N = 20 max) :

- Request:

slave address	function code	starting address	number of registers	byte count	data	…	CRC 16
1 byte	1 byte (10)	2 bytes	2 bytes	1 byte	2 bytes	2 bytes	2 bytes

- Response:

Slave address	Function code	Starting address	Number of registers	CRC 16
1 byte	1 byte (10)	2 bytes	2 bytes	2 bytes

1.4. Exception codes:

- Frame format:

slave address	function code + 80_H	exception code	CRC 16
1 byte	1 byte	1 byte	2 bytes

- Exception codes:

error code	meaning	description
01_H	illegal function	***Modbus-RTU*** function not supported by ***eNod3-C***
02_H	illegal data address illegal data value	- register address requested out of ***eNod3-C*** register table - forbidden data values
04_H	***eNod3-C*** not ready	***eNod3-C*** is not ready to answer (for example measurement request during a taring operation)

2. REGISTER MAP :

- **Note** : some of the functionalities of the registers with a * are only accessible with ***eNod3-C*** with a firmware version ≥ 2.60.

See specific descriptive § for each register.

address Hex.	bbytes (n)	type	name	access		§
0000	2	Uint	metrological version number	Read only	Adjustment parameters	2.11
0001	2	Uint	Analog to Digital converter A/D setting	Read / Write		2.1
0002	4	long	calibration load num. 1	Read / Write		2.2
0004	4	long	calibration load num. 2	Read / Write		2.2
0006	4	long	calibration load num. 3	Read / Write		2.2
0008	2	Uint	number of calibration segments	Read / Write		2.3
0009	4	float	scale coefficient num. 1	Read / Write		2.4
000B	4	float	scale coefficient num. 2	Read / Write		2.4
000D	4	float	scale coefficient num. 3	Read / Write		2.4
000F	4	Ulong	global span adjusting coefficient	Read / Write		2.5
0011	4	long	polynomial adjusting coefficient a	Read / Write		2.6
0013	4	long	polynomial adjusting coefficient b	Read / Write		2.6
0015	4	long	polynomial adjusting coefficient b	Read / Write		2.6
0017	4	Ulong	maximum capacity	Read / Write		2.7
0019	2	Uint	scale interval	Read / Write		2.8
001A	4	Ulong	sensor capacity	Read / Write		2.9

001C	4	long	zero calibration value	Read / Write		2.10
001E	12		reserved			
0024	2	Uint	legal for trade (R76) switch	Read/Write	Metrological parameters	2.12
0025	2	Uint	legal for trade counter	Read only		2.13
0026	2	Uint	legal for trade CRC16	Read only		2.14
0027	2	Uint	zero modes * / automatic zero correction range *	Read / Write		2.15
0028	2	Uint	motion and self-adaptive filter	Read / Write		2.16
0029	2	Uint	firmware version	Read only	Application parameters	2.17
002A	2	Uint	slave address	Read / Write		2.18
002B	2	Uint	protocols, functioning modes and treatment	Read / Write		2.19
002C	2	Uint	serial baud rate / CAN bus baud rate *	Read / Write		2.20
002D	2	Uint	reserved			
002E	16	Uintx8	text	Read / Write		2.21
0036	2	Uint	inputs functions	Read / Write		2.22
0037	2	Uint	outputs functions	Read / Write		2.23
0038	4	long	set point 2 high value	Read / Write		2.24
003A	4	long	set point 2 low value	Read / Write		2.24
003C	4	long	set point 1 high value	Read / Write		2.24
003E	4	long	set point 1 low value	Read / Write		2.24
0040	2	Uint	set point functions	Read / Write		2.25
0041	2	Uint	stabilization time (Ts) *Checkweigher mode*	Read / Write		2.26
0042	2	Uint	measuring time (Tm) *Checkweigher or triggered Peak control modes*	Read / Write		2.27
0043	2	Uint	dynamic zero time checkweigher mode	Read / Write		2.28
0044	4	long	trigger level *Checkweigher and Peak control modes*	Read / Write		2.29
0046	2	Uint	reserved			
0047	2	Uint	debounce time	Read / Write		2.30
0048	2	Uint	output 1 activation duration	Read / Write		2.31
0049	2	Uint	output 2 activation duration	Read / Write		2.31
004A	2	Uint	reserved			
004B	2	Uint	reserved			
004C	4	float	band-stop filter X coefficient *	Read / Write		2.35
004E	4	float	band-stop filter Y coefficient *	Read / Write		2.35
0050	2	float	band-stop filter Z coefficient *	Read / Write		2.35
0052	4	Ulong	Reserved			
0054	4	Ulong	sensor sensitivity	Read / Write		2.32
0056	2	Uint	low-pass filter order / band-stop filter activation *	Read / Write	Filtering	2.33
0057	4	float	filter coefficient 1/A	Read / Write		2.34
0059	4	float	filter coefficient B	Read / Write		2.34
005B	4	float	filter coefficient C	Read / Write		2.34
005D	4	float	filter coefficient D	Read / Write		2.34

005F	4	float	filter coefficient E	Read / Write		2.34
0061	4	long	checkweigher correction coefficient	Read / Write	Application	2.36
0063	2	Uint	status	Read only		2.37
0064	4	long	gross	Read only		2.38
0066	4	long	tare	Read / Write		2.39
0068	4	long	net	Read only		2.40
006A	4	long	A/D converter points	Read only		2.41
006C	4	long	result *Checkweigher mode*	Read only		2.42
006E	4	long	max *Peak control mode*	Read only		2.43
0070	4	long	min *Peak control mode*	Read only		2.44
0072	4	long	peak to peak value *Peak control mode*	Read only		2.45
0074	2	Uint	command register	Read / Write		2.46
0075	4	long	reserved			
0077	2	Uint	response register	Read only		2.47
0078	4	long	reserved			
007A	4	long	number of cycles *Checkweigher mode*	Read only		2.48
007C	4	long	running total *Checkweigher mode*	Read only		2.49
007E	4	long	average value *Checkweigher mode*	Read only		2.50
0080	4	float	standard deviation *Checkweigher mode*	Read only		2.51
0082	2	Uint	read Inputs	Read only		2.52
0083	2	Uint	read Outputs	Read only		2.53
0084	4	float	Checkweigher result quality	Read only		2.54

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

2.1. Analog to Digital (A/D) converter setting:

Address: 0001_H; n = 2
Format: binary code
Description:

bits b0,...b15	functionality		
b2b1b0	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 gages load cell
bit b3	analog signal type		
0	bipolar		positive and negative signal
1	unipolar		positive signal
bit b4	50Hz/60Hz rejection		
0	60Hz rejection		
1	50Hz rejection		default value
b8b7b6b5	Conversion rate in 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	default value
1100	200	240	
1011	400	480	
1010	800	960	
1001	1600	1920	

Setting up a new configuration of the A/D converter requires the following steps:

- EEPROM storage of the new configuration (Register address *0074_H*).
- Doing a reset (it can be done with power off, then power on, or command address register*0074_H*).

2.2. Calibration loads:

Addresses:

0002_H corresponds to calibration load 1
0004_H corresponds to calibration load 2
0006_H corresponds to calibration load 3.

n = 4
Format: admitted values are between 0 and 1 000 000_d.
Description: each load corresponds to the termination of a calibration segment.
EEPROM storage: register address 0074_H.
Actual *'calibration loads'* are the current ones even if they are not stored in EEPROM.

2.3. Number of calibration segments:

Address: 0008_H; n = 2
Format: admitted values: 1 to 3.
Description: the number of calibration segments can't exceed 3. Usually 1 is sufficient. 2 or 3 segments are used in case of non linearity.
EEPROM storage: register address 0074_H.
Actual *'number of calibration segments'* is the current one even if it is not stored in EEPROM.

2.4. Scale coefficients:

Addresses: 0009_H corresponds to scale coefficient segment 1.
$000B_H$ corresponds to scale coefficient Ssgment 2.
$000D_H$ corresponds to scale coefficient Ssgment 3.

n = 4
Format: floating decimal single precision (32 bits).
Description: coefficients are automatically produced during calibration process. Writing by you these coefficients is only valid for a copy of a previous calibration.

2.5. Global span adjusting coefficient:

Address: $000F_H$; n = 4
Format: the unit is 1/1000 000 (1E-6); that means $1\ 000\ 000_d$ = 1. Maximum and minimum values are: $1\ 100\ 000_d$ and $900\ 000_d$ (it corresponds to: 1.10 and 0.90).
Description: initial calibration value can be modified with a global span adjusting coefficient. Adjustment is done on the whole curve.
The new global span adjusting coefficient:only applies after:

- EEPROM storage of the new configuration (Register address *0074_H*).
- Doing a reset (it can be done with power off, then power on, or command address register *0074_H*).

2.6. Polynomial adjusting coefficients:

They are 3 polynomial adjusting coefficients.
Addresses: 0011_H corresponds to polynomial coefficient a.
0013_H corresponds to polynomial coefficient b.
0015_H corresponds to polynomial coefficient c.
n = 4
Format: the coefficients have specific values; each of them is expressed with its own unit:

- the unit for coefficient a is 1/1 000 000 000 000 (1E-12); that means $1\ 000\ 000\ 000\ 000_d$ = 1
- the unit for coefficient b is 1/ 1 000 000 000 (1E-9); that means $1\ 000\ 000\ 000_d$ = 1
- coefficient C is directly expressed as A/D converter points.

EEPROM storage: Register address 0074_H.
Description: coefficients are easily calculated using ***eNodView*** software.
Adjusting formula:

> Adjusted measurement = Mes – A $(Mes)^2$ – B (Mes) – C
> With Mes = actual measurement.

2.7. Maximum capacity:

Address: 0017_H; n = 4
Format: admitted values are between 0 and $1\ 000\ 000_d$.
Description: when the absolute value of gross measurement plus 9 divisions exceed the maximum capacity, bits b1 (positive overloading) or b3 (negative overloading) of status bytes are set to 1 at address 0063_H.
EEPROM storage: register address 0074_H.

2.8. Scale interval:

Address: 0019_H; n = 2
Format: acceptable values : 1_d, 2_d, 5_d, 10_d, 20_d, 50_d, 100_d.
Description: minimal difference between two consecutive calibrated measurements.
EEPROM storage: register address 0074_H.
Actual *'scale interval'* is the current one even if it is not stored in EEPROM.

2.9. Sensor capacity:

Address: $001A_H$; n = 4
Format: maximum value: $1\ 000\ 000_d$.
Description: sensor capacity is used with sensor sensitivity for a theoretical calibration.
EEPROM storage: register address 0074_H.

2.10. Zero calibration value:

Address: $001C_H$; n = 4
Format: admitted values are between 0 and $\pm 1\ 000\ 000_d$.
Description: zero reference in A/D converter points.
Zero calibration value corresponds to the A/D converter points measured during the '*zero acquisition*' step of a physical calibration. For a theoretical calibration it is necessary to set this value. It can be set automatically with the '*zero adjustment*' command.
EEPROM storage: register address 0074_H.

2.11. Metrological version number

Address : 0000_H ; n = 2
Format : read-only value between 1 et 65535_d.
Description : This number identifies the version of the part of the software that is dedicated to the metrolgy and the measurement exploitation.

2.12. Legal for trade (R76) switch

Adress : 0024_H ; n = 2
Format : the activation of the settings related to the use of ***eNod3-C*** in compliance with OIML R76 recommandation 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. §2.13).
- a new legal for trade CRC-16 value is calculated every a storage in EEPROM is request if a metrological setting has been modified (cf. §2.13).
- taring is now impossible if gross measurement is negative.
- the weight value is set to –1 during the 15 seconds that follow a device reset.
- the motion criterion (cf. § 2.16) is forced to *0.25d* and can not be modified anymore. An attempt to change its value is refused by an error frame.
- The A/D converter is set into *unipolar* mode (cf. § 2.1) and can not be modified anymore. An attempt to change its value is refused by an error frame.
- reading the net value during tare acquisition or the gross/net value during zero acquisition is impossible (error frame with error code (cf. §1.4) with error code 04_H).
- zero acquisition range is reduced from 10% of the capacity to 2%.

2.13. Legal for trade counter

Address : 0025_H ; n = 2
Format : read-only hex. value between 0000_H et $FFFF_H$.
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 zerosetting and zero tracking
- functioning mode
- stability criterion

2.14. Legal for trade CRC16

Address : 0026_H ; n = 2
Format : read-only hex. value between 0000_H et $FFFF_H$.
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 §2.13 has been modified.

2.15. Zero modes / automatic correction range:

Address: 0027_H; n =2
Format: binary code
Description:

bits b0,...b15	functionality	note
bit b0	**zero tracking**	
1	zero tracking enabled	zero tracking is limited to a ±10% range of the maximum capacity
0	zero tracking disabled	

bit b1	initial zero-setting (power-up zero)	
1	initial zero setting enabled	initial zero setting is limited to a ±10% range of the maximum capacity.
0	initial zero setting disabled	
bit b2	**automatic zero correction (checkweigher mode) ***	
1	automatic zero correction enabled	see description in user's instructions documentation ref 165702
0	automatic zero correction disabled	
b8....b15	**automatic correction range ***	
0 to 255 and 0 to 5 in legal for trade mode	automatic zero correction range (+/-) in checkweigher functioning mode	used if bit b2 is set

EEPROM storage: register address 0074_H.
Description for automatic zero correction range (+ /-) in checkweigher functioning mode :
This automatic correction of the zero value is only available in checkweigher functioning mode. It allows following the evolution of the zero in checkweigher functioning mode, for example on a conveyor belt on which there is some product accumulation. This function only is efficient when the measured signal is filtered enough with a few noise and oscillations.
Measurements out of correction range are rejected. Otherwise if a measurement is out of correction range with a positive value, some previous measurements are rejected also, this is because the product arriving on measurement platform has not to correct zero value.
Other criteria :

- A minimum 75 % ratio between accepted measurements and total measurements received during 'checkweigher dynamic correction time' is considered.
- A minimum of 10 measurements accepted is necessary.

In legal for trade mode :

- 'Checkweigher zero dynamic correction' is not done if measurement is stable.
- Maximum correction range is ±5d

2.16. Motion and self-adaptive filter:

Address: 0028_H; n = 2
Format: binary code.
Description: motion is indicated with the bit b4 of the status set to 1.
Motion criterion is preset according to the following table:

bits b0,...b15	functionality	
bits b2b1b0	**stability interval**	
000	no motion detection	measurement considered as always stable
001	0,25 d	d = division
010	0,5d	
011	1d	
100	2d	
bit b8	**self-adaptive filter**	
0	self-adaptive filter off	
1	self-adaptive filter on	

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 converter conversion rate		X
50Hz rejection	60Hz 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 Butterworth filter and 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.
EEPROM storage: register address 0074_H.

2.17. Firmware version:

Address: 0029_H; n = 2, Read-only register.
Format: admitted values are between 1 and 65535_d.

2.18. Slave address:

Address: $002A_H$; n = 2
Format: admitted values are between 01_H and $F7_H$. **Default value: 01_H**
Description: ***eNod3-C*** address on the network.
Setting up a new address requires the following steps:

- EEPROM storage of the new address (register address 0074_H).
- Doing a reset (it can be done with power off, then power on, or command address register 0074_H)

2.19. Protocols, functioning modes and signal processing:

Address: $002B_H$; n = 2
Format: binary code.
Description:

bits b0,...b15	functionality	
bits b2b1b0	**functioning mode**	
000	Transmitter	application mode
001	reserved	
010	Checkweigher transmission on request	
011	Non triggered peak control	
100	Triggered peak control	
bit b3	**signal processing**	
0	performed	low-pass filter, self-adaptive filter, set points and calculation for linearization.
1	skipped	
bits b9b8	**protocol**	
00	SCMBus	communication protocol
01	ModBus-RTU	
11	fast SCMBUS	

Setting up a new protocol and/or functioning mode, according to the above table, requires the following steps:

- EEPROM storage of the new configuration (Register address *0074*$_H$).
- Doing a reset (it can be done with power off, then power on, or command address register *0074*$_H$)

2.20. Serial Baud rate / CANbus baud rate *:

Address: 002C$_H$; n = 2
Format: binary code
Description:

bits b0,...b15	baud rate	
bits b2b1b0	serial (RS485, 422 or 232)	
001	9600	default value
010	19200	
011	38400	
100	57600	
101	115200	
bits b8b9b10	CANbus *	
001	20000	
010	50000	
011	125000	default value
100	250000	
101	500000	
110	800000	
111	1000000	

Setting up a new baud rate requires the following steps:

- EEPROM storage of the new baud rate (Register address *0074*$_H$).
- Doing a reset (it can be done with power off, then power on, or command address register *0074*$_H$)

2.21. Text :

Address: 002E$_H$; n = 16
Format: the text space is made by 16 bytes.
Description: it is a user memory space. It can be used to store some information. For example: Calibration date, or date of the next control....
EEPROM storage: register address 0074$_H$.

2.22. Inputs functions:

Address: 0036; n = 2
Format: Binary code. Most significant byte corresponds to input E2. Last significant byte corresponds to input E1.*Description*:

bits b0,...b15	functionality	notes
b2b1b0 or b10b9b8	input assignement	b2b1b0 = Input E1 b10b9b8 = Input E2
000	none	Inputs are ignored
001	tare	tare command
010	zero	limited to a ±10% range of the maximum capacity
011	dynamic zero (see § 2.42)	in Checkweigher mode ; limited to a ±10% range of the maximum capacity

100	measurement window	Triggered peak control mode
101	clear	checkweigher and peak control modes
110	start/allow new cycle	in Checkweigher and non-triggered Peak control modes (*)
111	stop checkweigher cycle	Checkweigher mode
bits b3 or b11	**logic mode**	**b3 corresponds to input E1 b11 corresponds to input E2**
0	negative logic	
1	positive logic	
b4, b7 or b12, b15	**reserved**	

EEPROM storage: register address 0074_H.
* : In Checkweigher mode, an input assigned to the '*start Checkweigher cycle'* has a higher priority than a trigger level. Thus, the trigger level is ignored.
In triggered Peak control mode, if an input is assigned to the '*Allow new cycle'* function, a new cycle only can be started if this input has been previously activated (rising or falling edge according to the choosen logic).

2.23. Outputs functions:

Address: 0037_H; n = 2
Format: Binary code. most significant byte corresponds to output S2. Last significant byte corresponds to output S1.
Description:

bits b0,...b15	**functionality**	
b2b1b0 or b10b9b8	**output assignement**	**b2b1b0 = ouput S1 b10b9b8 = output S2**
000	set points	
001	motion	
010	Checkweigher result available	Checkweigher mode
011	cycle in progress	Checkweigher Triggered peak control
100	defective measurement	see status
101	input image	
110	level on request	see §2.27
bits b3 or b11	**logic mode**	**b3 corresponds to output S1 b11 corresponds to output S2**
0	negative logic	
1	positive logic	

EEPROM storage: register address 0074_H

2.24. Set points 1 & 2, high and low values:

Addresses:

$003C_H$ corresponds to set point 1 high value
0038_H corresponds to set point 2 high value
$003E_H$ corresponds to set point 1 low value
$003A_H$ corresponds to set point 2 low value;

n = 4
Format: values are between 0 and ± 1 000 000_d
Description: If an output is assigned to set point function, its state depends on high and low values and functioning.
Set point 1 is assigned to output 1 and set point 2 to output 2.

EEPROM storage: register address 0074_H. Actual set points values are the current ones even if it they are not stored in EEPROM.

2.25. Set points functions :

Address: 0040_H; n = 2
Format: binary code. Most significant byte corresponds to set point 2; less significant byte corresponds to set point 1.
Description:

bits b0,...b15	functionality	
bits b0 or b8	**functioning**	**b0 corresponds to set point 1 b8 corresponds to set point 2**
0	window	see set points functioning description in user's instructions documentation ref 165702
1	hysteresis	
b3b2b1 or b10b9b8	**variable**	**b3b2b1 correspond to set point 1 b11b10b9 correspond to set point 2**
000	gross measurement	
001	net measurement	
010	max	Peak control mode
011	min	Peak control mode
100	peak-to-peak	Peak control mode
101	Checkweigher result	Checkweigher mode
110	Checkweigher running total	Checkweigher mode

EEPROM storage: Register address 0074_H.

2.26. Stabilization time (Ts), checkweigher mode:

Address: 0041_H; n = 2
Format: time Ts in milliseconds, values are between 0 and 65 535_d
Description: see '*checkweigher functioning mode*' in the document '*User's instructions*' Ref. 165 702
EEPROM storage: register address 0074_H.
Actual *'stabilization time'* is the current one even if it is not stored in EEPROM.

2.27. Measuring time (Tm), Checkweigher and triggered peak control modes:

Address: 0042_H; n = 2
Format: time Tm in milliseconds, values are between 0 and 65 535_d
Description: see '*checkweigher functioning mode*' and '*peak control functioning mode*' in the document '*User's instructions*' Ref. 165 702.
EEPROM storage: register address 0074_H.
Actual *'measuring time'* is the current one even if it is not stored in EEPROM.

2.28. Dynamic zero acquisition and / or correction time, Checkweigher mode:

Address: 0043_H; n = 2
Format: between 0 and 65 535_d . In legal for trade mode it cannot be < 1000 $_d$.
Description:

- Dynamic zero acquisition time: In checkweigher mode, an input assigned to the function *'Dynamic zero'* or a command sent by the master to ***eNod3-C*** can trigger the acquisition of a zero without any stability criterion. This new volatile zero value is obtained by averaging the measurements during the specfied time. It is only taken into account if it is included in a range of ±10 % of the capacity or ±2% in legal for trade mode.
- Dynamic correction time: In checkweigher mode, if '*checkweigher automatic zero correction'* is enabled, this time is used to define measurements to take in account for the zero correction.

EEPROM storage: Register address 0074_H.
Actual '*dynamic zero acquisition time*' is the current one even if it is not stored in EEPROM.

2.29. Trigger level:

Address: 0044_H; n = 4
Format: values are between 0 and ± 1 000 000_d
Description: see ‘*checkweigher functioning mode*’ and ‘*peak control functioning mode*’ in the document ’*User’s instructions’ Ref*. 165 702’.
Note: if an input is assigned to ‘*Checkweigher start cycle*’, ‘*Trigger level*’ is ignored.
EEPROM storage: Register address 0074_H
Actual *‘trigger level’* value is the current one even if it is not stored in EEPROM.

2.30. Debounce time:

Address: 0047_H; n = 2
Format: values are between 0 and 65535_d. The unit is millisecond.
Description: Debounce time corresponds to the required stabilization time of an input.
EEPROM storage: Register address 0074_H
Actual *‘debounce time’* value is the current one even if it is not stored in EEPROM.

2.31. Output 1 & 2 activation time:

Addresses: 0048_H and 0049_H; n = 2
Format: values are between 0 and 65535_d. The unit is millisecond.
Description: the outputs acitvation duration setting is taken into account if an output is assigned to the function *‘level on request’*. When an output activation command is sent to ***eNod3-C*** (see § 2.19), the output remains active :

- until the reception of an *‘output inhibtion’* command if the output activation time is equal to zero
- until the end of a timer whose value is equal to the output activation time (expressed in ms)

EEPROM storage: Register address 0074_H
Actual *‘outputs activation times’* are the current ones even if they are not stored in EEPROM.

2.32. Sensor sensitivity:

Address: 0054_H; n = 4
Format: values are between 0 and 900 000_d.
Description: the unit is 1mV/V x 10^{-5}. Example: 200 000_d for 2mV/V.
It is used for theoretical calibration of the ***eNod3-C***.
To calibrate ***eNod3-C*** it is necessary to know the sensitivity of the sensor and the corresponding capacity.
EEPROM storage: register address 0074_H

2.33. Low-pass filter order / band-stop filter activation *:

Address: 0056_H; n = 2
Format:

bits b0,...b15	functionality	
bits b2b1b0	**low-pass filter order**	
000	filter disabled	
010	2^{nd} order	filter described by A, B and C coefficients
011	3^{rd} order	filter described by A, B, C and D coefficients
100	4^{th} order	filter described by A, B, C, D and E coefficients
bit b8	**band-stop filter ***	
0	filter disabled	
1	filter enabled	filter described by X, Y and Z coefficients

Description:

- Bessel/Butterworth filter

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

- Low-pass filter *:

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

Coefficients depend on the Analog to Digital conversion rate and desired cut-off frequencies. The coefficients are defined using the ***eNodView*** software.
EEPROM storage: register address 0074_H.

2.34. Low-pass filter coefficients A, B, C, D and E :

Addresses: 0057_H corresponds to 1/A coefficient
0059_H corresponds to B coefficient
$005B_H$ corresponds to C coefficient
$005D_H$ corresponds to D coefficient
$005F_H$ corresponds to E coefficient

n = 4
Format: floating hexadecimal single precision (32 bits).
Description: Coefficients depend on the Analog to Digital conversion rate and the desired cut-off frequency. The coefficients are defined using the ***eNodView*** software.
EEPROM storage: Register address 0074_H.
Actual filter coefficients are the current ones even if they are not stored in EEPROM. Be careful, filter order and filter coefficients must be modified at the same time.

2.35. Band-stop filter coefficients X, Y and Z:

Addresses: $004C_H$ corresponds to X coefficient
$004E_H$ corresponds to Y coefficient
0050_H corresponds to Z coefficient

n = 4
Format: floating hexadecimal single precision (32 bits).
Description: coefficients depend on the Analog to Digital conversion rate and the desired cut-off frequencies (low and high). The coefficients are defined using the ***eNodView*** software.
EEPROM storage: Register address 0074_H.
Actual filter coefficients are the current ones even if they are not stored in EEPROM.

2.36. Checkweigher correction coefficient:

Address: 0061_H; n = 4
Format: hexadecimal. The unit is 1/1000 000. That means 1 000 000 = 1
Description: the correction coefficient is used to adjust the checkweigher result value.
EEPROM storage: register address 0074_H.

2.37. Status:

Address: 0063_H; n = 2. read only register.
Format: binary code.
Description:

	b7 (PF)	b6	b5	b4	b3	b2	b1	b0 (pf)
0		EEPROM OK		motion				
1	1	error in EEPROM	zero in the ¼ of the division	stable	negative overloading	sensor signal < Input signal range	positive overloading	sensor signal > input signal range
	b15	b14	b13	b12	b11	b10	b9	b8
0		no tare	S2 output	S1 output	E2 input	E1 input	00 = A/D converter points	

1	1	at least one tare has been processed	status	status	status	status	01 = Net 02 = Gross 03 = Tare

2.38. Gross:

Address: 0064_H; n = 4. read only register.
Format: signed hexadecimal (two's complement).

2.39. Tare:

Address: 0066_H; n = 4. read only register.
Format: signed hexadecimal (two's complement).

2.40. Net:

Address: 0068_H; n = 4. read only register.
Format: signed hexadecimal (two's complement).

2.41. A/D converter points:

Address: $006A_H$; n = 4. read only register.
Format: signed hexadecimal (two's complement).

2.42. Checkweigher result:

Address: $006C_H$; n = 4. read only register.
Format: signed hexadecimal (two's complement).
Description: result value is a net measurement value. If the result is not available this register is set to FF FF FF FF. This value can be reset by the *'Clear'* command or by an input assigned to this function.

2.43. Peak control maximum value (Max):

Address: $006E_H$; n = 4. read only register
Format: signed hexadecimal (two's complement).
This value can be reset by the *'Clear'* command or by an input assigned to this function.

2.44. Peak control minimum value (Min):

Address: 0070_H; n = 4. read only register.
Format: signed hexadecimal (two's complement).
This value can be reset by the *'Clear'* command or by an input assigned to this function.

2.45. Peak control Peak to Peak value:

Address: 0072_H; n = 4. read only register.
Format: signed hexadecimal (two's complement).
This value can be reset by the *'Clear'* command or by an input assigned to this function.

2.46. Command register :

Address: 0074_H; n = 2
Format: hexadecimal. See table.
Description: the command register is used to send functional commands. Their state is given by the response register(address *0077_H*).

- **Note: a new command is accepted, only if the command register is in IDLE state.**

code	functionality	note
0000_H	**set command register to idle state**	**IMPORTANT**: Must be written before any other functional command.
0035_H	clear Tare	deletes current tare value
0036_H	dynamic zero acquisition	in Checkweigher mode, limited to a ±10% range of the capacity. Zero value determined with this command can't be stored in EEPROM.
0037_H	output 1 activation	can be used if output 1 is assigned to the function *'level on request'*
0038_H	output 2 activation	see previous command *'output 1 activation'*
0039_H	output 1 inhibition	be used if output 1 is assigned to the function *'level on request'*
$003A_H$	output 2 inhibition	see previous command *'Output 1 inhibition'*
0080_H	reset	same effects as device power-up
0081_H	**EEPROM storage**	
$00C8_H$	**put in calibration mode**	starts a physical calibration procedure
$00C9_H$	zero acquisition	1st step of physical calibration
$00CA_H$	calibration with load 1	2nd step of physical calibration
$00CB_H$	calibration with load 2	3rd step of physical calibration (optional)
$00CC_H$	calibration with load 3	4th step of physical calibration (optional)
$00CD_H$	**save calibration**	EEPROM storage of calibration (theoretical or physical)
$00CE_H$	restore ***eNod3-C*** default parameters	***eNod3-C*** returns to its factory configuration
$00CF_H$	zero	limited to a ±10% range of the maximum capacity. Zero value used with this command can't be stored in EEPROM.
$00D0_H$	tare	
$00D1_H$	zero adjustement	saves zero value acquired with this command with the *'save calibration'* command
$00D2_H$	clear status	Bits b13 and b14 of status at address 0063_H are set to zero.
$00D3_H$	abort calibration	leaves the calibration procedure before it ends
$00D4_H$	**sensitivity adjustment**	adjustment with sensor's sensitivity and capacity, must be followed by the *'save calibration'* command
$00EA_H$	clear	resets the values determined by ***eNod3-C***
$00F1_H$	start cycle	starts an new checkweigher or peak control cycle
00F2	stop cycle	end of the checkweigher cycle, a new result is calculated

2.47. Response register:

Address : 0077_H; n = 2. read only register.
Format: hexadecimal. See table:

Code	functionality	note
0000_H	command register idle state	see command register code 0000_H
0001_H	command in progress	
0002_H	command achieved	
0003_H	error	Command execution cancelled

The response register gives an indication about the state of the command sent to ***eNod3-C*** through the command register.

2.48. Checkweigher number of cycles :

Address: $007A_H$; n = 4. read only register.
In checkweigher functioning mode, the number of complete cycles can be read through this register. This value can be reset by the *'Clear'* command or by an input assigned to this function.

2.49. Checkweigher running total :

Address: $007C_H$; n = 4. read only register.
Format: signed hexadecimal (two's complement).
In checkweigher functioning mode, the cumulated value of the checkweigher results can be read through tihis register. This value can be reset by the *'Clear'*command or by an input assigned to this function.

2.50. Checkweigher average value:

Address: $007E_H$; n = 4. read only register.
Format: signed hexadecimal (two's complement).
In checkweigher functioning mode, the average result can be read through this register. This value can be reset by the *'Clear'*command or by the an input assigned to this function.

2.51. Checkweigher standard deviation :

Address: 0080_H; n = 4. read only register.
Format : floating hexadecimal single precision (32 bits).
In checkweigher functioning mode, the standard deviation is caluclated after each complete cycle. This value can be reset by the *'Clear'*command or by an input assigned to this function.

2.52. Read inputs:

Address: 0082_H; n = 2. read only register.
Format: binary. Bit b0 is assigned to input E1; bit b1 is assigned to input E2.

2.53. Read outputs:

Address: 0083_H; n = 2. read only register.
Format: binary : Bit b0 is assigned to output S1; bit b1 is assigned to output S2.

2.54. Checkweigher result quality:

Address: 0084_H; n = 4. read only register.
Format: floating hexadecimal single precision (32 bits).
A value image of the quality of the result is determined. This value is the standard deviation of the measurements acquired during the measurement time. A low value means a good checkweigher result.

3. APPENDIX A : EXAMPLES

3.1. Physical calibration:

Follow the next steps:

1) Configure the Analog to Digital 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 calibration segments (1 segment by default); 3 (maximum) segments will only be used for a non-linear installation.
4) Another linearization possibility is an order 2 polynomial correction; in that case calibration is done with 1 segment.
5) Define the corresponding value for each calibration segment. Values are between 0 and 1000000_d.
6) Use the '*Put in calibration mode*' command to start calibration.
7) Be sure that the loading platform is empty, then send the '*zero acquisition*' command. This zero acquisition may take some time depending on the stability of measurements and the chosen motion criterion. Do not touch the loading platform during this sequence.
8) Read the response register to check if the zero acquisition is successful.
9) Put on the loading platform the first calibration load, then enter the '*Physical calibration with load 1*' command. Like the zero acquisition, the calibration may take some time.
10) Read the response register to check if the calibration with load 1 is successful.
11) Continue if necessary with loads 2 and 3 (steps 9 and 10).
12) Send the '*save calibration*' command.

- **Note 1**: Change the stability interval parameter settings if the different calibration steps take too long.
- **Note 2**: For tension-compression type sensors for which bipolar operation was selected, calibration is done only with loads to the positive direction, and the negative part is assumed to be symmetrical.

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

command or response descriptive	data frame sentt to *eNod3-C*	response	note
calibration loads : 17000, 39200 and 54800 and 3 segments	01 10 00 02 00 07 0E 00 00 42 68 00 00 99 20 00 00 D6 10 00 03 0D 56		
acknowledgement		01 10 00 02 00 07 20 0B	
command register set to idle state	01 06 00 74 00 00 C9 D0		
acknowledgement		01 06 00 74 00 00 C9 D0	
put in calibration mode	01 06 00 74 00 C8 C8 46		
acknowledgement		01 06 00 74 00 C8 C8 46	
command register set to idle state	01 06 00 74 00 00 C9 D0		
acknowledgement		01 06 00 74 00 00 C9 D0	
zero acquisition	01 06 00 74 00 C9 09 86		
acknowledgement		01 06 00 74 00 C9 09 86	
read response register	01 03 00 77 00 01 34 10		
		01 03 02 00 **01** 79 84	command execution in progress
read response register	01 03 00 77 00 01 34 10		
		01 03 02 00 **02** 39 85	command achieved
command register set to idle state	01 06 00 74 00 00 C9 D0		
acknowledgement		01 06 00 74 00 00 C9 D0	
calibration with load 1	01 06 00 74 00 CA 49 87		
acknowledgement		01 06 00 74 00 CA 49 87	
read response register	01 03 00 77 00 01 34 10		

		01 03 02 00 **01** 79 84	command execution in progress
read response register	01 03 00 77 00 01 34 10		
		01 03 02 00 **02** 39 85	command achieved
command register set to idle state	01 06 00 74 00 00 C9 D0		
acknowledgement		01 06 00 74 00 00 C9 D0	
calibration with load 2	01 06 00 74 00 CB 88 47		
acknowledgement		01 06 00 74 00 CB 88 47	
command register set to idle state	01 06 00 74 00 00 C9 D0		
acknowledgement		01 06 00 74 00 00 C9 D0	
calibration with load 3	01 06 00 74 00 CC C9 85		
acknowledgement		01 06 00 74 00 CC C9 85	
read response register	01 03 00 77 00 01 34 10		
		01 03 02 00 **01** 79 84	command execution in progress
read response register	01 03 00 77 00 01 34 10		
		01 03 02 00 **02** 39 85	command achieved
command register set to idle state	01 06 00 74 00 00 C9 D0		
acknowledgement		01 06 00 74 00 00 C9 D0	
save calibration	01 06 00 74 00 CD 08 45		
acknowledgement		01 06 00 74 00 CD 08 45	

- **Note:** If necessary calibration can be readjusted with '*global span adjusting coefficient*'.

3.2. Theoretical calibration:

Example: ***eNod3-C*** with address 01_H. Sensor sensitivity : 2.3450mV/V. Sensor capacity: 11725g

command or response descriptive	command sent to *eNod3-C*	response	note
sensor capacity 11725	01 10 00 1A 00 02 04 00 00 2D CD AE 19		
acknowledgement		01 10 00 1A 00 02 60 0F	
sensor sensitivity = 2.3450mV/V	01 10 00 54 00 02 04 00 00 00 03 94 04 68 63		sensitivty coded in 10^{-5} mV/V
acknowledgement		01 10 00 54 00 02 00 18	
command register set to idle state	01 06 00 74 00 00 C9 D0		
acknowledgement		01 06 00 74 00 00 C9 D0	
sensitivity adjustment	01 06 00 74 00 D4 C9 8F		
acknowledgement		01 06 00 74 00 D4 C9 8F	
command register set to idle state	01 06 00 74 00 00 C9 D0		
acknowledgement		01 06 00 74 00 00 C9 D0	
zero acquisition	01 06 00 74 00 D1 09 8C		
acknowledgement		01 06 00 74 00 D1 09 8C	
command register set to idle state	01 06 00 74 00 00 C9 D0		
acknowledgement		01 06 00 74 00 00 C9 D0	
save calibration	01 06 00 74 00 CD 08 45		
acknowledgement		01 06 00 74 00 CD 08 45	

3.3. Correction of the initial calibration value:

Example: ***eNod3-C*** with address 01_H. Correction: + 0,025% :

command or response descriptive	command sent to *eNod3-D*	response	note
global scale correction coefficient : 1.025	01 10 00 0F 00 02 04 0F A3 E8 23 4F		coefficient is coded 1025000_d = $0FA3E8_H$
acknowledgement		01 10 00 0F 00 02 71 CB	
command register set to idle state	01 06 00 74 00 00 C9 D0		
acknowledgement		01 06 00 74 00 00 C9 D0	
EEPROM storage	01 06 00 74 00 81 09 B0		
acknowledgement		01 06 00 74 00 81 09 B0	

3.4. Transmitter mode :

Example: ***eNod3-C*** with address 01_H. Reading a net measurement :

command or response descriptive	command sent to *eNod3-C*	response	note
reading net measurement	01 03 00 68 00 02 45 D7		
net measurement		01 03 04 00 00 61 02 52 62	measurement = +0024834

3.5. Checkweigher mode:

Switching to '*Modbus protocol*, *checkweigher transmission on request, signal processing performed* '.

- trigger level: 500
- stabilization time: 35 ms
- measuring time: 65 ms
- inputs 1 and 2: '*None*' '*positive logic*'
- output S1: '*cycle in progress*', '*positive logic*'.
- output S2: ' *Checkweigher result available*', '*positive logic*'.

Example: ***eNod3-C*** with address 01_H:

command or response descriptive	command sent to *eNod3-C*	response	note
ModBus-RTU protocol / Checkweigher transmission on request / signal processing performed	01 06 00 2B 01 02 79 93		
acknowledgement		01 06 00 2B 01 02 79 93	
stabilzation time: 35ms measurement time: 65ms trigger level: 500	01 10 00 41 00 05 0A 00 23 00 41 00 00 00 00 01 F4 9C 9B		writing to 4 consecutive addresses
acknowledgement		01 10 00 41 00 05 50 1E	
E1 = E2 = None, positive logic, S1 = 'cycle in progress', S2 = Checkweigher result available	01 10 00 36 00 02 04 08 08 0A 0B B4 54		writing to 2 consecutive addresses
acknowledgement		01 10 00 36 00 02 A1 C6	
command register set to idle state	01 06 00 74 00 00 C9 D0		
acknowledgement		01 06 00 74 00 00 C9 D0	
EEPROM storage	01 06 00 74 00 81 09 B0		
acknowledgement		01 06 00 74 00 81 09 B0	
command register set to idle state	01 06 00 74 00 00 C9 D0		
acknowledgement		01 06 00 74 00 00 C9 D0	
reset	01 06 00 74 00 80 C8 70		
acknowledgement		01 06 00 74 00 80 C8 70	

reading of measurement	01 03 00 6C 00 02 04 16		
response		01 03 00 6C 04 FF FF FF FF BE 4D	measurement not available
reading of measurement	01 03 00 6C 00 02 04 16		
response		01 03 00 6C 04 00 00 61 02 17 88	measurement = 24834

3.6. Peak control mode :

Example:

- setting to '*Triggered peak control*'
- input E1: '*Measurement window*', '*positive logic*'; Input E2: '*None*', '*positive logic'.*
- output S1: '*E1 image*', '*Positive logic;*' output S2: '*set point*', '*positive logic*'.
- set point 2 high value = 55000
- set point 2 low value = 45000
- set point 2 '*functioning in window'* set to '*Max'*.

Example: ***eNod3-C*** with address 01_H:

command or response descriptive	command sent to *eNod3-C*	response
triggered peak control	01 06 00 2B 01 04 F9 91	
acknowledgement		01 06 00 2B 01 04 F9 91
E1 = 'functioning in window', positive logic E2 = None, positive logic S1 = E1, positive logic S2 = Set point 2, positive logic	01 10 00 36 00 02 04 08 0C 08 0D 74 F7	
acknowledgement		01 10 00 36 00 02 A1 C6
set point 2 high value = 55000	01 10 00 38 00 02 04 00 00 D6 D8 AF 27	
acknowledgement		01 10 00 38 00 02 C0 05
set point 2 low value = 45000	01 10 00 3A 00 02 04 00 00 AF C8 0C A2	
acknowledgement		01 10 00 3A 00 02 61 C5
set point 2 functioning in window, set to Max,	01 06 00 40 04 00 8A DE	
acknowledgement		01 06 00 40 04 00 8A DE
command register set to idle state	01 06 00 74 00 00 C9 D0	
acknowledgement		01 06 00 74 00 00 C9 D0
EEPROM storage	01 06 00 74 00 81 09 B0	
acknowledgement		01 06 00 74 00 81 09 B0
command register set to idle state	01 06 00 74 00 00 C9 D0	
acknowledgement		01 06 00 74 00 00 C9 D0
reset	01 06 00 74 00 80 C8 70	
acknowledgement		01 06 00 7E 00 80 C8 70

4. APPENDIX B : MODBUS-RTU CRC-16 ALGORITHM

- **Note :** The CRC 16 is calculated on the whole frame but contrary to the datas contained , the first CRC16 emitted byte is the LSB.