PROFIBUS ENCODER

INSTALLATION MANUAL

Rel. 2.0

Ver. 20060416

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1. INTRODUCTION TO PROFIBUS STANDARD

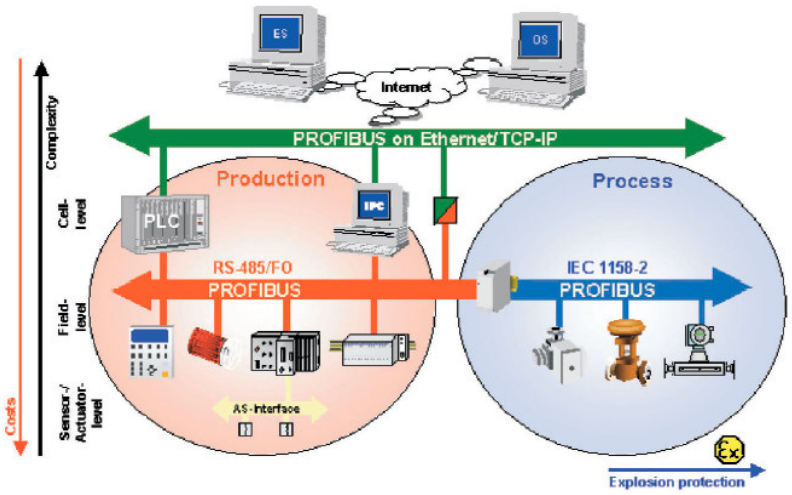


Figure 1 – Industrial Profibus Network

1.1 Profibus General Information

PROFIBUS (Process Field Bus) is a serial communications standard for devices related to automation networks (field bus). It is an open protocol defined by the DIN 19245 that became European standard as EN 50170 volume2. Profibus is promoted by Siemens and is widely diffused all over Europe. Thanks to the definition of three different communication profiles DP, FMS and PA. This field bus is suitable for many requirements in automation systems; starting with applications requiring a high cyclical exchange speed of a reduced number of bits (Profibus DP), until the management of complex communications between “intelligent” devices (Profibus FMS) or tasks strictly related to automation process (Profibus PA).

Hereinafter the attention will be focused on the DP version (decentralized periphery), which is the standard solution to manage devices by a bus. These devices usually are I/O modules, sensors/transducers or actuators on a low level in automation systems.

1.2 PROFIBUS DP CHARACTERISTICS

- **NETWORK TOPOLOGY :** It is a common bus structure (ended on both sides) where up to 126 devices can be connected at the same time. If the physical support is an RS485 interface, up to 32 nodes can be inserted without using signal repeaters/re-generators.

- **PHYSICAL LAYER:** Optical fiber connection can be used in addition to the RS485 differential serial technology transmission. Anyway, DP and FMS devices can co-exist in the same network. They use the same physical interface communication (they are the same levels 1 and 2 of the ISO/OSI stack). The standard established requires an extremely precise communication BaudRates between 9.6 kBaud (min) and 12 MBaud (max).

- **DEVICES PRESENT IN THE NETWORK:** it is possible to divide the devices into three classes: class 1 Master DP(DPM1), class 2 Master DP (DPM2) and Slave. The class 1 includes all the devices that cyclically exchanges information with distributed peripheral (they can directly manage the I/O network data with the other nodes, mainly slaves). Class 2 masters are designated to con-figure and to monitor network status and devices connected to it. Slaves have the task of directly exchanging information with the external world in both directions (in and out). Typical examples of slaves are digital I/O, encoders, drivers, valves, various transducers, etc.

- **BUS ACCESS METHODS**: Two configurations are available in a bus with single or multi master operating ways: the 'Token Passing' one, for exchanging information about network management between possible available masters, and the well known 'polling interrogation' for the master-slave communication.

- **MAIN FUNCTIONS**:

  The main characteristics implemented in the Profibus DP protocol are as follows:

  Periodic data exchange: after the slave initialization step, each master is configured in order to exchange a maximum of 244 input bytes and 244 output bytes with each slave. The effective data exchange rate is based on the selected BaudRate, on the nodes present in the network and on the specific bus settings. Considering the maximum data exchange rate of 12 Mbaud, the Profibus DP is one of the fastest field buses.

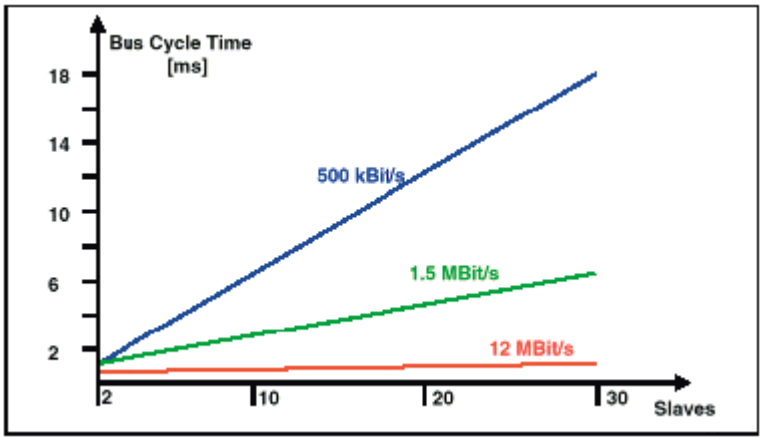


Figure 2 – Cycle time of monomaster DP network

Synchronization : Command controls are available (they are sent by the master in multicast) in order to give the possibility to create a synchronous acquisitions through a slave, a group of them or all the slaves (Freeze Mode). Outputs sent to the slave have similar behavior. (Sync Mode).

Parameterization and configuration security : the system goes into a safe status after a preset period of time, if the communication between the master/s and the slave/s is not repeated.

Diagnostic functions : for each slave can be requested to the master to be set up for reading its own diagnostic. In such way any possible problem in the slave can be easily localized. The diagnostic can contain up to 244 bytes of information. Among them, the first six are mandatory for each DP slave.

Dynamic slave management : There is the possibility to activate or deactivate slaves present in the network. Moreover, it is possible to change through the bus the slaves addresses that make possible that function.

Easy network configuration: main characteristics of each device present in the network are listed in a GSD file, complying to Profibus specifications. This makes easy setting up and configuring the device through graphic tools suitable for the purpose, such as the Siemens COM PROFIBUS software. As mentioned, the master-slave data exchange takes place periodically depending on the topology of the network and on the number of nodes present. However, before this step the slave has to be successfully parameterized and configured.

Parameter setting: the master sends to the slave a series of parameters necessary to specify its operation. The standard requires 7 bytes containing the mandatory information for the slave. Additional data can start from the eighth byte in the DU field (Data Unit, for more information see the Profibus DP) up to a maximum of 244 bytes for the communication frame.

2 ENCODER CHARACTERISTICS

2.1 Presentation

The Eltra multiturn Profibus encoder series (Identification Number 0x0599) is complying to the Profibus DP standard as described on the European Standard EN 50170 Volume 2. Particularly, Eltra Profibus encoders are according to “PROFIBUS Profile for Encoders, Order No. 3.062”. The Profibus DP interface maintains the same maximum resolution and characteristics (8.192 Pos/turn and 4.096 revolutions) of the stand-alone version but adds the plus of the Profibus DP network.
By the Profibus DP network is possible:

- Get the indication of the angular position from the encoder (during the periodic data exchange).
- Set the resolution on the single turn and on the revolutions (during the set up).
- Change the defaults increase direction count (during the set up).
- Perform the PRESET operation. (Set the encoder read to a specific position).
- Read the diagnostic operating mode.
- Info about the code supplied by the device.
- Set the activation threshold for ALARM and WARNING signals upon the code control.

Directly from the device it is possible :

- Display the ON/OFF status
- Display the device activity on the bus
- Give a RESET (Set the encoder current code to 0)
- Set the device address
- If requested insert on the bus the termination resistance.
- Change the count direction

3 FUNCTIONS

3.1 Device Classification

Among the characteristics and functions of this device, we consider first of all the class:

- The **Class 1** identifies a specific function concerning a type of products which main characteristic is that some characteristics are compulsory; the supported functions are:

FUNCTIONS	OCTET	TYPE OF DATA	DESCRIPTION
Data_exchange	1-4	Unsigned 32	Position value (in)
Data_exchange	1-4	Unsigned 32	Preset value (out)
RD_inp	1-4	Unsigned 32	Position value
Slave_diag	7	Octet	Ext. Diagnostic header
Slave_diag	8	Octet	Allarms
Slave_diag	9	Octet	Operating status
Slave_diag	10	Octet	Encoder type
Slave_diag	11-14	Unsigned 32	Singleturn resolution
Slave_diag	15,16	Unsigned 16	Number of revolution
Set_prm	9	Octet	Operating parameters

- The **Class 2** supplies all the functions of the Class 1 and optionally the functions as follows:

FUNCTIONS	OCTET	TYPE OF DATA	DESCRIPTION
Slave_diag	17	Octet	Additional alarms
Slave_diag	18,19	Octet	Supported alarms
Slave_diag	20,21	Octet	Warning
Slave_diag	22,23	Octet	Supported warning
Slave_diag	24,25	Octet	Profile version
Slave_diag	26,27	Octet	Software version
Slave_diag	28-31	Unsigned 32	Operating time

Slave_diag	32-35	Signed 32	Offset value
Slave_diag	36-39	Signed 32	Manufactured offset value
Slave_diag	40-43	Unsigned 32	Measuring units per revolution
Slave_diag	44-47	Unsigned 32	Total measuring range in measuring units
Slave_diag	48-57	Ascii string	Serial number
Slave_diag	58-59		Reserved for future use
Slave_diag	60-63		Manufactured specific diagnostic

3.2 How to choose the class

The choice of the device class depends on the characteristics of parameterization and setting. In fact, the class 1 is enough if the mono-or multiturn encoder has only to have the next additional characteristics: standard alarms and turn direction programming.

Instead, if you want to modify also the resolution on the single turn or on the revolutions (scaling), or an extended alarm range besides a series of warnings, it is necessary to choose a class 2 device.

Obviously it doesn't limit the available parameterization of the master on the slave; in fact if a device is set by master as belonging to the superior class, some optional characteristics of the class 2 can be available also on a class 1 device.

The slave class doesn't bind the master's one, besides a class 2 device can be downgraded to a class one, loosing the mentioned characteristics.

3.3 Specific characteristics

The Eltra multiturn Profibus encoder has all the class 2 profibus characteristics, thus the supported functions are:

- Indication of the angle position coming out from the encoder obtainable from the device periodic exchange. The data provided by encoder first of all is analyzed inside and then, only if it is correct, it is will be sent in output.
- **Scaling Control,** or more simply how to set the resolution on a single turn or on the revolutions. So, we offer to the costumer a really powerful and flexible function that allows to re-set the encoder according to the different needs. We remind that through the network an encoder can achieve any singleturn resolution (from 1 to 8192) and any turn resolution (from 1 to 4096). It is possible to change the counting direction (during the setting

phase); it allows acquiring an increasing or decreasing code independently from the physical rotation direction of the encoder's shaft.

- **Preset** : the indication of the binary code provided by encoder can be set on a certain level. We recommend making that operation during the setting phase and when the encoder is stopped.
- Diagnostic function is indicated by network, both alarms and warnings.

All these functions are in the setting octet following the next order:

OCTET 9			
BIT	**DESCRIPTION**	**0**	**1**
0	Code sequence status	Increasing position values with clockwise rotation (viewed from shaft)	Increasing position values with counter clockwise rotation (viewed from shaft)
1	Class 2 functionality	Not supported	Yes
2	Commissioning diagnostics	Not supported	Yes
3	Scaling function status	Disabled	Enabled
4	Currently not assigned		
5			
6			
7			

4 DIAGNOSTIC

4.1 Alarms

As described in the profile " PROFIBUS – Profile for Encoders, Order No. 3.062" the encoders diagnostic in the class 2 is managed using alarms and warnings.

The main difference between the two typo of signals is that the alarms block the normal encoder function, that is the updating output code is not anymore supplied, while a warning signals an anomaly, but the encoder still continues working.

The active alarms are those ones set on high level in the 19th octet, as follows:

OCTET 19								
BIT	7	6	5	4	3	2	1	0
BIN	0	0	0	0	0	0	0	1
FUN.	/	/	/	M.E.	C.D.	C.H.	S.V.	P.E.
HEX	**0**				**1**			

Considering the above table, the active alarms are:

- **Position error**, it is mentioned as soon as the code doesn't respect anymore the Grey code's consecutive characteristic, following the characteristics set in the scaling operation.

As a result, the alarms are set in the 19th byte, while they are signalled in the 8th diagnostic byte.

4.2 Warnings

Active warnings are those ones set on high level in the 23rd octet, as follows:

OCTET 23								
BIT	7	6	5	4	3	2	1	0
BIN	0	0	0	1	0	0	0	1
FUN.	/	R.W.	B.W.	O.T.L.	C.W.S.	L.C.	T.W.	F.W.
HEX	**1**				**1**			

As codified by the hex code in the octet number 23, the provided warnings are:

- **Frequency warning**, active in the case there is an overcoming of the code frequency due to an overcoming of the speed concurred from the particular one scaling applied from the customer. This warning marks a too much elevated frequency for one particular resolution but not a code error.
- **Operating time limit warning,** active after the overcoming of the temporal threshold (some years) set up from the manufacturer. From that date the manufacturer considers that the device one has the necessity of a control, even if it remains working.

As a result, the warnings are set in the 23th byte, while they are signalled in the 8^{21h} diagnostic byte.

The integrity level warning supplied by the encoder is available in the extended diagnostic and in particular it is marked in the **Diagnostica Specifica del Dispositivo (Specific Device Diagnostic)** in the octet 60.

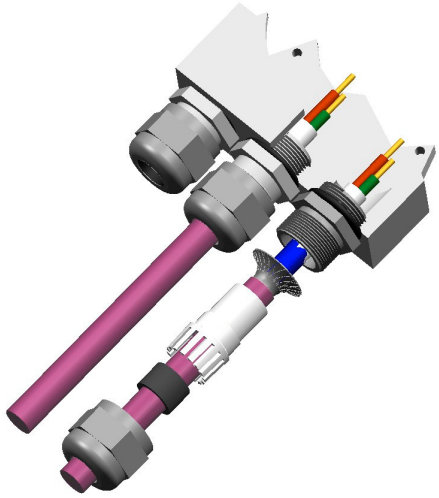
OCTET 60								
BIT	7	6	5	4	3	2	1	0
BIN	0	0	0	0	0	0	0	1
FUN .	/	/	/	/	/	/	/	W.P.E.
HEX	**0**				**1**			

4.3 Hardware signals

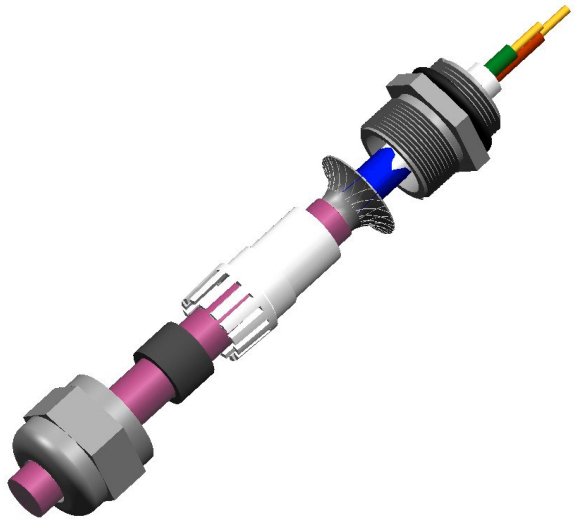
Besides the signals via network it is also possible on a local level to estimate the state of functionality of the device, using the two led placed on the back.
As it will be pointed out in the part concerning the hardware installation the **green** led indicates the state ON/OFF of the device, while the **red** one indicates the modality of access to the network of the device. In fact when it is off, it indicates that the slave is in state of periodic exchange with the master.

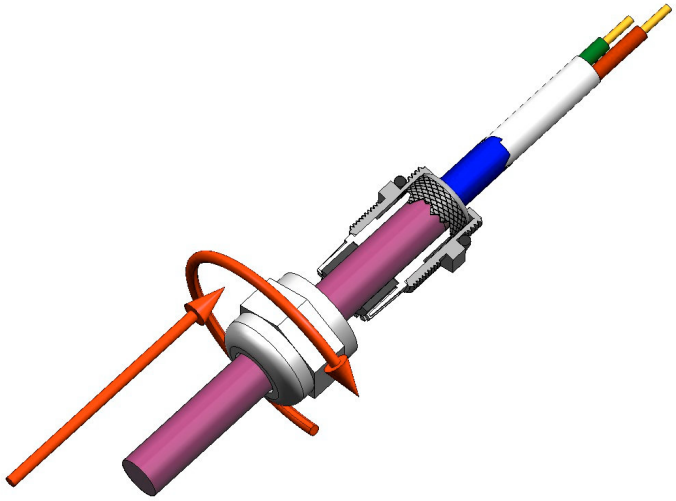
4.4 Installation and operation precautions

	Use of warning and alarm bits is essential for the safety reasons. These bits are provided by the device according to the Profibus DP standard.
	Assembling and installing personnel must be qualified. It's compulsory to carefully follow user's guide.
	Check the ground connection of the device body. If it is not available, provide additional external connection.
	The working area has to be free of corrosive agents (acids, etc.) or substances that are not compatible with the IP class of the device.
	Before powering on the system, always verify the voltage range is applicable to the device and protect it from exceeding the stated technical specifications.
	Connect power supply and signal cables in order to avoid capacitive or inductive interferences that may cause malfunction of the device.
	Use only network cables complying to the Profibus DP standard. Use only properly shielded power supply cables.
	Connect carefully the device to the network.



Ensure a good contact of the cable shield with the skintop connector on the internal shielded rings.





Cable wiring must be performed in a POWER-OFF condition.

It is strictly forbidden to connect or disconnect the setting cover and connectors in a POWER-ON status. This may cause permanent damages.

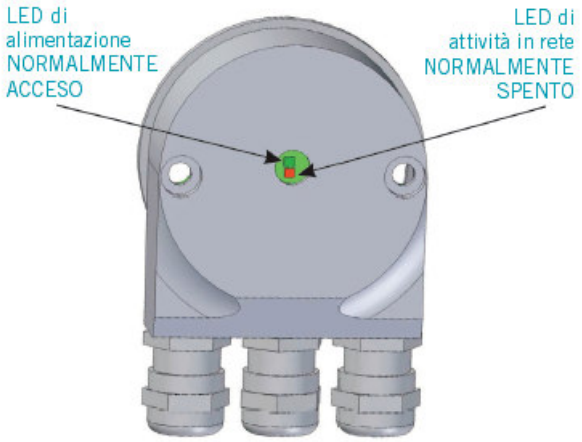
	For safety reasons, we strongly recommend to avoid any mechanical or electrical modification. In that case, they will void the warranty.

Encoders must be used respecting to their specifications in order to avoid damages to the device or malfunctions to the system.

5 HARDWARE DEVICE INSTALLATION

Installing the Eltra Profibus encoder in a network requires the execution of the standard steps necessary for configuring any Profibus DP slave. The sequence of steps is as follows:

1. Commissioning the slave on the master (see corresponding paragraph).
2. Wiring the encoder into the Profibus network with or without using the terminations. It depends on the physical position of the devices on the bus
3. Set directly the address for the slave (It must be unique in the network and the same as the one chosen in point 1).
4. Preparing the master side application/s and setting up the Profibus network.

On the back cover of the encoder (see picture) there are a led inspection window and a cower that allows the plug access for the local settings device. The device operating status can be controlled by the two leds through the window. The green one shows the power presence and must be permanently switched on. The red led is switched off only during the periodic data exchange between the Profibus master and the encoder.	

In the Figure 4 the two dip-switches for termination line and the eight dip-switches used to choose the device address are shown. In the reported picture, due to fact that the termination of the bus on the encoder is not considered, the two line termination contacts are in the OFF status.

For addressing the device only the first seven dip switches among the eight available are used. The maximum number of devices connected in a Profibus network is 126 elements. Moreover, the LSB of the address code is the contact # 8 while the contact # 2 is the MSB. The eighth switch (1) is used for the inversion of the code.

5.1 Network connection

Considering the connection of the encoder to the Profibus network, it is possible to access the cables by three skintops (anyhow only two of them may be used).

Usually a skintop is used for the connection to the bus, a second one to continue the network connection and the last one, optionally, to supply the power to the encoder (if the power supply is not available by the network and by the RS-485 twin wire connection).

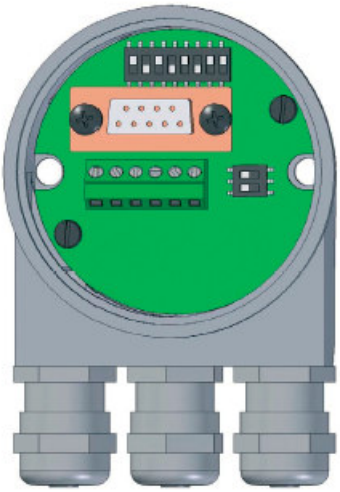
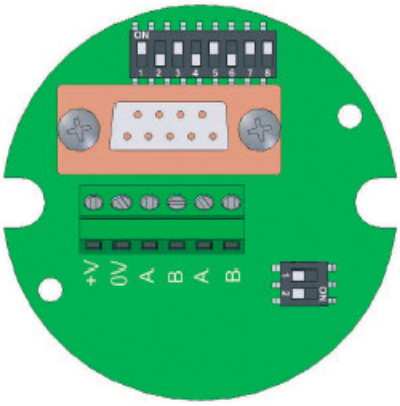


Figure 3 – Terminal block access

In order to access the terminal block unscrew the two screws on the rear plug and release the rear case from the main one by sliding it out from the sunken connector. Then proceed with wiring according to the serigraph on the connector and as reported on the following table:

+V: SUPPLY VOLTAGE	
0V: GROUND	
A: PROFIBUS DP LINE OUT (GREEN)	
B: PROFIBUS DP LINE OUT (RED)	
A: PROFIBUS DP LINE OUT (GREEN)	
B: PROFIBUS DP LINE OUT (RED)	

To set and configure the slave into the Profibus DP master (the 'commissioning' step) it is necessary to use the "Exx_0599.gsd" file delivered with the encoder and in any case available from our web site: www.eltra.it.

5.2 DIP-Switches settings

An example of Profibus line closing, device setting and the standard position of the address dip-switches is as follows:

Figure 4 – Standard settings

Figure 5 – Line closing

In this example a device LINE CLOSING address has been set. It corresponds to 1001101 as represented from bit 2 to bit 8, corresponding to 77 hex. Bit 1 is the 'inversion code' one which, in this example, is turned on.In questo esempio è stato impostato un indirizzo dispositivo pari a 1001101 dal bit 2 al bit 8, che corrisponde all'indirizzo decimale 77. Mentre il primo bit (1) corrisponde all'inversione delcodice che in questo esempio è attiva.

5.3 Network characteristics

Usually, an A type cable is adopted to make a DP/FMS network. This cable has specifications as follows:

Parameter	Cable type A
Characteristic impedance in Ω	135 ... 165 at a frequency of (3...20 MHz)
Operating capacity (pF/m)	< 30
Loop resistance (Ω/km)	< =110
Core diameter (mm)	> 0.64 *)
Core cross-section (mm²)	> 0.34 *)

This cable allows an optimization of network utilization. In fact, it is possible to reach the maximum communication speed allowed (12 MBaud). However, there are some limitations due to the maximum physical dimensions of a bus segment as follows:

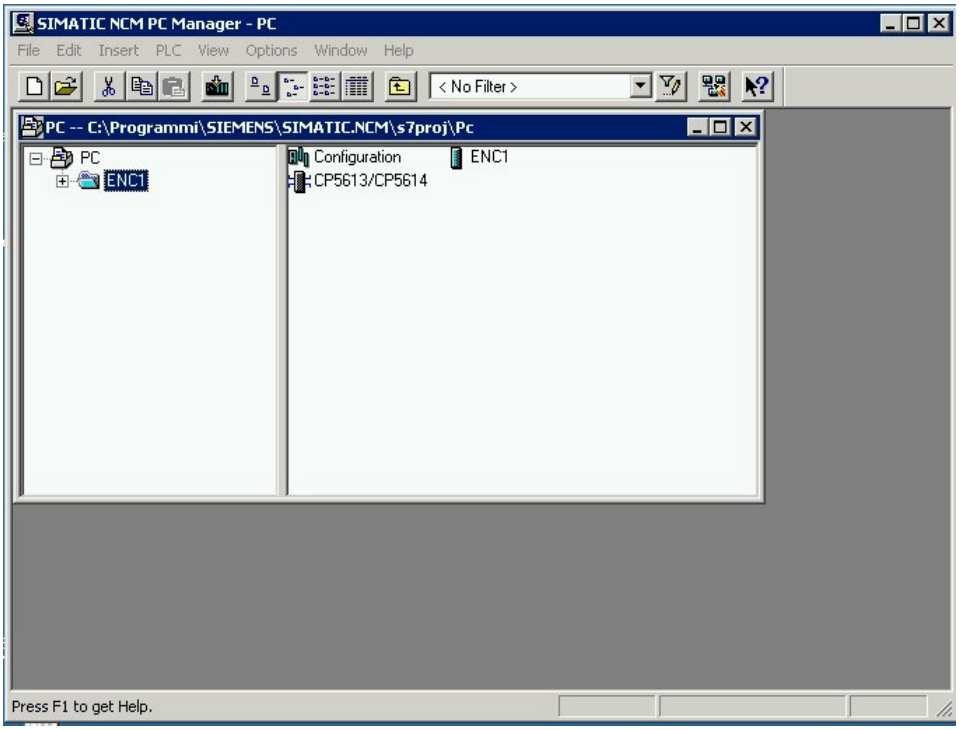
Data transfer rate in kbit/s	9.6	19.2	45.45	93.75	187.5	500	1500	3000	6000	12 000
Max. segment length in m	1200	1200	1200	1200	1000	400	200	100	100	100

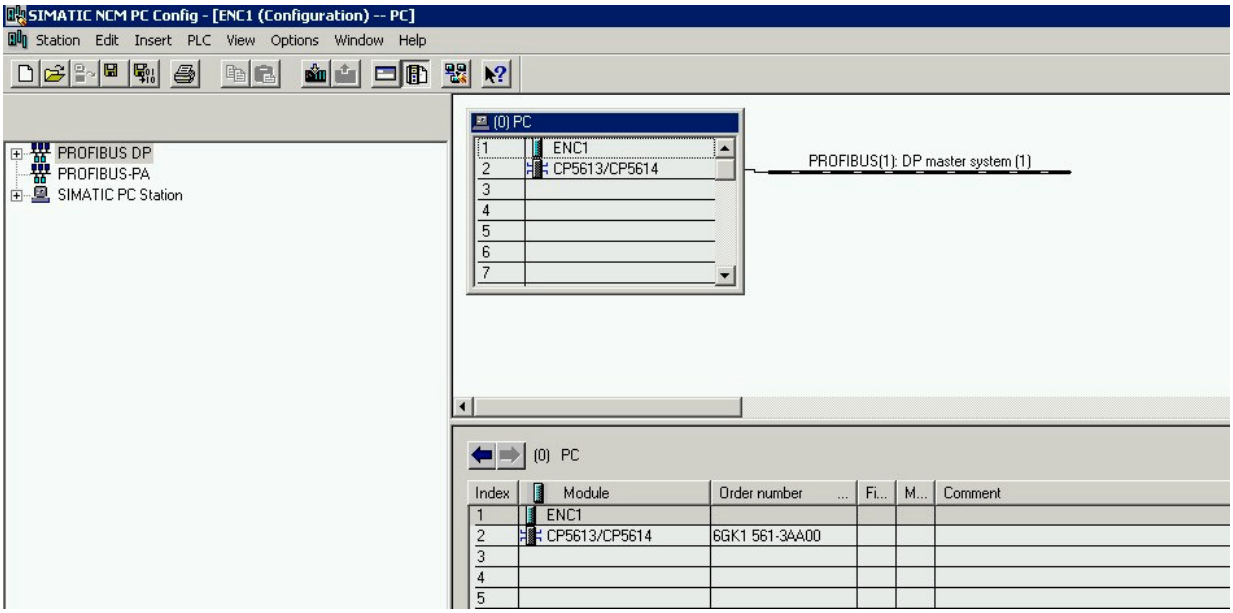
Finally, main physical and topographical specifications of a Profibus network are as follows:

Maximum number of stations participating in the exchange of user data	DP: 126 (addresses from 0 .. 125) FMS: 127 (addresses from 0 .. 126)
Maximum number of stations per segment including repeaters	32
Available data transfer rates in kbit/s	9.6, 19.2, 45.45, 93.75, 187.5, 500, 1500, 3000, 6000, 12000
Max. number of segments in series	According to EN 50170, a maximum of 4 repeaters are allowed between any two stations. Dependent on the repeater type and manufacturer, more than 4 repeaters are allowed in some cases. Refer to the manufacturer's technical specification for details.

6 SOFTWARE INSTALLATION

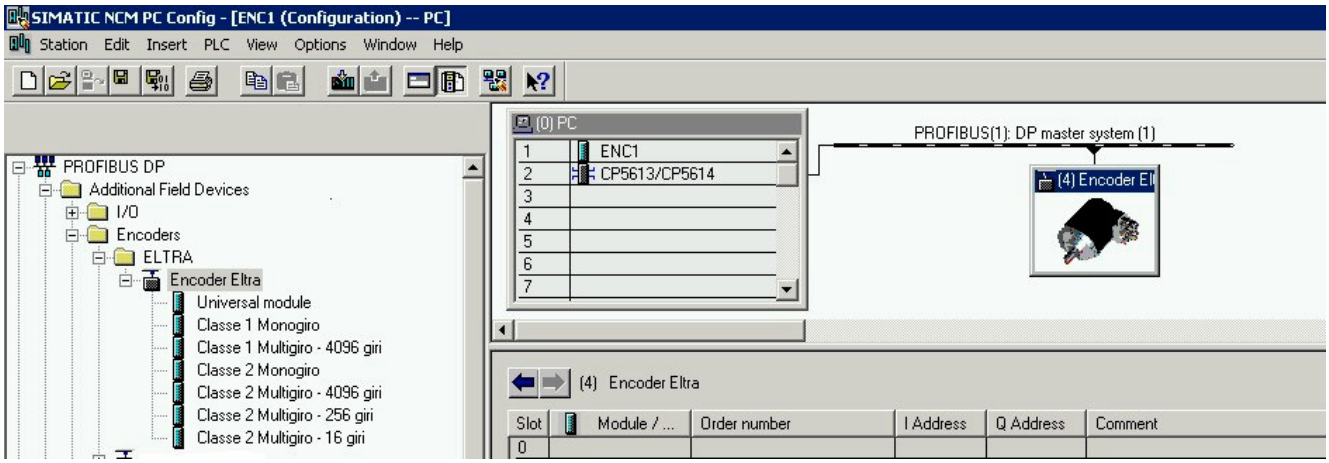
This installation guide briefly summarizes fundamental steps for the software connection of an Eltra profibus encoder using the SIMATIC NET tools and therefore it is addressed to already expert staff in the management of profibus DP networks. Supposing that the slave has been correctly installed and addressed it is possible to create through SIMATIC NCM PC Manager a new project.



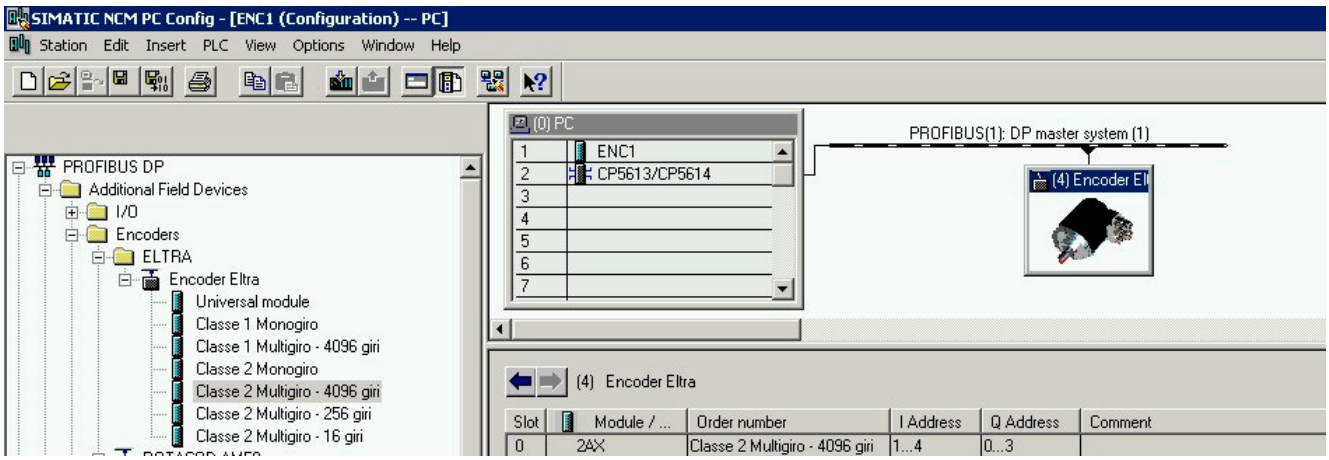


After that, activate the PC station which configuration is possible through SIMATIC NCM PC Config, install the GSD file **elt_0599** and finally to configure the master.

Now it is possible to build the profibus network selecting the suitable master and to couple to the network the encoder device. It is necessary just to drag it from the available PROFIBUS DP list, without forgetting to address it in agreement to the hardware setting.



Then, it is necessary to set the encoder profile configuration selecting the typology and the device class.Si passa poi alla configurazione del profilo encoder selezionando la tipologia e la classe del dispositivo.



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Three new different versions of firmware besides those already present in the previous version have been added. Each one is able to manage 4 (16 positions) - 8 (256 pos.) - 12 (4096 pos.) bit gears, and correspondent resolution turns, of the multiturn in class 2.

Therefore, the network configuratore has to consider the physical resolution of the acquired multiturn and has to load the suitable version to the available resolution per turns.

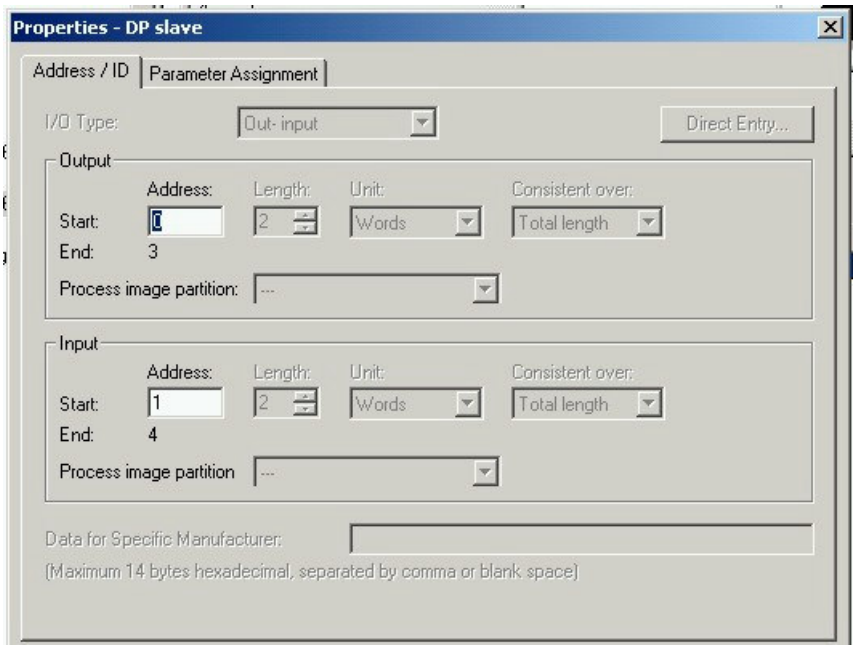
ES. A EAM63B 32 / 4096B…… has to be configured as the following device:

Class 2 Multiturn – 256 turns.

A EAM63D 2048 / 8192B…… has to be configured as the folllwoing follows:

Class 2 Multiturn – 4096 turns.

Once built the network, it is possible to set the operation characteristics by means of master properties.


Properties - DP slave
Address / ID
Parameter Assignment
I/O Type:
Out- input
Direct Entry...
Output
Address:
Length:
Unit:
Consistent over:
Start:
0
2
Words
Total length
End:
3
Process image partition:

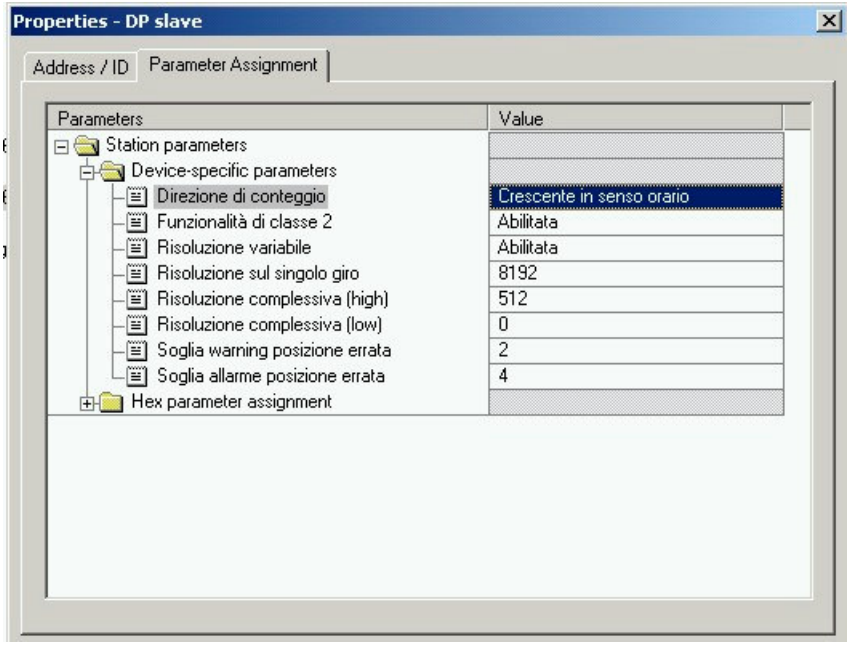
Input
Address:
Length:
Unit:
Consistent over:
Start:
1
2
Words
Total length
End:
4
Process image partition

Data for Specific Manufacturer:
(Maximum 14 bytes hexadecimal, separated by comma or blank space)

7 DEVICE PARAMETRIZATION

This is such an important step and it follows the installation and the device configuratio. Moreover, it characterizes the functionalities. Therefore, the slave proprieties has to be activated and the device characteristics has to be specified, such as the counting direction, class functions, etc.

Considering the resolution, compatibly to the custom demand, the maximum resolution per turn is equal to 8192, while the maximum on turns is equal to 4096 as reported below.



The total resolution is split in two words of 16 bits each one. The field (**high**) specifics the total resolution that exceeds the first 16 bits, and it is for this reason that in the field (**high**) does not appear number 4096 but 512.

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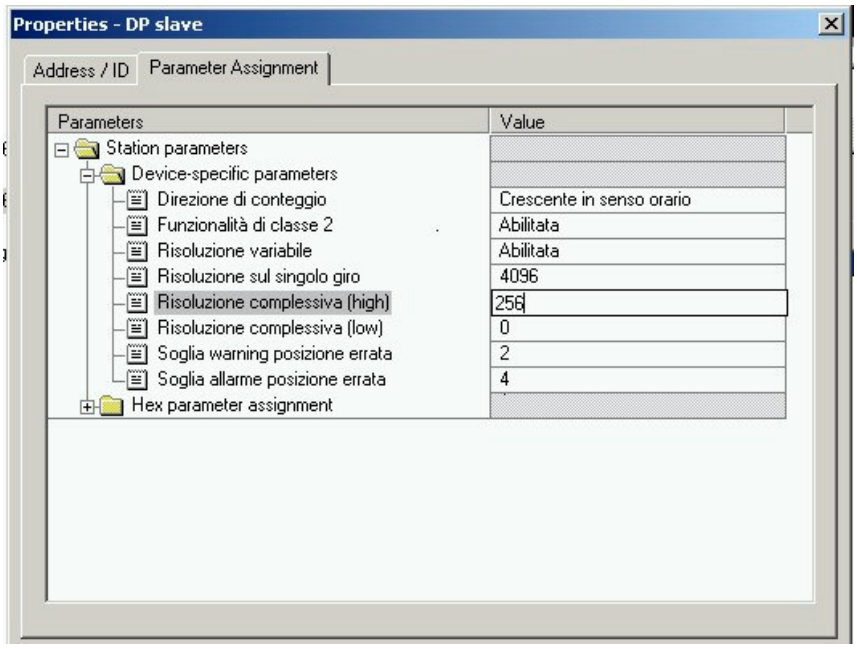


In order to explain better the parameterizing you can consider the bellow reported tables that recall the mentioned parametrizations.

In the first case the resolutions requested are 8192 per turn and 4096 per turns. So, the resolution per turn has to be written directly in the appropriate field, while the one per turns is split in two words as we have already mentioned. In fact:

8192 (13 bits) X 4096 (12 bits) = 33.554.432 (25 bits) if we consider these 25 bits as two separate words, aligning to the right we obtain:

	Res. Turns	**Res. Single tutn**
Physic resolution	4096 (12 bit)	8192 (13 bit)
Repart. Bits between words	512 (9 bit)	65536 (16 bit)
Parametrization	512 (high)	0 (low)

In the second case the resolutions requested are 4096 per turn and 4096 per turns. So, the resolution per turn has to be written directly in the appropriate field, while the one per turns is split in two words. In fact:

4096 (12 bits) X 4096 (12 bits) = 16.777.216 (24 bit) if we consider these 24 bits as two separate words, aligning to right we obtain:

	Res. Turns	Res. Single tutn
Physic resolution	4096 (12 bit)	4096 (12 bit)
Bits division between words	256 (8 bit)	65536 (16 bit)
Parametrization	256 (high)	0 (low)

Besides, it is possible to set different resolutions that we have not considered before, power of 2, and to provide the encoder with codes in power of 10 (1000 Cod.Turn x 100 Turns) or directly in mechanical degrees (360 Cod. Turn x 10 Turns). However never exceed the maximum physically available resolution that is indicated on the product's label.

In the case that you don't use the power of 2, then the following formula can be useful:

$$\frac{\text{COSTUMER RESOLUTION}}{\text{ENCODER RESOLUTION IN } 2^X} \times \text{VALUE IN } 2^X = \text{VALUE SCALED IN OUTPUT}$$

The difference between the outgoing value and the real one is due to the fact only the integer part had been considered.

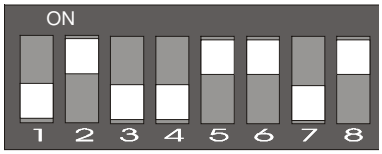
7.1 Preset Function

The value of preset to which the encoder's level can be loaded is defined as data (binary) placed in outgoing and managed in the **Exchange Date** step. The data has the canonical dimension of the 4 bytes and the Preset function is activated from the high logical value on the 31st bit (**Preset**).

Status bit							Resolution Turns												Resolution Turn											
P							12 bits per turns (4096)												13 bits per turn (8192)											
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

7.2 Count inversion function (Up – Down) .

This function is for default activated only in remote modality; therefore it is settable in phase of parameterization. Consequently, the **dip-switch 1** on the setting cap in this case indicates only rotation direction.



It is possible to change the encoder counting direction also on-board using directly the device by setting the **dip-switch 1**. This operation has to be preceded by a data exchange setting the 30th bit to a high logical state (Rotate).

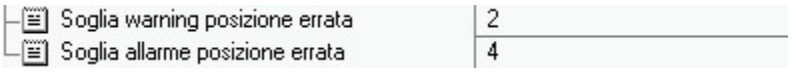
In this way, the direction control is transferred on the device upon the restart of the encoder for the setting updating.

Status bit							Number of turns													PPR											
	R						12 bit (4096 turns)													13 bit/turn (8192 ppr)											
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

7.3 Setting system updating and wrong position signals

In this new firmware version a double level of errors signalling has been implemented. It consists in a real alarm and in a warning signal.

Two specific and distinguished parameters (one for warning and one for the alarm) determine the threshold values that cause the activation of the warning and/or alarm signals are determined. Both are present in the GSD file and so modifiable by the customer.



Threshold settable values are from 1 to 10. The tolerance margin is higher as the number to which it refers to is higher (2 is more tightening than 6). It is possible to deactivate completely both warning and alarm signals by

setting the particular value 99. The setting of other values, not that one pre-established, will cause a wrong parametrization and consequently not visibility of the device in network.
Usually the alarm threshold will be higher or equal to warning one.
(ALL >= WAR).

In case of the activation of the warning, only a signal will be send to the master, signalling the anomaly, but without other consequences. Such condition will last the entire time in which will be had the overcoming of the relative errors threshold. The warning state is marked on the 60th byte of the diagnostic, in the **Diagnostica Specifica del Dispositivo (Diagnostic Detailed list of the Device)** typology.

In case of the activation of the alarm, a **Diagnostica Statica (Static Diagnostic)** signal – byte 8 – will be send to the master, but differently from the previous version the encoder's working process will not be stopped, avoiding undesirables machine stops.