WHAT IS AN ENCODER ?

The encoder is a transducer of position and speed which converts the angular or linear motion of a shaft (or axle) into a series of electrical digital pulses.

These electrical pulses are employed to control the motion of the mechanical shaft (that has generated them).
The encoder is composed by:

· **Mechanical interface**
· **Code wheel (or magnetic actuator or linear scale)**
· **Optoelectronic receiver (or magnetic sensor)**
· **Electrical interface**

Main technologies used in encoders to detect the signals are:

· **Photoelectrical or optical scanning (rotary or linear)**
· **Magnetic field variations (rotary or linear)**
· **Potentiometer (rotary or linear)**
· **Magnetostrictive effect (linear)**
· **Energy Harvesting Effect (rotary)**

Main applications of rotary and linear transducers are: machine-tools, material processing machinery, robots, motor feedback systems, measure and motion control devices.

MECHANICAL INTERFACE

The mechanical interface consists in all those components that allow the coupling of the encoder to the machine or device of application, which are:

1. An **axle**, connected to the shaft of the machine in rotation, designed in accordance to the type of fixing: **solid** or **blind/through hollow shaft**;
2. A **flange**, which fixes and adjusts the encoder to its support;
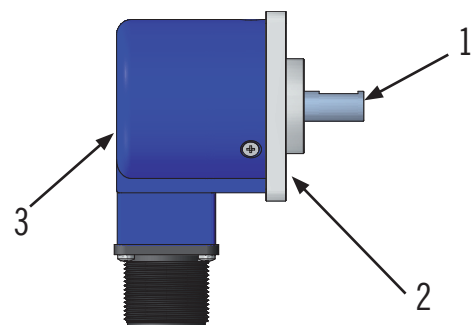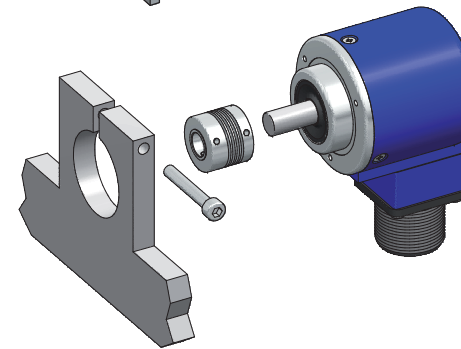
3. An **housing**, which contains and protects the disc and the electronic components.

Elastic couplings can also used to adapt the fixing between the motor shaft and the encoder.
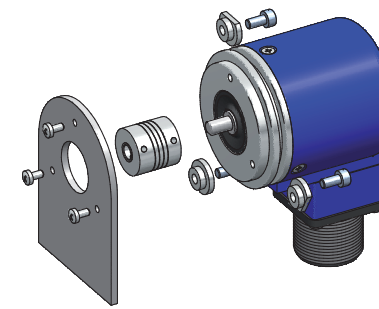
Some examples of encoders' mounting
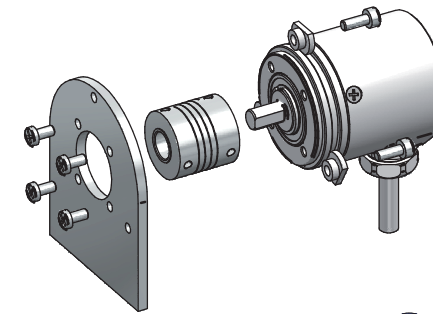
Solid shaft rotary encoder mounted by a fixing flange and the elastic coupling.
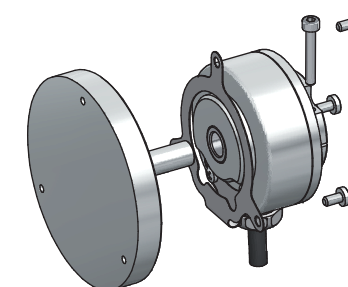
Solid shaft rotary encoder mounted by a clamping fixing.

Solid shaft rotary encoder mounted by a fixing flange (or by fixing clamps) and the elastic coupling.
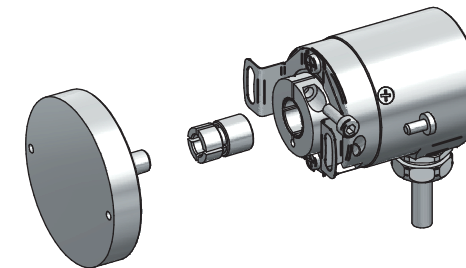
Blind hollow shaft rotary encoder mounted by a stator coupling with collar clamping shaft fixing.

Through hollow shaft encoder with a rear collar clamping shaft fixing.

eltra@eltra.it

www.eltra.it

ENCODER CODE WHEEL (OR MAGNETIC / LINEAR SCALE)

The encoder code wheel (or disc) defines the transmission code of pulses; it is formed by a support made of plastic, glass or metallic material, on which is engraved a pattern of alternated clear (transparent) and opaque segments. On linear scales this patter is replaced by a stationary opaque strip. With magnetic sensing codewheel or linear scale is substituted by a magnetic (north / south) pattern.
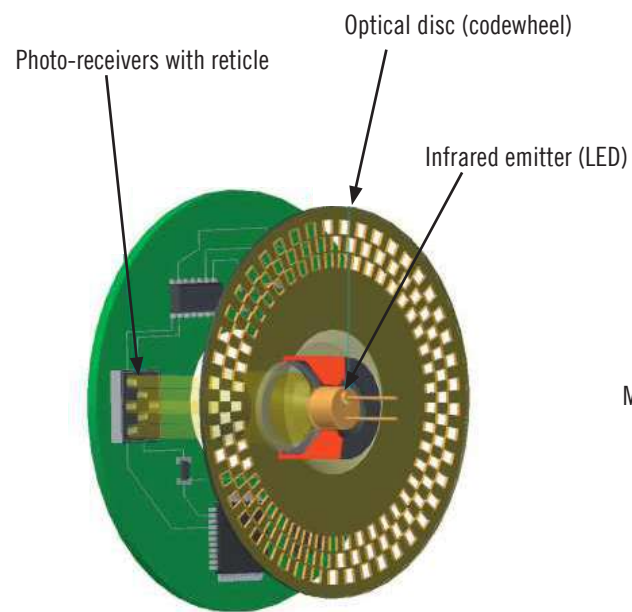
Example of a codewheel
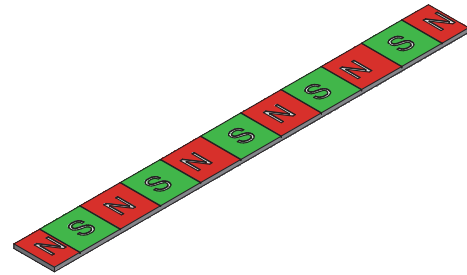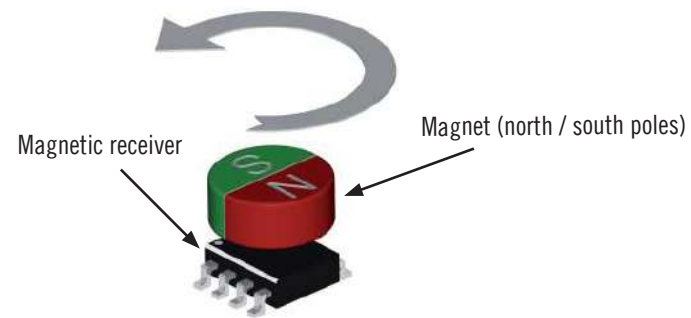
Example of magnetic linear tape

ENCODER OPTOELECTRONIC RECEIVER (OR MAGNETIC SENSOR)

The optoelectronic receiver is made by an array of sensor (photodiodes or phototransistors) which is illuminated by an infrared light source (IR LED). Between the receiver and the LED there's the graduated codewheel. The light projects the disk image on the receivers surface which are covered by a grating called reticle having the same disk steps. The receivers trasduce the occurring light variations caused by the disk shifting and convert them into their corresponding electrical variations.

In magnetic encoders system is made by a rotating actuator with a magnet and the magnetic sensor convert magnetic field variation into electrical signals.

Photo-receivers with reticle

Optical disc (codewheel)

Infrared emitter (LED)

Magnetic receiver

Magnet (north / south poles)

Example of optoelectronic sensor

Example of magnetic sensor

Electrical interface

The electrical interface is the way the encoder communicates data to a receiver. Electrical signals (can be digital or analogue) are trasmitted through the encoder cable to an intellegent device such as interface board, PLC, etc
Electrical interface depends on the encoder type, incremental or absolute.

Interfaces on incremental encoders are:
· **NPN**
· **NPN Open collector**
· **Push pull**
· **Line driver**

interfaces on absolute encoders are:
· **Analogue (voltage or current)**
· **Bit parallel (NPN / NPN Open collector / PNP / PNP Open collector / Push pull)**
· **Serial transmission (Serial Synchronous Interface SSI)**
· **Fieldbus (Profibus or Profinet)**

PHOTOELECTRIC OR OPTICAL SCANNING (ROTARY OR LINEAR)

There are two ways on optical scanning to build an optical system: trasmissive or reflective.

In the transmissive optical encoder, the scan system is based on the rotation of a graduated disc - or code wheel - patterned with alternating opaque and clear (transparent) segments; the code wheel is illuminated by an infrared light source positioned perpendicularly to the sensor.

The disc beams its image on the surface of several receivers, opportunely masked by another grid (called "reticle") with the same pitch as the other. The receivers have the task to sense the variations of light that take place during the rotation of the disc, converting them into corresponding electric pulses. In linear transducers the operating principle is similar, with the difference that the motion is detected on a linear reading system.

Receiver

Codewheel

LED

Bearing stage
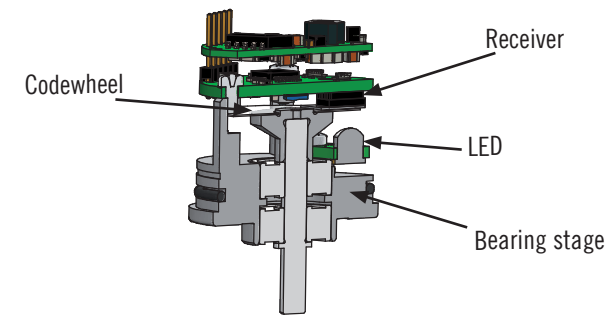
Example of trasmissive encoder

The reflective optical system is also based on the photoelectric scanning of a code wheel, but in this type of technology the light source and the receiver are in the same surface mount package: the light source illuminates the code wheel formed by darker segments alternated with reflective ones, where the light is reflected and detected by the sensor (receiver), which will transform the variations in corresponding pulses, as per the transmissive system. This type of reading allows reducing the size of the device while maintaining its performances; it's an ideal solution for those applications that require miniaturized encoders with a high resolution.

Reflective Sensor

Reflective codewheel

Bearing stage

Reflective tracks
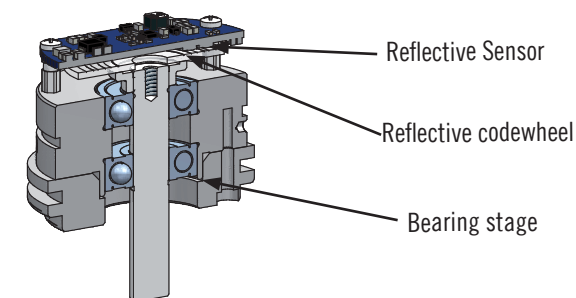
Example of reflective encoder

Example of reflective codewheel

eltra@eltra.it

www.eltra.it
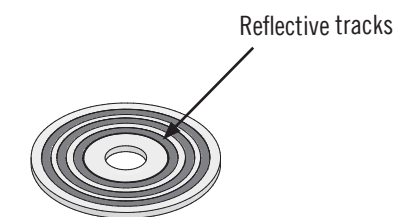
MAGNETIC SENSING (ROTARY OR LINEAR)

Magnetic encoders employ a signal detection system based on the variation of the magnetic flux generated by a magnet (one or more pole pairs) placed in rotation in front of a sensor, usually fixed to the encoder's shaft. The variation of the magnetic field is sampled by the sensor and converted into an electric pulse, which determines the position; the magnetic technology could be of two types: on axis or off axis.

The main benefit of the magnetic technology is the absence of contact in the detection system, which helps preventing the wear and it's therefore quite convenient in terms of cost, since it doesn't require maintenance and has a potentially infinite durability.

Magnetic encoders are particularly suitable for heavy duty applications that require high robustness, speed and a wide range of operating temperature, while ensuring, at the same time, an excellent reliability in the generation of signals.

Magnetic sensor
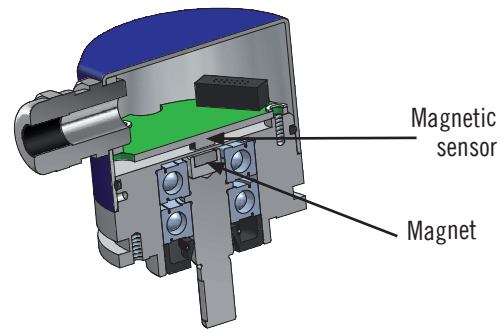
Magnet

Magnetic rotary encoder


Magnetic sensor

Magnetic band
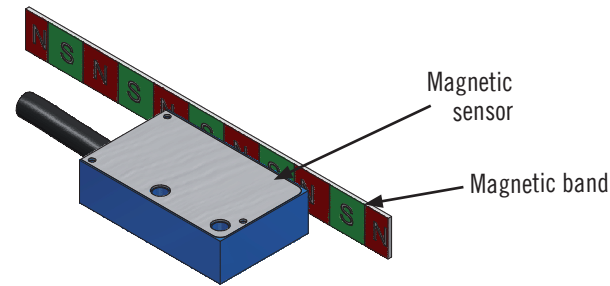
Magnetic incremental linear encoder

ENERGY HARVESTING (ROTARY)

On the multiturn side, the multiturn counting is enabled utilizing energy-harvesting technology.
When the shaft is rotating, the magnet mounted on the shaft moves in tandem. The energy-harvesting coil module cuts the moving magnet field, and generates energy as a result. The beauty of the energy-

harvesting effect is that the same amount of energy is generated independently of the rotation speed. The generated energy is sufficient to power up the revolution tracking circuitry. Therefore, no miscounts occur even in the absence of external power supply. It can replace traditional gear technology due to absence of wear (no contact technology).

Coil module

Magnet

Bearing stage
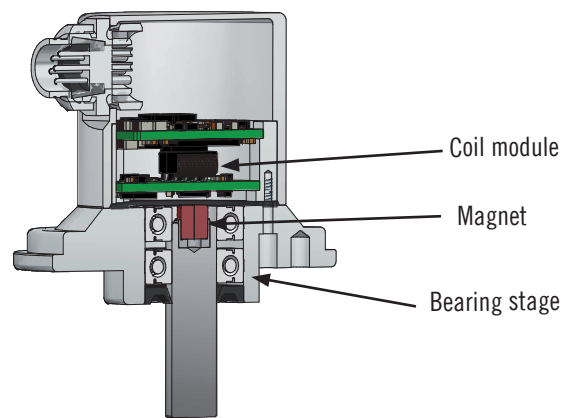
Energy Harvesting engine

POTENTIOMETRIC SENSING (ROTARY OR LINEAR)

This type of linear / rotary transducer is formed by a wire or a metal layer, winded up in a non-conductor support, and by a movable contact that shifts along the conductor.
The operating principle is based on the change in resistance of an electric circuit, caused by the displacement of the object of which the position must be determined.

Potentiometers are particularly suitable for the employment in thermoplastic, wood, marble, iron and steel processing machinery and for any application that requires position and motion absolute measurement.

Conductor

Moving part (sliding contact)
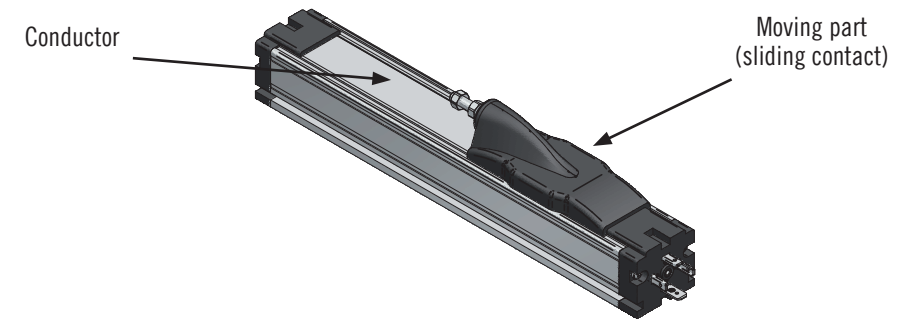
MAGNETOSTRICTIVE SENSING (LINEAR)

Magnetostrictive transducers are based on the magnetostriction principle for which certain materials expand and contract when they are put into an alternate magnetic field.
Those two magnetic fields are generated from the moving magnet and from the current pulse inside the tube of the transducer.
This interaction creates a strain pulse which travels inside the tube until it is detected by the electronics.

The absolute position is calculated by measure the time of the strain pulse compared to the current pulse who generate it.
The key factor of this technology is the absence of any electric contact on the slider, which makes the device highly resistant to wear and tear while ensuring great performances in speed and precision.

Moving magnet (cursor)

Electronics

Transducer tube

eltra@eltra.it

www.eltra.it
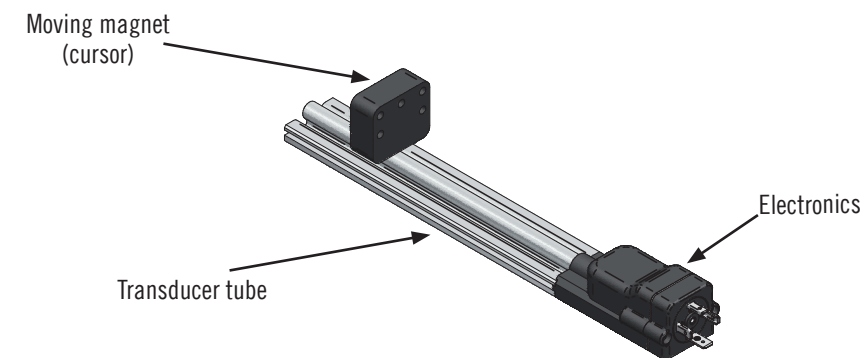
The incremental encoder is so defined since it tracks the increase (variation) in relation to a position taken as a reference point, independently from the direction of rotation. The incremental encoder senses rotation, speed and acceleration by counting the number of pulses sent by the output circuit, although the zero point of the machine must be reset at every new start.

Channel A
Channel B
Channel Z (Index)
Eltra

Example of 3 channels incremental encoder codewheel

The incremental encoder usually provides two types of squared waves, out-of-phase of 90° electrical degrees, which are usually called channel A and B. Channel A gives information only about the rotation speed (number of pulses in a certain unit of time), while channel B provides data regarding the direction of rotation, according to the sequence produced by the two signals. The resolution can be multiply by two or 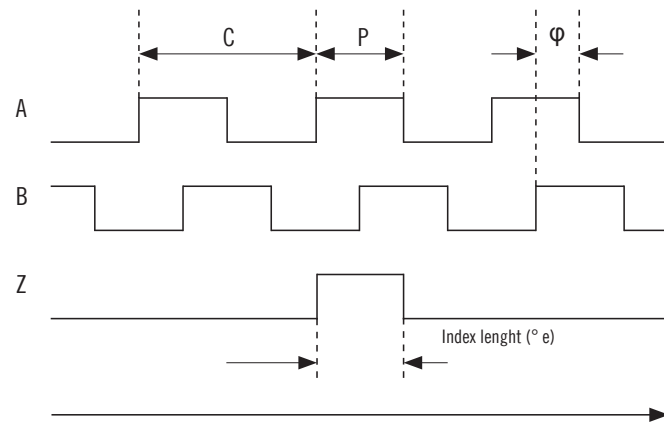four reading non only rising edges but also falling edges of A and B signals. With this method, for example, an encoder with physically 1000 pulses per revolutions can generate 2000 or 4000 pulses per revolution.
Another signal, called Zero (Z or Index) channel, is also available; it gives the absolute "zero" position of the encoder shaft and is used as a reference point.

A
B
Z

Incremental encoder output signals

C P φ

Index lenght (° e)

A leads B clockwise rotation (shaft view)

One Cycle: 360 electrical degrees (°e).
Cycle Error (ΔC): an indication of cycle uniformity. The difference between an observed shaft angle which gives rise to one electrical cycle, and the nominal angular increment of 1/N of a revolution.
Pulse Width (P): the number of electrical degrees that an output is high during 1 cycle. This value is nominally 50 % (or 180°e).
Pulse Width Error (ΔP): the deviation, in electrical degrees, of the pulse width from its ideal value. Typical value is max ± 10 % on optical encoders or ± 20 % on magnetic encoders.
Phase (φ): the numbers of electrical degrees between the center of the high state of the channel A and the center of the high state of the channel B. This value is nominally 90°e for a quadrature output.
Phase Error (Δφ): the deviation of the phase from its ideal value. Typical value is max ± 30°e on optical encoders or ± 40°e on magnetic encoders.
Index length (°e): Index is aligned on the channel A and its length can be 180 °e or 90 °e (called A&B)

Number of encoder pulses is determined from angular or linear resolution needed. For linear applications a calculation is required to convert linear movements into rotary.

$$\text{Encoder Resolution (ppr)} = \frac{\text{Circumference}}{\text{Accuracy}}$$

Encoder max pulse frequency can be considered according to the speed and the encoder resolution.

$$\text{Frequency} = \frac{\text{rpm x resolution (ppr)}}{60}$$

There are other encoders that integrate additional electrical output signals called incremental encoders with integrated commutation signals, normally used as motor feedback. These additional signals (called U, V, W) simulate the commutation (Hall) signlas, which are usually employed in brushless motors and are usually generated by integrated magnetic sensors.

Channel A
Channel B
Channel Z
Channel U
Channel V
Channel W

Example of 6 channels commutation encoder codewheel

In Eltra's encoders commutation signals are optically generated and are represented as 3 squared waves, shifted by 120° electrical degrees (see below table about the relation between motor poles and pulse degrees). These signals are used by the drive to generate the correct motor supply phases sequences.
These commutation signals can be repeated many times within one mechanical revolution, since they depend directly on the number of poles of the motor.

A
B
Z
U
V
W

INCREMENTAL SIGNALS

COMMUTATION SIGNALS (HALL)

A B C D E F
T

MOTOR POLES	A / B / C / D / E / F	T
4	30° ±1,5°	180°
6	20° ±1,5°	120°
8	15° ±1,5°	90°

A leads B clockwise rotation (shaft view)

eltra@eltra.it
www.eltra.it

The absolute encoder provides a unique digital code for each angle position of the shaft, storing the value of the current position and, therefore, preventing the loss of the information in case of restarting the system or of a power-loss.

The absolute encoder could be of two types:

· **Singleturn**
· **Multiturn**

LED

ABSOLUTE CODEWHEEL

PHOTO RECEIVER
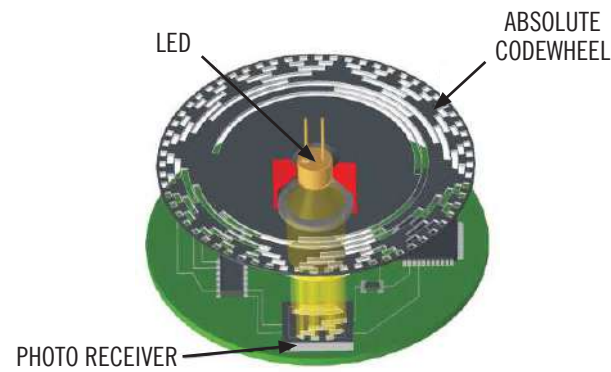
The singleturn absolute encoder allows a precise encoding of the angular position of the shaft, to which the encoder is coupled to, even if the power goes off. Therefore, each single degree position is converted into a specific code (Gray or binary) proportionally to the number of bit.

The multiturn absolute encoder allows a higher number of applications, representing a very interesting extension of the encoders' action field. Besides the angular tracking of the singleturn system, the multiturn stores also the counting of number of revolutions made.

GRAY CODE

In Gray code a single binary digit changes between consecutive steps; the code tracks are read crosswise, with respect to the direction of movement, avoiding encoding errors caused by bit changing in contiguous positions.

DECIMAL	BINARY	GRAY
0	0000	0000
1	0001	0001
2	0010	0011
3	0011	0010
4	0100	0110
5	0101	0111
6	0110	0101
7	0111	0100
8	1000	1100
9	1001	1101
10	1010	1111
11	1011	1110
12	1100	1010
13	1101	1011
14	1110	1001
15	1111	1000
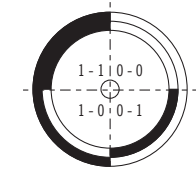
2 Bit optical disc with binary code
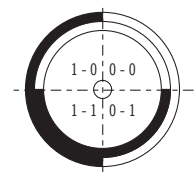
2 Bit optical disc with gray code

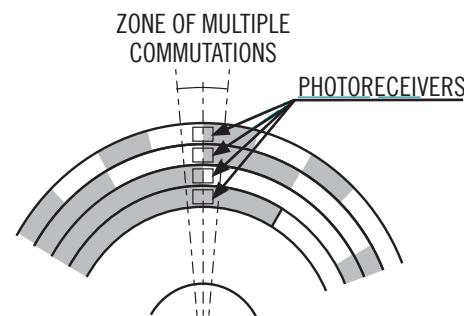Gray code can be converted to binary with a simple combinatory circuit (XOR).

GRAY OR BINARY CODE

Absolute encoders are so defined since they maintain the absolute position value also after an interruption or a power-loss, so it's essential that all data referring to the position should be always available. For this purpose binary codes are employed, set by the pattern of clear and opaque segments placed crosswise or lengthwise on the disc, in relation to the direction of the movement.

BINARY CODE

The natural binary code presents the disadvantage to have more binary digits changing between two consecutive positions. Because of mechanical tolerances, bounces or noise, it could happen that the commutation signals do not switch all at the same time when the state changes, causing intermediate situations that could produce errors in the calculation of the position.
To avoid this inconvenient and, therefore, to avoid errors in the output code, an output sync signal (STROBE) is used.

ZONE OF MULTIPLE COMMUTATIONS

PHOTORECEIVERS

THE GRAY EXCESS CODE

However, when the number of defined position is not a power of 2, even with the Gray code more than one bit can change simultaneously between the last and the first code value.
For example in a 12 ppr absolute encoder, the code should be as the one shown in the table below. It is clear that between the positions "11" and "0" 3 bit simultaneous change may involve into reading errors.

The Gray excess code is used to maintain the typical one-bit variation specificity by making the 0 position corresponding to the N value.
The N is a number that subtracted from the Gray code converted into binary provides the exact position value.

POSITION	GRAY
0	0000
1	0001
2	0011
3	0010
4	0110
5	0111
6	0101
7	0100
8	1100
9	1101
10	1111
11	1110
0	0000

Error

The formula to calculate the N value is:

$$N = (2^n - IMP) / 2$$

Where : IMP is the number of PPR
2   is the power of 2 multiple immediately higher than IMP

In our example N will be:

$$N = (2^4 - 12) / 2 = (16-12) / 2 = 2$$

eltra@eltra.it

www.eltra.it

NPN / NPN OPEN COLLECTOR

It is composed by an NPN transistor and a pull-up resistor used to match the output voltage to the power supply when the transistor is off (also called"sink output"). Output performances are limitated by cable length, signals frequency and load.
On the open collector variant there's no pull-up resistor so it is possible to

have signals with different voltages.
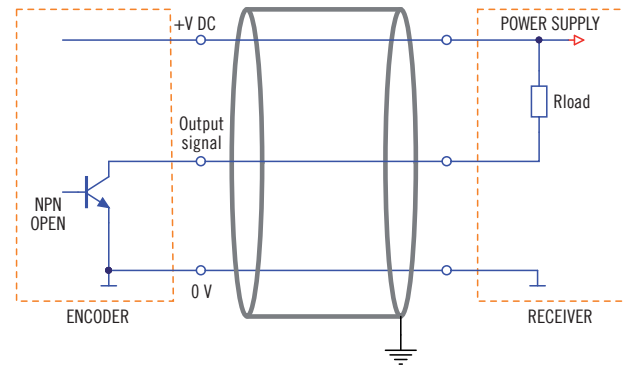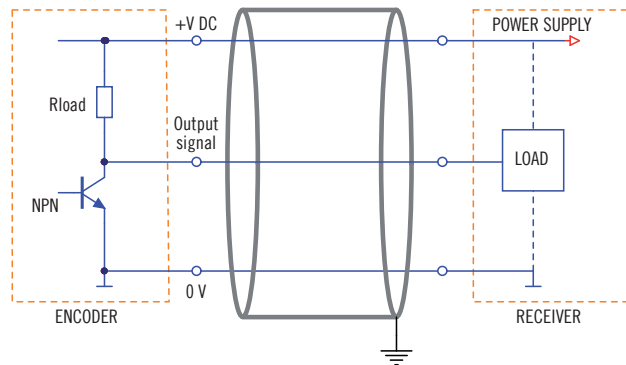
PNP / PNP OPEN COLLECTOR

Main difference is the transistor, which is a PNP type (also called"source output"). The resistor, if present, is in pull-down configuration.
It has same limitations as NPN in terms on cable length, frequency and load.
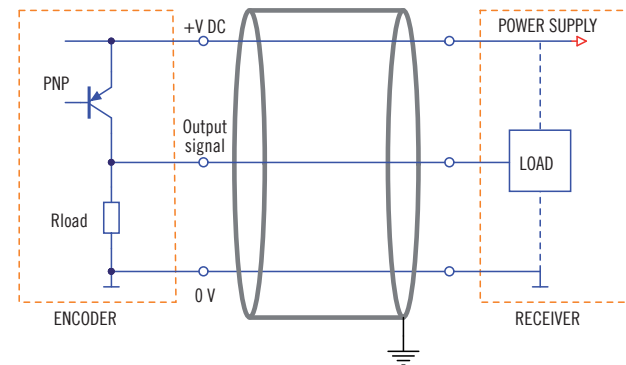
PUSH-PULL

In NPN or PNP frequency performances are limitated by the resistor, which has a much higher impedance than a transistor. To overcome this issue, push-pull electronic uses a complementary transistor, so the impedance is lower for commutation to positive level and to zero.
This solution increases frequency performances allowing longer cable connections and an optimal data trasmission.
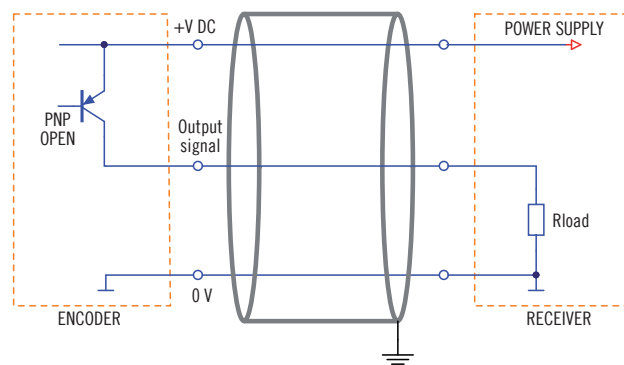Saturation levels are low but sometimes higher than in NPN and PNP

electronics. PUSH-PULL electronics can be use indifferently instead of NPN or PNP.
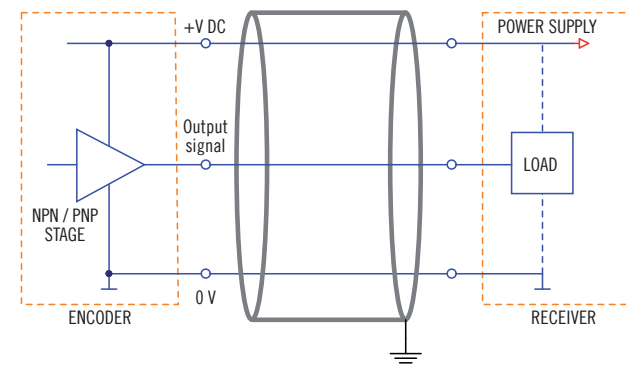
LINE DRIVER

LINE DRIVER is used when operating enviroments are particulary exposed to electrical disturbances or when the encoder is quite far from the receiver system. Data trasmiter and receiver work on two complementary channels so disturbances are limited (cross talk).
These interferences are known as "common mode disturbances" as their generation is due to a common point which is 0 V.

Instead, in LINE DRIVER transmitted and received signals are in "differential way" so differences between complementary channels are used and common mode signal are eliminated by the receiver.
This type of transmission is available both on +5 V DC (called RS-422) and +30 V DC models.
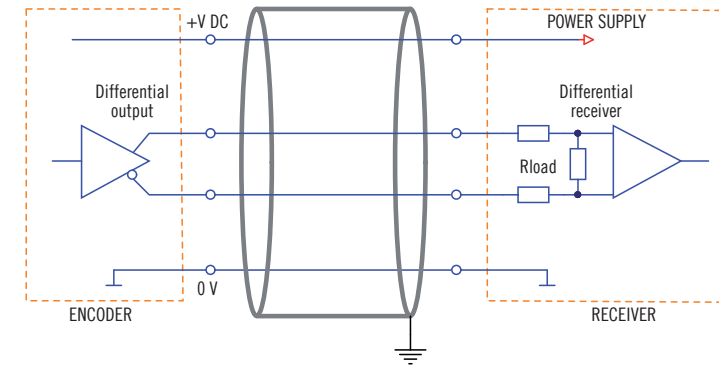
OUTPUT STAGE PROTECTION

A highly integrated ASIC is used to protect outputs from short circuits. This solution is based on an active sensor which controls instantly the temperature reached by the element to be protected.

Moreover, it ensures a constant protection against repetitive and permanent short circuits, that is why it is strongly suggested for heavy duty applications or harsh environments. It is available for LINE-DRIVER and PUSH-PULL electronics.

ANALOGUE INTERFACE

Analogue interface provides position by current or voltage signals. It can be used as potentiometer replacement.
Voltage range goes from 0 ... 5 V to 0 ... 10 V and current (sink or source configuration) range goes from 0 ... 20 mA to 4 ... 20 mA according to industry standard interfaces.
Current output
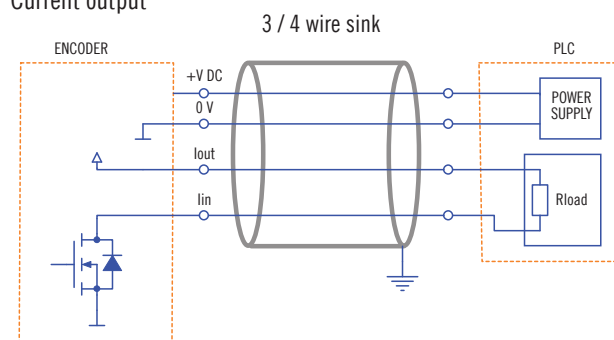
with 3 wires interface I_{out} is internally connected to +V DC
where $R_{LOAD}max = (V_{DC} - 2) / 0.02$

Voltage output
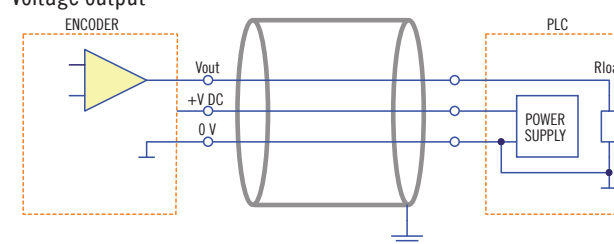
where $R_{LOAD}min = 1\ k\Omega$
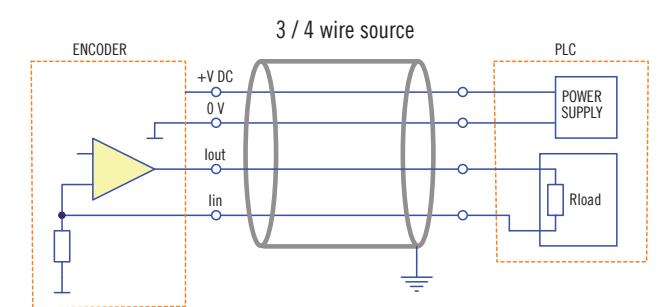
with 3 wires interface I_{in} is internally connected to 0 V

eltra@eltra.it

www.eltra.it

BIT PARALLEL INTERFACE

The parallel output is the standard interface for singleturn and multiturn absolute encoders. These encoders provide the data output regarding the position in a "bit by bit" encoding (according to Gray or binary standards) simultaneously, according to the resolution of the device.

Parallel transmission requires indeed a wire for each bit, therefore for a higher resolution of the device there will be a higher complexity of the wiring. To reduce the number of wires, other forms of data transmission like the
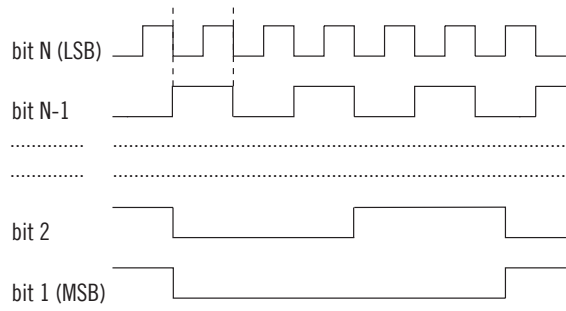
SSI or BiSS serial interfaces or field bus protocols (PROFIBUS or PROFINET) have been implemented.

Binary bit parallel output
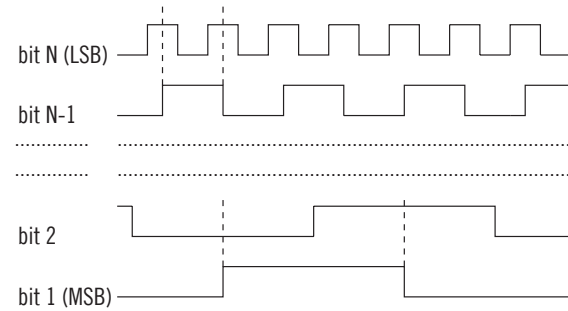
Gray bit parallel output

SSI INTERFACE

The continuous evolution of the automation field implies a growing request for precision in measurement devices and, therefore, also in absolute encoders. To satisfy this demand, absolute encoders have been designed with always higher resolution, which means an increasing number of bit and, as a consequence, also of wires.

The Synchronous Serial Interface (SSI) was created to solve these setbacks, in order to contain installation costs and simplify the wiring. This interface transmits digital data in a serial mode by using only two signals (CLOCK and DATA), independently from the number of bit of the encoder.
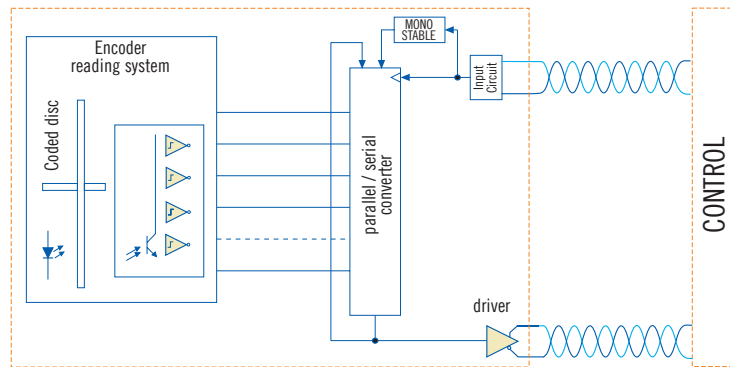
The position data is obtained by the encoder reading system and continuously transmitted to a parallel/serial converter (based by a "shift register" with parallel loading). When the mono-stable circuit is activated by a clock signal transition, the data is stored and transmitted to the output synchronized with the clock signal.

CLOCK and DATA signals are transmitted differentially (RS422) to enhance immunity from interference and to allow longer transmission distances.

When quiescent, CLOCK and DATA signals have a high logical level and the monostable circuit is disabled.

1. On the first CLOCK falling edge the monostable is activated and parallel value at the P/S converter input is stored into the shift register.
2. On the next CLOCK rising edge Most Significant Bit (MSB) is transferred into the DATA signal output.
3. On the next CLOCK falling edge (when the signal is stable) the controller acquires value from DATA signal and monostable is re-activated.
4. On each further CLOCK rising edge following bit up to the least significant one are copied in the DATA signal output and then acquired by the controller on falling edge.
5. At the end of the CLOCK pulse sequence, when the external control has also acquired the value of the Least Significant Bit (LSB), the CLOCK pulse sequence stops and therefore the monostable is no longer re-activated.
6. Once the mono-stable time (Tm) has passed, the DATA signal returns to a high logical level and monostable disables itself.

CLOCK — Input from controller
T — Clock signal period
Tm — Monostable time
Tp — Time between two clock sequences
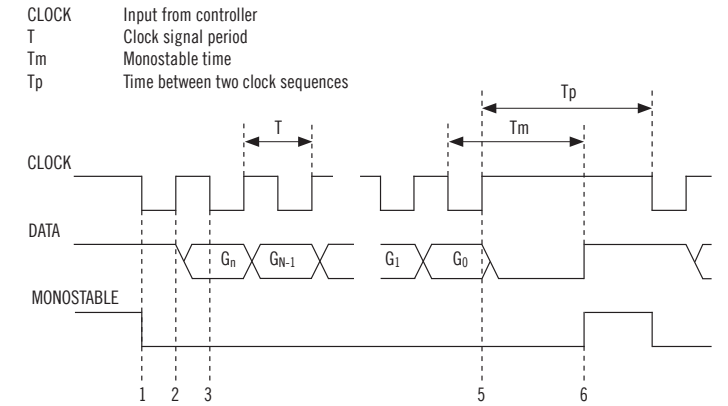
The frame length of the transmitted data depends only on the encoder type (singleturn or multiturn) and not on the resolution. In fact, the standard frame length for a singleturn encoder is 13 bit, while for a multiturn one is 25 bit.

With multitrun encoder with number of revolutions > 4096 frame length is 27 bit (14 bit for revolutions + 13 bit for singleturn) and 32 bit (19 bit for revolutions + 13 bit for singleturn).

Frame alignment is on the center as shown on below table:

n = number of bit per revolution

T = number of bit for revolutions Tc = clock period

$Ta = Tm - \dfrac{Tc}{2}$ Tm = monoflop time

T	2^T			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	Ta		2^n	n
12	4096	1	1	G_{n+11}	G_{n+10}	G_{n+9}	G_{n+8}	G_{n+7}	G_{n+6}	G_{n+5}	G_{n+4}	G_{n+3}	G_{n+2}	G_{n+1}	G_n	G_{n-1}	G_{n-2}	G_{n-3}	G_{n-4}	G_{n-5}	G_{n-6}	G_{n-7}	G_{n-8}	G_{n-9}	G_{n-10}	G_{n-11}	G_{n-12}	G_{n-13}	0	1	8192	13
11	2048	1	1	0	G_{n+10}	G_{n+9}	G_{n+8}	G_{n+7}	G_{n+6}	G_{n+5}	G_{n+4}	G_{n+3}	G_{n+2}	G_{n+1}	G_n	G_{n-1}	G_{n-2}	G_{n-3}	G_{n-4}	G_{n-5}	G_{n-6}	G_{n-7}	G_{n-8}	G_{n-9}	G_{n-10}	G_{n-11}	G_{n-12}	0	0	1	4096	12
10	1024	1	1	0	0	G_{n+9}	G_{n+8}	G_{n+7}	G_{n+6}	G_{n+5}	G_{n+4}	G_{n+3}	G_{n+2}	G_{n+1}	G_n	G_{n-1}	G_{n-2}	G_{n-3}	G_{n-4}	G_{n-5}	G_{n-6}	G_{n-7}	G_{n-8}	G_{n-9}	G_{n-10}	G_{n-11}	0	0	0	1	2048	11
9	512	1	1	0	0	0	G_{n+8}	G_{n+7}	G_{n+6}	G_{n+5}	G_{n+4}	G_{n+3}	G_{n+2}	G_{n+1}	G_n	G_{n-1}	G_{n-2}	G_{n-3}	G_{n-4}	G_{n-5}	G_{n-6}	G_{n-7}	G_{n-8}	G_{n-9}	G_{n-10}	0	0	0	0	1	1024	10
8	256	1	1	0	0	0	0	G_{n+7}	G_{n+6}	G_{n+5}	G_{n+4}	G_{n+3}	G_{n+2}	G_{n+1}	G_n	G_{n-1}	G_{n-2}	G_{n-3}	G_{n-4}	G_{n-5}	G_{n-6}	G_{n-7}	G_{n-8}	G_{n-9}	0	0	0	0	0	1	512	9
7	128	1	1	0	0	0	0	0	G_{n+6}	G_{n+5}	G_{n+4}	G_{n+3}	G_{n+2}	G_{n+1}	G_n	G_{n-1}	G_{n-2}	G_{n-3}	G_{n-4}	G_{n-5}	G_{n-6}	G_{n-7}	G_{n-8}	0	0	0	0	0	0	1	256	8
6	64	1	1	0	0	0	0	0	0	G_{n+5}	G_{n+4}	G_{n+3}	G_{n+2}	G_{n+1}	G_n	G_{n-1}	G_{n-2}	G_{n-3}	G_{n-4}	G_{n-5}	G_{n-6}	G_{n-7}	0	0	0	0	0	0	0	1	128	7
5	32	1	1	0	0	0	0	0	0	0	G_{n+4}	G_{n+3}	G_{n+2}	G_{n+1}	G_n	G_{n-1}	G_{n-2}	G_{n-3}	G_{n-4}	G_{n-5}	G_{n-6}	0	0	0	0	0	0	0	0	1	64	6
4	16	1	1	0	0	0	0	0	0	0	0	G_{n+3}	G_{n+2}	G_{n+1}	G_n	G_{n-1}	G_{n-2}	G_{n-3}	G_{n-4}	G_{n-5}	0	0	0	0	0	0	0	0	0	1	32	5
3	8	1	1	0	0	0	0	0	0	0	0	0	G_{n+2}	G_{n+1}	G_n	G_{n-1}	G_{n-2}	G_{n-3}	G_{n-4}	0	0	0	0	0	0	0	0	0	0	1	16	4
2	4	1	1	0	0	0	0	0	0	0	0	0	0	G_{n+1}	G_n	G_{n-1}	G_{n-2}	G_{n-3}	0	0	0	0	0	0	0	0	0	0	0	1	8	3
1	2	1	1	0	0	0	0	0	0	0	0	0	0	0	G_n	G_{n-1}	G_{n-2}	0	0	0	0	0	0	0	0	0	0	0	0	1	4	2

Number of revolutions ← multiturn → | ← singleturn → PPR

eltra@eltra.it

www.eltra.it

BiSS INTERFACE

BiSS is an open source digital interface for sensors and actuators.
BiSS is hardware compatible to the industrial standard SSI (Serial Synchronous Interface) but offers additional features and options like bidirectional data communication (serial s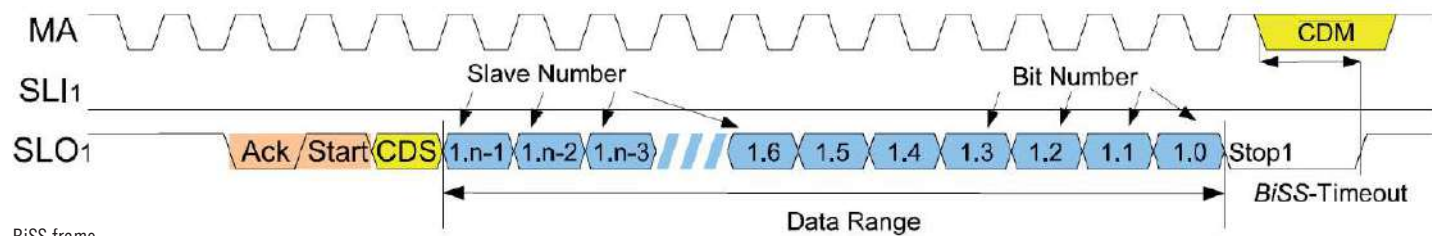ynchronous, continuous data communication) and two unidirectional lines clock and data (cyclic at high speed (up to 10 MHz), line delay compensation for high speed data transfer, request processing times for data generation at slaves, safety capable (CRC, errors, warnings) and bus capability for multiple slaves and devices in a chain.

The advantage of open source protocols is that the selection of components it is not imposed so the end customer can choose the proper products related to the application, increasing the cost-efficency.
Further advantage for the end customer is the compatibility between different manufactures.
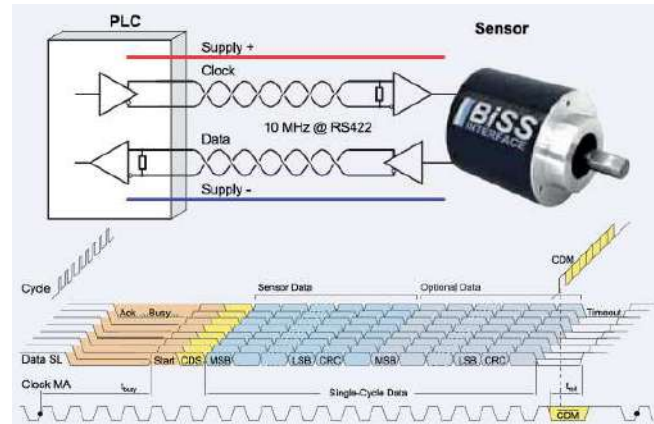
Typical BiSS encoder connection

Example of multi product BiSS connection

In point-to-point configuration, only one device with one or more slaves (sensors) is connected to the master. The master transmits the clock signal to the slave(s) via the MA line. The SL line carries the sensor data directly from the first slave back to the master.In point-to-point configuration the input SLI of the 'Last Slave' is connected to '0'. In bus configuration, all devices, which may also each include multiple slaves, are connected in a chain. Each slave therefore has two terminals (SLO and SLI) with drivers provided for high speed differential signals if applicable.

The MA line supplies the clock signal from the master simultaneously to all slaves and the SLO and SLI lines connect the master and all slaves in a chain.
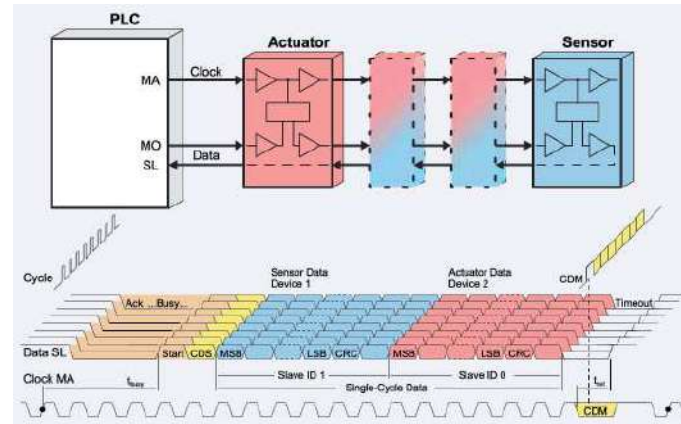

BiSS frame

The BiSS frame (transmission frame) is started by the master with the clock MA, clocked and ended. Here the first rising edge at MA is used for the synchronization of all slaves. It enables the isochronous scanning of sensor data and the isochronous output of actuator data. With the 2nd rising edge from MA, all slaves set their SLO line to "0" and generate their "Ack" (Acknowledge) signal with it; it remains active (SLO = "0") until the start bit arrives at the input SLI of the respective slave. The start bit is then passed on synchronously with the clock MA from each slave delayed by one clock pulse, while the CDS bit is either passed on by the slave or is set according to the rules of the control frame. Beginning with the 2nd bit after the start bit and up to the stop bit of the BiSS frame, the data range follows, which transmits the sensor data from the slaves to the master and the actuator data from the master to the slaves. The BiSS frame ends with the BiSS timeout. In this time no further clock pulses are sent to the

MA by the master. The inverse state of the MA line during the BiSS timeout is the state of the CDM (Control Data Master) bit. At the end of the data transmission, the master sets its output MO to the idle state "1". The slaves then pass on this "1" received at SLI to their output SLO as soon as they have detected the expiration of the timeout themselves. This ensures that the BiSS timeout on the line SL is only signaled to the master when all connected slaves have detected the timeout.
When the BiSS timeout expires, all slaves return to the idle state; all lines are set to the high signal level ("1") in the process.

All text and pictures copyright BiSS Association

CANOPEN INTERFACE

CAN is a field bus. It operates with the CSMA/CA (Carrier Sense Multiple Access / Collision Avoidance) method. It means that collisions during bus access
are avoided by a so called bitwise arbitration. The bits are coded NRZ-L (Non Return to Zero - Low).
A cyclic redundancy check (CRC) and other safety mechanisms provide a secure transmission. For synchronisation a mechanism called "bit stuffing" is used. CAN is a multi-master system, i.e. several equal bus nodes can be connected without a bus master supervising the communication. In principle a CAN bus can be realized with copper wire or in fibre optic cable. The common CAN implementation with copper wire operates with differential signals, transmitted via two wires: CANHIGH, CANLOW. Therefore CAN has a good common mode rejection ratio.
Data is transmitted with bits that can either be dominant or recessive. The dominant (0) always overwrites the recessive (1).
The topology of a CAN network is a line, which can be extended by stubs. The maximum length of a stub is limited to 0,5 m.

The network always has to be terminated on both ends with 120 Ohm each (between CANHIGH and CANLOW). Other locations or values are not allowed.
The arbitration mentioned before is used to control the bus access of the nodes by prioritization of the CAN-Identifier of the different messages. Every node monitors the bus. If more than on node wants access on the bus, the node with the highest priority of the messages ID succeeds and the other
nodes retreat until there is "silence" on the bus (see below example).
Technically the first dominate bit of the ID send overwrites the corresponding recessive
bit of the other IDs. In case that more than one node uses the same CAN-ID an error occurs only at a collision within the rest of the frame.
In principle a CAN-ID should only be used by a single node.
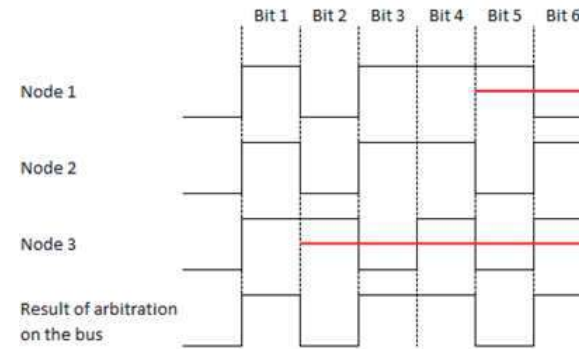
Example of arbitration

Due to the arbitration there is a ranking of the messages. The message with the lowest ID has the highest priority and therefore it has almost instant access on the bus. The exception is that an ongoing transmission will not be interrupted. So time critical messages should be assigned to the high priority CAN-IDs, but even then there is no determination in the time of transmission (non-deterministic transmission).

For the arbitration all nodes have to be synchronised. Due to the lack of a separate clock signal, the transmission of many identical bits in line would lead to the loss of synchronisation. The so called bit-stuffing is used to prevent this case. After five equal bits a complementary bit will be inserted into the transmission (the application will not notice). So the nodes can keep up resynchronising on the bit edges (see below figure).
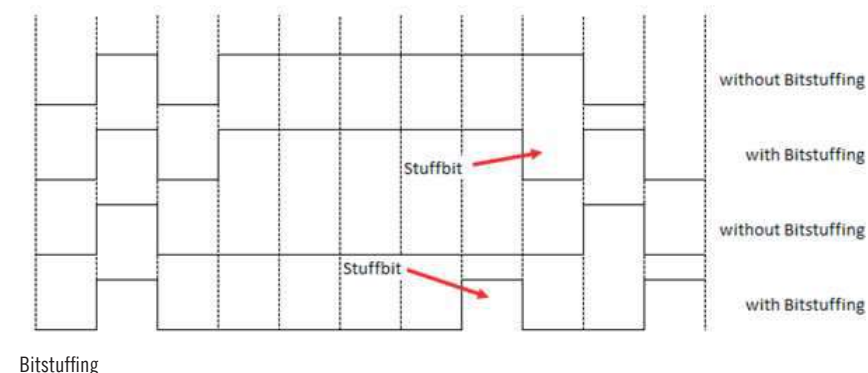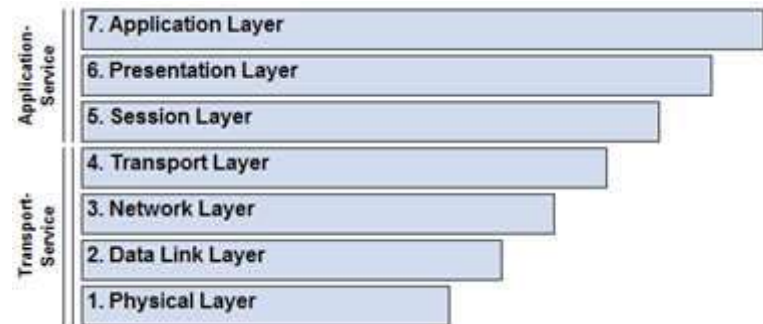

Bitstuffing

A CAN network can operate with baud rates up to 1 Mbit/s.
Due to the necessary synchronisation of the nodes, the maximum delay caused by the length of the cable has to be limited.

Baud rates (kbit /s)	Cable lenght (m)
10	6700
20	3300
50	1300
125	530
250	270
500	130
1000	< 40

CAN baud rates and recommended cable length limits

The limitation corresponds with the baudrate. There is a common recommendation of the maximum cable length at several baud rates:

CANopen

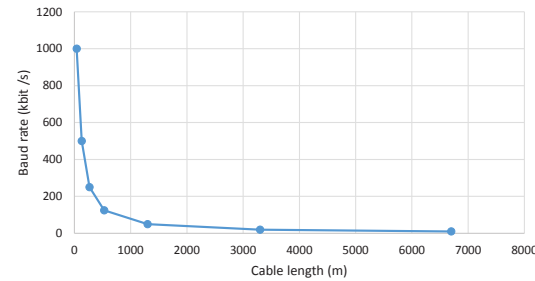CANopen is a specified higher protocol (layer 7 protocol)

ISO-OSI model

With CANopen it is possible to transfer larger amounts of data, emergency telegrams and process data.
CANopen describes how the communication is performed. That means that parameters to configure a device are transmitted in a defined form (profile).
A CANopen profile defines objects representing the different functions of a device. These objects form a table called object dictionary.
The communication profile defines the basic services and parameters of a CANopen device (e.g. service data objects SDOs, process data objects PDOs, used CAN-IDs, etc.). The device profile defines the specific functions of a device family (e.g. encoders, i/o devices, ...).
For encoders the device profile is the encoder profile CiA 406.

PROFIBUS INTERFACE

PROFIBUS (Process Field Bus) is a serial communications standard for devices connected to automation networks (field bus).
It is an open protocol defined by the DIN 19245 that became European standard as EN 50170 volume 2.
PROFIBUS is promoted by Siemens and is widely diffused all across Europe. Thanks to the definition of three different communication profiles (DP, FMS and PA), this field bus is suitable for many requirements in automation system. Starting with applications requiring a high cyclical exchange speed of a reduced number of bit (PROFIBUS DP), up to 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.

INDUSTRIAL PROFIBUS NETWORK
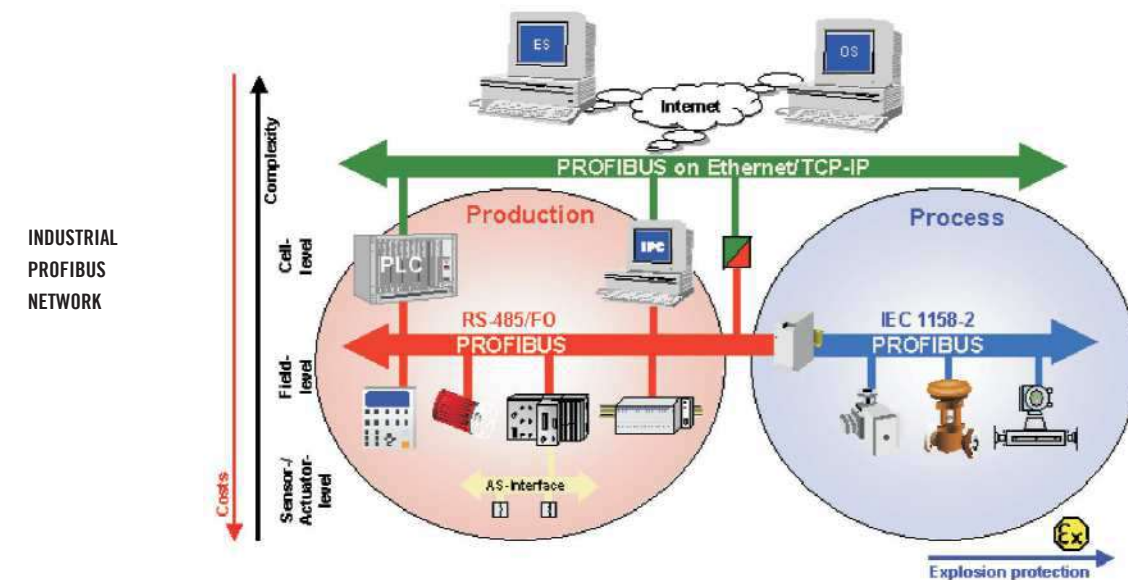
NETWORK TOPOLOGY: It is a common bus structure (closed on both sides) where up to 126 devices can be connected at the same time. If the physical support is an RS485 interface, up to 32 nodes can be inserted without using signal repeaters/re-generators.
HARDWARE LEVEL: In addition to the RS485 differential serial technology transmission, an optical fiber connection can be used. In any event, DP and FMS devices can co-exist in the same network. They share the same hardware interface communication (they are the same levels 1 and 2 of the ISO/OSI stack). The established standard requires an extremely accurate communication speed between 9.6 kBaud (min) and 12 kBaud (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 periodically exchanging information with distributed peripheral (they can directly manage the I/O network data with the other nodes, mainly slaves). The 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 word in both directions (in and out). Typical examples of slaves are: digital I/O, encoders, drivers, valves, different types of 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 among possible available masters, and the well known 'polling interrogation' for the master-slave communication.

eltra@eltra.it

www.eltra.it

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

Periodic data exchange: after the slave initialization step, every master is configured in order to exchange a maximum of 244 input bytes and 244 output bytes with every 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.

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

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

Diagnostic functions: each slave can require to the master to be set up for reading its own diagnostic. In such way any possible problem occouring 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 disactivate slaves present in the network. Moreover, it is possible to change by the bus slaves addresses that make possible this function.

Easy network configuration: main characteristics of each device present in the network are listed in the form of a GSD file complying to Profibus specifications. This simplify the set up and the configuration of the device by a graphic tools suitable for the purpose, such as the Siemens COM PROFIBUS software. As mentioned, the master-slave exchange data 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.

Configuration: This step starts when the master has successfully set slave's parameters. During this step the master specifies the number and type of data, or better, the number of bytes to be exchanged with the slave both for incoming and outgoing information. This data is also present in the DU field of the communication frame: if the slave accepts the configuration, it can periodically exchange with the master.

Periodic exchange: The master specifies within the DU field frame the necessary information and the slave sends requested data within the reply frame. During periodic exchange, the slave may advise the master that a new diagnostic data is ready and then it asks to the master if it prefers reading this information in the next polling instead of the input data coming from the peripheral.

As already mentioned, the master-slave data exchange is periodic and essentially depends on the network topology and on the present node number. However, before starting the data exchange, it is necessary that slave parameter settings and slave configuration have been successfully completed. More details are as follows:

Parameter setting: during this step the master sends to the slave a series of operating parameters necessary for specifying 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 up to a maximum of 244 bytes.

Configuration: when the master successfully set slave parameters, the configuration process starts. Then, the master specifies the number and type of data represented from the incoming and outgoing bytes number which has to be exchanged with the slave. This data is also present in DU field; if the slave accepts the configurations, it will begin to periodically exchange data with the master.

Periodic exchange: the master specifies within the DU field frame the needed information and the slave will send requested data in the reply frame. During periodic data exchange the slave may advise the master that a new diagnostic data is ready and then it asks to the master if it prefers reading this information in the next polling instead of the input data coming from the peripheral.

NETWORK CONFIGURATION BETWEEN THE GDS FILES
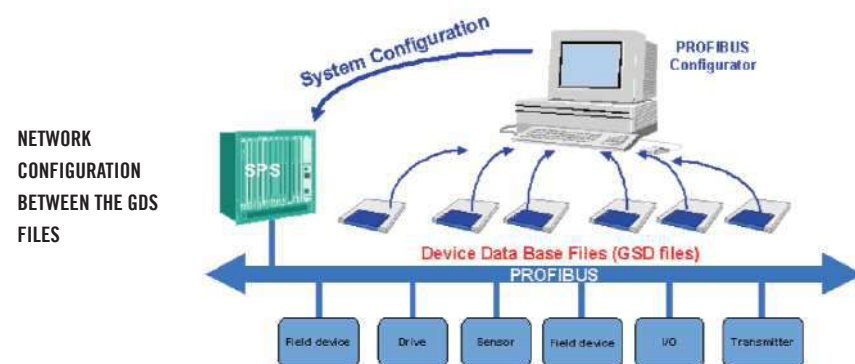
PROFINET INTERFACE

The ever-shorter innovation cycles for new products makes the continuous evolution of automation technology necessary. The use of fieldbus technology has been a significant development in the past few years. It has made possible to migrate from centralized automation systems to decentralized ones. PROFIBUS, as the global market leader, has set the benchmark here for 25 years. In today's automation technology, Ethernet and information technology (IT) are increasingly calling the shots with established standards like TCP/IP and XML.

Integrating information technology into automation opens up significantly better communication options among automation systems, extensive configuration and diagnostic possibilities, and network-wide service functionality.

These functions have been integral components of PROFINET from the outset. PROFINET is the innovative open standard for Industrial Ethernet.

PROFINET satisfies all requirements of automation technology; whether the application involves production automation, process automation, or drives (with or without functional safety), PROFINET is the first choice across the board.

As a technology that is standard in the automotive industry, widely disseminated in machine building, and well-proven in the food and packaging and logistics industries, PROFINET has found its way into all application areas.

New application areas are constantly emerging, such as marine and rail applications or even day-to-day operations, for example, in a beverage shop. And now: the new PROFIenergy technology profile will improve the energy balance in production processes.

PROFINET is standardized in IEC 61158 and IEC 61784.

The ongoing further development of PROFINET offers users a long-term view for the implementation of their automation tasks.

For plant and machine manufacturers, the use of PROFINET minimizes the costs for installation, engineering, and commissioning.

For plant owners, PROFINET offers ease of plant expansion and high plant availability due to autonomously running plant units and low maintenance requirements. The mandatory certification for PROFINET devices also ensures a high quality standard.
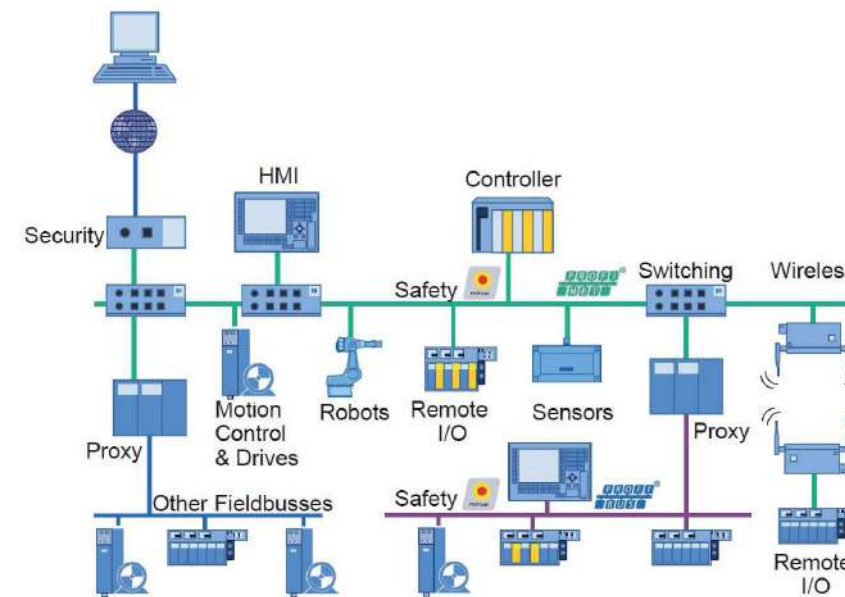
Example of plant network

The scope of functions supported by PROFINET IO is clearly divided into conformance classes ("CC").
These provide a practical summary of the various minimum properties.
There are three conformance classes that build upon one another and are oriented to typical applications (see figure).

CC-A provides basic functions for PROFINET IO with RT communication. All IT services can be used without restriction. Typical applications are found, for example, in business automation. Wireless communication is specified for this class.

CC-B extends the concept to include network diagnostics via IT mechanisms as well as topology information. The system redundancy function important for process automation is contained in an extended version of CC-B named CC-B(PA).

CC-C describes the basic functions for devices with hardware-supported bandwidth reservation and synchronization (IRT communication) and is thus the basis for isochronous applications.
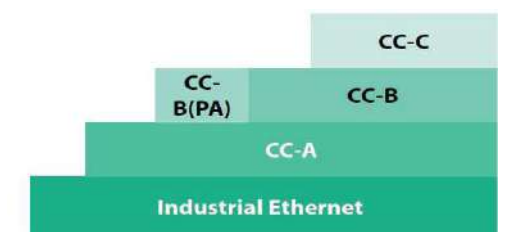

Structure of conformance classes

The conformance classes also serve as the basis for the certification and the cabling guidelines.
A detailed description of the CCs can be found in the document "The PROFINET IO Conformance Classes" [7.042].

eltra@eltra.it

www.eltra.it

The PROFINET concept was defined in close collaboration with end users based on standard Ethernet according to IEEE 802 in IEC 61158 and IEC 61784. Figure below lists additional specifications of the functionalities in the form of different joint profiles. These form the basis for device or

application-specific profiles. Instructions are created for the necessary planning, engineering, and commissioning steps.
The basics for this form the guidelines for engineering PROFINET systems.
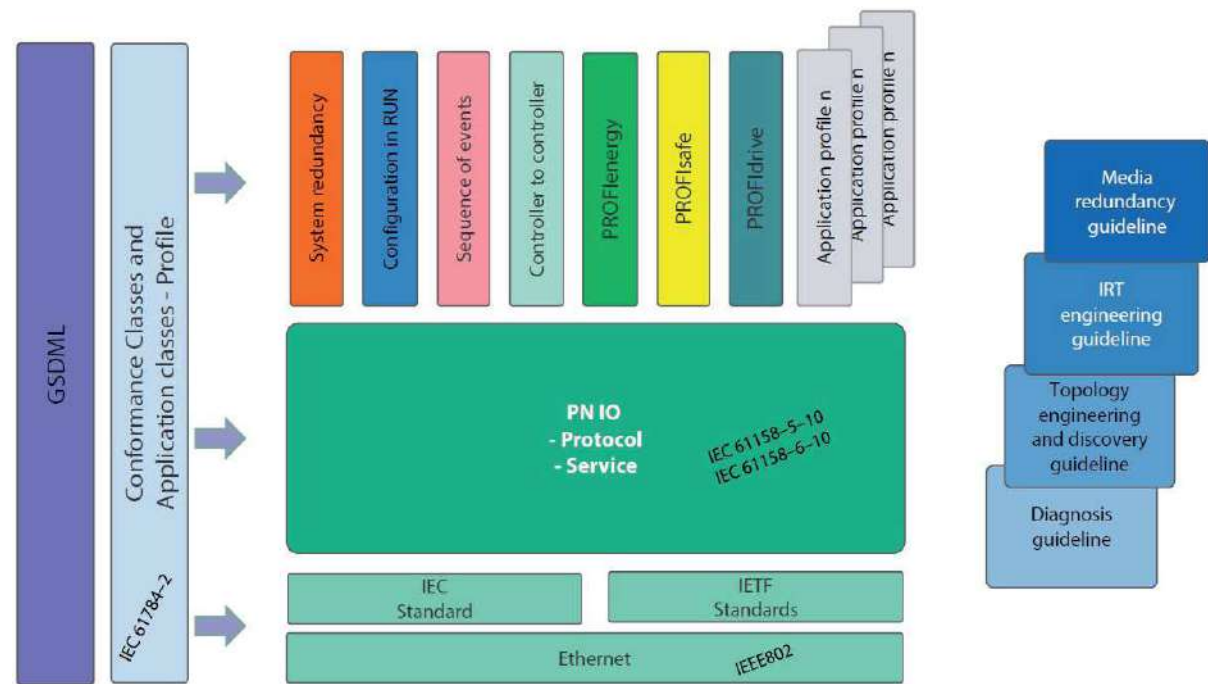
PROFINET IO follows the Provider/Consumer model for data exchange.
Configuring a PROFINET IO system has the same look and feel as in PROFIBUS.
The following device classes are defined for PROFINET IO (figure below):
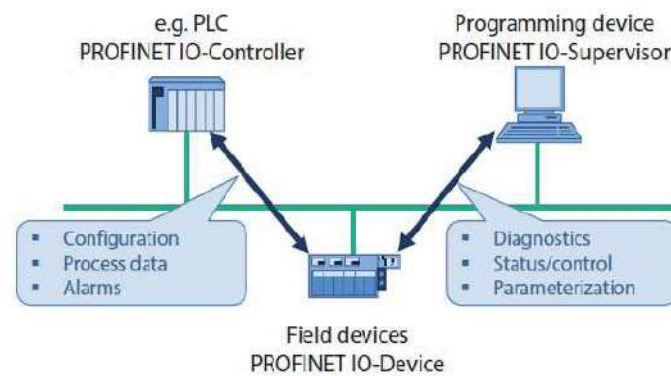
IO Controller: this is typically the programmable logic controller (PLC) on which the automation program runs. This is comparable to a class 1 master in PROFIBUS. The IO controller provides output data to the configured IO devices in its role as provider and is the consumer of input data of IO devices.

IO Device: an IO device is a distributed I/O field device that is connected to one or more IO controllers via PROFINET IO. It is comparable to the function of a slave in PROFIBUS. The IO device is the provider of input data and the consumer of output data.

All text and pictures copyright PROFIBUS International (PNO).

IO Supervisor: this can be a Programming Device (PD), personal computer (PC), or human machine interface (HMI) device for commissioning or diagnostic purposes and corresponds to a class 2 master in PROFIBUS.

A plant unit contains at least one IO controller and one or more IO devices. IO supervisors are usually integrated only temporarily for commissioning or troubleshooting purposes.

ETHERCAT INTERFACE

EtherCAT is Industrial Ethernet and utilizes standard frames and the physical layer as defined in the Ethernet Standard IEEE 802.3. However, it also addresses the specific demands faced in the automation industry, where:

· there are hard real-time requirements with deterministic response times
· the system is usually made up of many nodes, each only having a small amount of cyclic process data
· hardware costs are even more important than in IT and office applications

The above requirements make using a standard Ethernet network at the field level practicallyimpossible. If an individual Ethernet telegram is used for each node, the effectivedata rate sinks significantly for just a few bytes of cyclic process data: the shortest Ethernet telegram is 84 bytes long (including the Inter Frame Gap), of which 46 bytes can be used for process data. For example, if a drive sends 4 bytes of process data for the actual position and status information and receives 4 bytes of data for the target position and control information, the effective data rate for both telegrams sinks to $4/84 = 4.8$ %. Additionally, the drive usually has a reaction time that triggers the transmission of the actual values after receiving the target values. At the end, not much of the 100MBit/s transfer rate remains.
Protocol stacks, such as those used in the IT world for routing (IP) connection (TCP), require additional overhead for each node and create further delays through the stack runtimes.
EtherCAT overcomes the difficulties described in the previous section with its high performing mode of operation, in which a single frame is usually

sufficient to send and receive control data to and from all nodes!
The EtherCAT master sends a telegram that passes through each node. Each EtherCAT slave device reads the data addressed to it on the fly, and inserts its data in the frame as the frame is moving downstream. The frame is delayed only by hardware propagation delay times. The last node in a segment or branch detects an open port and sends the message back to the master using Ethernet technology's full duplex feature.
The telegram's maximum effective data rate increases to over 90 %, and due to the utilization of the full duplex feature, the theoretical effective data rate is even greater than 100 MBits/s.
The EtherCAT master is the only node within a segment allowed to actively send an EtherCAT frame; all other nodes merely forward frames downstream. This concept prevents unpredictable delays and guarantees real-time capabilities.
The master uses a standard Ethernet Media Access Controller (MAC) without an additional communication processor. This allows a master to be implemented on any hardware platform with an available Ethernet port, regardless of which real-time operating system or application software is used.
EtherCAT slave devices use an EtherCAT Slave Controller (ESC) to process frames on the fly and entirely in hardware, making network performance predictable and independent of the individual slave device implementation.

Ethernet header			ECAT	EtherCAT telegram				Ethernet	
DA	SA	Type	Frame HDR	Datagram 1	Datagram 2	•••	Datagram n	Pad.	FCS
(6)	(6)	(2/4)	(2)	(10+n+2)	(10+m+2)		(10+k+2)	(0...32)	(4)
EtherType 0x88A4									

EtherCAT in a standard Ethernet frame (according to IEEE 802.3)

EtherCAT embeds its payload in a standard Ethernet frame. The EtherCAT frame is identified with the Identifier (0x88A4) in the EtherType field. Since the EtherCAT protocol is optimized for short cyclic process data, the use of bulky protocol stacks, such as TCP/IP or UDP/IP, can be eliminated.
To ensure Ethernet IT communication between the nodes, TCP/IP connections can optionally be tunneled through a mailbox channel without impacting real-time data transfer.
During startup, the master device configures and maps the process data on the slave devices. Different amounts of data can be exchanged with each slave, from one bit to a few bytes, or even up to kilobytes of data.
The EtherCAT frame contains the frame header and one or more datagrams. The datagram header indicates what type of access the master device would like to execute:
- Read, write, or read-write
- Access to a specific slave device through direct addressing, or access to multiple slave devices through logical addressing (implicit addressing)
Logical addressing is used for the cyclical exchange of process data. Each datagram addresses a specific part of the process image in the EtherCAT segment, for which 4 GBytes of address space is available. During network

startup, each slave device is assigned one or more addresses in this global address space. If multiple slave devices are assigned addresses in the same area, they can all be addressed with a single datagram. Since the datagrams completely contain all the data access related information, the master device can decide when and which data to access. For example, the master device can use short cycle times to refresh data on the drives, while using a longer cycle time to sample the I/O; a fixed process data structure is not necessary. This also relieves the master device in comparison to in conventional fieldbus systems, in which the data from each node had to be read individually, sorted with the help of the process controller, and copied into memory.
With EtherCAT, the master device only needs to fill a single EtherCAT frame with new out put data, and send the frame via automatic Direct Memory Access (DMA) to the MAC controller.
When a frame with new input data is received via the MAC controller, the master device can copy the frame again via DMA into the computer's memory — all without the CPU having to actively copy any data.

eltra@eltra.it

www.eltra.it

Line, tree, star, or daisy-chain: EtherCAT supports almost all of topologies. EtherCAT makes a pure bus or line topology with hundreds of nodes possible without the limitations that normally arise from cascading switches or hubs.
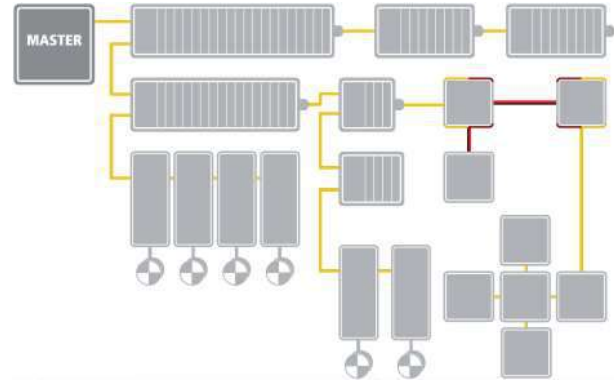
Flexible topology: line, tree, star, or daisy-chain

When wiring the system, the combination of lines with branches or drop lines is particularly beneficial: the ports necessary to create branches are directly integrated in many I/O modules, so no additional switches or active infrastructure components are required.

The star topology, the Ethernet classic, can also naturally be utilized.

Modular machines or tool changers require network segments or individual nodes to be connected and disconnected during operation. EtherCAT Slave Controllers already include the basis for this Hot Connect feature. If a neighboring station is removed, then the port is automatically closed so the rest of the network can continue to operate without interference. Very short detection times faster than 15 microseconds guarantee a smooth changeover.

EtherCAT offers a lot of flexibility regarding cable types, so each segment can use the exact type of cable that best meets its needs. Inexpensive industrial Ethernet cable can be used between two nodes up to 100m apart

In order to configure and diagnose slave devices, it is possible to access the variables provided for the network with the help of acyclic communication. This is based on a reliable mailbox protocol with an auto-recover function for erroneous messages.

In order to support a wide variety of devices and application layers, the following EtherCAT communication profiles have been established:
- CAN application protocol over EtherCAT (CoE)
- Servo drive profile, according to IEC 61800-7-204 (SoE)
- Ethernet over EtherCAT (EoE)
- File access over EtherCAT (FoE)
- ADS over EtherCAT (AoE)
A slave device isn't required to support all communication profiles; instead, it may decide which profile is most suitable for its needs. The master device
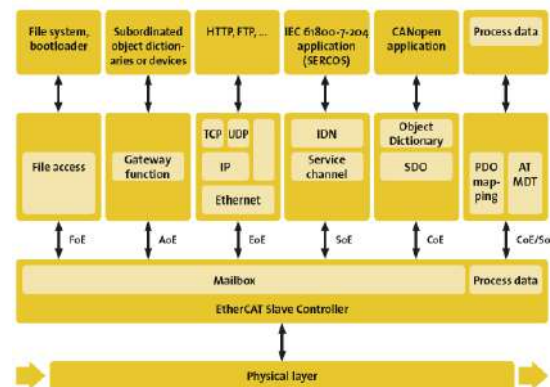
in 100BASE-TX mode. Furthermore, the protocol addition EtherCAT P enables the transmission of data and power via one cable.

This option enables the connection of devices such as sensors with a single line. Optical fibres (such as 100BASE-FX) can also be used, for example for a node distance greater than 100 m. The complete range of Ethernet wiring is also available for EtherCAT.

Up to 65,535 devices can be connected to one EtherCAT segment, so network expansion is virtually unlimited. Because of the practically unlimited number of nodes, modular devices such as sliced I/O stations can be designed in such a way that each module is an

EtherCAT node of its own. Hence, the local extension bus is eliminated; the high performance of EtherCAT reaches each module directly and without any delays, since there is no gateway in the bus coupler or head station any more.

is notified which communication profiles have been implemented via the slave device description file.

With the CoE protocol, EtherCAT provides the same communication mechanisms as in CANopen®-Standard EN 50325-4: Object Dictionary, Mapping of Process Data Objects (PDO) and Service Data Objects (SDO). Even the network management is similar.

This makes it possible to implement EtherCAT with minimal effort in devices that were previously outfitted with CANopen, and large portions of the CANopen Firmware are even reusable. Optionally, the legacy 8-byte PDO limitation can be waived, and it's also possible to use the enhanced bandwidth of EtherCAT to support the upload of the entire Object Dictionary. The device profiles, such as the drive profile CiA 402, can also be reused for EtherCAT.

Different communication profiles can coexist in the same system

---

OUTPUT SIGNAL LEVELS

According to specific electrical interface please consider output levels per table below

SIGNAL LEVELS

Output circuit	NPN	NPN Open collector	PNP	PNP Open collector	Push-pull	Line driver HTL	RS422
Ordering code	N	C	R	U	P / PC	L	S / RS
Load current	20 mA	20 mA	20 mA	20 mA	20 mA	20 mA	/
Signal levels HIGH (min) LOW (max)	+V DC - 2,5 V 0,5 V	/ 0,5 V	+V DC - 2,5 V 0,5 V	/ 0,5 V	+V DC - 2,5 V 0,5 V	+V DC - 2,5 V 0,5 V	2,5 V 0,5 V
Note		Ext. power supply max +30 V DC		Ext. power supply max +30 V DC			
Reverse polarity power supply protection	see product datasheet						
Short circuit proof outputs	see product datasheet					short circuit to 0V , +V DC or between channels[1]	

[1] when power supply correctly applied

ENCODER CABLE LENGTH
Based on the power supply, electrical interface and output frequency maximum cable length are as below tables:

INCREMENTAL ENCODERS

Power supply (+ V DC)	Electrical interface	Frequency (kHz)	Max cable length (m)
5V	RS-422	50	300
5V	RS-422	100	200
5/30V - 5/28V - 8/24V	Line driver HTL	50	80
5/30V - 5/28V - 8/24V	Line driver HTL	100	40
5/30V - 5/28V - 8/24V	Push-pull	50	60
5/30V - 5/28V - 8/24V	Push-pull	100	30

ABSOLUTE ENCODERS

Power supply (+ V DC)	Electrical interface	Frequency (kHz)	Max cable length (m)
8/28V - 8/30V	Push pull Bit parallel	25	100
5V - 8/28V - 8/30V	SSI	100	300
5V - 8/28V - 8/30V	SSI	200	200
5V - 8/28V - 8/30V	SSI	400	50
5V - 8/28V - 8/30V	SSI	1000	10
12/28V	Analogue (current)	-	200

System setup: ambient temperature (20°C / +68°F), load current 20 mA , Eltra AWG 24 shielded cable.

Depending on the application, maximum cable length might be shorter, particular eg: where a high level of electrical noise is present.
Please carefully select the power supply core diameter. Size should be enough to guarantee that encoder voltage levels will not go below minimum levels.
Use always shielded cables, for further details or informations please directly contact our offices.

AUXILIARY INPUTS / OUTPUTS
INPUTS
UP/DOWN (U/D):   when connected to logic HIGH encoder output will inverts the counting direction. It is equivalent to rotate the encoder shaft in the opposite direction.

LATCH: when connected to logic state HIGH, it freezes the current data output. In this way, while the encoder shaft is turning, the output data does not change.

RESET: when connected to logic state HIGH it sets the output position to zero.

INPUT	STATE HIGH	STATE LOW
U / D	Inverts the code	No effect
LATCH	Blocks the code	No effect
RESET	Output reset	No effect

OUTPUTS
STROBE: available on absolute encoders with binary code. It goes to logic state HIGH when the output data is valid (all output data has been updated).

PROPER INSTALLATION OF CABLES

· Make sure cable shield is connected to the ground and avoid connecting it to the power ground (0 V).
· Keep the encoder cable sufficiently far away from power lines.
· Choose the cable according to installation requirements.
· Lay the cable avoiding spirals.
· Minimum cable bending radius at least 10 times external diameter.

CUSTOM CABLES AND MORE ...

· Custom cables, extensions and connectors are available on demand.
· Production is 100% tested.
· Anti-vibration wiring system.
· **Contact us for further informations.**

CONNECTORS

Connector type	Ref. code
JIS-C-5432 7 pins cable mount straight plug (female)	PLS-20-7 (PLT® Apex)
JIS-C-5432 10 pins cable mount straight plug (female)	SCC6A16-10S (Sam Woo Electronics)
MIL 7 pins cable mount straight plug (female)	MS3106-16S-1 (Amphenol®)
MIL 10 pins cable mount straight plug (female)	MS3106-18-1 (Amphenol®)
M23 12 pins cable mount straight plug (female)	M23 12 pins CCW (contact arrangements)
V 9 pins cable mount straight plug (female)	D-Subminiature DE-9
M 12 5 pins cable mount straight plug (female)	M12 5 pins A coded 360° totally shielded
M 12 8 pins cable mount straight plug (female)	M12 8 pins A coded 360° totally shielded
MIL 19 pins cable mount straight plug (female)	MS3116-14-19S (Amphenol®)
VB 15 pins cable mount straight plug (female)	D-Subminiature DA-15
VC 15 pins cable mount straight plug (female)	D-Subminiature DE-15 (high density)
S3 5 pins cable mount straight plug (female)	M12 5 pins B coded Profibus
MIL 32 pins cable mount straight plug (female)	62IN-16PHM21-1832S624 (Amphenol®)

CABLES AVAILABILITY

WIRES	CEI MARKING	IEC MARKING	UL MARKING	SHIELD	INSTALLATION
5	CEI 20-22 II			FOIL	FIXED
		IEC 60332-1	UL-CSA	BRAID	FLEXIBLE
		IEC 60332-1	UL-CSA	FOIL	FIXED
	CEI 20-22 II	IEC 60332.3		BRAID	FIXED
8	CEI 20-22 II			FOIL	FIXED
	CEI 20-22 II			BRAID	FIXED
		IEC 60332-1	UL-CSA	BRAID	FLEXIBLE
		IEC 60332-1		FOIL	FIXED
	CEI 20-22 II	IEC 60332.3		BRAID	FIXED
10	CEI 20-22 II			BRAID	FIXED
12	CEI 20-22 II			FOIL	FIXED
16	CEI 20-22 II			FOIL	FIXED
32	CEI 20-22 II			FOIL	FIXED

Please directly contact our offices for non-standard cables availability

PRECAUTIONS AGAINST ELECTROSTATIC DISCHARGES

Be sure the metallic case of the connector is connected to the ground through a ring fixed to the screw of the connector itself. (Fig. 1)
Connect the cable shield to the ground and to the connector case. (Fig. 2)

Fig. 1

Fig. 2

For a better protection of the electronics against electrostatic discharges connect the metallic connector case to ground.

The transducer must be used in observance of its specifications. The transducer is a precision measuring instrument and it is not a safety device.

The personnel charges in mounting and commissioning of the device must be qualified and carefully follow installation instructions.
It is strongly recommended to avoid any mechanical or electrical modification for safety reasons, the warranty will lose in case of any modifications.

Don't expose the device to stresses or impacts in order to ensure the correct functioning.

Make sure that the mechanical coupling of the transducer is designed as indicated in the technical data sheet and that the product is installed as indicated the intallation instructions.

Check the operating environment is free from corrosive agents (acids, etc.) or substances that are not compatible with the device and with its IP rating.

Check the connection of the device to the ground; if necessary, provide an additional external connection.

Products with variant code (a number or combination of numbers after ".") may have different mechanical, electrical or connections from standard product. Please refer to the additional documentation.

Installation and wiring must be performed by trained personnel in a POWER-OFF condition.

To prevent short-circuits, insulate unused wires at different lengths; do not use unused pins on the connector.

Before switching on, verify the voltage range applicable to the device.

Place power and signal cables in order to avoid capacitive or inductive interferences that may cause malfunction of the device. Place also transducer cable far from power lines or any other cable with high noise levels.

The user who integrates the transducer in his appliance must observe CE regulations and he is responsible for the CE marking of the end machine/device.

The malfunctions due to failure to observe these usage and installation precautions will loose the warranty.

Eltra considers itself free from any liability for damages or injuries due to non-observance of these directives.

For storage leave the products in the original packaging. The storage location should be free of dust, dry and temperature-regulated without chemical influences or mechanical shock / vibrations.

For storage times greater than 12 months please rotate the encoder shaft every 12 months at low-speed (e.g. by hand) to allow bearing lubrification to distribute.

For sales conditions please see www.eltra.it

eltra@eltra.it

www.eltra.it